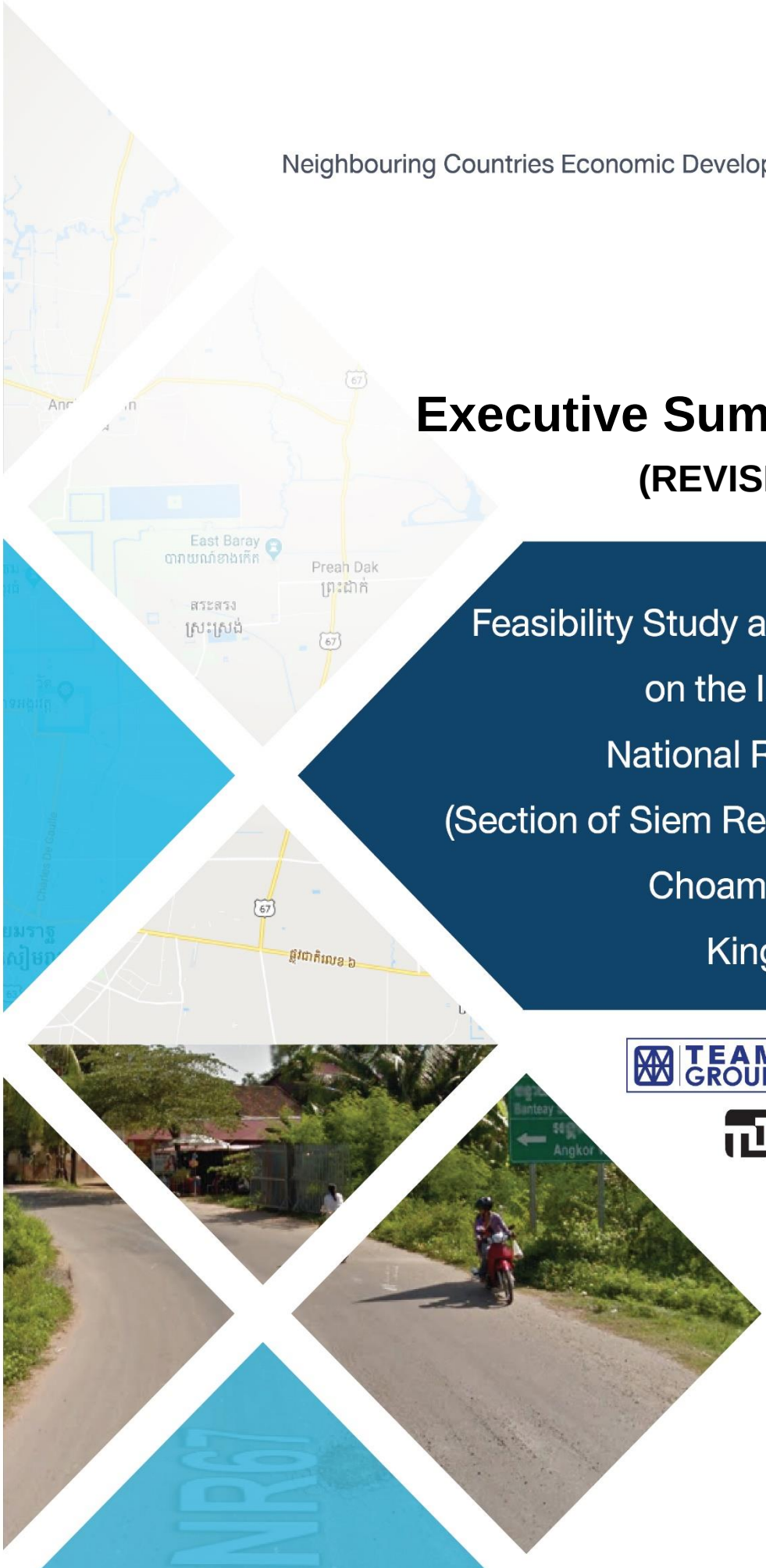
Neighbouring Countries Economic Development Cooperation Agency
(Public Organization)

Executive Summary Report

(REVISION)

Feasibility Study and Detailed Design on the Improvement of the National Road No. 67 (NR67) (Section of Siem Reap – Anlong Veng – Choam/Sa Ngam) Project, Kingdom of Cambodia



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LIST OF ABBREVIATION

DBST	Double Bituminous Surface Treatment
AC	Asphalt Concrete
DPWT	Department of Public Works and Transport, Cambodia
DoE	Department of Environment, Cambodia
DOH	Department of Highway, Thailand
DWRM	Department of Water Resource and Meteorology, Cambodia
EIA	Environmental Impact Assessment
IEE	Initial Environmental Examination, Thailand
IEIA	Initial Environmental Impact Assessment, Cambodia
MoE	Ministry of Environment, Cambodia
MPWT	Ministry of Public Works and Transport, Cambodia
NEDA	Neighbouring Countries Economic Development Cooperation Agency
PPE	Personal Protective Equipment
ROW	Right of Way
NESDC	Office of the National Economic and Social Development Council

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 PROJECT BACKGROUND

The National Road No. 67 (NR67) is an important road which links between Thailand and Cambodia to facilitate passenger travel, and logistic and services. It also benefits route tourism, and border trade between both countries, leading to expansion of communities along the alignment.

The 134-kilometer long highway starts from Siem Reap to Anlong Veng and ends at Choam/Sa Ngam Pass. It is the major road linking Siem Reap, which is the important tourist city of Cambodia, to Thailand via Si Saket province. It takes about 2.5–3 hours to travel on this road.

In 2006, The Royal Thai Government provided the Kingdom of Cambodia with assistance in constructing the NR67. The construction was completed and the road has been operational since 2009. The brief details about the road are presented below.

- The Siem Reap–Anlong Veng section of the NR67 with a 131 kilometers distance features two traffic lanes, each with 3.50 meters width; and shoulders of 1.50 meters width each side. The road surface is Double Bituminous Surface Treatment (DBST) paved on the soil cement base. The soft loan of about 1,300 million Baht was offered by the Export-Import Bank of Thailand for the road construction, and the Neighbouring Countries Economic Development Cooperation Agency (NEDA) was the lender's agent.

- The Anlong Veng–Choam/Sa Ngam Pass section of the NR67 is 18 kilometers long and consists of two traffic lanes, each with 3.50 meters width. The shoulder on each road side is 0.50 meter wide. The grant of 95 million Baht was provided for the construction of the DBST road. The Department of Highways (DOH) of Thailand was responsible for construction supervision of the road. Currently, the section from KM 130+000 to KM 142+000 with a total length of 12 kilometers was improved by the Ministry of Public Works and Transport (MPWT) of Cambodia to be the reinforced concrete road. The traffic lane of each side is 3.50 meters wide and the shoulder is 0.50 meter wide.

The Cambodian government has allocated the budget to maintain and repair this road to be always in good condition. However, the road has been used for a decade. Currently, the road is damaged and its materials is deteriorated, i.e. rutting and shoving on the pavement surface, bridge approach settlement, and faded lane lines. In addition, road

safety equipment is damaged, such as guide posts, guard rails and reflectors at designated locations. Due to the deteriorated conditions, the road is not able to efficiently accommodate the existing traffic volume. Moreover, no lighting is installed along the route alignment and at the merging and diverging points to provide road safety to motorists at night.

With the intention to maintain, improve and upgrade the NR67, the Cambodian government submitted the formal request to NEDA for technical assistance for the feasibility study and detailed design on the improvement of the NR67, Siem Reap–Anlong Veng–Choam/Sa Ngam Pass section, in the Kingdom of Cambodia. The project route starts at the intersection between the NR6 and the NR67 at KM 296+560 in Siem Reap province and ends at Choam/Sa Ngam Pass in Oddar Meanchey province. Its total distance is about 134 kilometers.

1.2 PROJECT OBJECTIVE

Objectives of this project are as follows:

1. To undertake the feasibility study, covering engineering, socio-economic, and environmental aspects, including the project impacts and benefits

2. To conduct survey, detailed design, cost estimation and tender document preparation

CHAPTER 2

DATA COLLECTION AND DOCUMENTATION

CHAPTER 2

DATA COLLECTION AND DOCUMENTATION

2.1 FEASIBILITY STUDY ON ECONOMIC, ENGINEERING, AND ENVIRONMENTAL IMPACT HIGHWAY ROUTE 67: SA NGAM PASS– ANLONG VENG – SIEM REAP BY DEPARTMENT OF HIGHWAY THAILAND, 2006 REVIEWS

The purpose of the review of the Department of Highways (DOH) of Thailand's Feasibility Study of on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng– Siem Reap (carried out in 2006) which include traffic and transportation, feasibility study, and problems within the project is to support the upgrading of National Road No. 67 (NR67) in order to maximize its benefits.

2.1.1 Traffic and Transportation Reviews

From DOH's study report (2006), the future traffic and transportation was forecasted. The results show that in year 2009-2028 (study period), the traffic growth rate of normal and generated traffic is 8 to 10 percent. From the reviewing of the DOH studied report (2006), the focus is on the future traffic and transportation forecasted. The result shows that in 2009-2028 (study period), the traffic growth rates of both normal and generated traffic are 8 to 10 percent. Table 2.1-1, shows the traffic growth rates by type of vehicles.

Table 2.1-1 Traffic Growth Rates for the Project Road.

unit : percent

Period	Vehicle type				
	Car, Pickup	**Etan**	**Medium Truck**	**More than 10 wheels truck**	**Motorcycle**
2009-2013	10.09	9.95	10.02	9.87	9.81
2014-2018	9.65	9.50	9.70	9.48	9.40
2019-2023	9.49	9.51	9.42	9.39	9.38
2024-2028	8.17	8.05	8.20	8.12	8.05

Source: Feasibility study Study on Economic, Engineering, and environmental Environmental impact Impact highway Highway route Route 67: sangam Sangam pass Pass –Anlongveng– Siem Reap, Department of Highway Thailand, 2006

In addition, the growth rates descripted above were used to forecast the future traffic in the project road in 2009-2028, annually. The forecasted traffic is shown by vehicle types classified in **Table 2.1-2**, **Table 2.1-3**, **Figure 2.1-1** and **Figure 2.1-2**. The results show that in 2028, motorcycles have the highest amount of composition at 4,900 veh/day (or 2,450 PCU/day), followed by cars/pickups, Etans, medium and heavy trucks at 3,258, 526, 409, 219 veh/day (or 3,258, 526, 817 and 657 PCU/day), respectively. Therefore, in

2028 the total amount of traffic for the project road is forecasted to be at 9,312 veh/day (or 7,708 PCU/day).

Table 2.1-2 Average Traffic Forecast for Road Number 67 Project (DOH, 2006) In Vehicle/Day

Year	Motorcycles	Etan	Car/ Pick-up	Medium trucks	Heavy trucks	Total vehicles	
						Without Motorcycle	With Motorcycles
2009	933	98	601	75	41	816	1749
2010	1024	108	661	83	45	898	1992
2011	1125	119	728	91	50	988	2113
2012	1235	131	801	101	55	1088	2323
2013	1356	144	882	111	60	1197	2553
2014	1484	158	967	121	66	1312	2796
2015	1623	173	1061	133	72	1438	3062
2016	1776	189	1163	146	79	1577	3353
2017	1943	207	1275	160	86	1729	3671
2018	2125	227	1398	176	95	1895	4020
2019	2324	248	1531	192	104	2075	4399
2020	2543	272	1676	210	113	2272	4814
2021	2781	298	1835	230	124	2487	5268
2022	3042	326	2010	252	135	2723	5765
2023	3327	357	2200	276	148	2981	6308
2024	3595	386	2380	298	160	3224	6819
2025	3884	417	2575	323	173	3487	7371
2026	4197	450	2785	349	187	3771	7969
2027	4535	486	3012	378	203	4079	8614
2028	4900	526	3258	409	219	4412	9312

Source: Feasibility Study on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng– Siem Reap, Department of Highway Thailand, 2006

Table 2.1-3 Average Traffic Forecast for Road Number 67 Project (DOH, 2006) in PCU/Day

Year	Motorcycles	Etan	Car/ Pick-up	Medium trucks	Heavy trucks	Total vehicles	
						Without Motorcycle	With Motorcycles
2009	466	98	601	151	124	974	1440
2010	512	108	661	166	136	1072	1584
2011	562	119	728	183	150	1179	1742
2012	617	131	801	201	164	1298	1915
2013	678	144	882	221	180	1428	2106
2014	742	158	967	243	198	1565	2307
2015	812	173	1061	266	216	1716	2527
2016	888	189	1163	292	237	1881	2769
2017	971	207	1275	320	259	2062	3033
2018	1063	227	1398	351	284	2260	3323
2019	1162	248	1531	384	311	2474	3636
2020	1271	272	1676	421	340	2708	3980
2021	1391	298	1835	460	372	2965	4355
2022	1521	326	2010	504	406	3246	4767
2023	1664	357	2200	551	445	3553	5217
2024	1798	386	2380	596	481	3843	5640
2025	1942	417	2575	645	520	4156	6098
2026	2099	450	2785	698	562	4495	6594
2027	2267	486	3012	755	608	4862	7129
2028	2450	526	3258	817	657	5258	7708

Source: Feasibility Study on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng– Siem Reap, Department of Highway Thailand, 2006

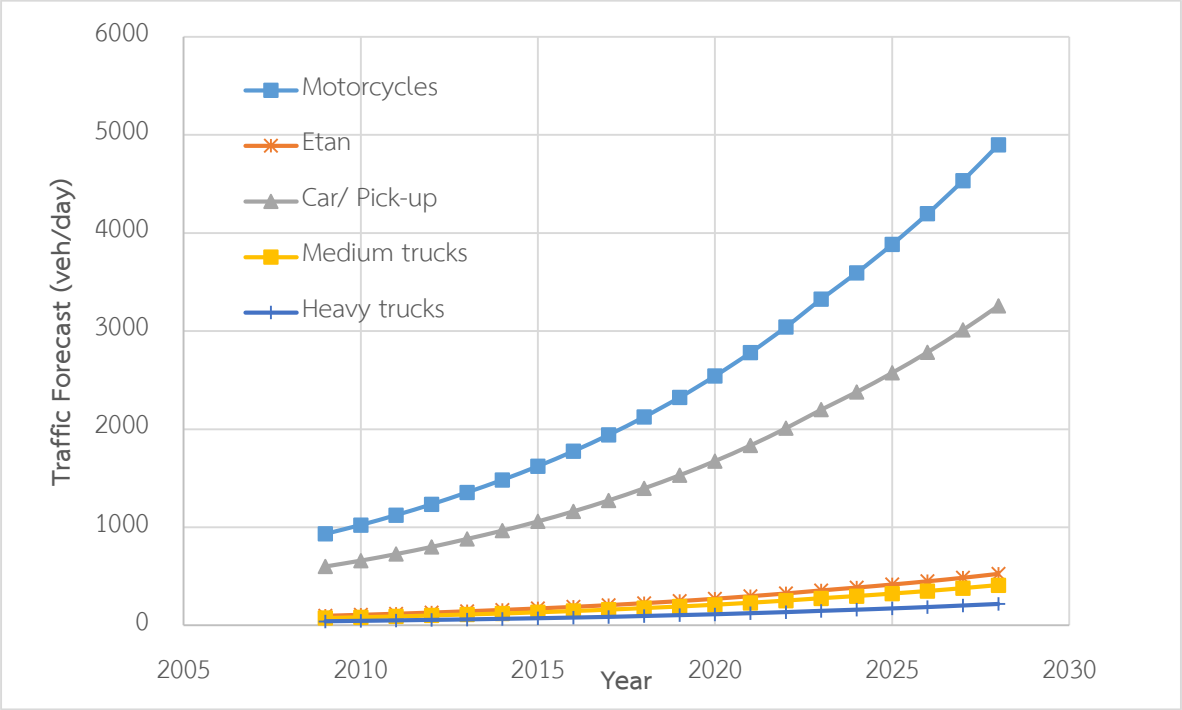
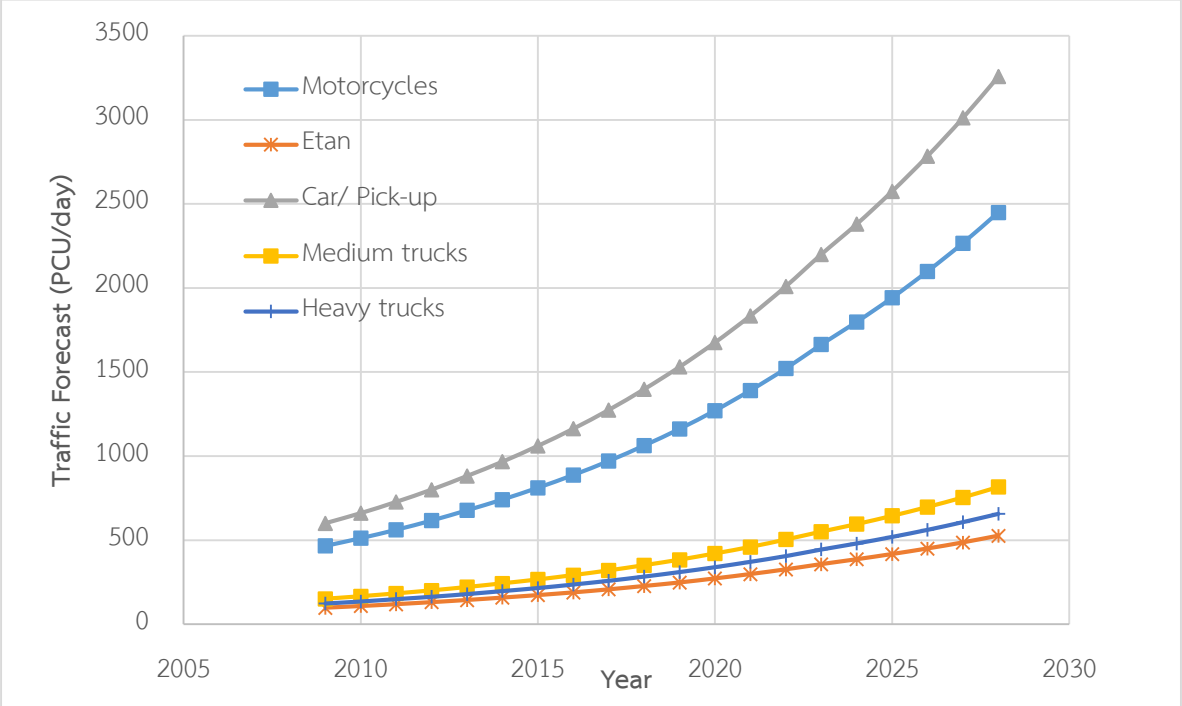


Figure 2.1-1 Traffic Forecast (Vehicle/Day)



Source: Feasibility Study on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng– Siem Reap, Department of Highway Thailand, 2006

Figure 2.1-2 Traffic Forecast (PCU/day)

From the review of the traffic and transportation studies, it shows that most of the traffic on Road No. 67 are motorcycles and private cars and that the growth rate of medium and heavy trucks were found to be relatively low maybe as a result from the Thai-Cambodian border trade as of year 2006 which is not in line with the current trade conditions.

2.1.2 Economic Evaluation Reviews

Another important study of the review of the DOH Study Report (2006) is the Economic Evaluation. This study will enable the consultant to identify the project cost, benefits and feasibility of the investment. This will lead to benefit maximization using limited resources. In addition, the consultant will also be able to establish additional ways in order to improve the project benefits for both Thailand and Cambodia.

As the benefits and costs mentioned above are quantifiable, the viability of the project would be evaluated by using the Net Present Value (NVP) method. The base conditions and input of the project are as follows;

Assumption	DOH's Study , 2006
Base Year of Calculation	2006
Discount Rate	12% (NESDC's Requirement)
Project Life	20 years
Total Benefits	Vehicle Operating Cost: VOC Saving Value of Time: VOT Saving
Total Costs	Construction Cost 29.2 Million US Dollar Maintenance Cost13.6 Million US Dollar
Salvage Value	50% of Total Construction Cost

In summary, the Feasibility Study on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng – Siem Reap, (Department of Highway, Thailand, 2006) has an Interest Rate of Return (IRR) of 15.88 %, Net Present Value (NPV) of 8.06 million USD and Benefit Cost Ratio of 1.4. Therefore, this project is considered feasible for investment. The consultant will use this reviewed information as reference and basis in the further studies of the Feasibility Study on the Upgrading of the National Road No.67 (NR67) Section of Siem Reap – AnlongVeng – Choam/Sa Ngam Pass, Kingdom of Cambodia. A summary of the feasibility and sensitivity analysis results are shown in **Table 2.1-4.**

Table 2.1-4 Sensitivity Analysis in Terms of EIRR

Cost / Benefit	Not change	increase 10%	Increase 20%	decrease 10%	decrease 20%
Not change	15.88%	15.27%	14.21%	17.89%	19.55%
increase 10%	17.75%	16.48%	15.37%	19.23%	20.97%
Increase 20%	18.96%	17.64%	16.48%	20.51%	22.33%
decrease 10%	15.14%	13.99%	12.98%	16.48%	18.06%
decrease 20%	13.72%	12.63%	11.67%	14.99%	16.48%

Source: Feasibility Study on Economic, Engineering, and Environmental Impact Highway Route 67: Sangam Pass – Anlongveng– Siem Reap, Department of Highway Thailand, 2006

2.1.3 Engineering Study Reviews

The Feasibility Study on Economic, Engineering, and Environmental Impact of Highway Route No. 67: Sa Ngam Pass - Anlong Veng – Siem Reap by Thailand's Department of Highway since 2003, has included the studies of the existing condition of the project route and topographic of surrounding area, investigation of the geotechnical properties of soil along the project route in accordance with AASHTO, ASTM and other appropriate standards for foundation and embankment design, inspection of material source and perform laboratory testing on the samples of soil utilized for construction, conducting the conceptual design in accordance with the standard of the Thailand's Department of Highway and AASHTO, and estimation of the construction cost according to the conceptual design. The summary of the study will be concluded within this report.

1) Existing condition of Highway Route 67

According to Thailand's Department of Highway, The Highway Route No. 67 study, the highway was divided into 2 sections as follows.

***The first section*: Siem Reap – Anlong Veng**

This section has a total road length of approximately 131 kilometers, the existing condition of the road varies from fairly paved to poor gravel of about 5-6 meters' of width. The major part of the road passes through a flat rural area with some villages located nearby, whereas the middle section of the road passes through the reserved forest. Nowadays, this section of the road has already been improved to a 2-Lane DBST surface road, with a total 10.00 meters in width, in which 3.50 meters in width per lane and 1.50 meters shoulder on each side.

***The second section*: Anlong Veng – Sa Ngam Pass**

This section has a total road length of approximately 18 kilometers located on flat terrain with an exception of the last 2 kilometers where the road passes through the steep mountainous section before joining the Cambodia/Thailand border at Sa Ngam Pass. Now, this section of road has already been developed into a 2-Lane reinforced concrete surface road with a total of 8.00 meters in width, 3.50 meters in width for each lane and 0.50 meter shoulder on each side.

2) Alignment of National Route 67

The original route of this highway passes through the UNESCO reserved area. The Department of Highways (Thailand) therefore has designed a new route which avoids and reduces the impact in this particular area.

The realigned route is on an original laterite paved surface road with a width of approximately 6-8 meters. In addition, the original road surface has been damaged on every 100 meters from regular use in which will need necessary improvement.

3) A Study on Highway Engineering

- **Road's Cross Section**

According to the studied studies of the projects' ADT (Annual Daily Traffic), it was found out that approximately 1000 – 2000 vehicles per day travel on this route. With this information the route can be categorized as "Highway Class 3" according to Thailand's Highway Standard or as equal to category "Secondary National Road R4" of Cambodia's Highway Standard. The Thailand's Department of Highway suggested that this highway route should have a roadway width of 3.50 meters per lane per direction with a roadway shoulder width of 1.50 meters and the pavement of this route to be Double Surface Treatment.

- **Design Speed**

According to American Association of State Highway and Transportation Officials (AASHTO), design speed for multilane highway in the higher range, 100 km/h, is normally used in level terrain, 60 km/h is normally used in rolling terrain. Considering the condition of the project's area, Thailand's Department of Highway concluded that the appropriate design speed of Highway Route No. 67 should be 80 km/h, in the level terrains, and 60 km/h, in rolling terrains.

- **Highway Drainage Design**

The results from the studies of the existing drainage system compared to the results of the engineering design work with the standards of AASHTO, Department of Highways Thailand, the drainage design consists of 29 R.C. Bridges, 7 Box Culverts and 106 R.C. Pipe culverts.

4) Cost Estimation

The total cost of construction of Highway Route No. 67 is approximately 1,170 million Baht or approximately 29.2 million United States Dollar. (reference to material prices, year 2003)

5) Conclusion of Study and Engineering Design

Reviewing of DOH engineering design such as geometry, pavement and drainage design made the consultant understand has contributed to the consultant's understanding of the original design principles which will be used as basic information for the improvement of the design concept of this road. The consultant will use this up to date data such as traffic forecast, material source and rainfall intensity to improve the design.

2.1.4 Environmental Study Reviews

The consultant has reviewed the final report of Feasibility Study on Economic, Engineer, and Environmental Impact Highway Route 67: Sangam Pass – Anlong Veng – Siem Reap, prepared by the Department of Highways of Royal Thai Government, January 2006, and the findings are :

1) The Project Location

The environmental study area of the Feasibility Study (FS) in 2006 is same area as The Feasibility Study on the Upgrading of the National Road No.67 (NR67) Section of Siem Reap – Anlong Veng – Choam/Sa Ngam Pass. The study examined the potential environmental effects from the construction and operation of the proposed project in 4 environmental aspects of physical resources, biological resources, human and economic development, and quality of life.

2) Identification of Environmental Impacts

Environmental Impacts were identified by phase as follows:

Construction Phase

Negative Impact: The Project is taking place in a highly isolated environment, free from significant or important natural features. The environment effects related to construction are considered to be minimal and of short duration.

Positive Impact: The impacts on the quality of life of the locals would be minor in nature but positive overall. During construction labour would be sought locally thereby providing employment to the local people leading to increased economy activity.

Operation Phase

Negative Impact: The main negative impacts during the project operation period would be increased traffic, air and noise emissions due to increased traffic levels. This may also result in an increase in safety risks from traffic accidents.

Positive Impact: The beneficial impacts are significant, long-term and wide ranging. The location and design will benefit the local people and other current users of the highway. Other long-term benefits are:

- Encouragement of country's economic growth
- A reduction of traffic congestion

3) Mitigation Measures and Monitoring Program

A number of mitigation measures and monitoring program for construction and operation phases are proposed to minimize potential impacts from operating of the upgraded road. Careful consideration has been given to route alignment to avoid environmental sensitive areas, existing villages and valuable agricultural land.

Findings show that development along this route has no significant adverse impact on both of environmental and social aspects. On the contrary, the positive impacts are significant. Nevertheless, the study provided information for the developer to awareness and monitoring the sensitive area during the entire project life.

The Initial Environmental Examination report for implementation of improvement of the National Road No.67 (NR67) (Section of Siem Reap – Anlong Veng – Choam/Sa Ngam) Project, Kingdom of Cambodia recognized positive and negative

impacts on environmental and social aspects in all periods of before improvement, during improvement and after improvement. Hence, the preventive and mitigation measures including monitoring measures were prepared in order to reduce the significant adverse impacts as stated in Chapter 6 in the final report. Moreover, the public participation was conducted in order to disclose the project information, impacts, mitigation measures and key monitoring measures including the hearings from Cambodian officials and local opinions and suggestions from the communities as stated in Chapter 9 in the final report.

2.2 STRATEGIC POLICY AND ECONOMIC COOPERATION REVIEW

The purpose of the data collection and study of the reports related to this review is to understand the relationship between the project and other projects under development and to be in compliance with the country's national and regional plans. The results from the data collection and study of documents will be used as part of the feasibility study which include the aspects in regards to the economic, social, and environmental aspects, and part of the design element. The study will emphasize on the documents related to the Cabinet Resolutions, country policies, rules and regulations, strategic planning in terms of infrastructure development which relate to both Cambodia and Thailand such as:

1) International Cooperation Program such as Greater Mekong Sub-region (GMS)
2) Cambodia National Strategic Development Plan (NSDP) 2014-2018
3) Strategies for Development of Tourism on the Thailand-Cambodia Border in the Si SaKet Province Area under the Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy

2.3 INTERNATIONAL TRANSPORT COOPERATION NETWORK

The consultants collected and reviewed the cooperation projects between Thailand and neighboring countries, ASIAN HIGHWAY NETWORK, to consider the relationship with the project and to forecast traffic volume and future freight.

2.3.1 ASEAN Economic Community: AEC

The AEC Blueprint 2025 is aimed towards achieving the vision of having an AEC by 2025,which is based on a convergence of interests of the ASEAN Member Countries to deepen and broaden economic integration such as Liberty of Goods, Trade facilitation, Elimination of Non-Tariff Barriers, Customs Integration, Liberalization of Trade, service and supporting on investment environment. ASEAN shall act in market-driven economy consistent with multilateral rules as well as adherence to rules-based systems for effective compliance and implementation of economic commitments.

Moreover, the AEC blueprint 2025 is also focusing on the development and implementation of a comprehensive trade facilitation work program which aims at simplifying, harmonizing and standardizing trade and customs, processes, procedures and related information flows by ASEAN Single Window or ASEAN-wide Self-Certification, ASEAN Trade Repository and Elimination of Non-Tariff Barriers (NBTs). This will mark businesses to be more transparent and benefit from AEC.

2.3.2 Greater Mekong Sub region Economic Cooperation: GMS

The project purposes are to encourage the ASEAN Economic Community. In 1992, the six country members which are Cambodia, the People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Region), Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam have signed the agreement to integrate their economies as part of sub-region in order to promote and encourage trading, industrials, agricultural and service investment. As a result, 11 practical plans have been defined.

