12.8 Analysis of Traffic Survey for the Gwalior Bypass

12.8.1 Classified Traffic Count Survey

(1) Traffic Characteristics

The average daily traffic volumes at three survey locations are summarised in Table 12-14. The traffic volumes on NH-3 at the Agra side was 14,900 PCU/day and 9,360 PCU/day at Munbai side.

Traffic characteristics such as vehicle composition, Peak Hour Ratio and Day Time Traffic Ratio by each survey location are shown in Table 12-15. The percentage share of trucks is the highest at south ending point of the Bypass (55.7%) and lowest at the central point (location No.7) with a share of 30.5%. On the other hand, the share of slow moving vehicles at location 7 is the highest because of number of cycles. The peak hour ratios are varying in the range from 6.4% to 8.1% with an average of 7.2%. The Day Time Traffic Ratio at location No. 7 is the highest due to the many local traffic are moving around this road section in day time.

Hourly traffic variations by each survey location are illustrated in Figure 12-9. The survey location No.7 which include many local traffic to/from Gwalior city shows the clear morning peak and evening peak.

(2) Average Annual Daily Traffic (AADT)

The AADT was estimated based on the comparison of results of traffic count survey conducted by the Study Team in May 1997 and the results of this time survey in November 1997. The results of comparison are shown in Table 12-16. There were big differences between traffic in May and November at the location No. 8 (Munbai side). Three days average traffic volumes in November at location No. 8 were lower than in May by about 60%. Although May is the peak season of traffic and traffic was affected by seasonal fluctuation to some extent, the differences above seemed too big to be explained only by seasonal fluctuation. Therefore, it was necessary to check whether the entire portion of above differences can be explained by the seasonal fluctuation or by other special factors. The three days average were broken down to day by day base in order to examine whether the averages of three days were affected by an irregular traffic in a particular day. The day by day base traffic volumes of each survey location are also presented in Table 12-16. Daily traffic of each survey day at location No. 8 indicates stable volumes during three days survey and no irregular traffic volumes are observed as like the case of the Bareilly Bypass. On the contrary, traffic volume of three days survey in May at the location No.8 seems varied in wide range except for trucks.

Table 12-14 Results of Traffic Count Survey (Gwalior : 3 days average)

Survey period : 3 days 24 hours at each station
Survey Date : from 10 Nov. 97 to 19 Nov. 97

Survey Location No.(km)	FAST MOVING VEHICLES									SLOW MOVING VEHICLES				Total Vehicles			Total PCUs		
	Car/Jeep Taxi	Van Tempo	Auto Rickshaw	Two Wheeler	Bus	Truck			Total of Truck	Tractor Trailer	Animal/ HD	Cycle	Cycle Rick	Fast	Slow	Total	Fast	Slow	Total
						LCV	2-Axle	MAV											
6 NH 3 (km103)	1484	408	74	1404	522	357	2867	97	3321	255	44	936	16	7213	1251	8464	13646	1254	14900
7 NH 3 (km115)	904	428	134	2142	381	359	2681	55	3095	308	65	2686	6	7084	3065	10149	12309	2354	14663
8 NH 3 (km133)	687	52	10	570	216	207	2171	78	2456	183	9	227	0	3991	419	4410	8826	534	9360

Note : LCV : Light Commercial Vehicle
2-Axle : 2-Axle Truck
MAV : Multi-Axle Truck

Table 12-15 Characteristics of Traffic on National Highway No.3

Survey Station No.	Chainage	ADT in Vehicles	Vehicle Composition (%)						Peak Hour Ratio %	Day Time Ratio %
			Cars	Buses	Trucks	2-W	Fast Vehicles	Slow Vehicles		
6	km 103	8464	23.2%	6.2%	39.2%	16.6%	85.2%	14.8%	7.1%	67.7%
7	km 115	10149	14.4%	3.8%	30.5%	21.1%	69.8%	30.2%	8.1%	74.4%
8	km 133	4410	17.0%	4.9%	55.7%	12.9%	90.5%	9.5%	6.4%	61.0%
Average			18.2%	4.9%	38.5%	17.9%	79.4%	20.6%	7.2%	67.7%

Note : Cars include passenger cars, jeeps, vans and three wheelers.
Day Time Ratio =(Day time traffic/ ADT)x100%
Day time traffic = Traffic from 06:00 till 18:00 hours.

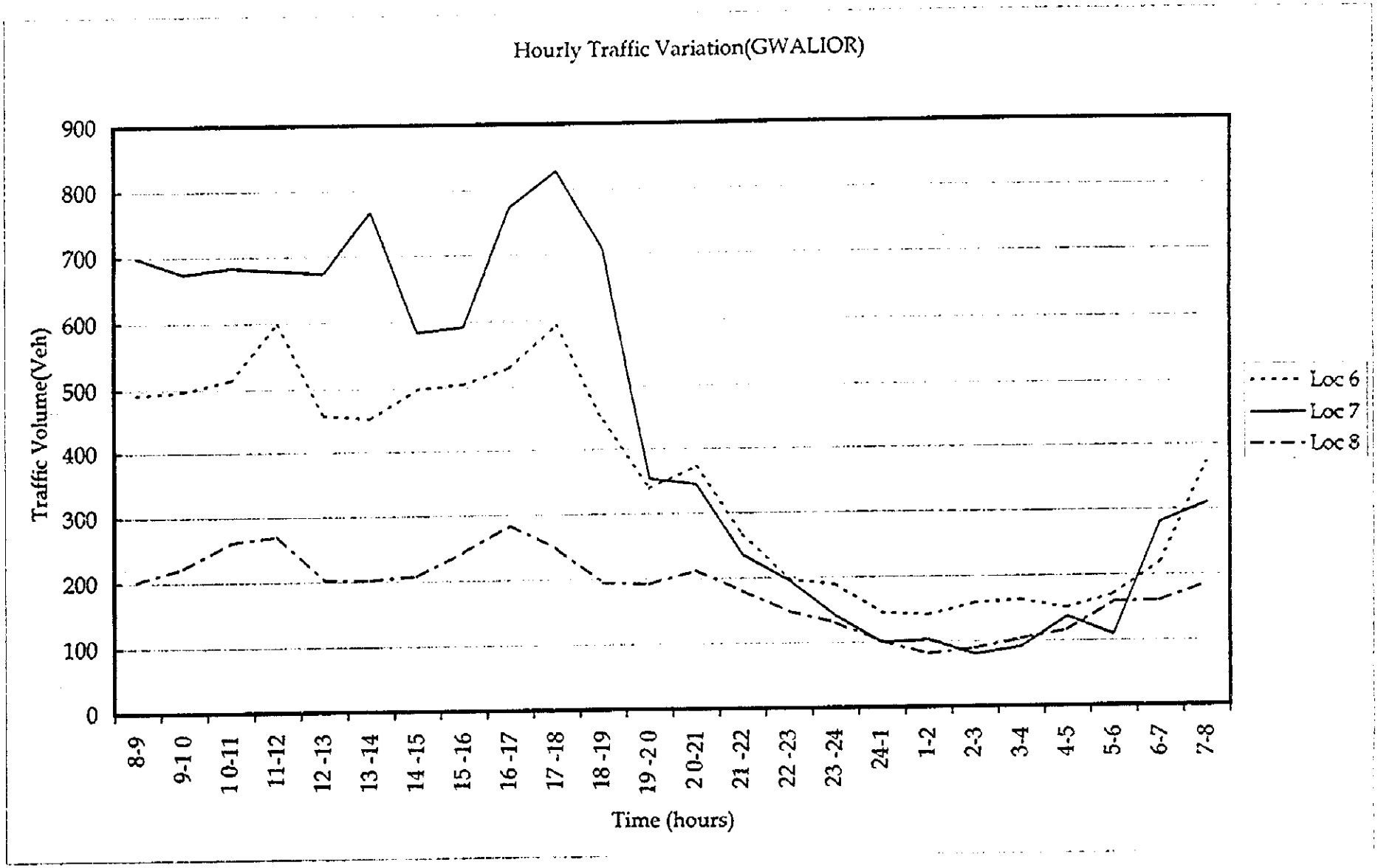


Figure 12-9 Hourly Traffic Variation (Gwalior)

The AADT was calculated as an average of traffic volumes surveyed in May and in November 1997 based on the above analysis.

12.8.2 Origin - Destination (O-D) Survey

(1) Sampling Rate

The sample size of the O-D survey on NH-3 ranged from 25.6% to 47.5% for fast vehicles and from 4.0% to 19.3% for slow vehicles as shown in Table 12-17. Total 7,518 samples of fast vehicles were collected during the two days survey. An average sampling rate of fast vehicles was at 30.5% of total 12-hour traffic.

(2) Present O-D Matrix

The present O-D matrices for fast vehicles and for slow vehicles are presented in Table 12-18 and Table 18-19 respectively. The volumes of through traffic are calculated as follows :

	Total vehicle trips (A)	Through traffic (B)	(B/A)x100%
Fast vehicles	13,942	4,734	34.0%
Slow vehicles	3,776	448	11.9%

Figure 12-10 shows the desire line diagram for fast vehicles.

12.8.3 Traffic Speed and Delay Survey

The average journey speed on NH-3 surveyed on divided five stretches is summarised in Table 12-20. The lowest journey speed by the test car in morning peak was at the stretch of Ghandinadi Ganj to Girhar Naka (stretch No. 3 to down direction) with average speed of 20 km/hour which was affected by 5.7 minutes delay time. The lowest speed in evening peak is observed at the same stretch.

12.8.4 Axle Load Survey

Axle load survey was carried out at NH-3 (km 133.3) and the summary of the results is shown in table 12-21. The distribution of axle load by truck type 3 (Medium truck with 2 axles) indicates the high average load on rear axle (6.07 tons).

12.8.5 Opinion Survey on Toll Bypass

The results of opinion survey on the toll bypass are summarised in Table 12-22. More than 98% of interviewed persons replied that the proposed Gwalior Bypass is necessary from the view points of traffic problem, accidents and pollution etc. However, about 68% of them do not agree the toll bypass. Farmers and persons of industries are main opposition parties not willing to pay. One of the reasons not willing to pay was that they already paid other road related taxes.

The amounts of willingness to pay vary depending on the degree of distance savings, time savings and by category. It should be noted, again, that the people tend to declare the amounts to the low side. Persons managing trade company/truck operators have replied the comparatively high toll level as shown in Figure 12-11 and Figure 12-12.

Table 12-16 Comparison of Three Days Traffic Variations (Gwalior)
(in November & May)

Survey Location No.	Survey Date	Vehicle Type (Fast vehicles) (Vehicles/day : Both directions)				
		Cars	Buses	Trucks	2-Whls	Total
6	10 Nov. 97(Mon.)	1878	624	2762	1611	6875
NH3	11 Nov. 97(Tue.)	1971	420	3719	1305	7415
(km103)	12 Nov. 97(Wed.)	2053	531	3482	1303	7369
	Average (Nov.)	**1967**	**525**	**3321**	**1406**	**7220**
	13 May 97 (Tue.)	1448	545	3282	1142	6417
	14 May 97 (Wed.)	1656	625	3676	1294	7251
	15 May 97 (Thu.)	1645	631	3834	1423	7533
	Average (May)	**1583**	**600**	**3597**	**1286**	**7067**
	AADT	**1775**	**563**	**3459**	**1346**	**7143**
8	17 Nov. 97 (Mon.)	846	182	2414	535	3977
NH 3	18 Nov. 97 (Tue.)	683	233	2451	523	3890
(km133)	19 Nov. 97 (Wed.)	735	243	2509	646	4133
	Average (Nov.)	**755**	**219**	**2458**	**568**	**4000**
(km134)	12 May 97 (Mon.)	1661	1017	5704	811	9193
	13 May 97 (Tue.)	2344	988	5881	1060	10273
	14 May 97 (Wed.)	2248	659	5760	1175	9842
	Average (May)	**2084**	**888**	**5782**	**1015**	**9769**
	AADT	**1420**	**554**	**4120**	**792**	**6885**

Table 12-17 Sample Size and Sampling Rate of O - D Survey
(Gwalior)

Survey Station No.	Date	Fast Moving Vehicles			Slow Moving Vehicles		
		Sample Size (Vehicles)	12 hour Traffic Volume	Sampling Rate (%)	Sample Size (Vehicles)	12 hour Traffic Volume	Sampling Rate (%)
6	10 Nov. 97	1255	4505	27.9%	140	1018	13.8%
NH 3	11 Nov. 97	1454	5116	28.4%	91	870	10.5%
(km 103)	Two days total	2709	9621	28.2%	231	1888	12.2%
7	12 Nov. 97	1388	5365	25.9%	128	2870	4.5%
NH 3	13 Nov. 97	1265	4944	25.6%	104	2583	4.0%
(km 115)	Two days total	2653	10309	25.7%	232	5453	4.3%
8	17 Nov. 97	1029	2330	44.2%	62	344	18.0%
NH 3	18 Nov. 97	1127	2372	47.5%	63	327	19.3%
(km133)	Two days total	2156	4702	45.9%	125	671	18.6%
Average		7518	24632	30.5%	588	8012	7.3%

Table 12-18 Present O-D Matrix for the Gwalior Bypass (Fast Vehicles, 1997)

(Vehicles/day)

O-D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	TOTAL
1	1538	169	897	3	1219	36	4	9	339	354	4	104	251	5	51	116	0	5100
2	265	25	0	0	312	1	0	0	0	1	2	14	35	0	35	0	0	690
3	852	0	0	0	11	0	2	0	0	0	0	9	25	0	5	0	0	905
4	15	4	14	0	21	0	0	0	8	14	0	12	6	0	5	9	0	109
5	1614	51	43	5	0	0	61	17	121	160	39	0	0	15	0	52	0	2178
6	36	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	40
7	161	0	6	0	17	0	0	0	6	16	2	2	5	0	0	9	0	225
8	11	4	0	0	0	0	0	0	3	0	0	2	7	0	0	0	0	28
9	192	22	0	0	29	2	5	0	0	0	0	15	29	0	7	0	0	302
10	339	22	0	0	99	3	24	0	0	0	0	206	296	0	22	0	0	1011
11	8	2	0	0	9	3	0	0	0	0	0	20	28	0	2	0	0	73
12	162	3	9	0	0	0	23	2	26	176	87	0	0	31	0	297	2	819
13	206	2	20	0	0	0	21	13	75	243	46	0	0	29	0	558	0	1213
14	26	2	0	0	23	0	0	0	0	0	0	16	33	0	10	0	0	110
15	111	1	0	0	0	0	11	12	24	42	24	0	0	20	0	38	0	282
16	108	18	0	0	23	0	17	0	0	0	0	346	310	0	28	0	0	850
17	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	6
TOTAL	5646	325	990	8	1763	46	168	53	607	1006	204	747	1030	100	166	1079	2	13942

Table 12-19 Present O-D Matrix for the Gwalior Bypass (Slow Vehicles, 1997)

(Vehicles/day)

O-D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	TOTAL
1	1640	104	241	1	380	3	0	0	12	2	0	2	3	0	0	0	0	2388
2	187	119	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0	516
3	200	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	206
4	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
5	458	10	0	3	24	0	0	0	0	6	17	0	0	0	0	0	0	518
6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7	33	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	36
8	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
9	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4
10	20	1	15	0	0	0	0	0	0	0	0	0	3	0	0	0	0	39
11	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
12	5	0	0	6	0	0	0	0	3	0	0	0	0	0	0	1	0	15
13	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
14	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
15	0	0	0	0	0	0	0	0	0	6	0	0	0	4	0	0	0	10
16	21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	22
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2580	234	258	10	620	3	0	0	17	23	17	2	7	4	0	1	0	3776

