Japan International Cooperation Agency (JICA)
Hanoi People's Committee

No.

The Comprehensive Urban Development Programme in Hanoi Capital City of the Socialist Republic of Vietnam (HAIDEP)

FINAL REPORT

Vol.2 Prefeasibility Studies

March 2007

ALMEC Corporation
Nippon Koei Co., Ltd.
YACHIYO Engineering co., Ltd.

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（average in 2006）

PREFACE

In response to the request from the Government of the Socialist Republic of Vietnam, the Government of Japan decided to conduct the Comprehensive Urban Development Programme in Hanoi Capital City and entrusted the program to the Japan International Cooperation Agency (JICA).

JICA dispatched a team to Vietnam between December 2004 and March 2007, which was headed by Mr. IWATA Shizuo of ALMEC Corporation and consisted of ALMEC Corporation, Nippon Koei Co., Ltd., and Yachiyo Engineering Co., Ltd.

In collaboration with the Vietnamese Counterpart Team, the JICA Study Team conducted the study including field surveys; demand forecast; conduct of pilot projects; formulation of comprehensive urban development program and subsector master plans for urban development, urban transportation, urban water and sanitation, and living conditions; and conduct of prefeasibility studies on the selected priority projects. It also held a series of discussions with the relevant officials of the Government of Vietnam. Upon returning to Japan, the Team duly finalized the study and delivered this report.

I hope that this report will contribute to the sustainable development of Hanoi City and to the enhancement of friendly relations between the two countries.

Finally, I wish to express my sincere appreciation to the officials of the Government of Vietnam for their close cooperation.

March 2007

MATSUOKA Kazuhisa
Vice President
Japan International Cooperation Agency

March 2007

MATSUOKA Kazuhisa
Vice President
Japan International Cooperation Agency
Tokyo

Subject: Letter of Transmittal

Dear Sir,

We are pleased to formally submit herewith the final report of the Comprehensive Urban Development Programme in Hanoi Capital City in the Socialist Republic of Vietnam.

This report compiles the results of the study which was undertaken both in Vietnam and Japan from December 2004 to March 2007 by the Team comprising ALMEC Corporation, Nippon Koei Co., Ltd., and Yachiyo Engineering Co., Ltd.

We owe a lot to many people for the accomplishment of this report. First, we would like to express our sincere appreciation and deep gratitude to all those who extended their extensive assistance and cooperation to the Team, in particular the Hanoi City People's Committee.

We also acknowledge the officials of your agency, the JICA Advisory Committee, and the Embassy of Japan in Vietnam for their support and valuable advice in the course of the Study.

We hope the report would contribute to the sustainable development of Hanoi City.

Very truly yours,

IWATA Shizuo
Team Leader
Comprehensive Urban Development Programme in Hanoi Capital City

THE COMPREHENSIVE URBAN DEVELOPMENT PROGRAM IN HANOI CAPITAL CITY OF THE SOCIALIST REPUBLIC OF VIETNAM (HAIDEP)

FINAL REPORT

VOL.2 PREFEASIBIITY STUDIES

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ABBREVIATIONS

AASHTO	American Association State Highway and Transportation Office
ADB	Asian Development Bank
B/C	Benefit/Cost ratio
BOT	Build-operate-transfer
BP	Basic equipment cost
BTO	Build-Transfer-Operate
CIF	Cost, Insurance and Freight
CO	Carbon Monoxide
dB	Decibel
DONRE	Department of Natural Resources and Environment
DP	Hourly (or daily) equipment depreciation cost
DY	Durable years
EIRR	Economic Internal Rate of Return
EPC	Environmental Protection Center
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GOV	Government of Vietnam
GRDP	Gross Regional Domestic Product
HAIDEP	The Comprehensive Urban Development Programme in Hanoi Capital City
HPC	Hanoi People's Committee
IWT	Inland Waterway Transportation
JICA	Japan International Cooperation Agency
km	Kilometer
kph	Kilometer Per Hour
LRFD	Load and Resistance Factor Design
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOF	Ministry of Finance
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
NFEZ	Northern Focal Economic Zone
NOx	Nitrogen Oxide
NPV	Net present value
OD	Origin-Destination
ODA	Official Development Assistance
O & M	Operation and Maintenance
PAP	Project Affected Person
PC	People's Committee
PCU	Passenger Car Unit
PPP	Public-Private Partnership

RAP	Resettlement Action Plan
RD	Redemption Rate
ROW	Right of Way
RR4	Ring Road 4
SPC	Special Project Company
STRADA	System for Traffic Demand Analysis
SWG	Survey Working Group
SWR	Shadow Wage Rate
TDSI	Transport Development and Strategy Institute
THC	Total Hydrocarbons
TSP	Total Suspended Particulates
TTC	Travel Time Cost
USD	US Dollar
VAT	Value Added Tax
V/C	Volume Count
VITRANSS	The Study on the National Transport Development Strategy in the Socialist Republic of Vietnam
VND	Vietnam Dong
VOC	Vehicle Operating Cost
WB	World Bank

1 CONTEXT OF STUDY

1.1 Background of RR4

Figure 1.1.1 illustrates the proposed HAIDEP urban transportation master plan which consists of eight (8) radial and four (4) ring roads. The radial roads are NH1 North and South, NH5 (to Hai Phong), NH3 (to Thai Nguyen), NH2 (to Vinh Phuc), NH32 (to Phu Tho), Hoa Lac Highway, and NH6 (to Hoa Binh). Moreover, the HAIDEP master plan includes four (4) ring roads, none of them, at present, has been completed (see Figure 1.1.2).

In the HAIDEP network, the RR4 performs as the outer ring road in the urban road network, which aims to enhance the connectivity among suburban centers surrounding Hanoi CBD and to create a bypass around Hanoi, thereby minimizing the need for inter-provincial through traffic from entering the city center. Moreover, RR4, functions as a physical barrier to control urban sprawl, as it creates a boundary for the Hanoi Urban Growth region as proposed in the HAIDEP urban development plan for Hanoi. (see Figure 1.1.3).

To fulfill its intended purpose, high level of service, (i.e. high speed and access controlled) is required of RR4, thus it is proposed that RR4 will be developed as an expressway, initially with four lanes.

The RR4 proposed in the HAIDEP Study is almost an entirely newly built road, except for sections overlapping NH5 and the lengthened NH5 in the north.

In the HAIDEP urban transportation master plan, RR4 which is in total is about 100km long, is around 15-20km from the city center and 5-8km from RR3. It generally follows the alignment of the regional ring rail It is subdivided into four packages as follows:

(1) TR-11: RR4 (Northwest Section)

(i) Phuc Yen/Noi Bai to Lang-Hoa Lac Expressway

(ii) Total length: 25.41 km, including Thuong Cat Bridge

(iii) This project intents to connect new urban village Me Linh (Vinh Phuc) with Thanh Noi, An Khanh new urban villages and Hoa Lac high-tech industrial zone (IZ), and also to connect Noi Bai-Viet Tri Expressway with NH2, NH32 (R-4) and Lang-Hoa Lac Expressway (R-3).

(2) TR-12: RR4 (Southwest Section)

(i) Lang-Hoa Lac Expressway to Phap Van-Cau Gie Expressway

(ii) Total length: 19.92 km

(iii) The project will connect high-tech Hoa Lac industrial zone with the south of Ha Dong town and new urban village Tu Hiep (Thanh Tri), it links Lang-Hoa Lac Expressway (R-3) with NH6 (R-2), NH1A (R-1), lane Phap Van-Cau Gie Expressway (R-8).

(3) TR-13: RR4 (Southeast Section)

(i) R-8 to NH1A

(ii) Total length: 25.38 km.

(iii) This project intends to connect new urban areas: Van Giang, Nhu Quynh and Tu Son. It also intent to link 4 main radial roads: NH1A new (R-8), NH5, NH1A new (R-6B), and NH1A (R-6A).

(4) TR-14: RR4 (Northeast Section)

(i) NH1A to Thang Long-Noi Bai Road

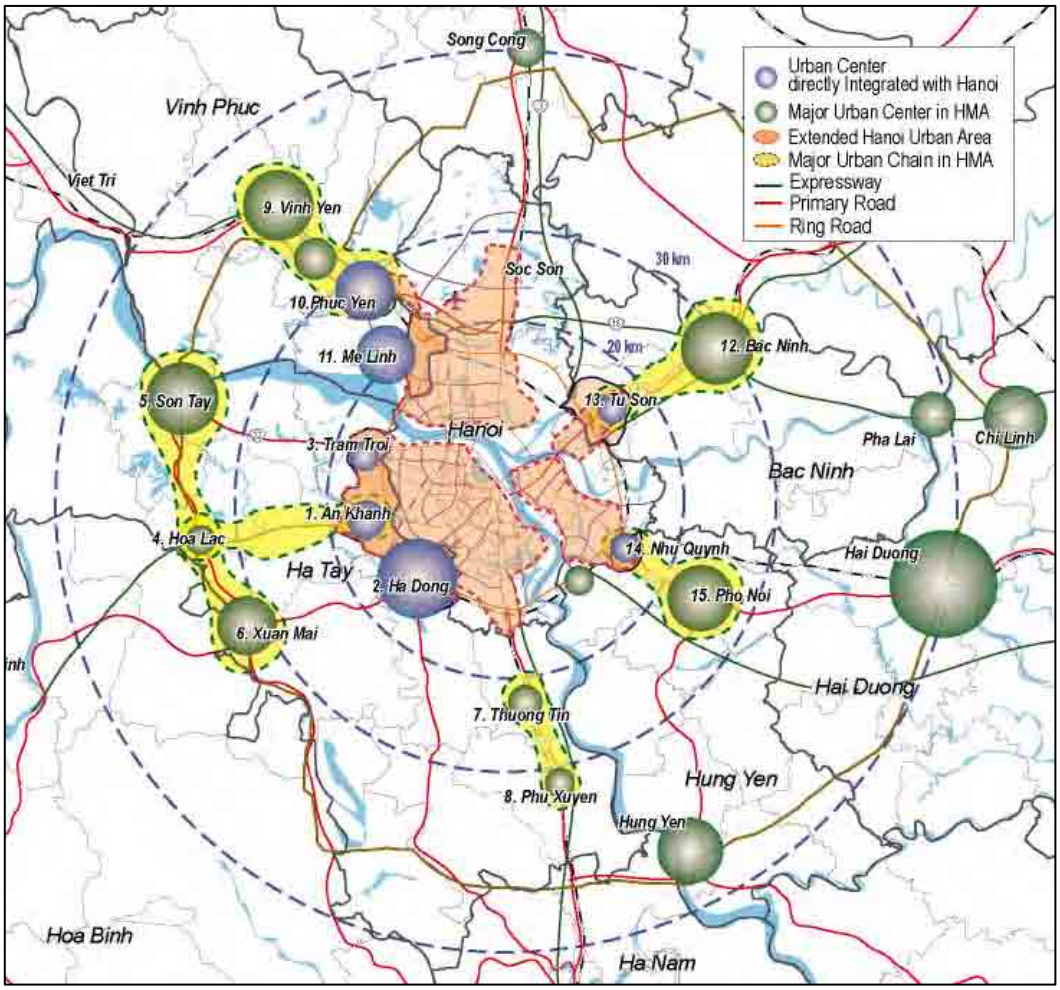
(ii) Total length: 30.07 km.

(iii) It links Tu Son new urban village to Noi Bai. It connects some important national arterial roads: NH1A (R-6A), Dong Anh-Thai Nguyen expressway, NH3, as an extension of RR2 (R-5B) and Thang Long-Noi Bai Road.

Based on a multi-criteria prioritization analysis of urban transportation projects in the HAIDEP urban transportation master plan, the Southwest Section (TR-12) is recommended for short-term implementation, while the other RR4 project packages are considered for implementation in the long-term. However, to maximize effectivity of the southwest segment, the implementation of the Northwest segment (TR-11) is strategic so that a viable north-south corridor could be formed.

