Socialist Republic of Viet Nam

Hanoi People's Committee (HPC)

Data Collection Survey for Hanoi Metro Line 2 Extension North

FINAL REPORT

(Prior Release Version)

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Japan International Cooperation Agency (JICA)

EXeIdea Ltd.

Tokyo Metro Co., Ltd.

Oriental Consultants Global Co., Ltd.

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Creative Research and Planning Co., Ltd.

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Yen/USD = 109.00

(Monthly averages of spot central exchange rates of Tokyo Market for the month of November 2019, Bank of Japan)

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List of Abbreviations

A	AFC	Automatic Fare Collection	Thu vé tự động
	ATC	Automatic Train Control system	Hệ thống điều khiển đoàn tàu tự động
	ATO	Automatic Train Operation system	Hệ thống
	ATP	Automatic Train Protection system	Hệ thống bảo vệ đoàn tàu tự động
	ATS	Automatic train supervision system	Hệ thống tự động không chế giám sát đoàn tàu
B	BOLT	Build – Operate – Lease – Transfer	Xây dựng – Vận hành – Cho thuê – Chuyển giao
	BOOT	Build – Own - Operate - Transfer	Xây dựng – Sở hữu – Vận hành – Chuyển giao
	BOT	Build – Operate – Transfer	Xây dựng – Vận hành – Chuyển giao
	BT	Build – Transfer	Xây dựng – Chuyển giao
C	CAAV	Civil Aviation Authority of Vietnam	Cục Hàng không Việt Nam
	CBD	Central Business District	Khu thương mại trung tâm
	CBI	Computer-based interlocking devices	Hệ thống liên khóa máy tính
	CBTB	Communication Based Train Control	Hệ thống Điều khiển đoàn tàu băng truyền thông không dây
	CCTV	Closed Circuit Television	Truyền hình mạch kín
	CPI	consumer price index	Chỉ số giá tiêu dùng
D	DARD	Hanoi Department of Agriculture and Rural Development	Sở Nông nghiệp và Phát triển Nông thôn Hà Nội
	DPA	Hanoi Department of Planning and Architecture	Sở Quy hoạch Kiến trúc Hà Nội
E	EIA	Environmental Impact Assessment	Đánh giá tác động môi trường
	EPBS	Earth Pressure Balance Shield	Khiên đào cân băng áp lực
F	FAR	Floor Area Ratio	Hệ số sử dụng đất
	FIRR	Financial Internal Return Rate	Tỷ lệ nội hoàn tài chính
G	GDP	Gross Domestic Product	Tổng sản phẩm quốc nội
	GRDP	Gross Regional Domestic Product	Tổng sản phẩm địa phương
H	HPC	Hanoi People's Committee	Uy ban Nhân dân thành phố Hà Nội
	HUPI	Hanoi Urban Planning Institute	Viện Quy hoach Xây dựng Hà Nội
J	JICA	Japan International Cooperation Agency	Cơ quan Hợp tác Quốc Tế Nhật Bản
	JST	JICA Study Team	Nhóm Nghiên cứu JICA
L	LCX	Radiation coaxial cable system	Hệ thống cáp đồng trục bức xạ
	LTS	Local train supervision equipment	Thiết bị giám sát tàu địa phương
	LVC	Land Value Capture	Giá trị tăng thêm của đất khi có dự án
M	METI	Ministry of Economy, Trade and Industry of Japan	Bộ Kinh tế, Thương mại và Công nghiệp Nhật Bản
	MRB	Hanoi Metropolitan Railway Management Board	Ban quản lý Đường sắt đô thị Hà Nội
N	NBIA	Noi Bai International Airport	Cảng Hàng không Quốc tế Nội Bài
	NH	National Highway	Quốc lộ
O	OCC	Transport control center	Trung tâm điều hành giao thông
	OCS	Overhead contact system	Hệ thống tiếp điện trên cao
P	PMU	Project Management Unit	Phòng dự án
	PPP	Public Private Partnership	Quan hệ Đối tác Công tư
R	RC	Reinforced Concrete	Bê tông cốt thép
	ROW	Right of Way	Chỉ giới đường đỏ
	RR	Ring Road	Đường vành đai
S	SCR	Station control room	Phòng điều khiển ga
	SPC	Special Purpose Company	Doanh nghiệp dự án
T	TOD	Transit Oriented Development	Phát triển đô thị gắn kết giao thông công cộng
	TSS	Traction substation	Trạm điện kéo
U	UMRT	Urban Mass Rapid Transit	Đường sắt đô thị
	UPS	Uninterrupted power supply system	Bộ nguồn điện liên tục
	uPVC	Unplasticized Polyvinyl Chloride	Nhựa uPVC
W	WPS	Water Pumping Station	Trạm bơm
	WTP	Water Treatment Plant	Trạm xử lý nước
	WWTP	Waste Water Treatment Plant	Trạm xử lý nước thải

Executive Summary

General Background

As one of eight Hanoi's Urban Mass Rapid Transit (UMRT) lines in the core city, the UMRT Line 2 is planned to connect Noi Bai International Airport with the City's center. By completion, in addition to serving the travel needs of the people of the Capital, Line 2 will also transport passengers between Hanoi and Noi Bai International Airport, which can contribute to improving the City's transport network and reducing traffic congestion in the City. From November 2017 to May 2018, the Ministry of Economy, Trade, and Industry of Japan (METI) assisted Hanoi People's Committee (HPC) with the study on the promotion of urban railway development in Hanoi. Based on the recommendation under METI study, Hanoi Metro Line 2 (Nam Thang Long- Noi Bai International Airport (NBIA) Section, hereinafter "Line 2.3") was selected as the first priority for development, and the agreement between HPC and Japan International Cooperation Agency (JICA), "Data Collection Survey for Hanoi Metro Line 2 Extension North (Line 2.3) ", financed by JICA was commenced in late June 2018.

The basic framework of this study is an integrated development planning of the railway and the urban developments by adopting the Transit-Oriented Development (TOD) approach. The first half of this report (Chapter 1-12) focuses on railway planning while Chapter 13-16 focuses on urban development planning, Chapters 17-19 on financial analysis and financial planning, and Chapter 20 on implementation systems. Chapter 21 deals with the environmental assessment, and finally Chapter 22 is for conclusion and summaries. In the actual study process, the railway alignment was first undertaking (Chapter 6), and then the station layout plan (Chapter 7) was undertaken. In the station layout plan (Chapter 7), the areas around the stations were identified and planned to maximize the benefits of TOD areas (Chapter 13). After identifying the TOD area, the resident population and the working population are estimated for each station area using the following procedure: 1) developable area, 2) spatial density setting and 3) floor area as described in Chapter 14. The forecast of rail transport passenger demand (Chapter 8) is based on the forecast of the future population in the TOD areas. Likewise, both railway and urban development plans are closely inter-linked. The outputs of this JICA Study shall form the basis to prepare a pre-feasibility study of the project by HPC.

The study team reviewed the existing legal framework of the Project. The following decrees are the most important.

- Decision No. 1259/QĐ-TTG dated 26/7/2011 by Prime Minister approving Hanoi general construction master plan up to 2030 and vision to 2050.
- Decision No. 519/QĐ-TTg dated 31/3/2016 by Prime Minister approving Hanoi Transport Master Plan up to 2030 and vision to 2050.
- Decisions Nos. 2269/QĐ-UBND dated 25/5/2012; 2270/QĐ-UBND dated 25/5/2012; 2271/QĐ-UBND dated 25/5/2012; 06/QĐ-UBND dated 5/1/2015; 6620/QĐ-UBND dated 2/12/2015; 6632/QĐ-UBND dated 02/12/2015 by HPC approving the zoning plan of N5, N7, N8, GN, GN(C) and H2-1 in Dong Anh and Soc Son rural districts and Tay Ho urban District of Hanoi where the project alignment runs through.

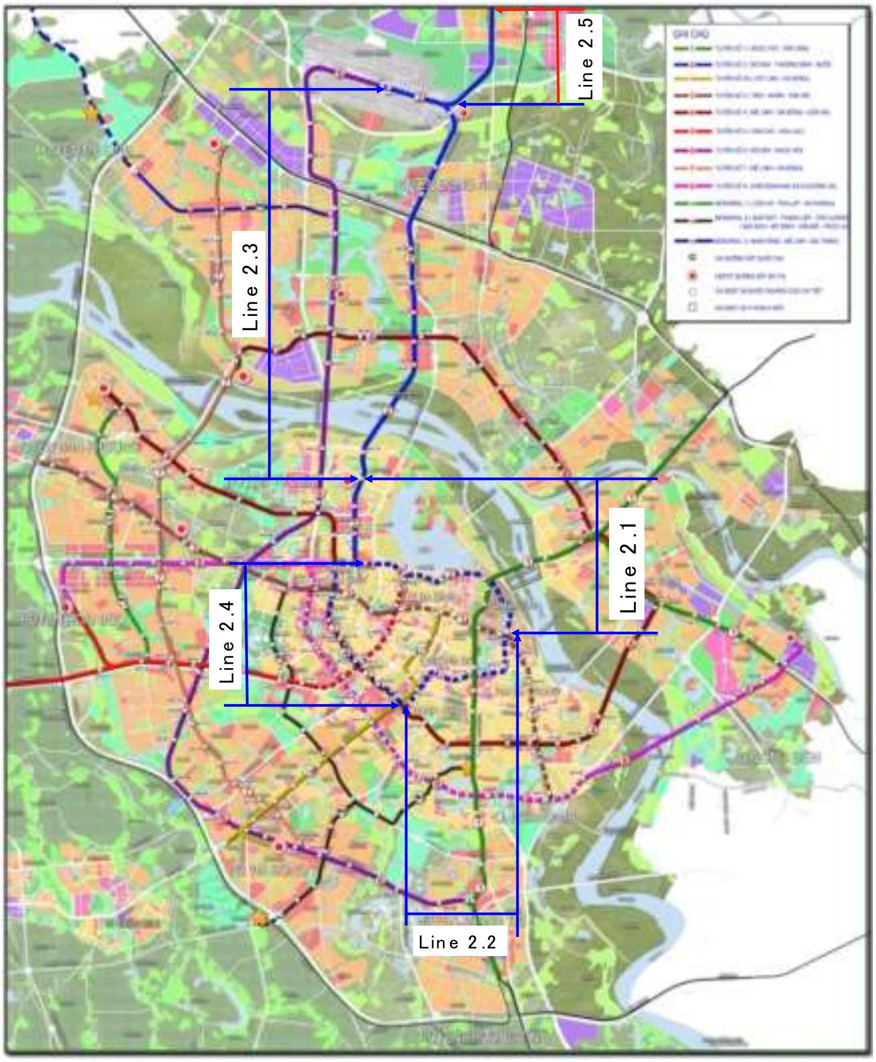
- Decision No. 6630/QĐ-UBND dated 02/12/2015 by HPC approving detailed master plan (1/500) along 2 sides of Nhat Tan- Noi Bai Road including sections 1, 2 and 3 (Vo Nguyen Giap Road) in Dong Anh and Soc Son Districts.
- Decision No. 590/2008/QĐ-TTg dated 20/5/2008 by Prime Minister approving the adjusted master plan of Noi Bai International Airport (NBIA) up to 2020 and orientation after 2020.
- Decision No. 2967/QĐ-UBND dated 29/6/2015 by HPC approving Soc Son District general construction plan (1/10.000).
- Memorandum of understanding between Hanoi People's Committee and JICA

Necessity of Project

In recent years, the annual economic growth of Hanoi capital was more than 8%. By merging with some neighboring areas in 2008, the City's area has increased by about 3.6 times. According to statistic data in 2015, the population of Hanoi was about 7.588 million; such a population creates a burden to the City's inadequate transport system. By 2050 the population of Hanoi is projected to be 10.8 million as maximum. In response to the projected situation, Hanoi will be developed as a large-scale international city, which will be a big political, cultural, scientific, educational, and economic center.

As illustrated in Figure 1, the Line 2.3 connects to the section of Line 2 which runs between Tran Hung Dao (C10) and Nam Thang Long (C1), hereinafter termed “Line 2.1”, and extend the line to the Noi Bai International Airport. The Line 2 phase 1 is a key route and has significant implications on sustainable development of the future urban areas of Hanoi. The Line 2.1 will provide massive transport capacity between Nam Thang Long Urban Area, Old Quarter (a thriving tourist area), French Quarter, the central administration areas, all of which are developing rapidly and attracting ever increasing number of visitors. Moreover, the Line 2.1 will traverse to provide direct linkages with other UMRT lines including Line 1, Line 3 and Line 5. The Line 2.3 will further the extend the Line 2 to the north of the Red River to constitute a new urban development corridor in the north to the international airport while providing connections to UMRT Line 4 and Line 6.

The extension of the Line 2.1 to 2.3 will prompt the transformation of life styles and mobility of Hanoi population. As a result, the project will contribute to the betterment of the urban environment of Hanoi in combatting traffic congestions and air pollutions.



Source: Hanoi Transport Master Plan (Decision 519/QD-TTg)

Figure 1. Alignment of Metro Line 2, Nam Thang Long - Noi Bai Section

Technical Standards of Railway

Technical standards to be applied for Line 2.3 shall follow those applied for Line 2.1 (Nam Thang Long - Tran Hung Dao Section) with necessary updates and supplements. The major technical standards to be applied for Line 2.3 are is indicated in Table 1.

Table 1. Technical Specifications of Line 2.3

No.	Item	Parameter
1	Gauge	1,435mm, double track
2	Max operation speed	110km/h
3	Max operation speed in curve	90km/h
4	Min radius of horizontal curve (main line/depot)	300m/160m
5	Min radius of vertical curve (normal/max.)	3000m/2000m
6	Max gradient	35‰
7	Max cant (normal/max.)	150mm (180mm)
8	Distance between 2 centerlines on main line/depot	3.8m / 5.0m
9	Max gradient of underground and elevated station	2‰
10	Axle load (tons/axle)	16
11	Power source	1,500VDC
12	Power supply method	High Voltage
13	Communications	(MSN): (Digital Trunking)
14	Signal	ATP, ATS, ATO, CBTC
15	Rolling stock	(EMU)
16	Clearance for roadway	H = 4.75m
17	Clearance for railway	H = 5.70m

Source:"Decision No. 6935/QD-UBND dated 15 November 2013 of Hanoi People's Committee on additional approval of technical standards applicable for Hanoi City Urban Railway Construction Project, Line 2: Nam Thang Long – Tran Hung Dao section"

Alignment and Profile

JICA Study Team conducted its alignment study of Line 2.3 according to the alignment, which is defined in the Hanoi Transportation Master Plan until 2030, vision to 2050 approved by the Prime Minister in Decision No. 519 / QĐ-TTg dated 31 March, 2016. In terms of alignment, the JICA Study Team recommendation is the same as envisaged in the Transport Master Plan (No.519/QD-TTg dated 31/3/2016) except for the end point at the Noi Bai Airport. The JICA Study Team recommends that the ending point of Line 2.3 for this study is the N0 station, opposite the T2 Terminal of the Noi Bai Airport to ensure efficient and convenient transfer operations. Therefore, Line 2.3 shall be 1.5km longer than that approved in the master plan. In accessing the Noi Bai International Airport, JICA Study Team recommends that Line 2.3 will take an underground access to the airport to fulfill the technical requirements of aviation.

In sum, the Line 2.3 connects to Line 2.1 at Nam Thang Long Station, running along the extended Nguyen Van Huyen Road, crossing through Phu Thuong Village, and crossing Red River, continuing to run along the planned road crossing over the extended NH-5 and Line 4 (planned on the separator of NH-5) and accessing the land strip planned for urban railway on Vo Nguyen Giap Road, then running in parallel with Vo Nguyen Giap Road and ending at passenger terminal T2 of NBIA. The alignment shall run through districts of Tay Ho, Dong Anh, and Soc Son. Total alignment length: 19.66km (Option 1) and 19.65km (Option 2).

The access to depot shall connect from the mainline, starting from N2 Station, crossing over NH-2, then accessing depot.

Red River Crossing Options

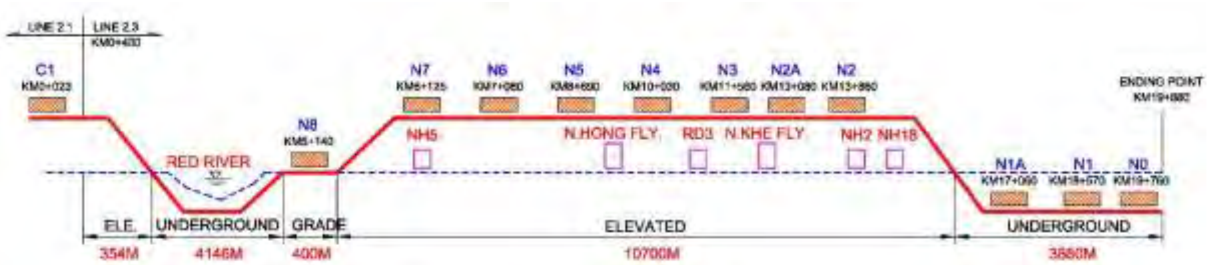
The Study Team evaluated two Red River Crossing Options, Option 1 by tunnel and Option 2 by bridge:

Source: The JICA Study Team

Figure 2 General Alignment Plan of Line 2.3 (Option 1)

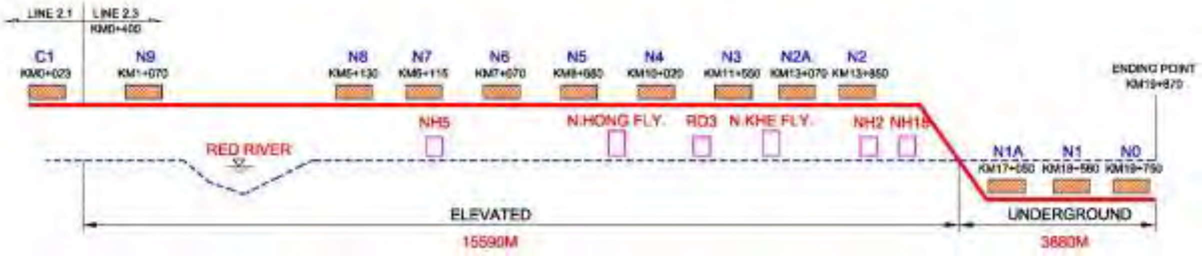
Source: The JICA Study Team

Figure 3 General alignment plan of Line 2.3 (Option 2)



Source: The JICA Study Team

Figure 4 Profile of Line 2.3 (Tunnel Option for the Red River Crossing)



Source: The JICA Study Team

Figure 5 Profile of Line 2.3 (Bridge Option for the Red River crossing)

The JICA Study Team has evaluated two options by comparing the plan of the tunnel and bridge crossing the Red River as shown in Table 2. As for the Red River crossing, the JICA Study Team recommends a more advantageous bridge option. However, the Study Team also proposed to add a tunnel option as an alternative, depending on the results of the environmental impact assessment and resettlement plan.

Table 2. Comparison of Red River Crossing Options

No	Items	Option 1 (Tunnel)	Option 2 (Bridge)
1	Compliance with Master Plan	Need to revise MP 519	In accordance with the MP 519
2	Resettlement	No houses. However, to ensure during the construction of the tunnel, it is necessary to relocate households above.	100 houses with approx. S =2,993m^2
3	N9 station (Ciputra urban area)	Construction is impossible because of the slope area of railway Reduced cost for construction of a station Will lose some ridership due to the absence of N9 Station catchment area. Depending on the plan of Line2.1, a substation is necessary around N9 station	Construction is possible
4	Construction period	Standard period (48 months) Not affected by weather and river water level The construction period is not affected by external factors.	Depends on conditions (48 months) Depends on the number of teams It is affected by weather and river water levels. Land acquisition and resident's relocation is unpredictable. It may take several years to relocate residents.
5	Environmental situation and landscape	No significant environmental impact on flora and fauna or riparian environment. Construction is quiet. No significant impact on plants and animals (Except for shaft construction) No significant impact on the landscape	No significant environmental impact after the commencement of operation. Some limited impact of noise and impact on plants and animals during construction A significant impact on the landscape but could be a positive one for an artistically designed bridge.
6	Maintenance	Maintenance cost is expensive. Periodic inspection frequency is every 5 years. Repair is possible only non-operation time at night.	The maintenance cost is low. Periodic inspection frequency is every 5 years. Repair is possible day and night.
7	Running cost	Ventilation and drainage expenses are necessary. In addition to running costs, periodic inspection is also higher.	The overall running cost is lower.

No	Items	Option 1 (Tunnel)	Option 2 (Bridge)
8	Impact on the river	There is no inhibition of water flow by bridge foundations. Does not affect the navigation of ships. Construction does not require access-roads in the river	There is inhibition of water flow due to bridge structures. Affects the navigation of ships. The bridge design needs to suppress the impediment ratio of river flow not more than 5%. Construction requires access-roads in the river.
9	Risk management of dyke	Dyke management committee requires vindication of no negative impact on the Red River embankments triggered by the tunneling or tunnel structures After a further detail analysis, it may be necessary to reinforce the dyke.	No impact on dykes
10	Risk to structures	It is necessary to undertake the riverbed surveys seasonally (quarterly) till the time of detail design implementation to collect the data for the tunnel design if this option is deemed more feasible. Depending on the results, the vertical alignment of the tunnel may have to be adjusted or construction methodology may be changed due to further depth of soil cover requirement of the shield tunnel. Tunnel structure has the following risks, such as loss of sufficient soil cover depth due to the hydrological issues as well as illegal river sand dredging to cause buoyancy or direct structural damage. Increasing soil cover depth or providing concrete protection structures can minimize risks.	Bridge pillars will change hydrological regimes and may prompt scouring of riverbed. However, it is possible to minimize the souring by having elliptical shape pillars and secure safety by having sufficient depth of foundations.
11	Risk in operation	No significant risks	Operation disruption by storm
12	N8 station	At-grade station because of transition slope from the tunnel to the elevated section ➔ loss of through traffic connections causing inconvenience and aesthetic damage to the streetscape	Viaduct station
13	Construction Cost	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>
14	Recommendation	A backup plan	Recommended

Source: The JICA Study Team

Station Plan

The total length of the alignment is 19.65 km, with 12 stations, including 9 elevated stations and 3 underground stations for the recommended bridge option. The total length of the alignment is 19.65 km, with 12 stations, including 9 elevated stations and 3 underground stations for the recommended bridge option. Given the number of planned stations, the investment cost for the stations comprise approximately 30% of the total cost. It is recommended to adopt a phased approach in station construction to limit the construction of stations in the initial stage to basic requirements. The rest of the stations should be built according to the needs by soliciting the core investors to share the investment costs.

Passenger Demand Forecast

The traffic demand forecast is based on the transport model established for the Hanoi Transportation Master Plan. Given the drastic changes in the demographic concentrations within TOD areas, the residential population and employments data and other parameters were modified to account for the specific characteristics of TOD approach while utilizing the original transport model.

Travel demand forecast results of commuting trains

The passenger demand forecast for commuting trains is shown in Table 3. In 2030, the passenger demand in Line 2.3 is estimated to be 104 thousand passengers per day, while that for Line 2 as a whole at 265 thousand passengers per day. In 2050, the passengers of Line 2.3 would reach 204 thousand passengers per day while that for Line 2 would reach 470 thousand passengers per day. The distance traveled by passengers is estimated to 1, 837 thousand passengers-km per day for Line 2.3 in 2030 and that for Line 2 would be 4,121 thousand passengers-km per day. In 2050 the Line 2.3 would transport 3,798 thousand passengers-km per day and Line 2 would transport 8,077 thousand passengers-km per day.

Table 3. Railway Passenger Forecast of Line 2 (Pax/day)

Station	2030						2050					
	Departure			Arrival			Departure			Arrival		
	Boarding	Alighting	On train	Boarding	Alighting	On train	Boarding	Alighting	On train	Boarding	Alighting	On train
N0	5,139		5,139		12,248		14,975		14,975		36,888	
N1	10,285	0	15,424	0	10,785	12,248	24,122	0	39,097	0	26,645	36,888
N1A	1,751	14	17,161	15	1,858	23,033	3,106	21	42,182	23	3,245	63,533
N2	3,704	67	20,798	103	3,442	24,876	6,683	128	48,737	227	6,281	66,755
N2A	919	31	21,686	39	856	28,215	1,737	59	50,415	77	1,643	72,809
N3	4,679	294	26,071	319	4,367	29,032	9,100	534	58,981	614	8,661	74,375
N4	15,078	861	40,288	728	16,387	33,080	27,291	1,684	84,588	1,415	29,722	82,422
N5	5,097	450	44,935	541	4,708	48,739	10,040	895	93,733	1,049	9,889	110,729
N6	2,826	681	47,080	710	2,379	52,906	6,463	1,525	98,671	1,580	5,782	119,569
N7	17,645	4,658	60,067	5,412	17,528	54,575	26,565	8,487	116,749	9,617	26,143	123,771
N8	5,895	1,787	64,175	1,799	6,037	66,691	11,126	3,391	124,484	3,359	11,082	140,297
N9	12,973	1,852	75,296	1,917	14,069	70,929	21,378	3,831	142,031	4,111	22,744	148,020
C1	2,306	504	77,098	510	2,588	83,081	5,893	1,282	146,642	1,296	6,521	166,653
C2	1,231	585	77,744	651	1,366	85,159	2,297	1,285	147,654	1,417	2,498	171,878
C3	1,160	645	78,259	710	1,296	85,874	2,171	1,415	148,410	1,545	2,373	172,959
C4	1,853	843	79,269	821	1,819	86,460	2,484	1,276	149,618	1,263	2,463	173,787
C5	19,279	11,539	87,009	12,675	19,479	87,458	24,327	21,522	152,423	25,127	25,159	174,987
C6	1,981	1,630	87,360	2,354	2,412	94,262	2,562	2,950	152,035	4,971	3,099	175,019
C7	1,904	1,786	87,478	1,831	1,986	94,320	2,512	2,940	151,607	3,013	2,621	173,147
C8	4,547	11,714	80,311	12,816	4,586	94,475	6,067	23,250	134,424	27,355	6,117	172,755
C9	1,815	2,497	79,629	2,831	1,674	86,245	2,464	3,900	132,988	4,346	2,262	151,517
C10	3,135	11,398	71,366	11,681	3,236	85,088	3,954	19,349	117,593	20,468	4,055	149,433
C11	313	1,136	70,543	1,190	274	76,643	453	1,729	116,317	1,867	420	133,020
C12	1,179	21,582	50,140	21,873	1,052	75,727	1,597	38,661	79,253	41,355	1,470	131,573
C13	485	7,218	43,407	7,572	506	54,906	695	9,392	70,556	10,186	752	91,688
C14	478	5,843	38,042	6,596	450	47,840	638	8,057	63,137	9,658	614	82,254
C15	0	8,212	29,830	8,722	0	41,694	0	11,252	51,885	12,699	0	73,210
C16		29,830		32,972		32,972		51,885		60,511		60,511
Total	127,657	127,657	↓	137,388	137,388	↑	220,700	220,700	↓	249,149	249,149	↑

Source: The JICA Study Team

Travel demand forecast results of airport passengers

JICA Study Team forecasts the air passengers to the year 2050 based on the trend analysis with GDP and population growth.

In estimating the passenger volume from the airport terminals of N0 and N1, the modal shares of Line 2.3 are assumed to increase from 10% of the airport passengers in 2030 to 15% in 2040 and maintain the same share onwards as shown in Table 4.

Table 4. Airline Passengers Ridership of Line 2.3

Unit: Passengers/Year

	Airport Passengers		Line 2 Passengers	
Year	Domestic	International	Domestic	International
2030	32,282,778	28,558,113	3,228,278	2,855,811
2035	36,469,768	34,185,527	4,376,372	4,102,263
2040	40,315,766	39,953,810	6,047,365	5,993,072
2045	43,820,772	45,821,039	6,573,116	6,873,156
2050	46,984,785	51,745,201	7,047,718	7,761,780

Source: The JICA Study Team

Operation Plan

The Line 2 will be operated in an integrated manner as a whole. However, there will be a large traffic demand gap between the sections of Line 2.1 and Line 2.3. To fill the differences in transport demand, N7 Station will serve as a reversing station for the half of the trains running on Line 2.1. The rest of the trains from Phase 1 will continue to reach the NBIA to run a full length of the Line 2 Phase 2, 1 and 3.

In order to accommodate the reversing of trains between Line 2.1 and Line 2.3, the N7 Station will be designed with two platforms with four railway tracks. Table 5 shows the planned headways, round trip times and the corresponding train requirements by phases and stages.

Table 5. Summary Table of Operation and Rolling Stock Requirements

Stage	Train	Section	Headways (min)	Round Trip (min)	Train Requirements (trains)	Car Requirements
Stage I	Standard Trains	Line 2.1 and Line 2.2 round trip	10	75	8	48
		Line 2.round-trip	10	120	12	72
		Spare Trains			3	18
		Total			23	138
		Phase 1 procurement			10	60
		Phase 2 procurement			7	42
		Phase 3 procurement			6	36
	Airport Express	Phase 1 and 3 round-trip	30	90	3	18
		Spare Trains			1	6
		Total			4	24
Stage II	Standard Trains	Line 2.1 and Line 2.2 round trip	6	75	13	78
		Line 2.round-trip	6	120	20	120
		Spare Trains			3	18
		Total			36	216
	Airport Express	Phase 1 and 3 round-trip	20	100	5	30
		Spare Trains			1	6
		Total			6	36
Final Stage*	Standard Trains	Line 2.1 and Line 2.2 round trip	4	75	19	114
		Line 2.round-trip	4	120	30	180
		Spare Trains			3	18
		Total			52	312
	Airport Express	Phase 1 and 3 round-trip	15	100	7	42
		Spare Trains			1	6
		Total			8	48

Note: * It will require some improvement works to the planned facilities to achieve this level of a headway.

Source: The JICA Study Team

Depot Plan

The depot with an area of 25 ha will be located in Pho Lo Commune as planned by the transport master plan and Zoning Plans of Soc Song. Among the depot access of two options 1) underground access from N1 Station of the domestic terminal of the Noi Bai Airport and 2) elevated access from N2 Station veering to the right. The JICA Study Team recommends the elevated access from N2 to the Depot.

TOD Plan

One prominent feature of Hanoi Metro Line2 Phase 3 Project is that the railway corridor is virtually undeveloped, largely consisting of agricultural production areas and sparsely occupied by villages. Thus the development can be classified as a typical “greenfield development.”

The main objectives of TOD are as follows;

Maximize Land Value Capture (LVC)

=>Recover the investment cost for railways

Maximize the ridership

=>Make railway business profitable

JICA Study Team has developed a set of TOD Guidelines particularly designed for greenfield development in North Hanoi.

Principles of TOD are as follows:

1) Compact City Principle
2) Mixed Land Uses
3) Small-sized Urban Block of 80m x120m
4) Internal Road Specification – Narrow Roads
5) Pedestrian-centric Design
6) Green Boulevard Design

TOD guidelines specially created for the implementation of Line 2.3 calls for the concentration of highest human densities, i.e., residential population and employments close to the station areas. The goals of TOD are to maximize the railway ridership and land value capture from urban developments near stations, in recognition of strong linkages between public transit and urban development. TOD encourages high human densities near the stations. More people near stations generate more traffic to enable railway operation to provide more frequent services. More frequent services increase convenience in terms of less travel time and, more importantly, less waiting time. More human traffic and better access improve the attractiveness of TOD areas, luring more business investments. The more investments increase the value of the land in the TOD area. The TOD guidelines aim to promote mixed land uses to create more business opportunities, thus bi-directional traffic to improve the operation efficiency of trains.

While preserving the framework provided by "the Decision No. 1259/QĐ-TTG dated 26/7/2011 by Prime Minister approving Hanoi general construction master plan up to 2030 and vision to 2050" the JICA Study Team concludes that TOD approach will necessitate the modifications of lower level land use plans.

TOD/LVC Areas

The areas of potential LVC areas by the station are tabulated, as shown in Table 6. A total area of 294 ha is identified. There are twice more areas in the west than in the east. The main reason behind this skewed proportion is because the existing investment licensing issued are largely concentrated on the eastern side of the Vo Nguyen Giap Road.

Table 6. LVC Area Estimated at Each Station

Unit: ha

Station	West	East	Total
N2	1	4	5
N3	62	6	68
N4	96	30	126
N5	10	21	30
N6	32	29	62
N7	0.3	0	1
N8	0.5	0	1
N9	0.8	0.8	2
Total	203	91	294

Source: The JICA Study Team

Population and Employment

The population and employment projection in LVC areas for the target year of 2050 are shown in Table 7.

Table 7. Population and Employment Projection of LVC Areas (Target Year: 2050)

Station	West				East				Total		
	Resi -dent	Office Worker	Service Worker	Student	Resi -dent	Office Worker	Service Worker	Student	Resi -dents	Workers	Student
N2	0	900	700	0	0	1,300	900	0	0	3,700	0
N3	35,300	3,400	1,000	3,500	4,100	2,400	600	400	39,400	7,400	3,900
N4	44,500	25,700	6,900	4,500	7,400	3,200	1,200	700	51,900	37,000	5,200
N5	6,600	12,700	2,800	700	17,200	19,100	5,100	1,700	23,800	39,600	2,400
N6	24,700	11,400	3,700	2,500	0	0	0	0	24,700	15,000	2,500
N7	500	900	200	0	0	0	0	0	500	1,100	0
N8	800	1,600	400	100	0	0	0	0	800	1,900	100
N9	300	400	100	0	300	400	100	0	0	0	0
Total	112,700	57,000	15,800	11,300	29,000	26,400	7,900	2,800	141,100	105,700	14,100

Source: The JICA Study Team

Investment

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

Railway Project Implementation Total Cost (Option 2: Bridge Case)

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

TOD/LVC Infrastructure

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

Financial Evaluation

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

Financing Plans For Railway Project

Vietnam has implemented many PPPs in energy, transport, water/sewerage, a total of 117 projects during the period of 1994 through 2018, according to the PPIAF Database of World Bank. The PPP projects under transportation are comprised of 10 port projects, 2 road projects, and 1 airport. There has been no railway project so far.

There is no PPP law in Vietnam. The current implementation is based on a decree on PPP which has some major drawbacks such as 1) guarantee for foreign exchange of the local currency based profits, 2) the government limitation on expenditure beyond the five year mid-term planning horizon, 3) arbitration rules, 4) termination conditions etc.

In the negotiation with the foreign investors and the preparation of the contract, a PPP financing must incorporate detailed provisions to the risks and costs at the time of various contingencies during the operation phase. Lack of experience on urban railways will become a major impediment for PPP.

The Vietnamese government is quite proficient with the process of ODA loans and thus will not require special provisions in risk and cost sharing against all the possible contingencies during the financing contract negotiations. The JICA Study Team estimates that the overall implantation period by PPP financing will require at least additional three years compared to ODA financing due to lack of PPP experience in railway projects. The ODA loan provides the best financial conditions that are available for infrastructure project construction with low interest, long grace and repayment periods. The JICA Study Team recommends that the ODA loan is more suited to the financing of the Line 2.3, which has a low financial but much higher economic returns on investment. In any case, the project needs an approval by the National Assembly to proceed to the next stage of implementation.

Environmental Impact Evaluation

The JICA Study Team undertook a preliminary environmental evaluation and proposes a scoping of EIA to be conducted for both bridge and tunnel alignment options since the most serious impact is the need for resettlement by the bridge option.

Project Implementation

Hanoi Metropolitan Railway Management Board (MRB) will be responsible for project implementation and official coordination with line departments and Hanoi PC. Project management will be carried out by the project implementation unit jointly formed by MRB and the consultant hired by MRB.

For the full implementation of TOD, ideally speaking, a unified office to ensure the synchronicity and synergy of urban and transit developments along the corridor should handle the implementation of both urban development and railway development. A legal framework to support the TOD implementation will expedite the planning and implementation process by legitimizing the integrated TOD implementation as a public consensus.

Way Forward

The project needs an approval by the National Assembly to proceed to the next stage of implementation. MRB has commissioned a local consultant to review and incorporate this Study to finalize the pre-feasibility study for the Hanoi URMT Line Phase 3 with the target completion date of June 2020 for the submission to the National Assembly in the second half of 2020.

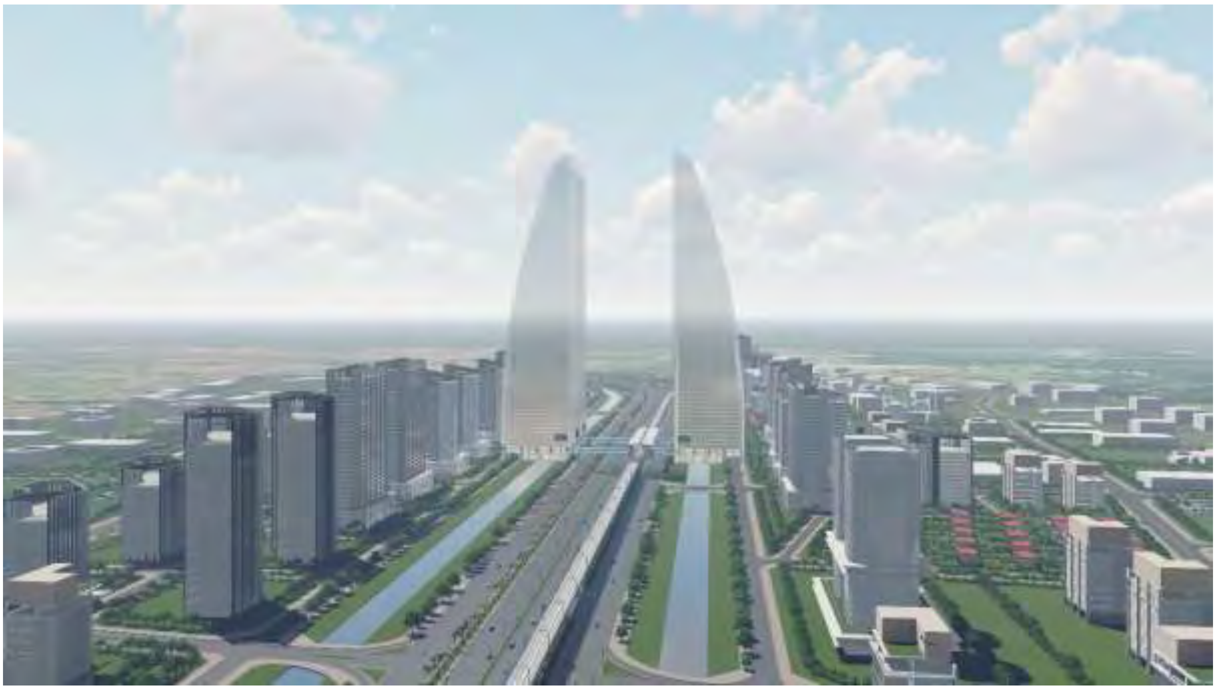


Figure 6. Bird's Eye View of Line 2.3 N5 Station

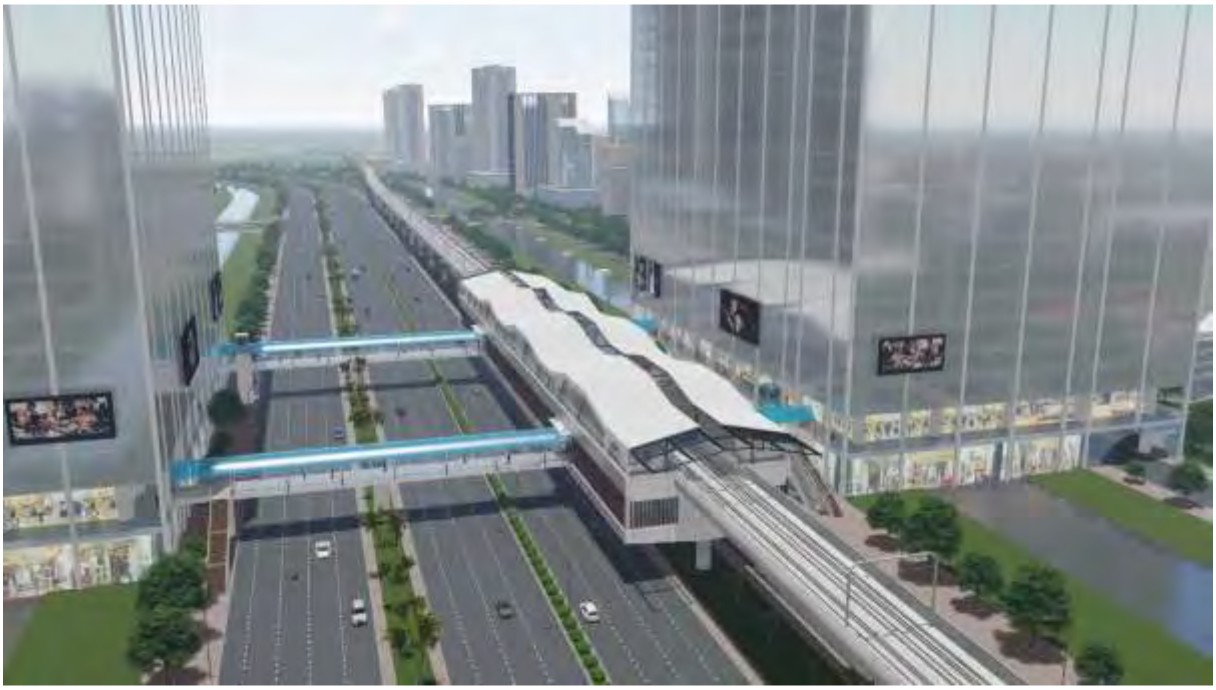


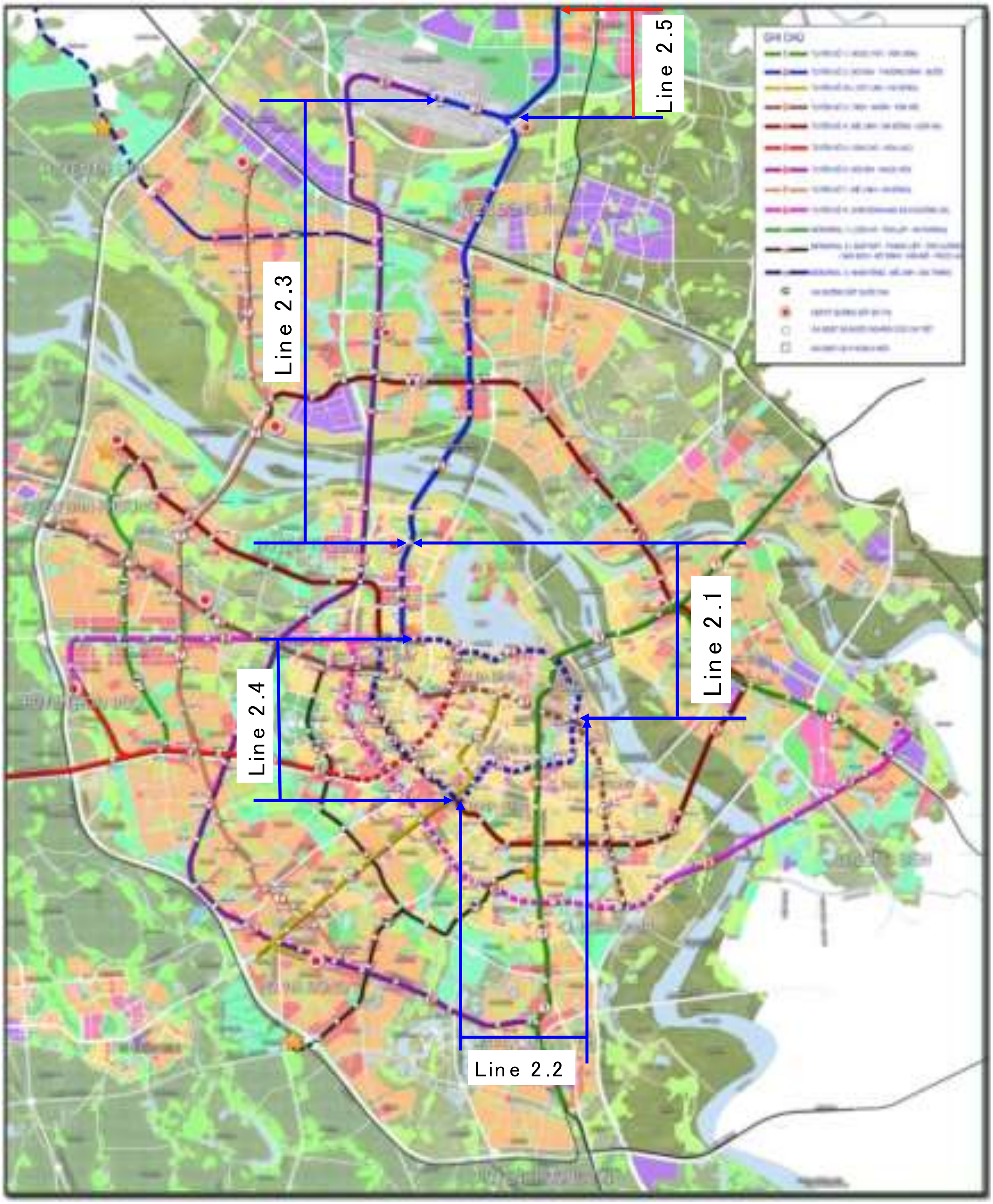
Figure 7. Line 2.3 Station N5 Image

Figure 8. Line 2.3 TOD Area Street View

1. General Background

In recent years, the city's road traffic infrastructure has been heavily invested, but traffic congestion still occurs on many roads, especially during peak hours. Experiences in other countries show that, in order to solve the problem of traffic in densely populated big cities like Hanoi, the optimal solution is to develop the public transport network, especially using medium and large transport vehicles such as subway, sky train, and monorail. The study and planning of a mass transit network have been considered right from the 80s of the 20th century in approved plans under Decision No.108/QD-TTg, Decision 90 /QD-TTg. After expanding the administrative boundary according to Resolution No.15/2008/NQ-QH12, the plans such as the Hanoi General Construction Plan until 2030 with a vision to 2050 and Detailed Plan of Hanoi Railway Hub Area and Hanoi Capital Transport Master Plan by 2030 with a vision to 2050 approved by the Prime Minister, also clearly show the public transport network. The Decision No.519/QD-TTg dated March 31, 2016, approving the Hanoi Transport Master Plan says "to build new urban railway lines connecting the core city with satellite cities, eight urban railway lines will be built for the core city in different stages to develop public services facilities along with the development of urban railway stations".

As one of eight UMRT lines in the core city, the UMRT Line 2 is planned to connect Noi Bai International Airport with the City's center. By completion, in addition to serving the travel needs of the people of the Capital, the Line 2 will also transport passengers between Hanoi and Noi Bai International Airport, that can contribute to improving the City's transport network and reducing traffic congestion in the City up to now, the City Government has allowed studying for investment in two sections of Line 2 Phase 3, i.e., Nam Thang Long – Noi Bai International Airport (NBIA) Section（(hereafter Line 2.3)）and Tran Hung Dao - Thuong Dinh Section (Phase 2, hereafter Line 2.2) . While Line 2 Phase 1, i.e., Nam Thang Long – Tran Hung Dao Section (hereafter Line 2.1) has completed the preparation of the detail designs and bid documents, the remaining sections of Line 2 are still in the planning stage. All the phased sections of Line 2 are shown in Figure 1-1.



Source: Hanoi Transport Master Plan (Decision 519/QD-TTg)

Figure 1-1. Alignment of Metro Line 2, Nam Thang Long - Noi Bai Section

To improve the connectivity between the City center and Noi Bai International Airport, Hanoi City has allowed studying for investment in Line 2.3 (Nam Thang Long - Noi Bai section). After construction completion, together with other sections of Line 2 and other Lines, the urban railway transport will be one of the major transport modes for connecting the City to Noi Bai International Airport.

2. Background and Objective of the Study

2.1 Background of the Study

From November 2017 to May 2018, Ministry of Economy, Trade and Industry of Japan (METI) assisted Hanoi People's Committee (HPC) with the study on the promotion of urban railway development in Hanoi with three major objectives as follows:

- To share successful experiences and examples of urban railway development in Japan with the City of Hanoi as useful references in handling various issues including acceleration of construction progress and cost reduction for urban railway projects in Hanoi.
- To identify priorities of the planned urban railway projects in Hanoi.
- To propose a TOD (Transit Oriented Development) model and PPP (Public Private Partnership) scheme for one urban railway in Hanoi.

Based on the recommendation under the METI study, Hanoi Metro Line 2.3 (Nam Thang Long-Noi Bai Section) was selected as the first priority for development, and the agreement between HPC and Japan International Cooperation Agency (JICA), "Data Collection Survey for Hanoi Metro Line 2 Extension North (Line 2.3)" financed by JICA was commenced in late June 2018. The Study Team dispatched by JICA (hereinafter called the JICA Study Team) includes experts from ExeIdea Ltd., Tokyo Metro Co., Ltd., Oriental Consultants Global Co., Ltd., Almec VPI Corporation and Creative Research and Planning Co., Ltd. In the Hanoi side, Hanoi Metropolitan Railway Management Board (MRB) was assigned by HPC (in its Official Letter No.3932/UBND-KH&DT) as the counterpart to coordinate with the JICA Study Team in the course of the Study.

On May 7, 2019, the Hanoi People's Committee issued Decision No. 2251 / QD-UBND approving the Technical Assistance Project document " Data Collection Survey for Hanoi Metro Line 2 Extension North, Nam Thang Long – Noi Bai section" supported by JICA.

2.2 Objective of the Study

The objective of the Study is to collect necessary data for further study on relevant issues of Line 2.3 and to design financing schemes recommended in the above METI study. The outputs of the JICA Study shall be the input data for HPC to prepare a pre-feasibility study of the project.

2.3 Necessity of the Project

- In recent years, the annual economic growth of Hanoi capital was more than 8%. By merging with some neighboring areas in 2008, the City's area has increased about 3.6 times. According to statistic data in 2015, the population of Hanoi was about 7,588 million; such a population creates a burden to the City's inadequate transport system. By 2050 the population of Hanoi is projected to be 10.8 million as maximum. In response to the projected situation, Hanoi will be developed as a large-scale international city, which will be a big political, cultural, scientific, educational, economic and foreign trade center.
- The Line 2.3 connects to the section of Line 2 which runs between Tran Hung Dao (C10) and

Nam Thang Long (C1), and extend the line to the Noi Bai International Airport. The Line 2.1 is a key route and has significant implications on sustainable development of the future urban areas of Hanoi. The Line 2.1 will provide massive transport capacity between Nam Thang Long Urban Area, Old Quarter (a thriving tourist area), French Quarter, the central administration areas, all of which are developing rapidly and attracting ever increasing number of visitors. Moreover, the Line 2.1 will traverse the city center to provide direct linkages with other UMRT lines including Line 1, Line 3 and Line 5. The Line 2.3 will further the extend the Line 2 to the north of the Red River to constitute a new urban development corridor in the north to the international airport while providing connections to UMRT Line 4 and Line 6.

- In the surrounding areas of the city center, five satellite cities will be built; they are Hoa Lac, Son Tay, Xuan Mai, Phu Xuyen and Soc Son developments. These satellite cities will include urban functions, such as residential, education and training, industrial, and service area. An estimated population of 5 satellite cities in 2030 is 1.3–1.4 million peoples, while a total land area to be developed is 35,200 ha.
- Noi Bai International Airport is an important traffic gateway of the country in general and Hanoi city in particular. According to preliminary statistics in 2018, the airport throughput reached nearly 27 million, surpassing the design capacity of the current two passenger terminals T1 and T2. As planned, the maximum capacity of NBIA is 100 million in the future. Thus, with the rapid increase in passenger traffic of NBIA, it is necessary to study additional forms of passenger transport from the airport to the city center and vice versa.
- The urban railway Line 2.3 (Nam Thang Long – NBIA) will improve passenger transport services and reduce commuting times between the Hanoi center and the north of Ha Noi area, especially from NBIA and planned developments along railway alignment. All the more, the operation of Line 2.3 will help to reduce traffic congestion and other environmental issues, and at the same time, it will contribute to the development of the Hanoi urban railway network in conformity of the approved transport master plan and will improve connectivity and convenience in passenger transfer.
- Along with economic growth and population increase, transport demand also rapidly increases. At present, the major commuting means are motorbikes, buses, taxi and bicycles. Among them the public transport means are only buses and taxis. To solve the traffic issues in Hanoi, a mass transit system, which is environmentally friendly, should be developed as soon as possible. Together with a short-term countermeasure, i.e., using existing transport structures, the city of Hanoi should have a medium and long term urban development plan, which includes the development of an urban railway network.
- In such a context, in order to improve transport network as planned and to meet with regional development as well as the future transport development demand, considering the financial abilities of Hanoi City, the prioritization of the Line 2.3 (Nam Thang Long – Noi Bai

International Airport) is a necessity and good policy.

3. Legal Basis

- Decision No. 1259/QĐ-TTG dated 26/7/2011 by Prime Minister approving Hanoi General Construction Master Plan up to 2030 and Vision to 2050.
- Decision No. 519/QĐ-TTg dated 31/3/2016 by Prime Minister approving Hanoi Transport Master Plan up to 2030 and Vision to 2050.
- Decisions Nos. 2269/QĐ-UBND dated 25/5/2012; 2270/QĐ-UBND dated 25/5/2012; 2271/QĐ-UBND dated 25/5/2012; 06/QĐ-UBND dated 5/1/2015; 6620/QĐ-UBND dated 2/12/2015; 6632/QĐ-UBND dated 02/12/2015 by HPC approving the zoning plan of N5, N7, N8, GN, GN(C) and H2-1 in Dong Anh and Soc Son rural districts and Tay Ho urban district of Hanoi where the project alignment runs through.
- Decision No. 6630/QĐ-UBND dated 02/12/2015 by HPC approving detailed master plan (1/500) along two sides of Nhat Tan- Noi Bai Road including sections 1, 2 and 3 (Vo Nguyen Giap Road) in Dong Anh and Soc Son Districts.
- Decision No. 590/2008/QĐ-TTg dated 20/5/2008 by Prime Minister approving the adjusted master plan of Noi Bai International Airport (NBIA) up to 2020 and orientation after 2020.
- Decision No. 2967/QĐ-UBND dated 29/6/2015 by HPC approving Soc Son District General Construction Plan (1/10.000).
- Memorandum of Understanding between Hanoi People's Committee and JICA
- Decision No. 2251 / QD-UBND dated 7/5/2019 by HPC approving the Technical Assistance Project document "Data Collection Survey for Hanoi Metro Line 2 Extension North, Nam Thang Long – Noi Bai section” is sponsored by JICA.

4. Scope and Scale of the Project

4.1 Scope of Project

Scope of the Data Collection Study for Hanoi Metro Line 2, Nam Thang Long- Noi Bai Section (hereinafter referred as Line 2.3) is as follows:

- Starting point: Ciputra, connection Station C1 of Hanoi Metro Line 2, Nam Thang Long- Tran Hung Dao Section (hereinafter referred as Line 2.1);
- Ending point: at N0 Station, connection with passenger terminals T2 of Noi Bai International Airport;
- Location: Tay Ho, Dong Anh, and Soc Son Districts of Ha Noi;
- Length: About 19.65km with a depot in Phu Lo Commune of Soc Son District.

Source: The JICA Study Team

Figure 4-1. Study Area for Metro Line 2, Nam Thang Long- Noi Bai Section

4.2 Scale of the Project

The scale of Hanoi Metro Line 2, Nam Thang Long- Noi Bai Section shall be determined based on the principle to ensure the synchronicity with the ongoing Line 2.1 project. Accordingly, the planning and design parameters of the project are as follows:

- Track: Double track
- Gauge: 1435mm (standard)
- Max design speed for trains: 120km/h
- Operation speed: 110km/h(90km/h in curve)
- Axial load: 16T/axel
- Max gradient on operation tracks: 35 ‰
- Min radius of horizontal curve: 300m
- Min radius of vertical curve: 3,000m
- Traction power: 1,500v-DC, overhead catenary system
- Rail: 60kg/m

"Decision No. 6935/QD-UBND dated 15 November 2013 of Hanoi People's Committee on additional approval of technical standards applicable for Hanoi City Urban Railway Construction Project, Line 2: Nam Thang Long – Tran Hung Dao section" has specified all the design parameter of Line 2.

5. Input Data for the Study

5.1 Summary of discussions with relevant departments under HPC

During the study with MRB supports, the JICA Study Team had meetings with Hanoi Department of Planning and Architecture (DPA) on 16th October 2018 and Hanoi Urban Planning Institute (HUPI) on 17th October 2018 and was provided with updated information on the development projects along two sides of Nhat Tan- Noi Bai Road and land use plan of the area planned for depot in Soc Son District.

On 26th October 2018, the JICA Study Team had a meeting with Civil Aviation Authority of Vietnam (CAAV) and was provided with information on the development plan of Noi Bai International Airport (NBIA). CAAV confirmed that Noi Bai International Airport development plan was approved under Decision No. 590/2008/QD-TTg dated 20/5/2008 by Prime Minister as the official document to follow. Accordingly, the section of Line 2.3 inside NBIA shall be underground and two underground stations shall be arranged corresponding to the locations of passenger terminals T1 and T2.

On 31st November 2018, the JICA Study Team had a meeting with Dyke Management and Flood Prevention Office under Hanoi Department of Agriculture and Rural Development (DARD) and was provided with information on the existing dyke conditions, dyke plan, dyke protection corridor and flood discharge plan of the Red River. The JICA Study Team also received their preliminary comments on the bridge and tunnel options for the Red River crossing.

On 24th January 2019, 9th May 2019, the JICA Study Team had meeting with DPA and relevant department under HPC to get the comments on alignment, station location and TOD area.

On 21st October 2019, the Hanoi People's Committee held a meeting to review the alignment, station location of Line 2.3 and announced the conclusion of Chairman of the City People's Committee Nguyen Duc Chung at the meeting on the alignment, station location and TOD area of Line 2.3 (Notice No. 1271 / TB-UBND dated October 28, 2019).

On 17th January 2020, the Hanoi People's Committee held a second meeting to review the alignment and station location of Line 2.3 and announced the conclusions of Chairman of the City People's Committee Nguyen Duc Chung at the meeting on the alignment, station location and TOD area of Line 2.3 (Notice No. 84 / TB-UBND dated February 4, 2020).

Apart from the discussions above, the JICA Study Team referred to the Data Collection Survey on Railway for Main Urban areas of Vietnam (METROS) by JICA in 2016. Also the JICA Study Team attended the meetings of the study of adjusting the Noi Bai Airport Planning by the French consultancy ADPi since October 2019.

5.2 Natural Conditions

5.2.1 Topographic Conditions

The Hanoi's terrain is gradually lower from the north to the south and from the west to the east, with an average height ranging from 5 to 20 meters above the sea level. The hills and mountainous zones are located in the northern and western parts of the city. Thanks to alluvial deposits, three-quarters of Hanoi's natural area is plain, located on the right bank of the Da River, on both sides of the Red River and tributaries of other rivers. Most of the hills and mountains belong to Soc Son, Ba Vi, Quoc Oai and My Duc Districts, with high peaks such as Ba Vi (1,281 m), Gia De (707 m), Chan Chim (462 m), Thanh Lanh (427 m) and Thien Tru (378 m).

Within the project area, the alignment mainly runs through fields, wetland, ornamental planting area and land area for traffic.

- Km0 + 000 - Km1 + 300: the terrain is relatively flat, the alignment mainly goes through ornamental planting areas and under-construction urban areas with quite convenient traffic conditions.
- Km1 + 300 - Km1 + 700: this section passes through residential areas in Phu Thuong Commune, Tay Ho District, the terrain is obstructed by a flood protection dyke, with quite convenient traffic conditions.
- Km1 + 700 - Km3 + 500: the alignment crosses the Red River and alluviation plain.
- Km3 + 500 - Km7 + 900: the alignment mainly goes through the Red River flood plain, rice fields, and farm fields and fish ponds.
- Km7 + 900 - Km20 + 000: the alignment runs along Vo Nguyen Giap Street, flat terrain, with quite convenient traffic conditions.

5.2.2 Geological Conditions

The terrain on the two sides of the bank is divided by local roads, irrigation canals, fish ponds and lakes. The terrain always changes due to the impact of natural and human activities. The terrain was formed of quaternary sediments including clay, sandy clay, clayed sand and sand.

The planned construction area is located in the north of Hanoi City. Sediments in this area include clay, silt, clayed sand, gravel and pebbles. Distribution of sediments by depth is as follows: soft soil, top soil, hard plastic clay/semi-hard plastic clay or dense sand/gravel and gravel layer located at a depth of above 30m. According to the geological map of Hanoi with scale 1/200,000, the geological characteristics of the planned area include the following main layers:

- Middle and Upper Pleistocene, Hanoi formation (aQ1^{2-3} hn)

Includes river sediments: gravels, yellow and white gray sand. This formation is found at a depth of 17.0m to 45.0m.

- Upper Pleistocene, Vinh Phuc formation (Q1^{3b} vp)

River sediments (Q1^{3b} vp): distributed at the edge of plain in Vinh Yen, Hiep Hoa, Me Linh, Soc Son, North Dong Anh, Thach That and Viet Tri. In the lower plains, river sediment is found at a depth of 20m to 40m. Sediments comprise gravel, silt, clay (patchy colored clay) with a thickness of

6.2m to 38m.

- Lower - middle Holocene, Hai Hung formation ($Q2^{1-2}$ hh)

Lake-marsh sediments (lb $Q2^{1-2}$ hh): formed before Flandri marine transgression. Sediments are distributed in the edge of the plain (Ba Vi, Yen Lang, Binh Xuyen, Hiep Hoa, Yen Phong), comprising: dark gray silty clay, dark gray with plant relicts, lignite lens with a general thickness of 13.5m.

- Upper Holocene, Thai Binh formation (Q_2^3 tb)

River/lake/swamp sediments (alb Q_2^3 tb): small areas in Van Tri, Uy No (Dong Anh), My Duc (Ha Tay), comprising silt, clay contaminated by a lot of plant relicts, lignite can be found in some places such as Che Me, Co Rua (lower depth), and at the upper part, woody plants and marsh grasses are growing while the plant decomposition into lignite is still ongoing.

5.2.3 Climate Conditions

- The climate of Hanoi is characterized by a tropical monsoon climate, with two main seasons in the year: hot and cold seasons. The hot season is from April to October, characterized by hot and humid and heavy rain, with the prevailing wind in the Southeast. During the hot season there are often thunderstorms. The months with the highest temperature in the year are June and July, and the month with the highest average rainfall is July. Therefore, the hot season and rainy season usually overlap.
- The cold season in Hanoi starts in November and usually ends in March. During this season, the climate in Hanoi is relatively cold and dry and the weather is less rainy. January is the month with the lowest average temperature and also has the lowest average rainfall of the year. The prevailing wind direction is northeast.
- April and October are considered transitional months, giving Hanoi four seasons: spring, summer, autumn and winter.
- The project area is located in the Northern Delta climate zone. The climate here shows all the characteristics of the regional climate: Winter is relatively dry in the first period and the second half is wet and rainy. However, regarding the low and flat terrain, the Northern Delta climate has specific features to other regions. The regional climatic conditions are analyzed as follows:
  + The annual average temperature is about 23°C. During three months of the year, an average temperature is below 20°C (from December to February). The coldest month is January with an average temperature of 16.4°C. The absolute lowest temperature observed in Hanoi is 2.7°C. Except for 2 to 3 months during the transition period, during the remaining five months from May to September, an average temperature exceeds 27°C. Two hottest months are June and July. The absolute maximum temperature observed is 42.8°C. An average temperature fluctuation between day time and night time is about 6.0°C. The largest temperature fluctuation occurs

during dry months in early winter, while the smallest fluctuation appears in the wet months at the end of winter.

+ The rainfall is quite evenly distributed, the average annual rainfall is 1,611mm with the average number of rainy days is 152 days. The rainy season lasts for six months, from May to October. Eighty-five percent of the annual rainfall is concentrated in the rainy season. Rainfall increases gradually from the beginning of the season to the middle of the season, reaching a maximum in July and August with an average rainfall of about 300mm. June and September also have an average rainfall of approximately 230mm. The remaining six months, from November to April, belong to the rainy season. The first months of winter are the least rainy period. On average, only 9 - 11 days of small rain are observed. The month with minimum rainfall is December, with 20mm rainfall and six rainy days. The second half of winter is a period of wet drizzle; although the rainfall does not increase much compared to the beginning of winter, the number of rainy days is significantly higher (10-15 days per month).
+ The annual average humidity is 82%. The wettest period is the last three months of winter (February, March and April), the average humidity reaches 84 - 86%. The driest period is the first three months of winter (November, December and January), in which December has the lowest humidity with an average of 80.9%.
+ The annual average number of hours of sunshine is about 1,500 – 1,600 hours. In general, it is sunny during the summer, with more than 150 hours of sunshine each month. The sunniest month is July with average sunshine hours of about 195.

5.2.4 Hydrological Conditions

Along the alignment of Line 2.3, it can be divided into sections with different hydrological regimes as follows:

- Km0 + 000 - km1 + 800: the section has an urban hydrological regime, which totally depends on short-term rain regime and urban drainage planning as well as the City's infrastructure planning.
- Km1 + 800 - km4 + 700, crossing the 2 Red River dykes: the section has the general characteristics of the Red River hydrological regime:
  + In addition to the effect of rain conditions, the hydrological regime of the Red River in the area that Line 2.3 runs through is also affected by the flood control operation of the upstream reservoir system, such as Hoa Binh, Son La and Lai Chau reservoirs on Da River; Na Hang and Thac Ba Reservoirs on Lo River. Flood season is from June to October; the highest flood is usually observed in August. With confluences in Viet Tri, floodwaters of the entire Red River system in the midland and mountainous areas flow to the delta area, where the terrain is low and the river bed is narrowed due to the surrounding dikes, therefore water levels and discharge at Viet Tri – Ha Noi section drastically and quickly change with extremely high flood. High floods on the Red River were observed in 1945, 1969, 1971, 1996, 2002 and 2008.
  + The Red River section, running through Hanoi is protected with dykes on both sides, of which the right dyke is special-grade dyke and the left dyke is grade-I dyke. As planned, water levels of the Red River in Hanoi is controlled at the height of 13.40m.

- Section from km4 + 700 to the end of the Line (Noi Bai International Airport): has on-farm hydrological regime:
  + The terrain is relatively flat, gradually lowering from North to South. The alignment crosses the Thiep River and Ca Lo River; those are two major drainage rivers for the whole area. Flood regime largely depends on seasonal rain conditions, in general, the month with high flood often appears coinciding with the month with heavy rainfall in the year, usually in August – October.

5.3 Existing Socio-economic Conditions and Orientation of Hanoi General Construction Plan up to 2030 and Vision to 2050

5.3.1 Existing economic conditions

- In recent years, the economy of Hanoi has developed rapidly, with the modernization and efficiency improvement of the economic structure, the total GDP of Hanoi ranks second next to Ho Chi Minh City.
- On average from 2009 to 2013, the economic growth rate reached 9.4%/year; in which the growth rate of agriculture, forestry and fishery increased by 2.9%/year, industry and construction increased by 9.4%/year and services increased by 10.1%/year.
- In 2016, the total GRDP (Gross Regional Domestic Product) of Hanoi City was estimated at VND 478.9 trillion, equivalent to about USD 21.10 billion. Per capita income in 2016 reached nearly 3,100 USD/person. Compared to 2015, the economic growth rate increased by 8.2%; investment in the area increased by 10%, Industry-construction by 9%, Services by 8.3%, Agriculture, forestry and fishery by 2.21%. The number of tourists coming to Hanoi is over 12 million, increasing by 7.5%. The consumer price index (CPI) increased by + 3%. In terms of urban construction and management, the progress of urban development in Hanoi is the fastest in the country. A series of housing development projects, especially condominiums, was completed and they are opened for sale, contributing to the growth of the construction industry. Their value-added the construction sector increased by 13.8%. Comparing with other regions in the country, GRDP of Hanoi accounts for 60% of Ho Chi Minh City and 12% of the whole country.

5.3.2 Existing Population and Labor Conditions

➢ **Population**

- According to the Hanoi Statistical Office, the average population in Hanoi in 2019 is estimated at 8,093,900 people, an increase of 2.3% compared with 2018, of which the urban population is 3,982,100 people, accounting for 49.2% of the total population and increasing by 2.0%; rural population 4,111,800 people, accounting for 50.8% and increasing by 2.5%.
- The population is unevenly distributed, basically concentrated in urban districts. The average population density is 2,169 persons / km^2, while in urban districts it is 21,945 persons / km^2. In the areas, which UMRT Line 2.3 is planned to run through, the population density is as follows:

Tay Ho (6,364 persons / km^2), Dong Anh (2,058 persons / km^2) and Soc Son (1,033 persons / km^2). The speed of urbanization is relatively fast. In 2013 the urban population accounted for about 41% (nearly 3.02 million people) and the rural population accounted for 59% (approximately 4.2 million people).

- In rural areas, population fluctuations are mainly due to migration flows to urban areas for livelihood or study. The trend of migration from newly merged provinces to Hanoi is significant, especially from the Red River Delta, which accounts for 70% of the total immigrants to Hanoi. Most of the immigrants settle in suburban areas and go to work in the inner cities.

➢ **Labor**

- The population of the working-age of Hanoi in both urban and rural areas is about 4.3 million, accounting for over 67% of the total population. The proportion of the young population is high, especially those who are trained and at the age of 20-25. They are great human resources, facilitating economic growth for Hanoi. In the economic sector, the working population in the public sector accounts for 15.4%, that in the private sector for 78.7%, and that in the foreign-invested sector for 5.9%.

5.3.3 Orientation of Hanoi General Construction Plan up to 2030 and Vision to 2050

According to the Decision No.1259 / QD-TTg, dated July 26, 2011 of the Prime Minister approving the General Construction Plan of Hanoi Capital up to 2030 with a vision to 2050:

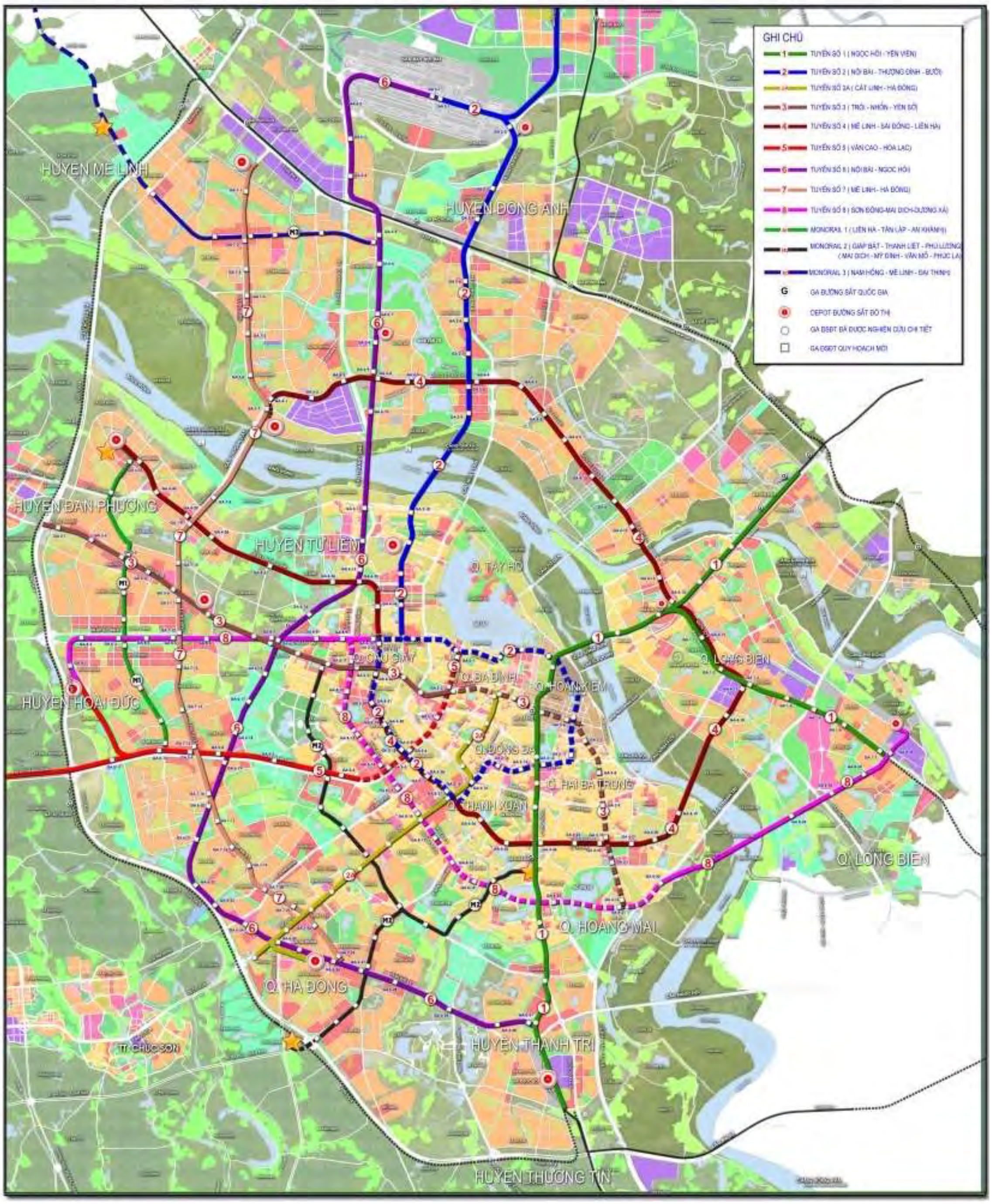
- With respect to the model of urban spatial development, Hanoi capital aims to develop the model of the urban cluster including the central urban area and the five satellite towns, connected by transport belt system with radial axes, which links with regional and national transport networks. The urban center is separated from satellite towns by a green corridor (accounting for 70% of the city's natural land area);

- The central city with urban areas will be developed from the inner city to the Ring Road 4 in South and West and to Me Linh and Dong Anh in the North and Gia Lam and Long Bien in the East. It is a high-quality administrative, economic, cultural, historical, service, medical and training center of Hanoi and the whole country. It is forecasted that population by 2020 will reach about 3.7 million people; urban developable land will be about 45,300 ha and civil land will be about 26,000 ha. The population by 2030 will reach about 4.6 million people; urban construction land will be about 55,200 ha; population density of the area to be extended toward the South of the Red River will be around 90-95m2/person and population density toward the North of the Red River will be around 75-90 m^2/person;

- Each of five satellite urban towns, Hoa Lac, Son Tay, Xuan Mai, Phu Xuyen and Soc Son Towns, has its functions, operating relatively independently to supplement and share with the central city. The population of each urban town is expected to reach 0.7 million by 2020. The plan is to arrange about 24,300ha for urban construction and about 6,300ha for residential land with a space of about 90m2 / person. In 2030, the population of each town will be about 1.3-1.4 million, urban construction land will be about 35,200 ha. Hoa Lac town has the main function of science and technology and training. Son Tay urban area is a historical and cultural city, and a tourist resort. Xuan Mai Town is a service-industrial city supporting the development of handicrafts and craft villages; the development of cottage industries and service centers for trade and training of universities and colleges. Phu Xuyen Town is an industrial city, a transport hub and goods transshipment. Soc Son Town is for aviation industry and services, and eco-tourism;

- Development orientation for rural development as model of "new countryside": focusing on rural transport development; preserving traditional occupations and religious and historical relics; establishing high-tech agricultural zones (areas of high-yield rice and clean vegetable production with advanced technologies); maintaining and expanding traditional vegetable and fruit growing areas, and concentrated breeding areas;

- Development orientation for green space and water area: green belt along Nhue River as well as green corridors in rural areas, river and lake system, natural hills and forests, agricultural areas and urban park systems. In the inner city. A priority is given to new parks and flower gardens such as Co Loa Historical Park, West Lake Entertainment Culture Park, Zoo, Thong Nhat Park, Yen So Garden, and Me Tri Garden to preserve and restore the system of rivers, lakes and swamps to balance the ecological environment.



Source: Hanoi Transport Master Plan (Decision 519/QD-TTg)

Figure 5-1. Planned Urban Railway System of Hanoi

- **Urban railway in the central area:**

- Line 1: consists of 02 branches: Ngoc Hoi - Hanoi Central Station - Gia Lam - Yen Vien and Gia Lam - Duong Xa (Phu Thuy). The elevated route combines the urban railway with the National Railway. The length of the route is about 36 km and the total number of stations is arranged with 23 stations and 2 depots in Ngoc Hoi and Yen Vien;

- Line 2: Noi Bai - Nam Thang Long - Hoang Hoa Tham - Bo Ho - Hang Bai - Dai Co Viet - Thuong Dinh - Belt 2.5 - Hoang Quoc Viet with a length of about 42 km, the route going to elevated from Noih Bai - Hoang Quoc Viet street and go underground on the remaining section with a total of 32 stations and two depots at Xuan Dinh and Phu Lo. This route is organized to run a combination radial belt train;

- Line 2A: Cat Linh - Nga Tu So - Ha Dong with a length of about 14 km, the route goes overhead with a total of 12 stations and one depot at Yen Nghia;
- Line 3: Troi - Nhon - Hanoi - Hoang Mai Station with a length of about 26 km, the route goes high on the Troi - Cau Giay section and mainly goes underground on the remaining section with a total of 26 stations. Line 2.1 builds the section from Nhon - Hanoi Station with 12 stations and one depot in Nhon;
- Line 4: Me Linh - Dong Anh - Sai Dong - Vinh Tuy - Ring Road 2.5 - Co Nhue - Lien Ha with a length of about 54 km. The section from Me Linh - Dong Anh - Sai Dong - crossing the Red River - Vinh Tuy - Thuong Dinh is planned to go high, the section from Thuong Dinh - Hoang Quoc Viet is planned to go underground and the section from Hoang Quoc Viet - Lien Ha is planned to go high. The total number of stations on the route is 41 and two depots in Lien Ha (Dan Phuong) and Dai Mach (Dong Anh). Line 4 connects with Lines 1, 2A, 3 and 5. The section along the Highway No.5 of Line 4 connects to the Line 2 and organizes proper train operation.
- Line 5: Duong Van Cao - Ngoc Khanh - Thang Long Boulevard - Belt 4 - Hoa Lac with a length of about 39 km. The section from South Ho Tay - Nguyen Chi Thanh - Tran Duy Hung - National Convention Center goes underground and the next section goes on the ground or goes high within the median strip of Thang Long Boulevard. The total number of stations on line 17 and two depots in Son Dong (Hoai Duc) and Hoa Lac;
- Line 6: Noi Bai - Phu Dien - Ha Dong - Ngoc Hoi with a length of about 43 km. The route is built based on the existing western ring railway and is planned to be high or equal to the total of 29 stations and two depots in Ngoc Hoi and Kim No;
- Line 7: Me Linh - Nhon - Van Canh - Duong Noi new town with a length of about 28 km, a high or all-high route combined underground in the urban area of East Belt 4, with the total of 23 stations and one depot in Me Linh;
- Line 8: Son Dong - Mai Dich (transshipment with line 2) - Ring 3 - Linh Nam - Duong Xa with a length of about 37 km. The section from Son Dong - Mai is planned to go high, the route follows the Ring Road 3 to Linh Nam underground and the section from Linh Nam - across the Red - Duong Xa River goes high. The total number of stations o Line 26 and two depots in Son Dong and Co Bi. On the route, it is possible to use the express bus section depending on the traffic volume of the phases.

➢ ***Connecting central urban areas with satellite towns:***

- Extending line 2 from Noi Bai to Trung Gia in Soc Son, about 9km in length;
- Extend line 2A from Ha Dong to Xuan Mai, about 20 km in length, along National Highway 6,

arrange a depot in Xuan Mai;

- Extend line 3 from Nhon to Son Tay satellite town in the direction of National Highway 32, length of about 30 km, layout a depot in Son Tay;
- Son Tay - Hoa Lac - Xuan Mai route: About 32 km in length, from Son Tay satellite urban area, the route follows National Highway 21 extending to Hoa Lac and Xuan Mai satellite towns;
- Monorail lines: Planning some monorail lines to support and better exploit the entire urban railway system including (1) Lien Ha - Tan Lap - An Khanh is about 11 km long; (2) Mai Dich - My Dinh - Van Mo - Phuc La, Giap Bat - Thanh Liet - Phu Luong is about 22 km long; (3) Nam Hong - Me Linh - Dai Thinh is about 11 km long, can be extended to Phuc Yen.

5.4 Existing Land Use Conditions

- From km0+000 to km1+200, the study alignment runs through Ciputra.
- From km1+200 to km1+800, the study alignment runs through the existing communities of Phu Thuong village, Tay Ho District.
- From km1+800 to km3+600, the study alignment runs across the Red River.
- From km3+600 to km8+000, the study alignment runs through paddy fields of Vinh Ngoc and Van Noi communes, Dong Anh District.
- From km8+000 to Noi Bai Airport, the study alignment runs on the land strip planned for an urban railway along Nhat Tan-Noi Bai Road. There are existing communities of Van Noi, Nguyen Khe communes (Dong Anh District) and Phu Lo commune (Soc Son District).

5.5 Population and Traffic Demand Forecast

5.5.1 Population Forecast

- By 2030, the population of Hanoi is projected to increase to nearly 10 million people and to increase to between 13 and 14 million people by 2050. From now to 2030, the population growth rate is estimated to be less than 2-3%/year and gradually decreased to less than 1.5% in 2030-2050 (1994-2007: 2.4%/year). The general natural growth rate is about 0.8-1%/year. Mechanic growth rate (by changes in administrative boundaries and urban attraction) is 1-2%/year (0.4%/year 2007) for the whole city and 3-4%/year for the urban area. The population of the rural area will decrease to less than 0% to -3% due to the decrease of rural areas and the restriction of immigration from the rural area to the urban area. The population density in the city center (4 districts: Hoan Kiem, Hai Ba Trung, Ba Dinh, Dong Da) will be controlled; the current population density of 33,300 people/km^2 is estimated to, gradually decrease to 23,000 people/km^2 by 2050. The population density of other urban areas will be less than 10,000 people/km^2 by 2050.
- By 2030, the city population is projected to be about 9.4 million people (with 6.4 million people in the urban area, 3 million people in rural areas and an urbanization ratio of 68.8%). The

population distribution in nuclear urban area is about 4.41 million people (with 1.69 million people in inner-city districts in the south of the Red River, 2.72 million people in new development areas in both south and north of Hanoi), 1.77 million people in the five satellite cities and 0.26 million people in the ecological urban area and existing townships.

5.5.2 Traffic Demand Forecast

1) JICA Metros

"Data Collection Survey on Railways in Major Cities (Metros) in Vietnam" by JICA in 2016 undertook a citywide 4 step transport modeling to simulate the traffic demand with different scenarios. The JICA Study Team has reviewed the study as well as the model to provide a basis for the traffic demand forecast of the Line 2.3.

2) TOD Based Forecast

There is a distinct difference in planning for this line 2.3 from others. This line is based on largely green field development with no significant existing population. Therefore, the traffic demands will be generated by the new in-coming population, not by the existing population. When the new metro line is planned for the existing built-up areas, there are sufficient traffics existing from the commuting areas. The critical issue in planning is how to **accurately estimate modal shifts** from other means such as automobiles to railways. For a new green field development, the issue is the other way around. It is a matter of how to **create traffics by applying TOD principles** (please refer to TOD Guideline in Appendix 2.). The future traffics are defined by two factors; the rate of future urbanization within the commuting zones from stations and the degree to which the principles of TOD are enforced in urban planning and development. While these two crucial factors are external factors in ordinary planning, but for a green field TOD project these factors are internal controllable variables. When TOD principles are properly applied at every stage of implementation, those who use the railway will be attracted to the TOD areas; thus no modal shift will be required.

For example, the final TOD/LVC (Land Value Capture) population forecast as shown in the total residential population will be 160 thousand. If we assume 60% of outside commuters and 30% railway share, the commuting traffic will be approximately 30 thousand passengers. This will require around 20 trains, reaching almost the maximum carrying capacity. The traffic demands will depend on how fast urbanization takes place in TOD areas, which is up to urban planning and market absorption of new property development projects. Therefore, the traffic demand is to be created.

5.6 Historical and Cultural Structures to be Preserved Along the Alignment

- Over 1,000 years of development, Hanoi has its unique values of tangible and intangible ancient Thang Long culture and the culture of Hanoi was formed and developed by the succession of dynasties. Besides the intangible cultural values, the lifestyle and customs nurtured by Hanoi people have been handed down from thousands of years to today. Hanoi also maintains a wide range of tangible cultural heritage that needs to be preserved as the historical core city; those include the Old Quarter, the French Quarter, the Duong Lam Ancient Village near the city, the

Thang Long Ancient Citadel, other architectural works including French colonial architectures and typical architectures of the peace period. The typical landscape and ecosystem are urban with many rivers and lakes, and green trees associated with agro-ecological zones.

- All planning solutions for alignment and urban planning are established based on conservation criteria. Along the route, it is necessary to preserve areas of ecological importance, especially the areas along the Red River and Van Tri Lagoon, as well as to avoid historical, cultural or religious works within the alignment and its impacted peripheries.

5.7 Projects and Plans Related to Hanoi Metro Line 2.3

There are following related plans and projects in the study alignment area:

- Line 2.1: Nam Thang Long - Tran Hung Dao. Line 2.3 connects Line 2.1 at Station C1- Nam Thang Long.
- Line 4: Me Linh - Dong Anh – Sai Dong - Vinh Tuy - Ring Road 2,5 - Co Nhue - Lien Ha. Line 4 intersects Line 2.3 in the area of intersection with NH5.
- Line 6: Noi Bai - Phu Dien - Ha Dong - Ngoc Hoi. Line 2.3 connects Line 6 at T2 of Noi Bai Airport.
- Ring Road 3 in the north: From Ninh Hiep to Nam Thang Long - Noi Bai Road, adjusted to run through control points Viet Hung - Dong Anh - Tien Duong - Nam Hong (in the south of ring railway in the north, making a bypass to the Co Loa historical area).
- Nhat Tan - Noi Bai Road.
- Extended NH5.
- Adjusting the planning of Noi Bai International Airport (in progress from October 2019).
- Urban development orientation along two sides of Vo Nguyen Giap Road, detailed master plan along two sides of Nhat Tan - Noi Bai Road (1/500) was studied and approved under Decision No. 6630/QĐ-UBND dated 2/12/2015 by HPC. Accordingly, the spatial development along 2 sides of Vo Nguyen Giap Road is planned in 4 sections as follows:
  + *Section 1- Gateway urban area*: From the intersection with NH18 to intersection with Ring Road 3 (the north of the Red River) in the Mai Đinh, Phu Lo and Phu Minh communes of Soc Son District; Bac Hong, Nguyen Khe, Tien Duong communes and Dong Anh Township of Dong Anh District. North part of Section 1 is in the green corridor of Ca Lo River and the south part is an urban development area under Zone N5. There are lots of open spaces on this section including parks, greenery, high-quality agricultural land, surface water of Ca Lo River and Sơn Du Lake, which connects the green corridor system of the city;

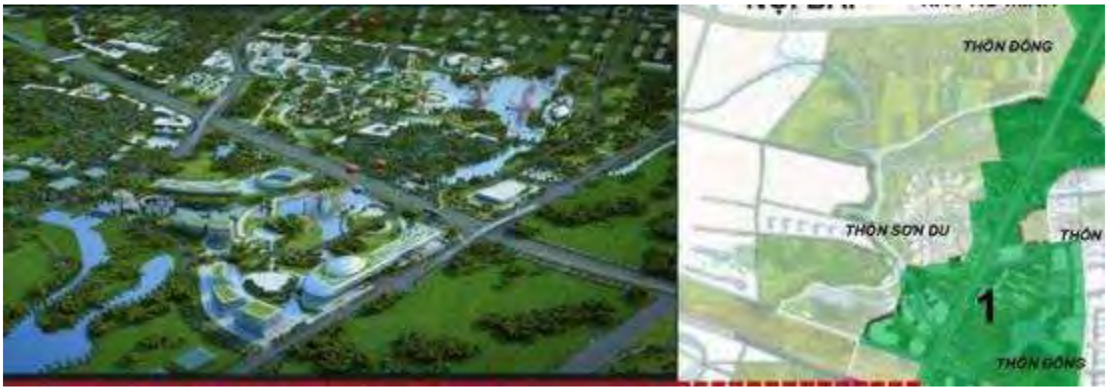


Figure 5-2. Section 1 -Gateway Urban Area

+ *Section 2 - International urban*: From the intersection with Ring Road 3 (the north of the Red River) to the area of the Thiep River - Van Tri lake, in Bac Hong, Van Noi and Tien Duong communes of Dong Anh District. There are lots of structures combined with open spaces forming and modern urban area lively;

Figure 5-3. Section 2 -International Urban Area

+ *Section 3 - Symbolic urban area:* From the area of Thiep River - Van Tri Lake to the Red River Dyke (existing), in Tien Duong commune, Dong Anh Township, Kim No, Hai Boi, Vinh Ngoc, Tam Xa and Xuan Canh communes of Dong Anh District. This section is in Zone N8 and Zone GN. There are lots of high rise buildings including the financial tower of 108 floors;

Figure 5-4. Section 3 -Symbolic Urban Area

+ *Sections 4 - Ecological urban area:* From the Red River Dyke (existing) to the planned road along the Red River (in the Red River urban zoning - Zone R), in Hai Boi, Vinh Ngoc, Tam Xa and Xuan Canh Communes of Dong Anh District.

Figure 5-5. Section 4 -Ecological Urban Area

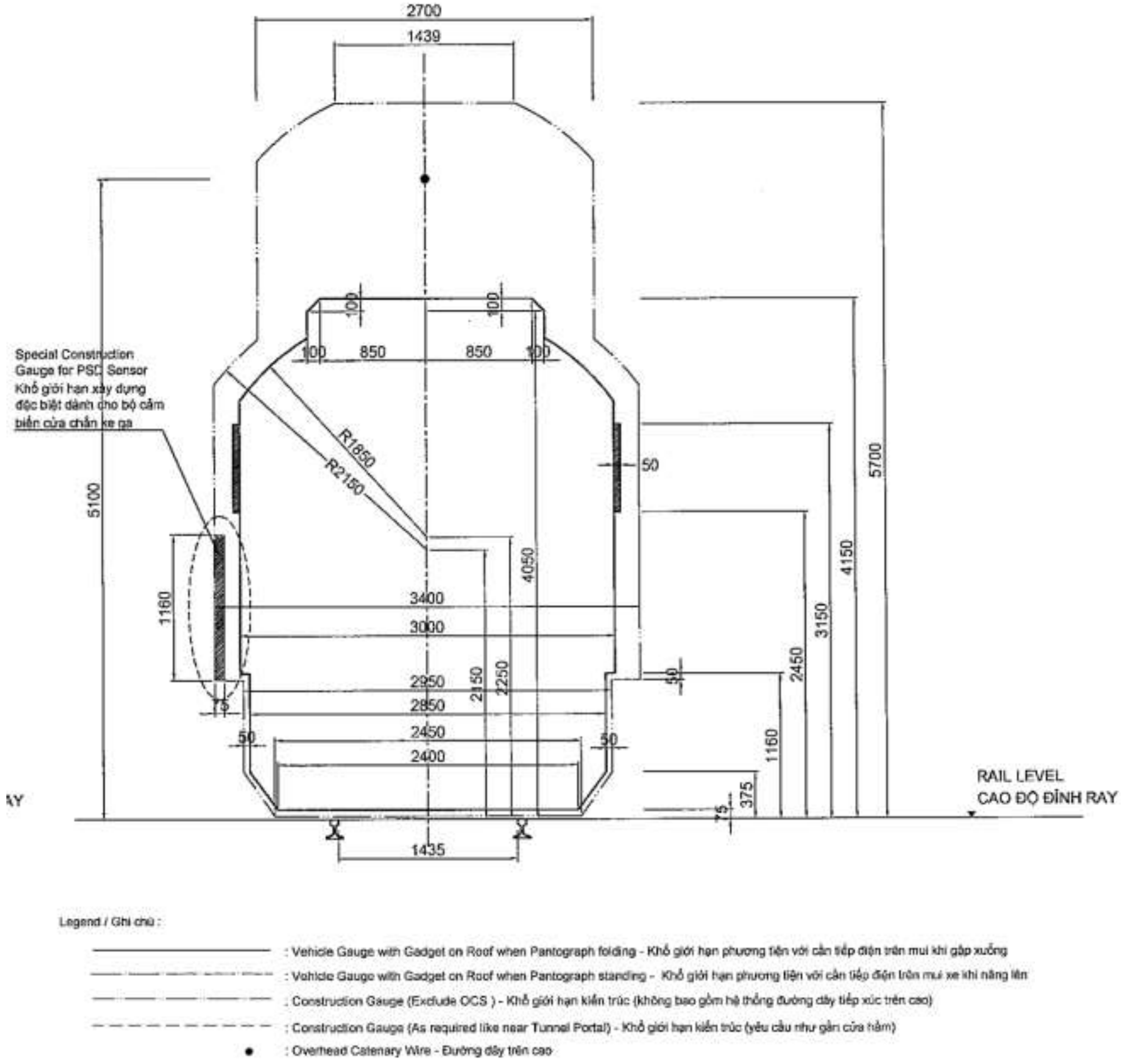
5.8 Technical Standards of Hanoi Metro Line 2.3

Technical standards to be applied for Line 2.3 shall follow those applied for Line 2.1 (Nam Thang Long - Tran Hung Dao Section) with necessary updates and supplements. Major technical standards to be applied for Line 2.3 are as follows:

Table 5-1. Technical Standards of Hanoi URTM Line 2.3

No.	Item	Parameter
1	Gauge	1,435mm, double track
2	Max operation speed	110km/h
3	Max operation speed in a curve	90km/h
4	Min radius of horizontal curve (main line/depot)	300m/160m
5	Min radius of vertical curve(normal/difficult)	3000m/2000m
6	Max gradient	35‰
7	Max cant (normal/difficult)	150mm (180mm)
8	Distance between 2 centerlines on main line/depot	3.8m / 5.0m
9	Max gradient of underground and elevated station	2‰
10	Axle load (tons/axle)	16
11	Power source	1,500VDC
12	Power supply method	Overhead catenary system
13	Communications	(MSN): (Digital Tracking)
14	Signal	ATP, ATS, ATO, CBTC
15	Rolling stock	(EMU)
16	Clearance for roadway	H = 4.75m
17	Clearance for railway	H = 5.70m
18	Construction Gauges	Refer to Figure 5-6

Source: "Decision No. 6935/QD-UBND dated 15 November 2013 of Hanoi People's Committee on additional approval of technical standards applicable for Hanoi City Urban Railway Construction Project, Line 2: Nam Thang Long – Tran Hung Dao section"



Source: "Decision No. 6935/QD-UBND dated 15 November 2013 of Hanoi People's Committee on additional approval of technical standards applicable for Hanoi City Urban Railway Construction Project, Line 2: Nam Thang Long – Tran Hung Dao section"

Figure 5-6. Construction Gauge

6. Alignment and Profile

6.1 Plan on Alignment

Hanoi City Urban Railway Construction Project, Line 2.3 is studied, selected according to the alignment which is defined in the Hanoi Transportation Master Plan until 2030, Vision to 2050 approved by the Prime Minister in Decision No. 519 / QĐ-TTg dated 31 March 2016. Accordingly, the urban railway Line 2.3 basically goes along the Nguyen Van Huyen (extension) - Vo Nguyen Giap (Nhat Tan - Noi Bai Highway).

6.2 Existing Conditions Along the Alignment

Based on the planned alignment, existing conditions along the alignment have been reviewed. Below are images of the existing conditions along the alignment.

- **From Station C1 (Line 2.1) to An Duong Vuong Road**

The study alignment connects Line 2.1 at Nam Thang Long Station, running on the viaduct on the separator of extended Nguyen Van Huyen Road, then turning to the right, running through Ciputra, Phu Thuong village and crossing over An Duong Vuong Road.

Station C1 (Line 2.1)

Location in the mid of roadway (Ciputra)

Location crossing 110kV line (Ciputra)

Location crossing An Duong Vuong Road

Figure 6-1. Existing Conditions from Station C1 to An Duong Vuong Road

- **From Red River to NH-5**

After crossing Red River, the study alignment runs on the viaduct on the separator of the planned road, crossing (grade-separated) NH5 and Line 4 (along NH5).

Location crossing Red River

Location crossing left dyke of Red River

Location crossing NH-5

Figure 6-2. Existing Conditions from Red River to NH5

- **From NH-5 to Ring Road 3**

After crossing NH5, the study alignment runs along Vo Nguyen Giap Road, crossing (grade-separated) Nam Hong Flyover, Ring Rod 3 and the existing national railway, ensuring the clearance for electrified railway and roadway.

Location along Vo Nguyen Giap Road

Location crossing Nam Hong Flyover

Location crossing Ring Road 3

Location crossing national railway

Figure 6-3. Existing Conditions from NH5 to RR3

- **From Ring Road 3 to NH-18**

After crossing Ring Road 3, the study alignment continues running along Vo Nguyen Giap Road, crossing (grade-separated) Nguyen Khe Flyover, NH2 and NH18, ensuring the clearance for the roadway.

Location crossing Nguyen Khe Flyover

Location crossing Ca Lo River

Location crossing over NH-2

Location crossing over NH-18

Figure 6-4. Existing Conditions from RR3 to NH18

- **From NH-18 to T2 of NBIA**

After crossing NH18, the study alignment runs on the separator of Nhat Tan - Noi Bai Road and plans to run underground connecting terminals T1 and T2 of Noi Bai International Airport.

Location along the parallel road

Location crossing underpass

Location of T1

Location of T2

Figure 6-5. Existing Conditions from NH18 to NBIA

In brief, the planned alignment of Line 2.3 basically runs along the corridor of existing roads, crossing through only the commune in the area bordering Red River (Phu Thuong Village).

6.3 Study Results on Alignment

Along the alignment in the study area, there are some control points of Line 2.3 which are listed as below:

- Nam Thang Long Station belongs to the Line 2.1: Nam Thang Long - Tran Hung Dao. This is the location which connects to Line 2.1.
- Location of Red River Passing. This is the huge location of the project, crossing the Red River at a distance between the two major dykes. The hydrological conditions are quite complex and there are some embankment improvement works that will affect the plans of the river crossing.

- Works along Vo Nguyen Giap Road: Thiep River Flyover, Ca Lo River Bridge, tunnel under Highway No.18.
- Flyovers at passenger terminal T1 and T2 at Noi Bai International Airport.
- Locations for connection and transfer to other urban railways.

+ **Line 2.1** (Nam Thang Long-Tran Hung Dao) at Nam Thang Long Station, connection and passenger transfer.
+ **Line 4** (Me Linh - Dong Anh - Sai Dong - Vinh Tuy - RR 2,5 - Co Nhue - Lien Ha) at N7 Station, passenger transfer.
+ **Line 6** (Noi Bai - Phu Dien - Ha Dong - Ngoc Hoi) at N0 Station - Noi Bai International Airport, passenger transfer in future connection.

- ***Starting point connecting C1(Line 2.1)***

Line 2.3 is designed from Km0+400, and shall connect and transfer to Line 2.1 at Station C1-Nam Thang Long.

- ***Location of Red River Crossing***

Two options for the beginning of the section of the alignment (crossing Red River) have been studied as follows:

Figure 6-6. Outline of the Options

- **Option 1** (following the planning): The alignment connecting Line 2.1 at Nam Thang Long Station, running along the extended Nguyen Van Huyen Road through Phu Thuong Village, crossing over An Duong Vuong Road and Red River, continuing to run along the planned road, crossing over NH-5 and Line 4 (planned to run on the separator of NH-5 and accessing the land trip planned for urban railway on Vo Nguyen Giap Road. Then, the alignment shall follow Vo Nguyen Giap Road from this point to NBIA.

- **Option 2**: The alignment connecting Line 2.1 at Nam Thang Long Station, running on the separator of the extended Nguyen Van Huyen Road and turning to the right running through Ciputra and Phu Thuong Village and crossing Red River. Then, the alignment shall run the same with Option 1 from this point.

Table 6-1. Comparison of Alignment Options Crossing Red River

No. TT	Item	Option 1	Option 2
1	Length	□ 4600m	□ 4400m
2	Construction cost	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>
3	Environmental Impact	The alignment runs along main road, so it affect the environment less than Option 2.	The alignment runs through Ciputra shall affect the landscape and environment of the area.
4	Compliance with existing plans	The alignment is running along the extended Nguyen Van Huyen Road, in line with the planning approved by HPC.	It deviates from the land use plan approved by HPC.
5	Conclusion	Recommended	Not Recommended

- **Recommendation:** After conducting a comparison, Option 1 is recommended: The alignment shall run along the extended Nguyen Van Huyen Road, crossing through Phu Thuong Village, then crossing Red River because of less impact to the environment and landscape.

- ***Ending point at Noi Bai International Airport***

According to Decision No. 519 / QD-TTg dated March 31, 2016, the end point of the urban railway No. 2 is determined at NBIA in general, in the drawing illustrating the endpoint corresponding to T1 passenger terminal (domestic station) of NBIA, connected to UMRT Line 6. According to the city plan, Line 6 has not yet determined the investment progress, while the number of international passengers is through the T2 passenger terminal is now very large, requiring research to connect traffic to Hanoi city center.

The arrangement of 2 urban railway stations connected to the airport terminal T1 and T2 is specified in NBIA plan according to the Prime Minister's Decision No. 590/2008 / QD-TTg. The Study Team recommended that the ending point of Line 2.3 for this study is the N0 station, opposite the T2 Terminal of the Noi Bai International Airport to ensure efficient operation. Therefore, Line 2.3 shall be 1.5km longer than that approved in the master plan.

Figure 6-7. Ending Point of Line 2.3

- ***Some main intersections***

- **Intersection with NH-5 and Line 4**

As expected, after crossing the Red River, Line 2.3 will basically go elevated, crossing the extended NH5. For Line 4 (is located on the median strip of extended NH5), it will go elevated and pass over Line 2.3.

Figure 6-8. Intersection with NH-5

- **Intersection with Nam Hong Flyover and Nguyen Khe Flyover**

These are flyover positions for the current road. Accordingly, line 2.3 passes over these flyovers. The plan to pass over the existing flyover is proposed to ensure the smoothness of railway profile.

Figure 6-9. Intersection with Nam Hong and Nguyen Khe Flyovers

- **Intersection with Ring Road No.3 and National Railway**

At present, Vo Nguyen Giap road crosses the planned RR3 and the national railway by the flyover system. Therefore, the profile of line 2.3 will also go elevated and pass over the RR3 and the current national railway.

Figure 6-10. Intersection with Ring Road No.3

- **Intersection with NH-2**

The area intersects with NH2 which is the area adjacent to the densely populated area, the width of the strip between the main road and the collection road of Vo Nguyen Giap Road tends to shrink. Meanwhile, Vo Nguyen Giap Road now passes NH2 by a flyover. Therefore, line 2.3 will also pass over the current NH2.

Figure 6-11. Intersection with NH2

- **Intersection with NH-18**

The intersection with NH18 has a densely populated area, the width of the strip between the main road and collection road is narrow, Vo Nguyen Giap Road goes under NH18 with a tunnel. Moreover, this area is located in the east of the planned airport expansion. Depending on the location the future runways will determine the obstacle limitation surfaces[1] which impose height restrictions on the elevation of all the facilities to be constructed. On that basis, the consultant has studied the solution of line 2.3's profile which will pass over the NH18.

Figure 6-12. Intersection with NH18

- **Noi Bai International Airport Approach**

The section will be located on the median strip between Vo Nguyen Giap Road within NBIA area is basically dominated by taxiways for aircraft as planned from the current airport to the extended area. Therefore, the profile of railway 2.3 will go underground to ensure the technical requirements of aviation.

[1] The OLS is defined as the airspace surrounding an airport that must be protected from obstacles to ensure aircraft flying in good weather during the initial and final stages of flight, or in the vicinity of the airport, can do so safely.

Figure 6-13. Plan at Noi Bai International Airport

- *Depot access plan*

+ Option 1: the starting point behind N1 Station at km17 + 826 (main line), the route goes underground under the axis of NBIA, QL18 and goes to the ground and enters to depot.

+ Option 2: the starting point before N2 Station at km14 + 245 (main line), the route goes elevated and passes over NH2 and the branch road connects with NH18, then the route goes on the ground and enters to the depot.

Figure 6-14. Plan of Depot Options

+ Comparison of alternative options for depot access

Table 6-2. Comparison of Depot Access Options

No.	Items	Option 1	Option 2
1	Length from terminal station to depot (operation length)	5.2km	7.1km
2	Length of depot access	3.0km (underground)	1.2km (elevated)
3	Construction cost	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>	<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>
4	Construction period	28 months	12 months
5	Land acquisition	None	26 houses with an area of about 980m^2. However, this area is planned to be a green area.
6	Train operation	Length of depot access is shorter than option 2	Length of depot access is long
7	Environmental situation and landscape	No	Less
8	Affect to height clearance of NBIA	No	maybe
9	Extension to Soc Son	More difficult than OP2 because the direction from Soc Son to the city center must go through NBIA	More favorable than OP1, it is possible to connect directly from Soc Son to the city center
10	Recommendation	Not Recommended	Recommended

Through comparative analysis, it was evaluated that option 2 has more advantages than option 1. Currently, an adjustment of Noi Bai International Airport is under study. Therefore, to ensure the progress of the project, the JICA Study Team agreed to propose the option 2 for depot access.

- **Conclusion on alignment plan**

- Line 2.3 connects to Line 2.1 at Nam Thang Long Station, running along the extended Nguyen Van Huyen Road, crossing through Phu Thuong Village, and crossing Red River, continuing to run along the planned road crossing over the extended NH-5 and Line 4 (planned on the separator of NH-5) and accessing the land trip planned for urban railway on Vo Nguyen Giap Road, then running in parallel with Vo Nguyen Giap Road and ending at passenger terminal T2 of NBIA.
- The access to depot shall connect from the main line, crossing over NH-2 then accessing depot.
- Total alignment length: 19.66km (Option 1) and 19.65km (Option 2).
- The alignment shall run through districts of Tay Ho, Dong Anh and Soc Son

Figure 6-15. General Alignment Plan of Line 2.3 (Option 1)

Figure 6-16. General Alignment Plan of Line 2.3 (Option 2)

6.4 Study on Profile

The profile of alignment will be constrained by many factors and has a great impact on the process of train operation as well as construction cost. At the same time, the design of profile is an important input to implement other planning works.

6.4.1 Control Points

There are some vertical control points along the study area as follows:

- The rail level of Nam Thang Long Station, connecting to urban railway Line 2.1 (Nam Thang Long - Tran Hung Dao).
- The clearance height of the left and right of Red River Dyke;
- The clearance height of the Red River, Thiep River and Ca Lo River;
- The clearance height of NH5 and urban railway Line 4;

- The height of Nam Hong and Nguyen Khe Flyovers;
- The rail level of the national railway for Dong Anh - Bac Hong section;
- Current elevation of NH2 and NH18
- Planning of Noi Bai International Airport Plan

6.4.2 Profile of Red River Crossing

- Tunnel option (Option 1)

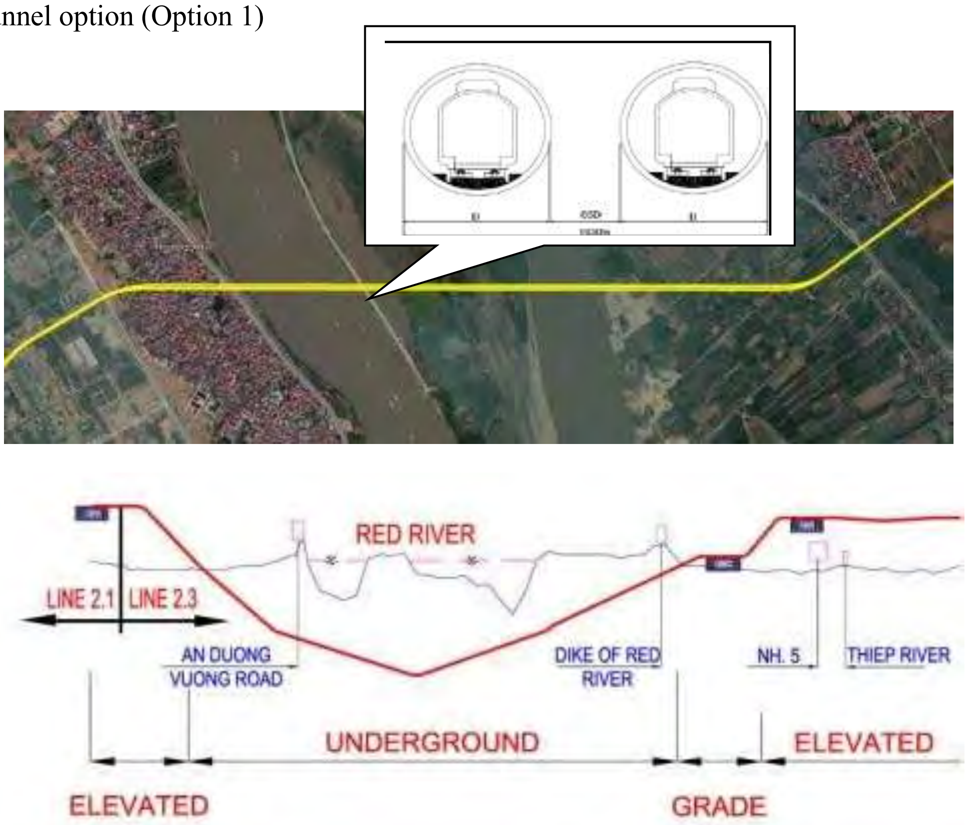


Figure 6-17. Profile of Option 1

Line 2.3 connects to Line 2.1 at Nam Thang Long Station, running on a viaduct along the extended Nguyen Van Huyen Road to km0+754.76, then lowering to run underground with gradient of 3.39% through Phu Thuong Village, crossing An Duong Vuong Road and Red River, then changing to run at grade with gradient of 2.5% at km4+900 on the planned road. The alignment changes to run on a viaduct with the gradient of 3.29% at km5+300, crossing the extended NH5 and Line 4 (planned on the separator of NH5) and approaching the land strip planned for the urban railway on Vo Nguyen Giap Road. From this point, the alignment runs along Vo Nguyen Giap Road to NBIA.

- *Bridge option (Option 2)*

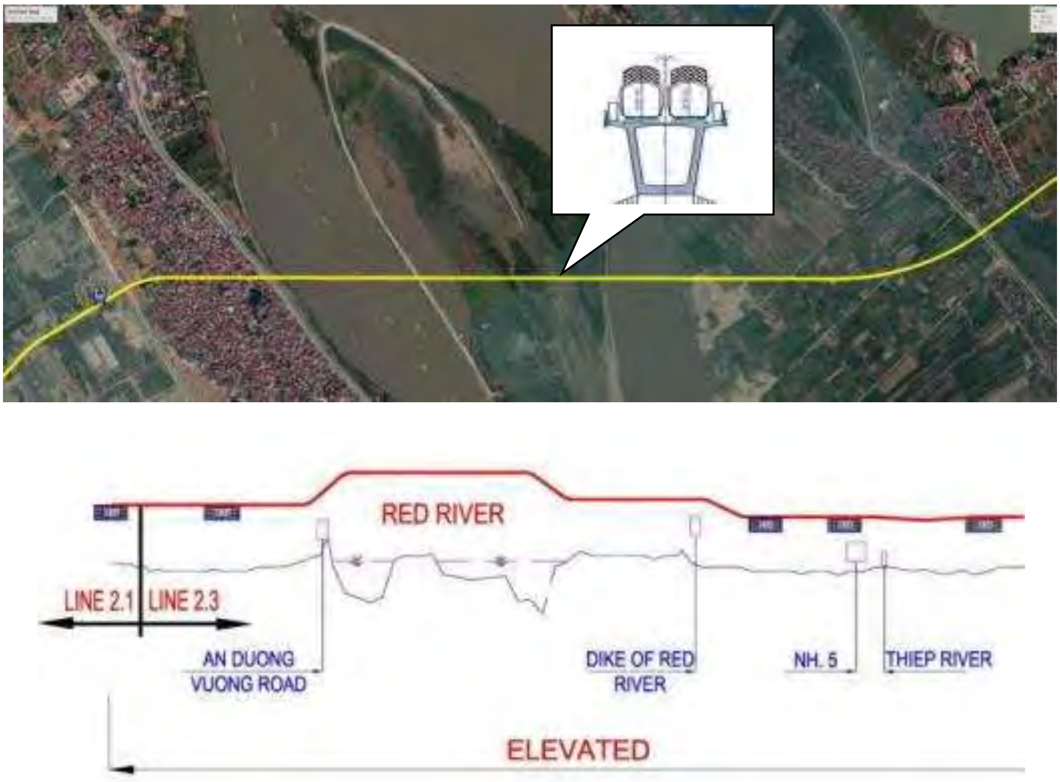


Figure 6-18. Profile of Option 2

Line 2.3 connects Line 2.1 at Nam Thang Long Station, running on viaduct along the extended Nguyen Van Huyen Road through Phu Thuong Village, at km1+600, the alignment runs with gradient of 2.72% to cross An Duong Vuong Road and Red River, then lowering the gradient to 2.26% to cross over left Red River Dyke, then running on the planned road. The vertical profile of the bridge over the Red River is designed with the same clearance as Nhat Tan Bridge built in 2015. The alignment continues running on viaduct crossing the extended NH5 and Line 4 (planned on the separator of NH5) and approaching the land strip planned for the urban railway on Vo Nguyen Giap Road. From this point, the alignment runs along Vo Nguyen Giap Road to NBIA.

6.4.3 Hydrological Consideration of Red River

The annual water flow of the Red River consists of two distinct seasons: flooding season and dry season. The water level and the flow quantity of the Red River fluctuate widely depending on the seasonal and meteorological conditions. The hydrological pattern at Hanoi Hydrological Station indicates the highest water level frequency in August and July (frequency of 53.4%), and the lowest water level in February (frequency of 30%), April (frequency of 29%) and March (frequency of 17%). The highest water level recorded is 1,397 cm (22/8/1971) and the lowest water level recorded is 157 cm (27/3/1956). The average seasonal water level fluctuation in flood during and dry seasons is about 9 m. There is a fluctuation in flow rates from 10 times to 20 times. The alignment of the project is a section where riverbed fluctuation is intense and the bed fluctuation is about 10 m.

Water in the Red River basin contains a large volume of sediment and the amount of sediment is extremely high. According to a survey in August 2002, the sediment load of the Hanoi section is around 100-200 tons/hour. The riverbed material consists of a mixture of fine sand (median particle diameter is 0.100 mm to 0.235 mm), fine sand (20 - 40%), silt (40 - 70%) and clay (10 - 20%). At a normal flow velocity of the river, the sediment is easily transferable and conveyed as suspended particles in water. The Red River is regularly dredged for the sake of sand collection for construction and maintenance of navigational channels for ships.

Due to the riverbed conditions above, it is most likely that the soil cover for the tunnels needs to be increased to offset the risks associated with the fluctuations.

The following Figure 6-19 illustrates changes in riverbed elevation according to survey data in 2007 and 2018:

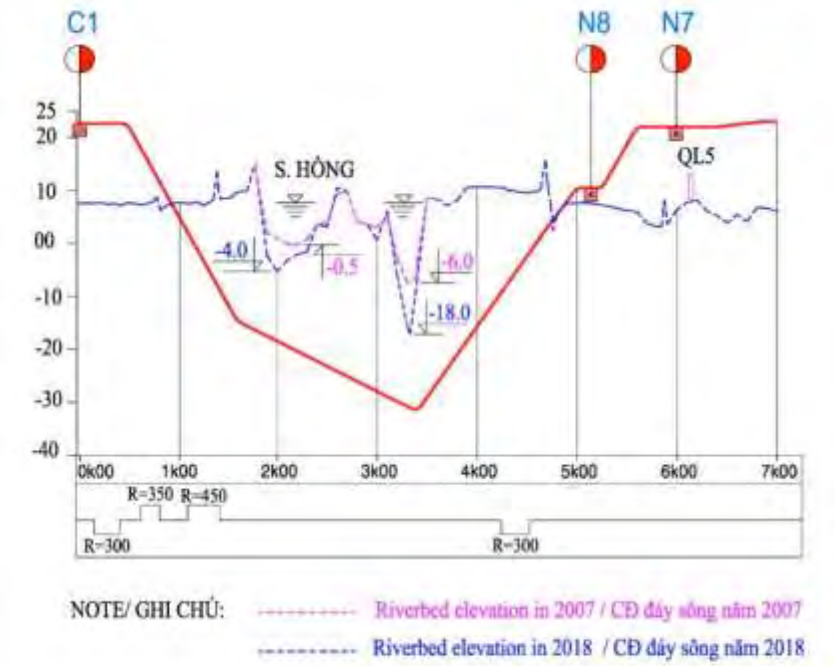


Figure 6-19. Changes in Elevation of the Red River Bed

6.4.4 Current Dyke Management Policy

Hanoi Department of Dyke Management and Flood, Storm Control provided the note after the meeting (Nov. 31, 2018) concerning the current conditions of the dyke management and pre-conditions for planning for structures crossing the Red River.

The note indicated that the high flood discharge of the Red and Thai Binh Rivers has affected adversely the Hanoi city. This has necessitated reviewing the management plan for water level and flood discharge of the Red and Thai Binh Rivers system by concerned government departments. Some of the protection measures from floods and for dykes are relocation of residential areas, limitation on the construction of a new road in the floodplain area, introduction of river protection structure etc. The detailed plan for flood and dyke control on the Red River and Thai Binh River System is under review with the Hanoi People's Committee.

The note indicated that for river crossing sections, the study for dyke safety and flood drainage should be based on a holistic approach of taking account of the stability of the available structures/facilities in the area, variations of river hydraulic regime, sedimentation and erosion of river bank etc. The note also indicated that the alignment options (bridge or tunnel) must conform to the pre-conditions as follows:

- *Bridge option:* It should be designed confirming to preventing possible impacts on stability and flood prevention safety of dykes during project operation. The design or the remedial measures should also include the effect of impacts by bridge abutment and piers to river flow change, sedimentation, erosion at bridge upstream and downstream etc.
- *Underground tunnel:* It should be designed confirming the stability and safety of dykes and be constructed with highly durable material for structure stability in a long term (to avoid leakage, flooding or breaking etc.). Stability and safety consideration should also include aspects on protection to the tunnel from high flood level and earthquake.

6.4.5 Risks Associated with Tunnel and Bridge

- Risks of Tunnel option and Bridge option are as follows:

The magnetic exploration for unexploded bombs during the detail design period needs to be undertaken. << Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

- Unexpected soft ground during excavation.

- Risks of Tunnel option are as follows:

- The countermeasures against flood in case of tunnel failure (tunnel joint leakage by an earthquake) during a high flood of the Red River.
- The possible impacts of vibration by tunnel operation to dike body structure.
- The protection method of tunnel structure and measures against buoyancy.
- The measures against flooding during tunnel excavation

- Risks of Bridge option are as follows:

- The impacts on stability and flood prevention safety of dikes.
- The impacts by bridge abutment and piers to river flow change, sedimentation, erosion at bridge upstream and downstream and remedial measures.
- Inhibition of water flow by bridge piers.
- Ecosystem damage in the river area.
- Long-term resettlement of residents.

6.4.6 Comparison Summary of Tunnel and Bridge Options

The criteria for comparing the plan of the tunnel and bridge crossing the Red River are shown in the following table.

Table 6-3. Comparison of Red River Crossing Options

No	Items	Option 1 (Tunnel)	Option 2 (Bridge)
1	Compliance with Master Plan	Need to revise MP 519	In accordance with the MP 519
2	Resettlement	No houses. However, to ensure during the construction of the tunnel, it is necessary to relocate households above.	100 houses with approx. S =2,993m2
3	N9 station (Ciputra urban area)	□ Construction is impossible because of the slope area of railway □ Reduced cost for construction of a station □ Will lose some ridership due to the absence of N9 Station catchment area. □ Depending on the plan of Line2.1, a substation is necessary around N9 station	Construction is possible
4	Construction period	□ Standard period (48 months) □ Not affected by weather and river water level □ The construction period is not affected by external factors.	□ Depends on conditions (48 months) □ Depends on the number of teams □ It is affected by weather and river water levels. □ Land acquisition and resident's relocation is unpredictable. □ It may take several years to relocate residents.
5	Environmental situation and landscape	□ No significant environmental impact on flora and fauna or riparian environment. □ Construction is quiet. No significant impact on plants and animals (Except for shaft construction) □ No significant impact on the landscape	□ No significant environmental impact after the commencement of operation. □ Some limited impact of noise and impact on plants and animals during construction □ A significant impact on the landscape but could be a positive one for an artistically designed bridge.
6	Maintenance	□ Maintenance cost is expensive. □ Periodic inspection frequency is every 5 years. Repair is possible only non-operation time at night.	□ The maintenance cost is low. □ Periodic inspection frequency is every 5 years. Repair is possible day and night.
7	Running cost	□ Ventilation and drainage expenses are necessary. □ In addition to running costs, periodic inspection is also higher.	The overall running cost is lower.
8	Impact on the river	□ There is no inhibition of water flow by bridge foundations. □ Does not affect the navigation of ships. □ Construction does not require access-roads in the river	□ There is inhibition of water flow due to bridge structures. □ Affects the navigation of ships. □ The bridge design needs to suppress the impediment ratio of river flow not more than 5%. □ Construction requires access-roads in the river.
9	Risk management of dyke	□ Dyke management committee requires vindication of no negative impact on the Red River embankments triggered by the tunneling or tunnel structures □ After a further detail analysis, it may be necessary to reinforce the dyke.	No impact on dykes
10	Risk to structures	□ It is necessary to undertake the riverbed surveys seasonally (quarterly) till the time of detail design implementation to collect the data for the tunnel design if this option is deemed more feasible. Depending on the results, the vertical alignment of the tunnel may have to be adjusted or	□ Bridge pillars will change hydrological regimes and may prompt scouring of riverbed. However, it is possible to minimize the souring by having elliptical shape pillars and secure safety by having sufficient depth of foundations.

No	Items	Option 1 (Tunnel)	Option 2 (Bridge)
		construction methodology may be changed due to further depth of soil cover requirement of the shield tunnel. □ Tunnel structure has the following risks, such as loss of sufficient soil cover depth due to the hydrological issues as well as illegal river sand dredging to cause buoyancy or direct structural damage. □ Increasing soil cover depth or providing concrete protection structures can minimize risks.	
11	Risk in operation	□ No significant risks	Operation disruption by storm
12	N8 station	□ At-grade station because of transition slope from the tunnel to the elevated section ➔ loss of through traffic connections causing inconvenience and aesthetic damage to the streetscape	Viaduct station
13	Construction Cost	□ << Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>	□ << Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>
14	Recommen-dation	Backup Plan	Recommended

Note *: Due to lack of project cases of TBM under a large river in Vietnam, the unit costs of various railway TBM projects in Japan were analyzed to derive the cost escalation factor of the under-the-river TBM to a standard TBM unit construction cost, i.e., 2.1 times.

After careful consideration of the advantages and disadvantages of the two options for crossing the Red River, the JICA Study Team proposed a more advantageous bridge. However, the Study Team also proposed to add a tunnel option as an alternative, depending on the results of the Environmental Impact Assessment and Resettlement Plan.

6.4.7 Profile for the Whole Alignment

The JICA Study Team designed the profile of the alignment according to the clearance parameters specified in Table 5-1.

- Section from C1 station (Line 2.1) to Vo Nguyen Giap Road

Option 1: The section runs on the viaduct from Station C1 - Nam Thang Long, then changing to run underground from the end of the section in Ciputra, crossing Red River, left Red River Dyke and changing to run at grade and on viaduct crossing over NH5 to Vo Nguyen Giap Road.

