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**DEPARTMENT OF RURAL ROADS**
**MINISTRY OF TRANSPORT**
**KINGDOM OF THAILAND**

# PREPARATORY SURVEY
# FOR
# THE CHAO PHRAYA RIVER CROSSING BRIDGE AT NONTHABURI 1 ROAD CONSTRUCTION PROJECT

# FINAL REPORT

JANUARY 2010

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

NIPPON KOEI CO., LTD.
CHODAI CO., LTD.

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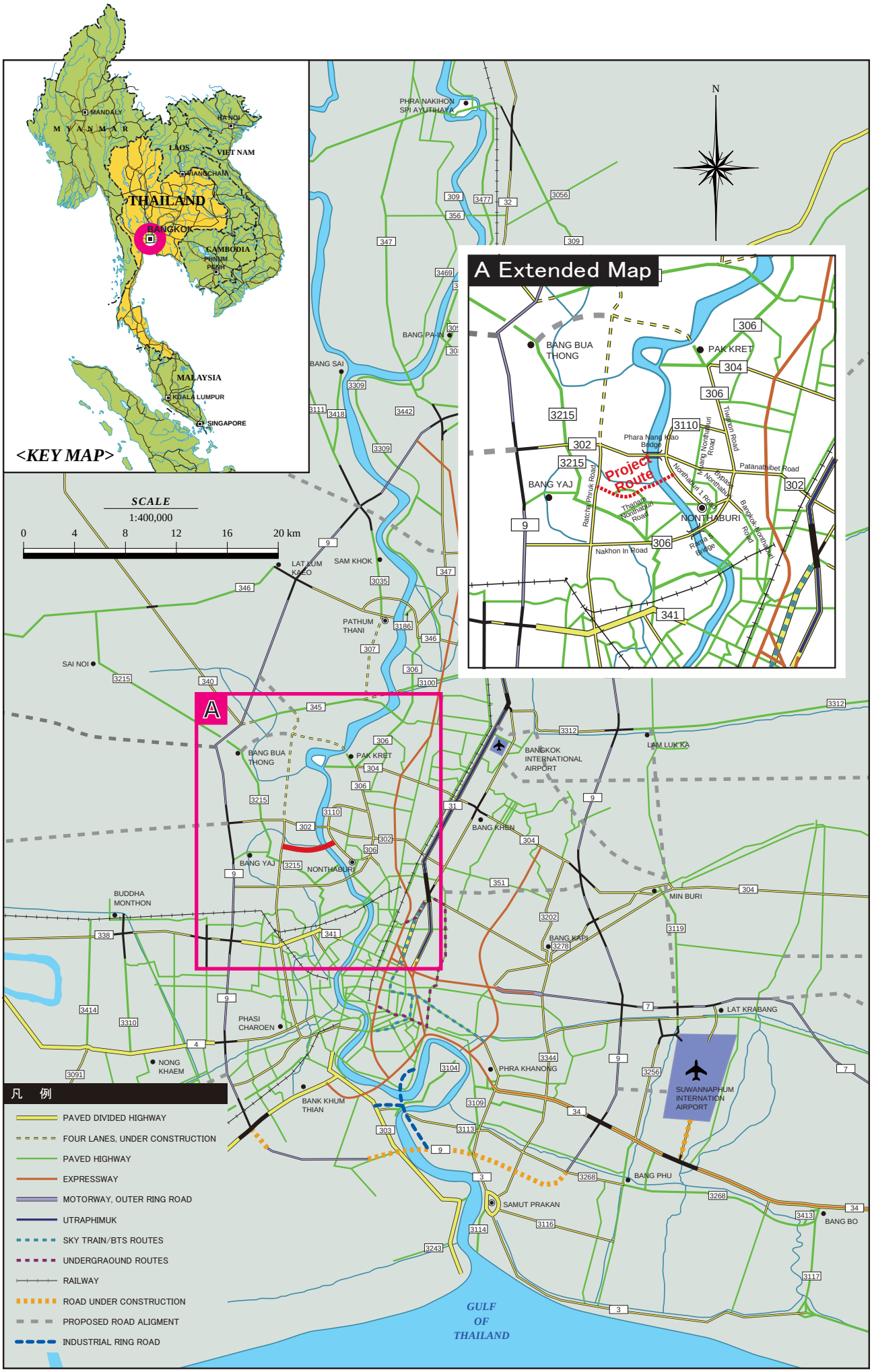
CURRENCY EXCHANGE RATE

Following currency exchange rates were adopted in this report unless otherwise stipulated.

(1) Thai Baht vs. US Dollar
USD 1= THB 34.5

(2) Thai Baht vs. Japanese Yen
THB 1 = JPY 2.75




Survey Location Map

Preparatory Survey
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## List of Abbreviation

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| AASHTO | American Association of State Highway and Transportation Officials |
| ADB | Asian Development Bank |
| AIDS | Acquired Immune Deficiency Syndrome |
| ARD | Office of Accelerated Rural Development |
| B/C | Benefit Cost Ratio |
| BMA | Bangkok Metropolitan Administration |
| BMR | Bangkok Metropolitan Region |
| BOD | Biochemical Oxygen Demand |
| BQ | Bill of Quantity |
| CFRP | Carbon Fiber Reinforced Plastics |
| CMLT | Commission of Management of Land Traffic |
| C/S | Construction Supervision |
| D/D, DD | Detailed Design |
| DOH | Department of Highways |
| DRR | Department of Rural Roads |
| DVD | Digital Versatile Disk |
| EIA | Environment Impact Assessment |
| EIRR | Economic Internal Rate of Return |
| E/N | Exchange of Notes |
| EXAT | Expressway Authority of Thailand |
| F/S | Feasibility Study |
| GDP | Gross Domestic Products |
| GRDP | Gross Regional Domestic Products |
| GMS | Greater Mekong Sub-region |
| H | Height |
| HDPE | High Density Polyethylene |
| Hgc | Height at Center |
| Hgs | Height at Support (Bearing) |
| HIV | Human Immunodeficiency Virus |
| HWL | High Water Level |
| IBRD | International Bank for Reconstruction and Development |
| IRR | Industrial Ring Road |
| JBIC | Japan Bank for International Cooperation |
| JICA | Japan International Cooperation Agency |
| L | Length |
| L/A | Loan Agreement |
| L/C | Letter of Credit |
| LCC | Life Cycle Cost |
| Lmax | Maximum Length |
| M/C | Motor Cycle |
| MEA | Metropolitan Electronic Association |

| | |
|---|---|
| M/M | Man-Month |
| MOF | Ministry of Finance |
| MOI | Ministry of Interior |
| MOT | Ministry of Transport |
| MRT | Mass Rapid Transit |
| MRTA | Mass Rapid Transit Authority of Thailand |
| MSL | Mean Sea Level |
| NESDB | Office of the National Economic and Social Development Board |
| NESDP | National Socio－Economic Development Plan |
| NPV | Net Present Value |
| OD | Origin and Destination |
| ODA | Official Development Assistance |
| O&M | Operation and Maintenance |
| ONEP | Office of Natural Resources and Environmental Policy and Planning |
| OTP | Office of Transport and Traffic Policy and Planning |
| PC | Pre-stressed Concrete |
| PCC | Property Compensation Community |
| PCU | Passenger Car Unit |
| PDMO | Public Debt Management Office |
| PPP | Public and Private Partnership |
| P/Q | Pre-Qualification |
| PWD | Public Works Department |
| RAP | Resettlement Action Plan |
| ROW | Right of Way |
| SAPS | Special Assistance for Project Sustainability (JBIC) |
| SRT | State Railway of Thailand |
| TDMC | Transport Data and Model Center |
| TDML | Transport Data and Model Integrated with Multimodal Transport and Logistics |
| UTDP | Urban Transport Development Partnership |
| VAT | Value-added Tax |
| V/C (VCR) | Volume/ Capacity Ratio |
| VOC | Vehicle Operating Cost |
| VOT | Value of Time |
| WB | World Bank |

# CHAPTER 1 INTRODUCTION

## 1.1 BACKGROUND OF THE SURVEY

### 1.1.1 ROAD AND BRIDGE DEVELOPMENT IN BANGKOK METROPOLITAN AREA

The Bangkok Metropolitan Region (BMR) consists of the Bangkok Metropolitan Administration (BMA) and the surrounding five provinces of Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom, with a total area of 7,761.5 km$^2$ and with 10.07 million population as of year 2008. BMR expands from BMA towards the surrounding five provinces and the recent population growth rate in BMR is 1.5% per annum. In Thailand, BMA is the most densely populated area with about 4,000 persons/km$^2$ or more, and the Nonthaburi Prefecture ranks next to BMA with about. 700 persons/km$^2$), and the Pathum Thani Prefecture ranks the seventh with about 600 persons/km2). Based on the recent population growth trend, a significant population increase is expected in these two provinces.

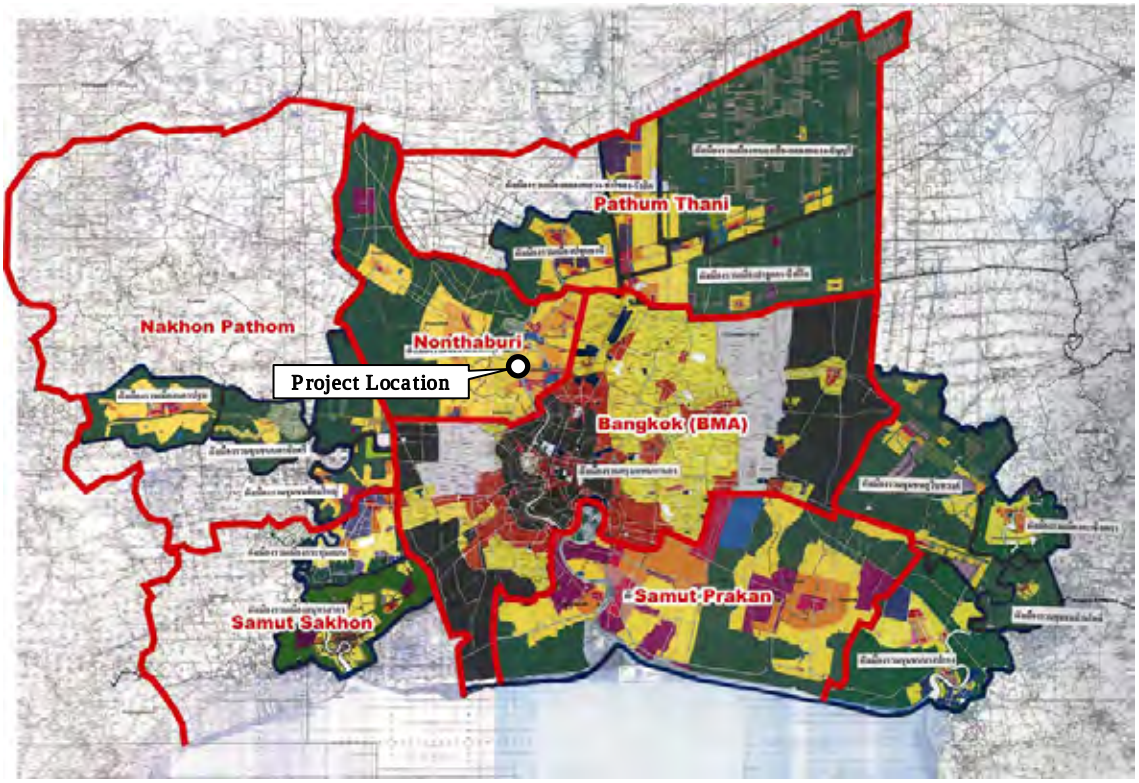



**Figure 1.1.1 Bangkok Metropolitan Region (BMR)**

In the past, major roads and bridges have been constructed by the Public Works Department (PWD) of the Ministry of Interior (MOI), the Department of Highways (DOH) of the Ministry of Transportation (MOT), the Expressway Authority of Thailand (EXAT) and the BMA. In October 9, 2002, the Department of Rural Roads (DRR) was established on October 9, 2009 under MOT by transferring the staff from PWD and the Office of Accelerated Rural Development of MOI. After its establishment, DRR has the responsibility of developing new road infrastructures in BMR other than the areas of BMA. However, the operation and maintenance of the existing bridges by the previous PWD are still under DRR.

DRR is the executing agency of "The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project" (the Project), which belongs to Nonthaburi Province.

### 1.1.2 ROAD AND BRIDGE DEVELOPMENT IN BANGKOK METROPOLITAN AREA

There are 20 bridges crossing over the Chao Phraya River in BMR as shown in Figure 1.1.2. The first bridge is Rama VI Bridge built in 1982 as a railway bridge under assistance of the French and British Governments. Afterwards, a number of bridges had been built, and there are 19 roadway bridges (North and South bridges of the Industrial Ring Road are counted at 1) and a railway bridge totaling 20 bridges as October 2009. Recently, one rail bridge carrying the BTS Sky Train was accommodated in the mid-space between the upstream and downstream side girders of the Taksin Bridge and this makes it two rail bridges in BMR. The summary of the existing bridges is presented in Appendix-1.

Among the existing 20 bridges, 15 bridges were built through the assistance of the Japanese Government. In 1950, the Nonthaburi, Krungthon and Krungthep Bridges, which are built of steel truss girders and bascule structure at the navigation course, were funded by Japanese Special Funds. Thirteen bridges have been developed through the utilization of the Japanese Official Development Assistance (ODA) loan since its first loan to Thailand in 1971, which is composed of the construction of 12 bridges and the rehabilitation of Krungthep Bridge. As well known that the BMR traffic congestion in the 1980s was really a problem, the new developments brought about by the Japanese ODA have greatly contributed to ease the traffic congestion in the metropolis. However, the rapid growth in industrial and economic activities in BMR is still causing traffic bottlenecks and congestion in many places resulting in the hampered flow of goods and passengers. Accordingly, there are six new bridge building projects that are underway through the various authorities. These projects are: 1) one project in Nonthaburi (this specific project, the Project) by DRR, 2) four projects by BMA and 3) one project by EXAT.

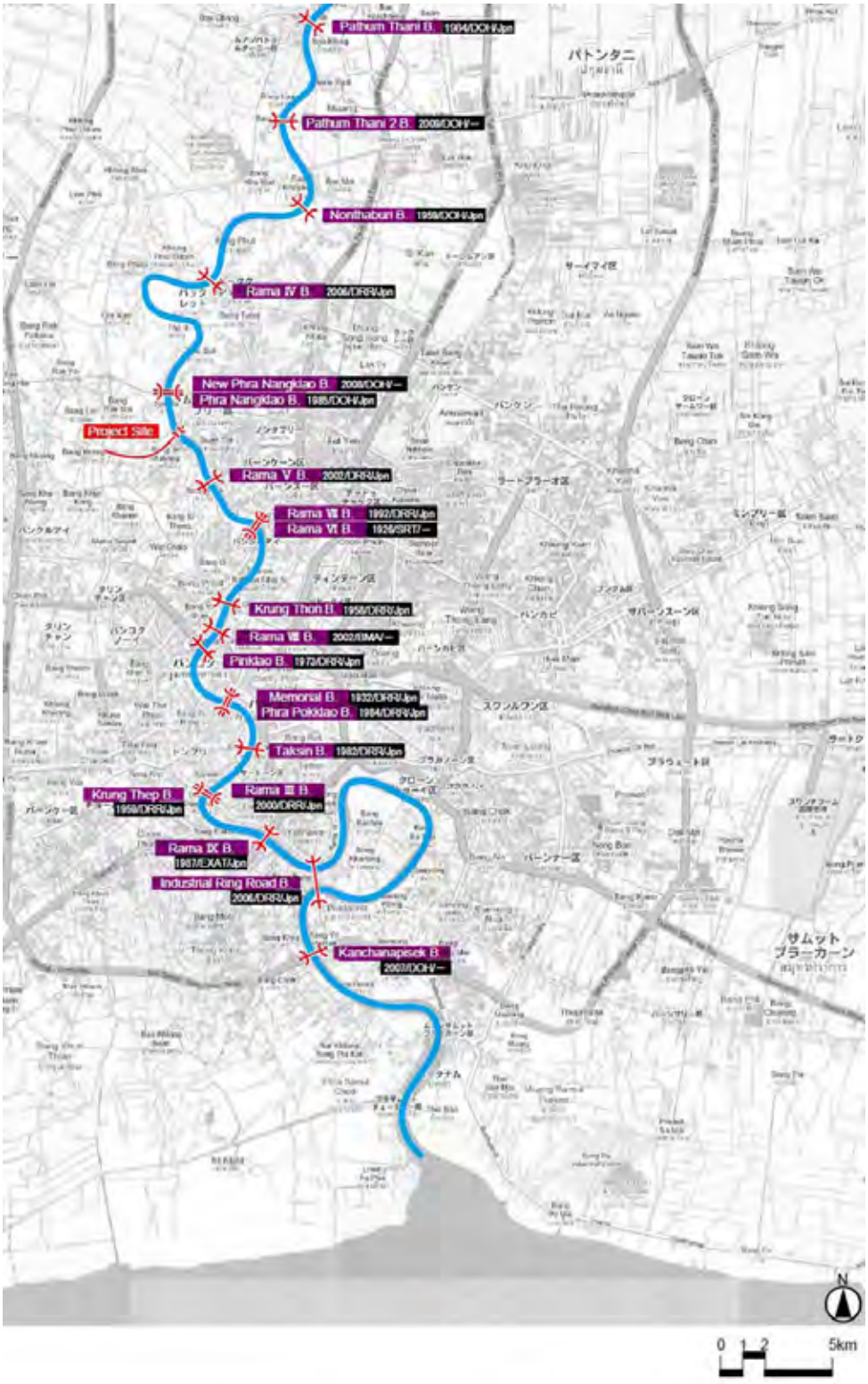



**Figure 1.1.2 Location Map of the Project and Existing Bridges**

### 1.1.3 THE CHAO PHRAYA RIVER CROSSING BRIDGE AT NONTHABURI 1 ROAD CONSTRUCTION PROJECT

There are five bridges in Nonthaburi Prefecture as of October 2009. These are the: 1) Nonthaburi Bridge in the border of Patum Thani Prefecture which was built through the Japanese Special Fund in 1959, 2) Rama IV Bridge, the so-called Pak Kret Bridge built in 2006 through the ODA 22nd loan, 3) New Phra Nangklao Bridge which was built in 2008), 4) Phra Nangklao Bridge which was built in 1985 through the ODA 8th loan, and 5) Rama V Bridge, the so-called Wat Nakorn-in in the border of BMA which was built in 2002 through the ODA 20th loan.

The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project (the Project) is proposed in Nonthaburi Prefecture, the second densely populated area in Thailand. The prefecture is located in the northern border of the BMA, the national capital and most densely populated area. The Project aims to provide a direct crossing between the east bank of the Chao Phraya, where traffic congestion is chronically severe during morning and evening peak hours, and the west bank, which has potential for economic growth.

The DRR of MOT is the executing organization to implement the project. At present, the feasibility study (F/S) and detailed design (D/D) have been completed by a Thailand national consultant team and draft tender documents for construction works are already prepared.

The Project is to construct a 4.3-km 6-lane road, including a 460-m long extradosed girder bridge, two interchanges (Nonthaburi 1 Road at the beginning point and Ratcha Phruk Road at the end point), and one flyover. The general concept and outline of the Project is shown in Figure 1.1.3.

As discussed above, the F/S and D/D were conducted by the Thailand national consultant team. Likewise, the Thailand Government intends to avail the services of Thai national consultants for the construction supervision of the Project

As the government of Thailand expects the Japanese ODA loan to extend assistance for the construction of the Project, the Japan International Cooperation Agency (JICA) decided to conduct the Preparatory Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project. In addition, the survey includes the identification of Japanese technical assistance in order to properly use the facilities completed in past ODA projects.

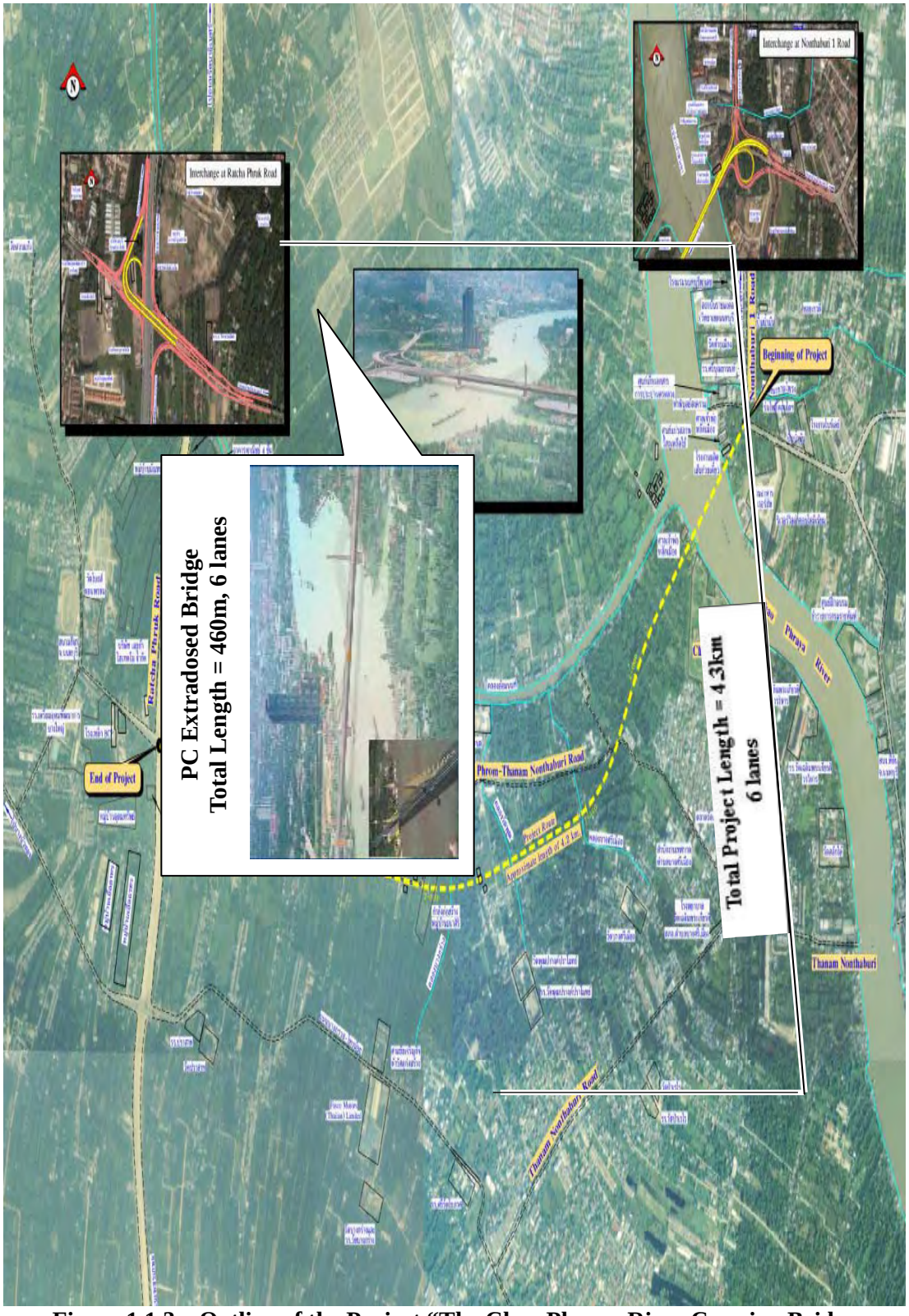



**Figure 1.1.3 Outline of the Project "The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project"**

## 1.2 PURPOSES OF THE SURVEY

The purposes of the preparatory survey for the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project are as follows:

1) To formulate the Project for the JICA appraisal, which includes the confirmation of the background and necessity of the Project, the appropriateness of the scope, implementation program and cost estimate prepared by DRR of the MOT of the government of Thailand. The Project includes the construction of an extradosed girder bridge of which technology has been developed in Japan. The survey includes the review of the detailed design and the identification of a possible technical assistance to the Project for assurance of the quality and safety during construction.
2) To confirm the development effects achieved from the existing 19 highway bridges over the Chao Phraya River, to conduct visual inspection on the existing 13 bridges completed by the ODA loan projects, and to identify the possible technical assistance to the maintenance organizations in-charge for the future effective use of the bridges.

## 1.3 SURVEY AREA

The survey area refers to the BMR. The technical survey is mainly conducted in and around the area of the Project which starts from the end of the planned interchange on Nonthaburi 1 Road to the end of the interchange on Ratcha Phruk Road, with a total length of 4.3 km.

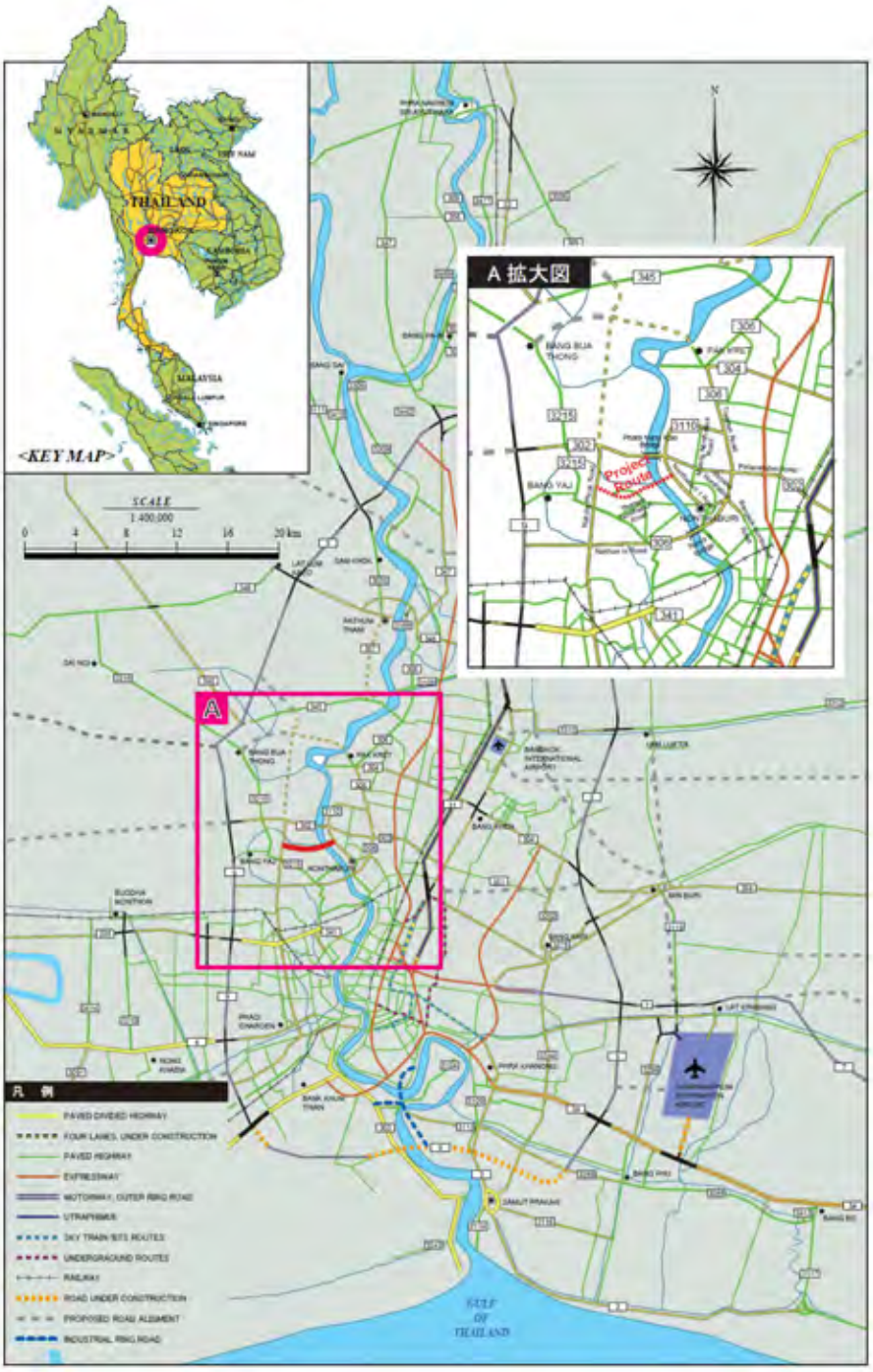



**Figure 1.3.1 Survey Area Map**

# CHAPTER 2 PROJECT BACKGROUND AND NECESSITY

## 2.1 PRESENT CONDITIONS AND ISSUES IN THE ROAD AND BRIDGE SECTOR IN BANGKOK METROPOLITAN AREA

### 2.1.1 GENERAL

In the Bangkok Metropolitan Area (BMA), urban traffic has become worse as the population and vehicles have significantly increased since the high-growth period in the late 1980's. Traffic congestion, especially on the arterial road between the downtown and residential areas which are expanding year by year, are getting serious.

Under such situation, the government of Thailand has taken several measures to ease the traffic congestion in the central BMA. The urban development policy aims to transfer from over concentration to multi-polarization. In the road and bridge sector, the development of intra urban highways and the separated four-lane development of major national roads have been undertaken since the Seventh Road Development Plan (1992-1996). Likewise, other road management authorities are developing and improving arterial roads to form the ring and radial road networks in and around the BMA.

### 2.1.2 CURRENT SITUATION OF ROADS AND BRIDGES

#### (1) Types of Roads and Administrators

As shown in Table 2.1.1, the roads in BMA are classified into six groups according to administrative management category.

**Table 2.1.1 Types of Roads and Administrators**

| Category | Administrators | Outline |
|---|---|---|
| National Highways | Department of Highways, Ministry of Transport | Major inter-city roads connecting the major cities nationwide. Two-lane is the standard and classified into the following three grades.<br>First: with one or two digit serial number connecting regions<br>Second: with three digit serial number running within the regions<br>Third: with four digit serial number connecting the regional center |
| Rural Roads | Department of Rural Roads (DRR), Ministry of Transport, Office of the National Security Council, Royal Irrigation Department, Ministry of Agriculture and Cooperatives, etc. | Roads outside of the local administration constructed by various public authorities<br>DRR constructs rural roads, industrial ring roads in Bangkok City, bridge over the Chao Phraya River, and Outer Bangkok Ring Road. |
| Municipal Roads | Bangkok Metropolitan Administration, Other Municipalities | Road networks in local administration. Major local governments such as Bangkok City construct and maintain the roads, however, others undertake maintenance only while the DRR constructs the roads. |
| Motorways | Department of Highways, and Ministry of Transport | High standard toll way. No.7 (Bangkok - Chonburi) and No. 9 (Outer Bangkok Ring Road: 146 km) are operated. |
| Expressways | Expressway Authority of Thailand | Intra-urban toll roads in Bangkok City<br>171 km operated, 4.7 km under construction |
| Concession Roads | Department of Highways, and Ministry of Transport | Private sector constructs under BOT (Build, Operate and Transfer) contract with the Department of Highways<br>Ex. Don Muang Toll Way |

Source: Economy Outlook of Thailand (2008/09), Japanese Chamber of Commerce, Bangkok

## (2) Road Development

BMA had expanded in the delta estuary of Chao Phraya River and water transportation via the canal is used as the major mode of transportation. Although the road network has been developed in the reclamation of canals since 1960, the capacity is still not enough.