It is therefore the intention of this prefeasibility study to examine more closely these two projects to confirm their viability and to initially address key issues to their realization. The southwest and northwest sections are herein referred to as the RR4 western section, as shown in Figure 1.1.4.

Figure 1.1.1 Proposed Spatial Structure Around Hanoi

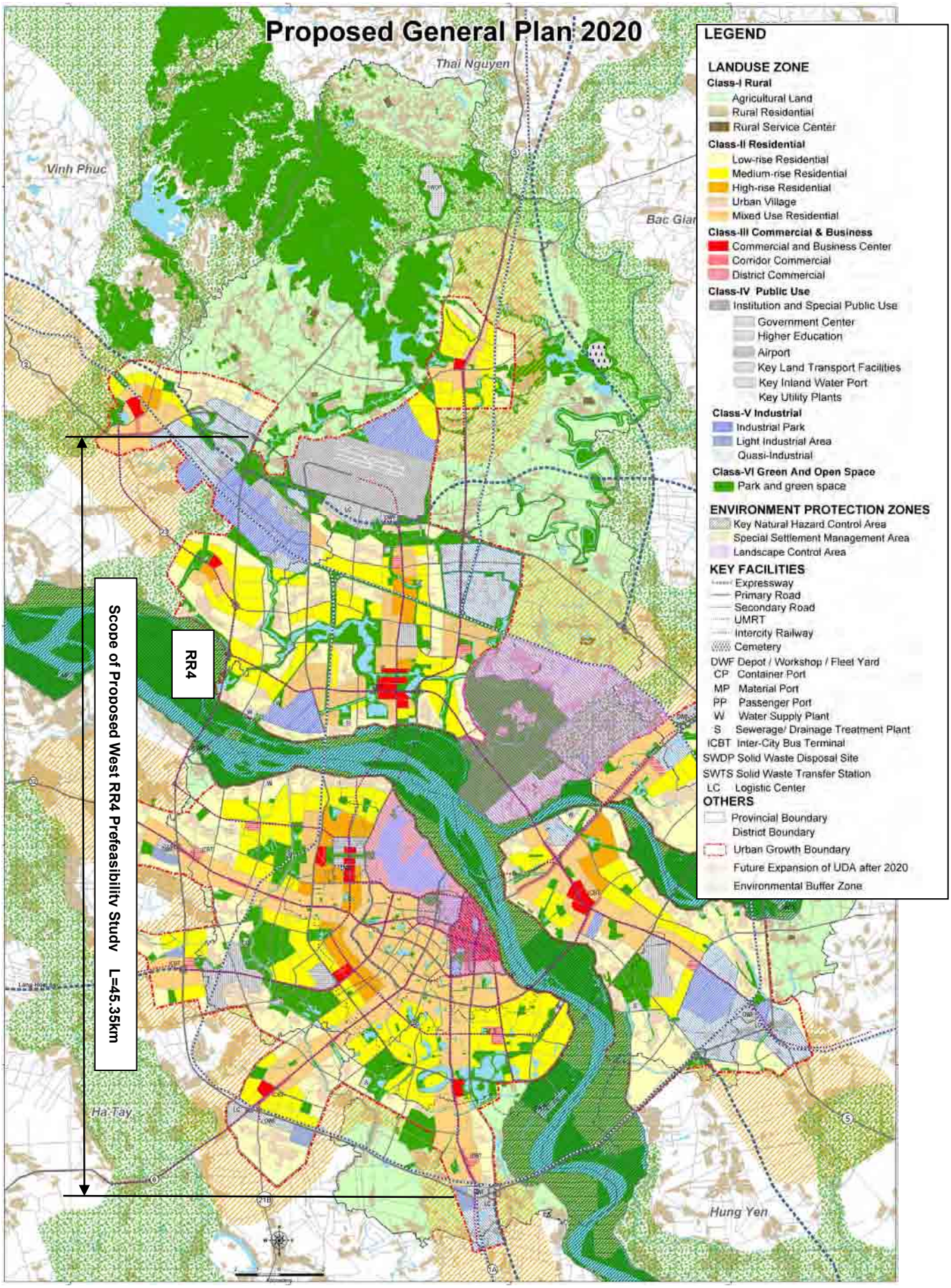


Source: HAIDEP Study Team.

Figure 1.1.2 HAIDEP Urban Transportation Master Plan Network

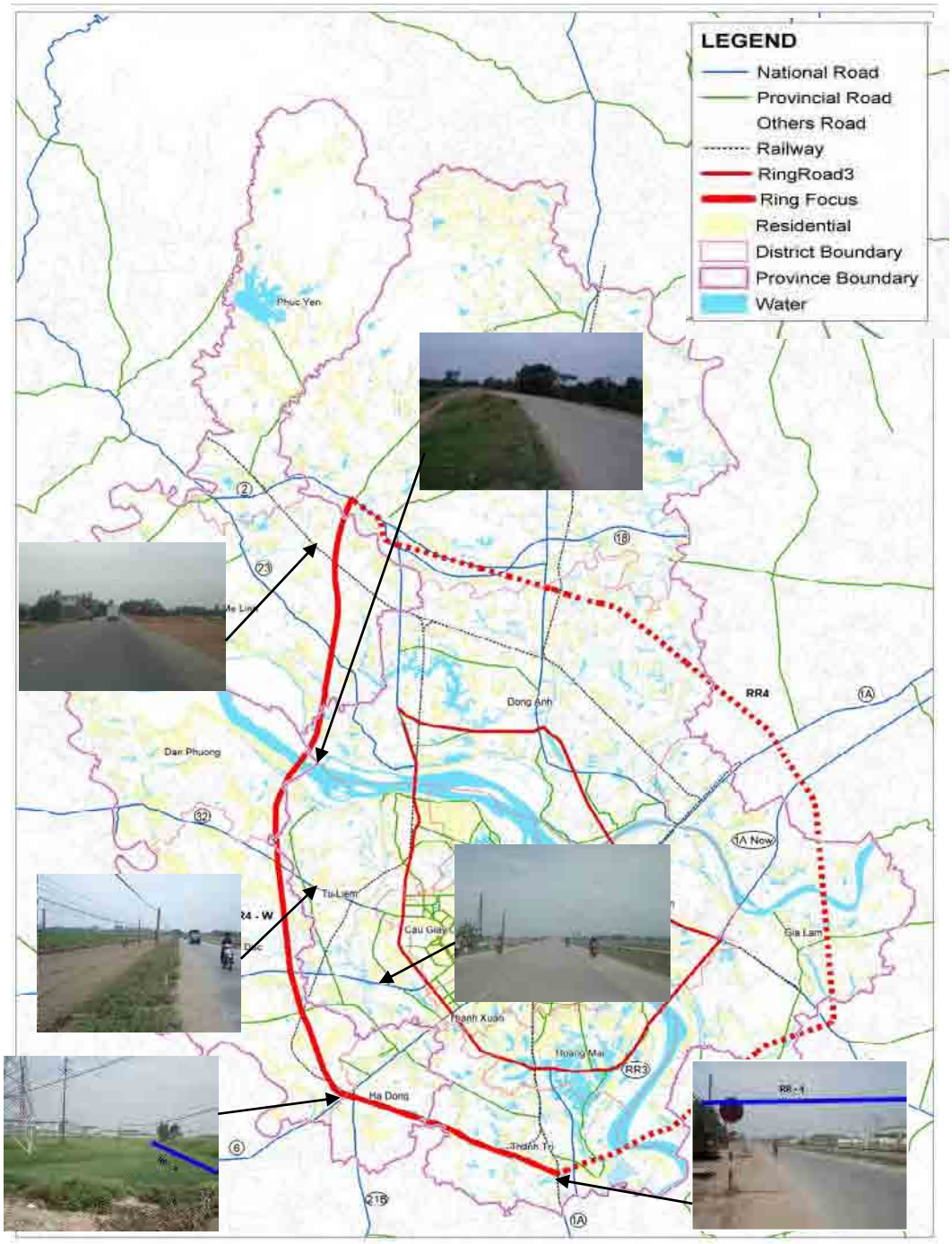
Source: HAIDEP Study Team.

Figure 1.1.3 HAIDEP General Plan up to 2020



Source: HAIDEP Study Team.

Figure 1.1.4 Location of RR4 West Section



Source: HAIDEP Study Team.

1.2 Comparison of Alignment of RR4 as Proposed by HAIDEP and Ministry of Transportation (MOT)

The RR4 has actually been initially proposed in the MOT master plan, however after review, HAIDEP has proposed major modifications. Figure 1.2.1 shows the alignment and basic information of the Ring Road No.4 based on the MOT and HAIDEP Master Plan. HAIDEP suggests that RR4 should be aligned closer to the urban area in order to play a role for both interregional traffic and urban traffic. The one proposed in the MOT Plan seems to play a role mainly for interregional traffic.

For a particular example, the northern segment of the MOT RR4 is significantly far from the city center, in which the Lao Cai-Hai Phong/Halong traffic would have to traverse a very long distance. Consequently, it is expected that much of the traffic will continue to traverse through the city center, severely diminishing the functionality of RR4 as a bypass and as a link between suburban areas. The HAIDEP proposed RR4 moves the alignment much closer and follow the natural path of the Lao Cai-Hai Phong corridor.

Figure 1.2.1 Comparison of RR4, MOT and HAIDEP

	MOT	HAIDEP
Function	For inter-provincial traffic	For interprovincial and urban traffic
Length (km)	135	90
Cost (US$ Million)	1,210	1,025

Source: HAIDEP Study Team.

Traffic demand estimation shows that due to the longer distance, and inconvenient alignment of the MOT RR4, particularly at the northern part, traffic volumes at all sections of the MOT RR4 are estimated to be lower compared to the HAIDEP RR4 alternative. In fact, it is estimated that traffic volumes of the MOT RR4 would be only half capacity by 2020, and this can be considered as an overinvestment (see Table 1.2.1).

Using the HAIDEP RR4, traffic using the RR4 would be about 70% interprovincial traffic and the rest urban traffic. Because of the proposed RR4 and other road developments, it is estimated that there will be only little inter-regional through traffic entering to the city center (see tables 1.2.2 and 1.2.3).

The HAIDEP RR4 will also play a role in guiding and shaping urban development. It is estimated that the urban area of Hanoi City will expand and will reach areas along the RR4. The RR4 would then play an important role by acting as a boundary or limit of urban development, thereby mitigating excessive urban sprawl. The MOT RR4 is too far from

the city center, thus could not be able to fulfill this function, especially in the northern part.

Due to the difference in alignment, the length of the RR4 in HAIDEP results to be shorter than the one in the MOT Plan, and the project cost would therefore be cheaper. The MOT RR4 is 18% more expensive than the HAIDEP RR4.

A downside of the HAIDEP RR4 is that it may give a wrong message that Soc Son is not part of the development strategy for Hanoi. However, this can be easily remedied by improving and adding radial roads going toward Son Son, such as NH3 and others.

Due to the lower cost and higher network performance, HAIDEP's RR4 shows higher economic efficiency. In addition, considering the land-use MP, the role of RR4 is very important. Therefore, the HAIDEP Study Team suggests modifying RR4's alignment as suggested in HAIDEP Plan. Moreover, the other proposed infrastructure development at Soc Son should be taken into account not to make it isolated from other districts within the RR4.

Table 1.2.1 Estimated Traffic Volume on R (2020)

	Capacity (000 PCU/day)	MOT		HAIDEP	
		Traffic Volume (000 PCU/day)	V/C Ratio	Traffic Volume (000 PCU/day)	V/C Ratio
NH1(East)-NH5	88	45	0.51	80	0.91
NH5-NH1(South)		49	0.56	79	0.90
NH1(South)-NH6		49	0.56	73	0.83
NH6-Hoa Lac		40	0.45	52	0.73
Hoa Lac-NH32		22	0.25	70	0.79
NH32-NH23		26	0.29	85	0.96
NH23-NH3		43	0.49	47	0.53
NH3-NH1(East)		53	0.60	79	0.90

Source: HAIDEP Study Team.