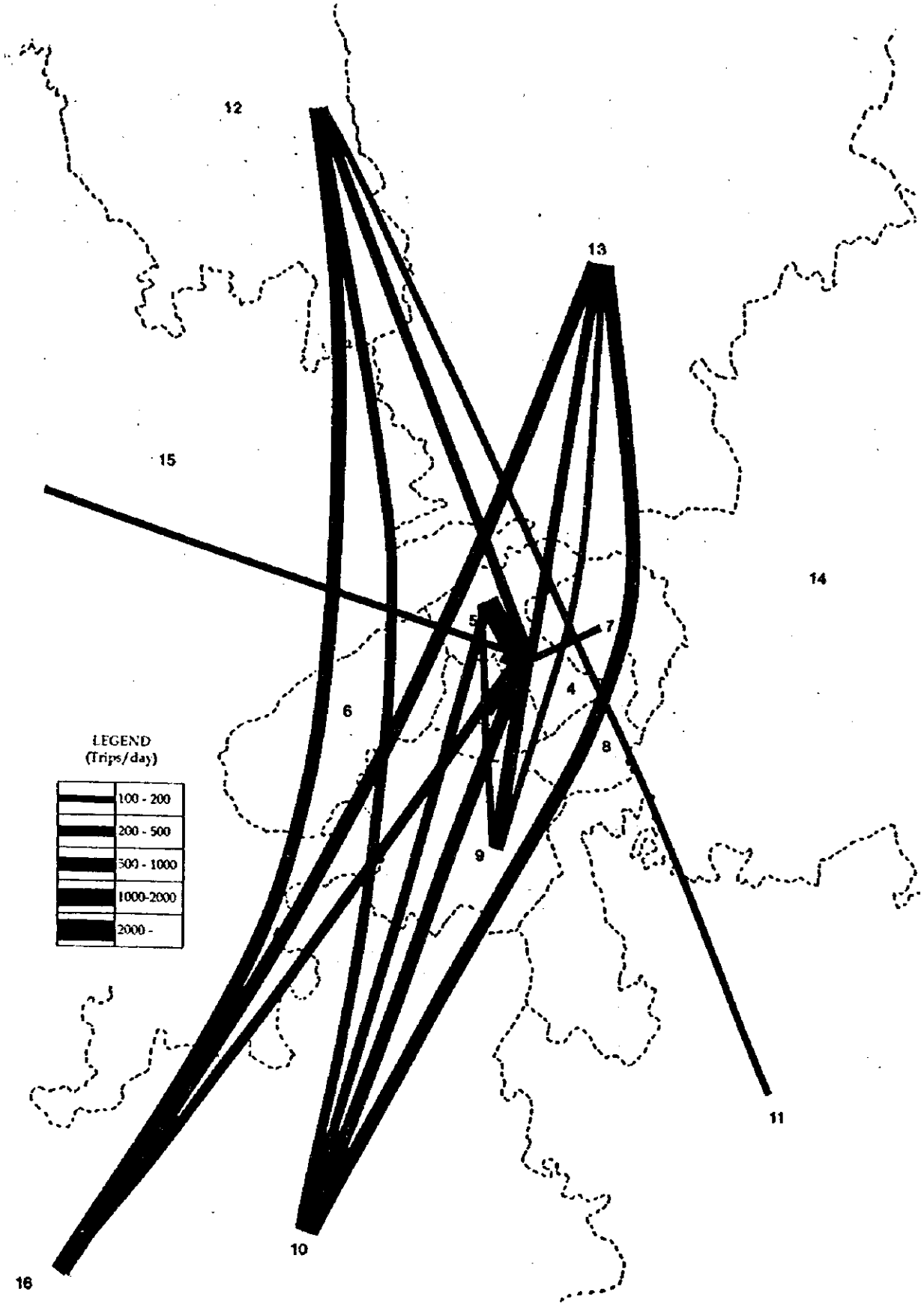


Figure 12-10 Desire-Line Diagram for Fast Vehicles (Gwalior)

Table 12-20 (1/2) Speed and Delay Data (1/2)

Gwalior (Average)

Road : NH 3
Date: 17 Nov. 1997 - 19 Nov. 1997
Direction : Up :(South to North) From : Parihar To : Rainu

Stretch No.	Stretch From	Stretch To	Run No.	Period	Total Km	Running Time (sec)	Delay Time (sec)	Journey Time (sec)	Test Car Journey Speed (km/hr)
1	Parihar	Barwaki Naka	1	Off Peak	8.3	480	0	480	62.3
			2	Off Peak	8.3	460	0	460	65.0
			3	Morning	8.3	500	0	500	59.8
			4	Evening	8.3	460	0	460	65.0
2	Barwaki Naka	Girhar Naka	1	Off Peak	7.2	680	0	680	38.1
			2	Off Peak	7.2	453	0	453	57.2
			3	Morning	7.2	560	0	560	46.3
			4	Evening	7.2	540	0	540	48.0
3	Girhar Naka	Ghadinadi Ganj	1	Off Peak	4.0	400	0	400	36.0
			2	Off Peak	4.0	440	0	440	32.7
			3	Morning	4.0	480	40	520	27.7
			4	Evening	4.0	640	0	640	22.5
4	Ghadinadi Ganj	Puranichawdi	1	Off Peak	7.7	1040	60	1100	25.2
			2	Off Peak	7.7	760	0	760	36.5
			3	Morning	7.7	1120	200	1320	21.0
			4	Evening	7.7	960	220	1180	23.5
5	Puranichawdi	Rainu	1	Off Peak	6.5	480	0	480	48.8
			2	Off Peak	6.5	540	0	540	43.3
			3	Morning	6.5	380	0	380	61.6
			4	Evening	6.5	340	0	340	68.8

Table 12-20 (2/2) Speed and Delay Data (2/2)

Gwalior (Average)

Road : NH 3
Date : 17 Nov. 1997 - 19 Nov. 1997
Direction : Down : (North to South) From : Rainu To : Parihar

Stretch No.	Stretch From	Stretch To	Run No.	Period	Total Km	Running Time (sec)	Delay Time (sec)	Journey Time (sec)	Test Car Journey Speed (km/h)
5	Rainu	Puranichawdi	1	Off Peak	6.5	360	0	360	65.0
			2	Off Peak	6.5	380	0	380	61.6
			3	Morning	6.5	440	0	440	53.2
			4	Evening	6.5	320	0	320	73.1
4	Puranichawdi	Ghadinadi Ganj	1	Off Peak	7.7	960	100	1060	26.2
			2	Off Peak	7.7	700	40	740	37.5
			3	Morning	7.7	980	180	1160	23.9
			4	Evening	7.7	880	260	1140	24.3
3	Ghadinadi Ganj	Girhar Naka	1	Off Peak	4	540	0	540	26.7
			2	Off Peak	4	320	0	320	45.0
			3	Morning	4	380	340	720	20.0
			4	Evening	4	500	200	700	20.6
2	Girhar Naka	Barwaki Naka	1	Off Peak	7.2	460	0	460	56.3
			2	Off Peak	7.2	480	0	480	54.0
			3	Morning	7.2	540	0	540	48.0
			4	Evening	7.2	560	0	560	46.3
1	Barwaki Naka	Parihar	1	Off Peak	8.3	500	0	500	59.8
			2	Off Peak	8.3	480	0	480	62.3
			3	Morning	8.3	580	0	580	51.5
			4	Evening	8.3	640	0	640	46.7

Table 12-21 Summary of Axle Load Survey (Gwalior)

Loaded Vehicles						
Vehicle Type	No. of Samples	Axle Loading (tons)				Gross Weight (tons)
		Axle 1	Axle 2	Axle 3	Axle 4	
2	8	13.61	33.66			47.27
(Average)		1.70	4.21			5.91
3	137	375.11	832.21			1207.32
(Average)		2.74	6.07			8.81
4	5	14.61	19.84	21.62		56.07
(Average)		2.92	3.97	4.32		11.21
Loaded and Unloaded Vehicles						
2	12	17.41	37.99			55.40
(Average)		1.45	3.17			4.62
3	160	420.67	899.95			1320.62
(Average)		2.63	5.62			8.25
4	5	14.61	19.84	21.62		56.07
(Average)		2.92	3.97	4.32		11.21

Weight per Axles (Loaded & Unloaded : tons)				
	2 Axles	3 Axles	4 Axles	
Total Weight	1376.02	56.07		
No. of Vehicles	172	5		
No. of Axles	344	15		
Weight per Axle	4.00	3.74		

Table 12-22 Summary of Opinion Survey (Gwalior Bypass)

No. of Samples						Reasons of "Yes" or "No" and Opinions on the Bypass
Category			Levying Toll			
		Yes/No	Yes	No	Total	
1	Farmers	Yes	8	62	70	a) Reduction of Accidents, Saving travel time.
		No	0	0	0	b) Should provide wide road, maintain the road in good condition.
		Total	8	62	70	c) Should not pass through cultivable land.
2	Traders & Truck Operators	Yes	39	9 (*)	48	a) Reducing travel time, improve fuel efficiency, reducing accidents.
		No	0	2(**)	2	b) Ready to pay for provided good facilities reducing transport costs.
		Total	39	11	50	(*) Not ready to pay toll since road taxes are already paid. (**) Not useful
3	Industries & Factories	Yes	0	50	50	a) Time saving and reducing accident costs.
		No	0	0	0	b) Reducing transport costs.
		Total	0	50	50	c) Provide wide divided roads.
4	Local Leaders	Yes	10	0	10	a) Reduce accidents, property damage, time savings.
		No	0	0	0	b) Can levy reasonable toll if the facility is providing good services.
		Total	10	0	10	c) Should levy toll only on cars, buses and trucks, not on farmer's vehicles.
All Categories		Yes	57	121	178	d) Should provide wide road.
		No	0	2	2	e) Maintain the road in good condition.
		Total	57	123	180	f) The access to cultivable land on both sides of Bypass should be given.

Necessity of Bypass

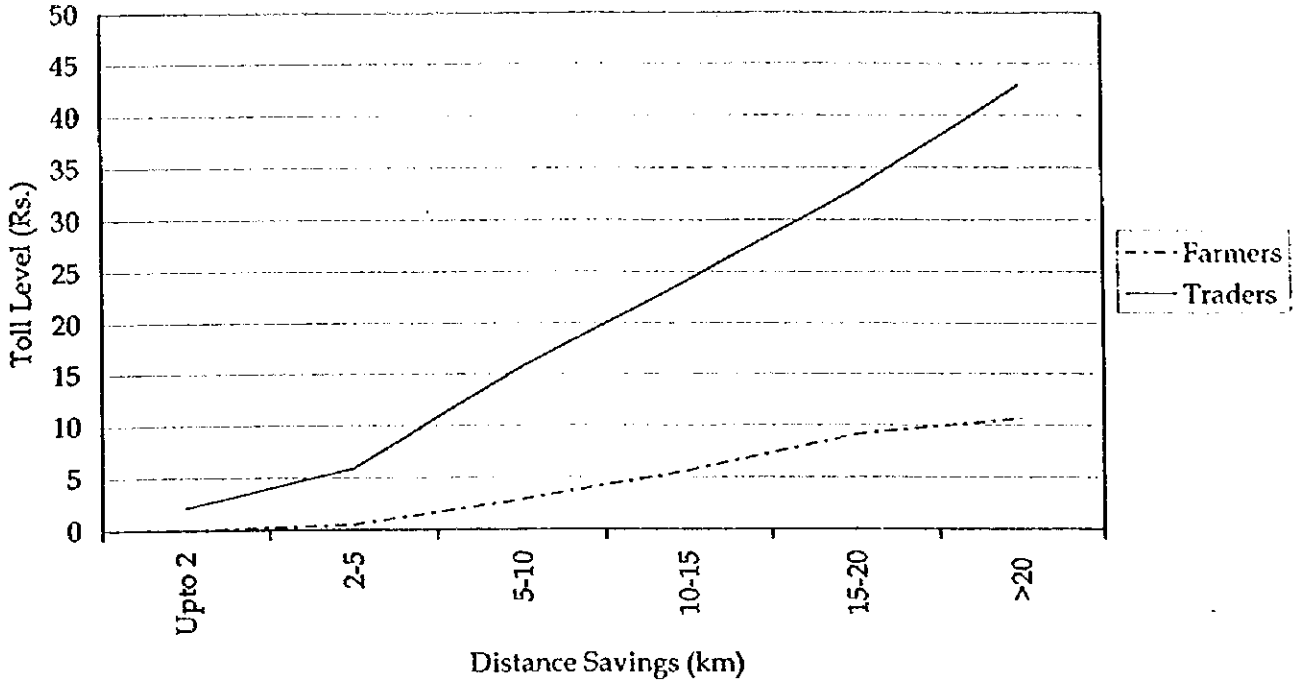


Figure 12-11 Average Toll Level Responded by Interviewees (1/2)

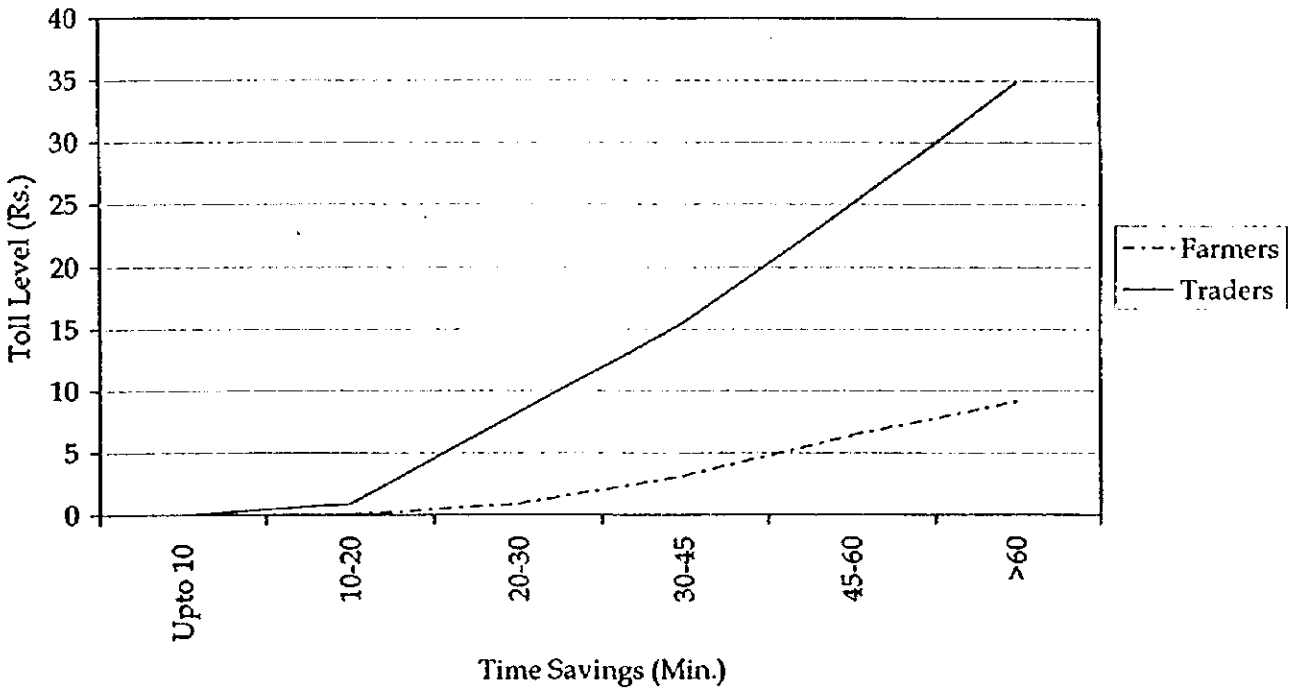


Figure 12-12 Average Toll Level Responded by Interviewees (2/2)

Feasibility Study

Chapter 11 *Socio-economic Conditions of the Study Area*
Chapter 12 *Supplemental Traffic Survey and Analysis*

Chapter 13
Future Traffic Demand Forecast

Chapter 14 *Field Investigations*
Chapter 15 *Design Standards*
Chapter 16 *Design for the Feasibility Study*
Chapter 17 *Construction Plan*
Chapter 18 *Toll Collection System*
Chapter 19 *Operation and Maintenance System*
Chapter 20 *Cost Estimates*
Chapter 21 *Economic and Financial Analysis*
Chapter 22 *Implementation Programme*
Chapter 23 *Recommendations*

13. Future Traffic Demand Forecast

13.1 Overall Flow for Traffic Forecast

The methodology and basic data (except for revised present O-D matrices) used in this Feasibility Study (F/S) are the same as adopted in the Pre-Feasibility Study (Pre-F/S), and applied to the both Bareilly Bypass and Gwalior Bypass.

Figure 13-1 indicates the overall flow chart for the Feasibility Study on the two bypasses.

13.2 Review of Future Traffic Growth

13.2.1 Macro Economic Growth

In the Pre – Feasibility Study, the following economic growth rates (GDP base) were assumed based on the Draft Ninth Five Year Plan :

- 1997 (base year) - 2002	6.0% p.a.
- 2002 - 2007	5.8%
- 2007 - 2012	5.6%

The Reserve Bank of India (RBI) has forecast recently that the growth of GDP would be at 6.0% during 1997-98. The above macro growth target was applied also in this Feasibility Study.

13.2.2 Traffic Growth Model

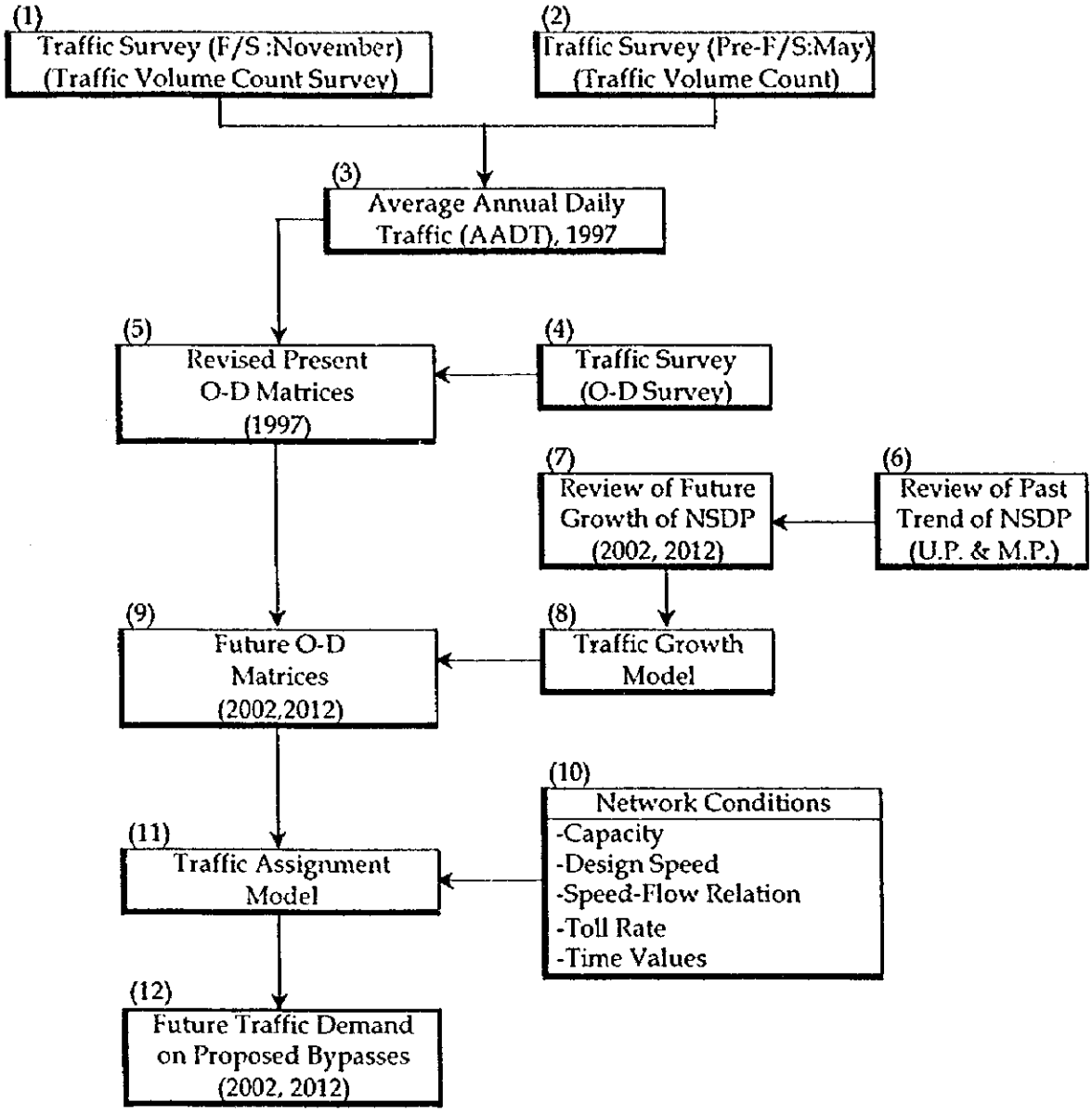
(1) Basic Model

The traffic growth model is generally constructed through empirical analysis of past traffic data and socio-economy in study areas. However, it was found that the available traffic census data by the State PWD showed high variations and large deviation from the results of traffic count survey conducted by the Study Team for this feasibility study.