- North-South Economic Corridor Development Plan connects Thailand-Myanmar/ Lao PDR-China by the route Chiangkong-Luangnumtha-Chiangrung-Khunming (R3A)
- East-West Economic Corridor Development Plan connects Thailand-Myanmar-Lao PDR
- Southern Economic Corridor Development Plan connects Thailand-Cambodia-Vietnam.
- Facilitating Cross-Border Trade and Investment Development Plan
- Enhancing Private Sector Participation and Competitiveness
- Development Human Resource and Skills Competencies
- Strategic Environment Framework
- Flood Control and Water Resource Management
- GMS Tourism Development
- Telecommunications Backbone
- Regional Power Interconnection and Trading Arrangements

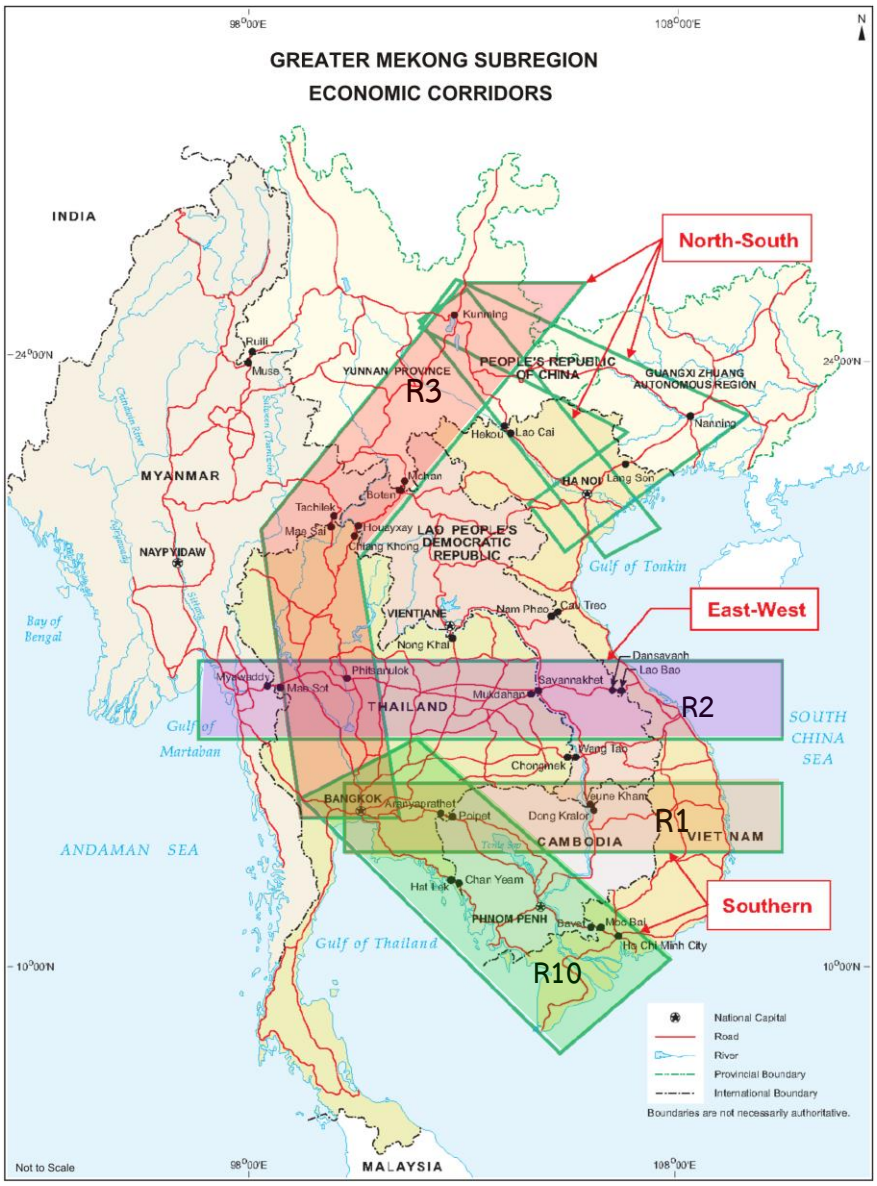


Figure 2.3-1 Greater Mekong Sub Region Economic Cooperation Network

The transportation network is significantly developed from the GMS in order to improve and promote the existing road network to reach the international transportation standards. Thailand has four important economic corridors:

- R1: Southern Economic Corridor (Bangkok- Phnom Penh- Ho Chi Minh City-Wieng Tao) connects Thailand-Cambodia-Vietnam. Its total distance is 1,040 kilometers

- R2: East-West Economic Corridor connects Myanmar-Thailand-Laos PDR-Vietnam. Its total distance is 1,530 kilometers

- R3: North-South Economic Corridor (Chiang Rai-Kunming-Myanmar-Laos PDR) connects southern part of China. The R3 distance is 2,705 kilometers.

- R10 :Bangkok-Trad-Koh Kong-Sihanoukville-Camao) connects Thailand-Cambodia-Vietnam. Its total distance is 900 kilometers

In addition, all road networks in Thailand are up to the standards. Only the need for infrastructure at the border connections are needed to be upgraded.

2.3.3 Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy: ACMECS

The economic cooperation of 5 member countries, Cambodia, Laos PDR, Myanmar, Vietnam and Thailand. The members have defined 5 major objectives as follows.

(1) To reduce the economic gap and level of development between Thailand and member countries.

(2) To reduce the impact that Thailand has received from human trafficking from neighboring countries (illegal immigration), transnational crimes, cross-border drug trafficking, communicable diseases and migrant workers.

(3) To maximize the benefits by the support of each member country's potent.

(4) To develop economic prosperity along the border by the generation of income as a result of the creation of jobs, therefore providing better living conditions to the people in the area.

(5) To promote a good relationship and build trust among the member countries.

Initially the framework covered 5 areas but later on increased the cooperation to cover up to 8 areas which are trade and investment, agriculture, transportation and logistics, tourism, human resource development, public health, industrial and energy, and the environment.

2.3.4 Asian Highway Network

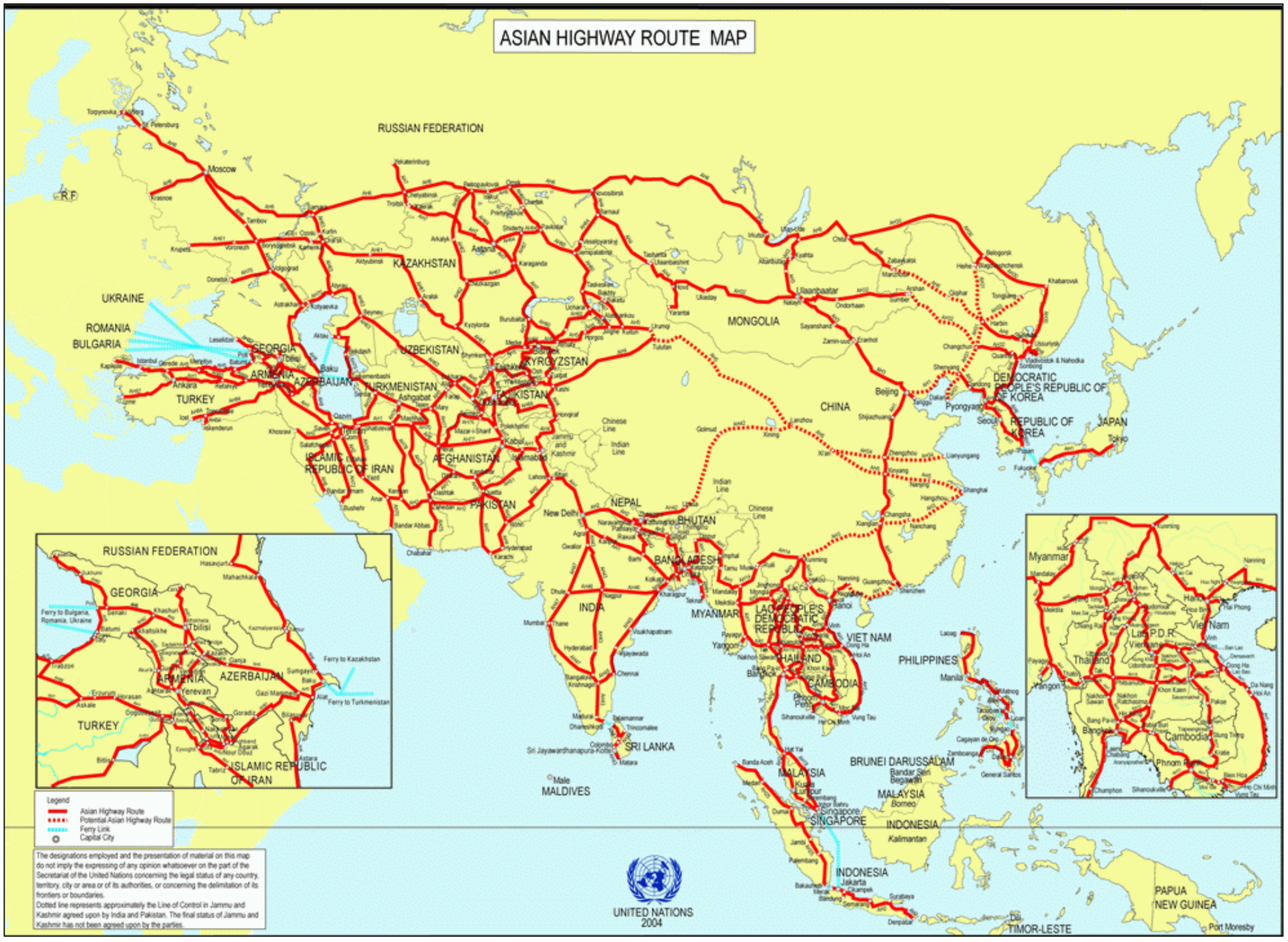
The Asian Highway Network project was initiated in 1959 with the aim to promote development of international road transportation and the development of transportation between industrial cities, ports, tourist attractions, and important domestic and regional trade regions. The agreements have been signed by 32 Asian member countries. Some of the countries taking part in the highway project are Afghanistan, Bangladesh, India, Iran, Nepal, Pakistan, Philippines, Sri Lanka, China, Mongolia and Thailand.

According to the agreement "The Intergovernmental Agreement on the Asian Highway Network (IGA)" in China 2004, the development of 55 Asian highway network routes (141,105 km.) was signed by 23 countries and later, 29 countries ratified the agreement. The details are as shown in **Figure2.3-2.** The agreement was valid since 4 July 2005. A total road distance is 5,110 km within Thailand. As shown **Figure 2.3-3,** 9 routes are mostly in operating at the present as shown in **Table 2.3.4-1**

Table 2.3.4-1 Asian Highway Network

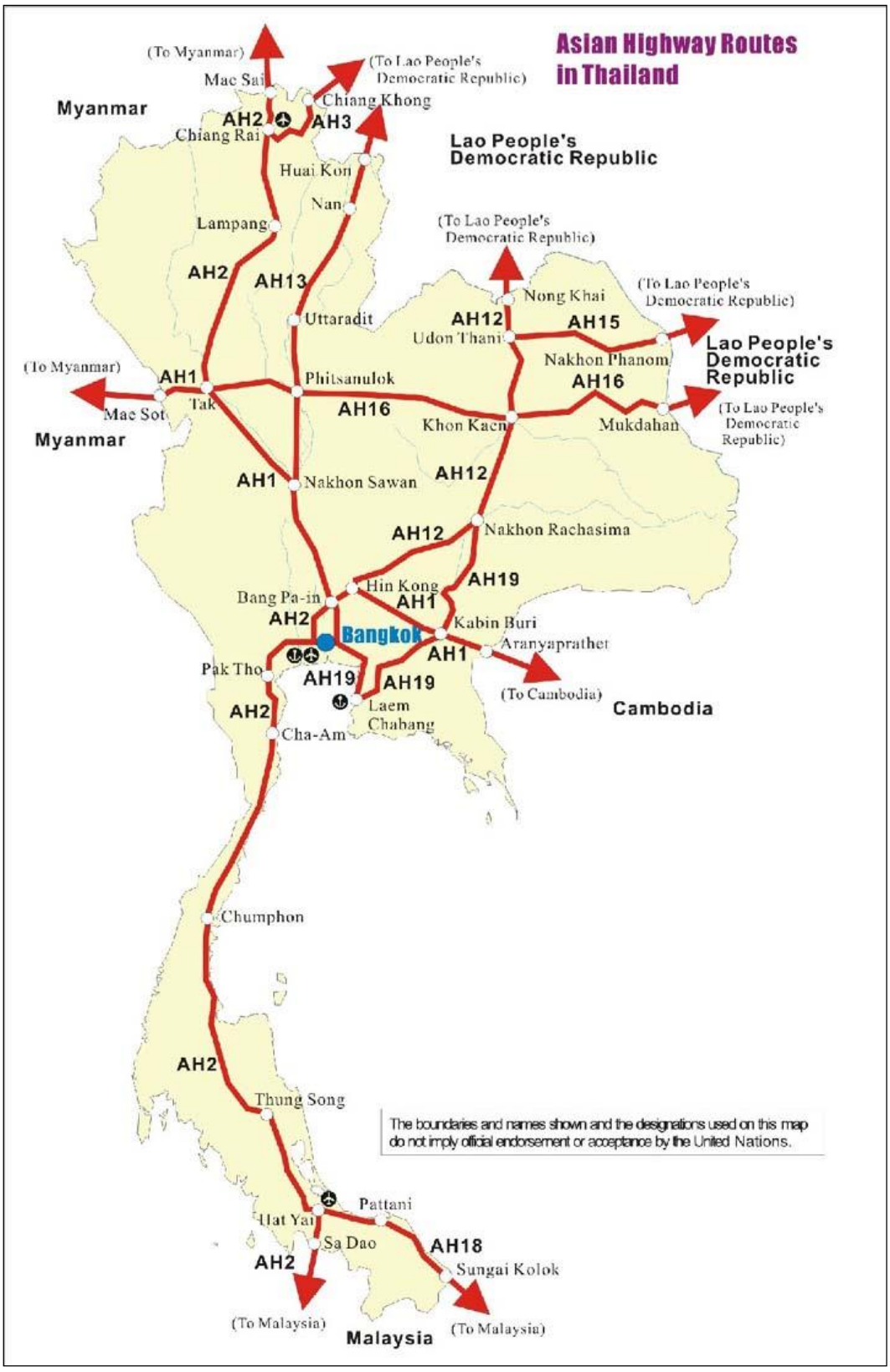
Route	Distance (km.)	Start	End
AH-1	701	Myanmar border at Mae Sot District	Cambodia border at Aranyaprathet District
AH-2	1,549	Myanmar border at Mae Sai District	Malaysia border at Sadao District
AH-3	116	Intersection from AH-2 at Chiang Rai Province	Laos PDR at Chiang Kong District
AH-12	511	Intersection from AH-1 at Hin Kong T junction	Nong Khai Province
AH-13	555	Intersection from AH-1 at Nan Province	Nakhon Sawan Province
AH-15	242	Intersection from AH-1 at UdonThani Province	Nakhon Phanom Province
AH-16	707	Mukdahan Province	Tak Province
AH-18	268	Intersection from AH-2at Hat Yai Province	Malaysia border at Su-ngai Kolok District
AH-19	459	Nakhon Ratchasima Province	Outer Bangkok ring road at Bang Phra District

Source: UNESCAP Website, http://www.unescap.org/ttdw/common/tis/ah/Member%20countries.asp, 21 February 2008



Source: *UNESCAP website, http://www.unescap.org/ttdw/common/TIS/AH/maps/AHMapApr04.gif, Nov 4th, 2005*

Figure 2.3-2 Asian Highway Network



Source: *UNESCAP website, http://www.unescap.org/ttdw/common/tis/ah/member%20countries.asp, Nov 4th, 2005*

Figure 2.3-3 Asian Highway Network in Thailand

2.3.5 Summary of the Review on International Transport Network Development and Cooperation Projects

The consultant has reviewed the cooperation and development of the international transportation network which is expected to benefit the study of this project for both Thailand and Cambodia. The reviewed projects are as below.

1) Greater Mekong Sub-region: GMS
2) ASEAN Economic Community: AEC
3) Ayeyawady - Chao Phraya- Mekong Economic Cooperation Strategy: ACMECS
4) Asian Highway Network

The results of the study of NR67 study project and relations to the reviewed projects are concluded in the **Table 2.3.5-1** as follows,

Table 2.3.5-1 International Transport Network Development and Cooperation Projects

Project	Detail of the project	Relationship
1. Greater Mekong Sub-region: GMS	- The project is planned to encourage the Asia-Pacific Economic Cooperation. - Its purpose is to develop the GMS border trading including transport and freight.	- The Southern Economic Corridor development phase that connects Thailand-Cambodia-Vietnam is divided into 2 routes: 1. Bangkok-Trat-Koh Kong-Sihanoukville-Ka Mao with a total distance of 900 kilometers (R10) 2. Chong Sangam-AnlongVeng-Siem Reap (NR67) with a total distance of 167 km and connected to North-East part of Thailand - The development of the 2nd route (NR67), is the route under study. The NR67 route is connected to R10 route at Si Saket and Surin province. Its development will encourage border trading and freight, and passenger transport among Thailand, Cambodia and Vietnam. Moreover, Si Saket, Surin and Siem Reap provinces are considered famous tourist attractions because of their historical sites. - In conclusion, the development of both GMS and NR67 project will encourage and facilitate the border trading and tourism among the mentioned countries.

Project	Detail of the project	Relationship
2. ASEAN Economic Community: AEC	AEC Blueprint 2025 was promoted to encourage an Integrated and Highly Cohesive Economy among ASEAN members - Facilitate the free trading among the members - Cancel or reduce the taxation - Improve the customs clearance process and its related standard. - Facilitate the employee and technician trading.	- The development and improvement of free trade, human resources, and transportation among the member countries are related to the NR67 study project . The development of NR67 route will facilitate the transport among the Northeast part of Thailand, Siem Reap of Cambodia and Vietnam. This will result in encouragement of border trading, traveling and freight transportation. Moreover, it will also result in the increase in trading and customer service.
3. Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy: ACMECS	- is a political, economic, and cultural organization among Thailand, Laos, Vietnam, Cambodia and Myanmar.	- ACMECS supports social development such as reducing the gap between the social aspects and education among the member countries. - ACMECS is not quite related to the NR67 project. - However, the consultant shall recommend the review of ACMECS as a guideline for further studies of the development NR67 route.
4. Asian Highway Network	- The road network connects 55 Asian countries with a total road distance of 141,105 kilometers.	- Route AH1 ,a member of Asian Highway Network, is the route that connects India- Myanmar- Thailand- Cambodia- Vietnam- China. This section passes through Cambodia and connects to NR67. Hence, the development of NR67 will facilitate the transportation between Thailand and AH1 route. Moreover, it will be also encourage tourism, freight and passenger transportation. As AH1 is the major Asian highway road, it will maintained and improved in the future. In addition, AH1 route passes through many developed countries which have high purchasing capabilities.

From the review of the Feasibility Study on Economic, Engineering, and Environmental Impact National Route 67: Sangam Pass – Anlong Veng – Siem Reap (Department of Highway, Thailand, 2006), and the reviews of the policies and strategies of international cooperation networks in regards to economic and transportation, the consultant shall implement the related data to this project study by selecting only the networks and projects that directly relate to this project. The related data implementation will be summarized and used in the further studies in Chapter 4, Traffic and Transportation.

CHAPTER 3

SOCIO-ECONOMIC STUDY

CHAPTER 3

SOCIO-ECONOMIC STUDY

The objective of the socio-economic study for the National Road No. 67 (Siem Reap – Anlong Veng – Choam/ Sa Ngam Section) Project is to understand the existing socio- economic conditions of the project area to forecast the future socio-economic conditions and the future number of passengers and traffic conditions in the next chapter. This study covers Oddar Meanchey province and Siem Reap province in Cambodia and Si Sa Ket and Surin provinces in Thailand.

- **Collection of Socio-economic Data of Cambodia**

The Consultant gathered Cambodia's socio-economic data from the related government agencies and relevant international organizations. The collected data comprise population, GDP, and employment from the National Institute of Statistics, Cambodia; consumer price index (CPI) data from the Asian Development Bank; international trade between Thailand and Cambodia from the Ministry of Commerce, Thailand; tourism-related data from the Ministry of Tourism, Cambodia; educational data from the Ministry of Education, Youth and Sport, Cambodia; and registered vehicle data from the Ministry of Pubic Work and Transport, Cambodia. Details of the collected data are presented below.

Population: In 2018 Cambodia had a total population of approximately 18.01 million, of which 1.18 million people in Siem Reap province and 0.14 million people in Oddar Meanchey province. The overall growth rate of population in Cambodia was 2.08 percent per year on average.

Gross Domestic Product (GDP): In 2017 the GDP of Cambodia was worth 49,177 billion Riels with an average annual growth rate of 6.23 percent. The trade and service sector had the highest GDP value, followed by the industrial sector and the agricultural sector.

Trade between Thailand and Cambodia: In 2017 the value of trade between Cambodia and Thailand was about 209,003.16 million Baht. Thus, Cambodia's trade deficit with Thailand was about 147,487.06 million Baht. The Thai-Cambodian border trade was worth about 125,364.14 million Baht in value, accounting for 59.98 percent of the total trade value between Thailand and Cambodia. Cambodia's trade deficit with Thailand was 78,279.70 million Baht in value.

Consumer Price Index (CPI): In 2017 the CPI of Cambodia was 169.9, with the average growth rate of 2.9 percent per year for the past ten years.

Employment: In 2013 there were about 7.95 million persons in employment, consisting of 49% in the agriculture sector, 31% in the service sector, and 20% in the industrial sector. The overall growth rate of employment in Cambodia was 2.98 percent per year.

Tourism: In 2017 Cambodia had about 5,602,157 international tourist arrivals, and the average length of stay for 6.6 days. The number of tourists increased at an average rate of 10.8 percent per year. The international tourists arriving by air, by land and by water were 59.1%, 38.3%, and 2.6% respectively.

Education: In 2017 there were about 3,077,660 registered students in Cambodia. The 10-year statistics revealed the decrease in the number of students by 0.95 percent per year. In the study area, there were 298,850 students, 83% of which in Siem Reap province and 17% in Oddar Meanchey province.

Registered Vehicles: In 2016 there were 525,764 registered vehicles in Cambodia with an average growth rate of 14.18 percent per year. Considering the proportion of vehicle types, motorcycles took a proportion of 88.4%, private cars of 7.1%, pick-up cars of 2.1%, trucks of 1.4%, vans of 0.9%, and buses of 0.1%.

- **Collection of Socio-Economic Data of Thailand**

The Consultant collected Thailand's socio-economic data from the related government agencies of Thailand. That is, population data were gathered from the Ministry of Interior; GDP data from the Office of the National Economic and Social Development Council; international trade between Thailand and Cambodia and CPI from the Ministry of Commerce; employment data from the National Institute of Statistics; tourism-related statistics from the Ministry of Tourism & Sport; educational data from the Ministry of Education, and registered vehicle data from the Ministry of Transport. Details of the collected data are presented below.

Population: In 2017, Thailand had 66.19 million population, slightly increased at an average rate of 0.49 percent per year. In the study area, there were 2.87 million population, of which 1.47 million people in Si Sa Ket province and 1.40 million people in Surin province. The average growth rate of population in the study area was 0.19 percent per year whereas the growth rates in Si Sa Ket and Surin provinces were 0.20 percent and 0.18 percent respectively.

Gross Domestic Product (GDP): In 2017 Thailand GDP was worth about 10,426,791 million Baht with an average annual growth rate of 3.21 percent. The trade and service sector had the highest GDP value, followed by the industrial sector, and the agriculture sector. The GPP of Surin province was worth 42,164 million Baht whereas the GPP of Si Sa Ket province was 38,859 million Baht in value.

Consumer Price Index (CPI): In 2017, Thailand's CPI was 100.85. The CPI change rate was 1.9 percent per year on average during the past ten years.

Employment: In 2017 about 37.46 million persons were in employment in Thailand, of which 45 percent in the service sector, 31 percent in the agricultural sector, and 23% in the industrial sector. The average growth rate of employment in Thailand was 0.33 percent per year during the past ten years.

Tourism: In 2017 Thailand had about 289.82 million visitors, of which 75 percent were Thais and 25 percent were foreigners. The average growth rate of visitors was

7.22 percent per year. As for the number of visitors in the study area, Si Sa Ket province had 1.48 million visitors, and Surin province about 1.29 million visitors.

Education: The number of student in Thailand decreased at an average of 0.73 percent per year. In 2017, there were is 13.00 million seats for Thai students. In addition, the numbers of students in Si Sa Ket and Surin provinces also shrank at an average of 1.00 and 2.35 percent per year, respectively. In the study area, there were totally 1,893 educational institutions and 484,564 students.

Registered Vehicles: At the end of 2017, there were 38,308,763 registered vehicles in Thailand. Surin province and Si Sa Ket province had 453,818 and 399,852 registered vehicles respectively.

- **Socio-economic Forecast**

Population Forecast

- Cambodia: In 2042, there will be 1.88 million people in Siem Reap province, increasing from 1.28 million people in 2022 at an average growth rate of 1.93 percent per year. In Oddar Meanchey province, the number of population will be 0.25 million in 2042, increasing from 0.15 million people in 2022 at an average growth rate of 2.47 percent per year.

- Thailand: In 2042, there will be 1.56 million people in Si Sa Ket province, increasing from 1.49 million people in 2022 at an average growth rate of 0.24 percent per year. In Surin province, there will be 1.47 million people in 2042, increasing from 1.41 million in 2022 at an average growth rate of 0.20 percent per year.

Table 3-1 Population Forecast in the Study Area (Thailand and Cambodia)

Area	Population Forecast (persons)					Growth Rate per Year
	2022	2027	2032	2037	2042	
Oddar Meanchey	152,702	174,747	196,226	221,011	248,927	2.47%
Siem Reap	1,280,344	1,418,224	1,555,916	1,709,344	1,877,903	1.93%
Surin	1,408,325	1,425,543	1,439,656	1,453,130	1,466,706	0.20%
Si Sa Ket	1,485,975	1,506,745	1,524,192	1,540,990	1,557,946	0.24%
Total	**4,327,346**	**4,525,259**	**4,715,990**	**4,924,475**	**5,151,482**	**0.88%**

Source: Computed by the Consultant

GPP Forecast

- Thailand: In 2042 the GPP in Surin province will be worth 91,999 million Baht with an average growth rate of 3.41 percent per year whereas the GPP of Si Sa Ket province will be 78,966 million Baht with an average growth rate of 3.02 percent per year.

Table 3-2 GPP Forecast of Thailand

Area	GPP Forecast Data (million Baht)					Growth Rate per Year
	2022	2027	2032	2037	2042	
Surin	47,087	55,720	67,484	81,711	91,999	3.41%
Si Sa Ket	43,534	50,344	59,478	70,219	78,966	3.02%
Total	**90,621**	**106,064**	**126,962**	**151,930**	**170,965**	**3.22%**

Source: Estimated by the Consultant

- **Thailand-Cambodia Benefit of Trading Analysis**

According to the data Thailand-Cambodia trading, top five Thailand's exports to Cambodia comprise non-alcoholic beverages; motor cars, parts and accessories; motorcycles, parts and accessories; spark-ignition reciprocating internal combustion piston engines and parts thereof, and machinery and parts thereof. Top five Thailand's imports from Cambodia include vegetables and vegetable products; wires and insulated cables; aluminum and products thereof; garment; and copper and products thereof. Considering the growth trends of these imports and exports during 2013-2018, they tend to continually expand because of the economic stability of Cambodia and the increase in the number of working age population that will be the main group of consumers in the future. As a result, both Thailand and Cambodia will continually benefit from the international trade and investment. This transportation infrastructure development project will also promote the international trade.

- **Study and Analysis of Existing Traffic Conditions and Services at Sa-ngam/Choam Border Checkpoint, Problems and Obstacles, and Suggestions**

According to the survey of the existing conditions of the Sa-ngam checkpoint (Thailand) and the Choam checkpoint (Cambodia), there are immigration offices and other office buildings for customs officials. Besides, the land preparation activities are found in the privately-owned areas around the border checkpoint, i.e. a large hotel construction project in the south and the preparation for a large building and hotel project in the east of the checkpoint.

Regarding the vehicle class proportion at the border checkpoint, motorcycle and passenger cars (travel of people) took the highest proportion of 93-96% on weekend and weekday whereas heavy vehicles occupied 7% at the maximum on weekend. During the peak time in 2042, there will be 370 PCU/hour at the border checkpoint, of which 345 PCU/hour are 2-4 wheel vehicles and 25 PCU/hour are vehicles with 6 wheels or more. As for the time spent at the border checkpoint, at present each truck takes only 5-10 minutes.

About 90% of motorcycles and 4-wheel vehicles at the checkpoint belong to local people. Each takes about 2-3 minutes to follow the customs procedures.

Considering the existing cross-border traffic volume, parking area, customs buildings, and facilities, it is not necessary to construct more buildings and parking area in the future in case of increase in the number of customs officials or customs document checking stations. This is because the traffic volume is not high and the customs procedures do not take a long time.

Since the number of passengers at the border checkpoint is not high, the existing immigration system and the customs clearance procedures can sufficiently serve the passengers and it does not take a long time. However, in the future when the number of passengers is higher, the paperless e-customs clearance procedures and the modern immigration system are required to provide faster services.

- **Study of Necessity and Feasibility for Promoting the Exchange of Traffic Rights to Facilitate Cross-border Transportation**

The objective of the National Road No. 67 (NR67) Improvement Project is to increase the efficiency and volume of transportation on the highway linking between Thailand and Cambodia at Choam/SaNgam border checkpoint. The major factors which will attract more traffic volume include simplified customs clearance and immigration procedures, and exchange of traffic rights which allows vehicles from one country to travel to other countries and thus facilitates cross-border transportation.

At present, the Greater Mekong Subregion (GMS) and the Asian Development Bank (ADB) have mutually entered into the GMS Cross-Border Trade Agreement (GMS CBTA) to reduce procedures for transportation of goods and passengers, including exchange of traffic rights, to bring about faster and more convenient transportation, reducing transportation costs, increasing trade and investment opportunities, and enhancing logistics business among the GMS countries.

At present, the pilot cross-border checkpoint between Thailand and Cambodia under this collaboration is the Aranyaprathet-Poipet border checkpoint which is included in the R1: Sothern Economic Corridor (Bangkok - Phnom Penh - Ho Chi Minh City - Vung Tau).

Since the GMS CBTA focuses on facilitation of goods transportation and travel of people in the GMS countries, the cross-border checkpoints of the member countries must be located on the GMS Economic Corridors and road networks in each country must meet the acceptable standards in order to accommodate more traffic volume.

Regarding the study of necessity and feasibility for exchange of traffic rights or registration of both personal and freight vehicles for cross-border transportation between Thailand and Cambodia, at present the number of vehicles is not high, and the existing immigration system and the customs clearance procedures can provide fast services. When the number of traffic volume increases in the future as a result of the improvement of the NR67, the exchange of traffic rights should be promoted to facilitate the cross-border transportation. The cooperation frameworks in relation to vehicle border pass between Thailand and Cambodia currently exist in the forms of convention or agreement.