Table 1.2.2 Estimated Traffic Volume by Urban and Interprovincial Traffic (HAIDEP M/P, 2020)

	Traffic Volume (000PCU/Day)		
	Inter-Province	Urban	Total
NH1(East)-NH5	62	18	80
NH5-NH1(South)	63	16	79
NH1(South)-NH6	54	19	73
NH6-Hoa Lac	41	11	52
Hoa Lac-NH32	51	19	70
NH32-NH23	49	36	85
NH23-NH3	32	15	47
NH3-NH1(East)	46	33	79

Source: HAIDEP Study Team.

Table 1.2.3 Project Cost of RR4, MOT and HAIDEP

			MOT	HAIDEP
Length (km)	Road		127	82
	Bridge		8	8
	Total		135	90
Project Cost (US$ Mil.)	Construction	Road	498	320
		Bridge	455	455
	ROW		257	250
	Total		1,210	1,025

Source: HAIDEP Study Team.

2 CONDITION OF THE PROJECT AREA

2.1 Natural Condition

1) The Terrain

(1) Terrain of Hanoi

Hanoi City is located at the center of the Red River Delta and it covers an area of 927.39 km^2. It includes seven urban districts (Ba Dinh, Hoan Kiem, Hai Ba Trung, Dong Da, Tay Ho, Cay Giay, Thanh Xuan) with a combined area of 82.78 km^2, making up 8.2% of the total area of Hanoi. Suburban districts are Gia Lam, Soc Son, Dong Anh, Thanh Tri, Tu Liem, covering 884.61 km^2 or 91.8% of Hanoi.

Hanoi is primarily flat terrain and the ground elevation is 5 to 20 meter above sea level. However, the northern and northwestern mountainous areas stand some 20 to 400 meters above sea level. The terrain declines southwards and eastwards which are illustrated by the direction of natural currents of major rivers crossing the city. Majority of the terrain is plain, built up on new alluvial grounds. High warps are intermixed with low-lying areas with lakes, and swamps which are the remains of an ancient river. The high areas of Hanoi are characterized by mountainous features with eroded hills which are mostly found in Soc Son district.

Majority of Hanoi lies in the depression zone of Triat, covered on the top with a layer of sediment of Red River silt. In terms of temporal formation, land in Hanoi City is divided into two subregions:

- **Ancient Alluvial Subregion:** This subregion has higher soil compression strength and mostly lies on the left bank of Red River.
- **New Alluvial Soil:** This subregion has weak ground strength and is located in the suburban area of Hanoi, primarily in Gia Lam, Thanh Tri, Tu Liem.

Based on the process of formation and topographical structure, Hanoi can be divided into two subregions as follows:

(a) Plain Subregion

This subregion exemplifies the typical feature of Hanoi topography, accounting for 90% of total natural land area including the urban areas of Dong Anh, Gia Lam, Tu Liem, Thanh Xuan districts and northern part of Soc Son district. Average ground elevation of this region is 4 to 10 meters.

Based on the features of alluvial formation, this subregion can be divided into three categories:

(i) **Category 1:** Alluvium terrace lying in the north of Hanoi as the transitional strip of mountainous and plain area, covering south of Soc Son and a large part of Dong Anh. This is poor soil area with winding and sloping terrain at the elevation of 6-11 meters. This type of terrain is characterized by strong weathering process. Erosion is strong during rainy season due to high and declining terrain. During the dry season, the area suffers from low water supply since the ground water level is low.

(ii) **Category 2:** Alluvial plain covers a large proportion of Hanoi its districts where RR4 passes through. It especially covers the districts of Tu Liem, Thanh Tri, Gia Lam and

urban core districts. This subregion is 3-10m high and is prone to flooding during the rainy season.

(iii) **Category 3:** The outside-dyke field runs along big rivers such as Red River, Cau River, Ca Lo River. Ground surface elevation ranges from 4 to 8 meters. This field is made up of mostly sand and sandy clay.

(b) Mountainous Subregion

This subregion covers northwest of Soc Son district with complex terrain characterized by low mountains and hills with average height of 50-100m. Soil layer is thin. This region is categorized into the following areas.

(i) **Mountainous Areas:** This is the end section of Con Voi Mountain range which runs along a northwest-southeast direction with altitudes going from 400-500m to 600-1000m.

(ii) **Hilly Areas:** This subregion lies within the territory of Soc Son district. Ranges of hills form a strip surrounding mountains and decline towards the east.

(2) Terrain of Vinh Phuc

Vinh Phuc is on a transition between the mid-land hill region and the Red River's plain. Located in the north of this province is Tam Dao Mountain, including three (3) main mountains: Thach Ban (elevation 1388 m), Thien Thi (elevation 1375m) and, Phu Nghia (elevation 1400m). The west and the south of Vinh Phuc are enclosed by Lo and Hong Rivers. Therefore, its topography gradually slopes from the Northwest to the Southwest and is divided into three regions: plain, midland and mountainous.

Vinh Phuc has many rivers, springs and lakes. The Red River flows through Vinh Phuc for 41 kms, the Lo River for 34 kms, the Ca Lo River for 14.8 kms and the Pho Day River for 22 kms. Huge lakes and dams located here are Dai Lai, Xa Huong, Van Truc, Lien Son and Dam Vac.

West-RR4 passes through the center of Me Linh district which adjoins Hanoi. This is the transition area between the plains and the hilly and mountainous areas.

(3) Terrain of Ha Tay

Ha Tay has a total area of 219,000ha and its topography gradually slopes from northwest to southwest and it is divided into two (2) main regions. Firstly, the plain regions in the east of the province which occupies two-thirds of the province, has a typical ground elevation of 5 to 7 meters. Secondly, the hilly region in the west which accounts for one- third of the area, has a typical ground elevation of 25 to 50m. The terrain also features a small share of mountainous area (17,000ha) with heights of over 300 meters.

Ha Tay has many rivers and big lakes. The Red River flows through Ha Tay for 127 km, the Da River flows for 32 km, the Day River for 103 km, the Tich River for 10km, the Nhue River for 47 km and the Bui river for 7 km. Big lakes here are the Dong Mo-Ngai Son with an area of 1260 ha and the Suoi Hai with an area of 671 ha.

The terrain slope down from the north to the south (like Hanoi). The northern area has geological conditions favorable to place structural foundation while that of the south is weak since this area is newly built alluvial subregion adjoining the districts of Tu Liem and Thanh Tri.

The West-RR4 passes Ha Tay is districts of Dan Phuong, Hoai Duc, Ha Dong town and

Thanh Oai which is in the east of the province and adjoins with the western districts of Hanoi.

2) Climatic Features of the Project Area

The project area's is described based on the conditions in Hanoi. The climate is characterized as a tropical climate with hot and cold seasons. The former lasts from April to October with high humidity and rainfall. Storms are common during this season. Highest temperature can be recorded in June to July while the highest rainfall period is in July. The hot season is likewise the rainy season in this regard. The cold season sets in from November and ends in March. During this season, the weather is cold and dry with little rain. Lowest temperatures and rainfall happens in January. April and October transitional are months, making the project area experience four seasons of spring, summer, autumn and winter.

(1) Temperature

Average temperature is fairly moderate at 23.9^0C. Monthly temperature variation is as high as 12.5^0C while day temperature variation is only 7^0C to 8^0C. However, temperatures during the day varies by 10-15^0C due to the influence of monsoons.

During the hot season, monthly average temperature can reach 27.4^0C, that is, 3.5^0C higher than annual average. Extreme temperatures may reach 40^0C but it rarely happens. The hottest months are June and July. Average temperature in June is 29.3^0C. However, early and late in the hot season, temperature may drop to lower than 20^0C.

During the cold season, the lowest temperature can be 6-7^0C, lasting for 7 to 12 days. Average temperature is 17^0C in January. However, there have been records of temperatures reaching 30-35^0C during the cold season.

(2) Humidity

Monthly average humidity ranges from 80% to 88%. Lowest humidity recorded is 16% in December and January.

(3) Rainfall

The project area is dominated by rainy weather with average annual rainfall of some 1600-1700 mm. Number of rainy days for one year may reach 140.

The rainy season starts in April and ends in October. Nearly 85% of rainfall comes during the rainy season, equal to some 1400-1500 mm. Monthly rainfall during the rainy season is about 200 mm/ month and the number of rainy days is 12-15 days/month.

Heaviest down pour often come in August with an average rainfall of some 300-350 mm/month and intensive rains during this time cause flooding.

(4) Storms

Monsoon normally starts in May and ends in October. Storms often come in the period from June to September. Highest wind speed recorded in Hanoi reached 24 m/sec.

Annually, Hanoi is affected by five to seven storms which are recorded at level 9-10, km/hr strong enough to damage trees, houses, crops and infrastructure. Rise in river water level often come with the storm, causing damage to agriculture, residences, and commerce outside the dyke.

(5) Hydrology

Flow of rivers in Hanoi is affected by topographic and climatic conditions. The flood prone periods coincides with the rainy season which lasts from June to October. Most flood prone month is August, which accounts for 70-75 % of the total rainfall of the year. Lowest river water level is in March.

Red River water level ranges from 2-12 m annually (highest level recorded is 14.13 m in 1971). Flooding often occurs in areas along rivers in Hanoi.

Hanoi is home to a number of lakes and ponds. As a result of urbanization, 50% of lakes and ponds were reclaimed for construction activities. Also, most of existing lakes and ponds are seriously contaminated due to discharges of wastewater.

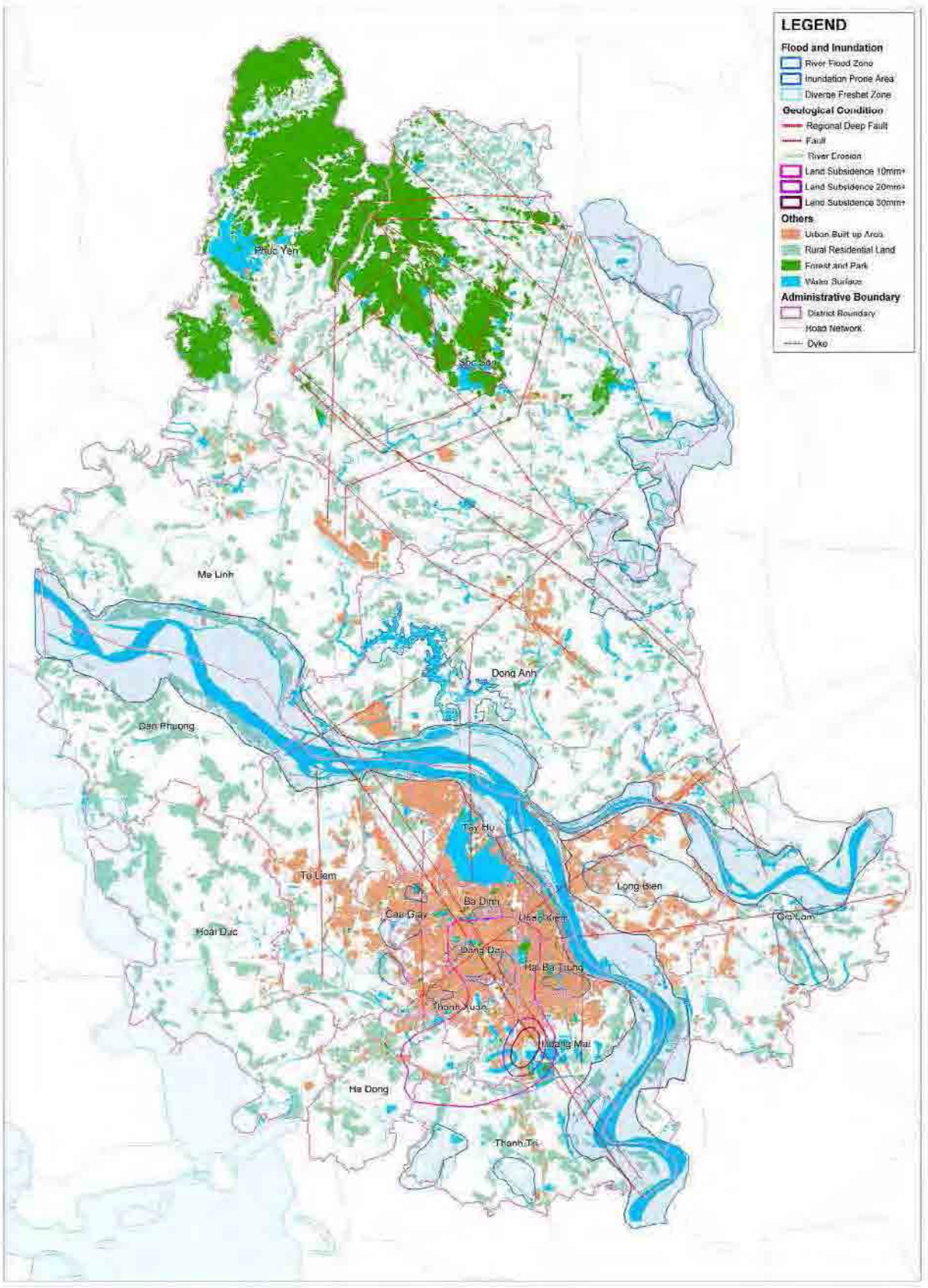
(6) Land Subsidence

Land subsidence is most prevalent in Hanoi and most of Hanoi are subsiding by 20 to 25 mm/year but in the northern areas subsidence is lower at 10 mm/year. Severely affected areas have subsidence levels of 35 to 40 mm/year. Areas along the Red River have not subsided. Subsidence is caused by over extraction of ground water and because of the thick soft soil layer being compacted by buildings and other facilities.