Option 2: The section runs on the viaduct from Station C1 - Nam Thang Long, crossing over Phu Thuong Village, the Red River, left Red River Dyke and NH5 to Vo Nguyen Giap Road.

Both options are designed with the following criteria:

- Road elevation (according to the longitudinal profile of the planned road);

- Clearance for roadway (extended NH5, beginning section of Vo Nguyen Giap Road)[2];
- Clearance for railway (planned for the case Line 4 runs on the mid separator of the extended NH5)[3];
- Riverbed elevation of Red River, navigation clearance of the Thiep River.

The longitudinal profile of the elevated section is determined on the basis to ensure the above technical requirements, and not to affect the urban landscape (height from the road pavement to the bottom of the girder is about 8.5m - 14m). The longitudinal profile of the underground section is determined on the basis to ensure safety with a depth equivalent to the tunnel diameter at least from the ground surface/riverbed to the tunnel crown. The longitudinal profile of at grade section is designed to basically follow the elevation of planned road. Since the station is at grade, adjustment of roadway is required to provide sufficient space for urban railway and station.

- The alignment runs on the viaduct from the intersection with frontage road on the left of Vo Nguyen Giap Road to km16+000 within the roadway in NBIA with the following criteria;
- Clearance for roadway (Vo Nguyen Giap Road, Ring Road 3, NH2 and NH18);
- Clearance for national railway;
- Navigation clearance of Ca Lo River;
- After Km16+000 the alignment lowers to run underground to the ending station T2 of Noi Bai Airport and connecting future Line 6 at this point.

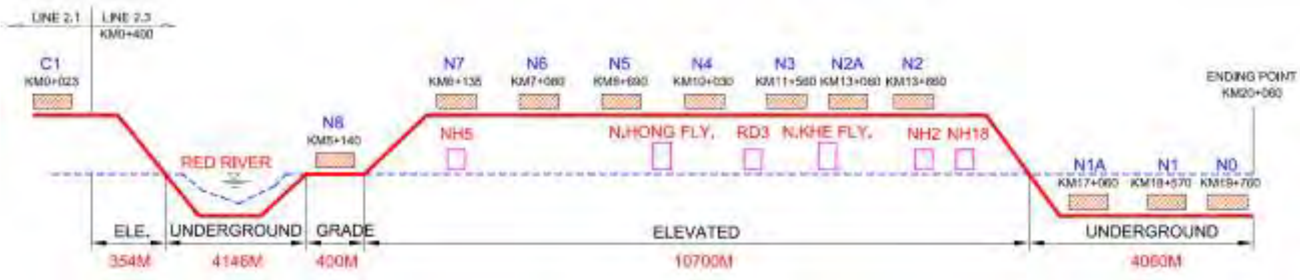


Figure 6-20. Profile of Line 2.3 (Tunnel option for Red River Crossing)

[2] Clearance for roadway H = 4.75m
[3] Clearance for railway H = 5.70m

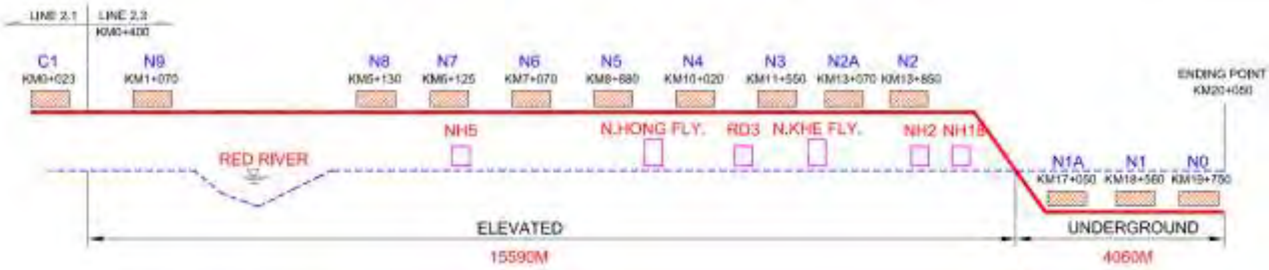


Figure 6-21. Profile of Line 2.3 (Bridge option for Red River Crossing)

7. Station Location Plan

7.1 Review of Existing Plans

Table 7-1 compares the station locations proposed by Transport Master Plan of Hanoi (Decision No. 519/QĐ-TTg dated 31/3/2016) and Detailed Land Use Plan. By Transport Master Plan Line 2.3 has ten stations with one station in Tay Ho District, seven stations in Dong Anh District and two stations in Soc Son.

By comparing the two plans, the intention behind planning becomes obvious. Transport Master Plan station locations on the left indicates that the station locations are determined to provide maximum access to the existing communes whereas the Detailed Land Use Plan places stations to provide access to the future development potentials. Another difference is the first station after the airport. The Transport Master Plan places the first station at the corner before joining the Vo Nguyen Giap Road where large communes do exist and also branching railway to Soc Son. The Detailed Land Use Plan's first station is at the top of the planned software park and the remainder of the alignment to the airport is buttressed by green buffer zones. Nevertheless, there are no substantial differences for the last three stations before crossing the Red River.

The JICA Study Team recommends placing one station at branching to Soc Son, but outside of the airport perimeter. The green buffers should be preserved as much as possible with inter-modal transfer facilities at the station. The JICA Study Team has decided to modify N2 TOD as shown in the attached drawing. All the urban blocks previously proposed have been eliminated except for the two blocks, which provide essential access to the station buildings. The modification was decided following the land use concepts displayed by the Hanoi General Construction Plan. Given the proximity to the airport, urban development should not be encouraged in this area.

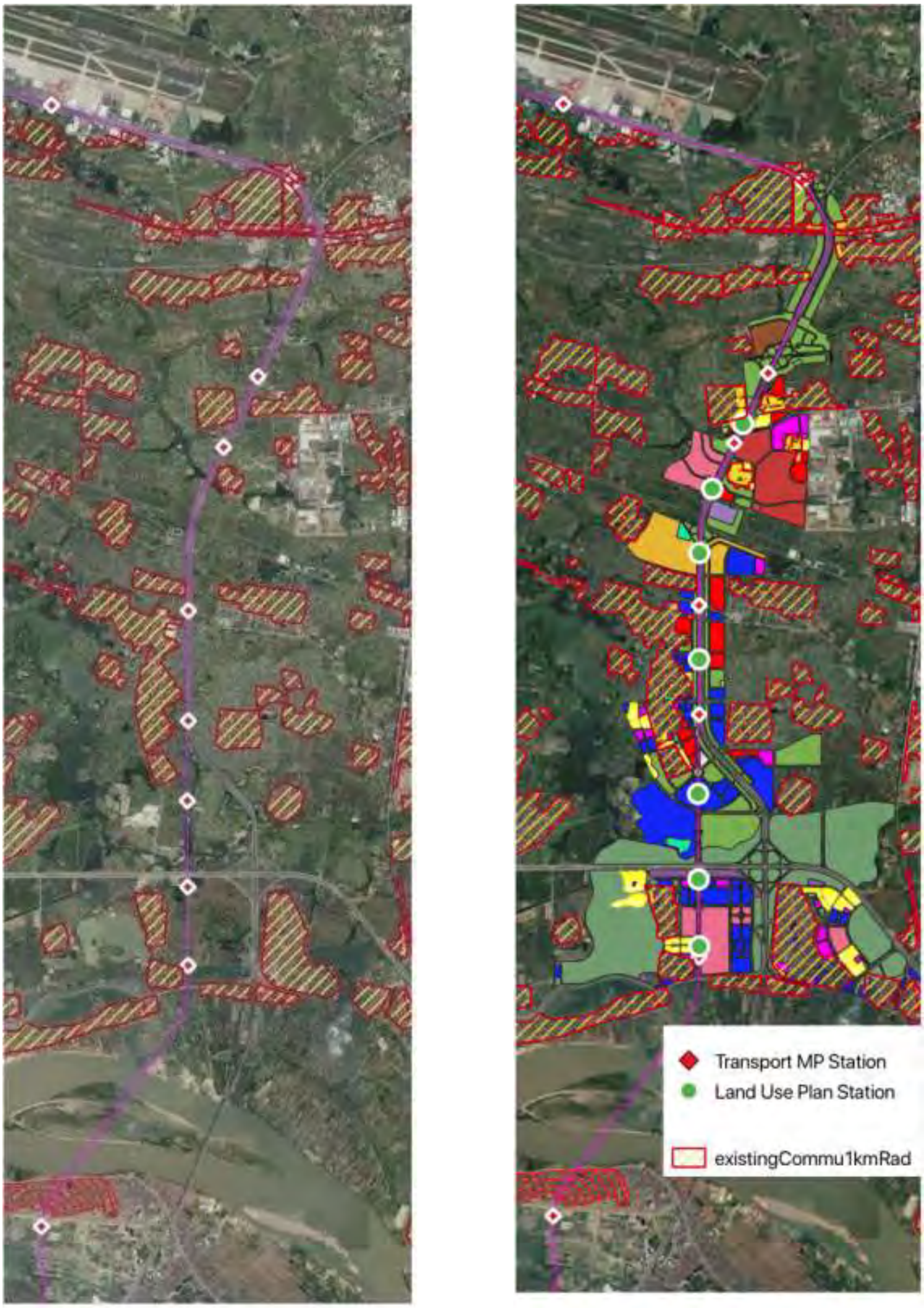


Figure 7-1. Comparison of Station Location Plans between Transport Master Plan and Land Use Plan

7.2 Station Planning Principles

1) Planning principles

First, there is a need for a holistic approach to the overall station planning. Secondly, we need to look at the economic implications and service quality implications which we will be studying more in detail later on. For one, adding another station will cost to the investment cost. In addition, more stations will require more workers and more maintenance, so the operation cost will also increase. In terms of operation plan, adding one more station will slow down the train therefore the time distance from the airport to the city center will increase.

A standard of having 1 km distance between stations is applicable to highly urbanized central urban districts. In western countries, the distance of 2-3 km in a suburb is a norm. As pointed out in the land use plan, it is necessary to have high densities around the stations, but there can be green buffers or preserved agricultural areas between station TOD areas. This will make it easier to maintain a garden city like environment along the alignment.

For example, in the case of Tokyo Metro, the Tozai Line, a typical urban line, has an average of 1.34 km (2.3 km at the time of opening) between stations while Ginza Line which runs the city center has 0.75 km.

In the urban areas of particularly N3 area, it is excessive to have two stations. A software park and campus may not attract high traffics during off-peak hours.

2) Planning target

The success of Line 2.3 depends on how to maximize the impacts of TOD which have two objectives of 1) maximum ridership and 2) maximum land value capture. The review of the existing plans has revealed that the planned population for new development areas within 1 km buffer zone of the alignment is 83 thousand of the population as shown in Figure 7-2. The corresponding ridership will not generate sufficient TOD impacts.[4] However, the application of TOD based land use planning could raise the target population to 300 thousand with heavier densities around the stations which will generate five times more passenger traffics than the existing plans.[5]

[4] The estimated but optimistic commuter demands (peak hours) for railway is 10,000-15,000 and daily passenger demands of 80,000 to 120,000 passengers per day which is too small to supplement the ridership revenue to and from the airport.

[5] The estimated commuter target demand during peak hours is 50,000 with the daily traffic demand target of 400,000.

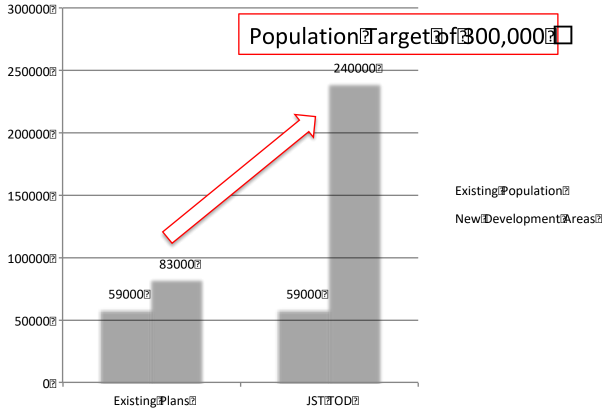


Figure 7-2. Planned Population Targets and Review of Existing Plans

7.3 Norms for Distance Between Stations

The appropriateness of distance between stations is raised by HPC related agencies at the meetings. The JICA Study Team believes that distances between stations should differ depending on the density of the urban demography. For suburban railways, it is a norm to have a much longer distance between stations and preserve rural and greens.

The next examples compare the inner metro railway and suburban railway in Tokyo, namely Ginza and Tozai Lines. At the time of opening, Tozai Line had only 6 stations with an average distance of 2.3 km between stations.

LINE	Total Length (km)	Number of Stations	Average Distance (km)
Ginza Line	14.3	19	0.75
Tozai Line	30.8	23	1.34
Tozai Line Grade Level Section	13.8	9	1.53

Figure 7-3. Map of Metro in Tokyo

7.4 The Number of Stations on Line 2.3

1) Number of stations

The number of stations for Line 2.3 is set at 10 in the Transport Master Plan. However, the number of stations should not be regarded as a target. More stations and shorter distances between stations lead to a slower average speed of trains.

The longest section on Line2.3, N1-N2, has an average speed of 66 km/h and the shortest section, N7-N8, has an average speed of 36 km/h. There is a strict tradeoff between the number of stations and the service quality level, i.e. the time required to travel between NBIA and the city center. Therefore The JICA Study Team had the intention of reducing the number of stations where possible.

2) Station location

After the meetings to present the alignment plan, the location of the station and the TOD area with the departments of Hanoi, especially receiving the comments at the meeting chaired by the Chairman of the Hanoi People's Committee on 21st October 2019, the JICA Study Team proposes station location as shown in Figure 7-4 below:

Note: N1A and N2A are the addition of stations.

Figure 7-4. Station Locations for Line 2.3

7.5 Station Plan at Noi Bai International Airport

By Decision No. 590/2008/QĐ-TTg dated 20/5/2008, there are 2 underground stations corresponding to passenger terminals T1 and T2. Station locations are shown below:

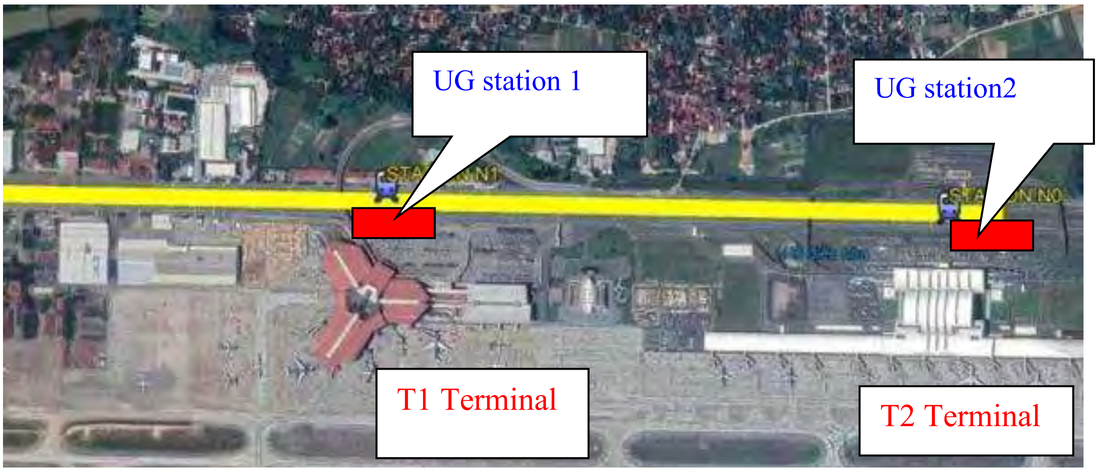


Figure 7-5. Station Locations in NBIA by NBIA Master Plan

7.5.1 Noi Bai International Airport Master Plan Revision

At present, a French consultant, ADPi has just initiated the revision of the Noi Bai International Airport Master Plan. According to their presentation to the Ministry of Transport on Oct 31, 2019, there are eight alternatives under consideration. The preliminary recommendation is to locate additional runways further south compared to the original plan to reduce the impact on and resettlement needs of the surrounding communities. Although there would be no impact to the alignment plan of Line 2 (the airport access section would be entering underground to the NBIA.) under all alternatives, the final appropriate locations of N2 and N3 stations need to await the decision of the master plan layout. In any case, the JICA Study Team has noted the prudence of NH18 areas to be reserved as green spaces for risk factors associated with the airport activities.

Figure 7-6. Noi Bai International Airport Expansion Plan (Alternative 6)

7.6 Criteria for selection of station locations

The major principles for the selection of urban railway station location are as follows:

1) **To suit to the transport plans**

2) **To provide a connection to existing other urban railways and public transport services for intermodal connectivity**

3) **To suit regional spatial development/land use plans for urban development around the stations**

4) **To provide railway access to the existing population to the maximum extent**

5) **To maximize the land area around the stations available for urban development using TOD scheme**

6) **To minimize environmental and social impacts including land acquisition**

7.7 Providing Access to Existing Population

Figure 7-7 shows the land areas of existing communes within 1 km boundary from the railway alignment. Furthermore, the commune areas within the 1 km boundary from the proposed stations are segregated by the boundaries of 1 km radius from each proposed station, shown in dirt color. The areas colored in pink are the commune areas beyond 1 km radius from the proposed station. The more precise spatial tabulation indicates the proposed stations cover 81% of the total commune areas within the 1km buffer of the alignment. As obvious from the layout shown in Figure 7-7, adding more stations or shifting stations do not substantively increase the coverage. Adding one more station between N3 and N2 would increase no more than 4% in the coverage. From an efficiency viewpoint of station access coverage, the JICA Study Team proposed stations provide optimum locations in the coverage efficiency.

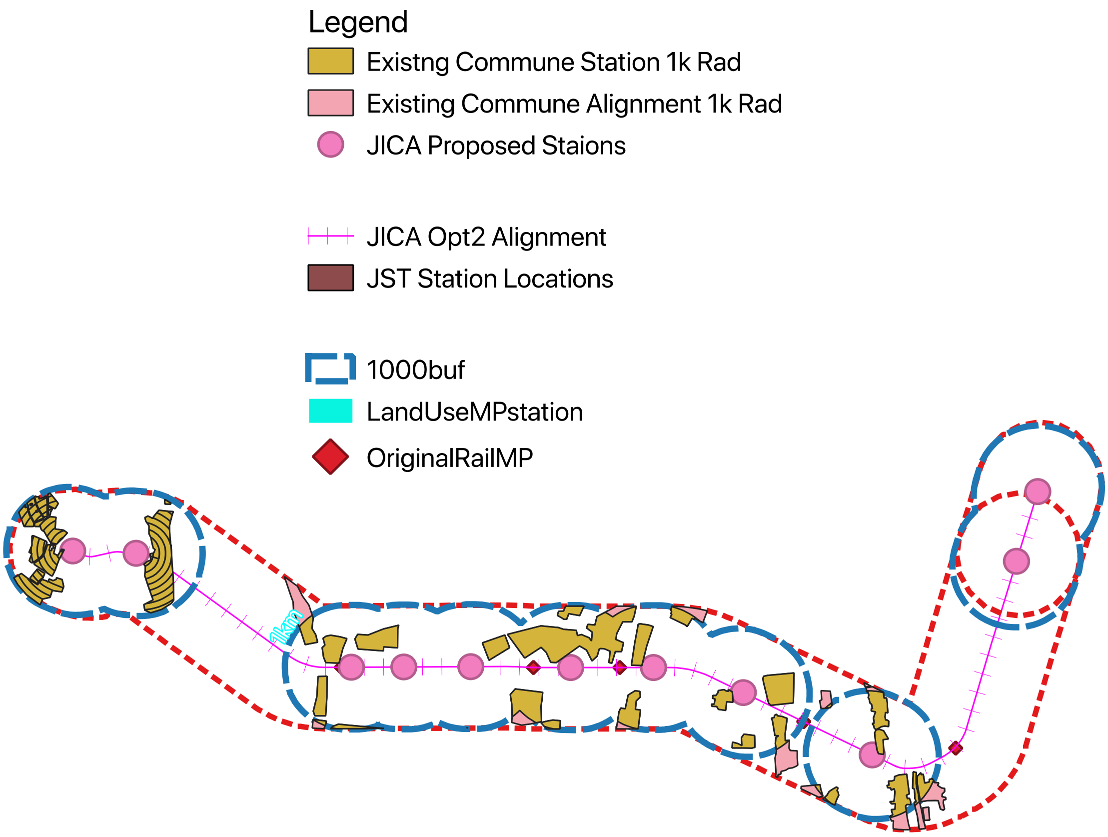


Figure 7-7. Coverage of Existing Communes by Proposed Station Locations on the Alignment

7.8 Proposed Station Locations

After studying Decision No.519/QĐ-TTg dated 31/3/2016 by Prime Minister approving Hanoi Transport Master Plan to 2030 and Vision to 2050 and Decision No. 6630/QĐ-UBND dated 2/12/2015 approving detailed master plan along Nhat Tan - Noi Bai Road together with design principles and station selection criteria mentioned above and received the comments of the departments as well as the direction of the Chairman of the Hanoi People's Committee at the meeting on 21/10/2019, the JICA Study Team proposed the number of station as follows:

- Option 1 (tunnel for Red River crossing): 11 stations including three underground stations, 1 at grade station and 7 elevated stations.
- Option 2 (bridge for Red river crossing): 12 stations including three underground stations and 9 elevated stations.

Figure 7-8. Proposed station locations on the alignment of Option 1

Figure 7-9. Proposed Station Locations on the Alignment of Option 2

7.8.1 N0, N1 and N1A Stations

- Locations proposed by the JICA Study Team: The N0 station will be located in front of the international terminal of T2 and the N1 station will be located in front of the domestic terminal T1 of Noi Bai International Airport, Soc Son District. The distance is 1,190m between N0 and N1. N1A Station is located opposite to the future cargo terminal, which is proposed to be supplemented with the original report of the Study Team to meet the airport expansion plan, the number of staff, traffic demand and consider the number of people currently working at the airport area is 9,124 as the Vietnam Aviation Administration said in letter No. 5020/CHK-QLC on 11/11/2019. The distance between N1 and N1A stations is 1,510m.
- Analysis of master plans: According to Decision No. 519 / QD-TTg dated March 31, 2016, the end point of the urban railway No. 2 is determined at Noi Bai International Airport in general, in the drawing illustrating the endpoint corresponding to T1 passenger terminal (domestic station) of Noi Bai International Airport, connected to UMRT Line 6. According to the city plan, Line 6 has not yet determined the investment progress, while the number of

international passengers is through the T2 passenger terminal is now very large, requiring research to connect traffic to Hanoi city center. The arrangement of 2 urban railway stations connected to the airport terminal T1 and T2 is specified in Noi Bai International Airport plan according to the Prime Minister's Decision No. 590/2008 / QD-TTg.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	Following Decision No. 590/2008 / QD-TTg on adjusting the planning of NBIA
2	**Connecting public transport services**	Line 6; Bus routes: 07 (Cau Giay – Noi Bai), 17 (Long Bien – Noi Bai), 86 and 86CT (HN station– Noi Bai), 07 (Kim Ma bus terminal – Noi Bai), 109 (My Dinh – Noi Bai); parking spaces of T1, T2 in NBIA
3	**Railway Access to Existing Transport Demand**	International terminal T2 and domestic terminal T1 of NBIA, Phu Cuong and Phu Minh communes
4	**TOD**	Tunnels connecting stations to terminals T1, T2 and T3, T4 (future) shall be underground commercial areas.
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 10.393m2-N0, 10.477m2-N1 and 10.308m2 - N1A)
6	**Impact on airport operation (taxiway for aircraft from T1- T2 am T3- T4)**	Due to the underground station, it does not affect the operation of the airport
7	**Affecting the environment and landscape**	Due to the underground station, it affects marginally to the environment and landscape

Figure 7-10. Locations of N0, N1, N1A Stations

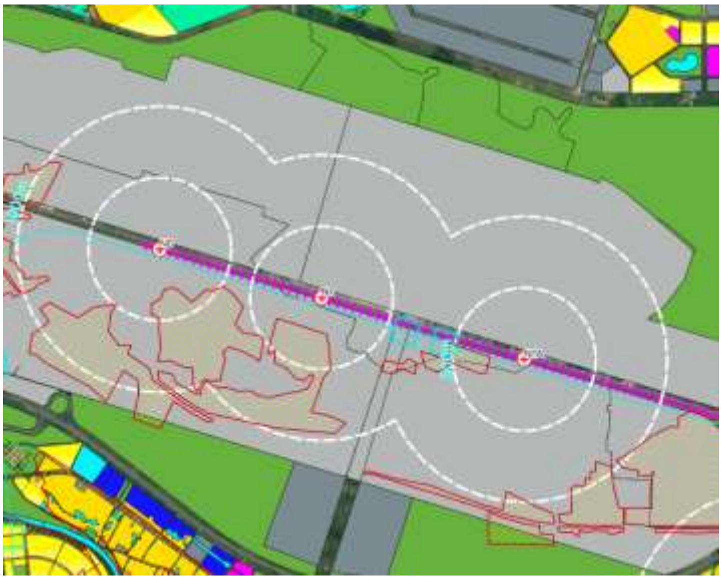


Figure 7-11. Locations of N0, N1 and N1A Stations by NBIA Master Plan

Figure 7-12. General Plan of N0 Station

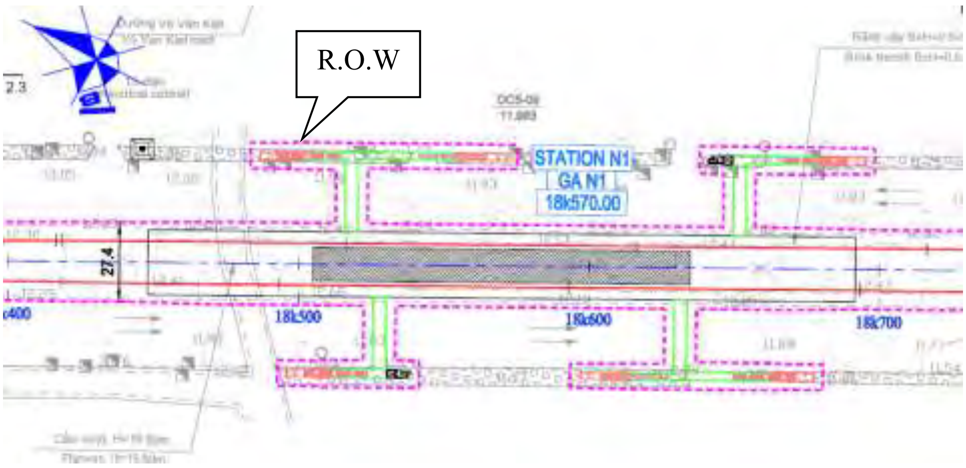


Figure 7-13. General Plan of N1 Station

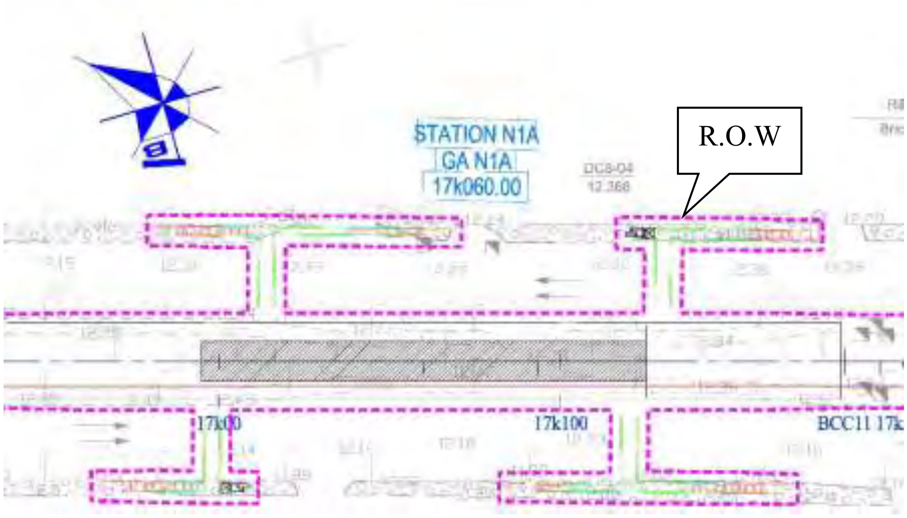


Figure 7-14. General Plan of N1A Station

7.8.2 N2 Station

- The location proposed by the JICA Study Team: The N2 Station will be located 500m south of NH2A and NH18, where suburban residential areas are spread.
- Distances between stations are 3,200m between N2 and N1A, 780m between N2 and N2A.
- Existing land use: The station will provide access to villages of 150 ha in the west and 140 ha in the east.
- Railway Junction: The station location is the junction where a spur line to the Noi Bai Depot and extension line to Soc Son where a station is desirable.
- Analysis of master plans: In the north of NH18, Noi Bai International Airport Terminal will be expanded, leaving no accesses to establish the N2 Station of Transport Master Plan. In the land use plans, no station is planned in this area. The area along the alignment is planned as a green area with an intention to provide buffers to the surrounding communities. However, fairly large existing Phu Lo and Phu Minh communes will exist in the vicinity requiring railway access. Therefore, the optimal solution is the proposed location.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	This station moves to south 1150m compared with Transport Master Plan 519 / QD-TTg to suit the current and future residents.
2	**Connecting public transport services**	Bus route 17 (Long Biên – Noi Bai); NH2; NH18
3	**Railway Access to Existing Transport Demand**	Phu Lo and Phu Minh communes
4	**TOD/LVC**	TOD is planned only for station areas in the west and east
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 7.352m2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of Nhat Tan - Noi Bai Road; thus it does not affect the landscape and traffic.

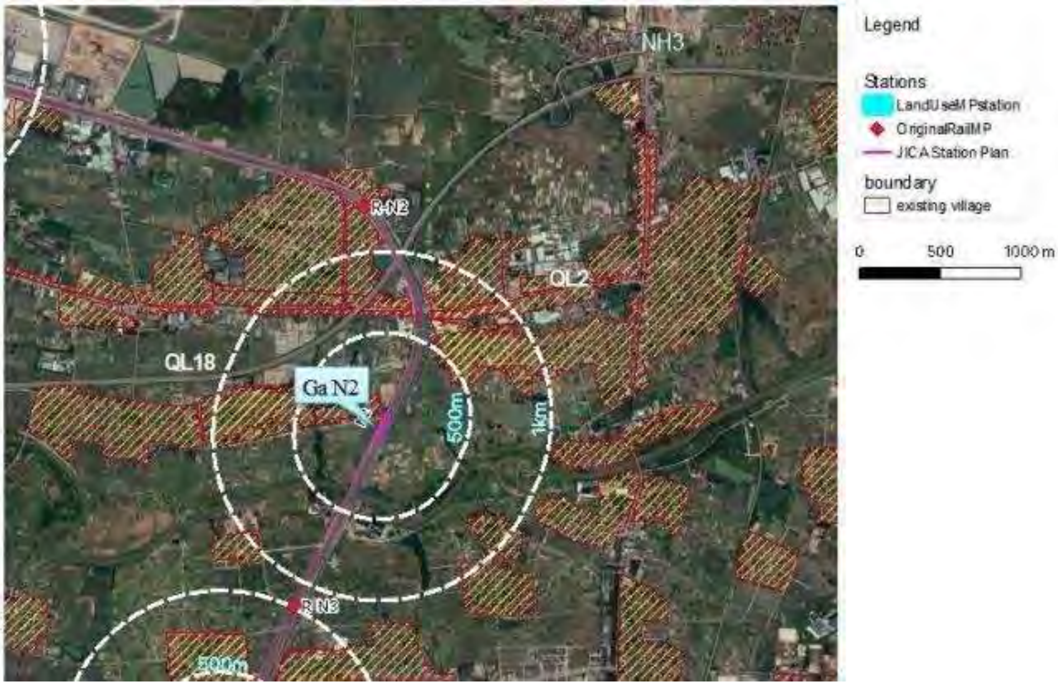


Figure 7-15. Location of N2 Station on Satellite Image

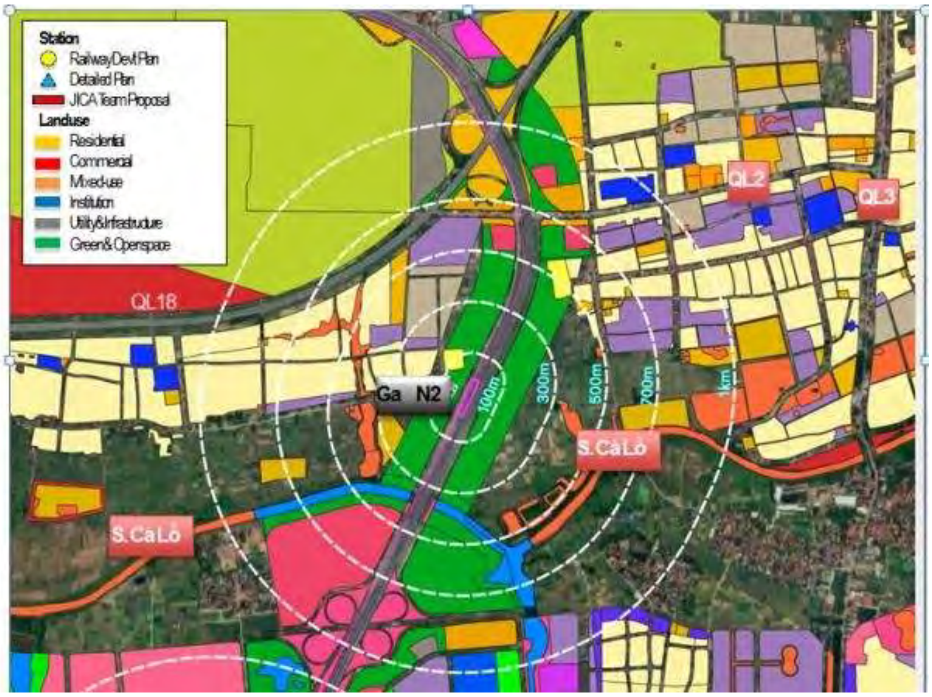


Figure 7-16. Location of N2 Station in Adjusted Detailed Master Plan

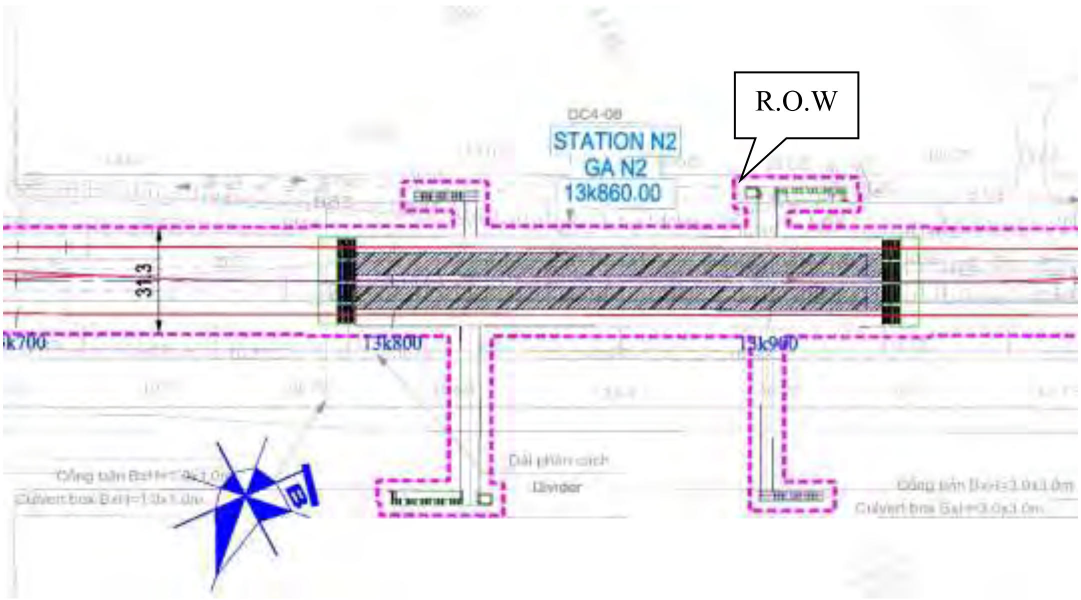


Figure 7-17. General Plan of N2 Station

7.8.3 N2A Station

Additional N2A Station is proposed, in addition to the draft report of the Study Team, to have railway access for the planned outlet mall or farmer's market, the detailed of which is not clarified in terms of the maturity of investment planning and approval. If such a large-scale commercial development materializes, there may be traffic demands via railway as large as 300-600 commuters and 1000 to 4000 shopping visitors per day. Single land use or investment may surge traffics once but may decline quickly to warrant some due diligence on the investment proposal to come. Also, there is a high chance that the airport expansion may absorb the area. Even if not, the area may be too close to the runways to avoid any incidents. Therefore, this station location is adopted tentatively as N2A station.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	This station moves to the north 450m compared with Transport Master Plan 519 / QD-TTg
2	**Connecting public transport services**	Bus route 96 (Nghia Do park – Dong Anh)
3	**Railway Access to Existing Transport Demand**	Planned outlet mall or farmer's market
4	**TOD/LVC**	TOD is planned only for station areas in the west but no definite area to the investment. No prospect for residential uses
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 6.882m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of Nhat Tan - Noi Bai Road, thereby not affecting the landscape or traffic.

Figure 7-18. Location of N2A Station on Satellite Image

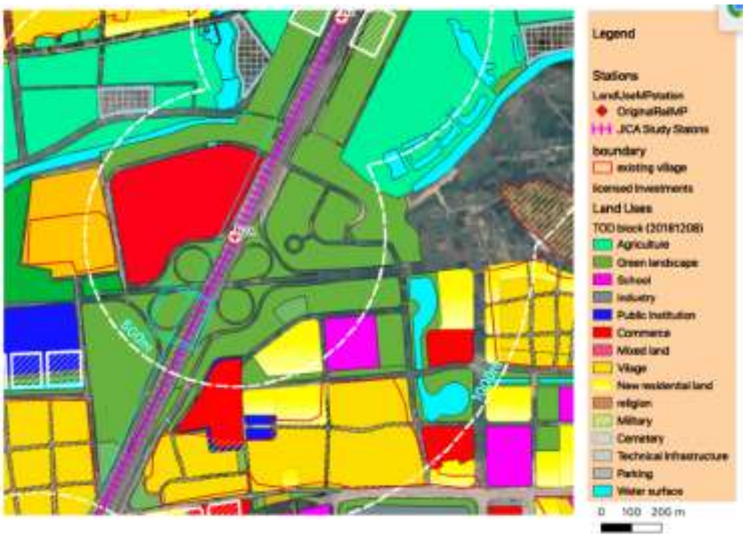


Figure 7-19. Location of N2A Station in Adjusted Detailed Master Plan

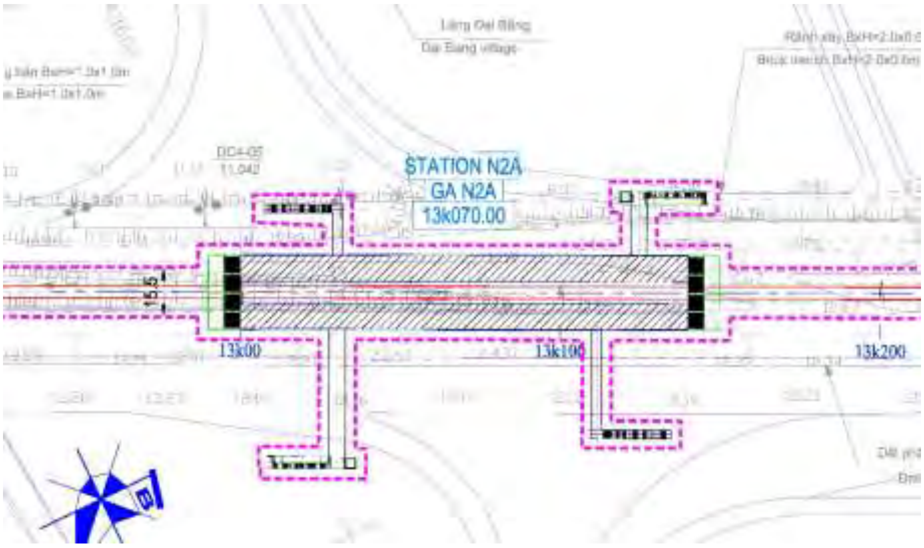


Figure 7-20. General Plan of N2A Station

7.8.4 N3 Station

- The location proposed by the JICA Study Team: The N3 Station will be located at the 300m-north of the Ca Lo River as shown in Figure 7-21.
- Distances between stations are 1520m between N3 and N2A, 1530m between N3 and N4.
- Existing land use: There are Nguyen Khe and Bac Hong Communes with 25ha in the area on both sides of the alignment, and industrial areas 1km east to the station, and the VNR cargo line runs 1km south of the station.
- Analysis of master plans: As shown in Figure 7-22, the Transport Master Plan recommended N3 Station is located inside the planned interchange proposed by the Revised Detail (Land Use) Plan. According to the land use plan, N3 Station of the Transport Master Plan is not possible. Thus the Revised Detail (Land Use) Plan moved the N3 location 600m to the south from the original location and similarly N4 station south close to the National Railway's Bac Hong – Van Dien Line. Then N3 and N4 by the Revised Detail (Land Use) Plan are located within 500-meter distance proving inefficient for operation and coverage. The JICA Study Team proposes to locate one N3 station instead of the two. The location is only 70m to the N4 Station planned by the Transport Master Plan. The land uses will be drastically changed, by the establishment of the software park, technical college, bus interchange, intermodal transport center, etc. The proposed N4 Station will be located in the mid-point of the software park in the east and open spaces in the west balancing the needs for connectivity to new urban facilities and LVC potentials. The planned bus interchange in the north and intermodal transportation center in the south is recommended to be integrated into one location, which should directly be connected to the station by a pedestrian bridge.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	This station moves to south 70m compared with Transport Master Plan 519 / QD-TTg to best serve the current and future residents as well as eliminating establishing two stations within 500 m distance.
2	**Connecting public transport services**	National railway (Bac Hong – Van Dien); Bus route 96 (Nghia Do park – Dong Anh)
3	**Railway Access to Existing Transport Demand**	Current: Nguyen Khe and Bac Hong Communes (25ha) Future: Industrial vocational training school, software park
4	**TOD/LVC**	TOD/LVC is planned around the station with an area of about 68 ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 7.165m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of Nhat Tan - Noi Bai Road, thereby not affecting the landscape or traffic.

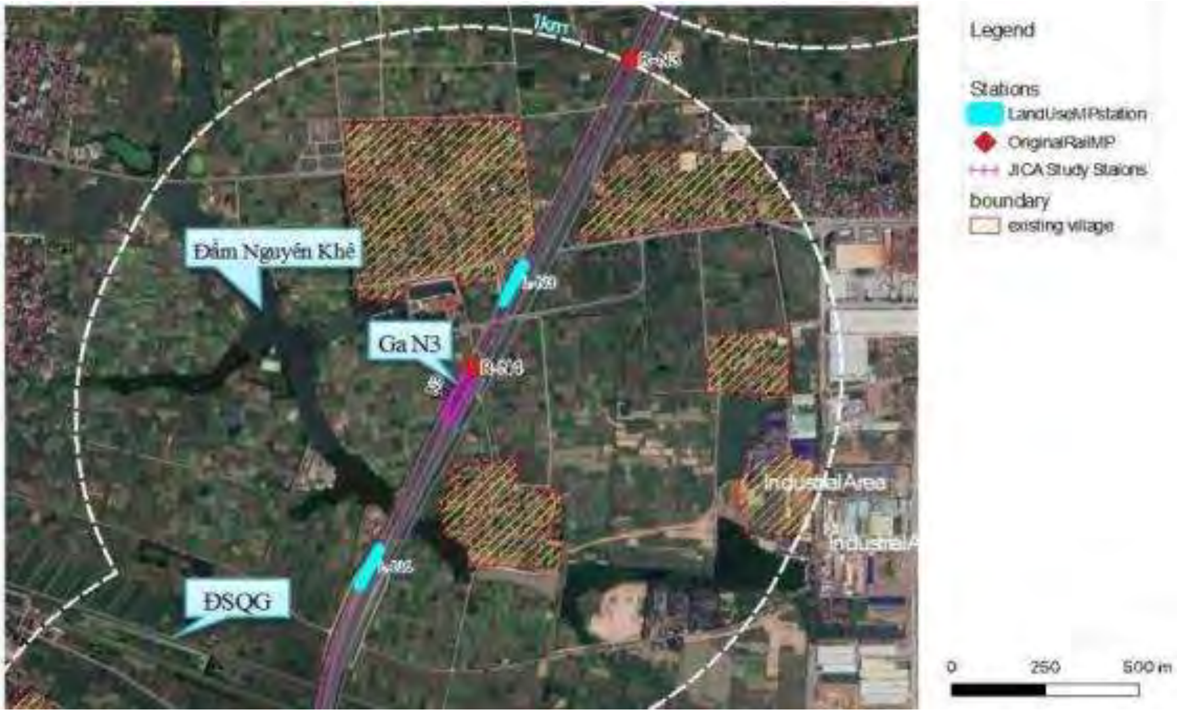


Figure 7-21. Location of N3 Station on Satellite Image

Figure 7-22. Location of N3 Station in Adjusted Detailed Master Plan

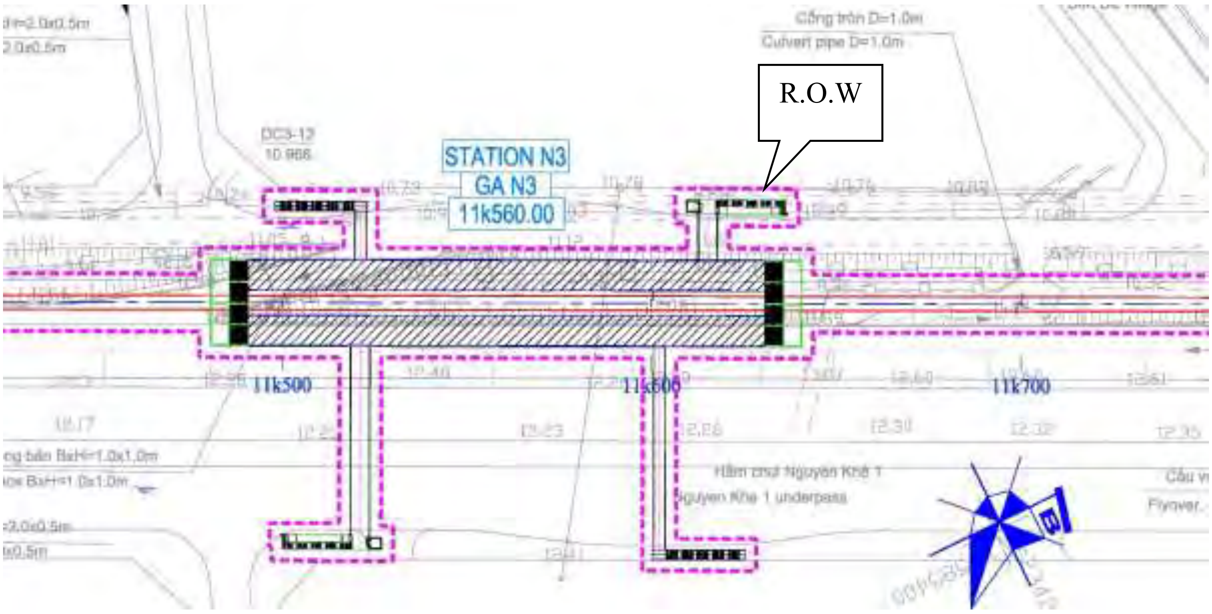


Figure 7-23. General Plan of N3 Station

7.8.5 N4 Station

- The location proposed by the JICA Study Team: The N4 Station will be located 500m-south of VNR railway 700m-north of NH23. Distances between stations are 1,530m between N4 and N3, and 1,340m between N4 and N5.
- Existing and future land use: The area is mostly paddy fields with scattered rural villages away from the station location, offering a larger space for new developments. Ring Road 3 will be extended south of the VNR railway in parallel. There will be a major interchange for the Vo Nguyen Giap Road and Ring Road 3. The area will have excellent potential as a transport hub, which makes this area to be qualified as “North CBD”. The distance to the Smart City CBD is 5km.
- Analysis of master plans: The JICA Study Team proposes the station be moved 130m south from the location indicated by the Revised Detail (Land Use) Plan to enable smooth traffic flows to and from the planned interchange. The station will be located in front of commercial and service function areas, and near to the planned interchange of Ring Road 3. The new investment projects have been approved such as commercial development, medical complex, social and low-income housing on the eastern side of the alignment. The Transport Master Plan had no plan to establish a station in this area but proposed N5 Station 560 meter to the south of the JICA Study Team proposed N4 Station. The intention of the Transport Master Plan was only to provide railway access to existing communes and not to capture TOD potentials for new urban developments.
- The proposed N4 station location is reasonable to allow smooth traffic flows to and from the planned intersection (between Ring Road 3 and Vo Nguyen Giap Road). If the National railway is to utilize the line for commuting to the industrial estates, the Bac Hong Station should be moved closer to N4 station for a better connectivity. In the case of connecting from Bac Hong station to N4 station, it will go (walk or pedestrian bridge) along Ring road 3 and turn right to Vo Nguyen Giap road

Summary of Proposed Location

1	**Compliance with the planning**	This station moves to the south 100m compared with the *Revised Detail (Land Use) Plan* to facilitate the future traffic flow of the intersection
2	**Connecting public transport services**	National Railway (Bac Hong – Van Dien); Ring Road 3; Bus Route 61 (Van Ha – Cau Giay Park), 96 (Nghia Do Park – Dong Anh)
3	**Railway Access to Existing Transport Demand**	At present: Van Noi, Bac Hong, and Tien Duong communes Future: CHI Hospital, VINGROUP commercial center, medical complex, multimodal transport service center
4	**TOD/LVC**	TOD is planned around the station with an area of about 126ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 7,039m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of Nhat Tan - Noi Bai Road; thus it does not affect the landscape and traffic.

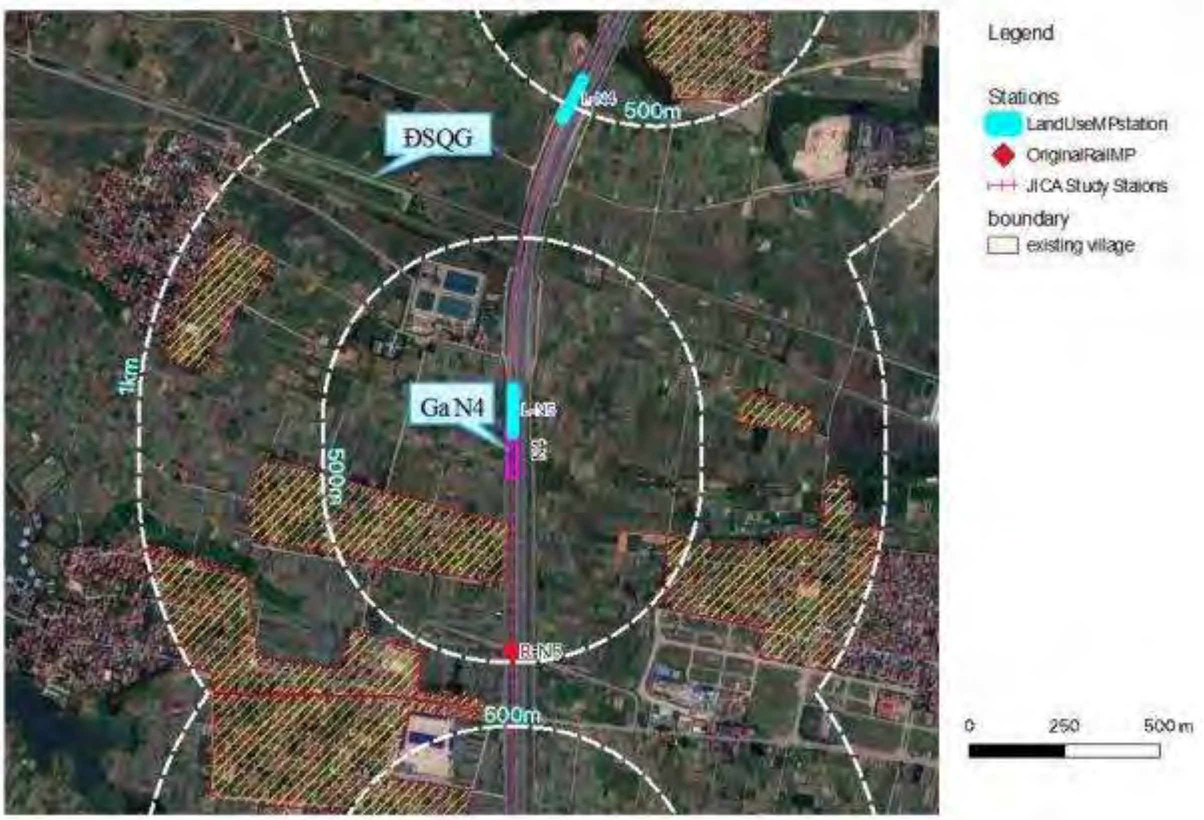


Figure 7-24. Location of N4 Station on Satellite Image

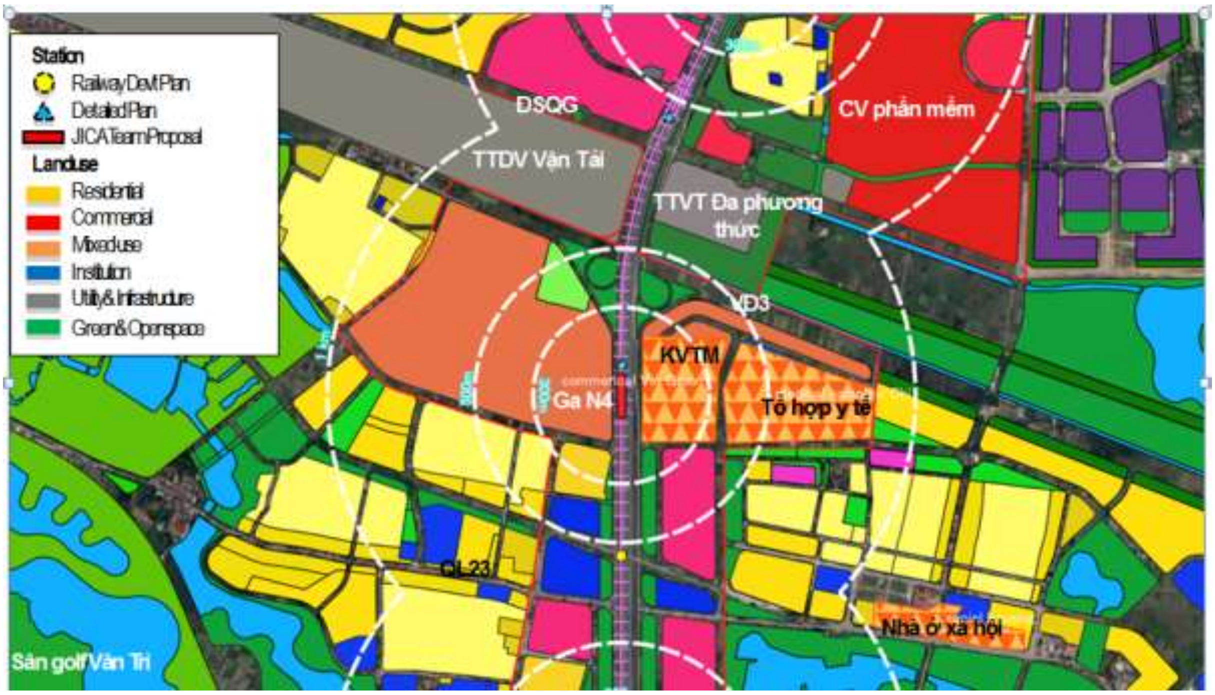


Figure 7-25. Location of N4 Station in Adjusted Detailed Master Plan

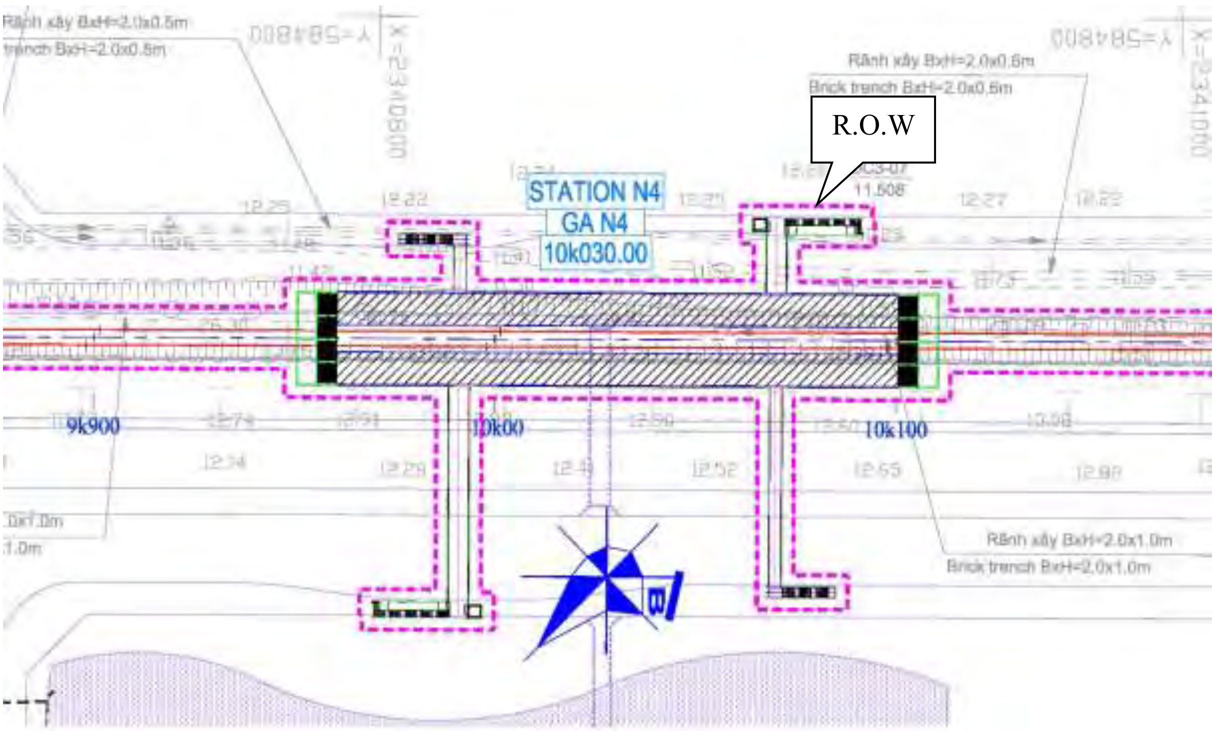


Figure 7-26. General Plan of N4 Station

7.8.6 N5 Station

- The location proposed by the JICA Study Team: The N5 Station will be located 700m-south of NH23. Distances between stations are 1,340m between N5 and N4, 1,610m between N5 and N6.

- Existing land use: Most of the surrounding areas are paddy fields, and rural villages cluster 300-500m west of the station. The land area is about 70ha with a population of about 6,000.
- Analysis of master plans: The station location is 120 m south to the one proposed by the Revised Detail (Land Use) Plan. The Transport Master Plan has no station planned in this area. The dominant land use will be residential, including existing villages and planned social and low-income housings with approved investment licenses. There will be a social housing scheme with 46 ha in area and the planned capacity of 11,000 populations to be developed on the eastern side of the Road.
- As described in the TOD Guidelines, access to the station should be secured by breaking the canal and park and green belt.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	This station moves to the south 120m compared with the *Revised Detail (Land Use) Plan*
2	**Connecting public transport services**	Bus route 96 (Nghia Do Park – Dong Anh)
3	**Railway Access to Existing Transport Demand**	At present: Van Noi and Tien Duong Communes Future: Social housing area by Vigracera – Hoang Thanh JV; commercial and service centers along Vo Nguyen Giap Road
4	**TOD/LVC**	TOD is planned around the station with an area of 30ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 7,006m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of Nhat Tan - Noi Bai Road; thus it does not affect the landscape and traffic.

Figure 7-27. Location of N5 Station on Satellite Image

Figure 7-28. Location of N5 Station in Adjusted Detailed Master Plan

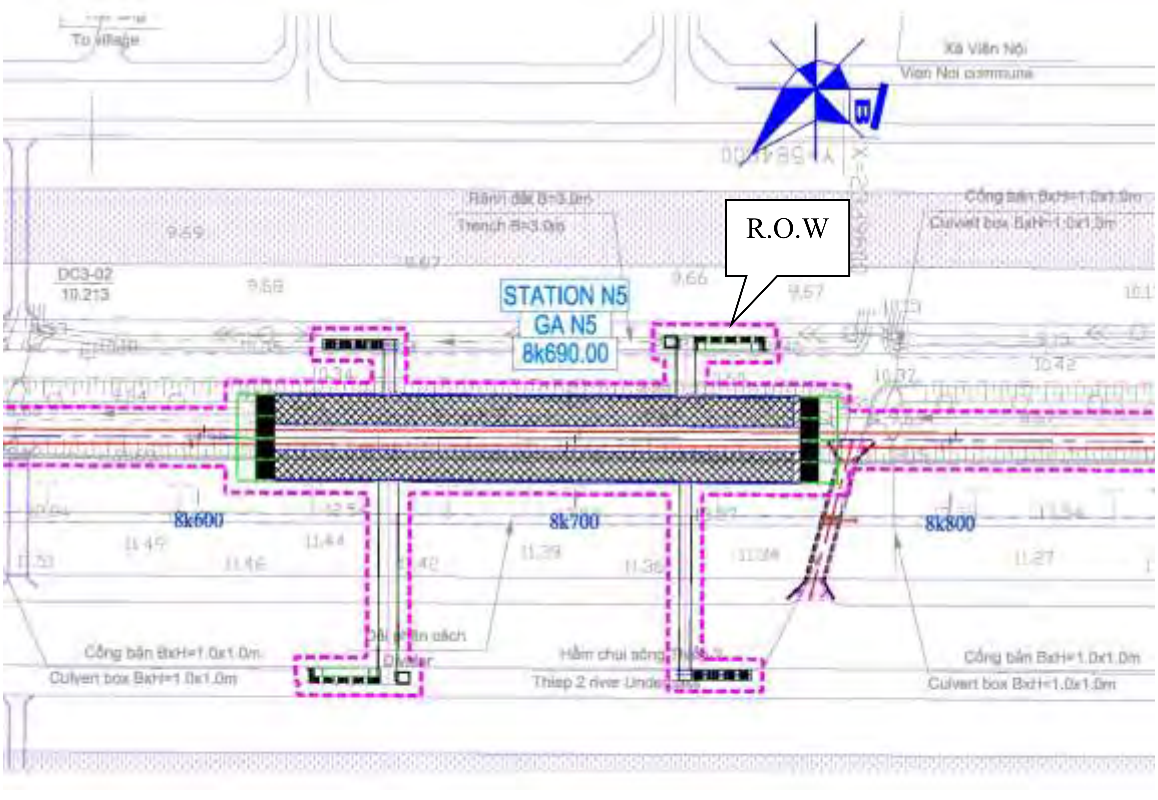


Figure 7-29. General Plan of N5 Station

Figure 7-30. Perspective of N5 Station Area

7.8.7 N6 Station

- The location proposed by the JICA Study Team: The N6 Station will be located 900m north of National Highway 500m west to the Vo Nguyen Giap Road. Distances between stations are 1,610m between N6 and N5, and 945m between N6 and N7.
- Existing land use: The N6 Station will be located surrounded by paddy fields and many ponds.
- Analysis of master plans: The station location is the same as the Transport Master Plan and the Revised Detail (Land Use) Plan. The surrounding area of the station will be converted to a commercial area and an international cultural center will be developed at the south-west of the station. There is an existing factory on the site. While commercial and cultural areas around the station will be accessible, new development area at the east of Vo Nguyen Giap Road is far from the station; thus feeder services may be needed. Possibly an additional flyover may be considered.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	Station location is similar to the Revised Detail (Land Use) Plan and the Transport Master Plan 519/QĐ-TTg
2	**Connecting public transport services**	Vo Nguyen Giap Road and the planned road connecting NH5 to Vo Nguyen Giap Road
3	**Railway Access to Existing Transport Demand**	At present: Van Noi and Tien Duong Communes Future: International cultural center, commercial-office center, medical complex
4	**TOD/LVC**	TOD is planned around the station with area of 63ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 6,538m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of the planned road; thus it does not affect the landscape and traffic.

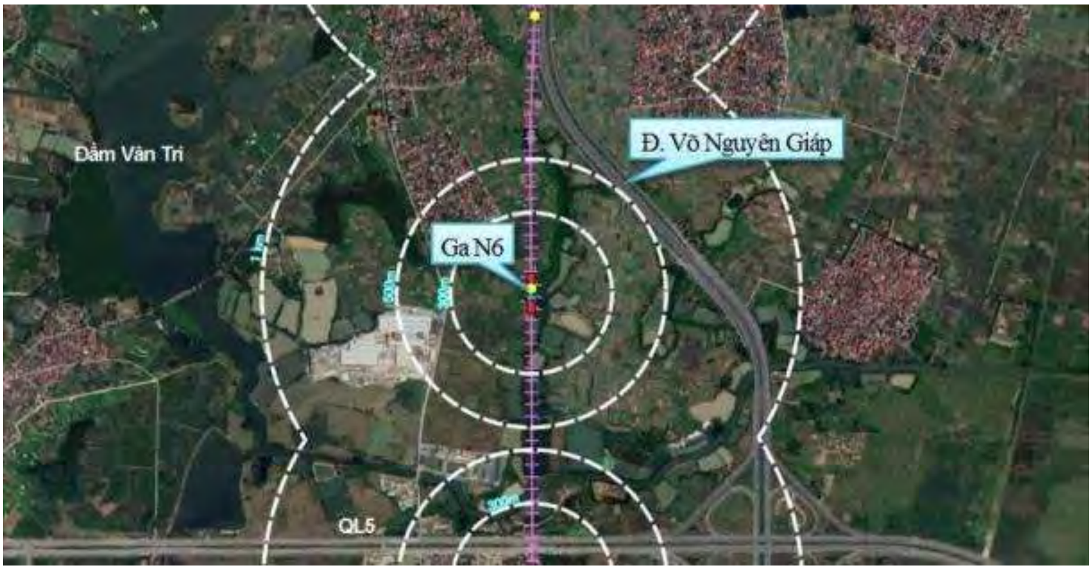


Figure 7-31. Location of N6 Station on Satellite Image

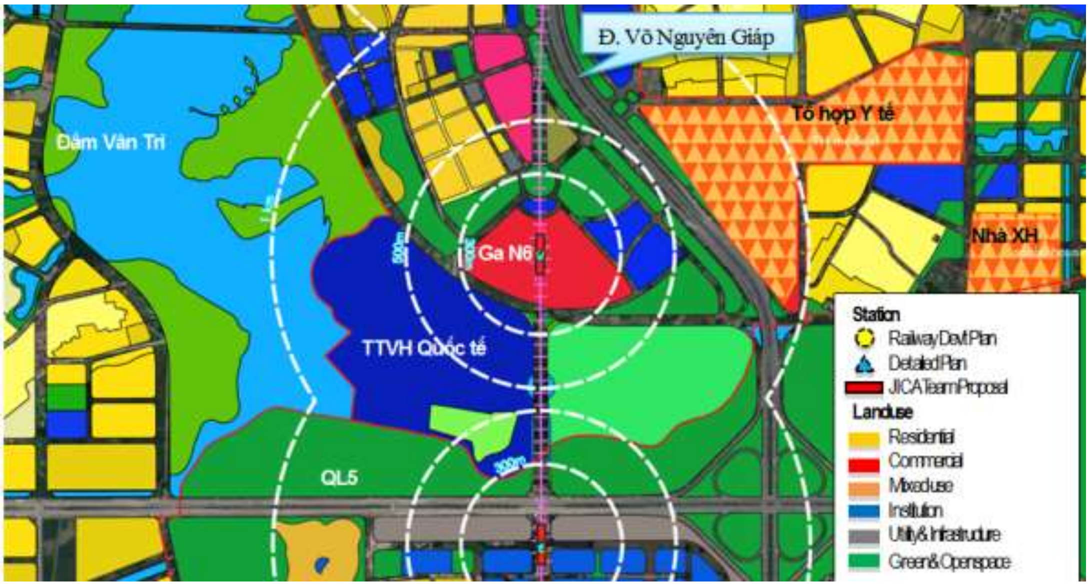


Figure 7-32. Location of N6 Station in Adjusted Detailed Master Plan

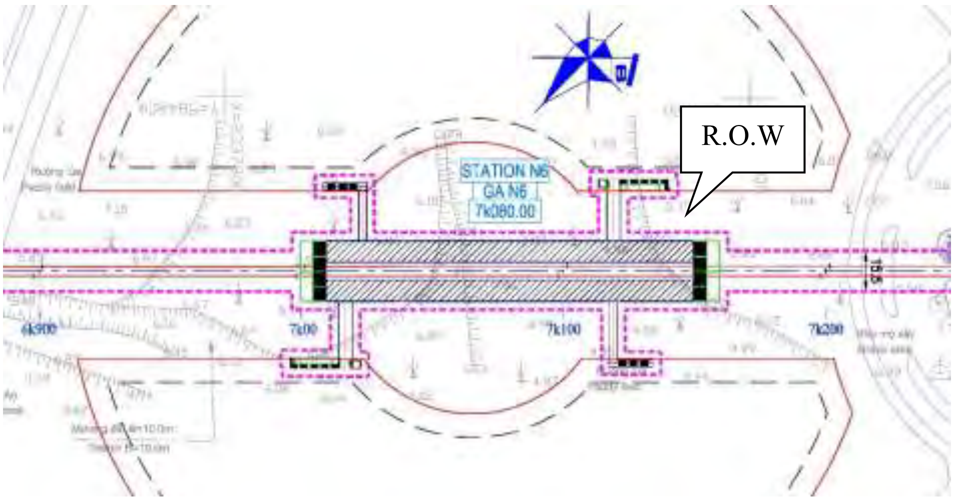


Figure 7-33. General Plan of N6 Station

7.8.8 N7 Station

- The location proposed by the JICA Study Team: The N7 Station will be located at the south of NH5A, 1km west to the interchange of Vo Nguyen Giap Road and NH5A. Distances between stations are 945m between N7 and N6 and 995m between N7 and N8.
- Existing land use: There are few residential areas.
- Analysis of master plans: According to the Railway Master Plan, Metro Line 4 will be constructed along the NH 5. Thus the station can be located at the juncture with Line 2. This area is a part of the Smart City, planned by BRG and Sumitomo Corporation Consortium Around the station. Hanoi City Governmental buildings will be clustered along the south side of NH 5. The plan is a large-scale relocation of city government functions from the city center. The station will be the gateway for the Hanoi City Government area. Therefore the station location is the same as the Transport Master Plan and the Revised Detail (Land Use) Plan. The station should have functions of intermodal transfers between public bus, automobile and Metro Lines of 2.3 and 4.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	Station location is similar to the Detailed Master Plan and Transport Master Plan 519/QĐ-TTg
2	**Connecting public transport services**	Line 4; Bus route 96 (Nghia Do Park – Dong Anh), 25 (Central Tropical Hospital No. 2 – Giap Bat Bus Terminal).
3	**Railway Access to Existing Railway Access to Existing Transport Demand**	At present: Vinh Ngoc Commune Future: Smart City
4	**TOD/LVC**	TOD is planned around the station with area of about 0.7ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 6,803m^2)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of the planned road, so it does not affect the landscape and traffic.

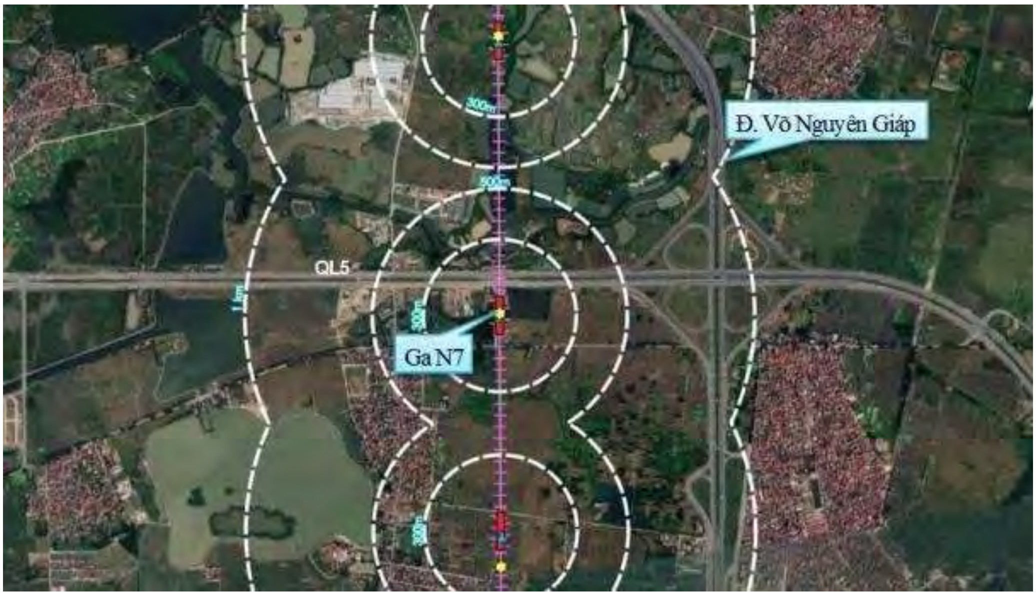


Figure 7-34. Location of N7 Station on Satellite Image

Figure 7-35. Location of N7 Station in Adjusted Detailed Master Plan

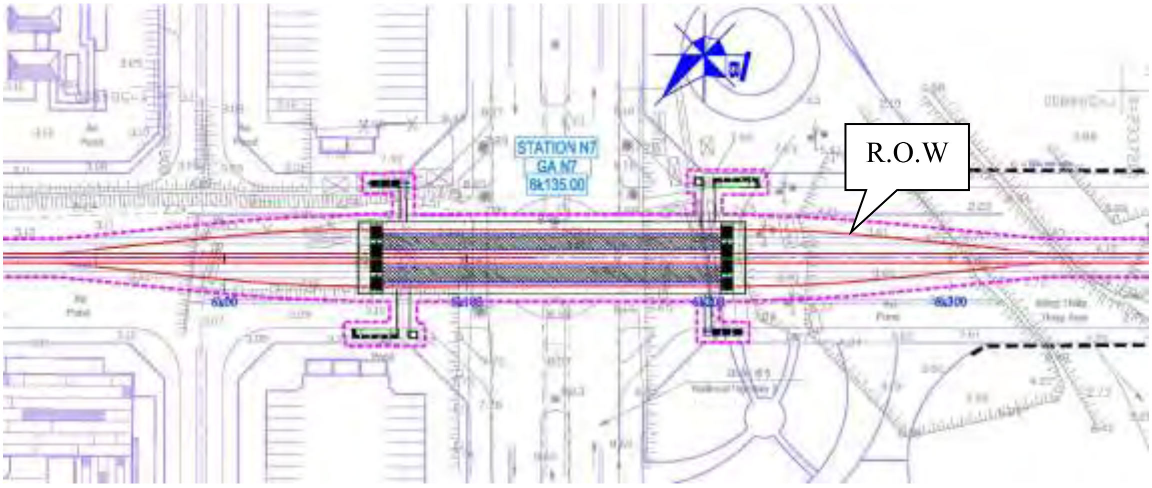


Figure 7-36. General plan of N7 Station

7.8.9 N8 Station

- The location proposed by the JICA Study Team: The N8 Station will be located at 500m-north of the Dyke Road. Distances between stations are 995m between N8 and N7 and 4,060m between N8 and N9.
- Existing land use: The surrounding areas are only paddy fields, without access roads. There is a relatively large pond in the west and temple in the west.
- Analysis of master plans: This area is a part of the Smart City, planned by BGC and Sumitomo Corporation Consortium. At the east of the station, high-rise mixed-use buildings will be clustered. In the west of the station, high-rise residential areas will be developed. According to the perspective of the Revised Detail (Land Use) Plan, there will be a large open space in front of the highest building in Vietnam, the Financial Tower. Though it may not be aesthetically ideal, access to N8 Station will be greatly enhanced if the park is located in the

east-west direction instead of the planned north-south direction to enable the realization of mobility routes to the residential and office buildings in the east side.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	Station location is similar to the detailed master plan and a shift to the north by 130m compared with Transport Master Plan 519/QĐ-TTg
2	**Connecting public transport services**	NH5 and left Red River Dyke
3	**Railway Access to Existing Transport Demand**	At present: Vinh Ngoc Commune Future: Smart City
4	**TOD/LVC**	TOD is planned around the station with an area of about 0.9ha
5	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 6.226m^2 for grade station and 5,902m^2 for the elevated station)
6	**Affecting the environment and landscape**	The elevated station is located in the strip land for the railway of the planned road; thus it does not affect the landscape and traffic. In the case of a ground station, it will affect the landscape and traffic.

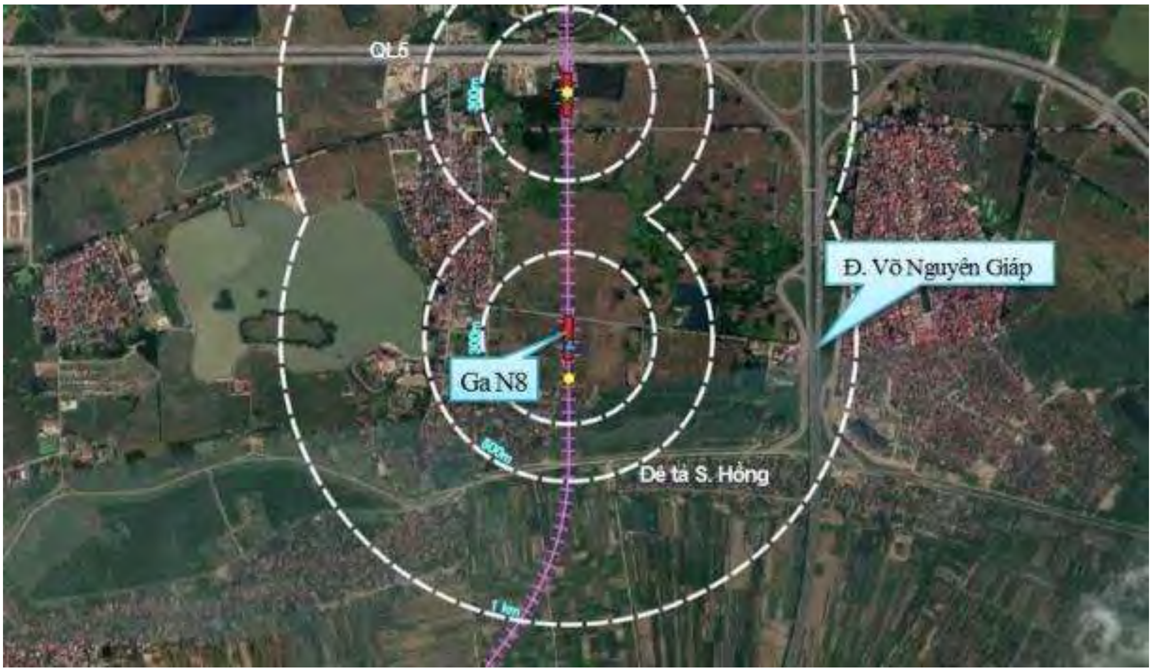


Figure 7-37. Location of N8 Station on Satellite Image

Figure 7-38. Location of N8 Station in Adjusted Detailed Master Plan

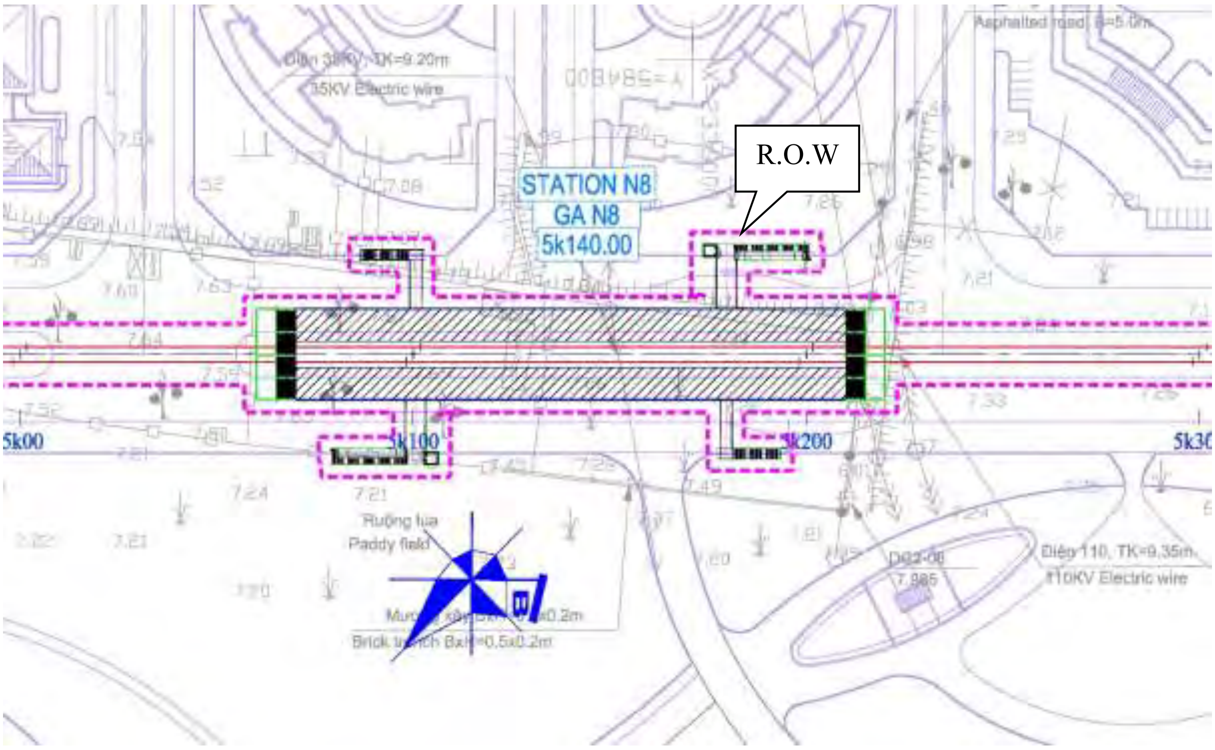


Figure 7-39. General Plan of N8 Station

Figure 7-40. Perspective of Financial Tower and Park

7.8.10 N9 Station (for Red River Crossing by Bridge)

- The location proposed by the JICA Study Team: The N9 Station will be located between the south of Dyke Road and the north of Ciputra. Distances between stations are 4,060m between N9 and N8 and 1,047m between N9 and C1.
- Existing land use: The area is now open cleared land ready for immediate residential development by the developer.
- Analysis of master plans: The Ring Road 2.5 will be developed along with the UMRT Line2, connecting to the dyke road. The station will serve for providing public transport service to residential areas of the dyke area, as well as the north gateway of the Ciputra.

Summary of Proposed Location

No.	Criteria	Evaluation
1	**Compliance with the planning**	Station location is similar to the transport master plan 519 / QD-TTg
2	**Connecting public transport services**	The main road planned in Ciputra and left Red River Dyke
3	**Railway Access to Existing Transport Demand**	At present: Phu Thuong Ward Future: North Ciputra
4	**TOD/LVC**	The proposed areas for TOD/LVC are the immediate areas adjacent to the station with an area of 1.8 ha.
6	**Land acquisition**	Station area and connections locating within approved red lined boundary (Land acquisition - public land is 5,663m^2)
7	**Affecting the environment and landscape**	The elevated station is located in the median of the planned road of Ciputra urban area, so it does not affect the landscape and traffic.

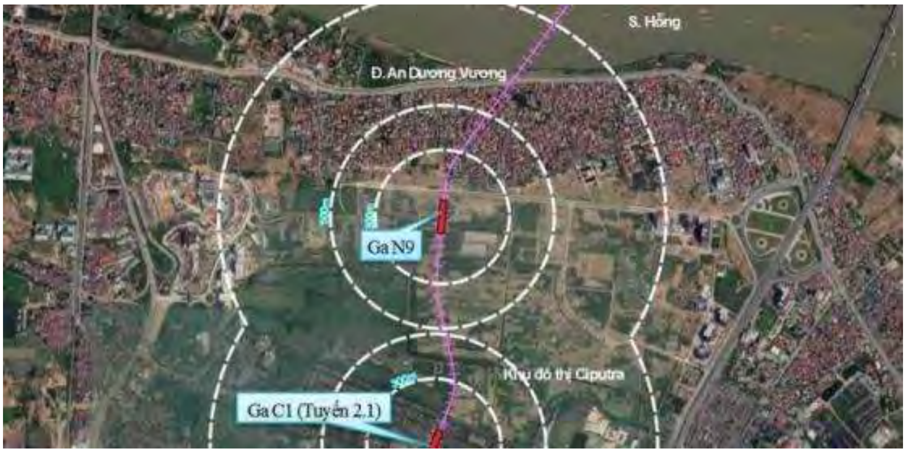


Figure 7-41. Location of N9 Station on Satellite Image

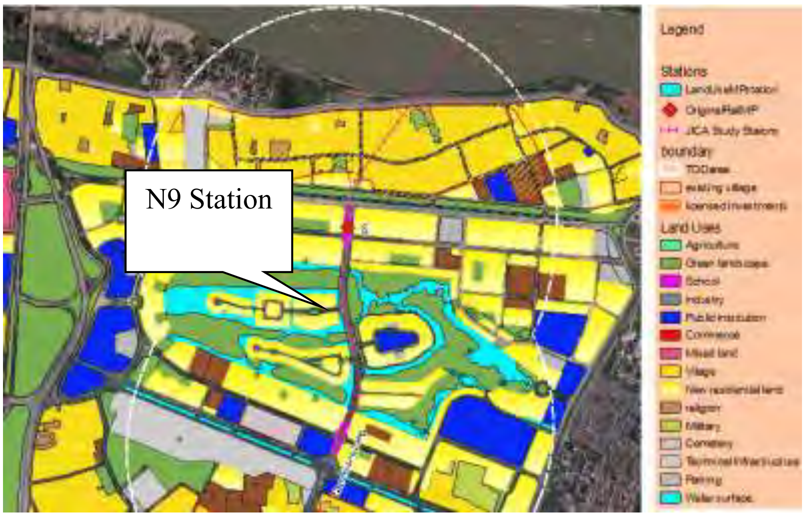


Figure 7-42. Location of N9 Station in Adjusted Detailed Master Plan

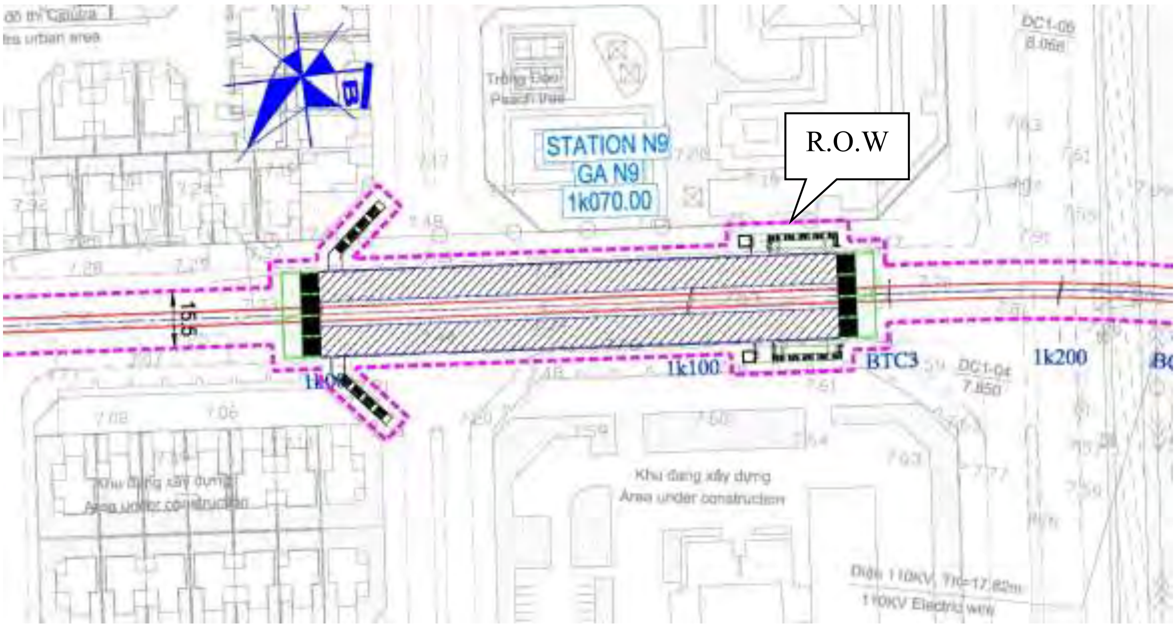


Figure 7-43. General Plan of N9 Station

7.8.11 Summary table of station locations

Table 7-1. Station Locations of Line 2.3 (Tunnel Option for Red River Crossing)

No	Name	Chainage	Distance (m)	District	Note
1	C1	0k023		Tay Ho	Elevated (Line 2.1)
2	N8	5k140	5117	Dong Anh	Grade
3	N7	6k135	995	Dong Anh	Elevated
4	N6	7k080	945	Dong Anh	
5	N5	8k690	1610	Dong Anh	
6	N4	10k030	1340	Dong Anh	
7	N3	11k560	1530	Dong Anh	
8	N2A	13k080	1520	Dong Anh	
9	N2	13k860	780	Soc Son	
10	N1A	17k060	3200	Soc Son	Underground
11	N1	18k570	1510	Soc Son	
12	N0	19k760	1190	Soc Son	

Table 7-2. Station locations of Line 2.3 (Bridge Option for Red River Crossing)

No	Name	Chainage	Distance (m)	District	Note
1	C1	0k023		Tay Ho	Elevated (Line 2.1)
2	N9	1k070	1047	Tay Ho	Elevated
3	N8	5k130	4060	Dong Anh	
4	N7	6k125	995	Dong Anh	
5	N6	7k070	945	Dong Anh	
6	N5	8k680	1610	Dong Anh	
7	N4	10k020	1340	Dong Anh	
8	N3	11k550	1530	Dong Anh	
9	N2A	13k070	1520	Dong Anh	
10	N2	13k850	780	Soc Son	
11	N1A	17k050	3200	Soc Son	Underground
12	N1	18k560	1510	Soc Son	
13	N0	19k750	1190	Soc Son	

7.8.12 Impact of adding more stations

The JICA Study Team has undertaken the determination of station locations with the following principles.

1) TOD Effects

In general principles, TOD requires providing access to the existing population as well as capturing the future land value increases from urban developments of undeveloped areas.

2) Negative Effects

At the same time, increasing the number of stations will have the following negative impacts on the financial feasibility of the railway project. Thus The JICA Study Team has been trying to reduce the number where it seems possible or postpone addition to a future stage.

The negatives of adding stations are:

(1) Adding one station will increase the investment cost.

(2) More stations will increase the costs for more workforce and utility costs during operation.

(3) Adding one station will increase the travel time due to loss of average speed due to deceleration before stopping as well as stopping time by one minute approximately.

3) Cost Impacts

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

4) Implementation Phasing of Station

The value of some station location is predicated on the provision of other infrastructure or business investments. In such a case, the construction of the station should not precede those pre-requisite investments. t is by far the single largest element in investment. While stations are sources for TOD/LVC, there is a need for strategy in actual implementation.

For example, N2A Station's main purpose is to serve a proposed outlet/farmer's market. Shifting of N3 to further south to provide access to Bac Hong Station of VNR is predicated on the critical completion of the Ring Road Three and its interchange with the Vo Nguyen Giap Road. Moreover, the provision of the station could add an attraction of the workers and drivers to commute to the center but is not critical. The most critical factor is the business need and the comparative advantage of the location with other competing locations. Therefore, the provision of the station could await such moves or petition from prospective investors.

The implementation of stations could be phased according to the surrounding economic preconditions as shown in Table 7-3 below.

Table 7-3. Implementation Phasing of Station

Station	Implementation Timing and Method
N0-N1A	Simultaneously with the initial construction, provided that CAAV has finished the basic plan for the future expansion plan.
N2	Simultaneously with the initial construction.
N2A	When the investor starts the construction of the market with the petition and contribution to the station buildings.
N3	When the investor starts the construction of TOD with the petition and contribution to the station buildings.
N4	Simultaneously with the initial construction.
N5	When the investor starts the construction of TOD with the petition and contribution to the station buildings.
N6	When the investor starts the construction of TOD with the petition and contribution to the station buildings.
N7	When the alignment design of Line 4 is finalized. The track arrangements for the express line overtaking and Line 2.1 train returns are to be constructed at the initial construction phase.
N8	Simultaneously with the initial construction.
N9	When the investor starts the construction of TOD with the petition and contribution to the station buildings.

Conclusion:

- The proposed station locations are all the possible station locations in the entire alignment development.
- In the implementation, prudent approach should be adopted for the actual construction of each station. The decision should be made only after the assessment of the feasibility and maturity of prospective investments to utilize the station.

7.8.13 Connection solution to Line 2.1, Line 4 and Line 6

➢ **Connect to Line 2.1**

According to the operation plan for the whole Line 2, trains from NBIA (N0 station) will go to C16 station (under Phase 2), so Line 2.3 will connect to Line 2.1 at C1 station - Nam Thang Long. In case the train has turn-around operation at C1 Station, it will use the scissor crossing which is located in front of C1 Station (direction from Noi Bai to Nam Thang Long).

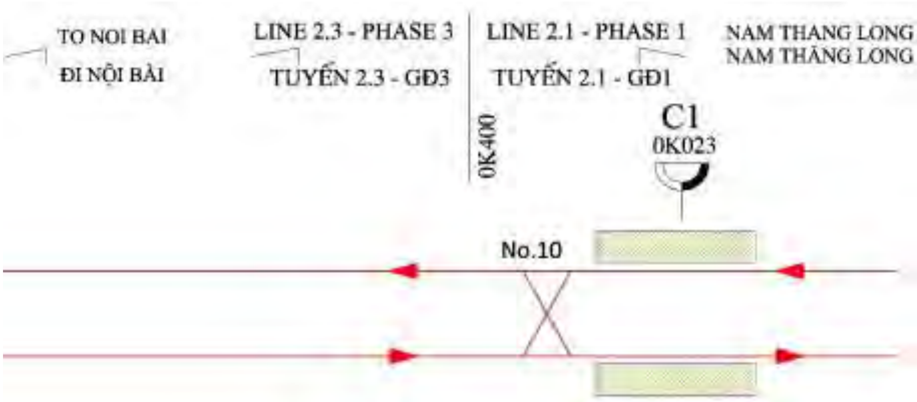


Figure 7-44. Connection between Line 2.3 and Line 2.1 at C1 Station

➢ **Connect to Line 4**

As planned, Line 4 will be located in the middle of the median strip of the extended NH5. It is expected that Line 4 will locate 1 station near the intersection with Line 2.3. According to the study of the Line 4 consultant, this station is located on an elevated platform over NH5.. Thus, according to the profile of Line 2.3, Line 4 will pass over Line 2.3. Therefore, it is proposed to integrate the two stations of Line 2 and Line 4 into one station (cross-shaped station) to have the best transfer between two lines.

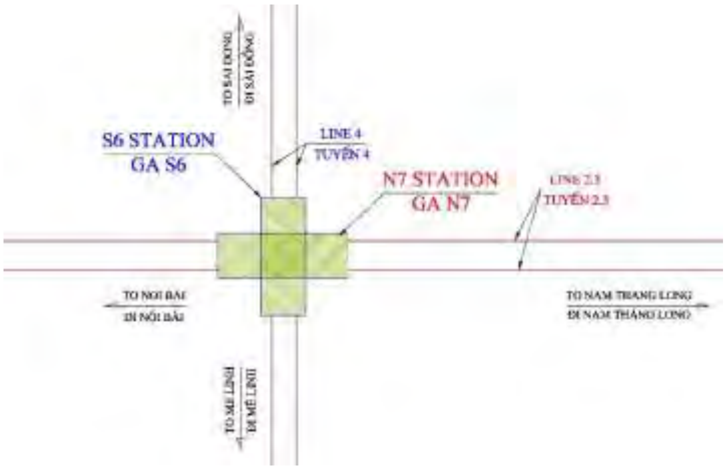


Figure 7-45. Connection between Line 2.3 and Line 4 at N7 Station

➢ **Connection to Line 6**

As planned, Line 2.3 will connect to Line 6 at the station located in NBIA area. Based on the location of stations of Line 2.3 as proposed by the Study Team, N0 station will be an intermediate station between Line 2.3 and Line 6. The Study Team will show the following connection options:

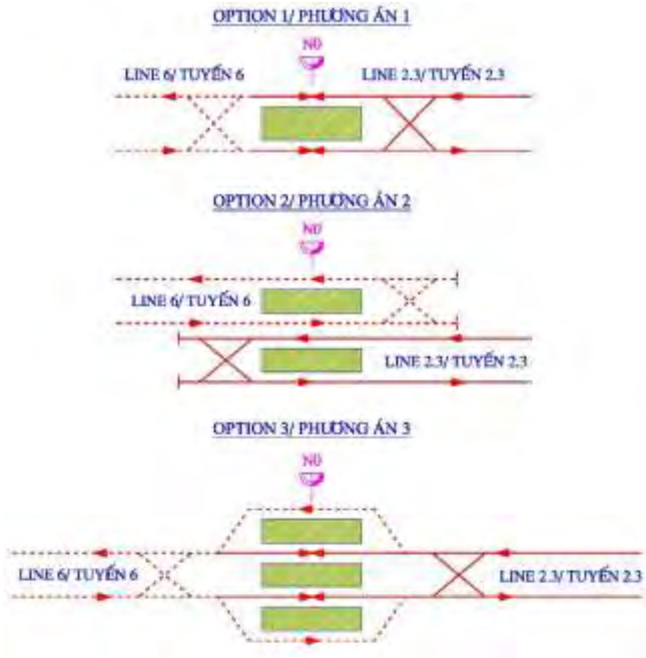


Figure 7-46. Connection Options between Line 2.3 and Line 6

Table 7-4. Comparison of Connection Option Between Line 2.3 and Line 6

No.	Items	Option 1	Option 2	Option 3
1	Description	One island platform for two lines with the same rail level	Two separate island platforms for each line with same rail level	Three island platforms for two lines with the same rail level
2	Advantages	Construction cost is lower than option 2 and option 3; it's convenient for passengers because of sharing the platform.	Construction cost is lower than option 3. Do not affect the train operation of each line.	Do not affect the train operation of each line.
3	Disadvantages	Operation is complicated. Technical synchronization between 2 lines is required.	Connecting passengers is not as good as option 1. Construction cost is higher than option 1.	Construction cost is higher than other 2 options.
4	Conclusion	Not Recommended	**Recommended**	Not Recommended

8. Operation plan

8.1 Travel demand forecast

8.1.1 Travel demand forecast framework

The traffic demand forecast is based on the transport model established for the Hanoi Transportation Master Plan. Given the drastic changes in the demographic concentrations within TOD areas, the residential population and employments data were modified and TOD cum railway parameters were modified to account for the specific characteristics of the TOD approach while utilizing the original transport model. The detail of the methodologies and underlying assumptions were explained in Appendix 8.

8.1.2 Travel demand forecast results of commuting trains

The schematic of station locations for the whole alignment as below:

Figure 8-1. Station Locations for Whole Alignment

The results of modeling are as shown in Table 8-1.

Table 8-1. Railway Passenger Forecast of Line 2 (Pax/day)

Station	2030						2050					
	To City Center			To Airport			To City Center			To Airport		
	Boar -ding	Aligh- ting	On train	Boar -ding	Aligh- ting	On train	Boar -ding	Aligh- ting	On train	Boar- ding	Aligh- ting	On train
N0	5,139		5,139		12,248		14,975		14,975		36,888	
N1	10,285	0	15,424	0	10,785	12,248	24,122	0	39,097	0	26,645	36,888
N1A	1,751	14	17,161	15	1,858	23,033	3,106	21	42,182	23	3,245	63,533
N2	3,704	67	20,798	103	3,442	24,876	6,683	128	48,737	227	6,281	66,755
N2A	919	31	21,686	39	856	28,215	1,737	59	50,415	77	1,643	72,809
N3	4,679	294	26,071	319	4,367	29,032	9,100	534	58,981	614	8,661	74,375
N4	15,078	861	40,288	728	16,387	33,080	27,291	1,684	84,588	1,415	29,722	82,422
N5	5,097	450	44,935	541	4,708	48,739	10,040	895	93,733	1,049	9,889	110,729
N6	2,826	681	47,080	710	2,379	52,906	6,463	1,525	98,671	1,580	5,782	119,569
N7	17,645	4,658	60,067	5,412	17,528	54,575	26,565	8,487	116,749	9,617	26,143	123,771
N8	5,895	1,787	64,175	1,799	6,037	66,691	11,126	3,391	124,484	3,359	11,082	140,297
N9	12,973	1,852	75,296	1,917	14,069	70,929	21,378	3,831	142,031	4,111	22,744	148,020
C1	2,306	504	77,098	510	2,588	83,081	5,893	1,282	146,642	1,296	6,521	166,653
C2	1,231	585	77,744	651	1,366	85,159	2,297	1,285	147,654	1,417	2,498	171,878
C3	1,160	645	78,259	710	1,296	85,874	2,171	1,415	148,410	1,545	2,373	172,959
C4	1,853	843	79,269	821	1,819	86,460	2,484	1,276	149,618	1,263	2,463	173,787
C5	19,279	11,539	87,009	12,675	19,479	87,458	24,327	21,522	152,423	25,127	25,159	174,987
C6	1,981	1,630	87,360	2,354	2,412	94,262	2,562	2,950	152,035	4,971	3,099	175,019
C7	1,904	1,786	87,478	1,831	1,986	94,320	2,512	2,940	151,607	3,013	2,621	173,147
C8	4,547	11,714	80,311	12,816	4,586	94,475	6,067	23,250	134,424	27,355	6,117	172,755
C9	1,815	2,497	79,629	2,831	1,674	86,245	2,464	3,900	132,988	4,346	2,262	151,517
C10	3,135	11,398	71,366	11,681	3,236	85,088	3,954	19,349	117,593	20,468	4,055	149,433
C11	313	1,136	70,543	1,190	274	76,643	453	1,729	116,317	1,867	420	133,020
C12	1,179	21,582	50,140	21,873	1,052	75,727	1,597	38,661	79,253	41,355	1,470	131,573
C13	485	7,218	43,407	7,572	506	54,906	695	9,392	70,556	10,186	752	91,688
C14	478	5,843	38,042	6,596	450	47,840	638	8,057	63,137	9,658	614	82,254
C15	0	8,212	29,830	8,722	0	41,694	0	11,252	51,885	12,699	0	73,210
C16		29,830		32,972		32,972		51,885		60,511		60,511
Total	127,657	127,657	↓	137,388	137,388	↑	220,700	220,700	↓	249,149	249,149	↑

The summary of passenger forecast and travel distances by phases of Line 2 is shown in Table 8-2.

Table 8-2. Summary of Passenger Demand Forecast

Data	Section	Unit	2030	2040	2050
Passenger	N0-C1	PAX/day	104,414	155,601	204,467
	N0-C16	PAX/day	265,032	373,032	469,850
Passenger km	N0-C1	PAX km/day	1,836,662	2,794,871	3,798,783
	N0-C16	PAX km/day	4,121,184	6,090,609	8,077,499
Average Distance Travel	N0-C1	km/PAX	18	18	19
	N0-C16	km/PAX	16	16	17

8.1.3 Travel demand forecast results of airport passengers

Table 8-3 shows the passenger traffics at the Noi Bai International Airport up to 2016. The airport authority is now undertaking the revision of its master plan with a view to expanding the capacity to 80-100 million passengers per year.

Table 8-3. Past domestic and international passengers at NBIA

Year	Passenger/Year			Share (%)	
	Domestic	International	Total	Domestic	International
2010	5,732,263	3,525,944	9,258,207	62%	38%
2011	6,231,882	4,041,286	10,273,168	61%	39%
2012	6,347,060	4,693,121	11,040,181	57%	43%
2013	7,446,255	5,346,540	12,792,795	58%	42%
2014	8,575,676	5,382,569	13,958,245	61%	39%
2015	10,568,408	6,259,170	16,827,578	63%	37%
2016	13,215,303	7,043,401	20,258,704	65%	35%

Source: Vietnam Airlines

Table 8-4 shows the JICA Study Team's forecast of the air passengers to the year 2050 based on the trend analysis with GDP and population growth. Table 8-5 shows the ridership of airline passengers using Line 2.3.

Table 8-4. Results of Traffic Demand Forecast at NBIA Planning

Unit: passenger/ year

Year	Domestic	International
2020	17,164,366	13,418,693
2025	24,979,316	20,801,850
2030	32,282,778	28,558,113
2035	36,469,768	34,185,527
2040	40,315,766	39,953,810
2045	43,820,772	45,821,039
2050	46,984,785	51,745,201

Source: Adjustment of Airport Development Master Plan and JICA Study Team

In estimating the passenger volume from the airport terminals of N0 and N1, the modal shares of Line 2.3 are assumed to increase from 10% of the airport passengers in 2030 to 15% in 2040 and stay constant thereafter.

Table 8-5. Airline Passengers Ridership of Line 2.3

Unit: Passengers/Year

	Airport Passenger		Line 2 Passengers To/From Airport	
Year	Domestic	International	Domestic	International
2030	32,282,778	28,558,113	3,228,278	2,855,811
2035	36,469,768	34,185,527	4,376,372	4,102,263
2040	40,315,766	39,953,810	6,047,365	5,993,072
2045	43,820,772	45,821,039	6,573,116	6,873,156
2050	46,984,785	51,745,201	7,047,718	7,761,780

Source: The JICA Study Team

8.2 Basic Policy of operation plan

The Line 2 will be operated in an integrated manner as a whole. However, there will be a large traffic demand gap between the sections of Line 2.1 and Line 2.3. To fill the differences in transport demand, N7 Station will serve as a reversing station for about half of the trains running on Line 2.1. The rest of the trains from Line 2.1 will continue to reach the NBIA to run a full length of the Line 2.1 and Line 2.1.

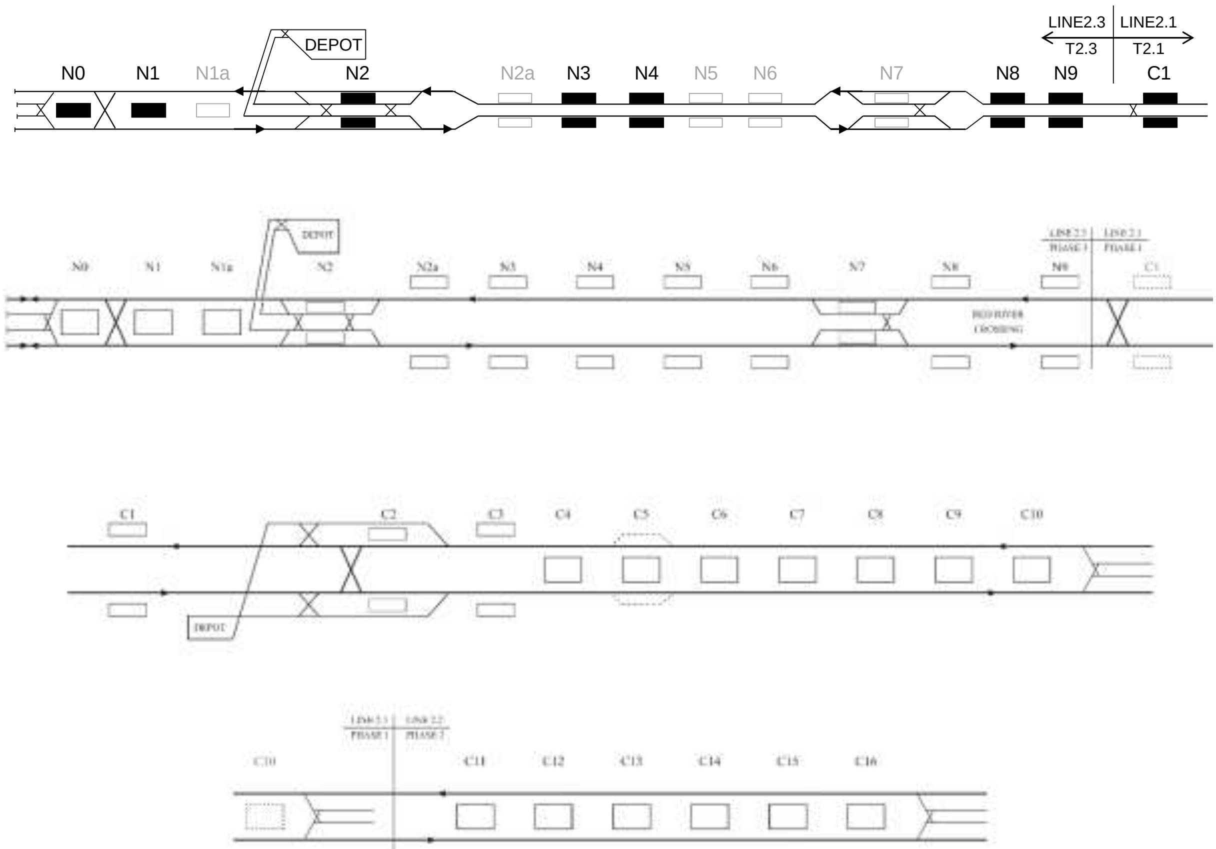


Figure 8-2. Railway Track and Platform Plan of Line 2

8.3 Operation Plan of Line 2

8.3.1 Standard Train Operation

1) Operation Schedules

The time requirements for operation including stopping time for the standard commuting trains of the entire Line 2 are tabulated in Table 8-6 .

Table 8-6. Standard Train Operation Schedules of Line 2 (Bridge Option)

No.	Name of Station	Location (km)		Operation Time Between Stations (m:s)		Stopping Time at Stations (m:s)	Total Operation Time from N0 (Including Stopping Time) (m:s)		Average Speed (km/h)
		Chainage	Between Stations	Calculated	Assessed				
N0		0.0				00:30	***	0:00:00	
N1		1.2	1.190	01:14	01:15	00:30	0:01:15	0:01:45	34.3
N1A		2.7	1.510	↓	↓	↓	↓		
N2		5.9	3.200	03:40	03:45	00:30	0:05:30	0:06:00	66.4
N2A		6.7	0.790	↓	↓	↓	↓		
N3		8.2	1.510	01:55	02:00	00:40	0:08:00	0:08:40	55.2
N4		9.7	1.530	01:23	01:25	00:40	0:10:05	0:10:45	46.1
N5		11.1	1.340	01:16	01:20	00:40	0:12:05	0:12:45	39.0
N6		12.7	1.610	01:27	01:30	00:40	0:14:15	0:14:55	44.3
N7		13.6	0.955	01:06	01:10	00:40	0:16:05	0:16:45	36.0
N8		14.6	0.985	00:56	01:00	00:40	0:17:45	0:18:25	28.8
N9		18.7	4.060	03:08	03:10	00:40	0:21:35	0:22:15	64.2
C1	Nam Thang Long	19.7	1.047	01:04	01:05	00:30	0:23:20	0:23:50	34.3
C2	Ngoai Giao Doan	20.5	1.000	01:38	01:40	00:30	0:25:30	0:26:00	27.7
C3	Tay Ho Tay	21.3	0.800	01:20	01:25	00:30	0:27:25	0:27:55	25.0
C4	Buoi	22.9	1.600	01:41	01:45	00:30	0:29:40	0:30:10	42.7
C5	Quan Ngua	24.6	1.700	01:45	01:50	00:20	0:32:00	0:32:20	43.7
C6	Bach Thao	25.9	1.300	01:29	01:30	00:20	0:33:50	0:34:10	42.5
C7	Ho Tay	26.7	0.800	00:59	01:05	00:50	0:35:15	0:36:05	33.9
C8	Hang Dau	27.8	1.100	01:17	01:20	00:20	0:37:25	0:37:45	30.5
C9	Hoan Kiem Lake	28.2	0.400	01:35	01:40	00:30	0:39:25	0:39:55	12.0
C10	Tran Hung Dao	30.1	1.900	01:45	01:50	00:20	0:41:45	0:42:05	48.9
C11	Cau Den	31.1	1.000	01:13	01:15	00:30	0:43:20	0:43:50	37.9
C12	Bach Khoa	32.4	1.300	01:22	01:25	00:20	0:45:15	0:45:35	40.7
C13	Kim Lien	33.2	0.800	01:07	01:10	00:20	0:46:45	0:47:05	32.0
C14	Chua Boc	34.1	0.900	01:07	01:10	00:20	0:48:15	0:48:35	36.0
C15	Nga Tu So	35.2	1.100	01:19	01:20	00:30	0:49:55	0:50:25	39.6
C16	Thuong Dinh	36.3	1.100	01:30	01:35		0:52:00	***	31.7
N0→N7			13.6				0:16:05		
N7→C1			5.9				0:07:15		
N0→C1			19.5				0:23:20		
C1→C10			10.6				0:18:25		
C10→C16			6.2				0:10:15		
N0→C10			30.1				0:41:45		
N0→C16			36.3				0:52:00		

2) Operation Diagrams of Standard Trains

The operation of trains during the morning rush hour of the initial period is shown in the operation diagram of Figure 8-3. The headway is set at 10 minutes for the Line 2.3 and 5 minutes for the Line 2.1 and Line 2.2.

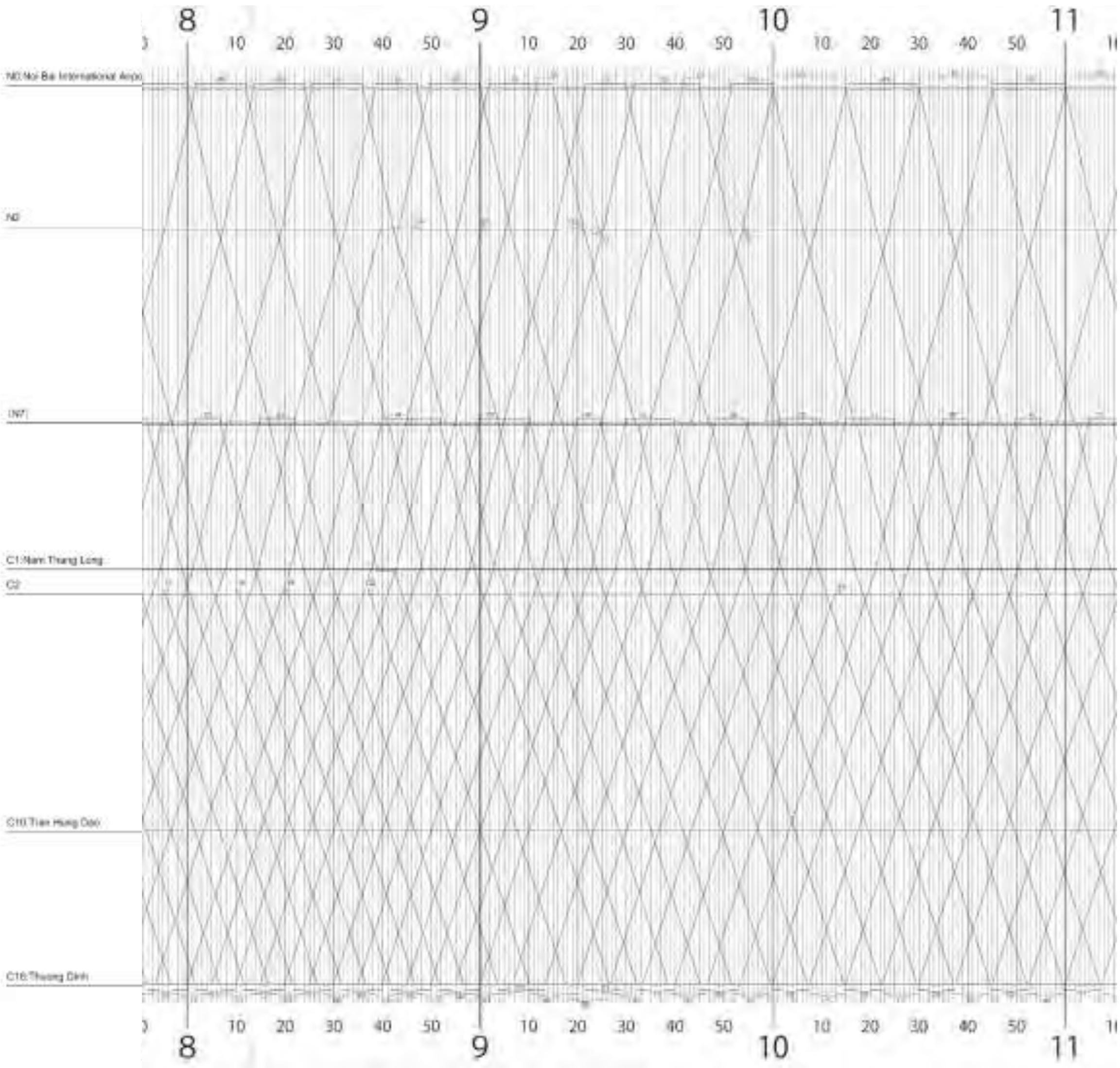


Figure 8-3. Line 2 Diagram of Standard Trains During Initial Period

As the traffic demand grows in time, the operation density of the Line 2.3 section needs to be increased as shown in the operation diagram of Figure 8-4. The headway is set at 6 minutes for the Line 2.3 and 3 minutes for the Line 2.1 and Line 2.2.

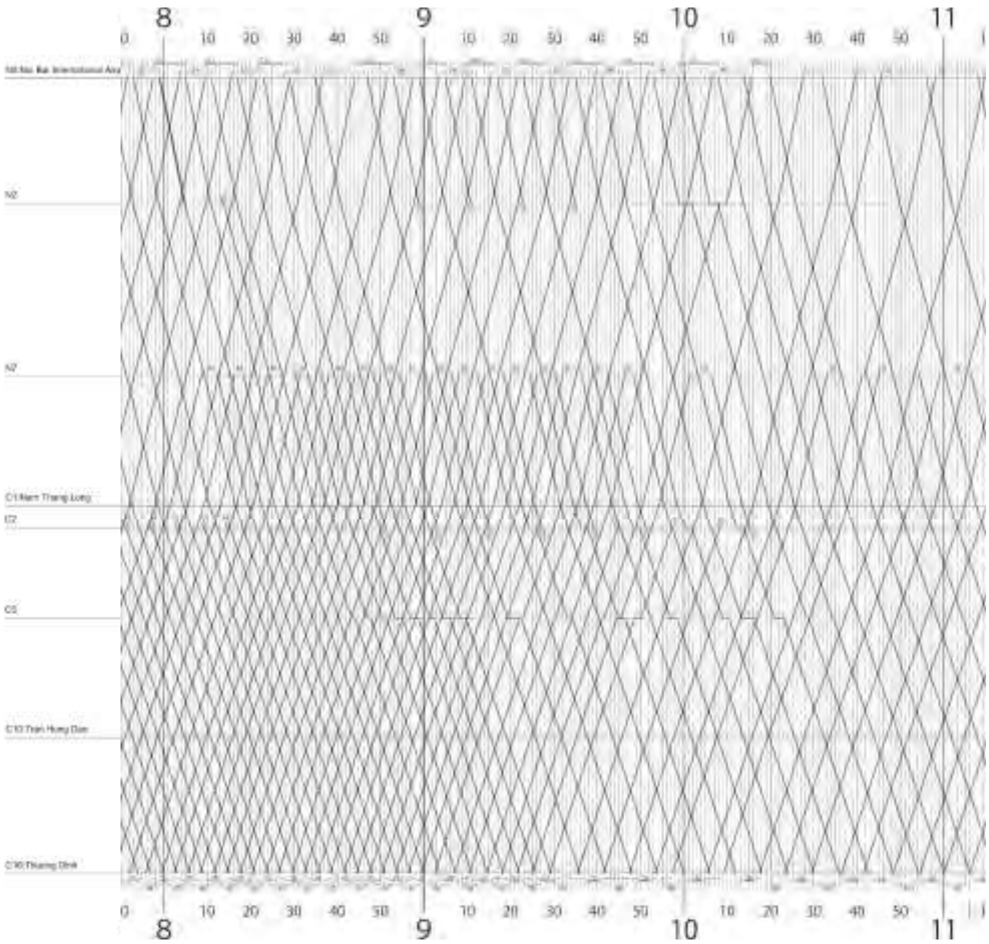


Figure 8-4. Line 2 Diagram of Standard Trains During Final Period

3) Overall Operation Plans

Table 8-7 shows the overall summary of operation plan by stages of development.

Table 8-7. Operation Plan of Standard Trains by Phases and Stage

Stage	Time zone	Line 2.3				Line 2.1 and 2.2	
		N0〜N7		N7〜C1		C1〜C16[27.6km]	
		Headway (min)	Hourly trains (trains/hour)	Headway (min)	Hourly trains (trains/hour)	Headway (min)	Hourly trains (trains/hour)
Initial Period	Morning Rush Hour	10	6	5	12	5	12
	Daytime	15	4	7.5	8	7.5	8
	Evening Rush Hour	10	6	5	12	5	12
	Nighttime	20	3	10	6	10	6
Second Period	Morning Rush Hour	6	10	3	20	3	20
	Daytime	12	5	6	10	6	10
	Evening Rush Hour	10	6	5	12	5	12
	Nighttime	20	3	10	6	10	6
Final Period	Morning Rush Hour	4	15	2	30	2	30
	Daytime	10	6	5	12	5	12
	Evening Rush Hour	6	10	3	20	3	20
	Nighttime	20	3	10	6	10	6

By combining the passenger demand forecast and train operation plan, *Table 8-8* investigates the congestion rates of each sections to assess the adequacy of the transport capacities. During the initial period the congestion rate is 125% at its maximum for the section of N6-N7 during the morning peak hour. At the final period of 2050, the most crowed section is N7-N6 during the evening peak hour with 158% in the congestion rate forecast. These congestion rates are subject to many factors and still acceptable.

Table 8-8. Operation Plan and Transport Capacities

Year	Direction	Line	Section with the maximum board passengers	Daily On Train Passengers	Peak Hour	Trains Per Hour	Standard Transport Capacity Per Train	Congestion Rate
2030	Toward C16	N0-N7	N6→N7	47,080	7,062	6	5652	125%
		N7-C10	C7→C8	87,478	13,122	12	11304	116%
		C10-C16	C10→C11	71,366	8,564	12	11304	76%
	Toward Airport	N0-N7	N7→N6	54,575	6,549	6	5652	116%
		N7-C10	C8→C7	94,475	11,337	12	11304	100%
		C10-C16	C11→C10	76,643	11,496	12	11304	102%
2050 (Final)	Toward C16	N0-N7	N6→N7	98,671	14,801	15	14130	105%
		N7-C10	C5→C6	152,423	22,863	30	28260	81%
		C10-C16	C10→C11	117,593	14,111	30	28260	50%
	Toward Airport	N0-N7	N7→N6	123,771	14,853	10	9420	158%
		N7-C10	C6→C5	175,019	21,002	20	18840	111%
		C10-C16	C11→C10	133,020	19,953	20	18840	106%

Note: Morning Peak Ratio is set 15% and evening peak ratio is set at 12%
The standard transport capacity per train is 942 passengers

8.3.2 Airport Express Operations

1) Operation Schedule

The time requirements for operation for the proposed airport express trains of the entire Line 2 are tabulated in Table 8-9. The express can reach C10 Station of Tran Hung Dao from the airport in 30 minutes. The factor that impedes the faster travel from the airport to the city center is the requirement to stop at every station on between C3 and C10 of Line 2.1. Due to the lack of extra tracks to bypass the standard trains, it is not possible to speed up for the faster train. A potential solution for the future improvements of Line 2 is to undertake extra work to provide overtaking tracks and platforms at C5. This option will be suggested later in Figure 8-6.