CHAPTER 4

TRAFFIC AND TRANSPORTATION STUDY

CHAPTER 4

TRAFFIC AND TRANSPORTATION STUDY

4.1 METHOD OF STUDY

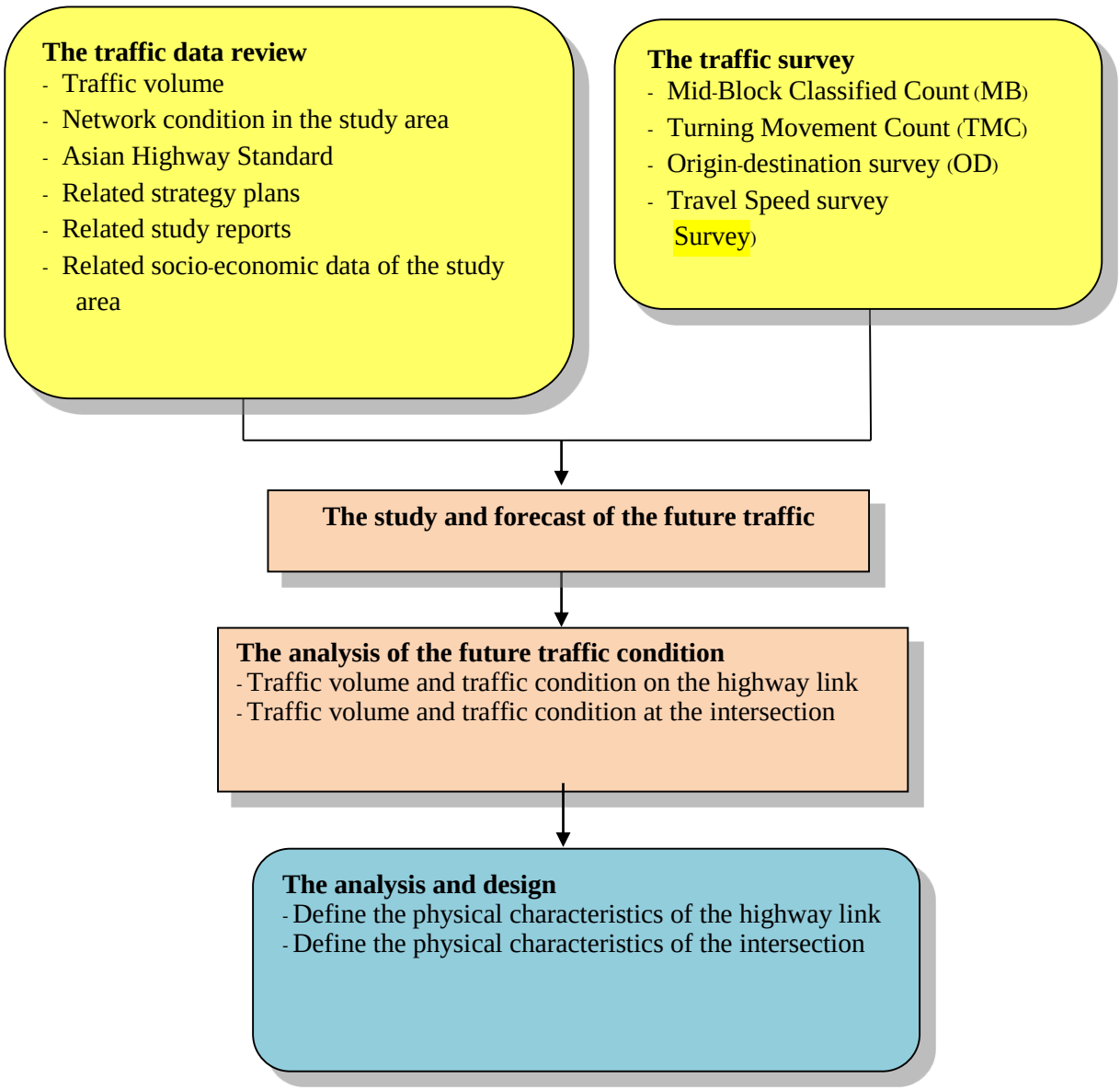
The traffic studies of this project aims to study the current demand and traffic volume on the network in the study area, including forecast of the traffic volume of the future year. The study results will be used in various fields of the study, as listed below:

- Project Benefits Assessment
- the Environmental Impact Assessment (EIA)
- the physical Geometric Design of the roadway and intersection in the project

This traffic and transportation study consists of 4 main procedures as follows;

1. The traffic data review
2. The traffic survey
3. The traffic volume forecasting
4. The analysis of the future traffic condition

The relationship of each procedure is shown in **Figure 4.1-1**



Source: The Consultant,2019

Figure 4.1-1 Traffic Study Procedures

4.2 FUTURE TRAFFIC VOLUME FORCASTE

Forecast of the future traffic and transport is based on the 4-step modeling process. In this project CUBE model was applied for traffic analysis purpose. Then, data on the existing socio-economic conditions and road network were input to calibrate the model. Then, the data from traffic and transport survey were entered to analyze the increased traffic volume in the future. Increase in the traffic volume can be divided into 4 types.

1. ***Normal Traffic***, the increasing of the traffic volume due to the socio-economic growth of the project area.

2. ***Diverted traffic***, the increasing of the traffic volume due to the traffic on another highway diverted to the project highway. These traffics expect to reduce the distance or travel time including the existing traffic on the project highway may divert to another highway route.

3. ***Induced Traffic***, the increasing of the traffic volume due to the new generated traffic as a result of the convenience and less travel time, including the new traffic from the Shift Mode.

4. ***Development Traffic***, the increasing of the traffic volume due to the economic growth of the influence area of the project as a result of the construction or rehabilitation of the highway in the future.

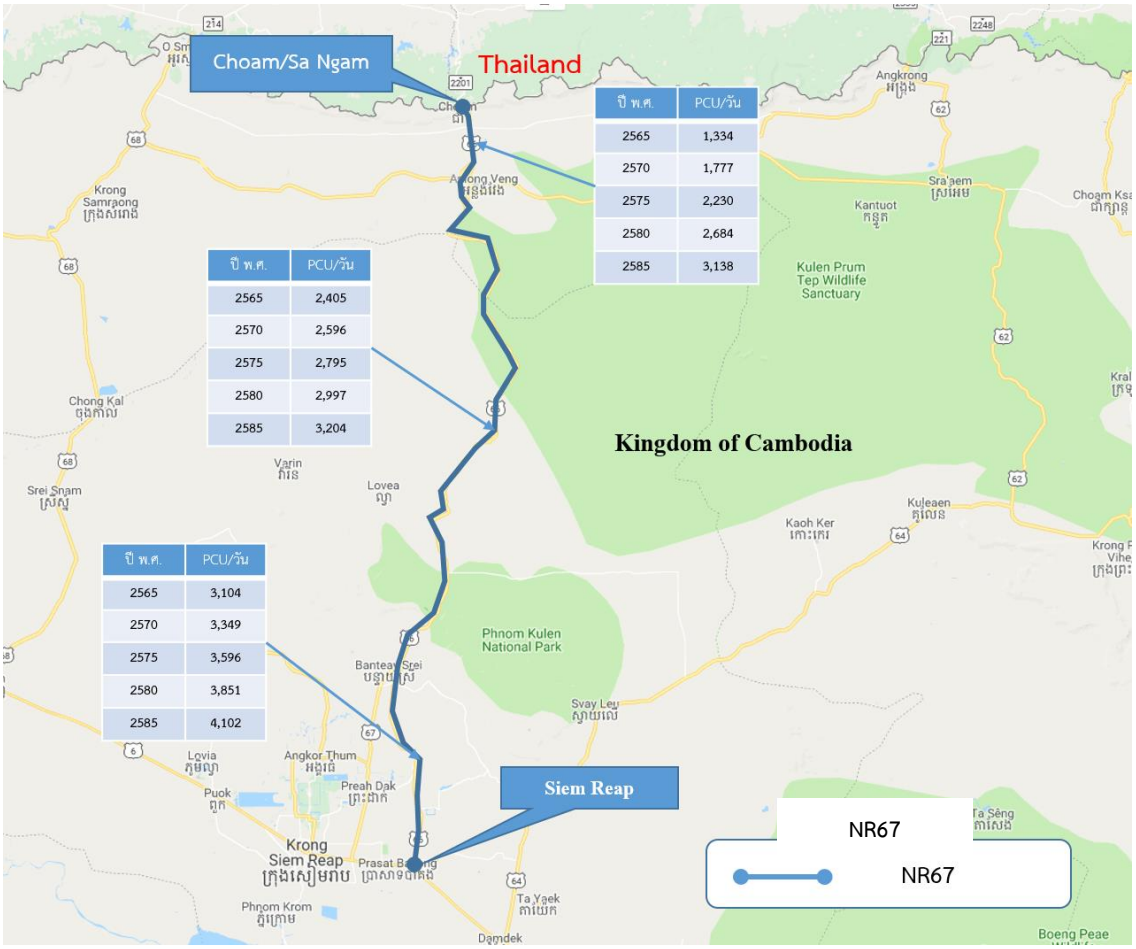
4.2.1 Traffic forecast

The consultant has analyzed 2 scenarios: with the project development and without the project development. The forecast was divided into 3 road segments by considering the physical conditions and roadside societies as shown in **Figure 4. 2-1** and **Figure 4.2-2**

- Section 1 from the beginning of the project road NR67 to the intersection Cambodia and Korea friendship road
- Section 2 from the the intersection Cambodia and Korea friendship road to bypass Anlong Veng road
- Section 3 bypass Anlong Veng road to Choam Sa Ngam border

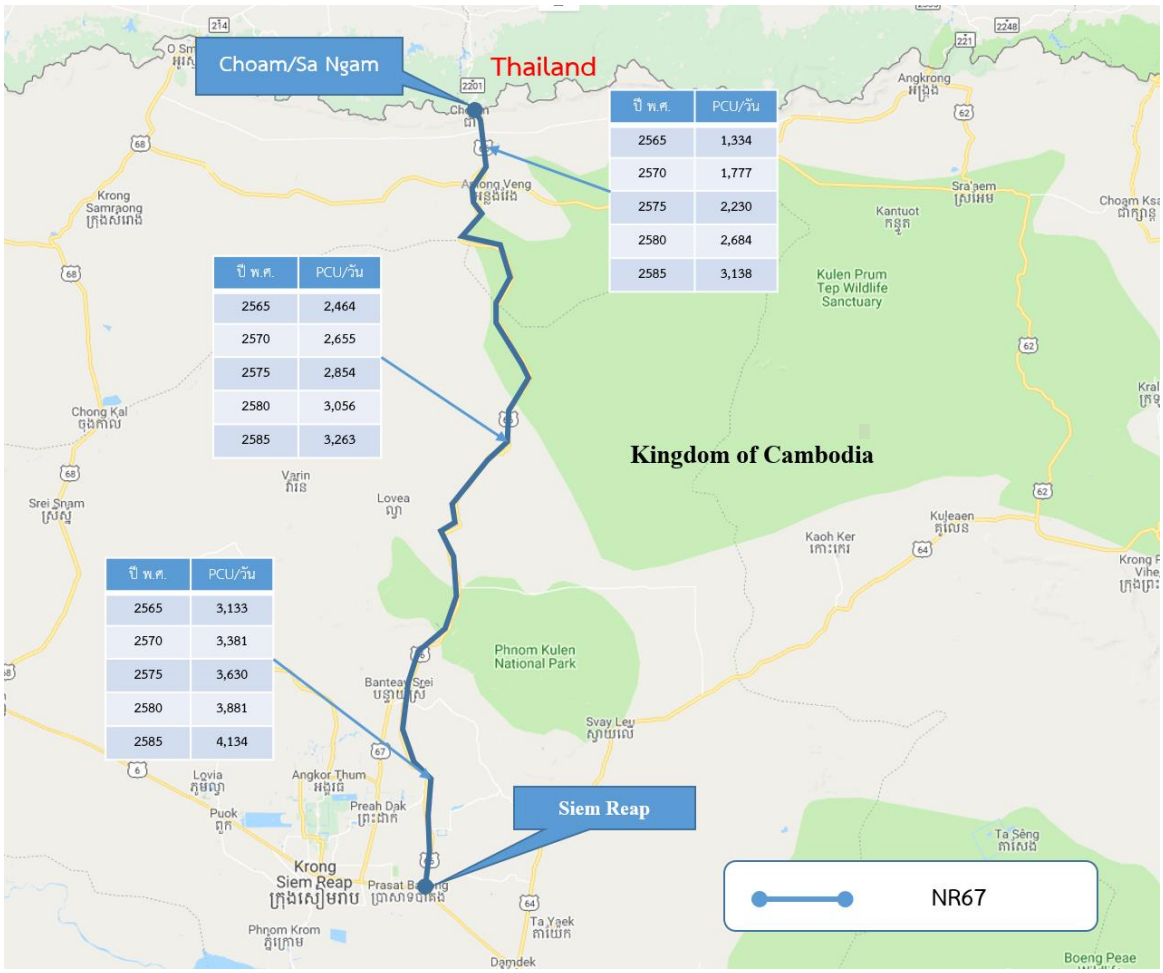
In case of project development, the consultant shall consider the Normal Traffic, Devert Traffic, Induced Traffic, Development Traffic (number of tourists and products transport that will be increased due to development of the project).The Development Traffic will be generated from the growing of economic in the study area. On the other hand, in case without the project development, the current road condition is asphalt pavement on section 1 and 2 with terrain and rolling. The section 3 is the concrete pavement pass through hill terrain and without asphalt paving plan. The forecast shall be focused on the opening project year 2022.

From the forecasted result, in 2022-2042 (asphalt paving plan 2042) the section 1 has the highest traffic volume, others are section 2 and 3 about 4,473, 3,603 and 3,478 PCU/day (2-directions), respectively. By comparing the traffic between 2018 and 2042, section 3 has the highest growth rate about 6.8 percent per year, others are section 2 about 2.6 percent per year and section 1 about 2.4 percent per year. On the other hand, consider in case of without project development, in 2018, there is traffic on section 1, 3 and 2 about 890 to 2,780 PCU/day (2 directions). By comparing between 2018 and 2042, section 1 has traffic growth rate about 2.0 percent per year, section 2 and 3 have 2.0 and 6.2 percent per year, respectively.



Source: the project model from the study team

Figure 4.2-1 Forecasted Traffic Volume in Case without Project Development (Year 2022-2042)



ปี พ.ศ.	PCU/วัน
2565	1,334
2570	1,777
2575	2,230
2580	2,684
2585	3,138

ปี พ.ศ.	PCU/วัน
2565	2,464
2570	2,655
2575	2,854
2580	3,056
2585	3,263

ปี พ.ศ.	PCU/วัน
2565	3,133
2570	3,381
2575	3,630
2580	3,881
2585	4,134

Source: the project model from the study team

Figure 4.2-2 Forecasted Traffic Volume in case with Project Development (Year 2022-2042)

4.3 FUTURE TRAFFIC CONDITION ANALYSIS

The consultant shall analyze the future traffic condition by using the Highway Capacity Manual (HCM) of 2lanes road. The analysis shall consider the Level of Service (LOS) of the project road. The project road LOS in the last operation year should not be worse than LOS C. The LOS condition shall be analyzed only in case with project development.

LOS analysis result

Level of Service, LOS of NR67 road was analyzed only 2 lane highway cases. The study area was devided into 3 sections as mentioned before. The LOS are shown in **Table 4.3-1**

Table 4.3-1 LOS of the Project Road (2 Lanes Highway Case)

Section	2022		2027		2032		2037		2042	
	PTSF	LOS	PTSF	LOS	PTSF	LOS	PTSF	LOS	PTSF	LOS
Section 1	33.9%	**A**	36.3%	**A**	38.7%	**A**	41.0%	**B**	43.4%	**B**
Section 2	28.1%	**A**	30.2%	**A**	32.3%	**A**	34.5%	**A**	36.7%	**A**
Section 3	27.4%	**A**	34.0%	**A**	39.8%	**A**	45.0%	**A**	49.5%	**B**

Source: Analyzed by the Consultant,2019

The LOS result shows that this project has suitable design for the 2 lane highway in order to support the increasing traffic volume. Section 1 and 3 have the LOS A from year 2022-2032 and LOS B from 2037-2042, while the section 2 always has the LOS A during the project operation period years 2022-2042.

Intersection traffic analysis result

For the traffic signal installation analysis, the consultant has analyzed all 3 important intersections.

- intersection 1 : The beginning of the project, NR67 road crosses NR6 (TMC1)
- intersection 2 : NR67 road crosses Cambodia and Korea friendship asphalt pavement road (TMC2)
- intersection 3 : NR67 road crosses Choam Jom border road(TMC3)

From the result in **Table 4. 3-2**, intersection 1 has to install traffic signal in year 2022, while intersections 2 and 3 do not have to install traffic signal during the project operation period (20 years)

Table 4.3-2 Analysis of the Traffic Signal Installation Year

Intersection	Peak hour traffic	Year					traffic signal installation year
		2022	2027	2032	2037	2042	
TMC1	Major road both direction	1,998	2,278	2,462	2,539	2,601	2022 (project open year)
	Minor road peaker direction	164	177	187	207	221	
TMC2	Major road both direction	244	264	287	309	333	Unnecessary
	Minor road peaker direction	50	54	58	63	67	
TMC3	Major road both direction	477	486	520	540	559	Unnecessary
	Minor road peaker direction	97	101	108	113	118	

Source: analyzed by the Consultant,2019

Conclusion of Traffic and Transportation Study

From the LOS analysis on the project road, the designed 2 lane highway is suitable for the increased traffic volume. Sections 1 and 3 have LOS A from year 2022 to 2032 and LOS B until year 2042, while section 2 has LOS A during the project operation period, 2022-2042.

The project road section Siem Reap – Choam Jom in Cambodia, at present, the asphalt pavement has been damaged. The average travel speed is 55 kph, and the traffic volume is about 900 – 2,770 PCU/day. When the project road has improved to be asphalt and paved up to standard, in 2022 the daily traffic forecast shall be 1,460 – 3,360 PCU/day. By considering the project operation period of 20 years, the improved project road shall have LOS A-B. Hence, the 2 lane highway with standard design shall support the traffic throughout the project operation period.

TMC1 has to be installed the traffic signal in 2022, when the road opens. The other intersections have to be suitably Geometric re-designed.

By comparing this study results (NEDA, 2018) with the study result from Department of Highway (DOH, 2006), the DOH study has forecated the total daily traffic of 4,020 vehicles/day in 2018, while this study (NEDA, 2018) has forecasted much different with total daily traffic of 2,813 vehicles/day in 2018. The differece should be the result of the crisis in economic and society which affected the transportation and development of Thailand and Cambodia crossing borders. In addition, in 2008-2009 there was a world economic crisis, and in 2011 there was a big flooding in Thailand. Moreover, the political crisis in Thailand could be also the obstacle of the development. Hence, these lead to the high decrease forecasted traffic volume of the DOH study.

The analyzed traffic and transportation data shall be used in further related design and project benefit analysis in this study.

CHAPTER 5

DETAILED DESIGN

CHAPTER 5

DETAILED DESIGN

5.1 SELECTION OF SUITABLE PAVEMENT IMPROVEMENT OPTION

The meeting on interim report acceptance with the Ministry of Public Works and Transport (MPWT), dated 22 February 2019 in Siem Reap, Cambodia, reached the resolution that the Consultant shall conduct additional study on the pavement options for improvement of the NR67. The pavement improvement options must be compared to select the most suitable one. Then, the selection result must be proposed to NEDA and MPWT for consideration and approval for further detailed design step. Three pavement improvement alternatives proposed for the project are as follows.

- Alternative 1 Asphalt Concrete Surface : Both Carriageway and Shoulder
- Alternative 2 Cape Seal Surface : Both Carriageway and Shoulder
- Alternative 3 Asphalt Concrete Surface : Carriageway
  Cape Seal/DBST : Shoulder

Pavement improvement options are depicted in **Figures 5.1-1 to 5.1-3.**

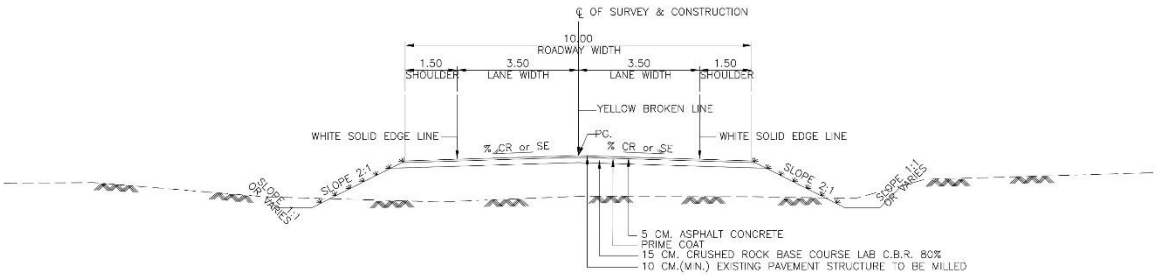


Figure 5.1-1 Alt.1 Asphalt Concrete Surface: Both Carriageway and Shoulder

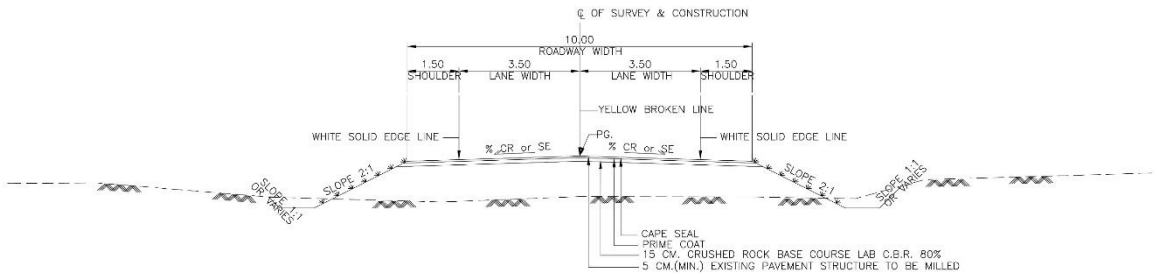


Figure 5.1-2 Alt.2 Cape Seal Surfac : Both Carriageway and Shoulder

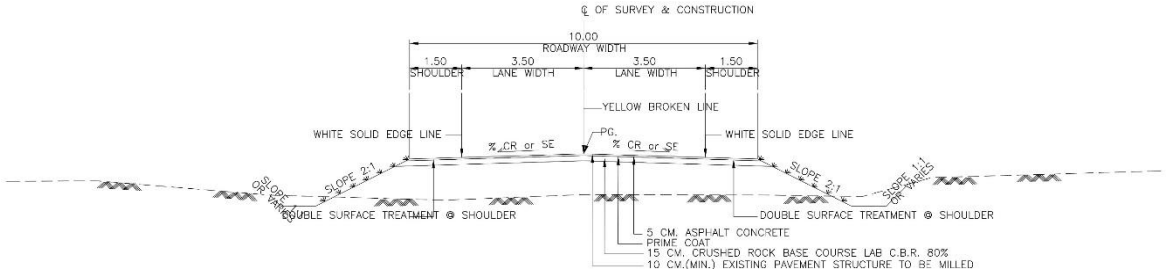


Figure 5.1-3 Alt.3 Asphalt Concrete: Carriageway and Cape Seal/DBST: Shoulder

5.1.1 COMPARISON OF CONSTRUCTION COSTS

The Consultant estimated the construction costs for the three pavement improvement alternatives as presented in **Table 5.5.1-1** and details of cost breakdowns in **Table 5.1.1-2**.

Table 5.1.1-1 Estimated Construction Costs of Pavement Improvement Alternatives

NO.	DESCRIPTION	AMOUNT		
		ALTERNATIVE 1 (THB)	ALTERNATIVE 2 (THB)	ALTERNATIVE 3 (THB)
A	**SUB-TOTAL CIVIL WORKS**	**822,252,401.46**	**583,496,680.63**	**749,062,579.93**
	1. GENERAL REQUIREMENT	33,564,792.00	33,564,792.00	33,564,792.00
	2. REMOVAL OF EXISTING STRUCTURES	51,072,000.00	51,072,000.00	51,072,000.00
	3. EARTHWORK	32,923,007.34	32,923,007.34	32,923,007.34
	4. SUBBASE AND BASE COURSES			
	4.1 SUBBASE	1,438,945.71	1,438,945.71	1,438,945.71
	4.2 BASE	142,559,316.48	142,559,316.48	142,559,316.48
	5. SURFACE COURSES			
	5.1 ASPHALT CONCRETE	436,711,413.43	197,955,692.59	363,521,591.89
	5.2 PORTLAND CEMENT CONCRETE PAVEMENT	5,272,374.60	5,272,374.60	5,272,374.60
	6. STRUCTURES	49,436,432.88	49,436,432.88	49,436,432.88
	7. MISCELLANEOUS			
	7.1 CONTRACT SIGN AND COLLABOLATION SIGN	92,545.20	92,545.20	92,545.20
	7.2 TRAFFIC SIGNS	296,439.90	296,439.90	296,439.90
	7.3 ROADWAY LIGHTING AND TRAFFIC SIGNAL	11,263,200.00	11,263,200.00	11,263,200.00
	7.4 MARKINGS	21,435,636.60	21,435,636.60	21,435,636.60
	7.5 GUARD RAIL	15,860,250.00	15,860,250.00	15,860,250.00
	7.6 SLOPE PROTECTION	9,980,016.00	9,980,016.00	9,980,016.00
	7.7 CURB AND GUTTER	716,633.64	716,633.64	716,633.64
	7.8 R.O.W. MONUMENT	745,778.88	745,778.88	745,778.88
	7.9 SOFT SPOT	204,433.92	204,433.92	204,433.92
	8. TRAFFIC MANAGEMENT DURING CONSTRUCTION	4,621,949.88	4,621,949.88	4,621,949.88
	9. ENVIRONMENTAL MANAGEMENT PLAN	3,213,000.00	3,213,000.00	3,213,000.00
	10. REST AREA	844,234.00	844,234.00	844,234.00
B	**CONTINGENCY OF CIVIL WORKS [10% OF A]**	**82,225,240.15**	**58,349,668.06**	**74,906,257.99**
C	**TOTAL CIVIL WORKS COST (A+B)**	**904,477,641.61**	**641,846,348.69**	**823,968,837.92**
	LOAN AMOUNT			
D	**CONSULTING SERVICE (3% OF C)**	**27,134,329.25**	**19,255,390.46**	**24,719,065.14**
E	**ADMINISTRATION COST (1% OF C)**	**9,044,776.42**	**6,418,463.49**	**8,239,688.38**
F	**LOAN CONTINGENCY (5% OF C)**	**45,223,882.08**	**32,092,317.43**	**41,198,441.90**
G	**SUB-TOTAL LOAN (C+D+E+F)**	**985,880,629.35**	**699,612,520.06**	**898,126,033.32**
H	**NEDA'S MANAGING FEE (0.15% OF G)**	**1,478,820.94**	**1,049,418.78**	**1,347,189.05**
I	**TOTOL LOAN OR PROJECT COST (G+H)**	**987,359,450.30**	**700,661,938.85**	**899,473,222.38**

According to **Table 5.1.1-1**, Alternative 1 has the highest project cost of approximately 987.36 million Baht, followed by Alternative 3 of approximately 899.47 million Baht, and Alternative 2 of approximately 700.66 million Baht.

5.1.2 COMPARISON OF MAINTENANCE COST AND ENVIRONMENTAL COST

The Consultant estimated the maintenance costs and environmental costs of Alternative 1, Alternative 2, and Alternative 3 throughout the project's service period of 20 years as presented in **Table 5.1.2-1, Table 5.1.2-2,** and **Table 5.1.2-3** respectively.

Table 5.1.2-1 Maintenance Cost and Environmental Cost of Alternative 1

Alt. 1 : AC pavement (Lane and Shoulder)

No.	Item	Year	1	2	3	4	5	6	7	8	9	10
			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
1	**Road Maintenance Cost (Million THB)**											
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		1.80	1.80	5.82	5.82	5.82	5.82	44.82	5.82	5.82	5.82
	1.2 Periodic Maintenance Cost (Overlay)											
2	**Environmental Mitigation Cost (Million THB)**											
	2.1 Fugitve Dust		0.44	0.44	0.44	0.44	0.44					
	2.2 Noise and Vibration		0.24	0.24	0.24	0.24	0.24					
	2.3 Surface water quality		0.11	0.11	0.11	0.11	0.11					
	2.4 Wifdlife		0.08	0.08	0.08	0.08	0.08					
	2.5 Traffic and public health		0.06	0.06	0.06	0.06	0.06					

No.	Item	Year	11	12	13	14	15	16	17	18	19	20	Total
			2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	
1	**Road Maintenance Cost (Million THB)**												
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		5.82	5.82	5.82	44.82	5.82	5.82	5.82	5.82	5.82	5.82	186.36
	1.2 Periodic Maintenance Cost (Overlay)					383.24							383.24
2	**Environmental Mitigation Cost (Million THB)**												
	2.1 Fugitve Dust												2.20
	2.2 Noise and Vibration												1.20
	2.3 Surface water quality												0.55
	2.4 Wifdlife												0.40
	2.5 Traffic and public health												0.30
Source : The Consultant , 2019													**574.25**

Table 5.1.2-2 Maintenance Cost and Environmental Cost of Alternative 2

Alt 2: Cape Seal Pavement (Lane and Shoulder)

No.	Item	Year	1	2	3	4	5	6	7	8	9	10
			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
1	**Road Maintenance Cost (Million THB)**											
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		1.80	1.80	5.82	5.82	5.82	5.82	44.82	5.82	5.82	5.82
	1.2 Periodic Maintenance Cost (Overlay)								185.12			
2	**Environmental Mitigation Cost (Million THB)**											
	2.1 Fugitve Dust		0.44	0.44	0.44	0.44	0.44					
	2.2 Noise and Vibration		0.24	0.24	0.24	0.24	0.24					
	2.3 Surface water quality		0.11	0.11	0.11	0.11	0.11					
	2.4 Wifdlife		0.08	0.08	0.08	0.08	0.08					
	2.5 Traffic and public health		0.06	0.06	0.06	0.06	0.06					

No.	Item	Year	11	12	13	14	15	16	17	18	19	20	Total
			2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	
1	**Road Maintenance Cost (Million THB)**												
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		5.82	5.82	5.82	44.82	5.82	5.82	5.82	5.82	5.82	5.82	186.36
	1.2 Periodic Maintenance Cost (Overlay)					185.12							370.24
2	**Environmental Mitigation Cost (Million THB)**												
	2.1 Fugitve Dust												2.20
	2.2 Noise and Vibration												1.20
	2.3 Surface water quality												0.55
	2.4 Wifdlife												0.40
	2.5 Traffic and public health												0.30
Source : The Consultant , 2019													**561.25**

Table 5.1.2-3 Maintenance Cost and Environmental Cost of Alternative 3

Alt 3: AC Pavement (Lane) and DBST (Shoulder)

No.	Item	Year	1 2022	2 2023	3 2024	4 2025	5 2026	6 2027	7 2028	8 2029	9 2030	10 2031
1	**Road Maintenance Cost (Million THB)**											
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		1.80	1.80	5.82	5.82	5.82	5.82	44.82	5.82	5.82	5.82
	1.2 Periodic Maintenance Cost (Overlay)											
2	**Environmental Mitigation Cost (Million THB)**											
	2.1 Fugitve Dust		0.44	0.44	0.44	0.44	0.44					
	2.2 Noise and Vibration		0.24	0.24	0.24	0.24	0.24					
	2.3 Surface water quality		0.11	0.11	0.11	0.11	0.11					
	2.4 Wifdlife		0.08	0.08	0.08	0.08	0.08					
	2.5 Traffic and public health		0.06	0.06	0.06	0.06	0.06					

No.	Item	Year	11 2032	12 2033	13 2034	14 2035	15 2036	16 2037	17 2038	18 2039	19 2040	20 2041	Total
1	**Road Maintenance Cost (Million THB)**												
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		5.82	5.82	5.82	44.82	5.82	5.82	5.82	5.82	5.82	5.82	186.36
	1.2 Periodic Maintenance Cost (Overlay)					383.24							383.24
2	**Environmental Mitigation Cost (Million THB)**												
	2.1 Fugitve Dust												2.20
	2.2 Noise and Vibration												1.20
	2.3 Surface water quality												0.55
	2.4 Wifdlife												0.40
	2.5 Traffic and public health												0.30
Source : The Consultant , 2019													**574.25**

In conclusion, the maintenance costs and environmental costs of Alternative 1 and Alternative 3 are 574.25 million Baht. Alternative 2 has the maintenance cost and environmental cost of 561.25 million Baht, which is lower than Alternative 1 and Alternative 3.

5.1.3 COMPARISON OF ECONOMIC ANALYSIS OF ALTERNATIVES

The Consultant carried out the economic viability analysis by considering and comparing EIRRs, NPVs and B/C ratios of the three alternatives as presented in **Table 5.1.3-1.**

Table 5.1.3-1 Economic Viability Analysis Results of Three Alternatives

Item	Alternative 1 AC		Alternative 2 Cape Seal		Alternative 3 AC : Lane + Cape Seal : Shoulde	
	Project cost		Project cost		Project cost	
	Financial cost	Economic cost	Financial cost	Economic cost	Financial cost	Economic cost
Construction Cost	949.7	835.7	673.9	593.1	865.2	761.3
Consulting Service	27.1	25.0	19.3	17.7	24.7	22.7
Administration Cost and Management Fee	10.5	9.7	7.5	6.9	9.6	8.8
Total (M THB)	**987.4**	**870.4**	**700.7**	**617.7**	**899.5**	**792.9**
Maintenance cost and Environmental Mitigation Cost	574.3	528.3	561.3	516.4	574.3	528.3
Grand Total (M THB)	**1,561.6**	**1,398.7**	**1,261.9**	**1,134.0**	**1,473.7**	**1,321.2**
Economic Indicator						
Economic internal rate of return (EIRR)		**16.1%**		**21.6%**		**17.8%**
Net present value (NPV) (M THB)		**230.5**		**400.1**		**292.2**
Benefit cost ratio (B/C Ratio)		**1.3**		**1.6**		**1.4**

Considering the economic indicators, all alternatives of this project meet the established economic viability criteria. The three alternatives have economic indicators which indicate different levels of economic feasibility. Alternative 2 is the most economically viable, i.e. EIRR of 21.6%, NPV of 400.1 million Baht, and B/C ratio of 1.6, followed by Alternative 3 which has EIRR of 17.8%, NPV of 292.2 million Baht and B/C ratio of 1.4. Alternative 1 is the least economically viable, i.e. EIRR of 16.1%, NPV of 230.5 million Baht and B/C ratio of 1.3.

