Appendix X-10

Ref. No. 11 JICA 87.
7th January, 1988.

Permanent Secretary
Ministry of Transport and Communications
P.O. Box 52692
Nairobi

ATTENTION: CHIEF ENGINEER (ROADS AND AERODROMES)

Thro'

Resident Representative
JICA
P.O. Box 50572
Nairobi

Dear Sir,

RE: THE DRAFT FINAL REPORT FOR FEASIBILITY STUDY ON THE NAIROBI
     BY-PASS ROAD PROJECT

I am in receipt of your letter Ref. No. R 7305/P.124 dated
18th November, 1987 in which you have mentioned your comments on the
Draft Final Report.

We studied your comments and prepared the reply to them after
discussion on the draft reply to your comments at JICA advisory
committee meeting held on 7th December 1987 which Mr. Wanyoike
(Ag Chief Superintending Engineer, Design, M.O.T.C.) attended.

I am pleased to forwarding our reply to your comments herewith.

Yours faithfully,

H. Ito
Project Manager
JICA Study Team

C.C. Ag. Chief Superintending Engineer, Design, M.O.T.C.

C.C. Chairman to JICA Advisory Committee.

REPLY TO COMMENT

Contents

Comment   1.   The report still needs editing. It seems that Revised Interim
               Report was not edited as requested at the Steering Committee
               meeting on 14th October, 1987. In this regard, there is little
               difference between the Draft Final Report and the Revised Interim
               Report. It is hoped that more editing will be done for the Final
               Report.

Reply   Adequate editing and correcting will be given to the Final
               Report.

Comment   2.   It was quite apparent at the said meeting that the outstanding
               issues in the report concerns traffic and economic analysis. In
               this connection, the following points were noted:-

               (a) On page IV-11 of the Draft Final Report (Summary), there is a
                    table showing future AADT on the various alternatives of the
                    by-pass. However, there is no mention of the alternative
                    chosen. Furthermore, there appears to be no correlation
                    between this Table and Table IV-3-3 on page IV-12 which
                    shows future traffic of the bypass by link. While future
                    traffic on page IV-11 ranges from 9,000 to 22,000, future
                    traffic on page IV-12 ranges from 9,433 to 25,594.

Reply   Table on page IV-11 of the Summary Report (Draft Final
                    Report), showing future traffic of the bypass, has a
                    typographical error. The figures in this table ought
                    to be indentical with those in Table on IV-12 of the
                    Summary Report.

                    As for the selection of alternative plan based on
                    estimated future traffic, the sentences on pages IV-10 and
                    IV-11 of the Summary Report will be changed as follows.

"The decrease of traffic congestion attributable to the bypass is shown in Table IV-3-2 as bottleneck link numbers. This suggests that alternative plan A-1-4 is most effective. It would be most advisable, therefore, to establish a 4-lane bypass on the shortest route by 2,000 year."

Comment   (b)   It is not explicitly stated in the report the total traffic used in the calculation of benefits. However, it was said that the traffic on page IV-12 is the one that was used in the calculation of benefits. Two questions arise from this:-

(i) Why was the traffic on page IV-11 not used?

Reply

The reason why the traffic on page IV-11 of the Summary Report was not used in the calculation of benefits is as follows:-

The future traffic of the Bypass in the table on page IV-11 of the Summary Report has some typographical error. The figures in this table ought to be identical with those in table on page IV-12 of the Summary Report.

Therefore the future traffic of the bypass shown on page IV-12 of the Summary Report and on page VI-27 of the Main Report are used for the calculation of benefit.

Comment

(ii) Why is there so much of a discrepancy between the traffic on page IV-12 of the Summary Report and the IV-13 of the main report? Through traffic plus the diverted traffic from Zones inside Nairobi comprise only a small portion of the traffic used in the calculation. It was obvious that traffic induced from other roads other than A104 has been considered. This traffic is far in excess of the traffic diverted from

A104. It was not explained why this is so. Further-
more, what are the results of the traffic survey with
respect to the proportion of traffic expected to be
induced from these other roads?

Reply

It is reasonable that there is discrepancy between the
traffics because the table in the page VI-13 of the
main report shows the converted traffic volume from
A104 to the Bypass, while the table in the page IV-12
of the Summary Report shows the total traffic volume at
the Bypass.

Converted traffic (VI-3-4) on page VI-13 of the Main
Report are given by an analysis of "VI.4. Traffic
Assignment" in the Main Report, and a new clause titled
"VI.4.7 Converted Traffic" will be provided additionally.
This Clause of VI.4.7 will include the conversion rate
of the Traffic pertaining to each OD pair and the OD
pair of bypass utilization. It will also clarify the
converted traffic from A104 throughout the bypass as
well as other roads for the calculation of benefits.

Reply

The results of the traffic survey with respect to the
proportion of traffic expected to be converted from
these other roads are as follows (1.- 6):

1. The future generated traffic in Nairobi is estimated
   1.95 times greater than current traffic. This
   estimation is based on various factors including the
   economic development plan of Kenya, future popula-
   tion planning of Nairobi, and the increase of traffic
   volume classified by car type.

2. Future generated traffic based on the future popula-
   tion by each zone in accordance with the land use
   plan of Nairobi city will increase sharply in the
   districts where industrial and housing development
   projects are being scheduled, that is, the south-

western (Zones 8, 16, 17, and 18) and southeastern
(Zones 9 and 10) parts of Nairobi City.
The bypass is just intended for linking these
districts together.

3. According to the analysis of future traffic
   distribution, the traffic passing through Nairobi
   from Mombasa toward Kisumu is estimated at 1,210
   V.P.D. in the future, that is, 1.73 times greater
   than at the present time (700 V.P.D.).

   According to the analysis of a desired line in
   aggregate zones, the desired line that runs near
   the proposed bypass route is supposed to form a
   trip capable of being diverted to the bypass.
   Including the through traffic mentioned above, it is
   foreseeable that the volume of this trip will
   increase radically to 31,800 VPD in the future, 2.61
   times greater than at the present time (12,200 VPD).
   This is because the bypass route is so effectively
   located at the points that link together the
   districts where a conspicuous population increase is
   anticipated.

4. According to the results of a traffic assignment
   analysis, a 4-lane bypass on the shortest route is
   considered most effective in order to eliminate
   traffic congestion occurring in the future. The
   following points have been confirmed as a result of
   the O.D. analysis of the converted traffic on the
   bypass.

   The through traffic in Nairobi incoming from Mombasa
   and outgoing to Kisumu will be almost totally
   dependent on the bypass since the running conditions
   on the bypass are better than on A104. Its volume is
   expected to reach 1,210 VPD in the future as compared
   to 700 VPD at the present time.

Trips whose OD (origin/destination) is at either the
beginning or ending point of the bypass and whose DO
is beyond either the ending or beginning point of the
bypass will be almost totally dependent on the bypass.
Without the bypass, these trips would be dependent on
A104, and their traffic volume is estimated at 5,070 VPD
in the future, 2.30 times heavier than at the present
time (2,200 VPD).

The volume of converted traffic other than from A104 to
the bypass is expected to reach 10,040 to 17,030 VPD
(depending on different bypass links) by 2,000 year.
These trips most often originate in Nairobi City. In
the case of closer direction of their OD pairs to that
of the bypass route, the higher conversion rate to the
bypass was assigned. In addition, there are OD pairs
with high growth potential, linking the increasing
populous districts to urban centers and industrial areas.
The direction of these OD pairs is close to that of the
bypass route and therefore the high conversion rates was
assigned in these pairs.