The road network densities of BMA and BMR are 0.88 km/km$^2$ and 2.60 km/km$^2$, respectively. These are far less than the preferred density for urban planning of 3.5 km/km$^2$.

**Table 2.1.2 Road Length by Type in BMA, 2006 (km)**

| Types/ Administrators | Type | | | |
|---|---|---|---|---|
| | Intra-urban Roads | Primary Roads | Secondary Roads | Tertiary Roads |
| Expressway Authority of Thailand | 173.2 | | | |
| Department of Highways, Ministry of Transport | | 346.2 | | |
| Department of Rural Roads, Ministry of Transport | | | | 1,447.1 |
| Bangkok Metropolitan Administration | | 1,215.4 | 407.0 | 2,453.7 |
| Other Municipalities | | 240.0 | 80.0 | 480.0 |
| Total | 173.2 | 1,801.6 | 487.0 | 4,380.8 |
| Grand Total | 6,842.6 | | | |

Source: Strategic Urban Transport Policy Directions for Bangkok, June 2007, World Bank

As shown in Table 2.1.3, the road ratio of BMA in 2000 was 7.03% and has increased to 8.1%. It is still low compared with other cities such as Tokyo urban areas (15.4%), London (16.6%), Paris (20.0%) and Washington DC (25.0%). (Source: Roads of Tokyo, 2000)

**Table 2.1.3 Road Ratio in BMA**

| Year | Road Area (km$^2$) | Road Ratio (%) | Growth rate (%/year) |
|---|---|---|---|
| 1986 | 38.4 | 2.45 | 6.13 |
| 1995 | 85.7 | 5.46 | 4.45 |
| 2000 | 110.3 | 7.03 | |

Source: Comprehensive Plan of Bangkok Metropolis, BMA

## (3) Road Network

All road development works in the central area of BMA were not under the long-term plan and some were developed by each road administrator. Therefore, the network is neither rational nor systematic. Although major arterial roads have been developed with high capacity roads through ring road development, grade separation of intersections, and viaducts, these structures cause chronic traffic congestion especially on arterial roads. This is mainly due to the many tertiary roads directly connecting to such arterial roads forming fishbone roads without mutual linkage. Such road network makes many vehicles turn at intersections that cause uneconomical driving routes for vehicles.

West BMA is connected with the central area by 19 bridges on Chao Phraya River as an important area of BMA. However, only two bridges which are about five kilometers apart, Phra Nangklao Bridge and Rama 5 Bridge, exist in the Nonthaburi Prefecture. Traffic congestion is chronic in this area due to the increase of traffic volume from expanded

residential areas in the recent years. Therefore, the Project will be one of the important radial roads connecting the BMA and the residential areas to distribute the traffic load of the existing bridges.

### (4) Bridges on Chao Phraya River

There are 19 road bridges on Chao Phraya River, including the Memorial Bridge constructed in the 1930's, and 14 of which are from the assistance of the Japanese Government. As shown in Table 2.1.4, the long-span bridges, such as PC box girder bridges and cable-stayed bridges, with main span of more than 200 m, are also included.

**Table 2.1.4 Outlines of Bridges on Chao Phraya River**

| | Name | Administrator | Operation Year | Main Span Length (m) | Superstructure | Bridge Distance (km) |
|---|---|---|---|---|---|---|
| 1 | Patum Tani Bridge | DOH | 1984 | 73 | PC Box | 5.6 |
| 2 | Patum Tani 2Bridge | DOH | 2009 | 160 | PC Box | 4.7 |
| 3 | Nonthaburi Bridge | DOH | 1959 | 64 | Metal Truss | 6.6 |
| 4 | Rama IV Bridge | DRR | 2006 | 134 | PC Box | 10.3 (5.6) |
| 5 | New Phra Nangklao Bridge | DOH | 2008 | 229 | PC Box | 0 |
| 6 | Phra Nangklao Bridge | DOH | 1985 | 84 | PC Box | 2.1 |
| 7 | Rama V Bridge | DRR | 2002 | 130 | PC Box | 2.8 |
| 8 | Rama VII Bridge | DRR | 1992 | 120 | PC Box | 3.2 |
| 9 | Rama VI Bridge | SRT | 1926 | 120 | Metal Truss | 4.3 |
| 10 | Krung Thon Bridge | DRR | 1958 | 64 | Metal Truss | 0 |
| 11 | Rama VIII Bridge | BMA | 2002 | 300 | Cable-Stayed | 4.3 |
| 12 | Pinklao Bridge | DRR | 1973 | 114 | PC Box | 1.5 |
| 13 | Memorial Bridge | DRR | 1932 | 78 | Metal Truss | 1.1 |
| 14 | Phra Pokklao Bridge | DRR | 1984 | 100 | PC Box | 3.1 |
| 15 | Taksin Bridge | DRR | 1982 | 92 | PC Box | 0 |
| 16 | Rama III Bridge | DRR | 2000 | 226 | PC Box | 3.1 |
| 17 | Krung Thep Bridge | DRR | 1959 | 64 | Metal Truss | 0 |
| 18 | Rama IX Bridge | EXAT | 1987 | 450 | Cable | 4.1 |
| 19-1 | Industrial Ring Road Bridge (North) | DRR | 2006 | 326 | Cable | 2.7 |
| 19-2 | Industrial Ring Road Bridge (South) | | 2006 | 398 | Cable | 16.8 (1.2) |
| | Kanchanapisek Bridge | DOH | 2007 | 500 | Cable | 3.3 |

Note) Bridge distance measured along river center. However, bridge distance shown in ( ) is linear distance due to S-shaped river.

As shown in Figure 2.1.1, some bridges are on the arterial roads from the central BMA and some are on the outer ring roads. The average interval of these bridges is two to three kilometers near the center and five to eight kilometers in the north.

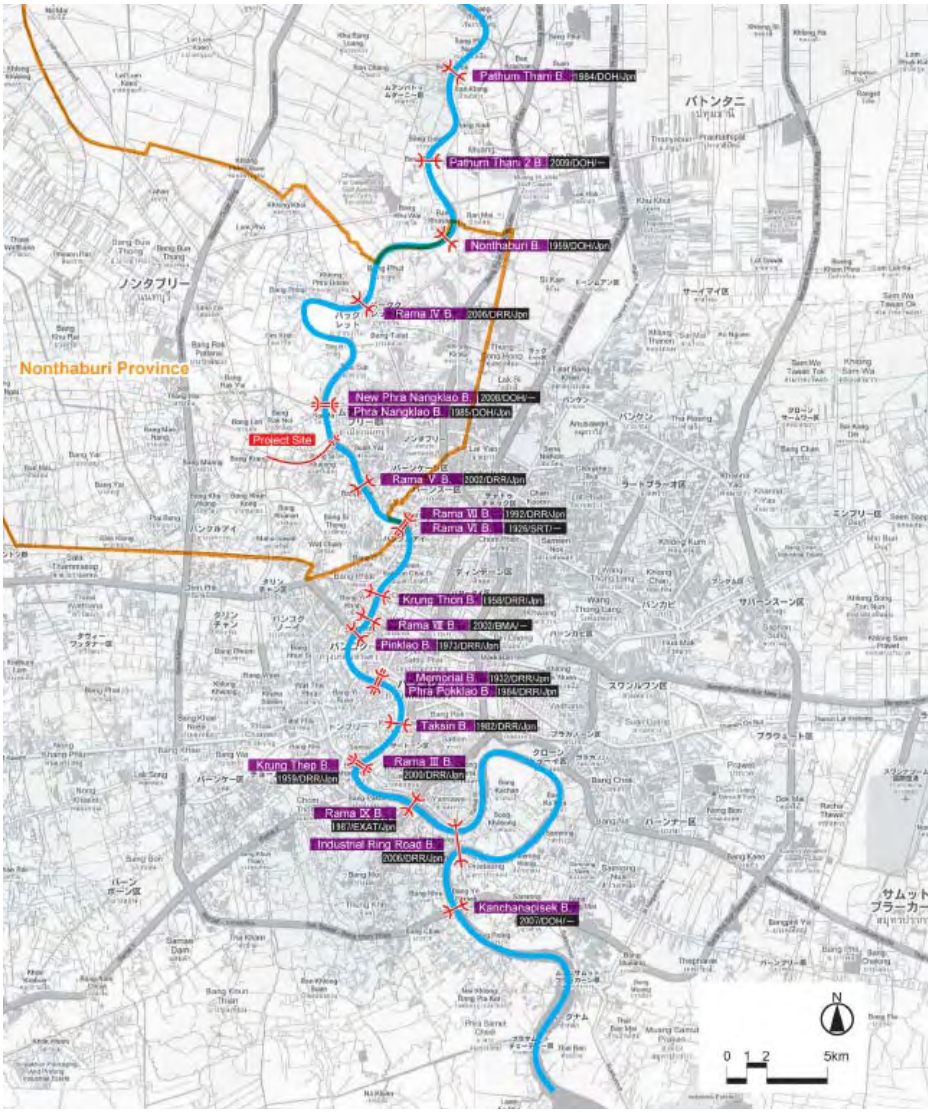



**Figure 2.1.1 Location of Bridges on Chao Phraya River**

## (5) Road Development Plan

The Ninth Road Development Plan (2002- 2006) planned by the Department of Roads, Ministry of Transport is underway as a rolling plan for arterial road network development. Major development targets in the plan are the i) east coast road network development, ii) west coast road network development and widening to four-lane in southern regions, iii) development of the southern part of the Outer Bangkok Ring Road, iv) development of major inter-city roads in the northern regions, and v) development of major inter-city roads in the northeastern regions. On-going inter-city road development projects are listed in Table 2.1.5. The projects located in BMR are Bang Yai-Nakhon Pathom, Nakhon Pathom-Samut Songkram, and Nakhon Pathom-Kanchanaburi.

Introduction of Public and Private Partnership (PPP) scheme for the implementation of Bang Pa In-Saraburi, Saraburi-Nakhon Rachasima, Pattaya-Map Ta Phut, Saraburi-Nakhon Rachasima, and Nakhon Pathom-Kanchanaburi are under discussion.

**Table 2.1.5 List of Inter-City Road Projects**

| ID | Sections | Length (km) | Project Cost (mil. THB) | Project Period |
|---|---|---|---|---|
| 81 | Bang Yai – Nakhon Pathom | 51 | 12,200 | 2006-2008 |
| 6 | Saraburi – Nakhon Rachasima | 156 | 21,800 | 2007-2009 |
| 7 | Pattaya – Map Ta Phut | 38 | 4,100 | 2007-2009 |
| 8 | Nakhon Pathom – Samut Songkram | 62 | 16,000 | 2008-2010 |
| 6 | Bang Pa In – Saraburi | 43 | 3,800 | 2008-2010 |
| 8 | Samut Songkram – Cha Am | 72 | 18,000 | 2009-2011 |
| 81 | Nakhon Pathom – Kanchanaburi | 47 | 6,410 | 2009-2011 |
| 5 | Bang Pa In – Ang Thong | 60 | 12,000 | 2009-2011 |
| 5 | Lampang – Lamphun –Chang Mai | 99 | 27,500 | 2009-2011 |
| 91 | Saraburi – Bang Pakopng | 150 | 36,500 | 2009-2011 |
| Total | | 778 | 158,310 | 2009-2011 |

Source: Department of Highways, MOT

As for the road development plan in BMR, several ring road and east-west corridor development projects are underway as major projects in the area as shown in Figure 2.3.2 and Appendix 3. Specific major projects are the Outer Bangkok Ring Road Development, Chaeng Watthana Road Improvement, Ram Intra Road Improvement, Ratana Thibet Road Improvement, Ngam Wongwan Road Improvement, and Prasoet Manunkit Road Improvement.

## 2.1.3 CURRENT ROAD TRAFFIC SITUATION

### (1) Vehicle Registration

Registered cars in BMA have increased by 3.5% per year since 2000 and 5.7 million in 2007, which is almost the same as the population of BMA.

**Table 2.1.6 Number of Registered Cars in BMA from 2000 to 2007 (Thousand)**

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Number | 4,495 | 4,464 | 5,399 | 5,481 | 4,288 | 6,253 | 5,557 | 5,715 |

Source: Thailand in Figures 2008/2009 Bangkok, Alfa Research

### (2) Traffic Volume

As shown in Table 2.1.6, the total traffic volume of BMA is increasing as the number of cars increase. The number of passenger cars increased significantly as shown in Table 2.1.7 which indicates the growing economic activities in the area.

**Table 2.1.7 Total Traffic Volume of Cars in BMA from 1996 to 2004 (million・km)**

| Type | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|
| Passenger cars | 10,250 | 10,914 | 10,356 | 11,100 | 14,451 | 14,043 | 14,520 | 17,823 | 14,045 |
| Trucks | 7,582 | 7,961 | 6,391 | 7,002 | 7,525 | 7,740 | 6,514 | 8,275 | 8,927 |
| Total | 17,832 | 18,875 | 16,747 | 18,102 | 21,976 | 21,783 | 21,034 | 26,098 | 22,972 |

Source: Department of Roads, Ministry of Transport

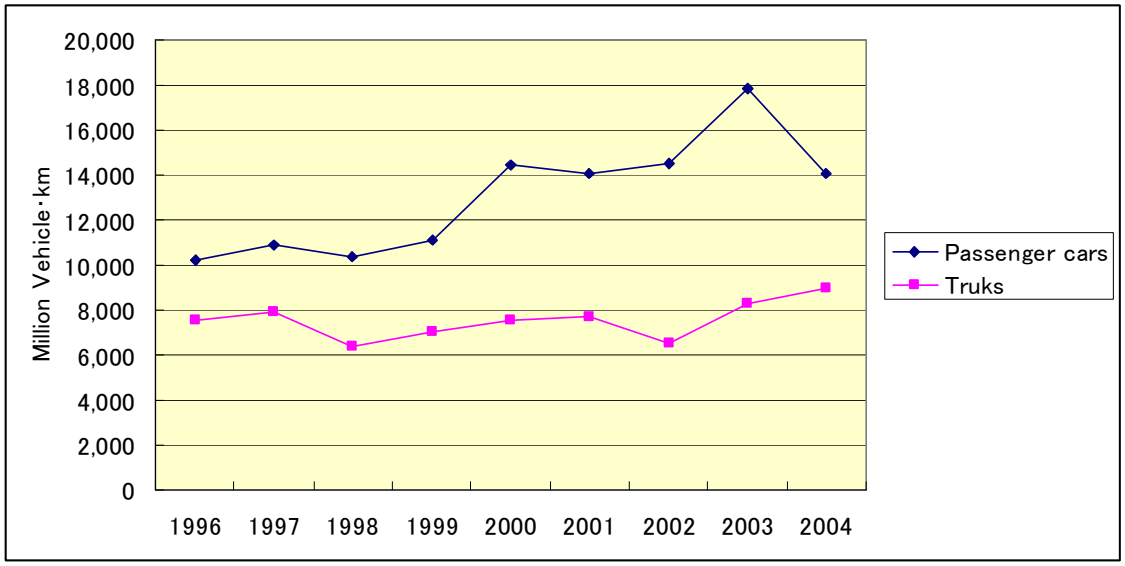



**Figure 2.1.2 Total Traffic Volume of Cars in BMA from 1996 to 2004**

Table 2.1.8 shows the traffic volume during peak hours in the morning, from 7:00 to 8:00, of each bridge on Chao Phraya River in 2005 and 2008. The volumes did not show significant changes and vary among the bridges. One possible reason why traffic volume did not increase from 2005 to 2008 is the economic crisis in BMA in 2008.

**Table 2.1.8 Traffic Volume of Bridges on Chao Phraya River in 2005 and 2008**

| Name of Bridges | Traffic Volume (Morning Peak Hour: PCU) | |
|---|---|---|
| | Tue., 14 June 2005 | Tue, 15 July 2008 |
| Patum Tani Bridge | - | 4,381 |
| Nonthaburi Bridge | - | 2,752 |
| Rama IV Bridge | - | 4,713 |
| Phra Nangklao Bridge | 5,160 | 4,170 |
| Rama V Bridge | 4,964 | 7,557 |
| Rama VII Bridge | 3,502 | 2,833 |
| Krung Thon Bridge | 2,966 | 1,733 |
| Rama VIII Bridge | 4,198 | 3,122 |
| Pinklao Bridge | 6,345 | 8,214 |
| Memorial Bridge | 3,240 | 2,611 |
| Phra Pokklao Bridge | 6,140 | 7,562 |
| Taksin Bridge | 4,864 | 4,849 |
| Rama III Bridge | 3,691 | 3,762 |
| Krung Thep Bridge | 4,247 | 1,886 |

Source: F/S (2005 data), TDML Study, OTP (2008 data)

### 2.1.4 ISSUES OF ROAD AND BRIDGE SECTOR

#### (1) Systematic Road Development Harmonizing with Land Use Plan

In the BMA road development, radial roads were prioritized due to rapid expansion of the urban area. However, these radial roads have not been connected and it has caused serious traffic congestion. A new ring road with appropriate length and distance is necessary to connect the radial roads practically and efficiently to ease the heavy traffic load.

Existing roads were not systematically developed to balance the arterial roads, secondary roads, and tertiary roads because land use policy was not clear and there are many areas where roads are ending at canals. Therefore, it is necessary to review the function of each road in the BMA network considering the land use plan and road development with the appropriate standards for each function.

#### (2) Road Development Supporting the Expansion of the Urban Area

The development of BMA started from the east of Chao Phraya River to the eastern areas, and then expanded to western area over the river. The existing bridges over the river contributed to the development of the western areas especially in Thonburi area where bridge distance is two to three kilometers, and this has been developed where urbanization is expanding to northern areas. On the other hand, in upper Chao Phraya areas, where the bridge distance is five to eight kilometers, the infrastructure for urbanization has not yet been developed enough. Therefore, it is necessary to construct bridges with appropriate spans for such areas with high potential for urbanization.

#### (3) Upgrading of Traffic Management

Traffic management measures on arterial roads in BMR are implemented not only through traffic regulations such as one-way restriction and reversible lanes, but also by installation of traffic signals and information boards. However, the implementation of these measures has not been alleviated to drastically decongest the traffic situation in BMR. Manual traffic regulation at the major intersections by traffic police is also an ad hoc countermeasure to mitigate but only tends to worsen the congested areas.

Therefore, the examination of comprehensive traffic management measure is needed with the consideration of the introduction of advanced and effective countermeasures such as area-controlled traffic signal system and Traffic Display Monitoring (TDM). Moreover, prompt organizational coordination among the traffic police and other road traffic authorities such as BMA, and institutional set up is essential.

## 2.2 TRANSPORTATION POLICY OF THE ROAD AND BRIDGE SECTOR IN BANGKOK METROPOLITAN AREA

### 2.2.1 TRANSPORTATION POLICY OF THE ROAD AND BRIDGE SECTOR

The development of the trunk road network in Bangkok Metropolitan Area is proceeding according to the master plan approved by the Commission of Management of Land Traffic (CMLT) on February 23, 2004, known as the CMLT's Resolution No.1/2547. Concrete planning is prepared by Bangkok City (BMA) and the Office of Transportation Planning (OTP) under the Ministry of Transport (MOT). The implementation of the plan is delegated to related organizations such as Bangkok City (BMA), concerned provinces, DOH and DRR and ETA of MOT.

In the master plan, 75 projects are listed as urgent to be developed and the priority order is

decided by the designated agencies. The present status, as of October 2009,, of these projects is shown in Figure 2.3.2. Some of them have been completed, while some were canceled.

The traffic congestion in Bangkok is serious, disturbing the transportation flow in the city. To alleviate this congestion, the first, second, and further, the third, ring roads are planned, outside and development is proceeding. To link to these roads, the development of the east-west and north-south roads, and mass transportation system such as the Purple Line with feeder roads, the improvements of intersections, and others are under implementation to strengthen the total transportation network. The accessibility from the Project road to the Purple Line is shown in Figure 2.2.1.

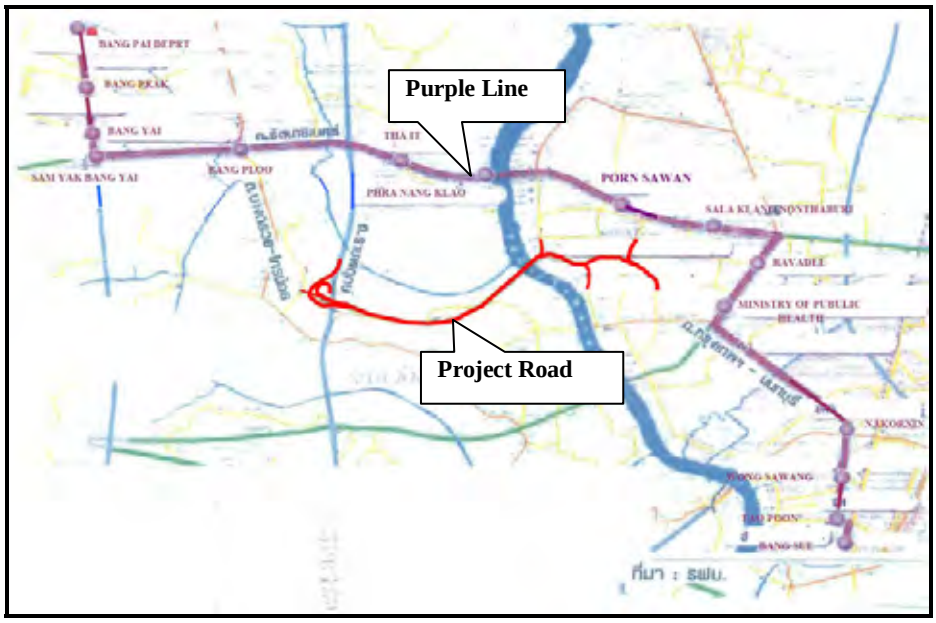



**Figure 2.2.1 Location Map of the Porn Sawan Station and the Project Route**

DRR considers that this project will be one of the transportation network development projects connecting the areas on both sides of the river. This will not only be an effective transportation route alternative but also a potential enhancement aspect in the economy, quality of life and environment for Nonthaburi people. Furthermore, the development of the transportation network in the upper area of Bangkok Metropolitan and Nonthaburi Province in accordance with the strategic plan to serve the community expansion in Bangkok Metropolitan and vicinity areas will be better fulfilled through the implementation of this project.

## 2.2.2 CONFORMITY WITH ROAD AND BRIDGE SECTOR DEVELOPMENT PLAN

### 1) The Commission of Management of Land Traffic's (CMLT) Resolution No.1/2547

The CMLT has approved the total 75 priority projects to alleviate traffic problems in Bangkok and vicinity areas in 2004 as per CMLT's Resolution No.1/2547. This Project is one of the approved top priority projects, which was assigned to DRR for implementation.

### 2) The Tenth National Economic and Social Development Plan (2007~2011)

The 10th Plan, which came into force on October 19, 2006, has emphasized the development of infrastructure and logistics system, both quantitative and qualitative, as one of the major factors to support the reform of the country's economic structure to increase productivity and competitiveness. The strategies include the development of the logistics network by improving every mode of transport and feeder routes, promotion of energy-efficient transport

to reduce production costs, and development of efficient transportation network in Bangkok Metropolitan and vicinity areas.

Moreover, the high-level public private cooperation committee (PPP committee) was set up in June, 2008 to secure the financial resources for the above development chaired by the Prime Minister. Three projects are approved to be implemented with PPP finance by the committee. The road development project between Bang Pa-in and Nakom Ratchasima of 199-km length is one of the three projects.

### 3) Ministry of Transport's Strategic Plan (2005~2009)

Approved by NESDB on April 17, 2006, the Ministry of Transport's Strategic Plan aims at developing an integrated transport system to support the country's economic growth and serve as a logistic hub for the Indochina regions. For Bangkok and vicinity areas, the improvement of the road network to alleviate traffic problems and to increase mobility, and the development of feeder routes for mass transit network are considered as major strategic issues to be addressed by the relevant departments in the Ministry.

### 4) Department of Rural Road's Road Network in the Greater Bangkok and Vicinity

This project will add to the existing road network in Bangkok and the five neighboring provinces under the responsibility of DRR, which covers the 11 major bridges crossing the Chao Phraya River and 1,666,926 km of road, as of October 2009. The project will also provide a linking network between two recently completed projects financed by Japanese ODA loans.

Three out of seven projects assigned by CMLT No. 1/2547 have not been completed. This Project is one of the uncompleted ones and DRR is processing it as the highest priority project. This road connects to Nonthaburi 1 Road, then to the Purple Line as a feeder road, and further, connecting to Red Line. In the west, the road connects to Ratcha Phruk Road and further, to the outer ring road. In the north, it is planned to connect to the north-south line, east-west line (Ratcha Phruk~Kanchana Phisek Connecting Road). There is no concrete development plan yet to extend the road in the west and east. However, in the north, DRR is preparing the east and west line as shown in Figure 2.2.2. In the phase 1 stage, the D/D is almost finished and DRR is preparing for funding, while the phase 2 line is now under planning.


**Figure 2.2.2 Road Extension Plan by DRR**

### 2.2.3 REVIEW OF OTHER DONOR'S ACTIVITIES IN THE TRANSPORTATION SECTOR

The main donors in Bangkok are the World Bank (WB) and Asian Development Bank (ADB). Both banks have been cooperating together to support the Thai Government, but for the past ten years, there was no project financing. It was reported that the reason for this is that the Thai Government did not express their need for project loans to the financing institution. For reference purposes, the International Bank for Reconstruction and Development (IBRD) and ADB 2nd Four-lane Highway Extension Project which was approved by the Thailand Parliament on November 10, 2009, is shown in Figure 2.2.3.

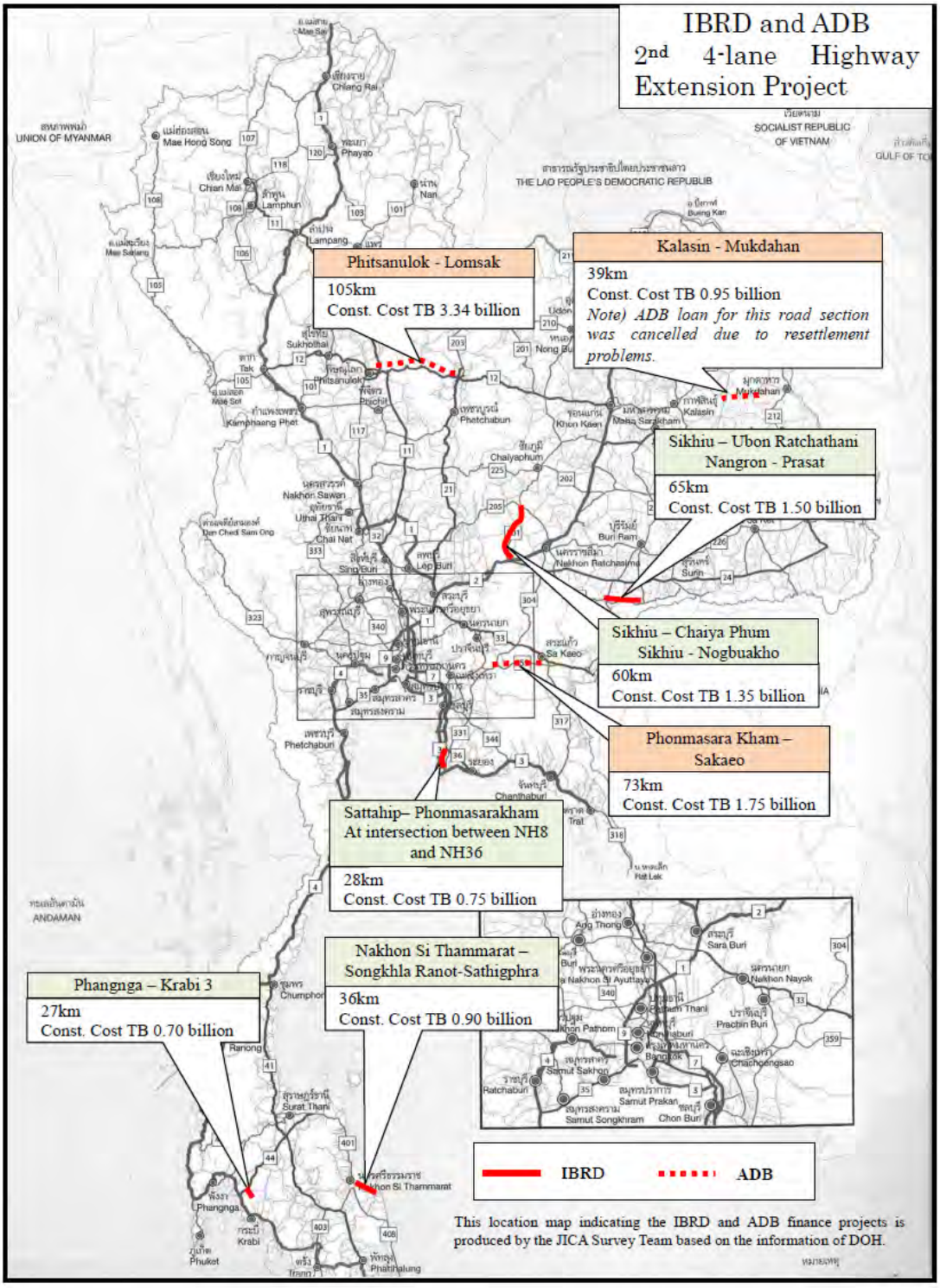



**Figure 2.2.3 New Highway Projects of DOH to be Financed by IBRD and ADB**

### 1) WB

The main aid by WB has been related to project preparation, assessment and feasibility studies. In collaboration with ADB, the French Agency and JICA, WB organized the Urban Transport Development Partnership (UTDP) and studied the traffic problems in Bangkok. The evaluation and recommendations are summarized in the report published in 2007. It was presented that the importance of the highway development is recognized and likewise, that of the improvement of the traffic management system is emphasized. Without the improvement of the total network system of modal mix with mass transit, bus network with common ticket, feeder roads and pedestrian roads, expensive mass transportation cannot produce the expected results to solve the traffic congestion.

WB has been helping DOH through its Highway Management Project. The objective of this project is to enhance the efficiency, productive use, and management of the road network. It especially, supports the commercialization of the road sector, including the PPP and BOT systems, strengthens the operations of the DOH, helps to preserve road assets, and improves the competition and transparency in the award of contracts.

WB will evaluate the possibility of financing of future road sector projects if and when the Thai Government will raise the need.

Table 2.2.1 shows the summary of WB under IBRD assistance projects to DOH in the past 20 years.