The second best method adopted in this study, therefore, was to apply the procedure frequently used in other studies in India. The future traffic growth rate was estimated applying the following formula :

$$GRi = [(1 + p/100) \times (1 + n/100) - 1] \times Ei \times 100$$
$$= [(1 + N/100) - 1] \times Ei \times 100$$

here, GRi : annum growth rate of vehicle type i (%)
p : annum growth rate of State population (%)
n : annum growth rate of per capita NSDP (%)



Note : NSDP : Net State Domestic Product
U.P. : Uttar Pradesh
M.P. : Madhya Pradesh

Figure 13-1 Overall Flow Chart for Future Traffic Demand Forecast

N : annum growth rate of NSDP (%)
Ei : elasticity of traffic growth rate for vehicle type i
NSDP : Net State Domestic Product

In the above equation, the value of elasticity (Ei) is theoretically equal to the parameter of (b) in the following exponential formula :

$$\text{Log (Traffic)} = a + b \text{ Log [(Population x per Capita NSDP)]}$$
$$= a + b \text{ Log (NSDP)}$$

(2) Growth of NSDP in Influence Area

Reviewing the past growth rate of NSDP (Net State Domestic Product) of the Uttar Pradesh State based on the latest data, the average annual growth rate of NSDP for the last ten years (1985/86 - 1995/96) was at 4.0 %. This past growth rate is almost the same level as adopted in the Pre - feasibility study (4.1 % per annum). Future growth rate of NSDP of Uttar Pradesh State in the Pre - Feasibility Study was estimated as follows :

Year	Growth Rate of NSDP of U.P.
1985 - 1995	4.0% (Actual)
1997 - 2002	5.0% per annum
2002 - 2007	4.7%
2007 - 2012	4.5%

There is no reason to change the above growth rate of future NSDP. The growth rate of total NSDP of the influence area of the Bareilly Bypass along the corridor of NH 24 is given as below (Table 13 - 1) :

Table 13-1 Future NSDP Growth Rate of Influence Area (1/2)
(Bareilly Bypass)

Bypass	Influence Area (States)	Growth rate of NSDP p.a. (%)		
		97-2002	2002-07	2007-12
Bareilly (NH-24)	Uttar Pradesh	5.0	4.7	4.5
	Haryana	6.8	6.5	6.3
	Delhi	7.9	7.6	7.3
	Total	5.8	5.6	5.4

The average annual growth rate of NSDP of the Madhya Pradesh State for the last ten years (1985/86 - 1995/96) was at 4.7 % . This past growth rate is slightly higher than that adopted in the Pre - feasibility study (3.7 % per annum). However, the future growth rate of NSDP of Madhya Pradesh State in the Pre - Feasibility Study was estimated as follows :

Year	Growth Rate of NSDP of U.P.
1985 - 1995	4.7% (Actual)
1997 - 2002	4.5% per annum
2002 - 2007	4.3%
2007 - 2012	4.0%

The above forecast of NSDP growth is considered to be reasonable and the growth rate of total NSDP of the influence area of the Gwalior Bypass along the corridor of NH-3 is given as below (Table 13 - 2) :

Table 13-2 Future NSDP Growth Rate of Influence Area (2/2)
(Gwalior Bypass)

Bypass	Influence Area (States)	Growth rate of NSDP p.a. (%)		
		97-2002	2002-07	2007-12
Gwalior (NH-3)	Madhya Pradesh	4.5	4.3	4.0
	Rajasthan	7.2	7.0	6.7
	Haryana	6.8	6.5	6.3
	Delhi	7.9	7.6	7.3
	Total	6.4	6.2	6.0

These growth rates of influence areas were estimated keeping the consistency with a macro economic growth target by the Ninth Five Year Plan (1997 - 2002) and taking into consideration the growth pattern of all other States/Union Territories.

(3) Estimation of Elasticity (Ei)

In the Pre - Feasibility Study, the future Elasticity of traffic demand to Net National Product (NNP) were estimated at national level through regression analyses between number of vehicle registration and NNP. The results of regression analyses are presented below :

Qc = - 2555.0 + 0.03434 NNP (R = 0.995)
Qb = - 137.22 + 0.0026 NNP (R = 0.996)
Qt = - 739.82 + 0.01161 NNP (R = 0.995)
Q2w = - 15103 + 0.15892 NNP (R = 0.993)

Here, Qc : No. of registration of car, three wheelers
Qb : No. of registration of bus
Qt : No. of registration of truck
Q2w : No. of registration of 2 wheeler
NNP : Net National Product

The future values of Elasticity by each category were calculated applying the future NNP to the above equations and according to the definition of elasticity (percentage growth rate of future traffic/ percentage of growth rate of future NNP). The results are summarised below :

Future Elasticity of Traffic Growth to NNP Growth

Category	1997 - 2002	2002 - 2007	2007 - 2012
1) Car, 3 wheeler	1.38	1.25	1.18
2) Bus	1.24	1.17	1.12
3) Truck	1.31	1.21	1.15
4) Two wheeler	1.54	1.34	1.24

The above figures of 1) to 4) were estimated in the Pre - Feasibility Study and adopted again in this Feasibility Study.

(4) Future Traffic Growth

Given the Elasticity (Ei) by vehicle type and future growth rate of NSDP in influence area, traffic growth rates are forecast as follows :

Table 13-3 Future Traffic Growth Rate per Annum (Bareilly : %)

Bypass	1997-2002				2002-2007				2007-2012			
	Car	Bus	Truck	2Whl.	Car	Bus	Truck	2Whl.	Car	Bus	Truck	2Whl.
Bareilly	8.0	7.2	7.6	9.0	7.0	6.6	6.8	7.5	6.4	6.1	6.3	6.7
(NH-24)	1.47	1.42	1.44	1.54	1.41	1.38	1.39	1.44	1.36	1.34	1.35	1.39
Elasticity	1.38	1.24	1.31	1.54	1.25	1.17	1.21	1.34	1.18	1.12	1.15	1.24

Note : Upper : Average Annual Growth Rate (%)
Down : Growth ratio for each five year period

Table 13-4 Future Traffic Growth Rate per Annum (Gwalior : %)

Bypass	1997-2002				2002-2007				2007-2012			
	Car	Bus	Truck	2Whl.	Car	Bus	Truck	2Whl.	Car	Bus	Truck	2Whl.
Gwalior	8.8	8.0	8.4	9.9	7.8	7.3	7.5	8.3	7.1	6.8	6.9	7.5
(NH-3)	1.53	1.47	1.50	1.60	1.45	1.42	1.44	1.49	1.41	1.39	1.40	1.44
Elasticity	1.38	1.24	1.31	1.54	1.25	1.17	1.21	1.34	1.18	1.12	1.15	1.24

Note : Upper : Average Annual Growth Rate (%)
Down : Growth ratio for each five year period

13.3 Future Traffic Demand on the Proposed Bypasses

13.3.1 Procedures

Future O-D matrices for the year 2002 and 2012 were forecast by multiplying the traffic growth rates estimated above to the present O-D matrices. The future O-D matrices were then assigned to the road network , both "with" and "without" the proposed bypass.

In order to keep consistency with the results of the Pre - Feasibility Study, the traffic assignment procedure adopted in this Feasibility Study is the same as used in the Pre - F/S Study i.e. iterative capacity - constraint assignment method. The flowchart for the traffic assignment is again illustrated in Figure 13-2.

Unlike the "All or Nothing" Assignment Method, this method can reflect the effect of traffic congestion in the process of route choice (Highway or Bypass).

13.3.2 Input Information for Traffic Assignment

(1) Road Network and Link Conditions

Road network is composed of nodes and links. Two kinds of nodes are identified in the road network i.e. zone centre nodes and intersection nodes. Node numbers are attached to all nodes (coding) and link information such as link length, road classification, number of lanes, daily capacity and design speed (Q-V Formula) are given to all links. Part of road network is shown in Figure 13 - 3.

(2) Speed - Flow Relation (Q-V Formula)

The Q-V formula is a tool to adjust the travel speed depending on the assigned traffic volume. It is basically specified when the design speed and daily capacity are given. The adopted Q-V formulas are the same types as the Pre-Feasibility Study and illustrated in Figure 13-4.

(3) Design Speed and Design Capacity

The design speed and road capacity for two-lane and dual four-lane roads were decided based on various standards in India as shown below :

1) Two-lane National Highways (Design speed : 80 km/hr.)

- Built-up Area (city centre area and suburbs : inside of bypasses)= 14,000 PCU/day

- Outside of bypasses = 16,000 PCU/day

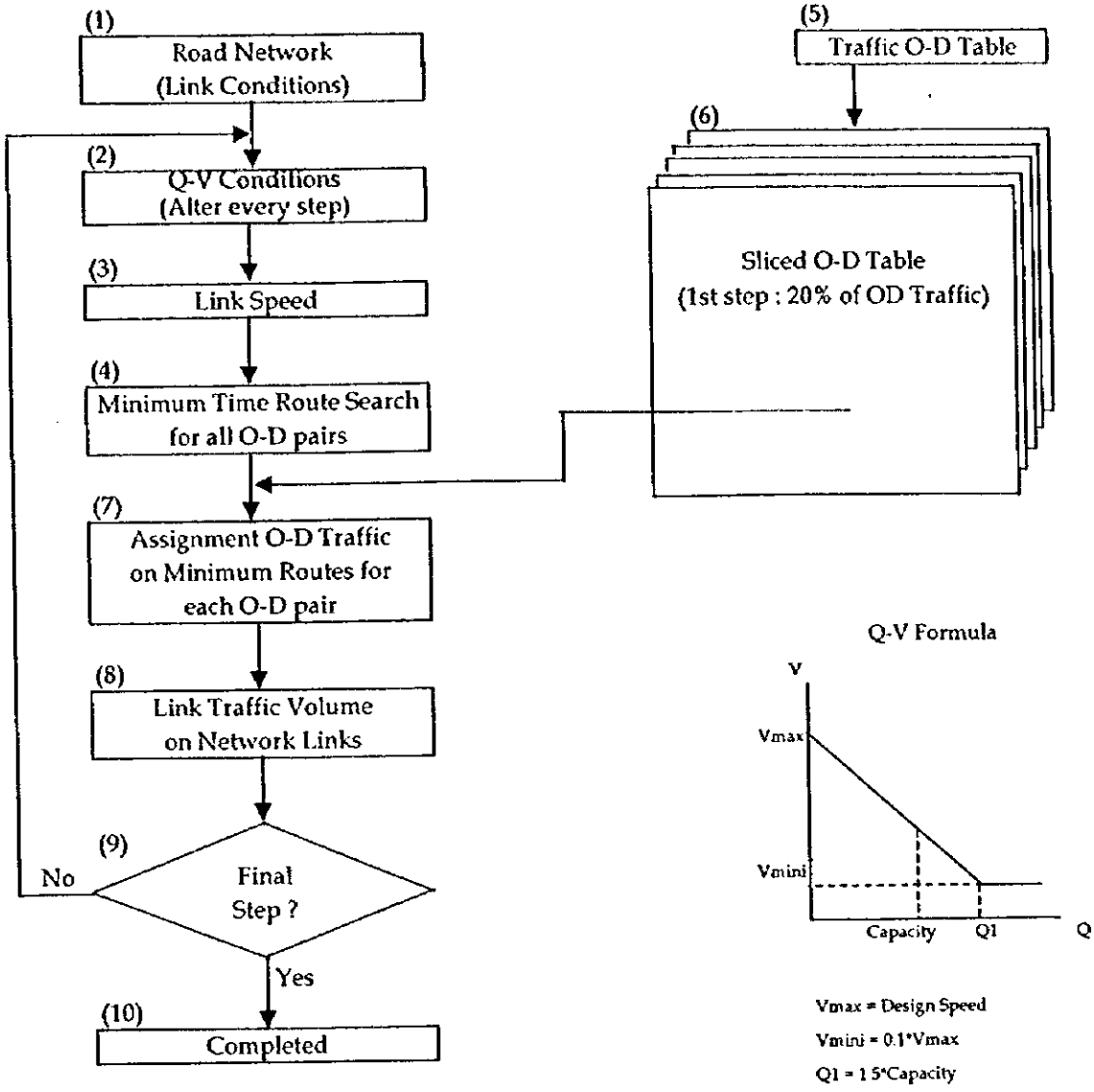


Figure 13-2 Flow Diagram for Traffic Assignment Method

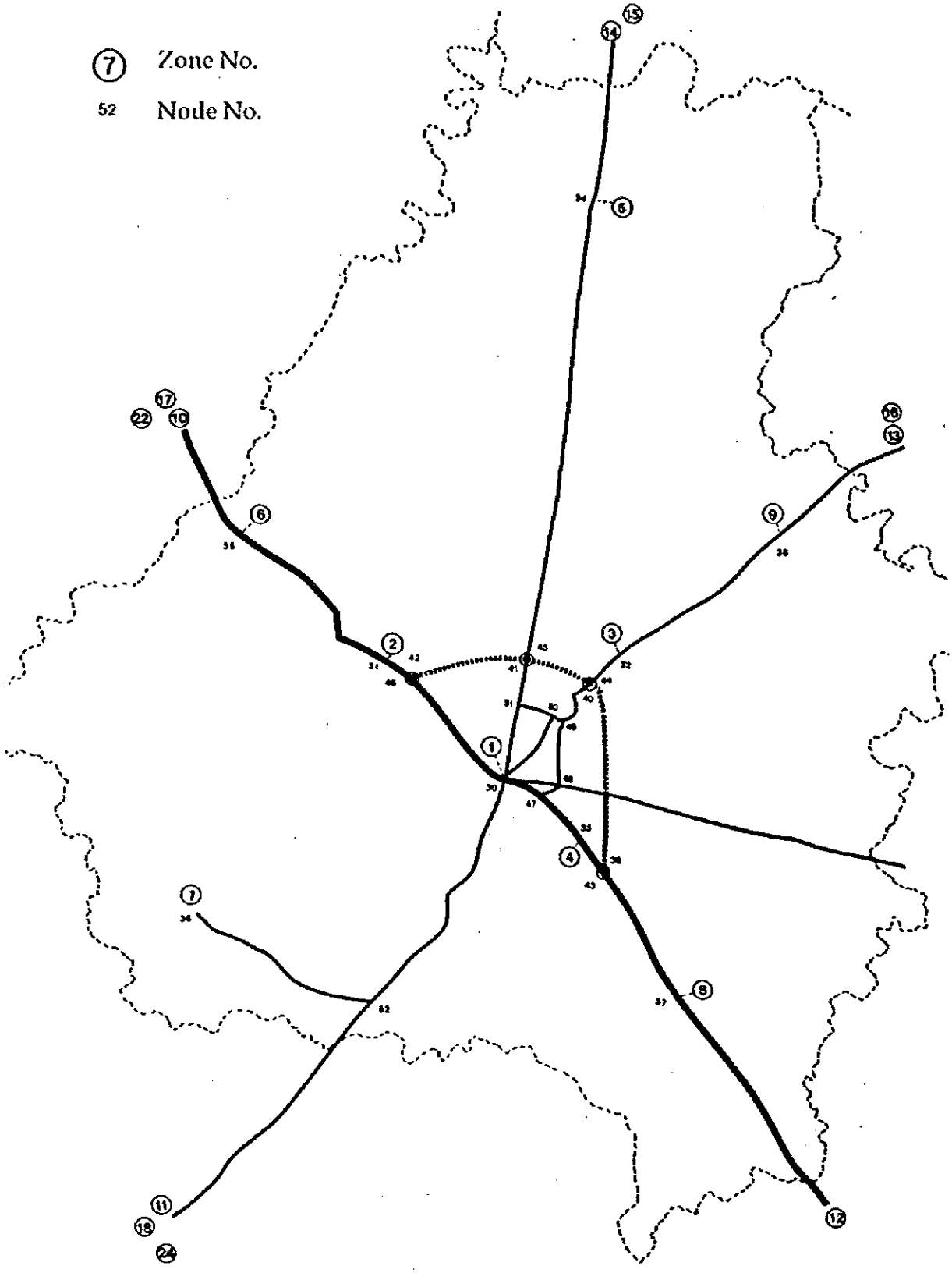


Figure 13-3 (1/3) Road Network for Traffic Assignment (Bareilly)