5.1.4 CONCLUSION OF PAVEMENT IMPROVEMENT COMPARISON

Consideration was made on the estimated project cost, maintenance cost and environmental cost throughout the project period of 20 years, and analysis of economic viability of the three alternatives. Engineering aspects, e.g. ease of construction and force of friction, were also taken into account. The advantages and disadvantages of each alternative are presented in **Table 5.1.4-1**.

Table 5.1.4-1 Comparison of Advantages and Disadvantages of Pavement Improvement Alternatives

Aspect	Pavement Improvement Alternatives		
	Alternative 1 AC Pavement (Lane and Shoulder)	**Alternative 2 Cape Seal Pavement (Lane and Shoulder)**	**Alternative 3 AC (Lane) and DBST/Cape Seal (Shoulder)**
Project Cost	Project Cost is more. (987.4 M THB)	Project Cost is less. (700.7 M THB)	Project Cost is moderate. (899.5 M THB)
Maintenance Cost and Environmental Mitigation Cost	Maintenance cost and Environmental mitigation cost throughout 20 years is more as Alternative 3. (574.3 M THB)	Maintenance cost and Environmental mitigation cost throughout 20 years is less. (561.3 M THB)	Maintenance cost and Environmental mitigation cost throughout 20 years is more as Alternative 1. (574.3 M THB)
Ease of Construction	The number of construction machines is moderate.	The number of construction machines is less.	The number of construction machines is maximum.
Life Span	Both lane and shoulder pavement have long life span approximately 14 years.	Both lane and shoulder pavement have shorter life span only 7 years.	Only lane pavement has long life span (14 years) but shoulder pavement has shorter life span only 7 years.
Force of Friction	More force of friction on both lane and shoulder surface. (Maximum safety)	Poor force of friction on both lane and shoulder surface. (Less safety)	More force of friction on only lane surface but force of friction on shoulder surface is poor (Moderate safety)
Project Feasibility	All economic Indicators are feasible. (EIRR= 16.1% ,NPV=230.5 M THB,B/C =1.3)	All economic Indicators are feasible. (EIRR= 21.6% ,NPV=400.1 M THB ,B/C =1.6)	All economic Indicators are feasible. (EIRR= 17.8% ,NPV=292.2 M THB,B/C =1.4)

Source: The Consultant, 2019

The advantages and disadvantages of the three alternatives were compared by considering three major aspects: project cost, engineering, and economic viability as summarized below.

- **Project Cost** covers construction cost, road maintenance cost, and environmental cost.

  - **Construction Cost:** Since the construction cost of the DBST/cape seal surface is lower than that of the asphalt concrete surface type, Alternative 2 (DBST for both carriageway and shoulders) requires the lowest construction cost of 700.7 million Baht. The construction cost of Alternative 3 (asphalt concrete for carriageway and DBST/cape seal for shoulders) is 899.5 million Baht. Alternative 1 (asphalt concrete for both carriageway and shoulders) has the highest construction cost of 987.4 million Baht.

  - **Road Maintenance Cost and Environmental Cost**: Based on the project's service period of 20 years, Alternative 2 has the lowest maintenance and environmental costs of 561.3 million Baht whereas Alternative 1 and Alternative 3 have the same maintenance and environmental costs of 574.3 million Baht.

Thus, considering the construction, maintenance and environmental costs, Alternative 2 has the lowest project cost.

- **Engineering Aspects** comprise ease of construction, project's service period, and force of friction as follows.

  - **Ease of Construction:** Consideration was made on the number of construction machines required for each alternative. The alternative with more complicated construction processes requires more machines. In contrast, the alternative with simple construction processes needs fewer machines. Alternative 2 (DBST for both carriageway and shoulders) uses the simplest construction method and requires fewer construction machines than the asphalt concrete road. Alternative 1 ranks second in terms of ease of construction. Alternative 3 uses the most complicated construction processes as it requires construction machines for both asphalt concrete and DBST types.

  - **Life Span :** The life span or service period of roads directly varies with the durability of each pavement type. The asphalt concrete road is more durable than the DBST and the cape seal ones. The asphalt concrete road generally has a service life of about 14 years whereas the DBST and the cape seal types have only 7 years of service life. Therefore, Alternatives 1 and 3 have longer service life than Alternative 2.

- **Force of Friction:** The frictional force between two surfaces–road and tire–was taken into account. Higher force of friction will bring about more road safety. The asphalt concrete road has greater force of friction than the DBST one. Therefore, Alternative 1 (asphalt concrete for both carriageway and shoulders) has the highest rood safe ty, followed by Alternative 3 (asphalt concrete for carriageway and DBST for shoulders), and Alternative 2 (DBST for both carriageway and shoulders) which has the lowest rood safe ty.

- **Project Feasibility:** As aforementioned in **5.1.3**, since the economic indicators of all alternatives meet the established economic analysis criteria, all alternatives are economically viable.

Comparing the advantages and disadvantages of the three alternatives, Alternative 1 (asphalt concrete for both carriageway and shoulders) requires higher construction, road maintenance, and environmental costs than other alternatives and has moderate ease of construction. However, it provides more advantages in engineering aspects than the two alternatives. That is, the road is more durable and has longer service life and road safety (as a result of higher force of friction) than other alternatives.

According to the Road Development Policy and Strategy formulated by the Ministry of Public Works and Transport (MPWT), Cambodia, in the Overview of the Transport Infrastructure Sector in the Kingdom of Cambodia (5th Edition) prepared by the MPWT in collaboration with the Japan International Cooperation Agency (JICA) by the name of the Infrastructure and Regional Integration Technical Working Group, published in 2015, the NR67 is included in the Strategy 6: Promotion of Tourism Development. It is an international road which requires pavement improvement to be an asphalt concrete or concrete road. This is in line with the result from the comparison of pavement improvement alternatives for the NR67 in which the road will be improved from DBST pavement to asphalt concrete pavement for both carriageway and shoulders.

5.2 ROUTE SURVEY AND LEVELING

5.2.1 Survey Details

The Consultant carried out route survey, leveling, and topographic survey to collect details and then created profiles and cross-sections. The route survey and leveling consist of the following steps.

1. Survey of Horizontal and Vertical Control Points

The Consultant conducted the survey in the project area to establish the locations of the horizontal and vertical control points by using the GNSS Receiver. There are totally 7 control points as presented in **Figure 5.2-1**. The UTM WGS84 Zone 48 was applied to the control points of the project.

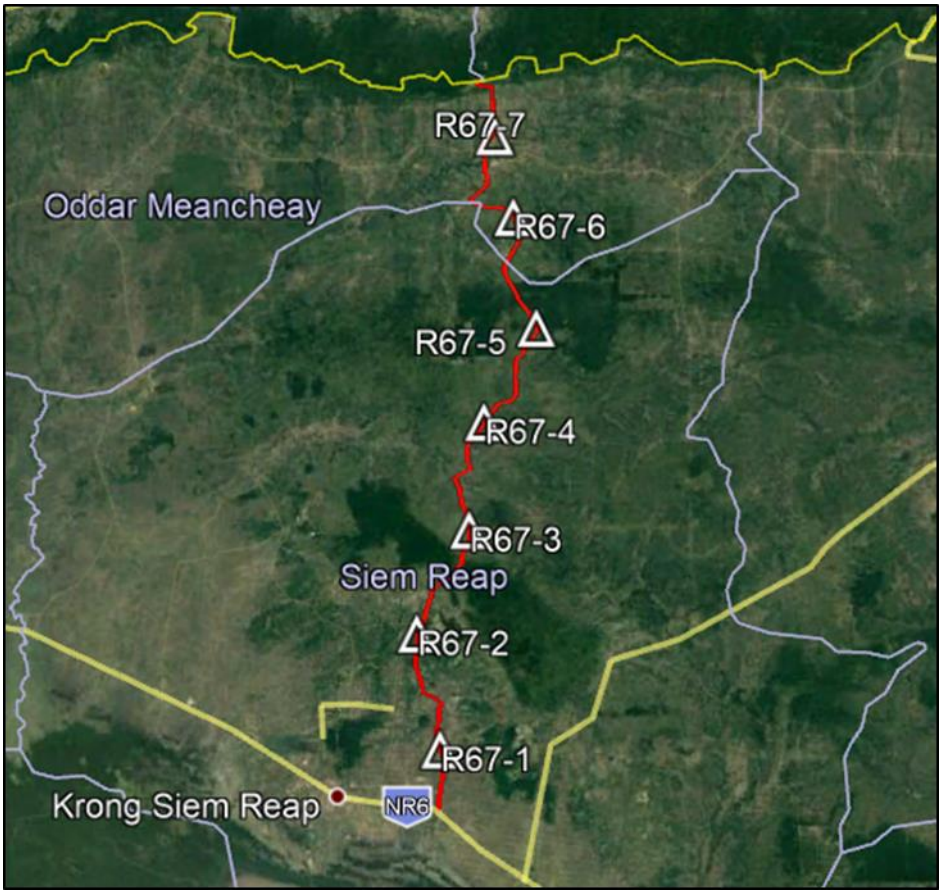


Figure 5.2-1 Locations of Horizontal and Vertical Control Points

2. Aerial Photography for Route and Topographic Survey

Detail survey was conducted within the rights-of-way of the project route and along the distance of 20 meters or more on each side from the rights of way to record necessary data for use in the design step, e.g. electric poles, power lines, buildings, connecting roads, utilities on the ground and underground, etc. The GNSS Receiver was used to conduct the survey by the APIS RTK method which offers the horizontal accuracy of 8 mm + 1 ppm of the base line distance and the vertical accuracy of 15 mm + 1 ppm of the base line distance.

3. Cross-section and Profile Survey

The Consultant determined the profile elevations at 25-m intervals lengthwise along the route and the cross-section elevations with the distance of 5 m from the center line of the road. Similar to the topographic survey, the GNSS receiver was used to conduct the survey by the APIS RTK method.

5.2.2 Survey of Horizontal and Vertical Control Points

Seven control points were determined by receiving a satellite signal for 6 hours for further data processing via the AUSPOS - Online GPS Processing Service, which has the horizontal deviation of 2 cm and the vertical deviation of 5 cm.

5.2.3 Route Survey and Topographic Survey

Route survey and topographic survey by UAV consists of the following steps.

1. Ground Control Point (GCP) Survey

The Consultant created ground control points at 600-m intervals for processing by using the APIS RTK method. The horizontal accuracy is 5 cm and the vertical accuracy is 10 cm.

2. Aerial Photography

The Consultant conducted the aerial photography by using a multi-rotor UAV with a 20-megapixel resolution camera to take 7-cm ground pixel resolution orthophotos. The flight covered the area of 135 km in length and 100 m in width on each road side as presented in **Figure 5.2-4**. The derived orthophotos can be used to produce aerial images on a scale of 1: 1,000 with the horizontal accuracy of 10 cm.

Figure 5.2-4 Orthophoto of the Existing Topographic Conditions

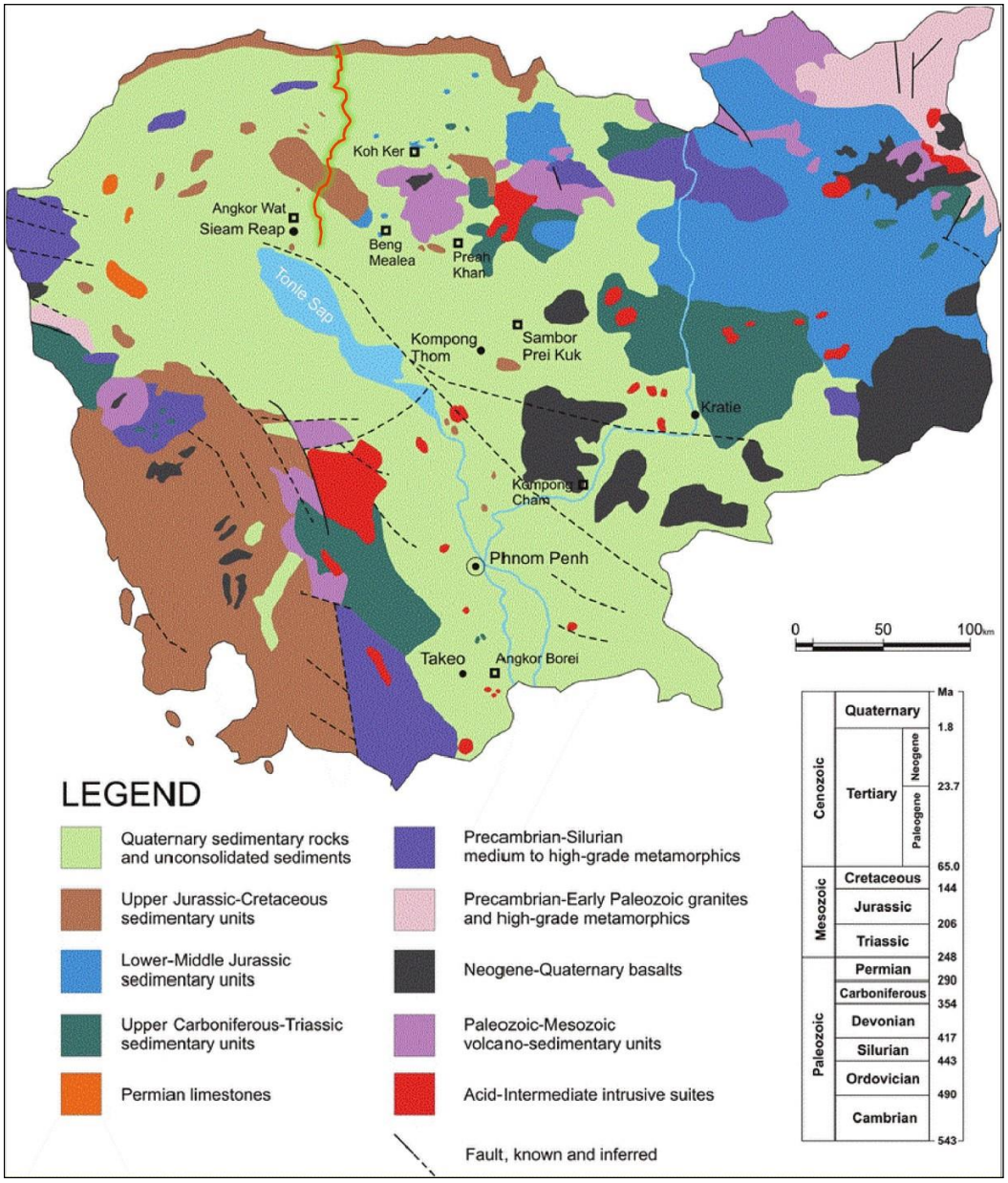
3. Ortho Rectification

Ortho rectification or image processing is a part of UAV aerial survey. The data obtained from the image processing are orthophotos, digital surface models (DSMs), and point clouds. The Consultant applied the principles of photogrammetry to process orthophotos.

In addition to the orthophotos obtained from UAV aerial survey, DSMs with a resolution of 50 cm and a 15 cm vertical accuracy were obtained to create profiles and cross-sections.

5.3 GEOLOGICAL AND MATERIAL INVESTIGATION

The Consultant collected the secondary data of geological conditions in the project area, e.g. geological map of the Kingdom of Cambodia as shown in **Figure 5.3-1**.

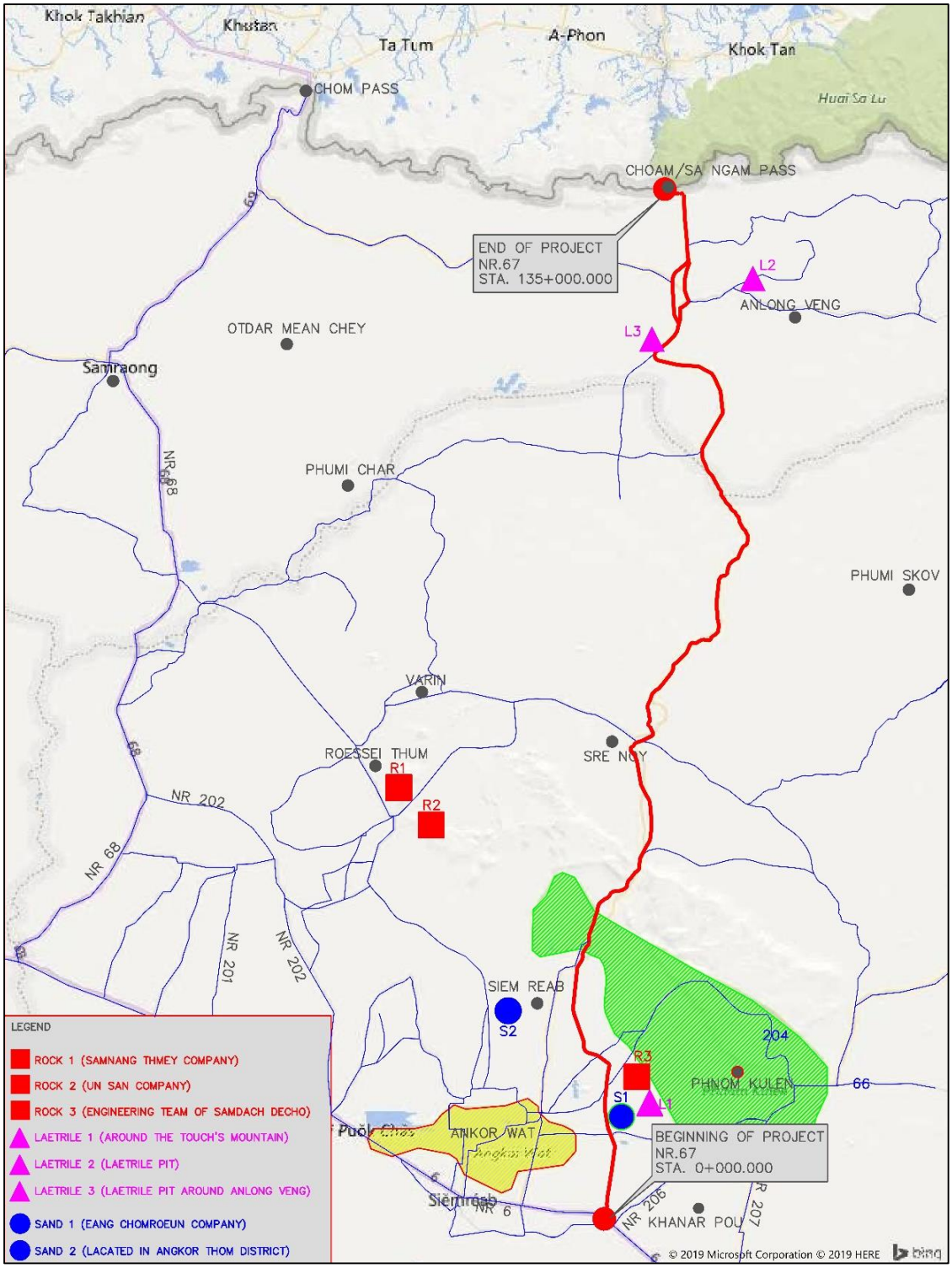


Source: Simplified Geological map of Cambodia, modified after United Nations 1993 (Douglas et al. 2010). Map Federico Casp

Figure 5.3-1 Geological Map of Cambodia

According to the geological map, the geological features along the project alignment are generally characterized by Quaternary sedimentary rocks and unconsolidated sediments, deposited by wind or water flows. Commonly found along waterways, plains, and beaches, the sedimentary rocks are composed of gravel, sand, silt, and clay.

Moreover, the Consultant reviewed and investigated the previous construction material sources used in 2009 and searched for the new material sources. Now, there are more sources of materials which are suitable and sufficient for construction, i.e. three sources of rock, two sources of sand, and three sources of laterite. **Figure 5.3-2** shows the locations of construction material sources.



Source: The Consultant

Figure 5.3-2 Locations of Material Sources

The Consultant also conducted the soil boring by using the dynamic cone penetrometer, investigation of test pits of the existing road, and examination of the existing road surface. The collected survey data are presented in Final Report.

5.4 PAVEMENT STRUCTURE DESIGN

To design the pavement structure, consideration was made on the existing traffic surface of the road. The roughness of a road can result in travel delay, excessive braking, increase in fuel consumption, increased maintenance cost and higher risk of traffic accidents.

The National Road No.67 currently consists of 2 types of pavement structures:

1. Double bituminous surface treatment (DBST) from STA 0+000 to STA 131+000; and
2. Concrete structure from STA 131+000 to STA 135+000 (RC slab of 20-cm. thickness, 4.00-m. width, and 10.00-m length for each span)

The typical pavement structures of "DBST" and "concrete" types of the NR67 are shown in **Figure 5.4-1** and **5.4.-2** respectively.

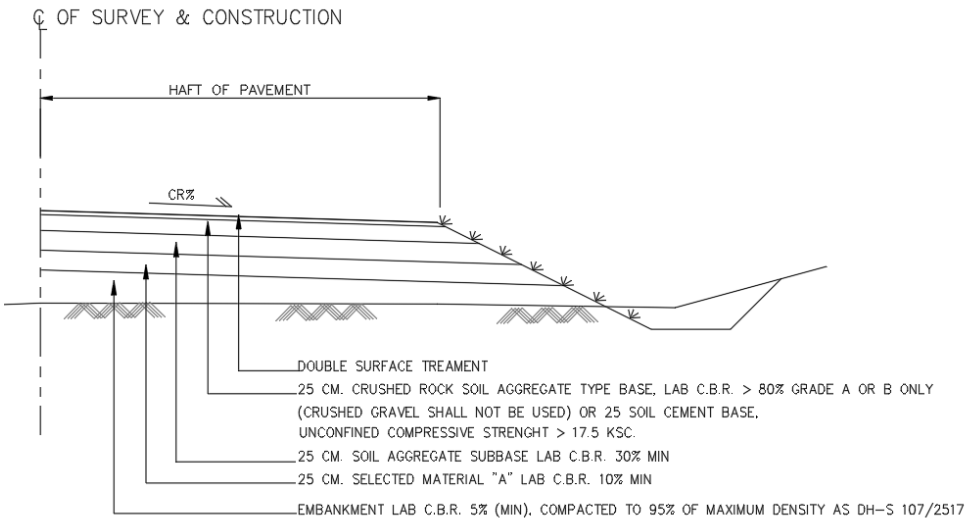


Figure 5.4-1 "DBST" Pavement Structure

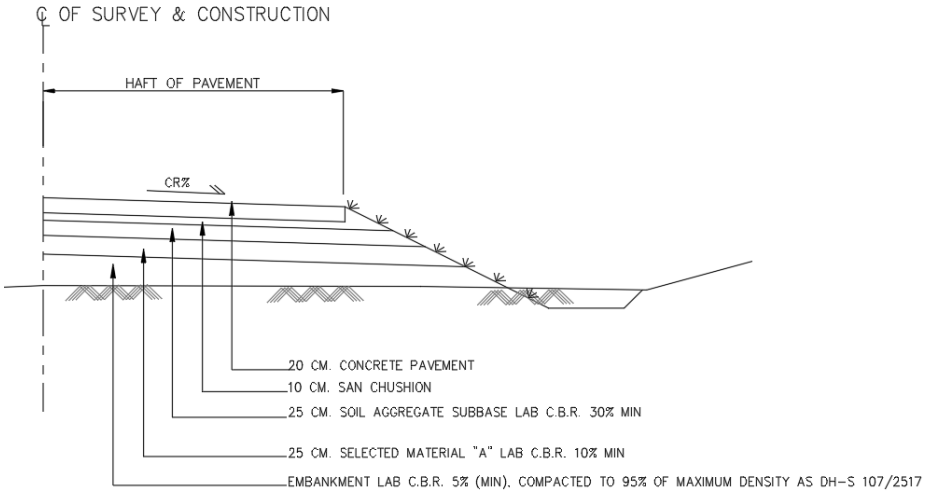


Figure 5.4-2 "Concrete" Pavement Structure

The National Road 67 was constructed in 2009. Normally, the service life of a DBST road which is regularly maintained is 7-10 years. Hence, the pavement of the NR67 should now be improved.

In January 2019, the Consultant surveyed the existing pavement conditions at 1-km intervals throughout the route alignment.

According to the inspection of the existing DBST pavement structure, despite the road repair, several types of defects were found along the route, e.g. cracks, potholes, depression, bleeding, rutting, raveling, and edge deterioration. These defects indicate the deteriorated road surface which require corrective maintenance.

According to the comparison of pavement improvement options in 5.1, the existing deteriorated DBST pavement will be improved by using the asphalt concrete pavement for both carriageway and shoulder option. The roundabout with damaged pavement will be improved to be of RC type. Moreover, the ending section of the route in mountainous terrain, the existing concrete pavement is still in good condition and improvement is not necessary. Pavement designs of road sections are shown in **Figures 5.4-3 to 5.4-8** respectively.

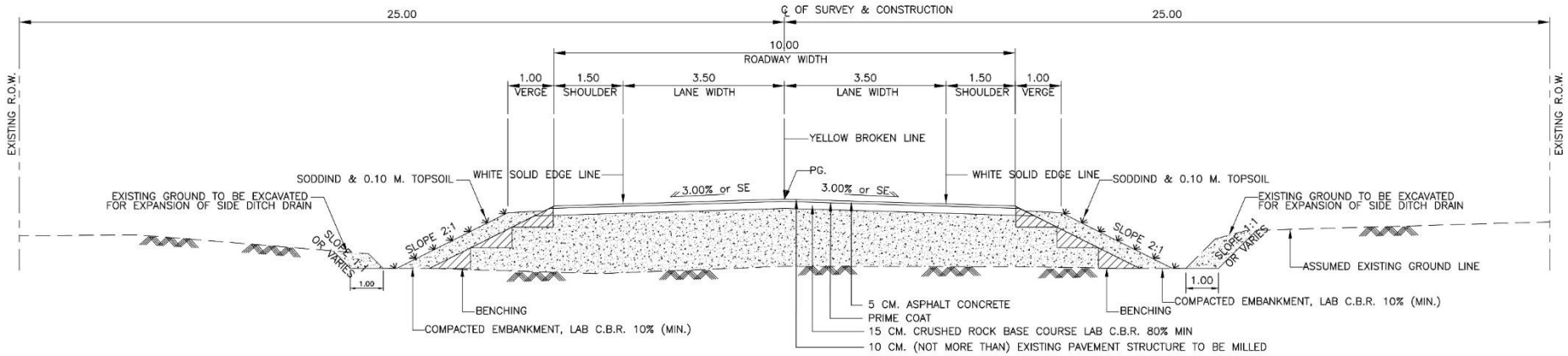


Figure 5.4-3 Typical Section of Sta. 0+150 – Sta. 28+800

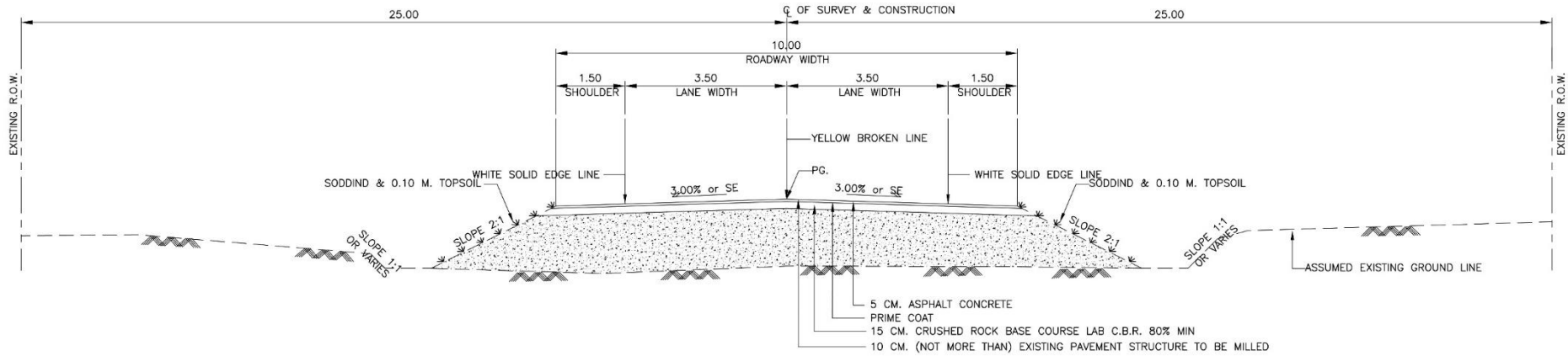


Figure 5.4-4 Typical Sections: Sta. 29+100– Sta. 56+900 and Sta. 57+300 – Sta. 131+460