**Table 2.2.1 DOH Highway Projects Assisted by WB -IBRD in the Past 20 Years**

| Loan No. | Loan Type | Project Outline | Amount (US$) | Signing Date | Effective Date | End of Contract |
|---|---|---|---|---|---|---|
| 2894-TH | SECTOR | NA | 50,000,000 | 17-Feb-88 | 15-Jun-88 | 31-Dec-92 |
| 3008-TH | 3 TOLLS | **Intercity Tollway** Saraburi-Nakhonratchasima(43.100KM.),Thonburi-Pak tho section2A(8+100KM.),Thonburi-Pak tho section2B(7.4KMS.),Bangpain-Nakhonsawan(17.259KMS.),Bangpain-Nakhonsawan(33.00KMS.) | 87,000,000 | 1-Mar-89 | 20-Jun-89 | 31-Mar-94 |
| 3220-TH | SECTOR | NA | 50,000,000 | 13-Jul-90 | 11-Oct-90 | 31-Dec-94 |
| 3446-TH | SECTOR | NA | 164,466,000 | 27-Mar-92 | 31 JU 1992 | 30-Jun-98 |
| 3968-TH | 4 LANES | **National Highway** Lampang-Lamphun(section2),Ubonratchathani-Mukdahan(20KM.)Khonkaen-A.Namphong(23+912.734KM),A.Banna-Nakhonnayok(14+993.929KM.),Pattaya-Rayong(58+625.380KM.) | 76,100,000 | 9-Feb-96 | 17-May-96 | 31-Dec-01 |
| 4721-TH | 4 LANES | **National Highway** A.Sichon-A.Thasala(20.00KMS),A.NikhomKhamSroi-A.LoengNokTha(22+600KMS.),B.NongBuaKhok-ChaiyaPhum(42.573KM.),Overpass at Route22 and UdonThani Bypass,Overpass at Km.8 Ramindra,RailwayOverpass at BanPong | 84,299,000 | 16-Dec-03 | 15-May-04 | 30-Jun-10 |
| TOTAL | | | 511,865,000 | | | |

### 2) ADB

ADB opened a Bangkok office five years ago and has been helping in the field of transportation, capital market, and energy sectors. At present, ADB is now preparing to finance the development of the highway improvement in response to the need of the Thai Government. This project is called as the Greater Mekong Sub-region (GMS) Highway Expansion Project and aims to improve part of the GMS highway by upgrading the narrow road to a four-lane highway, two sections in the east-west corridor (Phitsanulok – Lom Sak (105 km), Nakrai – Akamcha-e (39 km), and Phanom Sarakham – Sakaew (73km)) and one

section in the south corridor, for a total of 217 km. In collaboration with DOH, the preparation was started in 2008 and will be implemented after the approval of the Thai Parliament.

About the future possibility of financing a road sector project, there is no concrete plan yet since there is no request for project financing from the Thai Government.

Table 2.2.2 shows the summary of ADB-assisted projects to DOH in the past 20 years.

**Table 2.2.2 DOH Highway Projects Assisted by ADB in the Past 20 Years**

| Loan No. | Loan Type | Project Outline | Amount (US$) | Signing Date | Effective Date | End of Contract |
|---|---|---|---|---|---|---|
| 943-THA | SECTOR | NA | 110,000,000 | 17-Aug-89 | 28-Dec-89 | 31-Dec-94 |
| 1027-THA | SECTOR | NA | 34,343,843 | 27-Sep-91 | 8-Jan-91 | 28-Feb-97 |
| 1098-THA | 3 TOLLS | **Intercity Tollway** Kaengkhoi Interchange,Chainat Interchange,Sinburi Interchange,Outer ring road Interchange,Inburi Interchange,Angthong Interchange,A. Nong Bua-A.Tha Tako | 54,100,000 | 27-Sep-91 | 26-Dec-91 | 31-Aug-97 |
| 1176-THA | SECTOR | NA | 70,829,927 | 16-Sep-92 | 21-Mar-93 | 30-Jun-98 |
| 1306-THA | 4 LANES | **National Highway** A.Mae Chan-A. Mae sai(31.545KM.)A.Nago(10.0KM.),A.Lang suan-A.Chaiya(23.726KM.),A.Lang suan-A.Chaiya(25.00KM.),Lampang-Phayao(22.600KM.),Phayao-Jct.to A.Mae suai Section1(35.800KM.),Phayao-Jct.to A.Mae suai Section2(34.200KM.),Kamphaengphet-B.wang chao(33.327KM),B.wang chao-Tak(33.695KM.),22.00KM.,A.Namphong-Udonthani section1(40.643KM.),A.Namphong-Udonthani section2(42.837KM.) | 134,251,779 | 26-Aug-94 | 6-Dec-94 | 31-Dec-03 |
| 1391-THA | 4 LANES | **National Highway** Changmai-Tak, Nongkai-Udonthani, Pattani-Sungaikolog | 131,800,000 | 29-Sep-95 | 17-Jan-96 | 30-Jun-04 |
| TOTAL | | | 535,325,549 | | | |

In addition to the assistance to DOH, ADB has assisted DRR in 2000 to 2002, with its Bangkok Urban Transport Project (Loan 1195-THA), which aimed at constructing the Tonburi Road Extension, the so-called part of Rajapreuk Road, amounting to US$ 29.4 million of ADB loan out of the total project cost of US$ 131.7 million.

### 2.2.4 COMPATIBILITY TO REGIONAL PLANNING

#### (1) Regional Planning Policy on the National Level

The Thai Government formulates and updates the National Economic and Social Development Plan (NESDP). The first NESDP (1961 - 66) was formulated in 1961, and was updated every five years until the present plan, which is the 10th Plan.

The 1st NESDP was focused on the formation of the industrial base for the nation, and promoted the national and regional arterial road network, and called for the infrastructure development for the economic development. But one consequence of this was the high influx of population in BMR, together with aggravating urban problems such as environmental pollution and traffic jam. The 5th NESDP introduced a decentralization policy, calling for new growth centers such as the Eastern Seaboard developments.

The economic order after Plaza Accord on the exchange rates brought a rapid economic expansion to Thailand since 1975. Consequently, the accumulation of the economic activities in the metropolitan area further accelerated, and the regional gap in income and production expanded. The 8th NESDP (1997 - 2001) called for a new policy to promote

regional cities to lessen the one-polar structure of the national economy. In 1999, the Decentralization Act was passed, which promoted the budgetary basis for regional development.

In 2000, the Thai economy recovered from the Asian currency crisis and adopted the sustainable urban and rural development in the 9th NESDP (2002 – 2006), and called for the affluent urban and rural communities as well as the participatory PPP as the implementation instruments. The present is the 10th NESDP (2007 – 2011), continued to adopt to promote decentralization with the target of sustainable society and comfortable living environment.

### (2) Urban Planning for BMA

Urban planning in Thailand is practiced based on the Town Planning Act in 1975, and it includes the comprehensive plan for the entire administrative entity, and a specific plan for a selected area as necessary, although there has not yet been any specific plan formulated in Thailand. The comprehensive plan for BMA was modified in 2003, and this modified plan is called the 2nd modification plan and was approved and took effect in 2006, which is the present plan.

There are five pillars in the vision of the present comprehensive plan, as follows:

① Metropolis predominating in art and culture, with a national uniqueness

② Metropolis with quality of life of the people considering environmental conservation and natural resources

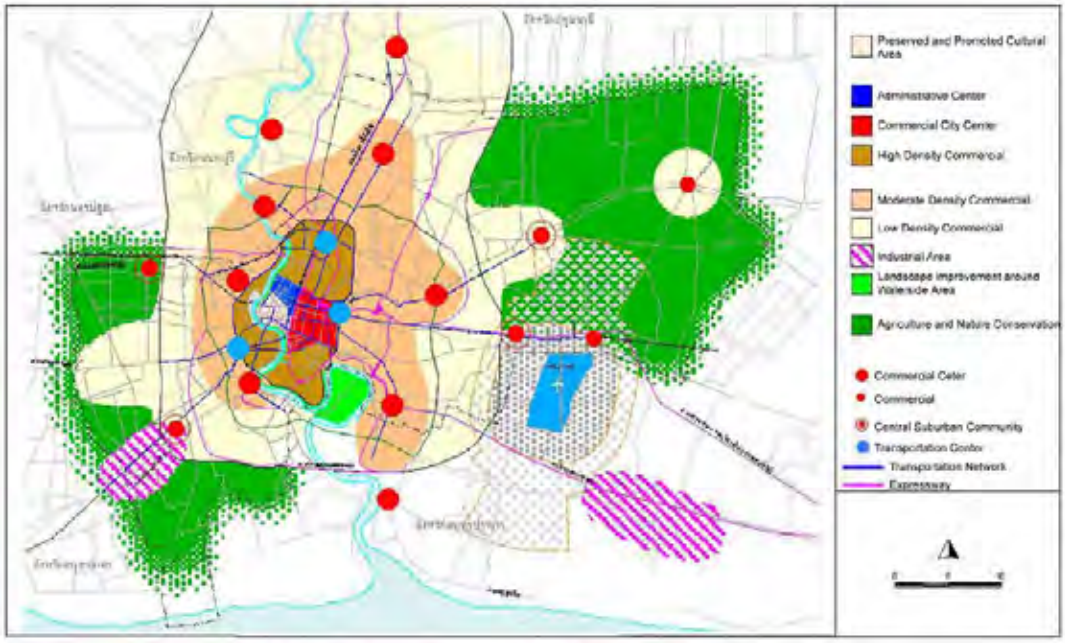
③ Metropolis that is the center of economic activities and technology of the nation and Southeast Asia

④ Metropolis that is the center of administration, institution and international organizations

⑤ Metropolis that is flexible and convenient with a communication and transport network

Further details on the present plan are discussed in Sub-section 2.5.2.

In relation to the third pillar of the vision, BMA promotes the formation of sub-centers around Bangkok as commercial centers supplemental to the Bangkok City Center. As can be seen in the figure below, there are two sub-center locations in the north of Bangkok, namely the Nonthaburi and Pak Kret.




Source; Bangkok Metropolitan Administration

**Figure 2.2.4 Future Image of Bangkok Metropolitan**

### (3) Urban Planning for Nonthaburi Province

In this sub-section, the present Comprehensive Plan for Nonthaburi Province is summarized and further details are described in sub-section, 2.5.2.

In Nonthaburi District which is included in the survey area, most of the urban areas are densely populated. In BMR, the Nonthaburi Province is located about 10 to 15 km from the Bangkok urban center, hence the population of Nonthaburi is fast growing and the urbanization is expanding rapidly. However, in the east bank areas of Chao Phraya River, urbanization has been much progressive and there are no more potential areas for future urban developments. This condition on the east bank is accelerating the present movement of urbanization on the west bank, especially the areas near the bridge crossings.

The comprehensive plan was modified in 2005 based on the actual circumstances of the urbanization on the west bank, and correspondingly, the land use zoning plan was also modified.

As discussed above, the urban area of the Nonthaburi Province has expanded and shifted from the east bank to the west bank of the river, as a result of the development and the construction of new roads and bridges in the west bank areas in recent years.

### (4) Possible Effects of the Project Bridge on Urbanization

As discussed in Item (1) above, historical changes in the urbanization in Bangkok indicates that one new road with a bridge across the Chao Praya is not quite enough to urbanize the area on the opposite side of the river, but rather create a “tongue” like road-side urbanization only. However, after a few bridges at intervals of two to three km are constructed, this would tend to convert the opposite side of the river into continuous urbanization.

The proposed Project bridge is the third bridge in the area, after Phra Nongklao Bridge on the north, and Rama V Bridge on the south. The existing two bridges are about five km apart, and the conditions for the continuous urbanization almost apply. The road network improvement in the Nonthaburi area may lead to significant urbanization considering that the

Nonthaburi area is located at about 10 to 15 km radius from the Bangkok City center. It is projected that the opposite side of Nonthaburi along the Project Bridge will face continuous urbanization in the near future as a result of the bridge construction.

#### (5) Conformity of the Project Bridge and Regional Planning

As discussed above, the Project bridge is located in the north of Bangkok, and Nonthaburi is considered as a candidate for the sub-center of Bangkok area The new bridge will give positive impact to the existing agricultural lands on the west side of the Chao Phraya River that will contribute to the continuous urbanization. The conformity of the Project with regards to the urban and regional planning in the national, capital, and provincial levels is considered to be high, as shown in Table 2.2.3 below.

**Table 2.2.3 Conformity of the Project Bridge to Regional Planning**

| Regional Unit | Relevant Plan | Conformity | Remarks |
|---|---|---|---|
| National Level | NESDP ($8^{th}$, $9^{th}$ and $10^{th}$) | High | • Countermeasure for excessive accumulation to Bangkok<br>• Promoting development of regional cities |
| Bangkok Metropolitan Region | BMA Comprehensive Plan | High | • High population growth in Nonthaburi to accommodate the increasing population in the BMR<br>• Development of Sub-Centers (Nonthaburi and Pak Kredt Cities) |
| Nonthaburi Province | Nonthaburi Province Comprehensive Plan | High | • Promotion of road network improvement and new urbanization in the west bank of Chao Praya River |

Source: JICA Study Team

### 2.2.5 NECESSITY OF THE PROJECT

DRR considers this project as necessary for the following reasons:

1) The traffic congestion of the related area is serious and this project contributes to solve the problem. The regional traffic network will be improved between the east side and west side of Chao Phraya River. This contributes to the improvement of the transportation network of Bangkok Metropolitan Area and its economic development.
2) The Thai Government recognized this project as one of the urgent project in the master plan (No.1/2547) and entitled DRR as the execution agency. DRR placed the first priority on this project among their road projects.
3) PWD under MOI conducted the Feasibility Study for Chao Phraya River Bridge Crossing in Greater Bangkok Area (FSBC) on April 1995, and the FS proposed 29 bridge projects. This Project is one of the 29 proposed projects and the DRR conducted FS for this project and the high value of the economic internal rate of return (EIRR) was confirmed.

## 2.3 REVIEW OF TRAFFIC DEMAND FORECAST

### 2.3.1 OVERVIEW OF PREVIOUS FEASIBILITY STUDY

#### (1) General

The previous feasibility study on the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project was carried out by the DRR, and MOT as one of components of the detailed design and land acquisition survey and the final report was submitted in October

2005. After submission of the final report, DRR prepared a series of additional documents to revise/update the final report from February 2009.

The traffic demand forecast for the Project in the above revised feasibility study presented the results of the forecast for the target years 2011, 2016, 2021, and 2026. The results of reviewing the demand forecast are summarized below.

## (2) Pre-Conditions of Traffic Demand Forecast of the FS

### 1) Development Plan(s) and Socio-Economic Framework

In the original version of the previous F/S, the future socio-economic data was taken from the BMTA Route Planning and Scheduling Project (BRPS) Traffic Model which was developed by the Office of Transport and Traffic Policy and Planning (OTP) in 2004.

On the other hand, the future socio-economic data for the revised F/S was based on another data source by the Transport Data and Model Center V (TDMC) which presently revised/updated to Transport Data and Model Integrated with Multimodal Transport and Logistics (TDML) developed by OTP in 2007.

There were no detailed explanations in the F/S report and in the technical report of TDML about the future development plans. According to the information from OTP and local consultants who have carried out the demand forecast, the development plans, including the future land use plan adopted for the bases of future socio-economic framework, were as follows:

(a) National Development Plan: The 9th National Economic and Social Development Plan (2002-2006)

(b) Regional/ Urban Development Plan/Socio-economic Data by Traffic Zone: available from the Division of Transport and Traffic Information Center (in OTP)

The following four kinds of future socio-economic data were projected for the traffic demand forecast:

- Population
- Average Income per Household
- Number of Employments
- Number of Students

The JICA survey team reviewed the socio-economic framework based on future socio-economic data by traffic zone obtained from the Division of Transport & Traffic Information Center (in OTP), the socio-economic data as shown in the F/S, and transitional statistical data of the above socio-economic indexes.

On the other hand, land use plans of the BMR as well as Nonthaburi Province were provided by the Ministry of Interior (MOI) as shown below:

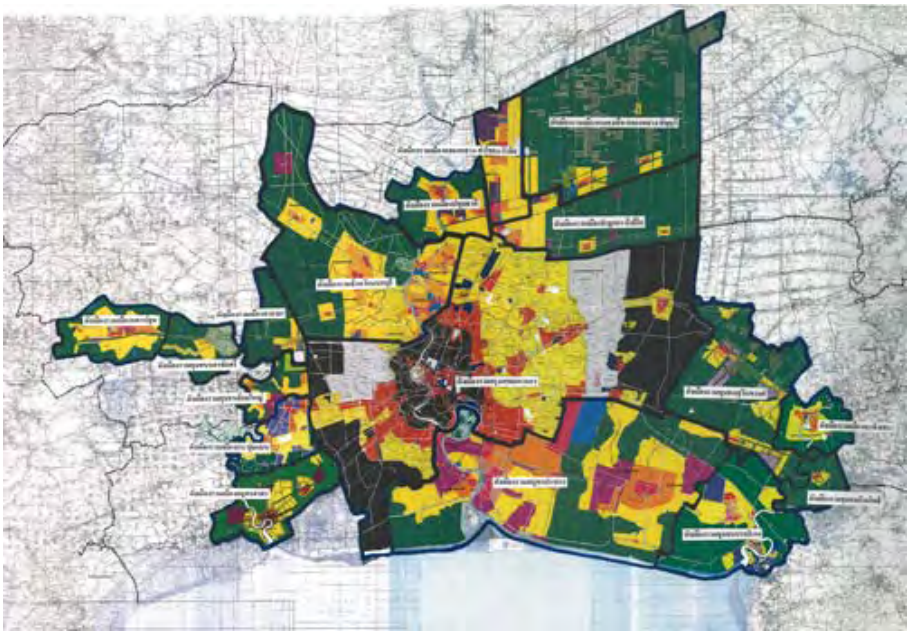


**Figure 2.3.1 Future Land Use Map (BMR)**

**2) Transport Network Plans**

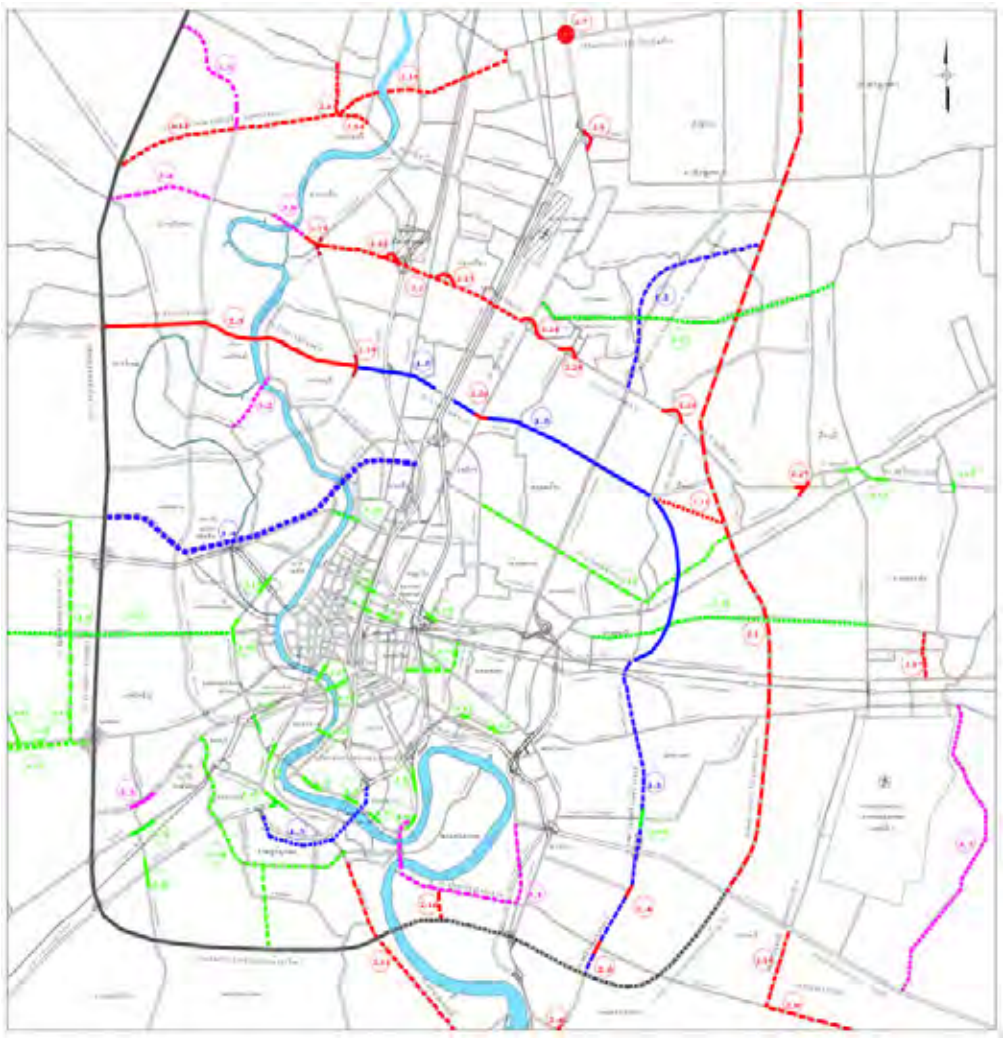
**a) Present Road Network (2009) for the bases of traffic demand forecast**

The present road network as of October 2009, including the completed and on-going projects, is shown below:

**b) Future Road Network**

The future road network for traffic demand forecast is composed of the future road development projects from the concerned government organizations listed below:

- Department of Rural Roads
- Bangkok Metropolitan Administration
- Department of Highways
- Expressway Authority of Thailand



Source: OTP

**Figure 2.3.2 Present and On-Going Road Projects in BMR (2009)**

### c) Public Transport Network

Major public transport modes in BMR are buses and the light railway system operated by the Mass Rapid Transit Authority of Thailand (MRTA), and the State Railway of Thailand (SRT). The expansion plan for the Mass Railway Transit (MRT) up to 2029 is shown below with its implementation schedule. Part of this plan was reflected in the traffic demand forecast.


**Figure 2.3.3 MRT Plan Map**

### (3) Methodology for Traffic Demand Forecast

The traffic models applied to the demand forecast for the Project bridge was based on the Transport Data and Model Center V developed by the Office of Transport and Traffic Policy and Planning, which has updated now to the Transport Data and Model Integrated with Multimodal Transport and Logistics. In this latest transport model, the study area, BMA and its surrounding five provinces, is subdivided into 625 traffic zones of which Nonthaburi Province, the direct influence area, is divided into 60 zones.

In the above traffic forecast system, the traffic demand forecast consists of the following four steps:

1) Trip Generation Model
2) Trip Distribution Model
3) Modal Split Model
4) Trip Assignment Model

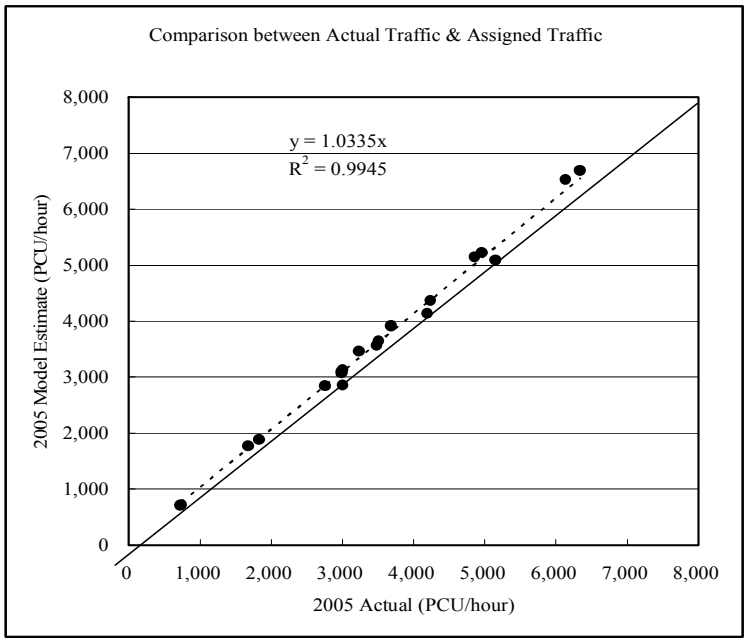
The trip generation model adopts the method of the trip rate per household explained with the household income and household size distribution. The trip distribution model applies the traditional gravity model explained with the trip generation, trip attraction by each traffic zone and inter-zonal impedance function. The modal split model applies the Binary Logit Type

model and forecasted two modes trips, public and private trips. At the final step, the equilibrium assignment method was used to assign all trips to the road network and the public transport network.

The forecast methodologies explained above are considered to be reasonable and concluded to be appropriate.

### (4) Confirmation of Validity of the Present Origin-Destination (OD) Matrix (2005) and Traffic Assignment

In order to confirm the validity of the present OD matrix, the passenger car unit (PCU)/hour in the morning time and the assignment procedure, a comparison between actual traffic counts and assigned traffic (model estimates) was made in the F/S and the results are shown below:




Source: JICA Survey Team (Original data: DD Report, 2005)

**Figure 2.3.4 Comparison between the Actual Traffic (Counted) and Assigned Traffic (Model Estimates)**

The results indicate that the percentage error is only about 3%, which is within the acceptable range. Therefore, it is confirmed that the present OD matrix and the traffic assignment procedure are both appropriate as the bases of the future demand forecast.

### (5) Results of Traffic Demand Forecast of the Previous FS

The forecasted results by the previous F/S are summarized below together with the influences to the existing two bridges, the Phra Nang Klao Bridge and Rama V Bridge.

**Table 2.3.1 Results of Traffic Demand Forecast by F/S (Morning Peak, to Bangkok, PCU/hour)**

| Bridge | Year Situation | 2016 | | 2021 | | 2026 | |
|---|---|---|---|---|---|---|---|
| | | PCU/hr | V/C | PCU/hr | V/C | PCU/hr | V/C |
| Phra Nang Klao Bridge | Without Project | 7,643 | 1.02 | 7,248 | 0.97 | 6,443 | 0.86 |
| | With Project | 6,796 | 0.91 | 6,421 | 0.86 | 5,792 | 0.77 |
| Project Bridge | | 3,159 | 0.70 | 3,200 | 0.71 | 3,913 | 0.87 |
| Rama V Bridge | Without Project | 4,708 | 1.05 | 4,608 | 1.02 | 4,552 | 1.01 |
| | With Project | 3,945 | 0.88 | 3,550 | 0.79 | 3,342 | 0.74 |

Source: F/S Report (1st Additional Information, 2009)
Note: V/C = Traffic Volume/Capacity, C=1,500 PCU

The traffic demand in 2026 in terms of PCU during morning peak hour from Nonthaburi to Bangkok was forecast at around 3,900 PCU per hour and congestion rate (V/C ratio) was estimated at 0.87.

Congestion on the existing two bridges will be mitigated and reduced to the lower level than the congestion rate 1.0 for both Phra Nang Klao Bridge and Rama V Bridge. The percentage of reduction of congestion rate will be 10% for the Phra Nang Klao Bridge, and 20% for the Rama V Bridge. The Phra Nang Klao Bridge was expanded to ten lanes from the four lanes of the old bridge and constructing another six-lane bridge above the old double deck type bridge in November 2008. It was confirmed that this capacity expansion to ten lanes of the Phra Nang Klao Bridge was already reflected in the above traffic demand forecast as a condition of the future road network.

In conclusion, it is judged that the results of the future demand forecast by the previous FS are appropriate after careful review of its pre-conditions and methodology.

It should be noted, however, that the congestion rates (V/C) for each target year of the project cases described in the document of the"1st Additional Information on General and Technical Issues" are not correct due to the input mistakes by the local consultants and the correct values of congestion rate are shown in the above table.

### 2.3.2 SUPPLEMENTAL TRAFFIC SURVEY

#### (1) General

The supplemental traffic survey is conducted to confirm the traffic volume transition from the F/S, and likewise, the reliability, and accuracy of the traffic demand forecast results in F/S. The survey results are as follows:

1) Hourly Traffic Count Survey （Morning and evening peak hours (4 hours each), 5 locations, a day on weekdays）
2) Travel Speed Survey （Morning and evening peak hours (4 hours each), 5 routes (3 round survey per route), a day on weekdays）

## (2) Hourly Traffic Count Survey

### 1) Survey Method

The hourly traffic count survey was conducted during morning peak hours from 6:00AM to 10:00AM and evening peak hours from 4:00PM to 8:00PM on 8th October, 2009. The classification of vehicle type is shown in Table 2.3.2.

**Table 2.3.2 Vehicle Classification**

| | | |
|---|---|---|
| 1) Bicycle | 5)Small Bus | 9) Middle Truck (2-axle) |
| 2) Tuk Tuk | 6) Large Bus | 10) Large Truck (more than 3 axle)/Trailer |
| 3) Motorcycle | 7) Pick Up | |
| 4) Sedan/Taxi/Jeep | 8) Small Truck | |

Five stations are subjected to the hourly traffic count survey as shown in Table 2.3.3 and Figure 2.3.5. The survey stations are selected consistent with the survey location selected in the FS.

**Table 2.3.3 Survey Station and Outlines**

| Survey Stations | Number of Lanes |
|---|---|
| M1:Ratcha Phruk Road | 6 lanes, median |
| M2: Rattanathibet (Pranang Klao Bridge) | Old bridge; 4 lanes<br>New bridge; 6 lanes |
| M3: Rama V Bridge | 6 lanes |
| M4: Bypass Nonthaburi | 4 lanes, median |
| M5: Nonthaburi 1 | 4 lanes, median |

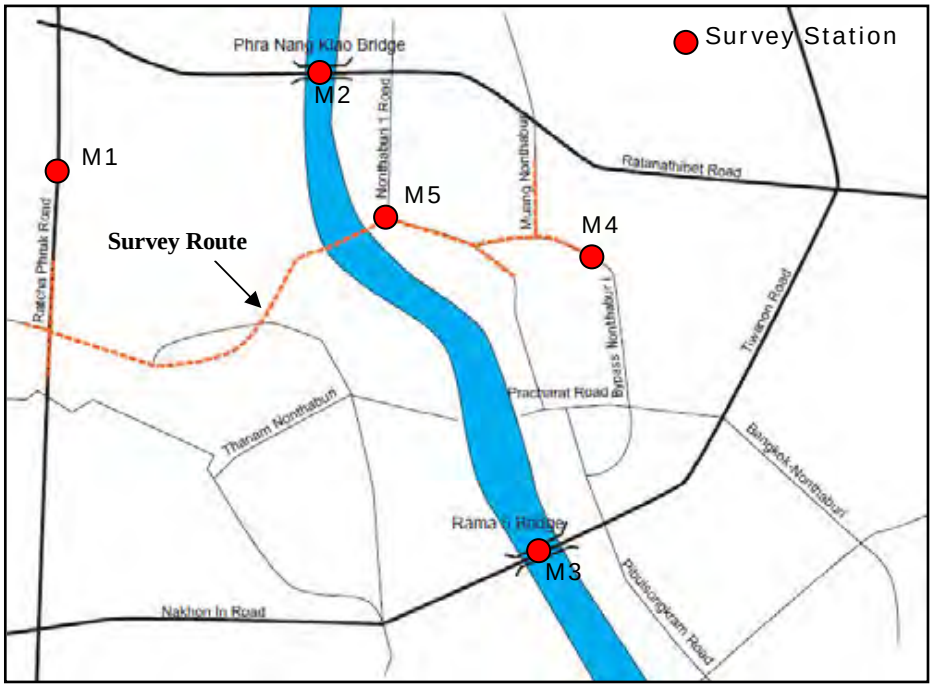



**Figure 2.3.5 Location Map of Survey Stations**

M1: Northbound

M1: Southbound

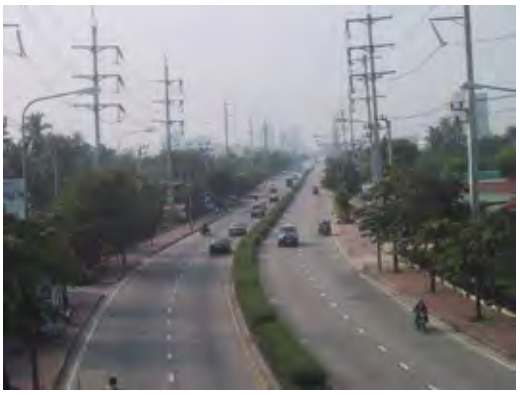
M2: Westbound(1)

M2: Westbound(2)

M3: Eastbound

M3: Westbound

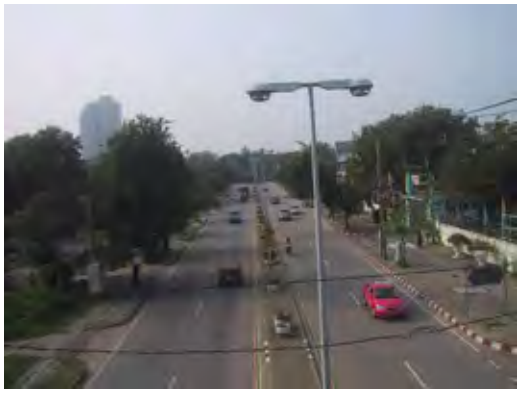
M4: Northbound



M4: Southbound

**Figure 2.3.6 Traffic Condition at Survey Stations (1/2)**

M5: Northbound



M5: Southbound

**Figure 2.3.7 Traffic Condition at Survey Stations (2/2)**

### 2) Survey Result

The weather was clear on the survey date, and there was not any road section restricted to passage due to road construction and/or flooding.