5. Based on the results of the traffic assignment in the
case of without bypass in 2,000 year, Future traffic volume
on C61 was forecasted about 45,800 AADT in PCU and the
congestion rate on C61 was estimated over 1.0 (see Fig.
A-VI-3(2)). But in the case of with bypass in 2,000 year,
Future traffic volume on C61 was forecasted as about
28,600 AADT in PCU and the congestion rate on C61 was
decreased as under 1.0 by the results of reasonable
amount of converted traffic from the roads other than
A104 to the bypass. (see Fig. A-VI-3(5))

6. Due to the reasons decribed above, it was forecasted
that much of the traffic from roads other than A104 will
be converted to the bypass.

Fig. A-VI-3-(2)   Future Traffic Volume for A-0 in the year of 2,000

LEGEND

| 1.10 | : Congestion Rate |
| 2,4267 | : AADT in pcu |

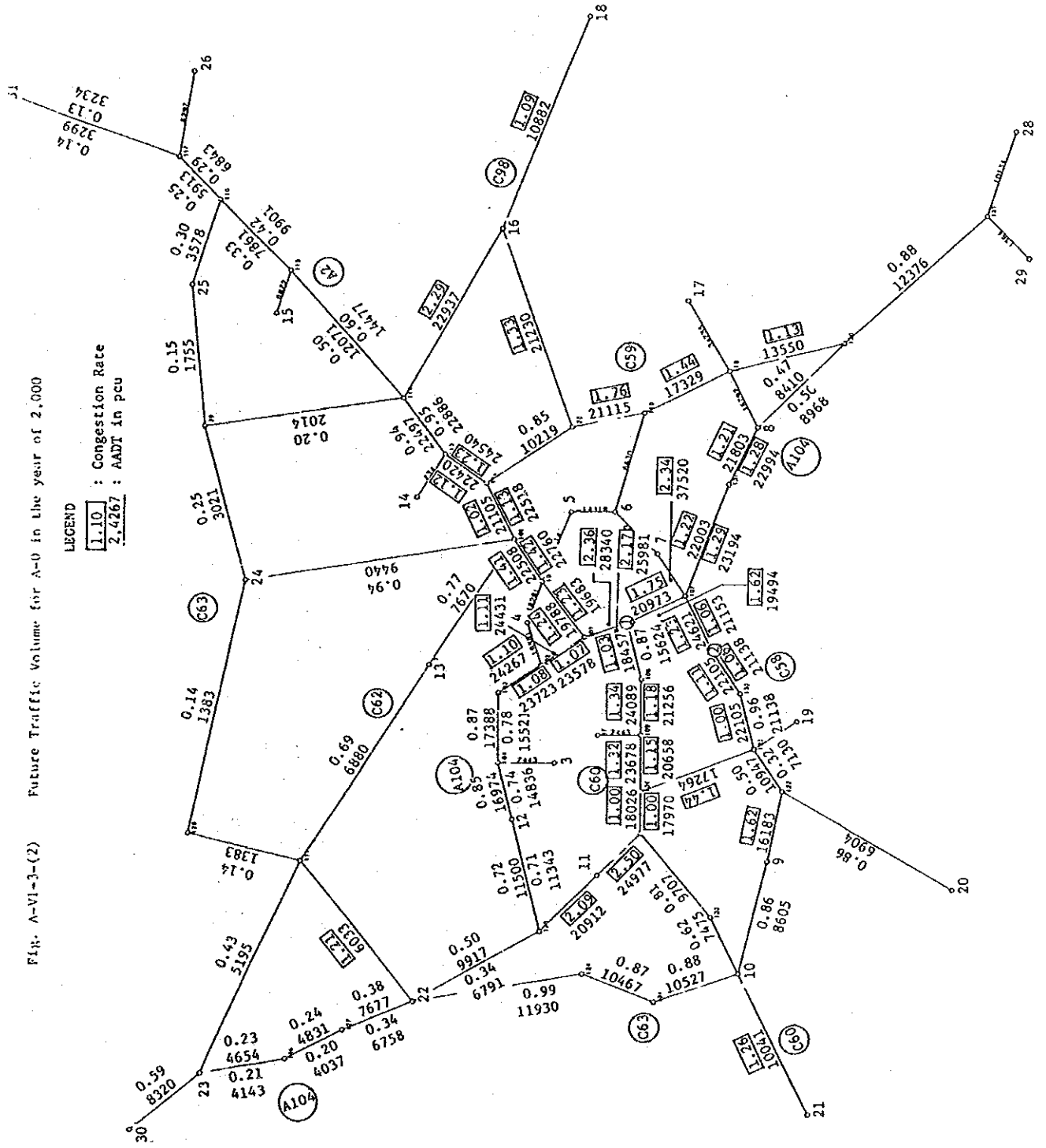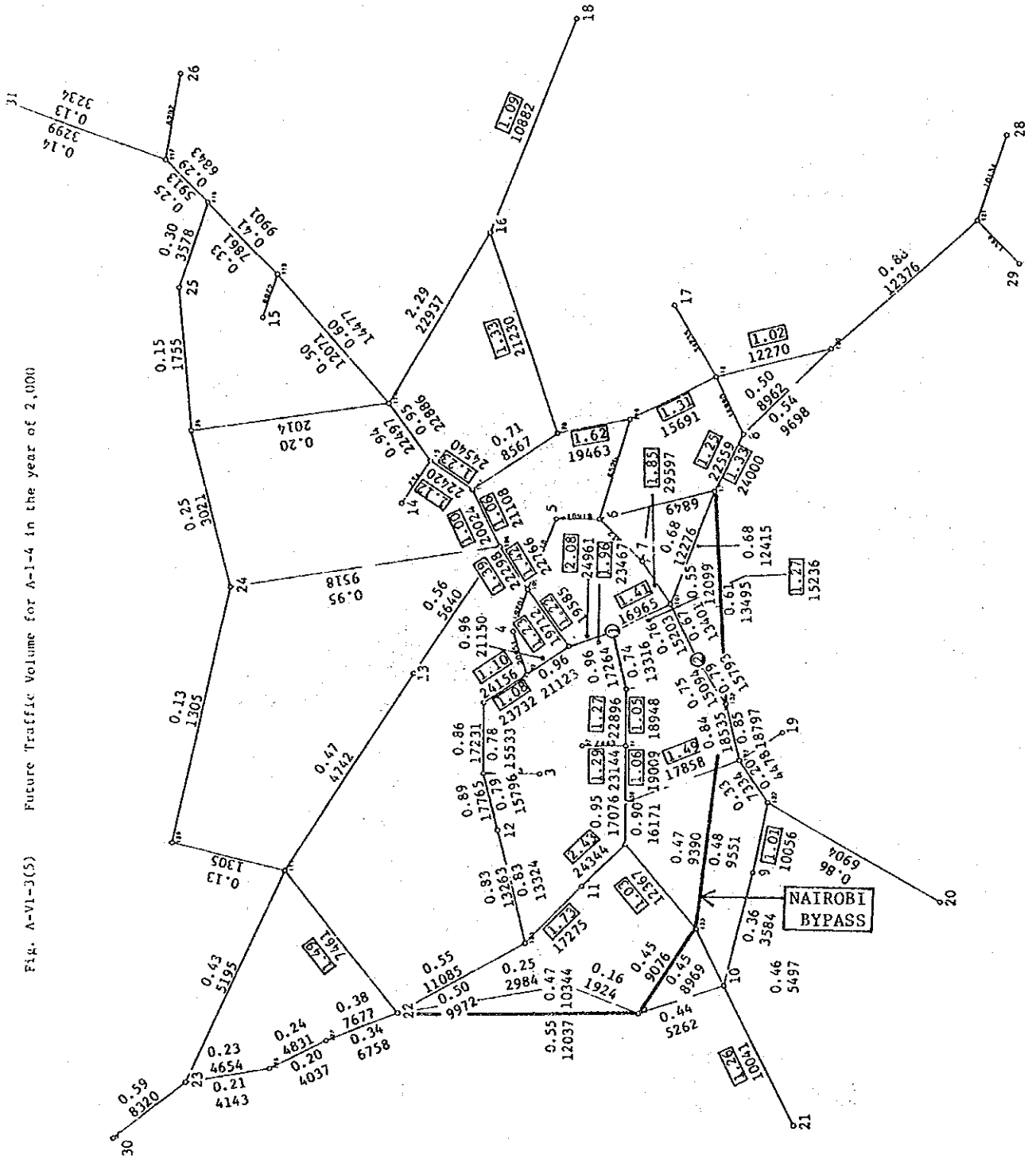Fig. A-VI-3(5)   Future Traffic Volume for A-1-4 in the year of 2,000
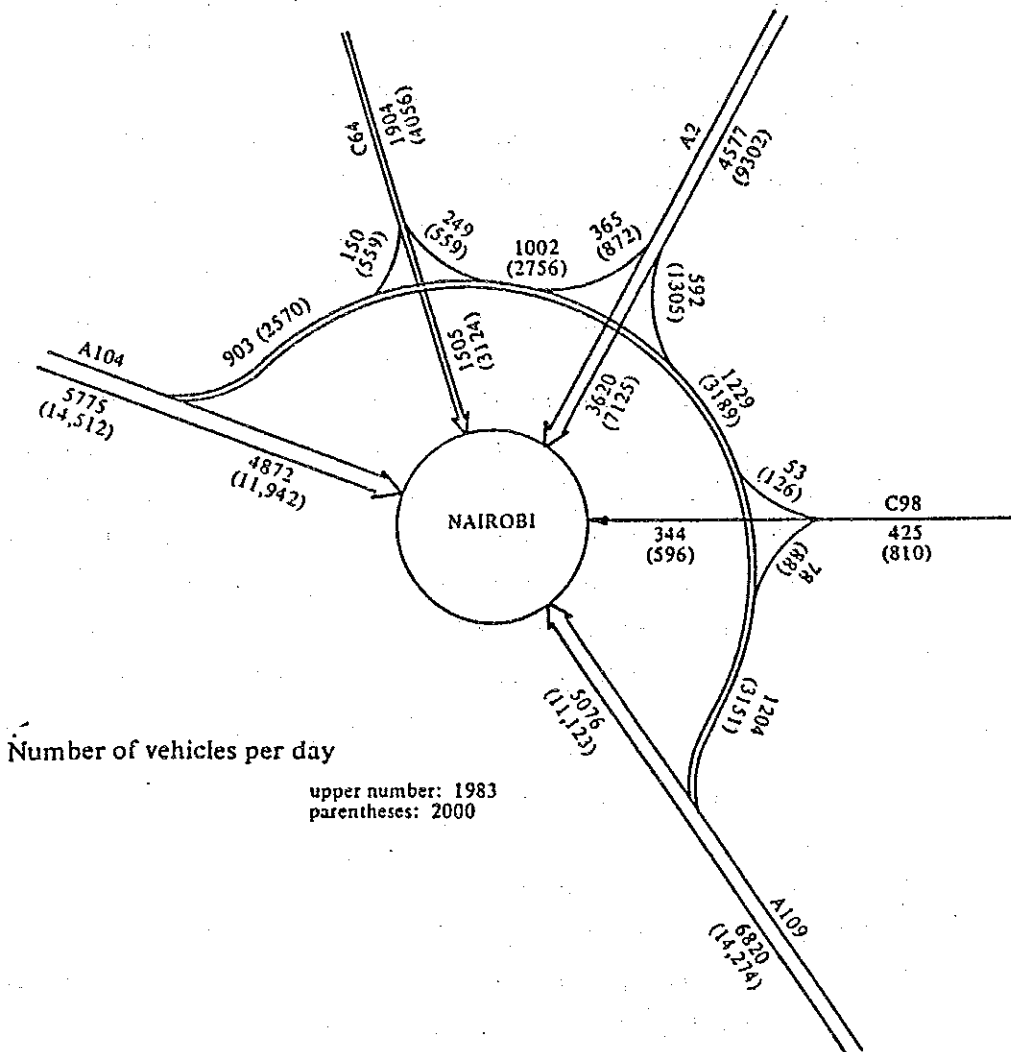
Comment   (c)   The report states that traffic on A104 that has its origin or
                   destination outside Nairobi is considered as through traffic.
                   This was pointed out at the meeting that it is not practical
                   at all. Trip purpose should be considered before such trips
                   are considered to be through traffic. Nairobi as such is well
                   placed for accommodation, shopping etc. and cannot be easily
                   by-passed. A factor not equal to unity should have been
                   established to convert through traffic to bypass traffic.

