PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR CONSTRUCTION
OF NEAK LOEUNG BRIDGE
IN
THE KINGDOM OF CAMBODIA

March 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

CHODAI CO., LTD.
ORIENTAL CONSULTANTS CO., LTD.
PREFACE

Japan International Cooperation Agency (JICA) conducted the preparatory survey on the Project for Construction of Neak Loeung Bridge in the Kingdom of Cambodia.

JICA sent to Cambodia a survey team from February 16 to April 27, 2009 (1st Site Survey, excluding Geological Survey), from May 21 to June 6, 2009 (2nd Site Survey), from July 1 to August 14, 2009 (3rd Site Survey), and from October 14 to October 24, 2009 (4th Site Survey).

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia in order to discuss a draft outline design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

January, 2009

Eiji Hashimoto
Vice President
Japan International Cooperation Agency
Letter of Transmittal

We are pleased to submit to you the preparatory survey report on the Project for Construction of Neak Loeung Bridge in the Kingdom of Cambodia.

This survey was conducted by the Consortium of CHODAI Co., Ltd. And Oriental Consultants Co., Ltd., under a contract to JICA, during the period from February, 2009 to January, 2010. In conducting the survey, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate outline design for the project under Japan’s Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Junji Yasui
Project Manager,
Preparatory Survey team on the Project for Construction of Neak Loeung Bridge in the Kingdom of Cambodia
the Consortium of CHODAI Co., Ltd.
and Oriental Consultants Co., Ltd.
Summary

1. Overview of Cambodia

The Kingdom of Cambodia is located in the south of Indochina Peninsula. The country borders Thailand to its west, Laos to its north and Vietnam to its east. In the southwest it faces the Gulf of Thailand. The area of whole country is 181 thousand km². Its geography is dominated by the Mekong River which comes from Laos and runs north and south in the country, and the Tonle Sap (the largest lake in South East Asia) which lies at the center of the country. Cambodia has two distinct seasons, rainy season and dry season, and its climate is dominated by tropical monsoons. Its population is 13.4 million (2008 census), and has been increasing by 1.6% p.a. in the past 10 years. Its economic growth rate exceeds 10% p.a. during 2004 ~ 2007. Although the rate is anticipated to stay 6.5% p.a. in 2008 and 4.8% p.a. in 2009 due to the downturn of global credit market, it is expected to keep the growth of 6 ~ 7% p.a from a mid- and long-term perspective.

2. Background and Summary of the Requested Project

The National Strategic Development Plan (NSDP) 2006 states the importance of the renovation and maintenance of the road network as one of the measures needed to accomplish the plan, and the quantitative target during NSDP 2006-2010 is to upgrade another 2,000 km of primary and secondary roads. Also, the concept of the Asian Highway was agreed at the United Nations Economic Commission for Asia and the Far East (“ECAFE”) in 1959 which aims the improvement of the road traffic which supports the promotion of regional development, trade and tourism of Asia. As a part of the Asian Highway No.1 (AH-1), the National Road No.1 of Cambodia is designated an international highway (Southern Economic Corridor) connecting Ho Chi Minh, Phnom Penh and Bangkok. The National Road No.1 (the NR1) is thus regarded as one of the most important roads, not only as the primary highway of Cambodia, but also as a major road serving the southern area of the Indochina Peninsula. The improvement of this road is expected to lead to high benefit for the economy of surrounding area and neighboring countries.

Under the situation noted above, in order to cope with the increase of traffic demand for the NR1 and to improve the traffic capacity across Mekong River at Neak Loeung (which is a bottleneck of transport along the NR1), the Royal Government of Cambodia (GOC) requested the Japanese Government to construct a bridge at this crossing point as a substitute for the existing ferry service.