Vehicle numbers are accumulated every 15 minutes, and tabulated for each direction and vehicle type, as shown in Table 2.3.5 to Table 2.3.9. The total hourly traffic volumes are estimated by applying the PCU conversion factor as shown in Table 2.3.4.

**Table 2.3.4 PCU Convert Factors**

| Vehicle Type | PCU Conversion Factors | Vehicle Type | PCU Conversion Factors |
|---|---|---|---|
| Motorcycle | 0.25 | Medium Bus, Heavy Bus | 2.00 |
| Car | 1.00 | Light Truck | 1.00 |
| Pickup | 1.00 | Medium Truck | 2.00 |
| Light Bus | 1.00 | Heavy Truck | 2.50 |

The composition of the major vehicle type in the counted traffic volume are; Motorcycle (12%-33%), Sedan/Taxi/Jeep (55%-74%), and Pickup (10%-29%). Peak hour mostly occurred in the morning and evening peak time.

**Table 2.3.5 Directional Hourly Traffic Volume by Vehicle Type (M1: Ratcha Phruk Road)**

Location M1: Ratchapreuk Rd. Direction Northbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 2 | 350 | 1,715 | 73 | 3 | 479 | 2 | 0 | 0 | 2,363 |
| 07:00 – 08:00 | 1 | 374 | 1,779 | 87 | 6 | 672 | 17 | 2 | 1 | 2,667 |
| 08:00 – 09:00 | 3 | 370 | 1,736 | 81 | 12 | 929 | 15 | 5 | 10 | 2,913 |
| 09:00 – 10:00 | 4 | 285 | 1,364 | 80 | 0 | 942 | 29 | 33 | 10 | 2,578 |
| Total | 10 | 1,379 | 6,594 | 321 | 21 | 3,022 | 63 | 40 | 21 | 10,522 |
| 16:00 – 17:00 | 3 | 412 | 2,273 | 62 | 3 | 900 | 16 | 13 | 3 | 3,394 |
| 17:00 – 18:00 | 3 | 580 | 2,426 | 75 | 4 | 961 | 13 | 9 | 2 | 3,652 |
| 18:00 – 19:00 | 1 | 575 | 2,601 | 58 | 8 | 642 | 3 | 2 | 5 | 3,481 |
| 19:00 – 20:00 | 1 | 373 | 1,756 | 58 | 6 | 487 | 0 | 4 | 19 | 2,462 |
| Total | 8 | 1,940 | 9,056 | 253 | 21 | 2,990 | 32 | 28 | 29 | 12,989 |

Location M1: Ratchapreuk Rd. Direction Southbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 3 | 1,012 | 2,524 | 9 | 2 | 841 | 21 | 26 | 1 | 3,707 |
| 07:00 – 08:00 | 1 | 894 | 2,329 | 10 | 6 | 878 | 24 | 24 | 6 | 3,540 |
| 08:00 – 09:00 | 4 | 524 | 1,776 | 14 | 2 | 1,007 | 44 | 26 | 15 | 3,067 |
| 09:00 – 10:00 | 10 | 329 | 1,435 | 47 | 1 | 811 | 154 | 54 | 38 | 2,737 |
| Total | 18 | 2,759 | 8,064 | 80 | 11 | 3,537 | 243 | 130 | 60 | 13,050 |
| 16:00 – 17:00 | 2 | 305 | 1,778 | 96 | 2 | 810 | 69 | 21 | 13 | 2,908 |
| 17:00 – 18:00 | 3 | 331 | 1,629 | 68 | 4 | 771 | 29 | 12 | 8 | 2,633 |
| 18:00 – 19:00 | 3 | 295 | 1,465 | 56 | 2 | 805 | 26 | 12 | 14 | 2,490 |
| 19:00 – 20:00 | 4 | 220 | 1,130 | 31 | 0 | 487 | 13 | 32 | 10 | 1,806 |
| Total | 12 | 1,151 | 6,002 | 251 | 8 | 2,873 | 137 | 77 | 45 | 9,836 |

## Table 2.3.6 Directional Hourly Traffic Volume by Vehicle Type (M2: Rattanathibet (Pranang Klao Bridge))

Location M2-1: New Pranangklao Bridge Direction Eastbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 0 | 162 | 824 | 81 | 2 | 89 | 1 | 0 | 1 | 1,042 |
| 07:00 – 08:00 | 0 | 756 | 1,275 | 71 | 3 | 125 | 3 | 1 | 0 | 1,671 |
| 08:00 – 09:00 | 0 | 629 | 1,130 | 80 | 2 | 175 | 3 | 0 | 0 | 1,549 |
| 09:00 – 10:00 | 0 | 469 | 782 | 76 | 2 | 155 | 15 | 6 | 0 | 1,161 |
| Total | 0 | 2,016 | 4,011 | 308 | 9 | 544 | 22 | 7 | 1 | 5,424 |
| 16:00 – 17:00 | 0 | 283 | 587 | 85 | 5 | 208 | 15 | 4 | 0 | 984 |
| 17:00 – 18:00 | 0 | 290 | 1,151 | 122 | 4 | 253 | 14 | 1 | 0 | 1,623 |
| 18:00 – 19:00 | 0 | 198 | 1,257 | 67 | 12 | 281 | 6 | 1 | 0 | 1,687 |
| 19:00 – 20:00 | 0 | 139 | 1,016 | 102 | 3 | 220 | 6 | 8 | 0 | 1,401 |
| Total | 0 | 910 | 4,011 | 376 | 24 | 962 | 41 | 14 | 0 | 5,694 |

Location M2-1: New Pranangklao Bridge Direction Westbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 0 | 63 | 559 | 21 | 1 | 80 | 1 | 4 | 0 | 687 |
| 07:00 – 08:00 | 1 | 156 | 649 | 73 | 1 | 188 | 5 | 1 | 0 | 958 |
| 08:00 – 09:00 | 0 | 120 | 629 | 57 | 2 | 279 | 5 | 3 | 0 | 1,010 |
| 09:00 – 10:00 | 0 | 96 | 579 | 51 | 3 | 324 | 5 | 18 | 0 | 1,025 |
| Total | 1 | 435 | 2,416 | 202 | 7 | 871 | 16 | 26 | 0 | 3,680 |
| 16:00 – 17:00 | 0 | 158 | 878 | 40 | 1 | 257 | 4 | 5 | 0 | 1,231 |
| 17:00 – 18:00 | 0 | 333 | 1,657 | 90 | 7 | 403 | 9 | 3 | 1 | 2,265 |
| 18:00 – 19:00 | 1 | 187 | 1,499 | 79 | 3 | 301 | 5 | 3 | 0 | 1,943 |
| 19:00 – 20:00 | 1 | 166 | 1,346 | 86 | 0 | 274 | 6 | 5 | 1 | 1,766 |
| Total | 2 | 844 | 5,380 | 295 | 11 | 1,235 | 24 | 16 | 2 | 7,205 |

Location M2-2: Old Pranangklao Bridge Direction Eastbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 2 | 702 | 1,094 | 216 | 48 | 283 | 16 | 0 | 4 | 1,891 |
| 07:00 – 08:00 | 10 | 795 | 1,257 | 211 | 63 | 371 | 10 | 2 | 0 | 2,180 |
| 08:00 – 09:00 | 7 | 778 | 1,395 | 183 | 50 | 451 | 18 | 5 | 5 | 2,366 |
| 09:00 – 10:00 | 8 | 354 | 863 | 127 | 50 | 335 | 21 | 16 | 25 | 1,631 |
| Total | 27 | 2,629 | 4,609 | 737 | 211 | 1,440 | 65 | 23 | 34 | 8,068 |
| 16:00 – 17:00 | 5 | 399 | 752 | 103 | 48 | 324 | 8 | 4 | 3 | 1,400 |
| 17:00 – 18:00 | 4 | 484 | 1,016 | 133 | 48 | 382 | 9 | 5 | 18 | 1,813 |
| 18:00 – 19:00 | 10 | 538 | 1,191 | 135 | 36 | 276 | 3 | 2 | 22 | 1,873 |
| 19:00 – 20:00 | 11 | 330 | 874 | 97 | 27 | 202 | 3 | 3 | 14 | 1,356 |
| Total | 30 | 1,751 | 3,833 | 468 | 159 | 1,184 | 23 | 14 | 57 | 6,442 |

Location M2-2: Old Pranangklao Bridge Direction Westbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 0 | 327 | 699 | 88 | 49 | 168 | 1 | 0 | 0 | 1,136 |
| 07:00 – 08:00 | 1 | 258 | 549 | 133 | 44 | 234 | 5 | 4 | 1 | 1,084 |
| 08:00 – 09:00 | 0 | 227 | 496 | 116 | 33 | 146 | 0 | 2 | 3 | 892 |
| 09:00 – 10:00 | 0 | 163 | 427 | 103 | 68 | 209 | 5 | 12 | 8 | 965 |
| Total | 1 | 975 | 2,171 | 440 | 194 | 757 | 11 | 18 | 12 | 4,077 |
| 16:00 – 17:00 | 0 | 221 | 703 | 115 | 65 | 255 | 1 | 3 | 0 | 1,265 |
| 17:00 – 18:00 | 0 | 348 | 979 | 134 | 60 | 369 | 3 | 16 | 1 | 1,727 |
| 18:00 – 19:00 | 1 | 429 | 967 | 100 | 51 | 198 | 0 | 4 | 6 | 1,498 |
| 19:00 – 20:00 | 0 | 336 | 613 | 56 | 28 | 128 | 2 | 7 | 7 | 971 |
| Total | 1 | 1,334 | 3,262 | 405 | 204 | 950 | 6 | 30 | 14 | 5,460 |

## Table 2.3.7 Directional Hourly Traffic Volume by Vehicle Type (M3: Rama V Bridge)

Location M3: Rama V Bridge Direction Eastbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 3 | 186 | 956 | 19 | 3 | 337 | 1 | 0 | 0 | 1,366 |
| 07:00 – 08:00 | 9 | 1,313 | 3,075 | 16 | 9 | 914 | 17 | 5 | 0 | 4,381 |
| 08:00 – 09:00 | 19 | 1,064 | 2,221 | 13 | 5 | 1,041 | 30 | 9 | 5 | 3,616 |
| 09:00 – 10:00 | 18 | 555 | 1,454 | 13 | 8 | 1,038 | 141 | 29 | 7 | 2,881 |
| Total | 49 | 3,118 | 7,706 | 61 | 25 | 3,330 | 189 | 43 | 12 | 12,244 |
| 16:00 – 17:00 | 5 | 506 | 1,524 | 20 | 6 | 847 | 46 | 5 | 1 | 2,589 |
| 17:00 – 18:00 | 8 | 804 | 1,835 | 21 | 11 | 998 | 28 | 10 | 2 | 3,132 |
| 18:00 – 19:00 | 6 | 599 | 1,522 | 9 | 9 | 770 | 25 | 2 | 0 | 2,499 |
| 19:00 – 20:00 | 6 | 432 | 1,097 | 13 | 7 | 548 | 18 | 3 | 4 | 1,816 |
| Total | 25 | 2,341 | 5,978 | 63 | 33 | 3,163 | 117 | 20 | 7 | 10,036 |

Location M3: Rama V Bridge Direction Westbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 53 | 175 | 538 | 24 | 2 | 143 | 1 | 0 | 1 | 770 |
| 07:00 – 08:00 | 32 | 517 | 1,020 | 62 | 15 | 271 | 15 | 11 | 1 | 1,560 |
| 08:00 – 09:00 | 15 | 525 | 987 | 75 | 4 | 330 | 31 | 15 | 0 | 1,596 |
| 09:00 – 10:00 | 14 | 343 | 811 | 137 | 0 | 361 | 87 | 33 | 0 | 1,551 |
| Total | 114 | 1,560 | 3,356 | 298 | 21 | 1,105 | 134 | 59 | 2 | 5,477 |
| 16:00 – 17:00 | 11 | 610 | 1,919 | 86 | 26 | 405 | 56 | 0 | 0 | 2,673 |
| 17:00 – 18:00 | 8 | 652 | 2,685 | 154 | 55 | 233 | 31 | 0 | 0 | 3,378 |
| 18:00 – 19:00 | 8 | 627 | 2,605 | 132 | 54 | 160 | 13 | 0 | 0 | 3,177 |
| 19:00 – 20:00 | 7 | 553 | 2,735 | 95 | 15 | 173 | 14 | 0 | 0 | 3,187 |
| Total | 34 | 2,442 | 9,944 | 467 | 150 | 971 | 114 | 0 | 0 | 12,415 |

**Table 2.3.8 Directional Hourly Traffic Volume by Vehicle Type (M4: Bypass Nonthaburi)**

Location M4:Nontaburi Rd. Direction Northbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 30 | 388 | 637 | 14 | 31 | 141 | 0 | 0 | 0 | 959 |
| 07:00 – 08:00 | 61 | 510 | 1,264 | 59 | 30 | 177 | 0 | 0 | 0 | 1,703 |
| 08:00 – 09:00 | 53 | 677 | 1,272 | 50 | 35 | 244 | 0 | 0 | 0 | 1,819 |
| 09:00 – 10:00 | 39 | 388 | 746 | 59 | 26 | 266 | 0 | 0 | 7 | 1,247 |
| Total | 183 | 1,963 | 3,919 | 182 | 122 | 828 | 0 | 0 | 7 | 5,727 |
| 16:00 – 17:00 | 59 | 360 | 828 | 43 | 15 | 168 | 0 | 0 | 0 | 1,174 |
| 17:00 – 18:00 | 32 | 572 | 920 | 40 | 12 | 159 | 0 | 0 | 2 | 1,299 |
| 18:00 – 19:00 | 27 | 445 | 909 | 38 | 7 | 304 | 0 | 0 | 0 | 1,383 |
| 19:00 – 20:00 | 23 | 369 | 770 | 36 | 4 | 237 | 0 | 0 | 7 | 1,167 |
| Total | 141 | 1,746 | 3,427 | 157 | 38 | 868 | 0 | 0 | 9 | 5,022 |

Location M4:Nontaburi Rd. Direction Southbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 5 | 70 | 654 | 48 | 50 | 65 | 2 | 14 | 0 | 916 |
| 07:00 – 08:00 | 24 | 200 | 995 | 45 | 50 | 189 | 1 | 8 | 0 | 1,402 |
| 08:00 – 09:00 | 20 | 268 | 948 | 51 | 46 | 172 | 3 | 10 | 0 | 1,358 |
| 09:00 – 10:00 | 11 | 189 | 424 | 41 | 45 | 257 | 8 | 23 | 0 | 916 |
| Total | 60 | 727 | 3,021 | 185 | 191 | 683 | 14 | 55 | 0 | 4,592 |
| 16:00 – 17:00 | 18 | 251 | 831 | 30 | 35 | 213 | 6 | 17 | 0 | 1,251 |
| 17:00 – 18:00 | 8 | 390 | 920 | 32 | 32 | 167 | 40 | 6 | 1 | 1,337 |
| 18:00 – 19:00 | 9 | 377 | 1,055 | 21 | 40 | 199 | 0 | 1 | 0 | 1,454 |
| 19:00 – 20:00 | 10 | 344 | 1,008 | 24 | 48 | 240 | 0 | 4 | 1 | 1,467 |
| Total | 45 | 1,362 | 3,814 | 107 | 155 | 819 | 46 | 28 | 2 | 5,509 |

**Table 2.3.9 Directional Hourly Traffic Volume by Vehicle Type (M5: Nonthaburi 1)**

Location M5:Nonthaburu 1Rd. Direction Northbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 51 | 211 | 297 | 119 | 10 | 92 | 1 | 4 | 3 | 610 |
| 07:00 – 08:00 | 40 | 205 | 282 | 130 | 14 | 71 | 2 | 2 | 1 | 581 |
| 08:00 – 09:00 | 45 | 254 | 402 | 82 | 20 | 104 | 5 | 3 | 0 | 714 |
| 09:00 – 10:00 | 58 | 166 | 363 | 76 | 16 | 125 | 4 | 7 | 2 | 675 |
| Total | 194 | 836 | 1,344 | 407 | 60 | 392 | 12 | 16 | 6 | 2,580 |
| 16:00 – 17:00 | 54 | 194 | 404 | 104 | 16 | 123 | 2 | 2 | 3 | 739 |
| 17:00 – 18:00 | 29 | 188 | 477 | 85 | 11 | 78 | 3 | 4 | 2 | 732 |
| 18:00 – 19:00 | 48 | 250 | 511 | 95 | 13 | 138 | 3 | 1 | 0 | 850 |
| 19:00 – 20:00 | 36 | 248 | 371 | 61 | 13 | 194 | 0 | 0 | 1 | 726 |
| Total | 167 | 880 | 1,763 | 345 | 53 | 533 | 8 | 7 | 6 | 3,046 |

Location M5:Nonthaburu 1Rd. Direction Southbound

| Time | Tuk Tuk | Motocycle | Sedan/Taxi Jeep | Small Bus | Large Bus | Pick Up | Small Truck | Middle Truck (2 axle) | Large Truck (≧ 3 axle) | PCU |
|---|---|---|---|---|---|---|---|---|---|---|
| 06:00 – 07:00 | 88 | 260 | 579 | 148 | 18 | 76 | 0 | 2 | 0 | 930 |
| 07:00 – 08:00 | 63 | 297 | 542 | 175 | 17 | 74 | 0 | 1 | 0 | 917 |
| 08:00 – 09:00 | 54 | 283 | 520 | 155 | 17 | 86 | 0 | 2 | 0 | 883 |
| 09:00 – 10:00 | 33 | 153 | 349 | 80 | 8 | 63 | 2 | 12 | 0 | 581 |
| Total | 238 | 993 | 1,990 | 558 | 60 | 299 | 2 | 17 | 0 | 3,311 |
| 16:00 – 17:00 | 55 | 159 | 308 | 96 | 9 | 50 | 1 | 0 | 0 | 527 |
| 17:00 – 18:00 | 45 | 235 | 348 | 109 | 9 | 70 | 3 | 1 | 0 | 620 |
| 18:00 – 19:00 | 54 | 258 | 351 | 86 | 5 | 61 | 0 | 1 | 0 | 588 |
| 19:00 – 20:00 | 24 | 169 | 262 | 52 | 4 | 42 | 1 | 1 | 0 | 415 |
| Total | 178 | 821 | 1,269 | 343 | 27 | 223 | 5 | 3 | 0 | 2,150 |

### 3) Traffic Volume Comparison with F/S

Table 2.3.10 shows the comparison between traffic result in the F/S (14th June, 2005) and the survey results. Morning peak hour traffic volume from 7:00AM to 8:00AM is subjected to the comparison as peak traffic volume data representative.

As a result of the comparison, significant increment is found at Ratcha Phruk Road, Rattanathibet (Pranang Klao Bridge) Road, and Nakorn-In (Rama 5 Bridge), especially at Ratcha Phruk Road (2.24 times). Major reasons of the increment seem that recent road development in the northbound extension of Ratcha Phruk after 2005 and Rama 4 Bridge in 2006 has developed into a new road network.

On the other hand, there was no increment found at the Nonthaburi 1 Road and Bypass Nonthaburi. The main reason for this seems that there is less impact by through traffic because the Nonthaburi 1 Road and Bypass Nonthaburi are categorized as secondary roads and these roads are located inside the area of primary road network. Hence, there is less trip generation due to saturated residential development.

As for river crossing traffic volume at Rattanathibet (Pranang Klao Bridge) Road and

Nakorn-In (Rama 5 Bridge), traffic volume has increased to 3.4%/year and 4.6%/year, respectively.

**Table 2.3.10 Comparison Results with F/S Traffic Volume (Morning Peak, 7:00-8:00)**

| Survey Stations | Direction | Traffic Volume | | | | 2009/2005 | |
|---|---|---|---|---|---|---|---|
| | | 2005 | | 2009 | | Directional | Both Direction |
| M1:Ratcha Phruk Road | Northbound | 995 | 2,766 | 2,667 | 6,207 | 2.68 | 2.24 |
| | Southboun | 1,771 | | 3,540 | | 2.00 | |
| M2: Rattanathibet (Pranang Klao Bridge) | Eastbound | 3,300 | 5,160 | 3,851 | 5,893 | 1.17 | 1.14 |
| | Westbound | 1,860 | | 2,042 | | 1.10 | |
| M3:Rama V Bridge | Eastbound | 2,788 | 4,964 | 4,381 | 5,941 | 1.57 | 1.20 |
| | Westbound | 2,176 | | 1,560 | | 0.72 | |
| M4:Bypass Nonthaburi | Northbound | 1,309 | 3,012 | 1,703 | 3,105 | 1.30 | 1.03 |
| | Southboun | 1,703 | | 1,402 | | 0.82 | |
| M5:Nonthaburi 1 | Northbound | 1,107 | 1,686 | 581 | 1,498 | 0.52 | 0.89 |
| | Southboun | 579 | | 917 | | 1.58 | |

In terms of congested ratio, all survey stations are about less than 0.5 except the Rattanathibet (Pranang Klao Bridge) Road which shows 0.86 in F/S. Meanwhile, the Ratcha Phruk Road and Nakorn-In (Rama 5 Bridge) Road exceeded 0.6 in the survey. However, Rattanathibet (Pranang Klao Bridge) Road is reduced to 0.39 due to the new development in the six-lane Pranang Klao Bridge.

**Table 2.3.11 Comparison Results with FS VCR (Morning Peak, 7:00-8:00)**

| Survey Stations | Number of Lanes | | VCR | |
|---|---|---|---|---|
| | 2005 | 2009 | 2005 | 2009 |
| M1:Ratcha Phruk Road | 6 | 6 | 0.31 | 0.69 |
| M2: Rattanathibet (Pranang Klao Bridge) | 4 | 10 | 0.86 | 0.39 |
| M3:Rama V Bridge | 6 | 6 | 0.55 | 0.66 |
| M4:Bypass Nonthaburi | 4 | 4 | 0.50 | 0.52 |
| M5:Nonthaburi 1 | 4 | 4 | 0.28 | 0.25 |

Note: C=1,500pcu/lane

## (3) Travel Speed Survey

### 1) Survey Method

Travel speed survey was conducted to measure the average travel speed on roads near the project by "Floating Car Method". The mechanics of the method is that the survey vehicle shall be driven at the same speed with the surrounding traffic flow and the vehicle shall not overtake the other car.

The travel speed survey was conducted during morning peak hours from 6:00AM to 10:00AM and in the evening peak hours from 4:00PM to 8:00PM on October 8, 2009. There are five survey and travel routes, as shown in Table 2.3.12 and Figure 2.3.8.

**Table 2.3.12 Survey Routes and Travel Routes**

| Survey Routes | Travel Routes |
|---|---|
| Ratcha Phruk Road | A-I-H |
| Rattanathibet (Pranang Klao Bridge) | A-B-C-D |
| Nakhon-In Road (Rama V Bridge) | E-F-G-H |
| Bypass Nonthaburi | K-L-M-N |
| Nonthaburi 1 | B-K-J |

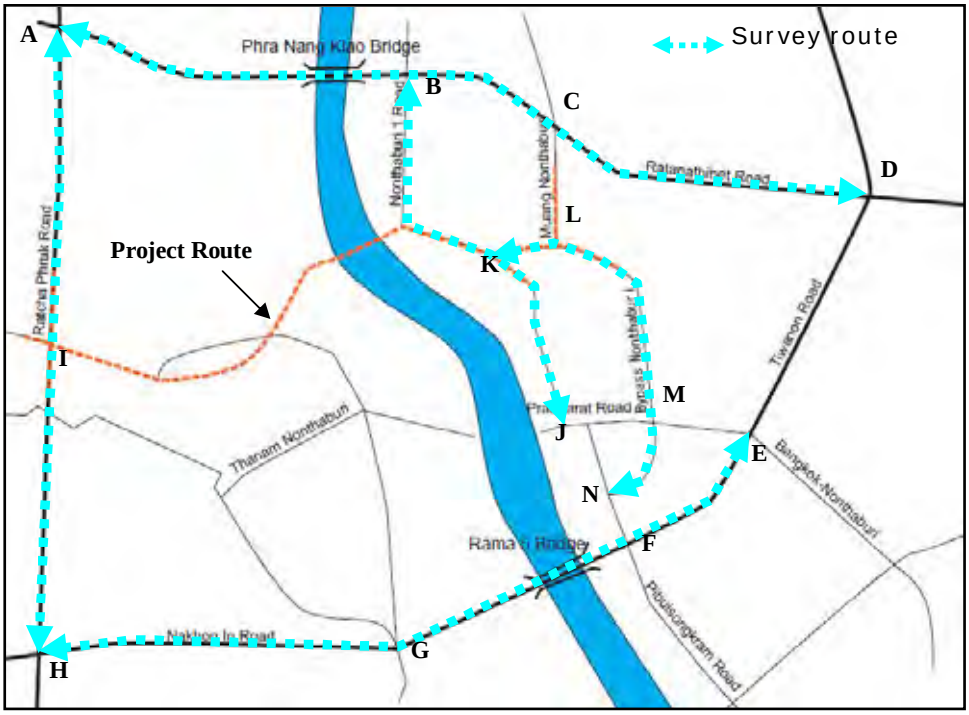



**Figure 2.3.8 Location Map of Survey Routes**

### 2) Survey Results

Table 2.3.13 shows the results of the survey.

Travel speeds of outbound traffic from the city center and northbound are generally higher than the opposite directions of each in conformity with the results of the counted traffic volume as shown in Table 2.3.10. Average travel speeds are higher than the one in the city center.