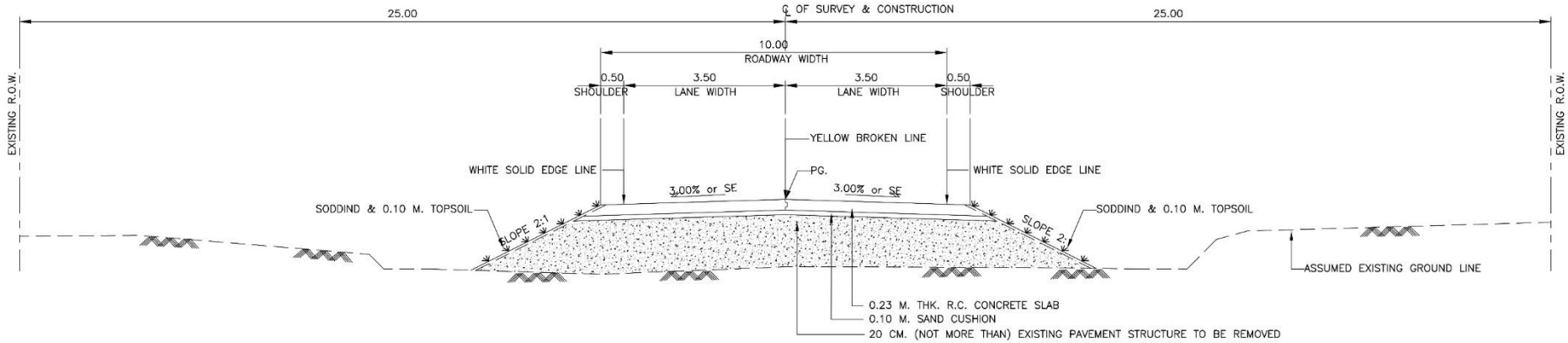


Figure 5.4-5 Typical Section of Sta. 28+800 - Sta. 29+100

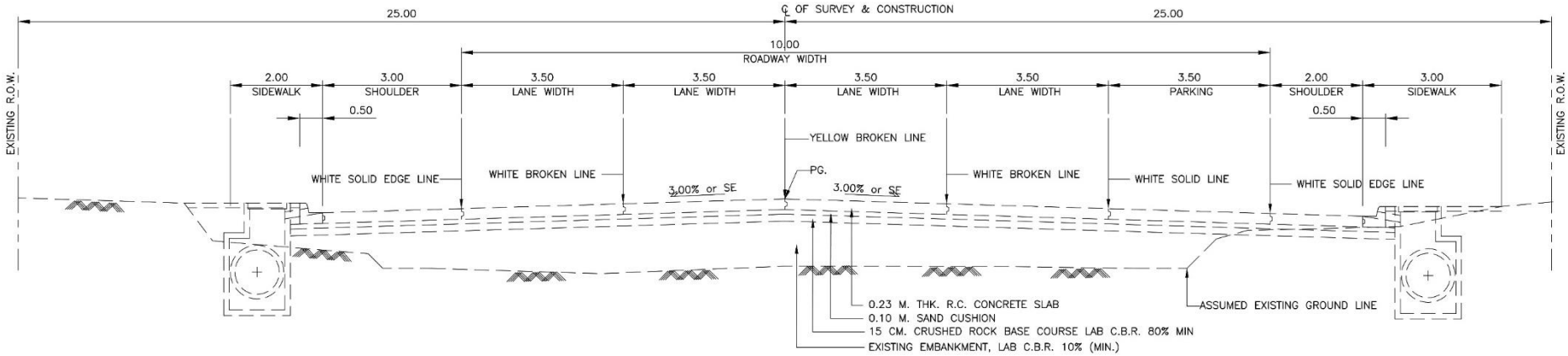


Figure 5.4-6 Typical Section of Sta. 56+900 - Sta. 57+300

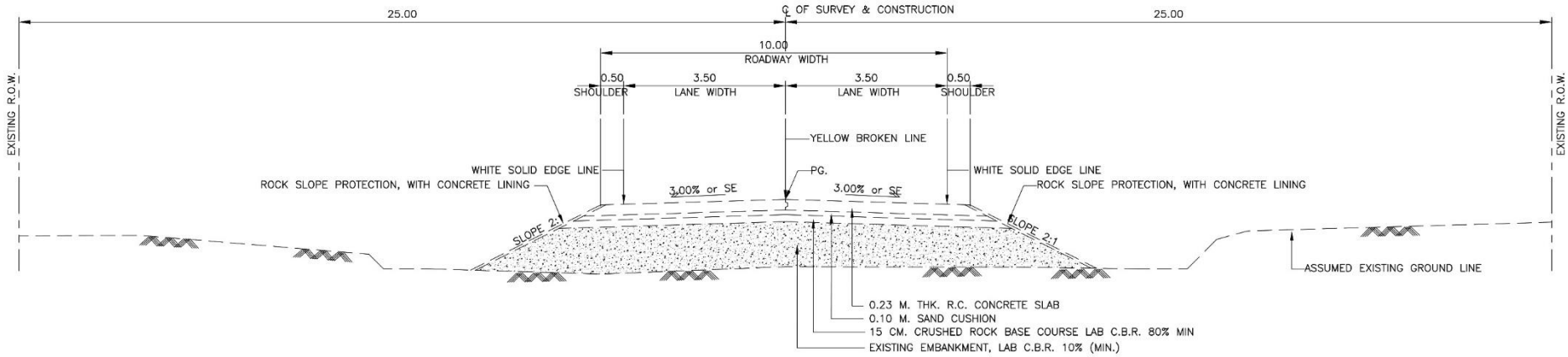


Figure 5.4-7 Typical Section of Sta. 133+945 - Sta. 134+678 (No Improvement)

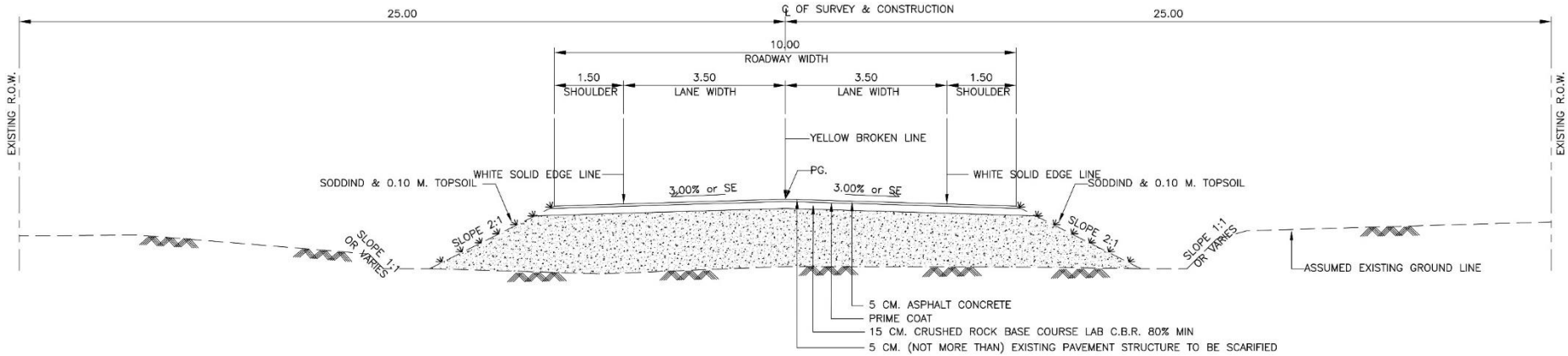


Figure 5.4-8 Typical Sections: Sta. 33+000 - Sta. 36+000, Sta.54+000 - Sta. 61+000, and Sta. 80+000 - Sta. 81+000

5.5 GEOMETRIC DESIGN

5.5.1 Horizontal Alignment

According to Road Design Standard: Part 1 Geometry, 2003 of the Kingdom of Cambodia (conform to AASHTO 2011), the design speed for the road sections passing the rural areas must not be greater than 80 KPH for the flat terrain, and not more than 70 KPH for the rolling terrain with the desirable minimum horizontal curve radii of 210 m and 165 m respectively at the superelevation rate of 10%.

Some horizontal curves do not meet the design standards. Adjustment to the alignment of these horizontal curves will affect the land acquisition and increase the construction costs. Therefore, the Consultant reduced the design speed for road safety. Speed limit signs and additional safety equipment will be also installed. Details of horizontal alignment designs are presented in the detail drawings.

In addition, the Consultant adjusted the geometric designs of 7 intersections to increase road safety and effectively accommodate the traffic volume as shown in **Figures 5.5.1-1 to 5.5.1-7.**

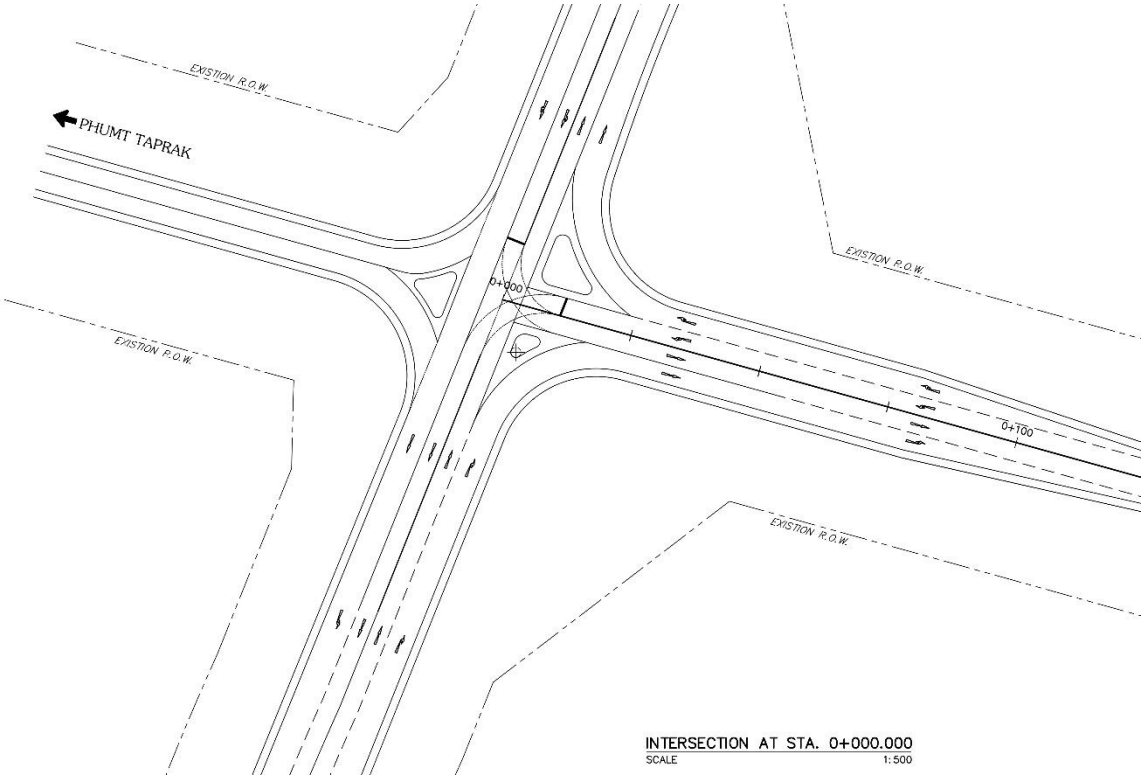


Figure 5.5.1-1 Intersection at Sta. 0+000.000

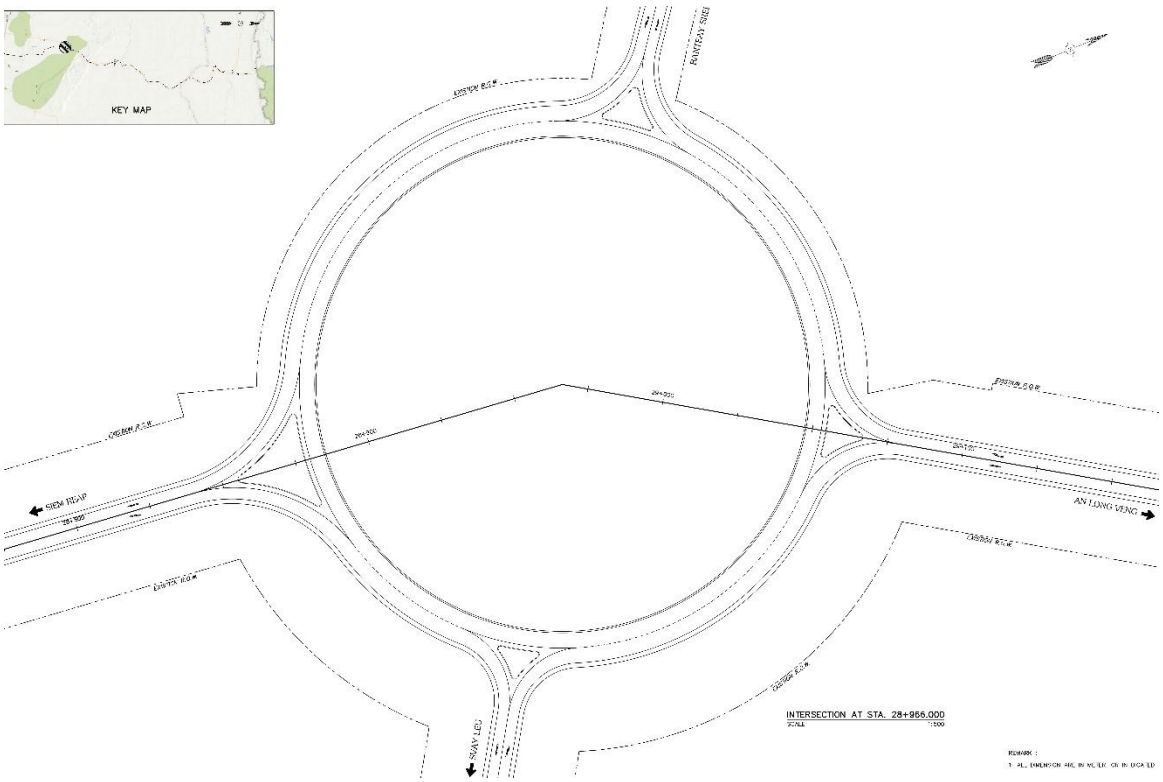


Figure 5.5.1-2 Intersection at Sta. 28+966.000

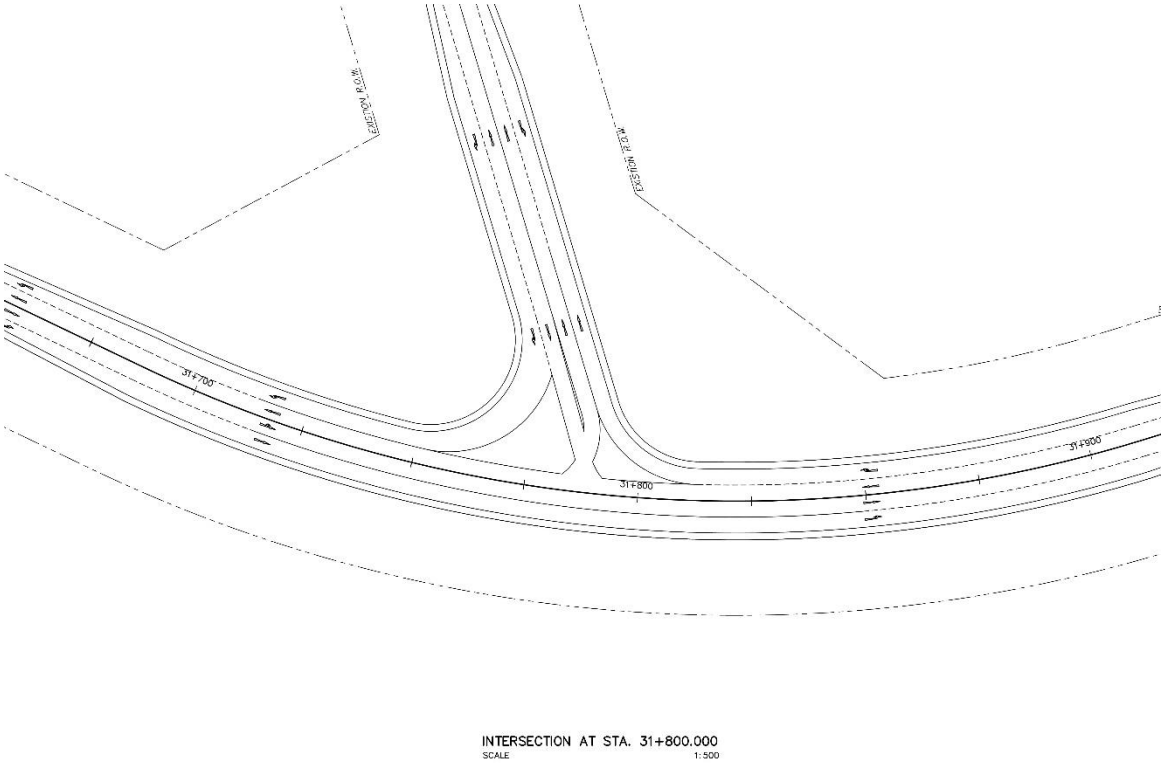


Figure 5.5.1-3 Intersection at Sta. 31+800.000

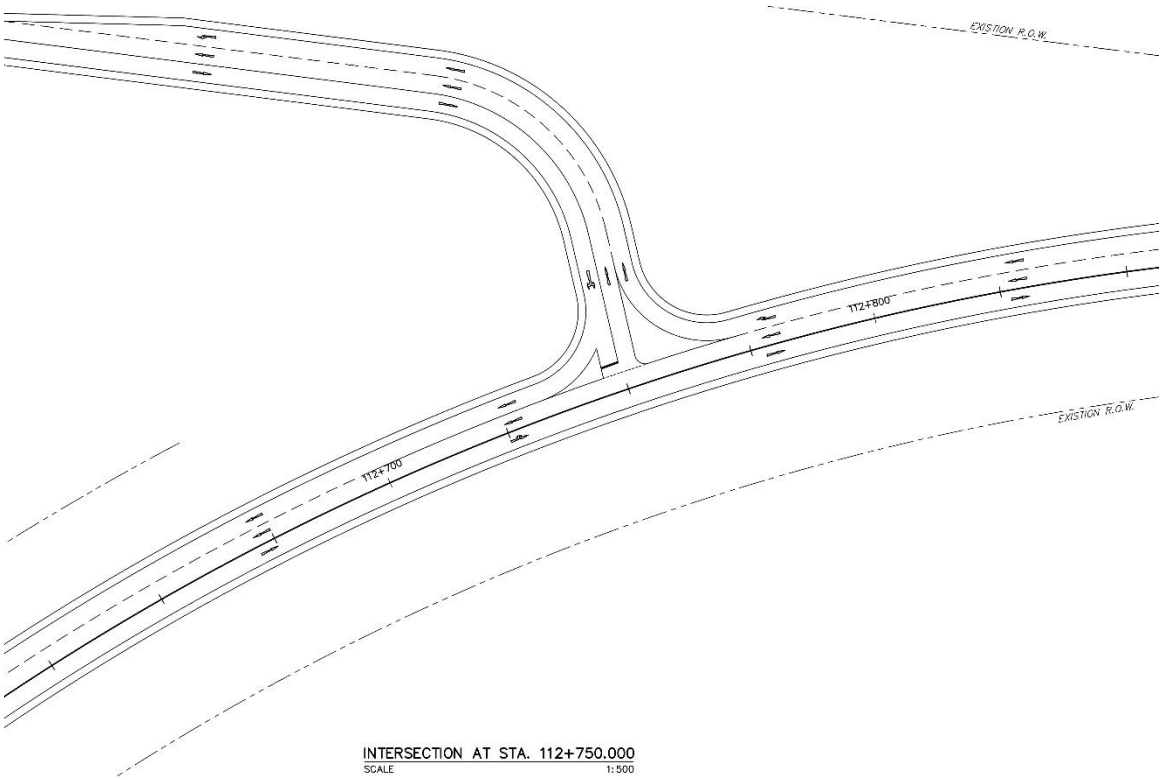


Figure 5.5.1-4 Intersection at Sta. 117+000.000

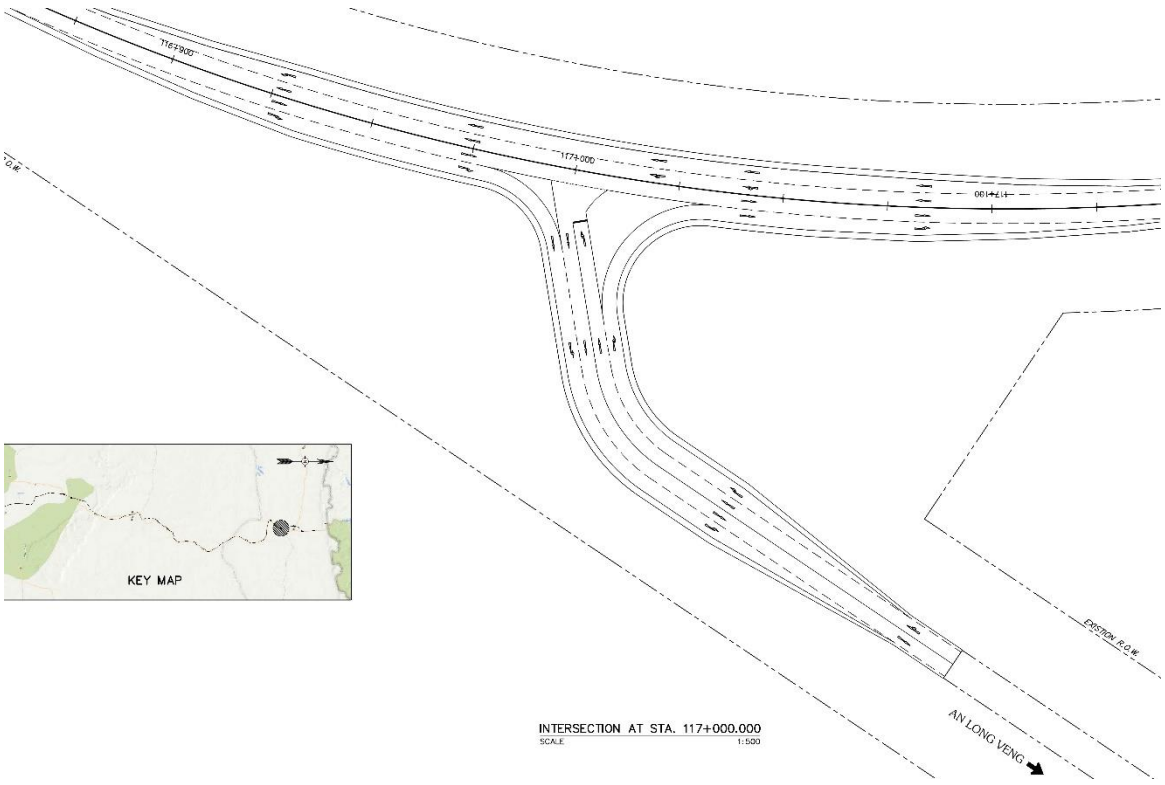


Figure 5.5.1-5 Intersection at Sta. 117+000.000

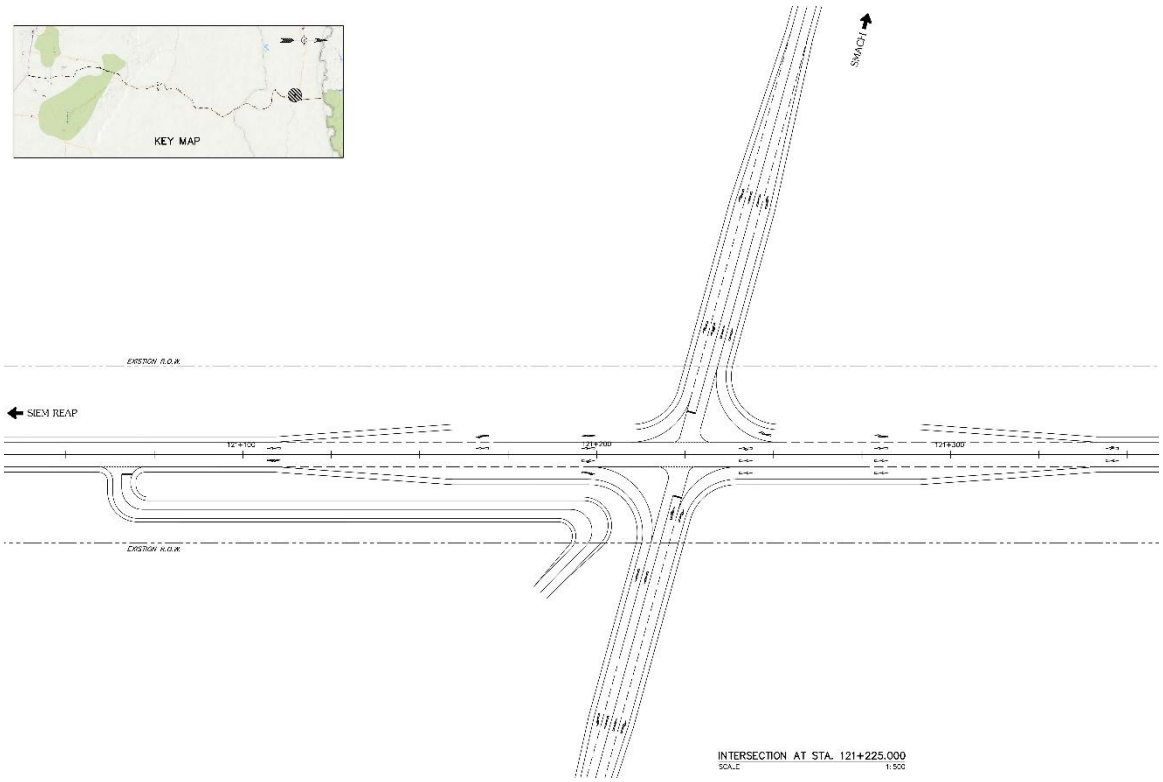


Figure 5.5.1-6 Intersection at Sta. 121+225.000

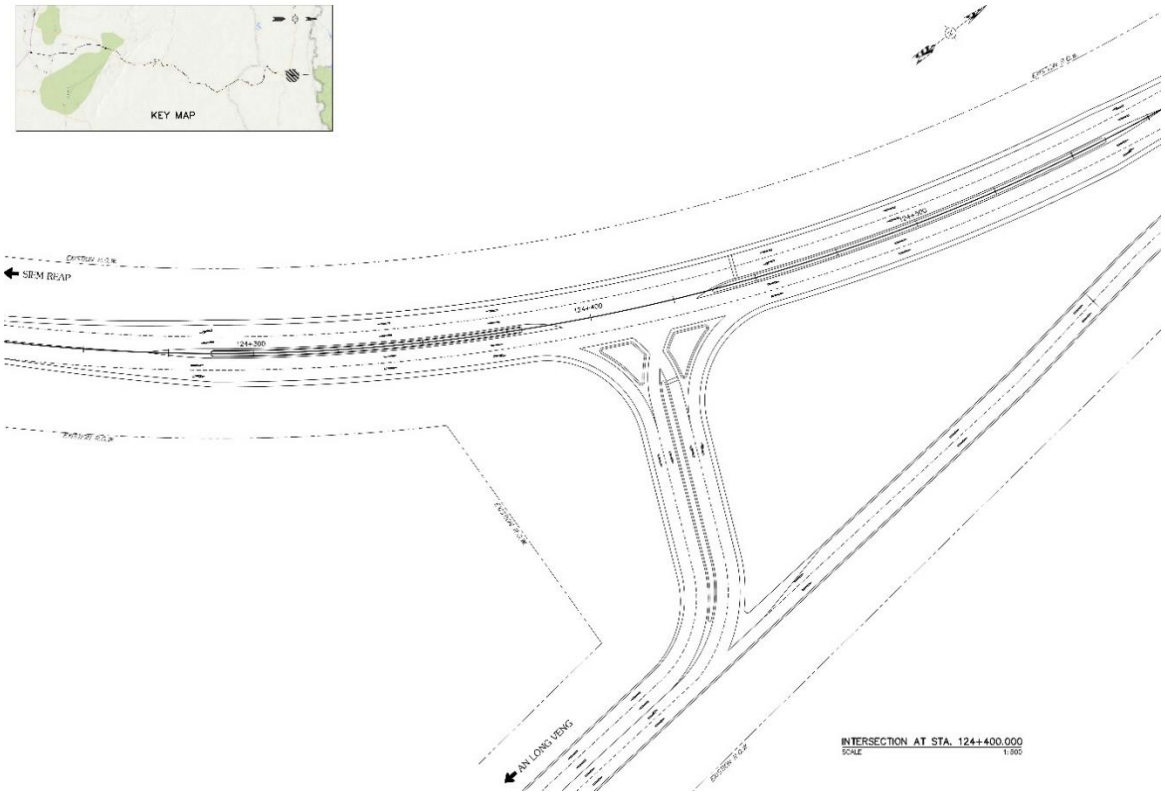
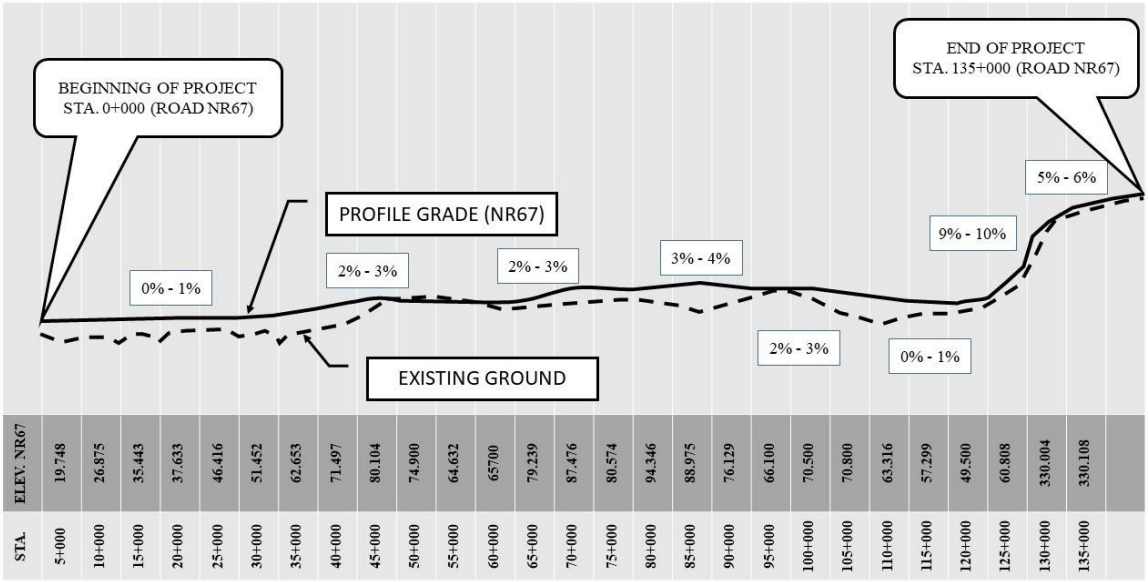


Figure 5.5.1-7 Intersection at Sta. 124+400.000

5.5.2 Vertical Alignment

Considering the physical characteristics of the NR67, it is mostly consists of flat terrain with the rolling terrain at STA 131+000. The vertical alignment design is generally good. That is the design gradients are in accordance with the highway standards of the Kingdom of Cambodia, with sufficient safety sight distance and overtake sight distance. The gradients of the NR67 are approximately 2-4% for the flat terrain and approximately 8-10% for the rolling terrain as presented in **Figure 5.5.2-1.** The average elevation of the road embankment is approximately 1.50 to 2.0 m higher than the existing ground level for the following sections: Sta. 0+000 to Sta.43+000; Sta.50+400 to Sta.90+800; and Sta. 95+600 to Sta.131+000.



STA.	ELEV. NR67
5+000	19.748
10+000	26.875
15+000	35.443
20+000	37.633
25+000	46.416
30+000	51.452
35+000	62.653
40+000	71.497
45+000	80.104
50+000	74.900
55+000	64.632
60+000	65700
65+000	79.239
70+000	87.476
75+000	80.574
80+000	94.346
85+000	88.975
90+000	76.129
95+000	66.100
100+000	70.500
105+000	70.800
110+000	63.316
115+000	57.299
120+000	49.500
125+000	60.808
130+000	330.004
135+000	330.108

Source: The Consultant

Figure 5.5.2-1 NR67 Elevations from STA 0+000 to STA 135+000

Although the NR67 is higher than the existing ground level by 1.50-2.00 meters, flood occurs at these road sections: Sta.33 + 000 to Sta.36 + 000; and Sta. 54 + 000 to Sta. 56 + 000. Therefore, it is necessary to raise the road elevations by 20 cm to avoid flood problem. Details of vertical alignment designs are presented in the detail design drawings.

5.6 IMPROVEMENT OF THE EXISTING BRIDGE STRUCTURES AND DRAINAGE SYSTEM

According to the field survey, the existing bridge structures are generally in workable condition. All bridge structures are of simple support system. There is no expansion joint but gaps of less than 40 mm exist between girders and between a parapet and a girder. Besides, the bridge slabs are in normal condition whereas the bridge slope protection, RC parapets, and WB-guard rails of some bridges are in damaged condition. Spalling concrete was found on minor components of some bridges as demonstrated in **Figure 5.6-1**.

The Consultant determined the suitable solutions based on the damaged condition to improve the bridges to be in workable condition, for example, removal and replacement of the bridge slope protection, RC parapets, and WB-guard rails, as well as repairing of spalled concrete surface by concrete patching method. Details of bridge repair are presented in **Table 5.6-1** and construction drawings.

Moreover, since no bridge approach slab was built, settlement was found at the joint between the bridge structure and the approach pavement. However, the settlement is slight and does not affect the driving condition. The Consultant will solve the settlement problem by raising the road elevation to be the same as the elevation of the bridge approach as presented in the detailed drawings.