Table 8-9. Airport Express Train Operation Schedules of Line 2 in 2030 (Bridge)

No.	**Name of Station**	**Location (km)**		**Operation Time Between Stations (m:s)**		**Stopping Time at Stations (m:s)**	**Total Operation Time from N0 (Including Stopping Time) (m:s)**		**Average Speed (km/h)**
		Chainage	**Between Stations**	**Calculated**	**Assessed**				
N0		0.0				00:30	***	0:00:00	
N1		1.2	1.2	01:14	01:15	00:30	0:01:15	0:01:45	41.1
N1A				↓	↓	↓	↓		↓
N2		5.9	4.7	02:56	03:00	00:00	0:04:45	0:04:45	80.6
N2A				↓	↓	↓	↓		↓
N3		8.2	2.3	01:21	01:25	00:00	0:06:10	0:06:10	97.4
N4		9.7	1.5	00:52	00:55	00:00	0:07:05	0:07:05	98.2
N5		11.0	1.3	00:45	00:50	00:00	0:07:55	0:07:55	93.6
N6		12.6	1.6	00:55	01:00	00:00	0:08:55	0:08:55	96.0
N7		13.7	1.1	00:38	00:40	00:00	0:09:35	0:09:35	99.0
N8		14.6	0.9	00:44	00:45	00:35	0:10:20	0:10:55	72.0
N9		18.7	4.1	02:29	02:30	00:00	0:13:25	0:13:25	79.8
C1	Nam Thang Long	19.7	1.0	00:51	00:55	00:30	**0:14:20**	0:14:50	65.5
C2	Ngoai Giao Doan	20.5	0.8	01:38	01:40	00:30	0:16:30	0:17:00	22.2
C3	Tay Ho Tay	21.3	0.8	01:20	01:25	00:00	0:18:25	0:18:25	25.0
C4	Buoi	22.9	1.6	01:41	01:45	00:00	0:20:10	0:20:10	54.9
C5	Quan Ngua	24.6	1.7	01:45	01:50	00:20	0:22:00	0:22:20	55.6
C6	Bach Thao	25.9	1.3	01:29	01:30	00:00	0:23:50	0:23:50	42.5
C7	Ho Tay	26.7	0.8	00:59	01:05	00:00	0:24:55	0:24:55	44.3
C8	Hang Dau	27.8	1.1	01:17	01:20	00:00	0:26:15	0:26:15	49.5
C9	Hoan Kiem Lake	28.2	0.4	01:35	01:40	00:00	0:27:55	0:27:55	14.4
C10	Tran Hung Dao	30.1	1.9	01:45	01:50	00:20	0:29:45	0:30:05	62.2
C11	Cau Den	31.1	1.0	01:13	01:15	00:30	0:31:20	0:31:50	37.9
C12	Bach Khoa	32.4	1.3	01:22	01:25	00:20	0:33:15	0:33:35	40.7
C13	Kim Lien	33.2	0.8	01:07	01:10	00:20	0:34:45	0:35:05	32.0
C14	Chua Boc	34.1	0.9	01:07	01:10	00:20	0:36:15	0:36:35	36.0
C15	Nga Tu So	35.2	1.1	01:19	01:20	00:30	0:37:55	0:38:25	39.6
C16	Thuong Dinh	36.3	1.1	01:30	01:35		**0:40:00**	***	31.7
N0→N7			13.7				0:09:35		
N7→C1			6.0				0:04:45		
N0→C1			19.7				0:14:20		
C1→C10			10.4				0:15:25		
C10→C16			6.2				0:10:15		
N0→C10			30.1				0:29:45		
N0→C16			36.3				0:40:00		

2) Operation Diagram

The express trains linking the NBIA to Tran Hung Dao (C10 Station) is planned for operations on a half hour interval in the initial period as shown as a diagram in Figure 8-5.

Figure 8-5. Line 2 Diagram of Airport Express During Initial Period

As the demand for the airport express grows, the operations will increase accordingly, as shown in Figure 8-6. The operation illustrated in Figure 8-6 requires overtaking of standard commuting trains at the stations of C2 and C5 to realize the travel time of 23 minutes between N0 to C10. [6]

[6] This implies the requirement of the additional works at these stations for extra tracks and platforms to enable overtaking.

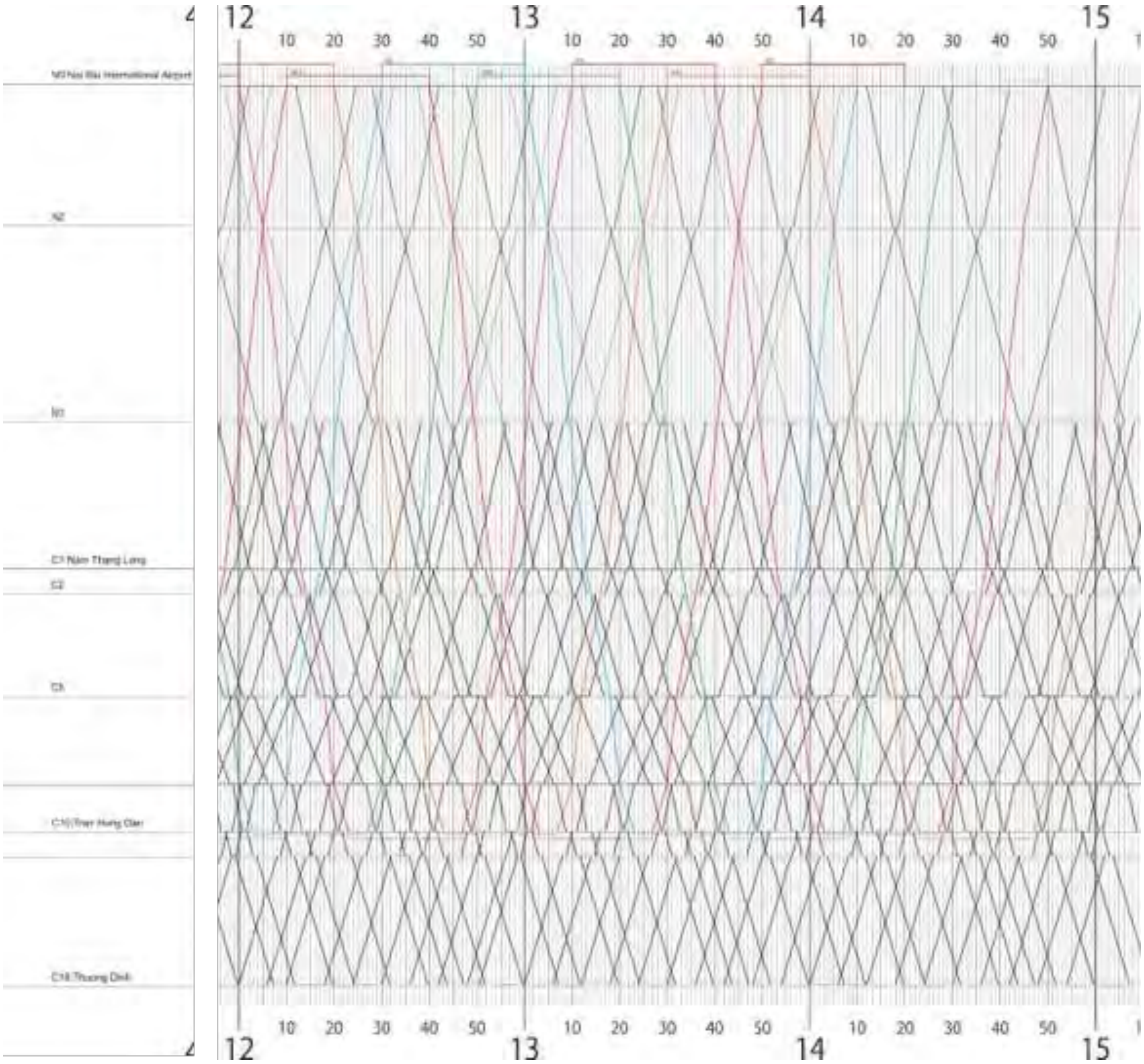


Figure 8-6. Line 2 Diagram of Airport Express at Second Stage

3) Overall Operation Plan

Table 8-10 shows the overall summary of the airport express train operation plan by stages of development.

Table 8-10. Operation Plan of Express Trains by Phases and Stage

Stage	Time zone	Line 2.3 and Line 2.1	
		N0〜C1	
		Headway (min)	Hourly trains (trains/hour)
Initial Period	Morning Rush Hour	45	1.5
	Daytime	30	2
	Evening Rush Hour	45	1.5
	Nighttime	30	2
Second Period	Morning Rush Hour	45	1.5
	Daytime	20	3
	Evening Rush Hour	45	1.5
	Nighttime	20	3
Final Period	Morning Rush Hour	30	2
	Daytime	20	3
	Evening Rush Hour	30	2
	Nighttime	20	3

8.4 Rolling Stock Requirements

Rolling stock requirements are calculated according to the following formula.

Physical requirement f =e ÷ d

e: time required for round trip

d: headway

Actual requirement = f + g

g: spare or reserve train.

Prior to the physical requirement calculation, the round trip time estimation is carried out by assuming a standard round trip operation.

As shown in Table 8-11, the rolling stock requirement of commuting trains for the entire Line 2 in the initial stage is 138 cars/23 trains and 216 cars/36 trains in the more mature stage. The rolling stock requirement of airport express trains for the entire Line 2 in the initial stage is 24 cars/4 trains and also 36 cars/6 trains in the more mature stage. The max requirement is tabulated as a basis for the depot stabling capacity requirement calculation. The maximum train deployment requirements are set at 360 cars/60 trains for the minimum headways of 2 minutes for the Line 2.1 and Line 2.2 sections and 4 minutes for the Line 2.3 section as well as 15-minute headways for the airport express.

Table 8-11. Summary Table of Operation and Rolling Stock Requirements

Stage	Train	Section	Headways (min)	Round trip (min)	Train Requirements (trains)	Car Requirements
Stage I	Standard Trains	Line 2.1 and Line 2.2 round trip	10	75	8	48
		Line 2 round-trip	10	120	12	72
		Spare Trains			3	18
		Total			23	138
		Phase 1 procurement			10	60
		Phase 2 procurement			7	42
		Phase 3 procurement			6	36
	Airport Express	Line 2.1 and Line 2.3 round-trip	30	90	3	18
		Spare Trains			1	6
		Total			4	24
Stage II	Standard Trains	Line 2.1 and Line 2.2 round trip	6	75	13	78
		Line 2 round-trip	6	120	20	120
		Spare Trains			3	18
		Total			36	216
	Airport Express	Line 2.1 and Line 2.3 round-trip	20	100	5	30
		Spare Trains			1	6
		Total			6	36
Final Stage*	Standard Trains	Line 2.1 and Line 2.2 round trip	4	75	19	114
		Line 2 round-trip	4	120	30	180
		Spare Trains			3	18
		Total			52	312
	Airport Express	Line 2.1 and Line 2.3 round-trip	15	100	7	42
		Spare Trains			1	6
		Total			8	48

Note: * It will require some improvement works to the planned facilities to achieve this level of a headway.

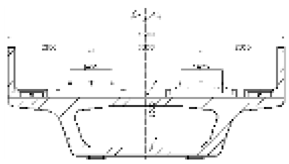
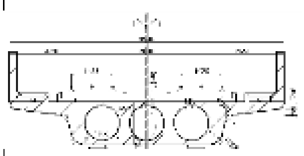
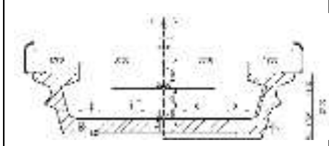
9. Railway Design

9.1 Bridge Works

9.1.1 Viaduct structure

With the viaduct feature built in the urban area which is not only to ensure the requirements of structural safety, it is also necessary to ensure aesthetics, suitable to the surrounding landscape, to meet the requirements of fast construction, construction in the narrow space, construction costs are not too high. Moreover, the beam structure must be able to exceed the large span (over 40m) to ensure the crossing at intersections. Based on that, the Study Team shows three options of elevated structures were compared, i.e. hollow slab, PC box girder and PC U-shape girder for the superstructure of elevated section.

Table 9-1. Comparison of Girder Options

No.	Criteria	OP1: Box girder	OP2: Hollow slab	OP3: U shape girder
1	*Cross section*			
2	*Height of girder*	2m	1.5m	2.2m
3	*Span length*	over 40m	30m	30m
4	*Aesthetic architecture*	The beam structure has a compact bottom, the slender outrigger wing creates a more airy feeling than option 3.	The beam structure has a compact bottom, the slender outrigger wing creates a more airy feeling than option 3.	Beams with a large bottom width creates a heavy feeling, not as open as options 1 and 3.
5	*Anti-twisting ability*	Best torsion resistance	Torsion resistance is better than option 3.	Less torsion resistance
6	*Construction ability*	Equivalent	Equivalent	Equivalent
7	*Construction cost**	1	1.08	0.92
8	***Conclusion***	**Recommended**	Not recommended	Not recommended

*Note: The ratio is based on the comparison of the past cases thus the ratios are approximately same but not practical to derive the unit cost.

In addition, due to Line 2.3 is the continuation of Line 2.1, to ensure the consistency and continuity of structure, increase the aesthetics in the urban area, the Study Team recommends using the reinforced concrete box girder which is used for the standard viaduct.

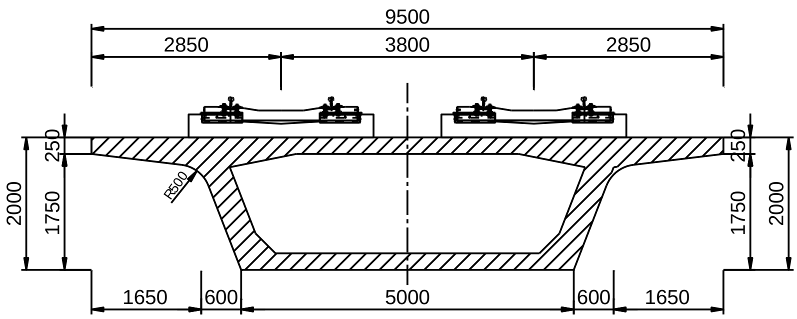


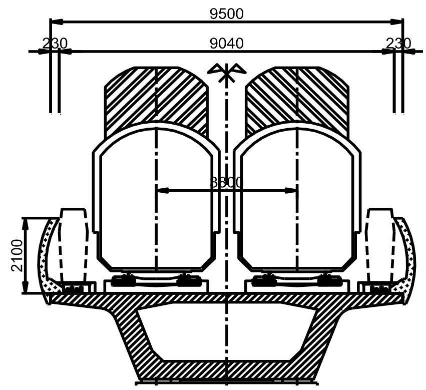
Figure 9-1. Cross Section of Box Girder for Standard Viaduct

Special bridges in the project are mainly the bridges crossing road junctions. Bridge span shall be determined based on road size and lane width, with minimum changing size of roads and traffic diversions while satisfies structural requirements and helps to save construction cost, in the other hand, position of green belt and splitter islands should be reasonably designed because of bridge pier is also located in the same place.

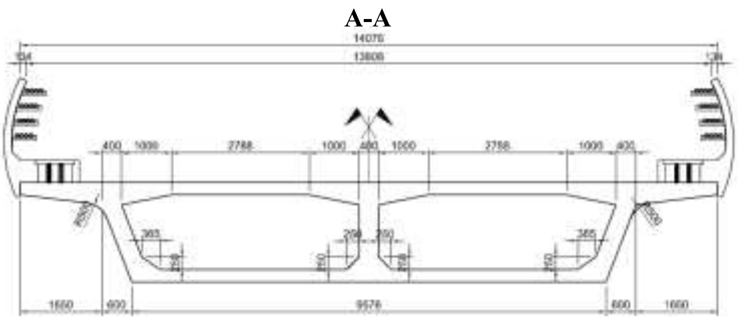
On Line 2.3, other than typical bridges, it is planned to construct interchange crossing bridge, railway crossing bridge, river crossing bridges as follows:

- Thiep River crossing bridge (Km6+331.00)
- RR3 and National railway crossing bridge (Km10+632.00)
- NH18 crossing bridge (Km14+950)

Based on the plan of junctions of the designed railway and existing roads and rivers, it is proposed to apply the PC box girder to be constructed by each segment assembly method (each segment at the construction site or in the factory).



Cross section of NH18, RR3,NR

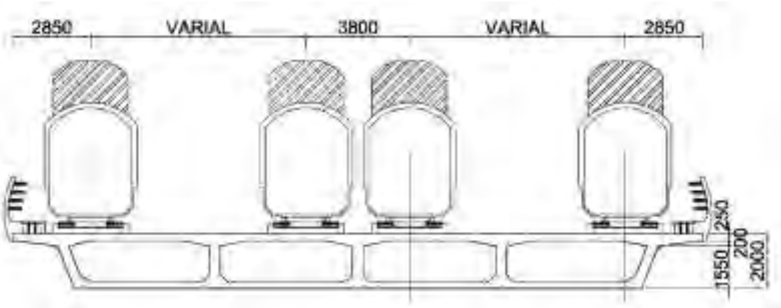


Cross section of Thiep River

Figure 9-2. Cross Section of Special Bridge

For the sections designed with many tracks:

B-B



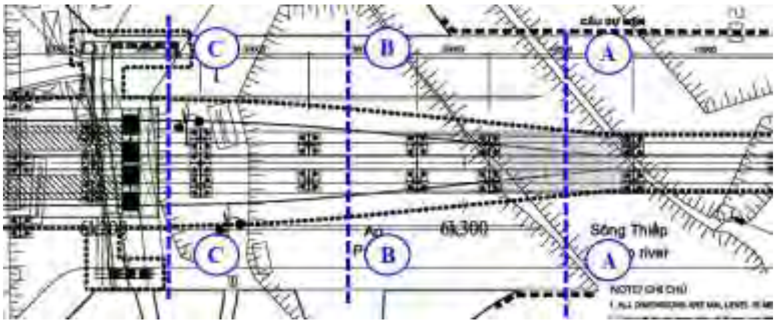


Figure 9-3. Cross Section of Girder with Variable-width

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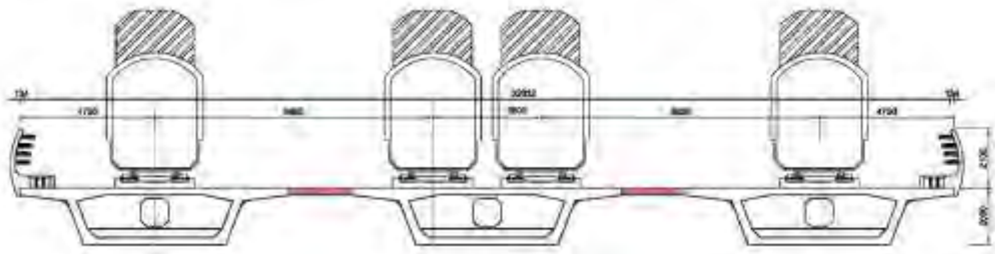
C-C



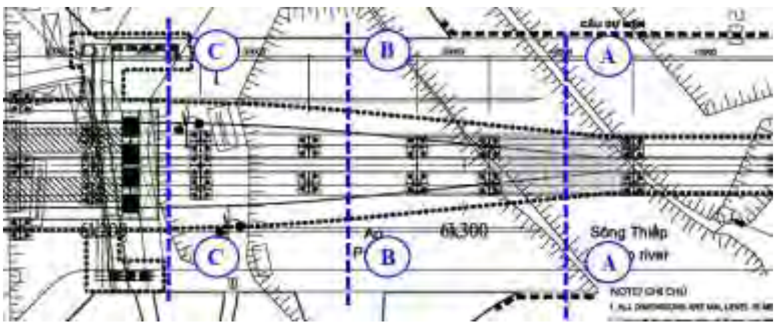


Figure 9-4. Cross Section of Girder with Constant-width

For variable-width box girders consisting of multiple partitions made by the method of cast-in-place. For constant width box girders manufactured in each segment at the construction site or in the factory, then transported to the site and installed according to each segment assembly method.

Table 9-2. List of Flyovers/Viaducts on the Alignment (Tunnel option)

No.	Bridge	Chainage	Total Length (m)	Span Structure	Span length (m)
1	Typical viaduct length		10,633	Typical box girder	@30
2	NH5 and Thiep river bridge	Km6+331.00	140	Cast-in- place box girder	@40, @30
3	RR3 and National Railway bridge	Km10+632.00	160	Typical box girder	@40
4	NH18 flyover	Km14+950	82.25	Box balanced girder	21.125@40@21.125

Table 9-3. List of Flyovers/Viaducts on the Alignment (Bridge option)

No.	Bridge	Chainage	Total Length (m)	Span Structure	Span length (m)
1	Typical viaduct length		13,828	Typical box girder	@30
2	Red river bridge		1,160	Box balanced girder	
3	NH5 and Thiep river bridge	Km6+331.00	140	Cast-in- place box girder	@40, @30
4	RR3 and National Railway bridge	Km10+632.00	160	Typical box girder	@40
5	NH18 flyover	Km14+950	82.25	Box balanced girder	21.125@40@21.125

9.1.2 Foundation and substructure

➢ **Selection of foundation structure**

- Based on the reference of the existing geological boreholes of the construction works around the project that the good geological layer is deep in the natural soil about 40 ~ 50m. Therefore, it is proposed to use the bored pile foundation to apply for the viaduct. The method of drilling piles is also suitable for overhead bridges, with huge loads from the train.
- For the works carried in the city, the construction is required not to affect the lives of people, therefore bore pile solution is chosen. The bored pile construction causes less noise, which meets the construction requirement in the city, the construction is fast and can drive piles down to the bearing layer under;
- At this design stage, the calculations of bored piles dimensions and lengths are based on the assumption that the next layers below the bores hole bottom are uniformed with less variation compared with the survey data of the above layer (according to calculation of some bored holes with the pile length is longer the bored hole depth). The calculation results of bored pile length are the estimation to provide the basis for the Total Investment Cost.

From the above analysis, the Study Team recommends using bored pile d=1.2m with appropriate length depended on the specific location of the Works.

➢ **Selection of pier column structure**

- Using a single-column pier to create the feeling of a clear landscape.

- From an aesthetic viewpoint, it is recommended to adopt round shapes for pier column.
- Pier column should be constructed by steel formworks, or high-quality plastic to form the smooth and flat external surface.

➢ **Future Bore Hole Test Requirement**

In preparation for the detail design, it is necessary to conduct a series of borehole tests and core samplings. Borehole tests should reach the supporting layer in each test on a variable quantity contract basis with the initial length of 30 meters. Core samples will be collected to carry out the tests as follows:

- Tri-axial compression test
- Particle size distribution test
- Standard penetration test
- Water permeability test, and
- Hole horizontally loading test

9.2 Tunnel works

9.2.1 Shield tunnel

For the Red River crossing, two options are proposed to be compared, namely:

- Option 1: double line-single tube using TBM;
- Option 2: single line-double tube using TBM.

The above options are compared based on criteria: construction cost and progress and influence on neighboring areas. The JICA Study Team adopted Option 2 as the most suitable option as its favorable conditions compared with other options. Please note that Hanoi Line 2.1 also adopted Option 2 for the same reason.

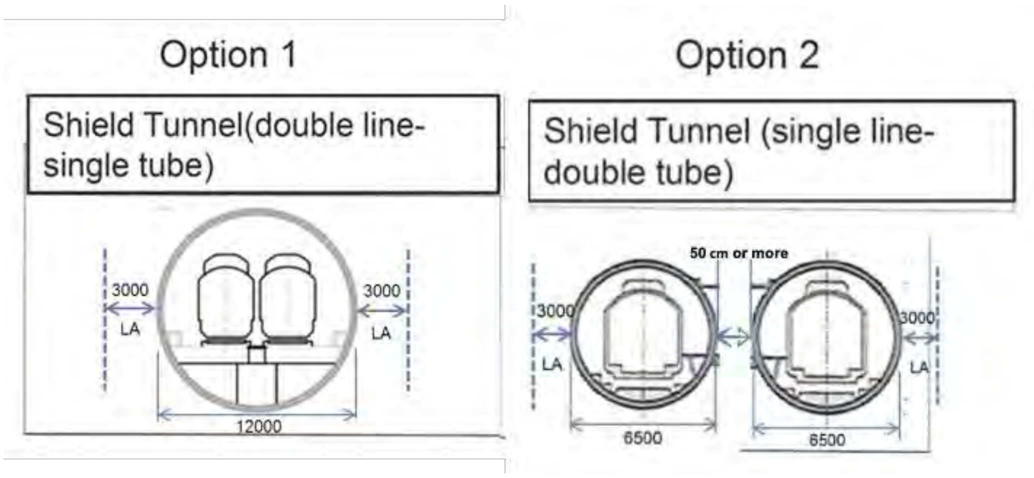


Figure 9-5. Options for Tunnel Construction Method

Table 9-4. Comparison Table of Tunnel Construction Method

Item	Option 1	Option 2
Description	Using shield tunnel with large diameter D=12m	Using a common shield tunnel with diameter D=6.5m
Construction time	Since only a single tunnel is needed, construction time will be reduced	If using a Tunnel machine, construction time will be much slower than plan 1. Based on the project schedule, Two tunnel machines simultaneously can be used; however, it will increase the cost.
Affect to around area	- Constructing just one tube makes it possible to better locate the route under the main streets and reduces the direct impact on the existing buildings. - The connection between the tracks is done directly in the space of the tunnel itself, without the need of building connection chambers (crossovers) which can be difficult to construct - especially if the mining solution has to be chosen - and can have a negative influence on the regular ventilation flows - The tunnel diameter shall be relatively large and thus may impose a deeper vertical alignment for stability reasons and for reducing the maximum expected total vertical settlement; - Being the stations deeper, they will be relatively more expensive as regards the retaining structures for allowing deeper excavations - Not fire safety	- A smaller tunnel diameter means smaller total settlement to be expected at the surface. - A smaller diameter will generally allow for a shallower alignment, shallower stations can also be designed, with economic benefits - The two tracks being independent can offer more flexibility for the conception of stations - In case of a train accident, the operation of the entire line can be resumed in the tunnel which has not been damaged - The area of influence at the surface due to the potential tunneling induced-effects is larger, and hence a larger number of buildings will be generally located in the potential influence area of the tunnels - Bypasses to connect the two tubes for safety reasons. - The construction time for the double-tube scheme will double if provided that the same number of TBM
Electric Signal and Communication Equipment	Less equipment	More equipment but the cost will be less than double
Construction cost Index	1.14	1.0
Maintenance Cost	Lower	Higher
Conclusion	Not recommended	Recommended

Comparison results are shown in the summary table as below:

Option	Construction cost	Schedule	Neighborhood impact	Results
Option 1	* Higher	Medium	Medium influence	Not Recommended
Option 2	Lower	Shorter	Minimum influence	**Recommended**

Remarks:

*: Because larger excavation is required compared to other methods

Dimensions of single-double tube using TBM are described as follows:

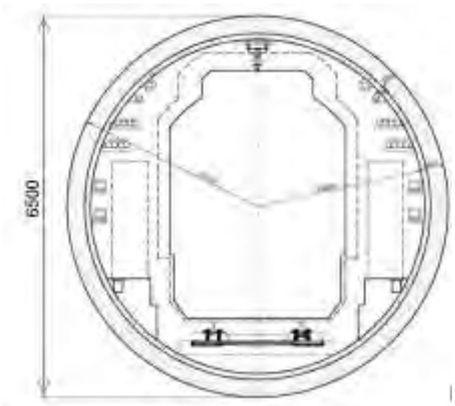


Figure 9-6. Dimensions of Single TBM

9.2.2 Cut and Cover Tunnel

Cut & Cover sections except the underground sections are designed to install turnouts, return-over tracks, technical areas, transition section from underground to elevated and underground section between stations at Noi Bai Airport.

Cut & cover section structures are described as follows:

- Construction of cut & cover section structures employs "Top Down Method";
- Temporary earth retaining wall (diaphragm wall) is used outside the tunnel as the permanent structure, diaphragm wall dimensions are determined depending on tunnel depth and effecting loads;
- Tunnel structures may be double walls (namely in situ concrete plus diaphragm wall to cater for the leakage control) as adopted by Hanoi Line 2.1.

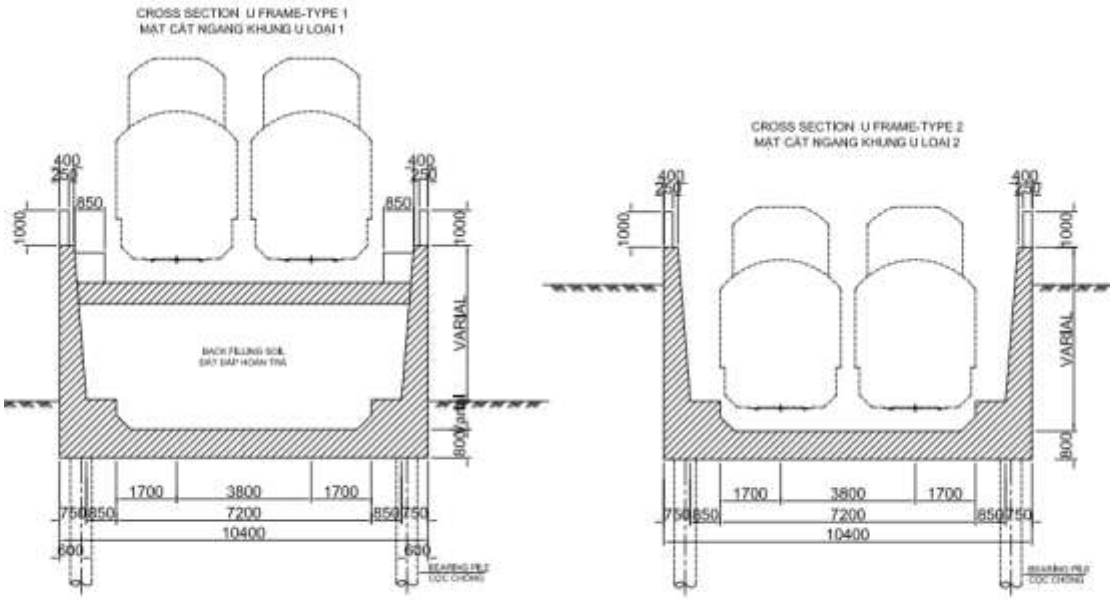


Figure 9-7. Cross Section of U Frame Using Cut & Cover Method

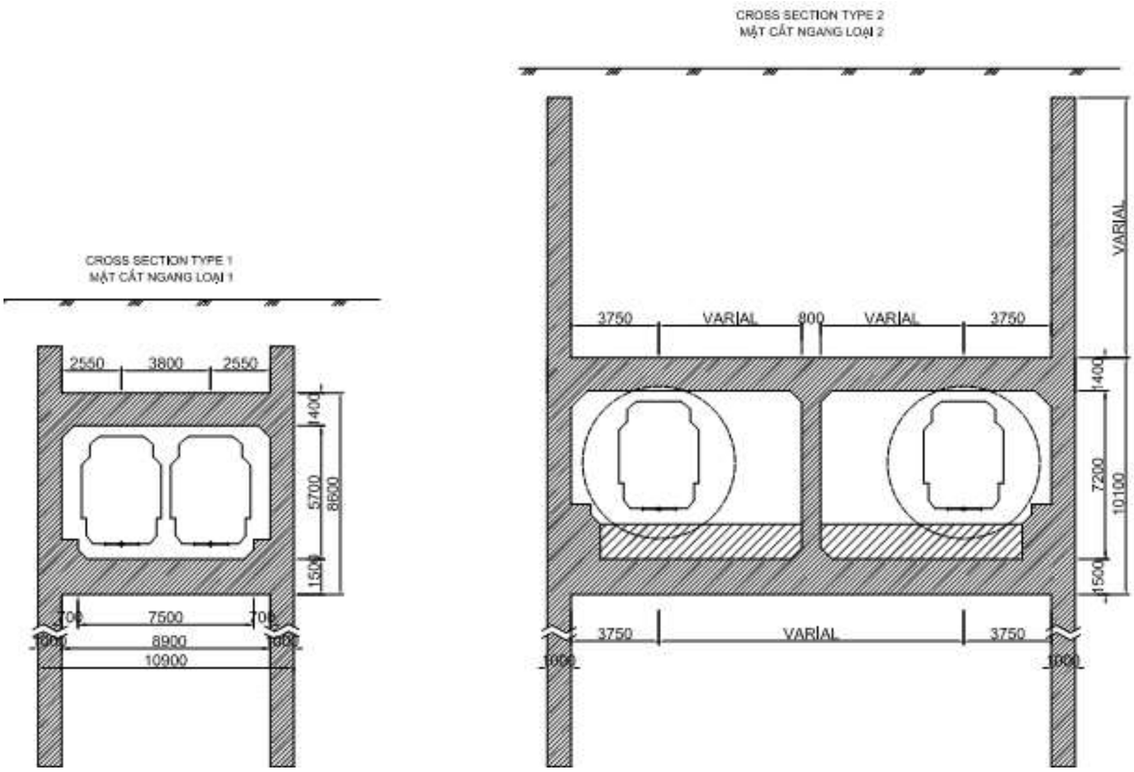


Figure 9-8. Cross Section of Box Tunnel Using Cut & Cover Method

- The thickness of overburden is 3.0m minimum.

Table 9-5. Proposed Tunnel Works (Option 1)

Section	TBM	Cut and Cover	U wall	Total Length
Nam Thang Long–Noi Bai	3,043 m	4,040 m	1,175m	**8,258m**

Table 9-6. Proposed Tunnel Works (Option 2)

Section	Cut and Cover	U wall	Total length
Nam Thang Long–Noi Bai	3,660 m	550m	**4,210m**

9.3 Station works

9.3.1 Technical solutions for station design

- Superstructure

+ Rail UIC 60;

+ Pre-stressed concrete sleepers;

+ Pre-stressed concrete sleepers laid on a concrete base with anti-vibration case used for elevated stations, while pre-stressed concrete sleepers laid on ballast base for ground stations;

+ Fasten fittings are used to be matched with the type of rail and sleepers of the main line.

- Platform

+ Platform is designed with the same elevation of car floor: height calculated from the top of rail to top of platform h=1,1m;

+ Distance from platform edge to track centerline: 1.55m (elevated and grade station) and 1.475m (underground station);

+ Platform length: 130m (length of 6-car train x 20m + 2x5m);

+ Platform width is determined by the number of passengers in the calculation year.

9.3.2 Scope of station

❖ **Underground station**

Cut & cover station construction including concourse level and platform level is conducted by cut & cover method combining retaining wall (diaphragm wall) as a permanent structure.

Inside length of station is 240m, while inside width is 22.35m (normal station) to meet the following requirements:

- Platform width: 11-12m based on passenger demand in the station.
- Diaphragm wall thickness will be 1.0 to1.2m considering the neighborhood impacts since the diaphragm wall is deflected resulting in the settlement.
- Drainage trench width is 400mm and brick wall thickness is 200mm which are proposed to apply to control water leakage.
- The overburden layer thickness is 2 to 3m. The average excavation depth is approx. 17.5m below the natural ground level.

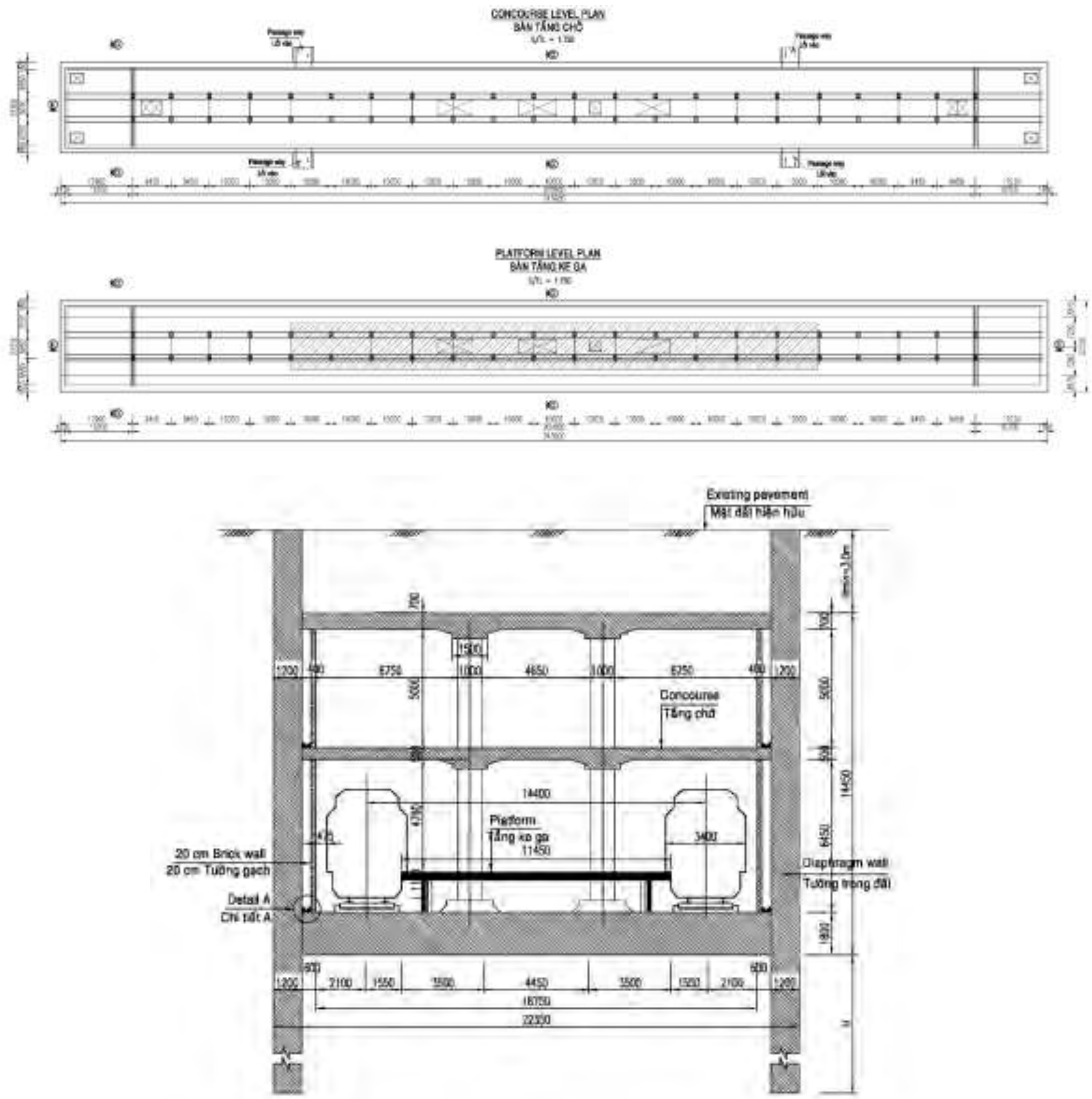


Figure 9-9. Plan and Cross Section of Typical Underground Station

❖ **Elevated station**

- The elevated station is 140m in length. The station width is 23.5m for a double-tracks station designed side-by-side platform, 26.2m for station design island platform with three tracks (N2 and N7 Stations).
- The concourse level comprises:

+ Passenger facilities (Concourse, ticket vending machines, automatic fare collecting gates, toilets);

+ Employee facilities (Passenger meeting rooms, disaster control center, rest area);

+ E&M area (Electrical equipment room) and other rooms;

+ Footbridge for pedestrians;

+ Shopping malls are also designed for the needs of shopping and eating of the passengers.

- The platform level comprises of passenger facilities (platform, bench/chairs, platform control room, etc.).

- The platform layout shall ensure the least interruption of passenger flows and the most convenience on buying tickets and boarding.

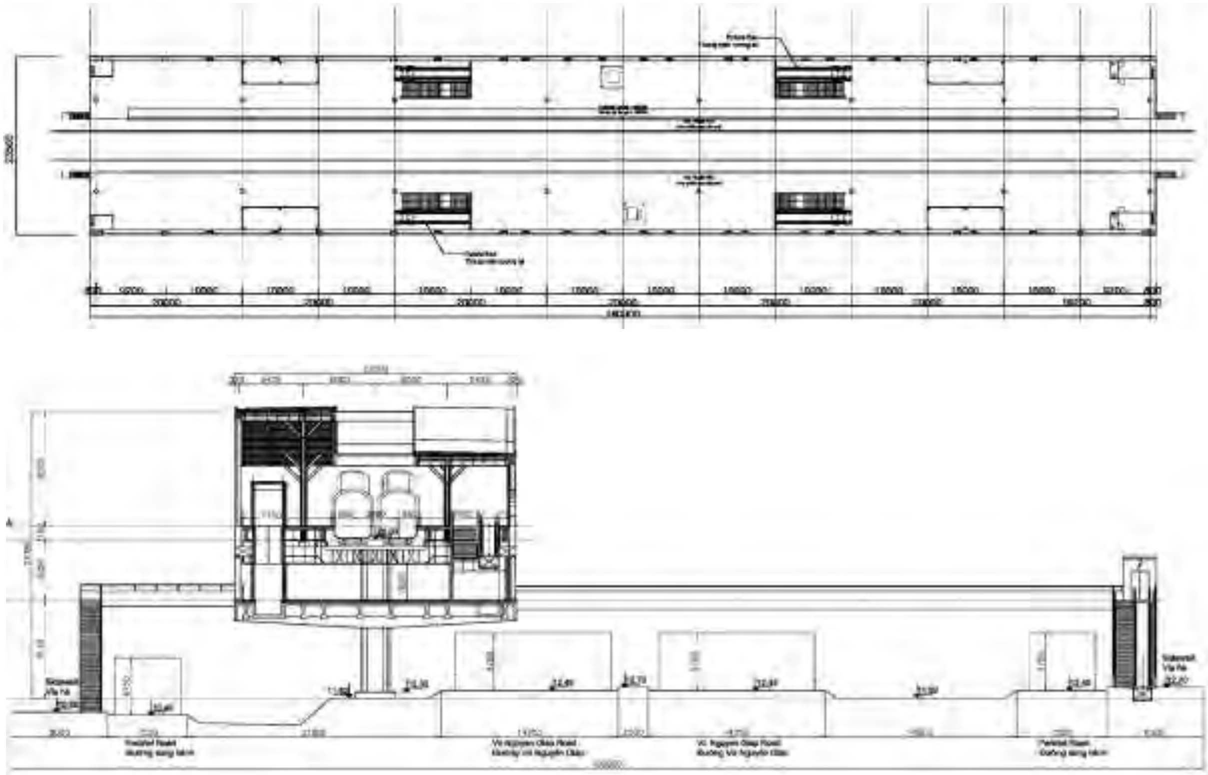


Figure 9-10. Plan and Cross Section of Double Tracks Station (elevated)

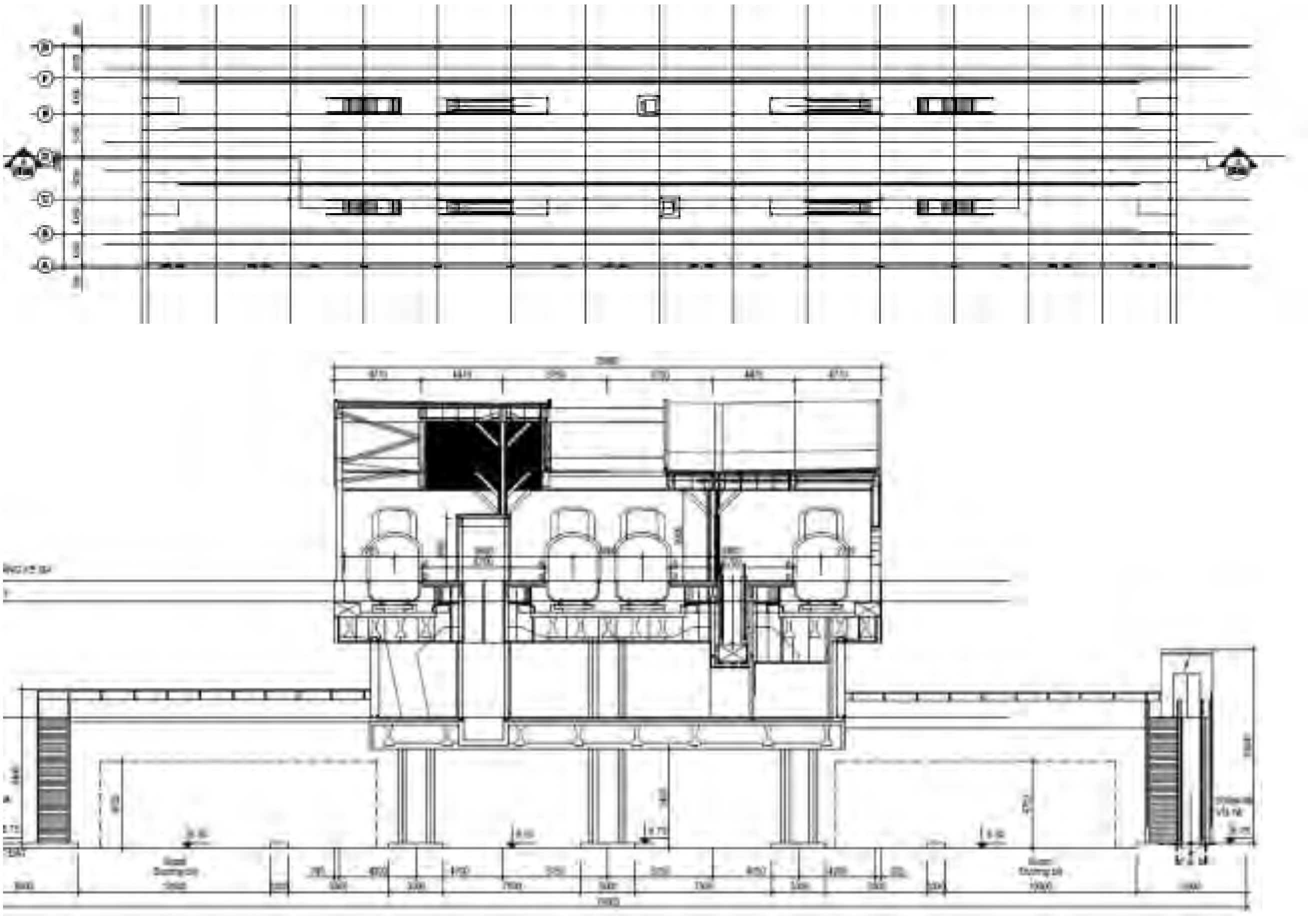


Figure 9-11. Plan and Cross Section of Four Tracks Station (elevated)

❖ **At-grade station**

- The at-grade station is designed as 140m inside length and 18.8m inside width for platform and rail. The total width of the whole station (including functional rooms) is 42.6m.
- The functional rooms comprise of:

+ Passenger facilities (Concourse, ticket vending machines, automatic fare collecting gates, toilets)
+ Employee facilities (Passenger meeting rooms, disaster control center, rest area)
+ E&M area (Electrical equipment room) and other rooms.
+ Footbridge for pedestrian with staircase and elevator.

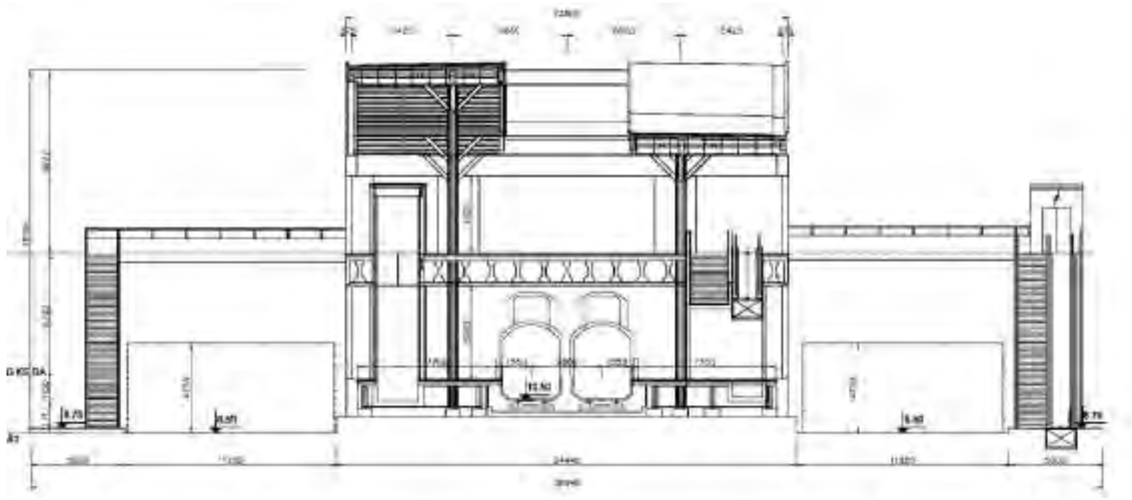


Figure 9-12. Cross Section of At-grade Station

9.3.3 Main equipment of station

❖ **Underground Station (typical)**

- Air conditioning facilities:

+ Air conditioning facility, Chiller tower (Including duct connection)
+ Pumping set concerning the freezer
+ Pumping set concerning air handling unit
+ Air handling unit (Including return exhaust fan)
+ Indoors Radiator (Fan coil)
+ Air condensing facility
+ A hole for exhaust fan , Hole for supply fan
+ Duct
+ Exhaust fan
+ Supply fan
+ Ventilation duct
+ Plumbing
+ Automatic control for air handling.

- Tunnel ventilation:

+ Supply fan & Exhaust fan
+ Noise reduction measure
+ Exhaust fan (for station track space)
+ Duct

- Facilities for water supply and drainage:

+ Water tank and appurtenances
+ Water supply pump
+ Sanitary facilities
+ Plumbing
+ Polluted water pit and pump
+ Drainage pump
+ Sewage disposal equipment.

- Fire prevention equipment:

+ Fire prevention water tank
+ Fire prevention water pump
+ Fire hydrant related matters
+ Fire prevention plumbing
+ Inert gas jet equipment
+ Kitchen gas equipment
+ Portable fire extinguisher

- Electric facilities:

+ Power supply facilities
+ Low voltage switchboard
+ Power switchboard
+ UPS (Uninterruptible Power Supply)
+ Indoor lighting and plug
+ Earth equipment
+ Fire alarm
+ Automatic architecture equipment

- Lift: elevator and escalator.

❖ **Elevated *Station (typical)***

- Air conditioning facilities:

+ Air conditioning facilities (Including duct connect)
+ Exhaust fan
+ Ventilation duct (Hole for exhaust fan, Hole for supply fan).

- Facilities for water supply and drainage:

+ Water tank and appurtenances
+ Water supply pump
+ Sanitary facilities
+ Plumbing.

- Fire prevention equipment:

+ Fire prevention water tank
+ Fire prevention water pump
+ Fire hydrant related matters
+ Fire prevention plumbing
+ Inert gas jet equipment
+ Portable fire extinguisher.

- Electric facilities:

+ Power supply facilities
+ Power switchboard
+ UPS (Uninterruptible Power Supply)
+ Indoor lighting and plug
+ Earth equipment
+ Fire alarm
+ Automatic architecture equipment.

- Lift: elevator and escalator.

❖ **At grade station:** equipment is the same as an elevated station.

9.3.4 Station entrance

❖ **Layout principles**

The station entrances layout on Hanoi Line 2.3 complies with the following principles:

- The station entrances should be arranged properly with the current conditions and future plan of Hanoi City;
- The station entrances shall secure the attraction and evacuation of passengers flows from many directions.

❖ **Design solutions**

- The entrances of stations must be designed to sit on the sidewalk. The design of entrance must ensure not to affect the regular passenger flow direction at sidewalks, and not to hide the vision of people who are in the traffic at the entrances near the junction.
- For the convenient access of passengers into the stations, stairs, escalators and elevators will be installed at the entrance of the station. Sizes of entrance shall not be smaller than 2.0 m in width and not less than 2.4 m in height to avoid any obstacles.

❖ **The access methodology of the station for the passenger**

The passengers can access the station in many ways such as walking to the station, using personal vehicles such as bicycles, motorbikes, cars, etc., or using public transportation such as buses, taxi, etc.

- **Walking to station:**

+ The best access for a railway is that people can walk to the station; for this, the sidewalks within the scope of the station must be upgraded, newly constructed, and should be paved by the same kind of tiles to ensure the sidewalks are flat, firm, clean and well drained.

+ In addition to the stair for people accessing the station, markings for pedestrian crossing, installation of signboards, signals around the station shall be supplemented.

+ The paths toward the entrance stairs shall be paved with distinguished materials for easy recognition.

+ Any obstacles on the walkways for pedestrians must be removed, and the access way must be wide enough, not be interrupted by motorbike, motorbike taxi or other business activities on the street.

+ Traffic regulation must be made for alleys and create the connection to the areas of station. The priority to the movement of pedestrian on the sidewalks shall be made.

- **Public transportation (bus, taxi, etc.)**

+ Bus stops and bus stations shall be placed at the locations where it is nearest the entrance stair within the scope of station. The bus stops can be supplemented at the locations if they do not exist. The bus lines in the corridor and the bus lines having connections with Line 2.3 need to be redesigned suitably when Line 2.3 is opened. Each station should have two bus stops. All the bus stops within the station area must be installed standard shelters with pavement markings, notice boards, etc..

+ The fixed notice boards are installed with LED monitors to show the information on time and names of arriving and leaving bus lines to instruct the passengers coming and leaving from the stations of Line 2.3 to the bus stops.

+ The balustrade is installed along in front and behind the curbs of each bus/taxi stop to ensure the safety and comfort for the passengers. The balustrade height about 0.75m made from stainless steel is design in such that protect passengers from falling to streets by pushing one another during the peak time.

- **Private vehicles (bicycle, motorbike, car, etc.)**

+ The private vehicles are not allowed to park on the scope of the station; parking lots should be installed around the station area to serve the passengers using private vehicles such as bicycles, motorbikes, cars, etc. can leave their vehicles and use Metro Line 2.3.

+ Locations of parking lots shall be convenient for passengers accessing the station; the sizes of parking lots shall be calculated based on the number of passengers boarding and alighting during the peak time.

- **Access for Disabled people**

+ Station area and walkways for pedestrians shall disabled-friendly by installing facilities that will provide passengers with disabilities to easier access.

+ All sidewalks shall be paved with dedicated tiles for visually impaired passengers. The dedicated tiles lines shall be paved along the paths for visually impaired passengers to lead them from the waiting, aligning areas to the lifts and along the path to the stairs as well as the adjacent junctions.

+ The sidewalks shall be lowered at the crossings for the pedestrians within the stations to ease the access of wheelchair users and voice signal devices shall be available for passengers with disabilities.

Lowered floor bus

Figure 9-13. Designs for Disabilities People

+ The dedicated waiting (seating) areas for the disabled shall be installed on sides of a station at the location near the lifts; the waiting area is indicated by poles and signboards for the disabled.

Table 9-7. Summary of station plan

No.	Station	Platform length (m)	Platform Layout	No. of elevators	No. of escalators	No. of stairs
1	N9	130	Side platform	4	6	8
2	N8	130	Side platform	4	6	8
3	N7	130	2 islands platform	4	6	8
4	N6	130	Side platform	4	6	8
5	N5	130	Side platform	4	6	8
6	N4	130	Side platform	4	6	8
7	N3	130	Side platform	4	6	8
8	N2A	130	Side platform	4	6	8
9	N2	130	2 islands platform	4	6	8
10	N1A	130	Island platform	3	5	7
11	N1	130	Island platform	3	5	7
12	N0	130	Island platform	3	5	7

9.4 Plan on Depot

9.4.1 Comparison of Plans

1) By transport plan

According to the transport plan, Depot of Line 2.3 is located between NH2, NH18 and NH3. The depot is located at Phu Lo commune, Soc Son District, Hanoi City.

Figure 9-14. Depot Location According to Transport Plan

2) By land use plan

According to the urban development plan (Decision No. 2967/QD-UBND dated June 29, 2015 of Hanoi People's Committee approving the general planning of construction of Soc Son District at scale 1/10,000), depot location is located at Phu Lo Commune, Soc Son District, Hanoi City.

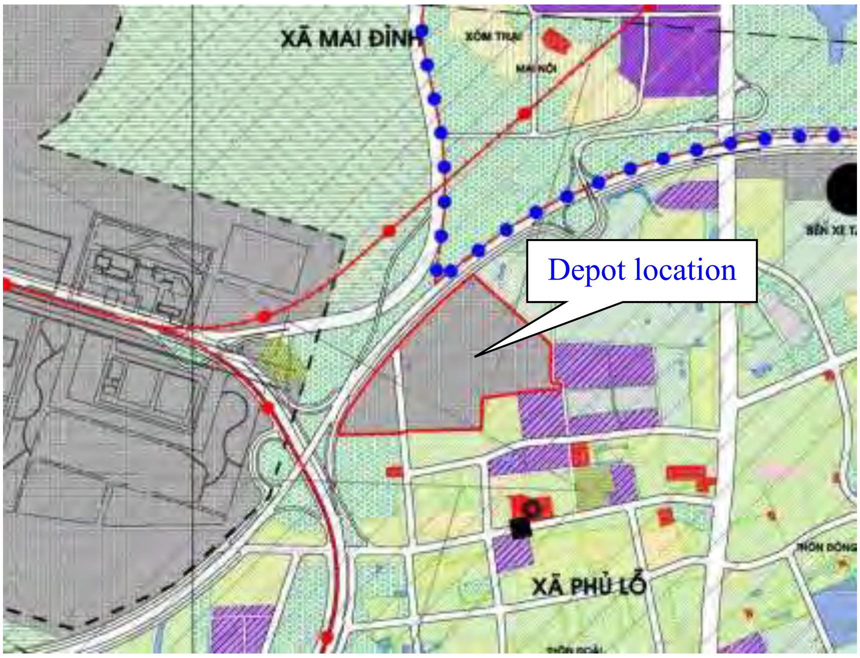


Figure 9-15. Depot Location According to Land Use Plan

9.4.2 Depot Scaling

1) Stabling Points

As shown in the section 8.4, the total requirements of trains are 27 for the entire Line 2 during the initial period, 42 for the second stage and the maximum requirements are 60 trains. In addition to depot based stabling points, it is a pragmatic option to have station-based stabling at night. The proposed stabling points at stations are 9 trains as shown in Figure 9-16. For a total of 60 stabling point requirements, the Xuan Dinh Depot has 32, Phu Lo Depot with 30 stabling points and 9 station stabling; the total stabling capacity is 71. There are 11 excess stabling points for operational redundancy and future expansion.

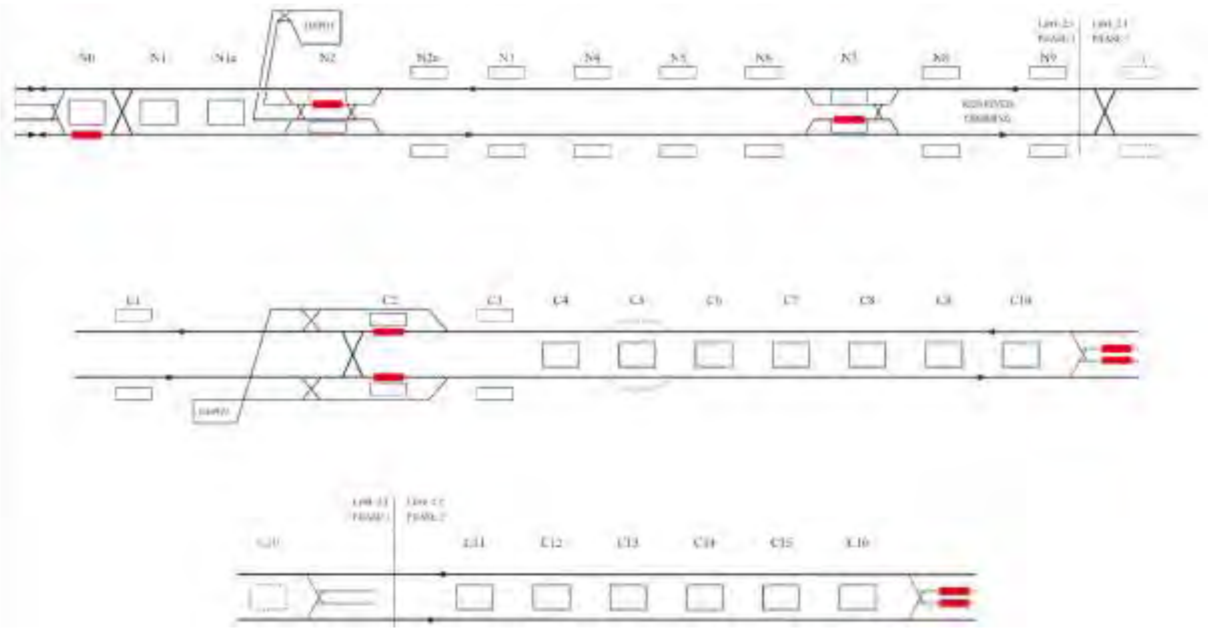


Figure 9-16. Station Stabling Plan

2) Depot Plan

The depot location is Phu Lo commune, Soc Son District with a total area of 25ha. The proposed plan of the depot is shown in Figure 9-17. The depot will have a capacity of a periodical check, maintenance, stabling and cleaning for 32 trains/ 6 cars.

The planned facilities will include:

- Shed for rolling stocks repair and maintenance.
- Night stabling tracks.
- Controlling E & M maintenance and facilities maintenance equipment.
- Depot office: power substation, overhead power lines, communications and signaling system for train movement inside depot area.
- Open storage area: water supply and drainage, etc.

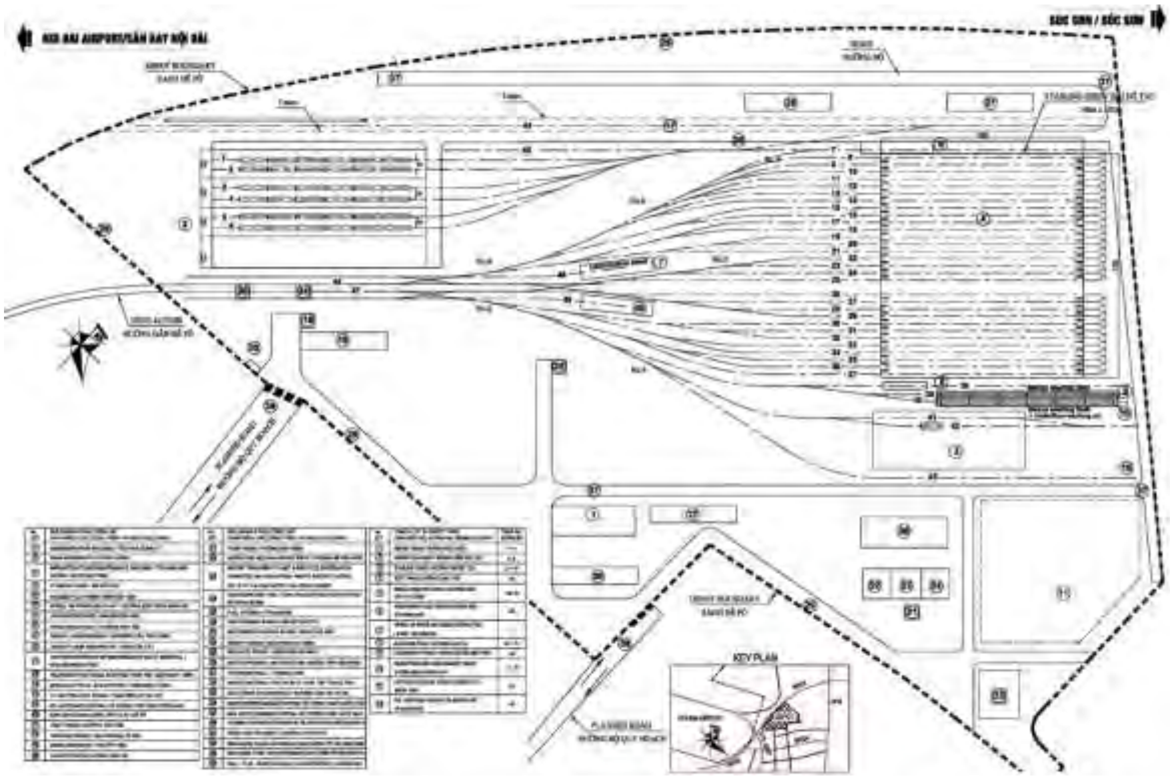


Figure 9-17. General Plan of Depot

3) Recommendation on Scale and Location of Depot

Depot of Line 2.3 is located at Phu Lo commune, Soc Son District with an area of about 25ha.

9.4.3 Track Elevation and Track Layout

Depot Track shall be at level throughout the Depot with T.O.R level based on 1/100 year return flood water elevation in the Depot area. The Depot track layout facilities are designed based on functional requirement and the following conditions/concepts:

- The Depot is designed for the capacity of 32 trains (6cars/train). Rolling stock dimensions for 6-car trains with a total length of approximately L=121.6m, width B:2.95m & height H:3.66m.
- Track layout in the Depot maintenance building/structure shall be in conformance to Rolling stock envelope of maximum moving dimension
- The conductor height of overhead catenary system (OCS) leading into the main workshop at train inspection tracks and final adjustment track for repaired trains shall be at approximately +15.50 to +16.00m distance.
- Train equipped with a train information system to facilitate train-wide equipment condition monitoring. TIS can be connected to failure logging & analyzing system at the Depot.
- Track layout configures to protect the mainline from the unauthorized train movements from Depot.

- Track work layout is arranged to permit the replacement of trains in the main workshop within a maximum of 20 minutes.
- Turnouts and scissors crossing in the depot to be used No.8 (1:8), a minimum length between each turnout end is 5.00m, use minimum curve radius inside depot R=120m.
- Summary of Depot Track is shown in the following:

Table 9-8. Summary of Depot Tracks

No.	Proposed Depot Facility	Qty	Track No.
1	Workshop Repair Track		
	● Major Repairs of 8 years interval	1	Track No. 1
	● Medium Repairs of 4 years interval & 2 years interval replacement of Wheels & Bogies.	1	Track No. 2
	● Unexpected / Emergency Repairs	1	Track No. 3
	● Final adjust of repaired train	1	Track No. 4
2	Workshop Inspection Track		
	● Technical Inspection of 3 months interval.	1	Track No. 5
	● Regular Inspection of 6 days interval.	1	Track No. 6
3	Wheel Re-profiling Track	1	Track No. 7
4	Stabling Track	30	Track No.8 to 37
5	**Train Washing Track**		
	● Train wash plant	1	Track No. 38
	● Manual washing track	2	Track No. 39 & 40
6	Infrastructure Maintenance Track	2	Track No. 41 & 42
7	Outdoor Storage Track	1	Track No. 43
8	Test Track	1	Track No. 44
9	Shunting Track	3	Track No. 45 to 47
10	Locomotive Shed	1	Track No. 48
11	Rail cum Road vehicle shed	1	Track No. 49
Total		49	

Figure 9-18. Sample of Stabling Tracks

Figure 9-19. Sample of Test Tracks

Figure 9-20. Inspection and Repair Tracks

Figure 9-21. Sample of Automatic Car Washing and Manual Car Washing

Figure 9-22. Wheel Re-profiling Facility

9.4.4 Functional Facilities

Functional facilities are planned based on the function for concerned activity by various departments namely, Depot & OCC administration office, Rolling stock stabling, Maintenance of rolling stock, infrastructure, E & M equipment maintenance, Training center, Power supply & distribution, Power supply to OCS system, Signal & telecommunication system, overhead catenary system, outdoor storage, Water supply and Discharging System, Service buildings for operation & maintenance administration etc.

9.4.5 Maintenance Systems

It may be preferable which are followed for the maintenance of rolling stock in references to the following;

- Vehicles must not be used unless they are kept in a condition that enables them to run safely.
- Newly manufactured or purchased vehicles and modified or repaired vehicles can be used only after they undergo inspection and test runs. Test runs may be omitted, however, for vehicles that have undergone minor modification or repair.
- Vehicles where derailment or other accidents occurred while they were operated and which may have failed and those which have not been used for some time are used, they must be inspected in advance, and their test runs must be made as required.
- The main parts of vehicles must be inspected according to the types of vehicles and the condition of their operation.
- If facilities or vehicles are inspected in accordance with the provision of the regulation, and if facilities or vehicles are remodeled, fixed or repaired in accordance with the same provisions, such work must be recorded and the records shall be kept.
- Besides the Vietnam Government regulation, Inspection/ repair intervals shall not exceed the periods specified in the following table.

Table 9-9. Inspection / Repair Intervals

Type of Inspection	Track No	Contents of Inspection/ Repair Work	Interval Time	Assumed Time/Train
Daily Inspection	Stab. Yard	To check the facility of train-set before starting operation.	everyday	20 min
Regular Inspection	6	To check the facility and condition of train-set.	every 6day	1 hour
Technical Inspection	5	To check the facility and condition of consumables, equipment.	every3month	2 days
Replacing Wheels & Bogies	2	To replace wheels and bogies then to check the condition of these.	every2 years	4 days
Medium Repair	2	To check facility, condition and major important equipment/ parts.	Shorter of every 4years or600,000 km	17 days
Major Repair	1	To check overall conditions of car, equipment and parts by dismantling and disassembling car and equipment.	Every year	20 days
Emergency Repairs	3	As per the condition of the train set	-	-
Final Adjustment	4	For repaired trains	-	-
Wheel Re-profiling	7	Re-profile the wheels as the per condition of train-set	130,000 km /cars	2 hours /car
Train Washing at Plant	38	Normal washing	every 6 days/train	1 hour /train
Train Washing Manually	39	Special washing	every 12 days /train	3 hour /train
Train Washing Manually	40	Under floor washing	Before major & medium repairs	2 hour /train

9.4.6 Depot Road System

Provide road network inside the Depot with access to all facilities for daily traffic circulation of private vehicles, commercial traffic for deliveries, local operation by trucks & vehicles for facility maintenance, security patrol, forklift as well as access by fire engines and ambulance vehicles. Roads shall be suitably marked for traffic circulation and contain the following provisions:

- Road with asphalt pavement except for level crossing part with tracks.
- 12m-wide carriageway with 3.0m wide sidewalk to the main entrance from the outside main street.
- 7.0m-wide carriageway with 2m sidewalks for the main roads in the Depot.
- 3.5m-wide carriageway service roads.
- Level crossing part to be taken into consideration moderate ground settlement and provision so as not to place undue stress on rails at building entrance.
- Provide sidewalk with width 2m or 3m along one side of the main entrance. Around the main workshop and access to infrastructure maintenance building also provide 2.0m width sidewalk for people access.
- At outdoor storage area provide concrete pavement for the stock of bulk infrastructure maintenance material and at unloading area for new rolling stocks.

9.4.7 Assessment of Yearly run-kilometers of Trains

Forty-five trains shall be operating on UMRT Line-2 by 2040. The routine work arising of repairs in trains shall depend upon distance covered by them over a period of time. So, for the planning of regular repairs and wheel profiling, assessment of distance coverage by 45 trains on line2 is done as under:

No	Items	Section	
		N1⇔ N8 ⇔ N1	N8⇔C16⇔ N8
1	Round trip distance – km= **(A)**	40	31
2	Daily operation hours = **(B)**	18	18
3	Headway = **(C)**	6 min	3 min
4	Average speed of train – kmph= **(D)**	50 kmph	50 kmph
5	Time travelled / kilometer – min (60 ÷D) =**(E)**	1.2 min	1.2 min
6	Time taken / Round trip/train -min.(AxE) = **(F)**	**48 min**	**37 min**
7	No. of trains / round trip with headway(F ÷ C) = **(G)**	**8 trains**	**12 trains**
8	No. of round trips in 18 hrs –No(18xG)÷F= **(H)**	**180**	**350**
9	Total distance travelled/ day – km(AxH) = **(I)**	**7200 km**	**10850 km**
10	Total distance travelled/ year – km(Ix365)= **(J)**	**2,628,000km**	**3,960,000km**
11	**Total distance traveled by 45 trains/ year in N1⇔C16 ⇔N1 section**	**6,588,000 km**	
12	**Total distance travelled / train /year (sharing by 45 trains)**	**1,46,400 km**	
13	**Wheel re-profiling work /year (@1,30,000 km / train)**	**51 trains (306 cars)**	
14	**Wheel re-profiling work/day**	**≈1 car**	

9.4.8 Depot Capacity

Taking into consideration the operational plan, the current headway, as well as the possibility for future improvement in headway in N1⇔N8 Section, the depot facilities in Phu Lo Depot are designed for 32 trains (6cars/train). The facilities planned for provision in the Depot now shall be sufficient to accommodate the workload of trains up to 32 trains (6cars/train). Capacity Check is based on the following assumptions:

- Working days in a year in repair shop: 300 days.
- Working days in a year in inspection shop & washing line: 365 days.
- Number of working shift daily: 2 shifts (15 h)
- Each track availability/month (in two shift /wkg):
    - For inspection & washing - 450 hrs
    - For repair shops - 375 hrs
- Capacity Checked time: 1600 hrs
- Number of trains: 32 trains, each train with 6 Cars

Table 9-10. Capacity Check of Depot Facility (tracks)

Activity	Content of Activity	Repair Track No	Monthly Workload / Monthly Track -hours					
			Assumed Time / Train	Train - Nos	Required Track – hours	Available Track – hours	% Utilization of Track	Judgment
Daily Inspection	To check facility of train-set before starting operation& Average stabling in Depot	SL SL	20 min 7 hr	960 960	320 + 6720	13500	52	OK
Regular Inspection	To check facility and condition of train-set.	6	1hr	160	160	450	35	OK
Technical Inspection	To check facility and condition of consumables, equipment.	5	2d	11	330	450	73	OK
Replacing Wheels & Bogies	To replace wheels and bogies then check the condition of these.	2	4 d	1.33	80 + 168	375	66	OK
Medium Repair	To check facility, condition and major important equipment/ parts.	2	17d	0.66				
Major Repair	To check overall conditions of car, equipment and parts by dismantling and disassembling car and equipment.	1	20 d	0.33	99	375	26	OK
Emergency Repairs	As per condition of train set	3		-		375		OK
Final Adjustment	For repaired trains	4		-		375		OK
Wheel Profiling	Re-profile the wheels as the per condition of train-set	7	2 hr/ car	30	60	375	16	OK
Train Stabling	Stabling in the Depot.	8-37	7 hr/ train	960	6720	13500	50	OK
Train Washing	At plant , normal washing every 6 days/ train	38	1 hr/ train	160	160	375	42	OK
Train Washing	Manually, special washing every 12 days/train	39	3 hr/ train	80	240	375	64	OK
Under Floor Washing	Before Major & Medium repairs on pit	40	2 hr/ train	1	2	375	0.5	OK

Upon check, the capacity of all the facility tracks (for different activities) is found to be adequate in terms of utilization percentile as tabulated above. Therefore, planned tracks are adequate for an operational load of 32 trains (6cars/train).

9.4.9 Embankment

1) Soft soil treatment in depot

Refer to the geological survey results of NH2 flyover near the Depot construction site. The stratum area from top to down consists of the following soil layers:

- Filling soil: Sandy gravel with broken brick and sandy clay brownish-grey medium stiff.
- Cultivated soil: clay mud, blackish grey.
- Layer 1b: Clay, grey, yellow, red, stiff.

- Layer 2: Sandy clay, grey, yellow, medium stiff.
- Layer 3: Sandy clay, grey with organic, soft.
- Layer 4: Fine sand, grey, yellow, loose to medium stiff.
- Layer 5: Medium sand, grey, yellow, medium dense.
- Layer 7: Clay, grey, yellow, stiff.
- Layer 8: Clay, grey, stiff.
- Layer 10: Sandy sand, grey, loose.
- Layer 11: Sandy clay, grey, yellow, stiff.
- Layer 12: Sandy clay, grey, medium stiff.
- Layer 13: Clay, grey, yellow, stiff.
- Layer 14 : Silty sand, grey, medium dense.
- Layer 15 : Medium sand, grey, medium dense to dense.
- Layer 16: Cobble gravel, whitish-grey, very dense.

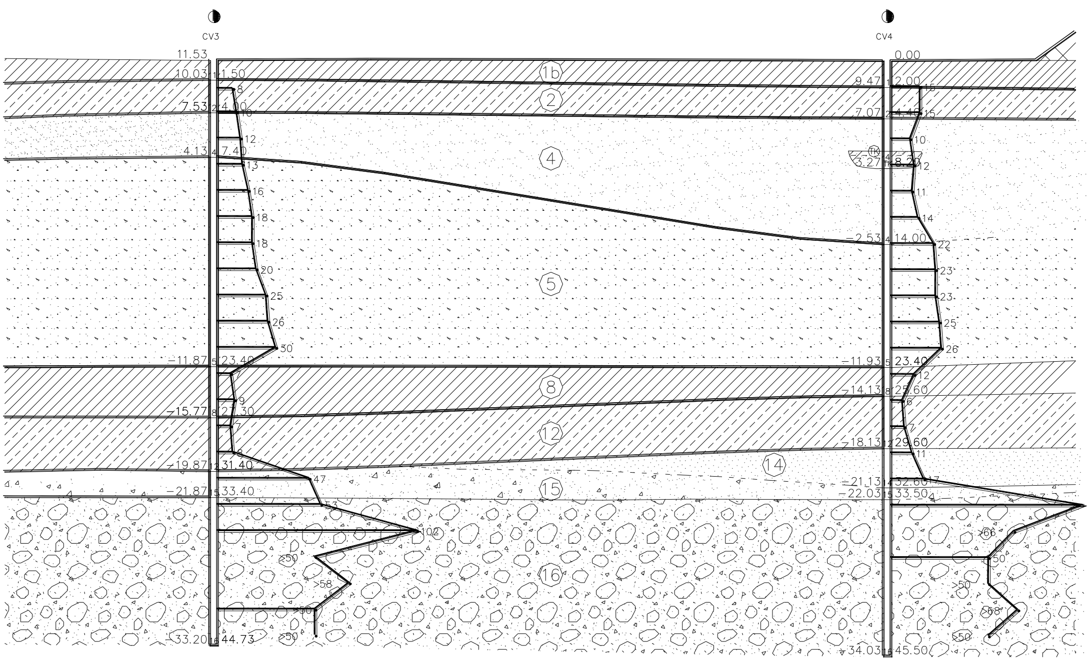


Figure 9-23. Geological Section for Reference

According to the survey results, layer 3 and layer 12 are soft soil layers with highly compressed settlement, so the settlement has been calculated with the leveling height of 3.0m for the settlement result S = 7.9cm. With settlement S = 7.9cm, the foundation does not need a solution to soil treatment. However, in the next steps, it is necessary to conduct a detailed survey for the depot area and calculate for each region.

2) **Solution of Embankment Design**

Leveling and filling elevation: According to Decision No. 2967/QD-UBND dated 29th June 2015 by HPC approving Soc Son District general construction plan (1/10.000), the Depot area is located in Phu Lo commune with control elevation for construction is minimum +12.5m; thus the Study Team recommends that the sand leveling level in this stage will be +13.0m as the Master plan.

Filling materials: In order to increase the stability of the embankment for the future construction of works inside the Depot, the Design Consultant recommends using fine sand for all areas to ensure the density K≥0.9.

Leveling slope: As leveling sand is the non-cohesive particles, the water drainage capacity is good. To facilitate the construction and acceptance for the sand leveling works, the entire areas within Depot are recommended to be leveled at the same elevation of +13.0.

9.4.10 Drainage System in Depot

The depot with an area of about 25ha is divided into 6 basins of storm water drainage which are connected to the discharge outlet via the main pipes to Ca Lo river. The storm water drainage system is separated from the wastewater system in Depot. The storm water from the buildings is collected into the storm water drainage pipes built in the buildings, then discharge into the pipes installed around the buildings.

At the railway area, the perforated PVC tubes are wrapped with geotextile and installed in the ditches surrounded by rocks, the storm water inside these tubes is discharged to the main pipes.

The depot area is divided into many small basins, depending on the location of discharge direction and slope, rainwater from these small basins will be collected to catch pits and sewers system beneath the internal roads, these culverts are RC round pipes with opening widths of each section are chosen based on hydraulic calculations.

9.5 Rolling stock

9.5.1 Applied Standard

- Vietnam standard "Urban railway standard for mass rapid transit (MRT) – General technical requirements" TCVN 8585:2011.
- International standards for reference: Urban railway system standards for Asia (May 2006)– STRASYA.

9.5.2 Main Technical Parameters

Table 9-11. Main Technical Parameters

1	Track gauge	1435 mm
2	Power	1500VDC
3	Maximum axle load	16 ton/axle
4	Maximum design speed	120 km/h
5	Height of platform	1100 mm
6	Minimum radius of curve (mail line)	300 m
7	Minimum radius of curve (depot)	160 m
8	Power	1500VDC
9	Maximum axle load	16 ton/axle

9.5.3 Selection Principles

- The selection of transportation vehicle and train configuration shall meet the travelling, convenient and comfortable needs of the passengers.
- Type of vehicles as smaller as possible to ensure the regular operation and maintenance.
- Rolling stock shall meet the requirements in terms of speed, acceleration, deceleration as well as certain cases on traction incident.
- Safe and reliable operation.
- Modern advanced manufacturing technology, high reliability.
- Environmentally friendly.
- Rolling stock shall be able to operate in any external condition of Hanoi City.

9.5.4 Train configuration

- Based on the transportation demand of each stage, the train composition is balanced by the transport department. In terms of rolling stock, there are many ways to arrange cars.
- The number of trailer cars and motor cars should be designed with a ratio of 1: 1. On a train, the number of trailer cars is not greater than the number of motor cars.
- It is necessary to change train composition in a flexible way when transportation demand changes.
- Train configuration in the first stage and the next stage: to meet the travel demand of passengers and according to the calculation results, configuration requirements at the beginning stage(2030) and the next stage (2040) consists of 6 cars as below:

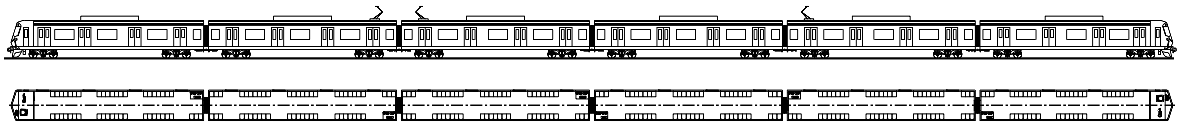


Figure 9-24. Six-car Train Diagram

9.5.5 Car Dimensions

1) Rolling stock gauge

- Rolling stock gauge shall be in accordance with the rolling stock gauge prescribed in Vietnamese Standard: “Urban railway standard for Mass Rapid Transit (MRT)- General technical requirements” code TCVN 8585:2011.

2) Car dimensions

- Maximum width : 2.950mm
- Overall length of car body : 19.500 mm

- Length between center of couplers : 20.000 mm (for middle cars)
- Maximum height from top of rail (excluding power collector and air conditioning): 3.650 mm
- Height of car floor from the top of rail : 1150 mm
- Distance between center of 2 bogies : 13,800 mm
- Numbers of access doors for passengers: 4 doors for each side of car.

3) Technical specifications of train

- Design speed 120 km/h
- Acceleration 0,92 m/s2 (3,3 km/h/s)
- Service braking deceleration 0,97 m/s2 (3,5 km/h/s)
- Emergency braking 1,25 m/s2 (4,5 km/h/s)
- Type of cars :

  +) Motor car (M)

  +) Trailer car with cabin (Tc)

  +) Trailer car (T)

4) Car body

- Seat arrangement in the car might be longitudinal (along with the car) or horizontal (transverse with the car) or mix.
- For a standard commuting car, in order to optimize passengers convenience with easy hopping on and off the car, and to increase the number of standing passengers, it is recommended to choose a longitudinal seat arrangement as shown in Figure 9-25.
- Below is the layout of the seats for the first car as well as the middle car.
- The airport express train may have different seating arrangements such as full seating as shown in Figure 9-26. The exact arrangement will be adjusted during the detail design based on more detailed demand forecast.

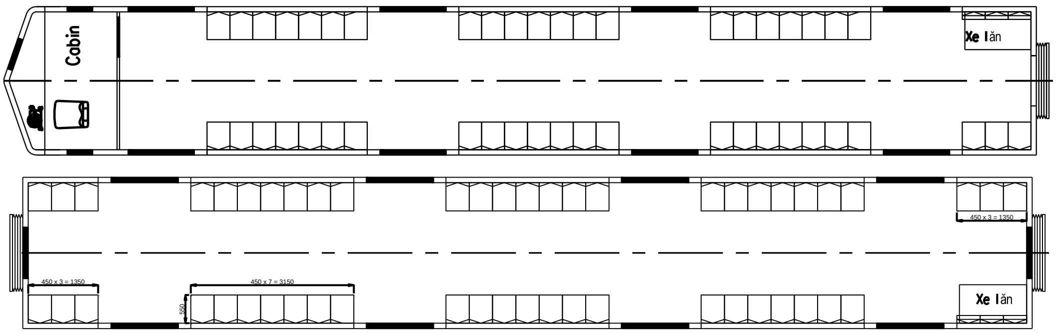


Figure 9-25. Seat Layout

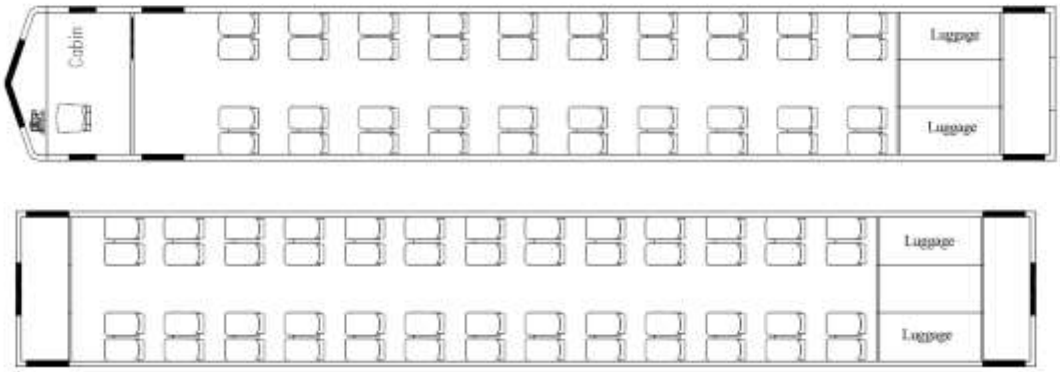


Figure 9-26. Seat Layout for Express Train

9.5.6 Car weight and Axle Load

1) Passenger transport capacity

According to Standard Urban Railway System for Asia STRASYA, the number of passengers in the car including seats and standings is as below:

Table 9-12. Number of Passenger on Car

Passenger	Tc	M	T
Seat	48	54	54
Standing	99	108	108
Seat + standing	147 (100%)	162 (100%)	162 (100%)

2) Car weight and axle load

- The number of passengers is considered to be 10 standing pax/m2 plus the number of seats according to the norm (TCVN 8585:2011).
- Axle load equal total car weight/axle (4 axles)
- The selection of car axle load is 16 tons/axle.

Table 9-13. Total Car Weight and Axle Load

Car type	Tc	M	T	Note
Dead load (ton)	30	32	28	
Passengers (seat + standing)	367	390	390	
Passenger load (ton)	20.18	21.45	21.45	55kg/person
Car load (ton)	50.18	53.45	49.45	
Axle load (ton)	**12.54**	**13.36**	**12.36**	

9.6 Track works

The superstructure length of Line 2.3 is about 36.5km, including underground sections, viaducts, section on embankment and spur lines in Depot on embankment. The superstructures shall be designed appropriately for those mentioned parts. The proposed designs follow the standard structures for all railway projects in Vietnam.

The superstructures of Line 2.3 for the underground section and viaducts include rail, sleeper, fasteners, anti-vibration fittings, concrete bed to ensure continuous operability and low maintenance costs.

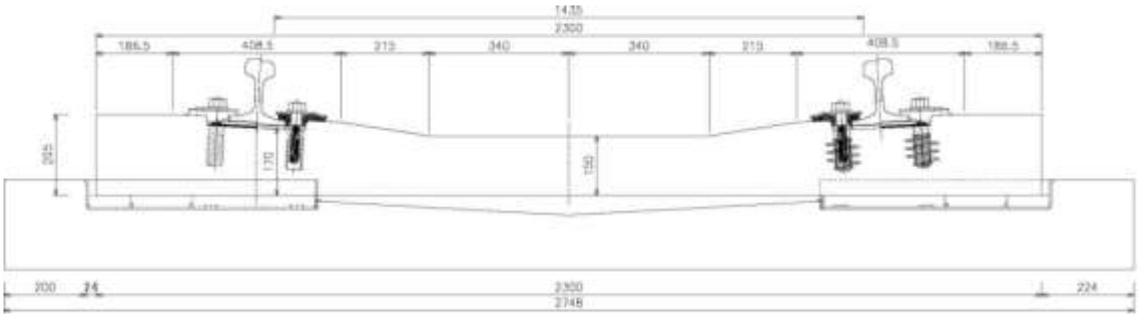


Figure 9-27. Typical Cross Section for Concrete Bed

The superstructure of Line 2.3 for the section on embankment and spur lines in the depot includes rails, ties, fasteners, and ballast bed with its advantage in low cost in investment.

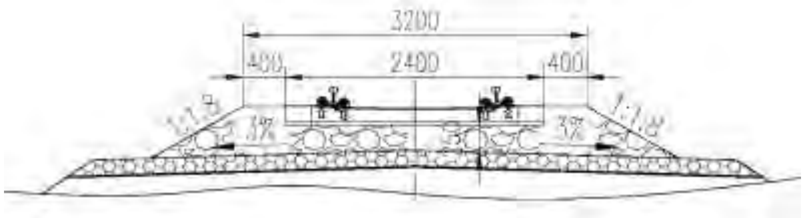


Figure 9-28. Typical Cross Section for Ballast Bed

9.6.1 Rail

1) Rail for main line:

Rail profile UIC 60 is used with following geometric specifications:

- Height: 172 mm
- Bottom width: 150 mm
- Head width: 74,3 mm
- Weight: 60.34kg/m

Figure 9-29. Rail UIC 60

The inclination of rail is 1:20 (leaning into the centerline of the road). This inclination is made on the side contacting rail bottom of the sleeper.

2) Rail for depot

Rail profile UIC 54 is used with following geometric specifications:

- Height: 159 mm
- Bottom width: 140 mm
- Head width: 72 mm
- Weight: 54.43kg/m

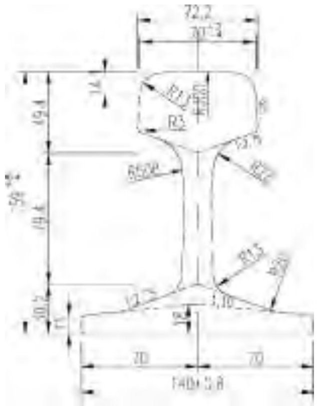


Figure 9-30. Rail UIC 54

The inclination of rail is 1:20 (leaning into the centerline of the road). This inclination is made on the side contacting rail bottom of the sleeper.

9.6.2 Sleeper

PC-sleepers placed on concrete beneath rail or ballast bed is applied. On main line, the distance between sleepers in the straight tracks and curves with a radius equal to or greater than 1200m is 750mm, the distance between sleepers in the straight tracks and curves with a radius less than 1200m is 625mm.

Depot Access Line has radius R=160m, the distance between sleepers: 600mm.

In Depot: the distance between sleepers on the straight tracks is 750mm and on curves is 650mm.

9.6.3 Fasteners

Fasteners are used to link rail with PC-sleepers, the track adjustment in horizontally and vertically is made on the rail foot pad or on the anti-vibration adjustment box.

- The rail is fastened resiliently with the concrete sleepers by two elastic rail clips or plates, a stiff elastomeric pad between the underside of the rail foot and the top surface of PC sleeper. An insulator is placed between the rail clip and the rail foot.
- Type A rail fasteners are recommended for the tracks placed on concrete slab and Type B rail fasteners for the tracks on ballast bed.

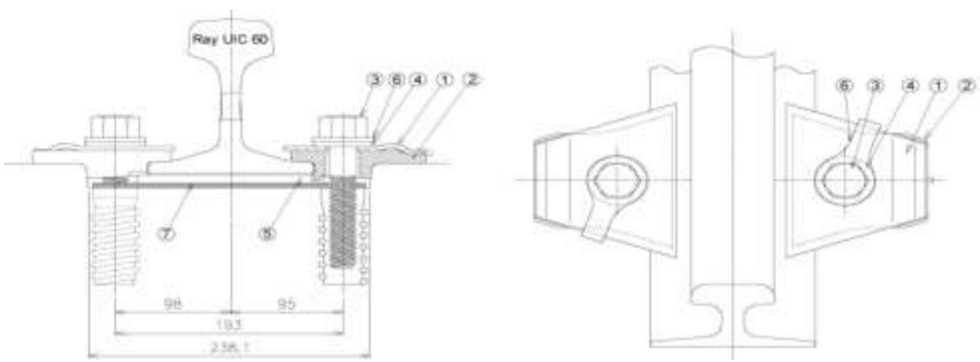


Figure 9-31. Fastener Type A

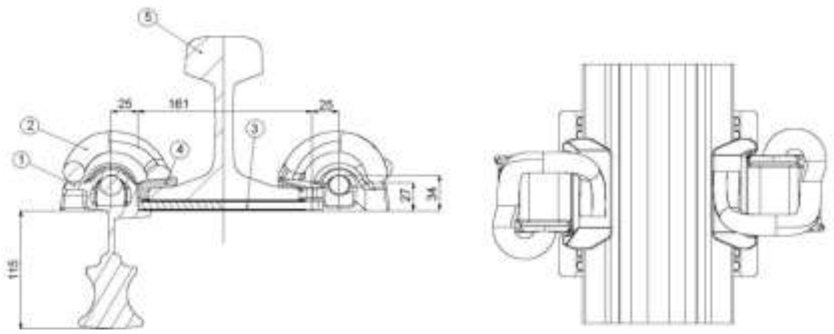


Figure 9-32. Fastener Type B

9.6.4 Concrete Bed

The concrete base is poured in two times with starter bars are arranged, their steel bars work as shear reinforcement ensuring no relative displacement caused by the load. The minimum thickness of the concrete slab under the anti-vibration box is 150mm. The gaps of 100mm width are left in the spacing of 5m-6m inside the concrete slab for installation of power cable, drainage pipe crossing the road.

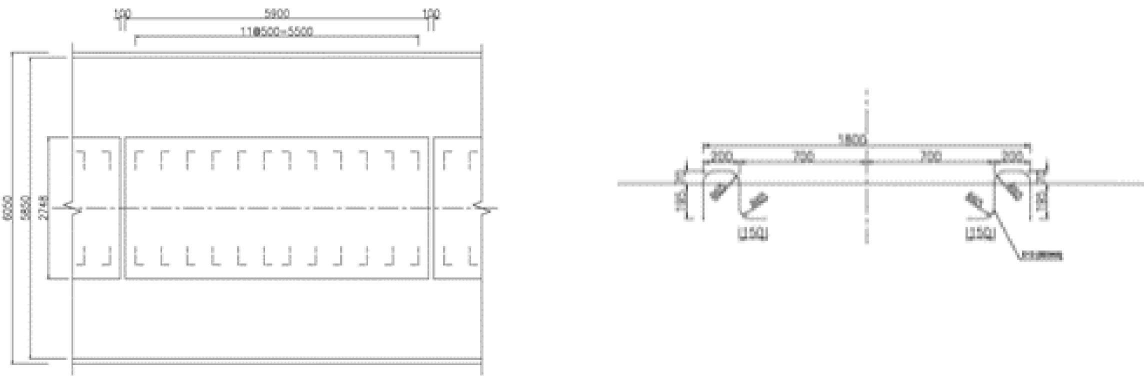


Figure 9-33. Starter Bar for Concrete Bed

9.6.5 Ballasted bed

Ballast is manufactured by grinding from original non-weathered rocks. Ballast must be clean, with no contamination of impurities, no flattened and long shapes.

Ballast shall ensure the rate of the passing sieve as following:

- Passes 60mm sieve: 100%
- Passes 50mm sieve: 80 - 100%
- Passes 40mm sieve: 25 - 70%
- Passes 25mm sieve: 0 - 20%
- Passes 20mm sieve: 0 - 5%

Ballast shall have high abrasion resistance, the abrasion of ballast calculated under Los Angeles test shall not exceed 27% for the main line and spur lines to Depot and not exceed 33% for Depot.

9.6.6 Turnouts

Crossings, turnouts are placed on the flat concrete slab with a thickness of 150mm. Synthetic plastic sleeper is used at positions of switches. The locations of crossings, switches are separated from the rail circuit among the basic rails, rail joints with 06 holes are sealed by insulation adhesive tape.

No part of turnouts shall be placed on movable expansion joints of the structure. Turnouts with tgα =1/10 are recommended for the main line and turnouts with tgα =1/8 are recommended for Depot and other tracks.

9.6.7 Buffer stop/wheel stop

Friction buffer stops are installed at the end of the main line and stabling tracks. Buffer stops shall be executed as friction buffer stops 8EB. Impact loads are calculated based on the weight of the train of 6 cars, and the impact speed is 12.5km/h.

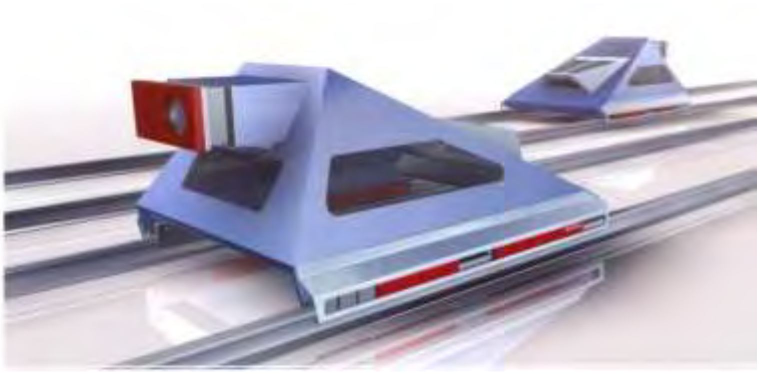


Figure 9-34. Buffer Stop

9.7 Signaling and communications systems

9.7.1 Signaling systems

1) General

The Hanoi City Urban Rail Construction Project, section Nam Thang Long - Noi Bai (Line 2.3) is the extension to the north of Ha Noi Metro Line 2 (section Nam Thang Long- Tran Hung Dao) .

The basic design of Line 2 (section Nam Thang Long- Tran Hung Dao) has been completed by the General Consultant (GC) and submitted to the National Assembly of Vietnam for approval.

The signaling system for line 2.1 is proposed use train control technology solution CBTB (Communication Based Train Control) with an automatic train control system (ATC) includes the following basic subsystems: signaling and Automatic Train Protection (ATP), automatic train supervision system (ATS) and automatic train operation system (ATO), in which ATC system will be controlled from the OCC transport control center or local train supervision equipment (LTS) installed in station control room (SCR) in case OCC center is not available. The train detection is proposed to be a combination of solutions: AF track circuit will be used for the turnout area, while CBTC will be applied for the main track

2) Design criteria

To ensure interoperability, integration and connectivity between Line 2.3 and Line 2.1. The consultant proposes the design criteria for Line 2.3 as below:

- Signaling and Automatic Train Protection systems will be designed with fail-safe principles;

- Full bi-directional working on the main line together with a depot, approach tracks shall be possible.
- Safety System will be validated following IEC62425 Standard at Safety Integrity Level 4(SIL4), and Software will be validated as per IEC62279 Standard at SIL4.
- All train movements will be under the supervision of train-drivers;
- Revenue Line design headway is not more than 2 minutes.
- CBTC solution using two-way radio communication between wayside equipment and onboard equipment used to determine the position of trains on the main line in the area without turnout. CBTC technology needs to comply with / conform to IEEE 1474.1-2004 standards.
- Proposed axle counting solution for detecting train at the stations with turnout;
- The feature detecting broken rails does not necessarily require as mandatory for the Line 2.3, because there is no major earthquake in Vietnam.
- The overall system shall be available for 99.95% over a minimum operational life of 15years.
- Requirement on the accuracy of stopping train at a station in case of normal operation for a platform with Platform Screen Door (PSD) shall be ± 0.25m.
- Service shall be satisfactorily proven with the transportation authorities for at least five years.
- The design life of the system signaling shall be 30 years.

3) Train operation mode

The automatic operation mode ATO (have driver) is proposed as an operation mode in normal conditions on the main line. The movement of trains on the track is controlled by automatic train operation (ATO) and automatic train protection system (ATP) equipment. The train driver undertakes the monitoring of the operation of the system on board, or takes on additional tasks if not equipped with equipment to open and close train door at the platform, or to open the train door in emergency.

In reality, no operation system can be absolutely functioning at any situation and any time even if it has proven to be efficient and reliable. Therefore redundant operation modes for substitution in case of malfunctioning of the major automatic train operation system (ATO) are needed. Only with system redundancy, diverse requirements of commercial operation can be ensured.

This ensures flexible requirements in commercial operation. To ensure the consistency with the train operation method of Line 2.1, a unified train operation method for line 2.3 as below will be considered.

Train Operating Mode		Characteristics/ Train Operating Area	Note
ATO		Normal Operation on the main line. The shunting routes for turning head at N1 Station will be considered for turning head automatic.	Except for the area between Depot and N2 Station. The shunting route for turning head at N2 and N8 Stations.
ATP	ATP	Operation in case of ATO breakdown (unavailable)	Supervised Manual Mode
		Normal operation for turning head at N1, N2 and N8 Stations.	
		Normal operation between N2 Station and depot access line.	
	Emergency	Operation in case of ATP way-side equipment breakdown	Restricted Manual Mode Speed limitation of 15km/h
	Cut-off	Operation in case of ATP on-board equipment breakdown	
Way-side Signaling		In the main line: In case the ATP system does not work so that train operation follows way-side signals. Way-side signals can be considered including replacement signals, shunting signals, dead-end signal, direction indication.	ATP doesn't work in this mode. Speed limitation of 15km/h
		In the Depot area: train operation follows Depot way-side signal	

4) Signaling system

a) For mainline

The signaling system of the main line includes but is not limited to the system components and devices are as below:

➢ **Interlocking system**

- Computer-based interlocking devices (CBI);
- Electric point machines with function locking, error detector and detection ;
- Train detection device for the main line without turnout : Use active solutions to detect and locate train on CBTC radio information;
- Train detection device for station area with turnout: Proposing to use vehicle axle counting device.
- Point-sensor devices (balise / transponder) will be installed at specific locations on the main line (curve, turnout-area, transition: underground - ground - viaduct), in the station to adjust the increase/ reduce the speed of the train or provide geographic information to repositioned train positions for ATO functions.
- Wayside Signal: Fixed signals for running trains on the main line are not necessary for the proposed signal router for the project. However, alternates signals, shunting signals, dead-end signal, direction indication, emergency buttons, etc. are proposed for consideration following the train operating mode on the line.

➢ **Automatic train control system (ATC)**

- Automatic Train Protection (ATP)
- Automatic Train Supervision (ATS)
- Automatic Train Operation (ATO)

➢ **Radio transmission system**

The radio system is used to transmit data between trains and wayside equipment with high speed and bi-directional.

Line 2.3 has a total length of about 19.65km of which 4.06km underground and 15.59km on viaduct. The structure of underground sections is 2 single tunnel pipes. Therefore, the radio communication system for data transmission between trains and wayside equipment is proposed to include two combined solutions as follows:

- Underground area: Using radiation coaxial cable system (LCX) to transmit/receive data;

Technical features of track circuits and digital radio information based on LCX

Technical Features			Track Circuit Technology	Digital radio technology based on LCX cable	Note
1	Operation direction	One direction	Yes	Yes	
		Omnidirectional	Yes	Yes	
2	Blocking system		Fix block	Moving block	
3	Verify the integrity of the train		Logic of ground equipment	Equipment on train	
4	Target stops		Boundary of the rail circuit with safety limit length.	Distance from the train ahead by a safe distance (equivalent to the length of the train)	
5	Amount of information and transmission speed		Small amount of information (01 channel).Low speed (64bit / sec).	Large amount of information (04 channels).High speed (1200 bits/sec).	
6	Transmission of ATC control information	Ground →Train	Yes	Yes	Ability to integrate communication applications on LCX cable transmission lines
		Train →Ground	No	Yes	
7	Train Management System		No	Yes	
8	Train dispatching information		No	Yes	
9	Radio information support maintenance		No	Yes	
10	Rail break control		Yes	No	
11	Construction costs		High	Low	
12	maintenance costs		Higher	Low	

Structure of LCX cable in tunnel section

- Ground and viaduct areas: Use radio stations / transmitters with directional antennas.

➢ **Uninterrupted power supply system (UPS): UPS with a minimum of 30 minutes battery back-up for the train control signal system.**

➢ **Other auxiliary systems.**

b) Depot system

The signaling system of the depot includes but is not limited the system components and devices are as below:

- ➢ **Interlocking system for depot**
- - Computer-based interlocking devices (CBI) ;
- - Electric point machines with function locking, error detector and detection. The ability to operate automatically by interlocking, manual operation in place is monitored by Depot control room ;
- - Train detection equipment: The depot area has many turnouts, train density and irregular use of tracks in the depot.
  To ensure stability and minimize maintenance, it is proposed to select the vehicle's axle counting device as a train detection device because it has many advantages compared to the track circuit;
- - Wayside Signal: Fixed signals for shunting, dead-end signal, direction indication, router indication, etc. are proposed for consideration in accordance with the train operating mode on the depot. The signals and indications are proposed LED technology.
- ➢ **Operation supervision and control equipment in Depot**
- ➢ **Uninterrupted power supply system (UPS): UPS with a minimum of 30 minutes battery back-up for the train control signal system**
- ➢ **Other auxiliary systems (include alarm and signal light shall be provided to alert staff when trains are approaching the staff Level Crossing in depot)**

9.7.2 Telecommunications system

The telecommunication system for line 2.3 is closely related to the selection of OCC construction for the line. The communication system for line 2.3 includes:

- - Transmission system: Main backbone transmission network between OCC, stations along the road, and Depot (Optical fiber cable network, network cable, metal cable and transmission equipment);
- - Telephone system: Traffic control telephone, direct telephone, staff phone (main switchboard PABX at OCC, satellite switchboards at stations);
- - Radio communication system: Providing radio communication lines from the ground to trains, serving the operation and maintenance of railway (radio stations and antennas, LCX cables);
- - CCTV system: The system of surveillance cameras sending images to operators (scanning cameras (PTZ), fixed cameras (FIX));
- - Public radio system: Used to notify passengers in the station area or on the train.
- - Passenger information display system: Passenger information system used for people is responsible for sending passenger photos information, train schedule;
- - Digital clock system: The system provides accurate and synchronous time on the entire line 2.3 (master clock in OCC and stations and slave clocks arranged in the concourse and platform);

The system of backbone transmission cable network of line 2.3 will be connected to the main transmission cable network of Line 2.1 at Nam Thang Long station, to integrate the data transmission of the information sub-systems of Line 2.3 with information sub-systems line 2.1. Accordingly, the entire data transmission of the internal PABX telephone system, radio system, CCTV, public radio system, passenger information display system and clock system of Line 2.3 are collected and controlled by the main control system of the corresponding information system of Line 2.1 located at the OCC equipment room. In particular, the transmission of data of the direct telephone system of Line 2.3 to the central control equipment of Line 2.1 direct telephone system located at OCC is done by connecting metal cables. Line 2.3 connects exclusively telephone systems directly to the system of line 2.1. It is fundamentally important that the entire Line 2 uses the same signaling and communication systems has the identical technical specifications i.e., need to be procured from the same vendor. Therefore, the procurement of the systems for Line 2.1 that is expected to precede that of Line2.3 needs to precondition the tender with the follow-up procurement for the other phases of the Line 2 including Line 2.3.

9.8 Power supply system

9.8.1 Receiving and traction power

The power system of Line 2.3 uses the same technology as of Line 2.1 to ensure compatibility when connecting. Accordingly, using a closed-loop medium-voltage power supply scheme from at least 2 sources with two parallel circuits from Nam Thang Long and Noi Bai, the busbar in the medium voltage system has segments and spare circuit breakers. The Automatic CB closes when there is a failure from the working source.

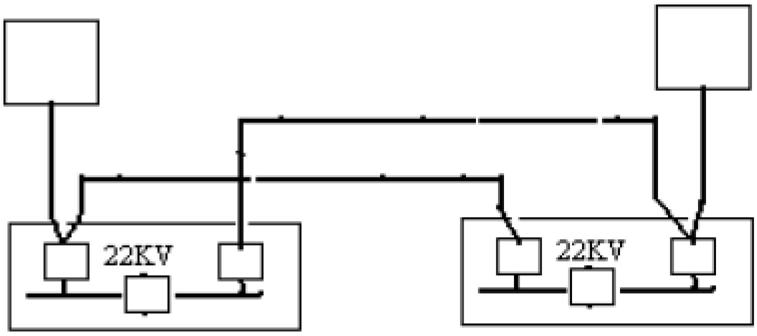


Figure 9-35. Power Supply Scheme for Railway

9.8.2 Specifications of the power supply system of Line 2.3

1) Traction power system

Based on alignment and station locations, capacity calculation, line 2.3 is expected to be arranged with 6 power stations. The stations in the inner city are about 4 km apart and the stations outside the inner city are about 6 to 7 km apart.

Table 9-14. Traction substation for urban railway Line 2.3

No	Name	Chainage
1	N8	Km 5+140
2	N6	Km 7+080
3	N4	Km 10+030
4	N2	Km 13+860
5	Depot	
6	N1	Km 18+570

In particular, the TSS (traction substation) at N8 station must ensure the power supply for the first section of the railway from Km 5 + 140 to Km 0 + 00 (the location connected to C1 station of Line 2.1) in case Line 2.3 is completed first

Each TSS uses 2 2x3000 kVA transformers.

Based on the city electricity planning map by 2020, based on the alignment and capacity of TSS, it is proposed the following power receiving solution:

- Electricity receiving substations include a 110 kV substation and a 22 kV switched substation, the locations expected for electric receiving substations are: 22 kV switched substation at N8 Station (Km 5 + 140) and a 110 kV power receiving substation at Depot.
- To ensure the backup safety, the 22kV switch substation will be electrified from two 22 kV cable lines from two separate substations.
- Receiving substation shall be located at the same location (same building) with a traction substation (rectifier substation) except in difficult circumstances.

Table 9-15. Location and Capacity of Receiving Substations

Location	Type of substation	Capacity (MVA)	Location for Receiving Connection	Length of Receiving Cable
N8 Station	22 kV	15	Hai Boi Substation E24+Xuan Canh Substation	2,8 km + 3,8 km
Depot	110 kV	30	Nguyen Khe Substation	3,2 km

2) Power feeding for train

Overhead contact system (OCS) is used in which the train takes power through the pantograph located on the roof.

Traction voltage is 1,500V. The OCS line will be a hard cable with a capacity of 3,000A. At the elevated sections, the cable will be hung on the column system, at the underground section, the power cable is fixed in overhead hard bars system.

Circuit breakers are used for each part of the OCS system. This device will disconnect a certain section of the system for maintenance and also used to separate a section when an accident occurs.

Each direction will have its own DC 1500 V circuit breaker for power supply and protection. OCS system will be segmented at each substation.

The traction substation converts voltage from 22 kV AC to 1500 V DC and this DC power will supply power to the train via fast circuit breaker and overhead contact system. The anode of the 1500 V DC voltage is connected to the ÓC line via a fast DC circuit breaker and the cathode connected to the running rail. The fast DC circuit breaker is used for both train operation power supply and circuit protection.

3) Distribution substation of stations and depot

Loads of distributed power systems are electrical equipment in the OCC building in Depot and railway stations. Accordingly, each area is equipped with a substation consisting of two transformers to ensure power supply throughout operating situations.

The transformer capacity of the depot is expected to be 2 x 3000 kVA, that at stations is 2 x 1500 kVA, and that for OCC center is 2 x 750 kVA.

4) Supervisory control and data acquisition of substation

Receiving substations and traction substations will be automatically operated, supervised and controlled by a supervision center at OCC.

9.9 Automatic Fare Collection (AFC)

9.9.1 Overview of automatic fare collection system

The AFC system is a system for public transport operators, such as railways and buses to replace manual ticket collection using electronic devices.

The AFC system uses contactless ICs to provide convenience to passengers, allowing it to travel on public transport with just one IC ticket. The system has many benefits for traffic operators as well as passengers because of its convenience and safety.

9.9.2 General principles

The system is selected and designed to maximize revenue (ticket sales), minimize losses and lower operating costs with the following requirements:

- Sustainable, reliable, economical and friendly passenger systems;
- Attract visitors at maximum volume;
- The system is capable of meeting the models of inter-line and multi-media,
- Perfect ticket control system, ticket check to avoid fraud;
- Equipment needs to be easily installed with 24h/7 day operation and without much maintenance;
- Ticket collection system in a closed cycle with the payment area, convenient for passengers;
- Minimize the evacuation time for guests from dangerous areas during emergencies.

9.9.3 Overview AFC system configuration

The AFC system is built with four levels:

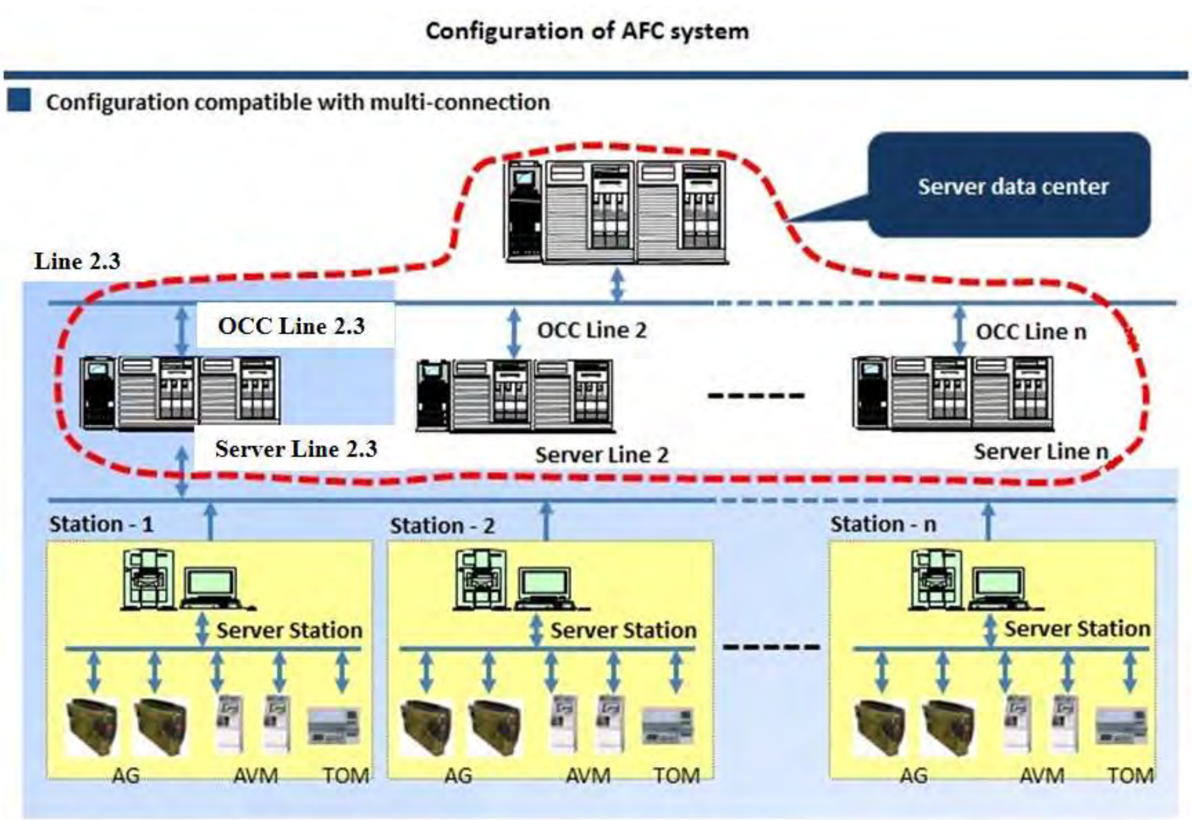


Figure 9-36. AFC System Configuration

- Grade 1 – IC Card: A ticket that is capable of storing ID and ticket information valid for processing and recording at Ticket Sales and Ticket Confirmation. The AFC device does the exchange, storage and updating of information through wireless communication.
- Grade 2: AFC equipment: Includes ticketing equipment such as automatic ticket machines, automatic refill machines, and ticket validation equipment such as automatic ticket control and automatic fare adjusters.
- Grade 3 – the Station Server: It is a system for receiving and controlling IC card transaction data at each terminal, and transmitting data between the AFC and the line server.
- Grade 4 – the Line Server: A system that collects and monitors data on IC card ticket transactions in a railway line.
- The AFC system ensures the ability to meet the interoperable model, collect and control the data needed to provide multi-link IC tickets between multiple operators.

9.10 Outline of construction plan

9.10.1 Station and Cut & Cover Tunnel Construction Plan

The typical construction methods with an underground station and cut&cover tunnel i.e. bottom up and top down methods are introduced and compared as follows:

- Bottom-up: excavation from the top down, transfer the soil discharged by fast and economic methods through direct access was available when digging at a moderate depth; then construct the structure from the bottom up.
- Top-Down: Use D-Wall, king post and permanent structure to keep stability during excavation. Use roof slab to cover the road surface to ensure the traffic above the tunnel. Construction of the permanent structure by excavation sequence.

Table 9-16. Excavation Method Comparison

Items	Advantage	Disadvantage
Top down	- The risk of diaphragm wall collapse can be minimized since it is supported by the rigid concrete slab. - The deflection of the diaphragm wall is small by the rigid slab support. - In general, construction cost is cheaper and the construction schedule is shorter compared to those of the bottom up method because only minimum propping are required and additional propping may not recur during any stage of construction. - Dry work can be done under the top slab umbrella.	- Excavation work is low in productivity and limited since it is carried out through slab opening. - Construction is difficult compared to that of the bottom up method. - In the case of soft ground condition, it is difficult to carry out propping work since it is also required between top slab and bottom slab.
Bottom up	- Construction is easier than that of the top down method. - Excavation work is higher in productivity and workability compared with that of the top down method. - For cut & cover tunnel, in general, the bottom up method may be adopted since the top slab position is lower than that of the station.	- The risk of diaphragm wall collapse is higher than that of the top dawn method. - The deflection of the diaphragm wall is larger compared to that of the top down method. - Excavation work is easily affected by rainwater.

From the above comparison, the top down method is recommended for the station construction and the bottom up method is suggested for the cut & cover tunnel.

The underground station and cut & cover tunnels construction plans are shown in the drawing method of construction of the preliminary design.

9.10.2 Shield tunnel construction plan

Table 9-17. Classification of Shield Tunnel

Type of Shield			Feature
Shield	Open Type	Hand Mining Shield	It can be adjusted for rock and gravel appearance because the front of the shield is opened. However, this can be applied only for the condition that the cutting face stability should be secured for a long time.
		Semi-mechanical Shield	This type can be applied for the ground securing the cutting face stability since generally, the cutting face is opened widely.
		Mechanical Shield	It has turning cuter head which can provide continuous excavation and therefore, the cutting face stability can be secured partially. But generally, it is for the ground securing the cutting face stability.
	Semi Open Type	Blind Shield	The cutting face opening ratio is adjustable according to soil conditions.
	Closed Type	Earth Pressure Balance Shield(EPBS)	It can be secured the cutting face stability and minimized surrounding ground settlement through checking driving data, since it has a control system based on earth pressure to coordinate the driving speed with the rate at excavated soil intake.
		Slurry Shield	This type can improve the cutting face stability compared to EPBS and therefore it is effective for places with high groundwater pressure such as under rive and seabed. The face is completely closed, providing a high level of safety and good environmental conditions, moreover minimizing surrounding ground settlement.

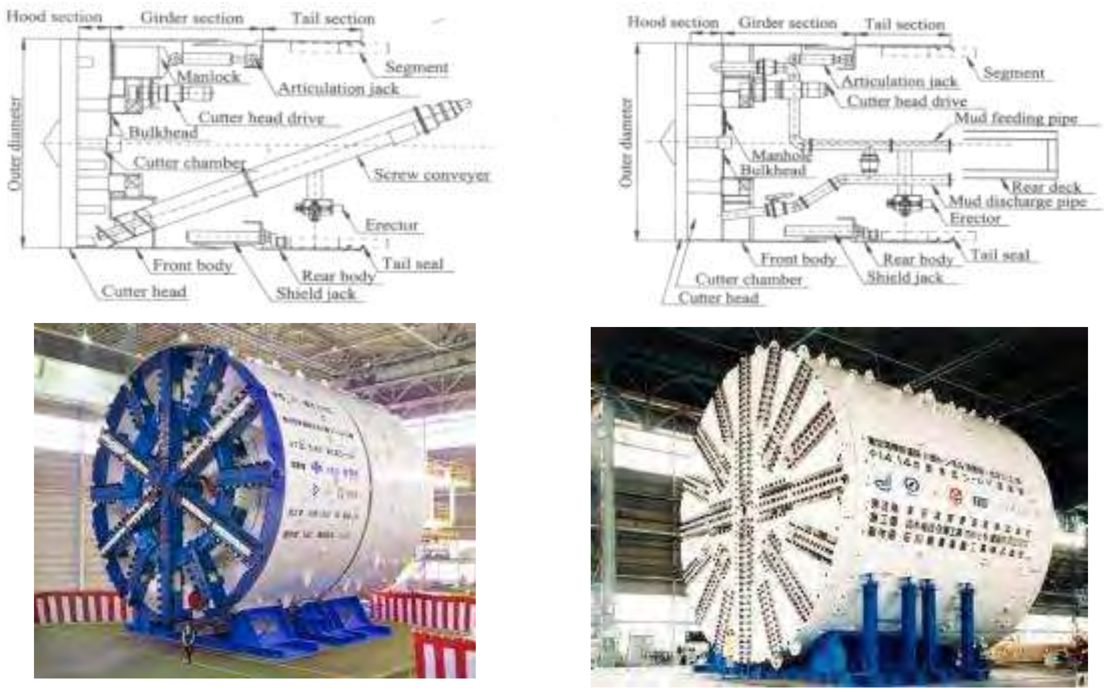
Table 9-18. Applicable Soil Conditions corresponding to each Shield tunnel

Soil Condition		N-value	Hand Mining Shield	Semi-mechanical Shield	Mechanical Shield	Blind Shield	EPBS	Slurry Shield
Soft Clay		0-5	△	×	×	○	○	○
		5-10	△	△	△	×	○	○
Stiff Clay		10-	△	△	△	×	○	○
Sand	Silt with Sand	10-15	×	×	×	×	○	○
	Loose	10-30	×	×	×	×	○	○
	Dense	30-	×	×	×	×	○	○
Gravel		40-	×	×	×	×	○	△

Note: ○ : Means basically applicable △ : Means necessary to study application × : Means no applicable

EPBS and Slurry Shield types are recommended in this project considering high groundwater (GL-1.2 to -7.0m), accumulation of soft clay and silty sand and the above tables.