In response to the request from GOC, Japan International Cooperation Agency (JICA) conducted a series of studies: the Feasibility Study (2004~2006), the Follow-up Study (2006, 2007) and Preparatory Study (2008) on the Project for Construction of Neak Loeung Bridge (formerly “the Second Mekong Bridge”) to examine the feasibility of the Project. In the Feasibility Study in 2004, it was recommended that the Bridge should be open to traffic in the Year 2012 before the existing
ferry capacity is saturated, according to the traffic demand forecast. In the Follow-up Study in 2006, the implementation planning of the Bridge was reconfirmed from comprehensive viewpoints through monitoring the traffic impacts by CBTA (Cross Border Transport Agreement) etc. Also, the feasibility of the Project, the contents of socio-environmental consideration to be implemented, and the approval of the EIA report were confirmed. In the Preparatory Survey in 2008, it was confirmed that the existing ferry capacity is almost saturated at the time of September, 2009, and that it is required to construct the Bridge as soon as possible and to eliminate the bottleneck for traffic. Also the need for sufficient consideration was confirmed on the impact of the construction of the bridge and road to the social environment.

3. Summary of the Survey and Contents of the Project

In response to the request from GOC and the result of previous studies above, the Government of Japan decided to implement the Preparatory Survey, and JICA sent to Cambodia a survey team from February to August, 2009 (1st site survey: February ~ April, 2nd site survey: May ~ June, 3rd site survey: July ~ August, 4th site survey: October). After the further study in Japan, the study team prepared a draft outline design report, and JICA sent a mission and discussed a outline design with GOC.

In the site survey, conditions regarding traffic, topography, geography, hydrology, environment, economy were studied together with the situation of procurement and costs for construction materials and facilities. In addition, it was confirmed that the navigation by 5,000 DWT ships to and from Phnom Penh Port (upstream of the Bridge Site) is expected in the future. Based on the survey results above, major conditions for the Bridge was designated, and the major dimensions such as the main span of the Main Bridge was determined. Major data of the structures constructed in the Project is tabulated as below.

<table>
<thead>
<tr>
<th>Bridges</th>
<th>Embankment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Bridge</td>
<td>Approach Bridge</td>
</tr>
<tr>
<td><strong>Bridge Type</strong></td>
<td><strong>Length</strong></td>
</tr>
<tr>
<td>Cable-Stayed Bridge</td>
<td>640m</td>
</tr>
<tr>
<td>Composite PC Girder</td>
<td>1,575m</td>
</tr>
<tr>
<td></td>
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5. Implementation Period and Cost Estimate of the Project

It is expected that it will take 6 months and 51 months for the detail design and for construction of the facilities of the Project respectively. The Project cost required for fulfilling the undertakings by GOC is estimated to be 188 million yen.

6. Examination of Project Validity

As the Project will benefit the economic development of south region of the Indochina Peninsula, its effect is expected to spread over the neighboring countries, not to mention the area nearby the Bridge Site. The effects anticipated from implementation of the Project are as follows:

Direct Effects

➢ Crossing time is reduced. (Waiting time for ferry: max. 20 ~ 38 minutes → 0 minutes)
➢ River crossing possible for 24-hours. No closed hour (0:00 ~ 5:00 for ferry)
➢ Safe crossing even under bad weather.

Indirect Effects

➢ The mobility of goods between Ho Chi Minh City (Vietnam) and Phnom Penh will be accelerated, and this leads to the economic development of Cambodia. Also, the local industries of the east bank region of Mekong River (such as agricultures) will be activated because the transport to the urban area will be stabilized.
➢ The standard of living will be enhanced because the access to the urban region will become easier and the opportunities will be increased to enjoy services such as health care and education for the residents on the east bank region.
➢ Employment creation for the neighboring residents is anticipated because the Project will attract the establishment of commercial facilities, support facilities for road traffic, rest facilities for road users etc.

The maintenance required for the bridge and road implemented by this Project has a great variety of
items such as routine inspection and repair of the bridge, repavement on the bridge, repainting of railings, leveling of shoulders and repair of slopes at the embankmen, replacement of various lighting lamps etc. Although GOC has been focusing on the construction of new roads and bridges in the past, recognizing the importance of maintenance in recent years, the budget for maintenance is increasing year by year. Also, the road maintenance guidelines were formulated in 2008 through the efforts of JICA experts. However, the maintenance structure for bridges has not been well developed so far. In addition, the cable-stayed bridge as the Main Bridge in this Project is a special type of bridge, it is required to establish an maintenance organization which is specialized in bridge engineering. With the growing awareness of the implementation organization for the maintenance, these recommendations is expected to be accepted, and the adequate structure will be developed.