**Table 2.3.13 Results of Travel Speed Survey**

(km/h)

| Survey Routes | Route | Mornning Peak | Evenning Peak |
|---|---|---|---|
| Ratcha Phruk Road | A-H | 38.57 | 29.15 |
| | H-A | 66.84 | 59.65 |
| Rattanathibet (Pranang Klao Bridge) | A-D | 26.9 | 26.1 |
| | D-A | 67.83 | 66.38 |
| Nakhon-In Road (Rama V Bridge) | H-E | 59.2 | 61.81 |
| | E-H | 71.81 | 71.23 |
| Bypass Nonthaburi | K-N | 37.83 | 31.89 |
| | N-K | 25.19 | 19.41 |
| Nonthaburi 1 | B-J | 27.74 | 42.16 |
| | J-B | 61.43 | 60.52 |

## Table 2.3.14 Results of Travel Speed Survey (Ratcha Phruk Road)

**Ratcha phruk Road** AM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| A | 0 | 7 | 10 | 19 | |
| brigde canal | 2.0 | 7 | 12 | 23 | 58.06 |
| Junction | 3.2 | 7 | 13 | 52 | 48.54 |
| Junction ( I ) | 4.1 | 7 | 15 | 37 | 30.86 |
| brigde canal | 5.2 | 7 | 17 | 45 | 30.94 |
| stop (Red Signal) | 5.3 | 7 | 18 | 19 | 10.59 |
| start (Green Signal) | 5.3 | 7 | 18 | 45 | - |
| H | 5.7 | 7 | 19 | 11 | 55.38 |
| **All Range** | **5.7** | **0** | **8** | **52** | **38.57** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| H | 0 | 7 | 21 | 21 | |
| brigde canal | 0.5 | 7 | 22 | 23 | 29.03 |
| Junction ( I ) | 1.8 | 7 | 23 | 26 | 74.29 |
| Junction | 2.6 | 7 | 24 | 3 | 77.84 |
| brigde canal | 3.7 | 7 | 25 | 0 | 69.47 |
| A | 5.7 | 7 | 26 | 28 | 81.82 |
| **All Range** | **5.7** | **0** | **5** | **7** | **66.84** |

**Ratcha phruk Road** PM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| A | 0 | 18 | 1 | 27 | |
| brigde canal | 2.2 | 18 | 2 | 59 | 86.09 |
| Junction | 3.4 | 18 | 4 | 2 | 68.57 |
| Junction ( I ) | 4.2 | 18 | 4 | 46 | 65.45 |
| stop (Red Signal) | 4.7 | 18 | 5 | 31 | 40.00 |
| start (Green Signal) | 4.7 | 18 | 6 | 10 | - |
| brigde canal | 5.2 | 18 | 7 | 12 | 29.03 |
| stop (Red Signal) | 5.4 | 18 | 8 | 22 | 10.29 |
| start (Green Signal) | 5.4 | 18 | 9 | 9 | - |
| H | 5.7 | 18 | 13 | 11 | 4.46 |
| **All Range** | **5.7** | **0** | **11** | **44** | **29.15** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. Km/Hr |
|---|---|---|---|---|---|
| H | 0 | 18 | 16 | 20 | |
| brigde canal | 0.5 | 18 | 17 | 31 | 25.35 |
| Junction ( I ) | 1.8 | 18 | 18 | 24 | 88.30 |
| Junction | 2.6 | 18 | 18 | 54 | 96.00 |
| brigde canal | 3.7 | 18 | 19 | 52 | 68.28 |
| A | 5.7 | 18 | 22 | 4 | 54.55 |
| **All Range** | **5.7** | **0** | **5** | **44** | **59.65** |

## Table 2.3.15 Results of Travel Speed Survey (Rattanathibet (Pranang Klao Bridge)

**Rattanathibate Road** AM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| A | 0 | 8 | 2 | 10 | |
| Upward brigde | 2.2 | 8 | 3 | 46 | 82.50 |
| B | 3.8 | 8 | 5 | 46 | 48.00 |
| downward Brigde | 4.2 | 8 | 6 | 45 | 24.41 |
| C | 4.6 | 8 | 7 | 31 | 31.30 |
| Front Hotel | 6.3 | 8 | 10 | 44 | 31.71 |
| D | 7.8 | 8 | 19 | 34 | 10.19 |
| **All range** | **7.8** | **0** | **17** | **24** | **26.90** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| D | 0 | 8 | 33 | 18 | |
| Front Hotel | 1.3 | 8 | 34 | 16 | 80.69 |
| C | 2.9 | 8 | 35 | 18 | 92.90 |
| Upward brigde | 3.9 | 8 | 36 | 27 | 52.17 |
| B | 4.3 | 8 | 37 | 4 | 38.92 |
| downward Brigde | 5.0 | 8 | 37 | 57 | 47.55 |
| A | 7.8 | 8 | 40 | 12 | 74.67 |
| **All range** | 7.8 | 0 | 6 | 54 | **67.83** |

**Rattanathibate Road** PM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| A | 0 | 18 | 22 | 52 | |
| Upward brigde | 2.2 | 18 | 25 | 17 | 54.62 |
| B | 3.8 | 18 | 26 | 23 | 87.27 |
| downward Brigde | 4.2 | 18 | 26 | 46 | 62.61 |
| C | 4.6 | 18 | 27 | 34 | 30.00 |
| Front Hotel | 6.3 | 18 | 32 | 32 | 20.54 |
| D | 7.8 | 18 | 40 | 48 | 10.89 |
| **All Range** | **7.8** | **0** | **17** | **56** | **26.10** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| D | 0 | 18 | 40 | 1 | |
| Front Hotel | 1.3 | 18 | 41 | 40 | 47.27 |
| C | 2.9 | 18 | 43 | 3 | 69.40 |
| Upward brigde | 3.9 | 18 | 43 | 53 | 72.00 |
| B | 4.3 | 18 | 44 | 12 | 75.79 |
| downward Brigde | 5.0 | 18 | 45 | 15 | 40.00 |
| A | 7.8 | 18 | 47 | 4 | 92.48 |
| **All Range** | 7.8 | 0 | 7 | 3 | **66.38** |

## Table 2.3.16 Results of Travel Speed Survey (Nakhon-In Road (Rama V Bridge)

**Nakhon-In Road** AM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| H | 0 | 9 | 43 | 18 | |
| Bangkoknoi Canal | 2.1 | 9 | 45 | 33 | 56.00 |
| G | 3.3 | 9 | 46 | 18 | 96.00 |
| Up | 4.9 | 9 | 47 | 27 | 83.48 |
| Ramp | 5.6 | 9 | 48 | 9 | 60.00 |
| F | 6.3 | 9 | 48 | 47 | 66.32 |
| Down | 6.4 | 9 | 49 | 19 | 11.25 |
| E | 7.4 | 9 | 50 | 48 | 40.45 |
| **All Range** | 7.4 | 0 | 7 | 30 | **59.20** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| E | 0 | 9 | 32 | 36 | |
| Up | 0.8 | 9 | 33 | 32 | 51.43 |
| F | 1.5 | 9 | 34 | 51 | 31.90 |
| Ramp | 1.8 | 9 | 35 | 16 | 43.20 |
| Down | 2.4 | 9 | 35 | 46 | 72.00 |
| G | 4 | 9 | 36 | 46 | 96.00 |
| Bangkoknoi Canal | 5.2 | 9 | 37 | 32 | 93.91 |
| H | 7.4 | 9 | 38 | 47 | 105.60 |
| **All Range** | **7.4** | **0** | **6** | **11** | **71.81** |

**Nakhon-In Road** PM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| H | 0 | 19 | 12 | 23 | |
| Bangkoknoi Canal | 2.1 | 19 | 14 | 33 | 58.15 |
| G | 3.3 | 19 | 15 | 40 | 64.48 |
| Up | 4.9 | 19 | 16 | 51 | 81.13 |
| Ramp | 5.6 | 19 | 17 | 32 | 61.46 |
| F | 6.3 | 19 | 18 | 4 | 78.75 |
| Down | 6.4 | 19 | 18 | 32 | 12.86 |
| E | 7.4 | 19 | 19 | 34 | 58.06 |
| **All Range** | 7.4 | 0 | 7 | 11 | **61.81** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| E | 0 | 19 | 19 | 49 | |
| Up | 1.4 | 19 | 20 | 53 | 78.75 |
| F | 1.5 | 19 | 21 | 10 | 21.18 |
| Ramp | 1.8 | 19 | 21 | 40 | 36.00 |
| Down | 2.4 | 19 | 22 | 19 | 55.38 |
| G | 4 | 19 | 23 | 44 | 67.76 |
| Bangkoknoi Canal | 5.2 | 19 | 24 | 40 | 77.14 |
| H | 7.4 | 19 | 26 | 3 | 95.42 |
| **All Range** | **7.4** | **0** | **6** | **14** | **71.23** |

**Table 2.3.17 Results of Travel Speed Survey (Bypass Nonthaburi Road)**

**BYPASS NONTHABURI Road** AM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| K | 0 | 6 | 10 | 19 | |
| stop (Red Signal) | 0.8 | 6 | 11 | 17 | 49.66 |
| start (Green Signal) | 0.8 | 6 | 11 | 34 | - |
| L | 1.6 | 6 | 12 | 27 | 54.34 |
| M | 2.6 | 6 | 14 | 29 | 29.51 |
| N | 3.1 | 6 | 15 | 14 | 40.00 |
| **All range** | **3.1** | **0** | **5** | **-5** | **37.83** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| N | 0 | 6 | 20 | 10 | |
| M | 0.7 | 6 | 21 | 11 | 41.31 |
| L | 2.5 | 6 | 24 | 32 | 32.24 |
| K | 3.1 | 6 | 27 | 33 | 11.93 |
| **All range** | 3.1 | 0 | 7 | 23 | **25.19** |

**BYPASS NONTHABURI Road** PM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. Km/Hr |
|---|---|---|---|---|---|
| K | 0 | 17 | 31 | 34 | |
| stop (Red Signal) | 0.3 | 17 | 32 | 35 | 17.70 |
| start (Green Signal) | 0.3 | 17 | 33 | 45 | - |
| L | 1.6 | 17 | 34 | 52 | 69.85 |
| M | 2.6 | 17 | 36 | 41 | 33.03 |
| N | 3.1 | 17 | 37 | 24 | 41.86 |
| **All Range** | **3.1** | **0** | **5** | **50** | **31.89** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. Km/Hr |
|---|---|---|---|---|---|
| N | 0 | 17 | 38 | 57 | |
| M | 0.7 | 17 | 39 | 52 | 45.82 |
| stop (Red Signal) | 1.3 | 17 | 42 | 23 | 14.30 |
| start (Green Signal) | 1.3 | 17 | 43 | 1 | - |
| L | 2.5 | 17 | 46 | 3 | 23.74 |
| K | 3.1 | 17 | 48 | 32 | 14.50 |
| **All Range** | 3.1 | 0 | 9 | 35 | **19.41** |

**Table 2.3.18 Results of Travel Speed Survey (Nonthaburi 1 Road)**

**NONTHABURI Road** AM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| B | 0 | 7 | 38 | 11 | |
| Nangklao Hospital | 0.6 | 7 | 39 | 40 | 24.27 |
| M5 | 1.6 | 7 | 40 | 45 | 55.38 |
| K | 2.3 | 7 | 41 | 34 | 51.43 |
| J | 4.3 | 7 | 47 | 29 | 20.28 |
| **All range** | **4.3** | **0** | **9** | **18** | **27.74** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| J | 0 | 7 | 48 | 11 | |
| K | 1.3 | 7 | 49 | 36 | 55.06 |
| M5 | 2 | 7 | 50 | 7 | 81.29 |
| Nangklao Hospital | 3.9 | 7 | 51 | 19 | 95.00 |
| B | 4.3 | 7 | 52 | 23 | 22.50 |
| **All range** | 4.3 | 0 | 4 | 12 | **61.43** |

**NONTHABURI Road** PM Peak Hour

*CW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| B | 0 | 17 | 0 | 13 | |
| Nangklao Hospital | 0.6 | 17 | 1 | 34 | 26.67 |
| M5 | 1.6 | 17 | 2 | 41 | 53.73 |
| K | 2.3 | 17 | 3 | 31 | 50.40 |
| J | 5.2 | 17 | 7 | 37 | 42.44 |
| **All Range** | **5.2** | **0** | **7** | **24** | **42.16** |

*CCW*

| Station | KM. | Hour | Min | Second | km./hr. |
|---|---|---|---|---|---|
| J | 0 | 18 | 40 | 1 | |
| K | 1.3 | 18 | 41 | 38 | 48.25 |
| M5 | 2.1 | 18 | 42 | 11 | 87.27 |
| Nangklao Hospital | 3.9 | 18 | 43 | 53 | 63.53 |
| B | 4.3 | 18 | 44 | 12 | 75.79 |
| **All Range** | 4.3 | 0 | 4 | 11 | **60.52** |

## 2.4 STUDY OF THE QUALITATIVE AND QUANTATIVE IMPACT OF 19 BRIDGES ACROSS CHAO PHRAYA RIVER

The gross regional domestic product (GRDP) in BMA accounts for about 43% of the country's GRDP and Bangkok Metropolitan Area has played its role in the economic activities in Thailand. Moreover, Thailand has spurred the development in surrounding countries as an economic center in the region, and plays the role to establish the presence of the Southeast Asian economic bloc in the world economy.

Therefore, the continuous economic development in BMA is indispensable, and the bridge development on Chao Phraya River has contributed to the expansion of social and economical activities. This project development will also support the streamlining and upgrading of the economic activities in BMA, which is essential to the economic growth.

Previously, the contribution of the past 20 bridge developments in Chao Phraya River, including those funded by Japanese assistance, is confirmed based on clarification results of quantitative and qualitative effect of the bridge development in the past.

### 2.4.1 CONSTRUCTION OF BRIDGES ON THE CHAO PHRAYA AND EXPANSION OF THE URBAN AREA

Historically, the Chao Phraya River has served as a substantial hindrance to the expansion of the Bangkok urban area.

As seen in Figure 2.4.1, Bangkok in 1900 was an urban agglomeration on one side of the Chao Phraya River, with a population of 600,000. When the first bridge over the Chao Phraya,

Rama VI Bridge, a railway bridge, was built in 1926, and then Memorial Bridge in 1932, these marked the start of the expansion of the urban area to the western bank of the river.

Today, there are 20 bridges constructed over the Chao Phraya. In this sub-section the relationship between the expansion of the urban area and the construction of new bridges in BMR will be analyzed.

**Table 2.4.1 Chronology of Bridges in Bangkok Metropolitan Region**

| | Name | Year | 1900's | 1910's | 1920's | 1930's | 1940's | 1950's | 1960's | 1970's | 1980's | 1990's | 2000's | 2010's |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North | Pathum Thani | 1984 | | | | | | | | | | | | |
| | Pathum Thani 2 | 2009 | | | | | | | | | | | | |
| | Nonthaburi | 1959 | | | | | | | | | | | | |
| | Rama Ⅳ | 2006 | | | | | | | | | | | | |
| | New Phra Nangklao | 2008 | | | | | | | | | | | | |
| | Phra Nangklao | 1985 | | | | | | | | | | | | |
| | New Nonthaburi | – | | | | | | | | | | | | |
| | Rama Ⅴ | 2002 | | | | | | | | | | | | |
| | Rama Ⅶ | 1992 | | | | | | | | | | | | |
| | Rama Ⅵ (Railway) | 1926 | | | | | | | | | | | | |
| | Krung Thon | 1958 | | | | | | | | | | | | |
| | Rama Ⅷ | 2002 | | | | | | | | | | | | |
| | Pinklao | 1973 | | | | | | | | | | | | |
| | Memorial | 1932 | | | | | | | | | | | | |
| | Phra Pokklao | 1984 | | | | | | | | | | | | |
| | Taksin | 1982 | | | | | | | | | | | | |
| | Rama Ⅲ | 2000 | | | | | | | | | | | | |
| | Krung Thep | 1959 | | | | | | | | | | | | |
| | Rama Ⅸ | 1987 | | | | | | | | | | | | |
| | Industrial Ring Road | 2006 | | | | | | | | | | | | |
| South | Kanchanapisek | 2007 | | | | | | | | | | | | |

As discussed earlier, the urban area of Bangkok in 1900 was limited to the east bank of the Chao Phraya River. The construction of Memorial Bridge in 1932 has brought new urbanization to the west bank area, which is generally observed in the development of new residential settlements in Thonburi and Bangkok Noi areas, but the overall urbanization on the west bank of the river took place during the years 1958 and 1968. It was during this period in the year 1959, when the Krung Thep Bridge, the third bridge in this district was built. This new bridge marked the commencement of the grid-like road network in the area, which presumably allowed for unrestricted traffic flow. In just about the same period as in Thonburi, new urban projects have been developed in Bangkok Noi area between the Krung Thon Bridge built in 1953 and Memorial Bridge. In 1968, the total population in BMA was about 2.7 million, which is more than 4.5 times that in 1900.

The situation in the north area of Bangkok Noi after the development as depicted in Figures 2.4.2 in 1968 and 1994 has demonstrated the gradual expansion of the urban area which are supported and serviced by the Krung Thon Bridge in 1953, Pinklao Bridge in 1973 and most recently, the Rama VII Bridge in 1992.

Figure 2.4.3 depicts the urbanization condition of Bangkok in 2004. There are a number of bridges over the Chao Phraya, such as Rama V Bridge on the north to Rama IX Bridge on the south, roughly at the interval of 2 to 3 km from one another, and the urban area on the west bank of the river is almost continuously urbanized due presumably to the combined effect of the bridges.

In regards to Nonthaburi Province, the interval between Rama V Bridge and the next bridge upstream, Phra Nangklao Bridge, is about five km. This is one of the reasons why urbanization does not reach beyond the river. If and when the Project is built, the interval between Rama V Bridge, the Project bridge and Phra Nangklao Bridge will be in the range of two to three km. It is estimated that urbanization shall go beyond the river from Nonthaburi to the west bank area, forming a new urban area with about two km belt, similar to what happened in Thongburi and Bangkok Noi areas.

As discussed above, in order for the urban area to go beyond the Chao Phraya, the construction of new bridges at an interval of two to three km would be necessary. The expansion of the urbanization in Bangkok may take the northern direction naturally, and the Project bridge now prepared shall accelerate widespread urbanization on the west bank of the river, combined with the construction of Ratchaphruek Road as a north-south arterial road.

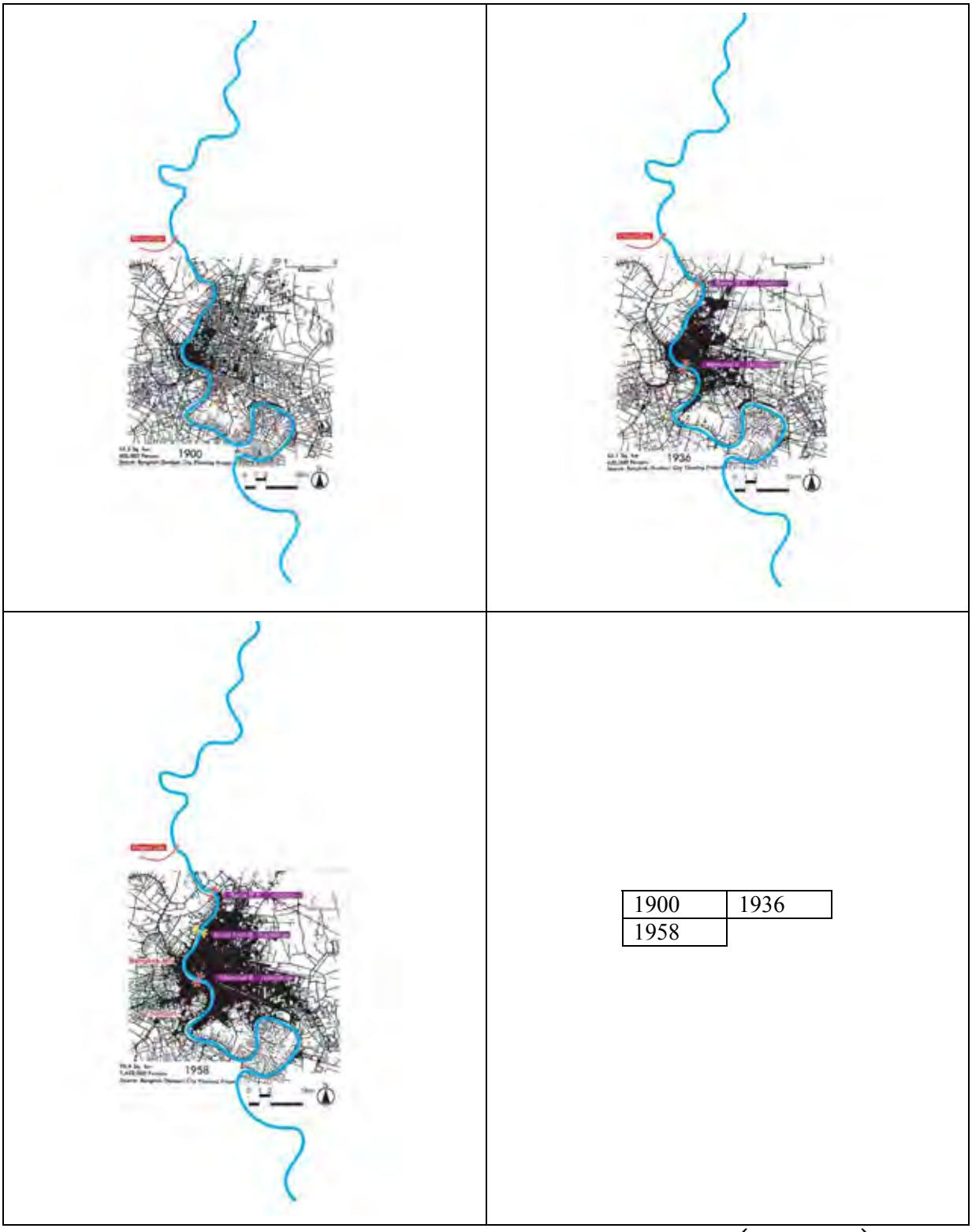
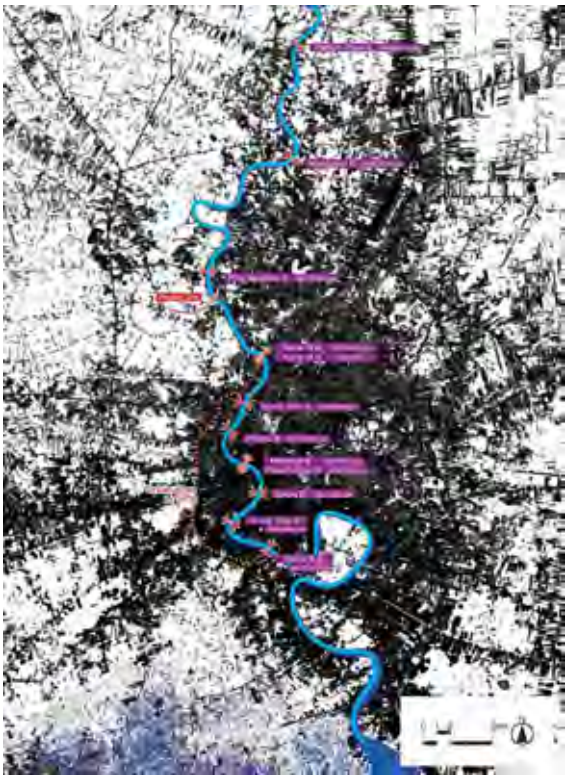
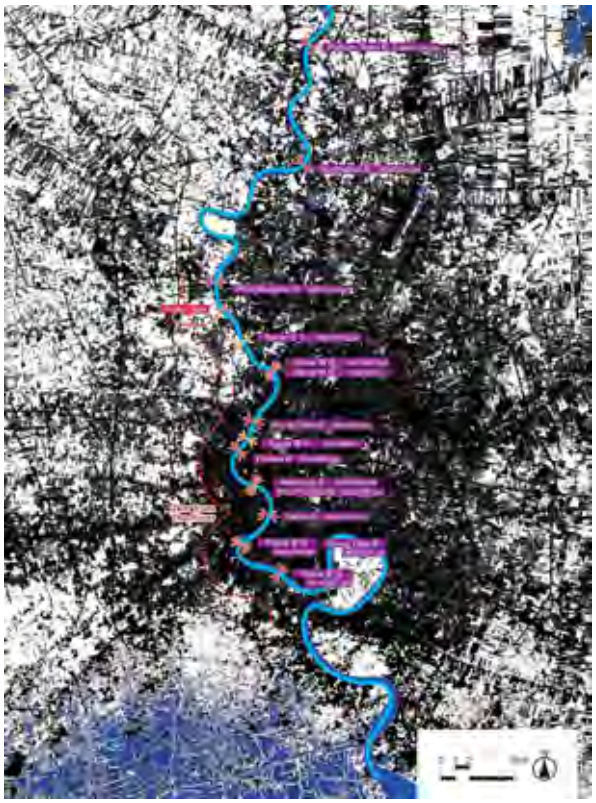



**Figure 2.4.1 Transition of Urban Area Expansion in BMA (1/2)（1900 - 1958）**



| | |
|---|---|
| 1968 | 1994 |
| 2004 | |

**Figure 2.4.2 Transition of Urban Area Expansion in BMA (2/2)（1968 - 2004）**

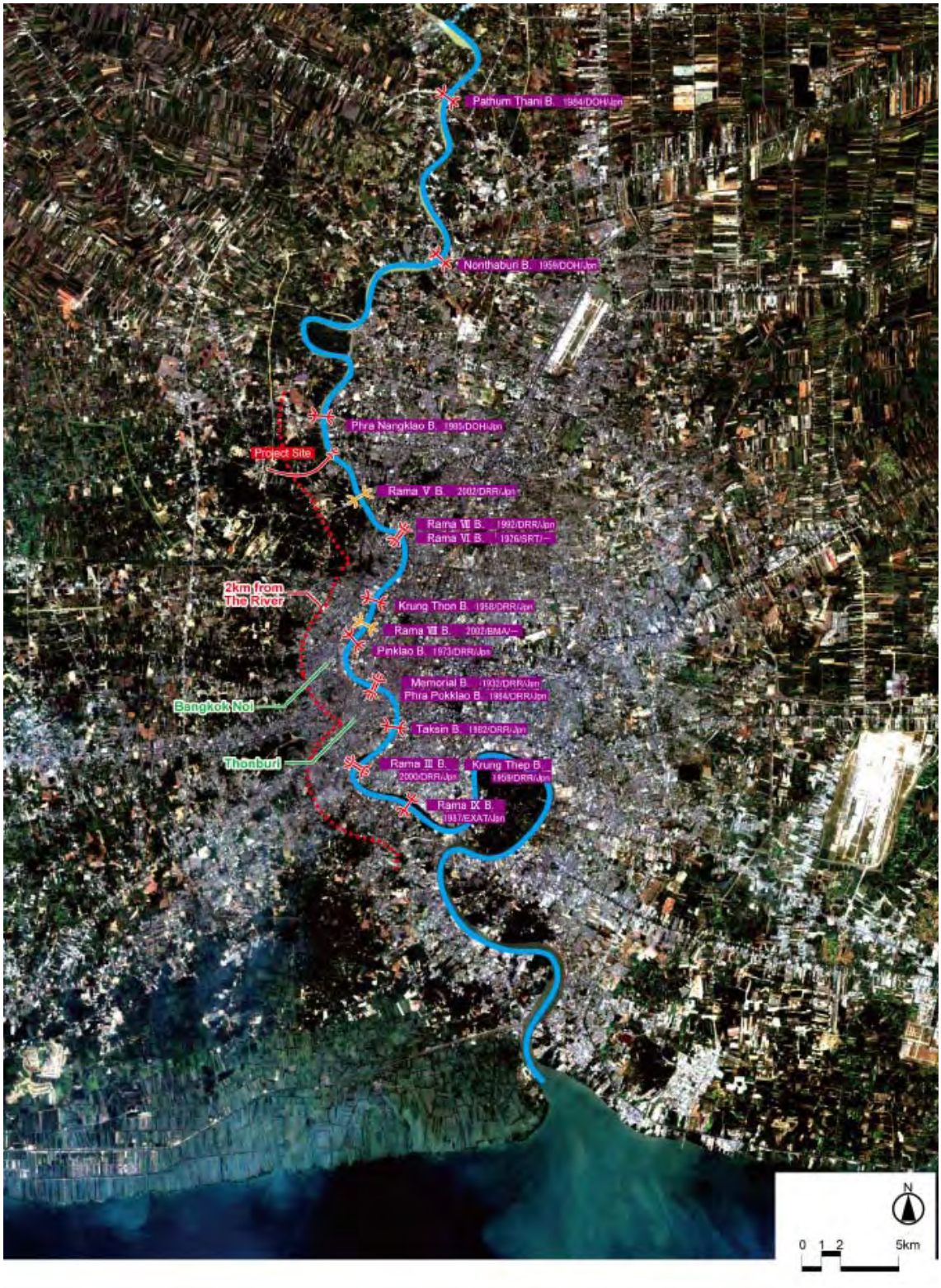



**Figure 2.4.3 Urban Area of BMA in 2004 Based on Landsat Data**

## 2.4.2 QUANTITATIVE EFFECTS

It was clarified in the foregoing paragraph that there are implications between the bridge development at Chao Phraya River and the urbanization of the district on its west bank.

In general, the generated and attracted traffic volume of the city is in proportion to its urban

size. Therefore, it is simple to visualize the trend of the urbanization in the west bank of Chao Phraya River in connection with the transition of the bridge traffic volume in the past.

Moreover, appropriateness of scale and schedule of the past bridge developments including the developments funded by Japanese assistance are assessed from the aspect of demand-supply balance to put the assessment results to practical use of verification for the project.

Transition of traffic volume and congestion ratio at sections of bridges crossing the Chao Phraya River is analyzed to clarify the quantitative effect from the above-mentioned viewpoint in this chapter.

### (1) Transition of Traffic Volume

Since there is no continuous and uniform traffic data of the 20 bridges crossing the Chao Phraya River in the past due to the different bridge administrators as shown in Table 2.4.2 and 2.4.3, collected traffic data in this survey was corrected to compare with each other. The correction for the traffic data was made based on the following assumption to compare the traffic volume uniformly:

- Morning Peak Hour Traffic Ratio: 0.06
- Proportion between PCU traffic volume and actual traffic volume: 1.2/1.0

Corrected traffic volume of each bridge is tabulated in Table 2.4.4 to Table 2.4.6.

Traffic volume after bridge operation on most of the bridges shows upward trend until close to the saturation capacity. However, the traffic volume on each bridge became stable or decreased in these years because new bridge developments have eased traffic flow. While the average growth rate of traffic volume on each bridge is 1.2% per year as shown in Table 2.4.6, the growth rate is still lower than the 3.5% per year of vehicle registration growth rate in BMA for years 2000 to 2007.

## Table 2.4.2 Sources of Traffic Data used in the Survey (1/2)

| Sl No. | Bridge Name | Data Details | | Survey Date | Source, Executing Agency |
|---|---|---|---|---|---|
| 1 | Pathum Thani | AADT, Vehicle/day | | | Average Annual Daily Traffic on Highway 2007, Bureau of Highway Safety, DOH |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 2 | 2nd Phatum Thani | | | | |
| 3 | Nonthaburi-Pathum Thani | pcu/day | AM Peak | 1993 | The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994 |
| | | pcu/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | exc. MC | 1981/6/30 (Tue) | Feasibility Study for Rama VI Bridge in the Kingdom of Thailand, JICA, 1981 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |
| 4 | Pak Kret (Rama IV) | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 5 | New Phra Nangklao | | | | |
| 6 | Phra Nangklao | pcu/day | AM Peak | 1993 | The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994 |
| | | pcu/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 7 | Wat Nakorn-In (Rama V) | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 8 | Rama VII | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | pcu/day | AM Peak | 1993 | The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 9 | Rama VI (Rail Bridge) | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| 10 | Krungthon | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Morning Peak (pcu/h) | 7:00-8:00 | | Ratcha Phruk Road Project Benefit Monitoring and Evaluation Report, 2005 |
| | | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLsurvey, OTP, 2008 |
| 11 | Rama VIII | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |

# Table 2.4.3 Sources of Traffic Data used in the Survey (2/2)

| Sl No. | Bridge Name | Data Details | | Survey Date | Source, Executing Agency |
|---|---|---|---|---|---|
| 12 | Phra PinkLao | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |
| 13 | Memorial (Phra Phutta Yodf) | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Vehicle/day | | 1990/11/Date is NA | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 14 | Phra Pok Klao (New Memorial) | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | Vehicle/day | | 1990/11/Date is NA | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DOR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDMLSurvey, OTP, 2008 |
| 15 | Taksin (Sathon) | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |
| | | Vehicle/day | 24 hr | 1996/9/17～1996/10/1 | The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 1996/9/17～1996/10/1 | The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000 |
| 16 | Krung Thep | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Vehicle/day | | | PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC) |
| | | AADT, Vehicle/day | | | Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC |
| | | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |
| | | Vehicle/day | 24 hr | 1996/9/17～1996/10/1 | The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000 |
| 17 | New Krung Thep (Rama III) | Vehicle/day | Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August | | DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2005/6/14(Tue) | The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 2008/7/15(Tue) | TDML Survey, OTP, 2008 |
| 18 | Rama 9 | Vehicle/day | | 1990/11/ | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| | | Vehicle/day | 24 hr | 1996/9/17～1996/10/1 | The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000 |
| | | Morning Peak (pcu/h) | 7:00-8:00 | 1996/9/17～1996/10/1 | The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000 |
| 19 | Industrial Ring Road (North) | Vehicle/day | 7:00-9:00<br>16:00-19:00<br>0:00-24:00 | 2006/11/21～2007/2/28<br>2007/11/15～2008/2/28 | Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA |
| 20 | Kanchanapisek | | | | |

**Table 2.4.4 Transitional Traffic Volume on Bridges crossing Chao Phraya River (1/3)**

(pcu/day)

| | Bridge Name | Administrator | Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
| 1 | Pathum Thani | DOH | | | | | | | | | | | | | | | |
| 2 | 2nd Phatum Thani | DOH | | | | | | | | | | | | | | | |
| 3 | Nonthaburi-Pathum Thani | DOH | | | | | | | | | | | | | | | 8,736 |
| 4 | Pak Kret（Rama IV） | DRR | | | | | | | | | | | | | | | |
| 5 | New Phra Nangklao | DOH | | | | | | | | | | | | | | | |
| 6 | Phra Nangklao | DOH | | | | | | | | | | | | | | | |
| 7 | Wat Nakorn-In (Rama V) | DRR | | | | | | | | | | | | | | | |
| 8 | Rama VII | DRR | | | | | | | | | | | | | | | |
| 9 | Rama VI (Rail Bridge) | SRT | 7,200 | | | | | | 16,800 | | 21,600 | | | 24,000 | | | 31,200 |
| 10 | Krungthon | DRR | 33,600 | | | | | | 48,000 | | 45,600 | | | 63,600 | | | 58,800 |
| 11 | Rama VIII | BMA | | | | | | | | | | | | | | | |
| 12 | Phra PinkLao | DRR | | | | | | | | | 68,400 | | | 98,400 | | | 105,600 |
| 13 | Memorial (Phra Phutta Yodf) | DRR | 127,200 | | | | | | 171,600 | | 127,200 | | | 118,800 | | | 141,600 |
| 14 | Phra Pok Klao (New Memorial) | DRR | | | | | | | | | | | | | | | |
| 15 | Taksin (Sathon) | DRR | | | | | | | | | | | | | | | |
| 16 | Krung Thep | DRR | 25,200 | | | | | | 46,800 | | 49,200 | | | 64,800 | | | 75,600 |
| 17 | New Krung Thep (Rama III) | DRR | | | | | | | | | | | | | | | |
| 18 | Rama 9 | EXAT | | | | | | | | | | | | | | | |
| 19 | Industrial Ring Road | DRR | | | | | | | | | | | | | | | |
| 20 | Kanchanapisek | DOH | | | | | | | | | | | | | | | |

Note: As the Rama VI Bridge was a single track railway cum road bridge until late 1992 when the construction of the Rama VII Bridge was completed, vehicle traffics on the Rama VI Bridge were recorded.