Comparison of EPB and Slurry Machine:



a) EPBS machine b) Slurry machine

Figure 9-37. Illustration of Two Types of Shield Machines

Table 9-19. Salient Feature of EPB and Slurry machines

Item	EPB	Slurry	Advantage
Face stabilization for very soft soil condition	Control pressure adjusting the volume balance with controlling screw conveyor speed.	No problem for the stabilization except for shallow earth covering.	Both
High water pressure	Normally, up to 4 bars. If the water pressure is very high, some special water cut off devices shall be attached to the screw conveyor.	Normally, up to 5 bars, but it can be used up to 10 bars.	Slurry
Very high permeability soil	High experiences are required to stabilize and improve the permeability.	It is possible by feeding slurry with additives and controlling viscosity of feeding slurry.	Slurry
Boulder excavation	A big screw conveyor can discharge boulders efficiently.	It can be applied, but severe wear of cutting tools occurs compared to that of normal geological condition.	Both
Construction Equipment	In general, EPB plant system on the surface is smaller than slurry plant system.	Sufficient space is required to install slurry plant. In the case that excavated soil having high quantity of fine particle, more large space is needed for the slurry treatment plant.	EPB
Noise and vibration	Not serious problem from the devises on the surface.	Noise and vibration from the slurry treatment plant (vibration screen etc.) is necessary to minimize.	EPB
Settlement	In early stage of development, the settlement was larger than that of slurry system, but nowadays there is no much difference between EPB and slurry systems.	The pressure control is easier than that of EPB system.	Slurry but only slightly

In detail the steps shield tunneling is shown in construction method drawings of the preliminary design.

9.10.3 Elevated section construction plan

- **Foundations and Temporary works**

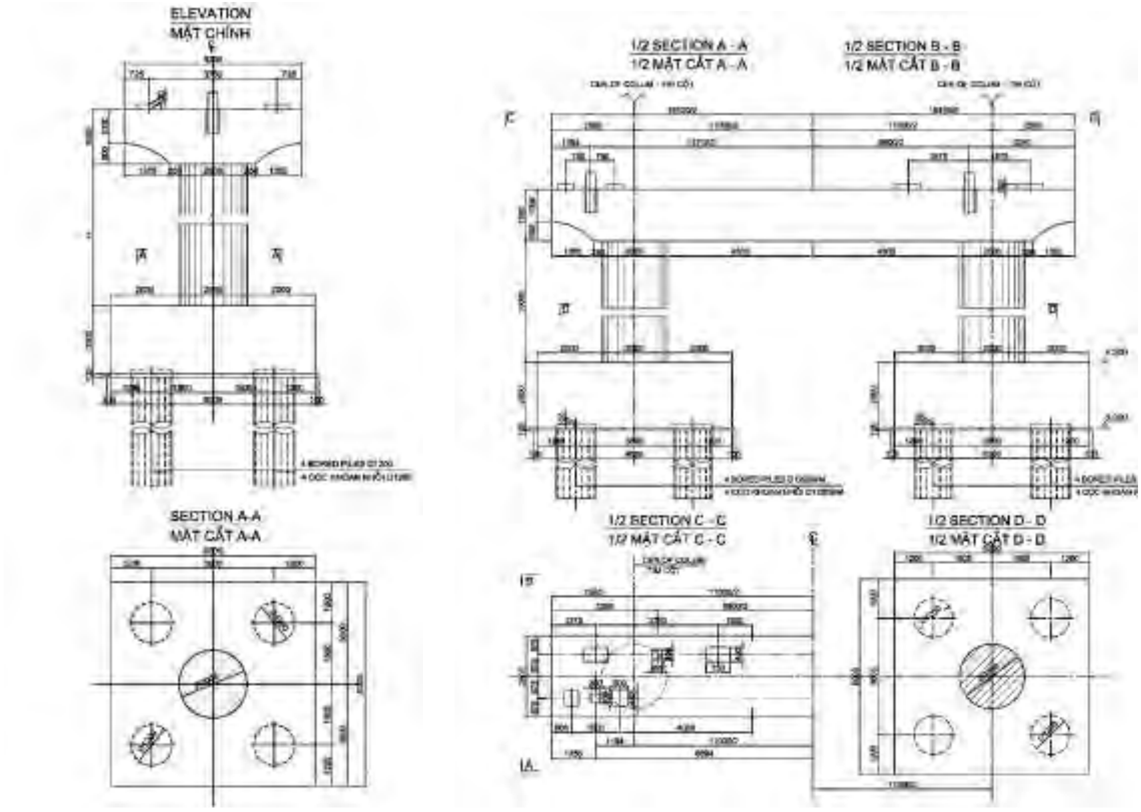
Foundations of the viaduct are consisting of cast- in- situ piles and pile caps.

For construction method for cast- in- situ piles, earth drilling method, which is widely used in Vietnam. This method uses bentonite slurry not casing pipe for protecting borehole from collapse and after completion of drilling, rebar cage is installed and then concrete casting with discharging bentonite slurry is carried out. After completion of cast- in- situ piles, ultrasonic test to confirm soundness and static loading test to confirm bearing capacity will be carried out. These tests are indispensable quality control tools in Vietnam and therefore this project also needs to adopt them. After quality confirmation of the piles, sheet pile driving and then excavation work are performed sequentially. Furthermore, propping work corresponding with excavation depth is carried out, and then leveling, pile head treatment, rebar assembling, concrete casting are performed, which is the construction sequence for piles caps. In addition, it is highly recommended that driving and extracting sheet piles will be carried out using the hydraulic method in the same manner with the station entrance for minimizing noise and vibration.

For the section between C1 to N6, the construction will take place over the existing roads which have multiple lanes thus one lane may be closed as a construction site during the construction period. For the section between N6 and N0, the right of way for the railway alignment is secured along the existing roads already, thus there is no need for the access road or construction yard for N6 to N0. In any case, the detail construction method and bill of quantities will be developed to optimize the traffic interferences and costs.

➢ **Substructure**

Substructure has single pier having RC column and double piers having RC columns.



a) Single Pier b) Double Pier

Figure 9-38. Pier Structure

Formwork system, false work and scaffolding are combined together and easily movable using crane and trailer in the site are adopted, since substructure has many similar sized members in order to ensure finishing quality on the concrete surface and shorten construction cycle time.

➢ **Construction for typical viaduct**

Precast post-tensioned girder which was fabricated in the precast yard is transported to the site and then it is installed in the designed position.

The precast girder has the following advantages compared with those of cast- in- situ concrete girder:

- Site work can be shortened and the road traffic influence can be reduced by transporting the precast girder in the night time.
- The concrete quality control is easier at the fabrication yard compared with the site work.
- Labors can be reduced compared to site work.
- It does not need to consider curing time for the concrete girder at the site since it was fabricated and cured until the required strength was obtained at the fabrication yard.
- It has advantages in terms of work efficiency, productivity and quality because the same steel formwork is used for the same member.

The box girder segment is installed by steel double truss gantry, steel box girder gantry, self-propelled gantry and so on. In normally, the gantry crane design is carried out installation expert of subcontractor hired by the contractor.

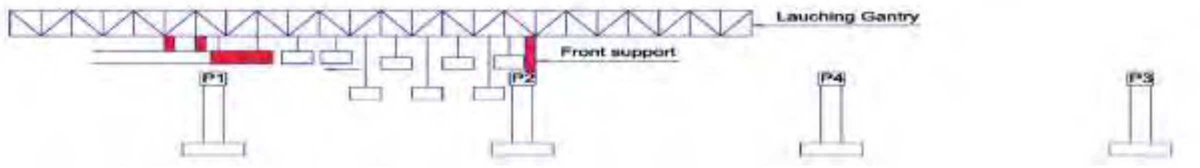


Figure 9-39. Construction for Typical Viaduct

- **Construction for a continuous box girder bridge**

Although formwork and false work will be set on the road, it is only partially occupied on the road, and therefore the road traffic influence can be minimized. Furthermore, this method is used for many bridges constructed in Vietnam.

Moreover, it is recommended adopting cast- in- situ balanced cantilever method not using precast segments in this section, since the box girder dimensions vary from place to place. As a result the advantages for precast segments are reduced and the construction cost may be higher than that of the cast- in- situ method.

Figure 9-40. Superstructure Installation by Balanced Cantilever Method-1

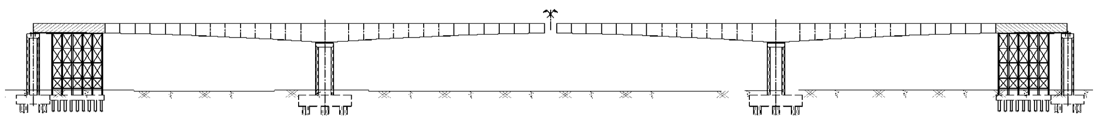


Figure 9-41. Superstructure Installation by Balanced Cantilever Method-2

In detail, the steps construction elevated section is shown in the construction method drawing of the preliminary design.

10. Intermodal Transfer Facilities

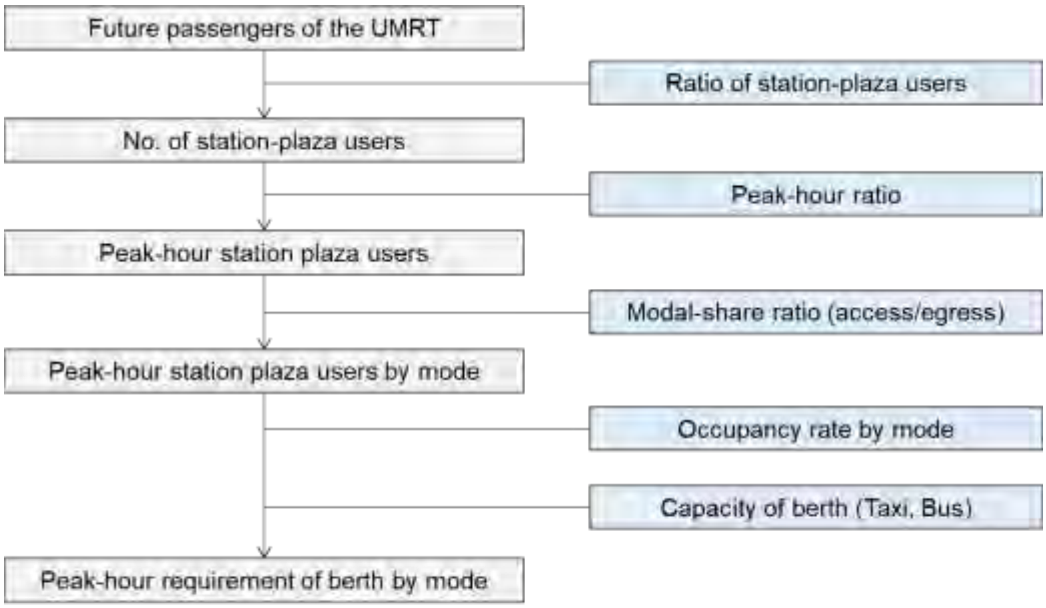
10.1 Demand for Intermodal Facilities

10.1.1 Capacity of Station Plazas and Bus

1) Methodology

Based upon "the Station Plaza Estimation 1998 in Japan", the capacity of station plazas and bus stops is estimated. Future passenger demand in 2050 is selected as the basis for the estimation. Since the bus operation plan has not been proposed, so only the peak requirement of bus berth is calculated.

The estimation process for the capacity of station plazas and bus stops is shown in Figure 10-1. Regarding the orientation of the intermodal facility plan, the peak requirements of berths by transport mode is applied.



Source: The JICA Study Team

Figure 10-1. Estimation Process for the Capacity of Station Plazas and Bus Stops

2) Result of the Estimation

Table 10-1 shows the estimation result regarding the capacity of station plazas, bus stops and other facilities for each station area.

Table 10-1. Required number of berths for the station plazas and bus stops

Station	Bus Berth (no. of lots)	Parking for Bus	Taxi Berth (no. of lots)	Taxi Pool (no. of lots)	Private Vehicle Berth (No. of lots)
N0	1		1	2	1
N1	1		1	2	1
N1A	0		0	0	1
N2	1		1	2	1
N2A	0		0	0	1
N3	1	Yes	1	2	1
N4	1	Yes	1	2	2
N5	1	Yes	1	2	1
N6	1	Yes	1	2	1
N7	1		1	2	3
N8	1		1	2	1
N9	1		1	2	2
C1	1		1	2	1

Source: The JICA Study Team

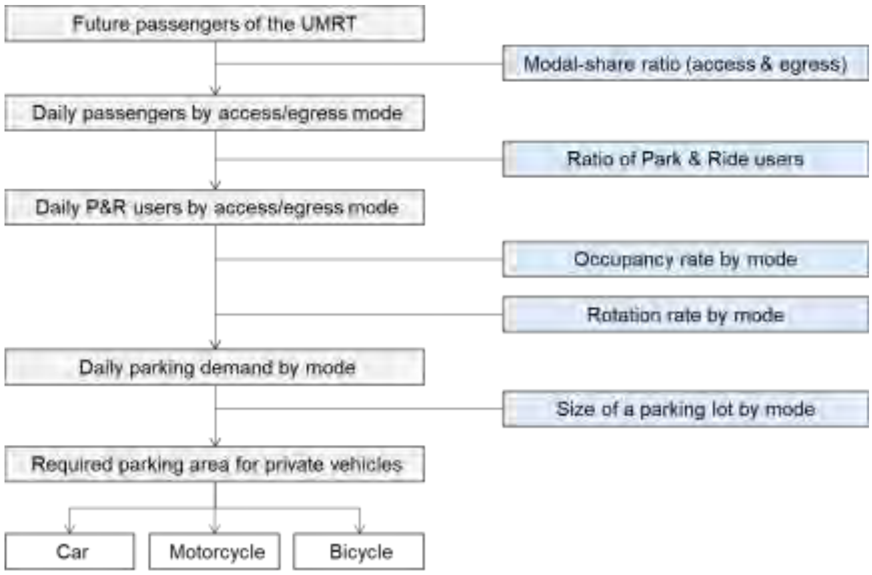
10.1.2 Parking Demand and Orientation for the Parking Plan

1) Methodology

Based upon the future UMRT passenger demand, parking demand for private vehicles (cars, motorcycles and bicycles) is estimated. In such estimation, future passenger demand in 2050 is selected as the basis.

2) Estimation Process

The estimation process for the requirements of parking is shown in Figure 10-2.



Source: The JICA Study Team

Figure 10-2. Estimation Process for the Capacity of Parking

3) Estimated Parking Demand

➢ **a) Estimation Factor**

The estimation factor for parking is shown in Table 10-2.

Table 10-2. Estimation Factors for Parking

Type of travel modes	Vehicle Occupancy (person/vehicle)	Rotation Rate (veh/parking/day)	Size of Parking Lot (m^2/lot)
Private Car	2.5	1.5	25
Motorcycle	1.38	1.5	3
Bicycle	1.35	1.5	0.9

Source: The JICA Study Team

➢ **b) Results**

Estimation results of parking for each station of UMRT Line 2 (North Section) are summarized in Table 10-3.

Table 10-3. Required Capacity of Parking in 2050

Station	Parking Demand (no. of lots)			Area of Parking (m^2)		
	Car	Motorcycle	Bicycle	Car	Motorcycle	Bicycle
N0	14	75	0	350	225	0
N1	14	73	0	350	219	0
N1A	1	9	0	25	27	0
N2	4	955	23	100	2,865	21
N2A	1	252	6	25	756	5
N3	5	1,356	33	125	4,068	30
N4	17	4,311	106	425	12,933	95
N5	7	1,569	38	175	4,707	34
N6	4	1,101	27	100	3,303	24
N7	21	5,078	124	525	15,234	112
N8	8	2,077	51	200	6,231	46
N9	15	3,733	91	375	11,199	82
C1	4	1,075	27	100	3,225	24

Source: The JICA Study Team

4) Orientation for Public Parking Plan

The key objectives of public parking development are as follows:

To promote Park and Ride for UMRT usage;

- To secure pedestrian space by encouraging the use of public parking spaces.
- Parking space should not obstruct the pedestrian passengers to stations or add extra distance to them. The pedestrian passengers will be given the highest priority.

The orientation for public parking plan are as follows:

MC and Bicycle Parking;

- Parking location: Tentatively, public parking for motorcycles and bicycles will be constructed in existing public land such as the ground floor of UMRT stations, under the viaduct space of the UMRT and in the green area of Vo Nguyen Giap Highway. Additionally, locations of such parking should be within a radius of 200-m from UMRT station. This will facilitate Park-and-Rider users.
- Parking capacity: The capacity of public parking for motorcycles and bicycles is based upon the availability of land, estimated parking demand and the requirement for parking location (within a radius of 200-m from UMRT station). Probably, the capacity of public parking may not cover the estimated parking demand. To cover such a shortage, it is expected that private parking will be developed.

Car Parking: Basically, it is important to prioritize feeder bus and Park-and-Ride facilities for motorcycles and bicycles. However, private car usage will increase in the future in Vietnam, so public parking for cars in surrounding areas of UMRT station should be taken into account.

10.2 Concept Plans by Zones

10.2.1 Region Vision and Strategies for Intermodal Facility Development

Given the predominance attached to walkability of TOD areas, the parking facilities and their approaches should not interfere with the pedestrian movement alignments. Moreover, the ambience should be entertaining for walkers. Therefore, there should be no passageways that present unsafe and uncomfortable environment to the pedestrians but to purport to the functionality of passage.

1) Airport Zone (N0 Station, N1&N1A)

Vision: Formulation of an advanced and convenience space to serve airport users directly accessing to the terminals from the city center by rail.

Development Strategy:

- Formulate an network of underground and bridges for pedestrians in order to connect the UMRT station with existing terminals (T1 and T2) as well as future terminals (T3 and T4).
- Develop Park-and-Ride facility by utilizing parking facilities of existing and future terminals.

2) The North of Dong Anh (N2 Station, N2A & N3)

Vision: Create an integrated new urban space for academia, IT and logistic services.
Development Strategy:

- Create an exclusive public transport service for students of Hanoi industrial college and workers in the Software Park as well as industrial park nearby.
- Set public services in the station to promote academia, IT and logistics activities.
- Renovate green space nearby the station in order to secure space for station plaza.
- Setting up attractive and convenient facilities for students and workers (e.g., restaurants, coffee shops and convenience stores).

3) The Central of Dong Anh (N4 Station, N5 & N6)

Vision: Create an integrated new urban space for commercial and trading activities.
Development Strategy:

- Promotion of TOD blocks in the nearby-station area.
- Develop Park-and-Ride facilities underground of station buildings
- Setting up attractive and convenient facilities for workers and visitors (e.g., restaurants, cafes and convenience stores).

4) The South of Dong Anh (N7 Station & N8 inside Smart City)

Vision: Create a smart lifestyle in an attractive, green and modern urban area.
Development Strategy:

- Develop Park-and-ride facilities by utilizing the space under a viaduct or nearby-station transport terminals.
- Formulation of a hub transport to promote UMRT commuting

5) Ciputra Zone

Vision: Create a living environment with high convenience for commuting residents.

Development Strategy:

- Sidewalks should be ensured
- Develop Park-and-ride facilities by utilizing the space under the viaduct

Table 10-4. Station-based Characteristics of the Intermodal Facilities

No.	Station	Layout	Proposed Intermodal Facility						
			Station Plaza	Bus Stop	Taxi Stop	Parking		Installation of pedestrian bridges/ tunnels	Improvement of access road
						Car	MC/Bike		
I. Airport Zone									
1.	N0		-	●	-	-	-	●	-
2.	N1		-	●	-	-	-	●	-
3.	N1A		-	●	-	-	-	●	-
II. The North of Dong Anh									
4.	N2	East	-	●	-	-	●	●	●
		West	●	●	-	-	●	●	●
5.	N2A	East	-	●	-	-	●	●	●
		West	-	●	-	-	●	●	●
6.	N3	East	●	●	-	-	●	●	●
		West	●	●	-	-	●	●	●
III. The central of Dong Anh									
7.	N4	East	-	●	-	-	●	●	●
		West	●	●	●	●	●	●	●
8.	N5	East	-	●	●	●	●	●	-
		West	-	●	●	●	●	●	-
9.	N6	East	●	-	-	-	●	●	●
		West	●	-	-	-	●	●	●
IV. The south of Dong Anh (Smart City)									
10.	N7	East	●	●	-	-	●	●	-
		West	●	●	-	-	●	●	-
11.	N8	East	-	-	●	●	●	●	-
		West	-	-	●	●	●	●	-
V. Ciputra Zone									
12.	N9	East	-	-	-	-	●	●	-
		West	-	-	-	-	●	●	-

Source: The JICA Study Team

11. Land Acquisition and Other Utilities

11.1 Land Acquisition

The total land area acquired for Line 2.3 includes land for living, public works, trees, transportation, etc. as follows:

Table 11-1. Total Land Acquisition

No	Items	Unit	Option 1 (tunnel for the Red River Crossing)	Option 2 (bridge for the Red River Crossing)
1	Land for living and construction	m^2	4.580	11.448
2	Land for public works, transportation, trees	m^2	699.962	665.183
3	The proposed number of affected households	household	42	113
	Total	ha	70,45	67,66

11.2 Relocation of Other utilities

The section runs on viaduct has crossings with high voltage lines such as:

Table 11-2. Crossing Location with 110kV High Voltage

No	Location	Option 1 (tunnel for Red river crossing)	Option 2 (bridge for Red river crossing)
1	Km1+225		•
2	Km5+220	•	•
3	Km9+430	•	•
4	Km12+125	•	•

- **Raising the high voltage line at the intersection with an elevated section**

The section runs on viaduct has crossings with high voltage lines such as:

- Km5+220: 110kV line;
- Km9+430: 110kV line;
- Km12+125: 110kV line.

To ensure the clearance between Line 2.3 and the high voltage line, two options were proposed for intersection, namely raising or underground laying the high voltage lines. The detailed design and construction method for relocation shall be carried out by a specialized management unit of power.

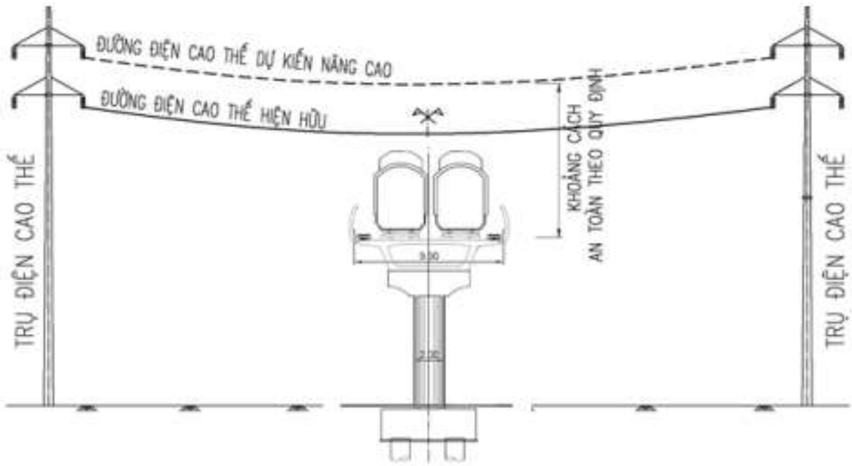


Figure 11-1. Illustrated Option for Relocation of
the High Voltage Power Lines at the Intersection with Line 2.3 - Raising

- **Relocation of other utilities**

It is based on underground works survey documents, site survey documents to identify the underground utilities (power cables, communication cables, drainage systems, water supply systems), which may affect the construction and operation of the project.

Depending on the impact level of the Line 2.3 to the utilities, the appropriate methods of relocation will be proposed during the detail planning stage.

General principles of treatment for utilities (pipelines, drainage, telecommunication cables, etc.) at the cut & cover sections, viaduct and the elevated station works, etc. are to hang and support or relocate from the scope of the works of Line 3a. The detailed design and construction method for relocation shall be carried out by specialized management units.

12. Preliminary Construction Cost

Preliminary total investment cost of Line 2.3 is estimated largely based on the actual or investigated investment costs of UMRT lines that are under implementation or completed in Hanoi city as well as Ho Chi Minh City (such as Ho Chi Minh City Line 1, Line 2, Line 3a, as well as Hanoi Line 2 - Phase 1, Line 3).

Due to lack of project cases of TBM under a large river, the unit costs of various railway TBM projects in Japan were analyzed to derive the cost escalation factor of the under-the-river TBM to a standard TBM unit construction cost.

12.1 Option 1: Tunnel for Red river crossing

12.1.1 Construction and equipment cost of Option 1

The estimated quantities of the line 2.3 for Option 1 (Tunnel) as part of the direct construction and equipment cost estimation is shown in the following table, Table 12-1.

Table 12-1. Total Investment Cost Option 1

No.	Items	Unit	Quantity	Cost	
				(bil. VND)	(mil. JPY)
A	**CONSTRUCTION COST**			*	*
I	**Main line**			*	*
1	**Cut and cover, U shape Retaining wall**			*	*
-	U shape retaining wall	*m*	*1,175*	*	*
-	Cut and cover type 1	*m*	*557*	*	*
-	Cut and cover type 2	*m*	2,940	*	*
2	**Shield tunnel**	m	3,043	*	*
3	**Special bridge**			*	*
-	*NH5*	*m*	80	*	*
-	*Thiep flyover*	*m*	60	*	*
-	*RR3 and NR*	*m*	160	*	*
-	*NH18 flyover*	*m*	82	*	*
4	**Viaduct**	m	*10,633*	*	*
5	**Grade**	m	*260*	*	*
6	**Station Structural**			*	*
-	Grade station (1 station, 2 floors)	m^2	3,290	*	*
-	Underground station (3 station, 2 floors)	m^2	32,667	*	*
-	Elevated station (7 stations, 2 floors)	m^2	47,758	*	*
II	**Depot**	m^2	250,000	*	*
III	**Other**	%	5	*	*
B	**EQUIPMENT COST**			*	*
I	**Main line**			*	*
1	**Station equipment**			*	*
-	Grade station	psc	1	*	*
-	Underground station	psc	3	*	*
-	Elevated station	psc	7	*	*
2	**Rolling stock**			*	*
-	Trains	car	60	*	*
3	**Track works**			*	*
-	Main line including depot access	m	20,850	*	*
-	Depot	m	15,870	*	*
4	**OCC**	**psc**	**11**	*	*
5	**Signaling system**	**Km**	**41.700**	*	*
6	**Telecommunications system**	**Km**	**41.700**	*	*
7	**Power system and distribution**	**Km**	**41.700**	*	*
8	**Overhead Catenary System (OCS)**	**Km**	**57.570**	*	*
9	**AFC system**	**psc**	**11**	*	*
10	**Platform Screen Doors**	**psc**	**11**	*	*
11	**Supervisory Control and Data Acquisition (SCADA)**	**psc**	**11**	*	*
12	**Connecting supplying Electricity of EVN Ha Noi (Including civil/equip. costs of Transmission Electricity Line 22KV)**	**Km**	**20.85**	*	*
13	**System user training, Operation training**	**psc**	**11**	*	*
14	**Maintenance fee (5 years)**	**%**	**5**	*	*
15	**Safety Certification**	**%**	**0.5**	*	*
II	**Depot**	LS	**1**	*	*
III	**Other**	%	5	*	*
C	**POWER RELOCATION COST**	Provisional		*	*
D	**LAND ACQUISITION COST**			*	*
	CONSTRUCTION + EQUIPMENT COST			*	*
E	**VAT**	%	10	*	*
	CONSTRUCTION + EQUIPMENT COST (AFTER-TAX)			*	*

Note *: Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

12.1.2 Total Investment Cost of Option 1

a) ODA scheme

Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

b) PPP scheme

Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

12.2 Option 2: Bridge for Red River Crossing

12.2.1 Construction and equipment cost of Option 2

The estimated quantities of the line 2.3 for Option 2 (Bridge) as part of the direct construction and equipment cost estimation is shown in the following table, Table 12-2.

Table 12-2. Construction and Equipment Cost Option 2

No	Items	Unit	Quantity	Cost (mil. VND)	Cost (mil. JPY)
A	**CONSTRUCTION COST**			*	*
I	**Main line**			*	*
1	**Cut and cover, U shape Retaining wall**			*	*
-	U shape retaining wall	*m*	*550*	*	*
-	Cut and cover type 2	*m*	2,940	*	*
2	**Special bridge**			*	*
-	*Red River bridge*	*m*	1,160	*	*
-	*NH5*	*m*	80	*	*
-	*Thiep flyover*	*m*	60	*	*
-	*RR3 and NR*	*m*	160	*	*
-	*NH18 flyover*	*m*	82	*	*
3	**Viaduct**	m	*13,828*	*	*
4	**Station Structural**			*	*
-	Underground station (3 stations, 2 floors)	m^2	32,667	*	*
-	Elevated station (9 stations, 2 floors)	m^2	61,404	*	*
II	**Depot**	m^2	250,000	*	*
III	**Other**	%	5	*	*
B	**EQUIPMENT COST**			*	*
I	**Main line**			*	*
1	**Station equipment**			*	*
-	Elevated station	psc	9	*	*
-	Underground station	psc	3	*	*
2	**Rolling stock**	**car**	60	*	*
-	Trains	car	60	*	*
3	**Track works**			*	*
-	Main line including depot access	m	20,840	*	*
-	Depot	m	15,870	*	*
4	**OCC**	**psc**	**12**	*	*
5	**Signaling system**	**Km**	**41.680**	*	*
6	**Telecommunications system**	**Km**	**41.680**	*	*
7	**Power system and distribution**	**Km**	**41.680**	*	*
8	**Overhead Catenary System (OCS)**	**Km**	**57.550**	*	*
9	**AFC system**	**psc**	**12**	*	*
10	**Platform Screen Doors**	**psc**	**12**	*	*
11	**Supervisory Control and Data Acquisition (SCADA)**	**psc**	**12**	*	*
12	**Connecting supplying Electricity of EVN Ha Noi (Including civil/equip. costs of Transmission Electricity Line 22KV)**	**Km**	**20.84**	*	*
13	**System user training, Operation training**	**psc**	**12**	*	*
14	**Maintenance fee (5 years)**	**%**	**5**	*	*
15	**Safety Certification**	**%**	**0.5**	*	*
II	**Depot**	LS	**1**	*	*
III	**Other**	%	5	*	*
C	**POWER RELOCATION COST**	Provisional		*	*
D	**LAND ACQUISITION COST**			*	*
	CONSTRUCTION + EQUIPMENT COST			*	*
E	**VAT**	%	10	*	*
	CONSTRUCTION + EQUIPMENT COST (AFTER-TAX)			*	*

Note *: Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

12.2.2 Total Investment Cost of Option 2

Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

a) PPP scheme

Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure.

13. TOD plan

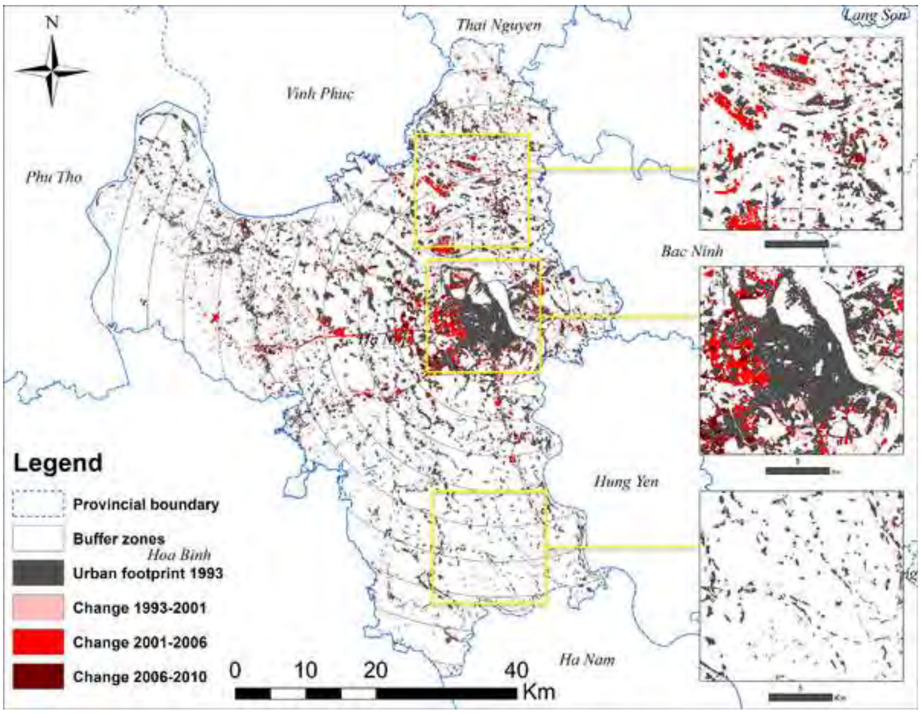
13.1 General

13.1.1 Overview

Uncontrolled Diffusion of Urban Development of Hanoi

The current urban development pattern of Hanoi is multiple linear diffusion of urban expansion along the major road corridors with spontaneous leapfrog patches in all directions. The situation is well depicted in Figure **13-1**. The overall diffusion pattern is attributed to enhanced mobilities by automobiles and motorbikes. For railway projects, diffusion of urban development means more spatial coverage to collect sufficient passenger base. With the current unabated urban diffusion to continue, the longer the government waits, the more difficult it gets to introduce railways. However, given the worsening urban environment of traffic and air pollutions, the city will come to a breakpoint one day if the current expansion continues.

The railway network development will have an impact of reverting or halting the diffusion patterns of urban development as the attractions of station areas present unique social and economic advantages if initiated soon enough. The Line 2.3 corridor presents unique and vast TOD development potentials.



Source: Nong DH, Lepczyk CA, Miura T, Fox JM (2018) Quantifying urban growth patterns in Hanoi using landscape expansion modes and time series spatial metrics. PLOS ONE 13(5): e0196940. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0196940

Figure 13-1. Historic Urban Development Pattern of Hanoi

Line 2.3 Opportunities of Green Field TOD

One prominent feature of the Hanoi Metro Line2 Phase 3 Project is that the railway corridor is virtually undeveloped, largely consisting of agricultural production areas and sparsely occupied by villages. It is a typical “greenfield development.” A greenfield development opens up a whole array of new economic development opportunities; however, at the same time, it requires the synchronization of urban development and railway development. Only timely coordination of railway and urban development brings out the best aspects of both. Given the nature of public transit and its purpose of alleviating traffic congestion and environmental alleviation, normally the public transit fares are kept low to encourage the modal shifts from automobiles. Such a transport policy implies that railway projects cannot expect substantive financial benefits. At the same time, traditionally, the railway businesses have failed to capture land value increases to the station vicinities except for the cases of the Japanese suburban private railway companies or Hong Kong SAR’s metro. The successful model indicates that greenfield development can offer the transfer of land value increases to cover the costs of railway development if property development is carried out to maximize the values. The objective of the urban part of this study is to quantify the potential values of land value increases and also the physical spatial requirements for land value capture.

13.1.2 Objectives of TOD

The main objectives of TOD are as follows:

1） Maximize Land Value Capture (LVC)
=>Recover the investment cost for railways

2） Maximize the ridership
=>Make railway business profitable

There is a strong linkage between public transit and urban development. In TOD, the mixed land uses are encouraged as much as possible. Mix land uses creates more business opportunities. It means the stations will not only send out commuters but will attract workers in the commuting peak hours. Thus mix land uses will create bi-directional traffics which improves the operation efficiency of trains. High human densities enabled by TOD principles will generate more traffic. The railway operation has to provide more frequent services to handle larger traffics. More frequent services increase convenience by affording less travel time and, more importantly allowing less waiting time. With more human traffics and better access, the value of locations near stations increases. The land value and traffics will grow concurrently. Improved attractiveness of the TOD area will attract more business investments that are sensitive to travel time. The more investments will increase the value of the land in the TOD area even further. Thus a virtuous cycle will set in its full motion.

Figure 13-2 Virtuous Cycle of TOD

13.1.3 FAR Control in Urban Planning

Most cities have a control mechanism of local population distribution and densities to balance the infrastructure capacities with the local demand, particularly road capacities. One typical restriction tool is the floor to area ratio (FAR) control. The higher the buildings, there will be more people and corresponding traffics; the relaxation of FAR restrictions could cause a severe bottleneck of infrastructure and road capacities in the area in question. However, TOD has the advantage of bestowing a higher absorptive capacity of traffics due to a higher mobility capacity of the railway compared to automobiles. People staying close to stations will be likely to use railways than automobiles. In other words, it is possible and desirable to allow higher FARs for the areas closer to stations.

Value of Land: Among countless factors that determine the land value, the FAR restrictions directly affect the value of the land. While the city managers are concerned with the adequacy of infrastructure capacities, the primary concern of the developer is how to maximize the sellable floor areas, and FAR determines the floor area size on a given size of land.

In allocating FARs to identified TOD areas, the following principles are applied:

i) Very high to low from the center to the outer areas to concentrate more population near the station,

ii) Achieve the overall population in the TOD/LVC area close to 200,000 with residential and employment population combined,

iii) Maintain the sustainability of infrastructures:

The biggest concern with a high concentration of people is a transport facility. In TOD, we should aim at 60-90% of the population using railways. Nevertheless, there will be an automobile and motorbike traffics to be generated and attracted to new TOD urban areas. The proposed design of small TOD urban blocks will have a high density of road with km/km2 ratio and the road area will comprise approximately 30% of the total areas. The maximum FAR is set at 900%, except for 2500% for the Sky Gate City; 900% is the limitation of FAR in the area near Tokyo Station.

13.1.4 Definition of TOD and LVC Areas

Definition of TOD Area: A standard radius of commuting distance from a station is set at 1 km, though a bit longer radius will be expected in the case of larger urban areas with some feeder transit services. A larger area is adopted for N4 Station TOD.

Definition of LVC Area: LVC areas open spaces that offer potential opportunities for the project implementation entity, public or private may be acquired for direct or indirect development, in conjunction with the railway development to channel land value increases, so that they will be able to finance the construction cost of the entire project.

Naturally, TOD areas are more expansive encompassing LVC areas within.

13.1.5 Study Flow

1. Analysis of existing urban land use plans and investment trends.
2. Determination of station locations.
3. Identification of LVC areas for land value captures.
4. The quantification of floor areas to be created by LVC and non-LVC areas within TOD areas.
5. Estimation of population and employment in TOD areas.
6. Estimation of land value for the floor areas created by LVC.
7. Investment needs for infrastructure development.

13.1.6 Principle of Transit-Oriented Development

The JICA Study Team has developed a set of TOD Guidelines mainly designed for greenfield development in North Hanoi. For details, please refer to Appendix 2 TOD Guidelines. Principally, those who can walk to the station will take trains. Unless ridership is maximized, neither railway or land value capture by TOD will succeed. Some key concepts are excerpted below.

1) Compact City Principle

TOD areas to be developed for the Line 2 Phase 3 must be structured strategically so that the residents and workers will not resort to their vehicles or motorcycles in daily commuting. Given ever-increasing traffic congestion and air pollution in the city of Hanoi, the government has decided to convert the city to a more public transit based society. According to General Construction Plan, the share of public passenger transport will account for 35% of the total travel demand by 2020 and 55%

by 2030. One specific solution for TOD is a compact city principle. The compact city is a notion in urban design to create a mix of land uses required for daily needs within short walking distances. The means of the mobility of compact cities are walking in their neighborhood areas and trains for inter-district travels. It aims at reversion from automobile-centric urban design to more traditional urban designs that are exemplified in the old city centers of Hanoi, Manhattan, New York or the downtown areas of Tokyo. It also improves the ecological soundness of the city by minimizing energy consumptions. Proposed drastic modal share shits to public transport will only take place if the TOD urban designs make people naturally choose to walk to the stations and use the railway for daily transport.

2） Mixed Land Uses

It has been long since urban planning professionals started promoting mix land uses. Strict separation of land uses lengthens the distances between residence and workplaces or between activities. Mix land use will allow a whole range of urban services within walking distance from residences as shown in Figure **13-3** such as shopping, dining and exercising. It will reduce dependence on automobiles and motorcycles, and encourage the use of trains. It is noted that the residents of Manhattan, NY can complete most of the activities within five minutes of walk. The city is the least automobile reliant place in the US. The car ownership in Manhattan is only 22% of households.

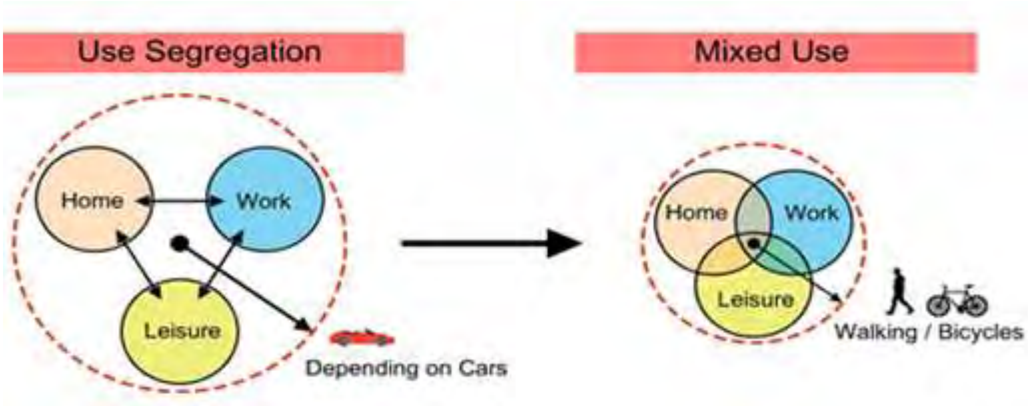
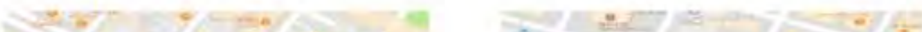


Figure 13-3. Land Use Segregation and Mixed Use

3） Guidelines on Urban Design

The size and design of urban blocks define the characteristics of the urban area and particularly the walkability of the area. For most of conventional TOD projects, an optimal size of urban block is not yet fully investigated. Figure **13-4** shows the block patterns of Manhattan and Portland in the US. Both are reputed as transit oriented cities. Interestingly both cities had adopted small blocks. In Portland's 60-meter blocks, the area is just large enough to allow for one or two large buildings. Most of the streets in Manhattan or Portland are one-way streets. Smaller blocks will create more streets. Thus street crossing becomes more frequent in reaching a destination. At the same time, street widths are

Manhattan, New York Thành phố Portland Oregon



narrower and easier to cross. Therefore overall walking experience in these cities is positive. These two cases of American cities give strong justifications for adopting small sizes of urban blocks.

Figure 13-4. Samples of Small Block Size Plan

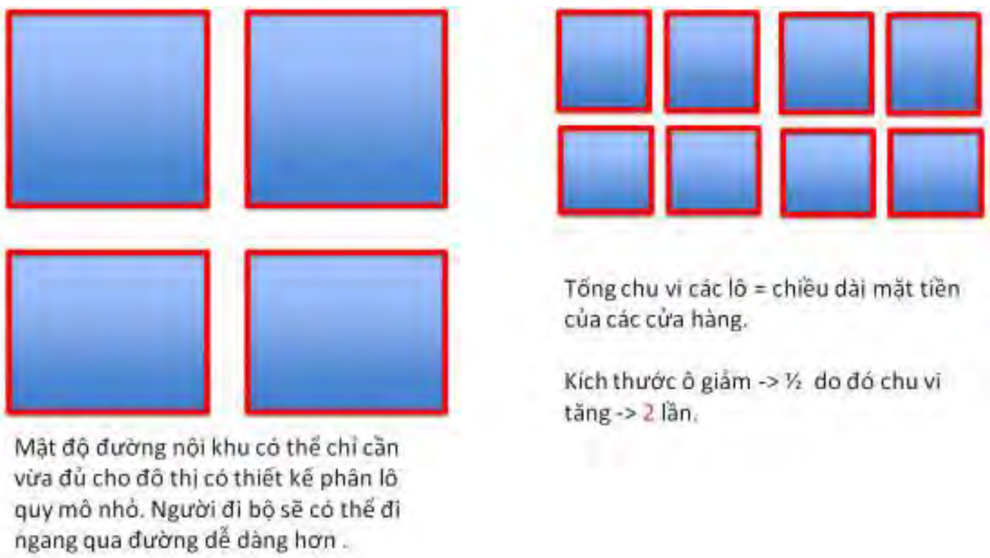


Figure 13-5. Efficiency of Small Block Size Plan

Once superblocks become predominant urban patterns, the use of automobiles and bikes becomes indispensable, as even neighborhood errands would require long-distance travel. Appendix 2 gives a further theoretical justification of urban blocks.

4) Internal Road Specification – Narrow Roads

In correspondence to the smallness of urban blocks, the internal roads that also define the walking experiences and the urban characteristics of TOD areas will have the specifications of the minimal width for vehicular traffics with more space for pedestrians to create a walkable environment for the residents and workers as shown in Figure 13-6. The narrowness will not impede vehicular traffics because the overall urban design of small blocks will increase road densities and total length. A higher road density will allow for one-way traffic regulations, thereby making it safer for the road crossing pedestrians, adding to the walkability of the area.

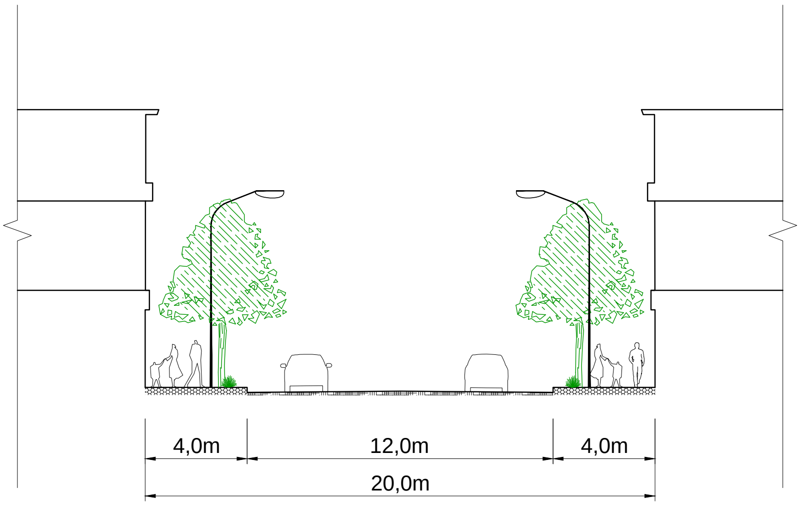


Figure 13-6. Specification of Internal Roads

5) **Bring convenience to the walkers on their daily commuting**

The walkability of a city is defined by street and block designs alone but the walking experience itself from residential neighborhoods to stations. The design guidelines are as follows:

- Enhance the pedestrian friendliness of station access routes by linking various commercial, hospitalities, greens, benches, fountains, art objects etc;

-Arrange greenery and roof to keep walkers from sunshine and rains.

-Arrange internal road of 12 m wide basically

-Internal roads may be curved to slow the speed of traffic.

-Arrange parking space for motorbikes at least valuable but station accessible areas and no parking allowed on the pedestrian way.

Figure 13-7. Keeping Pedestrians from Sunlight and Rains

6) Green Boulevard Design

To enhance walkability and the overall land value of the TOD areas, the JICA Study Team will propose some district-wide features that enhance both the walkability and economic values of the TOD areas in a collective manner. The JICA Study Team proposes the implementation of a network of green corridors with a wider span to accommodate a central green pedestrian way as shown in Figure 13-8. The main aim of the Green Corridors is to provide park-like green environment for pedestrians covering expansive residential communities and workplaces. The corridor will also provide space for installing LRT or BRT tracks to provide local transport access to the station to capture more substantial ridership in the future.

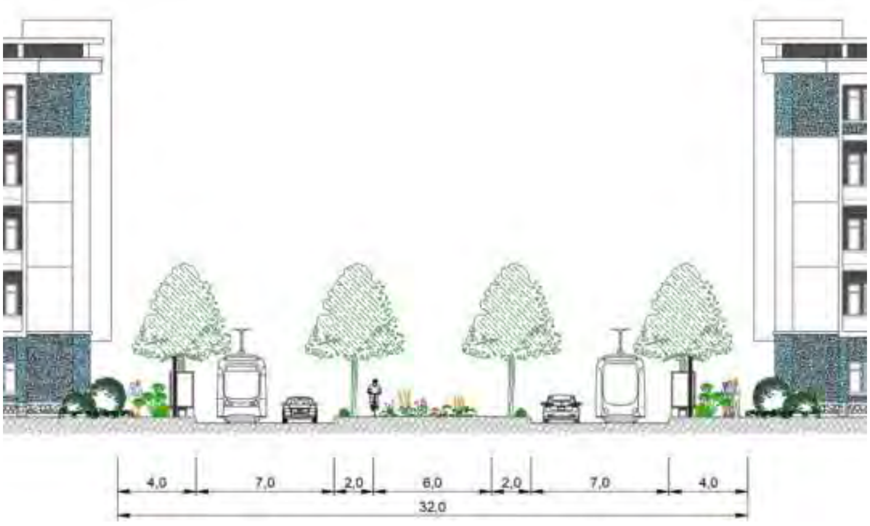


Figure 13-8. Sectional Design of Green Boulevard

13.2 LVC/TOD Target Areas Around Stations

The areas for the potential LVC/TOD areas were identified according to the following criteria:

1. To maximize the contiguous areas extending from each station.
2. To avoid the existing built-up areas, especially communes.
3. To avoid the areas where specific investors have acquired licenses for development except for a minimum plot required for intermodal transfer and passenger access.
4. To avoid surface water areas.
5. To avoid school areas designated by the land use plans.

13.2.1 Investment Trend in North Hanoi

The next Table 13-1 shows the investment-licensed areas along the Line2-Phase 3 corridor. A large section of land is allocated for software parks, college, medical complexes, commercial malls, housing schemes etc.. The licensed areas are concentrated on the eastern side of the Vo Nguyen Giap Road.

Table 13-1. List of projects licensed in North Hanoi

No.	Project	Population	Area (ha)	Note
1	Hanoi industrial vocational training school		10	
2	Software park by Sun Group	20,000	70	
3	Chi Hospital		10	
4	Commercial complex by Vingroup		7	
5	Social housing by JV of Hanoi Construction Corp. and Hoàng Thành	11,000	39.5	
6	Medical complex by TH Group		44	Decision No.3848
7	Social housing by JV of Vigracera and Vinalines	12,500	39	
8	Kim Quy Park by Sungroup		100	Decision No.6374/QD-UBND 21/11/2016
9	Smart City	8,543	271.4	
10	New urban area by Sungroup		421	
Total		52,043	1,012	

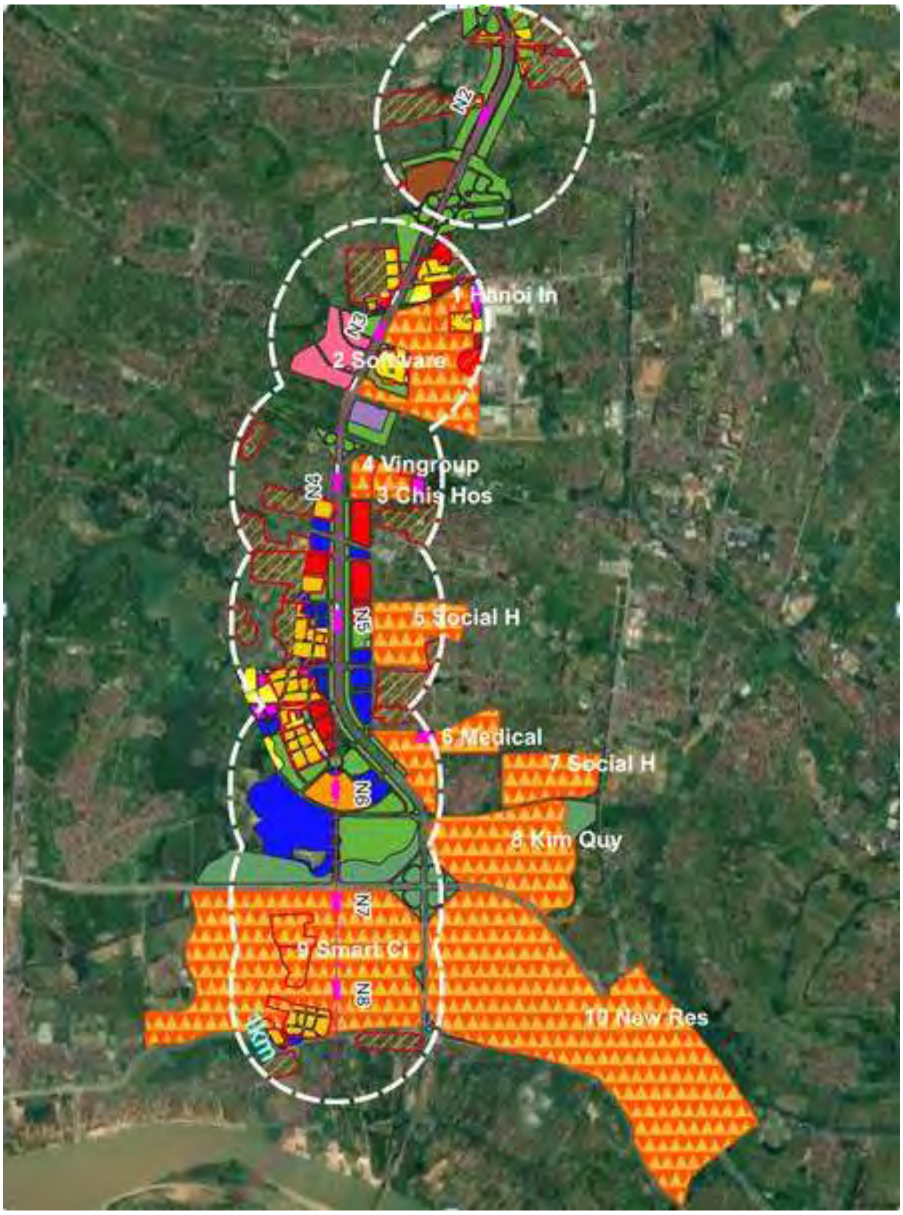


Figure 13-9. Projects Licensed in North Hanoi

Table 13-1 and Figure 13-9 provide information about the projects licensed in North Hanoi. By now, a total area of 1,012 ha has been granted to the investors.

13.2.2 LVC Target Areas Around Stations

In Figure **13-10**, the purple areas are the designated LVC/TOD areas within a 1-km radius in principle. A total area of 294 ha is identified for LVC/TOD.

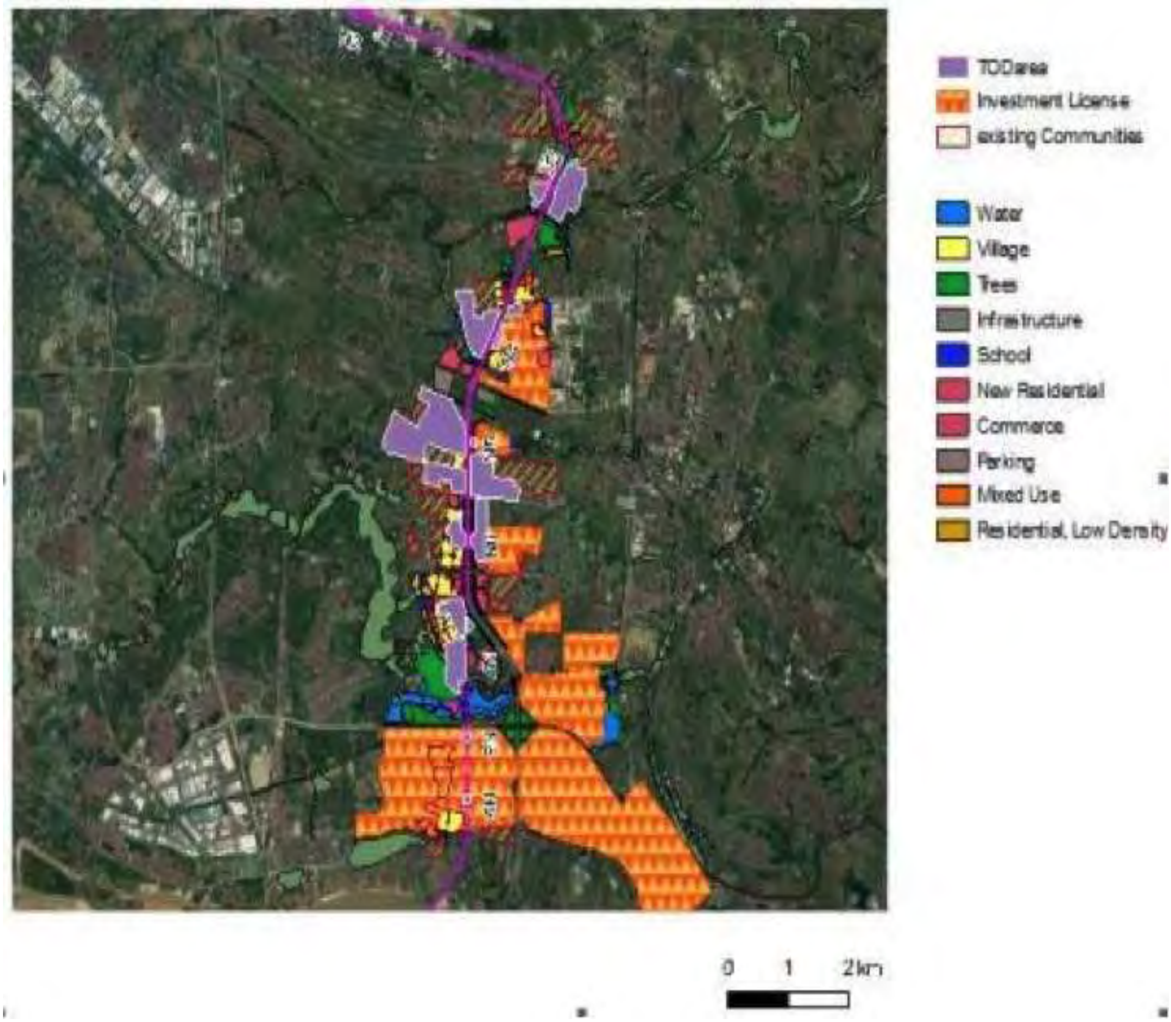


Figure 13-10. LVC/TOD areas in North Hanoi

The areas of potential LVC areas by station are tabulated as shown in **Table 13-2**. A total area of 294 ha is identified. There are twice more areas in the west than in the east. The main reason behind this skewed proportion is due to the investment licensing situation as described above. Once the railway is developed; however, the west side location has advantages over the east in its transport accessibility. The railway alignment will be located on the western side of the Vo Nguyen Giap Road. This means that the passengers entering stations from the west side will travel at least 100 meter less than those coming from the east side who must cross the 8-10 lanes of the road that span 80m in width.

Table 13-2. LVC Area Estimated at Each Station

Unit: ha

STATION	WEST	EAST	TOTAL
N2	1	4	5
N3	62	6	68
N4	96	30	126
N5	10	21	30
N6	32	29	62
N7	0.3	0	1
N8	0.5	0	1
N9	0.8	0.8	2
TOTAL	203	91	294

Source: The JICA Study Team

13.2.3 Regional Vision of North Hanoi

Figure **13-11** shows a vision of the area with each station representing urban functions to be developed in the area. The vision is largely in concurrence with the Revised Detail Plan already approved. The area will provide two core business districts both of which are located at the transport junctions, present Highway No.5 and future Ring Road 3 to the Vo Nguyen Giap Road.

After the airport, the first station serves extensively stretching communities on both sides of the alignment. The second station area would be "Campus Station" to provide access to investment licensed software parks and technical colleges. The entire area would be a full of young and aspiring engineers and entrepreneurs. Then, the next area would the CBD with access to Ring Road 3, the planned investments are medical complex and business/commerce areas. Down to the south, there is a wet area where the land use zoning is designated as amusement and recreational zone. Already there is an investment plan to open an amusement park by connecting abundant ponds and rivers. Passing over the Highway No.5 is an area under development, "Smart City." There will be two stations of N7 and N8 to serve this new CBD. Across the Red River, there will be N9 Station in the northern part of Ciputra development areas with the bridge crossing option.

Figure 13-11. Future Functional Vision of North Hanoi

13.2.4 LVC Area Plans

For each station, LVC block plans are laid out as indicated in

Figure **13-12** through Figure **13-20** below. The blocks are designed according to TOD guidelines as outlined in Appendix 2. Some of the land uses designated by the land use plans are replaced with mixed-use high densities. The plans are laid out for the purposes of enhancing the economic benefits of land value capture for Line 2 Phase 3.

(1) Station N2 area

In this area, there are villages with an area of 150 ha on both sides of the Vo Nguyen Giap Road with an estimated population of 12,000. The main motive of establishing a station here is to provide access to these inhabitants. The LVC area will provide connectivity to these existing villages by breaking off the green buffers planned in the Revised Detail Plan. Given the proximity to the Noi Bai International Airport, the area will be restricted to a 45m-height restriction. Therefore the LVC area will have a maximum FAR of 400%, or else the height limitation may additionally apply. The zoning plan set the long chain of the green areas in an east-west direction; therefore, the conversion of green or agricultural land uses to LVC is restricted to a minimum level just in front of the stations.

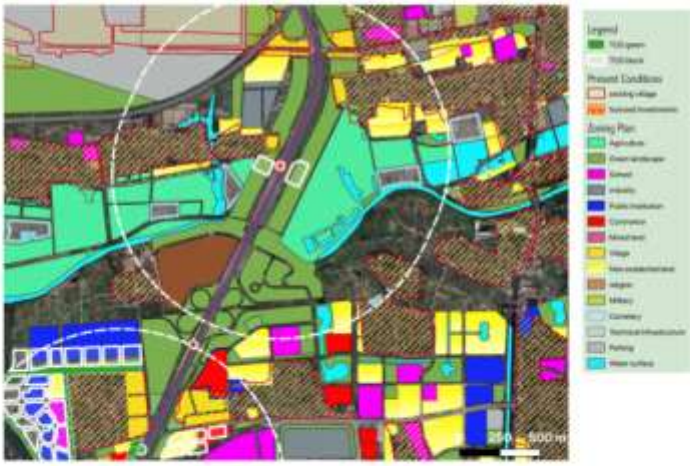


Figure 13-12. LVC Plan at Station N2

(2) Station N3 area

In the eastern side, the N3 Station will not have much space for LVC, because the planned software park and technical colleges occupy all the open space. On the western side, the existing communities cap the northern expansion and the lakes surround the south-west quadrant. As shown in Figure 13-13 below, the Revised Detail Plan allocates a large mixed-use land in pink color. Instead of reclamation, the incorporation of a water body for recreation and backdrop of higher quality residential and commercial developments appear to be adequate.

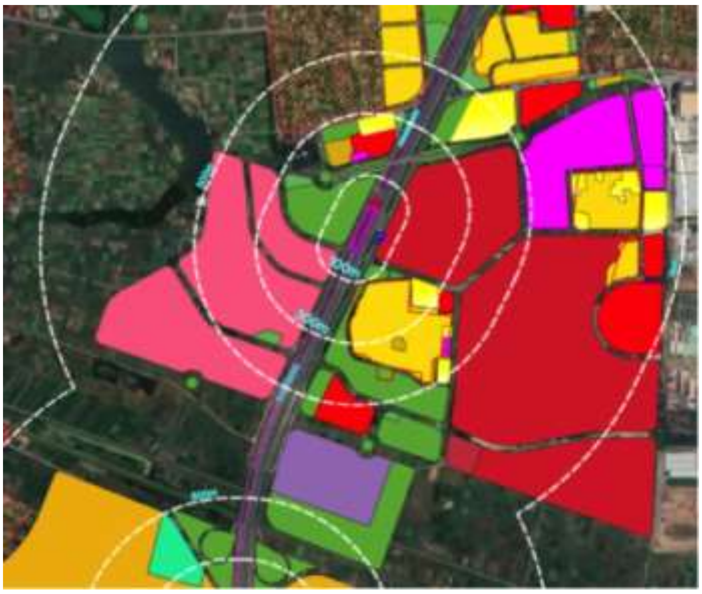


Figure 13-13. Station N3 and Detailed Land Use Plan

The planned software park has an area of 70ha in total. The planned workforce is 20,000. Assuming 20m^2 of workspace per worker and the average FAR of 400%, the building footprint requirements will be 10ha in total. The software park would like a college campus with cultural and leisure facilities in addition to ample green and water space. Still, there will be much space to allow for LVC/TOD addition along the railway and highway corridor as shown in Figure **13-14**. The LVC area will provide easy passenger access for the workers of the software park as well as fulfilling their shopping and dining needs. Some arrangement should be made to capture the value to recover the costs of railway station development.

Figure 13-14. LVC Plan at Station N3

(3) N4 Station Area

This area offers the most abundant LVC space with open spaces on both sides. In the future, there will be Ring Road 3 in the north with an interchange to the Vo Nguyen Giap Road. Due to its strategic importance as a transport hub, it is designated as North CBD. As seen in Figure **13-15**, some of the land uses designated by *the Revised Detail (Land Use) Plan* are replaced with mixed uses to maximize the benefits of LVC. The most extensive replacements are done with public institution areas and, secondly new residential areas, followed by green spaces. The green area should be provided outside of the LVC area to the extent possible. Schools are untouched as they may constitute a policy of broad regional education coverage which is beyond the scope of this study.

The north-east corner is given to investors for commercial and medical complex developments. Given the need to provide comfortable passenger access to the east side. There is a narrow strip of public buffer land around the interchange and Ring Road 3. A land bridge type of access area to the shopping complex is set aside. A small plot of this reserve land could offer small business opportunities on the paths between the station and the shopping mall as well as enhancing ridership.

Figure 13-15. LVC Plan at Station N4

(4) N5 Station Area

N5 will have very limited space on either side of the alignment with the existing communities stretching in the north-south direction in the west. There is a large social housing scheme planned in the east. As seen in Figure **13-16**, some of the land uses designated by *the Revised Detail (Land Use) Plan* are replaced by mixed uses to maximize the benefits of LVC. The largest replacements are done with commercial areas, buffer green space, public institution areas, and patches of new residential areas. All the existing communities are untouched. Public institutional areas in the southeast corner are untouched as a large number of future residents may require a range of public services as well.

Despite the available size, this station offers a unique opportunity to establish station buildings on both sides of alignment, whereas the investors already secure the eastern sides of other stations. Therefore some monumental buildings, as suggested in the city vision, should be sought for its realization to create a place for tourists (See Appendix 1 Proposal of 'Sky-Gate City' for CBD North).

Figure 13-16. LVC Plan at Station N5

(5) N6 Station Area

The railway alignment departs from the Vo Nguyen Giap Road to enter the Station N6. Thus the station will have access straight from both sides of the railway street. The area offers high values for LVC. The target area is limited by the existing communities in the north-west and the Vo Nguyen Giap Road in the east. The southward extension is circumscribed by a chain of ponds leading from the Van Tri Lake to the east.

The revised Detailed Plan has sketches of domes and indicates the land uses as public land. The proposed LVC areas have replaced largely with these public institution areas, green areas and car parks. The car parks are least compatible from the viewpoint of TOD/LVC. Due to its hydrological conditions, possibly, the *Revised Detail (Land Use) Plan* designated this area as amusement and recreational uses. Though it may be small, the risk of inundation makes the most suitable the temporary uses without permanent populations. Thus the LVC area is confined to a 400m radius. Further hydrological and geological study is required for the extent of the LVC area.

Figure 13-17. LVC Plan at Station N6

(6) N7 and N8 Station Area

The areas around Station N7 and N8 are designated as "Smart City." The investors already secure the entire areas around the stations. It is expected to witness its first construction activities in the year 2020 or so. The only issue is securing a sufficient space for intermodal transfer and passenger access to the stations. The situation is similar to the eastern sides of the Station N3 and N4. In the case of Stations N7 and N8, there should be accessible from both sides of the railway line. Our proposition here is to leave sufficient spaces around the station for constructing station buildings that will not only cross-bridges but also will realize high-density multiple-use station buildings. The secured areas should be concessioned to a prospective investor to at least cover the cost of the station construction.

Figure 13-18. LVC Plan at Station N7

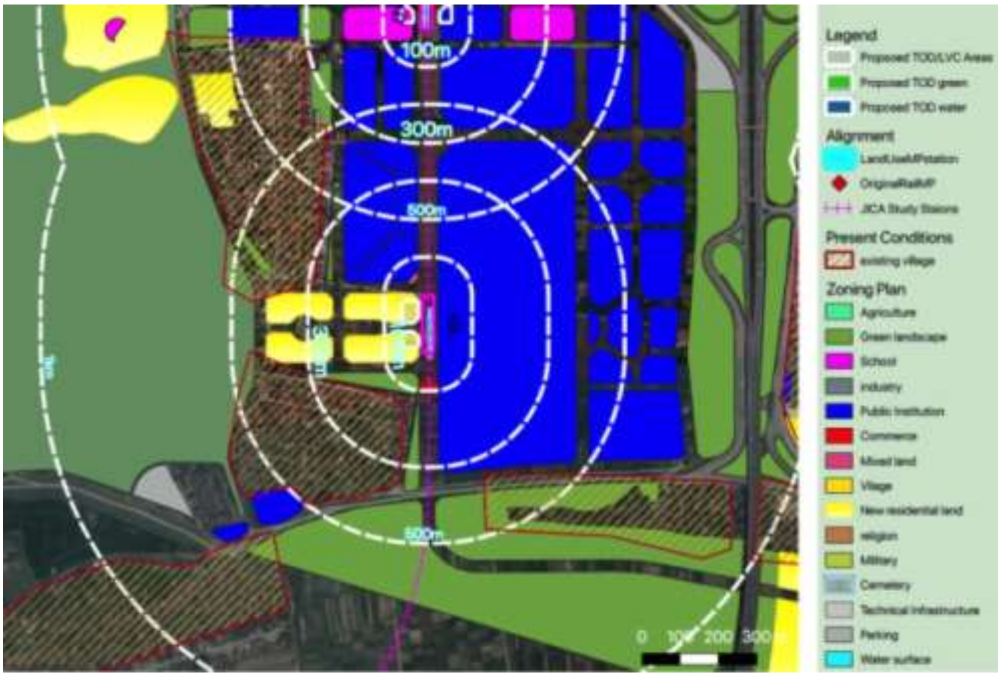


Figure 13-19. LVC Plan at Station N8

(7) N9 Station Area

The N9 Station is located within a designated private property compound of Ciputra. The possibility is similar to the situation for the case in the Stations of N7 and N8. The stations and access areas should be secured for the sake of TOD.

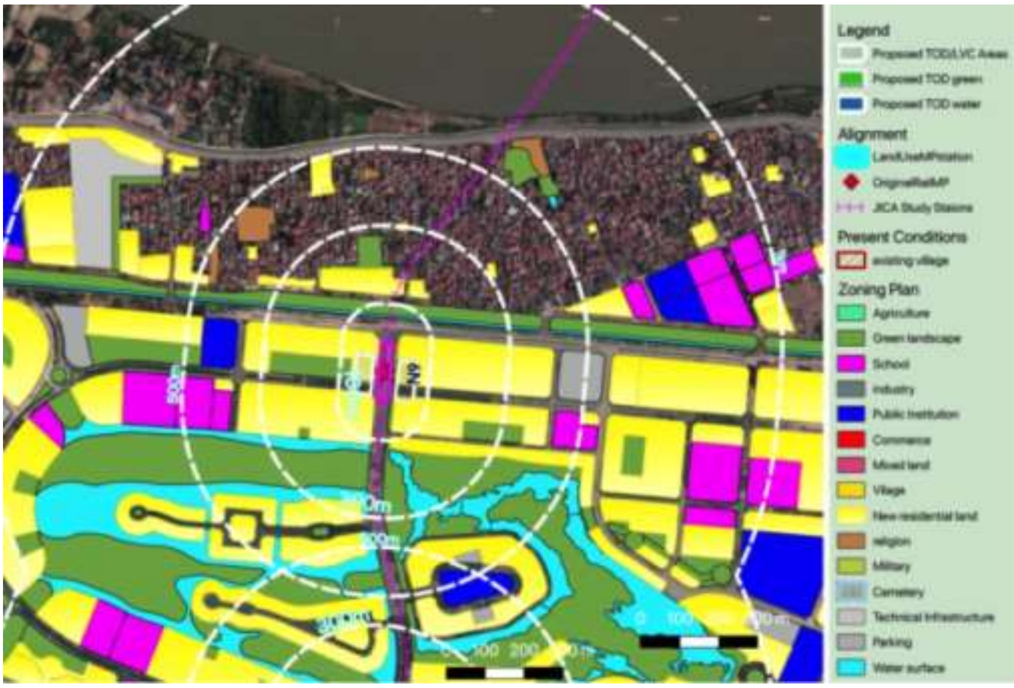


Figure 13-20. LVC Plan at Station N9

13.3 Modifications of Existing Land Use Plans

TOD Approach will necessitate the changes in the current land use plans at around the stations to be more densely populated with mixed land uses. For the success of the railway project and urban development, the changes are inevitable. However, in a broader regional context TOD approach will not affect much broader regional development framework such as population targets defined by Hanoi General Construction Plan. Instead, TOD will shift population in more limited urban development areas around the stations leaving more spaces outside for greenery or public purposes to rebalance the population distributions. Therefore, lower level land use plans, zoning and detailed plans need to be adjusted to accommodate these population redistributions.

Another difference in land uses will be mixed land use principles instead of designating single purpose land uses. Mixed uses create more vibrant economic and social activities of people by day and night throughout weekdays.

Compact high-density urban developments around the stations by the TOD approach will generate both railway traffics and will boost land values while containing urban sprawl and conserving ample green and agricultural areas in the surrounding areas. The development concepts here are more amenable to an urban development approach integrating global climate-conscious, energy efficiency and CO_2 emission reduction with railway ridership promotion.

13.3.1 Station Area Land Use Changes

Table 13-3 shows the impacts brought forth by the proposed TOD plans on the currently approved land use plans in the north Hanoi.

Table 13-3. Transit Oriented Development Plan Effects on Land Use Plan

Unit: ha

Major Land Uses Hạng mục Sử dụng đất	N2			N3			N4			N5			N6			Total		
	Zoning Plan /Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)	Zoning Plan /Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)	Zoning Plan /Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)	Zoning Plan /Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)	Zoning Plan /Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)	Zoning Plan/ Land Use Detailed Plan	JICA TOD Plan	Changes by JICA TOD (%)
Residential/Commercial/Office Khu dân cư / thương mại / văn phòng	78	81	3%	116	117	1%	168	164	-3%	109	120	11%	103	112	9%	575	594	3%
Green/Park Cây Xanh / Công viên	73	73	0%	93	101	9%	42	53	25%	39	36	-8%	104	103	-1%	351	366	4%
Water Surface Mặt Nước	16	16	0%	10	13	24%	2	1	-70%	10	9	-8%	18	18	0%	57	57	0%
Schools Trường học	3	3	0%	5	5	0%	6	6	0%	16	16	0%	6	6	0%	36	36	0%
Cultural/Public Space Không gian văn hóa / công cộng	0	0	0%	21	9	-58%	9	3	-72%	31	26	-17%	20	13	-37%	82	50	-38%
Roads/Bridges/Flyovers Outside of JICA TOD Đường / Cầu / Cầu vượt bên ngoài JICA TOD	66	64	-3%	66	66	1%	29	34	16%	69	67	-3%	65	64	-1%	295	295	0%
Others Khác	114	114	0%	7	7	0%	29	27	-8%	9	9	0%	8	8	0%	167	165	-1%
Total Tổng	351	351	0%	318	318	0%	287	287	0%	284	284	0%	324	324	0%	1,563	1,563	0%

Note: Green areas for JICA TOD includes Green Boulevard's green areas which account for 45% of the total boulevard area.

The N2 to N6 Stations are analyzed since development activities are already in progress in the other station areas, and the TOD plan can only marginally modify their land use plans. The impacts on land use vary from station to station. Overall, the TOD plans impacted on the increase in the development areas in general. However, the overall increase is only 6%. The areas for green space are increased by 1% by cleverly inserting park space in the center of Green Boulevards. The areas for schools are set aside apart. As described in the station planning, the water surface areas in the N3 Station TOD areas will increase while the water surface areas will be reduced in the N4-N5 planned CBD areas. Therefore, the overall balance is unchanged. There is some reduction in public space but the entire areas are small in either plan. Higher density buildings in the JICA TOD plan could provide sufficient floor areas if planned and designed well.

13.3.2 TOD Plan Impact on Existing Land Use Plans

In around the stations, active TOD implementation will necessitate replacing some green and public spaces into urban land uses with high population density. The concentration of human activities implies much fewer development pressures and scope for the preservation of greens in the outside areas of TOD. Figure 13-20 and Figure 13-21 juxtaposes two scenarios. Figure 13-21 shows the land uses stipulated by Zoning Plans. Figure 13-20 shows potential land uses made possible by TOD implementation. The differences in greenery preservation by the TOD plan is noticeable.

In a broader regional context, the target population is set at the same level as the General Master Plan of the city stipulates. At the same time, the TOD will shift the widespread population and employment into restricted areas around the stations, creating synergy and pressure for the creative urban economy.

Figure 13-21. Land Uses by Existing Zoning Plans

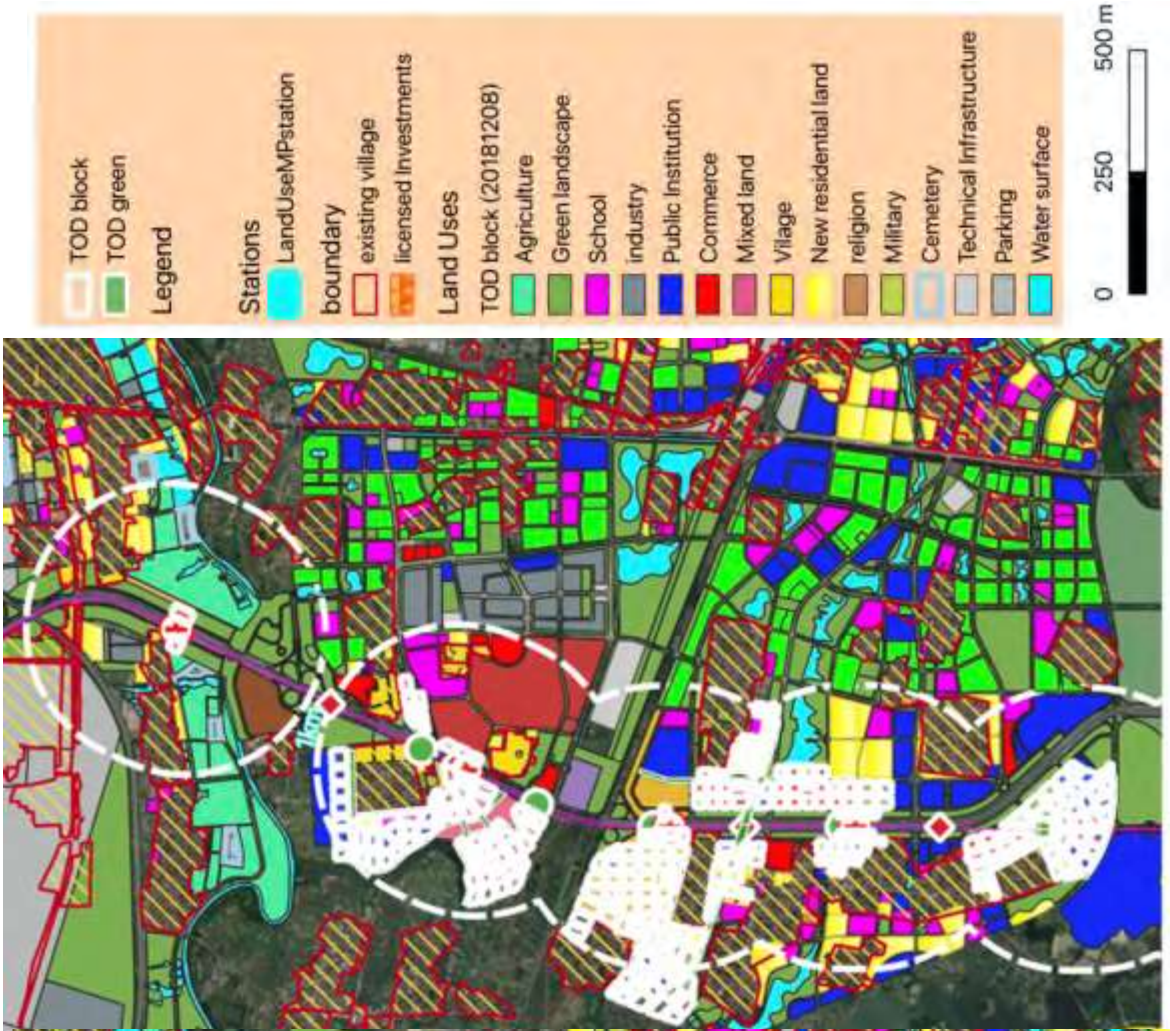


Figure 13-22. Land Uses by Strong TOD Implementation

14. Population Projection of TOD Areas

14.1 Population Framework

According to the Hanoi General Construction Plan, the planned population of Dong Anh urban areas is set at 550 thousand in 2030 with a maximum limit of 670 thousand. Given the planned population of 300 thousand in TOD areas will capture nearlhy half of the planned urban population of Dong Anh District in the future, the compactness of the TOD is likely to reduce the infrastructure investment in terms of per population. The more compact the city is built, the shorter is the required length of utility networks or even roads to reach the destinations. Therefore, the denser urban agglomeration will reduce overall investment and maintenance costs for the required infrastructures.

14.1.1 Objectives in Population Plan

One of the main goals of TOD area planning is to estimate the future population of the target areas so that it is possible to assess the financial benefits of the properties, the development costs of properties as well as infrastructures in the TOD/LVC areas. The most proximate financial revenue projections will be based on the floor areas to be supplied and sold for each type of customers such as residential, commercial and office use as well as other cultural purposes. For any large-scale property development in Vietnam, the investors are required to provide the basic urban infrastructures including roads, drainage, water supply, sewerage and power distribution. The population projections as well as coverage areas will determine the development quantities required for infrastructures.

14.1.2 Methodology

Within TOD areas, there are three types of land categories, 1)LVC areas that are this study, 2) Non-LVC areas which are largely the areas already secured by prospective investors that fall within a radius of 1 km from the station, 3) existing communities within a radius of 1 km from the station.

(1) TOD/LVC Area

In each TOD/LVC area, all the blocks have mixed land uses. Thus, the land itself does not indicate primary use and activities on any block. Instead, floor-area based uses are defined. The methodology for population projection is as follows:

- Urban Block Definition: preliminary road networks and urban grids were imposed on each TOD/LVC area according to TOD Guidelines to extract net developable areas after road development.
- FAR assignment: each block is assigned with FAR.
- Floor Area Calculation: floor area is calculated by block area x FAR.
- Floor Use Calculation: floor uses are defined by a set of simple rules depending on the level of FAR.
- Population and Employment Projection: Unit space requirement per person for use type is applied.

(2) NON-LVC Areas

Non-LVC areas are largely the areas already secured by prospective investors that fall within a radius of 1 km from the station. The areas also include small areas designated by the Zoning Plan but not contiguous to TOD/LVC. Similar to the LVC areas, the population and employment are calculated in the following manner. The only difference is not defining the blocks as the urban designs are to be determined by the investors.

- FAR assignment: each land use section is assigned with FAR.
- Floor Area Calculation: floor area is calculated by block area multiplied by FAR.
- Floor Use Calculation: floor uses are defined by a set of simple rules depending on the level of FAR.
- Population and Employment Projection: Unit space requirement per person for use type is applied.

(3) Existing Communes

Over the satellite imagery, all the existing communities have been identified in the project area. The methodology of the population projection is as follows:

- The boundary of communities within a radius of 1 km from each station is defined.
- The current density of existing communities is analyzed from the total areas of existing communities and population statistics (See Appendix Existing Urbanization in North Hanoi.).
- A population density is assumed for each segregated community.
- The populations of each segment are calculated by applying the assigned population density to the measured areas.

14.2 FAR Assignment for TOD/LVC areas

As seen in Figure 14-1 to Figure 14-8, each urban block of the LVC area is laid out in a hypothetical grid to estimate the net land area for development space. It is vital to concentrate a large number of population as well as employment near the station for TOD principles as described in TOD Guidelines. N2A station is included in the alignment plan, and the planned land use is an agriculture market. There is no detailed investment information as of now, thus it is exempted from TOD/LVC assessment.

14.2.1 N2 Station Area

Given the proximity to the Noi Bai International Airport, the area will be restricted to a 45m height restriction. Therefore, the station area will have limitations in building heights. LVC area will have a maximum FAR of 400%.

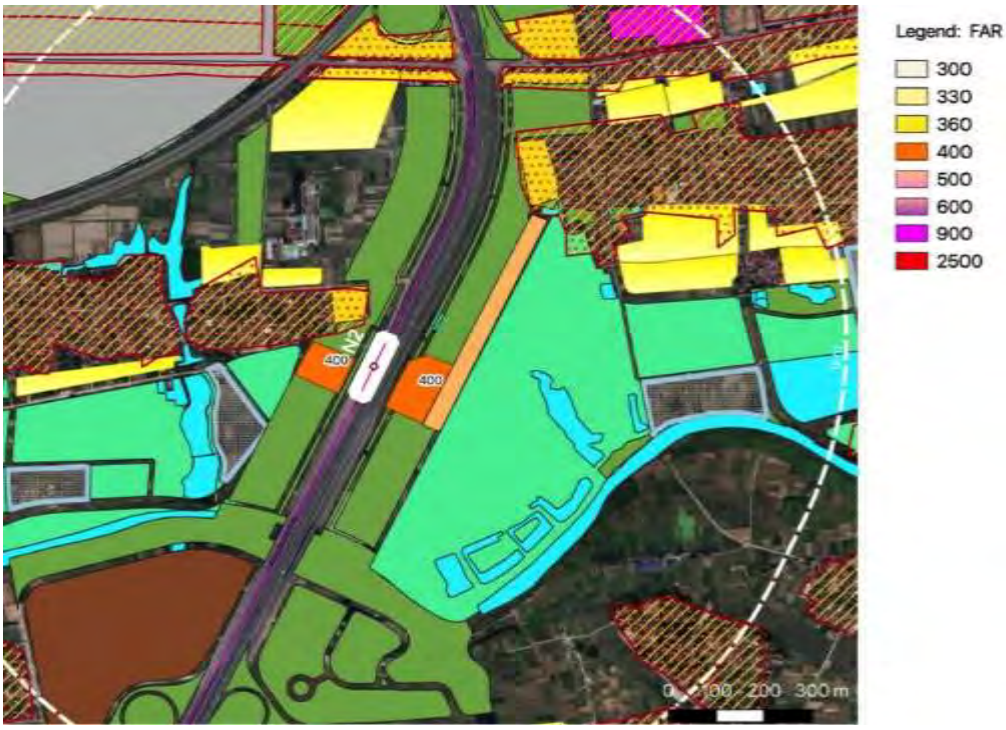


Figure 14-1. TOD/LVC Block and FAR Plan at Station N2

14.2.2 N3 Station Area

The eastern side will be developed as a software park and college, and the western side will be developed for LVC/TOD. The maximum FAR applied to this area is 600%.

Figure 14-2. TOD/LVC Block and FAR Plan at Station N3

14.2.3 N4 Station Area

Due to its strategic importance as a transport hub, it is designated as North CBD. Given the size of the LVC area, the maximum FAR is set at 900%. The FAR will taper down to 300% in the periphery.

Figure 14-3. TOD/LVC Block and FAR Plan at Station N4

14.2.4 N5 Station Area

N5 will have very limited space on either side of the alignment. In the north-south axis, this area will continue to serve as the CBD north of Station N4. This is the only location without any hindrance to acquiring free open space on both sides of the Vo Nguyen Giap Road for the immediate connection to the Station. Thus the two blocks in front of the Station are given the maximum FAR of 2,500% for the development of the proposed Skygate City (See Appendix 1).

Figure 14-4. TOD/LVC Block and FAR Plan at Station N5

14.2.5 N6 Station Area

This station area will offer some potential areas for LVC as the area is not divided by the Vo Nguyen Giap Road. Although there is no fixed investor in this area, the land uses for TOD may be restricted if the government wishes to establish a complex of cultural and recreational functions or in case that hydrological conditions do not permit. The maximum FAR is set at 600% around the station.

Figure 14-5. TOD/LVC Block and FAR Plan at Station N6

14.2.6 N7 and N8 Station Area

By the time when the railway construction starts, this area will be fully developed. At the same time, some areas around the Stations should leave some areas for the construction of large-scale station buildings. Therefore, the FAR is set at 900% at around the Stations.

Figure 14-6. TOD/LVC Block and FAR Plan at Station N7

Figure 14-7. TOD/LVC Block and FAR Plan at Station N8

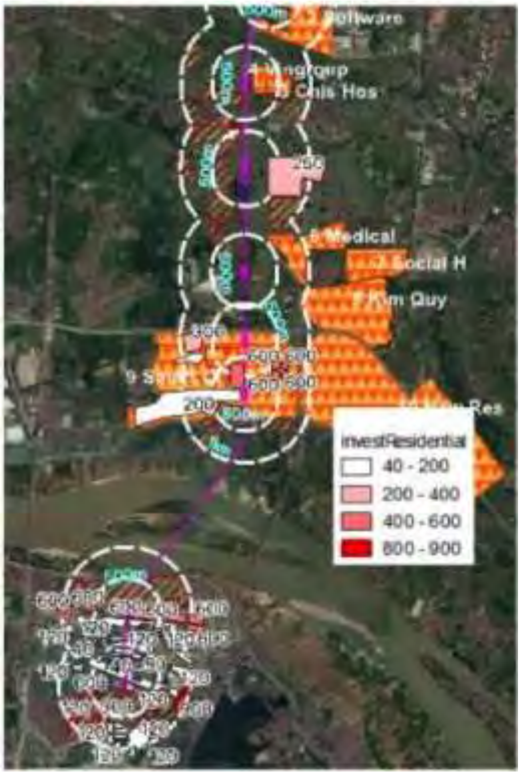
14.2.7 N9 Station Area

As part of Ciputra development, this area is under construction, by the time when the railway construction starts, this area is likely to be fully developed. At the same time, some areas around the Stations should leave some areas for the construction of large-scale station buildings. Therefore the FAR is set at 600% at around the Station.

Figure 14-8. TOD/LVC Block and FAR Plan at Station N9

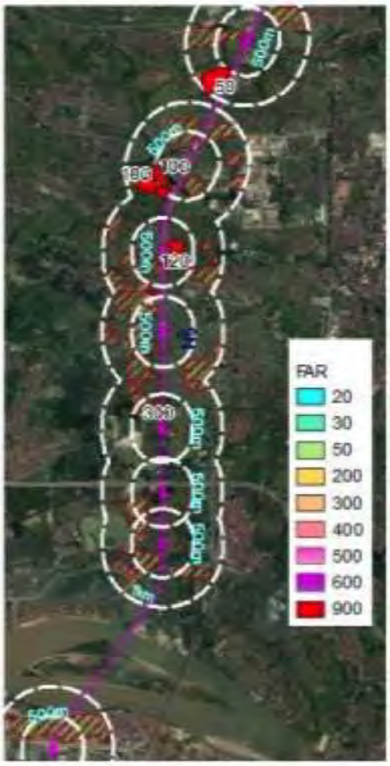
14.3 FAR Assignment for Non-LVC Areas

FAR were also assigned in Non-LVC areas within TOD areas. Most of the areas within a 1km radius on the eastern sides of the stations are secured by investors. The exact plans are yet to be determined. Thus FAR for these areas are set according to some preliminary information as well as observation of the Study Team. For some investment projects, the target residential population or employment sizes are registered. In those cases, the FAR parameters are adjusted to the targets. In other cases, parameters lower than LVC areas are applied. The office areas include software parks, medical complexes, government complexes and financial tower.

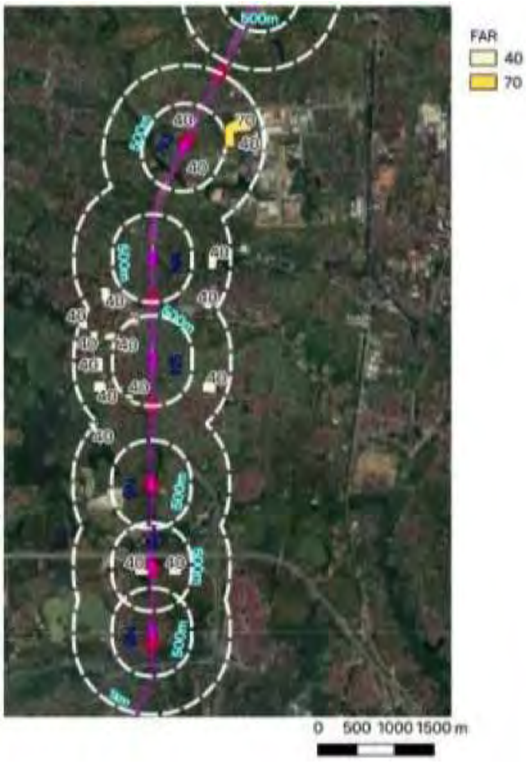


FAR Assignment in Non-LVC Residential Area

FAR Assignment in Non-LVC Office Area



FAR Assignment in Non-LVC Commercial Area



FAR Assignment in Non-LVC School Area

Figure 14-9. FAR Assignment in Non-LVC Land Area

Each urban block of the LVC area was laid out in a hypothetical TOD guideline-based grid to estimate the net land area for development space. The net land areas for the Revised Detailed Plan were estimated by applying coefficients to convert from gross to net land areas[1]. For the existing communes, the gross land areas are adopted as net land areas.

14.4 Net Land Areas and Floor Areas of TOD

14.4.1 LVC net land area

Table 14-1 shows the net land area after subtracting the road areas from the LVC areas.

Table 14-1. Net Land Areas of LVC Areas by FAR Assignment

Unit: ha

	West									East						Total
FAR	N2	N3	N4	N5	N6	N7	N8	N9	Total	N2	N3	N4	N5	N9	Total	
2500	0.00	0.00	0.00	1.42	0.00	0.00	0.00	0.00	1.42	0.00	0.00	0.00	1.58	0.00	1.58	3.00
300	0.00	36.61	19.75	0.77	6.10	0.00	0.00	0.00	63.23	0.00	2.01	2.23	1.22	0.00	5.46	68.69
330	0.00	0.00	5.01	0.00	1.28	0.00	0.00	0.00	6.29	0.00	0.00	0.00	0.00	0.00	0.00	6.29
360	0.00	0.00	0.00	0.00	10.28	0.00	0.00	0.00	10.28	0.00	0.00	4.00	3.02	0.00	7.01	17.29
400	0.93	4.42	10.79	1.51	9.44	0.00	0.00	0.00	27.09	1.35	1.38	2.03	11.72	0.00	16.48	43.57
500	0.00	0.00	7.87	0.00	0.00	0.00	0.00	0.00	7.87	0.00	0.00	0.55	0.00	0.00	0.55	8.42
600	0.00	1.58	3.61	1.01	4.61	0.00	0.00	0.35	11.17	0.00	1.72	0.00	0.00	0.35	2.07	13.24
900	0.00	0.00		1.00	0.00	0.48	0.82	0.00	8.53	0.00	0.00	0.57	2.04	0.00	2.62	11.14
Total	0.93	42.61	53.25	5.71	31.72	0.48	0.82	0.35	135.87	1.35	5.11	9.38	19.58	0.35	35.77	171.64

14.4.2 Non-LVC Land Area

Table 14-2 shows the gross land area for the non-LVC areas.

Table 14-2. Land Areas of Non-LVC Areas by Station

Unit: ha

	West					East					Total
Station	Residence	Office	Commerce	School	Total	Residence	Office	Commerce	School	Total	
N2			7		7			0		0	7
N3		2	16	0	19		66	0	10	75	94
N4		0	0	2	2		13	10	3	26	28
N5		4		11	15	44	14		3	61	75
N6		0	3	1	4		22	0	0	22	26
N7	15	21		3	39		0		0	0	39
N8	58	51			109		0			0	109
N9	59	2			62		0			0	62
Total	132	80	26	18	257	44	114	10	16	184	441

1The net land area is defined as developable land after subtracting road areas.

1） Existing Communities

Table **14-3** shows the gross land areas of the existing communes that are located within the 1 km radius boundary from the station locations.

Table 14-3. Land Areas of Existing Communities by Station

Unit: ha

Station	West	East	Total
N2	25	36	61
N3	31	19	50
N4	34	17	51
N5	63	19	81
N6	14	6	19
N7	11	0	11
N8	35	9	44
N9	59	0	59
Total	345	106	451

14.5 Floor Use Plans in LVC Area

Floor Allocation By Uses in Mixed-Use LVC Areas: As indicated in the TOD Guideline, mixed uses are critical in land use planning for TOD as well as a compact city. In the mixed land uses, the shares of residence, commerce and office uses are assumed according to FAR levels as indicated in the next

Table 14-4; the ratio follows a norm in general distribution. At a higher level of FAR, there will be more allocation of floor areas to office and commerce functions. Office uses will lose its share quickly as the FAR declines, indicating fewer opportunities for office use in residential areas away from stations. This method allows more flexibility in changing the population/employment matrix as the functions of the area may change its emphasis in the future course of planning. The characteristics of the local area are finally determined on a block-basis by the investor. More flexible planning adept at the changes in market dynamics will lead to more favorable economic outcomes.

Table 14-4. Urban Function in Mixed Land Use of Planned LVC Areas

FAR	Residential	Office	Commerce
2500	30%	55%	15%
900	40%	45%	15%
600	50%	40%	10%
500	60%	30%	10%
400	65%	20%	10%
390	70%	20%	10%
360	75%	15%	10%
350	80%	10%	10%
340	85%	8%	7%
330	90%	5%	5%
310	95%	0%	5%
300	100%	0%	0%

14.5.1 LVC floor area

Table 14-5 shows the tabulation results of floor area projections in LVC areas.

Table 14-5. Floor Areas by Type of Use in LVC Areas

Unit. ha

Station	West				East				Floor Space			
	Residen -tial	Office	Commer-cial	Total	Residen -tial	Office	Commer-cial	Total	Residen-tial	Office	Commer-cial	Total
N2	0	1	1	2	2	0	1	2	2	1	2	4
N3	88	5	2	95	95	10	4	15	184	15	6	110
N4	111	39	14	164	164	19	5	26	275	57	19	189
N5	16	19	6	41	41	43	29	82	57	62	34	123
N6	58	18	10	86	86	0	0	0	145	18	10	86
N7	1	1	0	3	3	0	0	0	4	1	0	3
N8	2	2	1	5	5	0	0	0	7	2	1	5
N9	1	1	0	1	1	1	1	1	2	1	1	3
Total	278	86	33	398	73	39	14	126	351	125	48	524

14.5.2 Non-LVC Floor Area

Table 14-6 shows the tabulation results of floor area projections in Non-LVC areas.

Table 14-6. Floor Areas by Type of Use in Non-LVC Areas

Unit: '000 m^2

Station	West				East				Total
	Residen-tial	Office	Commer-cial	Total	Residen-tial	Office	Commer-cial	Total	
N2	250,471	8,696	20,255	279,422	214,955	10,452	35,985	261,392	540,814
N3	882,493	28,152	48,412	959,057	103,401	19,064	30,531	152,996	1,112,054
N4	1,113,059	205,953	332,673	1,651,686	185,314	21,739	52,658	259,711	1,911,397
N5	189,344	103,733	118,917	411,994	458,056	156,818	220,247	835,122	1,247,116
N6	617,742	78,240	178,880	874,863	0	0	0	0	874,863
N7	12,114	7,571	10,599	30,284	0	0	0	0	30,284
N8	20,667	12,917	18,083	51,666	0	0	0	0	51,666
N9	7,436	2,974	4,462	14,872	7,432	2,973	4,459	14,864	29,736
Total	3,085,890	445,261	727,820	4,258,972	961,726	208,073	339,422	1,509,221	5,768,193

14.6 Population Projection

In the preceding sections, LVC areas are identified with designated FAR ratios ranging from 300% to 900%. The population planning for LVC areas is based on the supply of floor areas. After determining the floor areas to be supplied, the areas will be divided by area requirement per person for residence and workplace. In other words, the planned population is derived inversely from the planned floor areas.

14.6.1 Space Requirement Parameter per Resident or Worker

Net Usable Floor Area (Gross-Net Conversion)

Residence: 0.7

Large Scale Shopping: 0.6

Hospital: 0.6

School: 0.7

Others: 0.7

It is assumed that non-usable areas include parking space, walkways, corridors, machine rooms, etc.

Area per Person/Worker Requirement (m^2/person)

Residence: 25

Office: 15

Hospital: 15

School: 30

Shops/Restaurants: 20

Large Scale Shopping Areas: 40

14.6.2 Population and Employment Projection of LVC Areas

Population and employment projection in LVC areas for the target year of 2050 are shown in Table 14-7.

Table 14-7. Population and Employment Projection of LVC Areas (Target Year: 2050)

Station	West				East				Total		
	Resident	Office Worker	Service Worker	Student	Resident	Office Worker	Service Worker	Student	Resident	Workers	Student
N2	0	900	700	0	0	1,300	900	0	0	3,700	0
N3	35,300	3,400	1,000	3,500	4,100	2,400	600	400	39,400	7,400	3,900
N4	44,500	25,700	6,900	4,500	7,400	3,200	1,200	700	51,900	37,000	5,200
N5	6,600	12,700	2,800	700	17,200	19,100	5,100	1,700	23,800	39,600	2,400
N6	24,700	11,400	3,700	2,500	0	0	0	0	24,700	15,000	2,500
N7	500	900	200	0	0	0	0	0	500	1,100	0
N8	800	1,600	400	100	0	0	0	0	800	1,900	100
N9	300	400	100	0	300	400	100	0	0	0	0
Total	112,700	57,000	15,800	11,300	29,000	26,400	7,900	2,800	141,100	105,700	14,100

14.6.3 Population and Employment Projection of NON-LVC Areas

Population and employment projection in Non-LVC areas are shown in Table 14-8.

Table 14-8. Population and Employment Projection of Non-LVC Areas (Target Year: 2050)

Unit: Person

Station	Resident	Worker	Student
N2	0	2,000	0
N3	0	26,000	7,000
N4	0	2,000	3,000
N5	31,000	7,000	7,000
N6	0	6,000	1,000
N7	13,000	26,000	2,000
N8	41,000	96,000	0
N9	53,000	5,000	0
Total	138,000	171,000	20,000

14.6.4 Population Projection of Existing Communes

Population projection in the existing communities within TOD areas is shown in Table 14-9.

Table 14-9. Population Projection in Existing Communities

Unit: Person

	2030		
Station	West	East	Total
N2	2,900	4,100	7,000
N3	3,500	2,200	5,700
N4	3,900	2,000	5,800
N5	7,100	2,100	9,300
N6	1,500	600	2,200
N7	1,600	0	1,600
N8	5,000	1,300	6,300
N9	10,100	0	10,100
Total	35,600	12,300	48,000

15. TOD Urban Development

15.1 Population Trends of Hanoi

The average annual population growth rate of Hanoi City throughout the decade of 1999-2009 was 2.1 percent. As the former Hanoi City Area absorbed the surrounding areas such as the former Ha Tay Province in 2008, the new capital area's population increased to 6.35 million in 2008. The population continued its growth to a total of 6.87 million in 2011, and 7.15 million in 2013.

The population growth between 2009 and 2013 is more rapid at a rate of 2.9 percent annually in the former Hanoi city area, while the growth rate for the expanded area such as the former Ha Tay Province is comparatively low at 1.6 percent annually.

Table 15-1. Current Population Trend of Hanoi (2013-2030)

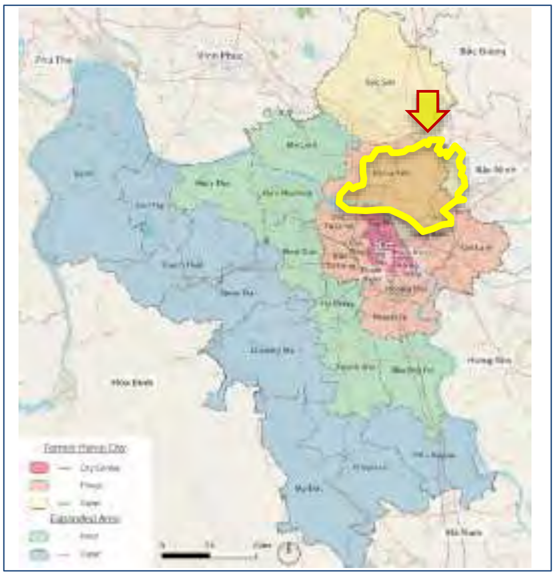
City/Province		Net Land Area	Population (000 Persons)		AGR (2009-13)	Density (2013)
		(000 ha)	2009	2013	(%/Year)	(No./ha)
Hanoi City	Former Hanoi	84.1	3,618	4,063	2.9	48.3
	Expanded Areas	225.1	2,834	3,065	2.0	13.6

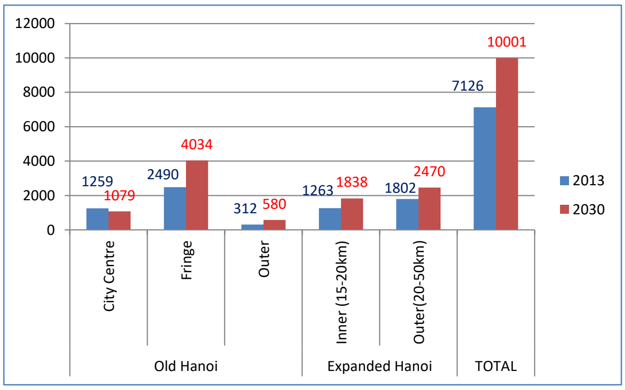
Source: METROS (METI 2015)

15.2 Future Projections for North Hano*i*

15.2.1 Whole Hanoi City

The population trend of Hanoi (2013-2030) is illustrated in Figure 15-1 and Table 15-2.





Source: Map-the JICA Study Team, Graph-METROS (METI 2015)

Figure 15-1. Current Population Trend of Hanoi (2013-2030)

In the City Centre, the current population of 1.26 million people will reduce to 1.08 million in 2030, while the adjacent areas (Fringe, Outer in Old Hanoi, and Expanded Hanoi) will continue rapid demographic increases toward 2030. The population of the whole Hanoi City which is 7.13 million presently is expected to reach approximately 10 million in 2030.

Table 15-2. Population Trend of Hanoi (2013-2030)

Area		2013	2030	Increment
Old Hanoi	City Centre	1259	1079	-14.3%
	Fringe	2490	4034	62.0%
	Outer	312	580	85.9%
Expanded Hanoi	Inner (15-20km)	1263	1838	45.5%
	Outer(20-50km)	1802	2470	37.1%
TOTAL		7126	10001	40.3%

Source: METROS (METI 2015)

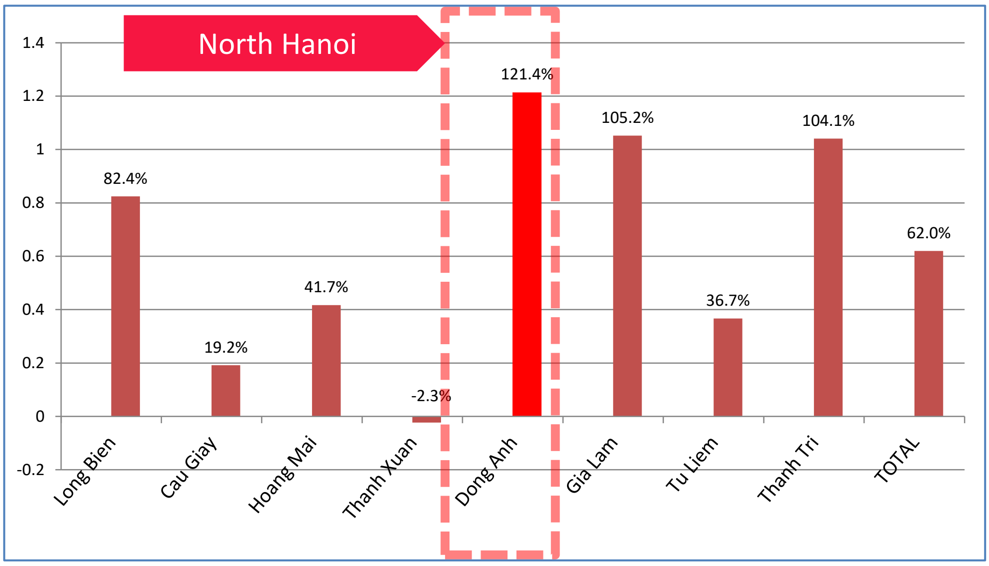
15.2.2 North Hanoi

The Line 2.3 corridor is designated as “ASEAN City” as an international gateway of north Vietnam. Dong Anh District is expected to have 121.4 % growth between 2013 and 2030 which is higher than any other district in the former Hanoi fringe according to Metros. This trend implies high development potential in the North Hanoi.

Table 15-3. Current Population Trend of the Former Hanoi Fringe Districts (2013-2030)

District (Old Hanoi Fringe)	2013	2030	Increment
Long Bien	267	487	82.4%
Cau Giay	250	298	19.2%
Hoang Mai	362	513	41.7%
Thanh Xuan	263	257	-2.3%
Dong Anh	374	828	121.4%
Gia Lam	251	515	105.2%
Tu Liem	504	689	36.7%
Thanh Tri	219	447	104.1%
TOTAL	2490	4034	62.0%

Source: METROS (METI 2015)



Source: The JICA Study Team

Figure 15-2. Current Population Trend of the Former Hanoi Fringe Districts (2013-2030)

15.3 Current Property Market Analysis

15.3.1 Residential Market

(1) Supply and Demand

The residential new supply trend in Hanoi in recent years and the near future is as shown in Table 15-4.

Table 15-4. New Supply in the Residential Market in Hanoi

	2014	2015	2016	2017	*2018*	*2019*	*2020*	*2021*
Grade A	422	358	2,913	5,831	*2,563*	*3,220*	*1,463*	*4,020*
Grade B	2,101	16,630	15,660	14,479	*22,907*	*26,842*	*24,463*	*22,459*
Grade C	2,580	13,582	10,599	8,940	*11,809*	*11,681*	*6,681*	*13,315*

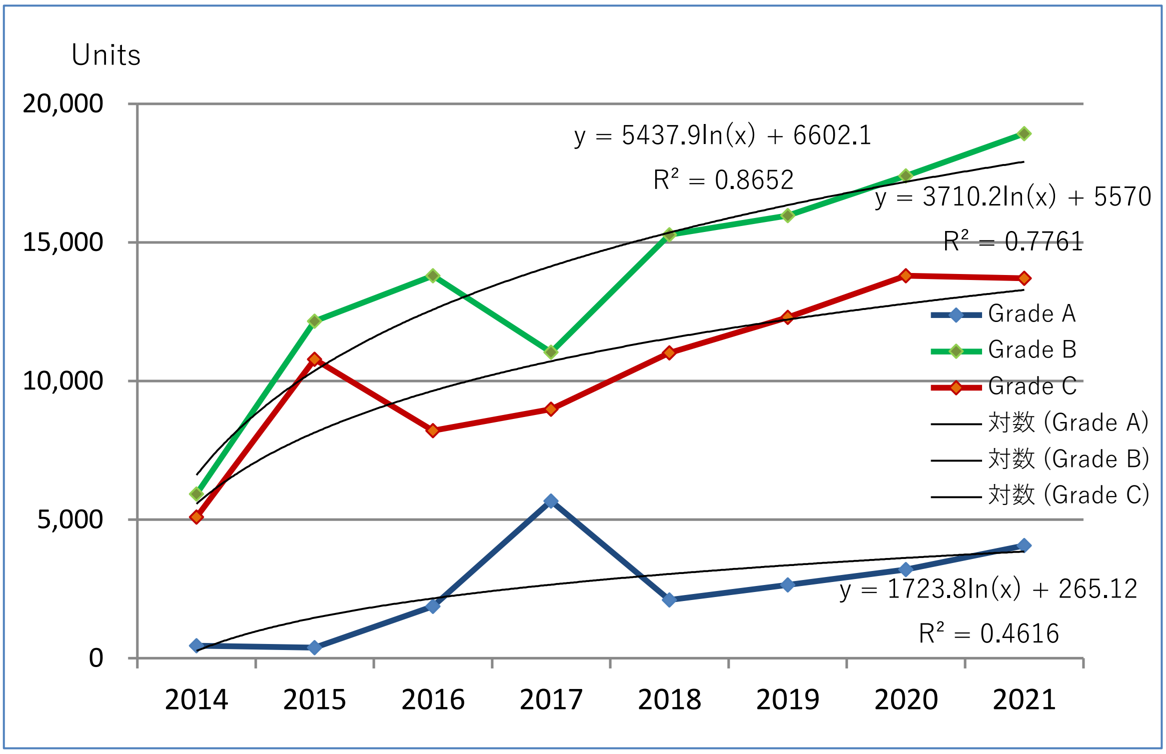
Note: Italics-Predicted Figures
Source: Savills Vietnam

The residential demand (sales) trend in Hanoi in recent years and the near future is as shown in Table 15-5 and Figure 15-3.

Table 15-5. Demand (Sales) in the Residential Market in Hanoi

	2014	2015	2016	2017	*2018*	*2019*	*2020*	*2021*
Grade A	448	380	1,875	5,676	*2,101*	*2,651*	*3,203*	*4,067*
Grade B	5,926	12,157	13,796	11,039	*15,274*	*15,974*	*17,399*	*18,919*
Grade C	5,099	10,790	8,215	8,985	*11,014*	*12,298*	*13,801*	*13,704*

Note: Italics-Predicted Figures
Source: Savills Vietnam



Source: The JICA Study Team

Figure 15-3. Demand (Sales) in the Residential Market in Hanoi

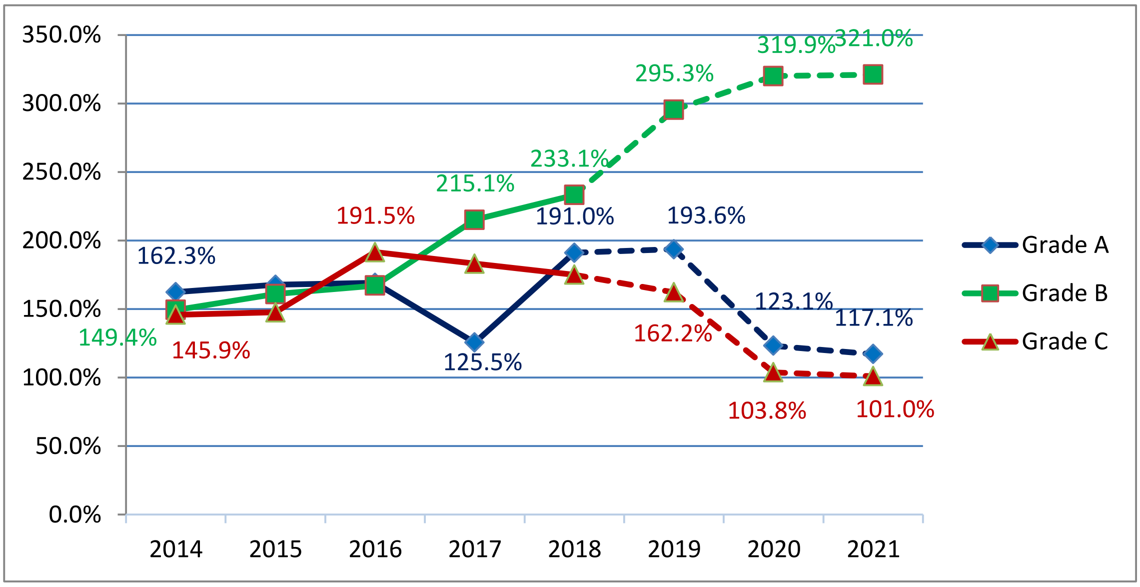
The residential cumulative supply trend in Hanoi in recent years and the near future is as shown in Table 15-6.

Table 15-6. Cumulative Supply in the Residential Market in Hanoi

	2014	2015	2016	2017	*2018*	*2019*	*2020*	*2021*
Grade A	727	637	3,170	7,126	*4,013*	*5,132*	*3,944*	*4,761*
Grade B	8,851	19,555	23,058	23,741	*35,609*	*47,177*	*55,666*	*60,726*
Grade C	7,437	15,920	15,729	16,454	*19,278*	*19,945*	*14,328*	*13,842*
Total	17,015	36,112	41,957	47,321	*58,900*	*72,254*	*73,938*	*79,329*

Note: Italics-Predicted Figures
Source: Savills Vietnam

The trend of the ratio of total supply to demand (sales) in the Hanoi residential market in recent years and the near future is shown in Figure 15-4. As many Grade B housing units are supposed to appear on the market in Hanoi toward 2021, the supply will substantially exceed the demand for the category B. On the contrary, the ratio of total supply to demand for the category A and C will be gradually dropping toward 2021 unless large-scale residential developments are started.

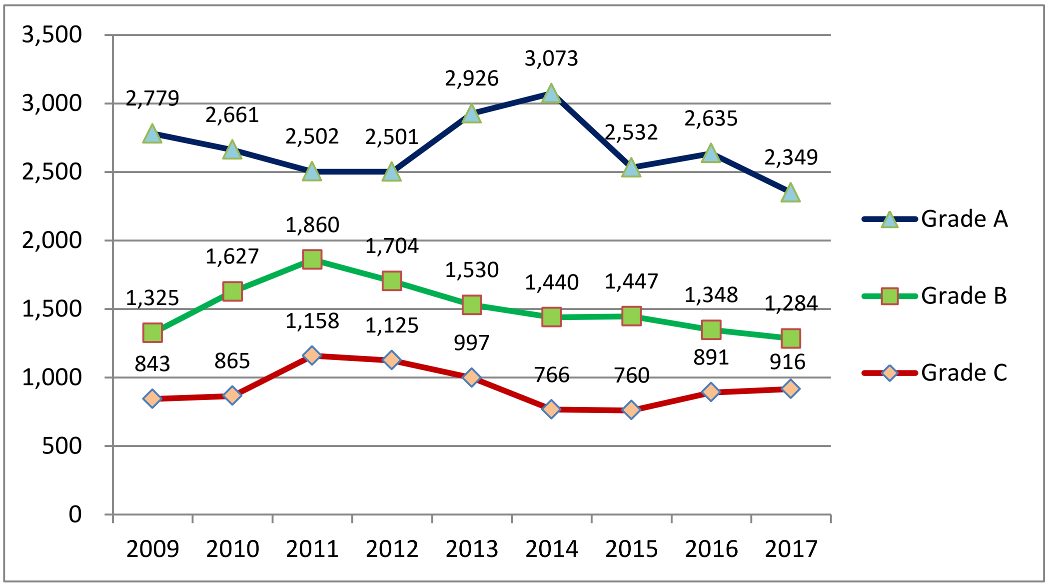


Note: 2018_2021-Predicted Figures
Source: Savills Vietnam

Figure 15-4. Ratio of Total Supply to Demand (Sales) in the Residential Market in Hanoi

(1) Price Trend in the Recent Years in Residential Market

The price movements of the residential market in Hanoi are shown in Figure 15-5. The price peak of Grade A was in 2014 after the property market started to recover, while that of Grade B and Grade C was in 2011. This might be because Grade B and Grade C housing is more in line with genuine demand and was less influenced by the worldwide financial crisis of 2007-2008.



Source: Savills Vietnam

Figure 15-5. Price Movements of the Residential Market in Hanoi

15.3.2 Office Market

(1) Supply and Demand in Office Market

The office new supply trend in Hanoi in recent years is as shown in Table 15-7.

Table 15-7. New Supply in the Office Market in Hanoi

	2010	2011	2012	2013	2014	2015	2016	2017
Grade A	45,033	101,500	-14,760	33,200	110,884	53,000	-1,119	-31,272
Grade B	15,591	77,940	41,940	102,969	77,312	53,950	57,419	9,507
Grade C	94,883	51,643	137,053	32,728	-2,907	-20,428	7,900	-2,250
Total	155,507	231,083	164,233	168,897	185,289	86,522	64,200	-24,015

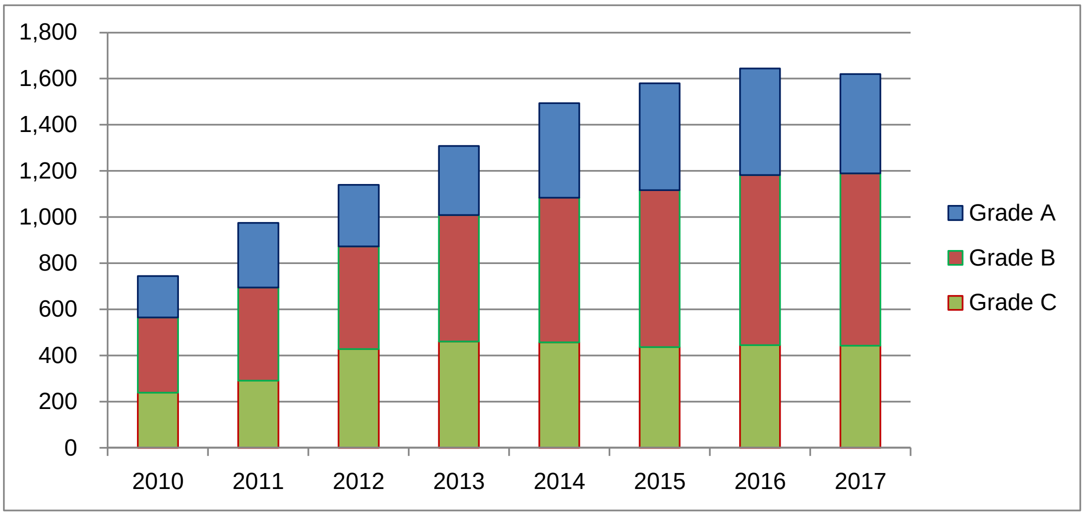
Note: Unit- m^2
Source: Savills Vietnam

The office total supply trend in Hanoi in recent years is as shown in Table 15-8 and Figure 15-5.

Table 15-8. Total Supply in the Office Market in Hanoi

	2010	2011	2012	2013	2014	2015	2016	2017
Grade A	178,854	280,354	265,594	298,794	409,678	462,678	461,559	430,287
Grade B	326,290	404,230	446,170	549,139	626,451	680,401	737,820	747,327
Grade C	238,669	290,312	427,365	460,093	457,186	436,758	444,658	442,408
Total	743,813	974,896	1,139,129	1,308,026	1,493,315	1,579,837	1,644,037	1,620,022

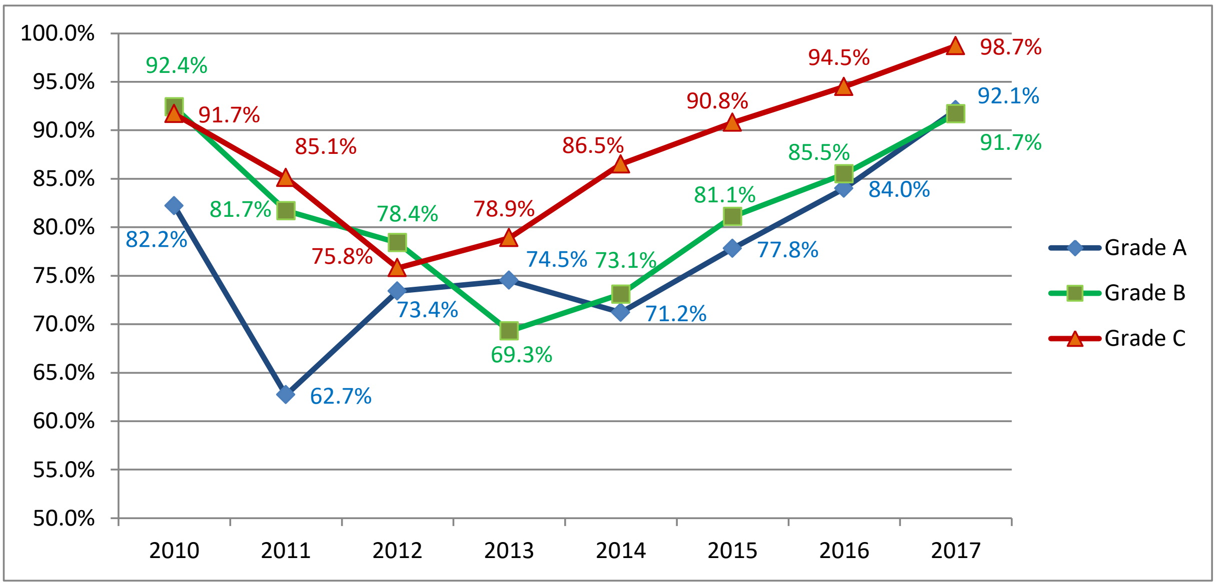
Note: Unit- m^2
Source: Savills Vietnam



Note: Unit-Thousand m^2
Source: Savills Vietnam

Figure 15-6. Total Supply in the Office Market in Hanoi

The office occupancy rate in Hanoi in recent years is as shown in Figure 15-7.