(7) Earthquake

Since 1277 to date, there have been more than 130 earthquakes among which three earthquakes reached 5.1 on the Richter scale (years of 1277, 1278, and 1285). Most severe earthquakes reached 5.3 and on the Richter scale in Vinh Phuc in 1958, and 5.6 Bac Giang in 1961. In the past, there had been some strong earthquakes that happened in Hanoi and since a major fault runs through Hanoi, it is possible that the city could be hit by another earthquake with intensity of 7-8 on the Richter scale.

Figure 2.1.1 Natural Conditions of the Project Area



Source: HAIDEP Study Team.

2.2 Socio-economy of Hanoi, Vinh Phuc, and Ha Tay

1) Hanoi

Hanoi population grows at the rate of 3%/year. As of 2003, Hanoi population reached 3 million of which 58% is urban population. Hanoi is home to 760,000 households with an average number of 4.3 persons per household of 4.3 persons.

Although population is growing fast in the whole city, the areas with the highest growth rates are the new urban districts of Thanh Xuan, Cau Giay, and Hoang Mai. However, it should be noted that the population is still growing in the urban core area despite its already high density and that growth in rural area is moderate.

In residential areas, density is as high as 622 persons/ha. In new urban districts, population density is controlled at 57 persons/ha, except for Thanh Xuan districts which has a density of 203 persons/ha and Cau Giay district which has a density of 131 persons/ha. However, population density in the old urban districts has rapidly grown to reach 211 persons/ha. A similar trend is seen in suburban areas where density in residential areas is 147 persons/ha, while average density of the whole area is 28 persons/ha.

Economically, Hanoi has grown significantly over the past decade. GDP growth rate of Hanoi is constantly higher than the national average: 1991-2000 recorded annual growth rates of 9%-12.5% and from 2001-2005 it recorded annual growth rates of 10%-11%. GRDP/capita has increased by over 7%/year. Development in this period is mostly attributed to fast-paced industrialization, led by public sector and foreign direct investment. Local and foreign tourists have made significant contribution to the growth of Hanoi as well.

Industrial production value grew the fastest among economic sectors, reaching 14.5%-15.5% growth rates per year, while export turnover grew by 16%-18%/year. Comparing to 1995, export-import turnover has sharply increased by 40% in recent years. Similar trend can be seen in the growth of foreign investment. Share of industry sector increased from 31% in 1995 to 36% and 38% in 2000 and 2003 respectively. On the other hand, share of service sector of Hanoi dropped from 64% in 1995 to 60% in 2000 and continuously plummeted to 58%.

Table 2.2.1 Socio-economic Indicators of Hanoi

Targets			1995	2000	2003	Growth Rate (%/year)	
						1995-2000	2000-2003
Area (km^2)			921			-	-
Population	Total (000)		2,335	2,756	3,008	3.4	3.0
	Urban (000)		1,221	1,593	1,732	5.5	2.8
	% of Urban Population		52.3	57.8	57.6	2.0	-1.0
Economy	GRDP (billion VND)	Price of 1994	12,021	19,999	27,390	10.7	11.1
		Current Price	14,499	31,513	47,953	16.8	15.0
	GRDP per Capita (million VND)		5,147	7,256	8,965	7.1	7.3
	Economic Sector (%)	Sector I	5.3	3.9	3.1	-	-
		Sector II	30.8	35.9	38.4	-	-
		Sector III	63.8	60.2	58.4	-	-
	Ownership (%)	Central Level	60.3	54.2	53.5	-	-
		Local Level	10.2	8.4	7.6	-	-
		Non-State	22.8	23.0	24.1	-	-
		Foreign Investment	6.7	14.5	14.8	-	-

Source: Statistical Book (2005), HAIDEP-HIS (2005)

2) Vinh Phuc

Vinh Phuc is located north of Hanoi, along the East-West international transport corridor (Kunming-Hai Phong) and in the northern focal triangle. This province is urbanizing and strongly attracting investment, including Foreign Direct Investment (FDI) compared to other provinces adjoining Hanoi.

In 2003, Vinh Phuc had a population of 1142.9 thousand, ranking the 27th among 61 cities and provinces. Urban population was 122.9 thousand, accounting for 11.0% of the province's population and rural population was 992.8 thousand, representing 89.0%. Vinh Phuc's population density in 2003, is 833.6 persons/km^2, ranking 11th among 61 cities and provinces and is 3.4 times higher than average population density of Vietnam.

Vinh Phuc has achieved high economic development growth in past years with GDP growth rate of 18.5%/year during the period 1995-2000; and 14.4%/year for 2001-2005. The industrial sector is growing by 22.1%/year which is highest in the Northern Focal Economic Zone (NFEZ), including Hanoi City. Vinh Phuc only follows Hanoi and Quang Ninh with respect to foreign investment attraction among eight provinces in the NFEZ. Already 46% of the province is designated for industrial use.

The West RR4 runs through Me Linh district which in 2004 had a population of 180.5 thousand people, accounting for 15.8% provincial population with average density of 1,281 persons/km^2.

3) Ha Tay

Ha Tay adjoins Hanoi in the west and southwest. It covers 2,193 km^2 (largest among provinces surrounding Hanoi) in which agricultural land accounts for 67.3%.

Population of Ha Tay in 2003 was 2,479.4 thousand persons. Ha Tay is the fifth most densely populated province among 61 provinces and cities, after Ho Chi Minh City, Thanh Hoa, Nghe An and Hanoi. Ha Tay's population density in 2003 was 1,131.1 persons/km^2, ranking 8th among 61 provinces and cities and 4.6 times higher than average population density of Vietnam.

The West-RR4 is aligned closely following the Ha Tay’s boundary, running along the sides of Dan Phuong, Hoai Duc districts and to the south of Ha Dong town and a part of Thanh Oai. Population of those districts was 638.9 thousand in 2004. However, population density is not evenly distributed with 1,399, 1,744, and 2,075 persons/km^2 in Thanh Oai, Dan Phuong and Hoai Duc respectively. A high density of 4,418 persons/km^2 is recorded for Ha Dong town, where population growth rate is very high at nearly 10%.

4) Socio-economic Conditions Surrounding West-RR4

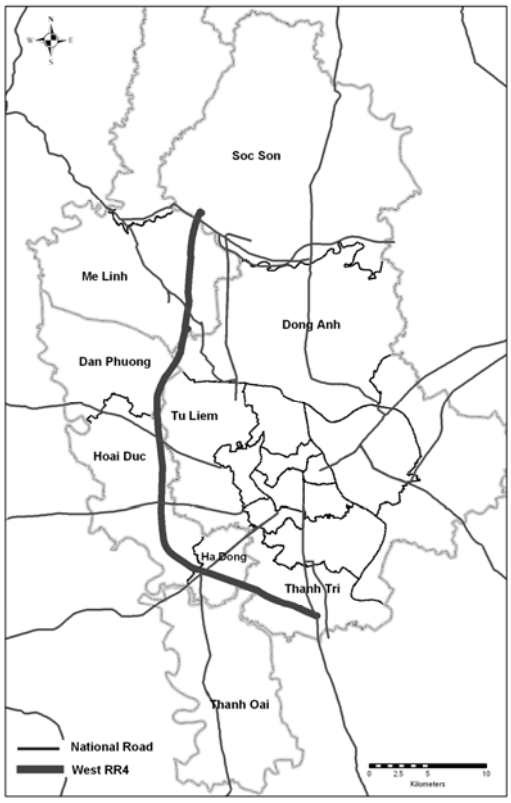
West RR4 traverses along 9 districts as shown in Figure 2.2.1 including rural districts of Soc Son, Dong Anh, Tu Liem, and Thanh Tri (Hanoi); Me Linh (Vinh Phuc); and, Dan Phuong, Hoai Duc, Ha Dong town and Thanh Oai (Ha Tay). Table 2.2.2 shows the population growth and density of these districts. The average density along the corridor is 16.2 persons/ha. Among them the districts of Tu Liem (Hanoi) and Ha Dong town (Ha Tay) are experiencing the highest growth rate of 6-10%.

Table 2.2.2 Population Growth and Density near RR 4 West Section

Province	District Name	Area (km^2)	Socio-Economy			
			Population (000 person)		Growth Rate (%/year)	Density (pax/km^2)
			2000	2004	2000 - 2004	2004
Hanoi	Soc Son	306.51	247.3	260.0	1.3	848
Vinh Phuc	Me Linh	140.95	177.3	180.5	0.5	1,281
Hanoi	Dong Anh	182.30	262.1	280.6	1.8	1,539
Hatay	Dan Phuong	76.60	126.6	133.6	1.4	1,744
Hanoi	Tu Liem	75.32	198.5	247.8	6.2	3,289
Hatay	Hoai Duc	88.30	191.4	183.3		2,075
Hatay	Ha Dong	32.90	98.0	136.5	9.8	4,418
Hatay	Thanh Oai	132.20	176.0	185.0	1.3	1,399
Hanoi	Thanh Tri	63.27	150.0	158.7	1.4	2,508
Total		1,098.35	1,650.2	1,776.0	1.9	1,618

Source: HAIDEP Study Team.

Figure 2.2.1 West RR4 and Adiacent Districts



Source: HAIDEP Study Team.

In the future, urban settlements and activities in Hanoi and satellite urban centers within 30-50 km will strongly develop due to the expansion of the planned transport network, especially road network. Those urban areas form an urban chain along national highways (see Figure 2.2.2) and these chains include the following:

(i) Vinh Yen-Phuc Yen-Me Linh along NH2.

(ii) Tu Son-Bac Ninh along NH1.

(iii) Nhu Quynh-Pho Noi along NH5.

(iv) Anh Khanh-Hoa Lac along Lang-Hoa Lac Road.

(v) Ha Dong along NH6.

(vi) Tram Troi-Phung along NH32.

(vii) Son Tay-Hoa Lac-Xuan Mai along NH21.