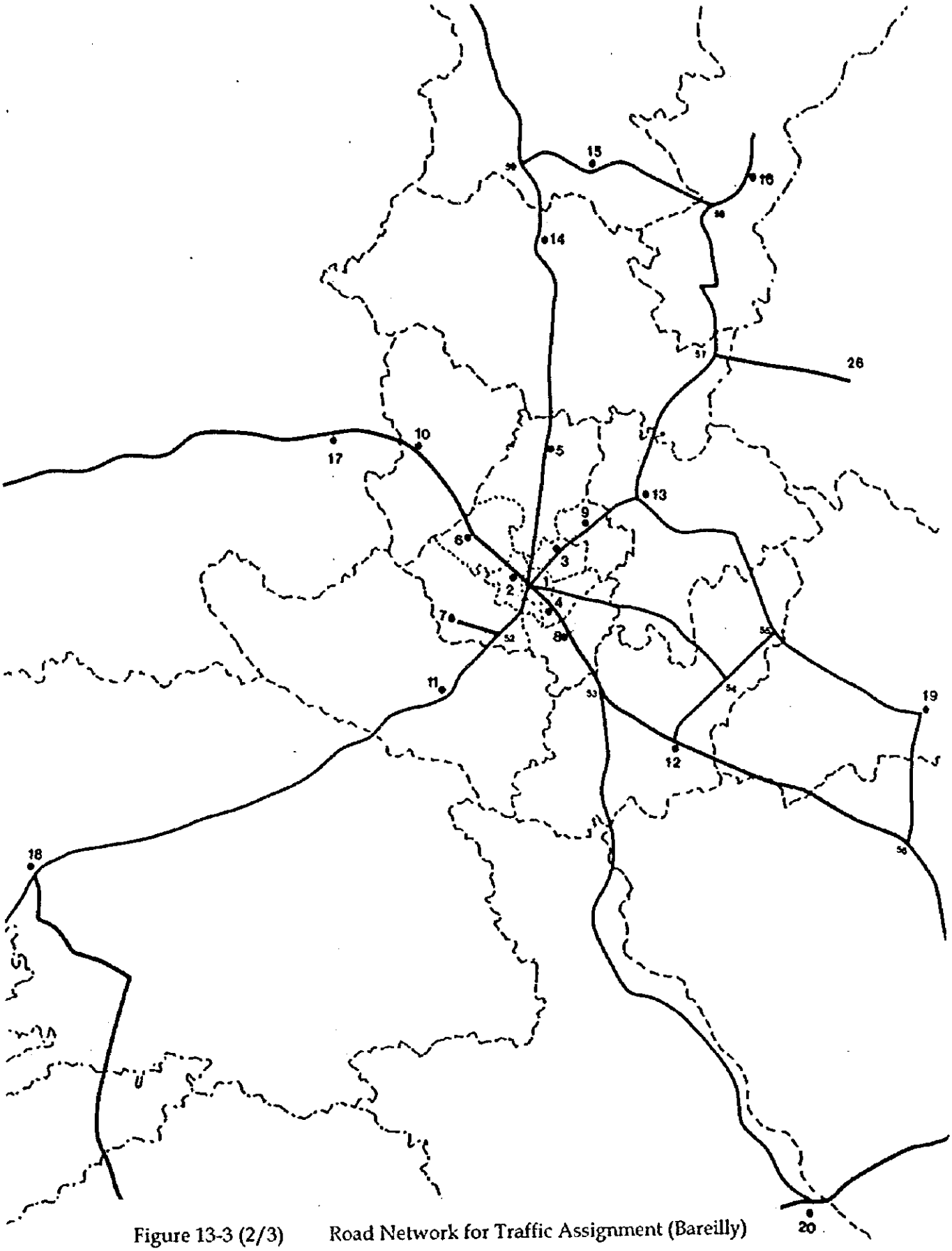


Figure 13-3 (2/3) Road Network for Traffic Assignment (Bareilly)

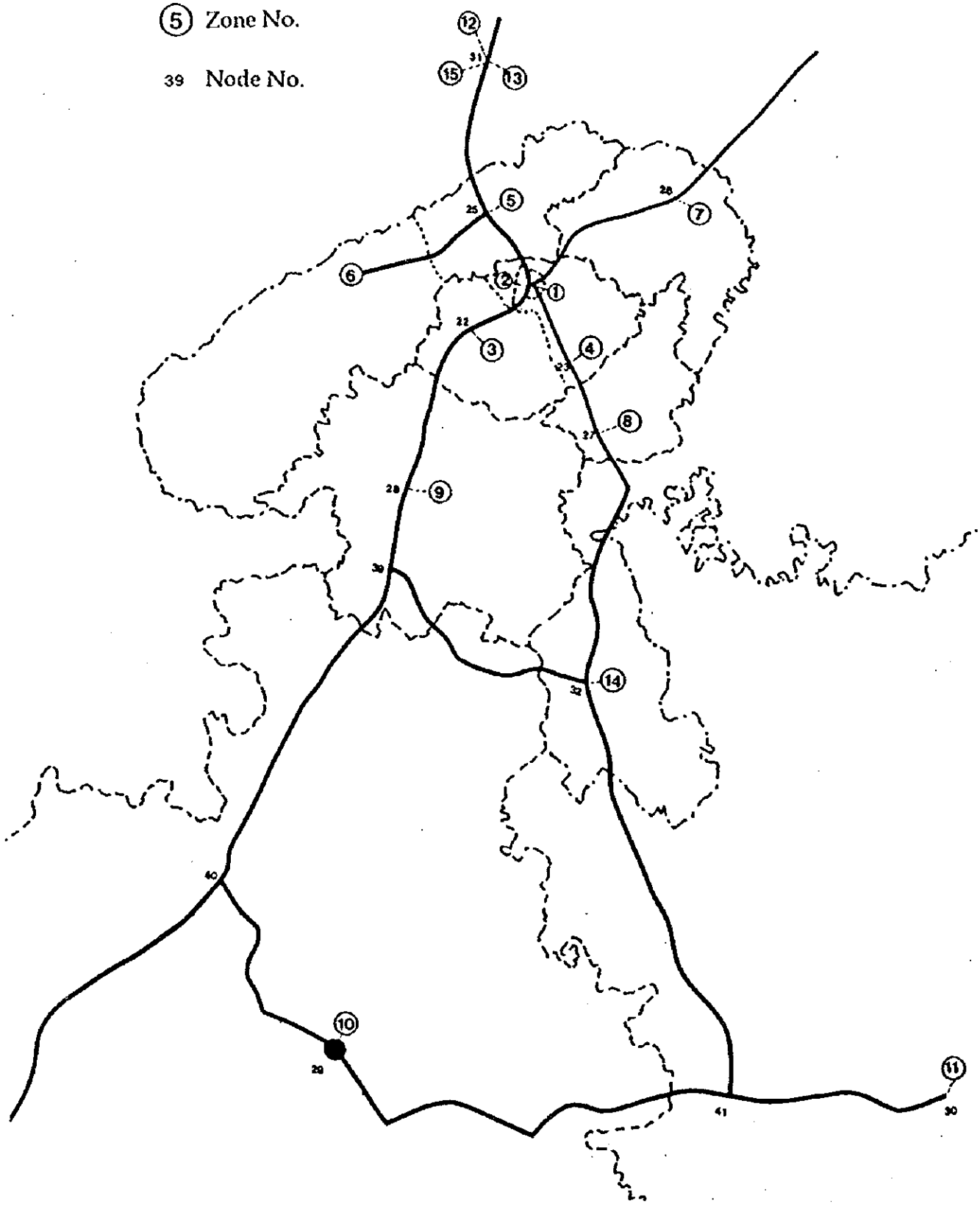


Figure 13-3 (3/3) Road Network for Traffic Assignment (Gwalior)

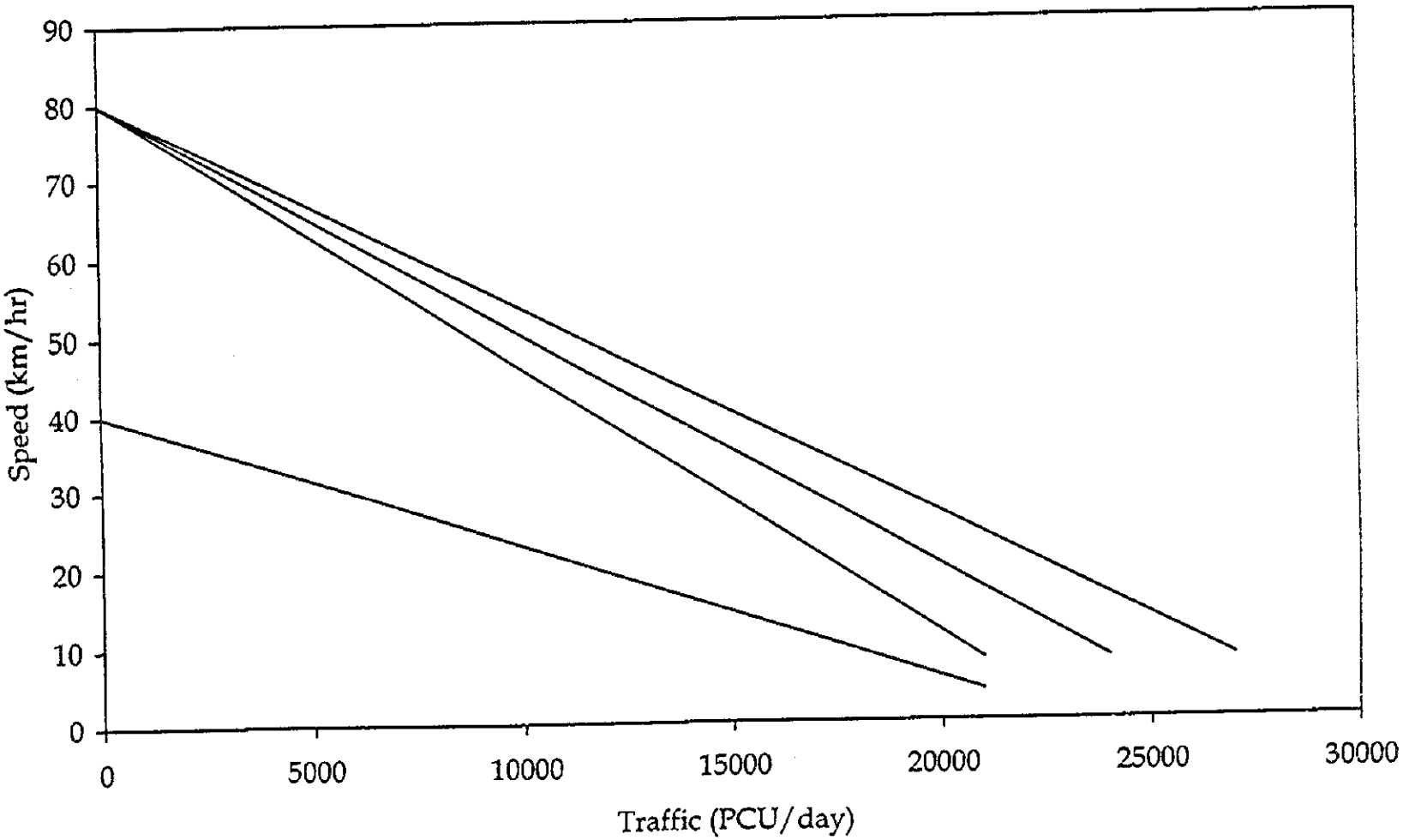


Figure 13-4 Q-V Formula (Speed - Flow Relation)

- Rural areas = 18,000 PCU/day

2) Four-lane access controlled bypasses (Design speed : 100 km/hr.) =52,800 PCU/day

(4) Toll rates and Travel Time Values

a) Toll Rates

In case of a Toll Bypass, the charged toll fees are converted into extra travel costs in terms of travel time and Total Travel Cost (TTC) including toll fees are expressed as generalised cost shown below :

$$TTC = t + F/w$$

here, TTC : total travel cost (in terms of time)
t : travel time
w: value of travel time (Rs./hour)
F: toll fees (in Rs.)

It was decided for this study to apply the following toll rates by referring to other recent studies on bypasses and expressway.

Car/Jeep/Van	Rs. 1.00 per km
Light Commercial Vehicle	Rs. 1.75 per km
Truck and Bus	Rs. 3.50 per km
Heavy construction machinery	Rs. 7.50 per km
Two wheeler (as half of cars)	Rs. 0.50 per km

b) Travel Time Values

The travel time values by vehicle type were estimated based on the time values of passengers and commodities transported as shown in the chapter of economic analysis. These time values were increased in accordance with the future growth rate of nominal income.

13.3.3 Results of Future Traffic Demand Forecast

(1) Assignment Cases

The following traffic assignment simulations were undertaken for the evaluation of the Bareilly Bypass and the Gwalior Bypass in 2002 and 2012 respectively :

1) "Without" Bypass
2) "With" Bypass but in Toll Free case
3) "With" Toll Bypass

(2) Traffic Volume on the Bareilly Bypass

Forecast traffic volumes on the Bareilly Bypass are sunmarised in Table 13-5 (Toll Free Case) and Table 13-6 (Toll Bypass). Since the Bareilly Bypass is a Ring road type and has two interchanges at SH 37 and SH 33, not only through traffic but the traffic which have their origin/destination in the Bareilly city will also use the Bypass.

(3) Traffic Volume on the Gwalior Bypass

Future traffic volumes on the Gwalior Bypass are summarised in Table 13-7 (Toll Free Case) and Table 13-8 (Toll Bypass). In the toll free case, all of the through traffic will divert to the Bypass both in 2002 and 2012. Average diversion rate is estimated about 80% of through traffic in the case of toll bypass.

13.3.4 Sensitivity of Traffic Demands to Toll Rates

In order to examine the effects of changes in toll rate, sensitivity tests were carried out for the following cases :

1) Toll rates go up by 20% and 50%
2) Toll rates go down by 20% and 50%

The definition of toll elasticity of traffic demands is given as follows and results of the tests are shown in Table 13-9 and Table 13-10.

Elasticity = [Changes in Traffic Demands (%) / Changes in Toll Rate (%)]

The traffic demands on the Bareilly Bypass in 2002 will be still under capacity and the traffic volume on the National Highway 24 will exceed its capacity even in the case of base toll rate with proposed bypass. The traffic demands will increase when the toll rates go down in these situations. The toll elasticity of traffic demands is less than unity for the both target years. In 2002, the elasticity is very low because of congestion of existing NH24. In 2012, congestion on NH 24 will become more severe and there will be no change in traffic demands on Bypass even if the toll rates go up by 50%.

The traffic demands on the Gwalior Bypass in 2002 will be still under capacity for both NH-3 and Bypass. In theses situation, 50% up/down in toll rate will result in 25% decrease/increase of traffic demands on the bypass and Elasticity will be just at 0.5. There are no changes in traffic in the case of 20% up/down in toll rate. In 2012, two-lane NH-3 will exceed its capacity even if the bypass is operated and no vehicles on the bypass will return to the two-lane NH-3 even if the toll rate goes up by 50%. If the toll rates in 2012 are decreased by 50%, traffic demands will increase by 25%. There will be no

changes in traffic in case of 20% /50% going up in toll rates in 2012 because of congestion of traffic on the existing National Highway.

In conclusion, the elasticity of traffic demands to toll rates will be very small (smaller than unity) for both bypasses.