Source: Savills Vietnam

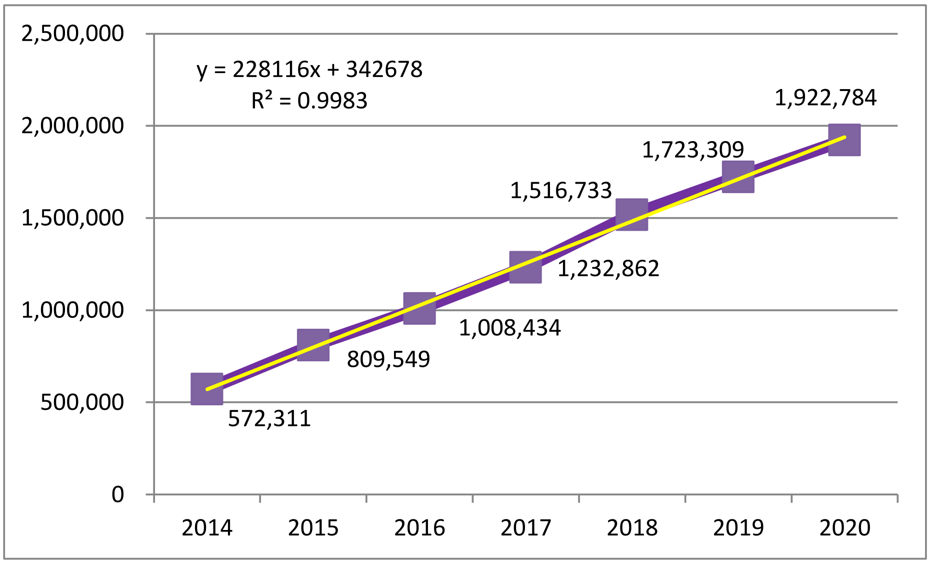
Figure 15-7. Total Supply in the Office Market in Hanoi

The office demand trend in Hanoi in recent years and the near future is as shown in Table 15-9 and Figure 15-8.

Table 15-9. Demand in the Office Market in Hanoi

	2014	2015	2016	2017	*2018*	*2019*	*2020*
Total	572,311	809,549	1,008,434	1,232,862	*1,516,733*	*1,723,309*	*1,922,784*

Note: Italics-Predicted Figures
Source: Savills Vietnam

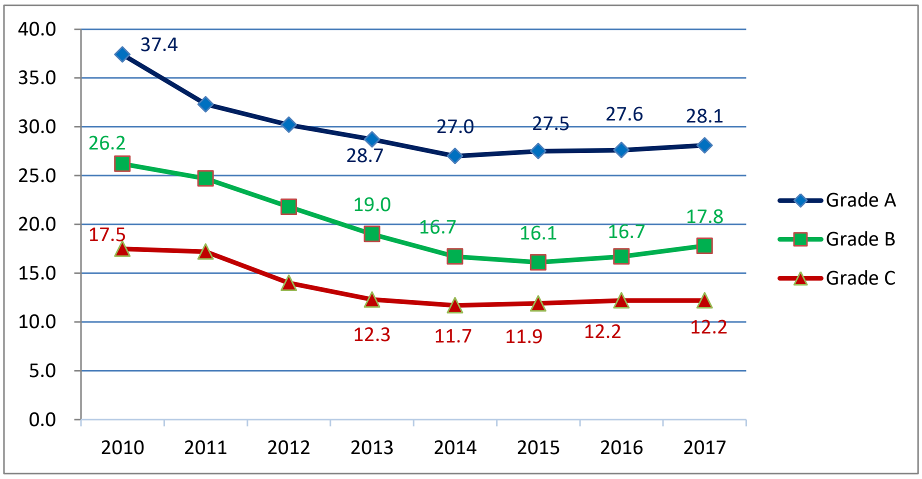


Source: The JICA Study Team

Figure 15-8. Demand in the Office Market in Hanoi

(2) Office Rent

The average gross office rent in recent years is as shown in Figure 15-9.



Note: Unit- US$/m^2/month
Source: Savills Vietnam

Figure 15-9. Average Gross Office Rent in Hanoi

15.3.3 Commercial Space Market

(1) Supply and Demand

The commercial space new supply trend in Hanoi in recent years is shown in Table 15-10.

Table 15-10. New Supply in the Commercial Space Market in Hanoi

	2012	2013	2014	2015	2016	2017
Department Store	5,138	24,925	30,000	42,223	-17,000	-
Shopping Center	96,172	170,078	7,434	63,814	77,866	58,378
Retail Podium	66,302	-24,487	15,184	21,747	46,115	18,989
Total	167,612	170,516	52,618	127,784	106,981	77,367

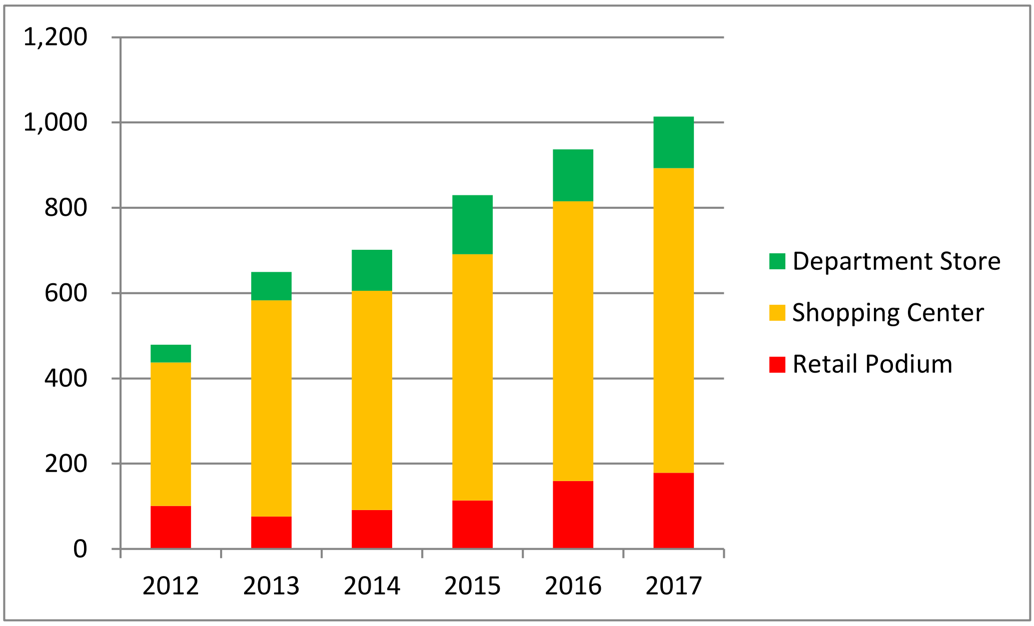
Note: Unit- m^2
Source: Savills Vietnam

The commercial space total supply trend in Hanoi in recent years is shown in Table 15-11, Figure 15-10.

Table 15-11. Total Supply in the Commercial Space Market in Hanoi

	2012	2013	2014	2015	2016	2017
Department Store	41,063	65,988	95,988	138,211	121,211	121,211
Shopping Center	336,603	506,680	514,114	577,928	655,794	714,172
Retail Podium	101,078	76,591	91,775	113,522	159,638	178,618
Total	478,744	649,259	701,877	829,661	936,643	1,014,001

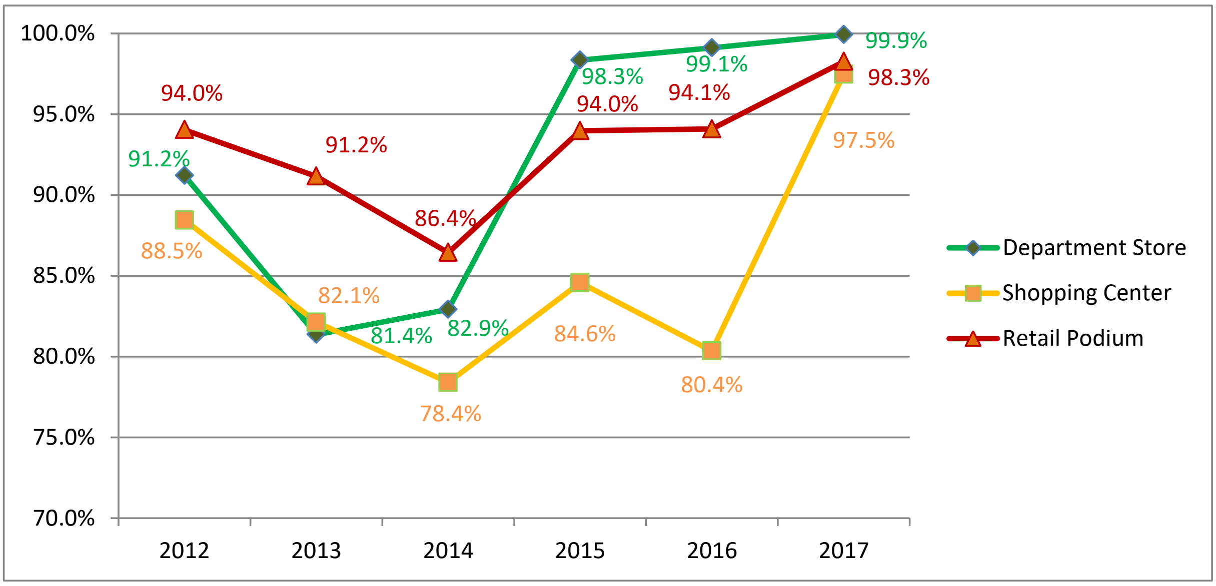
Note: Unit- m^2
Source: Savills Vietnam



Note: Unit-Thousand m^2
Source: Savills Vietnam

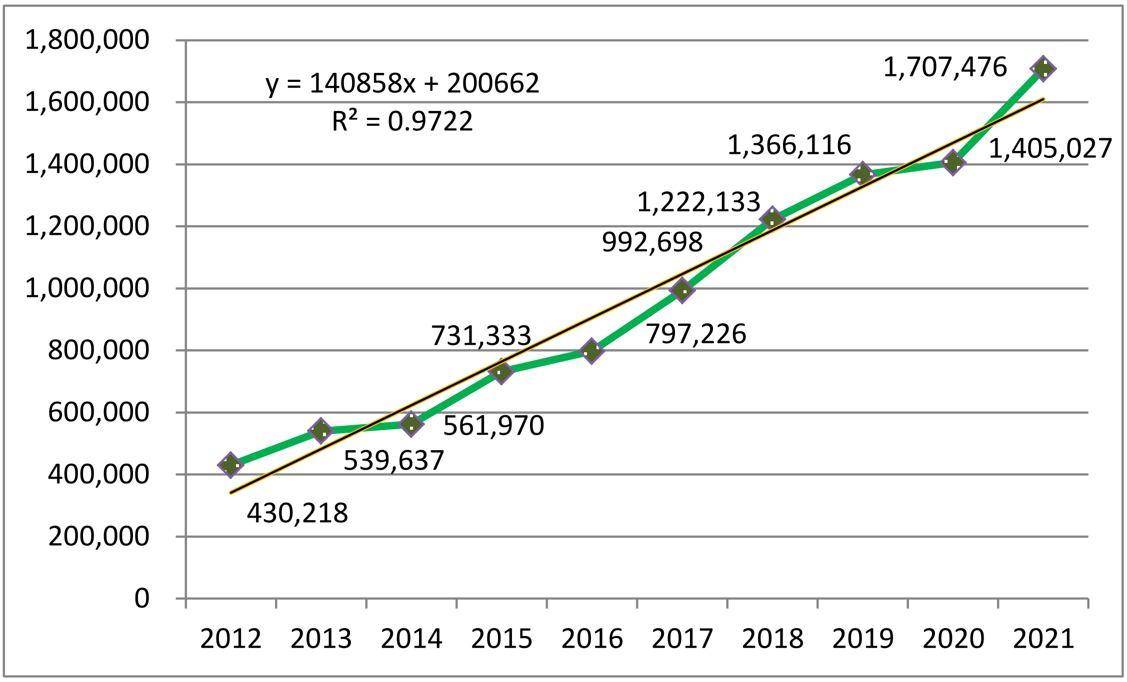
Figure 15-10. Total Supply in the Commercial Space Market in Hanoi

The commercial space occupancy rates and floor area demands in Hanoi in recent years are shown in Figure 15-11 and Figure 15-12.



Source: Savills Vietnam

Figure 15-11. Commercial Space Occupancy Rate in Hanoi

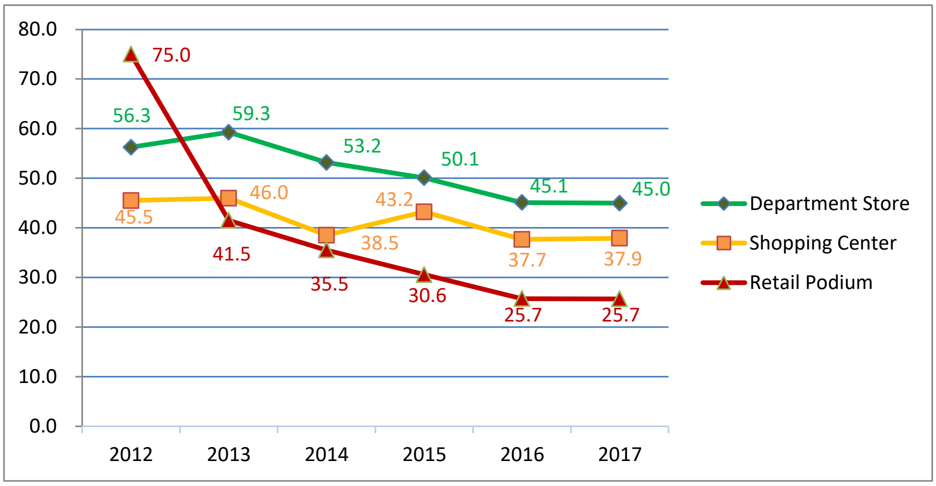


Source: The JICA Study Team

Figure 15-12. Floor Area Demand in the Commercial Market in Hanoi

(2) Rent

The average gross commercial space rent in recent years is shown in Figure 15-13.



Note: Unit- US$/m²/month; Figures are for the ground floor of each category.

Source: Savills Vietnam

Figure 15-13. Average Gross Commercial Space Rent in Hanoi (Ground Floor)

15.4 Future Prospects of Property Market in North Hanoi

15.4.1 Market Size Estimation

(1) Urbanization Trend

North Hanoi has almost no presence in the whole residential market in Hanoi until now as it is mainly North Tu Liem and South Tu Liem (West), Ha Dong (South-West), Thanh Tri (South), Long Bien and Gia Lam (East), etc. that are remarkably being urbanized in recent years. Judging from the city's infrastructure development trend and the development policy for North Hanoi, however, North Hanoi's residential market share could be assumed as 15% of the whole city in 2030, as shown in Figure 15-14.

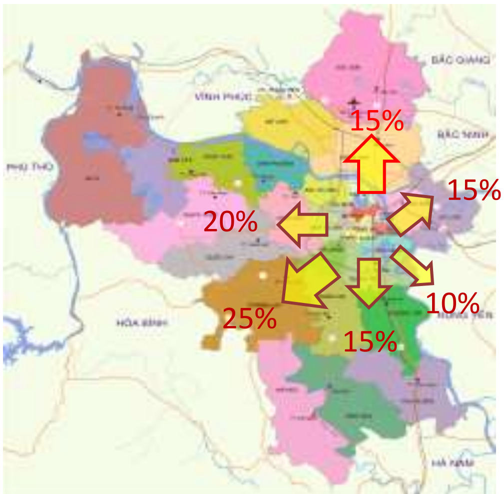
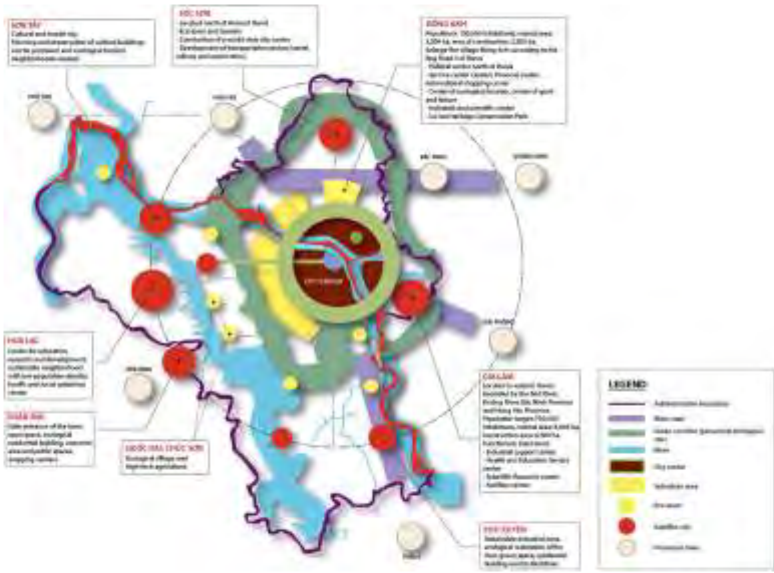


Figure 15-14 Property Market Development Directions

Especially the ASEAN City area along Vo Nguyen Giap Road, a new urban axis, which connects Noi Bai International Airport with the heart of the city via Nhat Tan Bridge, has a lot of development potential.

(2) Market Demand in North Hanoi

According to the Hanoi Capital Construction Master Plan to 2030 and Vision to 2050 as illustrated in in Figure 15-15, Dong Anh is designated as a political center, service center, financial center, international shopping center, and the like, which implies that a certain level of residential, office, and commercial agglomerations are expected in North Hanoi.



Source: HUPI

Figure 15-15. Functional Areas of the Hanoi Capital Construction Master Plan to 2030 and Vision to 2050

15.5 Urban Development for Line 2.3 TOD/LVC Areas

15.5.1 Development Schedule

As suggested above in the analysis of the property market in Hanoi, it is vital that the Hanoi city needs to carefully analyze the property market trends to maintain the profitability of the properties to be supplied in the market. Of course, there is a need to recover investment costs as early as possible. However, the release of products in a lump could depress property prices. An interplay of a demographic trend, economic situation, as well as location preferences constitutes the market absorption capacity, which the supply should not exceed. Therefore the releases of property products are distributed evenly over the planning time horizon.

Supply Schedule Parameters

The conditions used for the planning for the supply schedule are as follows: The urban blocks are developed from the nearest to the farthest from the stations. By assigning the market supply year for each urban block, the property sale schedule is developed, as shown in Figure 15-16.

Stations	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
	Type: All Uses																
N2																	
East		2239.5															
West		18668															
N3																	
East						145.5	85489	14314	21615	15143							
West			1565.1		68979	27345	117325	192642		193759	93872	39776	2357.4				
N4																	
East				71519	43994	59571	3255.2	238.8		15728	13623						
West				422879	118329	219857	196640	126659		142748	93613	77252	3458.7		9384.6	9516.9	15836
N5																	
East	2765	112269	16158		74948	57847	15699	3461.3		37367	22846	25576					
West																	
N6																	
West					193666	167835	112216		2722.4	6154.9	38338	1525.5		65816			
N7																	
West	3284.1																
N8																	
West	51666																
N9																	
East	14864																
West	14872																

Figure 15-16. Property Sale Schedule of Line 2.3 TOD/LVC Areas

In detail, the assignment of the sale release year of each urban block will determine the floor areas by type, i.e., residential, office, and commercial to be supplied to the market. Table 15-12 shows the planned sales schedule of residential properties. In actual implementation, the schedule may be modified according to the actual market situation as well as the strategic sequence of employment generation and residential capacity development.

Table 15-12. TOD/LVC Residential Floor Space Sales Schedule

Unit: ha

Stations	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total
N2																		
East																		
West																		
N3			2.0		7.0	17.0	17.0	19.0	1.0	20.0	9.0	4.0	2.0					99.0
East						1.0	5.0	1.0	1.0	1.0								10.0
West			2.0		7.0	16.0	12.0	17.0		19.0	9.0	4.0	2.0					88.0
N4				21.0	10.0	19.0	17.0	12.0		12.0	8.0	7.0	3.0		9.0	10.0	2.0	130.0
East				4.0	3.0	5.0	3.0	2.0		1.0	1.0							19.0
West				17.0	7.0	14.0	14.0	10.0		11.0	7.0	7.0	3.0		9.0	10.0	2.0	111.0
N5	16.0	10.0	14.0		5.0	4.0	1.0	2.0		3.0	2.0	3.0						59.0
East	8.0	6.0	10.0		5.0	4.0	1.0	2.0		3.0	2.0	3.0						43.0
West	7.0	4.0	5.0															16.0
N6					6.0	11.0	8.0		16.0	5.0	4.0	2.0		7.0				58.0
West					6.0	11.0	8.0		16.0	5.0	4.0	2.0		7.0				58.0
N7	1.0																	1.0
West	1.0																	1.0
N8	2.0																	2.0
West	2.0																	2.0
N9	1.0																	1.0
East	1.0																	1.0
West	1.0																	1.0
Total	**21.0**	**10.0**	**16.0**	**21.0**	**29.0**	**52.0**	**43.0**	**33.0**	**18.0**	**40.0**	**23.0**	**15.0**	**6.0**	**7.0**	**9.0**	**10.0**	**2.0**	**351.0**

Table 15-13 shows the planned supply schedule of office properties.

Table 15-13. TOD/LVC Office Floor Space Sales Schedule

Unit: ha

Stations	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total
N2		2.0																2.0
East		1.0																1.0
West		1.0																1.0
N3						4.0	3.0	1.0	0.0	0.0								9.0
East							3.0		0.0	0.0								4.0
West						4.0		1.0										5.0
N4				21.0	4.0	7.0	4.0	2.0		3.0	2.0	1.0	0.0					43.0
East				2.0	1.0	1.0	0.0	0.0		0.0	0.0							5.0
West				19.0	4.0	6.0	4.0	2.0		2.0	1.0	1.0	0.0					39.0
N5	29.0	8.0	6.0		2.0	1.0	0.0	1.0		1.0	0.0							48.0
East	15.0	4.0	5.0		2.0	1.0	0.0	1.0		1.0	0.0							29.0
West	14.0	4.0	1.0															19.0
N6					8.0	4.0	2.0		3.0	1.0	0.0							18.0
West					8.0	4.0	2.0		3.0	1.0	0.0							18.0
N7	1.0																	1.0
West	1.0																	1.0
N8	2.0																	2.0
West	2.0																	2.0
N9	1.0																	1.0
East	1.0																	1.0
West	1.0																	1.0
Total	**34.0**	**10.0**	**6.0**	**21.0**	**14.0**	**15.0**	**10.0**	**4.0**	**3.0**	**4.0**	**2.0**	**1.0**	**0.0**					**125.0**

Table 15-14 shows the planned supply schedule of commercial properties.

Table 15-14. TOD/LVC Commercial Floor Space Sales Schedule (Unit: ha)

Stations	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total
N2		2.0																2.0
East		1.0																1.0
West		1.0																1.0
N3						1.0	1.0	1.0	0.0	0.0								3.0
East							1.0		0.0	0.0								1.0
West						1.0		1.0										2.0
N4				7.0	1.0	2.0	2.0	1.0		1.0	1.0	0.0	0.0					16.0
East				1.0	0.0	0.0	0.0	0.0		0.0	0.0							2.0
West				6.0	1.0	2.0	1.0	1.0		1.0	1.0	0.0	0.0					14.0
N5	8.0	3.0	2.0		1.0	1.0	0.0	0.0		0.0	0.0							16.0
East	4.0	2.0	2.0		1.0	1.0	0.0	0.0		0.0	0.0							10.0
West	4.0	1.0	1.0															6.0
N6					5.0	2.0	1.0		2.0	1.0	0.0							10.0
West					5.0	2.0	1.0		2.0	1.0	0.0							10.0
N7	0.0																	0.0
West	0.0																	0.0
N8	1.0																	1.0
West	1.0																	1.0
N9	0.0																	0.0
East	0.0																	0.0
West	0.0																	0.0
Total	**9.0**	**4.0**	**2.0**	**7.0**	**7.0**	**6.0**	**4.0**	**2.0**	**2.0**	**2.0**	**1.0**	**0.0**	**0.0**					**48.0**

16. TOD Area Infrastructure Plan

16.1 Road Sector

16.1.1 Existing Road Facilities in the Region

There are two classes of existing and planned roads in the area, as shown in Figure 16-1. Those are:

- Primary urban trunk roads: National Highway 18 (TC22), Ring Road 3. (TC11), extended National Highway 5 (TC18), Red River Left Dyke Road (TC13), National Highway No.3 (TC21), Vo Nguyen Giap road (TC19) and Vo Van Kiet Road (CT2).

- Secondary urban trunk roads: TD7, TD8.

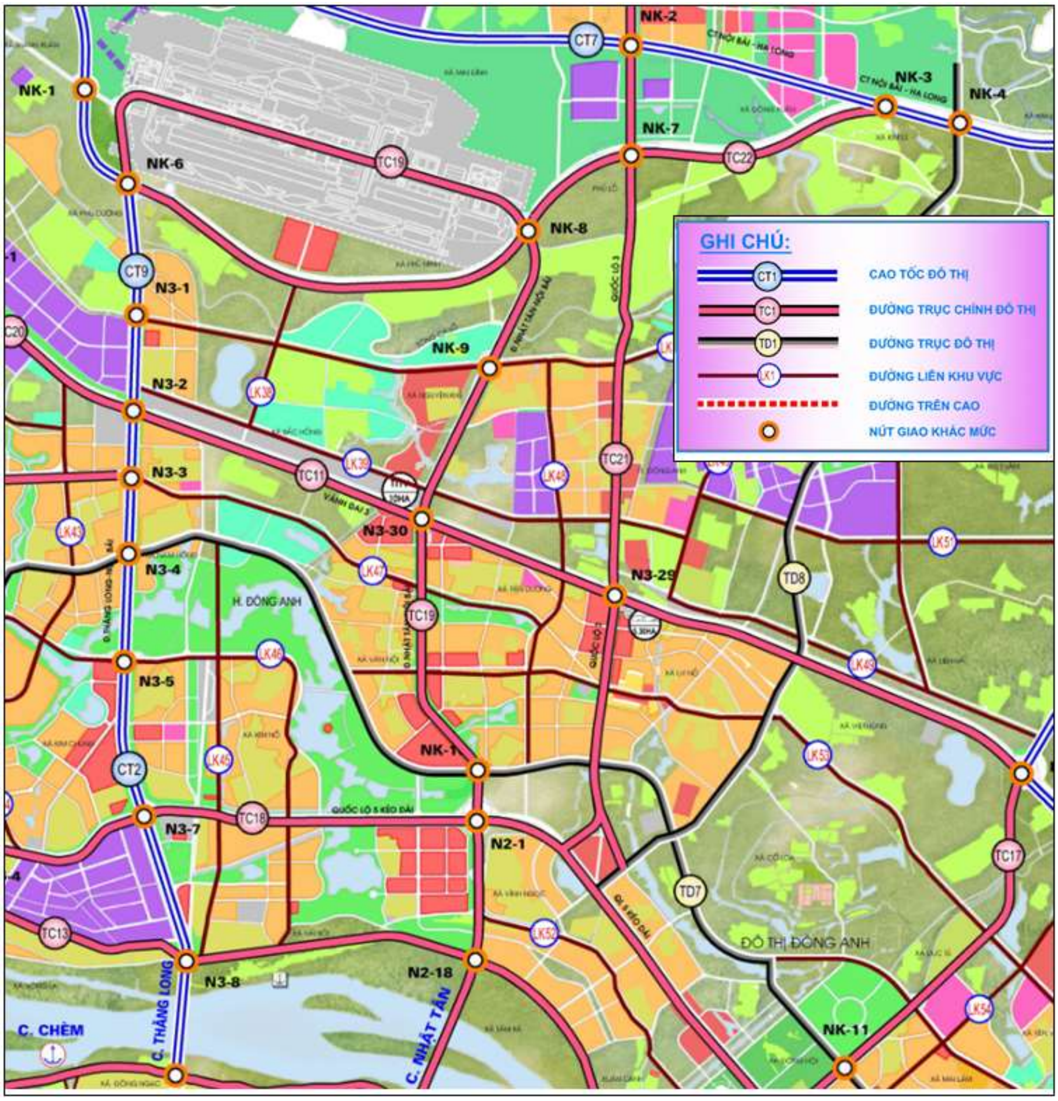


Figure 16-1. Planned Road Network Inside Line 2.3 Area

A. Prime trunk urban roads

1) Vo Van Kiet road (TC2)

Vo Van Kiet road (TC2) is a part of the Ring Road No.3. The section from Noi Bai International Airport - Thang Long Bridge is 12km long, the width of the cross-section B = 23-24m including 4 lanes of motorized vehicles, both sides have a strip for rudimentary vehicles.

Figure 16-2. Existing Vo Van Kiet Road

Development Plan: Vo Van Kiet Road is a part of Ring Road No.3, planned as an urban highway CT2, with a cross-section of 68-150m.

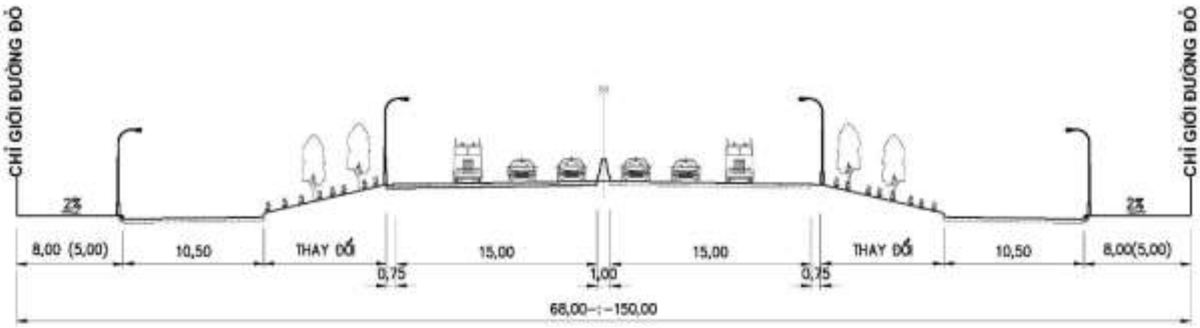


Figure 16-3. Planned Cross-section of Urban Highway CT2

2) Vo Nguyen Giap Road (TC19)

Vo Nguyen Giap Road (Nhat Tan - Noi Bai axis) is planned as the prime trunk road TC19. Currently, the road has been expanded according to planning, with the width of cross-section B = 100m.

Figure 16-4. Existing Vo Nguyen Giap Road (TC19)

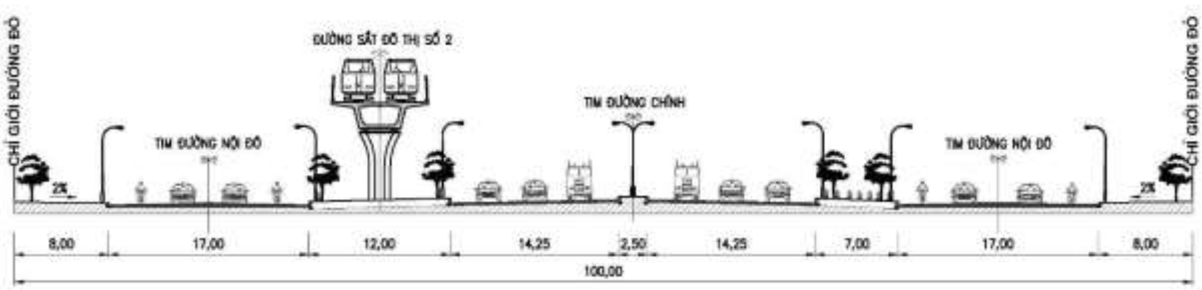


Figure 16-5. Planned Cross-section of TC19 Road

3) National Highway No.3 (NH3)

Present situation: the current scale status of NH3 is a 2-lane road with a width of cross-section B = 7m-9m. Particularly, the section running through Dong Anh town, the road base is B = 40m.

Figure 16-6. Existing NH3

Development Plan: NH3 is planned as the prime trunk road TC21, with 6 lanes, width of cross-section B = 50m.

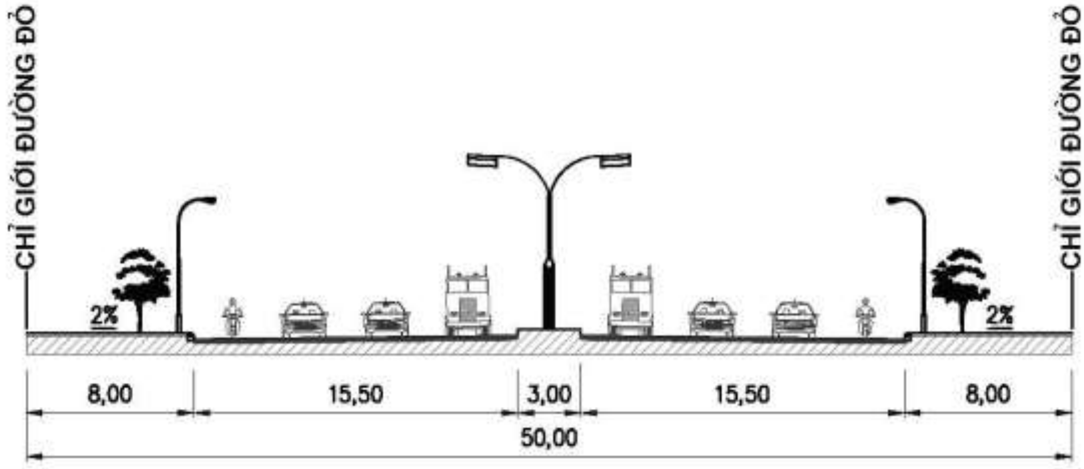


Figure 16-7. Planned Cross-section of TC21 Road

4) Ring Road 3

Bac Thang Long - Noi Bai - Mai Dich - Thanh Xuan - Phap Van - Sai Đong - Phu Dong bridge - Ninh Hiệp – same alignment with Hanoi – Thai Nguyen expressway (section Ninh Hiep to Duc Tu and further to the south of Ha Noi – Lao Cai National Railway then meets with Bac Thang Long - Noi Bai road at Quang Minh, form closed ring road.

Present situation: Basically, ¾ of Ring Road 3 has been completed (Noi Bai - Phap Van – Thanh Tri – Phu Dong – Ha Noi– Thai Nguyen Expressway). The northern section from Ha Noi– Thai Nguyen Expressway to Bac Thang Long - Noi Bai Road (the section crosses Line 2.3) remains undeveloped.

Development Plan: Ring Road 3 Section in the North from Ha Noi– Thai Nguyen expressway to Bac Thang Long - Noi Bai road is planned as urban trunk road TC11. The road's alignment runs parallel with Hanoi – Lao Cai national railway. The cross-section width is 68m.

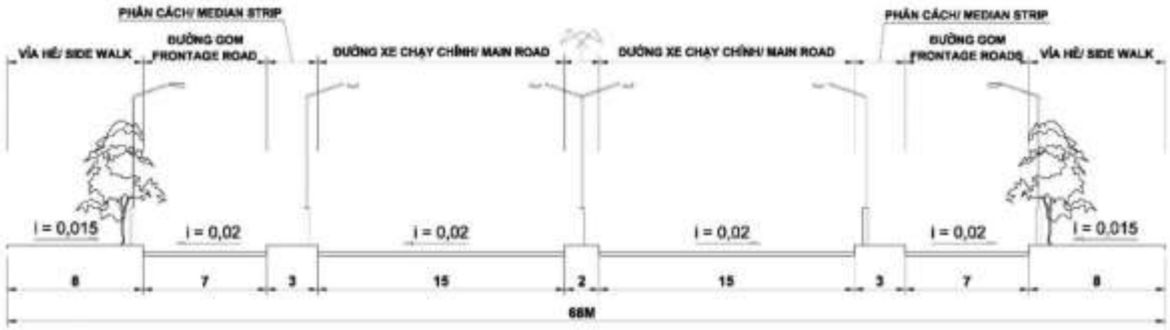


Figure 16-8. Planned Cross-section of TC1 Road

5) National Highway 18 (NH18)

Highway 18 starts from the intersection of National Highway 2. This is also the starting point of the Hanoi - Lao Cai Highway. Highway 18 is the traffic axis connecting Hanoi with the Northeast area and Cai Lan Port. The section inside Hanoi is 17km long and has been built as a 4-lane highway with cross-section width B = 27.5m

Figure 16-9. Present Conditions of National Highway 18

According to the plan, National Road 18 from Phu Cuong Intersection (intersection between NH18 and Bac Thang Long-Noi Bai Road) to the Intersection with Noi Bai - Ha Long Highway (Planned) in Kim Lu commune is planned as a TC22 urban trunk road. The road has a length of about 12km, and the cross-section of width B = 89m.

Figure 16-10. Cross-section of TC22 Road

6) Extended Highway 5:

The extended National Highway 5 is named Hoang Sa Street and Truong Sa Street. The road meets specifications of Grade 1 road with designed 80km / h, 8-lane cross-section with 8 lanes and cross-section width from 65m to 68.5m.

Figure 16-11. Present conditions of extended National Highway 5 (Hoang Sa Street)

As planned, the extended national highway 5 is planned to be the main urban road TC18. The road starts from Vinh Ngoc Intersection and ends at the northern end of Thuong Cat Bridge. The cross-section has 8-10 lanes with a width of 50-72.5m. The road section at the Metro Line 2.3 area is planned with a width of 72.5m.

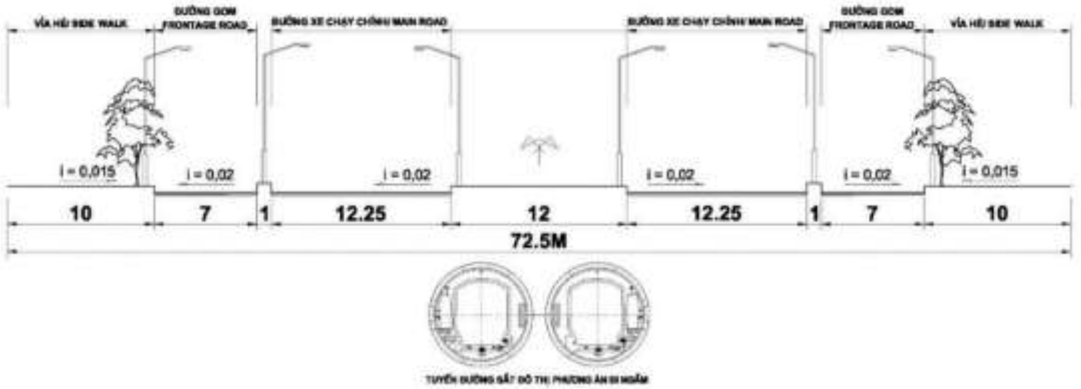


Figure 16-12. Cross-section of TC18 Road Section Inside Line 2.3 Area

7) Red River Left Dyke Road

Present situation: this is 2-lane with embankment width B=9m.

Figure 16-13. Present Conditions of type the Red River Left Dyke Road

The Red River Left Dyke Road is planned to be the primary urban trunk road of TC13. The starting point from the northern end of Thuong Cat bridge, the road runs along the left bank of the Red River to the beginning of Thanh Tri bridge connecting Hanoi - Hung Yen Road to the boundary of Hanoi, the route is 23.60Km long, the cross-section of 40-60 m width is planned with 8-10 lanes. After the road TC13 is just as important to the urban transport network, connecting the left-right city of Red river and landscape, greatly contributing to tourism development along the Red River.

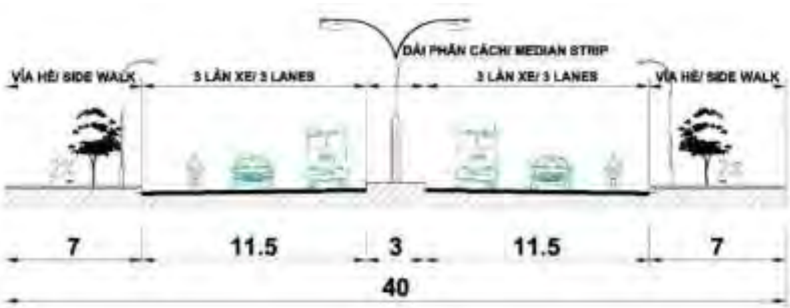


Figure 16-14. Planned TC13road from Thang Long Bridge to Tu Lien Bridge

B. Secondary urban trunk road

L-1. TD7 road:

Present situation: TD7 Road has not been constructed.

Plan: TD7 road starts from Co Bi, runs through Viet Hung–Co Loa–Van Noi (Van Tri) –Tiền Phong and ends at Đai Thinh with a total length of 33,11km, planned width B=40-50m.

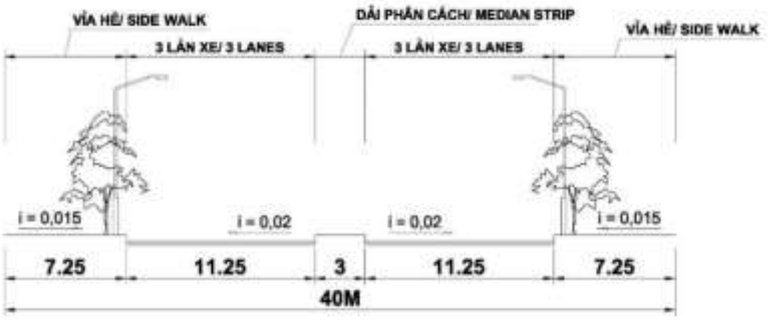


Figure 16-15. Planned Cross-section of TD7 Road, Section Crossing Line 2.3

L-2. TD8 (Co Loa – Viet Hung – Xuan Thu – Soc Son):

Present situation: TD8 road has not been constructed.

Plan: TD8 road is planned with width B=40-50m. The section crossing Line 2.3 is planned with cross-section is B=40m.

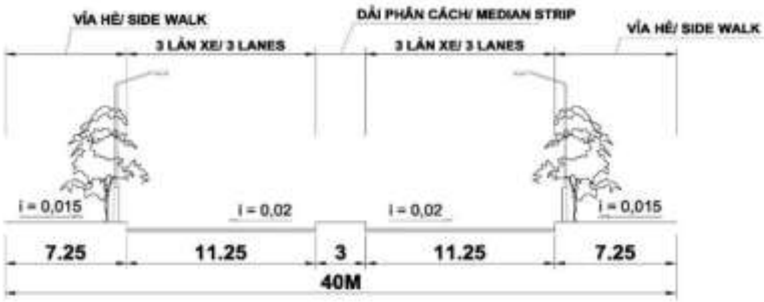


Figure 16-16. Planned Cross-section of Future TD8 Road

16.1.2 Completion of Ring Road 3 for TOD Promotion

The location of N4 Station will provide one of the best access to all the parts of the city and in the surrounding areas. It is the very reason to think of setting up a logistics center. While Line 2 enabling human mobility accesses, the Ring Road 3 will ensure the cargo mobility accesses. Therefore, it is necessary to include the completion of Ring Road 3 as part of the TOD investments as detailed in the next section.

16.1.3 Road Requirement and Investment Costs

There are two types of roads defined for the purpose of general planning for the TOD/LVC areas, first standard internal road and second, the Green Boulevard, the specifications of which are described in 4) and 6) of 13.1.6. The facility length requirements and cost estimations are shown in Table 16-1. The total length of internal roads is 51 km, whereas that for the Green Boulevards is 34 km. The extension of the Ring Road 3 is added to the plan to make a connection between National Highway No.3 to the Thang Long–Noi Bai Road for 7.2 km for an investment of USD …….. The investment costs for the road facilities are USD ………. in total. << Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

Table 16-1. Road Facility Length Requirements and Cost Estimates for TOD/LVC Areas

Stations	Internal Road		Green Boulevard		Bridge	
	Length (m)	Cost (USD '000)	Length (m)	Cost (USD '000)	Length (m)	Cost(USD '000)
N2	0		0		0	
East	0		0		0	
West	0		0		0	
N3	7,491	*	5,550	10,215	144	*
East	622	*	0		0	*
West	6,869	*	5,550	10,215	144	*
N4	10,264	*	7,151	13,162	267	*
East	2,378	*	1,721	3,168	134	*
West	7,886	*	5,430	9,994	134	*
N5	3,275	*	1,538	2,831		*
East	2,612	*	882	1,623		*
West	663	*	656	1,208		*
N6	4,395	*	2,887	5,314		*
East	4,395	*	2,887	5,314		*
N7	72	*		0		*
East	72	*		0		*
N8	47	*		0		*
East	47	*		0		*
N9	90	*		0		*
East	45	*		0		*
West	45	*		0		*
TOD/LVC	51,270	*	34,251	31,522	822	*
		*				
Ring Road						

Stations	Internal Road		Green Boulevard		Bridge	
	Length (m)	Cost (USD '000)	Length (m)	Cost (USD '000)	Length (m)	Cost(USD '000)
West	**4,300**	*		East	**2,900**	*

Note*: << Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

16.2 Water Supply

16.2.1 Existing Water Supply Systems

Currently, almost local residences in the project area do not have access to a standard water system. In recent years, with the development of the water supply system, there are three private investors with three water treatment plants contributing to provide water to the residence in this area. However, the current investments are concentrated in the water treatment plant and transmission pipeline, therefore the distribution and service pipeline still need to be constructed.

Duong River Water Treatment Plant has a capacity of 150,000 m^3/day (under upgrading to 300,000 m^3/day) with an expectation to provide 100,000 m^3/day to Dong Anh and Soc Son District. The rest is provided to the center and southern City.

Bac Thang Long Water Treatment Plant has a capacity of 150,000 m^3/day (operated since summer of 2018) to provide water supply to Dong Anh District. Currently, the water demand in Dong Anh District is limited and 50,000 m^3/day capacity of this plant is utilized to meet the demands in the center of Hanoi through two transmission lines crossing the Hong River.

In area of N3 station, there is pipeline D300 constructed by AquaOne Investor with source from Duong River WTP. In areas N4, N5 station there is a pipeline with a diameter of 300 mm in National Road QL23 managed by Water Company No2 from water production source from Bac Thang Long WTP. In addition, there are pipelines with a diameter of 400mm and 300mm constructed by AquaOne Investor with source from Duong River WTP

In area of N7 station, there are pipelines with diameters of 800mm and 400mm in National Road QL 5 from Bac Thang Long WTP managed by Hanoi Water Supply One Member Limited Company.

In area of N9 station, there is pipeline D600 from Cao Dinh WTP managed by Hanoi Water Supply One Member Limited Company.

The map of existing pipeline is shown in Figure **16-17**.

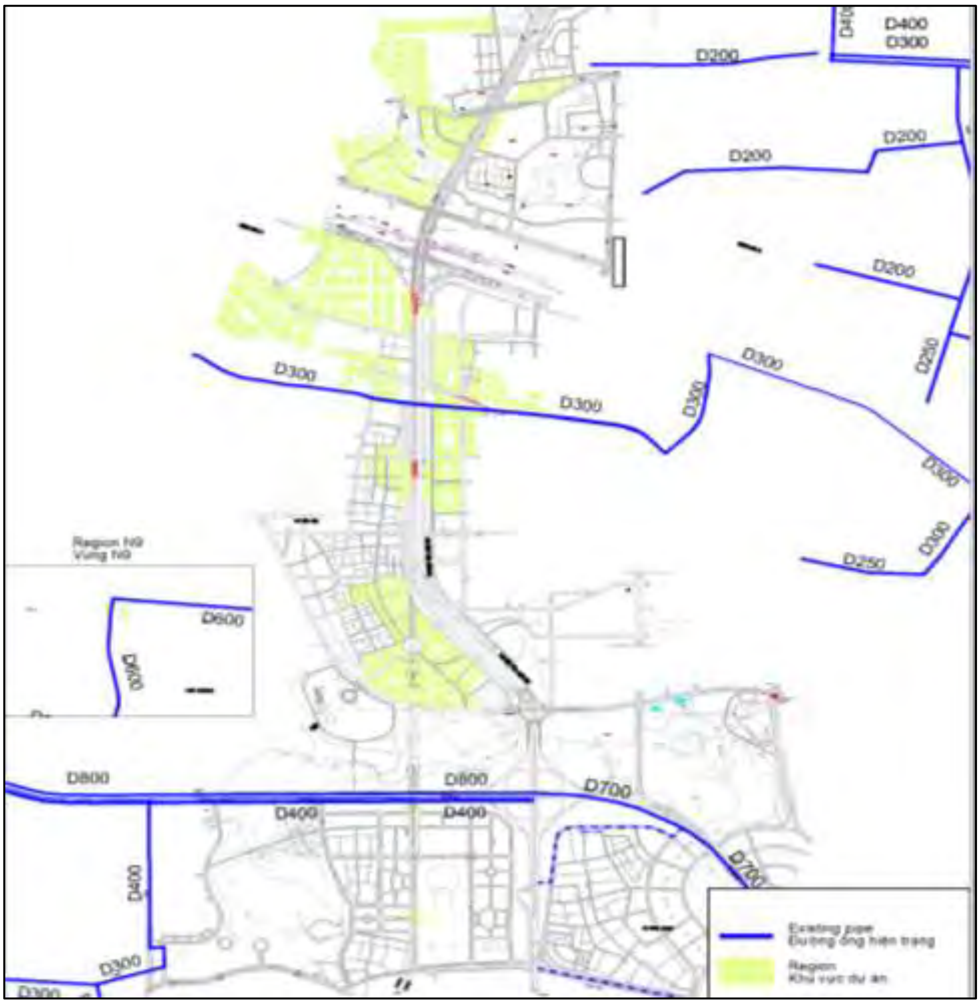


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Figure 16-17. Existing Water Supply Networks in Northern Hanoi

16.2.2 Planning Parameters

In Vietnam, the water consumption units shall be set by TCVN 33:2006 (External water supply system- Design standards).

Table 16-2. Unit Consumption in Water Supply

Water Users	Unit	By 2025 (liter per day)	By 2030 (liter per day)
Residents	1 person	150	150
Employment and Students	1 person	20	20
Public, Commerce, Service and other	-	(18%)	(20%)
Water leakage	-	(10%)	(5%)

*Note: * The Amount of leakage water and public water can be estimated by "total daily average amount" x estimated percent (%)*

Source: TCVN 33:2006 External Water Supply - Design standards

Peak hourly coefficient

In general, the peak coefficient depends on many factors, such as the water demands of domestic, commercial, and public facilities, and the socioeconomic conditions in the area. The water network and facilities must be designed to apply to the largest water flow. Peak coefficient (Kmax) 1.2 is applied to the target area according to TCVN 33:2006.

Planned Water Flow rate

Since this project is a water system as targeted, the flow rate of freshwater should be calculated in detail by each region/ zone of the project. The flow rate of water supply by each region is used to calculate the flow rate of pipes by connection points. Water pipe design is determined by applying an hourly peak coefficient (Kmax) to the maximum daily water demand as tabulated in Table **16-3**.

Table 16-3. Maximum Daily Water Demand (MDD)

Station	West Side (m^3/day)	East Side (m^3/day)
N2	56	62
N3	8,490	1,126
N4	12,213	1,966
N5	2,421	5,367
N6	6,358	0
N7	179	0
N8	299	0
N9	98	98
Total	**30,115**	**8,620**

Source: The JICA Study Team

Material and Minimum Diameter

The material of pipe for Water pipes that have resistance against external pressure (earth pressure and upper loads) should be selected. Considering a quality (corrosion resistance) of material and existing construction of water in recently, High Density Poly Ethylene (HDPE) for diameters which is below 400mm and Ductile Iron (DI) for the above ones is selected. A minimum diameter of 110 mm is determined from appropriately maintenance point of view to meet the requirements of the firefighting system.

Pressure Requirement

Minimum pressure required for low building areas is 20m. For high buildings, it’s necessary to arrange local booster pumps for each building depending on situation of them.

16.2.3 Layout of Water Supply Network

The water supply layout plans of TOD areas were designed according to the planning principles as follows;

- Route selection of pipe lines as short/shallow as possible,
- Conformity with district layout plans, and
- Compliance with Master Plan of Water Supply and zoning plans.

N2 residential area

Figure 16-18. Layout of Water Supply Network (region N2)

N3 Residential Area

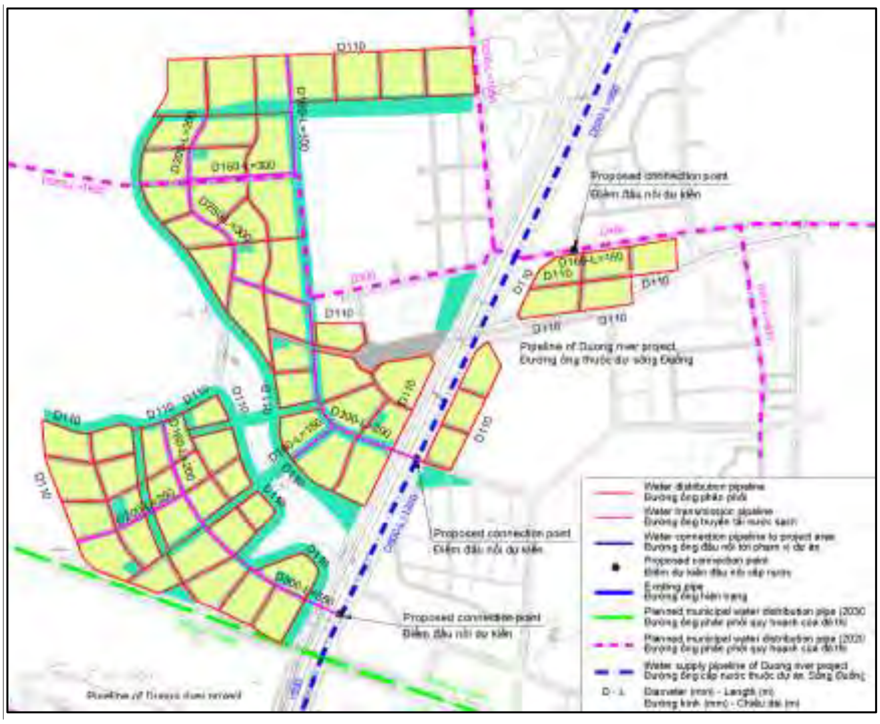


Figure 16-19. Layout of Water Supply Network (region N3)

N4 Residential Area

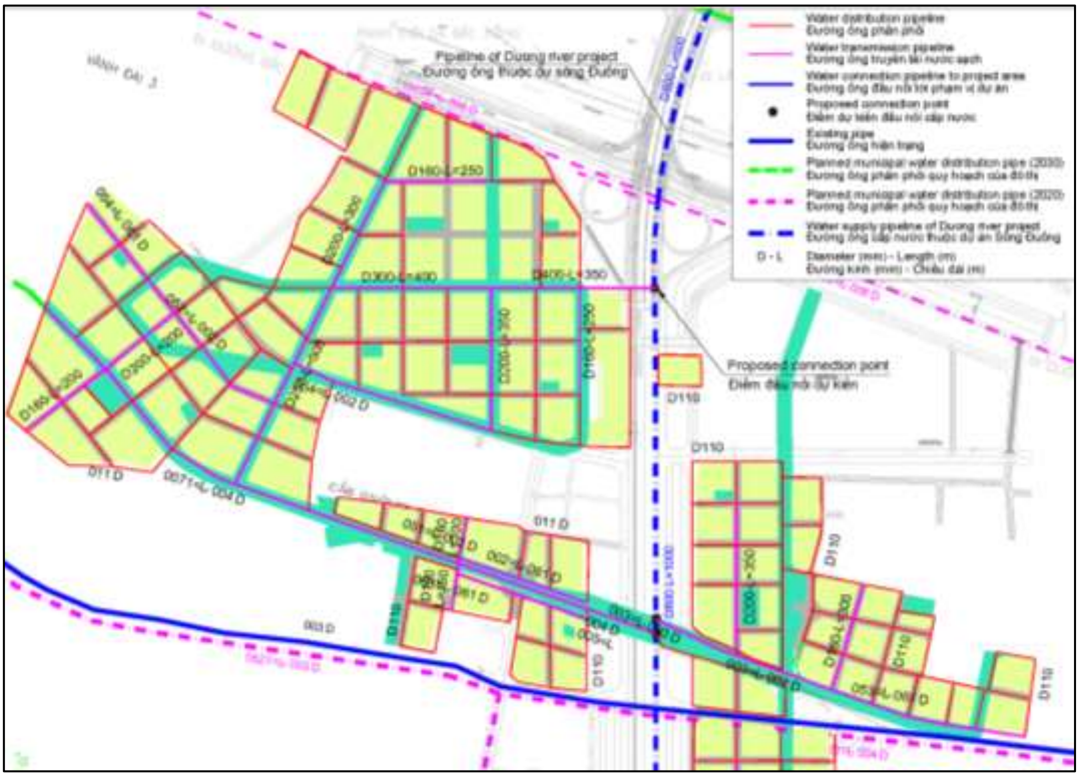


Figure 16-20. Layout of Water Supply Network (region N4)

N5 Residential Area

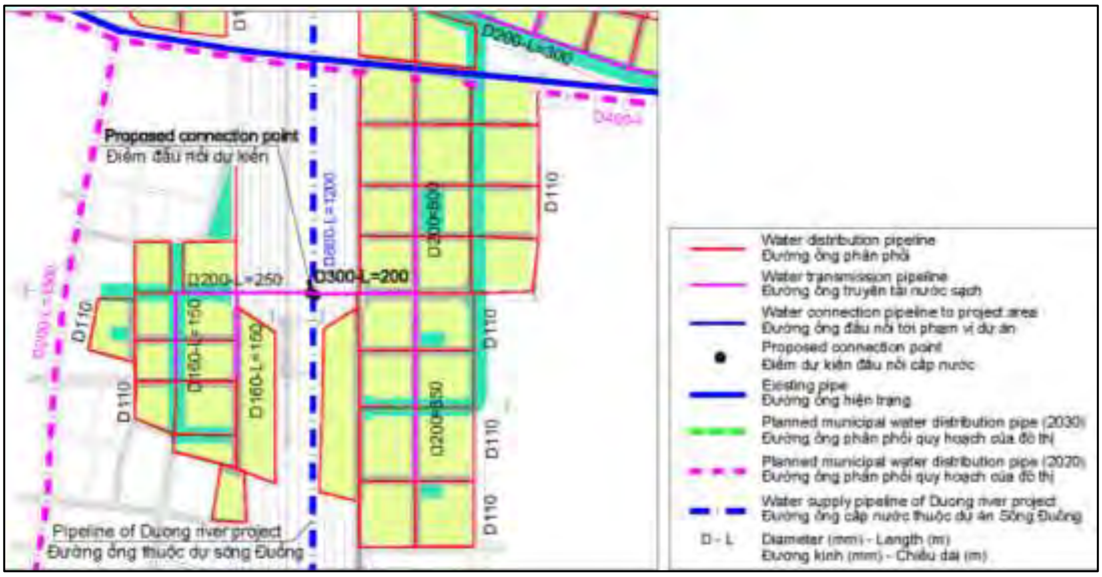


Figure 16-21. Layout of Water Supply Network (region N5)

N6 Residential Area

Figure 16-22. Layout of Water supply network (region N6)

N7&8 Residential Area

Figure 16-23. Layout of Water supply network (region N7 and N8)

N9 Residential Area

Figure 16-24. Layout of Water Supply Network (region N9)

16.2.4 Necessity of Booster Pumping Stations

According to the 16.2.3, Layout of Water Supply Network, it is not necessary to install a relay type booster pump station under the existing water distribution networks. With two water treatment plants having high capacities (Bac Thang Long WTP with 150,000 m^3/day and Duong River WTP 300,000 m^3/day by 2030) and planned Soc Son Booster Pumping Station, the existing system of water management units could meet the volume and pressure requirements from the future TOD developments.

However, there are many new development projects under planning and large land developments are in progress apart from this Study. Higher demand may arise to require a booster pump station to control local pressure. There may be a case where the Soc Son Booster Pump Station is not constructed in time. Under such circumstances, it is necessary to consider the construction of a local booster pump station especially for the TOD areas of N3 and N4.

16.2.5 Water Supply Investment Cost Estimation

Construction work items for the water supply system in the study area are listed in Table 16-4 below.

Table 16-4. Bill of Quantities of Water Supply

Station	West Side	East Side
N2	1.0 km water pipe with a diameter range from DN50-DN110 HDPE	1.0 km water pipe with a diameter range from DN50-DN110 HDPE
N3	32.3 km water pipe with a diameter range from DN50-DN350 HDPE	5.1 km water pipe with a diameter range from DN50-DN110 HDPE
N4	41.1 km water pipe with a diameter range from DN50-DN300 HDPE and 2.05 km DN400 DI	13.2 km water pipe with a diameter range from DN50-DN300 HDPE
N5	6.7 km water pipe with a diameter range from DN50-DN200 HDPE	11.9 km water pipe with a diameter range from DN50-DN300 HDPE
N6	26.6 km water pipe with a diameter range from DN50-DN350 HDPE	-
N7	1.0 km DN50-DN110 HDPE	-
N8	1.0 km DN50-DN110 HDPE	-
N9	0.6 km DN50-DN110 HDPE	0.6 km DN50-DN110 HDPE

Notes: DN = Nominal Diameter; HDPE = High Density Poly Ethylene; DI = Ductile Iron; km = kilometer

Source: The JICA Study Team

Table **16-5** shows the estimated investment costs of water supply system for TOD/LVC areas. The following preconditions are applied to the construction cost estimate.

- Typical cross-section and an average depth of pipe laying elevation;
- Construction unit cost of Hanoi City in Quarter IV of 2018;
- The unit cost of the water pipe is including all material cost, installation cost, and overhead cost.

Table 16-5. Water Supply Investment Cost Estimate

No.	Item	Unit	Quantity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
1	**N2 region**			*	*	*	*
1.1	**N2 West**			*	*	*	*
	DN50-HDPE	m	500	*	*	*	*
	DN110-HDPE	m	500	*	*	*	*
1.2	**N2 East**			*	*	*	*
	DN50-HDPE	m	500	*	*	*	*
	DN110-HDPE	m	500	*	*	*	*
1.3	**Connection**			*	*	*	*
	DN250-HDPE	m	1,000	*	*	*	*
2	**N3 region**			*	*	*	*
2.1	**N3 West**			*	*	*	*
	DN50-HDPE	m	16,150	*	*	*	*
	DN110-HDPE	m	13,000	*	*	*	*
	DN160-HDPE	m	950	*	*	*	*
	DN200-HDPE	m	550	*	*	*	*
	DN250-HDPE	m	300	*	*	*	*
	DN300-HDPE	m	1,350	*	*	*	*
	Booster Pump Station (Option) 8,000-10,000 m^3/day	**LS**	**1**	*	*	*	*
2.2	**N3 East**			*	*	*	*
	DN50-HDPE	m	2,550	*	*	*	*
	DN110-HDPE	m	2,550	*	*	*	*
3	**N4 region**			*	*	*	*
3.1	**N4 West**			*	*	*	*
	DN50-HDPE	m	20,550	*	*	*	*
	DN110-HDPE	m	14,000	*	*	*	*
	DN160-HDPE	m	1,900	*	*	*	*
	DN200-HDPE	m	1,700	*	*	*	*
	DN250-HDPE	m	500	*	*	*	*
	DN300-HDPE	m	400	*	*	*	*
	DN400-DI	m	2,050	*	*	*	*
	Booster Pump Station (Option) 8,000-10,000 m^3/day	**LS**	**1**	*	*	*	*
3.2	**N4 East**			*	*	*	*
	DN50-HDPE	m	6,600	*	*	*	*
	DN110-HDPE	m	5,000	*	*	*	*
	DN160-HDPE	m	650	*	*	*	*
	DN200-HDPE	m	650	*	*	*	*
	DN300-HDPE	m	300	*	*	*	*

No.	Item	Unit	Quantity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
4	**N5 region**			*	*	*	*
4.1	**N5 West**			*	*	*	*
	DN50-HDPE	m	3,350	*	*	*	*
	DN110-HDPE	m	2,800	*	*	*	*
	DN160-HDPE	m	300	*	*	*	*
	DN200-HDPE	m	250	*	*	*	*
4.2	**N5 East**			*	*	*	*
	DN50-HDPE	m	5,950	*	*	*	*
	DN110-HDPE	m	5,100	*	*	*	*
	DN200-HDPE	m	650	*	*	*	*
	DN300-HDPE	m	200	*	*	*	*
5	**N6 region**			*	*	*	*
5.1	**N6 West**			*	*	*	*
	DN50-HDPE	m	13,300	*	*	*	*
	DN110-HDPE	m	10,300	*	*	*	*
	DN160-HDPE	m	1,150	*	*	*	*
	DN200-HDPE	m	1,500	*	*	*	*
	DN350-HDPE	m	350	*	*	*	*
6	**N7 region**			*	*	*	*
	DN50-HDPE	m	500	*	*	*	*
	DN110-HDPE	m	500	*	*	*	*
7	**N8 region**			*	*	*	*
	DN50-HDPE	m	500	*	*	*	*
	DN110-HDPE	m	500	*	*	*	*
8	**N9 region**			*	*	*	*
8.1	**N9 West**			*	*	*	*
	DN50-HDPE	m	300	*	*	*	*
	DN110-HDPE	m	300	*	*	*	*
8.1	**N9 West**			*	*	*	*
	DN50-HDPE	m	300	*	*	*	*
	DN110-HDPE	m	300	*	*	*	*
	Option: D800-DI (in case this pipe is still not invested when the project is put in construction)	3	8,000	*	*	*	*
	TOTAL			*	*	*	*

Note*: << Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

Source: The JICA Study Team

16.3 SEWERAGE SYSTEM

16.3.1 Existing sewerage system

There is no sewerage system (both separated and combined system) in the project area.

16.3.2 Design Criteria

Wastewater Unit Rate

In general, the wastewater discharged from households is said to change according to lifestyle, the spread of water use equipment, or family composition. Also, the commercial water is supplied to shops, restaurants, educational facilities, public offices, offices, school and service facilities, etc. It is largely dependent on land use and city characteristics. In Vietnam, the water consumption unit shall be set by TCVN 7957:2008 (Drainage and Sewerage - External Network and Facilities - Design Standard) and equaling to the unit rate of water supply.

The unit amount of sewage referring from TCVN 7957:2008 is shown in **Table 16-6**.

Table 16-6. Planning Parameters in Wastewater

Water Users	Unit	By 2025 (liter per day)	By 2030 (liter per day)	Remark
Residents	One person	150	150	Equaling water rate described in Outline of revising Hanoi Water System Master Plan
Employment and Students	One person	20	20	
Public, Commerce, Service and other	-	(18%)	(20%)	
Inflation	-	(10%)	(10%)	TCVN 7957

*Note: * The Amount of leakage water and public water can be estimated by "total daily average amount" x estimated percent (%)*

Source: TCVN 7957:2008 Drainage and Sewerage - External Network and Facilities - Design Standard

Peak hourly coefficient

In general, the peak coefficient depends on many factors, such as the water demands of domestic, commercial and public facilities, and the socioeconomic conditions in the area. The water network and facilities must be designed to apply to the largest water flow. Peak coefficient (Kmax) 1.2 is applied to the target area according to TCVN 7957:2008. Maybe each residence area should have a booster pump station depending on the plan and budget of clients.

For designing of sewer pipe according to the hourly maximum sewage flow rate, the fluctuation rates (Ko) are indicated in Table **16-7**.

Table 16-7. Flow Rates of Sewerage

Coefficient	Average sewage flow rate (l/s)								
	5	10	20	50	100	300	500	1000	>5000
Ko max	2.5	2.1	1.9	1.7	1.6	1.55	1.5	1.47	1.44
Ko min	0.38	0.45	0.5	0.55	0.59	0.62	0.66	0.69	0.71

Source: TCVN 7957:2008 Drainage and Sewerage - External Network and Facilities - Design Standard

Planned Water Flow rate

Since this project is a water system as targeted, the flow rate of freshwater should be calculated in detail by each region/ zone of the project. The flow rate of water supply by each region is used to calculate the flow rate of pipes by connection points. For designing of water pipe as hourly maximum water flow rate, the water flow rate on the flow rate calculation sheet takes advantage of the fluctuation rate/ Peak Coefficient (Kmax). The planned water flow rates in TOD/LVC areas are shown in Table 16-8.

Table 16-8. Maximum Daily Sewerage Demand (MDD)

Station	West Side (m^3/day)	East Side (m^3/day)
N2	56	62
N3	8,490	1,126
N4	12,213	1,966
N5	2,421	5,367
N6	6,358	0
N7	179	0
N8	299	0
N9	98	98
Total	**30,115**	**8,620**

Source: The JICA Study Team

Material and Minimum Diameter

The material of pipe for sewerage that has resistance against external pressure (earth pressure and upper loads) should be selected. Considering a quality (corrosion resistance) of the material and existing construction of sewerage in recent years, HDPE or uPVC is selected. A minimum diameter of D200 mm is determined from the appropriate maintenance point of view.

16.3.3 Layout of Sewerage Network

The point to be considered when considering the layout plan of sewer lines is shown below.

- Select route with pipelines as short/shallow as possible
- Following the plans of land use and construction in future
- Compliance with Master Plan on Water Section and Zone plan

N2 residential area

Figure 16-25. Layout of Sewerage System (region N2)

N3 Residential Area

Figure 16-26. Layout of Sewerage System (region N3)

N4 Residential Area

Figure 16-27. Layout of Sewerage System (region N4)

N5 Residential Area

Figure 16-28. Layout of Sewerage System (region N5)

N6 Residential Area

Figure 16-29. Layout of Sewerage System (region N6)

N7&8 Residential Area

Figure 16-30. Layout of Sewerage System (region N7 and N8)

N9 Residential Area

Figure 16-31. Layout of Sewerage System (region N9)

16.3.4 Necessity of Wastewater Treatment Plant and Pump Station

According to the 16.3.3, Layout of Sewer Lines, it is nceccеary to consider with the relation of water level of outflow point in the water system of the project. The depth of pipe should not exceed 5 m, as the sewer lines will be planned by a gravity flow system. The inflow/storage pump is needed inside the sewage treatment plant.

Moreover, there are a lot of new residential areas around the area under planning and large land developments are advancing. Therefore, it’s expected to increase the pumping station for each region to reduce the depth of pipe invert and collect wastewater from the surrounding region.

According to Sewerage Master Plant and Zoning Plans, there is Son Du Wastewater Treatment Plant (WWTP) with a planned capacity of 100.000 m^3/day and some planned pumping stations (PS) with similar capacity in the project area. the JICA Study Team proposes a pumping station for the project following the proposed position in the plans mentioned above. In case the residential areas are constructed before construction of WWTP and WPS, the investors could be requested to construct a local WWTP (or decentralized WWTP) with the same capacity of the pumping station. There is a need to discuss and confirm with local authorities on this matter.

16.3.5 Sewerage Facility Investment Costs

Table 16-9 summarizes the construction work items for the sewerage system development in the study area.

Table 16-9. Bill of Quantities in Sewerage

Station	West Side	East Side
N2	0.34 km sewer pipe with diameter range D200 HDPE	0.54 km sewer pipe with diameter range D200 HDPE
N3	14.13 km sewer pipe with a diameter range from D200-D400 HDPE, 0.65 km D600 CP	2.55 km sewer pipe with a diameter range from D200-D315 HDPE
N4	16.5 km sewer pipe with a diameter range from D200-D400 HDPE, 2.32 km D500-D800 CP	5.45 km sewer pipe with a diameter range from D200-D315 HDPE, 0.2 km D500-D800 CP
N5	2.09 km sewer pipe with a diameter range from D200-D400 HDPE, 0.68km D500 CP	5.07 km sewer pipe with a diameter range from D200-D315 HDPE
N6	10.85 km sewer pipe with a diameter range from D200-D400 HDPE, 0.85km D500-D800 CP	
N7	0.6 km sewer pipe with diameter range D200 HDPE,	
N8	0.49 km sewer pipe with diameter range D200- HDPE	
N9	0.23 km sewer pipe with diameter range D200- HDPE	0.21 km sewer pipe with diameter range D200- HDPE

Notes: DN= Diameter; HDPE = High Density Poly Ethylene; CP =Concrete culvert; km = kilometer

Source: The JICA Study Team

The following preconditions are applied to the construction cost estimate.

- Typical cross-section and an average depth of pipe laying elevation;
- Construction unit cost of Hanoi City in Quarter IV of 2018;
- The unit cost of sewer includes all the material cost, installation cost, and overhead cost.

The Cost Estimated for option 2 also included in this table (for reference)

Table 16-10 summarizes the investment cost estimates of sewerage facilities for TOD/LVC areas.

Table 16-10. Sewerage Investment Cost Estimates

No.	Item	Unit	Quantity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
1	**N2 region**			*	*	*	*
1.1	**N2 West**			*	*	*	*
	D200-HDPE	m	340	*	*	*	*
	WWTP 55 m^3/day	LS	1	*	*	*	*
1.2	**N2 East**			*	*	*	*
	D200-HDPE	m	540	*	*	*	*
	WWTP 60 m^3/day	LS	1	*	*	*	*
2	**N3 region**			*	*	*	*
2.1	**N3 West**			*	*	*	*
	D200-HDPE	m	9,650	*	*	*	*
	D315-HDPE	m	2,800	*	*	*	*
	D400-HDPE	m	1,680	*	*	*	*
	DN600-CP	m	650	*	*	*	*
	WWTP 8,500 m^3/day	m	1	*	*	*	*
2.2	**N3 East**			*	*	*	*
	D200-HDPE	m	2,250	*	*	*	*
	D315-HDPE	m	305	*	*	*	*
	WWTP 750 m^3/day	LS	1	*	*	*	*
	WWTP 400 m^3/day	LS	1	*	*	*	*
	Option (according to Planning)						
	Pump Station No 1 (5,400 m^3/day)	LS	1	*	*	*	*
3	**N4 region**			*	*	*	*
3.1	**N4 West**			*	*	*	*
	D200-HDPE	m	12,700	*	*	*	*
	D315-HDPE	m	2,915	*	*	*	*
	D400-HDPE	m	860	*	*	*	*
	DN500-CP	m	1,560	*	*	*	*
	DN800-CP	m	760	*	*	*	*
	WWTP 8,500 m^3/day	LS	1	*	*	*	*
	WWTP 3,500 m^3/day	LS	1	*	*	*	*
3.2	**N4 East**			*	*	*	*
	D200-HDPE	m	4,000	*	*	*	*
	D315-HDPE	m	1,450	*	*	*	*
	DN500-CP	m	200	*	*	*	*
	WWTP 200 m^3/day	LS	1	*	*	*	*
	WWTP 1,800 m^3/day	LS	1	*	*	*	*
3.3	**Option (according to Planning)**			*	*	*	*

No.	Item	Unit	Quantity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
	Pump Station LV1 (52,000 m^3/day)	LS	1	*	*	*	*
	Pump Station No 9 (8,500 m^3/day)	LS	1	*	*	*	*
	Pump Station No 10 (10,200 m^3/day)	LS	1	*	*	*	*
	Pump Station No 7 (3,500 m^3/day)	LS	1	*	*	*	*
4	**N5 region**			*	*	*	*
4.1	**N5 West**			*	*	*	*
	D200-HDPE	m	1,910	*	*	*	*
	D315-HDPE	m	180	*	*	*	*
	D500-CP	m	680	*	*	*	*
	WWTP 2,400 m^3/day	LS	1	*	*	*	*
4.2	**N5 East**			*	*	*	*
	D200-HDPE	m	3,640	*	*	*	*
	D315-HDPE	m	940	*	*	*	*
	D400-HDPE	m	490	*	*	*	*
	WWTP 5,400 m^3/day	LS	1	*	*	*	*
							*
	Pump Station No 5 (20,500 m^3/day)	LS	1	*	*	*	*
	Pump Station No 6 (3,200 m^3/day)	LS	1	*	*	*	*
	Pump Station No 6 (5,000 m^3/day)	LS	1	*	*	*	*
5	**N6 region**			*	*	*	*
5.1	**N6 West**			*	*	*	*
	D200-HDPE	m	7,900	*	*	*	*
	D315-HDPE	m	1,210	*	*	*	*
	D400-HDPE	m	1,735	*	*	*	*
	DN500-CP	m	230	*	*	*	*
	DN800-CP	m	620	*	*	*	*
	WWTP 6,400 m^3/day	LS	1	*	*	*	*
	Pump Station No 1 (6,400 m^3/day)	LS	1	*	*	*	*
6	**N7 region**			*	*	*	*
	D200-HDPE	m	600	*	*	*	*
	WWTP 180 m^3/day	LS	1	*	*	*	*
7	**N8 region**			*	*	*	*
	D200-HDPE	m	490	*	*	*	*
	WWTP 300 m^3/day	LS	1	*	*	*	*
8	**N9 region**			*	*	*	*

No.	Item	Unit	Quantity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
8.1	**N9 West**			*	*	*	*
	D200-HDPE	m	230	*	*	*	*
8.1	**N9 West**			*	*	*	*
	D200-HDPE	m	210	*	*	*	*
	WWTP 200 m^3day	LS	1	*	*	*	*
	TOTAL			*	*	*	*

Note*: << Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

Source: The JICA Study Team

16.4 Drainage

16.4.1 Existing Drainage (Storm) System

Currently, there is not any completed drainage (storm) system in this region. The surface water mainly is self-filtration or flow to water bodies in the project area such as ponds, rivers, and lakes. From these water bodies, stormwater is gravity-discharged into canals or pumped through integrated irrigation pump stations in project areas such as Phuong Trach Pump Station and Van Tri Pump Station in the south of the project area. The areas in the north of the project area, stormwater is collected in the irrigation canal and discharged to the Ca Lo River of the Son Du Lake.

+ N2 station area belongs on the basin of Ca Lo River
+ N3 station area belongs on the basin of Ca Lo River and Son Du Lake
+ Areas of N4, N5, N6 stations belong on the basin of Thep River, Ngu Huyen Khe River, and Van Tri Lake.
+ Areas of Stations N7 and N8 belong to the basin of the Phuong Trach Lake

16.4.2 Collection Area

The collection area is all buildings and facilities in the boundary of each station. In basically, the collection area of the drainage system is the same with the area of the station, but the inflow of rainwater from outside is including in the collection area of the drainage system.

Table 16-11. Rainwater Collection Area

Station	West Side (ha)	East Side (ha)
N2	9334.0	15608.0
N3	779265.6	73271.1
N4	904176.7	253384.0
N5	94351.2	247869.6
N6	511015.6	
N7	6918.2	
N8	9256.5	
N9	4596.5	4593.9
Total	**2318914.3**	**594726.6**

Source: The JICA Study Team

16.4.3 Rainfall Intensity of Drainage Planning

The intensity of rainfall is generally indicated by assumed hourly rainfall flow, and the unit is shown as "mm/hour". The probability year means what year is the occurrence interval of the intensity of rainfall.

If the probability year is determined as 20 to 30 years and more for short duration rainfall, prevention of inundation (flood) is safer. However, the development of sewers is not economical due to increasing construction costs. While, if the target rainfall occurs a few times per year, the frequency of inundation is high, and the purpose of sewerage facilities is not achieved. Thus, the probability year is determined as five to ten years for the planning and design of sewer. In Vietnam, the probability year (the rainfall frequency) is determined by the Vietnam Standard TCVN 7957:2008. Normally it is designed with the probability year of 5-10 years for primary drainage system (Grade I) and two years for secondary drainage system (Grade II). 2 years as probability year is adapted to the drainage system in CUWC.

Table 16-12. Probability Year of Urban Area

City properties	Facility scale		
	Canal and River	Main Sewer	Branch Sewer
Special and grade I city	10	5	2 - 1
City grade II, III	5	2	1 - 0.5
Other town and city	2	1	0.5 - 0.33

Source: TCVN 7957:2008

Applying to this project in Hanoi (special city), the probability year is 10 for the canal, river, 5 for main sewer.

Table 16-13. Maximum Daily Drainage Demand (MDD)

Station	West Side (m^3/s)	East Side (m^3/s)
N2	0.315	0.524
N3	22.612	2.302
N4	26.789	7.262
N5	2.773	7.756
N6	15.358	-
N7	0.231	-
N8	0.311	-
N9	0.154	0.154
Total	**68.544**	**17.998**

Source: The JICA Study Team

16.4.4 Minimum and Maximum Velocity of Pipe

The calculated speed of minimum sewage depends on the components and dimensions of suspended particles in wastewater, hydraulic radius or filling of channel or pipe. For sewerage and drainage, the minimum velocity corresponding to the maximum calculated filling of the pipe shall be regulated as follows: (Source: QCVN 07-2:2016BXD)

- Diameter of 600 - 800 mm, V min = 1 m/s;
- Diameter of 900 - 1200 mm, V min = 1.15m/s;
- Diameter of 1300 - 1500 mm, V min = 1.2 m/s;
- Diameter of > 1500 mm, V min = 1.3 m/s.

The minimum velocity in culvert or pipe of sewage after biological treatment, it is allowed to be equal to 0.4 m/s. The maximum velocity of sewage in the metallic culvert shall not be more than 8 m/s, in the nonmetallic culvert shall not be more than 4 m/s. The maximum velocity of drainage in the metallic culvert shall not be more than be 10 m/s and in the nonmetallic culvert shall not be more than 7 m/s.

A minimum gradient of a sewer is adopted as the below.

- The minimum gradient of a sewer is 1/D (D: pipe diameter, mm)
- The minimum gradient of drainage ditch/trench on the roadside must not less than 0.003.

16.4.5 Study of Drainage Section Cost

Table 16-14 summarizes the construction work items for the drainage system in the TOD/LVC area.

Table 16-14. Drainage Bill of Quantities

Station	West Side	East Side
N2	0.79 km drain pipe with diameter range D600-D800 CP	0.66 km drain pipe with diameter range D600-D800 CP
N3	13.40 km drain pipe with diameter range D400-D2200 CP, 0.4 km 2xB2000xH2000	3.28 km drain pipe with diameter range D400-D1500 CP
N4	18.26 km drain pipe with diameter range D400-D1500 CP, 1.8 km B2000xH2000-B5000xH2000	4.19 km drain pipe with diameter range D400-D1000 CP
N5	2.67 km drain pipe with diameter range D400-D2200 CP	5.76 km drain pipe with diameter range D600-D1600 CP
N6	2.67 km drain pipe with diameter range D600-D2200 CP	
N7	0.35km drain pipe with diameter D400-CP, 0.124 km B1500xH1200	
N8	0.19 km drain pipe with diameter D400-CP, 0.125 km B1500xH1200	
N9	0.3 km drain pipe with diameter range D400-D600 CP	0.3 km drain pipe with diameter range D400-D600 CP

Notes: DN= Diameter; CP =Concrete culvert; km = kilometer

Source: The JICA Study Team

The following preconditions are applied to the construction cost estimate.

- Typical cross-section and an average depth of pipe laying elevation;
- Construction unit cost of Hanoi City in Quarter IV of 2018;
- The unit cost of concrete pipe includes all material, installation, and overhead cost.

Table **16-15** summarizes the investment cost estimates in drainage facilities for TOD/LVC areas.

Table 16-15. Drainage Investment Cost Esstimates

No.	Item	Unit	Quant-ity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
1	**N2 region**			*	*	*	*
1.1	**N2 West**			*	*	*	*
	D600-CP	m	510	*	*	*	*
	D800-CP	m	280	*	*	*	*
1.2	**N2 East**			*	*	*	*
	D600-CP	m	360	*	*	*	*
	D800-CP	m	300	*	*	*	*
1.4	**Connection**			*	*	*	*
		m		*	*	*	*
2	**N3 region**			*	*	*	*
2.1	**N3 West**			*	*	*	*
	D400-CP	m	3,680	*	*	*	*
	D600-CP	m	5,520	*	*	*	*
	D800-CP	m	490	*	*	*	*
	D1000-CP	m	630	*	*	*	*
	D1250-CP	m	1,910	*	*	*	*
	D1400-CP	m	100	*	*	*	*
	D1500-CP	m	550	*	*	*	*
	D1800-CP	m	110	*	*	*	*
	D2000-CP	m	200	*	*	*	*
	D2200-CP	m	250	*	*	*	*
	2xB2000xH2000	m	400	*	*	*	*
2.2	**N3 East**			*	*	*	*
	D400-CP	m	270	*	*	*	*
	D600-CP	m	1,940	*	*	*	*
	D800-CP	m	171	*	*	*	*
	D1250-CP	m	250	*	*	*	*
	D1500-CP	m	650	*	*	*	*
3	**N4 region**			*	*	*	*
3.1	**N4 West**			*	*	*	*
	D400-CP	m	3,855	*	*	*	*
	D600-CP	m	5,140	*	*	*	*
	D800-CP	m	3,855	*	*	*	*
	D1000-CP	m	3,855	*	*	*	*
	D1500-CP	m	1,550	*	*	*	*
	B2000xH2000	m	345	*	*	*	*
	B3000xH2000	m	850	*	*	*	*
	B4000xH2000	m	300	*	*	*	*
	B5000xH2000	m	260	*	*	*	*
3.2	**N4 East**			*	*	*	*
	D400-CP	m	1,083	*	*	*	*
	D600-CP	m	1,444	*	*	*	*
	D1000-CP	m	1,660	*	*	*	*
3.3	**Main canal**			*	*	*	*
	Main canal B20mxH3m	m	1,050	*	*	*	*
4	**N5 region**			*	*	*	*
4.1	**N5 West**			*	*	*	*
	D600-CP	m	1,212	*	*	*	*
	D800-CP	m	808	*	*	*	*
	D1000-CP	m	235	*	*	*	*
	D2200-CP	m	410	*	*	*	*
4.2	**N5 East**			*	*	*	*
	D600-CP	m	2,955	*	*	*	*
	D800-CP	m	1,267	*	*	*	*
	D1000-CP	m	1,070	*	*	*	*
	D1250-CP	m	215	*	*	*	*
	D1400-CP	m	200	*	*	*	*
	D1600-CP	m	50	*	*	*	*
4.3	**Main canal**			*	*	*	*
	Main canal B20mxH3m	m	1,450	*	*	*	*
5	**N6 region**			*	*	*	*

No.	Item	Unit	Quant-ity	Unit Cost (VND)	Amount (VND)	Value Added Tax	Total
5.1	**N6 West**			*	*	*	*
	D600-CP	m	4,500	*	*	*	*
	D800-CP	m	3,610	*	*	*	*
	D1000-CP	m	690	*	*	*	*
	D1250-CP	m	1,250	*	*	*	*
	D1500-CP	m	720	*	*	*	*
	DN2200	m	160	*	*	*	*
6	**N7 region**			*	*	*	*
	D400-CP	m	350	*	*	*	*
	B1500xH1200 (under planning)	m	124	*	*	*	*
7	**N8 region**			*	*	*	*
	D400-CP	m	192	*	*	*	*
	2B1200xH1200 (under planning)	m	125	*	*	*	*
8	**N9 region**			*	*	*	*
8.1	**N9 West**			*	*	*	*
	D400-CP	m	200	*	*	*	*
	D600-CP	m	100	*	*	*	*
8.2	**N9 West**			*	*	*	*
	D400-CP	m	200	*	*	*	*
	D600-CP	m	100	*	*	*	*
	TOTAL			*	*	*	*

Note*: << Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

Source: The JICA Study Team

16.5 Power Supply Infrastructure

16.5.1 Power Supply and Distribution Organizations in Vietnam

The largest entity in power generation and distribution is the Vietnam Electricity (EVN) established by the Government of Vietnam as a State-owned company in 1994 with the power generation capacity of 25,884 MW, which is 61.4% of the national power generation system as of the end of December 2016. Installed generating capacity owned by each enterprise and power source-wise breakdown is shown in Table 16-16. The EVN owns the entire substations and transmission and distribution systems and operates the national power system through the National Load Dispatch Centre.

Table 16-16. Power Generation Capacity in Vietnam

Owner	Capacity (MW)	(%)
Vietnam Electricity	25,884	61.4
Petro Vietnam	4,435	10.5
Vinacomin	1,785	4.2
BOT and other investors	10,031	23.8
Total	42,135	100

Source: EVN Annual Report 2017 (as of Dec-31, 2016)

16.5.2 Transmission Lines and Substation Facilities

220kV and 110kV Transmission Network

In Vietnam, 500kV transmission networks constitute the backbone network and a 220kV system is employed as area-wise power transmission, and the 110kV system is for power distribution to load centers. The transmission network of 220kV and 110kV transmission systems is shown in Figure 16-32, and shows the area near and around the project area.

Note: Red Line 20kV, Blue Line: 110kV

Source: World Bank HP

Figure 16-32. Transmission Network in North Hanoi

16.5.3 Existing Transmission Line facilities

Existing transmission lines around the project area are shown in Table **16-17**.

Table 16-17. Existing 110kV Transmission Line Around/Near Project Area

No	From Substation Name	To Substation Name	Voltage (kV)	No. of Circuits	Kind of Conductor	Length (km)	Kind of Cable	Length (km)	Line Length (km)	Remarks, if any
1	E1.1 Don Anh	E1.16 Noi Bai	110	1	TACSR 230	6.26			6.26	
2	E1.1 Don Anh	E1.23 Van Tri	110	1	AC 400	8.68			8.68	
			110	1	GZTACSR 200	8.68			8.68	
3	E1.1 Don Anh	E1.24 Hai Boi	110	1	AC 400	3.2	XLPE 1,200	0.8	4.00	
4	E1.23 Van Tri	E1.24 Hai Boi	110	1	AC 400	7.5			7.50	
5	E1.23 Van Tri	E1.42 San Bay Noi Bai	110	2	AC240	0.64	XLPE 1,200	2.44	5.14	Overhead + cable
			110	2	ACSR 240 Total OH	2.06 2.7				
6	E1.6 Chem	E1.40 Tay Ho	110	2	AC400	6.8	XLPE 1,200	0.25	7.05	
7	E1.6 Chem	E1.27 Nam Thang Long	110	1	AC400	7.1				Total of Chem - Nam Thang Long - Nhat Tan
8	E1.21 Nhat Tan	E1.27 Nam Thang Long	110	1	AC400					
220kV Transmission Line										
9	E1.6 Chem	E1.40 Tay Ho	220				This 2-cct 220kV line may be re-routed.			

Source: Power System Diagram Dated May 20, 2018

16.5.4 Substation Facilities

Existing substations around the project area and its installed transformers are listed in Table 16-18. Power supply to the project area, including railway stations and developing areas will be made from these existing substations, which are planned to be improved/rehabilitated and new substations. Table 16-19 shows planned substations to be newly constructed/improved/rehabilitated around the project area.

Table 16-18. Existing Substation Facilities in North Hanoi

Code	Substation Name	Distribution Transformer (MVA)					Total
		No. 1	No. 2	No. 3	No. 4	No. 5	(MVA)
Existing Substations							
220/110kV Substations		No information provided					
E1.19	Soc Son						
E1.1	Dong Anh						
E1.23	Van Tri						
E1.6	Chem						
E1.40	Tay Ho						
115/23/11 kV, etc.							
E 1.16	Noi Bai	63	40				103
E 1.42	San Bay Noi Bai	25	25				50
E 1.1	Dong Anh	63	63	63			189
E 1.23	Van Tri	63					63
E 1.24	Hai Boi	40	40				80
E1.6	Chem	63	63				126
E 1.27	Nam Thang Long	63	63				126
E 1.21	Nhat Tan	63	63	63			189
	Total						926

Source: Power System Diagram dated May 20, 2018, “Hanoi City Power Development Master Plan for 2016 to 2025” by the Ministry of Industry and Commerce

Table 16-19. Development Plan of Substations in North Hanoi

Code	Substation Name	Distribution Transformer (MVA)					Total
		No. 1	No. 2	No. 3	No. 4	No. 5	(MVA)
Improvement/Rehabilitation							
220/110kV substations							
E1.19	Soc Son	250	250				500
E1.1	Dong Anh	250	250				500
E1.23	Van Tri	250	250				500
E1.6	Chem						
E1.40	Tay Ho						
	Total						1,500
115/23/11 kV, etc.							
E 1.16	Noi Bai	40	40				80
E 1.42	San Bay Noi Bai	25	25				50
E 1.1	Dong Anh	63	63	63			189
E 1.23	Van Tri						0
E 1.24	Hai Boi	40	40				80
E 1.6	Chem	63	63	63			189
E 1.27	Nam Thang Long	63	63	63	63		252
E 1.21	Nhat Tan	63	63	63			189
	Total						1,029
New Construction							
110kV substations							
	Phu Dong	40	40				80
	Nguyen Khe	63	63				126
	Van Noi	40	40				80
	Total (MVA)						286

Source: Power System Diagram dated May 20, 2018, “Hanoi City Power Development Master Plan for 2016 to 2025” by the Ministry of Industry and Commerce

16.5.5 Existing Distribution Facilities

The existing distribution facilities in Hanoi employ the voltages of 35(38.5) kV, 22(23) kV, 10.5(11) kV, and 6.6kV. The power lines run overhead and underground. The low voltage lines and service wires in the old town area are so congested. Some of the distribution transformers are installed on elevated concrete foundations.

Distribution transformer on
elevated concrete foundation

Congested LV
distribution lines and power meters

Distribution lines in commercial area

110kV and 220kV transmission lines
(tw-1 to tw-2)

Mono-pole transmission line observed from tw-1 toward Chem SS

16.5.6 User Category-wise Power Capacity Requirements

Based on the floor areas of LVC areas and non-LVC areas in and Table 14-6, respectively, category-wise electric loads for both LVC areas and non-LVC areas are obtained by multiplying floor areas by unit power capacity demand coefficient, "kW/m^2" as shown in Table 16-20 and Table 16-21 respectively.

Table 16-20. Power Capacity Requirements in LVC Areas

Unit: kW

East					West				Total
Station	Residence	Office	Commerce	Total	Residence	Office	Commerce	Total	
N2	0	332	474	805	0	306	437	743	1,548
N3	2,016	999	648	3,663	17,209	1,402	1,113	19,724	23,387
N4	3,614	1,323	1,351	6,287	21,705	10,538	8,046	40,288	46,575
N5	8,393	7,837	5,921	22,152	3,208	5,193	3,225	11,626	33,778
N6	0	0	0	0	11,401	4,841	5,829	22,071	22,071
N7	0	0	0	0	236	372	266	874	874
N8	0	0	0	0	403	635	453	1,491	1,491
N9	145	162	87	394	145	162	87	394	789
Total	14,168	10,653	8,481	33,302	54,307	23,448	19,456	97,211	130,513

Table 16-21. Power Capacity Requirement in Non-LVC Areas

Unit: kW

East						West					Total
Station	Residence	Office	Commerce	School	Total	Residence	Office	Commerce	School	Total	
N2	0	0	0	0	0	0	0	8,073	0	8,073	8,073
N3	0	11,057	0	1,398	12,454	0	2,239	9,653	0	11,891	24,345
N4	0	710	4,856	280	5,845	0	0	0	215	215	6,060
N5	15,113	1,229	0	237	16,578	0	2,648	0	968	3,616	20,193
N6	0	3,003	0	0	3,003	0	0	585	108	693	3,696
N7	0	0	0	0	0	6,318	14,960	0	280	21,558	21,558
N8	0	0	0	0	0	20,202	56,211	0	0	76,413	76,413
N9	0	0	0	0	0	25,682	2,648	0	0	28,330	28,330
Total	15,113	15,998	4,856	1,914	37,879	52,202	78,706	18,311	1,570	150,787	188,667

16.5.7 Power Distribution Facility Development Cost Estimates

Table 16-22 and Table 16-23 show the total cost of distribution facilities for LVC and non-LVC areas, respectively.

Table 16-22. Bill of Quantities and Cost Estimation of Power Distribution Facilities (LVC)

Unit: $1,000

Zone	East / West	Transformer capacity (kVA) 250	320	400	560	630	1,000	RMU	LV Dist. Board	22kV XLPE Cable (m)	Total Equipment	Installation cost	Total Cost
N2	East	2	2	0	0	0	0	2	2		*	*	*
	West	4	0	0	0	0	0	2	2		*	*	*
	Sub-total	6	2	0	0	0	0	4	4	2,000	*	*	*
	Cost	150	54	0	0	0	0	2,800	600	400	*	*	*
N3	East	0	0	2	3	3	0	3	3		*	*	*
	West	1	0	0	3	9	16	7	7		*	*	*
	Sub-total	1	0	2	6	12	16	10	10	5,000	*	*	*
	Cost	25	0	60	222	480	928	7,000	1,500	1,000	*	*	*
N4	East	0	0	0	6	4	2	3	3		*	*	*
	West	0	0	0	0	25	32	11	11		*	*	*
	Sub-total	0	0	0	6	29	34	14	14	7,000	*	*	*
	Cost	0	0	0	222	1,160	1,972	9,800	2,100	1,400	*	*	*
N5	East	0	0	0	0	15	19	7	7		*	*	*
	West	0	0	0	4	9	0	4	4		*	*	*
	Sub-total	0	0	0	4	24	19	11	11	5,500	*	*	*
	Cost	0	0	0	148	960	1,102	7,700	1,650	1,100	*	*	*
N6	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	0	0	3	9	18	7	7		*	*	*
	Sub-total	0	0	0	3	9	18	7	7	3,500	*	*	*
	Cost	0	0	0	111	360	1,044	4,900	1,050	700	*	*	*
N7	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	4	0	0	0	0	3	3		*	*	*
	Sub-total	0	4	0	0	0	0	3	3	1,500	*	*	*
	Cost	0	108	0	0	0	0	2,100	450	300	*	*	*
N8	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	2	2	1	0	0	3	3		*	*	*
	Sub-total	0	2	2	1	0	0	3	3	1,500	*	*	*
	Cost	0	54	60	37	0	0	2,100	450	300	*	*	*
N9	East	3	0	0	0	0	0	3	3		*	*	*
	West	3	0	0	0	0	0	3	3		*	*	*
	Sub-total	6	0	0	0	0	0	6	6	3,000	*	*	*
	Cost	150	0	0	0	0	0	4,200	900	600	*	*	*
Total of Equipment		13	8	4	20	74	87	58	58	29,000		*	*
Total Cost		325	216	120	740	2,960	5,046	40,600	8,700	5,800		*	*

Note : Length of 22kV XLPE cable for a RMU 500 (m) a RMU 500 (m)
Installation /construction cost 30 (%) of equipment and material cost

*<< Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

Table 16-23. Bill of Quantities and Cost Estimation of Power Distribution Facilities (non-LVC)

Zone	East / West	Transformer Capacity (kVA)						RMU	LV Dist. Board.	22kV XLPE Cable (m)	Total Equipment	Installation cost	Total Cost
		250	320	400	560	630	1,000						
N2	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	0	0	0	5	6	2	2		*	*	*
	Sub-total	0	0	0	0	5	6	2	2	1,000	*	*	*
	Cost	0	0	0	0	200	348	1,400	300	200	*	*	*
N3	East	0	0	0	3	11	6	4	4		*	*	*
	West	0	0	0	0	12	6	3	3		*	*	*
	Sub-total	0	0	0	3	23	12	7	7	3,500	*	*	*
	Cost	0	0	0	111	920	696	4,900	1,050	700	*	*	*
N4	East	0	0	3	0	6	2	4	4		*	*	*
	West	1	0	0	0	0	0	1	1		*	*	*
	Sub-total	1	0	3	0	6	2	5	5	2,500	*	*	*
	Cost	25	0	90	0	240	116	3,500	750	500	*	*	*
N5	East	0	1	0	14	0	11	6	6		*	*	*
	West	0	0	0	1	6	0	2	2		*	*	*
	Sub-total	0	1	0	15	6	11	8	8	4,000	*	*	*
	Cost	0	27	0	555	240	638	5,600	1,200	800	*	*	*
N6	East	0	0	0	0	4	1	1	1		*	*	*
	West	1	1	1	0	0	0	2	2		*	*	*
	Sub-total	1	1	1	0	4	1	3	3	1,500	*	*	*
	Cost	25	27	30	0	160	58	2,100	450	300	*	*	*
N7	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	1	0	24	5	8	6	6		*	*	*
	Sub-total	0	1	0	24	5	8	6	6	3,000	*	*	*
	Cost	0	27	0	888	200	464	4,200	900	600	*	*	*
N8	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	0	0	0	54	51	18	18		*	*	*
	Sub-total	0	0	0	0	54	51	18	18	9,000	*	*	*
	Cost	0	0	0	0	2,160	2,958	12,600	2,700	1,800	*	*	*
N9	East	0	0	0	0	0	0	0	0		*	*	*
	West	0	0	0	1	21	18	7	7		*	*	*
	Sub-total	0	0	0	1	21	18	7	7	3,500	*	*	*
	Cost	0	0	0	37	840	1,044	4,900	1,050	700	*	*	*
Total equipment		2	3	4	43	124	109	56	56	28,000		*	*
Total cost		50	81	120	1,591	4,960	6,322	39,200	8,400	5,600		*	*

Note : Length of 22kV XLPE cable for a RMU 500m

Installation /construction cost 30% (%) of equipment and material cost

<< Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

16.6 Infrastructure Investment Summary

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

17. Financial Evaluation of Railway

17.1 Scope of Financial Evaluation

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

17.2 Assumptions for Financial Evaluation

<< Due to confidentiality reasons, the information contained herein is withheld from immediate disclosure. >>

18. Financing Plans For Railway Project

18.1 Alternative Financing Structure

For the financing of Line 2.3, there are mainly three options, i.e., ODA loan, PPP, and the hybrid of the two, as shown in Figure 18-1.

Figure 18-1. Financing Options for Line 2.3

18.2 Public-Private Participation

18.2.1 Objectives of PPP

Apart from complete privatization, usually not categorized into PPP, capital financing via PPP is a form of pre-finance. Whatever the amount of investment the private sector contributed had to be repaid in one way or another. Typically, there are only two ways for repayment. Those are user fees, i.e., ticket fares in the case of railway project and tax, i.e., government budget.

There are now many types of PPP, such as BOT, BT, BOLT, BOOT, etc. Regardless of difference in terms of repayment and ownership transfer timing, the economic reality of PPP capital financing cannot be changed. The money owed to the project has to be paid back eventually either by user fees or tax money.

18.2.2 Types of PPP

There are many types of PPP. Since the primary motive for PPP in the case of Line 2.3 is to have a pre-finance for the project to implement the project without affecting the public debt to GDP ceiling. There are four variants in this category of private investor financing of construction type of PPP, as shown in Table 18-1.

Table 18-1. Types of PPP with Investor Investment of Construction

	Type of PPP	Scope	Contract Period
1	Build Operate Transfer (BOT)	Funding, design, build, operate are by private. Investment is recovered by user fees from users. After the contract, the facilities are transferred to the government.	15 to 30 years
2	Build Own Lease Transfer (BOLT)	Funding, design, build, are by private. Investment is recovered by an annual fixed lease from a public entity. The facilities are owned by private during the contract and transferred afterwards to the government.	15 to 30 years
3	Build Transfer Operate (BTO)	Funding, design, build, operate are by private. The facilities are transferred to the public soon after their building. Investment is recovered by annual service fees from the public.	15 to 30 years
4	Build Transfer(BT)	Funding, design, build are by private. The facilities are transferred to the public soon after their building. Investment is recovered by exchanging for other public assets such as land/land rights	Construction Period

Source: The JICA Study Team

18.2.3 Past Performance of Railway PPP

The past performance of PPP projects all over the world is not commendable. As Table 18-2 indicates, nearly 50% of the projects had to be rescued by the government or cancelled. Most of the projects are undertaken in advanced countries with ample experiences and expertise in PPP such as England and Australia. At present, London is implementing a new urban rail project, "Crossrail" with 100% public funding. The London government has no intention of utilizing a PPP scheme for the railway sector after the failure and subsequent bailout of "London Underground/Metronet and Tube Lines" in 2007.

The public funding ratio is also noteworthy for the railway PPP. In general, there is a high level of public funding, i.e., the government grant. The second of all, it is quite often the case when the PPP failed, the government had stepped in to rescue the project with substantial public money. There are no so many cancellations. Since a railway project is regarded as a social project, the government had no choice but to intervene to complete the project. The private investor could take advantage of this asymmetrical relationship.

Table 18-2. Global Experience of Railway PPP Project

Type	Project	Country	Signing	Operation Start	Length (km)	Investment Costs	Public Funding Ratio	Bailout/Cancel / Loan Restructuring
Airport Rail Links	Stockholm - Arlanda Express	SU	1994	1999	39 (20)	€10 0,4 bln	Total cost SEK6billion2billion state grants	
	Sydney – Airport Rail Link	AU	1995	2000	30	A$ 0.8 bln	0%=>80%	2000 (B)
	Kuala Lumpur – KLIA ERL (Kuala Lumpur International Airport Express Link)	Mal	1997	2002	57	RM 2.4 bln	?	
	Brisbane – Airtrain	AU	1999	2001	16	A$ 233m	?	2003 (R)
	Seoul - A'REX	S. Korea	2001	2007	60	€ 2.2 bln	?	2011 (B)

Type	Project	Country	Signing	Operation Start	Length (km)	Investment Costs	Public Funding Ratio	Bailout/Cancel / Loan Restructuring
	Lyon - Rhônexpress	FR	2007	2010	23 (8)	€ 0,12 bln	€0.04bn-grants, 0.062bn-borrowed by Rhonexpress, the rest from shareholders	
	Delhi - Airport Rail Link	IN	2008	2011	23	$10 0.6 bln	57%	The operation was stopped after the commencement for defect corrective works and the maximum speed was reduced to 90km/h
Conventional Rail	Eurotunnel	UK/FR	1986	1994	51	12.5 Md€	?	97,07(R)
	Adelaide – Darwin	AU	2000	2004	1420	A$ 1.3 bln	57%	2008 (R)
	Perpignan – Figueres	ES/FR	2004	2010	44	1.1 Md€04	50%	
	Gautrain	S. Africa	2006	2010	80	$ 3.7 bln	86%	
	Diabolo	DE	2007	(2012)	3	€ 0.29 bln (0.55bn)	45% (Infrabel)*	
	Liefkenshoek	BE	2008	(2014)	16	€ 0.7 bln (0.84bn)	22%**	
	Denver Eagle P3	US	2010	(2015)	54	$ 2.1bn	57%***	
Renovation	London Underground/Metronet and Tube Lines	UK	1997	2007	-	BGP 17bn=>20bn	?	2007 (B)

Note: the orange cells indicate failed projects
*Belgium National Railway
**Public=Infrabel €0.075bn＋Flemish Gov. 0.107bn
***direct public funding: a $1,030 million FTA New Starts FFGA; $128 million in direct RTD contributions from FastTrack sales tax revenues; $62 million in other Federal grants; and $40 million in contributions from local city and county governments

18.2.4 Institutional Design for PPP

Figure 18-2 shows the institutional framework of PPP. The main body responsible for the implementation for the entire life of the project is a special purpose company (SPC). The special purpose company is a legal entity with a mandate limited only to the project construction and operation. The investors take part in the equity financing of the SPC. The SPC will solicit additional funding as loans from private or public lending institutions on a non-resource lending basis. Since the lending is not guaranteed, the lenders seek strictly 'bankable' financing design. In many cases in railway projects, it is difficult to make the project 'bankable' to recover the investment cost with the ticket fare revenues alone. In a simple term, the project may not be financially viable without some government support. To restore the bankability of the project, the government is required to provide a set of financial supports. It is called "viability gap funding" as shown in Box 1.

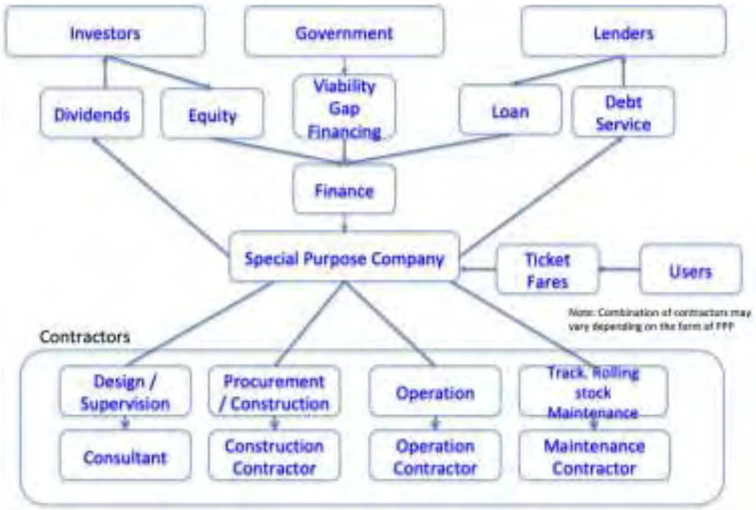
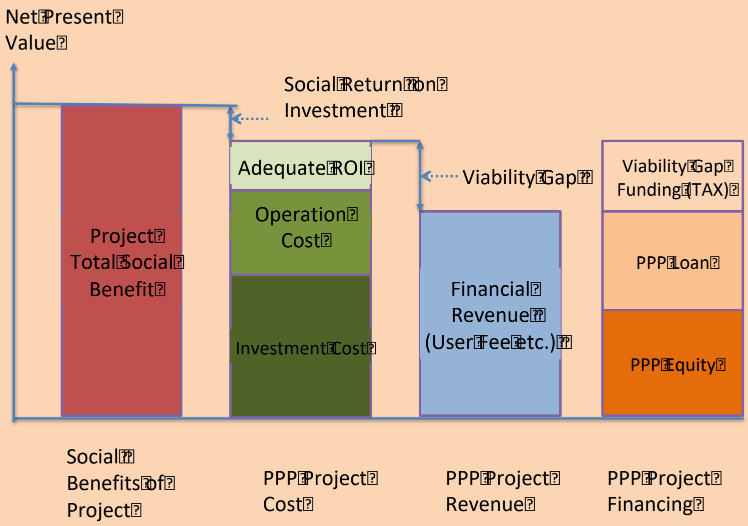


Figure 18-2. Organization and Financial Flow of Railway PPP

BOX 1 Viability Gap Funding

For a socially important project such as to improve the environment and public health, even if a project itself is not expected to provide the financial revenue sufficient to provide an adequate financial return on the investment, the project is deemed worth investing. The government has to fill the gap between the social and financial benefits.



Other important characteristics in PPP are that the SPC could be an entity without any expertise in construction or operation. Still, it can source all the necessary expertise from subcontractors in each aspect of project implementation. On the other hand, the SPC has to be set up with expertise in legal and procurement aspects. The SPC needs to foresee all the contingencies and associated risks and incorporate the countermeasures to avoid the unnecessary cost escalations. In other words, contractual and negotiation skills will determine the financial advantages of one party to the others in PPP.

18.2.5 PPP Options for Line 2.3

There are three options explored in this study as illustrated in Figure 18-1 and Table 18-1. In Option A, the PPP will undertake the infrastructure part while leaving the entire operation to Hanoi Metro[2]. Hanoi Metro will maintain the integrated control and operation of the entire metro network of Hanoi, including Line 2. In the case of Option B, the PPP will undertake the operation of Line 2.3, including the procurement of facilities and equipment required for operation. The government has to construct and maintain infrastructure. In Option C, the PPP will construct and maintain the section from N2 station to N0 station at the airport and most importantly will operate express trains from the Airport to the city center.

Option A: Infrastructure PPP

The PPP side will only need to construct mainly the civil work which needs to be tested and handed over to Hanoi Metro. The simplest system for this type of PPP is BOLT to lease the infrastructure facility to the operator, Hanoi Metro. There should be no contention on demand, the entire demand risks will remain with Hanoi Metro. Since most contingencies do not occur due to failures or negligence by a single party, the resolutions of disputes on damage liabilities need to be clearly defined and agreed upon. Delays, loss, accidents, and damages caused partly or wholly by the deficiency in design, construction, or maintenance by the SPC, need to be compensated in a pre-agreed procedure of damage assessment, arbitration, and penalty or performance payment from one party to the other. The lease agreement may be or may not be guaranteed by the government. Without the guarantee, the payoff may rise to account for the risk premium.

Option B: Operation PPP

The Hanoi Metro may provide nonstop trains from Phase 1 and 2 through Phase 3 to the Noi Bai Airport as well as the PPP side. If the revenue is expected to generate sufficient profits, the usage fee may be paid to the government by the PPP. The simplest system for this type of PPP is BOT. The demand risk may be assumed by the PPP if ample demand and revenue are expected. The availability payment may be provided if the demand is not expected to be sufficient. The revenue loss caused by delays, loss, accidents, and damages due to the deficiency in design, construction, or maintenance may be compensated in a pre-agreed procedure of damage assessment, negotiation, and arbitration. The availability payment may be or may not be guaranteed by the government. Without the guarantee, the payoff may rise to account for the risk premium.

Option C: Airport Access PPP

The PPP will operate express trains between the Noi Bai Airport and major stations on Metro Line 2 while the Hanoi Metro will control the operation of the express trains in conjunction with other commuting trains. The concession agreement for this type of PPP may be BOT. The government may

[2] Hanoi Metro is a subsidiary of HPC that is mandated to operate the metro network of the city.

guarantee the availability payment for the express train operations. At the same time, the PPP may provide the infrastructure usage fee for the excess demand above the minimum traffics defined in the availability conditions. The government will be providing the rest of the Line 2.3 development costs up to the N2 Station.

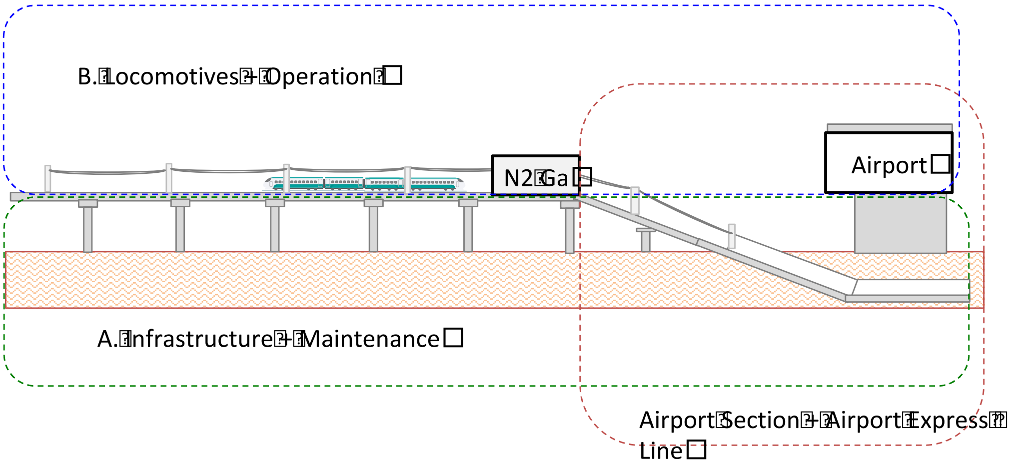


Figure 18-3. PPP Options for Line 2.3

Following the three options of A-C above, Table 18-3 shows how each option is reflected in the divisions of responsibilities and share of direct investment costs by partners.

Table 18-3. Characteristics of Line 2.3 PPP Options

PPP Type	Partner	Responsibility	Direct Investment Cost (Yen Billion)
A. Infrastructure + Maintenance	Private	Civil・Track・Station	
	Government（HPC)	Rolling Stocks・Signal・Power	
B. Rolling stocks + Operation	Private	Rolling Stocks・Signal・Power・Station	
	Government（HPC)	Civil・Track	
C. Airport Section + Airport Operation	SPC(Private＋CAAV)	N0-N2:Civil・Track・Power・Signal・Rolling Stocks	
	Government（HPC)	N2-C1:Civil・Track・Power・Signal	

Note: << Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

18.2.6 Financial Evaluation of PPP Options

<< Due to confidentiality reasons, the cost figure contained herein is withheld from immediate disclosure. >>

18.2.7 Risk Assessment of PPP Options

At every stage from the study phase to investment recovery phase, the PPP comes with risks to be dealt with as shown in Table 18-4.

Table 18-4. Risk Assessment of PPP Options

No	Stage	Current Situations in Hanoi	Risks	Risks for SPC (H: High, M: Middle, L: Low)		
				A	B	C
1	Demand Forecast/ Study	Accuracy in traffic demand forecast is dubious due to absence of urban railway service at present. A green field project presents an even more difficulties with no population base at present or no pricing information.	Insufficient Operation Revenue	M (if the payment is a lease basis)	M (if the availability payment is the condition) Otherwise H	L-M (Airport Passenger is more predictable)
2	Bidding	PPP needs to define the 20-30 year future operation / maintenance by contracts − Lack of experience in railway sector by the government of private sector	Winner's Curse i.e. choosing most risk-taking and optimistic bidder without experience and knowhow	H	H	H
3	Contract	− PPP needs to define the 20-30 year future operation maintenance by contracts − Lack of experience in railway sector − Difficulty of foreseeing a long term operation conditions and changing social environment	Elongated contract negotiation or cancellation	H	H	H
4	Construction	− Red River crossing is a technical challenge − Coordination with multiple entities such as CAAV and utility companies, landowners, public, and sub-contractors − Gov. making process	− Cost increase − Const. period elongation − Chance of Government Bailout	H	L	M
5	Operation	− Need for Training and capacity development of operators and maintenance crew − Need for Demand enhancement − Need for Service level Improvement	Line 2.3 is too short for obtaining scale of economy in operation or maintenance	M	H	L (Large part of maintenance can be transferred to Hanoi Metro)
6	Investment Recovery	− Difficulty in demand or tariff revenue estimation − Local currency based revenue and foreign currency repayment	Affordability of availability payment(government)	L with Gov. guarantee but M with only from Hanoi Metro	M (depending on the availability payment provisions)	L (depending on availability or revenue sharing arrangement)

18.2.8 Pre-requisites for PPP Implementation

PPP Framework

PPPs legal framework in Vietnam is Decree 63/2018/ND-CP on PPP and supplememted by Decree 69/2019/ND-CP on the use of public assets for payment to the investors in Build-Transfer projects. There have been many PPPs already implemented with varying degrees of success though there has been no railway PPP in Vietnam yet. Most countries with successful PPP programs rely on a sound PPP framework, which is a working-in-progress product of lessons from past successes and failures. International donors and businesses unanimously have pointed out that Vietnam requires a more positive and comprehensive PPP framework. A draft PPP Law is now to be presented to the National Assembly.

The "PPP framework" must consist of the policies, procedures, institutions, and rules to define the lifecycle of PPP projects on project formation, evaluation, prioritization, budget allocation, bidding, contracting, monitoring, public intervention, termination, compensation, transfer as well as public accountability. A PPP framework should promote governance to the projects by promoting accountability, transparency, and integrity. It ensures that the projects serve the government's development strategy and generate the highest social-economic returns with manageable risks within the fiscal capacity of the government. It also guarantees that consultation with stakeholders will be systematically undertaken and fair compensation awarded to those that are entitled to receive it. This generates greater private sector interest and public acceptance of PPP programs. These core principles are described in Good Governance for PPPs.

18.3 ODA Financing

18.3.1 Comparison Between ODA and PPP Schemes

The ODA loan provides the best financial conditions that are available for infrastructure project construction with low interest, long grace and repayment periods.

Repayment Period

For a commercial loan from banks or companies, the repayment period is normally ten years at the longest. On the other hand, the project life or depreciation period of the infrastructure project is more than 30 years. The mismatch in the depreciation periods and loan repayment often causes the cash crunch in repayment even if the operation is generating surpluses. Therefore, the ODA loan is the most suitable for infrastructure financing. Given the need for a minimum guarantee for the Option A or fixed lease or usage fee for Option B, the net cash flow for the implementation is most likely to be greater for the case of ODA than these PPP cases. In the case of Option C, the most lucrative operation is expected to be running the airport express. Thus the division will leave only much financially stressed section of commuter service portions between N2 to C1.

Construction Schedule

Figure 18-4 shows the implementation schedules comparing the cases for ODA funding and PPP funding. In short, the PPP case would take a longer time than the ODA case, which has a well-established procedure with clearly defined divisions of responsibilities. The PPP will involve a milliard of private parties in addition to multiple investors with varying incentives and risk recognitions. Therefore, the tender process and subsequent contract negotiation will be an elongated one as exhibited for various reasons.

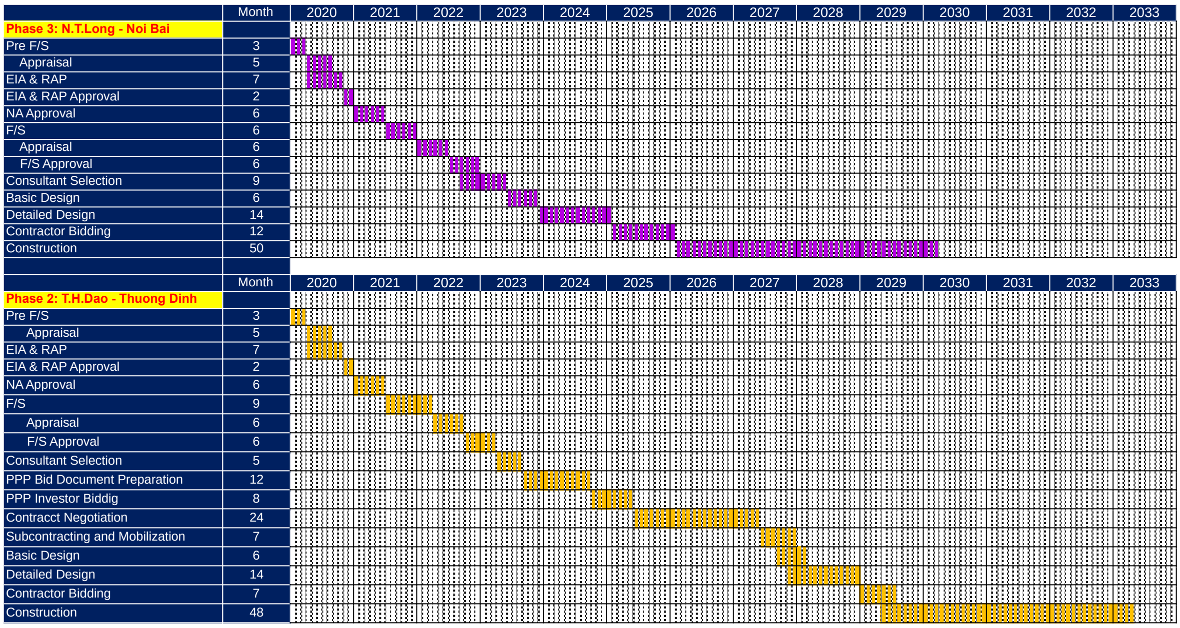


Figure 18-4. Comparison of Construction Schedule by ODA and PPP Financing

18.3.2 Applicability of PPP Scheme To Line 2.3

Vietnam has implemented many PPPs in energy, transport, water/sewerage in a total of 117 projects from 1994 through 2018, according to the PPIAF Database of World Bank. The energy sector has the highest concentration of 94 projects, followed by the transport sector of 13. The PPP projects under transportation are comprised of 10 port projects, two road projects and one airport. There has been no railway project so far. In terms of investment, the average investment size is USD 117 million in the transport sector with the largest investment being USD 276 million.