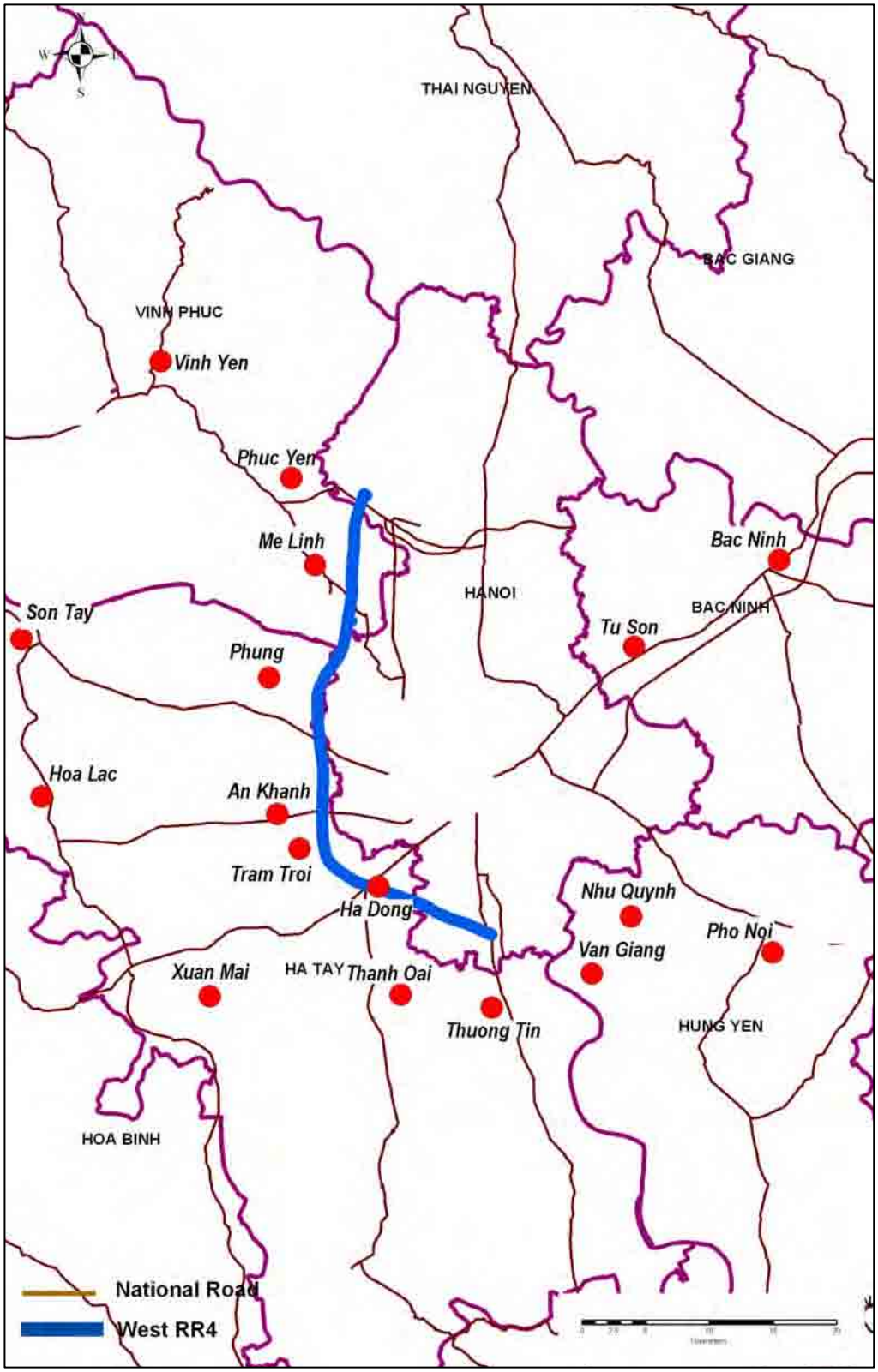
Key urban areas along the West RR4 are outlined in the following Table.

Table 2.2.3 Outline of Urban Areas near RR4 West Section

Urban Area	Location[1)]	Population[2)]	Major Features
1. An Khanh (Ha Tay)	15km from Hanoi, along road of Lang – Hoa Lac, adjoining Hanoi	0 [3)]	• Newly developed urban area, commercial and service area • Development projects are ongoing.
2. Bac Ninh (Bac Ninh Ninh)	30km from Hanoi, along NH18 from Hanoi to Cai Lan port	69,417	• City, provincial township • Administrative, social, economic and culture center of Bac Ninh province.
3. Ha Dong (Ha Tay)	15 km from Hanoi, along NH6	82,505	• Provincial town, township • Administrative, social, economic and culture center of Ha Tay province • Urban area adjoining Hanoi.
4. Me Linh (Vinh Phuc)	20 km from Hanoi, along NH23	0[3)]	• Newly developed urban areas functioning as industrial, commercial, service and tourism center • Home to IPs of Quang Minh and Tien Phong
5. Nhu Quynh (Hung Yen)	15km from Hanoi, along Nh5 from Hanoi to Hai Phong.	13,076	• Big economic hub of northern part of Hung Yen.
6. Pho Noi (Hung Yen)	25km from Hanoi, along NH5 from Hanoi to Hai Phong.	12,876	• Industrial area, commercial area of northern Hung Yen province.
7. Phuc Yen (Vinh Phuc)	along NH2 and rail route of Hanoi – Lao Cai, near Xuan Hoa and Hanoi	48,143	• Town • Developed infrastructure and strategic location along NH2 to Cai Lan port. • Fertile land with diverse ecosystem, favorable for tourism development. • Having key industries such as automotile, motorbike assembling factories.
8. Tram Troi (Ha Tay)	15km from Hanoi, along NH32 and adjoining Hanoi	4,260	• Aministrative, socio-economic and cultural center of Hoai Duc district
9. Tu Son (Bac Ninh)	15km from Hanoi, along NH1, adjoining Hanoi	3,842	• Aministrative, socio-economic and cultural center of Tu Son district • Tu Son IP has been developed and shall be expanded, it is possible to access Cai Lan port via NH1
10. Vinh Yen (Vinh Phuc)	40km from Hanoi, along NH2	66,024	• Provinical town, administrative, socio-economic and cultural center of Vinh Phuc province
11. Hoa Lac (Ha Tay)	30km from Hanoi, intersection between expressway of Lang - Hoa Lac and NH21.	0[3)]	• Largest urban area in the urban chain. • Functioning as education and training center with research institutes hi-tech industries.
12. Son Tay (Ha Tay)	40km from Hanoi, intersection between Nh32 and NH21A.	45,829	• Town • Center of industry and service. • Taking important role with respect to national defense and security.
13. Xuan Mai (Ha Tay)	30km from Hanoi at intersection between NH6 and NH21A	27,770	• Key industries include construction material production and mechanical engineering
14. Thanh Oai (Ha Tay)	20km from Hanoi along NH21B	6,376	• Aministrative, socio-economic and cultural center of Thanh Oai district
15. Phung (Ha Tay)	20km from Hanoi, along NH32	7,835	• Aministrative, socio-economic and cultural center of Dan Phuong district
16. Thuong Tin (Ha Tay)	15 km from Hanoi, along NH1A	6,199	• Aministrative, socio-economic and cultural center of Thuong Tin district
17. Van Giang (Hung Yen)	15km from Hanoi, along provincial road 390, along expressway of Hanoi-Hai Phong in the future	8,952	• Aministrative, socio-economic and cultural center of Van Giang district

Source: HAIDEP Study Team. 1) Distance from the center of Hanoi City. 2) As of 2004. 3) No data.

Figure 2.2.2 Key Urban Areas near RR4



Source: HAIDEP Study Team

2.3 Transportation Network in the Project Area

1) Radial Road Network

Located in the center of Red River Delta, Hanoi Metropolitan City is at the convergence of strategic National Highways such as NH1A, NH5, NH18, NH6, NH32, NH2, NH3, Thang Long-Noi Bai and Lang-Hoa Lac Expressway. These roads form a network of radial linkages between Hanoi and other economic and residential hubs, and are a strongholds of defense in the region.

Over the last few years, a number of projects aimed at renovating and upgrading the road networks in Hanoi and its surrounding provinces have been deployed, including projects to expand NH5 to become a 4-6 lane expressway; upgrading NH1A and an expressway running in parallel of Gie-Phap Van; Ninh Hiep-Bac Giang; improving NH18 comprising sections from Noi Bai to Bac Ninh to be constructed as a four-lane expressway; etc.

Key radial corridors are detailed as follows:

(a) **Lao Cai – Haiphong/Ha Long Corridor:** The NH 5, NH2, NH7, Noi Bai-Viet Tri Expressway and NH 18 forms a corridor linking Lao Cai (and Kunming) to Hanoi and to ports of Hai Phong and Cai Lan. Currently, NH5 has been improved to four lanes which resulted in the reduction of travel time by one-third. NH18 is being improved by constructing additional two lanes. Expressways connecting Noi Bai – Ha Long, Sai Dong-Dinh Vu (Hai Phong) are being planned.

(b) **Northern Segment of NH1A:** This corridor connects Hanoi with Dong Dang border gate of Lang Son province and this is a key link between Vietnam and China. This road is currently of Grade 3 standard. The newly constructed segment (4 lanes) runs in parallel with the current route (south side) to connect with Dong Bridge, and to connect with NH 5 at RR3 junction (Thanh Tri Bridge).

(c) **Southern segment of NH1A:** To ease existing traffic volume on this route, construction of an expressway section from Cau Gie-Phap Van was completed. This section is about 1200-2000 meters northward of NH1A. Ha Noi-Ninh Binh expressway is also starting to be constructed.

(d) **NH 6:** This route links Hanoi and northwestern provinces including the largest power plant in Hoa Binh (70 km from Hanoi). NH 6 is being upgraded and expanded in which the section from Nga Tu So to Ba La will become six lanes.

(e) **NH 3 (Hanoi-Thai Nguyen-Ta Lung Borde Gate:** This is an arterial road that links Ha Noi to Viet Bac and is Grade 3 standard. A parallel expressway to Thai Nguyen is being planned, and its starting points join with RR4 in the north.

(f) **NH 32:** It links the northwest region to the western part of Hanoi. The road surface is degraded, particularly the section from Trung Ha Bridge to Lao Cai. The section from Cau Giay-Cau Dien is being upgraded to 4 lanes. The Dien-Son Tay section is still narrow and is in bad condition. There is a plan to upgrade Dien-Son Tay-Trung Ha to 4 lanes.

(g) **Lang–Hoa Lac Expressway (Planned):** This will link Hanoi with urban areas of Mieu Mon-Xuan Mai-Hoa Lac-Son Tay.

2) Ring Road System

The master plan for metropolitan Hanoi for 2020 which was approved by the Prime Minister in 1998 provides orientations for transport network of Hanoi with three ring roads as follows:

(a) **Ring Road 1:** RR1 is planned as two major urban roads: one run east–west (from Nguyen Khoai-Kim Lien-O Cho Dua-Cau Giay) and the other running along the right bank of Hong River (from Thang Long bridge to Vinh Tuy).

(b) **Ring Road 2:** RR 2 has the following alignment: Minh Khai down to Nga Tu Vong-Nga Tu So-Lang road-Cau Giay-Buoi-Lac Long Quan-Nhat Tan Dyke and crosses Hong River at the new Nhat Tan Bridge to Vinh Ngoc, Dong Hoi, Dong Tru, NH 5, and again crosses Hong River at Vinh Tuy new bridge and joins Minh Khai slope to form a circle. Half of the circle has been shaped to follow south bank of Hong River.

(c) **Ring Road 3:** RR 3 starts from the north via Thang Long-Noi Bai-Mai Dich-Thanh Xuan-Phap Van-Thanh Tri Bridge-Sai Dong the rest of the section is overlapped with RR2 north. RR3 will initially play as an inter provincial road but will become a major artery of urban road in the near future, once Hanoi urban areas have expanded. At present, about a third of RR3 is open to traffic, which includes the section from Noi Bai-Thang Long Bridge-NH32-Tranduy Hung with the length of 23 km featuring 4 and 2 lanes for motorized and non-motorized vehicles, respectively. Construction work for the section from Phap Van-Sai Dong (including Thanh Tri Bridge: commenced late 2002. For Sai Dong-Cau Chui (overlapping with NH5) 6 lanes, the section of Cau Chui-Dongtru Bridge-Vinh Ngoc is now being prepared for construction. Work on the section Mai Dich-Phap Van has been postponed due to lack of funds and resettlement problems.