Figure 5.6-1 Damage of Bridge Slope Protection and Bridge Railings

Table 5.6-1 Improvements of Existing Bridges

NO.	STA.	STRUCTURAL DETORATION			
		SLOPE PROTECTION RENEWAL	CONCRETE RAILING RENEWAL	WB-GUARDRAIL RENEWAL	CRACKING REPAIR (CONCRETE PATCHING)
1	0+068.000	25.00 SQ.M.	-	-	-
2	8+612.000	54.00 SQ.M.	-	-	-
3	10+167.000	20.00 SQ.M.	-	-	-
4	20+445.000	10.00 SQ.M.	-	-	-
5	31+250.000	10.00 SQ.M.	-	-	-
6	36+320.000	96.00 SQ.M.	-	-	-
7	38+520.500	54.00 SQ.M.	-	-	-
8	41+340.760	-	-	-	-
9	41+878.310	105.6 SQ.M.	-	-	0.50 SQ.M.
10	42+700.000	77.76 SQ.M.	-	8 M.	0.50 SQ.M.
11	43+683.660	9.72 SQ.M.	-	-	-
12	53+762.330	10.00 SQ.M.	-	8 M.	-
13	56+313.550	10.00 SQ.M.	-	-	-
14	56+521.230	10.00 SQ.M.	-	-	-
15	56+875.000	-	-	-	-
16	59+630.350	-	-	-	-
17	59+391.500	20.00 SQ.M.	-	2 M.	-
18	67+648.720	-	-	-	-
19	68+862.690	-	-	-	-
20	71+568.510	-	-	-	-
21	72+989.680	12.00 SQ.M.	-	-	-
22	73+648.220	-	-	-	-
23	81+438.000	-	-	-	-
24	85+320.990	27.00 SQ.M.	-	-	-
25	86+373.060	-	-	-	-
26	87+138.210	20.28 SQ.M.	-	-	-
27	87+248.630	12.00 SQ.M.	-	-	-
28	87+759.390	38.00 SQ.M.	-	-	-
29	89+042.000	-	-	-	-
30	93+371.550	105.60 SQ.M.	-	-	-
31	96+721.430	38.00 SQ.M.	-	-	-
32	100+665.500	20.28 SQ.M.	-	-	-
33	106+722.000	-	-	-	-
34	109+714.080	-	-	-	-
35	113+433.080	-	-	-	-
36	114+740.310	-	-	-	-
37	118+456.500	-	-	-	0.50 SQ.M.
38	119+294.570	20.00 SQ.M.	-	-	0.50 SQ.M.
39	119+546.740	20.00 SQ.M.	-	-	

Apart from raising the road elevations to solve the problem of inundation on road pavements, additional culverts will be installed to increase the drainage capacity as presented in **Table 5.6-2**.

Table 5.6-2 Design of Drainage System

NO.	STA.	DRAINAGE STRUCTURE	REMARK
1	2+550.000	3-R.C.P. CULVERT X 20m.	DIA. 1.20m.
2	7+050.000	2-R.C.P. CULVERT X 20m.	DIA. 1.20m.
3	33+075.000	1-R.C.P. CULVERT X 20m.	DIA. 1.20m.
4	48+525.000	1-R.C.P. CULVERT X 20m.	DIA. 1.20m.
5	56+575.000	2-R.C.P. CULVERT X 20m.	DIA. 1.20m.
6	77+050.000	2-R.C.P. CULVERT X 20m.	DIA. 1.20m.
7	120+950.000	1-R.C.P. CULVERT X 20m.	DIA. 1.20m.
8	123+450.000	2-R.C.P. CULVERT X 20m.	DIA. 1.20m.

5.7 DESIGN OF ROAD SAFETY FACILITIES

For road safety to ensure the safety of the NR67, it is necessary to survey and inspect if the existing road safety facilities are sufficient and in good condition. If they are currently insufficient or in damaged condition, road improvement and increase of facilities are required. Details on design of the safety facilities for the project road can be summarized as follows.

- Design of appropriate and adequate sight distance
- Geometric design of the NR67 and curve radius to be suitable for the design speed, including adjustment of super elevation and widening of road width
- Improvement of traffic marking and traffic sign to be clearly visible
- Placement of rumble strips in community areas: from Sta. 50+ 400 to Sta. 80+000
- Installation of guardrails at the bridges or at the areas where embankment heights are greater than the roadside heights

Details of road safety facilities designs are presented in the detailed drawings.

5.8 DESIGN OF ROADWAY LIGHTING

Road lighting is very important to provide safety to drivers and road users deering the night time as it helps increase visibility. People will also clearly see road safety facilities, e.g. pavement markings, raised pavement markers, guide posts, reflectors, and flashing lights. The objectives of road lighting installation are as follows.

- To increase visibility during the night time apart from vehicular headlights
- To provide drivers with clear visibility of roadway
- To improve visibility of road safety facilities and other objects on or near the roadway
- To illuminate the roadway and the surrounding areas over a long distance
- To make it easier for drivers to perceive the road surface and characteristics

The road lighting design of this project was conducted in accordance with the following international standards:

- ASSHTO (An Information Guide for Roadway Lighting, 1984)
- IEC (International Electrotechnical Commission)
- IES (Illumination Engineering Society)
- CIE (Commission Internationale de l'Éclairage)
- NEC (National Electrical Code)

Considering the requirements on energy efficiency and lifetime of the light sources, especially those along the roadway, the durability and low maintenance of LED lamps can respond to the requirements. Thus, they are suitable for installation along the project road as they are durable and have long service life.

Presently, the integrated solar LED street light which integrates LED lamp and solar cell together becomes more popular. With the built-in brightness sensor, when the brightness is not enough, the LED lamp will be on automatically. Selection of suitable fixture, light emission pattern, and illuminance level is the first step of suitably designing the solar power system as illustrated in **Figure 5.8-1**.

According to the above reasons, the Consultant designed the road lighting system by using the integrated solar LED street lights which will reduce the electricity charges and maintenance expenses in the future.

Figure 5.8-1 Integrated Solar LED Street Light

5.9 DESIGN OF REST AREA

The rest area was designated at the midpoint of the NR67 or at Sta. 59+ 600. The rest area plan is shown in **Figure 5.9-1**. The components in the rest area comprise 10 parking lots, 4 toilets and 1 shelter as shown in **Figures 5.9-2** and **5.9-3.**

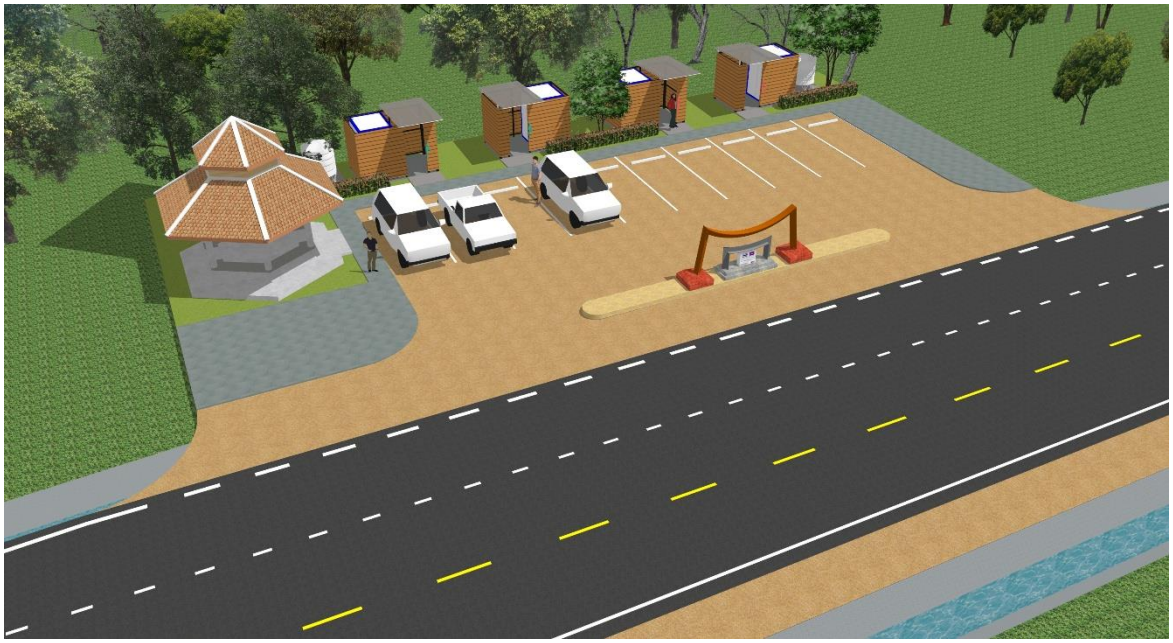


Figure 5.9-1 Rest Area Plan

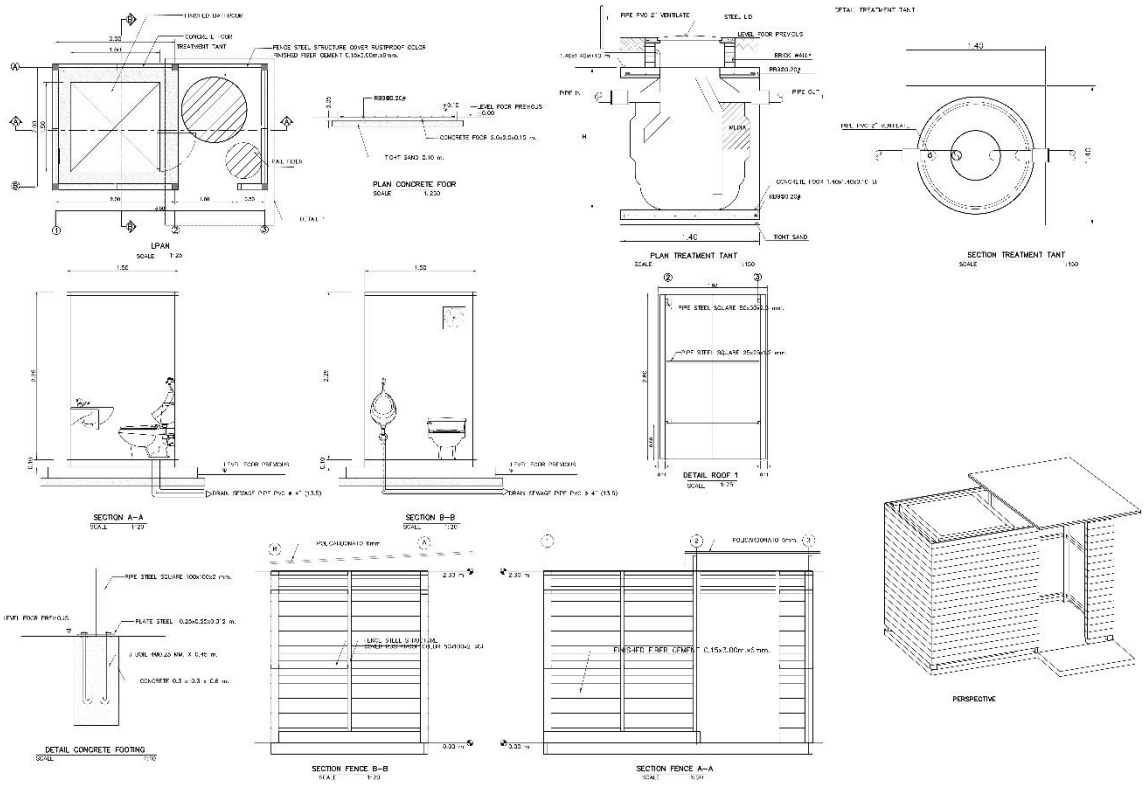


Figure 5.9-2 Details of Rest Area's Toilet

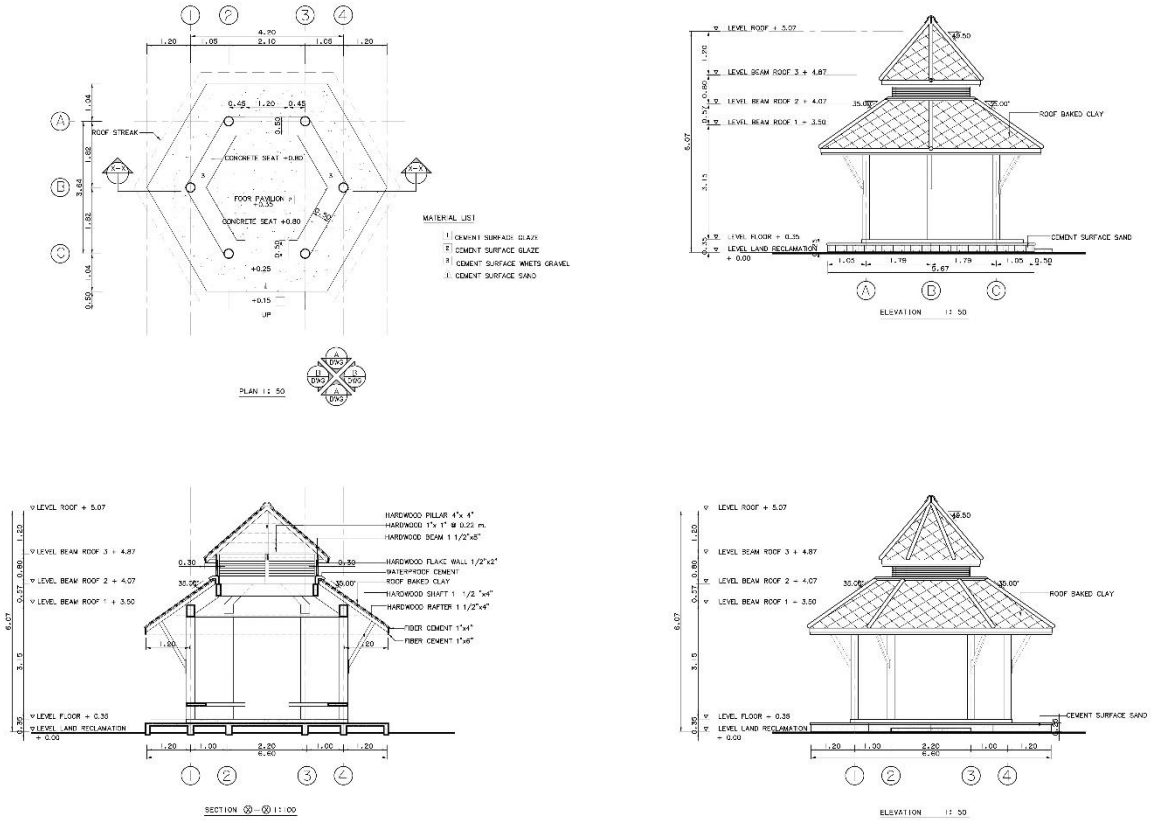


Figure 5.9-3 Details of Rest Area's Shelter

According to a consultant meeting with the MPWT on September 9, 2019 at the Road Infrastructure Department Building, Phnom Penh Cambodia. It was concluded that the location of rest area shall be specified again by MPWT at the construction stage for suitable appropriate position along the project road. The construction of other buildings, such as shelter and toilets, MPWT will proceed with the construction of the concession with the other private sector. Therefore, the rest area construction in this project will be only the construction of a parking lot, collaboration sign and street lighting.

5.10 ROCKFALL PROTECTION

The ending section of the NR67 runs along hillsides. Rockfalls were found, during the site survey, from STA 131+000 to STA 132+500, as presented in **Figure 5.10-1**.

Figure 5.10-1 Rockfalls from Hillsides

Rockfalls are dangerous for drivers and obstruct drainage of water on the ending section of the NR67. Thus, the Consultant designed the slope protection (Ferro Cement Type), together with improvement of the roadside drainage system.

5.11 COLLABORATION SIGN

The consultant designed six collaboration signs to be installed at important locations along the project route alignment as follows.

1. Sta. 0+000.000 (RT): Beginning of the project route
2. Sta. 28+856.680 : Southern connection road of roundabout
3. Sta. 0+096.733 of East connection road of roundabout
4. Sta. 0+080.831 of West connection road of roundabout (Korea Friendship Road)
5. Sta. 30+000.000 : Norther connection road of Roundabout
6. Sta. 59+600.000 (LT): at Rest Area

Figures 5.11-1 to **Figures 5.11-4** present the location where the collaboration signs will be installed whereas **Figure 5.11-5** shows details on the collaboration sign.

Figure 5.11-1 Collaboration Sign at Beginning of the Project

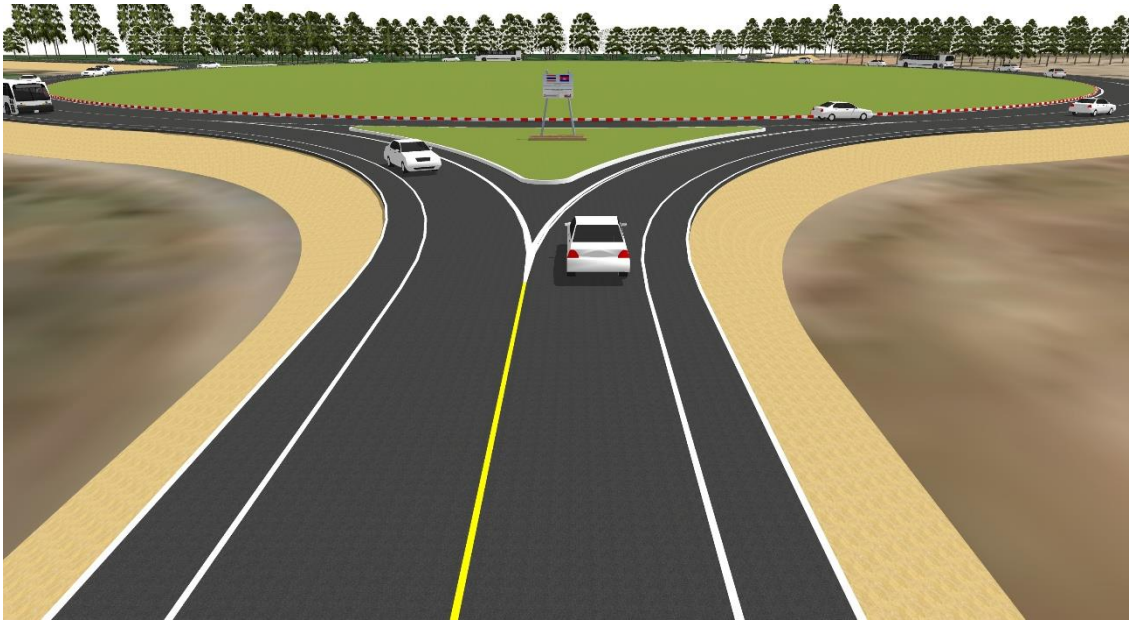


Figure 5.11-2 Collaboration Sign at Sta. 28+000.000 : Roundabout

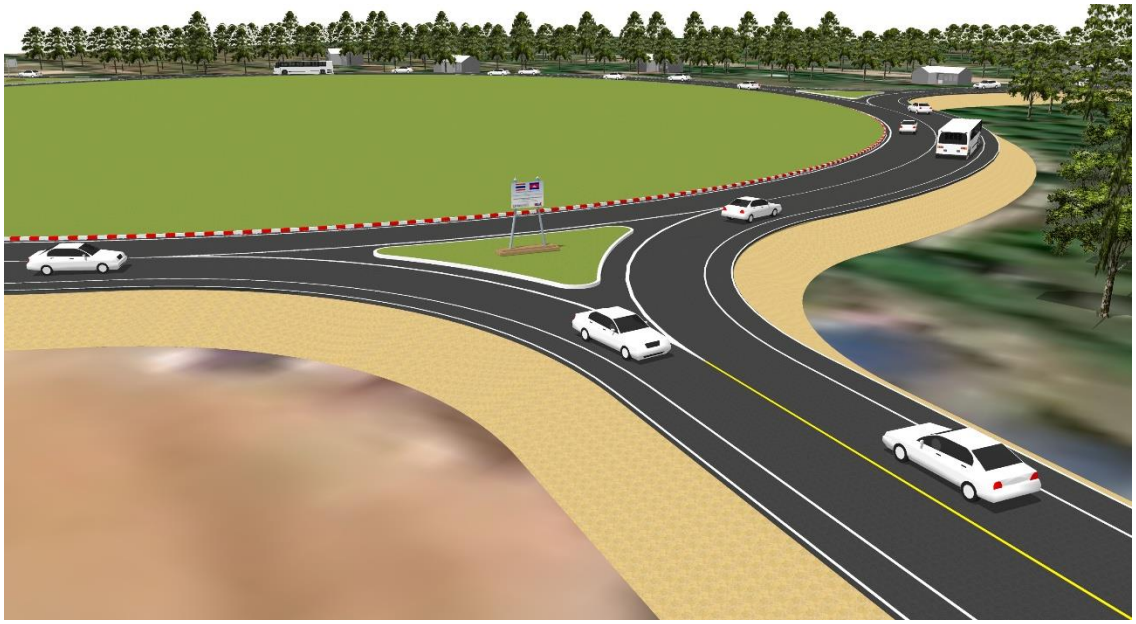


Figure 5.11-3 Collaboration Sign at Sta. 30+000.000 : Roundabout

Figure 5.11-4 Collaboration Sign at Sta. 59+600.000 (LT): Rest Area

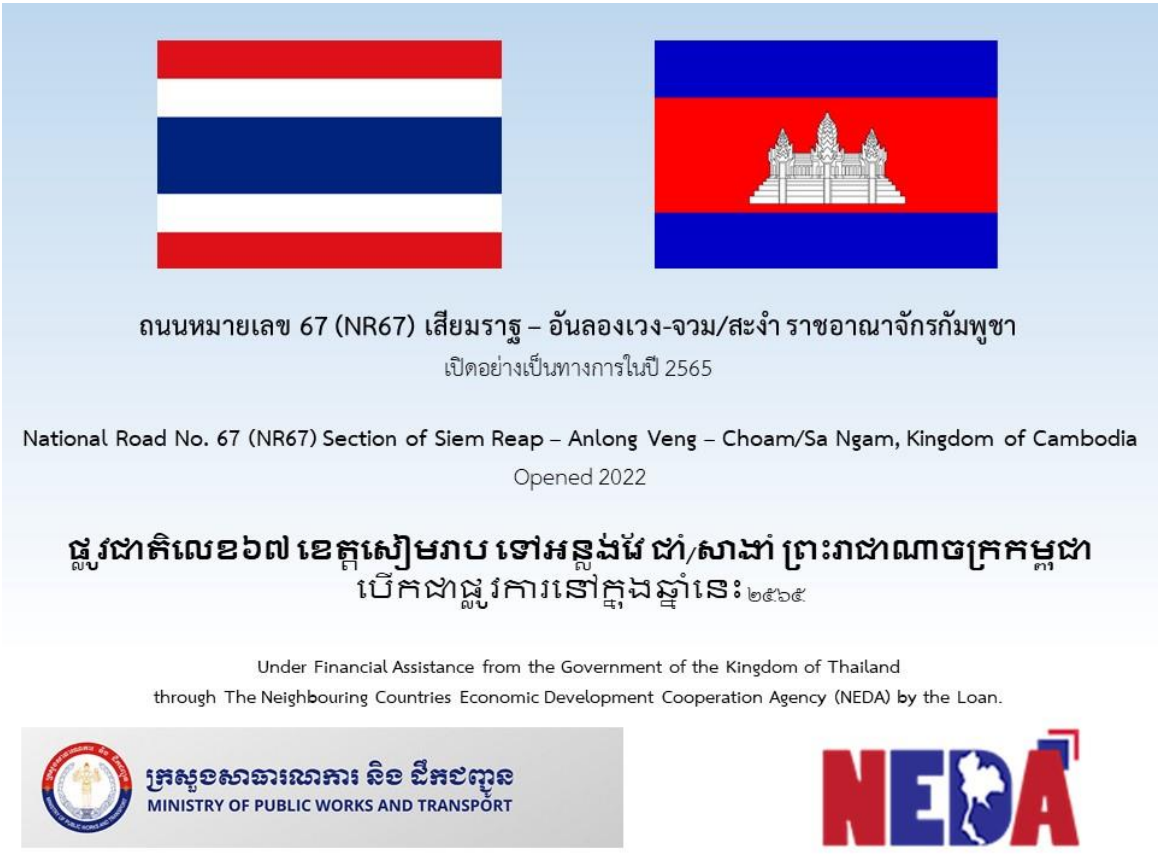


Figure 5.11-5 Details on the Collaboration Sign

CHAPTER 6

INITIAL ENVIRONMENTAL EXAMINATION AND PUBLIC PARTICIPATION

CHAPTER 6

INITIAL ENVIRONMENTAL EXAMINATION AND PUBLIC PARTICIPATION

6.1 INITIAL ENVIRONMENTAL EXAMINATION

6.1.1 Objectives and Study Area

According to Cambodian legislation such as National Laws Royal Decree/Sub Decree, National Declaration Prakas, National Environment Standards, World Health Organization Environmental Standard, either IEE or EIA report has to be prepared and approved by the MoE prior to infrastructure development. As improvement of NR 67 (Section of Siem Reap – Anlong Veng – Choam/Sa Ngam) Project is on the existing road, without construction of the new road or expansion, the IEE report is applied for this Project.

The main objectives of Initial Environmental Examination (IEE) of this study are:

1) To preliminarily assess environmental impacts arisen from implementation of improvement of the National Road No.67 Section of Siem Reap – Anlong Veng – Choam/Sa Ngam Pass.

2) To prepare preliminary measures to prevent and mitigate the negative impacts while promoting positive impacts to be in line with the Cambodian regulations.

3) To prepare Initial Environmental Examination report for Ministry of Public Works and Transport (MPWT) of Cambodia to further propose to relevant organizations for consideration of the project implementation without significant environmental impacts.

The study area has been defined based on the potential impacts to be induced by the improvement of National Road NR67 Section of Siem Reap-Anlong Veng-Choam/Sa Ngam Pass covering area within 500 meters strips on both sides along the total length of 134 kilometers of this road section (**Figure 6.1-1**).

The study area covers 38 villages in 12 communes of Anlong Veng district in Oddar Meanchey province and Varin district, Banteay Srei district, and Prasat Bakong district in Siem Reap province.

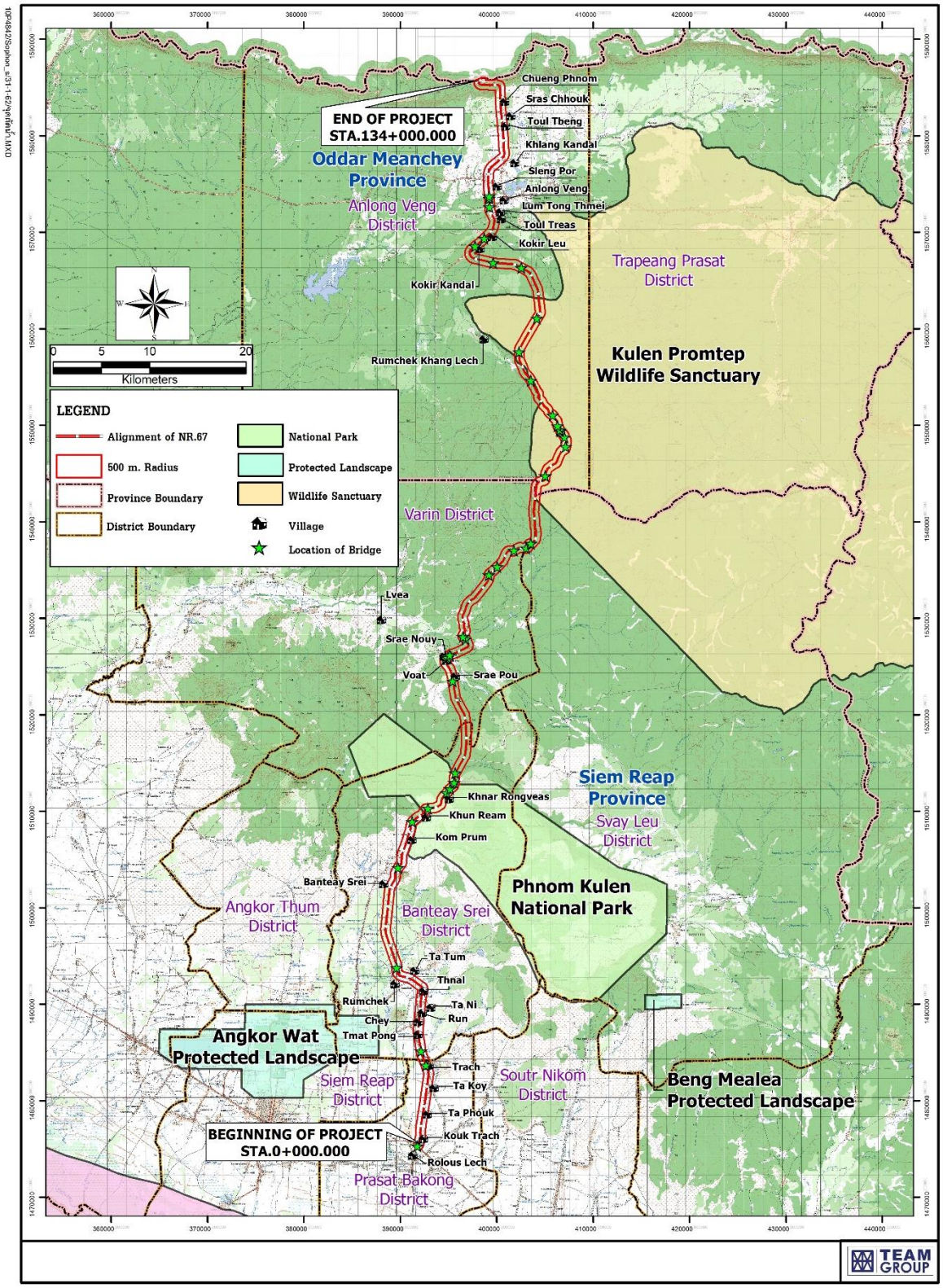


Figure 6.1-1 Project Location and Study Area

6.1.2 Description of Existing Environment

The area of interest covers all concerned environmental parameters in physical, biological, and socio-economic components. Information about the environment of the study area was compiled from secondary sources and field survey.

Physical Components

The project area is situated in Siem Reap and Oddar Meanchey Provinces. Its location is in the northwest of the Kingdom of Cambodia which is located in the low earthquake risk area**.** The southern part of the study area is located in Mekong-Tonle Sap river system. The middle part of the project alignment is located in the Phnom Kulen Mountain. The northern part of the project alignment is on a steep escarpment.

Siem Reap and Oddar Meanchey provinces have a tropical climate. The weather in Siem Reap province is hot throughout the year with average high temperatures over 30 ˚C and averages 1,405 mm of rainfall per year. The average high temperatures for Oddar Meanchey province never falls below 33 ˚C in any month, and averages 1,499 mm of rainfall per year.

Most of the study area along the National Road 67 (NR 67) is located in rural areas. Therefore, air quality is still good with low level of ambient noise and vibration.

There are 39 bridges over 8 permanent canals and small creeks along NR 67. The water is uesed for agriculture, domestic consumption and fishery/fishing, and dried up in the dry season.

Biological Components

In 2016, the forest land in Oddar Meanchey province and Siem Reap province covered 189,963 ha and 319,717 ha, respectively. This is equivalent to 28.64% and 30.32% of the province's total land area. Most of forest types in two provinces are deciduous forest and evergreen forest.

Based on a Biodiversity Survey of the Oddar Meanchey and Siem Reap Provinces Northwest Cambodia, April, 2016, a total of 26 mammal species were recorded including ten species classed as threatened by the IUCN Red List. For bird species, eight threatened bird species were recorded including two critically endangered species, one endangered species, two vulnerable species, and three near-threatened species (IUCN, 2014).

The existing National Road 67 traverses approximately 5 km. of the Phnom Kulen National Park and 20 km of Kulen Promtep Wildlife Sanctuary. National Road 67 passes through the northwest end of the Park and the middle section of the Sanctuary.

Phnom Kulen National Park is in the north of Siem Reap town with the total area of 37,500 ha. The Park composed of two main distinct vegetation types – evergreen forest and deciduous forest. Kulen Promtep Wildlife Sanctuary is located north of Phnom Kulen Park close to the Thai border in Preah Vihear and Oddar Meanchey provinces. The total area of the wildlife sanctuary is 402,500 ha. The principle habitats are lowland open dipterocarp forest.