As noted above, this Project will contribute to the activation of Cambodia and the neighboring countries, and to the boost of the livelihood of the residents living in the east bank area of the Mekong River, by constructing a new bridge at the crossing point of the Mekong River at Neak Loeung, which remains a bottleneck for the traffic along the NR1. This Project is thus expected to bring a large effect to the development of the area, and also to accelerate the realization of the concept of Asian Highway.
# Preparatory Survey Report

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PREPARATORY SURVEY ON THE PROJECT FOR CONSTRUCTION OF NEAK LOEUNG BRIDGE IN THE KINGDOM OF CAMBODIA

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Artist's impression of "Neak Loeung Bridge" 2
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Abbreviations

AASHTO : American Association of State Highways and Transportation Officials
ADB : Asian Development Bank
ADF : Asian Development Fund
AH-1 : Asian Highway No.1
AUSTROADS : The association of Australian and New Zealand road transport and traffic authorities
CBTA : Cross Boarder Transport Agreement
CPI : Consumer Price Index
DBST : Double Bituminous Surface Treatment
DMS : Detailed Measurement Survey
DPWT : Department of Public Works and Transport
DWT : Dead weight tonnage
ECAFE : The United Nations Economic Commission for Asia and the Far East
EIA : Environmental Impact Assessment
EIRR : Economic Internal Rate of Return
EMP : Environmental Management Plan
FIRR : Financial Internal Rate of Return
GDP : Gross Domestic Product
GMS : Greater Mekong Sub-region
GPS : Global Positioning System
HLP : Heavy Load Platform
HV : Heavy Vehicles
HWL : High Water Level
IEIA : Initial Environmental Impact Assessment
IICBTA : Initial Implementation of CBTA
IMF : International Monetary Fund
IUCN : International Union for Conservation of Nature
IRC : Inter-ministerial Resettlement Committee
JICA : Japan International Cooperation Agency
JRA : Japan Road Association
LLT : Lateral Load Test
LOA : Length OverAll
LV : Light Vehicles
LWL : Low Water Level
MC : Motorcycles
MEF : Ministry of Economy and Finance
MOE : Ministry of Environment
Chapter 1. Background of the Project

1.1 Current Situation

National Road No.1 (NR1) is one of the most important routes in Cambodia and stretches from Phnom Penh to the southern part of Cambodia. NR1 forms part of the Asian Highway Route AH-1 and connects Ho Chi Minh City and Bangkok through Phnom Penh. NR1 was improved by the ADB (between Neak Loeung and the Vietnam border) and Japanese Grant Aid (between Neak Loeung and Phnom Penh), to accelerate the mobility of goods and passengers and generate substantial benefits to Indochina and the Greater Mekong Sub-region (GMS).

In order to cope with the increase of traffic demand for the NR1 and to improve the traffic capacity across Mekong River at Neak Loeung (which is a bottleneck of transport along the NR1), the Royal Government of Cambodia (GOC) requested the Japanese Government to conduct the Study on the Construction of Neak Loeung Bridge to examine the feasibility of this Project.

In response to the request from GOC, Japan International Cooperation Agency (JICA) conducted a series of studies: the Feasibility Study (2004~2006), the Follow-up Study (2006, 2007) and Preparatory Study (2008) on the Construction of Neak Loeung Bridge (formerly “the Second Mekong Bridge”). The previous studies then elaborated conceptual design and implementation plan of the Project as summarized in Table 1.1-1 and Figure 1.1-1.
Table 1.1-1 Concept of the Feasibility Study of the Project

<table>
<thead>
<tr>
<th>1. Location of the Project</th>
<th>Neak Loeung on National Highway No.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Target Year</td>
<td>2020</td>
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3. Socio-economic Framework

Three development scenarios were set: high GDP growth rate (8% p.a.), medium growth rate (6%) and low growth rate (4%). The medium growth rate of 6% was applied as the base case of the socio-economic framework.