**Table 2.4.5 Transitional Traffic Volume on Bridges crossing Chao Phraya River (2/3)**

(pcu/day)

| | Bridge Name | Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
| 1 | Pathum Thani | | | | | | | | | | | | | | | |
| 2 | 2nd Phatum Thani | | | | | | | | | | | | | | | |
| 3 | Nonthaburi-Pathum Thani | | | | | | | | | 25,191 | | | 35,956 | | | |
| 4 | Pak Kret（Rama IV） | | | | | | | | | | | | | | | |
| 5 | New Phra Nangklao | | | | | | | | | | | | | | | |
| 6 | Phra Nangklao | | | | | | | | | 50,208 | | | 43,279 | | | |
| 7 | Wat Nakorn-In (Rama V) | | | | | | | | | | | | | | | |
| 8 | Rama VII | | | | | | | | | | | | 85,461 | | 163,273 | |
| 9 | Rama VI (Rail Bridge) | 32,400 | | | | | 49,200 | | | 59,683 | | | | | | |
| 10 | Krungthon | 60,000 | | 75,600 | | | 86,640 | | | 88,606 | 138,762 | | | | 116,533 | |
| 11 | Rama VIII | | | | | | | | | | | | | | | |
| 12 | Phra PinkLao | 106,800 | | 147,600 | | | 162,360 | | | 159,523 | 255,977 | | | | 229,648 | |
| 13 | Memorial (Phra Phutta Yodf) | 140,400 | | 176,400 | | | 88,320 | | | 78,922 | 109,754 | | | | 111,157 | |
| 14 | Phra Pok Klao (New Memorial) | | | | | | 144,120 | | | 153,238 | 193,529 | | | | 172,980 | |
| 15 | Taksin (Sathon) | 79,200 | | 157,200 | | | 169,560 | | | 174,316 | 256,044 | | | | 227,023 | 116,733 |
| 16 | Krung Thep | 57,600 | | | | | 82,200 | | | 104,467 | 119,681 | | | | 122,316 | 81,840 |
| 17 | New Krung Thep (Rama III) | | | | | | | | | | | | | | | |
| 18 | Rama 9 | | | | | | | | | 74,902 | | | | | | 135,433 |
| 19 | Industrial Ring Road | | | | | | | | | | | | | | | |
| 20 | Kanchanapisek | | | | | | | | | | | | | | | |

**Table 2.4.6 Transitional Traffic Volume on Bridges crossing Chao Phraya River (3/3)**

(pcu/day)

| | Bridge Name | Year | | | | | | | | | | | | | Growth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Rate |
| 1 | Pathum Thani | | | | | | | | | | 85,716 | | 79,683 | | 0.96 |
| 2 | 2nd Phatum Thani | | | | | | | | | | | | | | - |
| 3 | Nonthaburi-Pathum Thani | | | | | | | | | | | | 52,000 | | 1.07 |
| 4 | Pak Kret(Rama IV) | | | | | | | | | | 89,995 | 89,729 | 75,150 | | 0.91 |
| 5 | New Phra Nangklao | | | | | | | | | | | | | | - |
| 6 | Phra Nangklao | | | | | | | | | 86,333 | | | 71,817 | | 1.02 |
| 7 | Wat Nakorn-In (Rama V) | | | | | | | | | 82,733 | | | 130,867 | | 1.17 |
| 8 | Rama VII | | | | 172,303 | | 142,916 | | | 58,667 | 113,072 | 119,485 | 46,617 | | 0.96 |
| 9 | Rama VI (Rail Bridge) | | | | | | | | | | | | | | - |
| 10 | Krungthon | | | | 123,802 | | 107,536 | | | 49,933 | 80,384 | 91,565 | 31,750 | | 1.00 |
| 11 | Rama VIII | | | | | | | | | 69,967 | 85,916 | 85,516 | 61,100 | | 0.96 |
| 12 | Phra PinkLao | | | | 235,487 | | 207,144 | | | 105,750 | 120,864 | 124,386 | 148,900 | | 1.02 |
| 13 | Memorial (Phra Phutta Yodf) | | | | 98,178 | 0 | 105,114 | | | 54,000 | 62,708 | 69,319 | 56,000 | | 0.98 |
| 14 | Phra Pok Klao (New Memorial) | | | | 176,296 | | 196,172 | | | 102,333 | 121,961 | 133,813 | 140,633 | | 1.00 |
| 15 | Taksin (Sathon) | | | 227,225 | 210,265 | | 203,502 | | | 81,067 | 99,210 | 131,740 | 90,933 | | 1.01 |
| 16 | Krung Thep | 90,437 | 93,950 | 112,327 | 93,035 | | 117,043 | | | 70,783 | 67,637 | 62,074 | 70,967 | | 1.03 |
| 17 | New Krung Thep (Rama III) | | | | 83,015 | | 79,284 | | | 61,517 | | | 34,833 | | 0.90 |
| 18 | Rama 9 | | | 144,391 | | | | | | | | | | | 1.08 |
| 19 | Industrial Ring Road | | | | | | | | | | 54,646 | 61,460 | | | 1.12 |
| 20 | Kanchanapisek | | | | | | | | | | | | | | - |
| | | | | | | | | | | | | | Average | | 1.012 |

## (1) Transition of Congestion Ratio

The congestion ratio of each bridge in the past was calculated to assess the validity of

demand-supply balance between the bridge developments and traffic demand as shown in Table 2.4.7 to Table 2.4.9. In the congestion rate calculation, the following assumption was set to compare the congestion ratio uniformly based on the example of traffic survey result in BMR:

- Lane Capacity: 1,500 pcu

As mentioned earlier, the construction of bridges on Chao Phraya River has been implemented with appropriate scale and schedule considering the infrastructure capacity corresponding to the increase of traffic demand. Table 2.4.7 to Table 2.4.9 show the effect for decentralization of traffic demand with the new bridge constructions.

**Table 2.4.7 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (1/3)**

| | Bridge Name | Number of Lanes | Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
| 1 | Pathum Thani | 2 | | | | | | | | | | | | | | | |
| 2 | 2nd Phatum Thani | 2 | | | | | | | | | | | | | | | |
| 3 | Nonthaburi-Pathum Thani | 2 | | | | | | | | | | | | | | | 0.17 |
| 4 | Pak Kret(Rama IV) | 6 | | | | | | | | | | | | | | | |
| 5 | New Phra Nangklao | 6 | | | | | | | | | | | | | | | |
| 6 | Phra Nangklao | 4 | | | | | | | | | | | | | | | |
| 7 | Wat Nakorn-In (Rama V) | 6 | | | | | | | | | | | | | | | |
| 8 | Rama VII | 6 | | | | | | | | | | | | | | | |
| 9 | Rama VI (Rail Bridge) | 2 | 0.14 | | | | | | 0.34 | | 0.43 | | | 0.48 | | | 0.62 |
| 10 | Krungthon | 4 | 0.34 | | | | | | 0.48 | | 0.46 | | | 0.64 | | | 0.59 |
| 11 | Rama VIII | 4 | | | | | | | | | | | | | | | |
| 12 | Phra PinkLao | 6 | | | | | | | | | 0.46 | | | 0.66 | | | 0.7 |
| 13 | Memorial (Phra Phutta Yodf) | 6 | 0.85 | | | | | | 1.14 | | 0.85 | | | 0.79 | | | 0.94 |
| 14 | Phra Pok Klao (New Memorial) | 6 | | | | | | | | | | | | | | | |
| 15 | Taksin (Sathon) | 6 | | | | | | | | | | | | | | | |
| 16 | Krung Thep | 4 | 0.25 | | | | | | 0.47 | | 0.49 | | | 0.65 | | | 0.76 |
| 17 | New Krung Thep (Rama III) | 6 | | | | | | | | | | | | | | | |
| 18 | Rama 9 | 6 | | | | | | | | | | | | | | | |
| 19 | Industrial Ring Road | 6 | | | | | | | | | | | | | | | |
| 20 | Kanchanapisek | 6 | | | | | | | | | | | | | | | |

**Table 2.4.8 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (2/3)**

| | Bridge Name | Number of Lanes | Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
| 1 | Pathum Thani | 2 | | | | | | | | | | | | | | | |
| 2 | 2nd Phatum Thani | 2 | | | | | | | | | | | | | | | |
| 3 | Nonthaburi-Pathum Thani | 2 | | | | | | | | | 0.5 | | | 0.72 | | | |
| 4 | Pak Kret(Rama IV) | 6 | | | | | | | | | | | | | | | |
| 5 | New Phra Nangklao | 6 | | | | | | | | | | | | | | | |
| 6 | Phra Nangklao | 4 | | | | | | | | | 0.5 | | | 0.43 | | | |
| 7 | Wat Nakorn-In (Rama V) | 6 | | | | | | | | | | | | | | | |
| 8 | Rama VII | 6 | | | | | | | | | | | | 0.57 | | 1.09 | |
| 9 | Rama VI (Rail Bridge) | 2 | 0.65 | | | | | 0.98 | | | 1.19 | | | | | | |
| 10 | Krungthon | 4 | 0.6 | | 0.76 | | | 0.87 | | | 0.89 | 1.39 | | | | 1.17 | |
| 11 | Rama VIII | 4 | | | | | | | | | | | | | | | |
| 12 | Phra PinkLao | 6 | 0.71 | | 0.98 | | | 1.08 | | | 1.06 | 1.71 | | | | 1.53 | |
| 13 | Memorial (Phra Phutta Yodf) | 6 | 0.94 | | 1.18 | | | 0.59 | | | 0.53 | 0.73 | | | | 0.74 | |
| 14 | Phra Pok Klao (New Memorial) | 6 | | | | | | 0.96 | | | 1.02 | 1.29 | | | | 1.15 | |
| 15 | Taksin (Sathon) | 6 | 0.53 | | 1.05 | | | 1.13 | | | 1.16 | 1.71 | | | | 1.51 | 0.78 |
| 16 | Krung Thep | 4 | 0.58 | | | | | 0.82 | | | 1.04 | 1.2 | | | | 1.22 | 0.82 |
| 17 | New Krung Thep (Rama III) | 6 | | | | | | | | | | | | | | | |
| 18 | Rama 9 | 6 | | | | | | | | | 0.5 | | | | | | 0.9 |
| 19 | Industrial Ring Road | 6 | | | | | | | | | | | | | | | |
| 20 | Kanchanapisek | 6 | | | | | | | | | | | | | | | |

**Table 2.4.9 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (3/3)**

| | Bridge Name | Number of Lanes | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| 1 | Pathum Thani | 2 | | | | | | | | | | 1.71 | | 1.59 | |
| 2 | 2nd Phatum Thani | 2 | | | | | | | | | | | | | |
| 3 | Nonthaburi-Pathum Thani | 2 | | | | | | | | | | | | 1.04 | |
| 4 | Pak Kret(Rama IV) | 6 | | | | | | | | | | 0.6 | 0.6 | 0.5 | |
| 5 | New Phra Nangklao | 6 | | | | | | | | | | | | | |
| 6 | Phra Nangklao | 4 | | | | | | | | | 0.86 | | | 0.72 | |
| 7 | Wat Nakorn-In (Rama V) | 6 | | | | | | | | | 0.55 | | | 0.87 | |
| 8 | Rama VII | 6 | | | | 1.15 | | 0.95 | | | 0.39 | 0.75 | 0.8 | 0.31 | |
| 9 | Rama VI (Rail Bridge) | 2 | | | | | | | | | | | | | |
| 10 | Krungthon | 4 | | | | 1.24 | | 1.08 | | | 0.50 | 0.8 | 0.92 | 0.32 | |
| 11 | Rama VIII | 4 | | | | | | | | | 0.70 | 0.86 | 0.86 | 0.61 | |
| 12 | Phra PinkLao | 6 | | | | 1.57 | | 1.38 | | | 0.71 | 0.81 | 0.83 | 0.99 | |
| 13 | Memorial (Phra Phutta Yodf) | 6 | | | | 0.65 | | 0.7 | | | 0.36 | 0.42 | 0.46 | 0.37 | |
| 14 | Phra Pok Klao (New Memorial) | 6 | | | | 1.18 | | 1.31 | | | 0.68 | 0.81 | 0.89 | 0.94 | |
| 15 | Taksin (Sathon) | 6 | | | 1.51 | 1.4 | | 1.36 | | | 0.54 | 0.66 | 0.88 | 0.61 | |
| 16 | Krung Thep | 4 | 0.9 | 0.94 | 1.12 | 0.93 | | 1.17 | | | 0.71 | 0.68 | 0.62 | 0.71 | |
| 17 | New Krung Thep (Rama III) | 6 | | | | 0.55 | | 0.53 | | | 0.41 | | | 0.23 | |
| 18 | Rama 9 | 6 | | | 0.96 | | | | | | | | | | |
| 19 | Industrial Ring Road | 6 | | | | | | | | | | 0.36 | 0.41 | | |
| 20 | Kanchanapisek | 6 | | | | | | | | | | | | | |

### (2) Economic Internal Rate of Return (EIRR)

The economic evaluation index such as EIRR of the 20 bridges crossing Chao Phraya River was tabulated in Table 2.4.10 excluding the bridges developed without F/S which was constructed during old times or urgent project and bridges conducted F/S as integrated project with access roads.

Since most of the bridge developments were carried out after traffic demand for bridges became obvious, the EIRR for most of the bridge development projects were estimated at 20% or more. While, economic effects of the bridges missing their EIRR are obviously high because the high project benefits can be explained based on the high vehicle congestion ratio as shown in Table 2.4.7 to Table 2.4.9.

**Table 2.4.10 Project Evaluation Results of Bridges Crossing Chao Phraya River**

| | Bridge Name | Administrator | Operation Year | NPV (100 mil. Baht) | EIRR | B/C | Source |
|---|---|---|---|---|---|---|---|
| 1 | Pathum Thani | DOH | 1984 | | 27.2 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| 2 | 2nd Phatum Thani | DOH | 2009 | | | | |
| 3 | Nonthaburi-Pathum Thani | DOH | 1959 | | | | |
| 4 | Pak Kret (Rama IV) | DRR | 2006 | 33.95 | 33.9 | 3.39 | The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994 |
| 5 | New Phra Nangklao | DOH | 2008 | | | | |
| 6 | Phra Nangklao | DOH | 1985 | | 20.9 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| 7 | Wat Nakorn-In (Rama V) | DRR | 2002 | 8.86 | 17.4 | | Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991 |
| 8 | Rama VII | DRR | 1992 | 6.59 | 20.6 | 1.91 | The feasibility study on the Rama VI Bridge construction project, 1981.12, JICA |
| 9 | Rama VI (Rail Bridge) | SRT | 1926 | | | | |
| 10 | Krungthon | DRR | 1958 | | | | |
| 11 | Rama VIII | BMA | 2002 | | | | |
| 12 | Phra PinkLao | DRR | 1973 | | 12.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| | | | | | 45.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| 13 | Memorial (Phra Phutta Yodf) | DRR | 1932 | | | | |
| | | | | | | | |
| 14 | Phra Pok Klao (New Memorial) | DRR | 1984 | | 17.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| | | | | | 15.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| 15 | Taksin (Sathon) | DRR | 1982 | | 32.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| | | | | | 44.0 | | Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC |
| 16 | Krung Thep | DRR | 1959 | | | | |
| 17 | New Krung Thep (Rama III) | DRR | 2000 | 12.47 | 20.7 | 2.09 | Feasibility Study on New Krungthep Bridge Construction and Thonburi Road Extension, 1987, JICA |
| 18 | Rama 9 | EXAT | 1987 | | | | |
| 19 | Industrial Ring Road | DRR | 2006 | 100.94 | 18.9 | 1.82 | The Feasibility Study and Initial Environmental Impact Study of Industrial Ring Road Project, 1996, MOI |
| 20 | Kanchanapisek | DOH | 2007 | 260.18 | 23.9 | 3.30 | The Feasibility Study on the Southern Outer Bangkok Ring Road Project in Kingdom of Thailand, March 2000, JETRO |

## 2.4.3 QUALITATIVE EFFECTS

As clarified in the foregoing paragraph, the bridges crossing the Chao Phraya River has contributed to provide the traffic demand between the east and west banks of Chao Phraya River, which kept on increasing correspondingly with the improving economic activities in BMA. On the other hand, it is obvious that the urbanization from the east bank of Chao Phraya River to the west bank has accelerated the socio-economic activities in the west bank, resulting to huge benefits for the area.

In this chapter, the indirect benefit of bridge development is examined through comparisons of social trend index between Nonthaburi prefecture, as the representative area on the west

bank of Chao Phraya River, and BMA, as the representative area on the east bank of Chao Phraya River.

Moreover, it is considered that the evaluation and expectation of effectiveness for the developed bridges and the project through interview survey of the municipalities and business establishments that seemed to be direct beneficiaries. Assessment of the impact by the project based on the above examination afterward is carried out.

## (1) Development and Social Trend on the Surrounding Area of Chao Phraya River

### 1) Population

Table 2.4.11 shows the transition of population and growth rate of population increase on Nonthaburi and BMA. The growth rate in BMA and Nonthaburi has stagnated in 1980 and 1990, respectively. The timings are corresponding to the bridge development of Krung Thon Bridge, the Pinklao Bridge, Memorial Bridge, Krung Thep Bridge in BMA during 1970s, Nonthaburi Bridge, Pathum Thani Bridge, and Phra Nangklao Bridge in Nonthaburi during the 1980s. This correspondence indicates that the bridge development influenced urbanization on vicinal areas. Moreover, the population growth in Nonthaburi has been kept to 2.5% or more in these days as shown in Figure 2.4.4, and it is expected that further urbanization of Nonthaburi will continue as a suburb city in BMA.

**Table 2.4.11 Population Growth in Surrounding Area of Chao Phraya River ('000)**

| | 1970 | 1980 | 1990 | 2000 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 3,077 | 5,153 | 5,546 | 5,680 | 5,844 | 5,634 | 5,658 | 5,695 | 5,716 |
| Growth Rate(%/year) | - | 5.29 | 0.74 | 0.24 | 0.95 | -3.60 | 0.40 | 0.70 | 0.40 |
| Nonthaburi | 269 | 386 | 668 | 859 | 924 | 942 | 972 | 999 | 1,024 |
| Growth Rate(%/year) | - | 3.68 | 5.64 | 2.55 | 2.46 | 1.90 | 3.20 | 2.80 | 2.50 |

Source：Bureau of Registration Administration, Department of Local Administration, Ministry of Interior

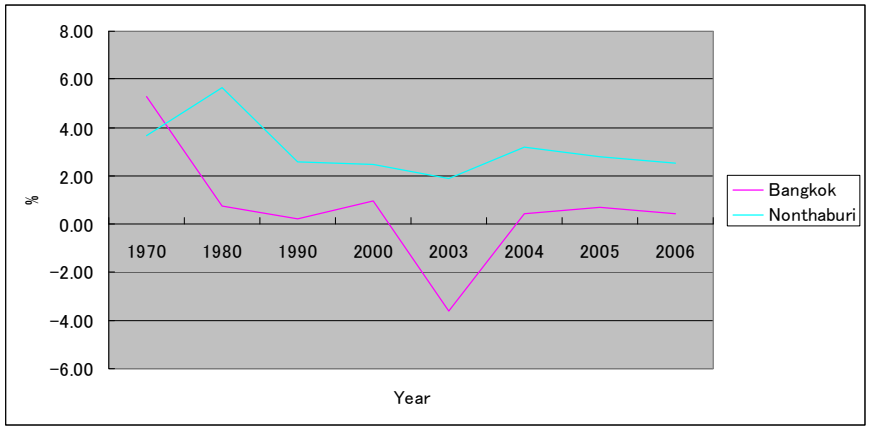



**Figure 2.4.4 Population Growth in Surrounding Area of Chao Phraya River**

### 2) Employees

Table 2.4.12 shows the transition of growth rate and number of employees of Nonthaburi and BMA. The trend of growth rate both in Nonthaburi and BMA are synchronized by the influence of economic performance. However, the growth rate of Nonthaburi has not been less than 0%, and it has kept above 1% to 5% of the growth rate of BMA.

**Table 2.4.12 Transitional Numbers and Growth Rate of Employees in the Surrounding Area of Chao Phraya River ('000)**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 3,165 | 3,379 | 3,135 | 3,185 | 3,094 | 3,457 | 3,200 | 3,213 | 3,192 |
| Growth Rate(%/year) | - | 6.80 | -7.20 | 1.60 | -2.90 | 11.70 | -7.40 | 0.40 | -0.70 |
| Nonthaburi | 201 | 173 | 155 | 166 | 176 | 201 | 202 | 216 | 217 |
| Growth Rate(%/year) | - | -13.90 | -10.40 | 7.10 | 6.00 | 14.20 | 0.50 | 6.90 | 0.50 |

Source：Year Book of Labour Protection and Welfare Statistics 2006, Department of Labour Protection and Welfare, Ministry of Labour

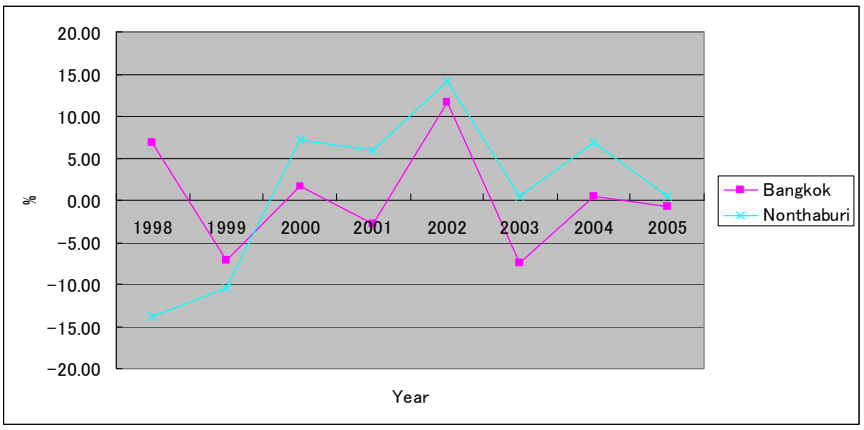



**Figure 2.4.5 Transitional Growth Rate of Employees in the Surrounding Area of Chao Phraya River**

### 3) Houses

Table 2.4.13 shows the transition of growth rate and numbers of houses of Nonthaburi and BMA. The growth rate from year 2000 and year 2002 of Nonthaburi and BMA were reduced, and the growth rate of BMA has been maintained to about 2% afterwards. After year 2002 Nonthaburi growth rate has been steadily maintained to about 4% and this indicates the high development potential of Nonthaburi as the bed town in BMR.

**Table 2.4.13 Transitional Numbers and Growth Rate of Houses in Surrounding Area of Chao Phraya River ('000)**

| | 1990 | 2000 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Bangkok | 1,176 | 1,905 | 1,963 | 2,020 | 2,050 | 2,091 | 2,150 | 2,207 |
| Growth Rate(%/year) | - | 4.94 | 1.51 | 2.90 | 1.50 | 2.00 | 2.80 | 2.70 |
| Nonthaburi | 148 | 365 | 377 | 388 | 404 | 421 | 449 | 468 |
| Growth Rate(%/year) | - | 9.45 | 1.63 | 2.90 | 4.10 | 4.20 | 6.70 | 4.20 |

Source：Bureau of Registration Administration, Department of Local Administration, Ministry of Interior

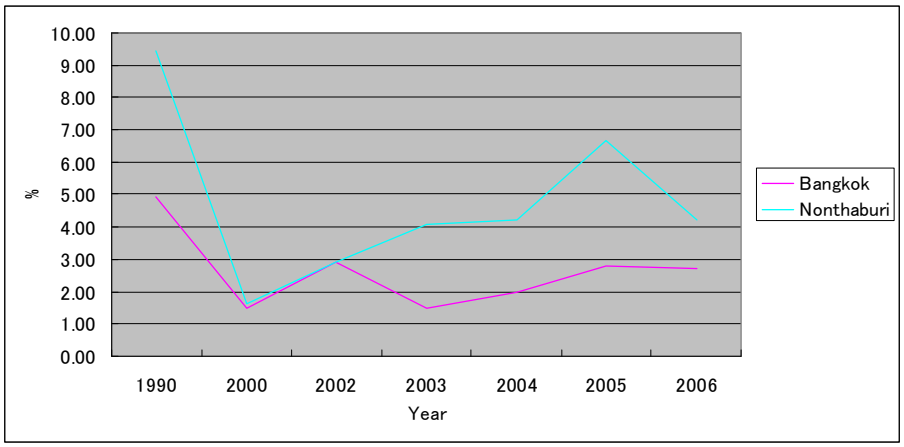



**Figure 2.4.6 Transitional Growth Rate of Houses in Surrounding Area of Chao Phraya River ('000)**

### 4) Business Enterprise

Table 2.4.14 shows the transition of growth rate and numbers of business enterprises of Nonthaburi and BMA. The transition of growth rate in BMA and Nonthaburi are synchronized. However, the data in 2003 and 2006 of Nonthaburi does not seem reliable because of its high fluctuation. The growth rate between 1998 and 2006 in Nonthaburi is 75% out of 8.5% in BMA, which indicates firm location in Nonthaburi has steadily proceeded compared to BMA.

**Table 2.4.14 Transitional Numbers and Growth Rate of Business Enterprise in Surrounding Area of Chao Phraya River**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 153,317 | 165,366 | 158,864 | 159,818 | 160,762 | 178,036 | 177,635 | 166,195 | 166,299 |
| Growth Rate(%/year) | - | 7.90 | -3.90 | 0.60 | 0.60 | 10.70 | -0.20 | -6.40 | 0.10 |
| Nonthaburi | 4,138 | 4,627 | 4,343 | 4,434 | 4,571 | 7,052 | 6,762 | 5,536 | 7,092 |
| Growth Rate(%/year) | - | 11.80 | -6.10 | 2.10 | 3.10 | 54.30 | -4.10 | -18.10 | 28.10 |

Source: Year Book of Labour Protection and Welfare Statistics 2006, Department of Labour Protection and Welfare, Ministry of Labour

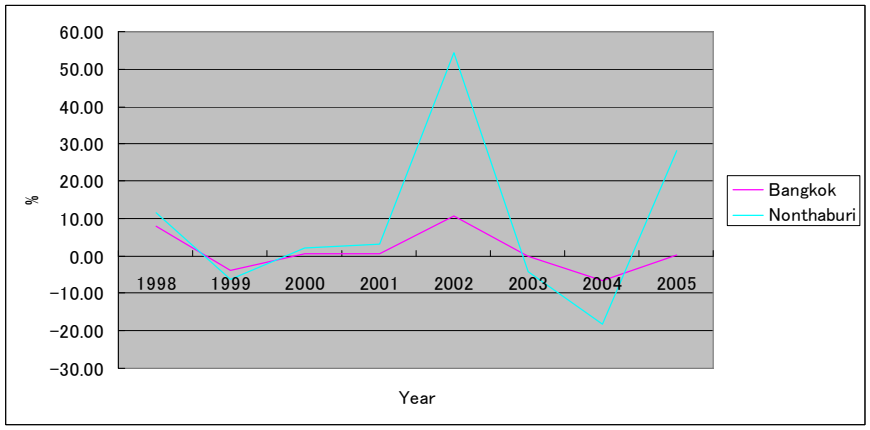



**Figure 2.4.7 Transitional Growth Rate of Business Enterprise in the Surrounding Area of Chao Phraya River**

### 5) Land Prices

Detailed data on land prices in Nonthaburi and BMA were not acquired. However, according to the post-evaluation survey for Rama V Bridge project conducted by JBIC, it was observed

by pre-post comparison that the land price increment was from 1 to 3 times in Ratcha Phruk Road and from 2 to 3.5 times in Nakorn In Road.

The bridge development commonly provides more significant accessibility than the roads, and a remarkable land price hike, especially near the bridge site on the westbank of Chao Phraya River, is obvious.

## (2) Interview Survey

### 1) Interview of Local Companies

Interview survey was conducted in order to gather qualitative effects caused by crossing bridge from companies located in some areas near the existing and new bridges. The survey areas were focused on the four areas where urbanization may have been brought from the east bank of the Chao Phraya River to the west bank by the effects of two or three bridges.

As a result, a total of 225 responses have been collected in this survey.