Table 13-5 Future Traffic Projection (Bareilly : Toll Free)

(Vehicles/day)

Bypass	Year	Vehicle Type	Case						
			Without Bypass		With Bypass				
			National Highway		National Highway		Bypass		
			N(W)	S (E)	N(W)	S (E)	N(W)	Centre	S(E)
		(Link No.)	46-61	33-47	46-61	33-47	41-42	40-41	39-40
BAREILLY	2002	Car	3,512	4,245	1,871	3,349	1,641	3,624	898
		Bus	2,359	1,532	1,184	957	1,175	1,590	576
		Truck	5,697	7,123	1,517	2,760	4,180	6,584	4,383
		2 Whls.	2,391	4,633	1,386	4,205	1,005	2,368	428
		Total	13,959	17,533	5,958	11,271	8,001	14,166	6,285
		Total (PCU)	28,876	32,527	10,667	16,603	18,209	29,330	15,989
		Congestion ratio	2.06	2.32	0.76	1.19	0.34	0.56	0.30
	2012	Car	6,681	7,760	3,560	4,346	3,121	7,917	3,466
		Bus	4,325	2,426	2,150	987	2,175	3,301	1,529
		Truck	10,636	10,882	2,654	3,327	7,982	12,691	8,018
		2 Whls.	4,741	9,068	2,738	6,963	2,003	5,404	2,114
		Total	26,383	30,136	11,102	15,623	15,281	29,313	15,127
		Total (PCU)	53,935	52,218	19,341	20,770	34,594	58,595	33,164
		Congestion ratio	3.85	3.73	1.38	1.48	0.66	1.11	0.63

Table 13-6 Future Traffic Projection (Bareilly : Toll Bypass)

(Vehicles/day)

Bypass	Year	Vehicle Type	Case						
			Without Bypass		With Bypass				
			National Highway		National Highway		Bypass		
			N(W)	S (E)	N(W)	S (E)	N(W)	Centre	S(E)
		(Link No.)	46-61	33-47	46-61	33-47	41-42	40-41	39-40
BAREILLY	2002	Car	3,512	4,245	1,981	2,954	1,531	2,775	1,294
		Bus	2,359	1,532	1,306	893	1,053	1,238	639
		Truck	5,697	7,123	2,723	3,826	2,974	4,550	3,317
		2 Whls.	2,391	4,633	1,407	3,877	984	1,843	756
		Total	13,959	17,533	7,417	11,550	6,542	10,406	6,006
		Total (PCU)	28,876	32,527	14,772	19,050	14,104	21,061	13,540
		Congestion ratio	2.06	2.32	1.06	1.36	0.27	0.40	0.26
	2012	Car	6,681	7,760	2,468	4,480	4,213	5,415	3,332
		Bus	4,325	2,426	1,529	1,120	2,796	2,466	1,395
		Truck	10,636	10,882	2,699	4,807	7,937	9,649	6,537
		2 Whls.	4,741	9,068	1,842	6,992	2,899	3,695	2,084
		Total	26,383	30,136	8,538	17,399	17,845	21,225	13,348
		Total (PCU)	53,935	52,218	16,073	25,757	37,862	43,608	28,170
		Congestion ratio	3.85	3.73	1.15	1.84	0.72	0.83	0.53

Table 13-7 Future Traffic Projection (Gwalior : Toll Free)

(Vehicles/day)

Bypass	Year	Vehicle Type	Case				
			Without Bypass		With Bypass		
			National Highway		National Highway		Bypass
			N(W)	S (E)	N(W)	S (E)	
		(Link No.)	44-50	38-45	44-50	38-45	42-43
GWALIOR	2002	Car	2,654	2,186	2,265	1,797	389
		Bus	873	797	718	642	155
		Truck	6,763	6,684	1,784	1,705	4,979
		2 Whls.	2,133	1,141	2,054	1,062	79
		Total	12,423	10,808	6,821	5,206	5,602
		Total (PCU)	26,629	25,200	10,798	9,369	15,831
		Congestion ratio	1.90	1.80	0.77	0.67	0.30
	2012	Car	5,423	4,470	4,638	3,685	785
		Bus	1,678	1,531	1,403	1,256	275
		Truck	13,582	13,422	3,582	3,422	10,000
		2 Whls.	4,560	2,434	4,394	2,268	166
		Total	25,243	21,857	14,017	10,631	11,226
		Total (PCU)	53,483	50,546	21,790	18,853	31,693
		Congestion ratio	3.82	3.61	1.56	1.35	0.60

Table 13-8 Future Traffic Projection (Gwalior : Toll Bypass)

(Vehicles/day)

Bypass	Year	Vehicle Type	Case				
			Without Bypass		With Bypass		
			National Highway		National Highway		Bypass
			N(W)	S (E)	N(W)	S (E)	
		(Link No.)	44-50	38-45	44-50	38-45	42-43
GWALIOR	2002	Car	2,654	2,186	2,343	1,875	311
		Bus	873	797	749	673	124
		Truck	6,763	6,684	2,780	2,701	3,983
		2 Whls.	2,133	1,141	2,070	1,078	63
		Total	12,423	10,808	7,942	6,327	4,481
		Total (PCU)	26,629	25,200	13,965	12,536	12,664
		Congestion ratio	1.90	1.80	1.00	0.90	0.24
	2012	Car	5,423	4,470	4,795	3,842	628
		Bus	1,678	1,531	1,458	1,311	220
		Truck	13,582	13,422	5,582	5,422	8,000
		2 Whls.	4,560	2,434	4,427	2,301	133
		Total	25,243	21,857	16,262	12,876	8,981
		Total (PCU)	53,483	50,546	28,129	25,192	25,355
		Congestion ratio	3.82	3.61	2.01	1.80	0.48

Table 13-9 Sensitivity of Traffic Demands to Toll Rates (Bareilly Bypass)

(Unit of Traffic : Vehicles/day)

Case	(Year 2002)					
	Traffic by Section			Elasticity		
	Section 1 N (W)	Section 2 Centre	Section 3 S (E)	Section 1 N (W)	Section 2 Centre	Section 3 S (E)
50% up	6,542	6,836	5,988	0.0	0.69	0.01
20% up	6,542	8,608	6,006	0.0	0.86	0.0
Base Case	6,542	10,406	6,006	-	-	-
20% down	6,724	11,513	6,633	0.14	0.53	0.52
50% down	7,272	11,550	7,107	0.22	0.22	0.37
	(Year 2012)					
50% up	17,845	21,225	13,348	0.0	0.0	0.0
20% up	17,845	21,225	13,348	0.0	0.0	0.0
Base Case	17,845	21,225	13,348	-	-	-
20% down	17,845	21,225	13,348	0.0	0.0	0.0
50% down	17,845	28,223	13,761	0.0	0.66	0.06

Table 13-10 Sensitivity of Traffic Demands to Toll Rates (Gwalior Bypass)

(Unit of Traffic : Vehicles/day)

Case	(Year 2002)	
	Traffic/day	Elasticity
50% up	3,360	0.50
20% up	4,481	0.00
Base Case	4,481	-
20% down	4,481	0.00
50% down	5,602	0.50
	(Year 2012)	
50% up	8,981	0.00
20% up	8,981	0.00
Base Case	8,981	-
20% down	8,981	0.00
50% down	11,226	0.50

Feasibility Study

Chapter 11 *Socio-economic Conditions of the Study Area*
Chapter 12 *Supplemental Traffic Survey and Analysis*
Chapter 13 *Future Traffic Demand Forecast*

Chapter 14
Field Investigations

Chapter 15 *Design Standards*
Chapter 16 *Design for the Feasibility Study*
Chapter 17 *Construction Plan*
Chapter 18 *Toll Collection System*
Chapter 19 *Operation and Maintenance System*
Chapter 20 *Cost Estimates*
Chapter 21 *Economic and Financial Analysis*
Chapter 22 *Implementation Programme*
Chapter 23 *Recommendations*

14 Field Investigation

14.1 Geodetic Survey

The Geodetic Survey for the project areas was carried out including items below:

1) Control Points Survey;
2) Centre Line Survey;
3) Longitudinal Profile Survey;
4) Cross-sectional Survey; and
5) Topographical Survey of the proposed bypasses.

The Control Points Survey was initially executed by applying Global Positioning System (GPS). Cement concrete pillars were embedded on the ground at the position of the Control Points. There are 35 numbers of the points at Bareilly site, and 29 numbers at Gwalior site. These pillars were co-ordinated by using GPS receivers to establish planimetric co-ordinates.

Then, after the establishment of control points by GPS, the survey centreline was established based on the Universal Transverse Mercator (UTM) co-ordinates system. Based on the survey centreline, Centre Line Survey, Longitudinal Profile Survey, Cross-sectional Survey and Topographical Survey was carried out with the co-ordinate system.

Geodetic Survey of Bareilly was carried out for 29.768 km of survey centreline and in addition 500 m at the beginning and 400 m at the end of the alignment along NH 24, and the survey of Gwalior Bypass was carried out for 26.497km of survey centreline and in addition 500 m at the beginning and 400 m at the end of the alignment along NH 3. Work quantity of the Geodetic Survey works was summarised as shown in Table 14-1.

Table 14-1 Work Quantity of Geodetic Survey

Items	Unit	Quantity		
		Bareilly	Gwalior	Total
Control Points Survey (GPS)	points	35	29	64
Centre Line Survey	km	29.77	26.28	56.05
Longitudinal Survey	km	29.77	26.28	56.05
Cross Section Survey	sections	288	264	552
Topographic Survey	Km^2	15.11	13.37	28.48
500 m at the beginning and 400 m at the end of the alignment, along the National Highway, was additional survey in 250 m wide.				

14.2 Geotechnical Survey

The geotechnical survey and collection of geotechnical data for the project areas was carried out including items below:

1) Field investigation of project areas;
2) Borehole drilling with Standard Penetration Test;
3) Laboratory test for both of sample from boreholes and test-pits;
4) Analysis of the test result; and
5) Summarise the survey result and propose of the design parameters.

Borehole drilling with Standard Penetration Tests (1 m depth interval) were conducted at 16 bore holes, totalling 400 m long. SPT Sampler was applied, 18 inches long and 1.5 inches of internal diameter, in order to obtain soil samples from bore holes.

The code of American Society of Testing and Materials (ASTM), in relation to Indian Standards (IS), was applied to the laboratory test as follows:

1)	Specific gravity	ASTM D854	IS-2720 (Part III)
2)	Grain size analysis	ASTM D422	IS-2720 (Part IV)
3)	Liquid limit	ASTM D4318	IS-2720 (Part V)
4)	Plastic limit	ASTM D4318	IS-2720 (Part V)
5)	Moisture content	ASTM D4253/4254	IS-2720 (Part VIII)
6)	Unit weight	ASTM D4253	IS-2720 (Part II)
7)	Modified Proctor	ASTM D1557	IS-2720 (Part VIII)
8)	Laboratory CBR Test	ASTM D1883	IS-2720 (Part XVI)

Taking both the field investigation and the result of laboratory test into account, the geotechnical condition of the project was analysed, and finally geotechnical design parameters for structure design, pavement design and construction programme were proposed.

The quantity of Geotechnical Investigation was summarised in Table 14-2 and Table 14-3.

14.2.1 Geotechnical Survey of Bareilly Bypass

14.2.1.1 Geological Description

Bareilly is situated in the Indo-gangetic alluvial plains and is about 100km from the lower Siwalik mountain ranges. The strata at different locations in Bareilly are in general alluvium of up to 35m thickness. The alluvium is categorised as the Bhangar or old alluvium, which corresponds in age with the Middle Pleistocene. The alluvium consists of silt, sand, clay or silt-clay mixture. The alluvium sometimes exhibit presence of calcareous matter.

Table 14-2 Quantities of Geotechnical Survey in Bareilly Bypass

Number of Soil Boring	Boring Depth (m)	Specific Gravity	Atterberg Limit	Grain Size Analysis	Moisture Content	Unit Weight
BH-1	25.45	8	2	8	8	8
BH-2	25.45	7	1	7	7	7
BH-3	25.45	10	3	10	10	10
BH-4	23.45	8	3	8	8	8
BH-5	24.45	9	2	9	9	9
BH-6	23.45	7	0	7	7	7
BH-7	24.45	6	1	6	6	6
BH-8	24.45	9	2	9	9	9
BH-9	24.45	7	3	7	7	7
BH-10	24.45	10	4	10	10	10
BH-11	23.45	8	2	8	8	8
BH-12	26.45	9	4	9	9	9
BH-13	26.45	9	3	9	9	9
BH-14	25.45	8	2	8	8	8
BH-15	26.45	6	2	6	6	6
BH-16	25.45	7	3	7	7	7
Total	399.20	128	37	128	128	128

Table 14-3 Quantities of Geotechnical Survey in Gwalior Bypass

Number of Soil Boring	Boring Depth (m)	Specific Gravity	Atterberg Limit	Grain Size Analysis	Moisture Content	Unit Weight
BH-1	7.95	4	0	4	4	4
BH-2	7.95	4	1	4	4	4
BH-3	7.95	4	2	4	4	4
BH-4	7.95	5	4	5	5	5
BH-5	10.65	5	3	5	5	5
BH-6	7.95	3	3	3	3	3
BH-7	13.95	6	6	6	6	6
BH-8	9.95	3	3	3	3	3
BH-9	13.75	6	3	6	6	6
BH-10	8.05	5	3	5	5	5
BH-11	7.50	3	1	3	3	3
BH-12	7.95	3	3	3	3	3
BH-13	7.95	3	3	3	3	3
BH-14	11.95	6	6	6	6	6
BH-15	11.05	5	5	5	5	5
Total	142.50	65	46	65	65	65

(1) Characteristics of Alluvium

The soils have developed on alluvium washing from inner or outer Himalayas transported by Ganges and its tributaries. The main minerals

constituting the alluvium are mica, feldspar, quartzite and heavy minerals. The clay mineral generally is illite.

(2) Description of soils

Ten soil series have been identified in the area. The description of soils was presented in Table 14-4.

Table 14-4 Soil Description

Area		Description
Up land, well drained area:	Gopalpur	Sandy loam, very deep, well drained 0~1% slopes
Mid up land & moderately well drained area:	Gopalpur	Loam, very deep, moderately well drained 0~1% slopes
Mid land & imperfectly drained area:	Birpur Kasimnagar	Silty loam, very deep, imperfectly drained 0~1% slopes
Low land poorly drained area:	Kantharia	Silty clay loam, very deep, poor drained 0~1% slopes

14.2.1.2 Location of Boreholes and Geological Profile

Location of borehole and geological profile of Bareilly Bypass is shown in Figure 14-1.

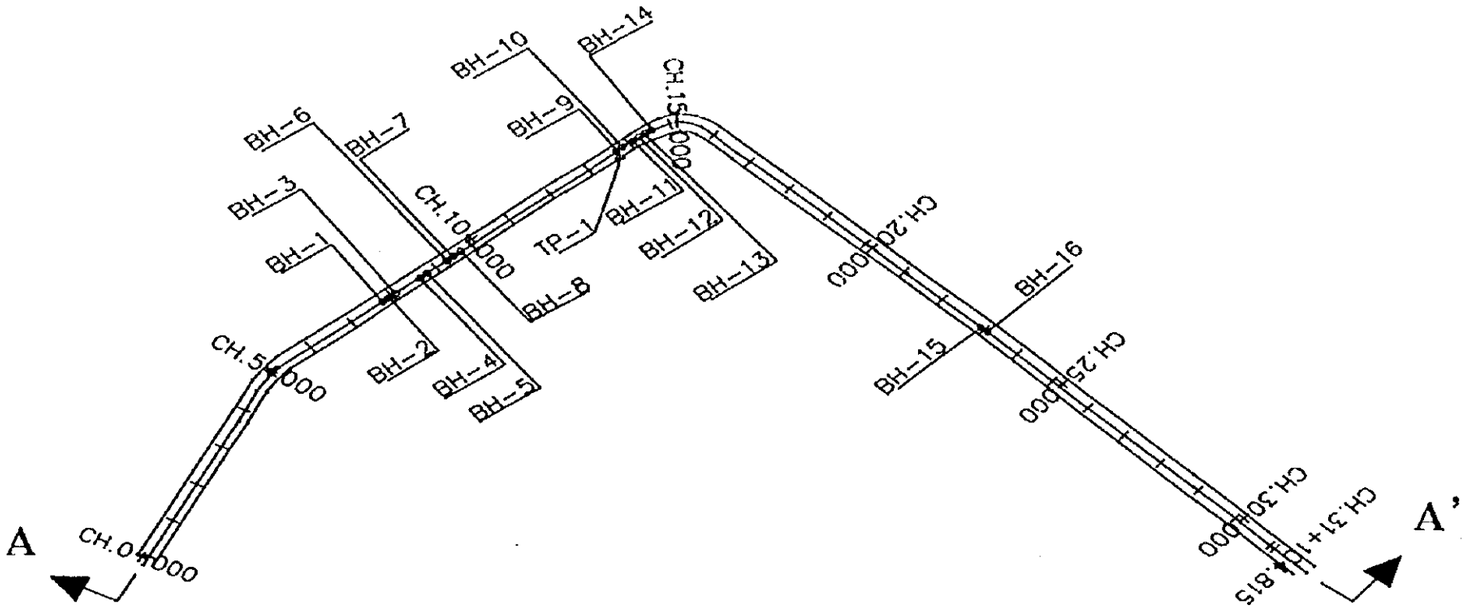
14.2.1.3 Boring

Sixteen Bore Holes (BH-1 to BH-16) were drilled at this site. Casing was used to retain the bore holes. The sub soil strata exist up to 23.45-26.45 m in depth consists predominantly of coarse grained soils i.e. Silty Sand (SM-SC/SM/SP-SM), medium to fine sand (SP) and fine sand (SP). N-values was varied from 4 to 62.

14.2.1.4 Test Pits

A trial pit was selected in the proximity of village Saidpur Chunhilal and Bareilly Pilibhit road in order to examine proctor and California bearing ratio (CBR) test and laboratory test to investigate the feasibility of using the soil as embankment and subgrade material.

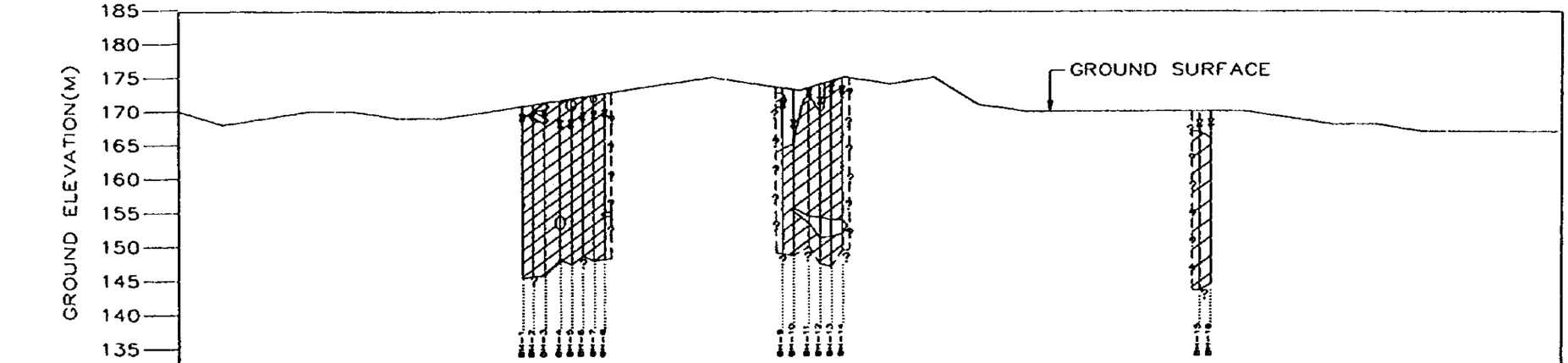
The test pits of size 1.0 m x 1.0 m in width was made up to 1.0 m depth below existing ground surface. 3 Nos. of disturbed soil samples were collected for conducting proctor compaction and CBR tests (saturated condition) and laboratory tests.