Socio-economic components

In 2017 ,the study area covers the area of 38 villages located in 12 communes of 4 districts of Oddar Meanchey and Siem Reap provinces. In this area, there are 47,833 persons living in 10,229 families. The people here mostly completed primary education. About 2,908 persons or 6% of total population (47,833) are illiterate.

There are 1,386 temporary shelters existing on the right of way (ROW) of NR 67. Most of the shelters are in small size, and owned by villagers who have houses behind. They are on small business, selling mostly food and fruits to passersby. Very few of them sell petro and construction materials.

Main occupation of the people in this area is agriculture. Its majority is rice farming and cultivation of other crops such as fruit trees and annual crop.

About half of land use in the study area is deciduous forest, and about 27% is paddy field.

In 2017, electricity supply within the study area was Electricite Du Cambodge (EDC) via its transmission line, battery and solar cell. Water supply within the study area was 1) pump mixed wells, 2) pond, 3) piped water, private pump well or private ring well, 4) rivers, lakes, natural ponds and reservoirs, and 5) rain water storage, respectively. There was no waste collection service in the study area.

In 2017, there were 29 health centers, 1 referral hospital, and 1 private hospital in the study area. The 29 health centers in the 4 districts had 20 beds and 197 medical personnel. A referral hospital in Anlong Veng district had 60 beds and 52 medical personnel. A private hospital in Anlong Veng district had 5 beds. Three major causes of mortality under diseases in the study area were dengue fever, tuberculosis (TB), and malaria, respectively. There were 7 deaths from traffic accidents.

The cultural heritage areas which are related to NR67 are Angkor Protected Landscapes zone and Phnom Kulen National Park. The Angkor Archaeological Park Area in Siem Reap is Cambodian most important cultural heritage site, and also the highest tourist attraction. The World Heritage Phnom Kulen National Park which is appointed as a world heritage in 2012 ,contains an important archaeological site, and protects an important part of the Siem Reap river basin. NR67 does not pass through the eastern buffer zone boundary of Angkor Protected Landscapes Zone, but passes through the northwest end of the Phnom Kulen National Park.

There are records of UXO incidents in various sites of the study area which covers 500 meter strip of NR 67, at village/urban, road/roadside, crop field and rice field. Records of UXO incidents in Varin and Bateay Srei disrtricts, Siem Reap province were found at the road/roadside. There were 4 victims, 2 injuries and 2 killed during 2007-2008.

6.1.3 Environmental Impacts and Environmental Management Plan

6.1.3.1 Environmental Impacts

Impact assessment of this Project on each environment and social issue will cover the period of before improvement, during improvement (construction) and after improvement.

Before Improvement

Major impacts of the Project during before improvement will be on air pollution from vehicles, noise and vibration generated from vehicles, tree moving and cutting at the proposed rest area, death and injury of wildlife from traffic accident, moving out of shelters on the right of way (ROW) of the national road 67 (NR 67), solid waste management, traffic accidents and risk of unexploded ordnance (UXO) Which still found the occurrence during the years 1960-1970.

During Improvement

During improvement will take about 2 years. Major impacts of the Project during improving period will include soil contamination from leakage of diesel or chemical substances, dust generated from earthworks, hauling of construction materials to site and operation of Asphalt Concrete Plant, noise and vibration from operation of construction equipment and transporting materials, an increase of surface water contamination and sediment, decrease of aquatic organisms, loss of trees and vegetation in the construction site nearby area, disturbance of wildlife, traffic accident, conflict between workers and local people, disturbance nearby communities, solid waste generation, health and safety impacts on workers and the local people and archaeological damage.

The positive impact will be on generating local economy.

After Improvement

Major impacts of the Project during after improvement will be on dust and vehicle emission, noise and vibration level generated from vehicles, surface water contamination from fuel oils, wildlife poaching, solid waste management in the rest area, traffic accidents, health and safety impacts on the local people, and archaeological damage.

The positive impact will be on generating regional and national economy.

6.1.3.2 Environmental Management Plan

The Environmental Management Plan (EMP) is to ensure that adverse environmental and social impacts are properly managed by suitable mitigation measures and monitoring programs in compliance with relevant laws and regulations stipulated by the authorities. This EMP provides the procedures and processes which will be applied to the Project activities to check and monitor compliance and effectiveness of the mitigation measures in mitigation plan and monitoring programs in monitoring plan for each phase (see **Table 6.1-1** and **Table 6.1-2**)

Table 6.1-1 Mitigation Plan

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
1. BEFORE IMPROVEMENT		
1.1 Air Quality Air pollution from vehicles such as exhaust emissions	Monitor baseline data of air quality at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67, one time before improvement.	Contractor
1.2 Noise and vibration Noise and vibration generated from vehicles	Monitor baseline data of noise and vibration levels at sensitive receptors (i.e. schools, temples, and communities) nearby the NR 67, one time before improvement.	Contractor
1.3 Surface water Water contamination from solid waste and garbage	Monitor baseline data of surface water quality at 8 permanent canals and creeks traversing the NR 67 one time before improvement.	Contractor
1.4 Aquatic Ecology Decrease of aquatic organisms	Interview the local people about fishery/fishing at permanent canals and creeks traversing the NR 67 by use of questionnaire for baseline data, one time before improvement	Contractor
1.5 Terrestrial Ecology and Protected Areas • Tree moving and cutting at the proposed rest area • Death and injury of wildlife from traffic accident	• Inspection and tagging of affected trees at the proposed rest area. • Record the number of death and injury for wildlife from traffic accident in the two protected areas of Phnom Kulen National Park and Kulen Promtep Wildlife Sanctuary.	Contractor
1.6 Socio-economic Moving out of shelters on the right of way (ROW) of NR 67	• Inform shelters' owners, their communities and local authorities about improvement schedule, at least 2 months in advance. • Conduct public relations one time before improvement, for listening to the complaint and problem solving.	Contractor
1.7 Land Use and Agriculture There might be impacted on land use or agricultural land on the ROW	• Regular inform/disclose information about the project activities and schedule to villagers in communities next to the project site.	Contractor
1.8 Solid Waste Management Garbage on the roadside and in the streams.	• Garbage bins should be provided in the communities' areas residing NR67 so that the garbage can be collected for proper disposal.	Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
1.9 Public health and traffic Traffic accidents and air pollution	• All vehicles that use for road improvement should be in good working condition. • Coordinate with local health centers and hospitals in Oddar Meanchey and Siem Reap provinces. • Collect data on incident/accident records one time before improvement.	Contractor
1.10 Unexploded ordnance (UXO) Risk of land mine or UXO	• Consult with the local authorities and local residents in case of construction any structures (i.e. campsites and Asphalt Concrete Plant) outside the road and ROW. • Consult with the Ministry of Public Works and Transport of Cambodia (MPWT) and Department of Public Works and Transport (DPWT) in case of construction any structures (i.e. campsites and Asphalt Concrete Plant) outside the road and ROW.	Contractor
2. DURING IMPROVEMENT		
2.1 Soil Soil contamination from leakage of diesel or chemical substances	• The design of diesel storage tank with facilities to contain the oil if leaked or accidentally released. • Chemicals should be stored in warehouse and lining with concrete or closing container to prevent directly leak into the soil. • In case of chemical leakage, the contractor must solve problems following Material Safety Data Sheet (MSDS) of each chemical immediately. • Monitor the soil condition in the leakage area after cleaning activities.	Contractor
2.2 Air Quality Dust generated from earthworks and hauling of construction materials to site	• Spray water on improvement sites in order to reduce dust dispersion in the ambient air and surrounded area. • Cover construction materials during transportation. • Regularly maintain equipment, machines and vehicles in good condition to minimize emissions. • Control the speed limit of vehicles and truck used for construction activities in order to have the least dust. • Avoid construction of Asphalt Concrete Plant (ACP) in community area (The proposed ACP is located at STA 25+000 to STA 26+000 which there is no communities nearby). • Monitor air quality at sensitive receptors (i.e. schools, temples, and communities) nearby the NR 67 every 6 month.	Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
2.3 Noise and vibration Noise and vibration generated from operation of construction equipment and transporting materials	• Restrict working time between 07:00 a.m. and 05.00 p.m. • Use vehicles and machinery that generate low noise level. • Vehicles and machinery to be turned off when not in use. • Operate heavy equipment away from vibration sensitive areas such as temples and similar old buildings and structures. • Avoid use of vibrating rollers near sensitive structures along the NR 67 such as temples and similar old buildings and structures. • Monitor noise and vibration levels at sensitive receptors (i.e. schools, temples, and communities) nearby the NR 67 every 6 month.	Contractor
2.4 Surface water • An increase of contamination and sediment in surface water • Generating of 15 cu.m./day of wastewater from workers at 2 campsites	• Berms and/or silt curtains should be constructed around all excavation/trench sites and along surface water to prevent soil erosion and surface water sedimentation. • The temporary worker camps must have adequate domestic waste collection facilities and sufficient pit latrines that are located away from public areas and surface water. • Erosion channels must be built around aggregate stockpile areas to contain rain-induced erosion. • All construction fluids such as oils, and fuels should be stored and handled well away from surface water. • No waste of any kind should be thrown into surface water. • No washing or repairing of machinery near surface water. • Temporary pit latrines to be located away from surface water, homes, and businesses. • All irrigation canals and channels to be protected in the same way as surface water. • Monitor surface water quality at 8 permanent canals and creeks traversing the NR 67 in the dry and the wet seasons during improving period. • Monitor effluent discharge at 2 construction sites every 6 month.	Contractor
2.5 Aquatic Ecology Decrease of aquatic organisms	• Implement all measures to mitigate water contamination and solid waste. • Control measures on illegal fishing with hazardous chemicals or electricity by workers. • Interview the local people regarding fishery/fishing at permanent canals and creeks traversing the NR 67 every 6 month.	Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
2.6 Terrestrial Ecology and Protected Areas • Loss of trees and vegetation at the rest area • Disturbance of wildlife inside or near Phnom Kulen National Park, and Kulen Promtep Wildlife Sanctuary	• Restrict all trees and vegetation removal into the right of way. • Prevent trees removal, and install protective physical barriers around trees that do not need to be removed. • All areas to be re-vegetated and landscaped after improvement completed. • Tree clearing in the rest area should be avoided as much as possible. • Monthly check growth and survival of planted trees in the rest area. • The following activities must not occur inside or near Phnom Kulen National Park, and Kulen Promtep Wildlife Sanctuary: - Creation of borrow pits or quarrying; - Storage or piling of all or any construction materials; - Parking of idle construction vehicles and heavy equipment. All vehicles are subjected to leave sensitive areas when not in use; - Maintenance of any construction vehicles or heavy equipment; - Establishment of Asphalt Concrete Plants; - Creation of fuel or materials storage depots; - Establishment of workers' camps; and - All workers and construction waste must be removed daily from the sites. • Monthly record the number of death and injury for wildlife from traffic accident in the two proteced areas.	Contractor
2.7 Socio-economic **Positive Impact** Chance to hire the locals and encourage local economy **Negative Impact** • Conflict between construction workers and the local people in case of not well control. • Disturbance by dust, noise, vibration and road safety on the locals and passersby	• Hire construction workers from local sources as many as possible. • Purchase and use construction materials locally when possible; i.e. gravel, stone and asphalt. • Closely control workers behavior to not disturb the people nearby construction area. • Apply prepared measures for air pollution, noise, vibration and road safety. • Provide communication channels between communities and the project developer to receive requests and to listen to problems and complaints including informing communities about project address and telephone number. • Monitor complaints from stakeholders, especially the locals and passersby.	Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
	• Monitor consultation meeting with the communities about impacts arisen from construction activities.	
2.8 Electricity Impact on electricity use of the local people.	• Contact the local utilities and services with schedule, and identify possible contingency back-up plans for outages. • Contact affected communities to inform them about planned outages. • Try to schedule all outages during low use time such as between 12.00 p.m. to 06:00 a.m.	Contractor
2.9 Water Supply • Generating of 180 m^3/day of water use for workers • Impact on water use on the local people.	• Contact local utilities and services with schedule, and identify possible contingency back-up plans for outages. • Contact affected communities to inform them about planned outages. • Provide water trucks to bring fresh water and store in the tanks for the use of construction and consumption. • Provide sufficient drinking water for staff/workers.	Contractor
2.10 Solid Waste Management • Generating of about 60 kg/day of domestic waste from workers • Generating of about 0.6 kg /day of hazardous waste • Generating of construction waste from dismantling of old structures such as wood scrap, cement bags, and concrete debris	***1) Non -Hazardous Waste*** • Provide large garbage bins in improvement sites. • A schedule of solid and liquid waste collection and disposal must be established and practiced accordingly in order to ensure construction sites are as clean as possible. • Solid waste should be separated and recyclables sold to buyers in communities. • Daily inspection of solid wastes collection and proper disposal at 2 campsites along the roadside. ***2) Hazardous Waste*** • Collection, storage, transport, and disposal of hazardous waste such as used oils, gasoline, road marker paint, and other toxics must follow the Government of Cambodia (GoC) regulations. • Wastes should be separated (e.g. batteries, paints) • Wastes must be stored above ground in closed, well labeled and ventilated plastic bins. They must be away from the areas of improvement, all surface water, water supplies, and cultural and ecological sensitive receptors. • Fuel/used oil should be collected, properly stored and disposed at an approved site.	Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
2.11 Traffic and Public Health • Accidents and safety risk to workers • Health and safety impacts on staff/workers and the local people nearby the road improvement areas	• Proper fencing, protective barriers, and buffer zones should be provided around all improvement sites. • Sufficient signage and information disclosure, and site supervisors and night guards should be placed at all sites. • Speed limits suitable for the size and type of construction vehicles, and current traffic patterns should be developed, posted, and enforced on all roads used by the Project's vehicles. • Standing water suitable for disease vector breeding should be filled in. • Worker education and awareness seminars for construction hazards should be given at beginning of improving period, and at ideal frequency of monthly. A construction site safety program should be developed and distributed to workers. • Appropriate safety clothing and footwear should be mandatory for all construction workers. • Adequate medical services must be on site or nearby all working sites. • Drinking water must be provided at all working sites. • Sufficient lighting is used during necessary night work. • All working sites should be examined daily to ensure unsafe conditions are removed. • Coordinate with local health centers and hospitals in Oddar Meanchey and Siem Reap provinces. • Collecting data for incident/accident records every 6 month.	Contractor

2.12 Cultural Heritage
There might be archaeological damage near the Angkor Protected Landscapes Zone and inside the Western Phnom Kulen National Park
	• In order to control and minimize impacts from road improvement activities that occur inside the protected areas, the following activities must not occur inside or near Angkor Protected Landscapes Zone and Western Phnom Kulen National Park:-
	  • Creation of borrow pits or quarrying;
	  • Storage or piling of all or any construction materials;
	  • Parking of idle construction vehicles and heavy equipment. All vehicles are subjected to leave the sensitive areas when not in use;
	  • Maintenance of any construction vehicles or heavy equipment;
	  • Establishment of Asphalt Concrete Plants
		Contractor

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
	• Creation of fuel or materials storage depots; • Establishment of workers' camps; and • All workers and construction wastes must be removed daily from the sites. • A cultural chance find management plan must be in place for cultural / historical / archaeological artifacts found during improving period.	
2.13 Unexploded ordnance (UXO) Risk of land mine or UXO	• Consult with the local authorities and local residents in case of construction any structures (i.e. campsites and Asphalt Concrete Plant) outside the road and ROW. • Consult with the Ministry of Public Works and Transport of Cambodia (MPWT) and Department of Public Works and Transport (DPWT) in case of construction any structures (i.e. campsites and Asphalt Concrete Plant) outside the road and ROW.	Contractor
3. AFTER IMPROVEMENT		
3.1 Air Quality Generation of dust and vehicle emissions	• Coordinate with related agencies regarding traffic management and emission tests of vehicles. • Regularly rehabilitate and maintain the road. • Monitor air quality at sensitive receptors (i.e. schools, temples, and communities) nearby the NR 67 every 6 month, within 5 years duration.	Contractor (years 1 -2) and MPWT (years 3 -5)
3.2 Noise and Vibration Generation of noise and vibration levels from vehicles.	• Regularly rehabilitate and maintain the road. • Limit loading weight of vehicles in the rehabilitation site. • Control all drivers to strictly follow traffic rules. • Monitor noise and vibration levels at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 every 6 month, within 5 years duration	Contractor (years 1-2) and MPWT (years 3-5)
3.3 Surface Water and Aquatic Ecology • Surface water contamination from fuel and oil leakage • Impact on aquatic animal due to low dissolved oxygen (DO) in the surface water	• Maintain cover plants along the banks and areas prone to erosion. • Clean and maintain the drainage system along NR 67. • Monitor baseline data of the surface water quality at 8 permanent canals and creeks traversing NR 67 twice a year, during the dry season (once) and the wet season (once), within 5 year duration.	Contractor (years 1-2) and MPWT (years 3 -5)

Potential Environmental and Social Impacts	Proposed Mitigation Measures	Responsibility
3.4 Terrestrial Ecology and Protected Area Encroachment of the two protected areas, Phnom Kulen National Park and Kulen Promtep Wildlife Sanctuary, on both sides of the road and wildlife poaching by local people due to easy accessibility.	• Prevention/restrictions of commercial and local development in the two protected areas. • Record the number of death and injury for wildlife from traffic accident and poaching at the two protected areas every 6 month, throughout 5 years after road improvement.	Contractor (years 1-2) and MPWT (years 3 -5)
3.5 Socio-economic **Positive Impact** • Encourage growth of national economy by supporting agriculture, tourism, investment, border trade, logistic system and employment in various sectors. • Cost and time saving of travelling		Contractor (years 1 -2) and MPWT (years 3-5)
Negative Impact • Problems of road safety, especially traffic accidents. • People may entry into the protected areas for illegal occupying after road improvement	• Apply the same mitigation measures as those for impacts on road safety • Not issue any right or land titles to those illegal occupiers.	
3.6 Solid Waste Management Generating of domestic waste from driver on the NR 67 and in the rest area.	• Provide large garbage bins in the rest area, and collect garbage for disposal.	Contractor (years 1 -2) and MPWT (years 3 -5)
3.7 Traffic and Public Health Health and safety impacts on the local people nearby the NR 67 caused by traffic accidents, noise and air pollution	• Ensure well marked safe speed limits along NR 67 are enforced. • Ensure all traffic lights, traffic signs, signals and road facilities are in good working condition. • Coordinate with local health centers and hospitals in Oddar Meanchey and Siem Reap provinces. • Collecting data for incident/accident records every 6 month.	Contractor (years 1-2) and MPWT (years 3-5)
3.8 Cultural Heritages Encroachment into the cultural protected areas (Angkor Wat Protected Landscapes Zone and Phnom Kulen National Park).	• Prevention /restrictions of commercial and local development	Contractor (years 1-2) and MPWT (years 3 -5)

Source: The Consultant

Table 6.1-2 Monitoring Plan

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
1. BEFORE IMPROVEMENT					
1.1 Fugitive Dust	• Total Suspended Particulate (TSP)-24 hr. • Particulate Matter less than 10 micron (PM10)-24 hr. • Particulate Matter less than 2.5 micron (PM2.5)-24 hr.	Duration 3 consecutive days including weekday and weekend Frequency 1 time before improvement	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractor	To be included in the Contract (220,000 THB/time)
1.2 Noise and Vibration	• Leq 24 hr (day time) • Lmax • L 90 • Vibration (frequency and velocity)	Duration 3 consecutive days including weekday and weekend Frequency 1 time before improvement	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractor	To be included in the Contract (120,000 THB/time)
1.3 Surface water quality	• Depth • Temperature • pH • Dissolved Oxygen (DO) • Turbidity • Suspended Solids (SS) • Oil and grease • Biochemical oxygen demand (BOD_5) • Total Coliform Bacteria	Frequency 1 time before improvement	8 permanent canals and creeks traversing the NR 67 • STA 20+445.000 • STA 31+250.000 • STA 36+320.000 • STA 38+520.500 • STA 42+700.000 • STA 56+521.230 • STA 87+138.210 • STA 93+371.550	Contractor	To be included in the Contract (55,000 THB/time)
1.4 Fishery	Interview the local people by questionnaire (10 persons)	Frequency 1 time before improvement	Communities nearby permanent canals and creeks traversing the NR 67	Contractor	To be included in the Contract (20,000 THB/time)
1.5 Forest	Inventory of affected trees in the rest area. • Inspection and tagging trees	Frequency 1 time before improvement	Rest area	Contractors	To be included in the Contract (2,000 THB/time)

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
1.6 Wildlife	Field observation • Number of wildlife death and accident	Frequency 1 time before improvement	Two protected areas (Phnom Kulen National Park and Kulen Promtep Wildlife Sanctuary)	Contractors	To be included in the Contract (2,000 THB/time)
1.7 Socio-economic	***1. Complaints*** • Complaints from villagers/passersby • Complaints' resolution is undertaken in a timely manner	Throughout before improvement period	Communities nearby NR 67	Contractors	To be included in the Contract (Operation cost)
	2. Public relation • Inform communities and passersby about activities related to road improvement and contact persons	1 time before improvement	Communities nearby NR 67	Contractors	To be included in the Contract (40,000 THB/time)
1.8 Traffic and public health	Collected data • Incident/ accident records	Frequency 1 time before improvement	• Update traffic accident in Oddar Meanchey and Siem Reap provinces • Communities nearby NR 67	Contractors	To be included in the Contract (30,000 THB/time)
1.9 UXO	Collected data • Incident/ accident records	Frequency Throughout before improvement period	Communities nearby NR 67	Contractors	To be included in the Contract (Total 586,000 THB)
2. DURING CONSTRUCTION					
1 Fugitive Dust	• Total Suspended Particulate (TSP)-24 hr. • Particulate Matter less than 10 micron (PM10)-24 hr. • Particulate Matter less than 2.5 micron (PM2.5)-24 hr.	Duration 3 consecutive days including weekday and weekend Frequency Every 6 month (3 times)	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractors supervision consultant (CSC)	To be included in the Contract - 220,000 THB/time (Total 660,000 THB)

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
2.2 Noise and Vibration	• Leq 24 hr (day time) • L_{max} • L_{90} • Vibration (frequency and velocity)	Duration 3 consecutive days including weekday and weekend Frequency Every 6 month (3 times)	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractors supervision consultant (CSC)	To be included in the Contract - 120,000 THB/time (Total 360,000 THB)
2.3 Surface water	***1. Surface water quality*** • Depth • Temperature • pH • Dissolved Oxygen (DO) • Turbidity • Suspended Solids (SS) • Oil and grease • Biochemical oxygen demand (BOD_5) • Total Coliform Bacteria	Frequency 3 times including the dry and the wet seasons during improving period	8 permanent canals and creeks traversing the NR 67 • STA 20+445.000 • STA 31+250.000 • STA 36+320.000 • STA 38+520.500 • STA 42+700.000 • STA 56+521.230 • STA 87+138.210 • STA 93+371.550	Contractors supervision consultant (CSC)	To be included in the Contract - 55,000 THB/time (Total 165,000 THB)
	2. Effluent discharge at 2 construction camps • BOD_5 • COD • Oil and Grease • pH • Total Suspended Solid • Total Nitrogen • Total Phosphorus • Total Coliform Bacteria	Frequency Every 6 month during improving period (3 times)	The outlets of effluent from 2 construction camps	Contractors supervision consultant (CSC)	To be included in the Contract - 45,000 THB/time (Total 135,000 THB)
2.4 Aquatic Ecology	Interview the local people by questionnaire	Frequency Every 6 months during improving period	Communities nearby permanent canals and creeks traversing the NR 67	Contractors supervision consultant (CSC)	To be included in the Contract - 20,000 THB/time (Total 60,000 THB)

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
2.5 Terrestrial Ecology	***1. Forest*** Check growth/survival of planted trees	Frequency On monthly basis	Rest area	Contractors supervision consultant (CSC)	To be included in the Contract - 2,000 THB/time (Total 42,000 THB)
	2. Wildlife Field observation • Number of wildlife death and accident	Frequency On monthly basis	National Road 67 transverses the Kulen Promtep Wildlife Sanctuary and the Phnom Kulen National Park	Contractors supervision consultant (CSC)	To be included in the Contract - 2,000 THB/time (Total 42,000 THB)
2.6 Solid waste	Field observation • Segregation of solid wastes • Inspection of solid wastes and proper disposal of solid wastes	Frequency Daily inspection	• At 2 construction camps • Roadside along the road improvement	Contractors supervision consultant (CSC)	To be included in the Contract (Operation Cost)
2.7 Socio-economic	***1. Complaints*** • Complaints from villagers/passersby • Complaints' resolution is undertaken in a timely manner	Throughout improving period	Communities nearby construction site	Contractors supervision consultant (CSC)	To be included in the Contract (Operation cost)
	2. Public Relations • Inform community about impacts from road improvement	2 times each for five communities' clusters (10 meetings)	5 communities' clusters nearby NR 67	Contractors supervision consultant (CSC)	To be included in the Contract - 220,000 THB/Time (Total 440,000 THB)
2.8 Traffic and public health	Collected data • Incident/ accident records	Every 6 month during improving period (3 times)	• Health centers and hospitals in Odder Meanchey and Siem Reap provinces • Communities nearby NR 67	Contractors supervision consultant (CSC)	To be included in the Contract - 30,000 THB/time (Total 90,000 THB)
2.9 UXO	Collected data • Incident/ accident records	Frequency Throughout improving period	Communities nearby NR 67	Contractors supervision consultant (CSC)	To be included in the Contract (Total 144,000 THB)

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
3. AFTER IMPROVEMENT					
3.1 Fugitive Dust	• Total Suspended Particulate (TSP)-24 hr. • Particulate Matter less than 10 micron (PM10)-24 hr. • Particulate Matter less than 2.5 micron (PM2.5)-24 hr.	Duration 3 consecutive days including weekday and weekend Frequency Every 6 month within 5 year duration (10 times)	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractor/ MPWT	• To be included in the Contract (year 1st and year 2nd) - 220,000 THB/time (Total 880,000 THB) • To be included in the annual budget of MPWT (from year 3rd to year 5th) - 220,000 THB/time (Total 1,320,000 THB)
3.2 Noise and vibration	• Leq 24 hr (day time) • L_{max} • L_{90} • Vibration (frequency and velocity)	Duration 3 consecutive days including weekday and weekend Frequency Every 6 month within 5 years duration (10 times)	4 stations at sensitive receptors (i.e. schools, temples, and communities) nearby NR 67 • STA 0+000 • STA 32+000 to STA 33+000 • STA 55+000 to STA 57+000 • STA 117+000	Contractor/ MPWT	• To be included in the Contract (year 1st and year 2nd) - 120,000 THB/time (Total 480,000 THB) • To be included in the annual budget of MPWT (from year 3rd to year 5th) - 120,000 THB/time (Total 720,000 THB)
3.3 Surface water quality	• Depth • Temperature • pH • Dissolved Oxygen (DO) • Turbidity • Suspended Solids (SS) • Oil and grease • Biochemical oxygen demand (BOD_5) • Total Coliform Bacteria	Frequency Twice a year during the dry season (once) and the wet season (once), within 5 year duration (10 times)	8 permanent canals and creeks traversing NR 67 • STA 20+445.000 • STA 31+250.000 • STA 36+320.000 • STA 38+520.500 • STA 42+700.000 • STA 56+521.230 • STA 87+138.210 • STA 93+371.550	Contractor/ MPWT	• To be included in the Contract (year 1st and year 2nd) - 55,000 THB/time (Total 220,000 THB) • To be included in the annual budget of MPWT (from year 3rd to year 5th) - 55,000 THB/time (Total 330,000 THB)

Environmental and Social Issues	Parameter to be Monitored	Duration/Frequency of Monitoring	Monitoring Location	Responsibility	Estimated Cost (THB)
3.4 Wildlife	Field observation and interview • Number of wildlife death and accident	Frequency Every 6 month within 5 year duration (10 times)	NR 67 transverses Kulen Promtep Wildlife Sanctuary and Phnom Kulen National Park	Contractor/ MPWT	• To be included in the Contract (year 1st and year 2nd) - 40,000 THB/time (Total 160,000 THB) • To be included in the annual budget of MPWT (from year 3rd to year 5th) - 40,000 THB/time (Total 240,000 THB)
3.5 Traffic and public health	• Incident/ accident records	Every 6 month within 5 year duration (10 times)	• Update traffic accident in Oddar Meanchey and Siem Reap provinces • Communities nearby NR 67	Contractor/ MPWT	• To be included in the Contract (year 1st and year 2nd) - 30,000 THB/time (Total 120,000 THB) • To be included in the annual budget of MPWT (from year 3rd to year 5th) - 30,000 THB/time (Total 180,000 THB)

Source: The Consultant

6.1.3.3 Estimated Cost of EMP

The total cost of EMP is provisionally estimated at approximately 1,075,000 THB before improvement, 2,138,000 THB during improving period, and 4,650,000 THB after improvement. The costs for EMP implementation of this Project are summarized in **Table 6.1-3**.

Table 6.1-3 Estimated Costs for EMPs

Period/Activity	Estimated Cost (THB)
1. Before Improvement	
1.1 Updating environmental baseline (Air quality, Noise, Vibration, Surface water quality, Aquatic ecology, Traffic and public health)	1,035,000
1.2 Public relation	40,000
Sub-total (1)	**1,075,000**
2. Improving Period	
2.1 Environmental quality	1,698,000
2.2 Public consultation	440,000
Sub-total (2)	**2,138,000**
3. After Improvement	
3.1 Environmental quality (Estimated cost is included in the contract.)	1,860,000
3.2 Environmental quality (Estimated cost is included in the annual budget)	2,790,000
Sub-total (3)	**4,650,000**
Grand Total	**7,863,000**

6.1.3.4 Reporting

Regular reporting on the implementation of mitigation measures and on monitoring activities before improvement, improving period, and after improvement of the project is required. A report on environmental monitoring and implementation of EMP will be prepared every six month (**Table 6.1-4**).

Table 6.1-4 EMP Reporting Plan

Report	Content	Prepared by	Submitted to	Frequency
Before improvement				
Project progress report	Progress of activities before road improvement	Contractors	Contractors supervision consultant (CSC)/ MPWT	Monthly basis
Environmental report	EMP Implementation and environmental monitoring	Contractors	CSC/MPWT	Semi-annual
During Construction				
Project progress report	Progress of road improvement activities	Contractors	CSC/MPWT	Monthly basis
Environmental report	EMP Implementation and environmental monitoring	Contractors	CSC/ MPWT	Semi-annual
After improvement				
Environmental report	EMP Implementation and environmental monitoring	Monitoring Team	CSC/MPWT	Semi-annual

Note: MPWT = Ministry of Public Works and Transport

6.2 PUBLIC PARTICIPATION

Public participation for this project had been carried out in forms of:

1. First public consultation: Interviewing key informants, and public meeting with local authorities and communities' leaders in Cambodia.

2. Second public consultation: Information disclosure about the project information, major impacts and mitigation measures/monitoring measures including seeking feedbacks from the local authorities and local residents.

3. Information disclosure to the Thai and Cambodian people.

4. The project website.

6.2.1 Conclusions on Results of the Public Participation

The 4 activities related to public participation, as proposed above were already undertaken. The results were highly successful. They are:

6.2.1.1 Information Disclosure to the Thai and Cambodian people

The leaflet contains the project information, location, objectives and benefits has been prepared in the 3 languages of English, Khmer and Thai. They were placed at Choam/Sa Ngam checkpoints so that the people and passersby could pick up and acknowledge the project.

6.2.1.2 Website

The project website was prepared in the 3 languages as well. The information contains background, objectives, area of concerns, scope of work including the traffic and transportation study area. The website has been displayed since March 2019, at http://www.nr67.net/. The website will be updated periodically until completion of the Project.