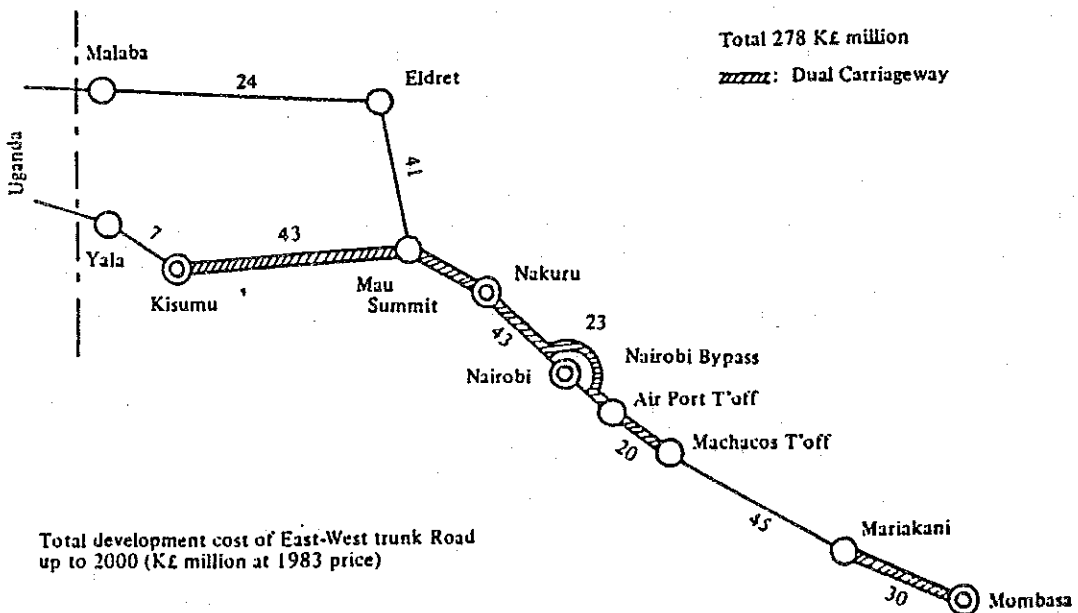Reply   1. The original OD investigation sheet was attached to the
                      inception report. Prior to the traffic survey, some changes
                      were made through consultation with the MOTC staff, and
                      then the survey started. In accordance with the OD sheet
                      after survey, we have reviewed various points on the route
                      regarding passenger cars and light goods vehicles involved
                      in the through traffic mentioned above, but we could not
                      determine whether these automobiles drop into city centers.