**Table 2.4.15 The Survey Areas of Interview**

| Area | | Bridges in Areas | Responses |
|---|---|---|---|
| Area A | Planning area<br>(Nonthaburi province) | New Bridge<br>Phra Nangklao (New Phra Nangklao)<br>Rama 5<br>(Rama 4) | 65<br>(+12 Japanese companies) |
| Area B | Bangkok Noi<br>(BMA) | Rama 7<br>Krung Thon<br>Rama 8<br>Pinklao | 66 |
| Area C | Thongburi<br>(BMA) | Memorial<br>Phra Pokklao<br>Taksin<br>Rama 3<br>Krung Thep | 72 |
| Area D | South of Thongburi<br>(BMA) | Rama 9 | 10 |

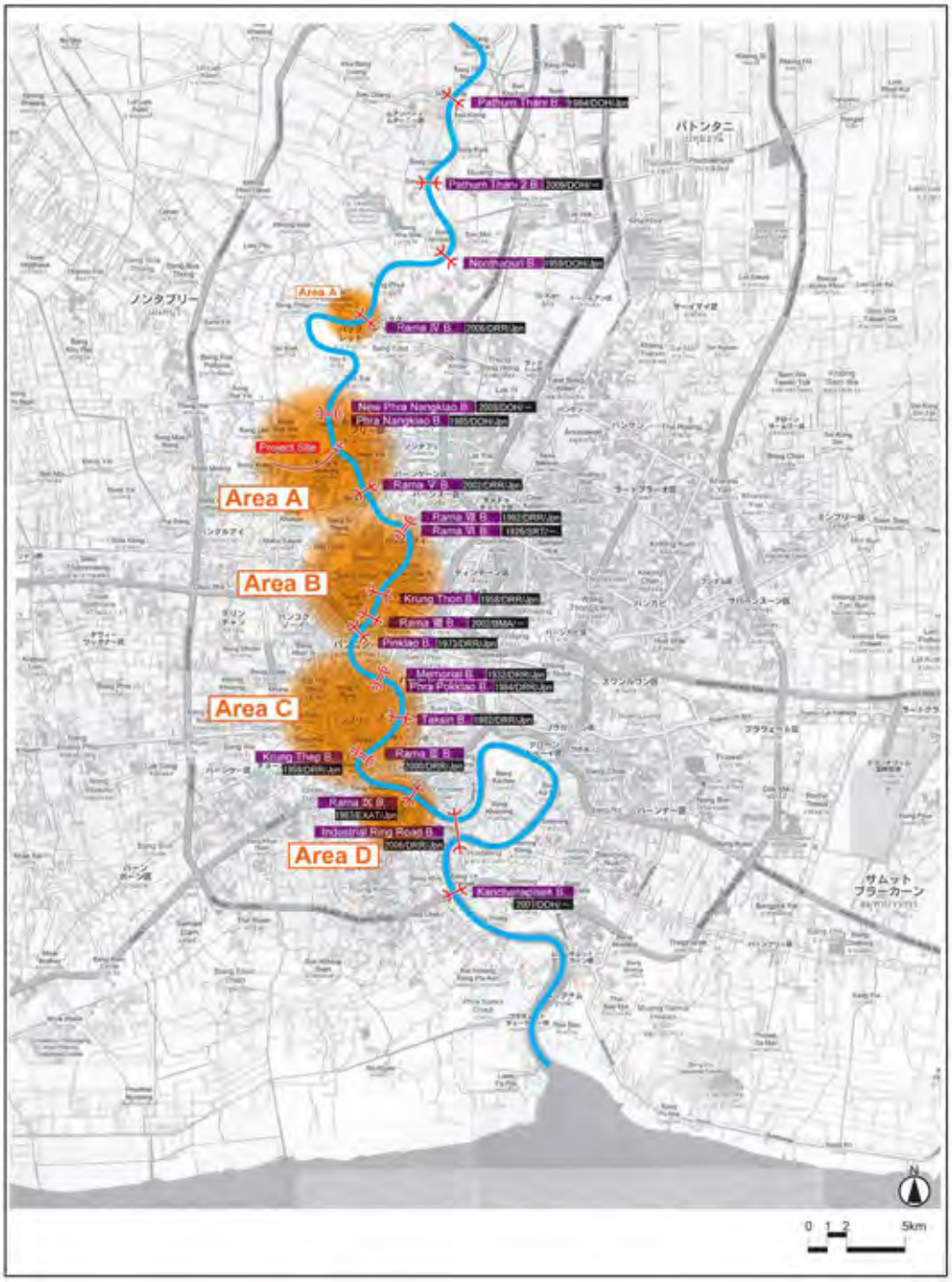



**Figure 2.4.8 The Survey Area of Interview**

The survey questionnaire consists of nine questions and each question is answered in five levels (much better benefit – much worthy impacts). The interviews were carried out by local surveyors through directly visiting the local companies, while the interviews to Japanese companies were done by the study team.

The details of the questionnaire form and the results are shown in Appendix-6.

**Table 2.4.16 Questions of Interviews**

| Items | Questions |
|---|---|
| For Business Value | Reduce Costs (fuel, time, etc), Increase Earnings, Sales and/or A Number of Customers, Improve Conveniences for Employees and/or Business Customers |
| For Accessibility | Reduce Times for Transport, Improve Access to Useful Facilities, Improve Access in Emergency (hospital) |
| For Lands Value | Increase Land Prices, Improve Life Environment (Noise, Atmosphere, etc), Reduce Traffic Accidents |

The results of this survey are summarized as follows:

### a) Result of Expectations for the New Bridge

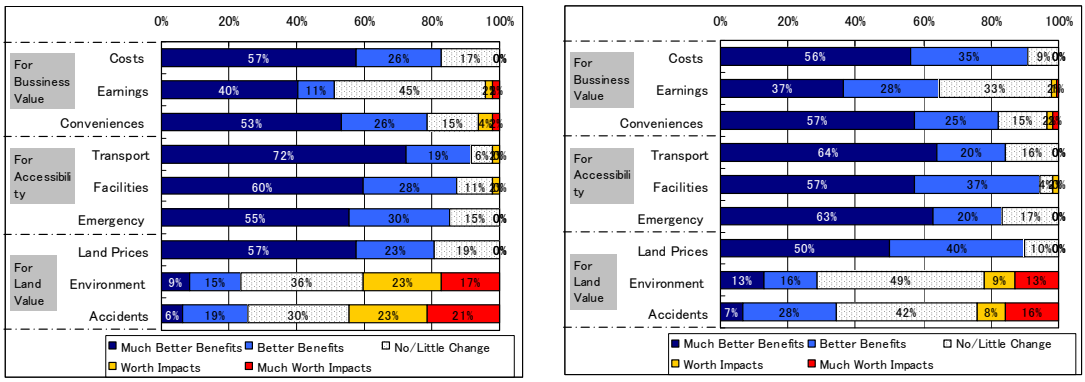



**Figure 2.4.9 The Results in Comparison between The New Bridge (L) and the others (R)**

Based on the comparison made between the new bridge and the other bridges, the result indicated that the new bridge has been highly expected in 5 out of 9 questions than the other bridges built in the past.

As the figure indicates, in regard to "Reduce Costs (fuel, time, etc)" for business value, 58% responded as "expect much better benefits" from the new bridge. It is likely that some reduction of costs and time in transport are expected. In the question of "Increase Earnings, Sales and/or a Number of Customers", positive expectations for the new bridge are 51% which is less than the others with 65%. One reason is to assume that the benefits for business values have not yet been sufficiently recognized by the local companies so far because it is not existing yet.

In regards to "Reduce Times for Transport" for accessibility, 91% responded positive in with the new bridge. This figure was 7% higher than that of the others, and this result clearly shows that there are many local companies that have high expectations.

In regards to "Improve Life Environment (Noise, Atmosphere, etc)" and "Reduce Traffic Accidents" for lands value, much worth impacts by the new bridge are their consideration. Generally speaking, this consideration and apprehensions are normal for the proposed projects. Thus, it is very important and necessary to consider appropriate measures.

As analyzed above, the construction of the new bridge is expected to be approved by the local companies as well as the residents, that will give emphasis on the aspects of reduce costs, improvement accessibility.

### b) The Results of Comparison among the Survey Areas

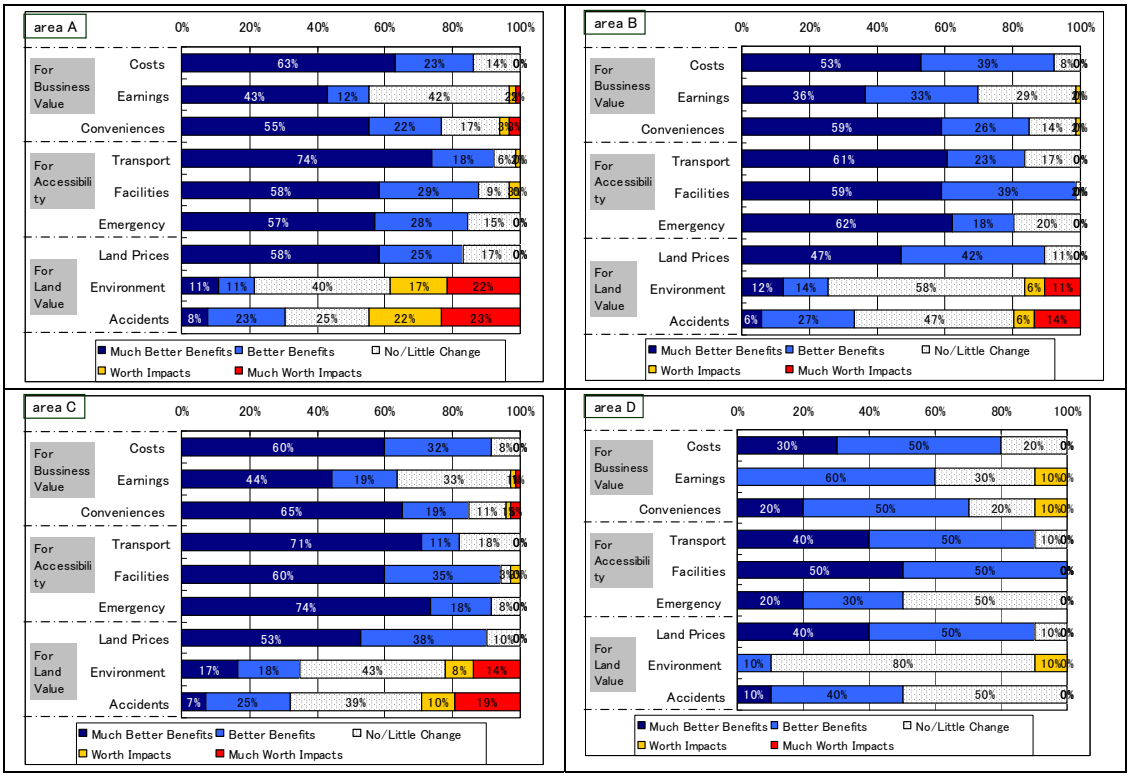



**Figure 2.4.10 The Results of comparison Among the Four Areas**

In this sub-section, the results were divided into four survey areas and analyzed.

The result indicated that there are no significant differences among area A, B and C in most of the questions. One important point is that the effects of crossing bridges have gotten high positive responses in all areas. In regards to business values and accessibility, more than 80% responded as "Expect (Got) Much Better Benefits" or "Expect (Got) Better Benefits", with the exception of one question about earnings. On the other hand, the answers of "life environment" and "traffic accident" have high negative responses especially in area A. As described earlier, this reason seems that area A includes the new bridge that will be constructed in the future. In addition, the result in area D was much less answers of "Got Much Better Benefits", compared with other areas. It is for this reason that the Rama 9 Bridge located in this area is now used in the expressway (EXAT), so there is less benefit for the local companies.

### 2) Interview of Local Government and Other Organizations

In addition to the local companies, the interview survey of local government and the other organizations have been conducted, such as Nonthaburi Province, Bangkok Metropolitan Administration, and the Ministry of Interior, as shown below.

**Table 2.4.17 Target Organizations of Interview Survey**

| Organizations | Respondents | Date |
|---|---|---|
| Nonthaburi Province<br>Department of City Planning | Ms. Unehaleeluk Anonthasorn<br><City Planner> | 7th October 2009 |
| Bangkok Metropolitan Administration<br>Department of City Planning | Mr. Sompong Chirabundarnsook<br><City Planner> | 6th October 2009 |
| Ministry of Interior<br>Department of Town and Country Planning and Public Works | Dr. Thongchai Roachanakanan<br><Director> | 9th October 2009 |

The following were obtained that the local government and the other two organizations also have positive outlook to the new bridge in general. The opinions from the person in charge of the city planning are; 1) The land price will increase and the urbanization in the Nonthaburi Province will be advance, and 2)The new bridge will bring expansion of urban area to west bank of the river in BMA. In addition, BMA has positive opinions as follows; 1) There is no idea on the negative impacts brought about by the new bridge, and 2) It is reasonable to consider for the mass labors that will inflow from Nonthaburi to Bangkok, because of the expansion and better accessibility of BMA areas.

On the other hand it is important that planning of transport network including the new bridge should be formulated regionwide for some considerations as stated in following opinions; 1) The improvements of traffic condition are much expected with the development of the new bridge, but there is a big problem that traffic bottleneck still remains at some intersections on the east bank of the Nonthaburi River.

With respect to the city plan, the new bridge project is not mentioned in the current comprehensive plan of Nonthaburi Province (2005 modified). According to the Department of City Planning in Nonthaburi, in the period between 2005 and 2010, the modification of current comprehensive plan is not estimated. Additionally, they have some opinion such as, "We never have any objection to the new bridge", and "When the new bridge opens to the public, urbanization in the west bank will be advanced and we should modify the next plan".

## 2.5 PROPOSED DEVELOPMENT PLAN FOR THE PROJECT AREA

### 2.5.1 PURPOSE AND TARGET OF THE PROPOSED AREA DEVELOPMENT PLAN

#### (1) Purpose

Historically, the Chao Phraya River has served as a substantial hindrance to the expansion of Bangkok urban area. Therefore, the urbanization has spread out firstly in the east bank of the river under the condition without enough bridges. It was pointed out in Sub-section 2.1.2 that the 20 bridges over the Chao Phraya River have contributed to the urbanization on the west bank. And in summary, the connections of the urban areas between east and west banks have been strengthened as the result of synergism with the two or three bridges.

This section describes the area development plan which is proposed by the study team. And the project area that seems to receive impacts drastically by the new bridge is selected as discussed below.

#### (2) The Target Area

As seen in the past movement, the significant expansions of urban areas have occurred in the range of 2 and 3 km belt along the river. Therefore, Nonthaburi District of Nothaburi Province was selected as the project area for the proposed development plan in view of the suited conditions. This Nonthaburi District includes Nonthaburi City municipality east bank which is the urban center of the province. On the other hand, the other areas in the west bank are rural with relatively low density new housing areas and their activities are generally centered on agricultural sector.

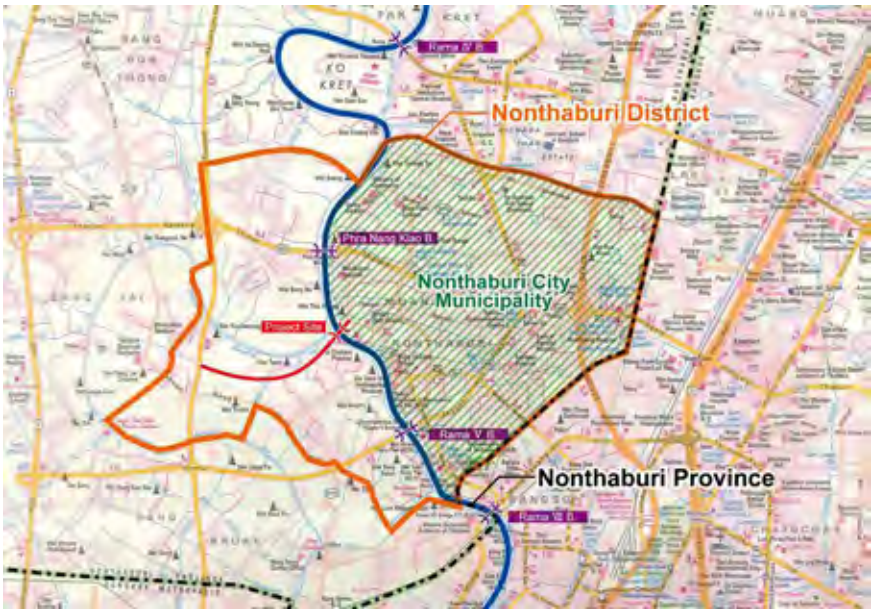



**Figure 2.5.1 Project Area for Development Plan "Nonthaburi District"**

## 2.5.2 RELATED PLANS

### (1) Socio-Economic Framework for Bangkok Metropolitan Region

Bangkok Metropolitan Region is composed of BMA and the five surrounding provinces. BMR is the mega-city in the region with a present registered population of 11 million[1]. About half of the BMR population lives in BMA area. The population projection for BMR up to 2026 is tabulated in Table 2.5.1. The projected population in 2026 is 13.78 million and the annual average growth rate for BMR is 1.15%. On the provincial level, the growth rate for BMA is as low as 0.39%, while those of Nonthaburi and Pathumthani on the north of BMA are comparably higher, 2.85% and 1.82%, respectively, and that of Samut Prakan is also high at 2.1%. On the other hand the annual growth rates for western provinces are in the range of 1.2 and 1.4%. These indicate that the expansion of urban population is leaning towards the north and southeast direction from the center of Bangkok.

**Table 2.5.1 Population Projection (Revised) for Bangkok Metropolitan Region**

| Province | 2011 | 2016 | 2021 | 2026 | Growth rate 2011-2026 |
|---|---|---|---|---|---|
| BMA | 6,525,170 | 6,579,331 | 6,696,170 | 6,913,536 | 0.39% |
| Samut Prakan | 1,358,976 | 1,517,066 | 1,674,966 | 1,855,559 | 2.10% |
| Nonthaburi | 1,378,608 | 1,615,245 | 1,845,528 | 2,100,137 | 2.85% |
| Pathumthani | 851,093 | 934,348 | 1,017,962 | 1,115,512 | 1.82% |
| Nakornpathom | 946,901 | 1,000,735 | 1,059,125 | 1,132,615 | 1.20% |
| Samut Sakorn | 532,882 | 568,688 | 606,380 | 652,641 | 1.36% |
| Total | 11,593,630 | 12,215,413 | 12,900,131 | 13,770,000 | 1.15% |

Source: "The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project 1st Additional Information on General and Technical Issues, DRR"

[1] Bangkok has a quite large unregistered population, which is said to be almost about 50% of the registered population. The total population of BMR could thus be estimated around 17 million.

### (2) Urban Plan of Nonthaburi Province

As seen in sub-section 2.2.4, one of the focal problems in BMR is the accumulation of economic activities in the metropolitan area. In order to solve this problem, the policy to promote regional cities called sub-centers to lessen the one-polar structure of the national economy is moved forward, and one of the sub-centers around Bangkok is Nonthaburi District. Two comprehensive plans for the Nonthaburi Province are shown in Figure 2.5.2, one for 1990 and the other for 2005.

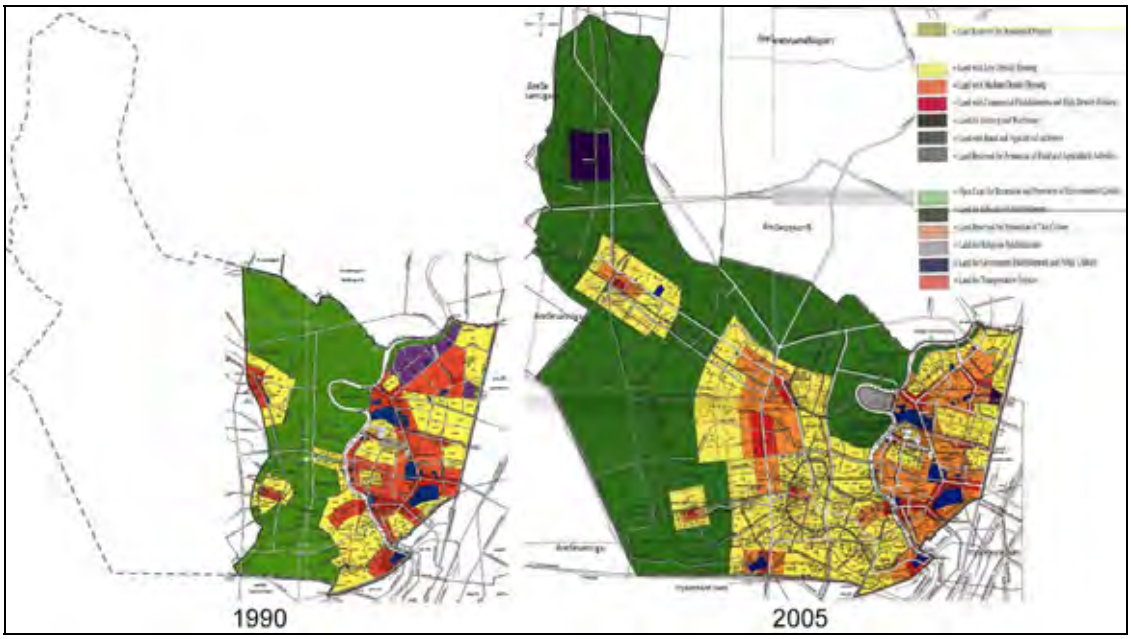



**Figure 2.5.2 Comprehensive Plans for Nonthaburi Province (1990 and 2005)**

In 1990, there are two expressways running through the Nonthaburi Province on both sides of the Chao Praya River, and there are a few roads connecting the two expressways in the east-west directions, including the Rattana Thibet Road in the central part of the province. Thus the trunk road network is a mere H shaped grid, and the connectivity within the province was weak and insufficient. There were plans for the Twanon and Chaeng Wattana Roads, but they had not been completed. On the north-south direction, there is a plan for Rachapuek Road, but not yet complete. The connection for the western and eastern banks of the Chao Praya River was remote and the land on the west of the river is more on agricultural use.

In the 2005 comprehensive plan, the two north-south road on the west bank of the river are complete in addition to the one existing expressway, and the above mentioned two east-west roads are now complete, making a ladder like network on both sides of the river.

The improvement in the road network also affected the land use in the province. On the west bank of the Chao Pray a belt between the river and Kanchanapaseuk Road was mostly urbanized except for the areas around Koh Kredt, particularly in the areas in the opposite side of Nonthaburi City. Comprehensive Plan of 2005 made a change in this area from the previous agricultural area (green) to residential area (yellow) in this riverside belt. Thus, as the result of the road network improvement, urbanization is proceeding to the west bank of the Chao Phraya in the opposite side of Nonthaburi City.

## 2.5.3 PROPOSED AREA DEVELOPMENT PLAN FOR THE PROJECT AREA

In this sub-section, the impacts brought by the new bridge are estimated by means of qualitative analysis mainly on the relationship between crossing the bridges in the past and expansion of urbanizations. Finally, the drafts of the area development plans targeted in both Nonthaburi Province and Nonthaburi District are proposed based on the detailed analysis.

### (1) Population Transition in Nonthaburi Province

In Nonthaburi Province, the population in 2007 was 1,024,191, which is more than 1.5 times the 1990 population. The average growth rate in 17 years period is about 2.6%. The population densities were 1,063/km$^2$ in 1990 and 1,646/km$^2$ in 2007.

**Table 2.5.2 Population Transition in Nonthaburi Province (1990-2007)**

| | 1990 | 1995 | 2000 | 2005 | 2007 |
|---|---|---|---|---|---|
| Population | 661,573 | 754,627 | 859,607 | 972,280 | 1,024,191 |
| Density (622.31km$^2$) | 1,063/km$^2$ | 1,213/km$^2$ | 1,381/km$^2$ | 1,562/km$^2$ | 1,646/km$^2$ |
| Growth of population | +362,618 (1990-2007) | | | | |
| Growth Rate | 2.6% (1990-2007) | | | | |

The population from each district was analyzed in this section. The analysis was conducted in the eight districts as illustrated in Figure 2.5.3. However there are normally 6 administrative districts in Nonthaburi Province. ①The Nonthaburi District and ②Pak Kret District cross over the Chao Phraya River, hence these districts were sub-divided into east and west banks in order to analyze exactly the impacts of the bridges.

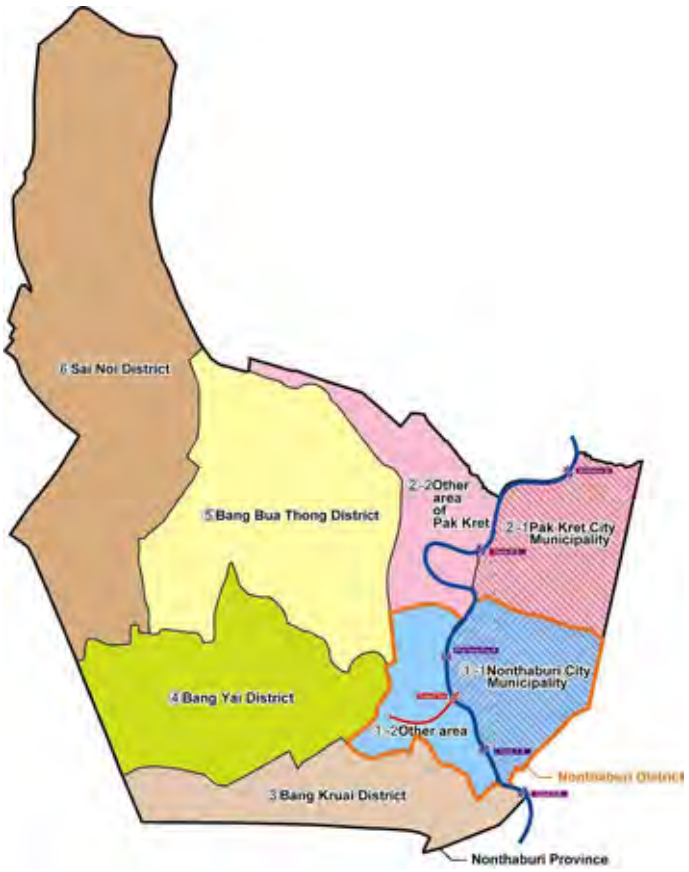



**Figure 2.5.3 Eight Districts of Nonthaburi Province**

Table 2.5.3 and Figure 2.5.4 summarize the 2007 population of the eight districts. As seen in them, the population of ①-1 Nonthaburi City Municipality is 265,796 which is 26% of the province population and that of ②-1 Pak Kret City Municipality is 169,782 which is 17% of the province population. These figures are much larger than the others. This shows that the total population of these two districts in the east bank is equivalent to 43% of the province population and about, 12% of the province area.

**Table 2.5.3 Population Transition in each District (1990-2007)**

| District Name | Population (Density) | | | | | Area ($km^2$) |
|---|---|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2005 | 2007 | |
| ①-1 Nonthaburi City Municipality | 254,678 (6,547) | 265,773 (6,832) | 269,315 (6,923) | 267,097 (6,866) | 265,796 (6,833) | 38.90 |
| ①-2 Other area of Nonthaburi | 47,247 (1,239) | 61,149 (1,604) | 70,330 (1,845) | 80,776 (2,119) | 87,684 (2,300) | 38.12 |
| ②-1 Pak Kret City Municipality | 116,356 (3,229) | 134,756 (3,739) | 150,354 (4,172) | 165,829 (4,601) | 169,782 (4,711) | 36.04 |
| ②-2 Other area of Pak Kret | 33,833 (0,639) | 34,288 (0,647) | 34,798 (0,657) | 37,280 (0,704) | 39,121 (0,738) | 52.98 |
| ③Bang Kruai District | 75,873 (1,322) | 80,973 (1,410) | 82,855 (1,443) | 91,419 (1,592) | 97,650 (1,701) | 57.41 |
| ④Bang Yai District | 35,283 (0,366) | 47,338 (0,491) | 61,148 (0,634) | 79,602 (0,826) | 92,215 (0,957) | 96.40 |
| ⑤Bang Bua Thong District | 64,203 (0,551) | 93,945 (0,807) | 148,000 (1,271) | 198,652 (1,706) | 218,030 (1,872) | 116.44 |
| ⑥Sai Noi District | 34,100 (0,183) | 36,405 (0,196) | 42,807 (0,230) | 51,625 (0,278) | 53,913 (0,290) | 186.02 |
| Total | 661,573 | 754,627 | 859,607 | 972,280 | 1,024,191 | 622.31 |

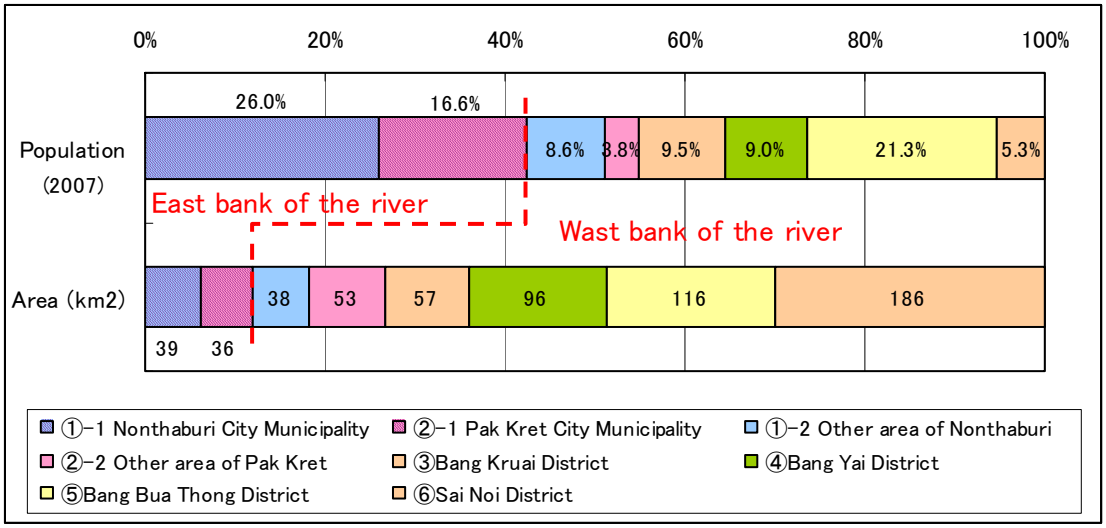



**Figure 2.5.4 The Proportion of Population and Area in each District**

As seen in Table 2.5.4, the population growth rate during the period from 1990 to 2007 in ①-1 Nonthaburi City Municipality and ②-1 Pak Kret City Municipality, are 0.3% and 2.2% respectively, which are lower than 2.6% the average growth rate in province. Furthermore, in the last five years the population in east bank seems to be much enough for its capacity, because the population has slightly decreased.

On the other hand, the growth rates form 1990 up to 2007 in the districts on west bank

indicate much high level, such as 7.5% in ⑤Bang Bua Thong District and 5.8% in ④Bang Yai District. Additionally, the growth rate in ①-2 Other Area of Nonthaburi District is 3.7% as the high level. Thus, from this viewpoint, one might say that the population increase in the future should be expected mainly in the west bank districts.

**Table 2.5.4 Growth Rate in each District**

| District Name | Growth Rate (Growth of Population) 1990-2007 | | | | |
|---|---|---|---|---|---|
| | | (1990-1995) | (1995-2000) | (2000-2005) | (2005-2007) |
| ①-1 Nonthaburi City Municipality | 0.3%<br>(11,118) | 0.9%<br>(11,095) | 0.3%<br>(3,542) | -0.2%<br>-(2,218) | -0.2%<br>-(1,301) |
| ①-2 Other area of Nonthaburi | 3.7%<br>(40,437) | 5.3%<br>(13,902) | 2.8%<br>(9,181) | 2.8%<br>(10,446) | 4.2%<br>(6,908) |
| ②-1 Pak Kret City Municipality | 2.2%<br>(53,426) | 3.0%<br>(18,400) | 2.2%<br>(15,598) | 2.0%<br>(15,475) | 1.2%<br>(3,953) |
| ②-2 Other area of Pak Kret | 0.9%<br>(5,288) | 0.3%<br>(0,455) | 0.3%<br>(0,510) | 1.4%<br>(2,482) | 2.4%<br>(1,841) |
| ③Bang Kruai District | 1.5%<br>(21,777) | 1.3%<br>(5,100) | 0.5%<br>(1,882) | 2.0%<br>(8,564) | 3.4%<br>(6,231) |
| ④Bang Yai District | 5.8%<br>(56,932) | 6.1%<br>(12,055) | 5.3%<br>(13,810) | 5.4%<br>(18,454) | 7.6%<br>(12,613) |
| ⑤Bang Bua Thong District | 7.5%<br>(153,827) | 7.9%<br>(29,742) | 9.5%<br>(54,055) | 6.1%<br>(50,652) | 4.8%<br>(19,378) |
| ⑥Sai Noi District | 2.7%<br>(19,813) | 1.3%<br>(2,305) | 3.3%<br>(6,402) | 3.8%<br>(8,818) | 2.2%<br>(2,288) |

## (2) The Structure and Restriction for Urbanization in Nonthaburi Province and BMA

As mentioned above, the recent growth rates of west bank are much higher than that of east bank, however, the population density of the west bank is 1,075/km$^2$, which is still much lesser than the east bank of 5,812/km$^2$. The estimated reasons are listed below and are shown in Figure 2.5.5.