PLAN SHOWING BOREHOLES & TRIAL PITS LOCATIONS

LEGEND

- LOCATION OF BOREHOLE
- LOCATION OF TRIAL PIT
- GROUNDWATER LEVEL MEASURED IN THE BOREHOLE APPROXIMATELY 24 HOURS AFTER COMPLETION OF BORING OPERATIONS.
- COARSE-GRAINED ALLUVIUM (SP,SW,SC,SP-SM,SM)
- FINE-GRAINED ALLUVIUM (ML,CL,ML-CL,CI)
- A A' SECTION ALONG A-A'
- --?--?-- EXTENT OF GEOLOGIC CONDITIONS UNCERTAIN



DATUM 130 M

GROUND ELEVATION(M)	168.0	169.0	170.0	170.0	169.0	169.0	170.0	171.0	172.0	173.0	174.0	175.0	174.0	173.0	175.0	174.0	175.0	171.0	170.0	170.0	170.0	170.0	170.0	170.0	169.0	168.0	168.0	167.0	167.0	167.0	167.0
CHAINAGE(KM)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00

NOTE

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GEOLOGIC PROFILE ALONG A – A'

INTERCONTINENTAL CONSULTANTS AND TECHNOCRATS PVT. LTD.
A-11, GREEN PARK
NEW DELHI-110016.
TEL: 6863000,6864757 FAX: 6855252

SCALE OF PLAN	1:125,000
HORIZONTAL SCALE (PROFILE)	1:111,111
VERTICAL SCALE (PROFILE)	1:715

Figure 14-1 Location of Boreholes and Geotechnical Profile of Bareilly Bypass

Table 14-5 Test Pit Tests Result

Optimum Moisture Content	W nop = 10.4 - 11.9%
Maximum Dry Density	γd = 1.81~1.85g/cm^3
CBR	15.0~17.14%
Type of Soil	Sand 80~93%, Silt 7~20%

14.2.1.5 Laboratory Test

The engineering properties of soil in the Study Area of Bareilly are summarised as Table 14-6.

Table 14-6 Engineering Properties of Soil

Classification	Water Content		Plastic Limit (W_P)	Liquid Limit (W_L)
	Range (%)	Average(%)	Average (%)	Average (%)
Alluvial Soil	11~25	17	30	21

14.2.1.5 Proposed Parameters for Design and Construction Plan

(1) Filling Material and Design CBR

Laboratory tests were conducted with the material from the Test Pit such as specific gravity test, grain size analysis, liquid limit test, plastic limit test, moisture content test and standard proctor compaction. It was clarified that the type of the soil as Silty Sand consist of maximum dry density range from 1.81 to 1.85 at optimum moisture content of 11.9 to 10.4%.

CBR tests gave CBR values ranging from 15.0% to 17.14% under 4 days soaked conditions. The CBR test results show a minimum design CBR for this material as 15.0%. According to the CBR values ranging from 15.0% to 17.14% greater than 3%, it was clarified that the use of the soil is feasible for subgrade material.

(2) Bulking Factor of Soil

According to the CBR test results, it was clarified that the type of soil as Sand 80~93%, Silt 7~20%. Bulking Factor of the soil shall be considered as follows;

When excavated : 1.10~1.20
When compacted for embankment : 0.95~1.00

(3) Fill Slope

The type of soil from the test pit as Silty Sand consists of Sand 80~93%, Silt 7~20%, and average value of the uniformity coefficient is 1.57 less than 4 which means the texture is poorly graded. Therefore recommended fill slope for the soil from the test pit shall be recommended as Table 14-7.

Table 14-7 Recommended Fill Slope in Bareilly Bypass

Embankment height (m)	Fill Slope
0.0 m~5.0 m	1 : 1.5
5.0 m~10.0 m	1 : 1.8

According to the data from the grain size analysis, texture of soil up to 3 meters below from ground level at most of the boring locations except BH-2, BH-5, BH-7, BH-10, BH-11, BH-12 is well graded. Therefore, when side borrow for embankment around the boring area is required, the fill slope 1:1.5 to be sufficient except the area of BH-2, BH-5, BH-7, BH-10, BH-11, BH-12 where 1:1.8 recommended.

For protection of the slope of embankment, grassing treatment shall be efficient and economical.

(4) Hauling Distance

Considering the earthwork, the straight line distance for hauling from the Borrow Pit (TP1) to be 8.2km~11.8 km unless changes with the Construction plan such as construction road.

(5) Basic horizontal seismic coefficient

The site is located at Bareilly in the state of Uttar Pradesh. The site falls in the seismic Zone-III of India and as per IS:1893-1984, the basic horizontal seismic coefficient (α_0) is 0.04.

(6) Ground Water Level

The depth of ground water table was checked/measured at the bore hole locations after completion of work/on full stabilisation of water table. The ground water table was encountered at depth 0.55-5.55 m below existing ground level at the locations of boreholes. It may rise up during heavy rains/rainy season or go down during dry season.

(7) N-value

According to the N-value obtained from Standard Penetration, most of bearing strata consist of Silty Sand except BH-2, BH-4, BH-7, BH-14, BH-15 which are Fine Sand Strata.

14.2.2 Geotechnical Survey of Gwalior Bypass

14.2.2.1 Geological Description of Gwalior Bypass

The general geological formations are alluvium, Gwalior shale, and Gwalior

sandstone. Soil is shallow and stony strata vary sandy loam on the escarpments to stiff clayey loam on the plateau. At the foot on the hill, soil is generally deep. The soil varies from light loam to stiff loam except where is generally clayey. The soil on slopes that are not rocky is deep varying from dark red to reddish in colour.

(1) Characteristics of Soil

Alluvial soil occupies the major the major part of the area. The soil is usually loam to sandy loam with clay admixture. At the foot on the hill and along the slopes, the depth of soil is greater due to the erosion or weathering of exposed rocky joints.

(2) Description of Soil

The outcrops of the Gwalior occupy an area of 50 miles long and 15~20 miles wide, with a very gentle northerly dip. They comprise sandstone, ferruginous jaspers, limestone and interbedded traps. The Gwalior System has been divided into a lower PAR SERIES up to 200 feet thick, and an upper MORAR SERIES which is over 2,000 feet thick. The Par Series consists of thin bedded sandstone at the base resting on an irregular denuded surface and some sandstone and shale into which sometime Bundelkhand quartz reefs project. The sandstone form well marked scarps. The Morar series consists of siliceous and ferruginous shale with bands of bright red jasper.

14.2.2.2 Location of Bore-Holes and Geological Profile

Location of bore hole and geological profile of Gwalior Bypass is shown in Figure 14-2.

14.2.2.3 Boring

Fifteen bore holes (BH-1 to BH-15) were bored at this site. Casing was used to retain the bore holes. The sub soil strata exist up to approximately 15 m deep before climbing the rocky hill. Stretch in the rocky hill, at the debris of the river, Sandy Gravel as bearing strata exist 10 m below the river bed. Plain terrain locates at the ending stretch, the sub soil strata exist up to approximately 10 m deep.

14.2.2.4 Test Pits

A trial pit was selected in the proximity of Jinaoh and Dense Khair in order to examine proctor and California bearing ratio (CBR) test and laboratory test to investigate the feasibility of using the soil as embankment and subgrade material.

The test pits of size 1.0 m x 1.0 m in width was made up to 1.0 m depth below existing ground surface. 3 Nos. of disturbed soil samples were collected for conducting proctor compaction and CBR tests (saturated condition) and laboratory tests.

Table 14-8 Test Pit Tests Result

Test Pit Tests Result	TP-1	TP-2	TP-3
Optimum Moisture Content: W_{nop}(%)	7.6	10.3	10.8
Maximum Dry Density: γ_d(g/cm³)	2.24	2.00	2.02
CBR (%)	55.2	41.9	45.7
Type of Soil	Gravel 73~86% Sand 9~11% Silt 3~12% Clay 0~6%	Gravel 79% Sand 19% Silt 2% Clay 0%	Gravel 83% Sand 14% Silt 3% Clay 0%

14.2.2.5 Laboratory Test

The engineering properties of soil in the Study Area of Gwalior are summarised as Table 14-9.

Table 14-9 Engineering Properties of Soil

Classification	Water Content		Plastic Limit (W_P)	Liquid Limit (W_L)
	Range (%)	Average(%)	Average (%)	Average (%)
Alluvial Soil	8~26	17	21	31

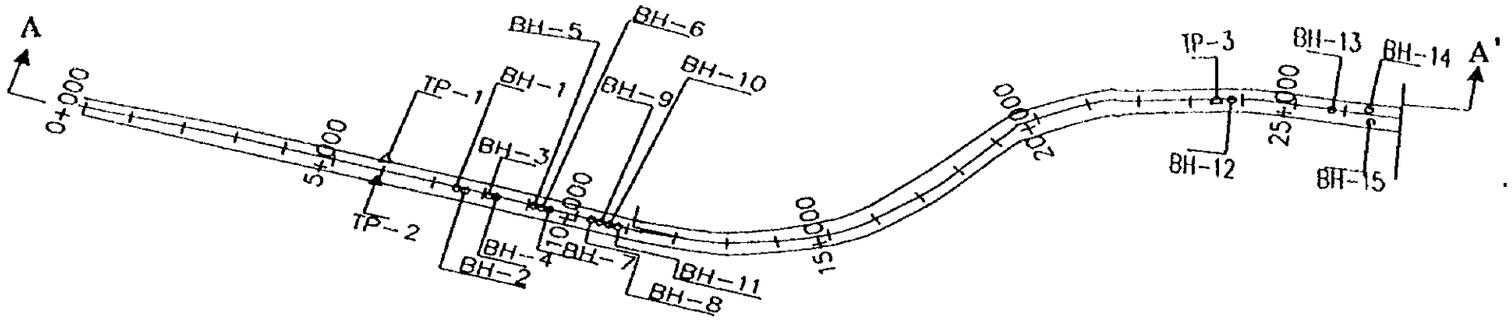
14.2.2.6 Proposed Parameter for Design and Construction Plan

(1) Filling Material and Design CBR

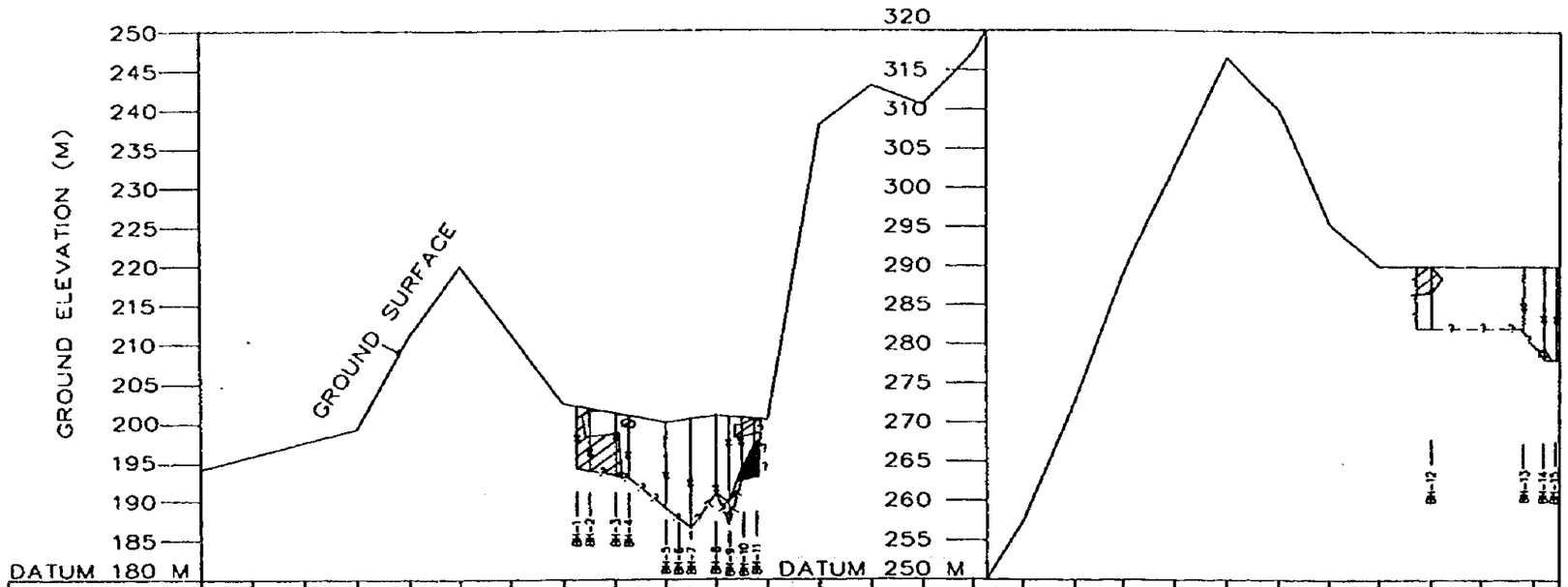
Laboratory tests for Test Pit was carried out including specific gravity test, grain size analysis, liquid limit test, plastic limit test, moisture content test and standard proctor compaction.

It was clarified that the type of the soil at TP-1 as Sandy Gravel consist of maximum dry density as 2.24 g/cm3 at optimum moisture content of 7.6%. At TP-2, it was Gravel consist of maximum dry density as 2.0 g/cm3 at optimum moisture content of 10.9%. At TP-3, it was Gravel consist of maximum dry density as 2.02 g/cm3 at optimum moisture content of 10.87%.

CBR values under 4 days soaked at TP-1 was 55.34%, TP-2 was 38.57%, TP-3 was 41.43%. The CBR test results show a minimum design CBR for the material at TP-1 as 55.34%, at TP-2 as 38.57%, at TP-3 as 41.43%. According to the CBR values at TP-1/TP-2/TP-3 ranging from 38.57% to 55.34%, it is clarified that the use of soil from those test pits is feasible for subgrade material.



PLAN SHOWING BOREHOLES & TRIAL PITS LOCATIONS



GROUND ELEVATION(M)	195.71	197.43	199.14	211.11	220.00	211.50	202.40	201.20	200.00	200.82	200.33	238.00	243.00	240.60	247.18	257.44	272.61	288.89	303.85	316.67	310.00	295.41	290.00	290.00	290.00	290.00	290.00
CHAINAGE(KM)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	26.50

LEGEND

- LOCATION OF BOREHOLE
- LOCATION OF TRIAL PIT
- GROUNDWATER LEVEL MEASURED IN THE BOREHOLE APPROXIMATELY 24 HOURS AFTER COMPLETION OF BORING OPERATIONS.
- COARSE-GRAINED ALLUVIUM (SP,SW,SC,SP-SM,SM)
- FINE-GRAINED ALLUVIUM (ML,CL,ML-CL,CI)
- SANDSTONE ROCK
- A A' SECTION ALONG A-A'
- -?- -?- EXTENT OF GEOLOGIC CONDITIONS UNCERTAIN

NOTE

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GEOLOGIC PROFILE ALONG A – A'

INTERCONTINENTAL CONSULTANTS
AND TECHNOCRATS PVT. LTD.
A-11, GREEN PARK
NEW DELHI-110016.
TEL: 6863000,6864757 FAX: 6855252

SCALE OF PLAN	1:125,000
HORIZONTAL SCALE (PROFILE)	1:111,111
VERTICAL SCALE (PROFILE)	1:715

Figure 14-2 Location of Boreholes and Geotechnical Profile of GwaliorBypass

(2) Bulking Factor of Soil

According to the CBR Test results, it is clarified that the type of soil at TP-1 as Gravel 73~86%, Sand 9~11%, Silt 3~12%, Clay 0~6%, TP-2 as Gravel 79%, Sand 19%, Silt 2%, TP-3 as Gravel 83%, Sand 14%, Silt 3%. Considering the earthwork, the Bulking Factor of soil for three test pits shall be considered as follows;

When excavated : 1.15~1.20
When compacted for embankment : 1.00~1.10

(3) Fill Slope

The type of soil from the TP-1 as Sandy Gravel consists of as Gravel 73~86%, Sand 9~11%, TP-2 as Poorly Graded Gravel consists of Gravel 79%, Sand 19%, Silt 2%, TP-3 as Poorly Graded Gravel consists of Gravel 83%, Sand 14%, Silt 3%. Due to the poor texture of the soil from three test pits, it is recommended that the fill slope for the soil from the test pit shall be recommended as Table 14-10.

Table 14-10 Recommended Fill Slope in Gwalior Bypass

Embankment height (m)	Fill Slope
0.0 m~10.0 m	1 : 1.5

According to the data from the grain size analysis, texture of soil up to 3 meters below from ground level at most of the boring locations except BH-11, BH-12, BH-13, BH-15 is well graded. Therefore, when side borrow for embankment around the boring area is required, the fill slope 1:1.5 to be sufficient except the area of BH-11, BH-12, BH-13, BH-15 which is 1:1.8 to be recommended.