                   2. According to the 1986 OD table surveyed, the volume of
                      through traffic in Nairobi totaled 930 (150 + 700 + 80) VPD
                      on the north-west cordon line and 1,180 (430 + 700 + 50) VPD
                      on the south-east cordon line, as illustrated in Figure VI-
                      3-1 of the Main Report (page VI-10). The corresponding data
                      obtained in 1983 are nearly equal to the above values, i.e.
                      903 and 1,204 VPD respectively, as shown in the diagram of
                      Nairobi Bypass given in the Summary and Recommendations
                      Report (page 63) of "the National Transport Plan" 1984 by
                      JICA. Therefore, the volume of through traffic based on the
                      results of this survey seems to be correct.

                      As evident from Figure VI-3-1 of the Main Report (page
                      VI-10), the total traffic on the south-east cordon line
                      amounts to 6,310 (1,180 + 5,130) VPD. Here, the through
                      traffic (1,180 VPD) accounts for 19% of the total traffic.
                      This suggests that most (81%) of the drivers seem to have
                      answered Nairobi as the origin or destination of their trip
                      in the case of dropping into Nairobi.

Nairobi Bypass: Location and Traffic Demand

C64 1904 (4056)

A2 4577 (9302)

150 (559)

249 (559)

1002 (2756)

365 (872)

592 (1305)

903 (2570)

A104

1505 (3124)

3620 (7125)

1229 (3189)

5775 (14,512)

4872 (11,942)

NAIROBI

53 (126)

C98

344 (596)

78 (88)

425 (810)

5076 (11,123)

1204 (3151)

A109 6820 (14,274)

Number of vehicles per day

upper number: 1983
parentheses: 2000

Development Cost

Total 278 K£ million

▨▨▨: Dual Carriageway

Malaba

Eldret

24

Uganda

Yala

7

43

41

Kisumu

Mau
Summit

Nakuru

23

43

Nairobi

Nairobi Bypass

Air Port T'off

20

Machacos T'off

45

Mariakani

30

Mombasa

Total development cost of East-West trunk Road
up to 2000 (K£ million at 1983 price)

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3. The converted traffic from A104 throughout the bypass which
   is anticipated through traffic of Nairobi in 2,000 year will
   reach about 1,210 VPD, as described in VI.4.7 (Converted
   Traffic) of the Main Report. The traffic of passenger cars
   and light goods vehicles amounts to about 580 VPD.

   Nairobi City Commission is planning to build a truck
   terminal near the starting point of the bypass and also
   planning the prohibitation of the truck parking in the
   city center. As a result of these public establishments,
   the traffic of freight vehicles will most certainly be
   converted to the bypass rather than passing through the
   city center.

   Let us assume, nonetheless, that all passenger cars and
   light goods vehicles (580 VPD) or half of the whole traffic
   (600 VPD) may go by way of the city center instead of
   being converted to the bypass, although it is an unrealistic
   assumption. Even if this becomes realistic, only a decrease
   of 600 VPD out of the calculated 6,282 VPD which is only
   9.5% reduction of the traffic.

   The decrease of 600 VPD which is mere 2.6 to 3.7% of the
   total bypass traffic (ranging from 16,318 to 23,308 VPD)
   is equivalent to a decrease by about 3% of the whole
   benefits. This is covered within tne range of 20% benefit
   cutdown in the sensitivity analysis.

4. It is true that Nairobi is well situated for accommodation,
   shopping, and other purposes. Therefore it may be
   considered that some of the through traffic may not select
   the bypass. The numerical values given above have been
   estimated on the basis of a traffic assignment model which
   applied the practical assignment method in order to estimate
   the traffic figures. These figures are not precisely
   identical with the real values.

In this respect, it is probable that a few passenger car and light goods vehicle driving through Nairobi City may drop into the city center, not diverting their course to the bypass. It is difficult, however, to determine the exact percentage. In addition, the probability would produce very little, or rather negligible, effect on the future traffic of the bypass and the economic evaluation of the project. Therefore, we believe that the estimated values based on the traffic assignment model are applicable, without any modification, for the calculation of benefits.

5. The foregoing statements will be summarized and incorporated into Clause VI-4-7 ("Converted Traffic") of the Main Report (contained in the Final Report), which is attached herewith for reference.

Comment   (d) The Interim Report rightly considered the benfits due to
                      induced traffic at 50% of the benefits due to normal traffic.
                      However, in the Draft Final Report the benefits has been
                      escalated to 100% without indicating any reasons thereof.

Reply   In general, traffic is classified into normal traffic
                      converted traffic and induced traffic. The definition of
                      normal traffic, converted traffic and induced traffic are as
                      follows:

                      (i)   Normal traffic   ...   Existing traffic and normal
                                                      growth traffic.

                      (ii)   Converted traffic ...   Present traffic that is
                                                      attracted to the new highway
                                                      from other highway routes to
                                                      see advantages thereon over
                                                      the former routings.

                      (iii) Induced traffic   ...   Generated traffic, only
                                                      because a new highway facility
                                                      is avairable.

                      Converted traffic from other roads discussed in "VI.4.7.
                      Converted Traffic" is clearly explained as the normal
                      trffic, therefore 100% of the benefit based on normal
                      traffic is adopted.

                      It was just misunderstanding that the study team had used
                      the term of induced traffic for converted traffic applying
                      50% of benefit at the stage of the Interim Report.

Comment   (e) In the economic analysis, it is apparent that time savings were
                     considered. Time savings usually become important if they
                     exceed 30 minutes. It is, however, difficult to see how
                     differentials in time between the bypass and A104 can be of this
                     magnitude given the differentials in lengths. In fact
                     differentials in time as shown on Table IX-2-4 on page IX-23
                     of main report appear negligible in view of the fact that the
                     saved time cannot be put into any significant use.

Reply   Time saving has been selected for the benefit calculation as
                     mentioned in IX.2.1, page IX-6.

                     It is the generally admitted methodology to consider time saving
                     for the economic evaluation of urban road.

                     It is the case of rural road project, mainly in the developing
                     countries to neglect the time saving, but not the case of urban
                     transportation.
                     However, the differentials of time in each link are samll, the
                     aggregation of total, considering more than 20,000AADT, can not
                     be negligible.

                     It should be noted that the time saving related to commodity
                     vehicles has not been calculated in the Study, considering
                     neglingible stand-by, which can not be utilized for additional
                     value.

                     Please refer to the table IX-2-4, page IX-23 in the Main Report.