Other than GDP growth rate, the population and employment were projected and taken into account in the socio-economic framework.

4. Traffic Demand Forecast

The traffic demand observed at Neak Loeung in May and June 2007 was 2,376 PCU (passenger car unit). The incremental traffic generated from the following development program was taken into consideration in estimating the traffic demand.

(A) Improvement of NR 1 (to be completed by early 2011).
(B) Implementation of cross border facilitation agreement at the border with Vietnam (to be executed in 2007).
(C) Modal change by the transfer from pedestrians and bicycle to mini-buses when the bridge is completed.
(D) Cross-border traffic between Cambodia and Vietnam after the implementation of cross border facilitation agreement (executed in 2005).
(E) Traffic generated by bridge construction.
(F) Traffic generated from the flood-free land development.

5. Outline of Preliminary Engineering Design

Highway Design

AASHTO and the design standards adopted in the past projects in Cambodia were studied and the Highway with two lanes of the carriageway and two motorbike lanes with design speed of 80 km/h is recommended.

Bridge Design

The horizontal clearance (180m) and the vertical clearance (37.5m) are recommended as main navigation route to allow a 5,000 DWT container ship pass under the bridge.

Navigation clearance applied for Kizuna Bridge was recommended for sub-navigation route for the safety of local ship.

Profile of the Project

The total length of the Project: 5,420 m
Bridge length: 2,220 m (600 m-long main bridge, approach bridges with length of 960 m on the west side and 660 m on the east side)
Approach road length: 3,200 m (800 m on the west side and 2,400 m on the east side)

6. Project Costs and Implementation Plan

Total project cost is estimated at US$ 74 million, including the construction cost, land acquisition and compensation costs, de-mining and UXO clearance costs, using the price level in September 2005. The total construction period, including the mobilization period is estimated at 45 months, and the overall project implementation period is to be about 6 years.

7. Economic and Financial Evaluation

The EIRR of the project is 23.0% and the sensitivity analysis results in 16.8%, when the traffic demand decreases by 20% and the project cost increases by 20%. It is, therefore, concluded that a high priority should be given to implementation of the project to promote economic and social development in Cambodia and GMS region as well.

The results of financial analysis show low FIRR of 6.6% (toll level equivalent to the current ferry tariff) or 2.9% (toll level to cover 100% of the bridge user benefit). Therefore, the project will not be attractive for the private sector to invest in without significant financial support by the government.

Figure 1.1-1 Location of the Project
In the selection of optimum crossing route, the optimum route of the bridge option was decided firstly. On this basis, an optimum method or facility to cross the River was selected from several alternatives. The optimum route and the optimum crossing method are selected by evaluating the result of interview to the stakeholders of each kind using AHP (Analytic Hierarchy Process). In the selection of optimum method, the following 4 alternatives were compared, and “4. Ferry Improvement + Bridge Option” was selected.

1: Zero Option
2: Ferry Improvement
3: Bridge Option
4: Ferry Improvement + Bridge Option

In the selection of optimum crossing route, the 3 routes shown in Figure 1.1-2 was compared, and Route A was selected.

![Alternative Crossing Routes](image)


**Figure 1.1-2 Alternative Crossing Routes (the Feasibility Study)**

In the selection of the crossing route, Route A is evaluated as the optimum, not only by the result of interview to the stakeholders, but also from the economic and technical studies. The alignment of the Project is selected considering the controlpoints on the route such as orphanages, antenna towers, graveyards, temples, residential areas, and is selected especially to minimize the number of houses to be resettled.
1.2 Conditions Surrounding the Project Site

1.2.1 Geological Condition

(1) Geological Condition

Neak Loeung is located on the plain in the central part of the country. The Mekong River, which originates in the Tibetan Plateau and has total length of 4,023 km, flows in the direction of north to south with a river-bed gradient of 1/16,000 in the project area.

Cenozoic formation including Holocene (Alluvium) and Pleistocene (Diluvium) deposits are widely distributed in the plain, the so-called Tonle Sap – Mekong Plain, and they are underlain by sandstone of Mesozoic era and plutonic rocks of unknown age.