6.2.1.3 First Public Consultation and the Results

The first public consultation was conducted during 3-6 December 2018. Main activities were interviewing head/representative of 12 agencies of key informants at the provincial level, and consultant meeting with the local authorities at the district and commune levels.

All of officials and communities' leaders were satisfied with consultation. They all appreciated and fully supported the project. They also identified the positive and negative impacts which might be arisen from the project implementation ,and expressed requests and suggestions at the same time.

Positive impacts: were identified as the project would help to boost up national economy, improve logistic system, save cost and time of travelling and transportation, improve standard of living and poverty reduction of the people including increase of land value and population in this area.

Negative impacts: were identified in the periods of before improvement, during improving and after road improvement. The identifications were in the areas of work and road safety, road damaged, harm on environment and protected area, water quality, shelters on ROW, illegal encroachment in the public land, etc.

Requests and Suggestions: All agencies gave good feedbacks. The major suggestions were:

- Prepare EIA study or updated previous EIA report;
- Compliance with Cambodian laws and cooperate with relevant agencies and the local authorities;
- Increase road facilities;
- Practice following environmental mitigation measures;
- Maintain the water quality and give priority to drainage system;
- Establish complaints channel;
- The Project should hire local people;
- Increase work and road safety;
- Not harming archaeological temples and ancient places;
- Villagers who are illegally occupying the public lands have to return those lands to the state whenever they are needed for development[1]; and
- The Land Management Department will not issue any rights or land titles to those who encroach lands in the protected area[2].

[1] Stated by Chief of Anlong Veng District Governor

[2] Stated by the Director of Land Management Urban Planning Construction and Cadaster Department, Siem Reap

6.2.1.4 Second Public Consultation

Second public consultation was conducted during 15-16 March 2019. Main activities were disclosure of the project information, major impacts and mitigation measures including open discussion with the locals in order to receive their feedbacks which will be further submitted to relevant authorities for consideration.

There were 200 persons from 4 districts in the study area who attended the consultation meeting. Officials from Anlong Veng district and DPWT in Siem Reap also joined the meeting.

The representative of Department of Public Works and Transport (DPWT), local authorities, communities' leaders and local residents satisfied with consultation. The meeting was in interactive mode. There were a lot of questions and answers in this session.

All participants acknowledged the major impacts which would be arisen before and during road improvement and accepted proposed mitigation measures. Major concerns in question and answer session were mainly on effects on shelters on the ROW.

With the question of what to do in case the government wants the land on ROW back, their answers were moving shelters backward, to be out of ROW. So, their shelters will be still on our land, in front of their houses. They will not move to other places.

6.2.2 Conclusions

Four activities related to public participation were already implemented. The results were success, as shown below:

1) There was good cooperation from the Cambodian and Thai authorities for activities related to information disclosure to the Thai and Cambodian people. So, the leaflets contain the Project information were placed and distributed at Choam/Sa Ngam checkpoints.

2) The Project Website was updated periodically.

3) The conduct of the first and second public consultations was highly successful. All relevant agencies, local authorities, communities' leaders and the local residents well cooperated with the project. They were willing to see the project getting started soon.

4) Major concern of the participants was on temporary shelters on the ROW. However, they didn't think of any problems in case the government asks them to move the shelters from ROW. They requested the Project to inform them in advance with sufficient time for moving.

5) Requests/suggestions related to road safety and road facilities raised by the participants in the 2 consultation meetings were included in the road design.

CHAPTER 7

QUANTITY TAKEOFF AND COST ESTIMATATION

CHAPTER 7

QUANTITY TAKEOFF AND COST ESTIMATATION

7.1 QUANTITY TAKEOFF

In this project, the quantity takeoff was based on the Government Median Price Calculation Manual of the Comptroller General's s Department, the Ministry of Finance, Thailand. The quantity of materials was determined from the final construction drawings to calculate the median prices for the project construction cost.

7.2 COST ESTIMATION

The cost estimation was undertaken according to the Government Median Price Calculation Manual of the Comptroller General's Department, the Ministry of Finance, for further use in the project analysis and preparation of investment plan or loan. The capital cost estimation covers the entire project period from the beginning until completion. The project capital costs consist of the following.

1) Sub-total Civil Works Cost

The quantity takeoff and cost estimates were prepared in unit costs, including operation cost and profit, for civil items of construction works. The construction cost was estimated based on the prices of construction materials in Surin province of Thailand. The other materials for earthworks and backfilling will be supplied from Cambodia. Otherwise, local labor wage in Cambodia will be used for unit cost calculation.

2) Contingency of Civil Works

The contingency of civil works was estimated at 10% of the summary of sub-total civil works cost.

3) Total Civil Works Cost

The total civil works cost was summation of sub-total civil works cost and contingency of civil works cost.

4) Consulting Service Fee

The consulting service fee was estimated at 3% of the total civil works cost.

5) Administration Cost

The administration cost was estimated at 1% of the total civil works cost.

6) Loan Contingency

The loan contingency cost was estimated at 5% of the total civil works cost.

7) Sub-total Loan

The sub-total loan was summation of the total civil works cost, the consulting service fee, the administration cost and the loan contingency.

8) NEDA's Management Fee

The NEDA's management fee was estimated at 0.15 % of the sub-total loan.

9) Total Loan or Project Cost

The total loan or project cost was summation of the sub-total loan and NEDA's management fee.

The project cost is summarized below in **Table 7.2-1**.

Table 7.2-1 Summary of Construction Cost

NO.	DESCRIPTION	AMOUNT (THB)
A	**SUB-TOTAL CIVIL WORKS**	**822,252,401.46**
	1. GENERAL REQUIREMENT	33,564,792.00
	2. REMOVAL OF EXISTING STRUCTURES	51,072,000.00
	3. EARTHWORK	32,923,007.34
	4. SUBBASE AND BASE COURSES	
	4.1 SUBBASE	1,438,945.71
	4.2 BASE	142,559,316.48
	5. SURFACE COURSES	
	5.1 ASPHALT CONCRETE	436,711,413.43
	5.2 PORTLAND CEMENT CONCRETE PAVEMENT	5,272,374.60
	6. STRUCTURES	49,436,432.88
	7. MISCELLANEOUS	
	7.1 CONTRACT SIGN AND COLLABOLATION SIGN	92,545.20
	7.2 TRAFFIC SIGNS	296,439.90
	7.3 ROADWAY LIGHTING AND TRAFFIC SIGNAL	11,263,200.00
	7.4 MARKINGS	21,435,636.60
	7.5 GUARD RAIL	15,860,250.00
	7.6 SLOPE PROTECTION	9,980,016.00
	7.7 CURB AND GUTTER	716,633.64
	7.8 R.O.W. MONUMENT	745,778.88
	7.9 SOFT SPOT	204,433.92
	8. TRAFFIC MANAGEMENT DURING CONSTRUCTION	4,621,949.88
	9. ENVIRONMENTAL MANAGEMENT PLAN	3,213,000.00
	10. REST AREA	844,234.00
B	**CONTINGENCY OF CIVIL WORKS [10% OF A]**	**82,225,240.15**
C	**TOTAL CIVIL WORKS COST (A+B)**	**904,477,641.61**
	LOAN AMOUNT	
D	**CONSULTING SERVICE (3% OF C)**	**27,134,329.25**
E	**ADMINISTRATION COST (1% OF C)**	**9,044,776.42**
F	**LOAN CONTINGENCY (5% OF C)**	**45,223,882.08**
G	**SUB-TOTAL LOAN (C+D+E+F)**	**985,880,629.35**
H	**NEDA'S MANAGEMENT FEE (0.15% OF G)**	**1,478,820.94**
I	**TOTOL LOAN (G+H)**	**987,359,450.30**

7.3 MAINTENANCE COST

The maintenance cost is the budget allocated for maintaining the road throughout the project period of 20 years. The maintenance cost consists of:

1) **routine maintenance cost:** mowing, improvement of road markings and traffic signs, and pavement repair; and
2) **periodic maintenance cost**: pavement overlay, etc.

7.4 ENVIRONMENTAL COST

It is the expense for environmental impact monitoring during the first 5 years (years 1 and 2 in of liability period: contractor responsibility and years 3 – 5 :MPWT responsibility) after the project road is opened to traffic. The environmental monitoring measures comprise measurement of particulate matters, noise and vibration, and surface water quality, as well as monitoring of the project impacts on wildlife, and occupational health and safety.

Estimation of maintenance cost and environmental cost during the project period of 20 years is presented in **Table 7.4-1**

Table 7.4-1 Road Maintenance Cost and Environmental Mitigation Cost After Improvement Period

No.	Item	Year	1 2022	2 2023	3 2024	4 2025	5 2026	6 2027	7 2028	8 2029	9 2030	10 2031
1	**Road Maintenance Cost (Million THB)**											
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		1.80	1.80	5.82	5.82	5.82	5.82	44.82	5.82	5.82	5.82
	1.2 Periodic Maintenance Cost (Overlay)											
2	**Environmental Mitigation Cost (Million THB)**											
	2.1 Fugitve Dust		0.44	0.44	0.44	0.44	0.44					
	2.2 Noise and Vibration		0.24	0.24	0.24	0.24	0.24					
	2.3 Surface water quality		0.11	0.11	0.11	0.11	0.11					
	2.4 Wifdlife		0.08	0.08	0.08	0.08	0.08					
	2.5 Traffic and public health		0.06	0.06	0.06	0.06	0.06					

No.	Item	Year	11 2032	12 2033	13 2034	14 2035	15 2036	16 2037	17 2038	18 2039	19 2040	20 2041	Total
1	**Road Maintenance Cost (Million THB)**												
	1.1 Routine Maintenance Cost (Grassing/Patching/ Road marking and sign plate renewal)		5.82	5.82	5.82	44.82	5.82	5.82	5.82	5.82	5.82	5.82	186.36
	1.2 Periodic Maintenance Cost (Overlay)					383.24							383.24
2	**Environmental Mitigation Cost (Million THB)**												
	2.1 Fugitve Dust												2.20
	2.2 Noise and Vibration												1.20
	2.3 Surface water quality												0.55
	2.4 Wifdlife												0.40
	2.5 Traffic and public health												0.30
Source : The Consultant, 2019													**574.25**

CHAPTER 8

PREPARATION OF TENDER DOCUMENTS

CHAPTER 8

TENDER DOCUMENTS PREPARATION

8.1 INTRODUCTION

The consultant prepared the tender documents which indicated below:

1) Tender document for the selection of Contractors
   - 1.1 Evaluation and Qualification Criteria
   - 1.2 Forms of Tender
   - 1.3 Instruction to Tenderers
   - 1.4 General and Particular Conditions of Contract
   - 1.5 Detailed Construction Specifications
   - 1.6 Contract Drawings
   - 1.7 Equipment and Material Specifications
   - 1.8 Bill of Quantities
   - 1.9 Cost Breakdown
   - 1.10 Terms of Reference: TOR

2) Tender document for the Construction Supervision Consultant
   The tender documents consist of the documents, criteria and necessary forms.

8.2 TENDER DOCUMENT FOR THE SELECTION OF CONTRACTORS

The consultants used selection of the criteria for the selection of Contractors in accordance with the regulations of the Ministry of Public Works and Transport, Kingdom of Cambodia and Asian Development Bank (ADB) standard procurement documents as shown in bidding documents volume I (Volume 1 Bidding Procedures)

General Conditions of Contract has been specified conforming to Fédération Internationale des Ingénieurs-Conseils: FIDIC, The Harmonised Multilateral Development Banks Form of Contract (Pink Book) which is the acceptable international standards as shown in bidding documents volume II (Volume 2 Conditions of Contract and Contract Forms)

Detailed Construction Specifications: The consultant proposed to use accordance with the construction specification of Department of Highway, Thailand as shown in bidding documents volume III (Volume 3 Requirements : Section 7A Detailed Construction Specifications (SPF)) which is indicated below:

DIVISION 1 GENERAL

1.1 SCOPE OF WORK

1.2 CONTROL OF WORK

1.3 CONTROL OF MATERIAL

1.4 RESPONSIBILITY OF THE CONTRACTOR

1.5 WORK PERFORMANCE

1.6 QUANTITY OF WORKS AND PAYMENT

DIVISION 2 EARTH WORK

2.1 CLEARING AND GRUBBING

2.2 ROADWAY EXCAVATION

2.3 EMBANKMENT

2.3.1 Earth Embankment

2.3.2 Sand Embankment

2.3.3 Rock Embankment

2.4 SELECTED MATERIAL

2.4.1 Selected Material B

2.4.2 Selected Material A

DIVISION 3 SUBBASE AND BASE COURSES

3.1 SUBBASE

3.1.1 Soil-Aggregate Subbase

3.1.2 Soil-Cement Subbase

3.2 BASE COURSE

3.2.1 Crushed Rock Soil Aggregate Type Base

3.2.2 Crushed Gravel Soil Aggregate Type Base

3.2.3 Cement Modified Crushed Rock Base

3.2.4 Soil Cement Base

3.3 SHOULDER

3.3.1 Soil-Aggregate Shoulder

3.4 MATERIAL TO CONTROL PUMPING UNDER CONCRETE PAVEMENT

3.4.1 Sand Cushion under Concrete Pavement

3.4.2 Crushed Rock Layer under Concrete Pavement

3.5 SCARIFICATION & RECONSTRUCTION OF EXISTING PAVEMENT

3.6 SOIL-AGGREGATE TEMPORARY SURFACE

DIVISION 4 SURFACE COURSES

4.1 SPRAYED ASPHALT TREATMENT

4.1.1 Prime Coat

4.1.2 Tack Coat

4.2 SURFACE TREATMENT

4.3 PENETRATION MACADAM SURFACE

4.4 ASPHALT CONCRETE

4.5 ASPHALT CONCRETE SURFACE EDGE

4.6 COLD MIXED ASPHALT

4.7 SLURRY SEAL

4.8 CAPE SEAL

4.9 PORTLAND CEMENT CONCRETE PAVEMENT

DIVISION 5 STRUCTURES

5.1 PORTLAND CEMENT CONCRETE STRUCTURES

5.1.1 Materials

5.1.2 Testing of Material

5.1.3 Concrete Mix

5.3.3 Measurement and Payment of Rectangular Reinforced Concrete Culvert

5.4 REINFORCED CONCRETE PIPE CULVERT

Equipment and Material Specification: This document in this section is special additional requirements as shown in bidding documents volume III (Volume 3 Requirements: Section 7B Special Provisions (SPP) (Equipment and Material Specifications))

8.3 TENDER DOCUMENT FOR THE SELECTION OF CONSTRUCTION SUPERVISION CONSULTANT

Term of reference (TOR) and request for proposal (REF) of the construction supervision consultants shall follow the Ministry of Public Works and Transport's (MPWT) Practice and the Asian Development Bank; (ADB)[1] : Standard Request for Proposals and User's Guide to Selection of Consulting Services for Borrowers[1].

The Prequalification (PQ) of the Consultant is not necessary in the Consultant selection, since the Request for Proposals (RFP) contains detailed technical proposals for qualification of the consultant firms and their financial proposal will be evaluated using Quality Cost Based Selection (QCBS) Method.

In the Consultant selection, it is preferred to have two steps in the Selection of the Consultant:

Step 1: Invitation of Expression of Interest (EOI). In this stage, the consultant firms submit the initial documents and express their interest for the Project. The four or five of the consultant firms who submitted their interest will be shortlisted based on the certain selection criteria. The details of EOI with the selection criteria and RFP will be revised in the due course of implementation.

Step 2: Shortlisted Consultant Firms are invited to submit the Request for Proposal. The Full Request for Proposal (RFP) must be prepared for this process using QCBS Method.

[1] Selection of Consultants - Asian Development Bank
https://www.adb.org/sites/default/files/page/83267/srfp-selection-consultants.doc
and https://www.adb.org/sites/default/files/selection-consulting-services.pdf

The RFP documents consists of the followings:

1. Preface
2. Request for Proposals
3. Section 1 - Letter of Invitation
4. Section 2 - Instructions to Consultants
   A. Data Sheet
   B. Appendix
5. Section 3 - Technical Proposal - Standard Forms
6. Section 4 - Financial Proposal - Standard Forms
   A. Appendix
7. Section 5 - Eligible Countries
8. Section 6 - Policy-Corrupt and Fraudulent Practices
9. Section 7 - Terms of Reference
10. Section 8 - Conditions of Contract and Contract Forms

CHAPTER 9

FEASIBILITY ANALYSIS

CHAPTER 9

FEASIBILITY ANALYSIS

9.1 APPROACH AND METHODOLOGY

The objective of the preliminary feasibility analysis is the maximization the benefit due to the limitation of resource. The development of the project must be worth for the investment. However, the economic analysis is similar to the finance analysis in term of analyzing the benefit of investment compare to its cost, the economic analysis analyzes the benefit in whole country scale. In addition, the economic analysis estimates the impact of the project on the people by comparing to the cost of investment.

For the project preliminary feasibility analysis in term of economic of the Feasibility Study on the Upgrading of the Nation Road No.67 (NR67), the consultant shall study the economic analysis by the process in **Figure 9-1:**

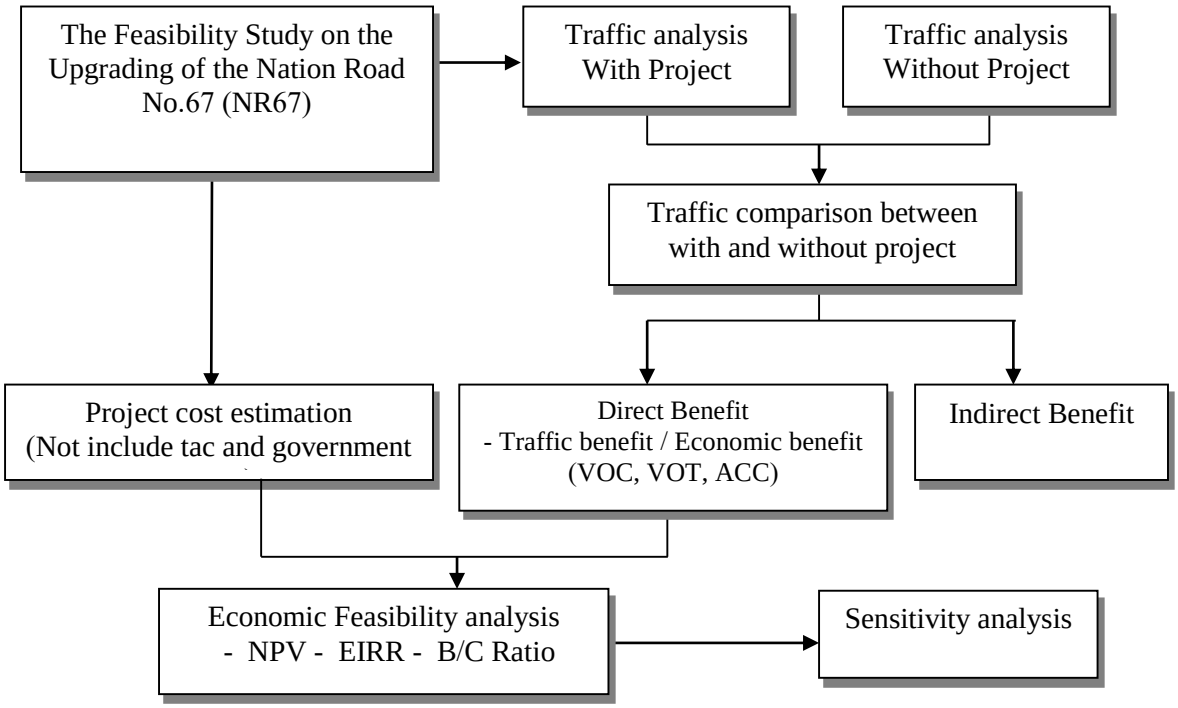


Figure 9-1 Economic Analysis Steps

9.2 ASSUMPTION AND CRITERIA

- Project period was assumed to be 20 years excluding construction period.
- Opportunity cost of capital was 12% per annum. (This reference rate was taken from the study of capital cost in Thailand conducted by the World Bank and Office of the National Economic and Social Development Council. It is presently adopted for economic analysis of public projects for many agencies, e.g. Department of Highways, Expressway Authority of Thailand, State Railway of Thailand, Office of Transport and Traffic Policy and Planning, etc.).
- Project costs were set at constant 2018 prices.
- The economic value is normally estimated by subtracting the financial price to adjust price distortion as the market prices are distorted due to various causes, e.g. imperfectly competitive market, market intervention by government, external impacts on production, and others. Financial values do not reflect the willingness to pay and the opportunity cost of the society. Therefore, the financial values are converted to economic values, using conversion factors.
- Salvage value of roads and infrastructure in the last year of the project depends on lifetime. Roads and infrastructure's lifetime is 40 years.

9.3 ECONOMIC COST ESTIMATION

The cost estimation composed of construction cost, operating cost, maintenance cost, land acquisition cost, compensation structure and other direct costs. The cost estimation will use the price at present year as the base year, the project cost should be the capital of asset to operate the project with deduction of tax, import and export duty, interest, and compensation, etc. For the analysis, financial value has to be converted to economic value by multiplying conversation factor. The details are as follows;

- Design and survey 0.92
- Civil work 0.88
- Building compensation 0.92
- Land acquisition 1.00
- Construction supervision 0.92
- Operating and maintenance 0.92
- Environmental cost 0.92

(Source: Sadig Ahmed; Shadow Prices for Economics Appraisal of Project: An Application to Thailand, World Bank Staff Working Paper, Number 609, Year 1983)

Table 9.3-1 Project Investment Cost

ITEM	Project investment cost (million baht)	
	Financial cost	**Economic cost**
CIVIL WORK[1)]		
- GENERAL REQUIREMENT	38.8	34.1
- REMOVAL OF EXISTING STRUCTURES	59.0	51.9
- EARTHWORK	38.0	33.4
- SUBBASE AND BASE COURSES	166.3	146.3
- SURFACE COURSES	510.5	449.2
- STRUCTURES	57.1	50.2
- MISCELLANEOUS	70.0	61.6
- TRAFFIC MANAGEMENT	5.3	4.7
- ENVIRONMENTAL MANAGEMENT PLAN (BEFORE AND IMPROVING PERIOD)	3.7	3.3
- REST AREA	1.0	0.9
CONSULTING SERVICE	27.1	24.9
ADMINISTRATION COST AND MANAGING FEE	10.5	9.7
TOTAL	**987.3**	**870.3**
MAINTENANCE AND ENVIRONMENTAL MANAGEMENT PLAN COST [2)]	574.3	528.3
GRAND TOTAL	**1,561.6**	**1,398.6**

Source: The Consultant, 2019

Remark: 1) Financial price includes Contingency of Civil Works (10%) and Loan Contingency (5%)
2) Calculated throughout Operation Period

9.4 ECONOMIC BENEFIT ESTIMATION

Economic Benefit is the direct benefit or profit in monetary term that is from selling the product in economic price. In addition, the indirect benefit that other third party earned from the project without any relationship or expenditure with the project. This project shall generate the direct and indirect benefit Shown in Table 9.4-1 as listed:

(1) Direct benefits

a. Vehicle Operating Cost: VOC Saving

b. Value of Time: VOT Saving

c. Accident Cost Saving, ACC Saving

(2) Indirect Benefits

In addition to the direct benefits mentioned above, which is a direct result of the highway improvement project. There are also indirect benefits including Tourism benefit, Benefit of border trade, City development and Improvement of living standard.

Table 9.4-1 Project Economic Benefit

Year B.E.	Direct benefit (Million baht/Year)			
	VOC Saving	VOT Saving	ACC Saving	Total
2565	65.7	85.4	0.1	151.2
2570	67.3	87.4	0.1	154.8
2575	68.8	89.5	0.1	158.4
2580	70.4	91.6	0.1	162.1
2584	72.1	93.7	0.1	165.9

Source: The Consultant, 2019

9.5 ECONOMIC FEASIBILITY ANALYSIS

Economic Feasibility Analysis is performed by comparing cost and benefit in terms of economic value. The indicators for economic feasibility analysis are;

(1) Net Present Value: NPV

(2) Benefit Cost Ratio: B/C Ratio

(3) Economic Internal Rate of Return: EIRR

The economic indicators derived from the economic feasibility analysis are EIRR of 16.1%, NPV of 230.5 million Baht, and B/C ratio of 1.3. It can be concluded that the project is economically viable as the economic indicators are higher than the specified criteria: EIRR of 12%, NPV of positive value, and B/C ratio of greater than 1.

9.6 ECONOMIC SENSITIVITY ANALYSIS

According to the project's economic sensitivity analysis result, if any of the above factors affects the project capital costs or benefits, the project's returns in some scenarios may be lower than the set criteria. For this project, the scenarios that are not economically viable comprise: Scenario 1: 20% increase in the project capital cost and 20% decrease in the project benefits; Scenario 2: 20% increase in the project capital cost and 10% decrease in the project benefits; Scenario 3: 10% increase in the project capital cost and 20% decrease in the project benefits.

As for the sensitivity analysis in case of delay in the project construction, the project capital cost will be higher due to the increasing prices of construction materials, and the more deteriorated condition of the road each year. The EIRRs for the 1-year, 2-year, and 3-year delay in the project construction are 14.6%, 13.2% and 10.0% respectively. In conclusion, if the construction is delayed for more than 2 years, the project capital cost will be higher as the road will be more deteriorated. Thus, the EIRR will be much lower than the set criteria and the project is unviable to invest in .These sensitivity analysis results shown in Table 9.6-1 as follow:

Table 9.6-1 Economic Sensitivity Analysis (In case of cost and benefit changing)

Rate of Change (%)			Cost				
			+ 20	**+ 10**	**0**	**- 10**	**- 20**
Benefit	**+ 20**	EIRR (%)	16.1	17.8	19.7	21.9	24.5
		NPV (Million THB)	276.7	356.5	436.4	516.3	596.2
		B/C Ratio	1.3	1.4	1.5	1.7	1.9
	+ 10	EIRR (%)	14.7	16.1	18.0	20.0	22.5
		NPV (Million THB)	173.7	253.6	333.5	413.4	493.3
		B/C Ratio	1.2	1.3	1.4	1.6	1.8
	0	EIRR (%)	13.1	14.5	16.1	18.1	20.5
		NPV (Million THB)	70.8	150.7	230.5	310.4	390.3
		B/C Ratio	1.1	1.2	1.3	1.4	1.6
	- 10	EIRR (%)	11.5	12.8	14.4	16.1	18.4
		NPV (Million THB)	-32.2	47.7	127.6	207.5	287.4
		B/C Ratio	1.0	1.1	1.2	1.3	1.4
	- 20	EIRR (%)	9.8	11.0	12.5	14.2	16.1
		NPV (Million THB)	-135.1	-55.2	24.7	104.6	184.4
		B/C Ratio	0.9	0.9	1.0	1.1	1.3

Source : The Consultant,2019

9.7 STUDY OF ADDED VALUE BY THE PROJECTS

The National Road No. 67 (NR67) improvement will help make the connection between Srisaket, Thailand and Siem Reap province, Cambodia more convenient. It will increase a potential of the border trade between Thailand and Cambodia. It also helps to increase the potential for attracting investment in this area. In addition, in the area of NR 67, there are many important historical sites which can be developed to a tourist attraction connected with tourist destinations in the northeast of Thailand as well. The road network from the center of Siem Reap Province can be shown that Siem Reap province is the point that can connect the journey to the northeast and the eastern part of Thailand.

For the Improvement of NR 67, the objective is to improve the roads to the standards of ASEAN highway. The transportation is more convenient and safer than ever. The development will help the areas along the route as well as the surrounding areas. If the government or other departments help promote such potential including reducing barriers to investment, trade and services, it would make both countries leverage from the investment to improve NR 67. For example, the development of trade and investment will allow both countries to take advantage of the investment to improve NR 67.

9.8 STUDY OF THE MUTUAL BENEFIT BETWEEN THAILAND AND CAMBODIA IN THE FUTURE

In the future after improvement of NR67, the road pavement will be smooth to provide efficient and convenient transportation and motorists will be able to safely drive and reach their destinations faster, shortening the travel time. Besides, NR67 will induce more cross-border movements, including import and export of commodities, between Thailand and Cambodia (the lower Northeast of Thailand and Siem Reap or Phnom Penh of Cambodia) via the Chuam–Sa Ngam border checkpoint instead of the Poipet checkpoint which is farther away.

In addition, the joint collaboration in promoting tourism clusters, for example, linkage of historical sites and natural attractions in Thailand and Cambodia by NR67, will further increase mutual benefits of the two nations.

CHAPTER 10

THE STUDY OF OBSTACLES

CHAPTER 10

CONSTRUCTION OBSTACLE STUDY

If minor obstacles occur during the construction of NR67, they may only cause a delay in the construction of the road. If the obstacles seriously affect the project, a possibility of the contractor abandoning the project may occur and cause a major effect to the owner and other parties such as pedestrians and drivers.

To prevent those events to happen, the consultant has studied and analyzed the factors that would cause those obstacles, including suggested methods to prevent each factor and to finally reduce any unwanted effects during construction.

10.1 FACTORS THAT AFFECT CONSTRUCTION

Factors that will negatively impact the project performance during the construction phase may come from many relative parties, such as the project owner, the contractor(s), the consultant, population around the project area, or labor, etc. Other factors such as shortage of materials required during construction, shortage of labor in comparison to the scale of the project, or insufficient funding, or weather conditions, etc. may also affect the construction of the project as well.

1) Factors caused by related parties
   - Competition of contract price
   - Construction delayed from contractor
   - Misunderstanding and miscommunication between construction consultant and contractor

2) Factors from resources and materials
   - Contractor's insufficient funding
   - Shortage of construction materials
   - Shortage of labor or construction equipment and machinery

3) Factors caused from natural disasters (weather conditions)
   - Flooding
   - Lack of water resources during dry season

10.2 PREVENTION GUIDELINES

The related parties and factors causing the obstacles which negatively impact the project during construction are descripted above. The consultant has studied and analyzed the results caused from those factors and came up with the method to prevent such events to occur, as shown in **Table 10.2-1.**

Table 10.2-1 Study of Obstacle during Construction

No.	Factor	Obstacles	Prevention
1	**Factors caused by related parties**		
1.1	Contract Price Competition	The Contractor abandons the project after winning the bid by proposing the price lower than the actual costs.	During the contractor selection, the selection process must keep in concern that the price factors must be reasonable.
1.2	Construction delayed from contractor	Project delayed leading to affect the whole project.	Fines or Penalties must be stated and specified in the contract documents.
1.3	Misunderstanding and miscommunication between construction consultant and contractor	Damage to the construction, project delay, each party avoids taking responsibility.	Communication between construction consultant and contractor must be in form of recorded document that can be traced later on.
2	**Factors caused by resources and materials**		
2.1	Contractor's insufficient funding	The contractor abandons the project or delays the construction work which leads to project delay.	During the bidding period, close attention to the contractor's financial status must be done.
2.2	Shortage of construction materials	Project construction delays.	In the design stage, the consultant must survey and consider the source of materials which has to be adequate for construction.
2.3	Shortage of labor or construction equipment and machinery	Project construction delays.	During the contractor selection, the selection process must consider and evaluate the contractor's ability to provide capable and sufficient labor, and sufficient construction equipment and machinery to the construction of the project.

No.	Factor	Obstacles	Prevention
3	**Factors caused by natural disasters**		
3.1	Flooding	Project construction delays and causes unease traffic to the population around/at the construction area.	During the feasibility study, the consultant must specify proper methodologies for construction during dry season.
3.2	Lack of water resources during dry season	Project construction delays and an increases of cost.	During the detailed design period, the consultant must allocate alternative water resources/alternatives to be sufficient during construction period.

Source: The Consultant,2019