Comment   (f) In general, the traffic assingnment approach and the resultant
                       economic analysis needs to be re-examined.

Reply   Based on the comments before mentioned, the traffic assignment
                       approach is reviewed. Then the team have understood that the
                       traffic assignment method and results are quite reasonable.

                       The processes and results of traffic forecast are summarized
                       and attached hereinafter.

                       As an over-estimation in benefit calcalation has been
                       come out in the last review of the Draft Final Report,
                       they are revised as follows.

                       (i)   It was misunderstood that the converted traffic
                              from A104 to the Bypass would be increased and then
                              time benefit of A104 should be increased based on the
                              decrease of its traffic contrary to the traffic forcast.
                              Therefore this misunderstanding should be corrected.
                              This misunderstanding was taken place due to
                              that only the through traffic from Monbasa to kisumu
                              (from kisumu to Monbasa) was considered as converted
                              traffic in the Revised Interim Report and in
                              the Draft Final Report stage the volume of the converted
                              traffic was corrected as it was.

                       (ii)   Correction of a double count of the converted traffic.

                              In a calculation of the benefit of the coverted
                              traffic from the roads other than A104, the coverted
                              traffic (5,069AADT 2,000Y) from A104 was also included
                              by mistake, so this should be corrected.

(iii) Other minor corrections are as follows.

Based on the implementation schedule, the benefit
of opening year was calculated for five months.
Because the Bypass would be opened at five months
before the end of the fiscal year. However, it had been
three months in the draft final report.

Table XI-2-3

Economic Benefit Stream

mid 1987, 10³ Shill.

Project Year	Fiscal Year	Time Benefit at A104	Benefit of Converted Traffic at Bypass from A104	Benefit of Converted Traffic at Bypass from other Roads	Total Benefit	Discounted 1/ 2/ by 12%
1	1988	0	0	0	0	0
2	89	0	0	0	0	0
3	90	0	0	0	0	0
4	91	0	0	0	0	0
5	92	5,755	6,033	3,820	15,608	9,919 3/
6	93	14,840	16,760	11,697	43,297	24,568
7	94	15,943	19,399	14,925	50,267	25,467
8	95	17,128	22,455	19,045	58,628	26,520
9	96	18,400	25,991	24,301	68,692	27,744
10	97	19,767	30,085	31,008	80,860	29,159
11	98	21,236	34,824	39,567	95,627	30,789
12	99	22,814	40,309	50,487	113,610	32,660
13	2000	24,509	46,663	64,421	135,593	34,803
14	1	25,489	48,530	66,998	141,017	32,317
15	2	26,509	50,471	69,678	146,658	30,009
16	3	27,569	52,490	72,465	152,524	27,866
17	4	28,672	54,589	75,364	158,625	25,875
18	5	29,819	56,773	78,378	164,970	24,027
19	6	31,012	59,044	81,513	171,569	22,311
20	7	32,252	61,405	84,774	178,431	20,717
Σ	20	361,714	625,821	788,441	1,775,976	424,751

1/ : discounted to initial year, 1988   2/ : 12%, opportunity cost of capital, PL2 refer to IX.3.1
3/ : estimated yearly benefit of 42%, considering partial utilization, based on implementation schedule

Table IX-3-1

Cost and Benefit Stream

Unit: mid 1987, 10^3 Shill.

Project Year	Fiscal Year	Cost Real	Cost Discounted by 19%	Cost Discounted by 12% 1/	Benefit Real	Benefit Discounted by 19%	Benefit Discounted by 12%
1	1988	4,418	4,418	4,418	0	0	0
2	89	8,263	6,944	7,378	0	0	0
3	90	41,479	29,291	33,067	0	0	0
4	91	214,092	127,046	152,386	0	0	0
5	92	127,344	63,502	80,929	15,608	7,783	9,919
6	93	272	114	154	43,297	18,144	24,568
7	94	272	96	138	50,267	17,701	25,467
8	95	272	80	123	58,628	17,349	26,520
9	96	272	68	110	68,692	17,082	27,744
10	97	14,738	3,080	5,315	80,860	16,897	29,159
11	98	272	48	88	95,627	16,792	30,789
12	99	272	40	78	113,610	16,765	32,660
13	2000	272	34	70	135,593	16,814	34,803
14	1	272	28	62	141,017	14,695	32,317
15	2	14,738	1,291	3,015	146,658	12,842	30,009
16	3	272	20	50	152,524	11,224	27,866
17	4	272	17	44	158,625	9,809	25,875
18	5	272	14	40	164,970	8,572	24,027
19	6	272	12	35	171,569	7,492	22,311
20	7	14,738	541	1,793	178,431	6,548	20,717
		△84,344 2/	△3,095 2/	△9,793			
Σ	20	358,730	233,589	279,419	1,775,976	216,509	424,751

1/ : discounted to initial project year, 1988   2/ : residual value,   △: minus

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In consideration of above mentioned corrections, Figures listed in the Final Report are ammended as follows.

Benefit (unit: 10^3 kshs)

	D/F Report	Final Report
Time Benefit at A104	524,855	361,714
Benefit of Converted Traffic At the Bypass from A104	781,065	625,821
Benefit of Corverted Traffic at the Bypass from other roads	932,860	788,441

Economic evaluation figures are given in the Final Report as follows.

	D/F Report	Final Report
I.R.R.	23.75	18.26
B/C Ratio	2.03	1.52
N.P.V. (10^3 kshs)	287,108	145,751

The Summary of the processes and results of traffic forecast

1. Traffic Survey

   Based on the Kenyan draft for the original Nairobi bypass route,
   the traffic survey was conducted in order to analyze the future
   traffic volume of roads that compete with or compensate for the
   bypass.

   The results of this survey were transformed into AADT after being
   checked in the light of traffic data compiled by MOTC. Using the
   AADT, we prepared up-to-date OD table classified by type of vehicle,
   which were assigned to the existing road network through traffic
   assignment method. Then, we confirmed that the survey results
   were almost identical with the actually measured values. This
   demonstrates that the accuracy of the current OD table and the
   traffic assignment method are satisfactory.

2. Traffic Generation and Attraction

   The growth rate of control total for each type of vehicle was deter-
   mined not only by analyzing the growth rates in the past but also in
   correlation with the growth of GDP achieved through the Kenyan
   economic programs. The traffic generation and attraction in
   each zone were estimated in view of the growth rate of zonal
   population and labor force, which had been determined on the basis
   of Nairobi City's land-use plan.

   As a result, the future traffic generation and attraction in
   Nairobi City as a whole have been estimated at 1.95 times greater
   than that of the present time. This growing tendency would become
   still greater in the southwestern and southeastern parts of Nairobi
   where industrial and housing development projects are under
   planning.

3. Traffic Distribution

The future OD tables classified by type of vehicle have been estimated by the present pattern method (the Frater method) using the future generation/attraction traffic by each type of vehicle in each zone and the present OD table by each type of vehicle. In Nairobi City, there are several developing areas, but it is not considered to arise the fundamental change in traffic patterns, and this is the reason why the above method has been applied.

The traffic patterns in the developed districts area based on the distribution pattern of the adjacent zones where land uses are similarly in progress.

According to the analysis of the future traffic distribution, the traffic passing through Nairobi from Mombasa toward Kisumu is estimated at 1,210 VPD in the future, this is 1.73 times greater than that of the present (700 VPD).