Table 18-5 shows the analysis of the strengths and weaknesses of PPP application to Line 2.3. At present, the first time a PPP law is under preparation in Vietnam. The current implementation is based on a decree on PPP which has some major drawbacks such as 1) guarantee by the government for minimum revenue or foreign exchange of the local currency based profits, 2) the government limitation on expenditure beyond the five-year mid-term planning horizon, 3) arbitration rules, 4) termination conditions, etc. The draft PPP law inherits the same impediments in promoting PPPs.

Even though the railway is a safe transport mode, there is a possibility of accidents. Unlike other infrastructure projects, the safety of passengers rests on the operation of the railway, which is then predicated on the quality of infrastructure construction as well. The separation of infrastructure and operation or sections by involving a PPP will lead to the issues of divisions of responsibilities and remedies once some accidents take place. In PPP, the original contracts have to take account of all the contingencies and the ways to revolve the issues through negotiation or litigation. In this sense, the arbitration conditions to be defined in the upcoming PPP will have large impacts on the direction of PPP.

In terms of railway operation experience, Vietnam has almost no experience in the urban railway sector. Given its stark differences in headways between urban and inter-city railways, lack of experience on urban railways is a major impediment for PPP. It would be difficult to set the contingency conditions in the operation stage for contractual document development or negotiations with foreign investors. In the case of the local investor as a PPP partner, there will be a total lack of experience on both partners potentially leading to extraordinary events and outcomes. A PPP arrangement will enable risk-sharing in construction activities. At the same time, the construction of a railway project requires a system integration of complex components, including civil work, signal, and control system, power distribution, tracks, rolling stocks as well as other equipment to ensure the safe operational conditions. Technical and functional complexity and multiplication in railway construction and operation require a high level of sophistication in management integration. The experience in PPP of simple roadways may not be applicable to the railway. A railway operator needs to assure the safety of passengers while maintaining the punctuality of train operations to provide more accurate trip-to-work scheduling for the passengers at large. Given the network economy that a railway system possesses, the segmentation of operations in any way could lead to the loss of scale economy or loss of technical integration.

The overall evaluations of the PPP options are shown in Table 18-5.

Table 18-5. Pros and Cons of PPP for Line 2.3

	Pros	Cons
Institution	Legally possible.	● No well-defined framework for the promotion or dispute resolution or government commitment ● The current framework does not provide a solid basis for the protection of investors to solicit well-experienced investors or provide a platform to resolve potential disputes among parties of PPP.
Experience	Possible to import experiences and know-how from overseas with a foreign investor.	Limited local knowledge in operation to form a well-prepared contract document which encompasses all the foreseeable contingencies in the operation phase.
Finance	Reduce the immediate direct financing requirement by the government.	● The overall net cash inflow for the government may be less than ODA. ● Financing arrangements could take time. ● Increased financial costs for dividend and higher loan interest payment
Construction	Sharing of risks by the private partner for construction cost escalation	● The ultimate risk of completion in excessive cost escalation rests on the government in railway PPP when the SPC defaults on the completion. ● Delay in either partner could lead to delay in entire operation start
Operation	Efficient and market responsive management (this is not the case of Option A where PPP is providing only the infrastructure)	● Loss of integrated management due to the segmented PPP only for Line 2.3. Thus there may be a loss of overall efficiency in the case of Option B. ● The clarification of responsibilities and corresponding remedies and compensations will be complicated process. ● The responsibility of safety provision by the government side is larger and the task is complicated in the case of Option B.
Schedule	Procurement and construction Period may be shorter if executed solely by the private party.	Formation of SPC, tendering and negotiation with the government could add extra time for the execution.

	Pros	Cons
Solvency	-	There is a default risk of the SPC if the investment cost escalates beyond the equity portion.
Safety and Availability	- Addition of extra rolling stocks may be quick (only applicable to Option B and C)	Increased difficulties in the distinction of responsibilities with overlapping responsibilities for safety.

Combining the overall pros and cons, the JICA Study Team finds that ODA financing is more suited at this point to revolve all the risks and daunting tasks for the countermeasures, preparations and negotiations. Furthermore, the prevailing investment promotion and PPP legal framework need to be improved to solicit well-qualified investors to cope with technical sophistication and complexity in railway business.

18.3.3 TOD Promotion Through ODA Financing

One of the biggest obstacles in creating high-quality communities in greenfield is an absence of implementation agency of urban infrastructure development. In the case of greenfield development as rightly exemplified in Line 2.3, the provision of infrastructure and organized urban developments become a chicken and egg problem. At present, the solution is only provided by a large-scale property developer who will implement the developments of infrastructure and properties simultaneously in a coordinated manner. It will require a large financing capacity to undertake such a large-scale development. As recommended in 20.2 “Project Implementation Institutional Setup for TOD/LVC”, the implementation of urban infrastructure planning and development is critical in promoting high-quality urban development. Financially it is also an option to seek the ODA funding for the concurrent infrastructure developments for roads and other utilities. A particularly important element for Hanoi north is the completion of the Ring Road 3. The financing needs as estimated in Chapter 16 are relatively small compared to the railway investment at the level of USD 300 million. Once the funding for the urban infrastructures is secured, it is possible to solicit smaller investors to participate in the urban developments of the TOD and its surrounding areas to achieve far speedier community developments along the Line 2.3 corridor.

19. Land Value Capture System for TOD

19.1 Land Value Capture Framework for TOD

19.1.1 Definition of Land Value Capture (LVC)

One of the twin goals of TOD is the achievement of land value capture. Land value capture means the transfer of increased value attached to land or location through various methods of taxing, barters, lease, or sales. Intrinsic land value enhancement will be realized on the condition of access to improved mobility nodes or enhanced business opportunities created by larger pedestrian traffics.

The term “land value capture”, was coined to draw the attention of policymakers to potential financing schemes for public transit by transferring the incremental land values generated by transit development.

19.1.2 General Tools of LVC

There are many ways to capture TOD land value increases as shown in Table 19-1. Some are monetization methods, while others rely on barters. The cash may be generated upfront or gradually over the years. There are two main categories of tax-based and development based. Vietnam has T1: Property and Land Tax, but the general level of property tax is very minimal. T2: Betterment Charges and Special Assessments are the measures to impose an extra tax for a designated area, but it is not available tools legally in Vietnam. T3 is borrowing via a bond for capital financing. It requires a well-developed bond market, which is not the case in Vietnam yet. The US has developed a variety of these so call public financing tools. The next category of development based land value capture tools is used in different parts of the world. D1 land sale or lease is possible when the government owns the land in the TOD areas. In principle, in Vietnam, the government owns all the land, while the individuals and corporations hold the right to use the land. Therefore, the government holds the ultimate authority for the transfer of user rights; however, the transfer requires negotiation and compensation much similar to land acquisition. Land sales will bring immediate cash to finance the investment required for transit development. Joint development is creating a large land parcel for development for new large-scale development with smaller or no public land in the area. D3 Air Right Sales is the monetization of rights for additional floor areas by relaxing the regulations on height restrictions, or building-to-land ratio. D3 has the advantage of being applied to the existing urban areas of relatively low density for seeking contributions from the investors. The application of this method may have much more significant impacts on the existing urban areas. Thus it may be quite useful for Line 2.1.

D4 and D5 are collective land pooling to generate money, they are widely employed in Japan to finance the required urban infrastructure mostly to widen road networks. Each landowner needs to be content with the reduction of their landholdings in the area but increases in monetary values. The understanding and believing in the tradeoff by all the stakeholders is a key to success. Land readjustment was applied first time to railway construction in Japan for the development of the Tsukuba Express, some 40 km line connection between Tokyo and Tsukuba Science City. For this implementation, the government passed a special law titled “Integrated Development of Railway and Housing” in 1989 to enable a large-scale land readjustment along the alignment.

Table 19-1. Land Value Capture Tools

Instrument		Description
Tax- or fee-based	T1: Property / Land Tax	Tax levied on the estimated value of land or land and buildings combined, with revenues usually going into budgets for general purposes.
	T2: Betterment Charges and Special Assessments	Surtaxes imposed by governments on estimated benefits created by public investments, requiring property owners who benefit directly from public investments to pay for their costs.
	T3: Tax Increment Financing (TIF)	A surtax on properties within an area that will be redeveloped by public investment financed by municipal bonds against the expected increase in property taxes. Mainly used in the United States.
Development-based	D1: Land Use Right Sale or Lease	Governments sell developers land or its development rights, whose values have increased thanks to a public investment or regulatory charge, in return for an up-front payment, leasehold charge, or annual land rent payments through the term of the lease.

Instrument		Description
	D2: Direct Single or Joint Development	A well-coordinated development of transit station facilities acquires the parcel of land adjacent to the stations singly or jointly with private property owners for the development of residential, office, or commercial properties. The development could realize one-off sales of properties or continuous flow of income for leasing or revenue sharing scheme for commercial uses. Used in Japan, the United States, and other countries.
	D3: Air Rights Sale	Governments sell development rights extended beyond the limits specified in land use regulations (such as floor area ratios [FARs]) or created by regulatory changes to raise funds to finance public infrastructure and services.
	D4: Land Readjustment	Landowners pool their land and contribute a portion of their land for sale to raise funds and partially defray public infrastructure development costs.
	D5: Land for Floor Space Trading	A landowner will trade its land rights to the floor areas equivalent in value for a space in a high-rise building to be developed by an investor.

Source: Hiroaki Suzuki, Jin Murakami, et al. "Financing Transit-Oriented Development With Land Values" D2 and D5 are modified by JICA Study Team

19.1.3 Difference From Build-Transfer Scheme

There is a clear difference from a BT scheme to the LVC. If a BT scheme is applied to the Line 2.3, the investor will undertake the construction work and deliver it to the railway company and receives the land possibly around the stations in exchange for the delivery of the constructed facilities. A BT scheme is based on an exchange of totally heterogeneous products, and the construciton infrastructure for land. The main problem with a BT scheme is the fact that the value of the land granted is not clearly or publicly exhibited, lacking in the transparency and accountability in the transaction. LVC tools also rely on the value of land, but the value aimed to be captured is materialized after the devcelopments thus the investors share the risks. In the case of a BT scheme, it is normally the excess profit arising from a normal property development. The valuation is similar but with a large degree of ambiguity leaving much room for negotiation.

In addition to ambiguity in evaluation, there are a host of problems in implementation and monitoring with regard to BT schemes. Therefore, the Ministry of Finance officially suspended the application of a new BT scheme in 2018 until the new legal framework is established.

19.2 Recommendation for LVC

19.2.1 Requirements for Establishing LVC Scheme

* *Introduction of Strong FAR Regulation*

Currently, the Hanoi land use plans regulate the development of districts by target populations. There is no precise control on FAR or building-to-area ratio. FAR defines the maximum floor areas to be developed thus closely corresponds to population targets. In terms of infrastructure planning, the current population targets give an easy-to-understand baseline for planning calculation. Therefore, the population target should be maintained as planning parameters.

At the same time, the FAR target should be introduced as planning regulation targets. FAR targets are physically easy to evaluate at the time of building design assessment and also at the time of construction. Thus it is the best simple physical target for monitoring and enforcement of regulation.

For the introduction of LVC tools, FAR regulations give the best measure for the realization of potential financial return as it defines the maximum developable floor areas to the designated land plot. The price for land sale or air rights will be determined by the net present value of the potential profit streams to accrue to the floor areas.

* *Introduction of Set Back, Height Control and Other Landscaping Regulations*

Aggressive adaptation of TOD and LVC means an increased density of people leading to larger volumes of buildings near stations. Large buildings without proper spacing prevent adequate sunlight or air circulation and also could incur a loss of privacy. The regulations to amend such instances is to set a setback regulation in relation to the height of buildings. Another issue is the irregularity of the skyline could instigate uneasiness to the residents or pedestrians. The regulation to prevent this negative impression is a skyline control. A skyline control regulation does not need to be a level but a shape, as suggested in Appendix 2 TOD Guideline. Aesthetical value is not only for eyes but for land value capture as well. The beautiful landscape always enhances the value of the area.

20. Project Implementation Institution

20.1 Project Organization For Railway

Herein we describe the general structure of railway project implementation when it is carried out as an ODA project.

Hanoi Metropolitan Railway Management Board (MRB) will be responsible for project implementation (the project investor) and official coordination with line departments and Hanoi PC as well as with the donor agency JICA. Project implementation management will be jointly carried out by MRB and the consultant hired by MRB under the supervision of the line departments and Hanoi PC. MRB will handle day-to-day coordination with districts and community stakeholders as well as with the donor agency JICA.

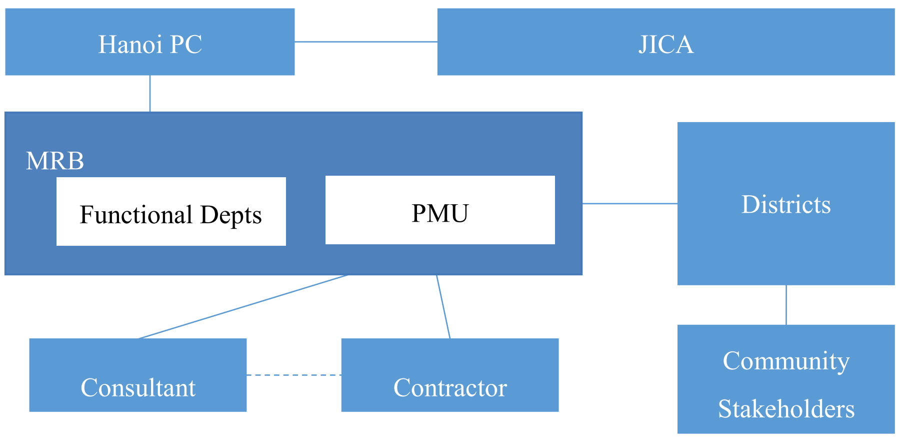


Figure 20-1. Project Implementation Structure

Relevant key agencies of the Vietnamese side who participate in the construction and operations of urban railway projects are illustrated in the following Figure **20-1**. The Central Government, Hanoi City have different functions and roles for the project implementation as shown in Table **20-1**.

Table 20-1. Project Stakeholders

Agency/Organization	Role in Project Implementation
Central Government	
MPI	-Investment policy in view of sector policy and ODA application policy -Approval of Total Investment Cost
MOF	-Application, consultation, execution of government budget -Becoming the receiving entity of ODA loan and on-lending to HANOI-PC
MOC	-Responsible for construction projects including urban development and urban infrastructures -Determination of quality standards, cost estimation standards, etc. for urban railway projects
MOT	-Responsible for national traffic and public transport sector -Determination of technical standards on traffic and E&M systems
MONRE	-Determination of EIA-related standards -Approval of EIA of nationally important projects
HANOI-PC and Line Department	
HANOI-PC	-Implementation of the Project in accordance with the decision of the Prime Minister -Responsible for key and important decisions of the Project
MRB	-Management of the Project as the implementing agency -Procurement of consultants and contractors
DPI	Budget management of the projects under HANOI-PC
DPA	-Issue of construction permits -Evaluation of consistency with city planning and impact on the urban landscape
DOT	-Management of the city's traffic and public transport sector -Leading public transport networking and common ticketing
DONRE	-Determination of EIA-related standards -Approval of EIA of nationally important projects
Land Acquisition Committee	Responsible for land purchase and acquisition
Hanoi Metro	Responsible for operation and maintenance of trains
District	
District-PC	Participation in coordination with community stakeholders

20.1.1 Project Implementation Agency

MRB was established in 2001 under the decision by HPC as the implementation agency of urban railway projects with the functions, authority and duties most recently stipulated in the Decision No. 4883/QD-UBND dated 24th July 2017 by HPC. The organizational structure of MRB is illustrated in the following Figure. MRB has four departments, namely, i) office, ii) planning and investment preparation, iii) technical appraisal, iv) accounting and finance, and two project management units.

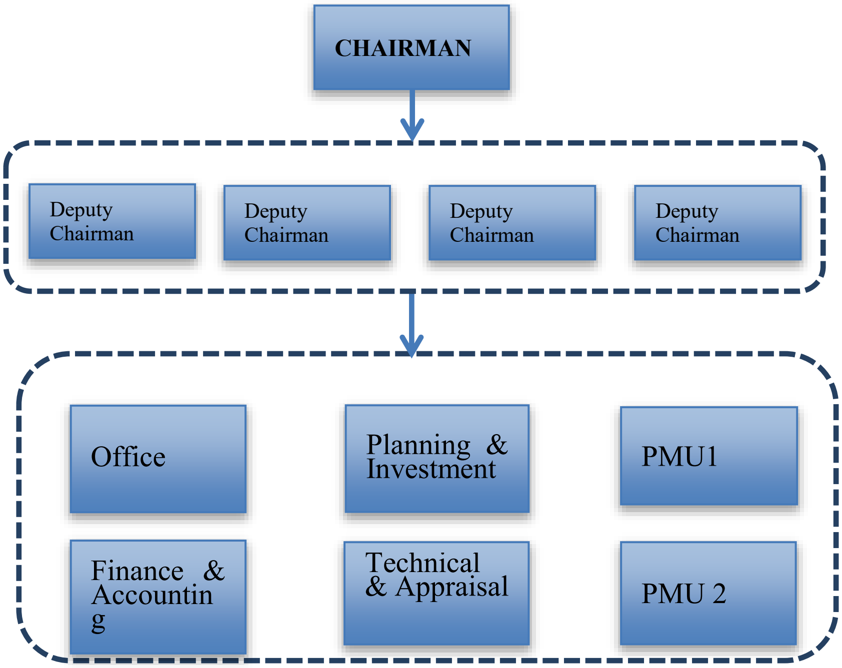


Figure 20-2. Existing MRB Organization Structure

The details of PPP organization are described in18.2.4 "Institutional Design for PPP."

20.2 Project Implementation Institutional Setup for TOD/LVC

Although the theory of TOD is easy to understand, the real challenge lies in its implementation. Usually there are many agencies involved in transport and urban development, both having completely different fields with different specialties. The coordination of the two areas is rarely done in a simple way towards a common goal.

20.2.1 Unification of Authorities Under One Umbrella

The best way for integration is to establish a new unified organization that builds the railway and develop the TOD areas under one umbrella as shown in Figure 20-3. The functions of TOD / LVC development agency start with planning including zoning modifications. The planning function should include the monitoring of property market trends to make sure the development will realize the highest values possible by limiting supplies at a time of market downturns. TOD investment/concession unit will prepare and implement the deals for the concession of TOD blocks or will undertake direct investment jointly or singly for the development of the properties on them.

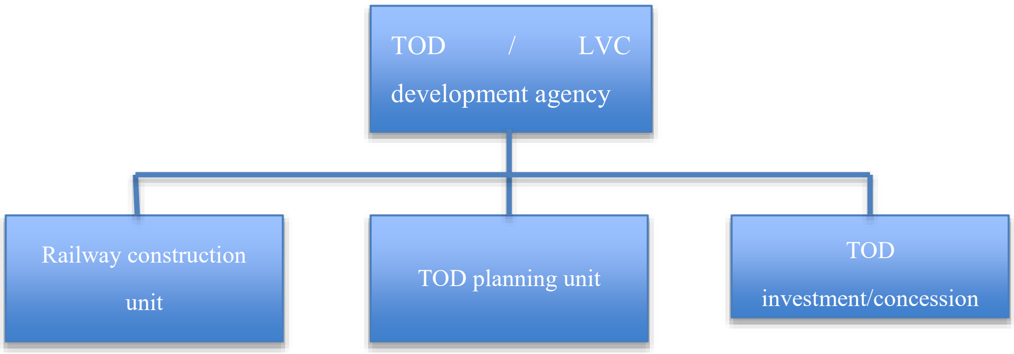


Figure 20-3. Organization of TOD/LVC Development Agency

20.2.2 Scope of Work for TOD Units

The time horizon or the duration of the TOD / LVC development agency is just as long as it takes to build a cluster of cities along the corridor of Line 2.3. The property development schedule shown in 15.5.1 assumes a 15 year period of development. Thus it would take more than 20 years from planning and preparation to completion. After developers have implemented the construction of properties, the individual investors or space renters have to occupy all the property spaces.

The activities must cover the following scopes:

1) Planning of land uses: TOD principles must be applied to revise the existing land use plans to promote pedestrian-centric high-density communities of mixed uses;

2) Strategic property development: The development of each district and plot should be designed in accordance with contemporary market needs and trends based on continual market researches;

3) Infrastructure development planning and coordination: Based on the future developments and estimated populations of designated TOD districts, planning of roads and utilities should be carried out and negotiated with organizations responsible for the development and operation of such facilities;

4) Land acquisitions and concessions: designated areas for development should be acquired at market rates comparable to the conditions without railway accessibility or adequate urban infrastructures;

5) Joint venture development: given the limitation in the capital for urban development, the TOD unit must continuously seek partnerships with private investors in urban development; and

6) Financing arrangements: sourcing of capital financing through various means of financial instruments, including ODA loans, commercial loans, bonds, and PPP.

20.2.3 Legal Framework

The current legal system, such as the Urban Planning Law and the Railway Law, does not have a clear definition of how to plan and authority for urban development in the direction of public transport. However, Chapter 7 on Urban Railway in the Railway Law stipulates in Article 70 the section on general requirements for urban railway that “Urban railway development must be in accordance with local development planning and create motivation for the process of urban development. ". This provision is important because it aims to combine the efficiency of urban railway development and urban development. This provision can be understood as a legal norm as a basis to support the promotion of urban development combined with the development of public transport.

Based on the Urban Planning Law and many other related laws, the Hanoi People's Committee issued Decision No. 70/2014 / QD-UBND on promulgating the regulation on management of general planning and architecture of the city. Hanoi (hereinafter referred to as the "Regulations"). In order to implement the idea of establishing TOD / LVC project implementation agency / unit, as well as unifying the competent agencies under an umbrella as mentioned above, the Hanoi People's Committee may revise and adjust the content of this Regulations in the direction of establishing an Agency or Steering Committee specializing in TOD / LVC, including the functional units as mentioned above by regulating and assigning some functions. The Department of Planning and Architecture for the TOD / LVC Steering Committee, for the Urban Railway Department and Hanoi Metro will be a key member with significant authority in that Steering Committee.

20.2.4 Orientation to amend the Regulations

Firstly, base on the laws and it is necessary to establish a separate chapter on TOD / LVC. Because the Railway Law also provides the basic norm of TOD / LVC development, the Regulations must also refer to the Railway Law as the legal basis. At the same time, the Regulations must establish a separate chapter on TOD / LVC as special regulation on TOD / LVC development.

Secondly, It is necessary to define the purpose and scope of TOD / LVC development. It is necessary to clearly define the scope of urban development activities and the scope of authority allowed for a TOD agency in a clear legal form to show social consensus.[3] The main objective is to promote balanced development of rail and urban areas to promote greater use of public transport, while allowing rail developers to capture an increase in land value. concerning railway development to complement the return on rail investment. The boundary of the activities must be limited to the railway corridor as a distance of 1-2 km from the urban railway system, except for some backup means such as roads and electricity. , water, sewers and drainage systems need to be expanded to connect the network. Operational authority may be limited to property development, property management and commercial services.

[3] The Japanese government passed a law allowing a public entity to buy land for both railway facilities and surrounding areas for integrated development in 1989. That helped achieve land acquisition.

20.2.5 Establish Steering Committee and TOD / LVC Development Agency

The JICA Study Team proposes the following TOD/LVC structure.

- The Steering Committee consists of Chairman of Hanoi People's Committee and members of City People's Committee, Department of Urban Railway Department, Director of Department of Planning and Architecture, relevant agencies to attend. advising the President of the Hanoi People's Committee to set up, appraise and approve zoning plans and details related to TOD / LVC development.

- TOD / LVC development agency may be formed by the Railway Administration and Hanoi Metro to make a draft of TOD / LVC development plans to submit to the Steering Committee for consideration and co-operation. In the meantime, through the functional units mentioned above under the TOD / LVC development agency, they will decide to invest, build and carry out everything related to real estate development investment within the development framework. TOD / LVC.

20.2.6 Orientation for Other Legal Issues

Land source, Land use plan: When the TOD / LVC development agency can acquire land at market prices on the basis that the price of the corresponding urban rail has not been developed, the T TOD / LVC development agency has the ability to capture land prices and that will offset the problem of low financial returns in rail business. At the same time, the operational area for TOD / LVC development should be clearly defined within the railway project impact area and not beyond that range. During the process of land acquisition and disposal, the TOD / LVC development agency should be empowered to proactively recover, buy and develop land to earn profits within the determined range of current market rates before Positive effects of railway prevails.[4]

TOD / LVC Development Investment Entities: The TOD / LVC development agency is required to self-invest, or joint venture and appoint contractors for real estate projects within TOD development / LVC. In particular, the TOD / LVC development agency should have the right to appoint or enter into joint ventures with private entities, establish procedures for selecting and appointing private investors.

[4] The HPC in its jurisdiction may acquire land without being affected by railroads or other related infrastructure development benefits. However, the legal clarification helps negotiate and resolve legal disputes. Assessing railway impact quantitatively is a challenge. The property data need to be collected to assess market fluctuations and perform factor analysis to provide benchmarks that expedite the process and avoid legal disputes.

21. Scoping for Environmental Impact Assessment

21.1 Confirmation of Environmental Setting In and Around the Project Site

(1) Existing Objects/Facilities to be Affected by the Project

Table 21-1 shows the exiting objects such as structures and facilities, residential areas, and farmlands to be affected by the implementation of the Project. The planned railway route along its northern half is located at the median or service road of the Highway (Vo Nguyen Giap), where there is no private land use, and therefore, no land acquisition or resettlement will be required. However, the southern half (from N6 to C1) of Line 2.3 is located at the private land use, and land acquisition is necessary. In addition to farmlands (parry and dry fields, orchards, fish ponds, etc.), there are about 50 residential houses in total within the ROW of the railway route; of which several houses around N7 and N8 Stations and about 50 houses are at the southern area of the Red River. Resettlement will be needed for the affected families in the residential areas, and compensation for the affected assets will be necessary.

Table 21-1. List of Existing Objects/Activities Affected by the Project

Area	Objects/Facilities to be Affected by the Project
Surroundings of Noi Bai International Airport (Section from N0 to N2)	• Trees planted in the median of the Highway (Vo Nguyen Giap) • Flyovers crossing the Highway and their piers/foundations • Road traffic in the Highway (main and approach lines) • Flights of airplanes taking-off and landing from and to the Noi Bai International Airport (relation with a height limit of the railway structure in the airport area)
Planned Construction Site of Depot	• Land acquisition (acquisition of farmlands, fish ponds, huts for farming, etc.)
Surroundings of Vo Nguyen Giap (Section from N4 to N5 stations)	• Road traffic at approach line of Vo Nguyen Giap • Existing water bodies (such as Ca Lo River) • Existing settlements located at the west of railway route (people’s daily life and economic activities) • Flyovers crossing the Highway at the north of N5 station and south of N4station • Existing transmission lines (at the south of N4 station)
Surroundings of the Railway Route from N6 Station to the Red River	• Existing settlements located at the west of railway route (people’s daily life and economic activities) • Land acquisition (farmlands, fish ponds, etc.) for ROW of the railway • Existing cemetery (access to the cemetery) • Land acquisition and resettlement of existing residential houses (approx. 10 in total) located in ROW of the railway • Farming and quarrying in the river area of the Red River
Surroundings from the Red River to Ciputra development area	• Existing houses (approx. 50 residential buildings), • Transmission lines (2 lines) • Housing environment of an existing high-class residential area near C1, • High schools and academy located in the adjacent area of the railway route

Source: The JICA Study Team

21.2 Legal Basis for Environmental and Social Considerations of the Project

Legal Basis for Environmental and Social Considerations of the Project regarding the project is shown in Table 21-2.

Table 21-2. Legal Basis for Environmental and Social Considerations of the Project

Area/Component	Title/Content
Environmental Protection	• Environmental Protection Law approved by the 13th National Assembly of the Socialist Republic of Vietnam, 7th session on 23/06/2014 and coming into effect on 01/01/2015, • Decree No. 18/2015/ND-CP dated 14/2/2015 of the Government stipulating environmental protection planning, strategic environmental assessment, environmental impact assessment, and environmental protection plan, • Circular No. 27/2015/TT-BTNMT dated 29/05/2016 of MONRE regarding strategic environmental assessment, environmental impact assessment, and environmental protection plan, • Decree No. 179/2013/ND-CP dated 14/11/2013 of the Government providing sanctions of administrative violations in the domain of environmental protection; • Circular No. 32/2015/TT-BGTVT dated 24/07/2015 of MOT regulations on environmental protection in traffic infrastructure development.
Air Quality	• Circular No. 28/2011/TT-BTNMT dated 01/08/2011 of MONRE regulating technical procedures for monitoring ambient air and noise; • QCVN 05:2013/BTNMT, National technical regulation on ambient air quality; • QCVN 06:2009/BTNMT, National technical regulation on hazardous substances in ambient air; • QCVN 19: 2009/BTNMT, National Technical Regulation on Industrial Emission of Inorganic Substances and Dusts; • QCVN 20: 2009/BTNMT, National Technical Regulation on Industrial Emission of Organic Substances.
Water Quality (Surface Water)	• QCVN 38:2011/BTNMT, National technical regulation on surface water quality for protection of aquatic lives, • Law No. 17/2012/QH13 on Water Resources; • Decree No.201/2013/ND-CP dated 27 Nov 2013 providing Stipulation on Implementation of some articles on Law on Water Resources affecting from 01 Feb 2014 (replacing Decree No.149/2004/ND-CP), • Circular No. 29/2011/TT-BTNMT dated 01/08/2011 of MONRE regulating procedures for monitoring inland surface water; • QCVN 08-MT: 2015/BTNMT, National technical regulation on the quality of surface water.
Water Quality (Groundwater)	• Circular No. 30/2011/TT-BTNMT dated 01/08/2011 of MONRE regulating the technical process of underground water monitoring; • QCVN 09-MT: 2015/BTNMT, National technical regulation on the quality of groundwater.
Water Quality (Waste Water)	• QCVN 14:2008/BTNMT, National technical regulation on domestic wastewater; • QCVN 40:2011/BTNMT, National technical regulation on industrial wastewater.
Noise	• QCVN 26:2010/BTNMT, National technical regulation on noise.
Vibration	• QCVN 27:2010/BTNMT, National Technical Regulation on vibration; • TCVN 7210:2002, Vibration and shock - Vibration emitted by road traffic - Maximum limits in the environment of public and residential areas.
Soil Contamination	• Circular No. 33/2011/TT-BTNMT dated 1 August 2011, of MONRE defining technical process of soil monitoring; • QCVN 03-MT: 2015/BTNMT National technical regulation on the allowable limits of heavy metals in the soils.
Sediment Quality	• QCVN 43:2012/BTNMT, National technical regulation on sediment quality.
Wastes	• Decree No. 59/2007/ND-CP dated 09/04/2007 on Solid Waste Management; • Decree No. 38/2015/ND-CP dated 24/4/2015 of the Government on the management of waste and discarded materials; • Circular No. 36/2015/TT-BTNMT dated 30/06/2015 of MONRE stipulating management of hazardous waste; • QCVN 07:2009 /BTNMT - National Technical Regulation on the hazardous waste threshold; • QCVN 61-MT: 2016/BTNMT: National Technical Regulation on Domestic Solid Waste Incinerator.
Protected Areas	• Forest Protection and Development Law No.29/2004/QH11, approved by the National Assembly of Socialist Republic of Vietnam dated 03/12/2004 and having effect from 01/04/2005; • Decree No.23/2006/QD-CP dated 03/03/2006 by the Government on implementation of the law on forest protection and development, • Decision No 61/2005/BNN dated 12/10/2005 on Classification of Protective Forest.
Protected Species	• Decree No.32/2006/ND-CP dated 30/03/2006 on Management of Endangered, Precious and Rare Forest Plants and Animals.
Biodiversity	• Biodiversity Law No.20/2008/QH12 approved by the National Assembly of Socialist Republic of Vietnam dated 13/11/2008; • Decree No.65/2010/ND-CP dated 11/06/2010 by the Government on detailing and guiding the implementation of biodiversity law having effect from 30/07/2010.

Area/Component	Title/Content
Forest Conservation	• Circular No. 20/2009/TT-BXD dated June 30, 2009, on amendments 20/2005/TT-BX on guidelines for urban forestry.
Land acquisition/ Involuntary Resettlement	• Law No. 45/2013/QH13 dated 29/11/2013: Law on Land; • Decree 43/2014/ND-CP of 15/05/2014 by the Government on guiding the implementation of Law on Land; • Decree 44/2014/ND-CP of 15/05/2014 by the Government on Land prices; • Decree No. 47/2014/ND-CP dated 15/5/2014 of the Government guiding compensation, support, and resettlement for land recovered by the State; • Circular No.36/2014/TT-BTNMT dated on 30 June 2014, regulating method of valuation of the land; construction, land price adjustment; specific land valuation and land valuation advisory; • Circular No. 37/2014/TT-BTNMT dated 30/06/2014 of MONRE guiding compensation, support, and resettlement for land recovered by the State.
Cultural Heritage	• Law No. 28/2001/QH10 of June 29, 2001, on Cultural Heritage; • Law issued in 2009 on Amendment and Supplement of some Articles of Law on Cultural Heritage issued in 2001; • Decree 70/2012/ND-CP on projects for reservation, restoration of historic-cultural heritage dated 18/09/2012; • Joint Circular 19/2013/TTLT-BVHTTDL-BTNMT guiding environment protection in tourism and cultural activities dated 30/12/2013 by MONRE and Ministry of Culture, Sport and Tourism; • Circular 18/2012/TT-BVHTTDL regulating on reservation and restoration of heritage dated 28/12/2012 by Ministry of Culture, Sport and Tourism.
Occupational Safety and Health	• Law No. 10/2012/QH13 dated June 18, 2012: Law on Labor Code; • Decree No. 05/2015/ND-CP on implementation of Labor Code; • Law No. 84/2015/QH13: Law on Occupational Safety and Health.

Source: The JICA Study Team

21.3 Environmental Impact Assessment (EIA) System in Vietnam

(1) Legal Basis for EIA System

The following are the basic laws and regulations for the EIA system in Vietnam:

- Law on Environmental Protection No. 55/2014/QH13 (referred to as Law 55/2014/QH13 hereinafter),
- Decree on Environmental Protection Planning, Strategic Environmental Assessment, Environmental Impact Assessment and Environmental Protection Plans No. 18/2015/ND-CP (referred to as Decree 18/2015/ND-CP hereinafter),
- Decree on Decree on Detailing the Implementation of Several Articles of the Law on Environmental Protection No. 19/2015/ND-CP (referred to as Decree No.19/2015/ND-CP hereinafter),
- Circular on Strategic Environmental Assessment, Environmental Impact Assessment, and Environmental Protection Plan No. 27/2015/TT-BTNMT (referred to as Circular 27/2015/ TT-BTNMT hereinafter).

(2) Amendment of Environmental Protection Law

The legal basis of the EIA system in Vietnam is provided by Environmental Protection Law (Law No. 55/ 2014/ QH13). The Law was amended in 2014 and enforced from January 1 in 2015. The main difference between the old law (2004) and the new one includes the following:

- A new concept of Environmental Protection Planning was introduced.
- Environmental Protection Plan was introduced substituted for Environmental Protection Commitment.

- Several new types of objects for SEA (Strategic Environmental Assessment) were added, and it was stipulated that SEA must be conducted at the same time as a formulation of the strategy, conception, and plan and be incorporated in their formulation.
- Many points were amended/added regarding EIA including the following:

- As objects subject to implement EIA, projects falling under the jurisdiction of the investment policy of the National Assembly, the Government, the Prime Minister (Article 18),
- Timing to conduct EIA is stipulated as “simultaneously with the formulation of feasibility study reports of projects in the old Law (2005), but it has been widened as the EIA shall be implemented during the preparatory period of the project in the new Law (Article 19),
- The cases that the project owner shall re-elaborate the EIA is stipulated (Article 20),
- It was required that the consultation with stakeholders including the local community shall be conducted and that the results of consultation meeting (in the form of community meeting) shall be incorporated in the EIA report (Article 21 and 22),
- Waste treatment and solutions, environmental management and monitoring programs, etc. were clearly described as the main contents of the EIA report (Article 22), etc.

(3) Screening

Four types of measures/ processes necessary for environmental conservation are stipulated in Vietnam, depending on the type of development plans and projects as listed below. Of which Environmental Protection Planning (EPP) and SEA are to be conducted by the competent authority to formulate the development plan and strategy including the master plan, and EIA and Environmental Protection Plan are to be conducted/developed by project owners.

- Environmental Protection Planning (EPP),
- Strategic Environmental Assessment (SEA),
- Environmental Impact Assessment (EIA), and
- Environmental Protection Plan.

EPP is to be formulated during the formulation of Socio-Economic Development Plans (2021-2030) of the State and Provinces, and it is classified into State level EPP and Provincial Level EPP. SEA is to be carried out during the formulation of general planning, strategy, and proposal on socio-economic and industrial developments. EIA, on the other hand, is to be conducted for the individual projects by a project owner. Environmental Protection Plan is to be formulated for individual projects with a relatively smaller scale than those mandated with EIA. These requirements are summarized in Table 21-3

Table 21-3. Screening on Environmental Conservation Measures and EIA in Vietnam

No.	Measure/Process	Objects	Legal Basis/Articles
1	Environmental Protection Planning (EPP)	Socio-Economic Development Plans (2021-2030) of the State and Provinces	Section 1 of Law on Environmental Protection（Law No.55/2014）

2	Strategic Environmental Assessment (SEA)	Formulation of strategy, planning, and proposal on socio-economic and industrial developments	Section 2 of Law on Environmental Protection (Law No.55/2014), Appendix I of Decree No.18/2015
3	Environmental Impact Assessment (EIA)	Individual Projects required by Decree No. 18/2015/ND-CP	Section 3 of Law on Environmental Protection (Law No.55/2014), Appendix II of Decree No.18/2015

Source: The JICA Study Team

(4) Necessity of EIA for this Project

Development projects requiring EIA are listed in Appendix II, Decree No. 18/2015/ND-CP. As for this Project (North Extension of Hanoi Metro Line 2, Phase 3), EIA is required pursuant to requirements of the Decree as shown in Table 20-5.

Table 21-4. Screening Result of this Project based on EIA System in Vietnam

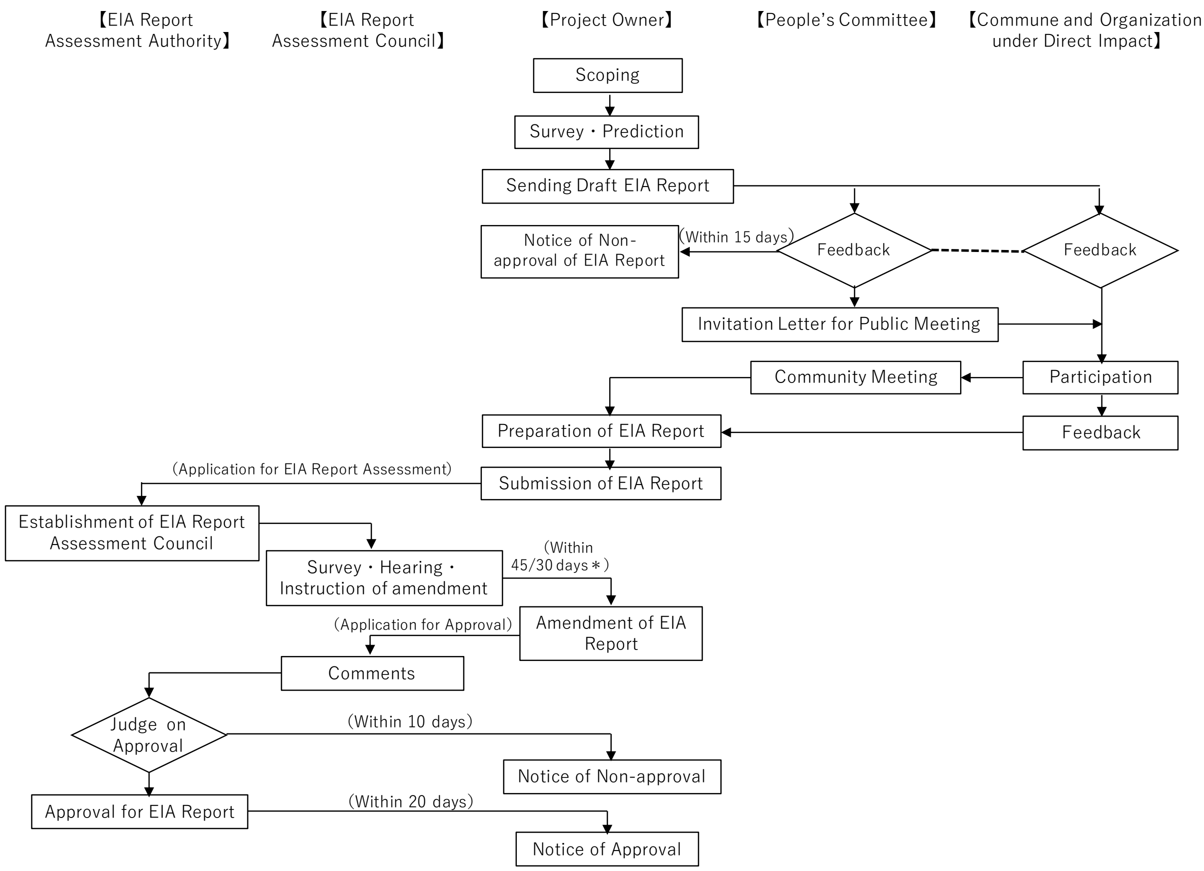
Project	Scope
Projects under competence to decide investment policies of the National Assembly, or Competence to determine investment approval of the Government or the Prime Minister	All
Construction projects for automobile highways and automobile roads from class I to III; mountainous road class IV; railways, overhead railways	All, regarding automobile highways and automobile roads from class I to III; railways, overhead railways; Length of class IV mountainous roads; at least 50 km.

Note) *: Appendix II, Decree No.18/2015

Source: JICA Study Team

(5) Procedural Flow of EIA

The procedural flow of EIA requirements is as shown in Figure 21-1.



Note) *: 45 days in case the competent authority of EIA report assessment is MONRE, and 30 days in other cases,

Source: JICA Study Team developed based on "EIA Guidebook – Vietnam Version (Revised) – for Business Development of Japanese Companies, Mar. 2018, Institute for Global Environmental Strategies."

Figure 21-1. Procedural Flow of EIA

(6) EIA Report

Main subject-matters of EIA report and report format are stipulated in Law on Environmental Protection (Law No.55/2014/QH13) and Circular Strategic Environmental Assessment, Environmental Impact Assessment, and Environmental Protection Plans (Circular No.27/2015/TT-BTNMTT), respectively, as shown in Table 21-5 and Table 21-6.

Table 21-5. Main Subject-Matters of EIA Report

(1)	Origin of the project, project owners, and the competent authority's approval of the project; method of the environmental impact assessment.
(2)	Evaluation of technological choice, work items, and any activity relating to the project which can cause bad effects on the environment.
(3)	Assessment of the current status of natural and socio-economic environment carried out at areas where the project is located, adjacent areas and demonstration of the suitability of the selected project site.
(4)	Assessment and forecast of waste sources, and the impact of the project on the environment and community health.
(5)	Assessment, forecast, and determination of measures for managing the risks of the project posed to the environment and community health.

(6)	Waste disposal measures.
(7)	Measures for minimizing the impact of the project on the environment and community health.
(8)	Consultation result.
(9)	Environmental management and supervision programs.
(10)	Budget estimate for the construction of environmental protection facilities and measures to be taken to minimize the environmental impact.
(11)	Alternatives to the application of measures for environment protection.

Source: Article 22, Law on Environmental Protection（Law No.55/2014）

Table 21-6. EIA Report Format

Table of Contents,
List of Abbreviations,
List of Tables and Figures
Preface (1. Need for and purpose of the Project, 2. The legal and technical framework for conducting EIA, 3. Conducting EIA, 4. Methods applied in EIA)
Chapter 1 Summary of Project
1.1 Project Name
1.2 Project Owner
1.3 Geographic Location
1.4 Project Description
Chapter 2 Natural Environment Conditions and Socio-economic Conditions in the Project Area
2.1 Natural Environment Conditions
2.2 Socio-economic Conditions
Chapter 3 Assessment and Predictions of Environmental Impact for Project
3.1 Assessment and Prediction
3.2 Comments about Details and Reliability of Results of Assessment and Prediction
Chapter 4 Measures for Prevention and Mitigation of Negative Impact and Response to Risks and Incidents of Project
4.1 Measures for Prevention and Mitigation of Negative Impact
4.2 Measures for Prevention and Response to Risks and Incidents of Project
4.3 Proposal for Execution of Environmental Protective Measures and Works
Chapter 5 Environmental Management and Surveillance Program
5.1 Environmental Management Program
5.2 Environmental Surveillance Program
Chapter 6 Consultation with the Community
6.1 Summary of Process of Consultation with the Community
6.2 Results of Consultation with the Community
Conclusion, Request and Commitment

Source: Appendix 2.3, Circular No.27/2015/TT-BTNMTT

(7) Assessment and Approval of EIA Report

a. The responsible authority of the assessment and approval of the EIA report

The responsible authority of the assessment and approval of the EIA report varies depending on the type and scale of the projects in question and on the organization to approve the projects as listed in Table **21-7** below:

Table 21-7. Responsible Authority of Assessment and Approval of EIA Report

Responsible Authority for Assessment and Approval	Projects as Object of EIA
a. MONRE	• Projects under competence to decide of the National Assembly, the Government and the Prime Minister, • Projects that use the land of national parks, wildlife sanctuary, etc. • Large scale projects (designated by sector), • Projects listed in Appendix II which are located in the administrative divisions of at least two provinces or on the territorial waters (Appendix III, Decree No.18/2015/ND-CP)
b. Responsible ministries and agencies to have competence in approval for investment, except for Appendix III of Decree No.18/2015	Other projects listed in the item above, which are approved for investment by ministries and agencies to have competence in approval for the investment.
c. Ministry of National Defense and Ministry of Public Security	Projects subject to national defense and security secrets and projects under their competence in approval for investment, except for projects prescribed in the item above.
d. Provincial Level People's Committee	Projects except for those listed in Item a, b, or c above.

Source: The JICA Study Team developed based on Article 14, Decree No.18/2015/ND-CP.

b. Documents Necessary for Application for EIA Report Assessment

Documents necessary for Application for EIA report assessment are stipulated in Article 6 of Circular No.27/2015/TT-BTNMTT. The project owner is required to submit the following documents to the competent authority for the application of EIA report assessment.

a) One (1) application form for EIA report assessment using the form prescribed in Appendix 2.1 of this Circular.

b) Seven (7) EIA reports of the project. If the number of members of the EIA report assessment council is more than seven (7) members, the project owner must provide additional EIA reports. The format of cover, endpaper, and requests for structure and contents of the EIA report shall use the form prescribed in Appendixes 2.2 and 2.3 of this Circular.

c) One (1) feasibility study report or investment project report or equivalent documents.

c. Period necessary for Assessment of EIA Report

Period necessary for assessment of EIA report is stipulated in clause 2, Article 14 of Decree No.18/2015/ND-CP as follows::

a) Within 45 working days from the date on which the satisfactory application is received regarding projects under assessment of the Ministry of Natural Resources and Environment;

b) Within 30 working days from the date on which the satisfactory application is received regarding projects not prescribed in Point of this Clause.

c) Documents Necessary for Application for EIA Report Approval

Documents necessary for application for EIA report assessment are stipulated in Clause 1, Article 9 of Circular No.27/2015/TT-BTNMTT. The project owner is required to submit the following documents to the competent authority for the application of EIA report approval.

a) One (1) application form for approval for EIA report,

b) Each EIA report insufficient number, with one (1) CD containing one (1) electronic text file in the format ".doc" contains the contents of the report and one (1) electronic text file in formats ".pdf" contains scanned content of the entire report (including appendixes).

c) Period necessary for Approval of EIA Report

Period necessary for approval of EIA report is stipulated in clause 2, Article 14 of Decree No.18/ 2015/ ND-CP as "Within 20 working days from the date on which the application for the EIA report approval, the head of the assessment authority shall issue the decision on the EIA report approval."

(8) Information Disclosure

a. Disclosure of EIA to the Public

Stipulations on disclosure of EIA to the public are provided in Article 131 of Environmental Protection Law, in which not only the EIA report but also the SEA report and Environmental Protection Plan are required to disclose to the public. Besides, the following information such as emission sources, emissions and treatment of waste, areas suffering from serious and particularly serious pollution, degradation, areas at risk of an environmental incident, and results of environmental inspections, are required to be disclosed to the public.

b. Stakeholder Meeting/ Community Consultation

The project owner is required to conduct public consultation during the EIA procedures. The public consultation is stipulated in Clauses 4 to 6 of Article 12 of Decree No.18/2015. Specifically, the project owner shall consult with the People's Committee of communes, wards and towns (hereinafter referred to as communes) where the project is carried out, and with organizations or community under the direct impact of the project. The project owner is also required to research and receive objective opinions and reasonable requests of relevant entities to minimize the adverse effects of the project on the natural environment, biodiversity, and community health. The procedure of public consultation is as follows::

a) The project owner shall send EIA reports to the People's Committee of the commune and organizations under the direct impact of the project together with the written requests for opinions.

b) Within 15 working days, from the date on which the EIA reports are received, the People's Committee of the commune and organizations under the direct impact of the project shall send their responses if they do not approve the project.

c) The consultation with the community under the direct impact of the project shall be carried out in the form of community meeting co-chaired by project owner and the People's Committee of the Commune together with the participation of representatives of Vietnamese Fatherland Front of communes, socio-political organizations, socio-professional organizations, neighborhoods, and villages.

The Ministry of Natural Resources and Environment (MONRE) shall provide guidance on forms of application for EIA report assessment, formulation, and issuance of EIA technical guidance.

(9) Re-compilation of EIA Report

The project owner must repeat the report on the EIA in the following cases (Clause 1, Article 20 of Law 55/2014/QH13):

a) The project is not executed within a period of 24 months as from the date on which the decision on approving the EIA report is made;

b) The project location has been changed as against the approved plan specified in the EIA report;

c) An increase in the size, capacity, and technological changes can cause adverse impacts on the environment in comparison with the approved alternatives identified in the EIA report.

(10) Gap Analysis between JICA Guidelines and EIA System in Vietnam

Based on the required contents in the EIA report for Category, a project required in the JICA Guidelines, the gap between the Guidelines and legal framework of the EIA system in Vietnam was analyzed. The result of the gap analysis is shown in Table 21-8 below:

Table 21-8. Gap Analysis between JICA Guidelines and EIA System in Vietnam

No.	JICA Guidelines (2010) / WB Safeguard Policies	EIA System in Vietnam	Gap	Measures (Proposal) to Mitigate the Gap
1	【Compliance with Laws, Standards, and Plans】Projects must comply with the laws, ordinances, and standards related to environmental and social considerations established by the governments that have jurisdiction over project sites (including both national and local governments). They must also conform to the environmental and social consideration policies and plans of the governments that have such jurisdiction.	Four types of measures/ processes necessary for environmental conservation are stipulated in the Environmental Protection Law (Law No. 55/2014/QH13) depending on the type of development plans and projects in Vietnam. EIA is one of them. Types and scales of the projects requiring EIA are stipulated in Appendix II of Decree No. 18/2015/ND-CP.	No-Gap	N/A
2	【Strategic Environmental Assessment】Underlying Principles】 environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan.	It is stipulated in Environmental Protection Law (Law No. 55/2014/QH13) that SEA is to be conducted for general planning, strategy, and proposal, but not stipulated that SEA is to be undertaken for individual projects.	SEA is not required for individual projects in Vietnam, but the alternative analysis is needed in terms of project location (refer to Item No. 3. below)	Regarding alternative analysis, not only project location but also those for technology, design, and operation shall be incorporated in the EIA report.
3	【Examination of Alternatives】 Multiple alternatives must be examined to avoid or minimize adverse impacts and to choose better project options in terms of environmental and social considerations.	It is stipulated in Circular No.27/ 2015/ TT-BTNMTT) that the description on “proposed locations (if any) and selected location” is required but not stipulated that alternatives other than project location such as technology, design, and operation, etc. are required.	The alternative analysis only for project location is required in the EIA system in Vietnam.	Same as Item No.2 above.
4	【Scope of Impacts to Be Assessed】The impacts to be assessed concerning environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna, and flora, including social impacts.	（Appendix 2.3, Circular No.27/ 2015/ TT-BTNMTT） Baseline survey should include the following elements: (1) natural environmental conditions (geography and geology, climate and meteorology, hydrography, the current quality of constituents of soil, water and air environment, and biological resources), (2) socio-economic conditions. Regarding the impact prediction of the project, natural environment components, biodiversity, community’s health, and climate change shall be assessed. Still, there is no description of the necessity of impact prediction on socio-economic conditions.	There is no gap regarding the elements of the baseline survey. As for those regarding impact prediction and assessment, there is no stipulation on socio-economic elements.	Impact prediction and assessment for socio-economic elements shall be additionally conducted to incorporate in the EIA report.
5	【Disclosure of Information/ Stakeholder Meeting】For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans.	It is stipulated in Article 12 of Decree No. 18 /2015/ ND-CP that the EIA report (draft) must be sent to the People’s Committee, and consultation with the community shall be carried out in the form of the community meeting. In this regard, the frequency (times) of holding consultation meetings is only one time at the submission of the EIA report (draft) in the Decree. However, two times of stakeholder meetings should be held at the time of scoping and submission of the EIA report (draft) in JICA Guidelines.	There is no big gap, but the stakeholder meeting is required to hold only one time at the submission of the EIA report (draft).	It should be requested to project owner that additional stakeholder meetings at the time of scoping be held.
6	【Monitoring Activity】	It is stipulated in Circular No.27/ 2015/ TT-BTNMTT that environmental	There is no stipulation in the	It should be requested to the

No.	JICA Guidelines (2010) / WB Safeguard Policies	EIA System in Vietnam	Gap	Measures (Proposal) to Mitigate the Gap
	Over a certain period of time, JICA confirms with project proponents, etc. the results of monitoring. The information necessary for monitoring confirmation by JICA must be supplied by project proponents etc. by appropriate means, including in writing. JICA discloses the results of monitoring conducted by project proponents etc. on its website to the extent that they are made public in project proponents, etc.	surveillance (monitoring) is required during the execution of the project as the results of EIA but the disclosure of the monitoring result is not stipulated in the Circular.	legal framework on the EIA system in Vietnam about the necessity to disclose the monitoring results to the public during the execution of the project.	project owner that monitoring results be disclosed to the public for a certain period of time.

Source: The JICA Study Team

21.4 Legal Framework of Land acquisition and Resettlement in Vietnam

(1) Laws and Regulations on Land Acquisition and Resettlement

The legal framework of land acquisition and resettlement including compensation to the Project-Affected Persons (PAPs) is provided in the Land Law (Law No.45/2013/QH13) and relevant decrees and circulars. According to the Land Law, “the State allocates land use rights” meaning that the State issues decisions on land allocation to transfer the land use rights to subjects having land use demand. The land-use rights may be transferred from one person to another by ways of exchange, transfer, inheritance or donation of land use rights, or capital contribution with land use rights. “The State recovers land” means the State decides to recover land use rights from a person that is allocated land use rights by the State, or from a land user that violates the Land Law.

Thus, “land use rights” is used instead of “land ownership rights,” and “land recovery” is used instead of “land acquisition” in Vietnam. In this report, “land acquisition” is used to describe the concept of the acquisition of land, as a general term, except for compulsory ones. “Land recovery” is used only for the case of quoting descriptions from Vietnam’s relevant laws, decrees, circulars, decisions, etc.

The Land Law was amended in November 2013 from the former Land Law (Law No.13/2003/QH11). In the former Land Law, the compensation price of the land use rights is to be set based on the land price provided once a year by the People’s Committee. It is, however, often pointed out that there is a big gap between the market price (the price for the transfer of land use rights) and the land price given by the People’s Committee, especially in an urban area where transaction of land use rights are often made.

In the new Land Law, the market price has been reflected in the compensation rate to some extent, and land compensation policy for development projects of the donor side has been considered. Thus, the gap between JICA Guidelines and the legal framework on land compensation in Vietnam has been substantially resolved.

Table 21-9 shows the applicable main laws and regulations on land acquisition, resettlement, and compensation in Vietnam.

Table 21-9. Main Laws and Regulations on Land Acquisition, Resettlement and Compensation in Vietnam

Date of Issue	Code/ Number	Title/Main Contents
Nov. 28/2013	Law No.45/2013/QH13	Land Law/ stipulates the regime of land use rights, powers, and responsibilities of the State, the regime of land management and use, the rights and obligations of land users.
Jun. 18/2014	Law No.49/2014/QH13	Law on Public Investment/ provides the stipulations on the plan, decision, and management regarding the public investment projects concerning the state budget.
Jun. 18/2014	Law No.50/2014/QH13	Construction Law/ stipulates the rights, obligations, and responsibilities of agencies, organizations and individuals and the state management in construction investment activities.
May 15/2014	Decree No.43/2014/ ND-CP	Decree/ detailing the articles of the Land Law
May 15/2014	Decree No.44/2014/ ND-CP	Decree/ providing regulations on land prices
May 15/2014	Decree No.47/2014/ ND-CP	Decree/ providing regulations on compensation, support, and resettlement upon expropriation by the state
May 19/2014	Circular No.23/2014/TT -BTNMT	Circular/ providing for a certificate of house ownership and other properties associated with the land
Jun. 30/2014	Circular No.36/2014/TT -BTNMT	Circular/ providing land pricing method; a compilation of and adjustment to land price tables; determination of specific land prices and consultancy on land pricing
Jun. 30/2014	Circular No.37/2014/TT -BTNMT	Circular/ detailing compensation, support, and resettlement upon land recovery by the State

Source: The JICA Study Team

(2) Procedures of Land Acquisition and Resettlement

According to Article 63 of the Land Law, land acquisition for national defense or security purpose; for socio-economic development in the national or public interest must be based on the following:

1. The projects fall in cases of land acquisition as prescribed in Articles 61 and 62 of this Law,
2. The annual district-level land use plans which are approved by competent state agencies, and
3. The land use schedule of the projects.

The cases conforming to Article 61 and 62 of the Land Law are: for the purpose of national defense or security purpose (Article 61), and socio-development in the national or public interest including national important projects and projects approved or decided by the Prime Minister, for which land must be acquired, investment projects for funded with ODA capital, and other important infrastructure development projects, etc. (Article 62).

Prior to the commencement of the land acquisition procedure, Investment Policy stipulated by the Law on Public Investment (2019) shall be approved, and Investment Decision shall be issued for the project in question. In this regard, a pre-feasibility study report shall be prepared and appraised for the approval of the Investment Policy. A feasibility study report shall be prepared and appraised for the issuance of Investment Decision.

In case that the bases, or pre-conditions stipulated by Article 63 of the Land Law are satisfied, the provincial-level People's Committee can issue a notification of land acquisition. After that, the procedure for land acquisition and resettlement is started as prescribed in Table 21-10 below.

Table 21-10. Procedures for Land Acquisition, Resettlement and Compensation Based on Land Law (2013)

No.	Steps	Descriptions	Articles/Clauses, etc. in Land Law
1	Notification of land acquisition	The provincial-level People' Committee (PC) shall notify land acquisition or authorize the district-level PC to do this. Land acquisition notification is sent to each organization, household or individual who has the land to be acquired. It is informed to local people via public meetings, local mass media and posting up at head offices of commune-level PC of localities.	Article 66 and Point a, Clause 1, Article 69
2	Conducting a Detailed Measurement Survey	The commune PC is responsible for coordinating with the organization in charge of compensation and site clearing to conduct the detailed measurement survey (DMS).	Point b, Clause 1, Article 69
3	Preparation of Plan for Compensation, Support and Resettlement Plan (Plan for CSR)	The organization in charge of compensation and site clearing shall prepare the Plan for Compensation, Support and Resettlement Plan (Plan for CSR).	Clause 2, Article 69
4	Collection of public comments on the Plan for CSR	Opinions of affected people are collected during the preparation of the Plan for CSR through the meetings with affected people in the project area; and through the notice of the plan at the commune PC offices, the public places in the communes. Opinions of affected people on the plan shall be recorded in minutes with confirmation of representatives of Commune PC, representatives of Commune Fatherland Front, and representatives of people whose land is acquired. The organization in charge of compensation and site clearing shall be responsible for summarizing these opinions in writing, with clear descriptions on the number of agreed and disagreed opinions, as well as the number of opinions, differed from the Plan for CSR. If the number of disagreed opinions is large, the responsible organizations have to explain to affected people. The organization in charge of compensation and site clearing shall adjust the Plan for CSR and submit it to the competent agency.	Point a, Clause 2, Article 69
5	Appraisal of the Plan for CSR	The competent agency appraises the Plan for CSR and submits it to the People's Committee for approval.	Point b, Clause 2, Article 69
6	Decision on land acquisition and decision on approval of the Plan for CSR	The authorized PC issues the decision on land acquisition and decision on approval of the Plan for CSR on the same date.	Point a, Clause 3, Article 69
7	Disclosure of the Plan for CSR	The organization in charge of compensation and site clearing shall coordinate with the commune-level PCs in disseminating the decision approving the Plan for CSR and post it at the offices of the commune-level PCs and public places in the affected residential areas. The decision on compensation, support and resettlement will be sent to each affected person, indicating the compensation and support level, arrangement of resettlement house or land (if any), time and place for paying compensation and allowances, and time for handing over the acquired land to the organization in charge of compensation and site clearing.	Point b, Clause 3, Article 69
8	Compensation payment	The organization in charge of compensation and site clearing shall pay compensation and allowances according to the approved Plan for CSR.	Point c, Clause 3, Article 69
9	Transferring ownership	The organization in charge of compensation and site clearing is responsible to manage the acquired land and hand over it to the project proponent.	Clause 4, Article 69

Source: The JICA Study Team arrangement of this table based on Land Law (2013)

(3) Procedures of Land Acquisition in Hanoi City

Procedure and requirement for acquiring land and resettlement in Hanoi City are prescribed in Decision 10/2017/QD-UBND dated 29th March 2017 issued by Hanoi PC. The procedure prescribed in the Decision is conformable to that of Land Law 2013 described above.

(4) Entitlement Matrix

According to Decision No. 10/2017/QD-UBND (issued by Hanoi PC on 29th March 2017), an entitlement matrix for a development project with land acquisition in Hanoi City where this Project is located is shown in Table 21-11:

Table 21-11. Entitlement Matrix for Development Projects with Land Acquisition in Hanoi City

Affected Objects	Eligible Persons / Level of Impact	Entitlements/ Detail/ Articles/Clauses, etc. in Decision No.10, Hanoi City
1. Residential land	Household or individual whose residential land is entirely acquired or area of the remaining residential land is smaller than 30m2 in town which is not enough to build a structure and does not have any other residential land or house in the same commune.	1) Household or individual who loses residential land with legal land use right and the land is located in the districts in the central area of Hanoi City will be compensated with one (01) housing block in the resettlement apartment for one (01) land user (Clause 2, Article 7). 2) Household or individual who loses residential land with land use right and the land is located in suburban areas will be compensated with residential land (Clause 3, Article 7). 3) If household or individual who loses residential land with legal land use right prefers compensation by cash regardless of the location of the acquired land, they will be compensated by cash and be provided with support for self-resettlement. (Article 30)
2.Non-agricultural land (except for residential land)	Household or individual who loses non-agricultural land but not the residential land	Compensation by cash with the rates specified for non-agricultural land (Article 8).
3. Cost of investment into the land to be acquired	Affected people who had invested in the land subject to be acquired (refer to Article 76 of the Land Law)	Compensated by cash with the rates classified by the type of agricultural land (such as wet rice paddy land, annual plants land, perennial trees land, aqua-cultural land); production forest; and non-agricultural land) (Article 10)
4. Houses/ structures	Partial impact: An unaffected portion of the house is not viable for use	Compensation for the whole house (Points a, b, Clause 1, Article 12).
	Partial impact: An unaffected portion of the house is still viable for use	Compensation for the demolished part, and an additional amount for reconstruction of the house (Points c, d, Clause 1, Article 12).
		Note) Depreciation shall be applied: The current value of affected house, structure are calculated based on the depreciation period (Clause 2, Article 12). Temporary house, other structures supporting agricultural production activities: 100% new-build value compensation.
5. Transportation expense	Affected household who has to relocate	Provision of compensation for relocation. The compensation rate depends on the location of the relocation site.
6. Grave / tomb	Affected household who has grave to be relocated	Grave / tomb to be relocated to the cemetery yard prepared by the state shall be compensated depending on the type and dimension of the grave/tomb in accordance with the prescribed rate in Article 17, and Decision 06/2017/QD-UBND, Appendix 3).
7. Crops, trees, livestock	Affected household	Department of Finance annually issues the rates for crops and trees, un-removable livestock to be the basis for district-level PC to decide the compensation rates (Article 18). For removable livestock, district-level PC decides the compensation for loss and transportation allowance, not exceed 30% the compensation rate.
8. Land in the protection corridor	Affected people/household	District level PC proposes a solution to Hanoi City PC for consideration and decide the specific compensation and support level for land located in the protection corridor of the project and the use of land is restricted (Clause 5, Article 19).

Affected Objects	Eligible Persons / Level of Impact	Entitlements/ Detail/ Articles/Clauses, etc. in Decision No.10, Hanoi City
9. Support to stabilize the living and production	Affected household stated in Clause 5, Article 4 of Decree 01/2017/ND-CP	Support allowances to households to be relocated are prescribed as following (Clause 1, Article 21): Allowance for living stabilization for one person is equal to 30 kg of rice per month and is paid (01) one time when paying compensation. The price of rice is determined annually by the Department of Finance.
	Economic organizations, households, and individuals running a business, foreign-invested enterprises stated in Clause 5, Article 4 of Decree 01/2017/ND-CP	Support allowances are prescribed as following (Clause 2, Article 21): Support for stabilizing production in cash equal to 30% of the annual income after tax, according to the average income of the preceding three years. It is paid (01) one time when paying compensation.
	Laborers employed by economic organizations, households and individuals, foreign-invested enterprises, as stated in Clause 5, Article 4 of Decree 01/2017/ND-CP	Support allowances are prescribed as following (Clause 2, Article 21): Support for job suspension with the allowance calculated based on the minimum salary rate multiplied with job levels of the relevant profession according to the current regulations of the State for a maximum period of 06 months. Pay (01) one time when paying compensation.
10. Support for vocational training, job change and job search	Affected household who directly engaged in agricultural production as stated in Clause 5, Article 4 of Decree 01/2017/ND-CP	The level of support for training, job change and job-seeking is equal to 5 (five) times of the agricultural land price issued by Hanoi People's Committee (Clause 1, Article 22).
	Affected household, individual who is using agriculture land as stated in Clause 6, Article 4 of Decree 01/2017/ND-CP	Support for vocational training, job change and job search (one time of support depending on the area of acquired land) (Clause 2, Article 22).
11. Other supports	Affected household and individuals whose land are acquired and have to relocate	An additional support to stabilize living in cash for the actual number of person(s) living in the acquired area (Clause 1, Article 24).
	Households, individuals who have to rent houses for temporarily residing during the transition period	Support allowance provided in Clause 2, Article 24.
	Organizations whose land are acquired and have to relocate offices, production facilities	Support allowance to rent a temporary office, production factory, workshop, store, etc., with a maximum duration of 12 months (Clause 3, Article 24):
	Social policy beneficiary families who are certified by the Department of Labor, War Invalids and Social Affairs, and have to relocate for the project	Support allowance is 3 - 7 Million VND / house owner or landowner (Clause 4, Article 24):
		Note) Bonus: All affected households moving out of the affected area right after receiving the compensation and support receive a bonus from 1 to 5 Million VND/household (Clause 5, Article 24).
12. Resettlement	Project affected household, individual who has to relocate when the State acquires land, but is not eligible to be compensated with residential land	If they do not have any other place for residing in the same commune/ward/town, they are considered for support in resettlement as follows: (Clause 1, Article 27): - In case they expect to buy resettlement apartments: they are eligible to purchase one small-sized block in the resettlement apartment prepared by the City. - In case they expect to receive resettlement land: they are eligible to have 1 plot of residential land.
	Household, an individual who is using residential house or land from encroachment before 1st July 2004 and has to relocate when the State acquires land but has no other place to move in.	They are eligible to buy one block with the smallest area in the resettlement apartment prepared by Hanoi City or to buy one resettlement land plot sized 30m^2, etc. (Clause 2, Article 27).
		Note) Other cases: Household who has entitlements as stated in the Clauses described above but does not expect to receive residential land or apartment is eligible to rent or buy the social house (Clause 3, Article 27).
13. Support for resettlement by oneself	Affected household, individual who has to relocate and prefers to relocate by oneself	Affected households being eligible to resettlement are urged to take compensation by cash. In such a case, they will be provided with certain support for "cash compensation" issued by Hanoi City PC (Article 30).

Affected Objects	Eligible Persons / Level of Impact	Entitlements/ Detail/ Articles/Clauses, etc. in Decision No.10, Hanoi City
		An affected household who is eligible to resettlement and expect to buy a house under the housing development projects or in a new urban area in the City territory may obtain an allowance equal to one time of registration fee.
14. Other supports	An affected household who has not enough money to obtain a resettlement house or apartment	District level PC shall consider the measure to allow affected households to rent the block in the resettlement apartment, instead of buying such block (Article 31).

Source: The JICA Study Team arrangement based on Decree No. 10/2017/QD-UBND issued by Hanoi PC

(5) Methods of Setting Compensation Rate for Land Acquisition

According to Article 13 of the Land Law, the State has the right to decide the land price. Accordingly, the State has the right to prescribe the principles and methods to determine land price, issue the land price frames, land price tables, and make decisions on land prices (Article 18). In this regard, the Central Government shall promulgate the "land price frames" every five years for each type of land and each region in the country. The provincial-level PCs shall develop the "land price tables" every five years and submit it to the People's Councils of the same level for review and consent.

In addition, the provincial level PC shall make a decision on the "specific land prices." The specific land prices shall be used as a basis for several tasks, including the calculation of compensation amount upon land acquisition by the State. According to Clause 3, Article 114 of the Land Law, the specific land price is determined based on the investigation, collection of information about land parcels, market land price and information on land price, and based on suitable valuation methods. And according to Article 4 of Decree 44/2014/ND-CP, the following methods stated as "suitable valuation methods" are used for land pricing: (1) direct comparison method, (2) subtraction method, (3) income-based method, (4) surplus-based method, and (5) method using land price coefficient.

(6) Process of Public Participation for Planning of Compensation, Support and Resettlement

The Land Law stipulates the process for Public Participation for Planning of Compensation, Support and Resettlement. In Clause 2, Article 69 of the Law, the following stipulations are provided for the preparation and appraisal of the Plan for Compensation, Support and Resettlement (Plan for CSR):

- The organization in charge of compensation and land acquisition shall make the Plan for CSR and coordinate with the commune-level PC in the locality to conduct consultations on the Plan for CSR in the forms of meetings with land users living in the acquired area, posting up the Plan for CSR at offices of the commune-level PC and at common public places of the residential areas of which land is acquired.
- The consultation results must be recorded in minutes which are certified by representatives of the commune-level PC, land users whose land is acquired, etc.
- The organization in charge of compensation and land acquisition shall make a written summarization of opinions which clearly specifies the numbers of opinions for, against and other opinions regarding the Plan for CSR; coordinate with the commune-level PC in the locality in

organizing dialogues with those who have objections on the Plan for CSR; and improve the Plan for CSR for submission to competent agencies.

(7) Application of Donor's Policy on Land Acquisition, Resettlement and Compensation

Land Law stipulates that in case of conflict in policies of Vietnam legal framework and donor's guidelines on land acquisition, resettlement and compensation for loss caused by projects, donor's policy shall be applied by the stipulation "*For projects using loans from international or foreign organizations for which Vietnam has committed to a policy framework for compensation, support and resettlement, that framework policy shall apply*" (Clause 2, Article 87). In this connection, there is also a similar prescription in Decree No. 16/2016/ND-CP under Law on Public Investment (Law No.49/2014/QH13). Therefore, if there is some conflict in the policy of Vietnam legislation with JICA Guidelines, the Project proponent can require the application of JICA guidelines.

(8) Points of Public Investment Law in terms of Investment Project

a. Overview

The Public Investment Law (Law No.49/2014/QH13), which was promulgated in providing the stipulations on the plan, decision, and management regarding the public investment projects with respect to the state budget. This law is composed of six (6) chapters including 108 articles. Article 1 stipulates the management and use of the capital budget for public investment; the state management of public investment; the right, obligation, and responsibility of agencies, organizations, and individuals involved in public investment activities. Articles 6 to 10 provide the criteria for the classification of investment projects, and Articles 19 to 27 stipulate the authority to decide the investment policies, procedures and necessary documents for the decision of the policy. Articles 39 to 45 stipulate the approval of Project Investment Decision of public investment projects, procedural steps of formulation, appraisal, and decision for public investment project, including projects financed by ODA funds, documents necessary for the approval of the projects, etc.

b. Classification of Public Investment Projects

Public investment projects are classified into National Important Projects, Group-A Projects, Group-B Projects, and Group-C Projects, depending on their purpose/sector and scale.

National Important Projects: Projects using a sum of VND 10,000 billion as budget capital for public investment, those having the possibility of creating substantial impacts on the environment such as nuclear power plants, projects requiring the conversion of land use purpose such as a national park, a wildlife sanctuary, etc. (Article 7);

Group-A Projects: Except for national important projects described above, projects located at extremely important areas in terms of national defense and security, projects with the purpose of energy development financed by the total investment amount of more than VND 2,300 billion, projects with the purpose of infrastructure development financed by the total investment amount of more than VND 1,500 billion, etc. (Article 8);

Group-B Projects: Projects with the purpose of energy development financed by the total investment amount ranging from VND 120 billion to below VND 2,300 billion, projects with the purpose of infrastructure development financed by the total investment amount ranging from VND 80 billion to below VND 1,500 billion, etc. (Article 9);

Group-C Projects: Projects with the purpose of energy development financed by the total investment amount of below VND 120 billion, projects with the purpose of infrastructure development financed by the total investment amount of below VND 80 billion, etc. (Article 10);

Articles 17 and 39 stipulate the authorities to decide on investment policies on public investment programs and projects, and the decision on investment program or project, respectively.

c. Decision of Investment Policy

The National Assembly has the authority to decide on investment policies on public investment programs and projects of a) National target program and b) National important project. The policies of target programs are required for decision by the Government, those of Group-A projects are by the Prime Minister, and those of Group-B and C projects are by heads of ministries and central agencies, the People's Councils, and the People's Committee depending on their source of budget and funds.

Requirements and procedures for the decision of investment policies are stipulated in Articles 19 to 27. National important projects, Group-A projects and the projects financed by funds derived from ODA are required to prepare a pre-feasibility study report and be subject to appraisal for approval. The contents of the pre-feasibility study report are stipulated in Article 35, including a general plan for site clearing, compensation, residential resettlement, environmental protection measures, and initial analysis and evaluation of impacts on the environment and society.

d. Decision of Investment Program/Project

Article 39 of the Law stipulates the authority to make decision on investment program or projects. The Prime Minister shall have the authority to decide (a) national target projects, (b) target project subject to the Government's decision, and (c) investment programs and projects funded by ODA fund, etc. The investment programs or projects policies of Group-A, Group-B and C projects are to be decided by heads of central bodies, the President of provincial People's Committee, and the President of district/communal People's Committee depending on their source of budget and funds.

Requirements and procedures for the decision of investment programs/projects are stipulated in Articles 44 to 45. National important projects and the projects financed by funds derived from ODA are required to prepare a feasibility study report and be subject to appraisal for approval. The contents of the feasibility study report are stipulated in Article 47, in which construction projects are required to abide by the provisions of Construction Law (Law No.50/2014/QH13). The Construction Law (Article 54) stipulates a plan on construction ground clearing and resettlement (if any), assessment of the project's impacts related to land acquisition, ground clearing and resettlement; protection of landscape and ecological environment, etc. as necessary contents of the feasibility study report.

(9) Gaps between JICA Guidelines and Laws on Land Acquisition and Resettlement in Vietnam

Based on the discussion so far and analysis of legal framework on land acquisition, resettlement and compensation, the results of comparison (gap analysis) between JICA Guidelines including WB OP 4.12 and Vietnamese legislation is shown in Table 21-12.

Table 21-12. Comparison of JICA Guidelines with Laws on Land Acquisition and Resettlement in Vietnam (Gap Analysis)

No.	JICA Guidelines/ WB Safeguard	Legal Framework in Vietnam/ Hanoi City	Gap	Policy to fill up the gap (Proposal)
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives (JICA Guidelines)	In Vietnam's legal framework, the measures to avoid or reduce involuntary resettlement and loss of means of livelihood are not clearly stated. However, the obligation to conduct EIA (environmental impact assessment) for infrastructure development projects is stipulated in the Construction Law. And then, the obligation to conduct project alternative analysis during EIA is stated. Consequently, measures to avoid/ mitigate impacts on land acquisition and resettlement shall be discussed during the analysis of project alternatives and the EIA report preparation process.	No big gap.	Not necessary
2	When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected. (JICA Guidelines)	According to the Land Law, preparation of the Plan for Compensation, Supports, and Resettlement (the Plan for CSR) is obligatory when the State acquires land from the people. It may be considered as a measure to minimize the impact caused by the project to affected people. Consultation with affected people on the content of the Plan for CRS is also stated in the Land Law and other regulations relevant to land acquisition.	No big gap.	Not necessary
3	Project owners must make efforts to enable people affected by a project and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels. (JICA Guidelines)	In Article 83 of the Land Law, the principles of supports to be given to affected people are stated, including supports to stabilize living and production, vocational training, finding new jobs, establishing new businesses, etc. Article 85 of the Land Law stipulated the necessity of infrastructure development in the resettlement site. And, Article 86 states that in case people having land acquired are resettled while the amount of compensation and support is not enough to buy the minimum resettlement plot, the State shall make up the deficit.	No big gap.	Not necessary
4	Compensation, at full replacement cost, must be provided as much as possible. (JICA Guidelines)	[Compensation for land] The Land Law states that *"specific land price"* shall be applied to calculate the compensation for the acquired land. And Decree No.44/2014 stipulates that information on market land prices shall be collected, synthesized, and analyzed to determine the *"specific land price."* However, it is said that the *"specific land price"* determined by local government is usually different from the replacement cost defined under JICA Guidelines. [Compensation for structures] Article 89 of the Land Law specifies that the compensation amount shall be equivalent to the	[Compensation for land] *"Specific land price"* is not the same as replacement cost. [Compensation for structures] [Compensation for structures]	Ensuring compensation at full replacement cost under the JICA Guidelines.

No.	JICA Guidelines/ WB Safeguard	Legal Framework in Vietnam/ Hanoi City	Gap	Policy to fill up the gap (Proposal)
		value of new construction facilities equivalent to technical standards prescribed by a specific law. However, it is not clear whether "equivalent to the value of new construction" has the same meaning of "replacement cost" under JICA Guidelines or not. Also, according to Article 9 of Decree No.47/2014/ND-CP, compensation for the affected houses/ structures prescribed in Clause 2, Article 89 of the Land Law shall be equivalent to total existing value of the affected houses/structures, and the amount of money is calculated in percentage of the current value (i.e., residual value) of such houses/structures. Thus, the compensation for affected houses/structures is not equivalent to "full replacement cost" due to consideration of depreciation.	Compensation is not always provided at full replacement cost.	
5	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in a timely manner. (JICA Guidelines)	According to the Land Law (Clause 2, Article 83), supports to affected people shall include: (1) supports to stabilize living and production, (2) supports for vocational training, changing job, seeking new jobs, and (3) support to resettle. And *"supports in vocational training, job changing and job seeking to households and individuals directly involved in agricultural production upon expropriation of agricultural land"* are stipulated in Article 20 of Decree 47/2014/ND-CP. Similarly, *"supports in vocational training, job changing and job seeking to households and individuals whose inhabited land linked with business and services thereon is subject to expropriation"* is stipulated in Article 21 of Decree 47/2014/ND-CP. However, there is no stipulation on the measure to ensure the efficiency of these supports. In actuality, supports are provided but usually do not meet the requirement of affected people.	There is a stipulation on compensation/support to PAPs but there is no stipulation to ensure fair compensation and sufficient supports in a timely manner.	Ensuring fair compensation and sufficient supports in a timely manner pursuant to JICA Guidelines.
6	For projects that will result in large-scale involuntary resettlement, resettlement action plan (RAP) must be prepared and made available to the public (JICA Guidelines)	Plan for CSR shall be prepared and approved for any project that needs to require land acquisition, regardless of the scale of resettlement.	No big gap, although the contents of the Plan for CSR is not completely the same as those of RAP.	Not necessary.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA Guidelines)	The Land Law (Clause 2, Article 69) stipulates that "People's Committee in the locality shall conduct consultations on the Plans for Compensation, Supports and Resettlement in the forms of meetings with land users living in the acquired area, post up the Plan for Compensation, Supports, and Resettlement at offices of the commune-level People's Committee and at common public places of the residential areas of which land is acquired.".	No gap.	Not necessary.
8	Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and	PAPs are consulted about compensation and support policies, resettlement plan when the Plan for CSR is drafted (Land Law), as above mentioned in item No.7.	Necessity of monitoring during the implementation stage of	Ensuring formulation and implementation of the monitoring plan

No.	JICA Guidelines/ WB Safeguard	Legal Framework in Vietnam/ Hanoi City	Gap	Policy to fill up the gap (Proposal)
	monitoring of resettlement action plans and measures to prevent the loss of their means of livelihood. (JICA Guidelines)	And according to the Land Law (Clause 3, Article 84), "During the process of making plans for vocational training, job changing and job seeking, provincial- and district-level People's Committees shall organize consultations with, and give an explanation and assimilate opinions from, people whose land is acquired." However, during the stages of implementation and monitoring of the Plan for CSR, the participation of affected people, and consultation with them are not stipulated.	resettlement is not stipulated in the legal framework in Vietnam.	pursuant to JICA Guidelines.
9	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA Guidelines)	The Land Law (Article 204) stipulates the affected people's right to raise complaints. The order and procedures for settling complaints about administrative decisions or administrative acts involving land comply with the Law on Complaints (Law No.02/2011). The order and procedures for settling lawsuits against administrative decisions or administrative acts involving land comply with the Law on Administrative Procedures (Law No.93/2015). Law on Complaints (Article 7) prescribes the mechanism to raise and settle complaints.	No big gap.	Not necessary
10	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey including population census that serves as an eligibility cut- off date, asset inventory, and socioeconomic survey. Preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. (WB OP 4.12 Para. 6)	Affected people are identified only after the notification of land acquisition. According to the Land Law (Clause 1, Article 69), the process to identify affected people are as following: Step 1: Identification of the affected households by mapping the affected land lots, and using the cadastral maps and data to identify the land user. Step 2: Conduct the Detailed Measurement Survey (DMS) to identify affected households, household members, affected assets, etc. Consequently, the day of notification of land acquisition can be considered as the cut-off date, but it is not always at an early stage of a project. However, there is no clear stipulation on the measures to prevent the subsequent influx of encroachers who wish to take advantage of the benefits to be provided to affected people.	Notification of land acquisition, which is corresponding to cut-off-date, is to be issued at not always an early stage of a project. There is no specific stipulation to prevent an influx of encroachers of others in Vietnam.	Baseline surveys are to be conducted at an early stage of the project (before notification of land acquisition). The first day to enter the project site for the surveys shall be clearly set as a cut-off-date.
11	Eligibility to benefits includes (1) PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law) (2) PAPs who do not have formal rights to land at the time of census but have no recognized legal right to the land they are occupying. (WB OP 4.12 Para. 15)	Eligibility for receiving compensation when the State acquires land is stipulated in detail in Article 75 of the Land Law. According to this Article, the land users who are entitled to compensation, supports and resettlement shall satisfy the following conditions: a) Those who have a certificate of land use right or ownership of non-land assets; b) Those who do not have a certificate of land use right or equivalent documents, even though being eligible to have such certificates but not granted that certificate yet. In addition, according to Article 77 of the Land Law, for agricultural land which was used before July 01, 2004, of which land users are households and individuals directly engaged in agricultural production but have not been granted a certificate or not being eligible to be granted a certificate of s and ownership of houses and other land-attached assets under this Law, the compensation must be made for the land area which is actually used and does not	Those who do not have ownership of non-land assets, or who do not have a certificate of land use right or equivalent documents are not eligible to receive compensation.	To take appropriate measures depending on the actual situation of PAPs in the project sites regarding eligibility to benefits following WB OP4.12.

No.	JICA Guidelines/ WB Safeguard	Legal Framework in Vietnam/ Hanoi City	Gap	Policy to fill up the gap (Proposal)
		exceed the agricultural land allocation quota prescribed in Article 129 of this Law.		
12	Preference should for the given to land-based resettlement strategies for displaced persons whose livelihood are land-based. (WB OP 4.12 Para. 11)	According to the Land Law (Clause 2, Article 74): "The compensation must be made in the form of allocating new land with the same land use purpose with the acquired land. If there is no land available for compensation, the land users shall receive compensation in money.	Compensation for land acquisition is to be done in the allocation of new land as a primary responsibility, so there is no big gap (no interference).	Not necessary
13	Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4.12, para.6)	There is no stipulation on the support for the transition period.	There is a gap between Vietnam and the donor side.	To make sure the support to resettled PAPs for the transition period in accordance with WB safeguard.
14	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP 4.12 Para. 8)	There is no stipulation on the particular attention to vulnerable groups.	There is a gap between Vietnam and the donor side.	To make sure the particular attention to vulnerable groups of PAPs in accordance with WB safeguard. WB
15	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, an abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Similarly to Item 6 above, the Plan for CSR shall be prepared and approved for any project that needs to require land acquisition, regardless of the scale of resettlement.	Basically, there is no gap although the contents of RAP and the Plan for CSR are completely the same.	Not necessary

Source: The JICA Study Team

21.5 General Issues on Land Acquisition, Resettlement and Compensation Seen in Vietnam

In this Study, a Land Acquisition Framework Survey was conducted by sub-contracting to a local consulting firm, in which the legal framework of land acquisition, resettlement and compensation in Vietnam and their actual situation was surveyed through case studies of the following three (3) infrastructure projects.

1. Song Hinh Hydroelectric Power Dam Construction Project (Construction Period: 1995-2001),
2. Long Thanh – Dau Giay Expressway Construction Project (Construction Period: 2009-2015), and
3. Da Nang – Quang Ngai Expressway Construction Project (Construction Period: 2013-2018).

The following description summarizes the results of the case studies focusing on issues often seen in Vietnam on land acquisition, resettlement, and compensation related to development projects.

(1) Timing to Conduct Baseline Surveys on Land Acquisition and Resettlement

There are differences in necessary surveys and their timing between those required in Vietnamese legislation and donor sides. Specifically, baseline surveys such as census survey, socio-economic survey, inventory of loss and replacement cost survey, preparation of Resettlement Action Plan (RAP), and conduct of EIA and approval of EIA report, etc. are required in parallel with pre-feasibility and/or feasibility studies, which are the stages before Loan Agreement (L/A) in donor sides. In contrast, these surveys and processes are to be conducted after the L/A (Article 6, Land Law) in Vietnam. Monitoring during the project implementation and operation is strictly required in the donor side while there is no clear stipulation on its requirement in the legal framework in Vietnam.

(2) Accuracy of Information Described in RAP

As mentioned above, there is a difference in the timing to conduct baseline surveys with respect to the land acquisition of development projects between donor sides and Vietnam. A series of surveys related to land acquisition is to be commenced after the issuance of the notice of land acquisition. Therefore, it is difficult to do interviews and meetings with project-affected persons (PAPs) in the project site and to prepare RAP before the notification of land acquisition. It is, therefore, challenging to obtain the necessary information with an accuracy required by the donor side and prepare a RAP, which often causes a big gap/conflict in data/information in RAP prepared before L/A and updated one prepared after it.

(3) Rate of Land Compensation

There are a lot of conflicts between land users whose land is acquired and the Government with respect to the compensation price for land acquired in the infrastructure development projects in Vietnam. According to government statistics, 70% of citizen's complaints are related to land disputes and many of them have remained in a deadlock for a long time.

According to the Land Law, the local authorities shall establish the annual "specific land prices" and use these prices for determining compensation land prices when acquiring land from people. However, affected people are usually discontented about these "specific land prices," saying that they are too low compared with the market land prices. On the contrary, the local authority explains that they would face many difficulties if people affected by other projects in the same locality could request them to apply the same compensation price as market land price, while the local authority has a limited budget to accommodate the requests.

Another issue is such that these "specific land prices" are usually determined at the time before the project implementation; however, after the commencement of the project, the land use purpose is changed, and it leads to a significant increase in the land price. For this reason, people who lost land are usually discontented and think that compensation is not fair. Despite the above description, there are also such cases in recent years that replacement cost surveys were periodically (semi-annually) carried out (case study 2 and 3) upon the request of donors (ADB, WB), and the results were adopted to calculate compensation rate under the approval of project proponent.

(4) Development of Resettlement Site

The following complaints were often voiced by affected people who were relocated to the resettlement sites arranged by local authorities for implementation of development projects in Vietnam:

- Lack of consultation with affected people on the resettlement construction plan,
- Poorly developed infrastructure (roads, etc.), public facilities (school, clinic, etc.), utilities (electricity, etc.) and housing,
- Difficult to carry out business activities in the resettlement sites,
- Limited access to the benefits of the project such as irrigation, fishery, and electricity,
- Resettlement sites are usually located far from PAP's existing resident, thus it causes discontinuation of the relationship between PAP and their relatives and people in the existing commune, and
- Inadequate consideration of the receiving communities.

These issues are identified in case study 1, which is rather old (construction period: 1990 – 2001) project.

(5) Support for Livelihood Recovery of Displaced PAPs

Restoration of livelihoods is one of the most difficult challenges of the resettlement process and often results in the need for significant resources. However, the need to establish and implement comprehensive plans with an aim to restore the livelihood of displaced people is not described clearly in Vietnam's legal framework.

In the Land Law and other relevant decrees or circulars, there are many articles which prescribe in detail the contents of compensation and support as measures for mitigating impacts mostly caused by "physical displacement" (i.e., relocation or loss of shelter or land). However, measures with an aim to mitigate impacts caused by "economic displacement" (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) are totally ignored in Vietnam's legal framework. For this reason, in Vietnam, the concept of "baseline socio-economic surveys" (which help to capture both the standard of living and all the types of livelihood that displaced people are dependent on) is not familiar among local government officers.

Displaced people may lose their traditional jobs and need to find new means of livelihood. Still, they are generally provided with compensation or supports by cash instead of supports for establishing sustainable means of livelihood. Furthermore, there is also such a case that cultural and non-material losses (traditional culture, belief, etc.) were also ignored even though indigenous people (Ede and Bana) are included in PAPs who had to resettle (case study 1).

Besides, the investors and local authorities do not pay due attention to the livelihood restoration plans proposed by donors in case of projects with ODA funds. Consequently, the tasks of monitoring and evaluating the effectiveness of the livelihood restoration plan are almost ignored in many projects.

However, there is such a case in recent years that an Income Restoration Plan (IRP) was prepared and implemented with ADB's fund aiming to stabilize livelihood activities or sources of sustenance of severely-affected and vulnerable households.

(6) Measures for Socially Vulnerable Groups

For projects financed by international donors or JICA, the organization of local stakeholder consultation is required from the early stage of resettlement planning. Besides, according to Vietnam's legal framework, such a consultation meeting shall be organized after the Plan for CSR is drafted. Therefore, affected people cannot participate in the process of resettlement planning from the early stage. Furthermore, the following shortcomings are seen in many projects in Vietnam:

- Lack of stakeholder analyses before the meetings,
- Lack of information provided to stakeholders before the meetings,
- Lack of assessment of the special needs of the poor and vulnerable households, and
- Lack of separate meetings with the poor and vulnerable households.

As for "lack of needs assessment," the third item above, is also identified in the case study 1. Even though there were various needs of relocated PAPs in the resettlement site for requesting support for farming, no adequate consideration was provided.

(7) Grievance Redress Mechanism

Article 204 of the Land Law 2013 prescribes that: "Land users and people who have land use-related rights and obligations are entitled to lodge complaints about, or file lawsuits against, administrative decisions or administrative acts in land management." (Clause 1); and "The order and procedures for settling complaints about administrative decisions or administrative acts involving land comply with the Law on Complaints (Law No.02/2011/QH13). The order and procedures for settling lawsuits against administrative decisions or administrative acts involving land comply with the Law on Administrative Procedures (Law No.93/2015/QH13)" (Clause 2).

According to Article 7 of the Law on Complaints, the procedure for lodging grievances on compensation, resettlement generally consists of the following four steps:

Step 1: PAPs who are not satisfied with the compensation, resettlement, or with the process may file their complaints/petitions to the Commune People's Committee (CPC);

Step 2: If PAPs are not satisfied with the decision of CPC, they may appeal to the District People's Committee (DPC);

Step 3: If PAPs are still not satisfied with the decision of DPC, they may elevate the complaint to the Provincial People's Committee (PPC); and

Step 4: If PAPs are still dissatisfied with the decision of PPC, they may escalate the complaint to the court of law.

However, the grievance redress mechanism in Vietnamese is complicated, and it normally takes a long time for a reply. In this regard, taking a long time to resolve complaints is also pointed out in case study 3. The cause of the problem is related to that the province, district and commune PC are authorities to receive the complaints as well as solving the problems while they are also the units issuing approval decision for compensation, land acquisition, and resettlement plan. Thus, this overlap of functions and obligations will harm the transparency of the resettlement plan implementation.

(8) Monitoring and Post-evaluation

In Vietnam's legal framework, there is no clear stipulation on the requirement of monitoring and evaluation of the implementation of the resettlement plan (such as the Plan for CSR). In Article 199 of the Land Law, there is a stipulation which prescribes the right of the citizen to supervise and report on wrongdoings and violations in land management and land use. However, it does not require each project to monitor and evaluate the resettlement outcomes and their impacts on the standards of living of displaced people. Of course, there is also no requirement to engage an external expert to monitor the implementation of the resettlement plan. After the completion of the land acquisition as prescribed by the procedure, there is no agency that takes on the responsibility to follow up and/or monitor the progress of livelihood restoration among displaced people.

For projects financed by international donors, external monitoring is usually required to monitor the compliance of safeguards throughout project implementation. Project proponent usually hires independent consultants for this task. However, they cannot always receive cooperation from local authorities since they are not administrative authorities. Furthermore, the project proponents usually do not pay due attention to utilize the external monitoring results to figure-out the problems and improve the performance of the resettlement plan. In addition, there is no stipulation on the need to carry out the post-project evaluation in Vietnam's legal framework. Therefore, most of the projects funded by the state budget do not perform this task.

Despite the above description, there is also such a case in recent years that external monitoring, i.e., Social Safeguard External Monitoring, was conducted by a local consulting firm hired by the project proponent (case study 3).

21.6 Identification of Impact Sources Associated with the Implementation of the Project

(1) Impact Source

This project is the railway construction project with a length of approx. 18km from C1 station, which is the terminal station of Metro Line Phase 2.1, to N0 station at the terminal 2 of Noi Bai International Airport. The details of the project are described in Section 5-9 and Table **21-13.** shows the potential impact sources by project stage: pre-construction, construction, and operation.

Table 21-13. Potential Impact Sources of the Implementation of the Project

Project Stage	Potential Impact Sources
Pre-construction	• Demolition of existing structures and facilities including residential houses • Displacement of existing infrastructures and utilities located in the project site (ROW)

	• Land acquisition and displacement of people living in the project site (ROW) • Compensation for affected assets by the implementation of the project
Construction	• Land preparation (vegetation removal, topographic and geological survey) • Earth works including excavation and backfilling • Transportation of construction equipment and materials and construction wastes (solid, liquid and hazardous ones) • Operation of basecamp including office and accommodation • Tunneling* works (when necessary) for railway construction • Construction works of viaduct including a bridge** across the rivers (when necessary) • Operation of construction equipment and vehicles
Operation	• Existence of railway structure (viaduct, bridge** or tunnel*) • Modification of land use (an increase of impermeable ground) • Operation and maintenance of train, stations and depot • Influx of people into the railway stations and surrounding areas

Note) *: In case of tunnel construction across the Red River, **: In case of bridge construction across the Red River.

Source: The JICA Study Team

(2) Impact Matrix

Relation of the potential impact sources itemized above and potential impacts including pollution, and impacts on natural and social elements are shown in

Table 21-14. In the table, environmental and social elements are set under the JICA Guidelines. It should be noted that due to the limitation of the survey period because of the nature of this data collection survey, collected information for developing the matrix is not always enough and therefore this analysis is preliminary level.

Table 21-14. Impact Matrix for the Project

No.	Project Stage	Pre-construction stage				Construction stage							Operation stage			
	Impact sources / Environmental and social elements	Demolition of existing structures and facilities including residential houses	Displacement of infrastructures and utilities	Land acquisition and displacement of people living in the project site	Compensation for affected assets	Land preparation (vegetation removal, topographic and geological survey)	Earth works including excavation and backfilling	Transportation of construction equipment and materials and wastes	Operation of basecamp including office and accommodation	Tunneling works (when necessary) for railway construction	Construction works of viaduct including a bridge across the rivers (when necessary)	Operation of construction equipment and vehicles	Existence of railway structure (viaduct, bridge and tunnel)	Modification of land use (increase of impermeable ground)	Operation and maintenance of trains, station and depot	Influx of people into the railway stations and surrounding areas
(1)	**Physical Environment/ Pollution**															
	1. Air pollution	B-				B-	B-	B-		B-		B-			B-	
	2. Water pollution	C-				B-	B-		B-	B-	B-				B-	B-
	3. Noise and vibration	B-				B-	B-	B-	B-	B-	B-	B-			B-	
	4. Soil contamination	C-								C-					C-	
	5. Wastes	B-				B-	B-		B-	B-	B-				B-	B-
	6. Ground subsidence									C-						
	7. Offensive odor	C-							C-			C-				
(2)	**Natural Environment**															
	1. Topography and geology					B-	B-			B-						
	2. Soil erosion					B-	B-									
	3. Groundwater flow/level						C-			B-			C-	B-		
	4. Hydrological situation (flooding)					B-	B-							B-		
	5. Terrestrial flora and fauna / terrestrial ecosystem					B-	B-									
	6. Aquatic organisms / aquatic ecosystem					B-	B-									
	7. Protected area															
	8. Threatened species					C-	C-									
(3)	**Socio-economic Environment**															
	1. Involuntary resettlement			A-	A-											
	2. Local economy (livelihood and employment and livelihood)	C-	C-	C-	C-				B±		B±					A+
	3. Land use / Usage of local resources			B-		B-										
	4. Water use/ water rights		C-				C-			C-					C-	C-
	5. Social institution / Social infrastructure		C-							C-						
	6. Historical and cultural heritages															
	7. Road traffic / Water transportation	B-						B-		B-	B-				A+	
	8. Landscape	B-				B-	B-				B-		A±	B±	A±	B±
	9. Infectious diseases such as HIV/AIDS								C-							

Note) A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent. C+/-: Possibility of impact and its magnitude are unknown. (Further examination is needed, and the impact could be clarified as the study progresses.) D: No impact is expected. Source: JICA Study Team

(3) Preliminary Scoping of EIA for the Project

Table 21-15 shows the result of the preliminary scoping of EIA for the Project. In this regard, due to the uncertain part of the construction plan, namely, that the structure to cross the Red River is constructed with a bridge or a tunnel, it should be noted that the scoping in the table covers both cases.

Table 21-15. Preliminary Scoping for the Project

Environmental Elements	Assessment			**Reason for Assessment**
	Pre-construction	Construction	Operation	
(1) Physical Environment / Pollution				
1. Air pollution	B-	B-	B-	【Pre-construction】 Dust (TSP) will be generated during the demolition of existing structures and facilities including houses and transportation of wastes (demolished materials). 【Construction】 Dust and emission gas will be generated during various types of civil works (land preparation, earth works, transportation of construction materials, tunneling, operation of construction equipment and vehicles, etc.). 【Operation】Emission gases will be generated during maintenance works at Depot.
1. Water Pollution	C-	B-	B-	【Pre-construction】 Water pollution would be generated during the demolition of drainage facilities installed at the existing structures and facilities including houses. 【Construction】Turbid water will be generated at the sites of various types of civil works during heavy rain, and wastewater will be generated from offices and accommodation in the base camp. 【Operation】 Waste water will be generated from railway stations, offices, and Depot during maintenance works.
2. Noise and Vibration	B-	B-	B-	【Pre-construction】 Noise and vibration will be generated during the demolition of existing structures and facilities including houses and transportation of wastes 【Construction】Noise and vibration will be generated during various types of civil works and operation of base camp. 【Operation】 Noise and vibration will be generated from train operation.
3. Soil Contamination	C-	C-	C-	【Pre-construction】 Soil contamination pollution would be generated during the demolition of drainage facilities installed at the existing structures and facilities including residential houses. 【Construction】 There is the possibility of soil contamination in excavated materials from tunneling work. 【Operation】 There is the possibility of soil contamination if the wastewater generated at Depot is not adequately treated/disposed during maintenance work.
4. Wastes	B-	B-	B-	【Pre-construction】Various types of solid wastes will be generated during the demolition of existing structures and facilities including houses. 【Construction】Construction wastes will be generated during railway construction including tunneling work and bridge construction. Various types of wastes (solid and liquid) will be generated from base camp (office and accommodation). Hazardous waste including used oil and oil-mixed wastes will be generated during construction works. 【Operation】Various types of wastes (solid and liquid wastes) will be generated during railway operation and

Environmental Elements	Assessment			Reason for Assessment
	Pre-construction	Construction	Operation	
				population influx. Wastewater and hazardous wastes would be generated during maintenance work at Depot.
5. Ground Subsidence	D	C-	D	【Pre-construction】There is no impact factor to generate ground subsidence. 【Construction】There is the possibility of ground subsidence during tunneling work. 【Operation】There is no impact factor to generate ground subsidence.
6. Offensive odor	C-	C-	D	【Pre-construction】Offensive odor would be generated during the demolition of drainage facilities installed in the existing structures and facilities including houses. 【Construction】Offensive odor would be generated from the base camp and during the operation of construction equipment and vehicles. 【Operation】There is no impact factor to generate offensive odor.
(2) Natural Environment				
1. Topography and Geology	D	B-	D	【Pre-construction】There is no impact factor to cause topographic and geologic modification. 【Construction】There will be a modification of topography and geology due to various types of civil works (land preparation, earthwork, tunneling, etc.). 【Operation】There is no impact factor to cause topographic and geologic modification.
2. Soil Erosion	D	B-	D	【Pre-construction】There is no impact factor to cause soil erosion. 【Construction】There will be the possibility of generation of soil erosion during heavy rain due to various types of civil works (land preparation, earthwork, etc.) accompanied by the removal of vegetation. 【Operation】There is no impact factor to cause soil erosion.
3. Groundwater Flow/Level	D	B-/C-	B-/C-	【Pre-construction】There is no impact factor to change groundwater flow/level. 【Construction】There is a possibility to change groundwater flow/level during tunneling work. 【Operation】There is the possibility of groundwater drawdown due to the decrease of recharge water in the ground to be caused by alteration of land use. There is a possibility of a change of groundwater flow/ level due to the existence of a tunnel.
4. Water Regime (Flooding)	D	B-	B-	【Pre-construction】There is no impact factor to change the surface water regime. 【Construction】Discharge of rainwater will increase during various types of civil works (land preparation, earthwork, etc.) accompanied by the removal of vegetation, which will cause a negative impact on existing drainage facilities. 【Operation】Discharge of rainwater will increase due to alteration of land use, i.e., increase of impermeable ground cover.
5. Terrestrial Flora and Fauna, and Ecology	D	B-	D	【Pre-construction】There is no impact factor to affect terrestrial flora and fauna, and ecology. 【Construction】Vegetation cover will be removed in the project site (ROW) during land preparation and earthworks, which would adversely affect terrestrial ecology around the project area. 【Operation】There is no impact factor to affect terrestrial flora and fauna, and ecology.
6. Aquatic Organisms, and Ecology	D	B-	D	【Pre-construction】There is no impact factor to affect aquatic organisms and ecology. 【Construction】Water bodies located in the project site (ROW) will be backfilled, and the water regime will be changed during land preparation and earthworks,

Environmental Elements	Assessment			Reason for Assessment
	Pre-construction	Construction	Operation	
				which would affect aquatic ecology in and around the project area. 【Operation】 There is no impact factor to affect aquatic organisms and ecology.
7. Protected Area	N/A	N/A	N/A	There is no protected area in and around the project area.
8. Protected Species	D	C-	D	【Pre-construction】There is no impact factor to affect protected species. 【Construction】Protected species growing/inhabiting in and around the project site, if any, would be affected during land preparation and earthworks accompanied by removal of vegetation and change of water regime. 【Operation】 There is no impact factor to affect protected species.
(3) Social Environment				
1. Involuntary Resettlement	A-	A-	D	【Pre-construction/ Construction】Land acquisition in the project site (ROW) and resettlement of the Project-Affected Families (PAFs) living in the ROW (approx. 100 in total) will be needed (in case of bridge construction across the Red River). 【Operation】There is no impact factor to newly cause land acquisition/ involuntary resettlement.
2. Local economic activities (livelihood/ employment)	C-	B±	A+	【Pre-construction】Demolition of existing structures and facilities including houses, land acquisition and resettlement, and compensation for lost assets would affect the livelihood of PAPs and the local economy. 【Construction】 Employment of local people is expected for the construction works and operation of base camp. On the other hand, construction works will cause impacts on daily life and traffic, which will cause an adverse impact on the local economy. 【Operation】Train operation and population increase will greatly contribute to the local economy.
3. Land Use and Usage of Local Resources.	B-	B-	D	【Pre-construction/ Construction】Land acquisition in the project site (ROW) will affect agriculture products in farming (paddy and dry field, and orchard) and aquaculture in the fish pond. 【Operation】There is no additional impact factor to affect land use/usage of local resources.
4. Water Use/ Water Rights	C-	C-	C-	【Pre-construction/Construction】Water use would be affected by the demolition and displacement of existing water supply and sewerage facilities. 【Operation】 Operation of railway and influx of population will increase water use, which would affect existing water use around the project area.
5. Social Institution/ Social Infrastructure	C-	C-	D	【Pre-construction/ Construction】 Utility facilities located along the planned railway route would be affected by the demolition of existing structures and construction works of the railway. 【Operation】There is no impact factor to affect social institutions/ infrastructures.
6. Historical and Cultural Heritage	N/A	N/A	N/A	There is no historical and cultural heritage in and around the project area.
7. Road Traffic/ Water Transportation	B-	B-	A+	【Pre-construction】 Road traffic will be affected during the transportation of wastes (demolished materials). 【Construction】 Transportation of construction equipment and materials and wastes would cause traffic jams and accidents, as well as an adverse impact on daily life and economic activities of the local community. 【Operation】Operation of the railway will mitigate traffic volume on Vo Nguyen Giap connecting Hanoi City and Noi Bai International Airport.
8. Landscape	B-	B-	B±/A±	【Pre-construction/construction】 Demolition of existing structures and facilities including houses during pre-construction, and various types of civil works (land

Environmental Elements	Assessment			Reason for Assessment
	Pre-construction	Construction	Operation	
				preparation, earthworks, construction of the viaduct, etc.), as well as operation of base camp, will change landscape along the railway route. 【Operation】Existence of the railway and its operation, as well as the change of land use and an influx of population in and around the project area will change the landscape from suburban to urban landscape.
9. Infectious Diseases (HIV/AIDS, etc.)	D	C-	D	【Pre-construction】There is no impact factor to generate infectious diseases. 【Construction】Influx of construction workers would generate infectious diseases including HIV/AIDS in and around the project area. 【Operation】There is no additional impact factor to generate infectious diseases.
10. Other Elements (Poverty Group, Indigenous People/ Ethnic Minority, Misdistribution of Benefit, Local Conflicts of Interest, Gender/ Socially Vulnerable Group, Rights of Children, etc.)	-	-	-	There is no enough information to analyze the impacts of the project.

Note) A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent. C+/-: Possibility of impact and its magnitude are unknown. (Further examination is needed, and the impact could be clarified as the study progresses.). D: No impact is expected.

Source: The JICA Study Team

(4) Methodology of Baseline Survey and Impact Prediction of the Project (Proposal)

Based on the result of preliminary scoping above, the methodology of the baseline survey and impact prediction of the implementation of the project, including the evaluation criteria of the impacts was examined and summarized in Table **21-16**. In this regard, due to the uncertain part of the construction plan, namely, whether the structure to cross the Red River is constructed with a bridge or a tunnel. It should be noted that the description in the table covers both cases.

Table 21-16. Methodology of Baseline Survey and Impact Prediction (Proposal)

Environmental Elements	Baseline Survey	Objects and Method of Impact Prediction
(1) Physical Environment/Public		
1. Air Pollution	Status of air quality/ air pollution: Survey item: Ambient air quality with parameters (TSP, PM2.5, NOx, SOx, CO, HC, etc.). Survey method: Primary data collection (sampling and laboratory analysis) and secondary data collection and analysis. Survey location: Selected points along the planned railway route.	Pre-construction/ Construction: Prediction of types of heavy machine and vehicles to be used for demolition works of existing structures and facilities, various types of civil works for construction of a railway, and transportation of construction materials of wastes. Based on the types of heavy machine and vehicles, emission factors will be identified/set by pollutants (TSP, NOx, SOx, CO, HC, etc.). The number of heavy machine and vehicles will be predicted, by which emission volume and concentration of pollutants will be predicted. Operation: Type of emission gas including pollutants and volume during maintenance works at Depot will be predicted based on empirical values.
2. Water pollution	Status of water quality (surface water and groundwater): Survey item: Concentration of representative parameters (pH, DO, BOD,	Pre-construction: Possibility to generate water pollution during the demolition of existing structures and facilities will be described.

Environmental Elements	Baseline Survey	Objects and Method of Impact Prediction
	TSS, Coliform, etc.) and pollutants (heavy metals, oil, and grease, etc.). Survey method: Primary data collection (sampling and laboratory analysis) and secondary data collection and analysis. Survey location: River and other water bodies and groundwater along the planned railway route.	Construction: Pollution load in wastewater to be generated from base camp will be quantitatively predicted by the parameters (BOD, TSS and T-Coliform). Types of liquid wastes (wastewater from concrete work, tunneling work, piling work, etc.) to be generated during construction will be identified and the possibility of water pollution in the water body and groundwater around the project site will be described. Operation: Types of liquid wastes including hazardous ones and their volume to be generated from railway stations, offices and during maintenance works at Depot will be estimated and the possibility of discharge to surrounding areas and causing water pollution will be described.
3. Noise and Vibration	Ambient noise and vibration: Survey item: Noise level and vibration level. Survey method: Primary data collection (field measurement). Survey location: Selected points along planned railway route, including a residential area, school, hospital/clinic, if any, etc.	Pre-construction/ Construction: Prediction of types of heavy machine and vehicles to be used for demolition works of existing structures and facilities, various types of civil works for construction of a railway, and transportation of construction materials of wastes. Noise and vibration levels at benchmark points will be confirmed/ set based on the secondary data by type of heavy machine and vehicle. The number of heavy machine and vehicles, as well as their operation pattern, will be predicted, and finally, noise and vibration levels will be quantitatively predicted. Operation: Noise and vibration from train operation will be quantitatively predicted using a simulation model.
4. Soil contamination	Status of soil contamination: Survey item: concentration of pollutants (heavy metals, oil and grease, etc.) in the soil and record of past land use, if any, at the tunneling site, and the possibility of soil contamination. Survey method: Primary data collection (sampling of soil and laboratory analysis), and secondary data collection and analysis. Survey location: Section of tunneling of the planned railway route.	Pre-construction: The possibility of soil contamination due to drainage of wastewater during demolition work of existing structures and facilities will be described. Construction: The possibility of soil contamination of excavated materials to be generated from tunneling work will be described based on the analysis result of the soil contamination survey. Operation: The possibility of soil contamination due to drainage of liquid waste during maintenance work at Depot will be described.
5. Wastes a. Pre-construction Municipal wastes (solid)	Inventory of existing structures and facilities including houses to be demolished.	Based on the inventory of baseline, types and volume of wastes to be generated as the result of demolition of existing structures and facilities including houses will be calculated.
b. Construction Municipal wastes (solid)	Secondary data collection on type and volume of solid waste per capita (unit generation) to be generated from base camp.	The total volume of solid wastes from base camp will be calculated based on the number of construction workers including engineers to be mobilized and the survey result of unit generation.
Construction waste (solid)	Secondary data collection on types and volume of construction wastes, Confirmation of waste management system including collection, treatment and disposal and its legal basis in Hanoi City.	The volume of construction wastes such as concrete debris, excavated materials (soil and rock), etc. will be estimated based on the construction plan of the project. The possibility of illegal disposal of construction wastes will be described.
Municipal waste (liquid)	Secondary data collection on the volume of wastewater per capita (unit generation) to be generated from base camp.	Pollutant loads (BOD, TSS, T-Coliform, etc.) and concentration of the pollutants in the wastewater will be quantitatively predicted based on the number of construction workers including engineers to be mobilized and the unit generation of wastewater per capita.
Construction waste (liquid)	Secondary data collection of sources and types of wastewater to be generated from construction work.	Types and volume of wastewater to be generated during the construction works such as concrete work, tunneling, piling work, etc. will be estimated, and the possibility of discharge of the wastewater to surrounding water bodies will be described.
Hazardous waste	Secondary data collection on types and volume of hazardous waste including oil-mixed waste from construction work. Confirmation of waste management system including collection, treatment and disposal and its legal basis in Hanoi City.	Types and volume of hazardous wastes (used oil, solvent, oil-mixed materials, bentonite, etc.) to be generated during the construction works will be estimated. The possibility of scattering/discharge and illegal disposal of hazardous waste will be described.

Environmental Elements	Baseline Survey	Objects and Method of Impact Prediction
c. Operation Municipal wastes (solid/ liquid)	Confirmation of the manpower necessary for operation and maintenance for the project (Hanoi Metro Line 2.3) and expected passengers as the source of waste generation (solid and liquid).	Types and volume of solid wastes to be generated from railway stations, offices and passengers will be estimated. Types of wastewater to be generated from railway stations, offices and passengers, as well as the concentration of pollutants included in the wastewater, will be estimated.
Industrial waste	-	Types and volume of wastewater to be generated during maintenance work at Depot will be predicted.
6. Ground subsidence	Geology, soil property and groundwater: Survey item: geology (stratigraphy, the existence of soft ground, if any), soil property (consolidation, permeability), groundwater level, etc. Survey method: Boring survey, geotechnical test, inspection at the borehole, secondary data collection and analysis at a nearby location, if any. Survey location: Area along the planned railway route.	Construction: The possibility of ground subsidence will be described based on the tunneling method (a type of civil work) to be adopted by the project.
7. Offensive odor	Source of offensive odor: Survey item: Confirmation on if there is a source of offensive odor such as sewerage facility in the structures and facilities to be demolished. Survey method: Inventory through field reconnaissance. Survey location: Project site, especially the site requiring demolition of existing structures and facilities.	Pre-construction: The possibility of offensive odor to generate during the demolition of existing structures and facilities will be described. Construction: The possibility to generate offensive odor from base camp and operation of heavy machine and vehicles will be described.
(2) Natural Environment		
1. Topography and geology	Topography and geology: Survey item: topography (elevation, gradient, etc.), geology (stratigraphy, soil property, etc.), hydrogeology (permeability, groundwater level, etc.). Survey method: Boring survey, geotechnical test, inspection at borehole, etc. Survey location: Selected locations along the planned railway route.	Construction: Dimension/degree of topographic modification based on the civil work plan (land preparation, earthwork, and tunneling) will be described. The volume of earthwork and excavated materials will be calculated and the way of disposal and/or efficient use of excavated materials will be described.
2. Soil erosion	Status of vegetation: Survey item: Area of vegetation cover in the project site, Survey method: Measurement of an area on the aerial photo (Google earth), Survey location: Project site (ROW).	Construction: Area of vegetation removal due to various types of civil works (land preparation, earthwork, and tunneling, etc.) will be estimated, and the possibility of soil erosion will be described.
3. Groundwater flow/ level	Status of groundwater: Survey item: Groundwater level, permeability, soil property, groundwater recharge, Survey method: Primary data collection (actual survey of groundwater level at borehole), laboratory analysis for soil property, secondary data collection and analysis on meteorological conditions such as annual rainfall, runoff coefficient, etc. Survey location: Selected location along the planned railway route	Construction: Change of groundwater flow/level will be predicted/simulated using a mathematical model. Operation: Change of groundwater level to be caused by a decrease of groundwater recharge will be estimated. The possibility of a change of groundwater flow/level around the tunnel section of the railway route will be described.
4. Hydrological situation (flooding)	(1) Meteorological condition: Survey item: Rainfall including the number of rainy days and record-high daily maximum rainfall, temperature, humidity, wind direction, and velocity, etc. Survey method: Secondary data collection and analysis. Survey location: meteorological stations in Hanoi City	Construction: The possibility of flooding and inundation due to an increase of rainwater discharge to be caused by vegetation removal will be described. Operation: The possibility of flooding and inundation due to an increase of rainwater discharge to be caused by the change of land use, specifically, an increase of impermeable ground cover will be described.

Environmental Elements	Baseline Survey	Objects and Method of Impact Prediction
	(2) Past flooding record: Survey item: Record on the water level, if any, at the hydrological station, or rivers /other water bodies along the planned railway route, and record of past inundation, if any. Survey method: Secondary data collection. Survey location: Area along the planned railway route.	
5. Terrestrial flora and fauna, and ecology	Terrestrial flora and fauna, and ecology: Survey item: Vegetation, flora, and fauna (growing/inhabiting species), existing tree species, kinds of crops, etc. Survey method: Primary data collection (inventory). Survey location: Project site (ROW) and its surrounding area.	Construction: Impact on vegetation, trees, and crops (area of vegetation removal, the number and species of trees to be cut/ displaced, area of farmland, etc.) will be described based on inventory results and construction plan of the project.
6. Aquatic organisms, and ecology	Aquatic organisms and ecology: Survey item: Inhabiting aquatic organisms (fish and benthos). Survey method: Primary data collection and secondary data collection (hearing). Survey location: River/pond located along the railway route.	Construction: Impact on aquatic organisms and ecology to be caused by modification of land (earthwork and backfilling of ponds, etc.) and increase of rainwater discharge as the result of vegetation removal, etc. will be described.
7. Protected area		There is no protected area in and around the project area.
8. Protected species	Status of growing/inhabiting protected species: Survey method: Confirmation on if there are protected species based on the inventory results of terrestrial flora and fauna and aquatic organisms. (Ref. item 5. Terrestrial flora and fauna, and ecology, and item 6. Aquatic organisms and ecology)	Construction: The possibility of an impact on protected species will be described based on the inventory results of terrestrial flora and fauna and aquatic organisms.
(3) Socio-economic Environment		
1. Involuntary resettlement	Status of project-affected-families and assets: Survey item: Status of project-affected-families and assets. Survey method: Census and socio-economic survey on affected families. Inventory on affected assets (private properties and public facilities), replacement cost survey. Survey location: project site (ROW).	Pre-construction/Construction: Calculation of necessary land acquisition (location and area), affected families and assets (types and the numbers), and compensation amount of affected assets will be done based on the results of the baseline survey. In addition, the resettlement site of affected families will be examined and proposed. Livelihood recovery measures will be examined and proposed.
2. Local economy (Livelihood and employment)	Confirmation of houses and utility facilities to be affected based on inventory results of existing facilities including houses (ref. item 5. Wastes, (1) Physical Environmental/ Pollution, and item1. Resettlement, (3) Socio-economic Environment)	Pre-construction: Possibility of the impact of demolition work, various types of civil works on daily life and the local economy will be described. Construction: Impact of transportation of construction materials and wastes on road traffic and local economic activities will be described calculating the additional traffic volume of construction activities of the project. The possibility of employment of local people as a construction worker (non-skilled) will be described. Operation: Economic effect by the railway operation will be described based on the result of cost-benefit analysis.
3. Land use/ Usage of local resources	Status of current land use: Survey item: Area by land use in the project site. Survey method: Measurement of an area on the aerial photo (Google earth). Survey location: Project site (ROW).	Pre-construction/Construction: Impact of land acquisition on farmland and agricultural production by cropping, aquaculture in fish ponds, etc.
4. Water use / Water rights	Confirmation of existing utility facility (water supply and sewerage) located in the project area, based on the collected data on existing structures and facilities (ref. item 5. Wastes, (1) Physical Environmental/ Pollution)	Pre-construction/Construction: Impact of demolition work of existing utilities on water supply and water use of local people will be described. Operation: The possibility of an adverse impact on existing water supply around the project area due to the

Environmental Elements	Baseline Survey	Objects and Method of Impact Prediction
	Confirmation of status of the water source and potential water supply quantity.	significant increase of water use to be caused by an influx of population along with railway operation.
5. Social institution/ Social infrastructure	Confirmation of existing utility facilities (electricity, water supply and sewerage, communication, etc.) in and around the project area based on the results of inventory (ref. item 5. Wastes, (1) Physical Environmental/ Pollution). Confirmation of existing transmission lines crossing the planned railway route.	Pre-construction/Construction: Possibility of impact on existing utility facilities due to the demolition of existing structures and facilities during pre-construction and to various types of civil works during construction. The possibility of an impact on transmission lines located over the planned railway route will be described.
6. Historical and cultural heritage		There is no historical and cultural heritage in and around the project area.
7. Road traffic/ Water transportation	(1) Road traffic: Survey item: traffic volume by type of vehicle, Survey method: Primary data collection through the counting of hourly traffic volume in a day (24 hours), Survey location: Locations on main roads around the project area (2) Water traffic Survey item: Traffic volume of vessels on the Red River by type/purpose of vehicle, Survey method: Primary data collection through the counting of hourly traffic volume in the daytime (12 hours), Survey location: Location of planned bridge construction crossing the Red River	(1) Impact on road traffic Pre-construction/Construction: Impact of transportation of construction materials and wastes, etc. on road traffic will be predicted the possibility to cause traffic jams by calculating the additional traffic volume of construction activities of the project. The prediction includes the possibility of an impact on daily life and the local economy. Operation: The positive impact, i.e., mitigation effect of the traffic situation on the Highway (Vo Nguyen Giap) between Hanoi City and Noi Bai International Airport will be predicted. (2) Impact on water traffic Construction: Possibility of the impact of bridge construction of the railway on existing water transportation including quarrying in the Red River will be described based on the survey results of water traffic.
8. Landscape	Confirmation of land use and existing structures and facilities, and features of the landscape around the project area.	Pre-construction/Construction: Change of landscape feature due to the demolition of existing structures and facilities and to various types of civil works will be described. Operation: Change of landscape feature from the landscape in the area of suburban to that in urban/city area due to railway operation and an influx of population will be described.
9. Infectious diseases such as HIV/AIDS, etc.	Status of infectious disease: Survey item: Status (morbidity, mortality, etc.) of typical infectious diseases in Vietnam, including HIV/AIDS. Survey method: Secondary data collection. Survey location: Hanoi City and the whole country.	Construction: Possibility to generate infectious diseases including HIV/AIDS due to influx of construction workers. Possibility to deteriorate sanitary condition around the project site such that to increase water-borne disease, increase of pathogenic insects, etc., and that to cause adverse impact on community health due to air pollution and noise, will be described.

Source: The JICA Study Team

22. Conclusion and Recommendations

In terms of alignment, the JICA Study Team recommendation is the same as envisaged in the Transport Master Plan (No.519/QD-TTg dated 31/3/2016) except for the end point at the Noi Bai Airport. The Study Team recommends that the ending point of Line 2.3 for this study is the N0 station, opposite the T2 Terminal of the Noi Bai International Airport to ensure efficient and convenient transfer operations. Therefore, Line 2.3 shall be 1.5km longer than that approved in the master plan.