3) Network of Local Roads

(a) **Network of Provincial and District Roads in the Area of West-RR4:** Provincial and district roads in the project area of West-RR4 play a very important role in inter-provincial transportation (Ha Tay and Vinh Phuc) with Hanoi. Most important is the transportation of materials (heavy trucks), foods and vegetables and tourists. It is necessary to consider these roads in the preliminary design of West-RR4. Outline of these roads are in Table 2.3.1.

Table 2.3.1 Provincial Roads along West-RR4

No.	District	Province / City	Road	From-To	Length (km)	Width / Surfacing
1	Soc Son	Hanoi	35	Trung Gia-Soc Son	16.3	3.5 m/BTN
			16	Phur Lo-Kim Lu	7.0	3.5 m/BTN
			131	Soc Son-Thanh Xuan	9.0	7 m/BTN
2	Dong Anh	Hanoi	Nam Hong	Dong Anh-Nam Hong	8.4	3.5 m/TNN
			23B	Vong La-Dai Mach	5.0	3.5 m/TNN
3	Me Linh	Vinh Phuc	301	NH23 Thang Long-Noi Bai	2.2	5.5 m/TNN
			312	NH23 Thach Da dyke	7.2	3.5 m/TNN
			317	NH23 Dai Lai lake	14.5	5.5 m/BT+BTN
4	Dan Phuong	Ha Tay	70	Van Mo-Van Phuc	3.2	9-21 m/BTN
	Hoai Duc		71	Binh Da-Hong Van	20.2	4.5 m/TNN
	Thanh Oai		428	Vân Đình-Quang Lang	27	3.5 m/TNN
5	Thanh Tri	Hanoi	70A	Van Dien-Dai Mo	20.6	6.0 m/BTN
	Tu Liem		70B	Dong My-NgocHoi	3.5	5 m/TNN

Source: HAIDEP Study Team.

4) Railway Network

The project area features a regional rail network that presently forms a radial network with Hanoi as its focal point and a partially completed ring rail, at the western part of Hanoi which traverses the boundary of Hanoi and the province of Ha Tay. These are described as follows:

(a) **Hanoi – Ho Chi Minh:** The railroad connecting Hanoi and Ho Chi Minh City runs from the North to the South through 20 provinces and cities with a total length of 1730 km and it has a gauge of 1000 mm. Over years of renovation, this railroad got a hefty investment from the state including construction of bridges, top floor structure, locomotives, signals, etc.

(b) **Hanoi – Lao Cai:** The railroad connecting Hanoi and Ho Kieu in Lao Cai goes through Vinh Phuc, Phu Tho, Yen Bai, Lao Cai provinces and a number of industrial parks such as Viet Tri, Lam Thao, Bai Bang, and Lao Cai Apatite mining zone. Total length of the route is about 300 km with gauge of 1000 mm.

(c) **Hanoi – Thai Nguyen:** This route connects Hanoi to Go Dam Industrial Park, Thai Nguyen metallurgy zone, coal mine of Hong Mountain and Cam village. The section from Hanoi to Quan Trieu is 75 km long and the section from Gia Lam to Luu Xa is dual gauge (1000 mm and 1435 mm). Gauge of the section from Lu Xa to Nui Hong is 1000 mm.

(d) **Hanoi – Lang Son:** The railroad from Hanoi to Huu Nghi border gate of China runs through the province of Lang Son, and it has dual gauge of 1000 mm and 1435 mm.

(e) **Hanoi – Hai Phong:** This route connects Hanoi and Hai Phong City. The total length is 102 km and the gauge measure is 1000 mm.

(f) **Ring Rail:** Rail ring road of Hanoi includes two branches: eastern railroad and western railroad. The former one has a gauge of 1435 mm but it is still incomplete. The latter one starts from Bac Hong along the Hanoi-Lao Cai corridor, running through Thang Long Bridge, Kim No, Phu Dien, outer fringe of Ha Dong to join with North-South trunk road at Ngoc Hoi. The road-bed of the western branch is 10.5 meters wide, and is reserved for a double-track railway. In the first stage, only single track railway of 1000 mm gauge was put into service.

5) Inland Waterway Transport

The project area features an active Inland Waterway Transport system. The base of this network are the following rivers:

(a) **Hong River:** Hong River is the largest in the North, starting from Van Nam of China and leading to sea at the estuary of Balat. The Hanoi section is from Thuong Cat to Van Phuc, 47 km long and is 500-700 meters wide, and 3.5-5 meters and 7-9 meters deep during the dry and rainy season, respectively.

(b) **Duong River:** Duong River is the connection of Hong River and Thai Binh River. It is 68 km long, and the section running through Hanoi is 37 km long. This section features several bends and sandbars. Depth during the dry season is 1.2-1.5 m; and the width of river is 40-50 m.

(c) **Cau River:** A section of the Cau River runs through Hanoi from Ca Lo confluence to Cong River and is 15 km long. Average width of the river is 150 m and depth during the dry season is 1.2-1.5m.

(d) **Cong River:** The section of Cong River in Hanoi is about 12 km long, and two kilometers from Da Phuc Bridge to Cau confluence is useable for waterway transportation. This section is 90-100 m wide and 1.2-1.8 meters deep during the dry season.

Key IWT ports include Hanoi Port, Khuyen Luong Port on Red River; Duc Giang Port and Go Diem Port on Duong River. However, there are many other ports for loading and unloading of goods and construction materials.

Major inland waterway routes being operated in Hanoi on two key rivers are:

(i) Thuong Cat (Tu Liem) to Van Phuc (Thanh Tri) along the Red River by barge fleet of 4x200t barge or, self-propelled barge of 200t.

(ii) Dau gate to Trung Mau (Gia Lam) of 37 km along the Duong River, by barge fleet of 4x200t or self-propelled barge of 200t.

(iii) The waterway route from Cong River to Da Phuc Port is also operated.

3 ENGINEERING AND OPERATION

3.1 General

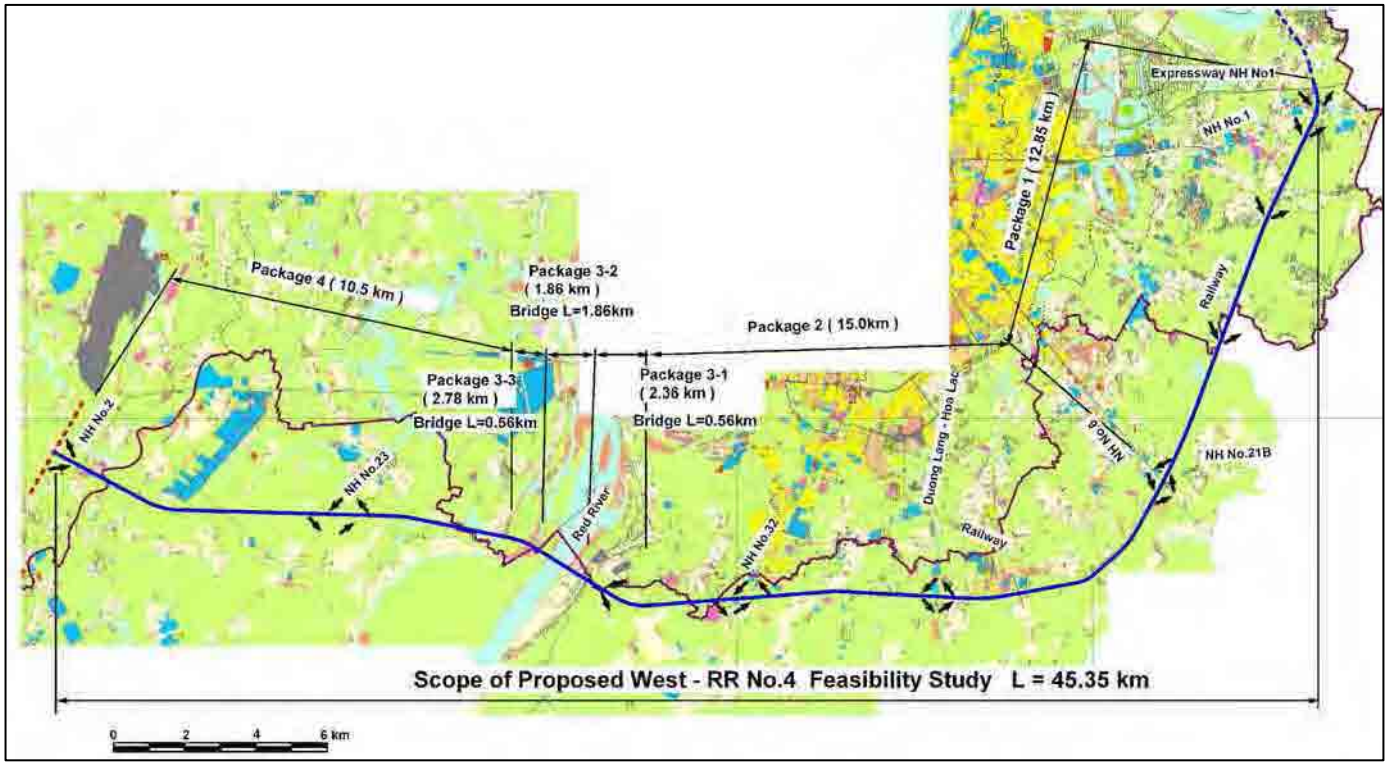
The project scope covers the RR4 West Section, and it was divided into four packages for preliminary design as shown in Figure 3.1.1 and Table 3.1.1. Package three features the bridge to cross the Red River, so it is furthered decomposed into three subpackages: two for the approaches and one for the bridge.

Table 3.1.1 List of Divided Sections

Section No.	Section	From	To	Length (m)
Package 1	NH 1 Expressway-NH 6	44+850	32+000	12,850
Package 2	NH 6-Red River Approach Bridge 1	32+000	17+000	15,000
Package 3-1	Red River Approach 1 Bridge	17+000	14+640	2,360 (Embankment: 1,800, Bridge: 560)
Package 3-2	Red river Main Bridge	14+640	12+780	1,860
Package 3-3	Red River Approach 2 Bridge	12+780	10+000	2,780 (Embankment: 2,220; Bridge: 560)
Package 4	Red River Approach 2 － NH 2 Expressway	10+000	0－500	10,500

Source: HAIDEP Study Team.

Figure 3.1.1 Location of RR4 Project Packages



Source: HAIDEP Study Team

3.2 Design Standards

1) General

The RR4 is to be designed as a full access-controlled expressway with four lanes, and the adopted standards for its design are described below.

"A Policy on Geometric Design of Highways and Streets" published by AASHTO has been widely referred to in the preparation of the geometric design standards in many countries, including Vietnam. In Vietnam, the Highway Design Standards (22TCN-273-01) were prepared in 2001. However, these standards are not universally followed by local engineers.

The road, bridge, and other road structures will be planned and designed based on the Vietnamese standards together with AASHTO specifications. The major standards and references are:

(i) Specifications for Bridge Design (22 TCN-272-01) published in 2001
(ii) AASHTO LRFD Bridge Design Specifications, Second Edition 1998 published by the American Association of State Highway and Transportation Officials
(iii) Vietnamese Bridge Design Codes published in 1979
(iv) Highway Design Standards of Vietnam (TCVN 4054-98)

The Specifications for Bridge Design (22 TCN-272-01) are newly established based on AASHTO LRFD and the contents are basically the same as those of AASHTO.

2) Design Speed

Design speed is the maximum speed for safe travel that can be maintained for a specified section of a road and it is determined with respect to the terrain, adjacent land use, type of road, and the design speed of adjoining sections. The design speed will directly affect many geometric elements, like the horizontal and vertical alignments, sight distance, provision of super elevation, etc.

Other features, such as lane width and shoulder width, are also influenced by design speed. HAIDEP selected and proposed design speeds within the permissible range of the Vietnamese standards as shown in Table 3.2.1.

Table 3.2.1 Design Speed in Urban Area

Category or Class	Design Speed (km/h)					
	20	40	60	80	100	120
RR4				●	●	
Primary Road			●	●		
Secondary Road		●	●			
Tertiary Road		●				

Source: HAIDEP Study Team.