According to the analysis of the desired line in the aggregate zones, the desired line traffic running near the proposed bypass route are supposed to form the trips being diverted to the bypass. Including the through traffic mentioned above, the trips will increase to 31,800 VPD in 2000 year, 2.61 times greater than that of the present (12,200 VPD). This is because the bypass route is located effectively at the site where linking together the districts where a conspicuous population is anticipated.

4. Traffic Assignment

1) Assignment method

The traffic assignment have been carried out according to the
Practical Assignment Method (PAM). Basically, the traffic volume
of each O-D pair shall be assigned to each link of the route so as
to make the required travel time shortest; but in the case of the
practical assignment method, the traffic volume of all O-D pairs
were partitioned into n parts and assigned n times iteratively.
Since the travelling speed on each link of each assignment is
determined by the aggregate volume of traffic assigned up to the
previous time by referring to the K-V curve formula, the phenomenon
of traffic jam or detouring of vehicles that take place with the
traffic congestion are reproduced.

In forecasting traffic demand for urban roads, P.A.M. allows
route selection which takes into account the grade of road and
congestion, and at the same time it can select the shortest
distance routes at the initial stage of assignment, resulting
in realistic and reliable forecast.

It should be noted that K-V curves, a basic component of P.A.M.,
have been prepared on the basis of the road inventory survey and
vehicle running speed survey conducted in Nairobi area, and
they serve as a model showing relationship between actual degree
of congestion and running speeds on major roads of class A, B
and C.

In the estimation procedure, the number of time of partitioning
was five time, and the method of partitioning into five equal
part was adopted in each OD table by type of vehicle.

2) Alternative Network

Alternative A-0, without the scenario, consists of the present
trunk roads, the roads under construction and the following
planning roads.

- A104 widening (Upper Parkland Estate - Orthopaedic Hospital
                 Section)
- A104 widening (Kabete-Lumuru Section)
- Ngong Road widening (Uhuru Highway-Dagoretti Corner Section)
- Langata Road widening (Uhuru Highway-Animal Orphanage Section)
- New Link Road (Between Ngong Road and Langata)

For with the scenario, three alternative routes were prepared as
for the bypass starting from the neighborhood of Wilson Aerodrome
and taking the same route until the eastern end of the Dagoretti
Forest and from here to the A104, each alternative took the
shortest, the longest and the intermediate route respectively.
The traffic assignment were made on the shortest route and the
longest route. (Functionally, the intermediate route was assumed
as the same as the longest route). Further, both four-lane and
two-lane roads were assigned for each plan.

3) Evaluation of Alternative Network

A macroscopic comparison of the results of the traffic assignment
was made for each Alternative Network using the indexes of a
total Vehicle-Km, a total Vehicle hours, Mean Travelling Speed,
Mean Congestion Rate, Mean Trip Length and Number of Bottleneck
Links. After the comparison, the Alternative network of the
shortest Bypass with four-lane was selected as the most effective
plan for the mitigation of the future traffic congestion.

4) Converted Traffic

According to the results of the traffic assignment analysis,
a 4-lane bypass on the shortest route is considered to be
the most effective for eliminating the future traffic congestion.
The following points have been confirmed based on the O.D. analysis
pertaining to the instance where the bypass is actually
utilized.

The through traffic in Nairobi incoming from Mombasa and outgoing
to Kisumu will be almost totally dependent on the bypass since
the running conditions on the bypass are better than on A104.
Its volume is expected to reach 1,210 VPD in the future as compared
to 700 VPD at the present time.

Trips whose OD (origin/destination) is at either the beginning or
ending point of the bypass and whose OD is beyond either the ending
or beginning point of the bypass will be almost totally dependent
on the bypass. Without the bypass, these trips would be dependent
on A104, and their traffic volume is estimated at 5,070 VPD in
the future, 2.30 times heavier than at the present time (2,200 VPD).

The volume of converted traffic other than from A104 to the bypass
is expected to reach 10,040 to 17,030 VPD (depending on different
bypass links) by 2,000 year. These trips most often originate
in Nairobi City. In the case of closer direction of their OD
pairs to that of the bypass route, the higher conversion rate to
the bypass was forecasted. But in the case of rather different
direction from that of the bypass route, the lower conversion
rate to the bypass was forecasted. In addition, there
are OD pairs with high growth potential linking the increasing
populous districts to urban centers and industrial areas. The
direction of these OD pairs is closer to the bypass route, the
higher the convertion rate will become.

Appendix 1.

VI-4-7. Converted Traffic

(1) Objectives of analysis

When measuring an effects of improvement on ordinary urban
roads, the shortening of driving time and vehicle running
distance in an entire road network constitute a benefits
thereof.

The construction of the bypass, however, has two major purposes
which are converting the through traffic of Nairobi from A104
to the bypass so that eliminating traffic congestions on the
roads in the city. Accordingly it is necessary to divide the
bypass traffic in accordance with the purposes of their
utilizations so that the benefit pertaining to each division
may show the effects of the improvement.

Furthermore, the benefits accruing from this project were
calculated conservatively basically in terms of the items
capable of being quantified. There is something what is
numerically uncertain and small amount on the urban road network
with both the development traffic and induced traffic expecting
incidentally at the completion of the bypass. Because, most
of development schems are including in the future Land use plan
and most of existing roads are already paved. Excluding these,
therefore, the future traffic assigned to the bypass should
include only the normal traffic converted from the existing roads.

(2) Results of the analysis

Standpoints in the analysis

There are three main different standpoints in the analysis, as
describing below, concerning the bypass traffic in A.D. 2000.
The conditions in utilization of the bypass and the character-
istics of the traffic will be analyzed in the following
standpoints.

- Trend of the utilization of bypass categorized in types of
  traffic as internal, external, and through traffic.

- The rate of traffic conversion into the bypass (the traffic
  utilizing the bypass/the total traffic of OD pairs utilizing
  the bypass x 100).

- The traffic converted from A104 to the bypass utilizing
  throughout the bypass.

Results of the analysis

Table VI-4-5 shows the distribution ratio and conversion rate
of the traffic utilizing the bypass classified by Bypass link
and itemized by traffic category. Using both of the table
VI-4-5 and the converted OD trip table (given in the appendix),
the trends of bypass utilization and the characteristics of
bypass traffic were analyzed and the volume of traffic converted
from A104 into the bypass was calculated.