(4) Cut Slope

Cut sections will be appeared at the stretch of rocky hills at the middle of the whole bypass. There are shallow sub soil laying on the sandstone mass which is highly flaggy in nature and quartzitic in composition.

Table 14-11 Recommended cut slope

Geology	Cut Slope
Sub Soil (0~7.0 m)	1 : 1.0
Rock	1 : 0.5

(5) Hauling Distance

Considering the earth work, the straight line distance for hauling from the

Borrow Pits (TP-1/TP-2) to Sojna village to be approximately 11 km, from TP-3 to Sojna village to be approximately 8 km unless changes with the Construction plan such as construction road.

(6) Basic horizontal seismic coefficient

The site is located near Gwalior in the state of Madhya Pradesh. The site falls in the seismic Zone-II of India and as per IS:1893-1984, the basic horizontal seismic coefficient (α) is 0.02.

(7) Ground Water Level

The depth of ground water table was checked/measured at the bore hole locations after completion of work/on full stabilisation of water table. The ground water table was encountered at depth 2.30-8.15 m below existing ground level at the locations except BH-6/BH-11/BH-12 where the ground water was not met during Boring work.

(8) N-value

According to the N-value obtained from SPT, most of bearing strata consists of Clay at BH-4, BH-7, BH-14, BH-15, and Sandy Gravel at BH-8, BH-9, BH-10, BH-11.

14.3 Hydrological Survey

The hydrological survey and collection of hydrological information for the project areas was carried out for the following items:

1) The study of catchment areas;
2) Study of previous flood condition;
3) Study of existing water channel;
4) Collection of climatological & hydrological data; and
5) Hydrological analysis.

The study of catchment areas includes to identify the watershed which may cross the proposed bypass, to specify the watershed on the topographic map on a scale of 1:50,000, to provide its area, slope condition, and ground surface condition. The previous flood condition was studied based on any records, flood marks in the field or local inquiry.

The existing water channel which will likely cross the proposed road was categorised based on its characteristics and the detail of the individual channel was investigated. The climatological and hydrological data which gives the various design parameters such as temperature, rainfall and discharge was collected from the related agencies.

The hydrological analysis was carried out to estimate design rainfall and/or design

discharge with the return period of 3, 5, 10, 25, 50 and 100 years. The design rainfall intensity and the intensity curves were also calculated.

The applied formulae for the hydrological analysis were presented below.

- Weibull Formula for Recurrence Interval

$$T = \frac{N+1}{m}$$

where: T = Recurrence in year
N = Number of years records used
m = the order assigned to the magnitude of rainfall

- Rainfall Intensity

$$I = \frac{k \cdot T^x}{(D+a)^n}$$

where: I = Rainfall Intensity in cm/hr
k = Constant for a given catchment
x = Constant for a given catchment
a = Constant for a given catchment
n = Constant for a given catchment
T = Return period in years
D = Duration in hours

Table 14-12 Constants for Rainfall Intensity[1)]

	k	x	a	n
Bareilly[2)]	6.93	0.189	0.5	0.878
Gwalior[3)]	11.45	0.156	1.25	1.032

1) Constants provided by Central Soil and Conservation Research and Training Institute
2) Values for North Indian River Catchments
3) Values for Nagpur

- Barlow Formula for Run-off in UP

$$R = K \cdot P$$

where: R = Run-off in millimeter
K = Constant (15)
P = Monsoon rainfall in millimeter

- Dicken Formula for Flood Discharge

$$Q_p = C_d \cdot A^{3/4}$$

where: Q_p = Maximum flood discharge (m3/sec)
C_d = Dicken constant, 6 for plain and 11 for hill
A = Catchment-area in square km

Table 14-13 Constants of Dicken Formula

No.	Region	Constant
1	North Indian Plains	6
2	North Indian Hilly Region	11-14
3	Central India	14-28
4	Coastal Andra & Orissa	22-28

Source: K. Subramanya, Engineering Hydrology, 1997

- Rational Formula for Flood Discharge

$$Q = 0.028 \cdot p \cdot f \cdot A \cdot Ic$$

where: Q = Maximum flood discharge (m3/sec)
p = Percentage coefficient of run-off for the catchment characteristics
f = Factor depends on the extent of catchment-area
A = Area of catchment-area in hector
Ic = Intensity of rainfall in mm

Table 14-14 Design Return Period of Rainfall Intensity

No.	Structure Type	Design Return Period (Years)
1	Road Surface Drainage (Open Drain, Side Drain, Kerb)	3 1)
2	Surround Area Drainage (Box-Culvert, Pipe-Culvert)	10 1)
3	Cross Drainage (Bridge, Box-Culvert)	50 2)

1) Japan Highway Public Corporation Design Manual Vol. 1, Drainage Design
2) IRC: 5-1985, Standard Specification & Code of Practice for Road Bridges, Section I-General Features of Design, Clause 103.1

14.3.1 Hydrological Survey of Bareilly Bypass

14.3.1.1 The Study of Catchment Areas

The project area is underlain by thick alluvial sediments brought down by the Ganga

river system. The fluvial sediments are the admixture of sands of different grades and clays. The top layer sediments have high porosity and medium permeability.

The study area represents nearly flat topography, gently sloping towards south. The highest elevation is around 195 m above mean sea level (MSL) in the north while close to proposed bypass, the ground level is around 168 m above MSL.

Two catchment areas were identified in Bareilly Bypass area as shown in Figure 14-3. The length of the catchment affecting the bypass is approximately 27 km and 40 km, respectively. The average ground slope of the area is 50 cm per km. The areas are being drained by the rivers Deonarain and Nakatia. Both of these rivers are perennial rivers. During rainy season these streams flow in full swing. Deonarain river carries more discharge as compared to Nakatia.

Table 14-15 Catchment-Areas in Bareilly Bypass

Name of river	Nakatia nadi	Deonarain
Place of origin	South of Gopandi village	North of Munapur village
Length of river	80 km	50 km
Catchment area	110 sq. km	200 sq. km.
Maximum elevation	185 m above MSL	195 m above MSL
Lowest elevation	168 m above MSL	168.5 m above MSL
Length of catchment	27 km	40 km
Width of catchment	5 km	5 km
Average slope	0.63 m/km	0.67 m/km

Both the rivers are braided river. The river banks height is variable from 2 to 3 m throughout its course so is the width of channel depending upon morphology, slope and nature of formation. Both the streams represent typical anatomising pattern a characteristic pattern of plains. The river channel meanders making numerous cut off and bends. The entire catchment is mainly being cultivation. The rivers are not being gauged hence no discharge data could be obtained.

14.3.1.2 Study of Previous Flood Condition.

The flood marks of rivers have been identified through local inquiry as shown in Table 14-16.

14.3.1.3 Study of Existing Water Channel

A traverse has been taken along the proposed alignment of bypass. The channels/canals likely to cut proposed alignment have been marked on map and critically examined. The relevant details of canal were obtained from irrigation department. Four (4) canals are investigated as shown in Table 14-17.

Table 14-16 Details of Rivers in Bareilly Bypass

Name of river	Nakatia nadi	Deonarain
Location	South west of Ahmednagar	South west of Belwa village.
Nature	Perennial	Perennial
Bed width	20 m	20 m
Catchment area	200 sq. km	110 sq. km
Highest level of catchment	195 m above MSL	185 m above MSL
Lower level near proposed road	168 m above MSL	168 m above MSL
Maximum depth	3 m below general elevation	3 m
Highest flood level	1 m above present bridge (173 m AMSL approx.)	2.5 m above river bed (171 m AMSL approx.)
Catchment character	Flat cultivated land	Flat cultivated land

Table 14-17 Details of Canals in Bareilly Bypass

Name	Mundia minor	Bhojipur Dy	Bareilly Dy	Kumra Minor
Location	South East of Tihulia village	East of Birpur village	East of Hajipur near Ahmednagar	East of Kumra village
Width	1.0 m	3.0 m	2.5 m	1.2 m
Water depth	0.5 m	0.8 m	0.5 m	0.4 m
Ground level	166 m above MSL	166 m above MSL	166 m above MSL	166 m above MSL
Design discharge	0.8 m^3	20 m^3	4.1 m^3	0.4 m^3

14.3.1.4 Collection of climatological & hydrological data

(1) Climate

The climate of this district is influenced by its proximity to the hills and the terai swamps to the north. The dryness of the air in the summer is as in the western districts of Uttar Pradesh, the comparatively damp climate in the rest of the year. Period from middle of June to the end of September is the monsoon season.

(2) Rainfall

The average annual rainfall in the project catchment area is 1149.4 mm based on 50 years normal for 1901-50. Rainfall increases generally from the Southwest towards the Northeast. On an average there are 46 rainy days and there is not much variation in this number in different parts of the district. The heaviest rainfall in 24 hours recorded is 533.4 mm at Nawabganj, 477.5 mm at Baheri and 378.5 mm at Bareilly.

WATERSHED OF BAREILLY AREA

1 2 3 4 5 6 KM

SCALE

LEGEND

WATER SHED

RIVER/ STREAM

CANAL

EXISTING HIGHWAY(NH-24)

PROPOSED BYPASS

SPOT LEVEL 175

BAREILLY

HYDROLOGICAL STUDY

Figure 14-3 Catchment Area in Bareilly Bypass

The monthly rainfall data collected for the three stations for the Project area (Bareilly, Baheri and Nawabganj) for the period 1951 to 1996.

The rainfall frequency curve has been plotted for the project area considering average rainfall of the study area using simple empirical technique by arranging rainfall series in descending order of magnitude and assigning an order 'm'. The recurrence interval T has been calculated for each using Weibull formula as shown in Table 14-18.

Table 14-18 Estimated Average Rainfall

Return Period (Years)	Average Rainfall (mm)
3	1100
5	1250
10	1450
25	1650
50	1800
100	1900

Invariably, the evaluated normal rainfall for the study area (1056 mm) occurs at the interval of 2.5 years.

(3) Rainfall intensity

For design purposes, DAD (Depth Area Duration) analysis is one of essential parameter. The rainfall depth of different duration over the catchment is required to evaluate the probable flood over the catchment. The rainfall intensity of different duration and different return periods was calculated using the above values of the constants and the result was as shown in Table 14-19.

Table 14-19 Rainfall Depth for Different Duration and Return Period in Bareilly Bypass

Return period (years)	Duration (hours)								
	0.25	0.50	1	3	6	12	24	48	72
3	27.5	42.6	59.7	85.2	98.9	111.4	123.4	135.5	142.8
5	30.2	46.9	65.8	102.2	108.9	122.7	135.9	149.3	157.3
10	34.5	53.5	75.0	116.5	124.2	139.9	154.9	170.2	179.3
25	40.2	63.7	89.2	138.6	147.7	166.3	184.3	202.3	213.2
50	46.7	72.5	101.7	157.9	168.3	189.6	210.0	230.7	243.1
100	53.2	82.7	115.9	180.0	191.9	216.2	239.5	262.9	277.1

Note: Values present accumulative total depth (mm/Duration(hr))

(4) Temperature

There is a meteorological observatory at Bareilly the records of which may be

taken as preventative of the meteorological conditions for the study area. From about the middle of November temperature decreases rapidly and January is the coldest month. In association with the cold waves in the wake of western disturbances passing eastwards, the minimum temperature may go down to the freezing points. Temperature rises rapidly after February. May and early June form hottest period, with the advance of the Southwest monsoon into the district in the later half of the June, day temperatures drop appreciably but nights continue to be warm as in summer.

(5) Humidity

Air is very humid in the Southwest monsoon season and to a lesser extent in the post monsoon. Thereafter there is a decrease in the humidity in the cold season. The summer season is the driest part of the year when the relative humidity in the afternoon is as low as 20 to 25%.

14.3.2 Hydrological Survey of Gwalior Bypass

14.3.2.1 Study of Catchment-areas

The study area is underlain by Vindhyan group of rocks belonging to upper Kaimur series. The rock type encountered is purple medium grained sandstone with minute specks of Jaspar. Generally sandstone is highly arenaceous in nature and quartzitic in composition. At places flaggy and shaly bands are present. The thickness of these bands varies from half to two metres. Bands are massive in nature. The general strike direction of formation is N 30 E-S 30 W.

The study area and surroundings have rugged terrain marked by hillocks and escarpments. Specially the terrain to the east of proposed bypass alignment is marked by prominent isolated hillocks attaining a height over 350 m above MSL.

The entire drainage system developed belongs to Sank nadi drainage system flowing few kilometres west of proposed bypass. The drainage forms isolated narrow valleys, which may have impact on road alignment. At number of places the bunds have been build to stop the flow of rainwater for use by local habitants. All these streams are seasonal and reported to flow in spate during rainy season. By the end of November/December the flow in these streams ceases. The Sank nadi is the perennial river on which a dam has been constructed in early part of this century.

The field investigation carried out to study the respective catchments having impact on the road alignment. These streams are dry during lean period while they overflood their usual width. The maximum depth of these streams ranges between 4 and 6 m below general ground elevation. In all 5 number of catchments were identified as shown in Table 14-20 and illustrated in Figure 14-4.

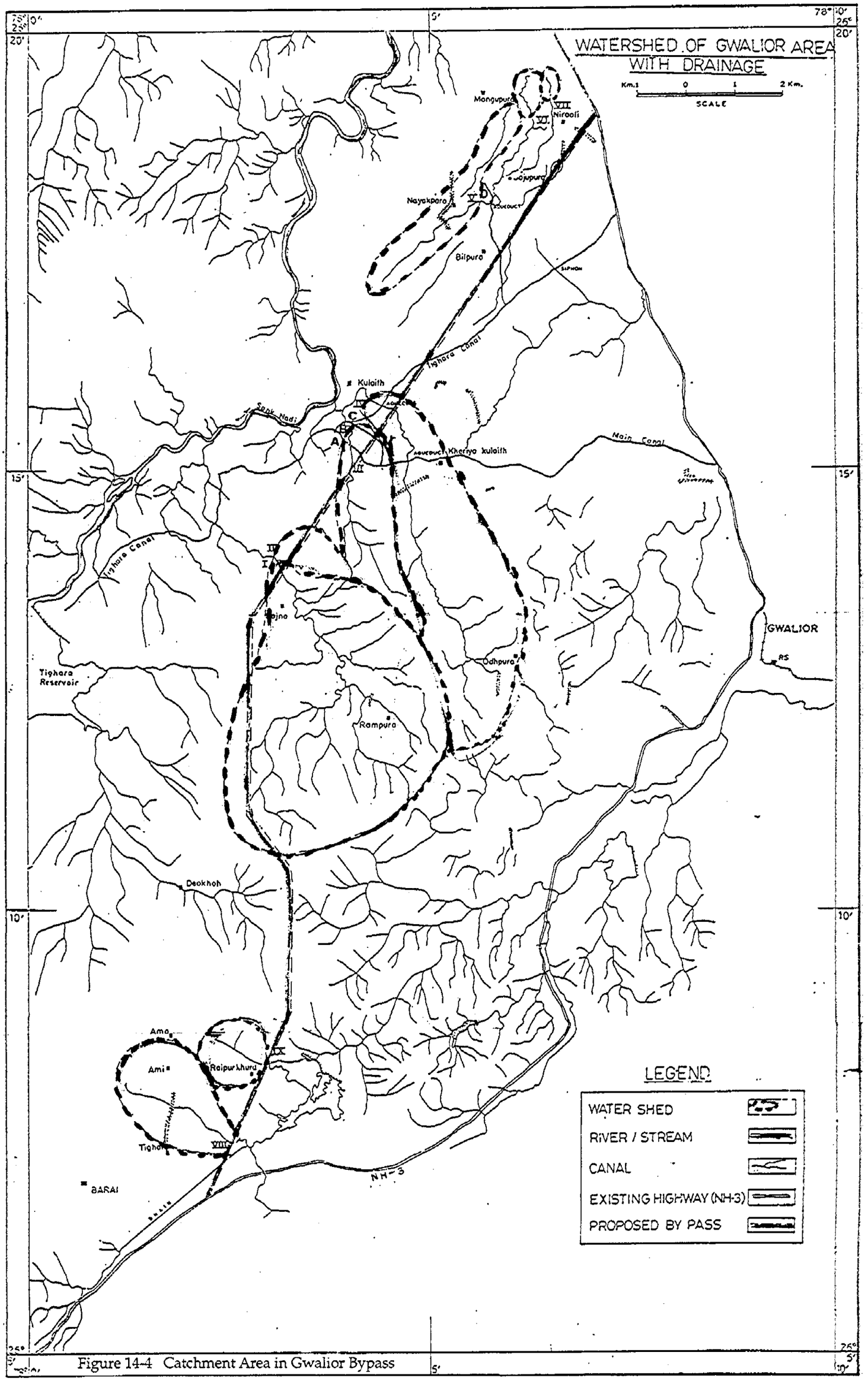


Figure 14-4 Catchment Area in Gwalior Bypass

Table 14-20 Catchment-areas in Gwalior Bypass

Location/Village	Kharai nala	Bandha nala / Babukapura	Rai ka Pura/ Sojina	Raipur Khurd	Raipur Tighara nala
Catchment area (km^2)	12	1	22	1	3
Maximum elevation Above MSL	305	N.A.	300	295	295
Lowest elevation Above MSL	220	N.A.	200	290	280
Length of water course (km)	15.5	0.5	40.0	1.7	2.3
Drainage density (km/km^2)	1.3	0.5	1.8	N.A.	N.A.
Average slope	1/180	N.A.	1/60	1/400	1/160

14.3.2.2 Study of previous flood condition.

The flood marks of rivers have been identified through local inquiry as shown in Table 14-21.