3) Cross-section

Cross-sectional elements are proposed based on Vietnamese standards and consideration of road functions. Based on road function and projected traffic demand, the RR4 West Section will initially be developed with four lanes. Space for future expansion will be reserved by utilizing an expanded median, which can provide space for additional

two lanes. Moreover, as urban development is expected to occur along the RR4, frontage roads will be necessary to ensure accessibility to these areas. These frontage roads will be designed for both local motorized traffic as well as heavy pedestrian movement, thus oversized walkways and planted strips will be provided. Frontage roads basically follow standards for tertiary roads. The basic parameters of the RR4 cross-section elements are below (see Table 3.2.2).

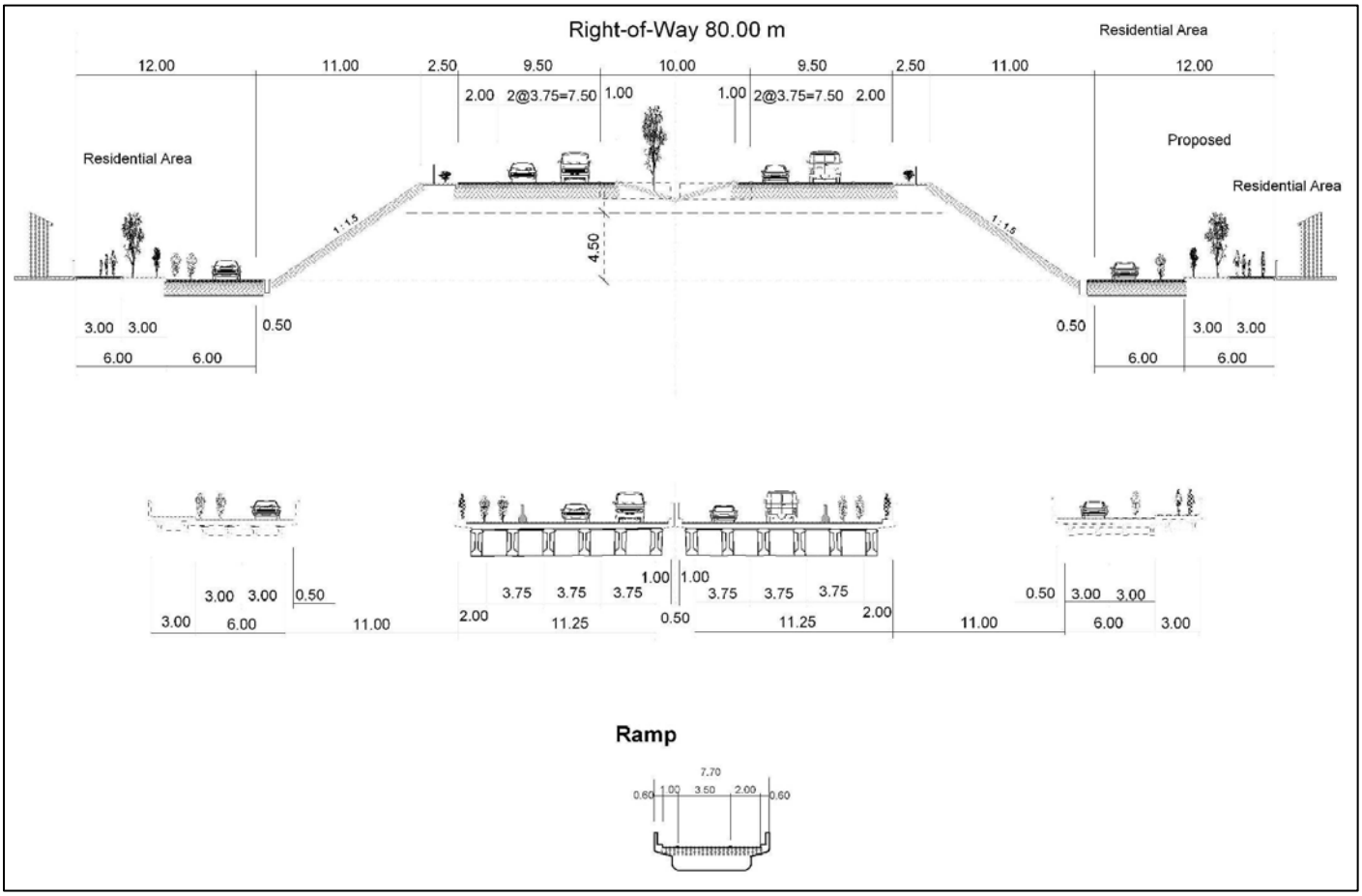
Table 3.2.2 Typical Cross-sections of Proposed Roads

Function	Lane Width (m)	Median (m)	Shoulder (m)	Sidewalk		Remark
				Walkway	Planted Strip	
RR4	3.75	10.00	2.00	3.00[1)]	3.00[1)]	ROW 4 lanes = 80m
Urban Primary	3.50	2.00	1.50	2.00	3.00	ROW 6 lanes=33.5m
Urban Secondary	3.25	2.00	2.00	2.00	2.00	ROW 4 lanes=27m
Tertiary Road	3.00	-	2.00	1.50	2.00 (0.00)	ROW 2 lanes=15m

Source: HAIDEP Study Team.
1) Applied to frontage roads.

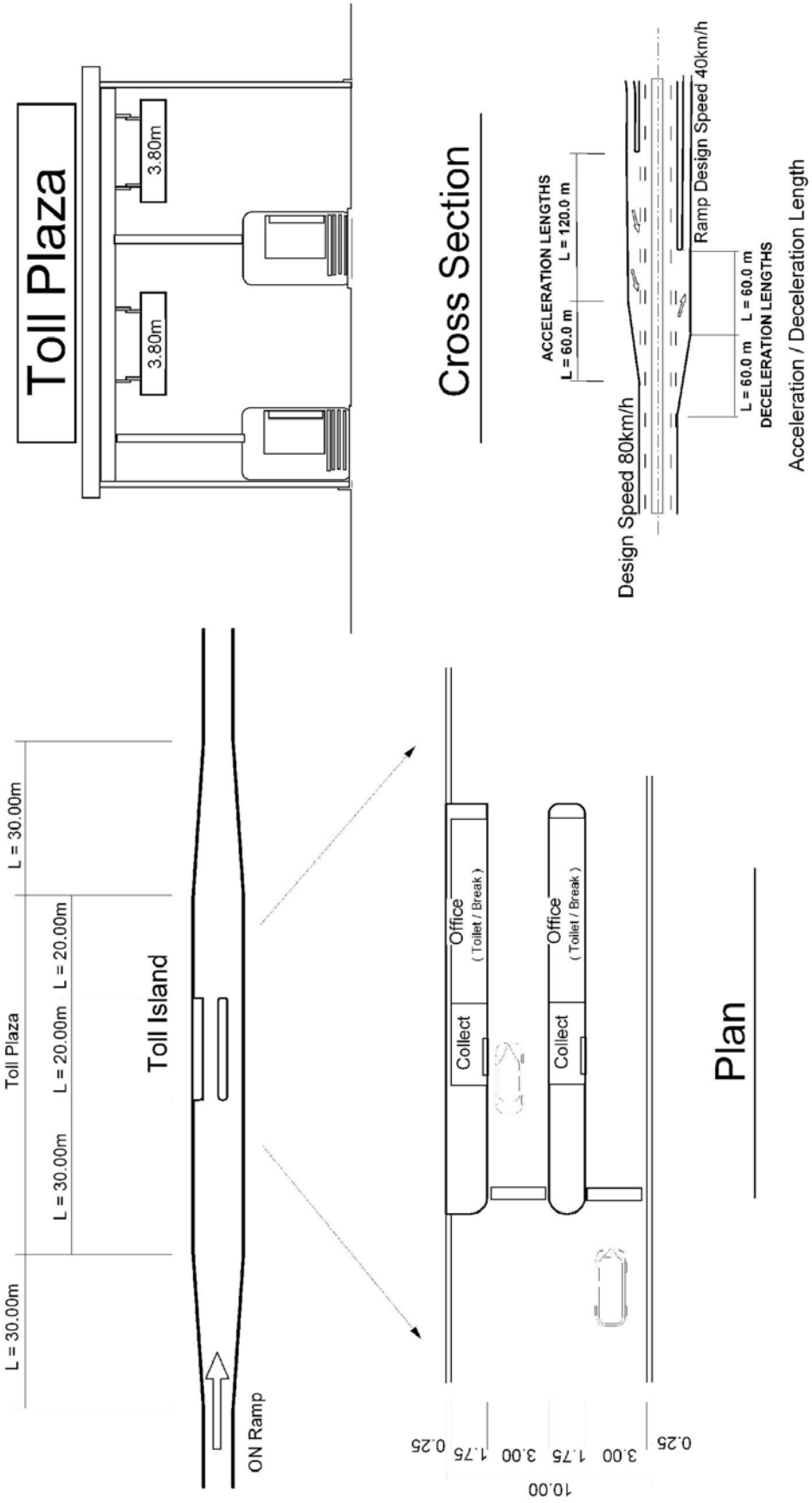
Typical cross-section of RR4 West is shown in Figure 3.2.1. Also, since RR4 will be operated as a tolled expressway, typical toll plaza design is shown in Figure 3.2.2.

Figure 3.2.1 Typical Cross-sections of RR4 West Section



Source: HAIDEP Study Team.

Figure 3.2.2 Typical Toll Plaza Design



Source: HAIDEP Study Team

4) Intersections

In the case of RR4, the alignment would feature several major intersections as follows:

(i) Two with expressways (NH2 Expressway, NH1 Expressway)

(ii) Four with primary roads (NH6, Duong Lang Hoa Lac, NH32, NH23)

When two roads intersecting each other have four or more lanes, it would be typically recommend that it be grade-separated with consideration to traffic volume, traffic safety, road network configuration, interval between intersections, and topography.

In selecting the appropriate type of intersection, both traffic operation and economic aspects are to be considered. The basic engineering policy on the selection of type of intersection is outlined in Table 3.2.3.

Table 3.2.3 Types of Crossing Structure

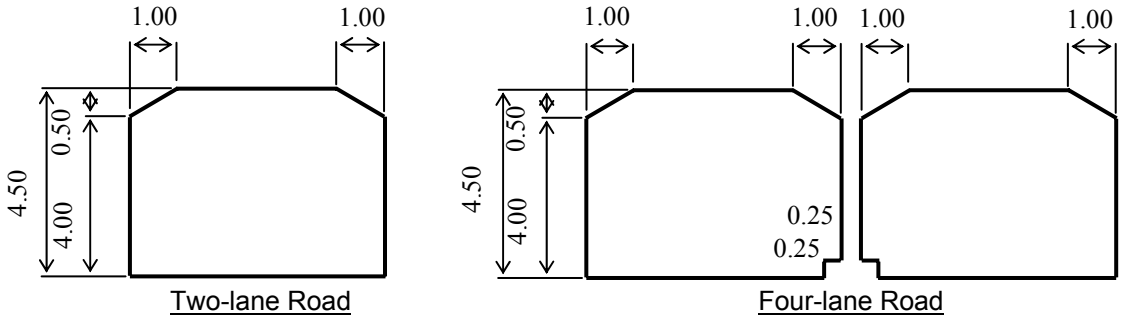
Crossing	Typical Arrangement
1. Expressway and Expressway	• Interchanges in all cases.
2. Expressway and Primary/Secondary	• Interchanges, but no access would be provided where interchange spacing is too close.
3. Primary and Primary	• Grade separated intersection.
4. Primary and Secondary Secondary and Secondary	• At-grade intersections, but grade separations can be justified where capacity limitation cause serious delays and incidence of traffic accidents is high

Source: HAIDEP Study Team.

5) Bridge Design Criteria

The clearance of bridges crossing over all classes of roads were determined in accordance with the “Design Specifications for Highway TCVN 4054/ 1998”. The project bridges will cross over Class I roads, thus required clearances as depicted in Figure 3.2.3: For navigation clearances for IWT navigation and railroad along the Red River, the following clearances are tabulated in Table 3.2.4.