The results of the analysis are summarized as followings.

a) Regarding the bypass's traffic volume itemized by traffic
    category, the internal plus external traffics represents
    more than 90% in every section, whereas the through traffic
    ranges approximately from 1,200 to 1,300 vehicle/day, or less
    than 10% of the total traffic. (see table VI-4-5)

b) The conversion rate becomes the higher as the direction of
    the desired line between zones the closer to that of the
    bypass route.

c) The through traffic has its trip end on the extensions of
    both beginning and ending points of the bypass. The through
    traffic shows a very high conversion rate of over 95%.
    (shown in table VI-4-5)

d) The conversion rates of the external and the internal traffics
    are about 80% and 50% respectively. It is the suggestive
    tendency that the bypass conversion rate becomes lower as
    the gap between the direction of the bypass route and that
    of the desired line becomes greater. Such a tendency seems
    to reflect the effect of The Traffic Assignment Method capable
    of selecting the shortest time route. (shown in table VI-4-5)

e) The traffic running through the bypass as converted from A104
    to the bypass is considered to include both the through
    traffic and the external traffic which has its origin near
    by the beginning point of the bypass (in or around the
    airport, industrial area, and other districts) and its
    destination beyong the ending point of the bypass. The
    results of an analysis of converted O.D. trips on the Bypass
    show that the volume of converted-throughout traffic amounts
    to a total of 6,282 vehicle/day, consisting of 1,213 through
    and 5,069 external trips (as shown in table VI-4-6). The
    bypass conversion rates of these cars are nearly 100%,

f) The converted traffic from A104 to the bypass throughout,
    which is anticipated Nairobi's through traffic in 2,000 year,
    will reach about 1,210 VPD, as shown in Table VI-4-6. The
    traffic of passenger cars and light good vehicles will
    amount to about 570 VPD.

    Nairobi City Commission is planning to build a truck terminal
    near the starting point of the bypass and also planning the
    prohibitation of the truck parking in the city center. As a
    result of these public establishments, the traffic of freight
    vehicles will most certainly be converted to the bypass rather
    than passing through the city center.

    Let us assume, nonetheless, that all passenger cars and
    Light goods vehicles (570 VPD) or half of the whole traffic
    (600 VPD) may go by way of the city center instead of being

converted to the bypass, although it is an unrealistic
assumption. Even if this becomes realistic, a decrease
of 600 VPD out of the calculated 6,282 VPD is only a 9.5%
reduction of the traffic.

The decrease of 600 VPD which is mere from 2.6 to 3.7% of
the total bypass traffic which are ranging from 16,318 to
23,308 VPD or equivalent to a decrease of 3% of the whole
benefits. This is within the range of 20% benefit cutdown
in the sensitivity analysis.

Nairobi is obviously well situated for accommodation,
shopping, and other purposes. Therefore it may be considered
that some of the through traffic may not take the bypass.
The numerical values due to above have been estimated on the
basis of a traffic assignment model being applied the
practical assignment method. These figures have not been
identical as the real values.

In this respect, it will be probable to consider that a few
passenger car and light good vehicle driving through Nairobi
City may drop into the city center, instead of diverting to
the bypass. It is however difficult for us to determine the
exact percentage of the traffic. Further, the traffic
would be very little, or rather be negligible in an economic
evaluation of the project. Accordingly, we believe that the
estimated values based on the traffic assignment model are
fully applicable, without any modification.

g)   Therefore, the traffic volume excluding 6,282 vehicle/day
     constitutes the volume of other converted traffic as shown
     in Table VI-4-6.

     The volume of converted traffic other than from A104 to the
     bypass is expected to reach 10,040 to 17,030 VPD in depending
     on different bypass links by 2,000 year. These trips

mostly originate in Nairobi City. In the case of closer
direction of their OD pairs to that of the bypass route,
the higher conversion rate to the bypass was assigned.
In addition, there are OD pairs with high growth potential
linking the increasing populous districts to urban centers
and industrial areas as southwest and southeast development
area of Nairobi.

Based of the results of the traffic assignment in the case
of without bypass in 2,000 year, Future traffic volume on
C61 was forecasted about 45,800 AADT in PCU and the
congestion rate on C61 was estimated over 1.0 (shown in
Appendix Fig. A-VI-3(2)). But in the case of with bypass
in 2,000 year, Future traffic volume on C61 was forecasted
as about 28,600 AADT in PCU and the congestion rate on C61
was esteemed to decrease under 1.0 as the results of estimat-
ing converted traffic from the roads other than A104 to the
bypass. (shown in Appendix Fig. A-VI-3(5)

Based on the many reasons described above, it was forecasted
that much of the traffic from roads other than A104 would be
assigned to the bypass.

Concerning the bypass traffic in A.D. 2,000, the volume of
bypass traffic in 1991 is translated as shown in Table VI-4-6
which was required for the benefit calculation in this study.

The traffic volume in 1991 has been determined by means of
the interpolation between the traffic volumes in 1986 and
2000.

The Future traffic volume on A104 by type of car were used
for the benefit calculation as shown in Table VI-4-7.

TABLE VI-4-5 Trends of Bypass Utilization in A.D. 2000 by
the Bypass Link

Bypass Link / Traffic Category	Link 1			Link 2			Link 3			Link 4		
	Traffic Volume (100 VPD)	Distribution ratio (%)	Conversion rate (%)	Traffic Volume (100 VPD)	Distribution ratio (%)	Conversion rate (%)	Traffic Volume (100 VPD)	Distribution ratio (%)	Conversion rate (%)	Traffic Volume (100 VPD)	Distribution ratio (%)	Conversion rate (%)
Internal Traffic	138	60	64	80	47	49	61	38	47	75	39	51
External Traffic	82	35	84	79	46	80	90	55	78	105	54	74
Through Traffic	12	5	95	12	7	98	12	7	100	13	7	99
Total	232	100	71	171	100	62	163	100	63	193	100	64

Note:

Internal Traffic : Zone pairs having both trip ends inside Nairobi City

External Traffic : Zone pairs having their trip ends both inside and outside of Nairobi City

Through Traffic : Zone pairs passing through Nairobi City

TABLE VI-4-6 TOTAL CONVERTED TRAFFIC TO THE BYPASS BY LINK

Unite: AADT

Bypass Link No.	Converted Traffic from		1991 Year							2000 Year						
			Car	L.G.V.	M.G.V.	H.G.V.	BUS	MA.	Total	Car	L.G.V.	M.G.V.	H.G.V.	BUS	MA.	Total
1	from A104	(1)	237	150	122	388	11	--	908	351	222	132	496	12	--	1,213
		(2)	1,009	1,336	415	424	18	--	3,202	1,778	2,309	460	502	20	--	5,069
		(1)+(2)	1,246	1,486	537	812	29	--	4,110	2,129	2,353	592	998	32	--	6,282
	from other roads		3,990	1,799	186	13	135	--	6,123	10,621	5,919	373	68	223	--	17,026
	Total		5,236	3,285	723	825	164	--	10,233	12,750	8,272	965	1,066	255	--	23,308
2	from A104	(1)	237	150	122	388	11	--	908	351	222	132	496	12	--	1,213
		(2)	1,009	1,336	415	424	18	--	3,202	1,778	2,309	460	502	20	--	5,069
		(1)+(2)	1,246	1,486	537	812	29	--	4,110	2,129	2,353	592	998	32	--	6,282
	from other roads		3,009	1,626	38	4	4	--	4,681	6,651	4,194	179	1	5	--	10,852
	Total		4,255	3,112	575	816	33	--	8,791	8,780	6,547	771	999	37	--	17,134
3	from A104	(1)	237	150	122	388	11	--	908	351	222	132	496	12	--	1,213
		(2)	1,009	1,336	415	425	18	--	3,202	1,778	2,309	460	502	20	--	5,069
		(1)+(2)	1,246	1,486	537	812	29	--	4,110	2,129	2,353	592	998	32	--	6,282
	from other roads		3,871	1,136	105	78	4	--	5,194	7,242	2,867	67	29	9	--	10,036
	Total		5,117	2,622	642	890	33	--	9,304	9,371	5,220	659	1,027	41	--	16,318
4	from A104	(1)	237	150	122	388	11	--	908	351	222	132	496	12	--	1,213
		(2)	1,009	1,336	415	425	18	--	3,202	1,778	2,309	460	502	20	--	5,069
		(1)+(2)	1,246	1,486	537	812	29	--	4,110	2,129	2,353	592	998	32	--	6,282
	from other roads		5,727	1,940	89	103	16	--	7,875	8,792	4,235	91	103	16	--	13,059
	Total		6,973	3,426	626	915	45	--	11,985	10,921	6,588	683	1,101	48	--	19,341