In accessing the Noi Bai International Airport, the JICA Study Team recommends that the Line 2.3 will go underground to fulfill the technical requirements of aviation.

The depot with an area of 25 ha will be located in Pho Lo Commune as planned by the transport master plan and Zoning Plans of Soc Song. Among the depot access of two options 1) underground access from N1 Station of the domestic terminal of the Noi Bai Airport and 2) elevated access from N2 Station veering to the right. The JICA Study Team recommends the elevated access from N2 to the Depot.

As for the Red River crossing, the JICA Study Team recommends a more advantageous bridge option. However, the Study Team also proposed to add a tunnel option as an alternative, depending on the results of the environmental impact assessment and resettlement plan.

The total length of the alignment is 19.65 km with 12 stations, including nine9 elevated stations and three underground stations for the recommended bridge option. Given the number of planned stations, the investment cost for the stations comprise approximately 30% of the total cost. It is recommended to adopt a phased approach in station construction to limit the construction of stations in the initial stage to basic requirements. The rest of the stations should be built according to the needs by soliciting the core investors to share the investment costs.

TOD guidelines specially created for the implementation of Line 2.3 calls for the concentration of highest human densities, i.e., residential population and employments close to the station areas. The goals of TOD are to maximize the railway ridership and land value capture from urban developments near stations, in recognition of strong linkages between public transit and urban development. The TOD guidelines aims to promote mixed land uses to create more business opportunities thus bi-directional traffic to improve the operation efficiency of trains. TOD encourages high human densities near the stations. More people near stations will generate more traffic to enable railway operation to provide more frequent services. More frequent services increaseincreases convenience in terms of less travel time and more importantly, less waiting time. More human traffic and better access will improve the attractiveness of TOD areas, luring more business investments. The more investments will increase the value of the land in the TOD area.

The project needs to be implemented urgently in order to have an impact on the current trends in urban development, traffics, and air qualityqualities in Hanoi. The Vietnamese government faces a debt ceiling at present. If a PPP method is to be selected to avoid this constraint, there requires a series of reforms to be carried out in terms of investment and PPP framework in order to solicit qualified investors with experiences and a real know-howknowhow in the railway sector. The tendering for the private investor needs to be properly arranged appropriately to counter all the foreseeable risks and contingencies in order to avoid the unexpected and unwanted outcomes experienced in the railway PPP cases in the developed and developing countries alike. Lack of experience on urban railways is a major impediment for PPP, particularly to set the contingency conditions in operations for contractual documents. Technical and functional complexity in railway construction and operation requires a high level of sophistication in management integration.

The Vietnamese government is quite proficient with the process of ODA loans and thus will not require special preparations for the loan negotiations. The JICA Study Team estimates that the overall implantation period by PPP financing will require at least additional three years compared to ODA financing due to lack of PPP experience in railway projecgts. The ODA loan provides the best financial conditions that are available for infrastructure project construction with low interest, long grace, and repayment periods. For the financing of a technically sophisticated project of this magnitude, the JICA Study Team recommends that the ODA loan is the best commensurate with a low financial return on investment, and a long gestation period of TOD urban development before the full social economic benefits come into blossom.

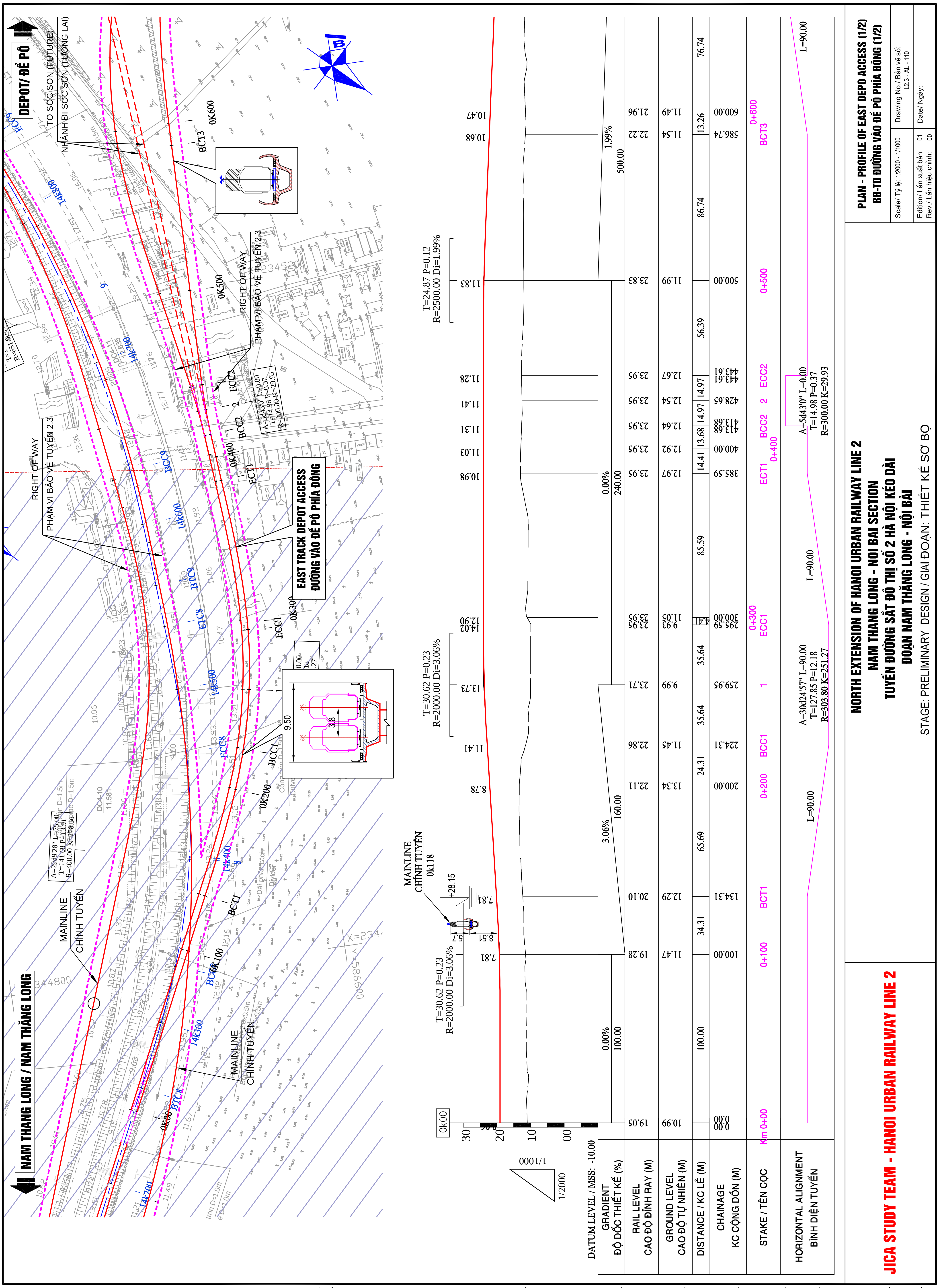
While preserving the framework provided by "the Decision No. 1259/QĐ-TTG dated 26/7/2011 by Prime Minister approving Hanoi general construction master plan up to 2030 and vision to 2050", the JICA Study Team concludes that TOD approach will necessitate the modifications of lower- level land use plans namely, the zoning plan of N5, N7, N8, GN, GN(C) and H2-1 in Dong Anh and Soc Son rural districts and Tay Ho urban districtDistrict of Hanoi approved by HPC.

For the full implementation of TOD, a unified office should handle the implementation of both urban development and railway development to ensure the synchronicity and synergy of urban and transit developments along the corridor. A legal frameworkfrawework to support the TOD implementation will expedite the planning and implementation process by legitimizing the integrated TOD implementation as a public concensus.

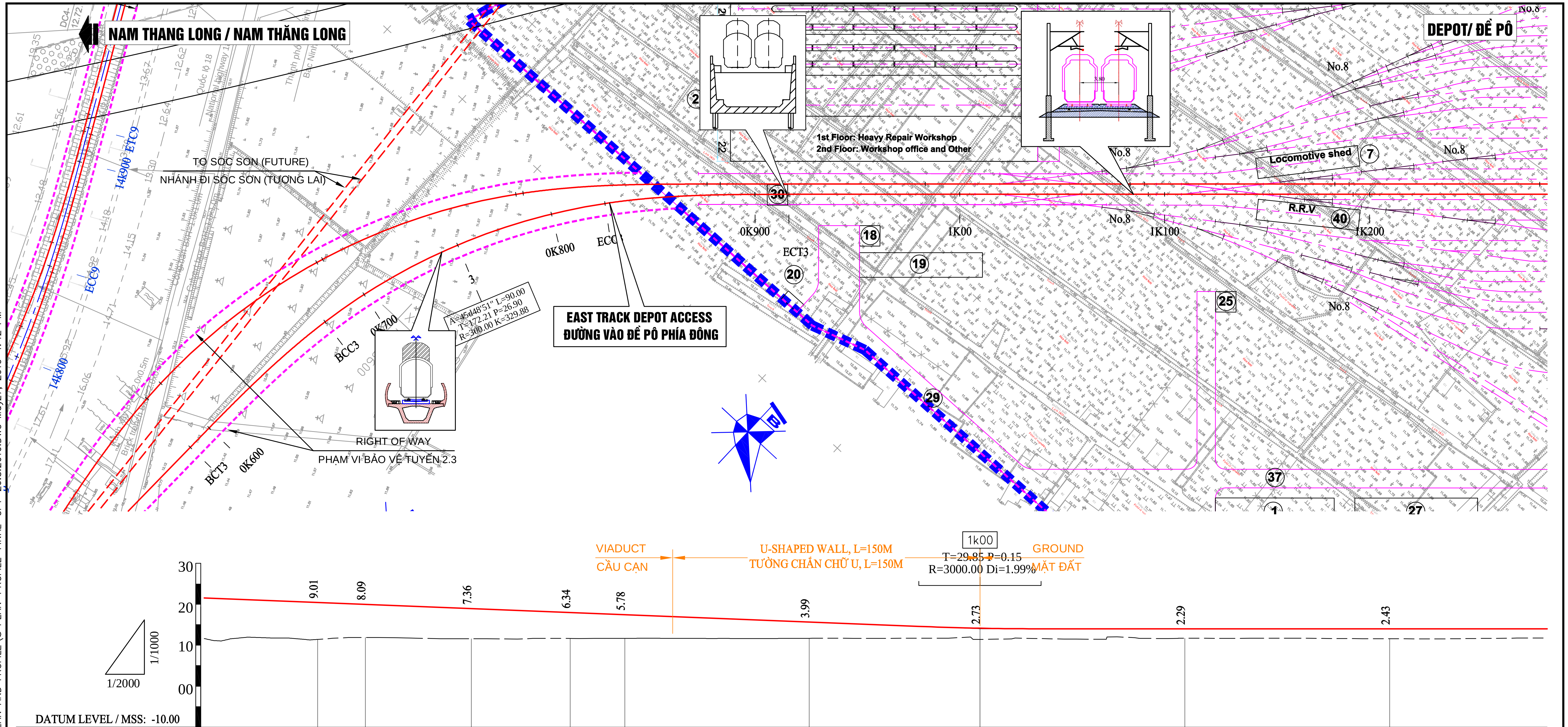
The project needs an approval by the National Assembly to proceed to the next stage of implementation. MRB has commissioned a local consultant to review and incorporate this Study to finalize the pre-feasibility study for the Hanoi UMRT Line Phase 3 with the target completion date of June 2020 for the submission to the National Assembly in the second half of 2020.

2. PLAN OF DEPOT ACCESS

2. BÌNH ĐỒ ĐƯỜNG VÀO ĐỀ PÔ



PLAN - PROFILE OF EAST DEPO ACCESS (1/2)
BĐ-TD ĐƯỜNG VÀO ĐỂ PÔ PHÍA ĐÔNG (1/2)
NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ
JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2
Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - 110
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:
EAST TRACK DEPOT ACCESS
ĐƯỜNG VÀO ĐỂ PÔ PHÍA ĐÔNG
NAM THANG LONG / NAM THĂNG LONG
DEPOT/ ĐỂ PÔ
TO SOC SON (FUTURE)
NHÁNH ĐI SÓC SƠN (TƯƠNG LAI)
RIGHT OF WAY
PHẠM VI BẢO VỆ TUYẾN 2.3
MAINLINE
CHÍNH TUYẾN
DATUM LEVEL / MSS: -10.00
GRADIENT
ĐỘ DỐC THIẾT KẾ (%)
RAIL LEVEL
CAO ĐỘ ĐỈNH RAY (M)
GROUND LEVEL
CAO ĐỘ TỰ NHIÊN (M)
DISTANCE / KC LẺ (M)
CHAINAGE
KC CỘNG DỒN (M)
STAKE / TÊN CỌC
HORIZONTAL ALIGNMENT
BÌNH DIỆN TUYẾN
1/1000
1/2000
T=30.62 P=0.23
R=2000.00 Di=3.06%
T=24.87 P=0.12
R=2500.00 Di=1.99%
A=30d24'57" L=90.00
T=127.85 P=12.18
R=303.80 K=251.27
A=5d43'0" L=0.00
T=14.98 P=0.37
R=300.00 K=29.93
D:\@WORK\07. LINE 2.3 HN\@ 2018\2. PRE-FS\@ DRAWINGS\02. ALIGNMENT\02. PLAN AND PROFILE\@ PLAN-PROFILE-FINAL-OP1-26.5.2019.DWG May27, 2019-1:42 PM



GRADIENT / ĐỘ DỐC THIẾT KẾ (%)	1.99% 500.00						0.00% 500.00		
RAIL LEVEL / CAO ĐỘ ĐỈNH RAY (M)	20.43	19.97	18.94	17.98	17.45	15.66	14.15	14.00	14.00
GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)	11.42	11.88	11.58	11.64	11.67	11.67	11.42	11.71	11.57
DISTANCE / KC LẺ (M)	76.74	23.26	51.68	48.32	26.62	90.00	83.38	100.00	100.00 / 100.00
CHAINAGE / KC CỘNG DỒN (M)	676.74	700.00	751.68	800.00	826.62	916.62	1000.00	1100.00	1200.00
STAKE / TÊN CỌC	BCC3	0+700	3	0+800	ECC3	ECT3	Km 1+00	1+100	1+200
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN	L=90.00	A=45d48'51" L=90.00 T=172.21 P=26.90 R=300.00 K=329.88			L=90.00				

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE OF EAST DEPO ACCESS (2/2)
BĐ-TD ĐƯỜNG VÀO ĐỀ PÔ PHÍA ĐÔNG (2/2)

Scale/ Tỷ lệ: 1/2000 - 1/1000 | Drawing No./ Bản vẽ số: L2.3 - AL - 110
Edition/ Lần xuất bản: 01 | Date/ Ngày:
Rev./ Lần hiệu chỉnh: 00

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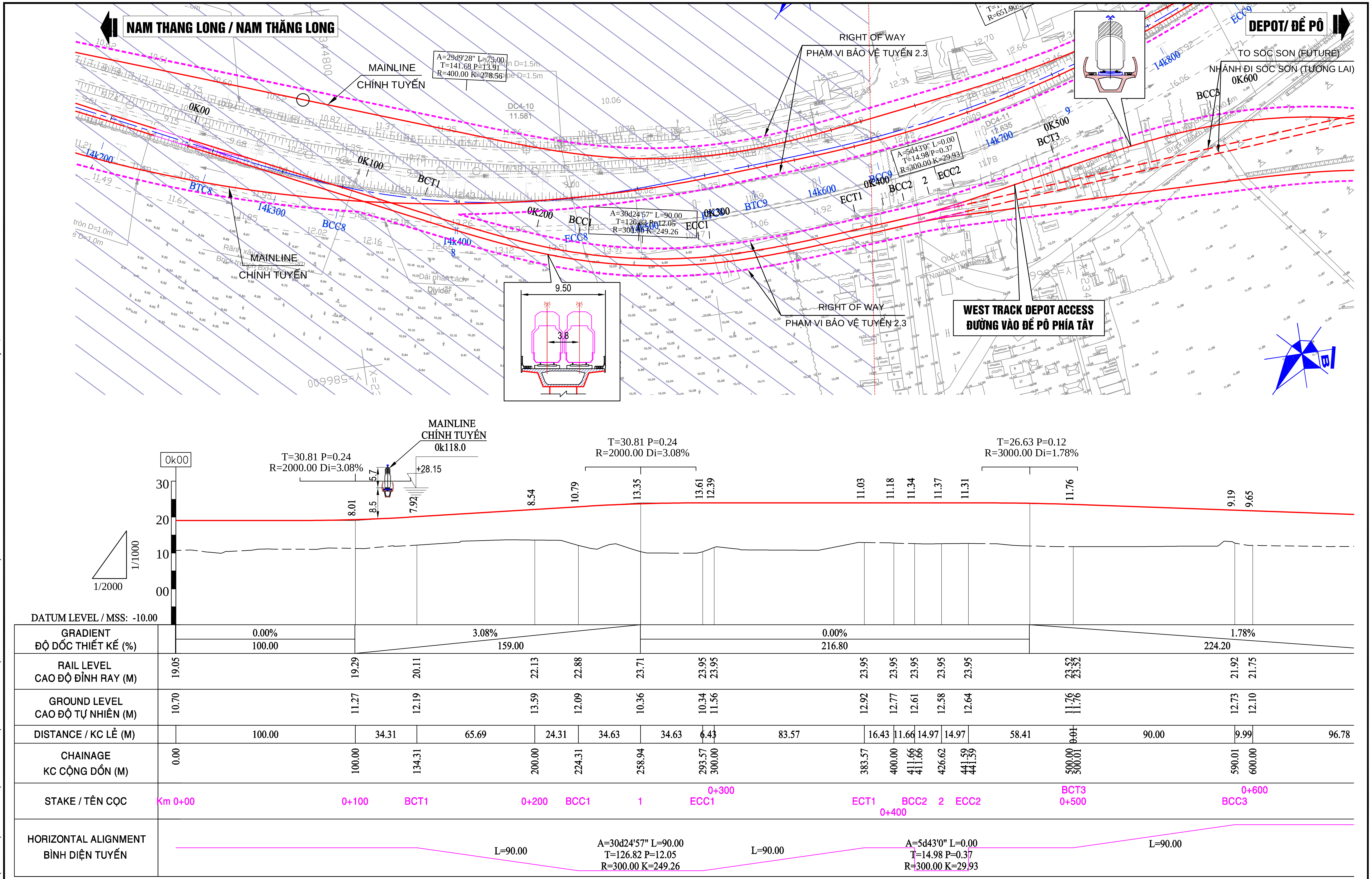

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE OF WEST DEPO ACCESS (1/2)
BĐ-TD ĐƯỜNG VÀO ĐỂ PÔ PHÍA TÂY (1/2)

Scale/ Tỷ lệ: 1/2000 - 1/1000 | Drawing No./ Bản vẽ số: L2.3 - AL - 120
Edition/ Lần xuất bản: 01 | Rev./ Lần hiệu chỉnh: 00 | Date/ Ngày:

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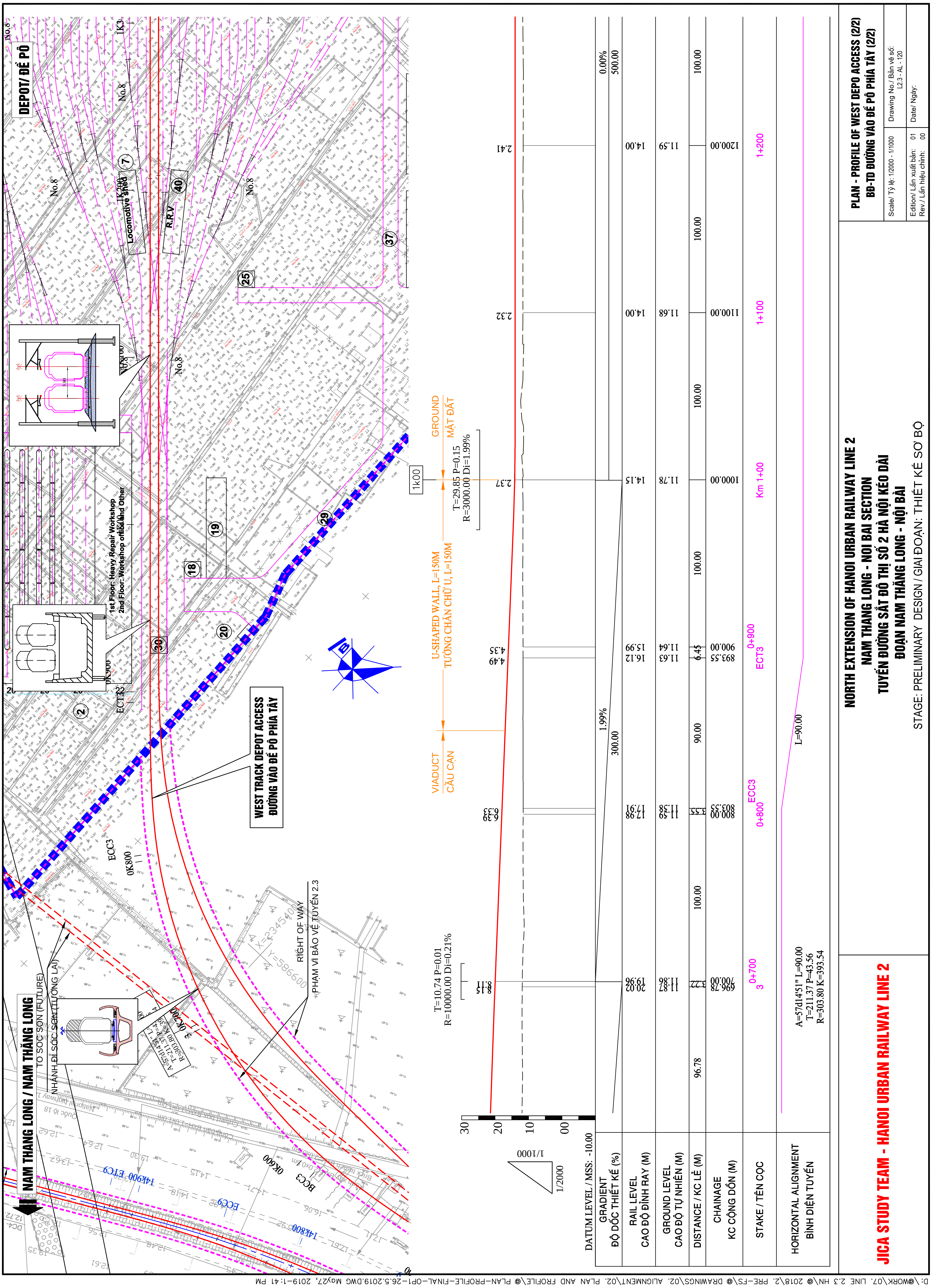
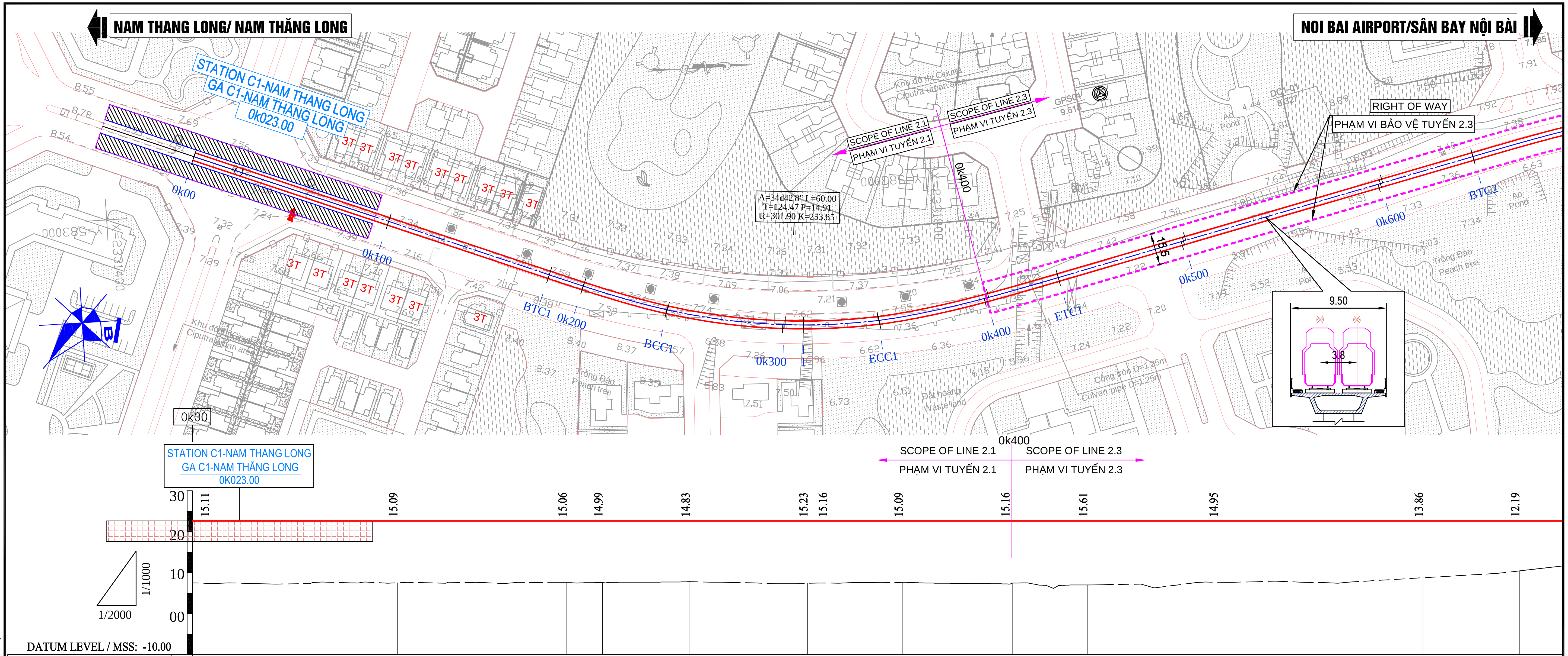


NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ
PLAN - PROFILE OF WEST DEPO ACCESS (2/2)
BĐ-TD ĐƯỜNG VÀO ĐỀ PÔ PHÍA TÂY (2/2)
JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2
Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - 120
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:
DEPOT/ ĐỀ PÔ
NAM THANG LONG / NAM THĂNG LONG
TO SOC SON (FUTURE)
NHÁNH ĐI SÓC SƠN (TƯƠNG LAI)
WEST TRACK DEPOT ACCESS
ĐƯỜNG VÀO ĐỀ PÔ PHÍA TÂY
RIGHT OF WAY
PHẠM VI BẢO VỆ TUYẾN 2.3
Locomotive shed
R.R.V
1st Floor: Heavy Repair Workshop
2nd Floor: Workshop office and Other
VIADUCT
CẦU CẠN
U-SHAPED WALL, L=150M
TƯỜNG CHẮN CHỮ U, L=150M
GROUND
MẶT ĐẤT
T=10.74 P=0.01
R=10000.00 Di=0.21%
T=29.85 P=0.15
R=3000.00 Di=1.99%
A=57d14'51" L=90.00
T=211.37 P=43.56
R=303.80 K=393.54
L=90.00
DATUM LEVEL / MSS: -10.00
GRADIENT / ĐỘ DỐC THIẾT KẾ (%)
RAIL LEVEL / CAO ĐỘ ĐỈNH RAY (M)
GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)
DISTANCE / KC LẺ (M)
CHAINAGE / KC CỘNG DỒN (M)
STAKE / TÊN CỌC
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN
1.99%
300.00
0.00%
500.00
96.78
100.00
90.00
100.00
100.00
100.00
100.00
100.00
0+700
0+800
ECC3
0+900
ECT3
Km 1+00
1+100
1+200
1/1000
1/2000

3. PLAN & PROFILE OF MAIN LINE- OPTION 2

3. BÌNH ĐỒ & TRẮC DỌC CHÍNH TUYẾN - PHƯƠNG ÁN 2



GRADIENT / ĐỘ DỐC THIẾT KẾ (%)	0.00% 1600.00													
RAIL LEVEL / CAO ĐỘ ĐỈNH RAY (M)	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65
GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)	7.54	7.56	7.59	7.66	7.82	7.42	7.49	7.56	7.49	7.04	7.70	8.79	10.46
CHAINAGE / KC CỘNG DỒN (M)	0.00	100.00	182.54	200.00	242.54	300.00	309.47	346.39	400.00	436.39	500.00	600.00	647.01
STAKE / TÊN CỌC	0k00	0k100	BTC1	0k200	BCC1	0k300	1	ECC1	0k400	ETC1	0k500	0k600	BTC2

DISTANCE / KC LẺ (M): 100.00 | 82.54 | 17.46 | 42.54 | 57.46 | 9.47 | 36.93 | 53.61 | 36.39 | 63.61 | 100.00 | 47.01

HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN

NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC: L=60.00; A=34d42'8" L1=60.00 L2=90.00, T=123.88 P=14.83, R=300.00 K=252.70; L=90.00; L

SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM: L=60.00; A=34d42'8" L1=60.00 L2=90.00, T=125.07 P=15.00, R=303.80 K=255.00; L=90.00; L

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (1/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (1/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000 | Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01 | Rev./ Lần hiệu chỉnh: 00 | Date/ Ngày:

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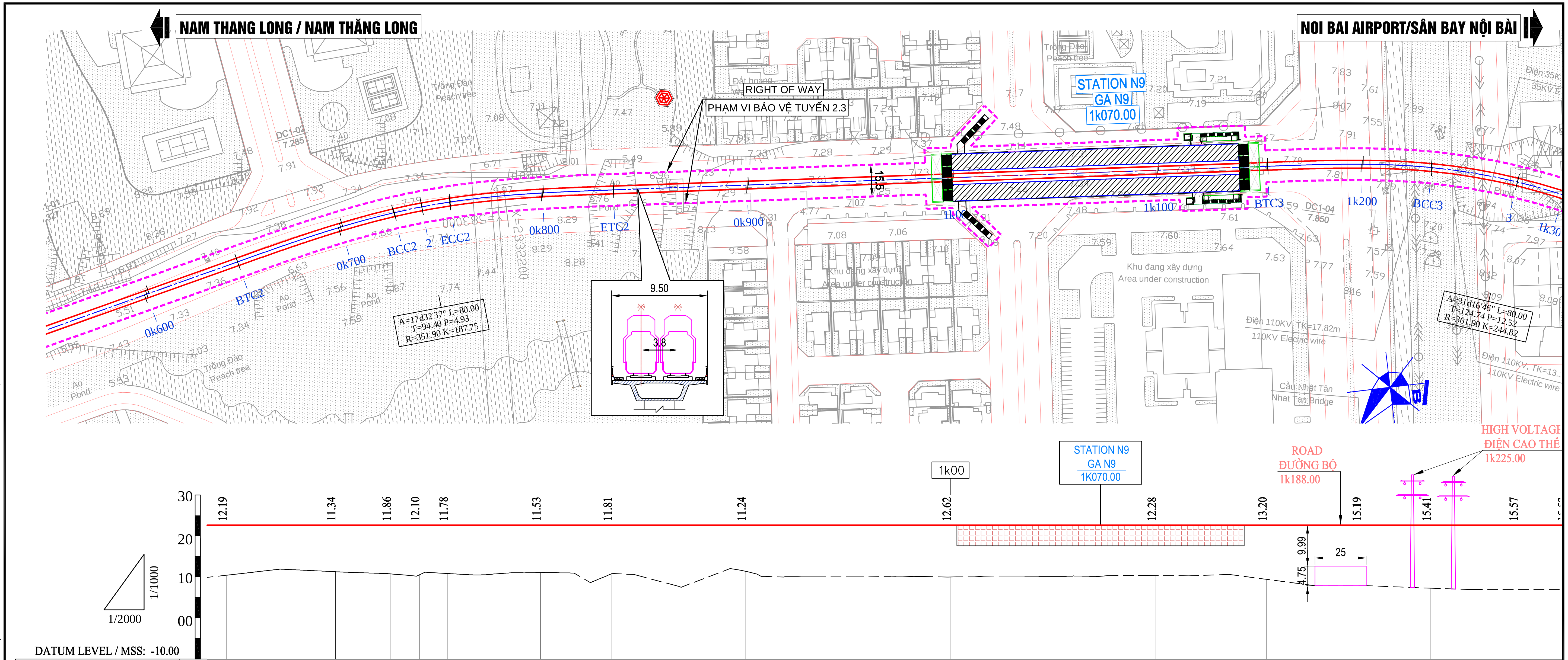

STAKE / TÊN CỌC	CHAINAGE / KC CỘNG DỒN (M)	RAIL LEVEL / CAO ĐỘ ĐỈNH RAY (M)	GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)	DISTANCE / KC LẺ (M)
BTC2	647.01	22.65	10.46	
				52.99
0k700	700.00	22.65	11.31	
				27.01
BCC2	727.01	22.65	10.79	
				13.88
2	740.88	22.65	10.55	
				13.88
ECC2	754.76	22.65	10.87	
				45.24
0k800	800.00	22.65	11.12	
				34.76
ETC2	834.76	22.65	10.84	
				65.24
0k900	900.00	22.65	11.41	
				100.00
1k00	1000.00	22.65	10.03	
				100.00
1k100	1100.00	22.65	10.37	
				53.98
BTC3	1153.98	22.65	9.45	
				46.02
1k200	1200.00	22.65	7.46	
				33.98
BCC3	1233.98	22.65	7.24	
				42.41
3	1276.39	22.65	7.08	
				23.61
1k				

GRADIENT / ĐỘ DỐC THIẾT KẾ (%): 0.00% — 1600.00

HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN					
NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC	L=80.00	A=17d32'37" L=80.00 T=94.69 P=4.95 R=353.80 K=188.33	L=80.00	L=80.00	A=31d16'46" L=80.00 T=125.27 P=12.59 R=303.80 K=245.85
SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM	L=80.00	A=17d32'37" L=80.00 T=94.11 P=4.91 R=350.00 K=187.17	L=80.00	L=80.00	A=31d16'46" L=80.00 T=124.21 P=12.46 R=300.00 K=243.78

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (2/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (2/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000	Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01 Rev./ Lần hiệu chính: 00	Date/ Ngày:

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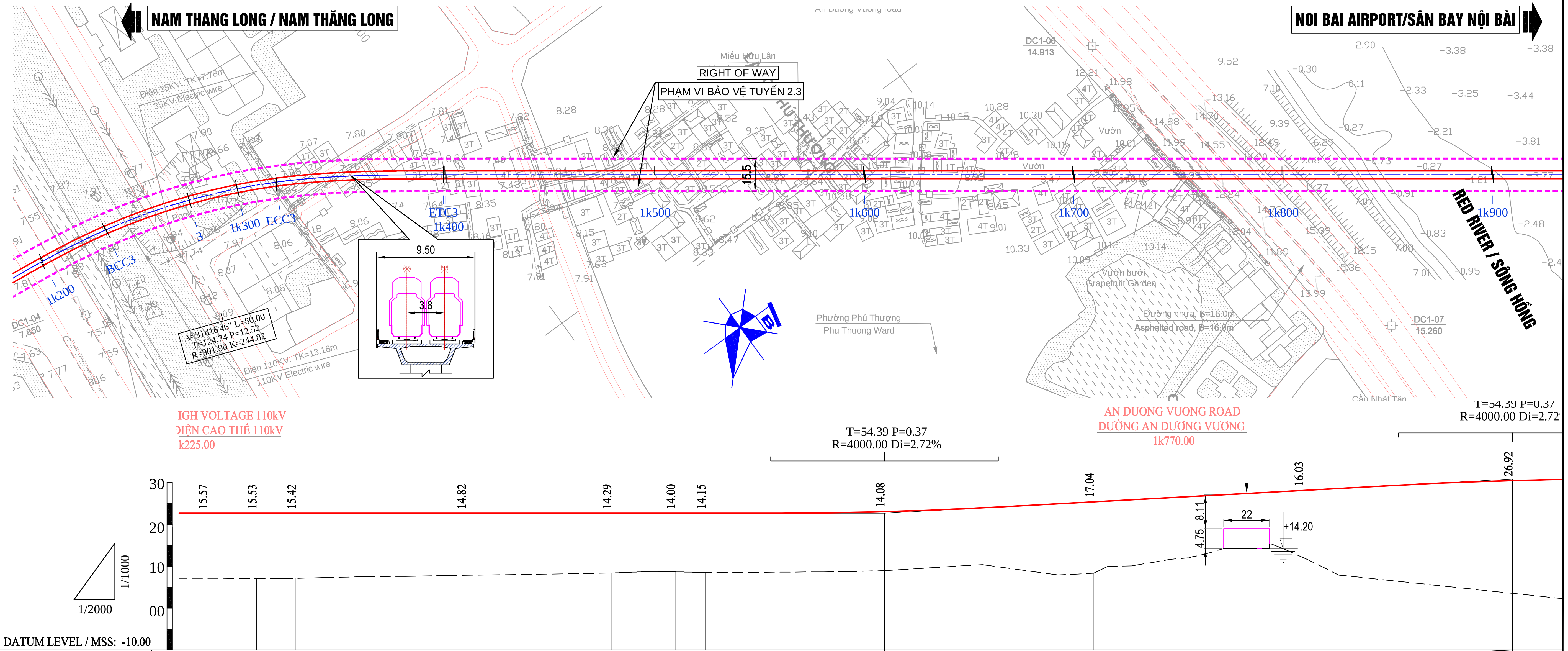

GRADIENT / ĐỘ DỐC THIẾT KẾ (%)	0.00% 1600.00							2.72% 300.00			
RAIL LEVEL / CAO ĐỘ ĐỈNH RAY (M)	22.65	22.65	22.65	22.65	22.65	22.65	22.65	23.02	25.37	28.09	30.44
GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)	7.08	7.12	7.23	7.83	8.36	8.65	8.50	8.94	8.33	12.06	3.52
DISTANCE / KC LẺ (M)		23.61	18.80	80.00	69.48	30.52	14.48	85.52	100.00	100.00	100.00
CHAINAGE / KC CỘNG DỒN (M)	1276.39	1300.00	1318.80	1400.00	1469.48	1500.00	1514.48	1600.00	1700.00	1800.00	1900.00
STAKE / TÊN CỌC	3	1k300	ECC3	1k400 ETC3		1k500		1k600	1k700	1k800	1k900

HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN		
NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC	46" L=80.00; 7 P=12.59; 0 K=245.85	L=80.00
SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM	46" L=80.00; 1 P=12.46; 0 K=243.78	L=80.00

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (3/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (3/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000	Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01; Rev./ Lần hiệu chỉnh: 00	Date/ Ngày:

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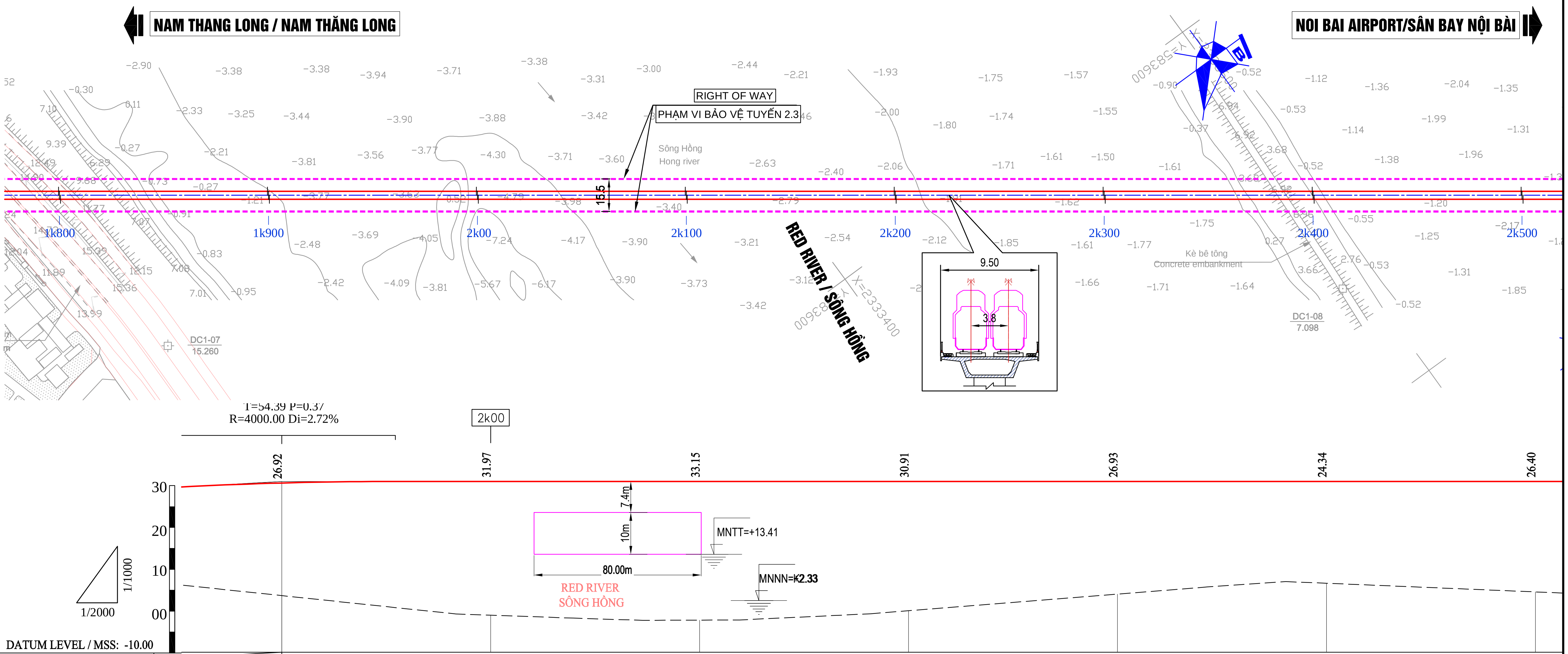

GRADIENT ĐỘ DỐC THIẾT KẾ (%)		0.00% 1500.00						
RAIL LEVEL CAO ĐỘ ĐỈNH RAY (M)		30.44	30.81	30.81	30.81	30.81	30.81	30.81
GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)		3.52	-1.16	-2.34	-0.10	3.88	6.47	4.41
DISTANCE / KC LẺ (M)	00	100.00	100.00	100.00	100.00	100.00	100.00	
CHAINAGE KC CỘNG DỒN (M)		1900.00	2000.00	2100.00	2200.00	2300.00	2400.00	2500.00
STAKE / TÊN CỌC		1k900	2k00	2k100	2k200	2k300	2k400	2k500
HORIZONTAL ALIGNMENT BÌNH DIỆN TUYẾN — NORTH BOUND TRACK ĐƯỜNG RAY HƯỚNG BẮC								
HORIZONTAL ALIGNMENT BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK ĐƯỜNG RAY HƯỚNG NAM								

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (4/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (4/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:

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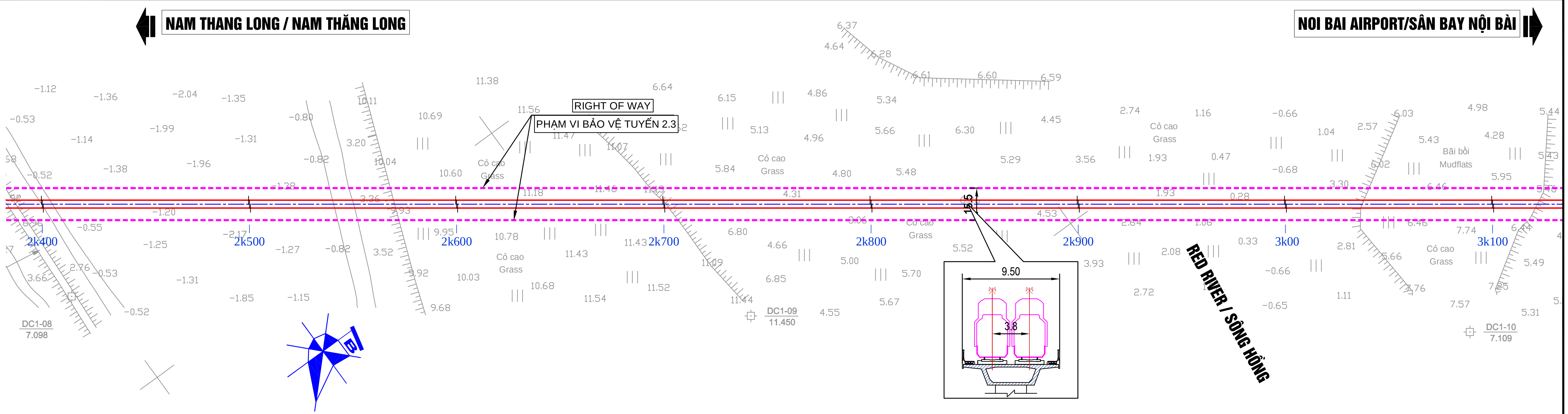

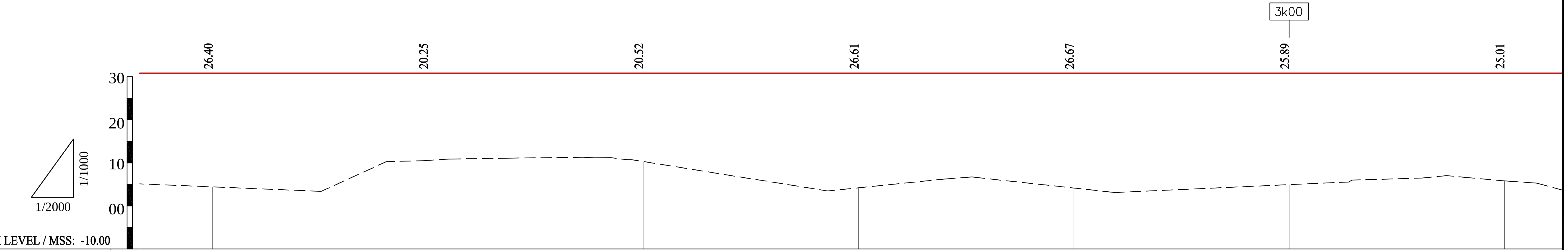

DATUM LEVEL / MSS: -10.00

GRADIENT ĐỘ DỐC THIẾT KẾ (%)	0.00% 1500.00						
RAIL LEVEL CAO ĐỘ ĐỈNH RAY (M)	30.81	30.81	30.81	30.81	30.81	30.81	30.81
GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)	4.41	10.56	10.29	4.20	4.14	4.92	5.80
DISTANCE / KC LẺ (M)	100.00	100.00	100.00	100.00	100.00	100.00	
CHAINAGE KC CỘNG DỒN (M)	2500.00	2600.00	2700.00	2800.00	2900.00	3000.00	3100.00
STAKE / TÊN CỌC	2k500	2k600	2k700	2k800	2k900	3k00	3k100
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC							
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM							

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (5/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (5/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:

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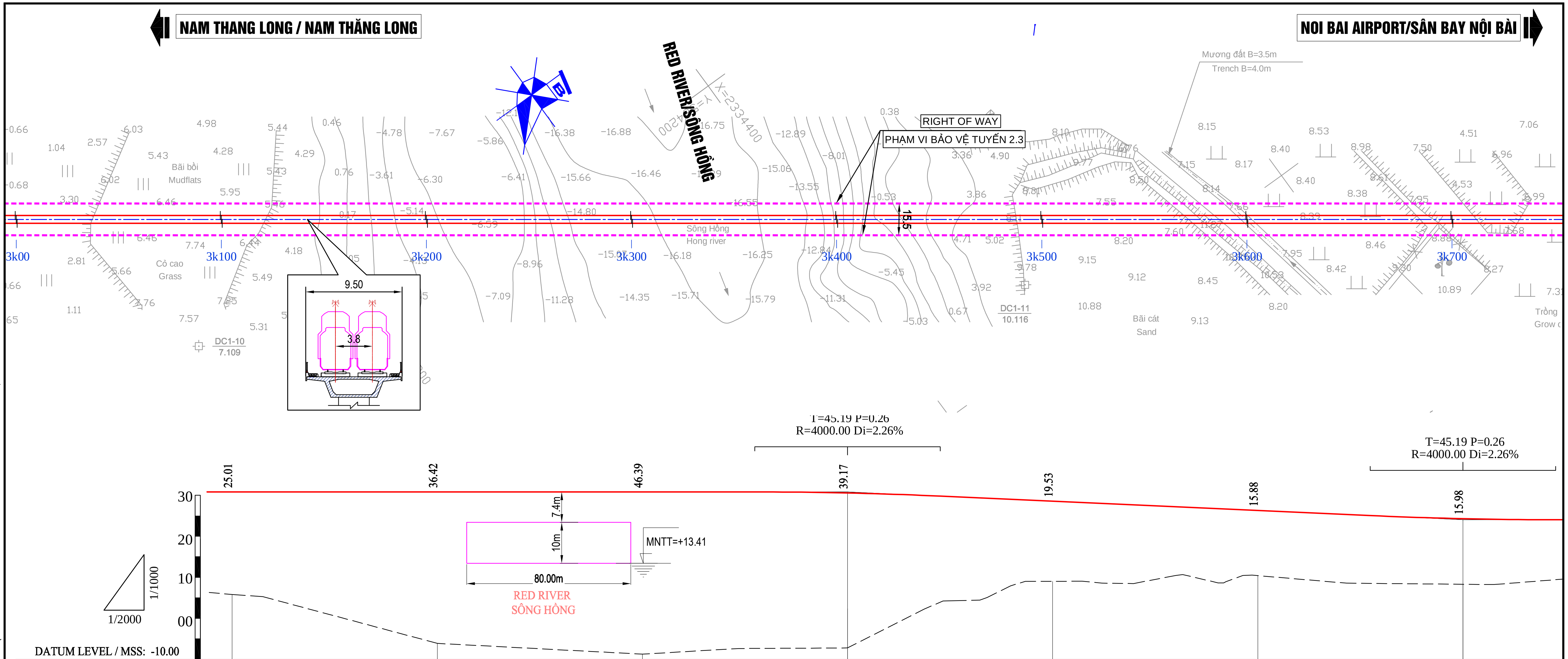

GRADIENT ĐỘ DỐC THIẾT KẾ (%)	0.00% / 1500.00				2.26% / 300.00			0.00% / 1600.00
RAIL LEVEL CAO ĐỘ ĐỈNH RAY (M)	30.81	30.81	30.81	30.55	28.55	26.29	24.29	
GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)	5.80	-5.61	-15.58	-8.62	9.02	10.41	8.31	
DISTANCE / KC LẺ (M)	100.00	100.00	100.00	100.00	100.00	100.00	10	
CHAINAGE KC CỘNG DỒN (M)	3100.00	3200.00	3300.00	3400.00	3500.00	3600.00	3700.00	
STAKE / TÊN CỌC	3k100	3k200	3k300	3k400	3k500	3k600	3k700	
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC								
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM								

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (6/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (6/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:

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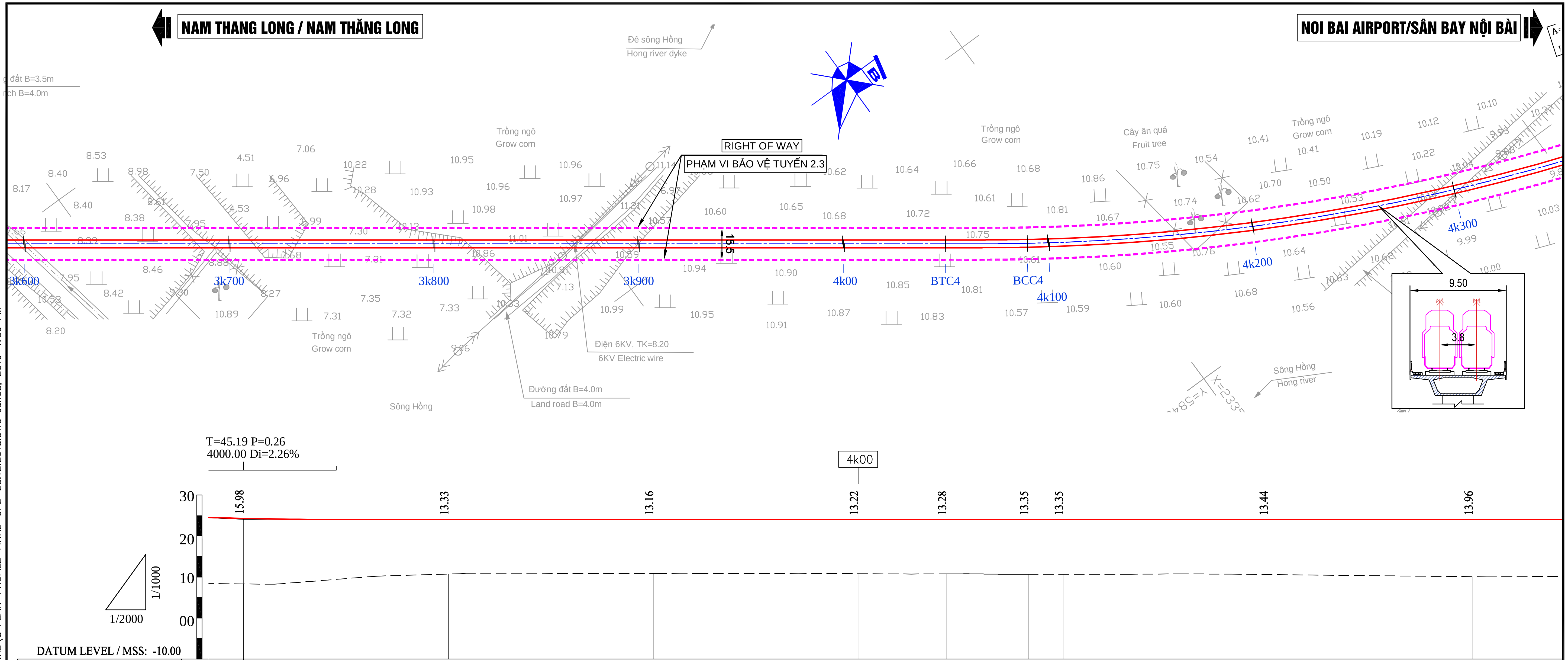

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GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)	8.31	10.70	10.87	10.81	10.75	10.68	10.68	10.59	10.07	
DISTANCE / KC LẺ (M)	100.00	100.00	100.00	43.00	40.00	17.00	100.00	100.00	81.2	
CHAINAGE KC CỘNG DỒN (M)	3700.00	3800.00	3900.00	4000.00	4043.00	4083.00	4100.00	4200.00	4300.00	
STAKE / TÊN CỌC	3k700	3k800	3k900	4k00	BTC4	BCC4	4k100	4k200	4k300	
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC	L=40.00									
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM	L=40.00									

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (7/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (7/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:

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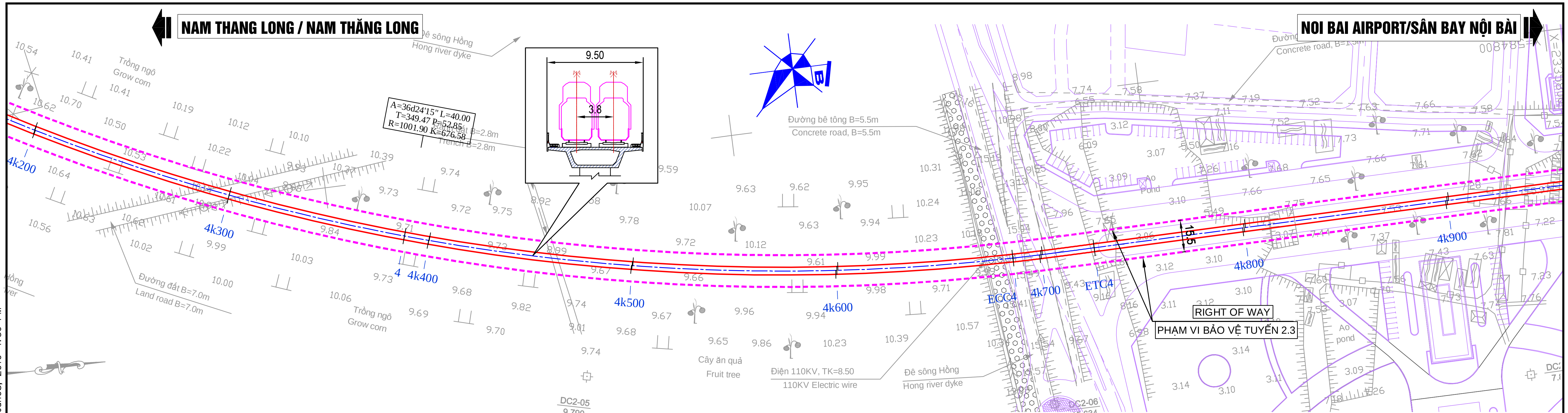

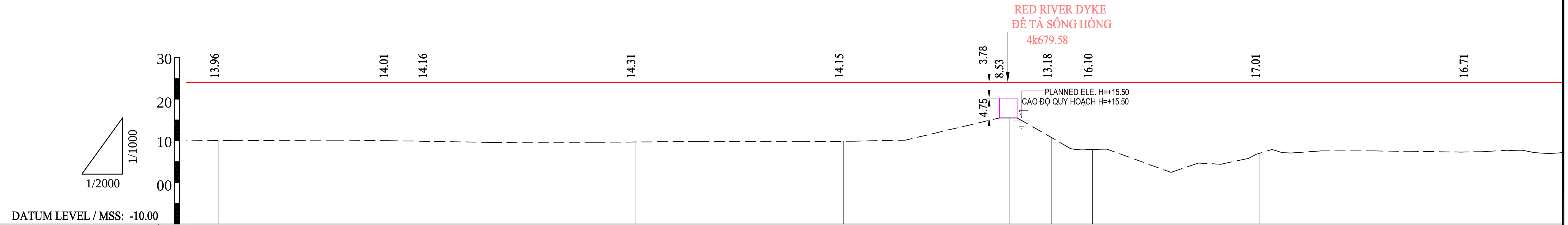

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GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)	10.07	10.02	9.87	9.72	9.88	15.50	10.85	7.93	7.02	7.32
DISTANCE / KC LẺ (M)		81.29	18.71	100.00	100.00	79.58	20.42	19.58	80.42	100.00
CHAINAGE KC CỘNG DỒN (M)	4300.00	4381.29	4400.00	4500.00	4600.00	4679.58	4700.00	4719.58	4800.00	4900.00
STAKE / TÊN CỌC	4k300	4	4k400	4k500	4k600	ECC4	4k700	ETC4	4k800	4k900

HORIZONTAL ALIGNMENT BÌNH DIỆN TUYẾN		
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SOUTH BOUND TRACK ĐƯỜNG RAY HƯỚNG NAM	A=36d24'15" L=40.00 T=350.09 P=52.95 R=1003.80 K=677.79	L=40.00

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (8/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (8/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000	Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01 Rev./ Lần hiệu chỉnh: 00	Date/ Ngày:

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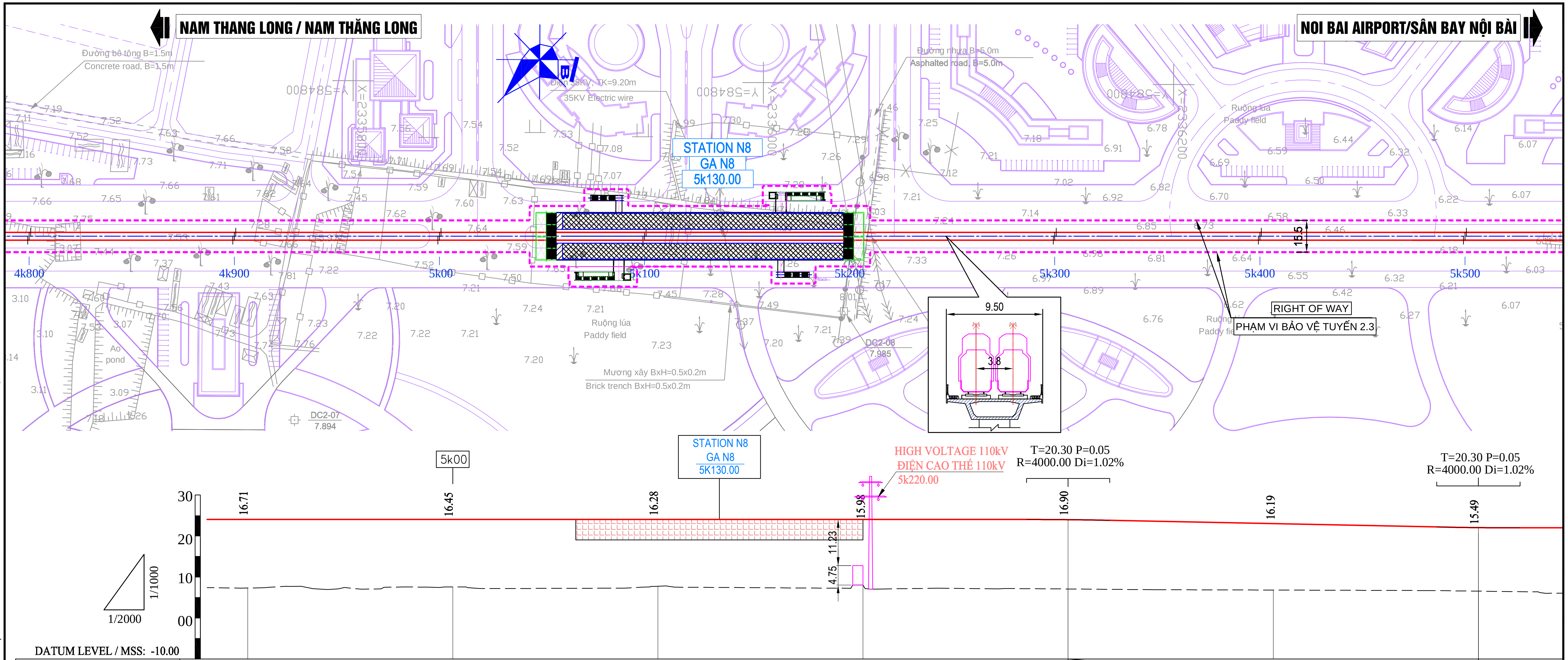

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GROUND LEVEL / CAO ĐỘ TỰ NHIÊN (M)	7.32	7.58	7.75	8.05	7.08	6.82	6.56
DISTANCE / KC LẺ (M)		100.00	100.00	100.00	100.00	100.00	100.00
CHAINAGE / KC CỘNG DỒN (M)	4900.00	5000.00	5100.00	5200.00	5300.00	5400.00	5500.00
STAKE / TÊN CỌC	4k900	5k00	5k100	5k200	5k300	5k400	5k500
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC							
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM							

JICA STUDY TEAM - HANOI URBAN RAILWAY LINE 2

NORTH EXTENSION OF HANOI URBAN RAILWAY LINE 2
NAM THANG LONG - NOI BAI SECTION
TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI KÉO DÀI
ĐOẠN NAM THĂNG LONG - NỘI BÀI
STAGE: PRELIMINARY DESIGN / GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (9/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (9/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày:

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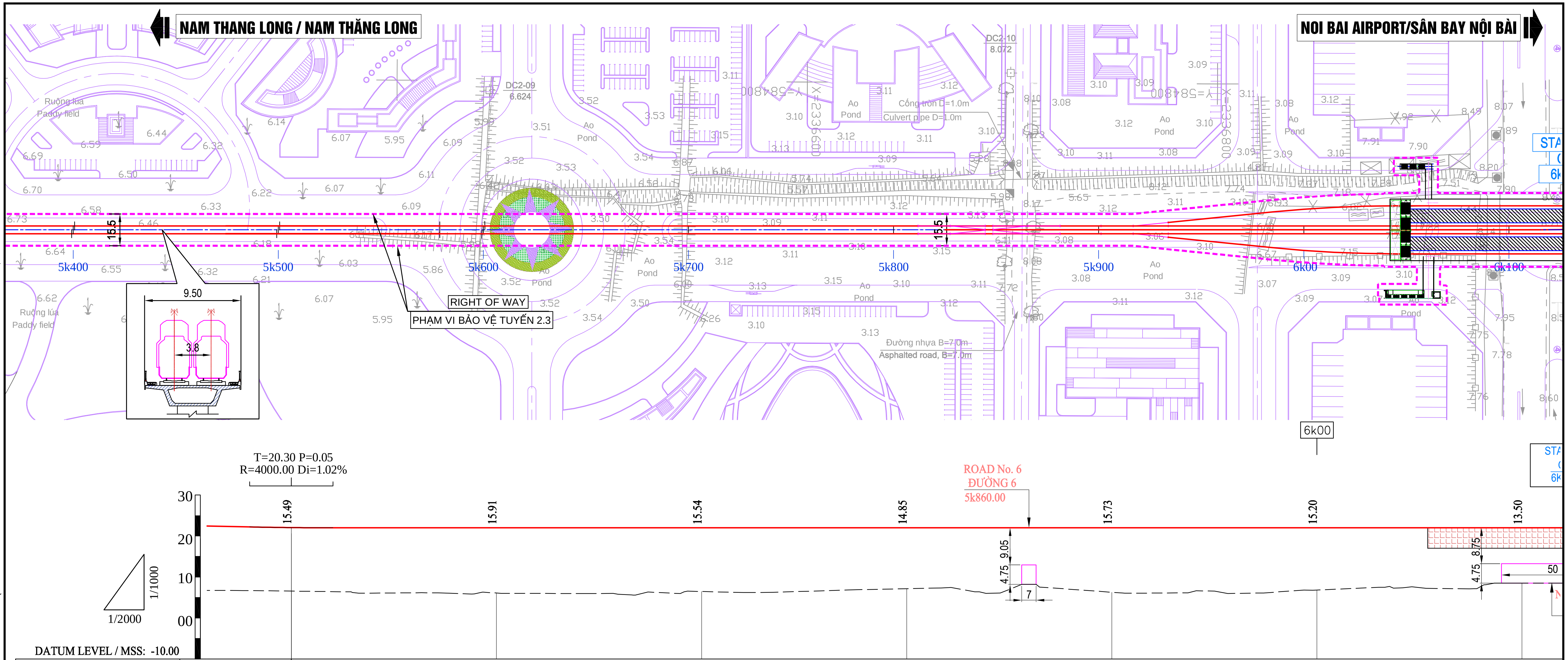

	5k500		5k600		5k700		5k800		5k900		6k00		6k100
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GROUND LEVEL CAO ĐỘ TỰ NHIÊN (M)	6.56		6.09		6.46		7.15		6.27		6.80		8.50
DISTANCE / KC LẺ (M)		100.00		100.00		100.00		100.00		100.00		100.00	
CHAINAGE KC CỘNG DỒN (M)	5500.00		5600.00		5700.00		5800.00		5900.00		6000.00		6100.00
STAKE / TÊN CỌC	5k500		5k600		5k700		5k800		5k900		6k00		6k100
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — NORTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG BẮC			A=2d51'30" L=0.00 T=19.96 P=0.25 R=800.00 K=39.91			A=2d51'30" L=0.00 T=19.96 P=0.25 R=800.00 K=39.91							
HORIZONTAL ALIGNMENT / BÌNH DIỆN TUYẾN — SOUTH BOUND TRACK / ĐƯỜNG RAY HƯỚNG NAM			A=2d51'30" L=0.00 T=19.96 P=0.25 R=800.00 K=39.91			A=2d51'30" L=0.00 T=19.96 P=0.25 R=800.00 K=39.91							

ỦY BAN NHÂN DÂN THÀNH PHỐ HÀ NỘI
BAN QUẢN LÝ ĐƯỜNG SẮT ĐÔ THỊ

TỔNG CÔNG TY TƯ VẤN THIẾT KẾ GIAO THÔNG VẬN TẢI - CTCP (TEDI)

DỰ ÁN TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI
ĐOẠN NAM THĂNG LONG - TRẦN HƯNG ĐẠO

GIAI ĐOẠN: THIẾT KẾ SƠ BỘ

PLAN - PROFILE (OP2) (10/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (10/10)

Scale/ Tỷ lệ: 1/2000 - 1/1000
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Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày: 17.01.2020

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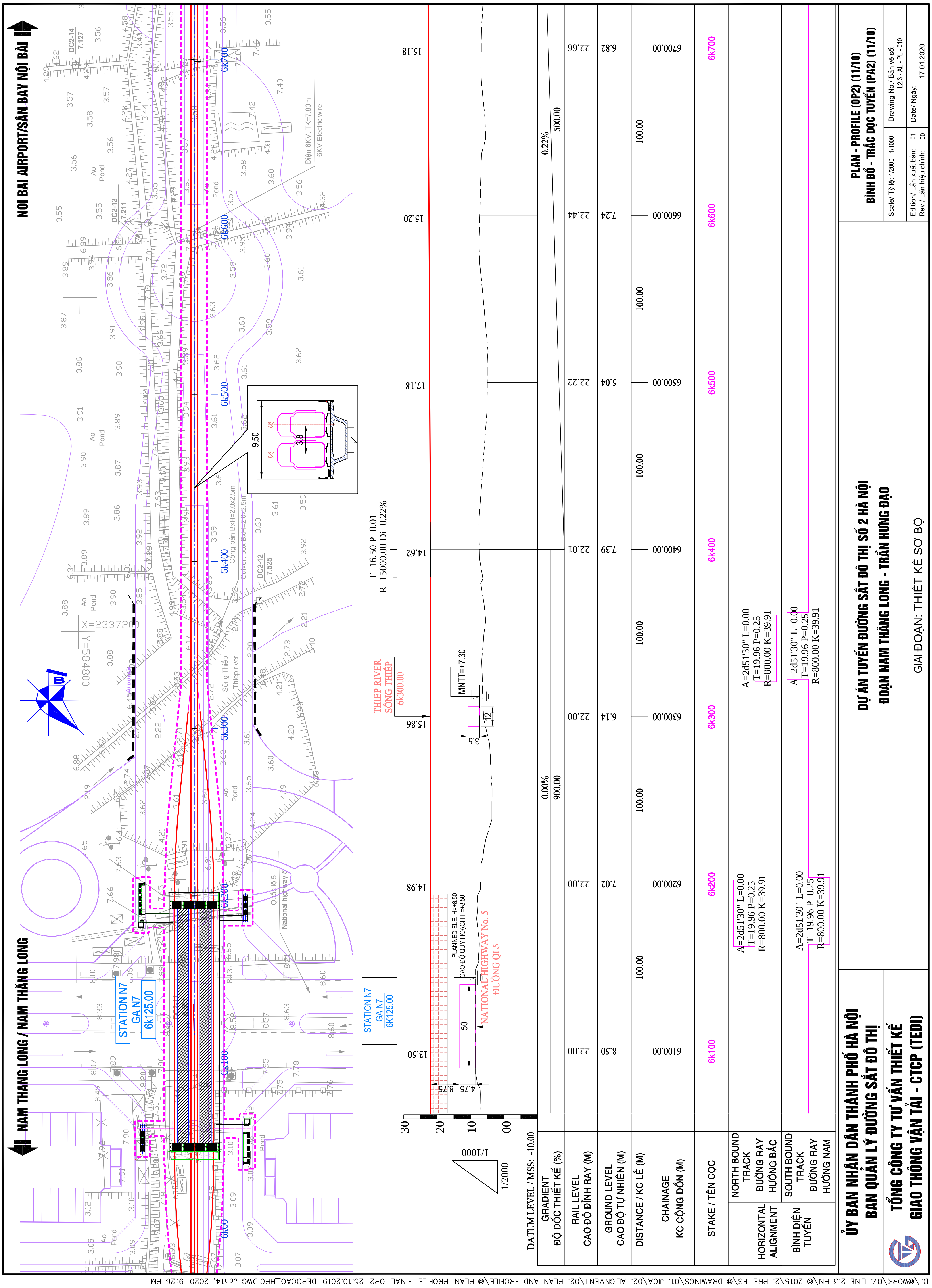
NOI BAI AIRPORT/SÂN BAY NỘI BÀI
NAM THANG LONG / NAM THĂNG LONG
STATION N7
GA N7
6k125.00
THIEP RIVER
SÔNG THIỆP
6k300.00
NATIONAL HIGHWAY No. 5
ĐƯỜNG QL5
PLANNED ELE. H=+8.50
CAO ĐỘ QUY HOẠCH H=+8.50
MNTT=+7.30
T=16.50 P=0.01
R=15000.00 Di=0.22%
1/1000
1/2000
DATUM LEVEL / MSS: -10.00
GRADIENT
ĐỘ DỐC THIẾT KẾ (%)
RAIL LEVEL
CAO ĐỘ ĐỈNH RAY (M)
GROUND LEVEL
CAO ĐỘ TỰ NHIÊN (M)
DISTANCE / KC LẺ (M)
CHAINAGE
KC CỘNG DỒN (M)
STAKE / TÊN CỌC
HORIZONTAL ALIGNMENT
BÌNH DIỆN TUYẾN
NORTH BOUND TRACK
ĐƯỜNG RAY HƯỚNG BẮC
SOUTH BOUND TRACK
ĐƯỜNG RAY HƯỚNG NAM
A=2d51'30" L=0.00
T=19.96 P=0.25
R=800.00 K=39.91
0.00%
900.00
0.22%
500.00
6k100
6k200
6k300
6k400
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6100.00
6200.00
6300.00
6400.00
6500.00
6600.00
6700.00
ỦY BAN NHÂN DÂN THÀNH PHỐ HÀ NỘI
BAN QUẢN LÝ ĐƯỜNG SẮT ĐÔ THỊ
TỔNG CÔNG TY TƯ VẤN THIẾT KẾ
GIAO THÔNG VẬN TẢI - CTCP (TEDI)
DỰ ÁN TUYẾN ĐƯỜNG SẮT ĐÔ THỊ SỐ 2 HÀ NỘI
ĐOẠN NAM THĂNG LONG - TRẦN HƯNG ĐẠO
GIAI ĐOẠN: THIẾT KẾ SƠ BỘ
PLAN - PROFILE (OP2) (11/10)
BÌNH ĐỒ - TRẮC DỌC TUYẾN (PA2) (11/10)
Scale/ Tỷ lệ: 1/2000 - 1/1000
Drawing No./ Bản vẽ số: L2.3 - AL - PL - 010
Edition/ Lần xuất bản: 01
Rev./ Lần hiệu chỉnh: 00
Date/ Ngày: 17.01.2020
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Appendix 1 Proposal of 'Sky-Gate City' for CBD North

Concept: Sky-Gate City

The 66 story buildings with a height of 300 meters will have integrated functions of office, shops, restaurants, hotels and residence as an independent city. It will be the closest urban community to live, work and enjoy life.

One minute Away To Station

Following the core principles of transit-oriented development, these two buildings offer one minute walk proximity between the station and home or work place as well as commerce. It is the real embodiment of TOD and compact city. Choice for residence or office in these buildings are made due to convenience of train access, offering a perfect match to the integrated development of city and railway.

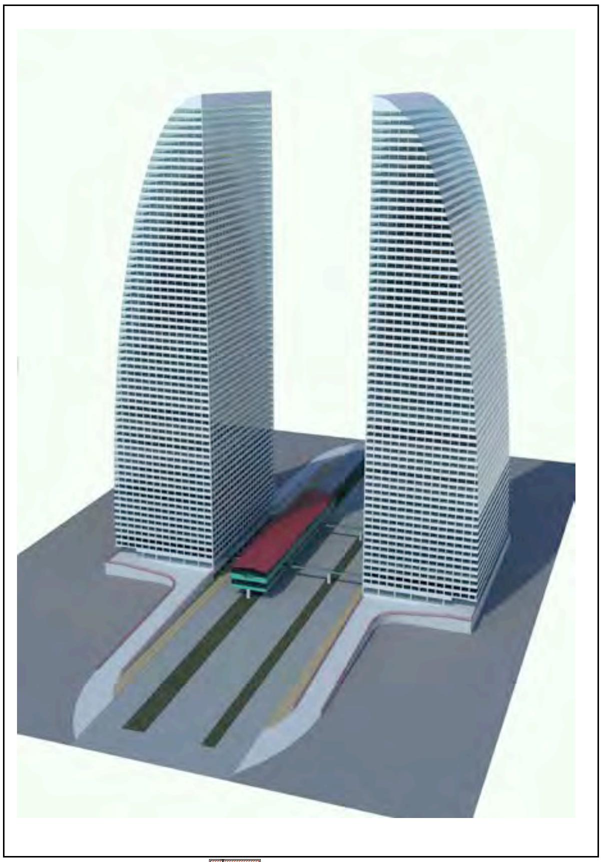
To offset the long walk from the East Tower, the walkways from the East Tower will be equipped with two people moving walkways to and fro the station.

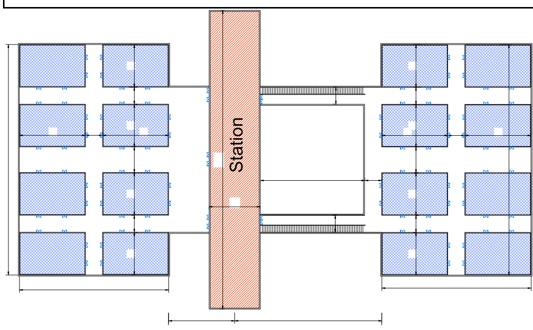
Floor Area

The floor area of the building extends over 22,000 m2 at the ground to the third level, offering space for high end to discount goods and services, sufficient space for local entrepreneurs to thrive in new business schemes. A total floor area is 330,000 m2, catering for middle to high-income residents, transit tourists and office workers.

New Symbol for Hanoi

As a symbolic structure for the proposed new CBD, we propose a two mirror symmetrical buildings directly connecting to the station to form an image of a monumental gate to the city. The twin towers represent the gateway to the Noi Bai Airport. The towers commemorate the history of Vietnam as 'Arc de Triomphe' of Hanoi to honor Gen. Vo Nguyen Giap as the two buildings will buttress the airport highway appropriately named after the general. The visitors from the airport will pass through the gate to the city of Hanoi to reflect on the history of Vietnam.





Appendix 2 Transit Oriented Development Guideline

2.1 Principle of Transit Oriented Development

2.1.1 Attractive City

"Four generators of diversity" that "create effective economic pools of use"

[Jane Jacobs (1961)]

1 Mixed primary uses, activating streets at different times of the day

2 Short blocks, allowing high pedestrian permeability

3 Buildings of various ages and states of repair

4 Density

Attractive cities have some common features as Jane Jacobs mentioned above. She, who is famous as having criticized orthodox urbanism and proposed these alternatives, argued "a feature of a great city is the mobility of residents and fluidity of use across diverse areas of varying size and character, not modular fragmentation". Now her alternatives became a kind of patterns and her writings became a kind of a Bible for urban designers and projects of developing/redeveloping an attractive city.
This TOD project also should be based on this thinking for branding the city and creating a high quality for residents.

She recommends the following "4 pillars of effective city neighborhood planning"
- To foster lively and interesting streets
- To make the fabric of the streets as continuous a network as possible throughout a district of potential sub-city size and power.
- To use parks, squares, and public buildings as part of the street fabric, intensifying the fabric's complexity and multiple uses rather than segregating different uses
- To foster a functional identity at the district level

2.1.2 Compact City Principle

TOD areas to be developed for the Line 2 Phase 3 must be structured so that the residents and workers will not resort to their own vehicles or motor cycles in daily commuting. Given an ever increasing traffic congestion and air pollution in the city of Hanoi, the city has decided to convert the city to more public transit based society. According to General Construction Plan, the share of public passenger transport will account for 35% of total travel demand by 2020, and 55% by 2030. One definite solution is a compact city principle. Compact city is a notion in urban design to create a mix of land uses required for daily needs within a short distance, preferably walking distance. It aims at reversion from automobile centric urban design to more traditional urban design which is exemplified in the old city centers of Hanoi or Manhattan of New York or downtown areas of Tokyo. It is also compatible with ecological city concept to minimize energy consumption. The means of mobility of compact city are walking in its neighborhood areas and trains for inter-district travels.

The proposed drastic modal share to public transport will not take place without corresponding urban design changes to compact and walkable ones to make people naturally choose to use railway for daily transport.

2.1.3 TOD Cycle

There is a strong linkage between public transit and urban development. However, public transport development and urban development were separately by rigid professional walls, largely due to the fact that the former sector were implemented by the public sector while the latter was implemented by the private sector. Since the land use planning have been dominated by automobile-centric mobility planning approach, it is not easy to convert the urban design to TOD oriented urban designs.

However some successful cases of integration of both in Toronto, Stockholm, Copenhagen, Hong Kong and Tokyo led to realization of mutual benefits through an integrated approach called transit-oriented development (TOD).

Figure 1 Virtuous Cycle of TOD

Figure 1 shows the virtuous cycle of TOD design. In TOD the mixed land uses are encouraged as much as possible. Mix land uses creates more business opportunities. It means the stations will not only send out commuters but will attract workers in the commuting peak hours. Thus mix land uses will create bi-directional traffics which improve the operation efficiency of trains. Additional revenue creates additional capacity for investing on service improvements such as headway reduction. Shorter waiting time or more comfortable access and transfer are critical in improving the location advantage of the station. Improved attractiveness of TOD area will attract more business investments which are sensitive to travel time. The more investments will increase the value of the land in the TOD area. The early movers welcome value increases of their assets.

2.1.4 Mixed Land Uses

It has been long since urban planning professionals started promoting mix land use. Separation of land uses lengthen the distance between residence and place of activities or between activities. Mix land use will allow diverse activities such as shopping, dining, exercising, and enjoying a whole range of other urban services within walking distance from residences as shown in Figure 2. It will reduce dependence on automobiles and motor cycles and encourage use of trains. It is noted that the residents of Manhattan, NY can complete most of the activities within five minute of walk. The city is the least automobile reliant place in the US. The car ownership in Manhattan is only 22% of households.

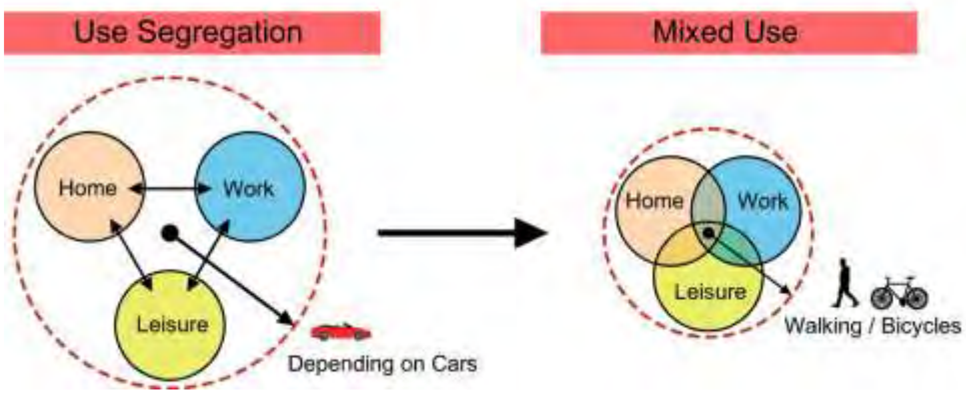


Figure 2 Land Use Segregation and Mixed Use

2.1.5 Mixed Use and Bi-directional Traffic

Mix land uses are the best development tool in promoting employment creation. Small businesses will spring up here and there to provide all sorts of services that the residents enjoy. In modern age, the majority of employment is created as office work. In our vision of the North Hanoi, we have proposed to add another CBD at around the station N4 and N5 capitalizing on location advantages. Figure 3 illustrates the contrasting cases of land use impact on bi-directional transport demands. In the top case of bedroom suburban development, the morning traffics going to the city center may be full but the in-coming trains are almost empty. In the lower case of mixed use town, the employment created in the town will create traffics on the incoming trains. In terms of train operation, it is evident that the mixed use case will generate more revenues and operation efficiency is superior.

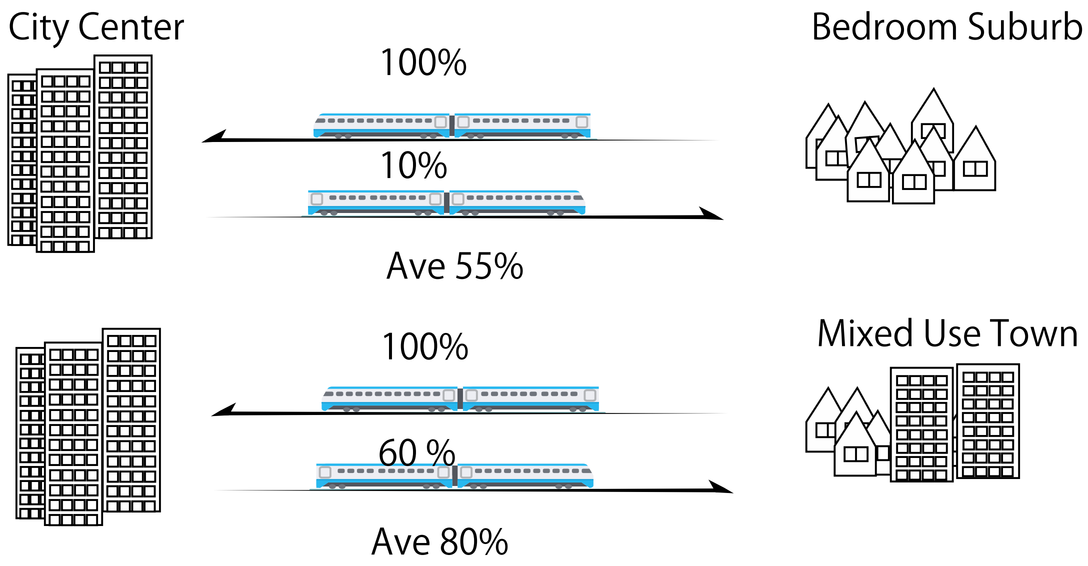


Figure 3 Impacts of Mixed Land Uses on Bi-directional Traffic Generation

The increased revenues generated with more passengers will also open up the possibility for the investment in rolling stocks.

2.1.6 Improved Services: Shorter Headways

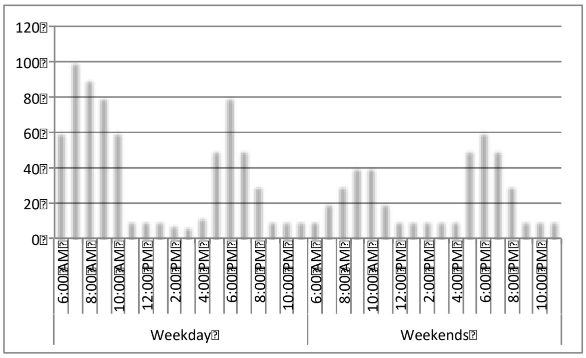
With more passenger traffics, the needs for increased transport capacities will arise. A simple way to respond to the increased demands is to add more trains and more trains means a shorter headway.

It is a human psychology that passengers find waiting time more mundane than the time spent on moving. A shorter headway, i.e. more frequent services, will increase the attractiveness of the station and consequently increase the value of land in the area.

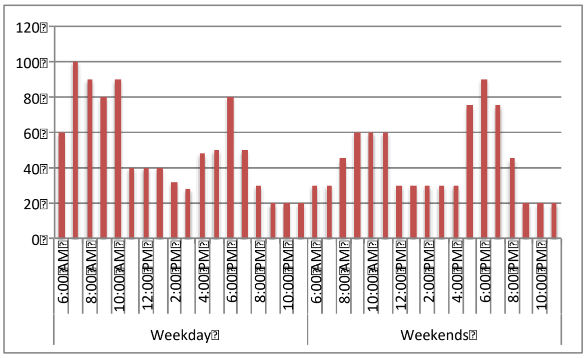
2.1.7 Smoothing Traffics

Figure 4 shows traffic changes by time of the day. Since the transport capacities are defined at its peak demand in principle, large variations in traffics means that there will be idle capacities during the downturns. Mixed land uses will attract visitors throughout the day there will be less variations i.e. less idle capacities. Another aspect in train operation efficiency.

If the mix land uses cater for residence and work, there will be much less traffics during weekends. The mixed land use should incorporate leisure functions to avoid idle capacities during weekends.



Suburban Station Passengers



Mixed Use Town Station Passengers

Figure 4 Passenger Traffic Changes by Day and Time

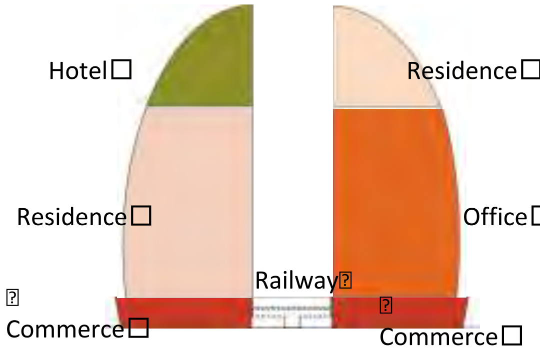
2.1.8 Aged and Children Friendly City

Vietnam is becoming grey rapidly following the path of Japan. The philosophy of TOD, compact city, mixed use is amenable to the valuable and young population alike. The aged citizens will have difficulty in driving cars or motor cycles and if they do, they pose menace to others and themselves. For the young, automobiles are the biggest threats. Walkable and compact city will present numerous opportunities to enjoy and explore life in the city. Access to trains through TOD will provide access the events and services available in other parts of the city even for the aged and young. TOD is more equitable to all spectrum of age groups and even create more commercial opportunities as the old and young will take more walk and will be attracted to consume more goods and services within their neighborhood.

2.1.9 Branding and Destination Strategy

North Hanoi is still not on the metal map of Hanoi people. It is not a destination. To secure the population movement, the place needs to establish its own brand such as airport gateway. Beyond branding it is important to establish a strong destination strategy. Another idea is to have symbolic monumental station buildings that represent the concept of gateway and new business hub with architectural impressions. The financial tower planned at the Smart City zone is one such attraction. The building is planned to have 108 floors to become the tallest building in Vietnam. Such undertakings will not only attract investors but also could attract tourists. Another proposal here is the Arc of Triumph Buildings to be located at the gate of Station N5. A pair of symmetrically juxtaposed half arc buildings will represent the gateway to the airport, honoring Gen. Vo Gyuen Giap by buttressing the highway and railway corridor. The buildings will have mixed uses of residence, office, hotel and commerce to create self-contained mini-city in themselves.

Financial Tower in Smart City



Proposal for Arc De Triumph Station Buildings

Figure 5 Development of Symbolic Structures As Destination

2.2 Guidelines on Urban Design

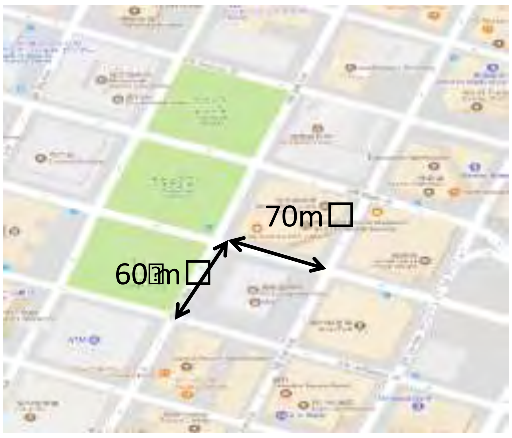
2.2.1 Human Scale Design

What is critical in urban design for mixed use and walkable city is its design scale. The basic design will be based on human scale as the residents should be walking to the stations. The beauty and comfort of the city must not be felt by driving through the area but rather by living there and walking around the neighborhood and most importantly walking to the station every day. Therefore the scale of design needs to have traditional human scale and the perspective for the judgment of the city must be based from human eye levels.

2.2.2 Urban Block Patterns

The size and design of urban blocks define the characteristics of the urban area and walkability of the area. For most of conventional TOD projects, an optimal size of urban block sizes is not yet fully investigated. Figure 6 shows the block patterns of Manhattan and Portland in the US. Both are reputed as a transit oriented cities. Interestingly both cities had adopted small blocks. In Portland's 60 meter blocks, the area is just large enough to allow for one or two large buildings. Most of the streets in Manhattan or Portland are one way streets. Smaller blocks will create more streets. Thus street crossing become more frequent in reaching a destination. At the same time street width are narrower and easier to cross. Therefore overall walking experience in these cities are positive. These two cases present give strong justifications for adopting small sizes of urban blocks. The sections to follow will give further theoretical justifications for small blocks

Manhattan, New York



Portland Oregon

Figure 6 Block Sizes of Manhattan and Portland

2.2.3 Adoption of Small Blocks

In this study small block grids were adopted for two reasons, 1) compliance with TOD principles, and 2) adaptability in planning for population, physical floor spaces and financial evaluation. Though small grid blocks do not immediately conform to the land use plans currently adopted, it is hoped that after specific investment licenses are granted, block patterns should be modified to adopt small block as design standards. Figure 7 shows a schematic block design recommended in this study. The average length of blocks is 80 m while the maximum is set at 120 m. The reasons for recommending small blocks are two-folds. First of all it creates more business opportunities and also creates pedestrian friendly environment as explained below.

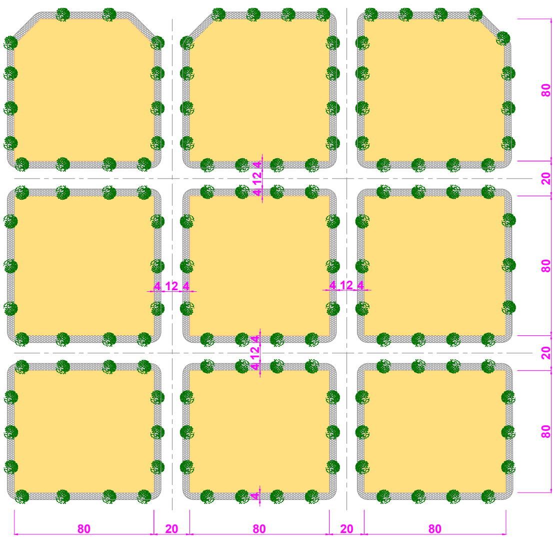


Figure 7 Block Design of TOD Area

2.2.4 Size of Blocks and Business Opportunities

Be it a restaurant or shop, the front window is the place to have a direct appeal to the passing-by potential customers. Pedestrians at the same time enjoy window shopping while reaching a destination. Therefore the length of shop front matters and not floor area for customer attraction.

Figure 8 shows a simple effect on shop front length by reducing block sizes to the half. When the block sizes are reduced in half, the total perimeter lengths of all the blocks becomes twice.

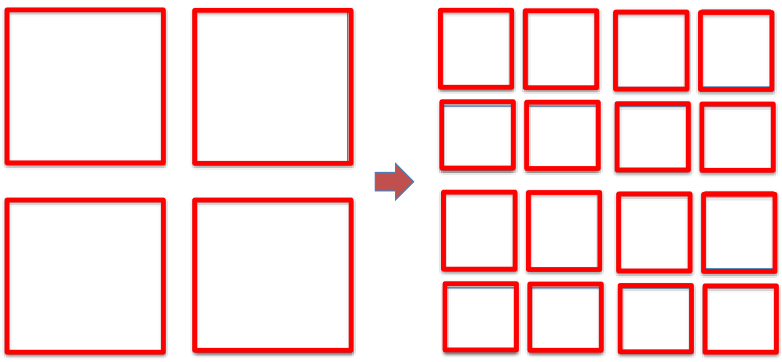


Figure 8 Effect of Reducing Block Sizes By Half

2.2.5 Block Size Effects on Mobility and Pedestrian Safety

A larger block will generate more traffics, therefore the roads need to be broader accordingly. On the other hand, smaller blocks will generate less traffics per block. At the same time as shown above, the road length is far longer. Therefore the road density is higher. Thus as shown in Figure 9, it is more acceptable to allow for one way traffic. One way traffic is not only safer for road crossing pedestrians but also convenient for drivers. Drivers can park and access both sides of the road without turning. It could create smoother traffic movement.

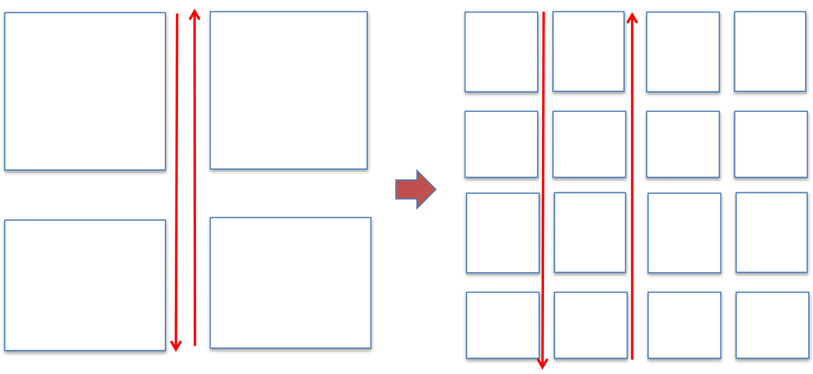


Figure 9 Block Size, Road Width and Traffic Direction

2.2.6 Land Use Design

In order to promote TOD, the uses of land areas close to stations are very critical. Near-to-station lands are prime locations for commercial areas and also time sensitive commuters for residential choices. Parks provide good ambience and environment but at the same time, it will not only deprive such commercial opportunities but also increasing walking time to the stations. In the past, the US cities promoted the concept of 'park and ride' by providing ample parking space in front of transit stations. This approach only marginally increased transit ridership but failed in creating transit oriented cities. Figure 10 contrasts the layout modification recommendations for LVC/TOD approach. Parks do not serve the commuters but the residents and local workers may open space during breaks, lunch time, holidays or morning jogging. If that is the case the park should be surrounded by as many residents as possible instead of becoming access elongation to stations. From human scale design and daily livability enhancement perspectives, small parks in neighborhood has much larger utility than big parks for occasional visits. The recommended TOD layout includes pocket parks within 200-300 meters of walking distance where small children can play and aged can exercise.

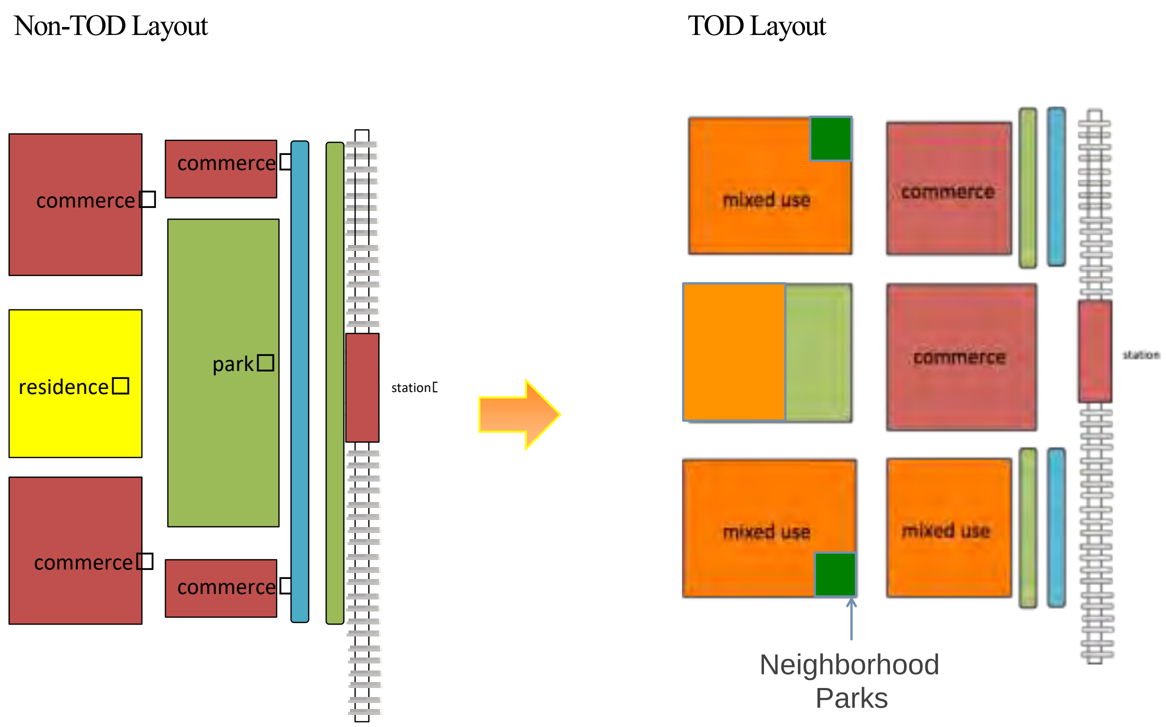


Figure 10 LVC/TOD Inductive Land Use Layout

2.2.7 Activity Design

"Only architecture that considers human scale and interaction is successful architecture."

"First life, then spaces, then buildings - the other way around never works."

[Jan Gehl]

Searching and thinking the "activities in the city" is necessary to design or provide better space, architecture and district. The better the space, the more the attractive city will be.

- take a meal, drink...
- walk, run, move...
- shop, play, appreciate, stay,...



And social activities are the important elements.

- children's play
- greetings and conversations
- communal activities of various kinds



- simply seeing and hearing other people

At that time, Public Space in cities will play an important role.

- street
- sidewalk
- plaza & park

2.2.8 Street Design

Motomachi Shopping Street, Yokohama, Japan

Marunouchi Naka-Dori, Tokyo, Japan

The street is not only a space for cars but also for pedestrians and it is important for activities as well. Therefore, streets should be designed carefully from small to large dimensions.

Lower part

The first floor should be used for commercial and should be 2m away from the sidewalk to make it a lively street and more enjoyable, comfortable and easier for the pedestrians.

Street tree, furniture, etc.

Street trees, street furniture and illuminations promote people's activities to create lively atmosphere.

2.2.9 Access Road Design

As part of the block pattern, the standard design for the access roads follows the dimensions shown in Figure 11. The road capacity is more correlated to the areas of roads. As the block design recommended are in small sizes, the road densities too increases even the below defined roads of 12 meters. Inclusive of pedestrian ways, the average road areas in TOD areas will comprise 25%-30% of the total areas. The road design below will provide two lanes on both directions. However, it is usually the case the street sides are used for parking very often blocking the traffics. As mentioned above, if the road is used as one-way traffic flows, the roads will have ample carrying capacities for traffics generated by high density dwellings.

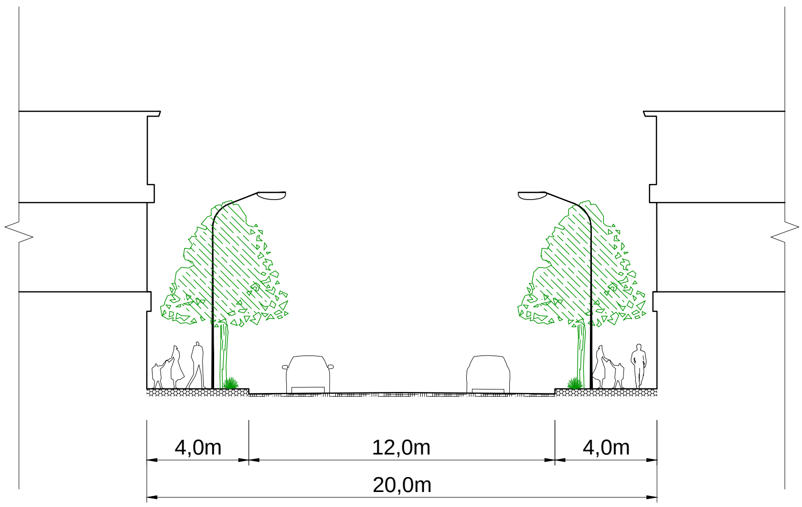


Figure 11 Sectional Design of Access Roads

2.2.10 Green Corridor Design

The TOD areas will have a network of green corridors with a wider span to accommodate a central green pedestrian way as shown in Figure 12. The main aim of the Green Corridors is to provide park-like green environment on a daily use basis for expansive residential and working communities. The corridor will also provide tracks for installing LRT or BRT to provide local transport access to the station to capture larger ridership in the future.

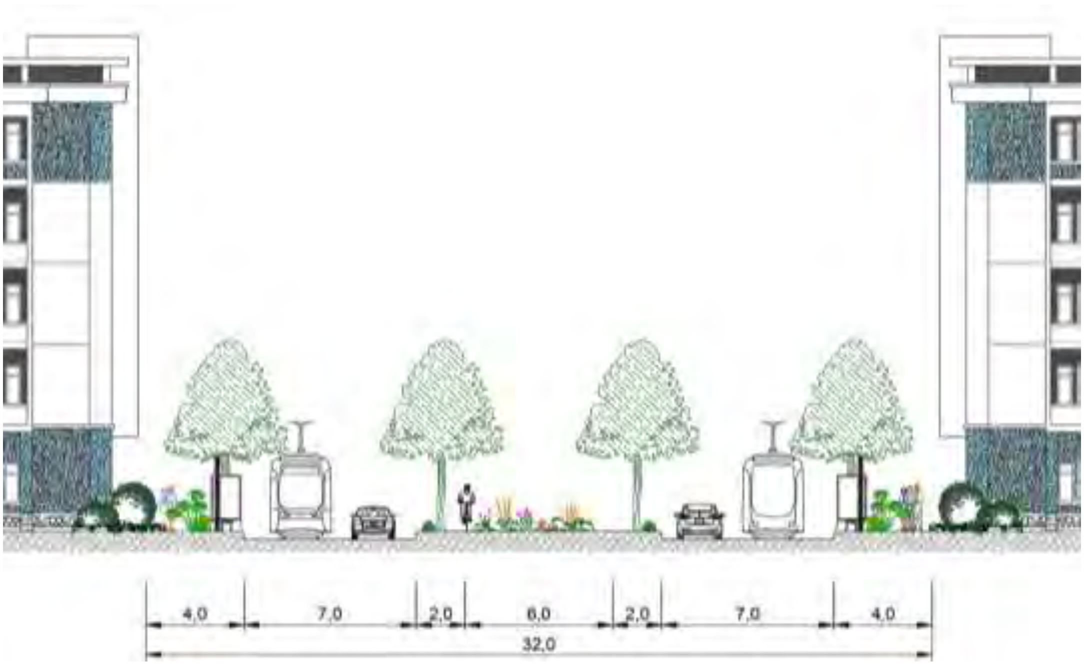


Figure 12 Sectional Design of Green Corridor

2.2.11 Sidewalk & Street Corner Design

Sidewalk and street corners are the key elements of the district's character. The attractiveness of a district depends on street designs.


24th Street Parklet, San Francisco , USA


The Riverwalk, San Antonio, Texas, USA

Paving

The elevation difference between a road and sidewalk should be as flat as much as possible for pedestrian to cross the road more easily. The barrier between the road and sidewalk should be in the same level as well.

Width

The sidewalk width should be at least 4 m to incorporate useful tools and hold optional activities on the sidewalk without obstructing passageway. For instance, street trees, street furniture, open-cafe, park-let, etc. could be placed.

Street trees

The pitch of trees should be less than 3 m to achieve a better environment by creating shadows and verdure on a sidewalk.

Illumination

The illumination is important both for creating better atmosphere and safety walking. At that time, the color temperature of illumination should be less than 3000K to give pedestrians sufficient light and a warm ambiance.

2.2.12 Park & Plaza Design


Ten-Shiba, Osaka, Japan


Plaza in front of Himeji Station, Hyogo, Japan

Park and Plaza improves the quality of life of residents by creating an urban margin. These design should be constructed from various points of view.

User

The design should consider various scenes and functions because the users of park and plaza are diverse. Particularly, it should be friendly for the minority, for instance, children, elderly people.

Waterfront space

Waterfront space is very important for Hanoi people's life because of the history and environment. Therefore, on a park and plaza waterfront space is need and should be designed appropriately with aesthetics and function in mind.

Useful tools

Park and Plaza should be convenient as well as comfortable. For instance, Movable furniture could encourage users to be more active since it will give them options on how to use the space freely. Free Wi-Fi could also be provided for added convenience.

PPP

It is possible to have park and plaza to be developed by private sector through PPP. For instance, in Japan there are cases where a development company provides large and beautiful green parks with trade-off of relaxing density or height restrictions from the city government.

2.2.13 Building Design Code

Buildings are the most influential factors for constituting cityscape and developing public space. On the other hand, each building usually a different owner, thus, each building design will be decided by a different criterion. Therefore, before starting to develop a city, Building Design Code should be defined and shared.

Nihon-Odori, Yokohama, Japan

Around Tokyo station, Japan

Shape

The bigger the building is, the more massive the surface becomes. Therefore, separating a building to 2 parts, lower part (~2nd,3rd floor) and higher part (3rd,4th floor~) to reduce oppressiveness.

Set back

The higher part should be set few meters back from the lower part to prevent giving pedestrians massive impression.

Color & Material, Lighting

The color and material of the lower and the hanger parts should be different as well as the lighting. The lower part should be warm because it’s closer to the pedestrians and the higher part should be cool because it’s closer to the sky.

Height & Skyline

It will look too massive and boring if all buildings are high-rise and same height. Design Code should control each building height and be basement for designing beautiful skyline.

Advertisement & Billboard

Too much advertisements and billboards spoil cityscape. Therefore, Design Code should control its size, color, position, content, etc.

2.2.14 Pedestrian Grade Separation To Station Access

Modal changes do bother commuters who are in a rush particularly in the morning. In general train users would prefer to walk to a train station and walk to their destinations after getting off at a station. Thus it is important to provide walking axes to the station within the TOD catchment areas.

Figure 13 shows an example of securing pedestrian walk on the ground level and the concourse level of the 2-3 floor level with the corresponding setbacks to provide park-like pedestrian access on the rooftop to the station. Automobiles and motor cycles are threats to pedestrians in Hanoi. Securing safety of pedestrians to stations are important in retaining a maximum ridership.

Figure 13 Enjoyable Station Access Plan

The commuters feel wasting time on a path offers no side attractions or chances for errands. If the commuting axes offers opportunities for shopping, dining, drinking, or simply enjoying the view, the time for walking becomes more of pleasure to enhancing ridership.

2.2.15 Keeping Pedestrians from Sunlight and Rains

In Hanoi, there are many months of rains and strong sunshine. Under these climatic conditions, people tend not walk. In an old Hanoi urban design, the streets are narrower and trees planted on both sides provide good shelter from sunshine and rains. It is possible even to provide an artificial roof cover to give better protection even some air conditioning on the commuting axes.

Galleria Vittorio Emmanuelle in Milan, Italy

Kyoto Nishiki Mall, Japan

Figure 14 Keeping Pedestrians From Sunlight and Rains

2.2.16 Parking Needs for Motor Bikes and Bicycles

Provide space for motor bike parking in around the stations to attract more passengers and ban parking on pedestrian walks. One of the potential site for such bike parking if exists at the space under the elevated railway tracks. This space will not offer much value due to noise of trains. There are enough clearance to construct 3 floor parking space for bikes. Attracting bike passengers will increase the radius of TOD by 2-3 times easily. It is time of commuting that matters to the passengers.

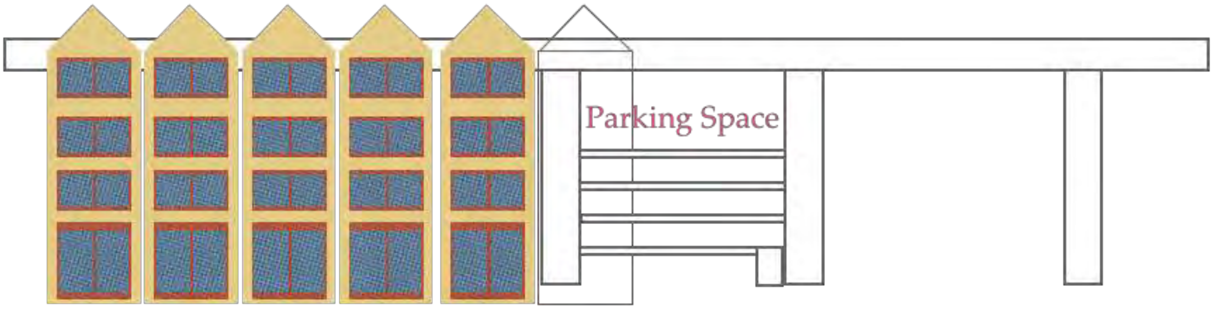


Figure 15 Parking Space Design for Motor Bikes and Bicycles

2.3 Guidelines on Population Distribution

The ultimate goal of TOD is to shift daily traffics from automobile uses to transits, in the context of this study, to railways. For this goal, naturally the urban designs of the area must be centered on stations. The feeder roads must be prioritized to be connected to the stations. Most importantly there should be highest density of population and employment should be created with the higher density to the station. The population density distribution should be represented like a bell curve with the peak at the center.

2.3.1 FAR Distribution

In urban planning for infrastructure requirements, the setting of population target is the foundation of planning. In Vietnam, the population is the target control variable in land use and zoning planning. However, the population itself is not controllable for the government as they move fluidly. Therefore we propose here to adopt FAR control. FAR is defined by the land area and number of floors of the building of concern.

In TOD areas it is recommended to adopt FAR based control of resident population control. Architectural controls must be imposed to maximize the developable floor areas around the station areas with a priority to commercial and residential land uses.

For a large scale TOD/LVC area, the maximum FAR is set at 900% while the maximum is set at 400% for a small scale TOD/LVC area. The 900% provides ample space between buildings if the average floor height is 26 as shown in Figure 16.

	Floor-to-Area Ratio							
Building to Area Ratio	2500%	900%	600%	500%	400%	360%	330%	300%
80%	31	11	8	6	5	5	4	4
60%	42	15	10	8	7	6	6	5
50%	50	18	12	10	8	7	7	6
35%	71	26	17	14	11	10	9	9
25%	100	36	24	20	16	14	13	12

Figure 16 Buidling Floors by Floor-to-Area Ratio and Building to Area Ratio

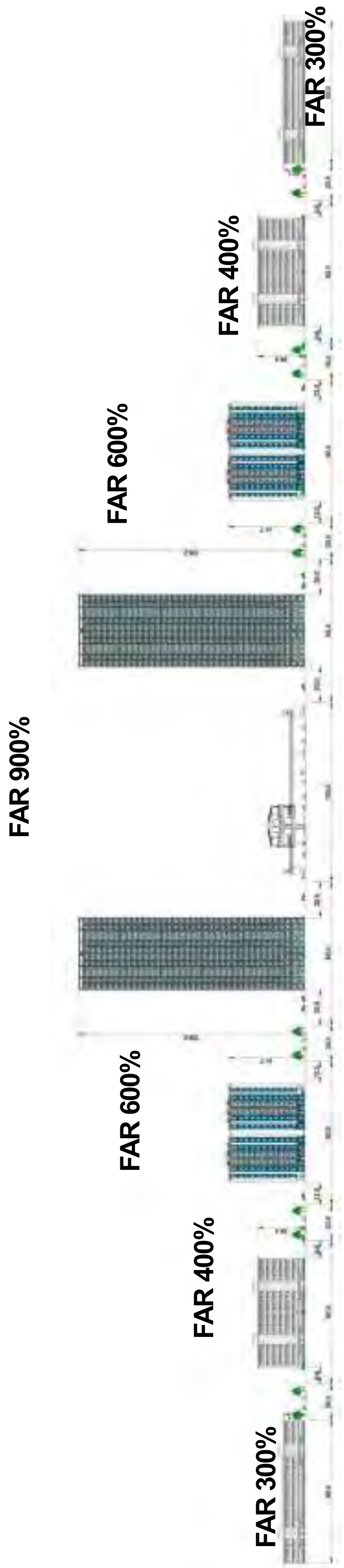


Figure 17 FAR Distributions in TOD Area

2.3.2 Urban Design Control

As shown in the Figure 18, the skyline of building can be better controlled with FAR to create urban design harmony along the railway corridor.

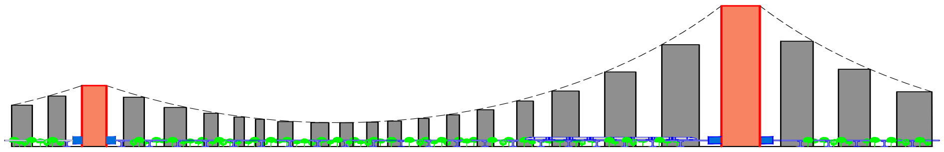
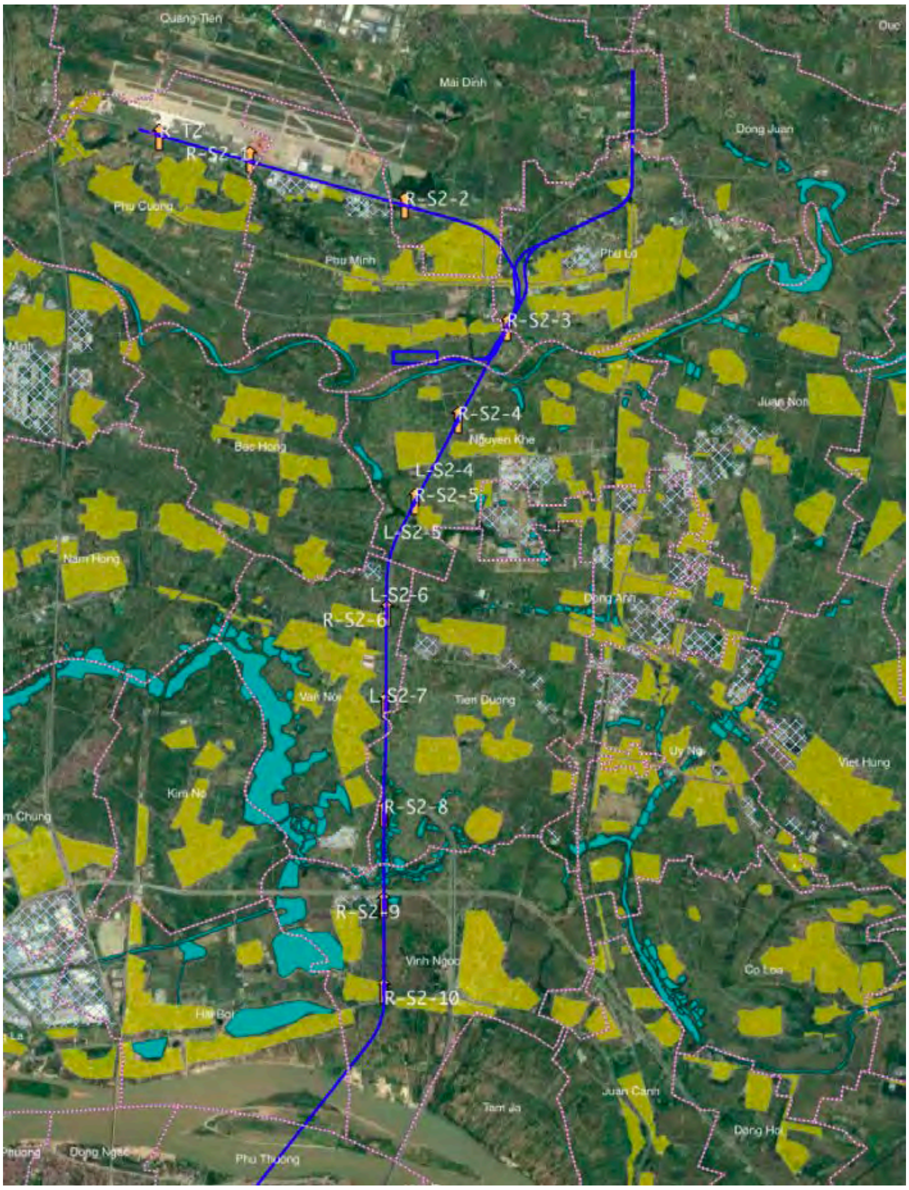


Figure 18 FAR Control and Skyline Control

Appendix 3 Analysis of Existing Communities in Hanoi North

1 Current Conditions

A bird eye view of the current urbanization in Dong Anh and Soc Son areas indicate wide spread of urbanization colonies throughout the area as shown in Figure 1. As is evident from this satellite imagery, the distribution of the urban colonies are widespread and evenly spread out.



Note: the pink dotted line indicates the boundaries of communes. The blue line is the alignment of Line2 Phase 3.
Source: JICA Study Team

Figure 1. Project Current Status of Urbanization

2 Methodology

As shown in the Figure above, we have identified all the builtup areas on the Google Earth satellite imagery. These spatially defined areas were tagged with commune names to calculate the actual built up areas and by corresponding to the population data for each commune, the current population density on built up area basis are tabulated.

3 Current Land Use

The following Table 1 shows the composition of the land uses of Dong Anh District. The surveys were conducted on a desk top basis on satellite images and maps. Therefore there is some margin of errors in classification. In addition, given our goal of exercise, land uses for classification were limited to ones related to inhabitation. The total areas of inhabitable land uses of Dong Anh is 4196 ha. In comparison to a total area of the district of 18,588 ha, the target areas constitute 23% of the entire district.

Table 1. Current Land Use Composition of Dong Anh District

	Residential	Commercial Mix Use	Industry/Institution	Total
Dong Anh District	3,087	137	972	4,196
Bac Hong	102	0	0	102
Co Loa	131	0	0	131
Dai Mach	45	0	0	45
Dong Anh	36	83	498	617
Dong Hoi	93	0	0	93
Duc Tu	145	0	23	168
Hai Boi	72	0	42	114
Xuan Canh	107	0	1	108
Xuan Non	85	15	18	118
Kim Chung	152	0	64	216
Kim No	98	0	0	98
Lien Ha	69	0	0	69
Mai Lam	113	0	0	113
Nam Hong	135	0	4	140
Nguyen Khe	165	6	37	208
Tam Xa	36	0	0	36
Thuy Lam	215	0	0	215
Tien Duong	139	5	24	169
Uy No	269	28	35	332
Van Ha	163	0	0	163
Van Noi	156	0	17	173
Viet Hung	168	0	45	213
Vinh Ngoc	167	0	8	175
Vong La	118	0	156	275

Source: The JICA Study Team

4 Current Population Density

Table 2 shows the population density of each commune per built up area basis. The areas are calculated based on the most updated satellite images (2017) and population estimates are based on 2009 Census. The estimation of population for 2017 is based on average population growth rate between 1999 and 2009, thus some estimates are too high such as Kim Chung possibly. Conservative estimates of population density would be the data for 2009 since the area data for any year are ones based on the latest satellite images and the population data are based on Census data. The average population density for the built up area in Dong Anh is over 100 persons per hectare. The density is much lower than those in the city center of Hanoi. However, there are some areas that have population densities around 200 person per hectare such as Dai Mach, Dong Anh, Hai Boi, Kim Chung, and Lien Ha.

Table 2. Population Density Estimation of Each Commune

Areas	Habitable Areas	Population 1999		Population 2009		Population 2017	
	Ha	Population	Density	Population	Density	Population	Density
Dong Anh District	3,224	260871	81	333337	103	440,695	137
Bac Hong	102	10,197	100	11,696	114	13,052	128
Co Loa	131	14,496	111	16,648	127	18,597	142
Dai Mach	45	8,492	190	9,756	218	10,901	244
Dong Anh	119	21,957	185	22,757	192	23,418	197
Dong Hoi	93	8,780	94	10,006	107	11,109	119
Duc Tu	145	13,806	95	16,085	111	18,176	125
Hai Boi	72	9,690	135	16,034	223	23,989	334
Xuan Canh	107	9,040	84	10,136	95	11,108	104
Xuan Non	101	10,630	106	14,026	139	17,509	174
Kim Chung	152	8,206	54	30,730	202	88,371	582
Kim No	98	10,482	107	12,367	126	14,116	144
Lien Ha	69	12,840	187	15,428	225	17,869	260
Mai Lam	113	9,271	82	12,227	109	15,257	136
Nam Hong	135	10,137	75	12,530	93	14,845	110
Nguyen Khe	171	10,654	62	12,729	74	14,676	86
Tam Xa	36	3,844	108	4,201	118	4,510	126
Thuy Lam	215	15,026	70	16,763	78	18,296	85
Tien Duong	144	13,990	97	15,317	106	16,469	114
Uy No	297	12,750	43	17,144	58	21,727	73
Van Ha	163	7,876	48	9,371	58	10,769	66
Van Noi	156	9,086	58	10,626	68	12,044	77
Viet Hung	168	12,727	76	17,202	102	21,891	130
Vinh Ngoc	167	10,754	64	12,638	76	14,380	86
Vong La	118	6,140	52	6,920	58	7,615	64

Source: The JICA Study Team

Appendix 4 Case Studies of Transit Oriented Development

1 Bay Area Rapid Transit (BART)

1.1 Background

The Bay Area Rapid Transit(BART)'s construction was completed in 1972, starting its operation in the same year. The railway system was aimed at connecting the sprawling suburbs of San Francisco, namely Oakland and Berkeley through a cross bay tunnel to the city center. With the maximum speed of 130 km per hour, automatic control and elevated tracks within urbanized areas, it was heralded as the state of art technology at the time.