- The Chao Phraya River flows from north to south through the province area
- The railroad of SRT runs east - west on the boundary of Nonthaburi and BMA
- Agricultural lands and Kokret, which is famous for historical heritage, spread out in northern areas of province

The construction of the new bridge is one of most important factors for the expansion of urban areas to west bank, because the population in the east bank seems close to upper limit capacity. In addition, the movement of urbanization in BMR is extending gradually northwards.

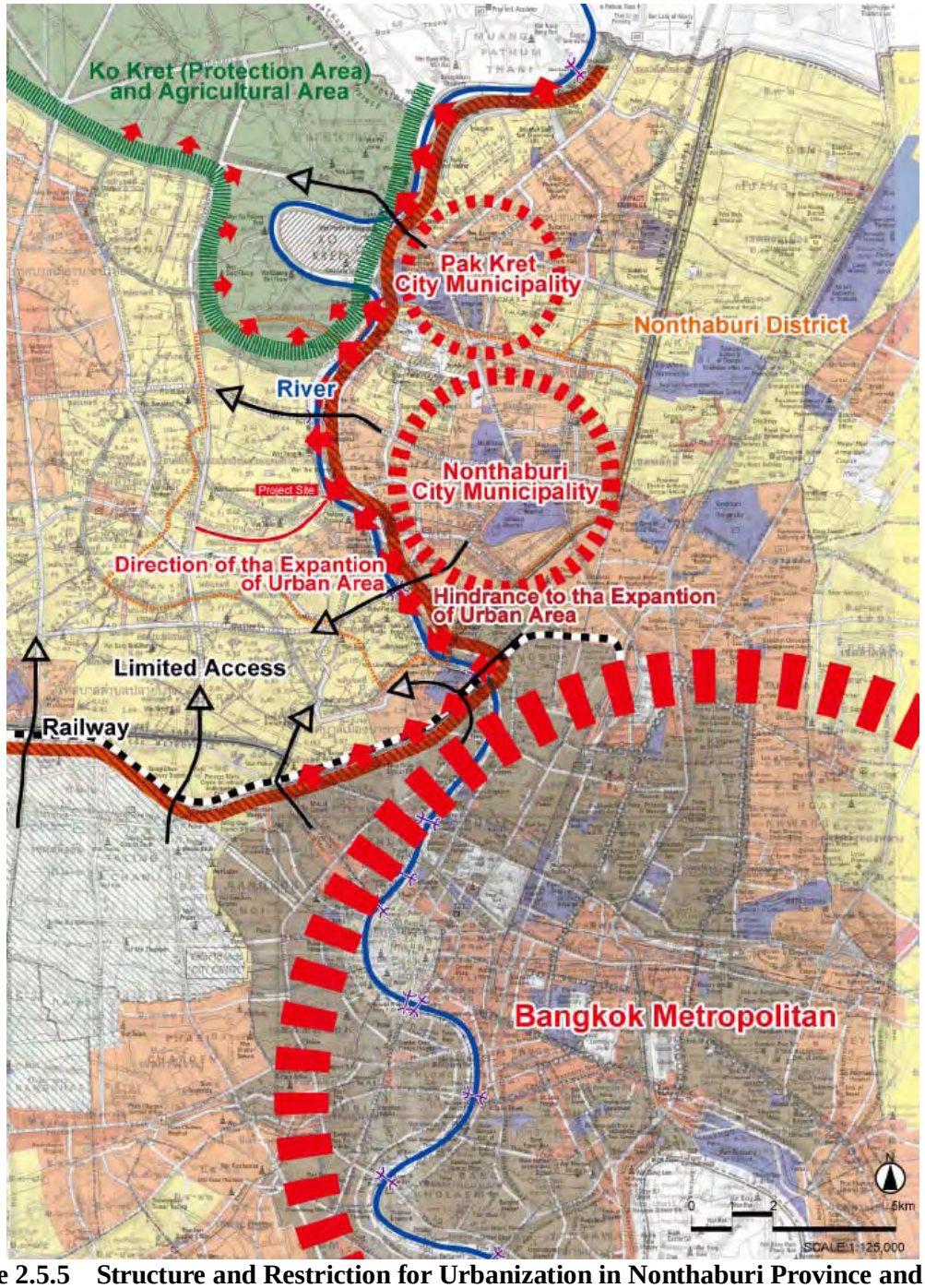



**Figure 2.5.5 Structure and Restriction for Urbanization in Nonthaburi Province and BMA**

### (3) The Population Framework for Nonthaburi Province

The 2007 population of Nonthaburi Province is 1,024,191 and its density is 1,646/km$^2$. The average growth rate from 1990 to 2007 is about 2.6%. The population projection in Table 2.5.1 indicates 1,378,608 in 2011 and 1,615,245 in 2016. Based on this projection, 5.2% growth rate in 2007 to 2016 is much higher than that in past as seen in Figure 2.5.6. Hence, this rate indicates that the Nonthaburi Province shall be the future potential settlement area in the Metropolitan.

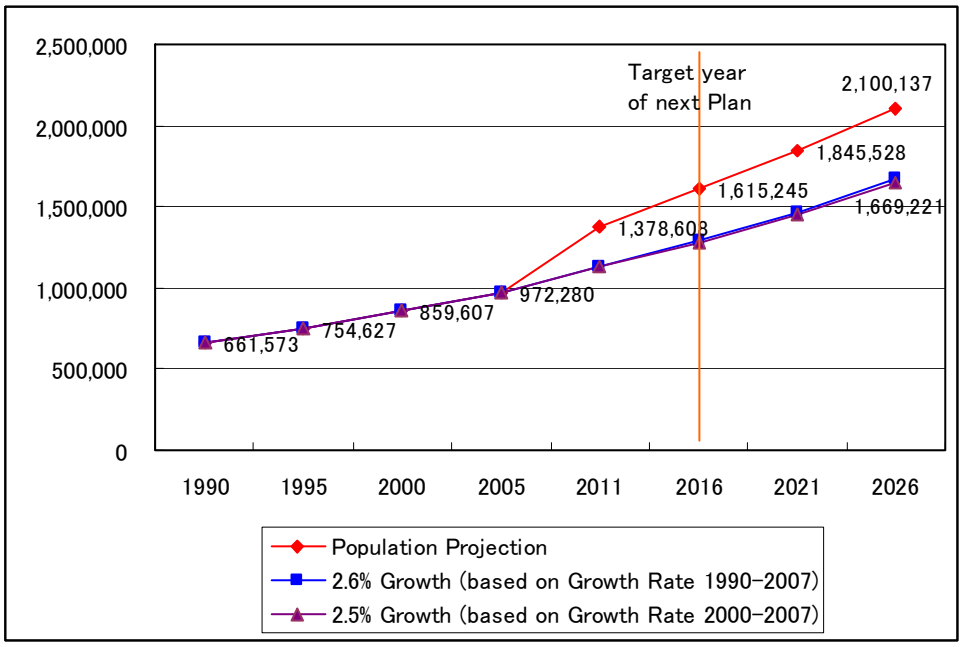



**Figure 2.5.6 The Population Projection for Nonthaburi Province**

In each district, it might be inferred from the decrease of population in ①-1 Nonthaburi City Municipality that the density in east bank is close to full capacity. It is reasonable to assume that the upper limit of density of east bank is 7,000/km$^2$, based on the current density of 6,833/km$^2$. Additionally, the same figure can apply to ②-1 Pak Kret City Municipality in the east bank.

Table 2.5.5 summarized the proposed population framework of each district in the target year 2016. This framework is based mainly on the proper population density in the future and partly on the growth rate in the past. In addition, this framework has been finalized considering the feedback of the results in the following sub-sections (4) and (5).

**Table 2.5.5 Proposed Population Framework in Each District**

| District Name | 2007 | | Growth Rate | | Increase of Population | 2016 | |
|---|---|---|---|---|---|---|---|
| | Population | Density | 1990-2007 | 2007-2016 | | Population | Density |
| ①-1 Nonthaburi City Municipality | 265,796 | 6,833 | 0.3% | 0.3% | 7,204 | 273,000 | 7,000 |
| ①-2 Other area of Nonthaburi | 87,684 | 2,300 | 3.7% | 8.3% | 92,316 | 180,000 | 4,700 |
| ②-1 Pak Kret City Municipality | 169,782 | 4,711 | 2.2% | 4.5% | 83,218 | 253,000 | 7,000 |
| ②-2 Other area of Pak Kret | 39,121 | 738 | 0.9% | 4.5% | 19,879 | 59,000 | 1,100 |
| ③Bang Kruai District | 97,650 | 1,701 | 1.5% | 4.8% | 51,350 | 149,000 | 2,600 |
| ④Bang Yai District | 92,215 | 957 | 5.8% | 11.8% | 158,785 | 251,000 | 2,600 |
| ⑤Bang Bua Thong District | 218,030 | 1,872 | 7.5% | 3.7% | 82,970 | 301,000 | 2,600 |
| ⑥Sai Noi District | 53,913 | 290 | 2.7% | 11.9% | 95,087 | 149,000 | 800 |
| Total | 1,024,191 | 1,646 | 2.6% | 5.2% | 590,809 | 1,615,000 | 2,595 |

The three consideration points related to this framework are the following. Firstly, it is supposed that the upper limit of density of east bank is 7,000/km$^2$. Secondly, the construction of the new bridge will bring the expansion of urban area to the west bank, especially in ①-2

Other Area of Nonthaburi District. It is quite likely that the urbanization in this district will be advanced, most remarkably among the west bank districts, and the density will reach around 5,000/km$^2$ in ①-2. Thirdly, it is estimated in ③ - ⑤ districts that the population densities in the future will be getting closer to each other to about 2,600/km$^2$, which is the average density of province, since three districts have similar conditions of accessibility to BMA and current land uses.

### (4) Urban Structure of Nonthaburi Province in the Future

The new bridge would lead to the expansion of urban area to west bank, combined with the existing bridges such as Phra Nang Klao Bridge and Rama 5 Bridge, as seen in Figure 2.5.7. Furthermore, middle or high density urban areas will be formed mainly along the primary roads, such as Kanchanaphisek Road, Ratchaphruek Road, Rattana Thibet (302) Road and Twanon (306) Road. As a consequence , three urban centers in Nonthaburi City Municipality expanding more to west bank, Pak Kret City Municipality, and Bang Bua Thong City, will be developed in the province. Finally, the fringe of urban areas will spread out throughout the whole province, mainly due to the expansion of the low density housing areas.

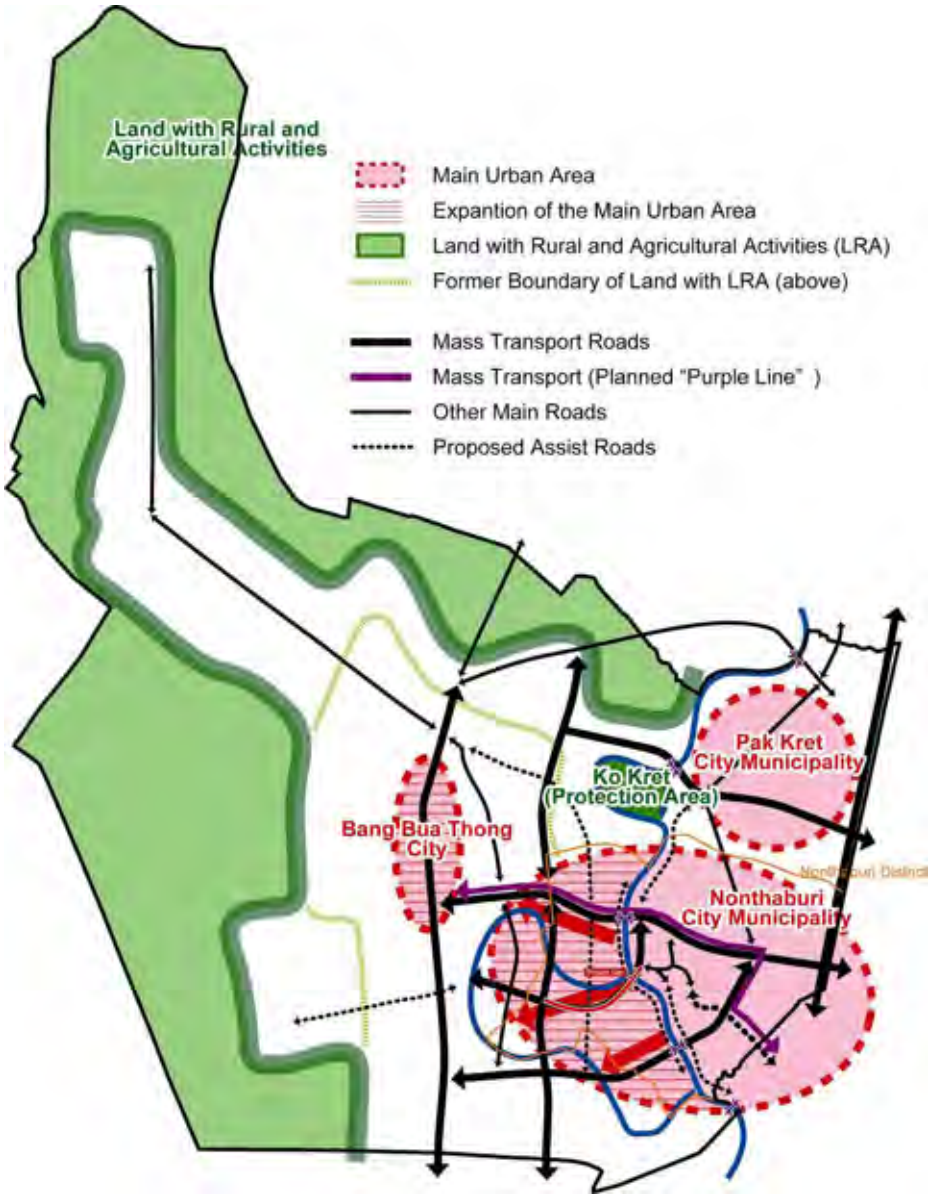



**Figure 2.5.7 Urban Structure of Nonthaburi Province in the Future**

## (5) Proposed Area Development Plan for Project Area

The current comprehensive plan for Nonthaburi Province has effect basically in the five-year period from 2005 to 2010, however, this period will be extended to another one or two years according to the interview survey of Nonthaburi Province. As a result, it is estimated that the next comprehensive plan will be modified in 2011 – 2013 and targeted at 2016 – 2018. The time of next modification might correspond to the time of opening of the new bridge to the public, therefore the next comprehensive plan including impacts by the new bridge will be proposed in this section.

Table 2.5.6 shows the proposed land use plan for each district on the basis of population framework as shown in Table 2.5.5. This is not to say that these figures are based on the accurate or official source, but these were roughly estimated only in this study.

**Table 2.5.6 Distribution of Land Use in each District (Rough Estimate)**

| District Name | Plan | Ratio of Land Use (Rough Estimate) | | | |
|---|---|---|---|---|---|
| | | Medium-High Density Housing | Low Density Housing | Industry & Public Utilities | Rural & Agricultural Activities |
| ①-1 Nonthaburi City Municipality | 2005 Plan | 70% | 20% | 10% | 0% |
| | Next Plan | 90% | 0% | 10% | 0% |
| ①-2 Other area of Nonthaburi | 2005 Plan | 20% | 70% | 0% | 10% |
| | Next Plan | 90% | 10% | 0% | 0% |
| ②-1 Pak Kret City Municipality | 2005 Plan | 40% | 50% | 5% | 5% |
| | Next Plan | 90% | 0% | 5% | 5% |
| ②-2 Other area of Pak Kret | 2005 Plan | 0% | 0% | 0% | 100% |
| | Next Plan | 0% | 40% | 0% | 60% |
| ③ Bang Kruai District | 2005 Plan | 10% | 50% | 10% | 30% |
| | Next Plan | 40% | 20% | 10% | 30% |
| ④ Bang Yai District | 2005 Plan | 10% | 30% | 0% | 60% |
| | Next Plan | 40% | 20% | 0% | 40% |
| ⑤ Bang Bua Thong District | 2005 Plan | 20% | 20% | 0% | 60% |
| | Next Plan | 40% | 20% | 0% | 40% |
| ⑥ Sai Noi District | 2005 Plan | 0% | 10% | 10% | 80% |
| | Next Plan | 0% | 20% | 10% | 70% |

The ideal population densities for each kind of land use are proposed. The proposed figures and reasons are given below.

- Medium-High Density Housing: The proposed population density is 5,000/km$^2$. It is reasonable to assume that the density in ①-1 Nonthaburi City Municipality that occupied mainly by this land use is equivalent to 5,000/km$^2$ at present. In addition, this corresponds to the lower limit density defined as the Densely Inhabited District (DID) in Japan. On the other hand, the density of east bank districts is set at 7,000/km, because of the current conditions.
- Low Density Housing: The proposed population density is 2,000/km$^2$. It is also reasonable to assume that the density in ①-2 Other Area of Nonthaburi District that occupied mainly by this land use is equivalent to 2,000/km$^2$. In addition, this corresponds to the lower limit defined as the urban area, according to some literatures[2].

[2] Source: "New Outlane for City Planning (Kyoritsu Syuppan Co., Ltd.)"

- Rural & Agricultural Activities, Industry & Public Utilities: The proposed population density is 500/km$^2$. It is also reasonable to assume that the density in ②-2 Other area of Pak Kret and ⑥ Sai Noi District that occupied mainly by this land use is equivalent to 500/km$^2$.

It corresponds to the population framework as shown in Figure 2.5.5 that the estimated population multiplied the distributions of land use as shown in Figure 2.5.6 by the proper population densities

Based on the above discussion, the area development plan of Nonthaburi Province which will be as the next comprehensive plan is proposed as follows. It is presumed that the target period of this plan is from 2011–2013 to 2016–2018. Figure 2.5.8 shows the land use plan and Figure 2.5.9 shows the area development plan.

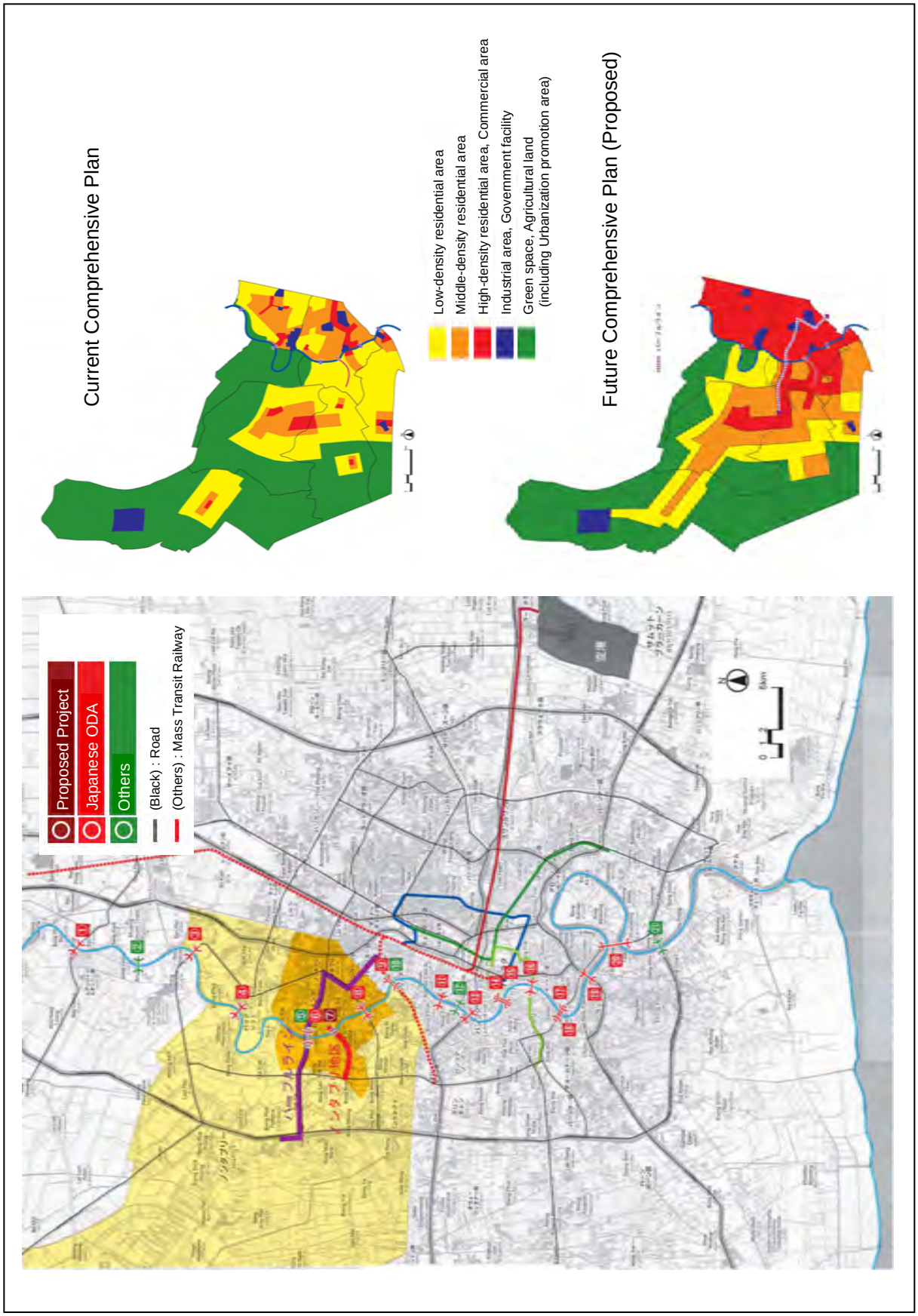



**Figure 2.5.8 Proposed Land Use Plan in Nonthaburi Province**

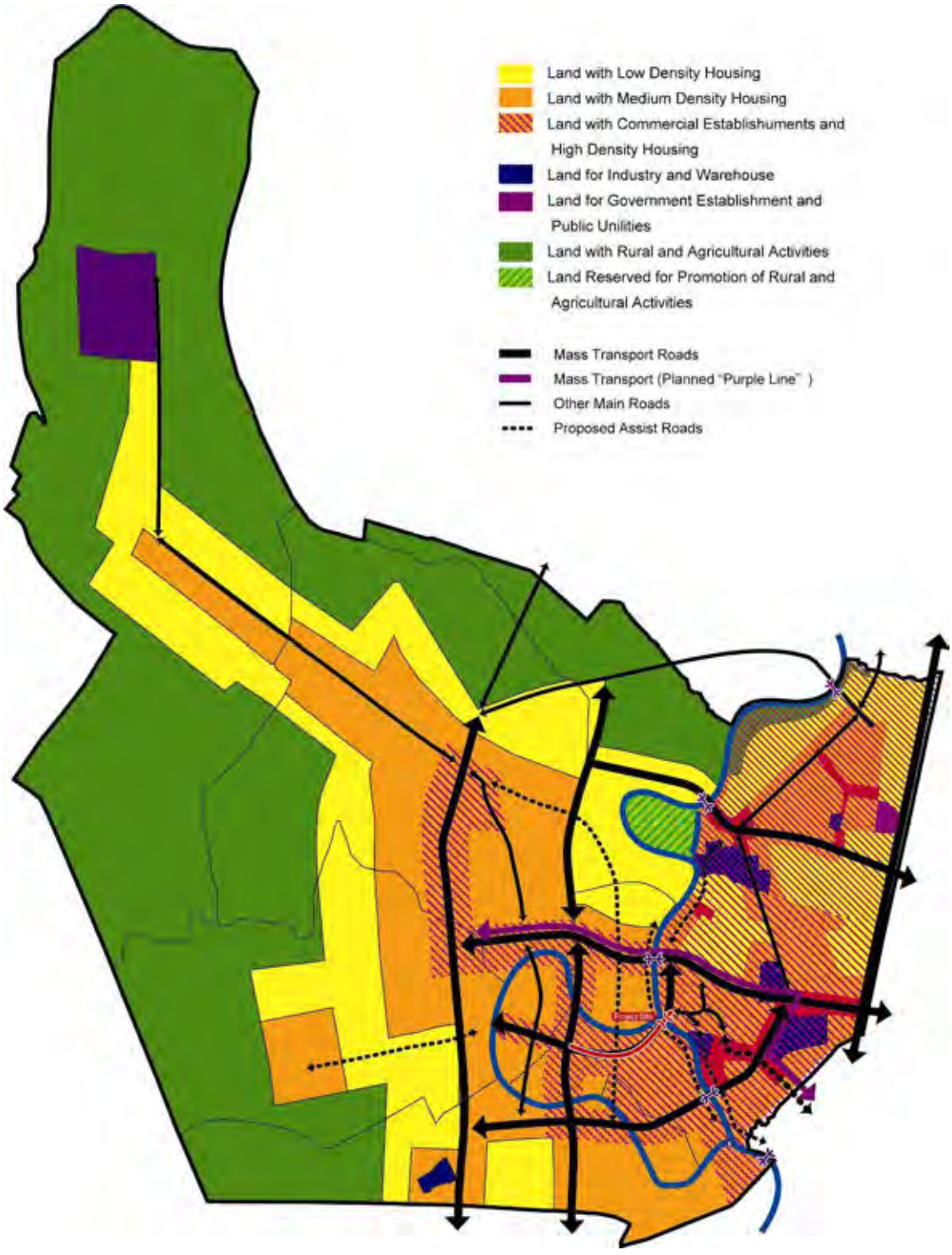



**Figure 2.5.9 Proposed Area Development Plan of Nonthaburi Province -the Next Comprehensive Plan (Draft)**

Lastly, the area development plan of Nonthaburi District is proposed as follows. Figure 2.5.10 is abstracted only from the project area in Figure 2.5.9, besides the area development plan has been finally summarized.

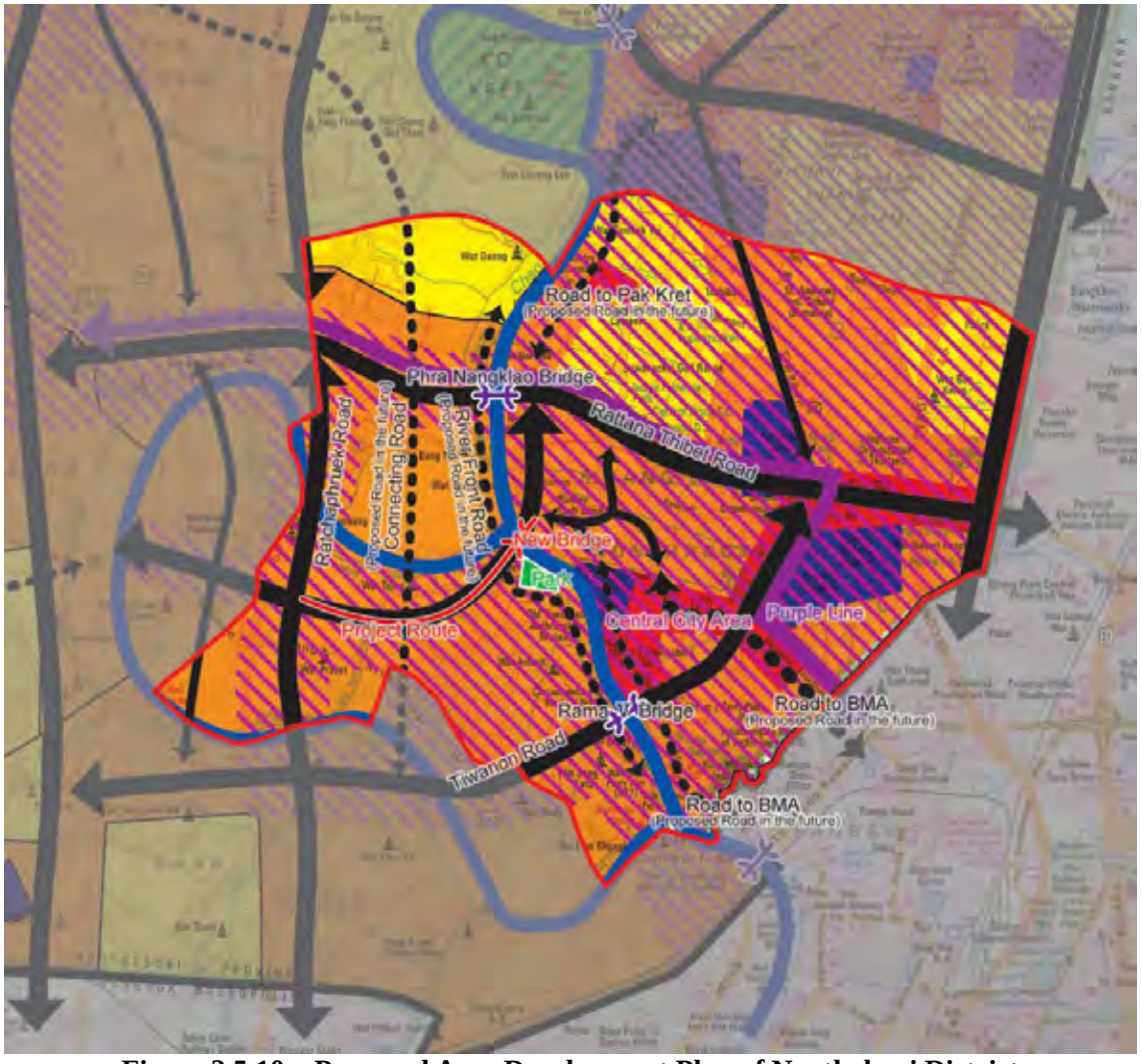



**Figure 2.5.10 Proposed Area Development Plan of Nonthaburi District**

As discussed in sub-section 2.2.4 (4), the middle and high density urbanization seems to expand widely to the west bank of the river caused by the new bridge, especially in the project area.

It is quite likely that this urbanization will expand rapidly as soon as the new bridge opens to the public. Therefore, it is recommended that the new bridge in the new road should be lowered to the ground level as much as possible, and then the connection between the new roads and existing local roads, housing, parks should be strengthened. This will lead to make and penetrate the benefits of the new bridge for the project area. In addition, some measures should be taken in order to maintain and improve the local resources and values for the future. One of these measures, for example, is the local area management considered in forming attractive landscape by appropriate use of the river front spaces or existing well-managed park. In the long-term span, it is expected that the river front roads which run from the north to south on west bank should be constructed.

Similarly, it is also likely that urbanization will expand continuously along the new road between the new bridge and the Ratchaphruk Road. This will lead to make middle-high density urban area on the west bank as large as the east bank in the future. In view of this

movement, it is expected that the commercial and governmental center and the north-south assist roads should be constructed on west bank in the long-term span.