Note:
L.G.V. : Light Goods Vehicle
M.G.V. : Medium Goods Vehicle
H.G.V. : Heavy Goods Vehicle
MA. : Matatu

(1) : Through-Traffic of Nairobi converted from A104 to Bypass
(2) : Converted from A104 to Bypass of both or either O-D inside Nairobi (External Traffic)

Table VI-4-7 AADT on A104 in the case of Alternative A-1-4

(Vehicle/day)

Link No. of A104	Original Link No.	Year in 1991							Year in 2000						
		Car	L.G.V.	M.G.V.	H.G.V.	BUS	MA.	Total	Car	L.G.V.	M.G.V.	H.G.V.	BUS	MA.	Total
A104-1	1043	4,514	2,590	356	279	274	808	8,821	5,620	3,954	340	294	313	808	11,329
	1044	5,819	2,695	411	190	275	538	9,928	6,571	3,470	414	205	299	538	11,497
Both Direction		10,333	5,285	767	469	549	1,346	18,749	12,191	7,424	754	499	612	1,346	22,826
A104-2	1001	9,549	4,755	373	162	174	638	15,651	9,328	5,517	387	173	181	638	16,224
	1002	9,585	4,283	302	79	205	638	15,092	8,714	4,648	316	80	222	638	14,618
Both Direction		19,134	9,038	675	241	379	1,276	30,743	18,042	10,165	703	253	403	1,276	30,842
A104-3	1008	11,252	6,354	396	187	570	638	19,397	13,490	8,429	412	197	593	638	23,759
	1009	11,598	5,961	394	184	408	638	19,183	13,329	7,454	407	187	429	638	22,444
Both Direction		22,850	12,315	790	371	978	1,276	38,580	26,819	15,883	819	384	1,022	1,276	46,203
A104-4	1010	9,620	5,061	194	139	552	638	16,204	11,838	6,880	202	142	553	638	20,253
	1011	9,811	4,703	209	143	519	638	16,023	11,274	5,833	221	147	524	638	18,637
Both Direction		19,431	9,764	403	282	1,071	1,276	32,227	23,112	12,713	423	289	1,077	1,276	38,890
A104-5	1012	10,160	5,567	199	139	552	638	17,255	13,315	8,399	207	142	553	638	23,254
	1013	10,315	5,154	208	143	519	638	16,977	12,558	7,162	220	147	524	638	21,249
Both Direction		20,475	10,721	407	282	1,071	1,276	34,232	25,873	15,561	427	289	1,077	1,276	44,503
A104-6	1014	5,636	3,157	79	11	339	1,128	10,350	8,791	5,989	87	14	340	1,128	16,349
	1056	5,791	2,744	88	15	345	1,128	10,111	8,034	4,752	100	19	345	1,128	14,378
Both Direction		11,427	5,901	167	26	684	2,256	20,461	16,825	10,741	187	33	685	2,256	30,727
A104-7	1015	5,742	3,061	71	16	344	1,128	10,362	9,285	5,999	81	23	347	1,128	16,863
	1057	6,005	2,622	45	10	346	1,128	10,156	8,583	4,636	49	13	354	1,128	14,763
Both Direction		11,747	5,683	116	26	690	2,256	20,518	17,868	10,635	130	36	701	2,256	31,626
A104-8	1016	3,404	2,248	57	17	358	1,074	7,158	6,512	4,751	68	23	372	1,074	12,800
	1017	3,926	2,170	73	16	347	1,182	7,714	6,190	4,114	94	21	372	1,182	11,973
Both Direction		7,330	4,418	130	33	705	2,256	14,872	12,702	8,865	162	44	744	2,256	24,773
A104-9	1018	3,478	1,995	165	5	321	236	6,200	5,382	3,476	232	8	332	236	9,666
	1058	3,272	1,664	144	30	343	236	5,689	4,634	2,706	239	47	367	236	8,229
Both Direction		6,750	3,659	309	35	664	472	11,889	10,016	6,182	471	55	699	472	17,895

Note   L.G.V. : Light Goods Vehicle   M.G.V. : Medium Goods Vehicle
        H.G.V. : Heavy Goods Vehicle   MA.   : MATATU

CONVERTED OD TRIPS ON THE BYPASS (LINK-1) IN 2000
TYPE OF VEHICLE: TOTAL

NAIROBI CITY

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CONVERTED OD TRIPS ON THE BYPASS(LINK-1) IN 2000
TYPE OF VEHICLE:TOTAL

OUTSIDE NAIROBI

ZONE No	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(28)	(29)	(30)	(31)	TOTAL
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2								222			0.0	280 (76.5)
3								(65.9)			0.0	417 (44.3)
4								(43.5)	(42.5)		0.0	0.0
5											0.0	0.0
6	68.2	57	64.2*	13.8*						28.4*	0.0	516 (35.4)
7	48.8	36.5*	38.8*0.0	22.1*						545*	0.0	2004 (36.6)
8	88.6	86.8	300.0*	25.7*				74		14*	0.0	2327 (32.9)
9	100.0	100.0	122 (100.0)	(100.0)				(100.0)	(100.0)	(100.0)	0.0	1957 (28.9)
10											0.0	77 (9.7)
11	33.5	19						76	19.3		0.0	64.3
12	35.6	36.5						56.4	57.5		0.0	2301 (50.7)
13	100.0	100.0						88	87.5		0.0	1081 (9.5)
14	34.5	35.33						(100.0)	(100.0)		0.0	0.0
15											0.0	0.0
16			278	13						57	0.0	120
17			(100.0)	229 (100.0)						(100.0)	0.0	35.9
18											0.0	3504 (28.7)
19											0.0	34.3 / 84.2
20		0.0	0.0	0.0				(100.0)	(100.0)		0.0	545 (84.0)
21											0.0	712 (76.8)
22								6 (80.6)	2 (31.1)		0.0	1408 (98.8)
23											0.0	908
24		2		73							0.0	98.9
25		(100.0)		(100.0)				(100.0)			0.0	0.0
26											0.0	0.0
28	100.0	2	41.0*	73*				343	76*	446*	0.0	949 (80.7)
29	100.0	(100.0)	(100.0)	(100.0)				(100.0)	(100.0)	(100.0)	0.0	143 (1.6)
30	0.6										0.0	1578 (98.5)
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	309 (76.3)	362 (87.7)	818 (94.7)	656 (93.8)	0.0	0.0	0.0	883 (89.7)	181 (87.4)	1156 (89.0)	0.0	23308 (71.7)

NAIROBI CITY ← → NAIROBI ← OUTSIDE NAIROBI →

LEGEND
UPPER :NO.OF CONVERTED OD TRIPS
(LOWER):% OF CONVERSION RATE
　※ : CONVERTED TRIPS FROM A104

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