Today, the BART has 6 lines and 180 km of railway tracks with 48 stations. Its ticket fares range bertween USD 2.5 to 16.65 in accordance to the travel distance. Its weekday passenger averages with 460,000 and 340,000 per day on weekends. Financially, the revenue in 2017 was USD 540 million against the operating expense of USD 908 million with a net operating loss of USD 361 million.

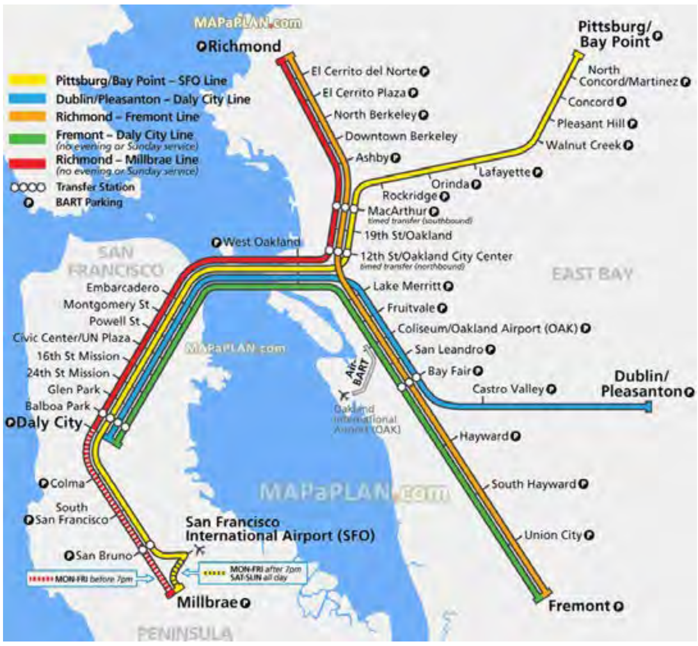


Figure 1 Bay Area Rapid Transit Network Map

1.2 Park'nd Ride

Confronted with less than expected ridership, one of the countermeasures that the planners and managers came up with was so-called "Park and Ride" system. In order to encourage automobile users to switch from automobile to railway commuting, all the suburban stations had built super-sized parking lots to provide undisrupted intermodal transfer from automobile driving from home to a train ride to commute to a work place. Despite these generous and wasteful land uses, the ridership in BART did not take off. The BART even permitted carrying of bicycles into carriage wagons but all the attempts made small impacts.

Figure 2 Park and Ride System at Walnut Creek Station (2014)

1.3 Evaluation

BART was expected to bring a major modal shift from automobiles to railway to alleviate growing traffic congestions taking place in the Bay Area. The shift did not take place in a scale anticipated therefore the residents in the area saw ever-worsening traffic conditions up to the present day. A promoinant urban planning scholar, Peter Hall, exemplified BART as a big planning failure in his book titled "Planning Disaster." The major problem was the miscalculated traffic demand and too generous construction budget with scant network coverage of sprawling suburbia of low density in the region.

One of the evaluation studies concluded[2], "it simply does not serve the needs of the Bay Area residents. These people care about door-to-door journey time; BART's planners were obsessed with time on the BART journey alone. By choosing a rail system they created a configuration that puts BART out of walking rearch for most people. Since they must use buses or cars to feed into BART stations, most consider that they might as well continue with those modes. It is the door–to-door, no waiting, no-transfer feature of the automobile that by eliminating access time, make private cars so attractive to commuters. "

Simply put, it was not just enough to construct a railway system to shift passengers to railway. BART did not succeed in transforming transport system of the region. Nevertheless, without BART, the regional economy may be stifled to a halt by traffic congestions due to economic success of Silicon Valley. The economic growth spurred

[2] Melvin M. Webber, "The BART Experience –what we have learned", 1976.

un-ending urban growth which prompts more traffic demands that simply the regional road infrastructure cannot accommodate.

1.4 Birth of TOD

The phase of 'Transit Orient Development' was coined by a renowned urban designer, Peter Calthorpe when he published his article in New York Times. In "The New American Metropolis" in 1993, Calthorpe defined TOD as "a mixed-use community that encourages people to live near transit services and to decrease their dependence on driving." UC Berkeley Professor with expertise on land use and transport, Robert Cervero, in his early studies of transit joint development, had found a correlation between urban densities and transit ridership on the Bay Area's BART rail system. He started promoting for high density urban development even though clearly political inclination of suburbia at that time was down-zoning for low densities. The landowners firmly believed that low densities will increase their property values instead of increasing. It was a typical case of contradiction where summation of individual welfare maximization leads to social welfare degradation.

1.5 Two Contrasting Suburban Stations: Pleasant Hill vs Walnut Creek

Even though TOD has become a new urban development policy in the region, not all the cities followed this new approach yet. Two stations in the east of Pleasant Hill and Walnut Creek, two adjacent stations on the same line, present most interesting cases. While the city of Pleasant Hill embraced this new concept and converted the vast parking lots around the station into a new urban development with the concept of TOD as shown in Figure 3, the city of Walnut Creek stayed with 'park and ride' system of huge parking space.

Figure 3 Pleasant Hill Station Area Transformation Between 2002 and 2018

Table 1 contrasts the sizes of population and ridership of two cities and indicates Pleasant Hill is a clear winner in generation of ridership. The city owes its success to its TOD implementation. Now Walnut Creek is following the suit to convert its parking space to mixed use urban development.

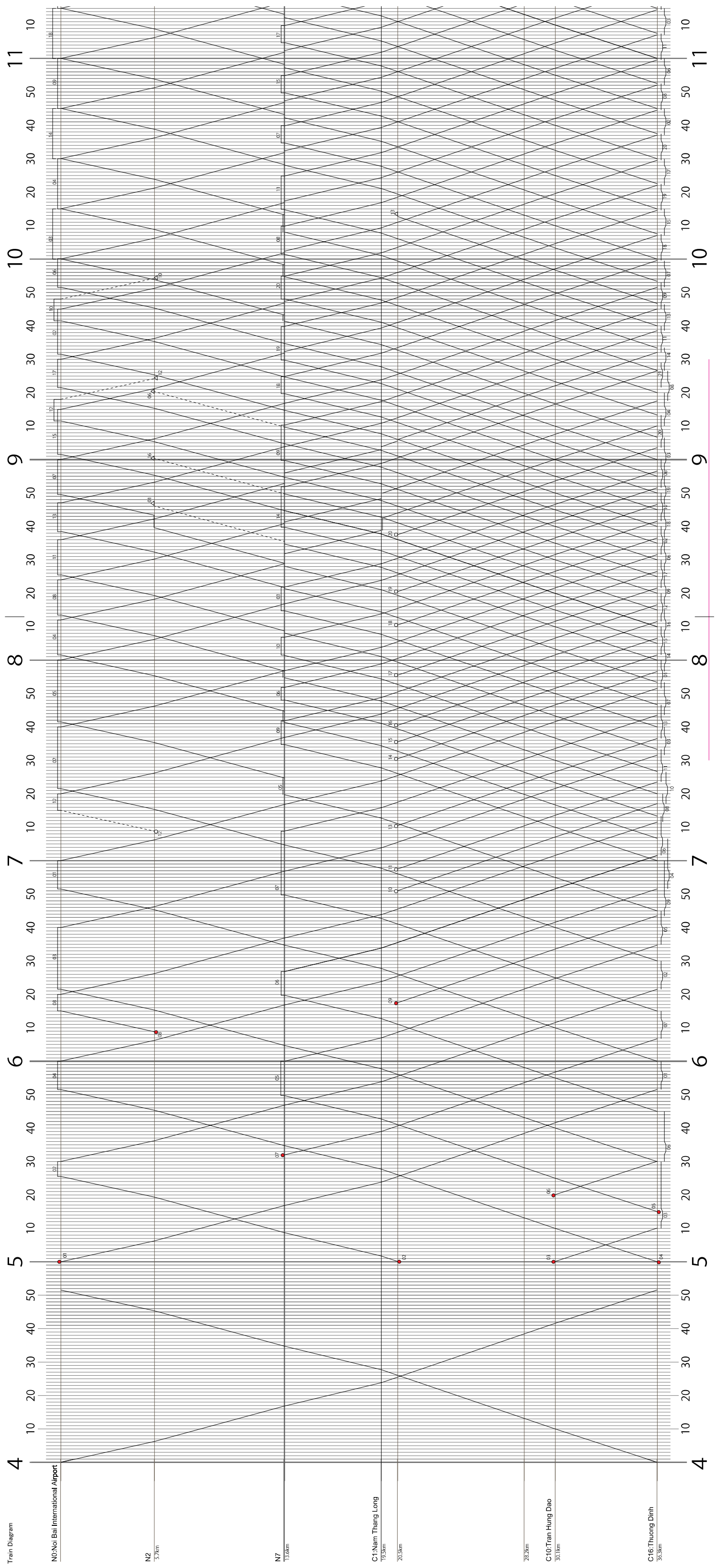
Table 1 Population and Ridership of Pleasant Hill and Walnut Creek

	Pleasant Hill	Walnut Creek
Population	35,000	70,000
Average Ridership per day	14,000	12,000

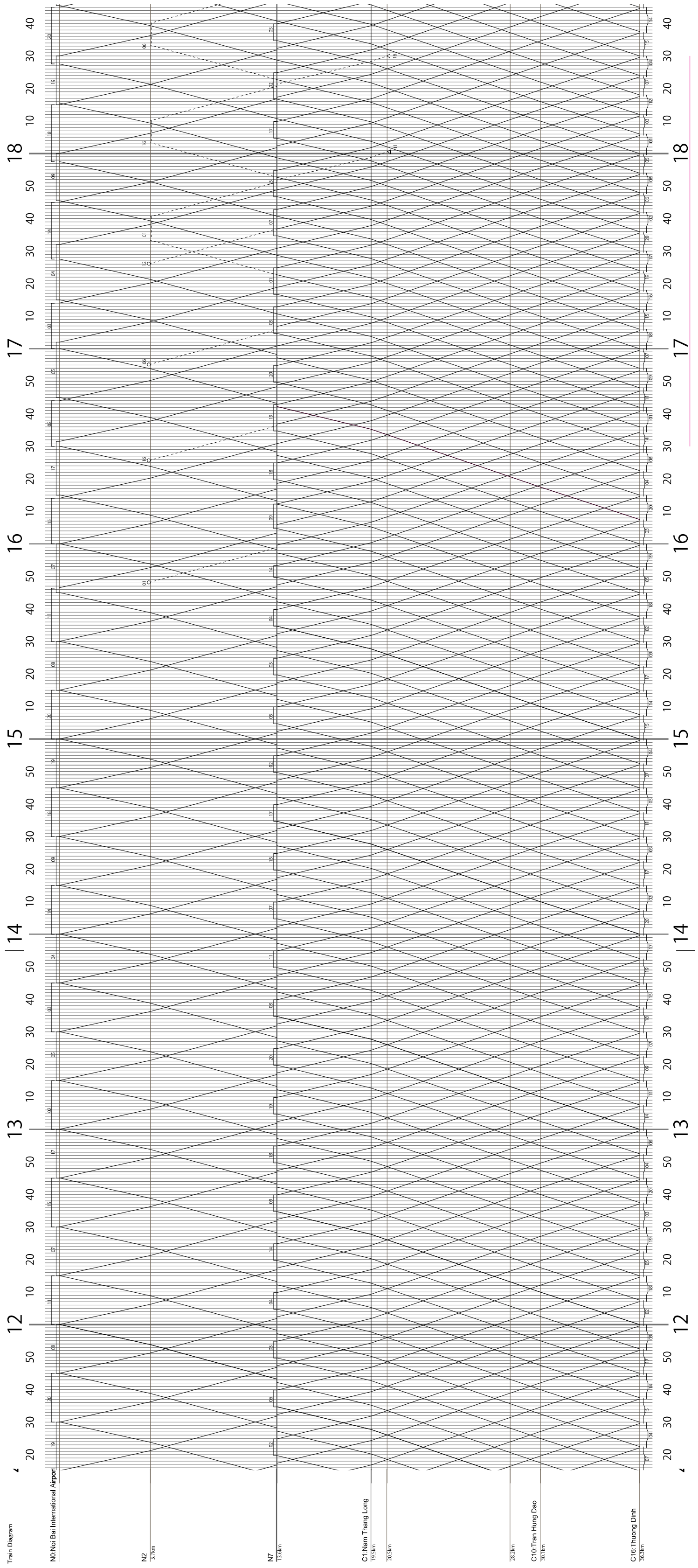
Source: BART

Appendix 5 Operation Diagram

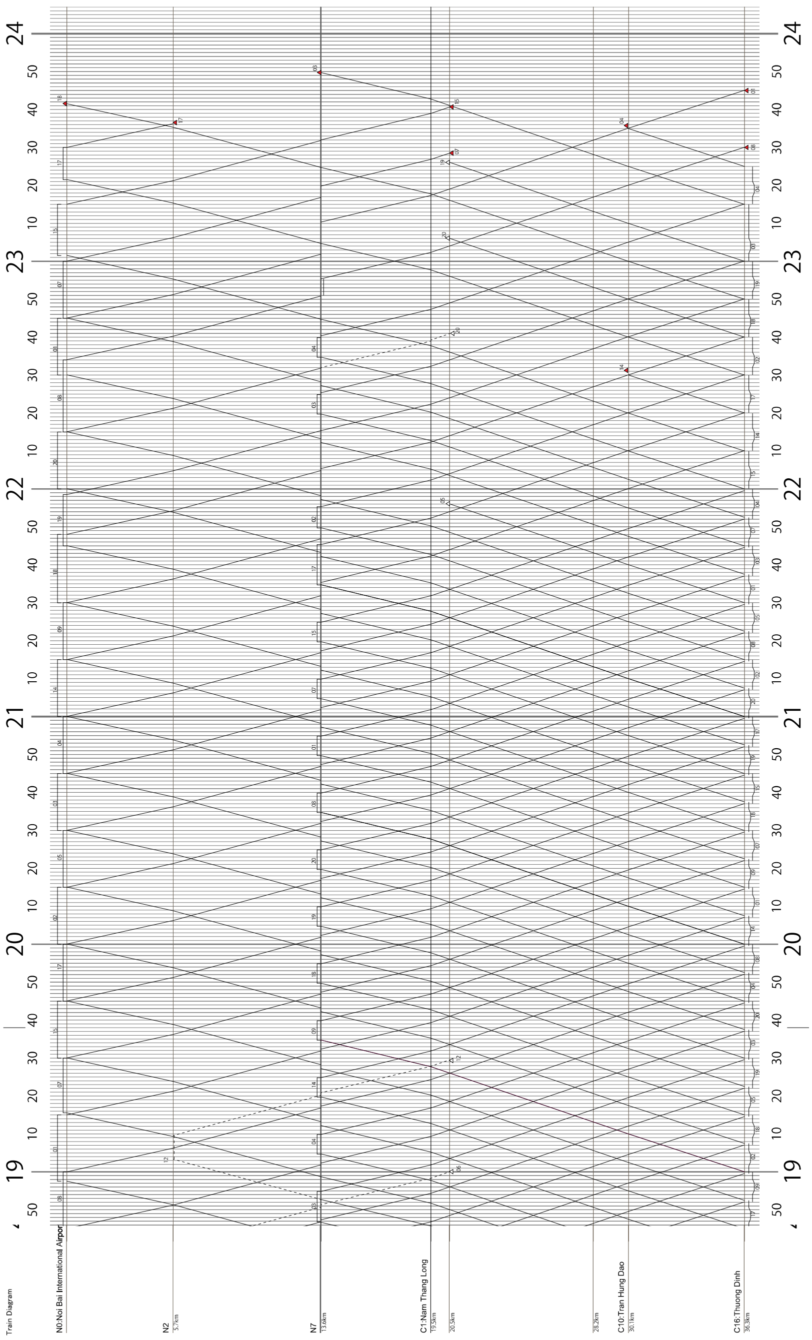
Operation Diagram for Commuting Trains 1/3 of A Day



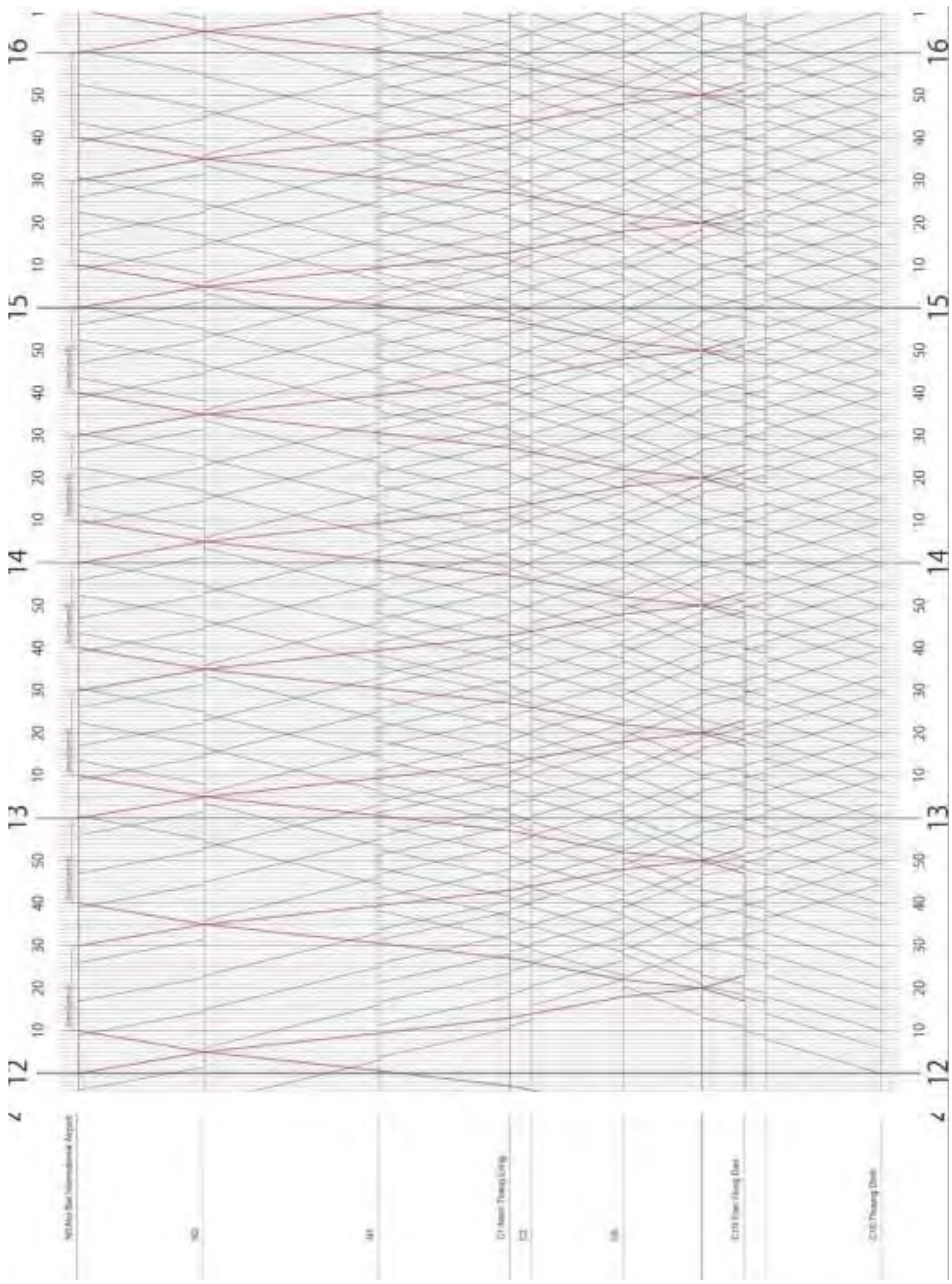
Operation Diagram for Commuting Trains 2/3 of A Day



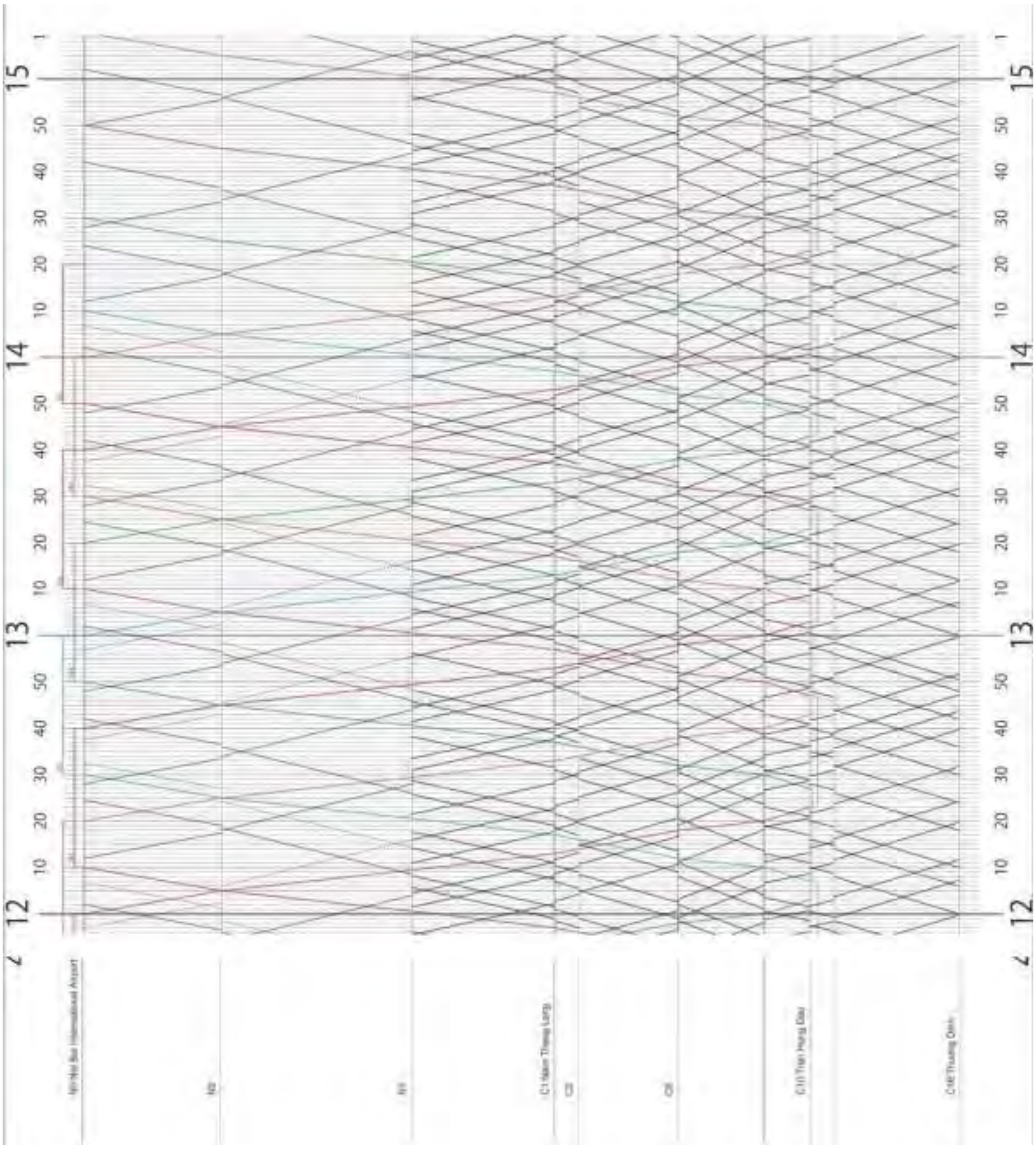
Operation Diagram for Commuting Trains 3/3 of A Day



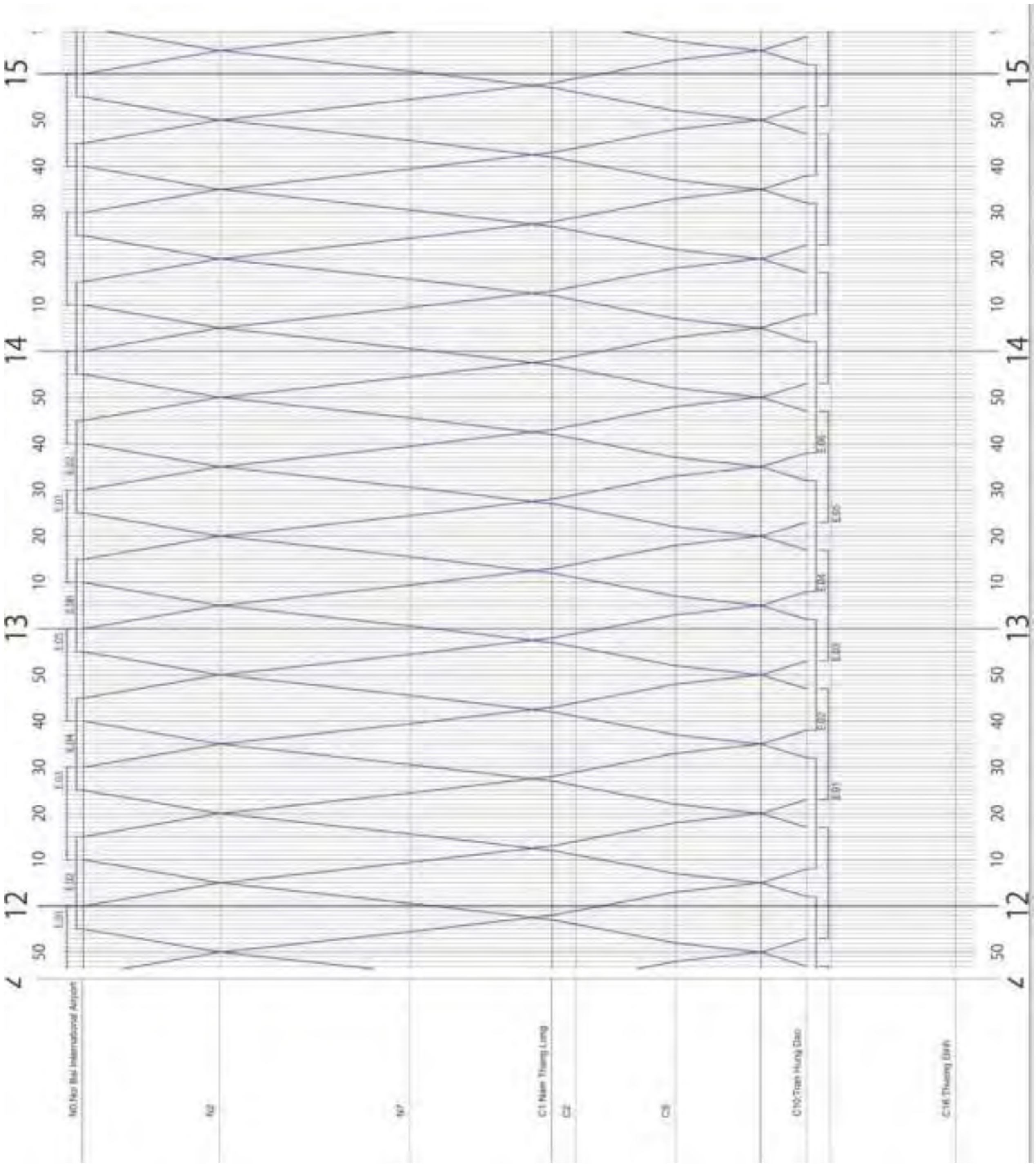
1 Operation Diagram for Express Trains 30 min Headway



2 Operation Diagram for Express Trains 20 min Headway



Operation Diagram for Express Trains 15 min Headway



Appendix 6 Report on comments of Hanoi Department of Planning & Architecture (Official Letter ref. 4406/QHKT-HTKT dated 8 / 8 / 2019)

1. Depot options

1.1. Recommendations

JST recommends basically the adherence to the original plans of depot developments according to the Transport Master Plan with each depot for Line 2.1 and Line 2.3. Line 2 has over 40 km in its full length with busiest operations in the middle section of Line 2.1. The depot of Xuan Dinh will manifest its full buffering functions to ensure regular punctual and safe operations with the best cost efficiency.

Simultaneous development of Line 2.1 and Line 2.3 does not reflect the unforeseen challenges, risks and delays of a large-scale project implementation and consequential economic losses. Therefore a pragmatic conservative approach for stage-wise implementation is much recommended.

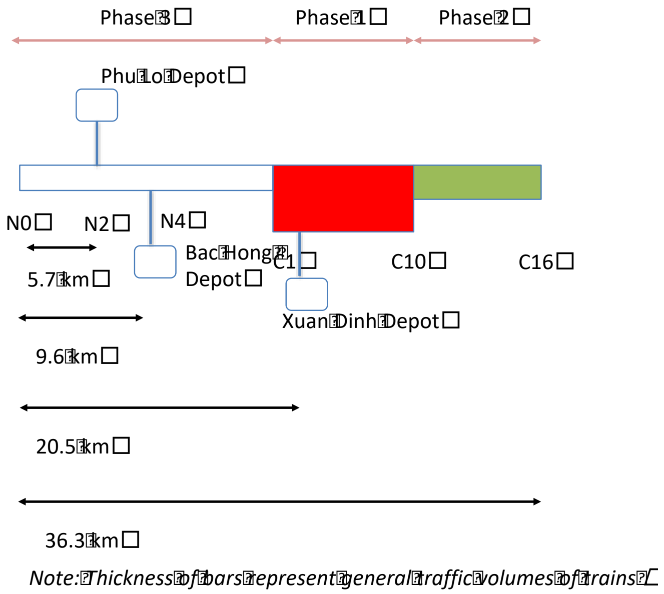


Figure 1. General Locations of Line 2 Sections and Depots

1.2. Option 1: Phu Lo only option

There is some proposal that the integrated simultaneous development of phase 1 through 3 of Line 2 could eliminate the needs for the Xuan Dinh Depot by concentrating all the functions at Phu Lo.

(1) Pros of Phu Lo Depot Only

Urban Development Potential

Eliminating the Xuan Dinh will release some 15 ha of land for urban land development potential to achieve higher economic values.

(2) Cons of Phu Lo Depot Only

Loss of Operation Effectiveness

An urban railway system has inherent risks in maintaining regular operation schedules. In the case of Line 2, the busiest section is the section going through the city center between the stations C1 through C10, i.e. Phase 1. As the operation plan suggests, a standard practice in daily modifications of headways between peak hours and off peak hours is halving the operating trains during the off peak hours to the morning peak hours, implying the half of the trains go off line after the morning peak hours to be stabled at a depot and have to be restored from the depot before the evening peak hours. For deployment and subtraction of trains between peak and off-peak hours, there is a need for running empty trains, so-called “deadhead trains.” The longer distances of about 15 km from C1 to the Phu Lo Depot means increased operation times and costs for the deadhead trains.

Less Adaptability At Emergencies

If there is any instance of train stoppage taking place during the off peak hours due to malfunctioning or damages on the section of Phase 3, there is a chance that Phase 1 together with Phase 2 section will not be able to restore the peak headways until the problem in phase 3 is resolved, possibly not being able to transport all the passengers. Delays in operation undermine the railway’s transport mode value since the railway excels best in punctually to other modes of transport with proper operation practices. With the Xuan Dinh Depot in place, immediate remedial action is likely to provide trains to restore the operations at the time of emergencies.

Economic Loss in Commencement Delay

The total length of Line 2 is some 36 km in distance crossing the Red River while tunneling work will be close to its half distance. A cumulative investment may reach close to USD 4 billion. The Line 2 is the largest and most sophisticated project of all the lines in Hanoi metro system. With only one depot at the end of the line in the north means that the commencement of any section of the Line 2 will not be possible unless the Phu Lo Depot and the subsequent Phase 3 sections including the Red River crossing are all completed and ready for operation. In other words any delay in the components of the Phase 3 section will lead to the delays of operation of the entire line. The policy makers must be aware of risk implications and the hidden but real opportunity costs of delay of a gigantic system. If we presume a 5% discount rate or cost of capital, one month delay in Line 2 is tantamount to USD 16 million per month or more.

(3) Evaluation of Phu Lo Depot Only

The potential economic loss for delayed commencement alone outweighs the short-term gain in urban development potential.

1.3. Option 2: Bac Hong depot

(1) Pros of Bac Hong Depots

There is some 120 ha of land reserved as a marshaling yard for National Railway at this location of Bac Hong. It may be possible to eliminate the needs for depots at Phu Lo and Xuan Dinh.

(2) Cons of Bac Hong Depots

Loss of Operation Effectiveness

From this location, the stabled trains will enter the tracks at N4 Station, 9.6 km from N0 Station for the Phase 3 operations and 9.9 km to C1 Station for Phase 1 operations.

Less Adaptability At Emergencies

Like Option 1 of Phu Lo Only, the distance from the busiest section of Phase 1 makes adjustments of operation schedules less adaptable at the time of emergency. Extra distances makes the adjustment operations of peak and off-peak train deployments more costly than Phu Lo and Xuan Dinh Dual Operation case.

Economic Loss in Commencement Delay

As is the case with the Option 1 of Phu Lo Only, the commencement of the Phase 1 operation is predicated on the completion of the entire Phase 3. This increases the risk of economic losses by the delay of the Phase 3.

Need for Coordination with National Railway

Since the area is already allocated to the National Railway for its marshaling yard purpose, the changes of their land for the depot and its access will require serious coordination and agreement with the National Railway.

(3) Evaluation of Bac Hong Depots

The economic risks of investment coordination as well as operation risks outweighs the economic benefits of foregoing the Xuan Dinh and Phu Lo depots.

1.4. Option 3: Double depots of Xuan Dinh and Phu Lo

(1) Pros of Two Depots

Flexible and More Punctual Operations

Since Xuan Dinh depot is directly connected to the busiest Phase 1 section, it will serve to minimize the effects of operation emergencies in other sections.

Efficient Operation

Since the deployment and removal of trains between peak and off-peak hours will require least distances of running empty trains, therefore the best operation efficiency and least costs.

(2) Cons of Two Depots

The requirement of 15 ha land close to the city center of Hanoi is a loss of economic opportunities for large scale property developments.

(3) Evaluation of Two Depots

The economic gains and reduction of risks by having two depots outweigh a short term property development economic gains by expending Xuan Dinh Depot.

(4) Redevelopment of Xuan Dinh Depot in the Future

Another proposition is to reduce the size of Xuan Dinh Depot and leave more room for urban development in order to capitalize the potential urban development values from the space saved from the original depot area. From a TOD perspective and long standing experience in railway operations lead to a conclusion the surrounding areas to a railway depot will not generate much value because the depot is a vast open space with no appeal to urban aesthetics. Simply put, the depot is a minor nuisance facility. Therefore, the value attained by converting the surrounding areas for urban development may be very limited. However, the potential value of converting the Xuan Dinh Depot in the future is quite immense. The values of potential urban development may be attained by totally shielding the depot from the outside by building an artificial ground over the tracks and workshops. Such similar cases are exemplified by Mark City in Shibuya in Tokyo and the Hudson Yards n Manhattan.

Mark City Shibuya: Tokyo Metro has a depot totally covered within a tower building at one of the central locations in Tokyo.

Hudson Yards in Manhattan: The Hudson Yards Redevelopment Project is a PPP project by New York City and New York State executed by the Metropolitan Transportation Authority (MTA) to encourage development on Manhattan's Far West Side facing the Hudson River. The centerpiece of the project is a 11.3-hectare mixed-use real estate development by Related Companies and Oxford Properties over the rail yards. The construction is now halfway in progress to cover the yard with the deck to build various facilities and buildings over it (See Figure 2 and Figure 3).

1.5. Conclusion

Having two depots provides a desired redundancy for system stabilization. In addition, the Xuan Dinh Depot is more crucial than the Phu Lo since the Xuan Dinh is directly connected to the most important section of the Line 2. **Therefore, JST proposed the Option 3 for depot option.**

Figure 2. Hudson Yards Project – the original site view in 2010

Figure 3. Hudson Yards Project – Work in Progress 2018

2. Red River Crossing

2.1. Profile of Red River crossing

1） Tunnel option (option 1)

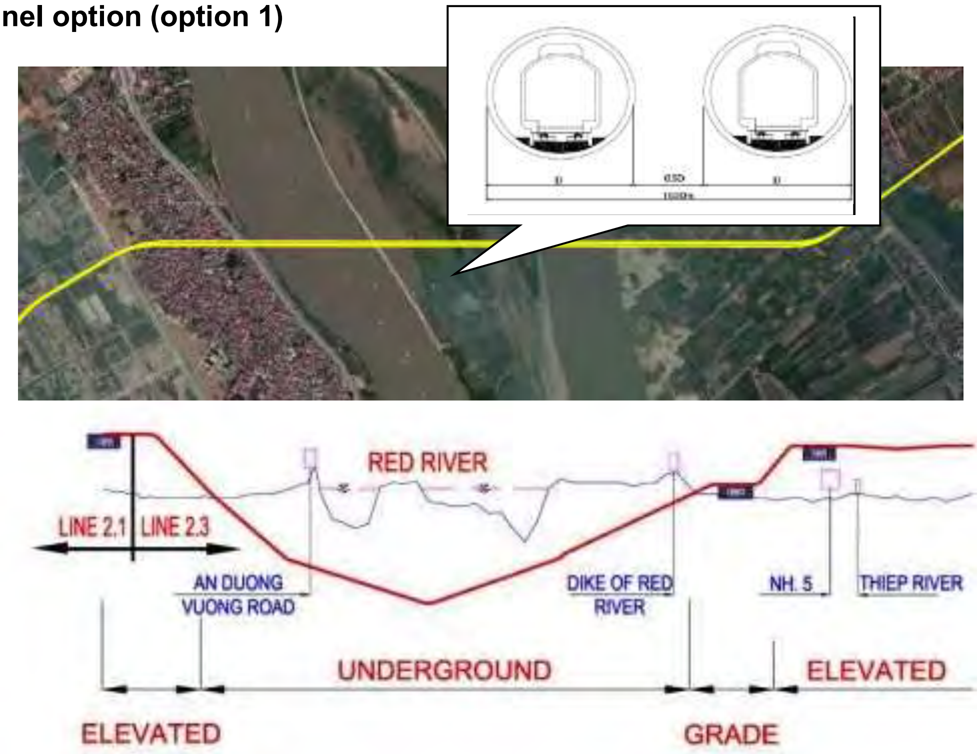


Figure 4. Profile of Option 1

Line 2.3 connects Line 2.1 at Nam Thang Long Station, running on viaduct along the extended Nguyễn Văn Huyên Road to km0+754.76, then lowering to run underground with gradient of 3.39% through Phú Thượng Village, crossing An Dương Vương Road and Red River, then changing to run at grade with gradient of 2.5% at km4+900 on the planned road. The alignment changes to run on viaduct with gradient of 3.29% at km5+300, crossing the extended NH5 and Line 4 (planned on the separator of NH5) and approaching the land strip planned for urban railway on Vo Nguyen Giap Road. From this point, the alignment runs along Vo Nguyen Giap Road to NBIA.

2) Bridge option (option 2)

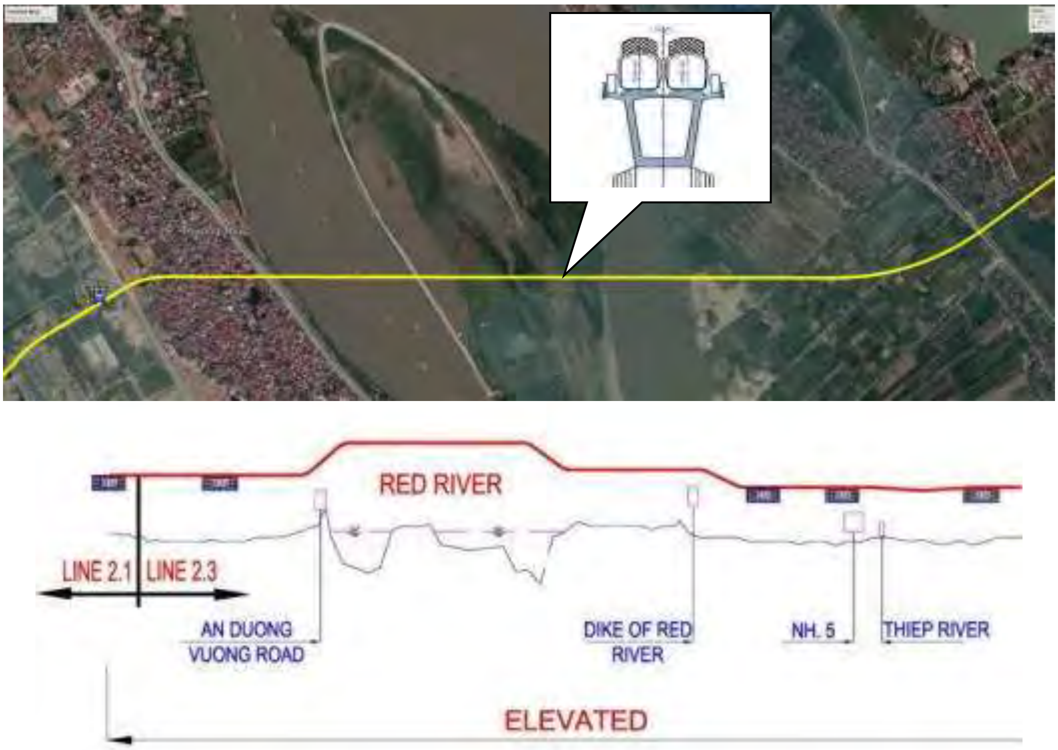


Figure 5. Profile of option 2

Line 2.3 connects Line 2.1 at Nam Thang Long Station, running on viaduct along the extended Nguyễn Văn Huyên Road through Phú Thượng Village, at km1+600, the alignment runs with gradient of 2.72% to cross An Dương Vương Road and Red River, then lowering the gradient to 2.26% to cross over left Red River Dyke, then running on the planned road. The alignment continues running on viaduct crossing the extended NH5 and Line 4 (planned on the separator of NH5) and approaching the land strip planned for urban railway on Vo Nguyen Giap Road. From this point, the alignment runs along Vo Nguyen Giap Road to NBIA.

2.2. Road and Railway Combined Bridge Option

Combination of railway bridge and road bridge is not suitable due to the following reasons:

- The distance from Line 2.3 to Nhat Tan and Thang Long bridges is 1.2 km and 2.3 km.
- Combining road and railway bridges will increase construction costs.
- Need land clearance in two aprroach roads for the bridge. In the south (Nam Thang Long urban area) has been planned, land acquisition cost will be very expensive.
- Urban railway runs continuously with headway of 3-5 minutes / trip. Running together will cause noise affecting road traffic.

2.3. Hydrological Consideration of Red River

The annual water flow of the Red River consists of two distinct seasons: flooding season and dry season. The water level and the flow quantity of the Red River fluctuate widely depending on the seasonal and meteorological conditions. The hydrological pattern at Hanoi Hydrological Station indicates the highest water level frequency in August and July (frequency of 53.4%), and the lowest water level in February (frequency of 30%), April (frequency of 29%) and March (frequency of 17%). The highest water level recorded is 1,397 cm (22/8/1971) and the lowest water level recorded is 157 cm (27/3/1956). The average seasonal water level fluctuation in the flood during and dry seasons is about 9 m. There is a fluctuation in flow rates from 10 times to 20 times. The alignment of the project is a section where riverbed fluctuation is intense and the bed fluctuation is about 10m.

Water in the Red River basin contains heavy sediment and the amount of sediment is extremely high. According to a survey in August 2002, the sediment load of the Hanoi section is around 100-200 tons / hour. The riverbed material consists of a mixture of fine sand (median particle diameter d50 is 0.100 mm to 0.235 mm), fine sand (20 - 40%), silt (40 - 70%) and clay (10 - 20%). At a normal flow velocity of the river, the sediment is easily transferable and conveyed as suspended particles in water. The Red River is regularly dredged for the sake of sand collection for construction and maintenance of navigational channel for ships.

Due to the riverbed conditions above, it is most likely that the soil cover for the tunnels need to be increased to offset the risks associated with the fluctuations. The shield tunnels require the soil covering of the depth no less than twice the diameter of the tunnel. Therefore the unexpected scouring at some sections of the alignment menas the need for the profile modifications of the tunnel.

The following is a picture of illustrating changes in riverbed elevation according to survey data in 2007 and 2018:

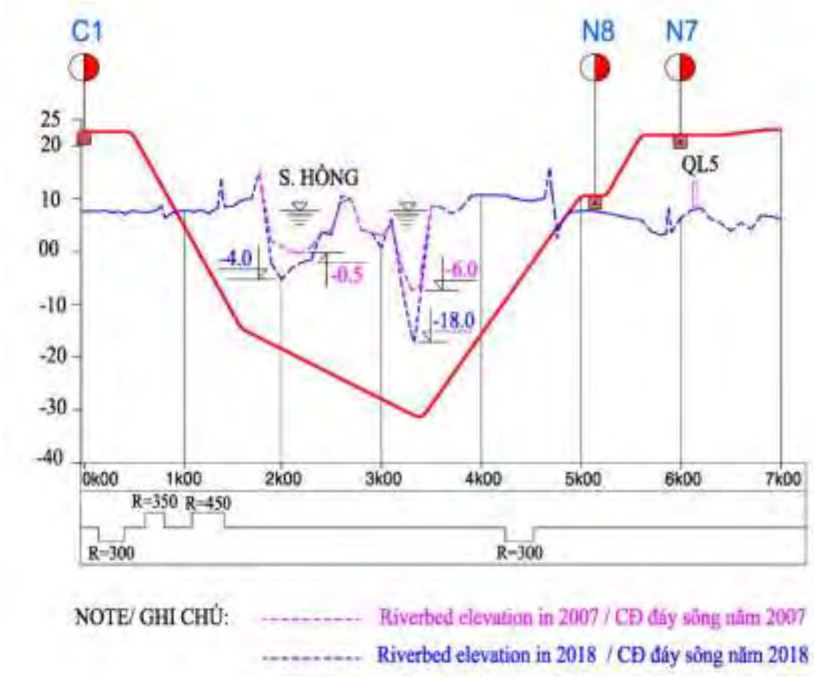


Figure 6. Elevation of the Red River bed

2.4. Current Dyke Management Policy

Hanoi Department of Dyke Management and Flood, Storm Control provided the note after the meeting (Nov. 31, 2018) concerning the current conditions of the dyke management and pre-conditions for planning for structures crossing Red River.

The note indicated that the high flood discharge of Red and Thai Binh Rivers has affected adversely the Hanoi city. This has necessitated reviewing the management plan for water level and flood discharge of Red and Thai Binh Rivers system by concerned government departments. Some of the protection measures from flood and for dykes are relocation of residential area, limitation on construction of new road in floodplain area, introduction of river protection structure etc. The detailed plan for Flood and Dyke control on the Red River and Thai Binh River System is under review with the Hanoi People's Committee.

The note indicated that for river crossing sections, the study for dyke safety and flood drainage should be based on holistic approach of taking account of stability of the available structures/facilities in the area, variations of river hydraulic regime, sedimentation and erosion of river bank etc. The note also indicated that the alignment options (bridge or tunnel) must conform to the pre-conditions as follows:

- *Bridge option:* It should be designed confirming to preventing possible impacts to stability and flood prevention safety of dykes during project operation. The design or the remedial measures should also include the effect of impacts by bridge abutment and piers to river flow change, sedimentation, erosion at bridge upstream and downstream etc.
- *Underground tunnel option:* It should be designed confirming the stability and safety of

dykes and constructed with highly durable material for structure stability in long term (to avoid leakage, flooding or breaking etc.). Stability and safety consideration should also include aspects on protection to the tunnel from high flood level and earthquake.

2.5. Risks Associated with Tunnel and Bridge

Risks of Tunnel option and Bridge option are as follows:

- The cost of magnetic exploration for unexploded bombs during construction period is necessary. The cost of magnetic exploration at tunnel option (approx. 870 mil. VND ~ 37 thou. USD) is higher than bridge plan. (approx. 78 mil. VND ~ 3,3 thou. USD)
- Unexpected soft ground during excavation.

Risks of Tunnel option are as follows:

- Flood in case of tunnel failure (tunnel joint leakage by earthquake) during high flood of Red River.
- The possible impacts of vibration by tunnel operation to dike body structure.
- The extra protection required for the suppression of buoyancy of tunnel structures.
- Flooding during tunnel excavation

Risks of Bridge option are as follows:

- The impacts by bridge abutment and piers to river flow change, sedimentation, erosion at bridge upstream and downstream and remedial measures.
- Inhibition of water flow by bridge piers.
- Ecosystem damage in river area.
- Long-term resettlement of residents.

2.6. Comparison Summary of Tunnel and Bridge Options

The multiple criteria evaluation of the tunnel and bridge options for crossing the Red River is shown in the following table.

Table 1. Comparison of Red River Crossing Options

No.	Items	Option 1 (Tunnel)	Option 2 (Bridge)
1	Transport master plan	• Different from Transport MP (519)	• In line with Transport Master Plan (519)
2	Resettlement	• No houses. However, to ensure during construction of the tunnel, it is necessary to relocate households above.	• 100 houses with approx. S =2,993m^2 • LA cost about 259.9 bil. VND (~11.6 mil. USD)
3	N9 station (Ciputra urban	• Construction is impossible because of slope area of rail way	• Construction is possible

No.	Items	Option 1 (Tunnel)	Option 2 (Bridge)
	area)	• Reduced cost for construction of station • Will lose some ridership due to absence of N9 Station catchment area. • Depending on the plan of Line2.1, substation is necessary around N9 station	
4	Construction period	• Normal period (48 months) • Not affected by weather and river water level • Construction period is not affected by external factors.	• Depends on conditions (48 months) • Depends on number of teams • It is affected by weather and river water level. • Land acquisition and resident's relocation is unpredictable. • It may take several years to relocate residents.
5	Environmental situation and landscape	• No significant environmental impact on flora and fauna or riparian environment. • Construction is quiet. No significant impact on plants and animals (Except for shaft construction) • No significant impact to landscape	• No significant environmental impact after the commencement of operation. • Some limited impact of noise and impact on plants and animals during construction • Significant impact on landscape but could be a positive one for an artistically designed bridge.
6	Maintenance	• Maintenance cost is expensive. • Periodic inspection frequency is every 5 years. Repair is possible only non-operation time at night.	• Maintenance cost is low. • Periodic inspection frequency is every 5 years. Repair is possible day and night.
7	Daily running cost	• Ventilation and drainage expenses are necessary. • In addition to running costs, periodic inspection is also higher.	• Daily running cost is lower.
8	Impact on river	• There is no inhibition of water flow by bridge foundations. • Does not affect the navigation of ships. • Construction does not require access road in the river	• There is inhibition of water flow due to bridge foundations. The river product inhibition rate should be 5% or less. • Affects the navigation of ships. • Construction requires access roads in the river.
9	Risk management of dyke	• Dyke management committee requires vindication of no negative impact on the Red River embankments triggered by the tunneling or tunnel structures • After a further detail analysis, it may be necessary to reinforce the dyke.	• No impact on dykes
10	Hydrological Risks	• It is necessary to undertake the riverbed surveys seasonally (quarterly) till the time of detail design implementation in order to collect the data for the tunnel design if this option is deemed more feasible. Depending on the results, the vertical alignment of the tunnel may have to be adjusted or construction methodology may be changed due to further depth of soil cover requirement of the shield tunnel.	• No significant risks
11	Risk management of structures	• Tunnel structure has following risks such as loss of sufficient soil cover depth due to the hydrological issues as well as illegal river sand dredging to cause buoyancy or direct structural damage. • Risks can be minimized by increasing soil cover depth or providing concrete protection structures.	• No significant risks
12	Risk management of operation	• No significant risks	• Stop operation by storm
13	N8 station	• At-grade station because of transition slope from tunnel to the elevated section loss of through traffic connections causing inconvenience and aesthetic damage to the streetscape	• Viaduct station
14	Construction Cost	• Retaining wall: L0=546m • Cut & cover: L1=1,293m	• Continuous beam bridge: L1=1,160m • Viaduct: L2=2,986m

No.	Items	Option 1 (Tunnel)	Option 2 (Bridge)
		• TBM: L2=3,043m Total length L=4146m **Cost: 3104 bil. VND equivalent USD 131.1 mil.** Extra cost may be added to minimize the risks listed above.	Total length L=4,146m **Cost: 1471 bil. VND equivalent USD 62.7 mil. (including land acquisition cost)**
15	Conclusion		**Recommended**

After carefully consideration of the advantages and disadvantages of the two options for crossing the Red River, JICA Study Team proposed the bridge option to be more advantageous. However, the Study Team also proposed to add a tunnel option as an alternative, depending on the results of the Environmental Impact Assessment and Resettlement Plan.

3. Station location

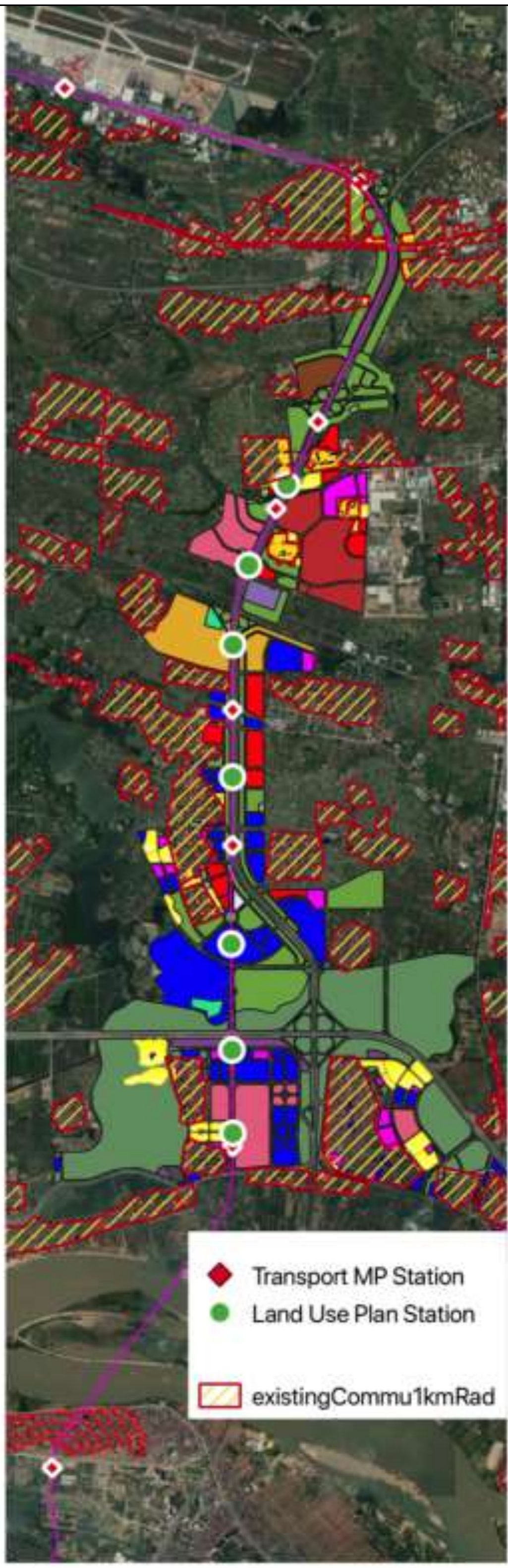
3.1. Review of Existing plans

Figure 7 compares the station locations proposed by Transport Master Plan of Hanoi (Decision No. 519/QĐ-TTg dated 31/3/2016) and Detailed Land Use Plan. By transport master plan Line 2.3 has 10 stations with 01 station in Tay Ho District, 07 stations in Đông Anh District and 2 stations in Soc Son.

By comparing the two plans, the intention of planning becomes obvious. Transport Master Plan station locations on the left indicates that the station locations are determined to provide maximum access to the existing communes whereas the Detailed Land Use Plan places stations to provide access to the future development potential. Another difference is the first station after the airport. The Transport Master Plan places the first station at the corner before joining the Vo Nguyen Giap Road where there are large communes do exist and also branching railway to Soc Song. The Detailed Land Use Plan’s first station is at the top of the planned software park and the remainder of the alignment to the airport is buttressed by green buffer zones. Nevertheless, there are no substantial differences for the last three stations before crossing the Red River.

JST recommends to place one station at branching to Soc Song, but outside of the airport perimeter. The green buffers should be preserved as much as possible with inter-modal transfer facilities at the station. JST have decided to modify N2 TOD as shown in the attached drawing. All the urban blocks previously proposed have been eliminated except for the two blocks which provide essential access to the station buildings. The modification was decided following the land use concepts displayed by the Hanoi General Construction Plan. Given the proximity to the airport, urban development should not be encouraged in this area.

Transport Master Plan



Land Use Master Plan

Figure 7. Comparison of Station Location Plans between Transport Master Plan and Land Use Plan

- **Station plan at Noi Bai International Airport**

By Decision No. 590/2008/QĐ-TTg dated 20/5/2008, there are 2 underground stations corresponding to passenger terminals T1 and T2. Station locations are shown below:

Figure 8. Station Locations in NBIA by NBIA Master Plan

3.2. Providing Access to Existing Population

Figure 9 shows the land areas of existing communes within 1 km boundary from the railway alignment. Furthermore, the commune areas within the 1 km boundary from the proposed sations are segregated by the boundaries of 1 km radius from each proposed station, shown in dirt color. The areas colored in pink are the commune areas beyond 1 km radius from the prosed station. The more precise spatial tabulation indicates the proposed stations cover 81% of the total commune areas within the 1km buffer of the alignment. As obvious from the layout shown in the Figure 9 adding more stations or shifting stations do not increase the coverage in a substantive way. Adding one more station between N3 and N2 would increase no more than 4% in the coverage. From an efficiency viewpoint of station access coverage, the JST proposed stations are optimum locations in the coverage efficiency.

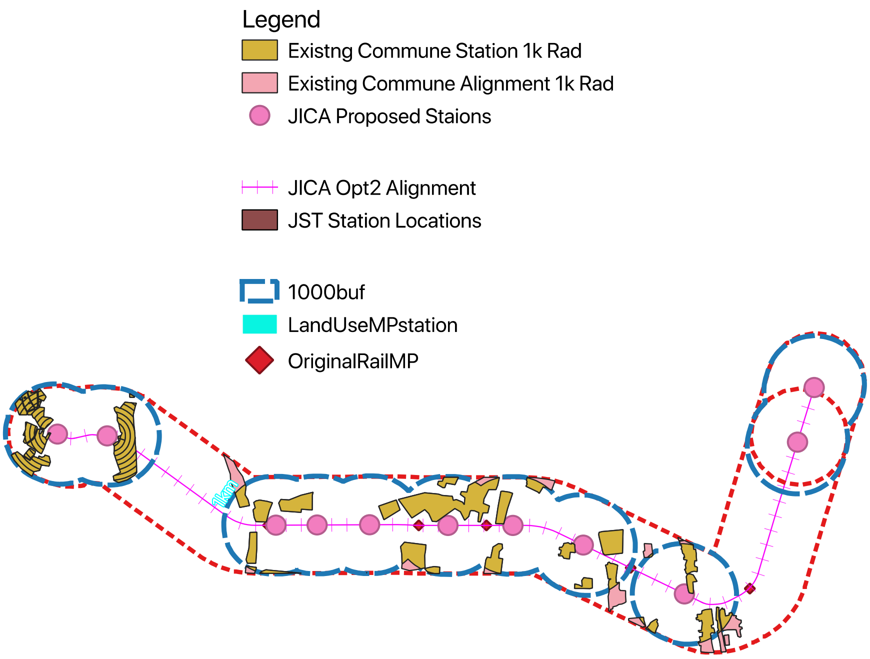


Figure 9. Coverage of Existing Communes by Proposed Station Locations on the Alignment

3.3. Proposed station locations

After studying Decision No.519/QĐ-TTg dated 31/3/2016 by Prime Minister approving Hanoi Transport Master Plan to 2030 and Vision to 2050; Decision No. 6630/QĐ-UBND dated 2/12/2015 approving detailed master plan along Nhật Tân - Nội Bài Road and Decision No. 590/2008/QĐ-TTg dated 20/5/2008 by Prime Minister approving the adjusted master plan of Nội Bài International Airport (NBIA) up to 2020 and orientation after 2020 together with design principles and station selection criteria mentioned above.

The major principles for the selection of urban railway station location are as follows:

- To suit to the transport plans,
- To provide connection to existing other urban railways and public transport services for intermodal connectivity,
- To suit regional spatial development/land use plans for urban development around the stations,
- To provide railway access to the existing population to the maximum extent,
- To maximize the land area around the stations available for urban development using TOD scheme, and
- To minimize environmental and social impacts including land acquisition.

JICA Study Team proposed the number of station as follows:

Table 2. Analysis on station locations along line 2.3

No	Map	Station Location	Distance	Compatibility to existing plans	Intermodal Connectivity	Targeted passengers	TOD area	Land acquisition	Impact level
1		N0: in front of T2 terminal		Compliance with Noi Bai airport master plan	- Connectivity with Line 6; - Bus routes: 07, 17, 86, 109	- Noi Bai airport - Phu Cuong and Phu Minh communes	Undergroundacces s with commercial areas to airport	10393m2 of transport land	No impact to environment and landscape
2		N1: in front of T1 terminal	to N0 station: 1190m					10477m2 of transport land	
3		N2: in the south of NH 2 and NH 18 (500m)	to N1: 4710m	1150m moved to the south compared to Transport Master Plan	- Bus 17 (Long Bien - Noi Bai)	Phu Minh and Phu Lo communes	about 5ha on both side of station	7352m2 of transport land	Locates on Vo Nguyen Giap highway, no impact to landscape
4		N3: in the north of Ca Lo river (300m)	to N2: 2330m	70m moved to the south compared to in Transport Master Plan	Bac Hong - Van Dien National Railway; Bus 96 Nghia Do - Dong Anh	Nguyen Khe, Bac Hong communes; Vocational College, Software Park	about 68ha on both side of station	7165m2 of transport land	Locates on Vo Nguyen Giap highway, no impact to landscape

5		N4: in the south of national railway line (500m)	to N3: 1530m	100m moved to the south compared to Detailed Plan of Nhat Tan - Noi Bai axis	Bus 61 Van Ha - Cau Giay; Bus 96 Nghia Do - Dong Anh	Van Noi, Bac Hong, Nguyen Khe communes; Chi Hospital, VINCOM Shopping Mall	about 126ha on both side of station	7039m2 of transport land	Locates on Vo Nguyen Giap highway, no impact to landscape
6		N5: in the south of NH 23 (500m)	to N4: 1340m	Shifted about 120m toward the south from original location in Detailed Plan of Nhat Tan - Noi Bai axis		Van Noi and Tien Duong communes, Vigracera Social Houses, Commercial and Servicees Center	about 30ha on both side of station	7006m2 of transport land	Locates on planned railway land strip, no impact to landscape
7		N6: in the north of Hoang Sa road (900m)	to N5: 1610m	Same location with the one in relevant approved plans		Van Noi and Tien Duong communes, International Cultural Center, Shopping Malls and offices	about 62ha on both side of station	6538m2 of transport land	Locates in planned railway land, no impact to landscape

8		N7: adjacent to he south of Hoang Sa	to N6: 1090m	Same location with the one in relevant approved plans	Bus 25, bus 96 Nghia Do - Dong Anh	Vinh Ngoc commune, Smart City	about 0.7ha on both side of station	6803m2 of transport land	Locates in planned road, no impact to landscape
9		N8: adjacent to the south of Hoang Sa	to N7: 850m	same location with the one in Detailed Plan of Nhat Tan - Noi Bai axis		Vinh Ngoc commune, Smart City	about 0.9ha on both side of station	6226m2 of transport land	Locates in planned road, no impact to landscape
		N9: adjacent to Ciptra	To N8: 4,060 m and 1,047 m to C1	Same location as Transport Master Plan		Phu Thuong commune and Ciputra North	About 1.8 ha	5,663m2 of transport lands	The elevated station is located on thee median of the planned road of Ciputra

3.4. Connect to Bac Hong station (NR)

Bac Hong station according to Decision 519/QĐ-TTg dated 31/3/2016 is a marshaling station. Therefore, N4 station of Line 2.3 mainly serves the passengers of Van Noi, Bac Hong, Tien Duong communes (currently) and areas of health, commerce, services ... (in the future).

The location of N4 station as proposed is reasonable location to enable smooth traffic flows to and from the planned interchange (between Ring Road 3 and Vo Nguyen Giap road). If the NR is to utilize the line for commuting to the industrial estates, the Bac Hong Station should be moved closer to N4 station for a better connectivity. In the case of connecting from Bac Hong station to N4 station, it will go along Ring road 3 and turn right to Vo Nguyen Giap road by walk or pedestrian bridge.

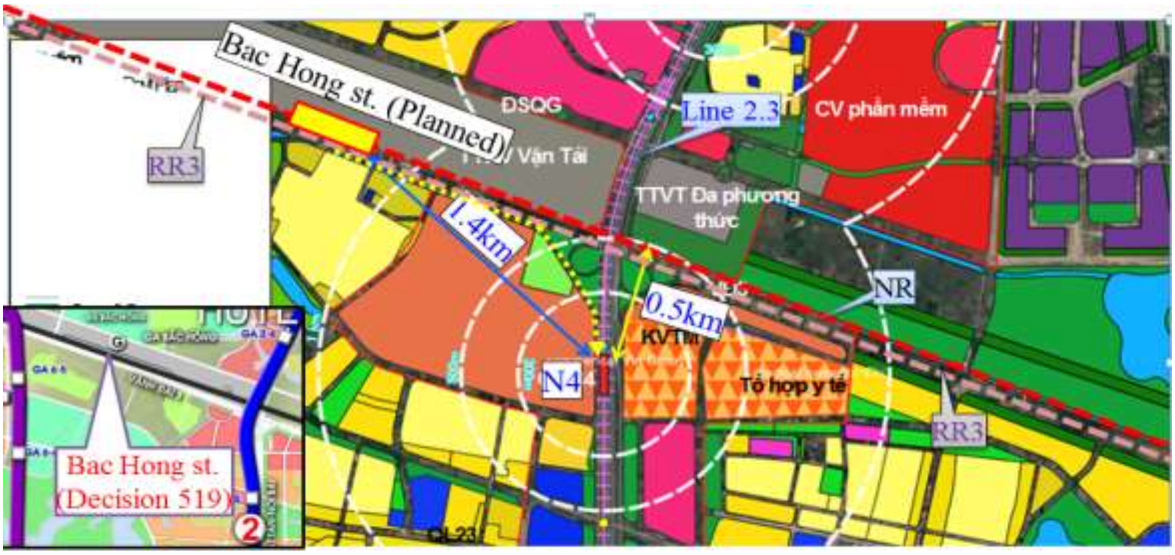


Figure 10. Location of N4 station and Bac Hong station

Appendix 7 Bill of Quantity and Cost Estimation of Power Distribution Facilities

1 Methodology

The requirements for transformers and distribution line

Load demand was estimated by applying "Specific Energy Consumption" published by BEMA (The Building-Energy Manager's Association of Japan) as described in the following sub-clause.

2 Specific Energy Consumption

Specific energy consumption (SEC) of each year for all categories is summarized in Building Facilities Pocketbook (2019) as shown in Table 1. SECs in 2016, are generally decreased compared with the value in 2006. The reason of this tendency is considered to be 1) improvement of efficiency of electric appliances and facilities and 2) energy saving policy. In this urban development project in Hanoi, 70% value in 2016 will be applied due to the difference of energy consumption per capita between Vietnam and Japan.

Also, 9.83 (MJ/kWh) of Joule conversion to kWh is specified.

Table 1 Specific Energy consumption of "Building Facilities Pocketbook-2019"

		Average : $(MJ / m^2 \text{g}year)$
Category	2006	2016
Residence	1,300	1,000 (700)
School	1,900	1,100 (770)
Office	1,900	1,400 (980)
Hospital	2,900	2,400 (16,80)
Commerce	2,900	3,000 (2,100)
Shop/restaurant	2,800	2,000 (1,400)
	Source: Building Facilities Pocketbook - 2019	
Note: Figures in parenthesis show 70% of specific energy consumption.		
Joule conversion to kWh (MJ/kWh)		9.83

3 Load per Square Meters

The figures in Table 1 are converted from "MJ/m^2・year" to "kW/m^2" in the following procedure.

1) MJ → kWh
2) Year → day
3) Justification for "10-hrs" per day
   a. Residence : 5:00 to 9:00 (4-hrs) + 17:00 to 23:00 (6-hrs) = Total 10-hrs.
   b. Office, Hospital, Commerce and shop/restaurant
      8:00 to 18:00 = Total 10 hrs.

The next equations show the conversion tabulation for residential users.

$$700(MJ/m^2 \cdot yer) = \frac{700 \times \dfrac{MJ}{m^2 \cdot year}}{9.83 \times \dfrac{MJ}{kWh}} = \frac{700}{9.83}\left(\frac{MJ \cdot kWh}{MJ \cdot m^2 \cdot year}\right)$$

$$\frac{700}{9.83}\left(\frac{MJ \cdot kWh}{MJ \cdot m^2 \cdot year}\right) = 71.21\left(\frac{kWh}{m^2 \cdot year}\right) = \frac{71.21}{365}\left(\frac{kWh}{m^2 \cdot day}\right) = 0.195\left(\frac{kWh}{m^2 \cdot day}\right)$$

Assumed as operating hours per day is 10 hours.

$$0.195\left(\frac{kWh}{m^2 \cdot day}\right) \rightarrow 0.0195\left(\frac{kW}{m^2}\right)$$

Table 2 shows the estimated unit floor load, "kW/m^2" for all user categories.

Table 2 "MJ/m^2・year "to "kW/ m^2"

	assumed as 70%	(1)	(2)	(3)
Year : 2016				
	$(MJ / m^2 \cdot year)$	$\left(\frac{kWh}{m^2 \cdot year}\right)$	$\left(\frac{kWh}{m^2 \cdot day}\right)$	$\left(\frac{kW}{m^2}\right)$
Category	MJ-basis	kWh-basis	day-basis	10-hrs basis
Residence	700	71	0.195	0.0195
School	770	78	0.215	0.0215
Office	980	100	0.273	0.0273
Hospital	1,680	171	0.468	0.0468
Commerce	2,100	214	0.585	0.0585
Shop/restaurant	1,400	142	0.390	0.0390
Joule conversion to kWh (MJ/kWh)		9.83		
One year to days (days)		365		
Operating hrs per day (hrs)		10		
Assumed as % of given data (%)		70		

4 Station Based Power Load Estimation

Based on the power load per unit floor for each type of users, the power capacity demands are derived by applying the floor areas of each TOD area of the proposed stations. The floor areas of LVC and Non-LVC areas, the power demand capacity requirements are derived in Table 3-4 and Table 5-6 respectively.

Table 3 Floor Areas by type of Use in LVC areas

Unit: m^2

Station	East				West				Total
	Resi-dence	Office	Com-merce	Total	Resi-dence	Office	Com-merce	Total	
N2	0	12,144	8,096	20,240	0	11,201	7,467	18,668	38,908
N3	103,401	36,581	11,080	151,062	882,493	51,358	19,023	952,874	1,103,935
N4	185,314	48,470	23,086	256,871	1,113,059	385,992	137,535	1,636,586	1,893,457
N5	430,406	287,085	101,220	818,711	164,531	190,224	55,128	409,883	1,228,594
N6	0	0	0	0	584,680	177,311	99,649	861,640	861,640
N7	0	0	0	0	12,114	13,628	4,543	30,284	30,284
N8	0	0	0	0	20,667	23,250	7,750	51,666	51,666
N9	7,432	5,946	1,486	14,864	7,436	5,949	1,487	14,872	29,736
Total	726,553	390,226	144,968	1,261,747	2,784,980	858,912	332,582	3,976,474	5,238,221

Table 4 Floor Areas by type of Use in non-LVC Areas

Unit: m^2

	East					West					
Station	Resi-dence	Office	Com-merce	School	Total	Resi-dence	Office	Com-merce	School	Total	Total
N2					0			138,000		138,000	138,000
N3		405,000		65,000	470,000		82,000	165,000		247,000	717,000
N4		26,000	83,000	13,000	122,000				10,000	10,000	132,000
N5	775,000	45,000		11,000	831,000		97,000		45,000	142,000	973,000
N6		110,000			110,000			10,000	5,000	15,000	125,000
N7					0	324,000	548,000		13,000	885,000	885,000
N8					0	1,036,000	2,059,000			3,095,000	3,095,000
N9					0	1,317,000	97,000			1,414,000	1,414,000
Total	775,000	586,000	83,000	89,000	1,533,000	2,677,000	2,883,000	313,000	73,000	5,946,000	7,479,000

5 Estimation of Number of Transformer and RMU

Power factor of 0.9 is applied to "kW" in Table 3 and Table 4 to obtain total load "kVA" in Table 5 for LVC areas and Table 6 for non-LVC areas.

Capacity-wise number of transformers and RMUs are derived from above calculated kVA and were shown in Table 7-8 for LVC areas and Table 9-10 for non-LVC areas.

Table 5 Power Capacity Requirement by type of Use in LVC areas

Unit:kW

	East				West				
Station	Resi-dence	Office	Com-merce	Total	Resi-dence	Office	Com-merce	Total	Total
N2	0	332	474	805	0	306	437	743	1,548
N3	2,016	999	648	3,663	17,209	1,402	1,113	19,724	23,387
N4	3,614	1,323	1,351	6,287	21,705	10,538	8,046	40,288	46,575
N5	8,393	7,837	5,921	22,152	3,208	5,193	3,225	11,626	33,778
N6	0	0	0	0	11,401	4,841	5,829	22,071	22,071
N7	0	0	0	0	236	372	266	874	874
N8	0	0	0	0	403	635	453	1,491	1,491
N9	145	162	87	394	145	162	87	394	789
Total	14,168	10,653	8,481	33,302	54,307	23,448	19,456	97,211	130,513

Table 6 Power Capacity Requirement by type of Use in non-LVC areas

Unit:kW

Station	East					West					Total
	Resi-dence	Office	Com-merce	School	Total	Resi-dence	Office	Com-merce	School	Total	
N2					0			8,073		8,073	8,073
N3		11,057		1,398	12,454		2,239	9,653		11,891	24,345
N4		710	4,856	280	5,845				215	215	6,060
N5	15,113	1,229		237	16,578		2,648		968	3,616	20,193
N6		3,003			3,003			585	108	693	3,696
N7					0	6,318	14,960		280	21,558	21,558
N8					0	20,202	56,211			76,413	76,413
N9					0	25,682	2,648			28,330	28,330
Total	15,113	15,998	4,856	1,914	37,879	52,202	78,706	18,311	1,570	150,787	188,667

1) LVC Areas

Table 7 (1/2) Capacity-wise Number of Transformers and RMUs

								Power factor		0.9	
Station	East / West		Load (kVA)	Tr capacity (kVA)						Total kVA	No. of RMU
				250	320	400	560	630	1,000		
N2											
	East										
		Residence	0							0	
		Office	368	2						500	1
		Commerce	526		2					640	1
		Sub-total	895	2	2	0	0	0	0	1,140	2
	West										
		Residence	0							0	
		Office	340	2						500	1
		Commerce	485	2						500	1
		Sub-total	825	4	0	0	0	0	0	1,000	2
		Total	1,720	6	2	0	0	0	0	2,140	4
N3	East										
		Residence	2,240				3	1		2,310	1
		Office	1,110					2		1,260	1
		Commerce	720			2				800	1
		Sub-total	4,070	0	0	2	3	3	0	4,370	3
	West										
		Residence	19,121					7	16	20,410	5
		Office	1,558				1	2		1,820	1
		Commerce	1,236	1			2			1,370	1
		Sub-total	21,915	1	0	0	3	9	16	23,600	7
		Total	25,985	1	0	2	6	12	16	27,970	10
N4	East										
		Residence	4,015					4	2	4,520	1
		Office	1,470				3			1,680	1
		Commerce	1,501				3			1,680	1
		Sub-total	6,986	0	0	0	6	4	2	7,880	3
	West										
		Residence	24,116					16	16	26,080	6
		Office	11,708					4	10	12,520	3
		Commerce	8,940					5	6	9,150	2
		Sub-total	44,764	0	0	0	0	25	32	47,750	11
		Total	51,750	0	0	0	6	29	34	55,630	14
N5	East										
		Residence	9,325					6	8	11,780	3
		Office	8,708					4	7	9,520	2
		Commerce	6,579					5	4	7,150	2
		Sub-total	24,613	0	0	0	0	15	19	28,450	7
	West										
		Residence	3,565					3	2	3,890	1
		Office	5,770				4		4	6,240	2
		Commerce	3,583					6		3,780	1
		Sub-total	12,918	0	0	0	4	9		13,910	4
		Total	37,531	0	0	0	4	24	19	42,360	11

Table 8 (2/2) Capacity-wise Number of Transformers and RMUs

								Power factor		0.9	
Station	East /		Load	Tr capacity (kVA)						Total	No. of
	West		(kVA)	250	320	400	560	630	1,000	kVA	RMU
N6	East										
		Residence	0							0	
		Office	0							0	
		Commerce	0							0	
		Sub-total	0	0	0	0	0	0	0	0	0
	West										
		Residence	12,668					5	10	13,150	3
		Office	5,378				3		4	5,680	2
		Commerce	6,477					4	4	6,520	2
		Sub-total	24,524	0	0	0	3	9	18	25,350	7
		Total	24,524	0	0	0	3	9	18	25,350	7
N7	East										
		Residence	0							0	
		Office	0							0	
		Commerce	0							0	
		Sub-total	0	0	0	0	0	0	0	0	0
	West										
		Residence	262		1					320	1
		Office	413		2					640	1
		Commerce	295		1					320	1
		Sub-total	971	0	4	0	0	0	0	1,280	3
		Total	971	0	4	0	0	0	0	1,280	3
N8	East										
		Residence	0							0	
		Office	0							0	
		Commerce	0							0	
		Sub-total	0	0	0	0	0	0	0	0	0
	West										
		Residence	448				1			560	1
		Office	705			2				800	1
		Commerce	504		2					640	1
		Sub-total	1,657	0	2	2	1	0	0	2,000	3
		Total	1,657	0	2	2	1	0	0	2,000	3
N9	East										
		Residence	161	1						250	1
		Office	180	1						250	1
		Commerce	97	1						250	1
		Sub-total	438	3	0	0	0	0	0	750	3
	West										
		Residence	161	1						250	1
		Office	180	1						250	1
		Commerce	97	1						250	1
		Sub-total	438	3	0	0	0	0	0	750	3
		Total	438	6	0	0	0	0	0	1,500	6

2) Non-LVC Areas

Table 9 (1/2) Capacity-wise Number of Transformers and RMUs

									Power factor	0.9	
Zone	East / West	Category	Load (kVA)	Tr capacity (kVA) 250	320	400	560	630	1,000	Total kVA	No. of RMU
N2											
	East										
		Residence	0							0	0
		Office	0							0	0
		Commerce	0							0	0
		School	0							0	0
		Sub-total	0							0	0
	West										
		Residence	0							0	
		Office	0							0	
		Commerce	8,970					5	6	9,150	2
		School	0							0	
		Sub-total	8,970					5	6	9,150	2
		Total	8,970	0	0	0	0	5	6	9150	2
N3	East										
		Residence	0							0	
		Office	12,285					11	6	12,930	3
		Commerce	0							0	
		School	1,553				3			1,680	1
		Sub-total	13,838				3	11	6	14,610	4
	West										
		Residence	0							0	
		Office	2,487					4		2,520	1
		Commerce	10,725					8	6	11,040	2
		School	0							0	
		Sub-total	13,212					12	6	13,560	3
		Total	27,050	0	0	0	3	23	12	28,170	7
N4	East										
		Residence	0							0	
		Office	789			2				800	1
		Commerce	5,395					6	2	5,780	2
		School	311			1				400	1
		Sub-total	6,494			3		6	2	6,980	4
	West										
		Residence	0							0	
		Office	0							0	
		Commerce	0							0	
		School	239	1						250	1
		Sub-total	239	1						250	1
		Total	6,733	1	0	3	0	6	2	7,230	5
N5	East										
		Residence	16,792				11		11	17,160	4
		Office	1,365				3			1,680	1
		Commerce	0							0	
		School	263		1					320	1
		Sub-total	18,419		1		14		11	19,160	6
	West										
		Residence	0							0	0
		Office	2,942					5		3,150	1
		Commerce	0							0	0
		School	1,075				1	1		1,190	1
		Sub-total	4,017				1	6		4,340	2
		Total	22,437	0	1	0	15	6	11	23,500	8

Table 10 (2/2) Capacity-wise Number of Transformers and RMU

								Power factor	0.9		
Zone	East / West	Category	Load (kVA)	Tr capacity (kVA) 250	320	400	560	630	1,000	Total kVA	No. of RMU
N6	East										
		Residence	0							0	
		Office	3,337					4	1	3,520	1
		Commerce	0							0	
		School	0							0	
		Sub-total	3,337					4	1	3,520	1
	West										
		Residence	0							0	
		Office	0							0	
		Commerce	650		1	1				720	1
		School	119	1						250	1
		Sub-total	769	1	1	1				970	2
		Total	4,106	1	1	1	0	4	1	970	3
N7	East										
		Residence	0							0	0
		Office	0							0	0
		Commerce	0							0	0
		School	0							0	0
		Sub-total	0							0	0
	West										
		Residence	7,020				8	5		7,630	2
		Office	16,623				16		8	16,960	4
		Commerce	0							0	
		School	311		1					320	
		Sub-total	23,953		1		24	5	8	24,910	6
		Total	23,953	0	1	0	24	5	8	24,910	6
N8	East										
		Residence	0							0	0
		Office	0							0	0
		Commerce	0							0	0
		School	0							0	0
		Sub-total	0							0	0
	West										
		Residence	22,447					15	13	22,450	5
		Office	62,456					39	38	62,570	13
		Commerce	0							0	
		School	0							0	
		Sub-total	84,903					54	51	85,020	18
		Total	84,903	0	0	0	0	54	51	85,020	18
N9	East										
		Residence	0							0	0
		Office	0							0	0
		Commerce	0							0	0
		School	0							0	0
		Sub-total	0							0	0
	West										
		Residence	28,535					17	18	28,710	6
		Office	2,942				1	4		3,080	1
		Commerce	0							0	
		School	0							0	
		Sub-total	31,477				1	21	18	31,790	7
		Total	31,477	0	0	0	1	21	18	31,790	7

5.2 Bill of Quantities and Construction Cost

(1) Unit Cost

Table 11 shows unit costs of equipment, materials and construction works applied to the cost estimation in this section.

Table 11 Unit Cost of Equipment / Material / Work

Items	Construction cost ($/km)	Ratio (%)	Demolishing cost ($/km)
1. 110kV, 2-cct, steel tower (per km)	340,000	40	136,000
2. 110kV, 2-cct, steel pole (per km)	990,000	25	247,500
3. 220kV, 2cct + 110kV, 2-cct, steel pole (per km)	1,400,000	25	350,000
4. 220kV, 2cct + 110kV, 2cct, dead-end steel pole (per set)	420,000	-	-
5. 110kV, 2cct, dead-end steel pole (per set)	250,000	-	-

Items	Unit cost ($/m)	Unit cost ($/set)
1a. 220kV, XLPE, 1-core, 1,600 sqmm, copper conductor	560	
1b. Cable bushing		6,000
1c. Straight Joint		13,000
2a 110kV, XLPE, 1-core, 1200 sqmm, copper conductor	430	
2b. Cable bushing		4,800
2c. Joint (set)		9,000
3a. 22kV, XLPE, 3-core, 240 sqmm, copper conductor	200	
3b. Straight joint		7,000
4. Cable protection pipe		
4b. 200-diameter	60	
4c. 150-diameter	50	
5. Lightning arrester		
5a. for 220kV with surge counter		12,000
5b. for 110kV with surge counter		9,000
6. Distribution facility		
6a. RMU		700,000
6b. LV distribution board		150,000
7. Distribtion transformer		
7a. 250kVA		25,000
7b. 320kVA		27,000
7c. 400kVA		30,000
7d. 560kVA		37,000
7e. 630kVA		40,000
7f. 1,000kVA		58,000

(2) Distribution Facilities

Total cost of distribution facilities for LVC and non-LVC areas is obtained by substituting unit costs on the assumption that installation/construction costs are to be 30% of total equipment cost as shown in Table 12 and Table 13 respectively.

Table 12 Total Cost of distribution facilities (LVC)

Unit: $1,000

Zone	East / West	Transformer capacity (kVA)						RMU	LV dist. board	22kV XLPE cable (m)	Total equipment	Instal- lation cost	Total Cost
		250	320	400	560	630	1,000						
N2	East	2	2	0	0	0	0	2	2				
	West	4	0	0	0	0	0	2	2				
	Sub-total	6	2	0	0	0	0	4	4	2,000			
	Cost	150	54	0	0	0	0	2,800	600	400	4,004	1,201	5,205
N3	East	0	0	2	3	3	0	3	3				
	West	1	0	0	3	9	16	7	7				
	Sub-total	1	0	2	6	12	16	10	10	5,000			
	Cost	25	0	60	222	480	928	7,000	1,500	1,000	11,215	3,365	14,580
N4	East	0	0	0	6	4	2	3	3				
	West	0	0	0	0	25	32	11	11				
	Sub-total	0	0	0	6	29	34	14	14	7,000			
	Cost	0	0	0	222	1,160	1,972	9,800	2,100	1,400	16,654	4,996	21,650
N5	East	0	0	0	0	15	19	7	7				
	West	0	0	0	4	9	0	4	4				
	Sub-total	0	0	0	4	24	19	11	11	5,500			
	Cost	0	0	0	148	960	1,102	7,700	1,650	1,100	12,660	3,798	16,458
N6	East	0	0	0	0	0	0	0	0				
	West	0	0	0	3	9	18	7	7				
	Sub-total	0	0	0	3	9	18	7	7	3,500			
	Cost	0	0	0	111	360	1,044	4,900	1,050	700	8,165	2,450	10,615
N7	East	0	0	0	0	0	0	0	0				
	West	0	4	0	0	0	0	3	3				
	Sub-total	0	4	0	0	0	0	3	3	1,500			
	Cost	0	108	0	0	0	0	2,100	450	300	2,958	887	3,845
N8	East	0	0	0	0	0	0	0	0				
	West	0	2	2	1	0	0	3	3				
	Sub-total	0	2	2	1	0	0	3	3	1,500			
	Cost	0	54	60	37	0	0	2,100	450	300	3,001	900	3,901
N9	East	3	0	0	0	0	0	3	3				
	West	3	0	0	0	0	0	3	3				
	Sub-total	6	0	0	0	0	0	6	6	3,000			
	Cost	150	0	0	0	0	0	4,200	900	600	5,850	1,755	7,605
Total of equipment		13	8	4	20	74	87	58	58	29,000			
Total cost		325	216	120	740	2,960	5,046	40,600	8,700	5,800	64,507	19,352	83,859

Note : Length of 22kV XLPE cable for a RMU 500 (m)

Installation /construction cost 30 (%) of equipment and material cost

Table 13 Total cost of distribution facilities (non-LVC)

Unit: $1,000

Zone	East / West	Transformer capacity (kVA) 250	320	400	560	630	1,000	RMU	LV dist. board	22kV XLPE cable (m)	Total Equipment	Instal-lation cost	Total Cost
N2	East	0	0	0	0	0	0	0	0				
	West	0	0	0	0	5	6	2	2				
	Sub-total	0	0	0	0	5	6	2	2	1,000			
	Cost	0	0	0	0	200	348	1,400	300	200	2,448	734	3,182
N3	East	0	0	0	3	11	6	4	4				
	West	0	0	0	0	12	6	3	3				
	Sub-total	0	0	0	3	23	12	7	7	3,500			
	Cost	0	0	0	111	920	696	4,900	1,050	700	8,377	2,513	10,890
N4	East	0	0	3	0	6	2	4	4				
	West	1	0	0	0	0	0	1	1				
	Sub-total	1	0	3	0	6	2	5	5	2,500			
	Cost	25	0	90	0	240	116	3,500	750	500	5,221	1,566	6,787
N5	East	0	1	0	14	0	11	6	6				
	West	0	0	0	1	6	0	2	2				
	Sub-total	0	1	0	15	6	11	8	8	4,000			
	Cost	0	27	0	555	240	638	5,600	1,200	800	9,060	2,718	11,778
N6	East	0	0	0	0	4	1	1	1				
	West	1	1	1	0	0	0	2	2				
	Sub-total	1	1	1	0	4	1	3	3	1,500			
	Cost	25	27	30	0	160	58	2,100	450	300	3,150	945	4,095
N7	East	0	0	0	0	0	0	0	0				
	West	0	1	0	24	5	8	6	6				
	Sub-total	0	1	0	24	5	8	6	6	3,000			
	Cost	0	27	0	888	200	464	4,200	900	600	7,279	2,184	9,463
N8	East	0	0	0	0	0	0	0	0				
	West	0	0	0	0	54	51	18	18				
	Sub-total	0	0	0	0	54	51	18	18	9,000			
	Cost	0	0	0	0	2,160	2,958	12,600	2,700	1,800	22,218	6,665	28,883
N9	East	0	0	0	0	0	0	0	0				
	West	0	0	0	1	21	18	7	7				
	Sub-total	0	0	0	1	21	18	7	7	3,500			
	Cost	0	0	0	37	840	1,044	4,900	1,050	700	8,571	2,571	11,142
Total equipment		2	3	4	43	124	109	56	56	28,000			
Total cost		50	81	120	1,591	4,960	6,322	39,200	8,400	5,600	66,324	19,897	86,221

Note : Length of 22kV XLPE cable for a RMU 500 (m)

Installation /construction cost 30 (%) of equipment and material cost

Appendix 8 Traffic Demand Forecast

1 Assumptions to update the population projection

Population and employment forecast results are updated according to Hanoi Transport Master Plan and population projection result of JICA Study Team as following tables:

Table 1 Results of Population and Employment Projection of districts on Hanoi City

Unit: thousand person

No.	District	Population				Employment			
		2020	2030	2040	2050	2020	2030	2040	2050
1	Ba Dinh	250	251	251	251	222	205	221	238
2	Hoan Kiem	163	163	163	163	138	208	185	161
3	Tay Ho	120	120	164	174	87	113	125	136
4	Long Bien	249	350	362	375	189	247	267	287
5	Cau Giay	160	148	148	148	179	144	134	125
6	Dong Da	419	419	419	420	243	373	349	326
7	Hai Ba Trung	332	332	332	332	196	265	269	274
8	Hoang Mai	240	255	281	308	197	258	278	299
9	Thanh Xuan	180	135	135	135	152	159	148	138
10	Soc Son	343	499	566	634	340	444	500	555
11	Dong Anh	627	793	892	991	549	748	844	940
12	Gia Lam	419	536	560	584	322	420	422	423
13	Tu Liem	414	588	638	688	409	534	615	697
14	Thanh Tri	215	304	336	369	188	245	265	285
15	Me Linh	216	284	312	341	128	168	181	194
16	Ha Dong	245	350	468	585	153	276	316	356
17	Son Tay town	240	246	267	287	41	53	81	109
18	Ba Vi	258	208	215	222	26	34	36	39
19	Phuc Tho	209	233	247	261	21	27	29	31
20	Dan Phuong	292	314	343	372	24	32	34	37
21	Hoai Duc	209	300	326	352	40	53	57	61
22	Quoc Oai	1115	1402	1570	1738	98	128	138	149
23	Thach That	497	775	859	944	48	169	207	245
24	Chuong My	468	554	616	678	80	105	114	122
25	Thanh Oai	185	204	218	231	29	37	40	43
26	Thuong Tin	310	358	386	414	57	75	81	87
27	Phu Xuyen	319	299	322	345	32	62	80	97
28	Ung Hoa	307	261	276	291	22	28	31	33
29	My Duc	282	224	240	256	18	23	25	27

Source: JICA study team (JST)

** The list of 29 districts is taken according to the old planning. Currently, Hanoi has 30 districts due to separation of Tu Liem district into 2 districts of Bac Tu Liem and Nam Tu Liem in 2014.*

2 Traffic demand forecast for Line 2.3

a) Methodology

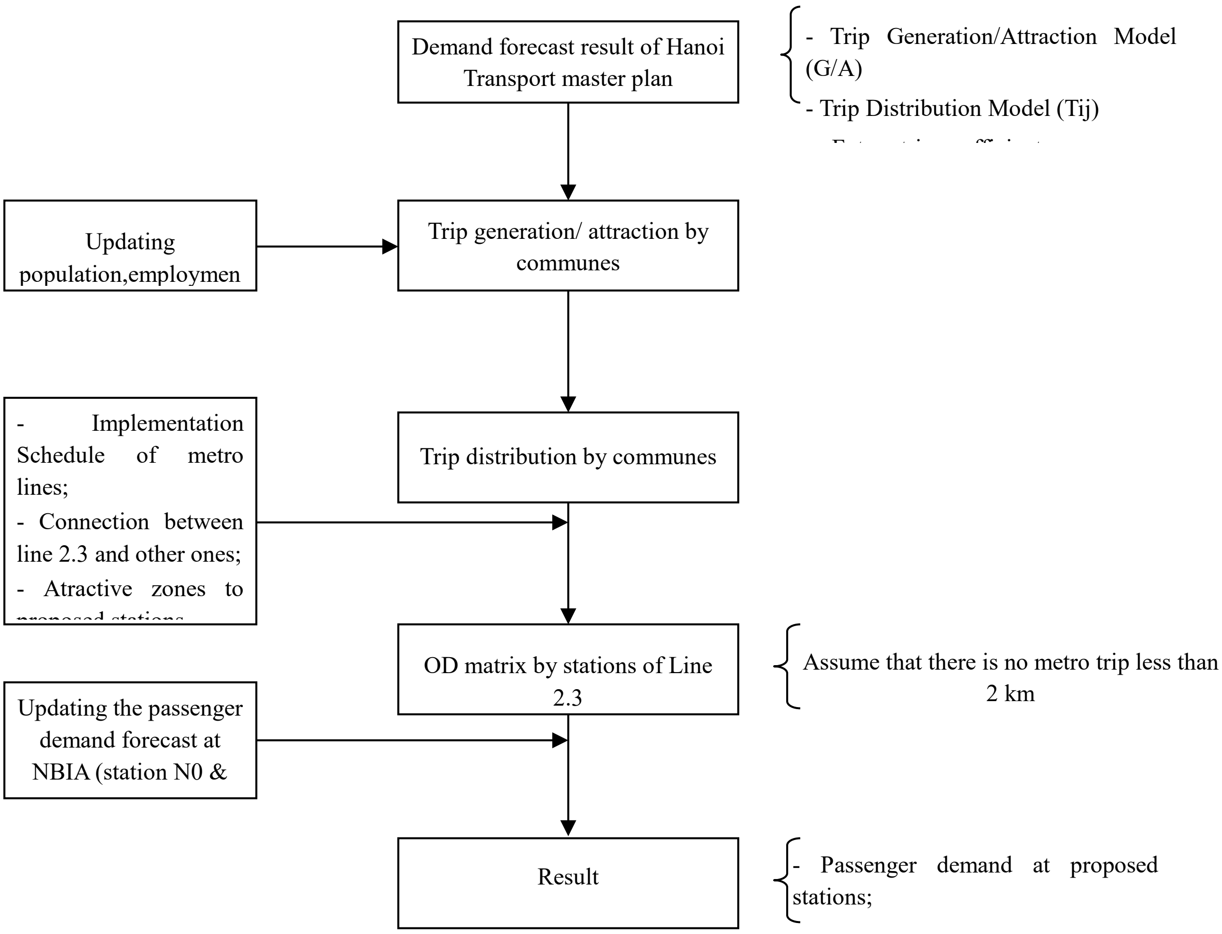


Figure 1 Methodological diagram

Based on the result of traffic demand forecast of Hanoi city of Hanoi Transport Master plan to 2030 and vision to 2050 to implement the traffic demand forecast for Line 2.3.

Updating the traffic demand forecast of regional in Hanoi City:

- According to Hanoi Transport Master plan, whole city had 577 wards/ communes which divided to 320 zones by conditions as follow: socio-economic indicators; transport demands; geographical locations.

- Generation/ Attraction Model: Population, workers and students were adopted in the regression equations.

Generation: $Gi = \Sigma ak\ Xki + C$

Attraction: $Aj = \Sigma bk\ Xkj + D$

where: Gi : Generation of zone i

Aj : Attraction of zone j

Xkj : variables of zone i including:

X1i : Population

X2i: Workers

X3i: Students

ak, bk : parameters

C,D: constants

+ Distribution Model:

$$T_{ij} = \mathrm{K} * \frac{G_i^{\alpha} * A_j^{\beta}}{d_{ij}^{\gamma}}$$

Where, Tij: Number of trips between zone i and j,

dij: impendence between i and j,

K, α, β, γ: parameters

Traffic demand forecast of Line 2.3:

Table 2 Scope of attraction of Line 2

No.	Commune/ward	District
1	Trúc Bạch	Ba Dinh
2	Vĩnh Phúc	Ba Dinh
3	Cống Vị	Ba Dinh
4	Liễu Giai	Ba Dinh
5	Nguyễn Trung Trực	Ba Dinh
6	Quán Thánh	Ba Dinh
7	Ngọc Hà	Ba Dinh
8	Đội Cấn	Ba Dinh
9	Kim Mã	Ba Dinh
10	Hàng Mã	Hoan Kiem
11	Lý Thái Tổ	Hoan Kiem
12	Chương Dương	Hoan Kiem
13	Tràng Tiền	Hoan Kiem
14	Trần Hưng Đạo	Hoan Kiem
15	Phan Chu Trinh	Hoan Kiem
16	Hàng Bài	Hoan Kiem
17	Phú Thượng	Tay Ho
18	Nhật Tân	Tay Ho
19	Tứ Liên	Tay Ho
20	Quảng An	Tay Ho
21	Xuân La	Tay Ho
22	Bưởi	Tay Ho
23	Thụy Khuê	Tay Ho
24	Nghĩa Đô	Cau Giay
25	Nghĩa Tân	Cau Giay
26	Dịch Vong	Cau Giay
27	Dịch Vọng Hậu	Cau Giay
28	Quan Hoa	Cau Giay
29	Yên Hòa	Cau Giay
30	Trung Hòa	Cau Giay
31	Quang Trung	Dong Da
32	Trung Liệt	Dong Da
33	Phương Liên	Dong Da

No.	Commune/ward	District
34	Thịnh Quang	Dong Da
35	Trung Tự	Dong Da
36	Kim Liên	Dong Da
37	Phương Mai	Dong Da
38	Ngã Tư Sở	Dong Da
39	Bùi Thị Xuân	Hai Ba Trung
40	Ngô Thì Nhậm	Hai Ba Trung
41	Lê Đại Hành	Hai Ba Trung
42	Bách Khoa	Hai Ba Trung
43	Nhân Chính	Hai Ba Trung
44	Thượng Đình	Hai Ba Trung
45	Khương Trung	Hai Ba Trung
46	Thanh Xuân Trung	Hai Ba Trung
47	Sóc Sơn	Soc Son
48	Trung Giã	Soc Son
49	Phù Linh	Soc Son
50	Thanh Xuân	Soc Son
51	Mai Đình	Soc Son
52	Phù Lỗ	Soc Son
53	Phú Minh	Soc Son
54	Phú Cường	Soc Son
55	Quang Tiến	Soc Son
56	Dong Anh town	Dong Anh
57	Bắc Hồng	Dong Anh
58	Nguyên Khê	Dong Anh
59	Nam Hồng	Dong Anh
60	Tiên Dương	Dong Anh
61	Vân Nội	Dong Anh
62	Kim Nỗ	Dong Anh
63	Kim Chung	Dong Anh
64	Vĩnh Ngọc	Dong Anh
65	Hải Bối	Dong Anh
66	Võng La	Dong Anh
67	Tầm Xá	Dong Anh
68	Đông Ngạc	Tu Liem
69	Đức Thắng	Tu Liem
70	Thụy Phương	Tu Liem
71	Xuân Đỉnh	Tu Liem
72	Xuân Tảo	Tu Liem

Source : JST

Traffic demand on the metro line includes: direct trips (with departure and arrival points in wards/communes with this railway crossing) and transitional trips (with departure or destination points of wards / communes with this railway crossing).

Traffic demand forecast of Line 2 accounts for 5% of intra-regional trips to Hanoi City and 21% of the demand for going to / from the airport.

Traffic demand on Line 6 is the total urban transport demand on line 6 and the demand for transportation to the airport on Line 6.

b) Updating the results of traffic demand forecast for regional in Hanoi City

Table 3 The results of traffic demand forecast for regional in Hanoi City

Year	2020	2030	2050
Travel coefficients	2,9	3,1	3,12
Trips (thous. trips/ day)	26.914	33.793	40.209

Source : JST

Table 4 Generation/ Attraction forecast result by districts of Hanoi

Unit: Trips/day

No.	District	2020		2030		2050	
		G	A	G	A	G	A
1	Ba Dinh	1.011.249	1.009.743	1.231.014	1.231.154	1.215.363	1.239.666
2	Hoan Kiem	672.992	675.609	806.217	806.100	812.864	811.868
3	Tay Ho	329.629	329.482	352.452	352.177	489.391	488.635
4	Long Bien	693.591	693.264	1.005.373	1.004.990	1.105.656	1.104.524
5	Cau Giay	447.071	446.907	434.039	433.381	436.849	435.654
6	Dong Da	1.703.263	1.701.644	2.046.928	2.045.426	2.101.807	2.098.738
7	Hai Ba Trung	1.375.040	1.375.405	1.644.248	1.644.586	1.680.632	1.680.027
8	Hoang Mai	643.426	643.104	714.922	714.694	886.177	885.047
9	Thanh Xuan	496.946	496.560	383.279	383.213	403.083	402.431
10	Soc Son	890.479	889.825	1.395.450	1.395.230	1.801.562	1.800.310
11	Dong Anh	1.679.743	1.679.172	2.240.534	2.240.307	2.941.195	2.938.972
12	Gia Lam	1.132.203	1.131.725	1.489.660	1.489.013	1.663.391	1.662.011
13	Tu Liem	1.130.434	1.130.560	1.695.695	1.695.631	1.973.018	1.972.135
14	Thanh Tri	601.528	601.112	880.600	879.512	1.081.920	1.080.070
15	Me Linh	595.608	595.707	817.612	817.678	1.002.150	1.001.688
16	Ha Dong	660.370	659.806	996.092	995.275	1.649.585	1.646.833
17	Son Tay town	661.477	661.443	697.726	697.592	826.134	825.221
18	Ba Vi	719.108	719.469	593.571	593.752	643.889	643.717
19	Phuc Tho	581.139	581.431	682.350	682.677	778.802	778.743
20	Dan Phuong	812.991	813.399	919.561	920.003	1.108.525	1.108.440
21	Hoai Duc	540.197	540.205	878.562	878.984	1.048.847	1.048.767
22	Quoc Oai	3.053.485	3.054.759	4.104.559	4.106.530	5.184.660	5.184.263
23	Thach That	1.357.547	1.357.923	2.253.466	2.253.804	2.817.198	2.816.346
24	Chuong My	1.234.052	1.234.233	1.621.607	1.622.386	2.023.340	2.023.186
25	Thanh Oai	493.129	493.164	570.764	570.733	658.971	658.558
26	Thuong Tin	874.978	874.824	1.048.417	1.048.921	1.236.237	1.236.142
27	Phu Xuyen	880.323	880.700	868.279	868.544	1.006.376	1.005.757
28	Ung Hoa	855.683	856.112	762.884	763.251	867.425	867.358
29	My Duc	786.002	786.396	655.993	656.308	763.883	763.824
	Total	26.913.683	26.913.683	33.791.852	33.791.852	40.208.931	40.208.931

Source : JST

c) Traffic demand forecast on Line 2.3

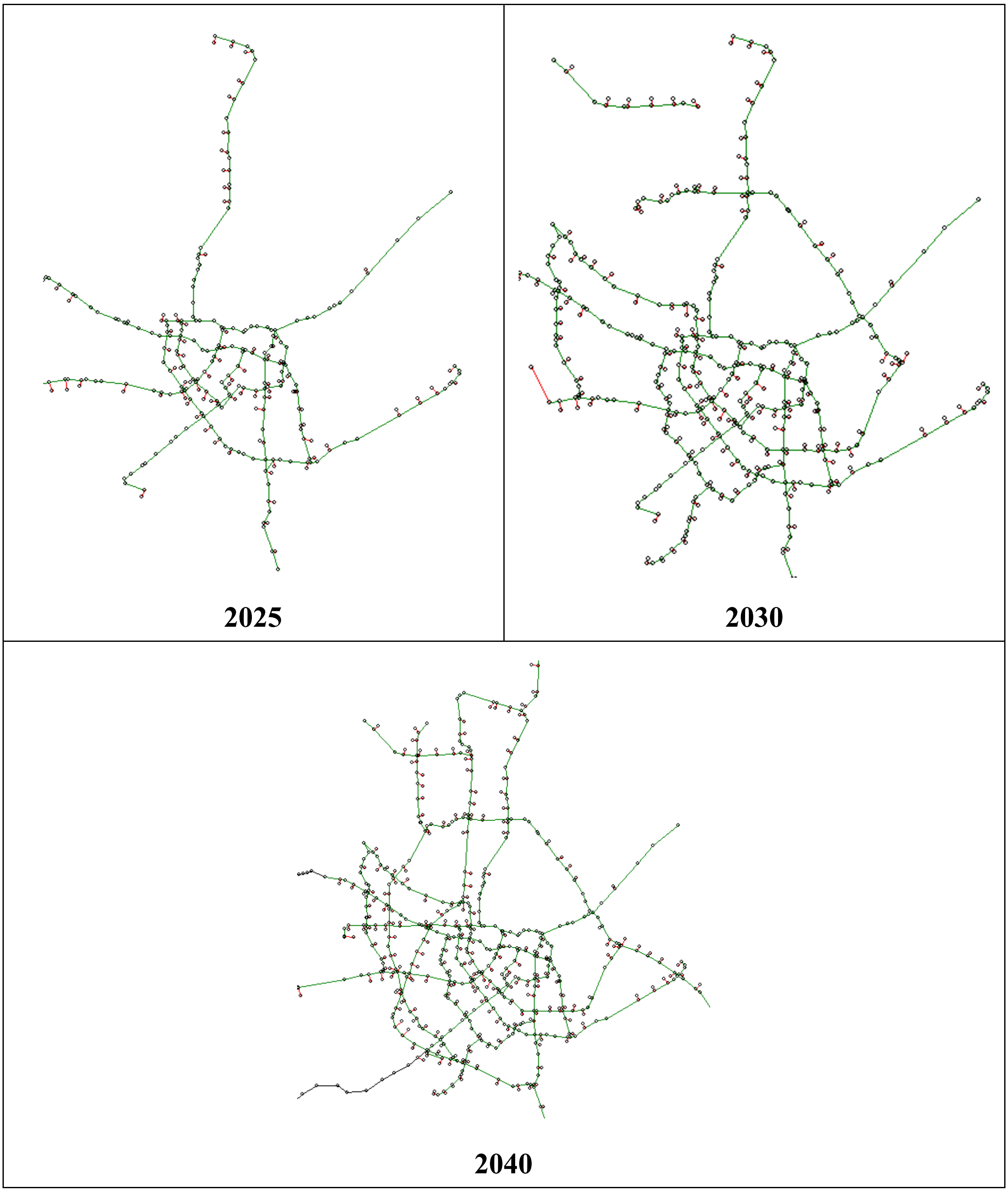


Figure 2 Metro network's scenarios

- Year 2025: Metro network will have six lines while Line 1 will connect with Line 2 at C8 and C12 Stations, Line 2A will connect with Line 2 at C16 Station, Line 3 will connect with Line 2 at C10 and D5 Stations; Line 5 will connect with Line 2 at C5 Station.

- Year 2030: Metro network will have 7 lines and 3 monorail lines while Line 4 additional, which will connect with Line 2 at N7 Station and overlap with Line 2 at 6 Station (Thuong Dinh - Buoi section) ; Line 5 will connect with Line 2 at C5 and D2 Stations;

- Year 2040: Metro network will have 9 lines and 3 monorail lines while Line 6 additional, which will connect with Line 2 at N0 Station.

Appendix 9 Prediction of Air Passenger Using UMRT Line 2.3

1 General

The route of Line 2 (Phase III) begin at Nam Thang Long (Tay Ho district), then it go cross Red River and through Dong Anh district. The end point of this line is at Noi Bai International Airport (NIA). Obviously, Line 2 (Phase) serves not only Hanoi citizens but also air passengers at NIA. The purpose of this summary is to forecast the number of air passengers who use UMRT Line 2. It should be noted that NAI is the key airline hub of Vietnam. Therefore, the air passenger forecast is based on levels of socio-economic in Vietnam. Then, the forecasted number of air passengers using Line 2 is based on different scenarios of modal share.

2 Methodology

2.1 Framework

Air passenger at NIA is forecasted by formulating econometric models. Such models is based on the correlation between number of passengers and socio-economic indices (i.e. GDP and/or Population) in the past. Methodology of the forecast is outline as below:

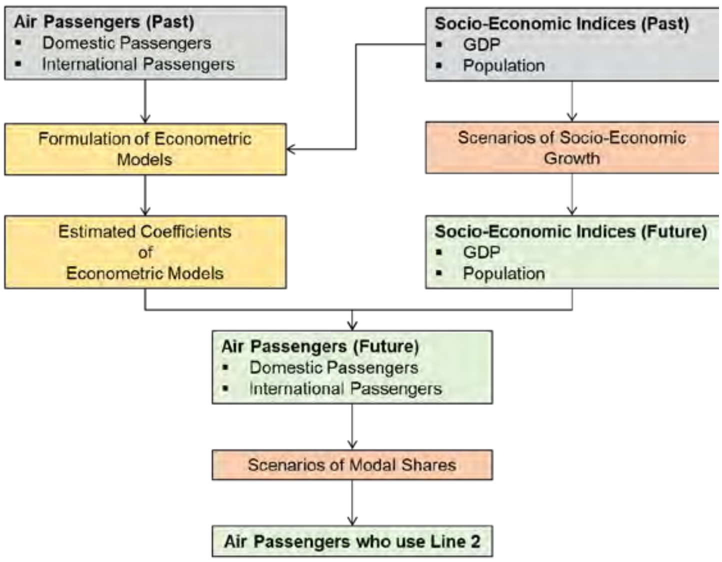


Figure 1: Workflow for Estimation of Air Passengers Using Line 2

Source: Study Team

2.2 Econometric Models

According to the Manual on Air Traffic Forecasting (ICAO, 2006), there are several alternative forms of econometric models, including: i) linear, ii) multi-plicate (or log-log), iii) exponential (or log-linear). In order to develop most reliable econometric models for air traffic forecast, several alternative models with different forms and explanatory variables (GDP and/or population are tested. Specifically, the different econometric models are shown below:

1. Linear function: only GDP is explanatory variable

$$\mathbf{AP = a + b * GDP}$$

Where:

AP: Number of air passengers;

a & b: coefficients;

GDP: Gross domestic product.

2. Linear function: GDP & Population are explanatory variables

$$\mathbf{AP = a + b * GDP + c * Population}$$

3. Multiplicative function (or log-log form): GDP & Population are explanatory variables

$$\mathbf{AP = a * GDP^{b} * Population^{c}}$$

Then, taking the log of both sides as follows:

$$\mathbf{Ln(AP) = Ln(a) + b*Ln(GDP) + c*Ln(Population)}$$

4. Multiplicative function (or log-log form): only GDP is explanatory variable

$$\mathbf{AP = a * GDP^{b}}$$

Then, taking the log of both sides as follows:

$$\mathbf{Ln(AP) = Ln(a) + b*Ln(GDP)}$$

5. Exponential function (or log-linear form): only GDP is explanatory variable

$$AP = e^{a+b*GDP}$$

Then, taking the log of both sides as follows:

$$\mathbf{Ln(AP) = a + b*GDP}$$

3 Growths of Population, GDP and Air Passenger

3.1 Population Growth

3.2 Past Trend of Population

As shown in Table 1, annual average growth rate of population in the past 22 years is 1.13%.

Table 1: Growth of Population in Vietnam

Year	Population (million)	Growth Rate
1994	73.93	-
1995	75.20	1.72%
1996	76.37	1.56%
1997	77.45	1.41%
1998	78.45	1.29%
1999	79.39	1.20%
2000	80.29	1.13%
2001	81.14	1.06%
2002	81.96	1.01%
2003	82.75	0.97%
2004	83.53	0.94%
2005	84.31	0.94%
2006	85.09	0.93%
2007	85.89	0.93%
2008	86.71	0.95%
2009	87.57	0.99%
2010	88.47	1.04%
2011	89.44	1.09%
2012	90.45	1.14%
2013	91.50	1.16%
2014	92.54	1.14%
2015	93.57	1.11%
AAGR 1994-2015		1.13%

Source: World Bank

(1) Future Trend of Population

According to General Statistic Office of Vietnam (2016), there are three scenarios of future population growth in Vietnam (see Table 2)

Table 2: Growth Rate of Future Population in Vietnam

Period	Population - Growth Rate		
	Low	*Medium*	*High*
2018-2020	0.96%	1.05%	1.09%
2021-2025	0.74%	0.80%	0.90%
2026-2030	0.52%	0.60%	0.68%

Source: General Statistics Office of Vietnam

3.3 GDP Growth

(1) Past Trend of GDP

It can be seen from Table 3 that the annual average growth rate of GDP is the past 22 years is 6.67%.

Table 3: Growth of GDP in Vietnam

Year	GDP (billion US) at 2010 Constant Price	Growth Rate
1994	39.89	-
1995	43.70	9.54%
1996	47.78	9.34%
1997	51.67	8.15%
1998	54.65	5.76%
1999	57.26	4.77%
2000	61.15	6.79%
2001	64.93	6.19%
2002	69.04	6.32%
2003	73.80	6.90%
2004	79.36	7.54%
2005	85.35	7.55%
2006	91.31	6.98%
2007	97.82	7.13%
2008	103.36	5.66%
2009	108.93	5.40%
2010	115.93	6.42%
2011	123.17	6.24%
2012	129.63	5.25%
2013	136.66	5.42%
2014	144.83	5.98%
2015	154.51	6.68%
AAGR 1994-2015		6.67%

Source: World Bank

(2) Future Trend of GDP

Regarding GDP, there are three scenarios of growth rate in the future (see Table 4).

Table 4: Growth Rate of Future GDP in Vietnam

Period	GDP - Growth Rate		
	Low	*Medium*	*High*
2018-2020	3%	5%	7%
2021-2025	3%	5%	7%
2026-2030	3%	5%	7%

Source: Study Team

3.4 Air Passenger Growth

The statistics of air passengers in NIA from 1994 to 2015 are shown in Table 5. The annual average growth of domestic and international passenger is about 14%.

Table 5: Statistics of Air Passengers in NIA

Year	Passengers (000 pax)		Growth Rate	
	Domestic	*International*	*Domestic*	*International*
1994	689.983	428.454		
1995	925.798	461.798	34.18%	7.78%
1996	1,044.392	550.654	12.81%	19.24%
1997	1,043.522	554.859	-0.08%	0.76%
1998	1,028.706	549.428	-1.42%	-0.98%
1999	1,051.395	562.578	2.21%	2.39%
2000	1,175.276	649.008	11.78%	15.36%
2001	1,407.220	799.832	19.74%	23.24%
2002	1,670.922	1,043.400	18.74%	30.45%
2003	1,721.434	1,118.555	3.02%	7.20%
2004	1,939.301	1,702.700	12.66%	52.22%
2005	2,254.312	2,085.684	16.24%	22.49%
2006	2,670.607	2,505.637	18.47%	20.14%
2007	3,404.816	2,899.782	27.49%	15.73%
2008	3,946.801	3,050.996	15.92%	5.21%
2009	4,879.534	2,970.194	23.63%	-2.65%
2010	5,858.289	3,677.820	20.06%	23.82%
2011	6,371.270	4,221.909	8.76%	14.79%
2012	6,516.805	4,815.973	2.28%	14.07%
2013	7,467.841	5,379.215	14.59%	11.70%
2014	8,578.491	5,564.725	14.87%	3.45%
2015	10,824.242	6,413.985	26.18%	15.26%
AAGR 1994-2015			14.39%	14.37%

Source: Civil Aviation Authority of Vietnam

4 Results of Estimation

4.1 Model Performance

(1) Adjusted R Square & Collinearity

Table 6 presents a comparison of adjusted R square. The values of all models are larger than 0.9, indicating a sufficiently high level of model accuracy. Additionally, the correlation of GDP and Population is examined. As a result, there is very strong correlation between those explanatory variables. Therefore, the model with GDP and Population as explanatory variables are refused. Only GDP is remained as explanatory in three different forms of model: linear, log-log and log-linear.

With respect to domestic passengers, the log-linear mode has highest adjusted R square (0.986), followed by log-log (0.970) and linear (0.928). In aspect of international passengers, adjusted R square of log-log model (0.973) is larger than that of linear and log-linear ones (0.971 & 0.951)

Table 6: Performance of Different Econometric Models

No.	Form of Model	Adjusted R square		Correlation of GDP & PoP		Accept or Not
		Domestic	*International*	*Domestic*	*International*	
1	Linear (GDP)	0.928	0.971	-	-	Yes
2	Linear (GDP, Pop)	0.975	0.994	0.988	0.988	***No***
3	Log-log (GDP, Pop)	0.975	0.989	0.988	0.988	***No***
4	Log-log (GDP)	0.970	**0.973**	-	-	Yes
5	Log-linear (GDP)	**0.986**	0.951	-	-	Yes

Source: Study Team

(2) Estimation vs Observation

In addition to adjusted R square, three different mode forms of GDP are compared in aspect to estimation versus observation (in reality). With respect to the linear model with GDP as explanatory variable, it underestimates the number of air passengers. Even estimated value of 1994 is negative (see Figure 2)

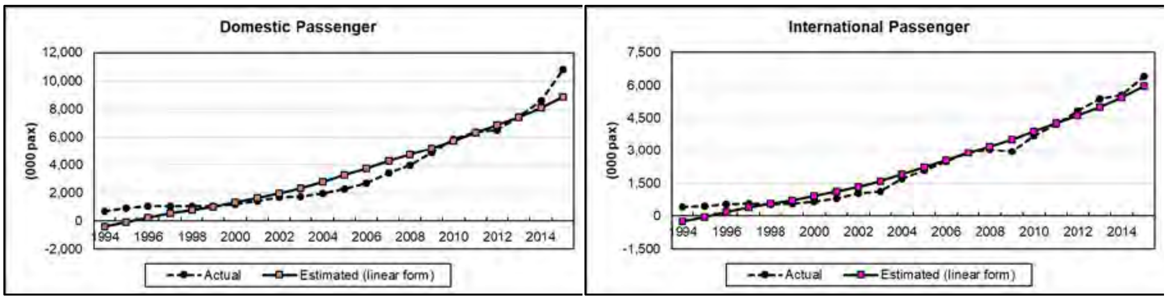


Figure 2: Linear Model (Estimation vs. Observation)

Source: Study Team

In aspect to the log-linear model with GDP as explanatory variable, it overestimates the number of air passenger (see Figure 3)

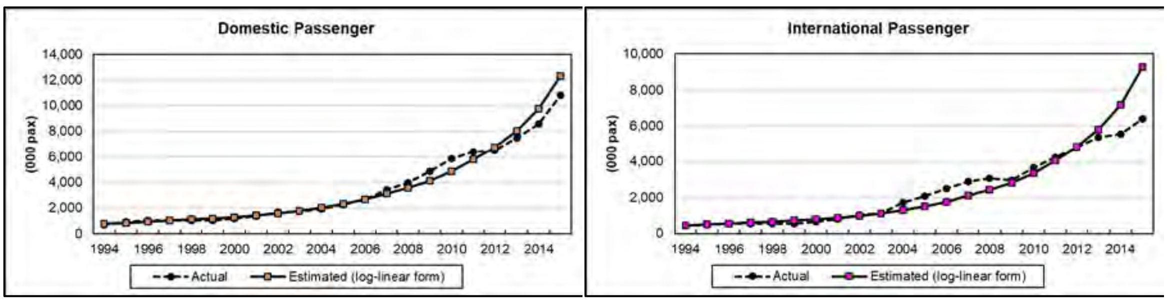


Figure 3: Log-Linear Model (Estimation vs. Observation)

Source: Study Team

As for log-log model, it seems to be most appropriate (see Figure 4). According to to the Manual on Air Traffic Forecasting, ICAO (2006) recommended that the log-log model is generally considered as the most appropriate form in case of the estimation of air traffic demand at an aggregate level such as global or regional flows.

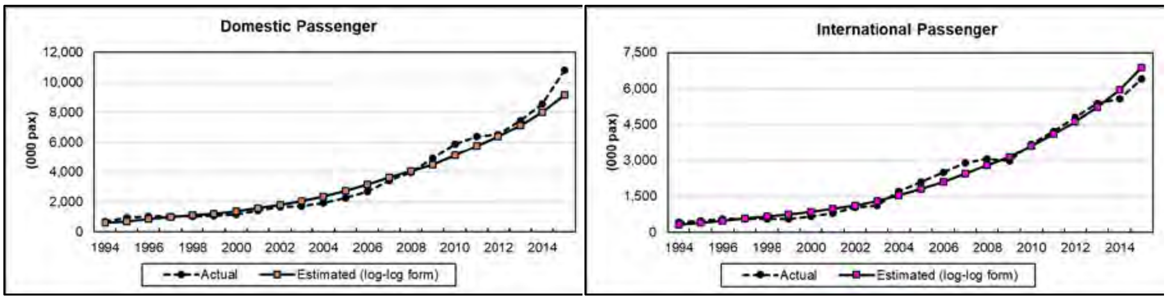


Figure 4: Log-Log Model (Estimation vs. Observation)

Source: Study Team

(3) Final Model and Results

Based upon the result of model performance, the log-log model is selected as final form.

$$\mathbf{AP = a * GDP^b}$$

Then, taking the log of both sides as follows:

$$\mathbf{Ln(AP) = Ln(a) + b*Ln(GDP)}$$

(4) Estimated coefficients & air passengers

The results of estimated coefficients are shown in Table 7.

Table 7: Estimation Result of Log-log Model

Variable	Domestic Passengers		International Passengers	
	Parameter	*t-statistic*	*Parameter*	*t-statistic*
a (Constant)	-1.127	-3.277	-2.547	-7.058
b (GDP)	2.033	26.108	2.259	27.647

Source: Study Team

The estimation of air passengers at NIA in the future is presented in Table 8. In accordance with three scenarios of GDP growth, there are three scenarios of air passenger forecast for NIA. The "medium" scenario will be selected as final result.

Table 8: Air Passenger Forecast for NIA

Year	Domestic+ International (000 pax)		
	Low	*Medium*	*High*
2020	25,333.78	28,651.45	32,329.76
2025	34,725.61	48,232.44	66,598.19
2030	47,612.32	81,256.55	137,388.93

Source: Study Team

References：General Statistic Office of Vietnam. (2016). *Vietnam Population Forecast 2014 - 2049 (in Vietnamese)*.

International Civil Aviation Organization. (2006). *Manual on air traffic forecasting*. http://doi.org/DOC 8991 AT172213