Table 14-21 Details of Rivers in Gwalior Bypass (1/2)

Name of river	Kharai nala	Bandha nala	---
Location	---	Babukapura	Rai ka Pura/ Sojina
Nature	Water only in rainy season	Water only in rainy season	Dry in lean period
Bed width (m)	7.0	25.0	14.0
Catchment area (km^2)	12	1	22
Highest level of catchment	305	N.A.	300
Lowest level near proposed road	220	N.A.	200
Maximum depth (m)	5.0	5.0	6.3
Highest flood level Above MSL	326	7-8 m above bed level	208
Catchment character	---	Basement bed Sandstone	Basement of the Nara is hard and compact sandstone

Table 14-21 Details of Rivers in Gwalior Bypass (2/2)

Name of river	---	Raipur Tighara nara	
Location	Raipur khurd	---	
Nature	Water only in Rainy Season	0.2-0.3 m Water remains most of the year and dries in the drought period only	
Bed width (m)	12.0	13.25	
Catchment area (km^2)	1	3	
Highest level of catchment	295	295	
Lowest level near proposed road	290	280	
Maximum depth (m)	4.0	5.75	
Highest flood level Above MSL	296	288	

14.3.2.2 Study of Existing Water Channel

A traverse has been taken along the proposed alignment of bypass. The channels/canals likely to cut proposed alignment have been marked on map and critically examined. The relevant details of canal were obtained from irrigation department. Four (4) canals are investigated as shown in Table 14-22.

Table 14-22 Details of Canals in Gwalior Bypass

Name	Kuleth Kharia Mouza	Kuleth Kharia	Kuleth	Jigsauli Minor
Location	Tighra east of Rai Ka Pura village			
Max. width	5.0	5.0	14.25	10.5
Max. depth	2.0	2.0	2.25	2.0
Discharge during non monsoon period (cusec)	20	20	20	10-12
Running days during non monsoon period	200-250	225	200-250	200

14.3.2.3 Collection of Climatological & Hydrological Data

(1) Climate

The study area experiences typical climate prevailing over plateau region. The review of mean climatological parameter indicate daily maximum temperature varies between 23 °C to 40.8 °C while minimum between 7.2 and 30.2 °C. December being coldest and June hottest period of the year. April being driest recording lowest humidity.

(2) Rainfall

The average annual rainfall being 900.2 mm based on mean value for the period 1901 to 1950. On an average there are 44 rainy days in a year. The heaviest rainfall in 24 hours records is 316.2 mm during 1891. The 50 years normal rainfall data indicates that the month of July is the wettest month with a rainfall of 273.8 mm.

The latest monthly rainfall data collected from Gwalior for the period 1976 to 1996 shows that mean rainfall for Gwalior town is 815.02 mm which is slightly lower than 50 years normal value. The monsoon rainfall data for Tighra dam site located west of Gwalior township for the period 1984 to 1997 given average rainfall of 625.9 mm at this site. The daily rainfall data for the purpose of hydrological analysis has been collected for Gwalior for the years 1995, 1996 and 1997.

The rainfall frequency curve has been plotted for the project area considering average rainfall of the study area using simple empirical technique by arranging rainfall series in descending order of magnitude and assigning an order 'm'. The recurrence interval T has been calculated for each using Weibull formula as shown in Table 14-23.

Table 14-23 Estimated Average Rainfall

Return Period (Years)	Average Rainfall (mm)
3	800
5	1025
10	1100
25	1175
50	1200
100	1200

Invariably, the evaluated normal rainfall for the study area (815 mm) occurs at the interval of 1.2 years while long term normal (900 mm) has got a 1.5 years.

(3) Rainfall intensity

For design purposes DAD (Depth Area Duration) analysis is of significant value. The rainfall depth of different duration over the catchment is required to evaluate the probable flood over the catchment. The rainfall intensity of different duration and different return periods is calculated using the above values of the constants, the Table 14-24 was developed.

Table 14-24 Rainfall Depth for Different Duration and Return Period in Gwalior Bypass

Return period (years)	Duration (hours)								
	0.25	0.50	1	3	6	12	24	48	72
3	22.4	38.1	58.9	91.6	105.6	113.3	116.5	116.9	116.4
5	24.2	41.3	63.7	87.3	114.4	122.7	126.2	126.6	126.1
10	28.9	46.1	70.9	97.3	127.5	136.8	140.6	141.1	140.5
25	31.4	53.1	81.9	112.3	147.0	157.8	162.2	162.8	162.1
50	34.7	59.2	91.2	125.1	163.8	175.8	180.7	181.3	180.6
100	38.6	65.9	101.6	139.3	182.5	195.8	201.3	202.0	201.2

Note: Values present accumulative total depth (mm/Duration(hr))

14.4 Environmental Impact Assessment (Natural Aspects)

The large scale operations involved in the construction of the bypass will make it imperative to prepare Environmental Impact Assessment (EIA) report for the project and Environmental Management Plan (EMP) to suggest measures to mitigate the adverse environmental impact.

In order to have a better perception of the post project environmental quality, quantification of the anticipated impacts was carried out. The environmental quality assessment of the post project scenario with the implementation of the environmental management plan highlights the benefits accrued from the EMP.

The environmental quality evaluation was conducted using Battelle Environmental Evaluation System (BEES) which is a widely accepted method for civil construction projects. As per BEES, the environmental quality (EQ) is classified into four environmental components viz. ecological environment, environmental pollution, aesthetics and human interest. These components are further divided into various environmental parameters. Weights are assigned to all the parameters based on their importance as given in Table 14-25.

The quality index (QI) of each parameter is determined from the already established value function curves which help in calculating the Environmental Impact Unit (EIU) of the respective parameter. The likely impact on each parameter changes their respective QIs. The determination of QI is highly subjective and the value is arrived at taking views from experts in the field. The changed values of EIU quantifies the change in the environmental quality in the post project scenario (with or without the implementation of EMP). The identification of environmental impact is based on the base line condition, nature of proposed activities, and other indirect resultant activities.

Table 14-25 Assigned Weights for Environmental Parameters

Ecological Environment (300)		Environmental Pollution (300)		Aesthetics (200)		Human Interest (200)	
Terrestrial	(200)	Air	(100)	Variety within	30	Economy output	20
Natural vegetation	30	CO	20	Veg. Type		Employment	20
Crops	30	NOx + HC	20	Animals-domestic	30	Housing	20
Land use	40	SO_2	20	Native fauna	30	Education	20
Forest land	40	SPM	20	Appearance of	30	Drinking water	20
Non forest land	40	Diffusion factor	20	Water		supply	
Species diversity	20	Noise	(100)	Visual quality	40	Sanitation	20
Aquatic	(100)	Community noise	50	Sound	40	Transportation &	20
Streams	40	Occupational	50			Communication	
Stream flow	40	Noise				Community health	20
Variation		Land	(100)			Occupational	20
Basin hydrologic	20	Soil chemistry	50			Health	
Loss		Soil erosion	50			Social welfare	20

Parameter wise Environment Impact Units (EIU) was arrived at as per standard BEES methodology using the relevant value function graphs for the pre-project scenario and post project scenario with the implementation of EMP.

14.4.1 Existing Environment and Baseline Survey for Bareilly Bypass

14.4.1.1 Climate

The climate of this district is influenced by its proximity to the hills and the Terai swamps to the north. Period from middle of June to the end of September is the monsoon season. The area comes under semi arid, sub-tropical monsoonic climate. The climatological parameters are given in Table 14-26. The average temperature is 21.6°C.

Table 14-26 Climatological Parameters in Bareilly

Month	1	2	3	4	5	6	7	8	9	10	11	12
Temperature (°C)												
Maximum	21.3	24.2	30.0	36.5	38.3	37.3	33.1	32.9	32.6	32.0	28.2	23.2
Minimum	6.9	9.2	13.7	19.1	23.1	24.9	25.7	24.9	23.1	17.7	11.4	7.9
Average	14.1	16.7	21.8	27.9	30.7	31.1	29.4	28.9	27.8	24.8	19.8	15.6
Rainfall (mm)	21	15	10	9	39	112	332	226	201	32	4	18

(1) Temperature

The annual mean daily temperature of Bareilly varies from 22.0°C to 45.5°C. The month of March is the beginning of the hot weather. The day temperature begins to fall with the arrival of south-west monsoon in the latter half of June.

(2) Rainfall

The average annual rainfall in the project area is 1149 mm based on 50 years normal for 1901~50. Rainfall increases generally from the Southwest towards the North East. The variation in the rainfall from year to year is appreciable. In the fifty year period form 1901 to 1950, highest rainfall in 1936 amounted to 167% of the normal and the lowest one in 1918 fell by 57% of the normal.

(3) Winds

Winds are generally light which strengthen in force during the later part of summer and monsoon seasons. During the south-west monsoon period, the wind blows mainly from the sector between south-west and north-west. By October, north-easterly and easterly become predominant and continue to predominate in the next two months. In January and February, wind blows from the south-west and the north-west directions and is as common as the easterly and north-easterly, particularly in the afternoons. In the summer season, westerly to north-westerly winds is predominant. The average monthly wind speed is 1.2(AM), 0.7(PM) m/s

(June) and 0.5(AM), 0.2(PM) m/s (Nov). Mean annual wind speed based on 1996 data is 0.7 m/s.

14.4.1.2 Geology

The soils of Bareilly have developed on alluvium washings from inner or outer Himalayas transported by Ganges and its tributaries. The main minerals constituting the alluviums are mica, feldspar, quartzite and heavy minerals like zircon, hornblende, tourmaline etc.

14.4.1.3 Topography

The topography along the proposed alignment of the bypass is generally plain. The alignment crosses railway line (metre gauge), irrigation canals, drainage channels and roads (including public roads and panchayat roads). Topographically, the district comprises a part of the lower Himalayan ranges and Upper Gangetic Basin. The typical features of the district are the hilly ranges of the Himalayas adjoining the northern boundary and the plains of Gangetic Basin in the south.

14.4.1.4 Water Environment

There are a number of seasonal rivers in Bareilly district. All these rivers become full and active during the rainy season and in summer, they generally dry up entirely. During this season, most of these rivers cannot be utilised for irrigation or for navigation purposes. Greater part of the tract experiences great scarcity of water especially after January each year. Many of the wells dry up in summer creating water scarcity. The water table is generally low in rocky and ravenous areas. River Sank flows near the project area. Tighra Dam has been constructed on this river. The bypass alignment intercepts Tighra canal. No other major stream/water body exist in the project area. Hence, no significant change in the present drainage system in the project area is anticipated with the completion of the project.

The study area represents nearly flat topography, gently sloping towards south. The area is being perennially drained by the river Deorani and Nakatia. During rainy season these streams flow in full swing. Deorani river carries more discharge as compared to Nakatia. Catchment areas of Nakatia and Deorani are 110 sq. km and 200 sq. km respectively.

14.4.1.5 Air Quality

Air quality monitoring was carried out at 2 stations - Kali Bari and Kantharia. The location of the monitoring stations are shown in Figure 14-5. The details of the analysis of eight hourly samples collected at the above mentioned locations are summarised in Table 14-27.

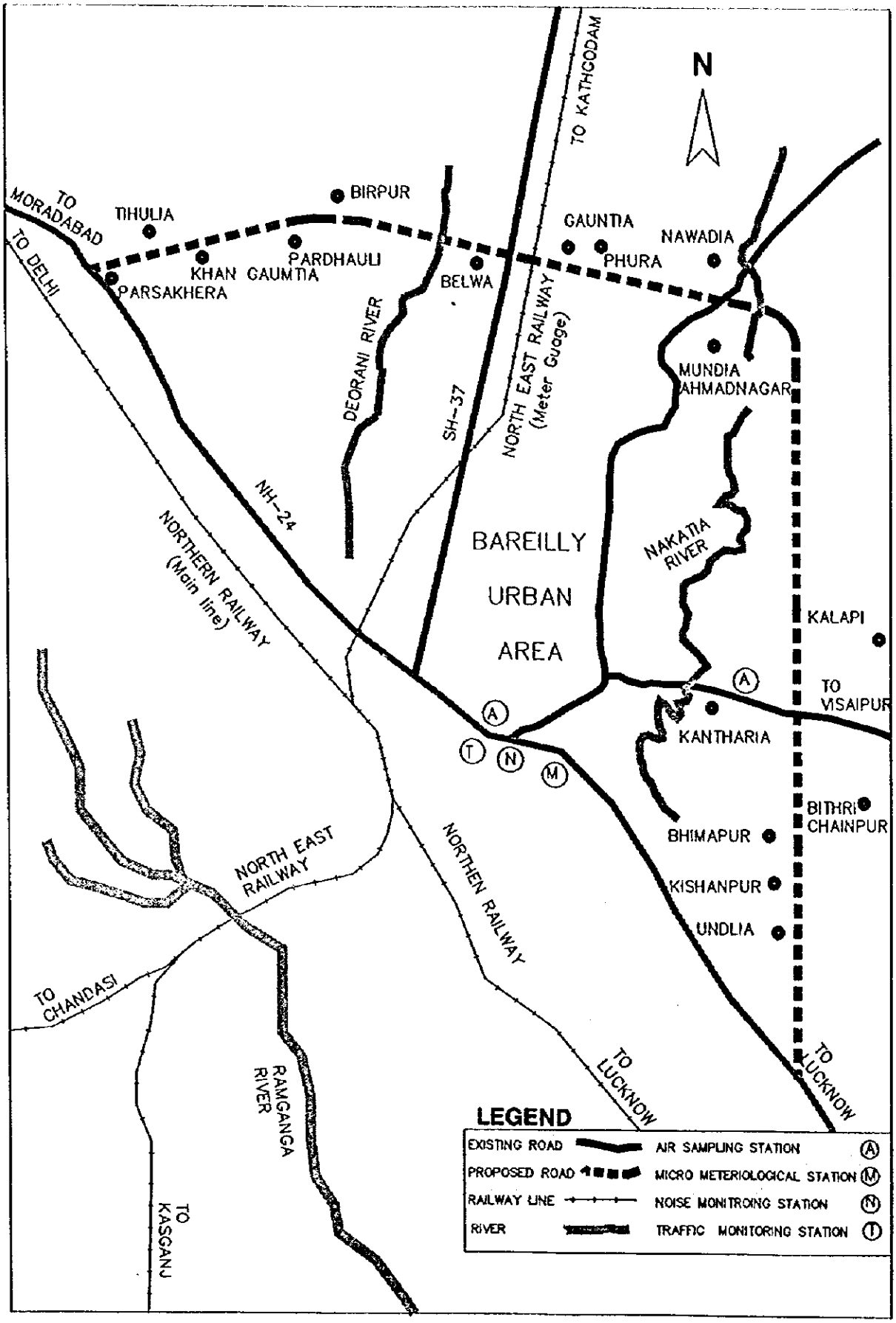


Figure 14-5 Monitoring Stations for Bareilly Bypass

A perusal of the table shows that the 24 hourly average concentrations of SPM, SO_2 and NOx were found to be high along the existing highway but well within the limits prescribed for industrial area. Lead content was found to be ranging from 1.7 $\mu g/m^3$ to 2.2 $\mu g/m^3$ at Kali Bari which is above the permissible limit of 1.5 $\mu g/m^3$ for industrial area.

Meteorological data during the air quality monitoring period is shown in Table 14-28. Max. wind speed was 1.19 m/s, average temperature was 15.5°C and humidity varied from 56% to 95%. The predominant wind direction was South - East, as shown in Figure 14-6.

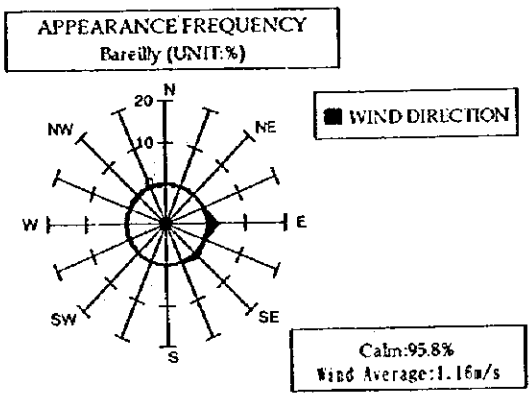
Table 14-27 Ambient Air Quality

Location	Date of Sampling	Avg. 24 hrs Concentration ($\mu g/m^3$)				
		SPM	SO_2	NOx	Pb	CO*
Kali Bari (Existing Highway inside the town)	8~9/12/97	406	7.3	4.32	1.7	Less than 167
	10~11/12/97	442	8.8	4.29	2.2	
	12~13/12/97	414	7.9	4.62	2.0	
Kantharia village (proposed bypass alignment)	12~13/12/97	73	6.1	4.27	Nil	
National Ambient Air Quality Standards (CO*: 8 hrs)	Industrial	500	120	120	1.5	5000
	Residential/Rural	200	80	80	1.0	2000
	Sensitive	100	30	30	0.75	1000

Table 14-28 Survey results of meteorological data

Wind Speed (m/s)			Temperature (°C)			Humidity (%)		
Ave.	Max.	Calm (%)	Ave.	Max.	Min.	Ave.	Max.	Min.
0.4	1.2	95.8	15.5	21.0	12.5	85	95	56

Note : Calm is defined as wind condition below 1 m/sec wind speed.



Note : Wind Average except calm

Figure 14-6 Windrose Diagram during 03~08/12/1997