Figure 3.2.3 Road Clearance



Source: HAIDEP Study Team.

Table 3.2.4 Navigation Clearance

Location	Navigation Clearance
Red River	Dike Elevation = 14.00m Construction Clerance = 10.00m Proposed Max. Beam Thickness = 10.00m
Railway	Construction Clearance = 4.95m

Source: HAIDEP Study Team.

6) Summary of Design Standards

As a summary, the table below outlines the design criteria for RR4 West.

Table 3.2.5 Geometric Design Criteria for Ring Road No.4

Item	Unit	Design Criteria
A. General		
A1 Section	-	West
A2 Design Speed	km/h	80 - 1 00
B. Cross-sectional Elements[1)]		
B1 Number of Lanes	-	4 (6) + Frontage Road at Both Sides
B2 Traveled Lane Width	m	3.75
B3 Shoulder Width	m	2.0
B4 Median[2)]	m	10 (with reservation for 2 lanes)
B5 Walkway + Planted Strip	m	6.0
B6 Frontage Road[3)]	m	6.0 (2 lanes)
B7 Sidewalk	m	6.0
B8 Cross Fall	%	2.0
B9 Type of Pavement	-	Asphalt concrete
C. Design Elements[1)]		
C1 Stopping Sight Distance	m	160
C2 Maximum Super elevation	%	4.0
C3 Minimum Horizontal Curve Radius	m	1,000
C4 Maximum Grade	%	4.0
C5 Minimum Curve Radius (Crest)	m	6,000
C6 Minimum Curve Radius (Sag)	m	3,000
C7 Vertical Clearance	m	4.9/4.5

Source: HAIDEP Study Team.
1) See design criteria for each package.
2) To be laid between traveled lanes.
3) Design speed of frontage road is assumed at 40 kph.

3.3 Horizontal and Vertical Alignment

1) General

This section describes the proposed vertical and horizontal alignment of the RR4 West Section. Since the project is planned in sub-urban areas, where settlements and commercial establishments are scattered over agriculture lands, the alignments, therefore, are determined to avoid or minimize the impact to the existing developments.

In the design of horizontal and vertical alignments the following considerations are set:

(i) The horizontal alignment is designed to avoid (as much as possible) residential areas.

(ii) The alignment in the section is designed to avoid the railway.

(iii) The control point for the horizontal alignment is the planned development area.

(iv) Plan elevation was set to existing road level plus 6.5m (Construction Clearance = 4.5m, Construction Thickness = 2.0m).

In addition, key design considerations for each project package are laid out in Table 3.3.1.

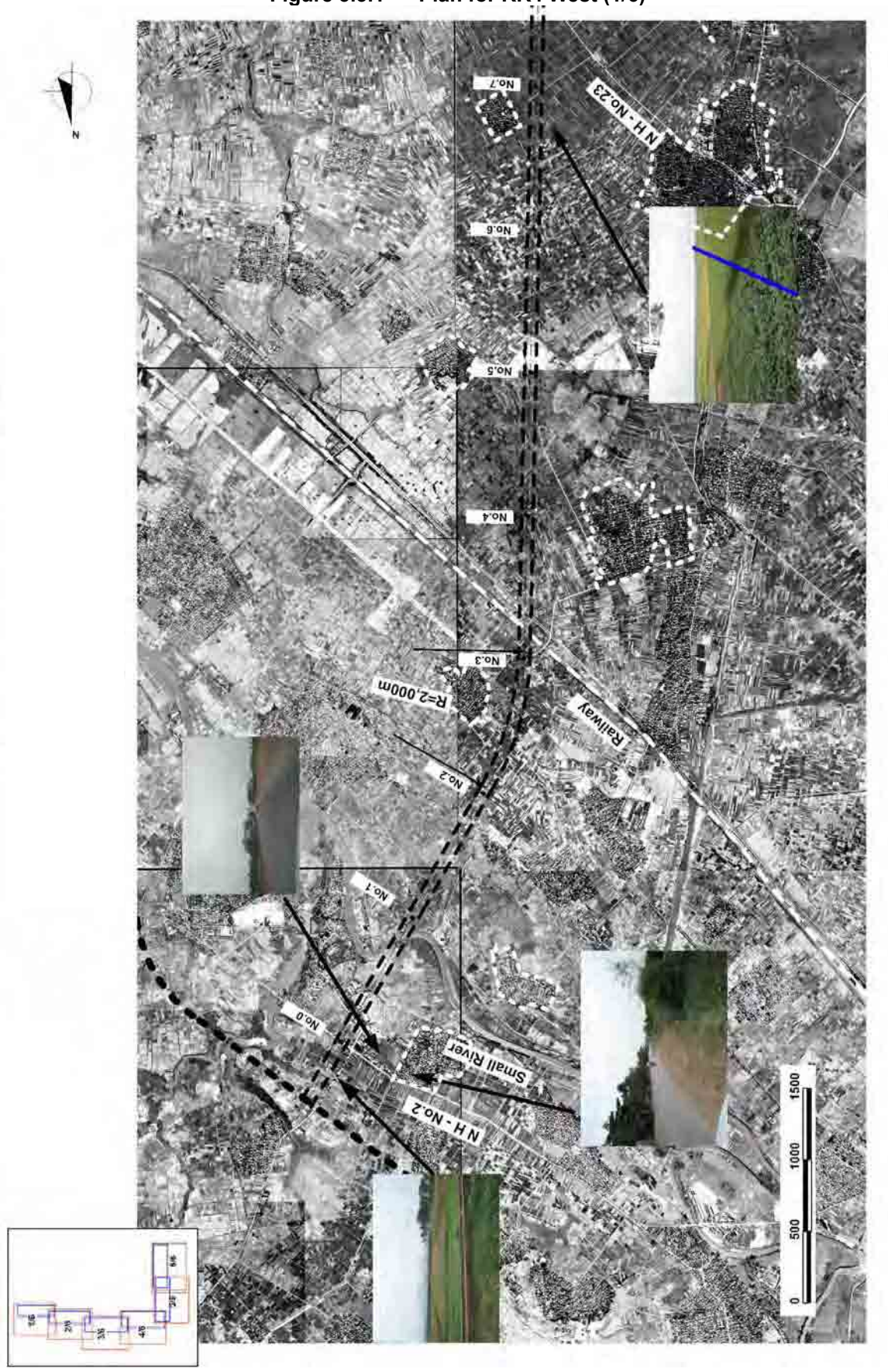
Figures 3.3.1 to 3.3.6 show the horizontal alignment and figures 3.3.7 to 3.3.12 detail the coordination of the horizontal and vertical alignment of RR4 West.

Table 3.3.1 Special Design Considerations for RR4 Project Packages

Package	Horizontal Alignment	Vertical Alignment
Package 1 (NH1 Expressway-NH6 L=12.85 km)	• The roaside land use is mostly rice field. • The junction with NH1 Expressway is provided with a four leaf clover interchange • The intersection with NH6 is provided with a half clover-leaf interchange	• Because the RR4 goes through mostly rice field area, the design as much as possible follows the existing terrain of the rice field. • Vertical alignment control points are NH1 Expressway, NH1/Railway, NH6.
Package 2 (NH6-Red River L = 15.00 km)	• The intersection with Duong Lang Hoa Lac and NH32 is provided with a four clover-leaf form interchange.	• The vertical alignment control points is NH32
Package 3 (Red River L=7.00 km) with Bridge Length=2.98km		• The vertical alignment control point is Red River clearance of 34m = Embankment Elevation (14.00m) + Clearance (10.00m) + Proposed Max. Beam Thickness (10.00m)
Package 4 (Red River-NH2 Expressway L+10.50 km)	• The intersection with NH23 is provided with a four clover-leaf form intersection	• The vertical alignment control points are NH2, Railway

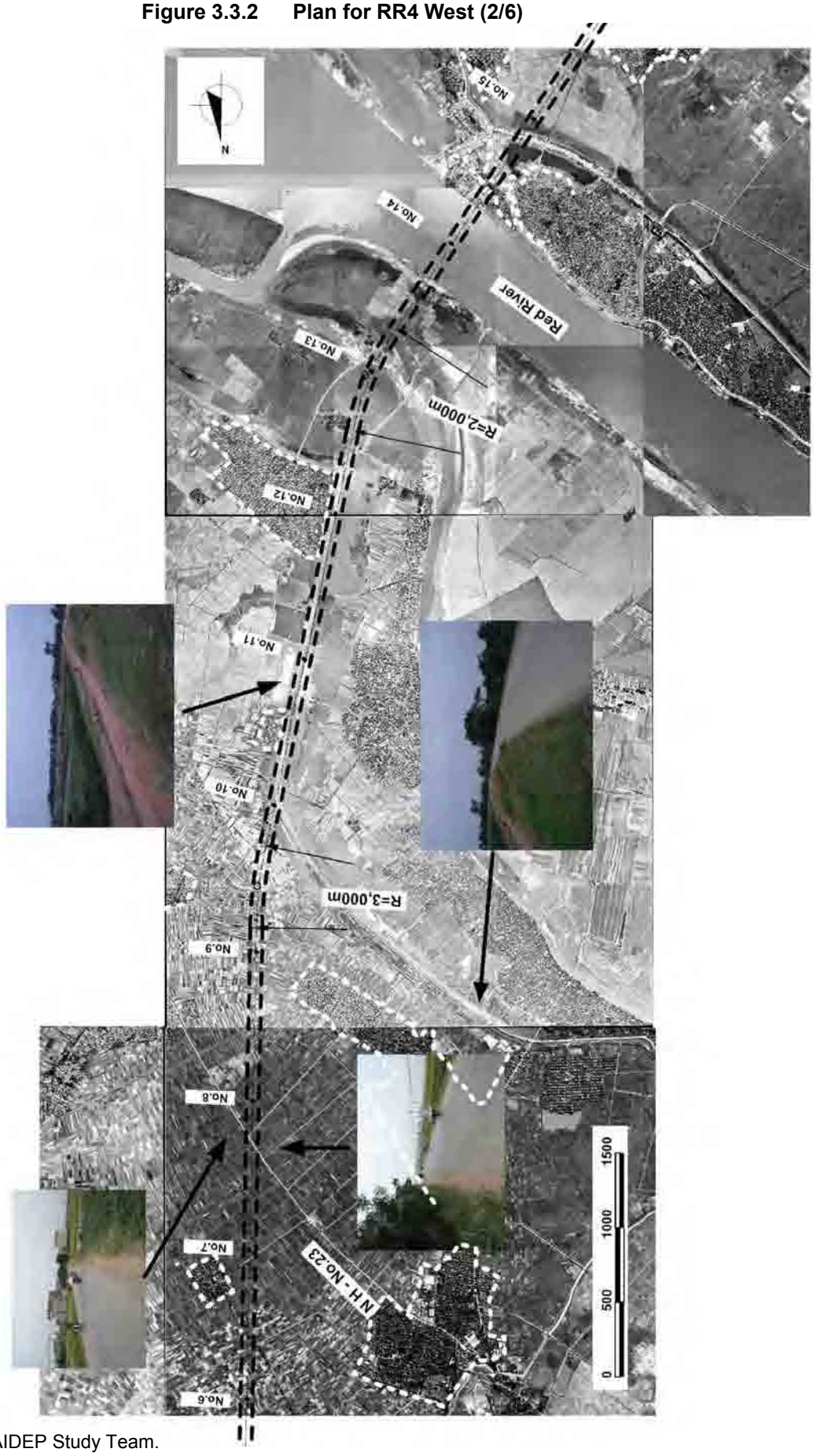
Source: HAIDEP Study Team.

Figure 3.3.1 Plan for RR4 West (1/6)



Source: HAIDEP Study Team.

Figure 3.3.2 Plan for RR4 West (2/6)



Source: HAIDEP Study Team.

Figure 3.3.3 Plan for RR4 West (3/6)

Source: HAIDEP Study Team.