The hills and terrains, which are distributed in the area between Phnom Phen and Neak Loeung, consist mainly of Mesozoic sandstone. The hilly terrain, which is mined for quarry and located nearly 10 km in the east of Neak Loeung, is composed of plutonic rocks of unknown age.

(2) Geological Investigation

Geological investigation was carried out in order to confirm the bearing layers for embankments and bridge foundations and to evaluate the engineering properties of soils. For on-site investigation, boring survey (including SPT and LLT) and resistivity survey were carried out. The location of geological survey is shown in Figure 1.2-1.

![Figure 1.2-1 Location of Geological Survey](image-url)
(3) Result of Geological Investigation

Geological and geotechnical condition, Geological Profile, and Distribution of N value in Project Area are shown in Table 1.2-1, Figure 1.2-2 and Figure 1.2-3 respectively.

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>EPOCH</th>
<th>GEOLOGY</th>
<th>ENGINEERING GEOLOGY</th>
<th>N value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Description</td>
<td>Classified</td>
<td>Description</td>
</tr>
<tr>
<td>QUATERNARY</td>
<td>PLEISTOCENE</td>
<td>Loose gravel, sand, silt, clay and their mixtures soil. Mainly present river deposits,</td>
<td>Clay rich layer (Ac)</td>
<td>Soft and loose with high water content</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand rich layer (As)</td>
<td>Loose and high water content</td>
<td></td>
</tr>
<tr>
<td>QUATERNARY</td>
<td>PLEISTOCENE</td>
<td>Consolidated and relatively consolidated soil consisting of gravel, sand, silt and clay.</td>
<td>Clay rich layer (Dc)</td>
<td>Relatively consolidated with low water content</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand rich layer (Ds)</td>
<td>Consolidated and relatively consolidated layer</td>
<td></td>
</tr>
<tr>
<td>UNKNOWN</td>
<td></td>
<td>Bedrock appears to be Plutonic rock of unknown age (older than Mesozoic era),</td>
<td>Bedrock (B/R)</td>
<td>Hard &amp; compact in fresh condition. Weathered in top portion and boundary with Pleistocene deposits is not clear at places.</td>
</tr>
</tbody>
</table>
1.2.2 Topographic Survey

(1) Location of Survey

The location of the topographic survey in this study is shown in Figure 1.2-4.
(2) Survey Datum

Basically the existing control points established by the feasibility study in 2005 were used as references. Based on the survey report of the feasibility study, there are seven (7) ground control points measured by GPS (static method) referenced by national control point No.1401. These control points were used for detailed topo-survey, alignment setting, profile and cross survey.

The vertical reference point is located in Neak Leoung Hydrology office on the east side of the Mekong River. This point is the first class national benchmark (H=7.592m) above the mean sea level at HA TIEN. All control points in the site were connected for each elevation by direct leveling with high-precision auto-level.

Detailed explanation of survey datum is as follows.

Geographic coordinate

- Datum: World Geodetic system 1984 (WGS 84)
- Reference Ellipsoid: Geodetic Reference System 1980 (GRS80)
- Semi-major axis: \( a = 6378137.0000 \)
- Reciprocal Flattening: \( 1/f = 298.257222101 \)

Plane rectangular coordinate (UTM, Zone48)

- False Northing: 0.000m
- False Easting: 500,000.000m
- Longitude of Origin: 105° 00' 00.0000"
- Latitude of Origin: 0° 00' 00.0000"
- Scale factor at Central Meridian: 0.9996

Vertical datum and reference

- Mean Sea Level at HA TIEN
- Reference Point at Hydrology office: H = 7.592

The temporary benchmarks (TBM) established in this survey are shown in Table 1.2-2 and Figure 1.2-5.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of TBM</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBM #16M</td>
<td>Casted by Concrete</td>
<td>04/May/2009</td>
</tr>
<tr>
<td>TBM #16N</td>
<td>Casted by Concrete</td>
<td>04/May/2009</td>
</tr>
<tr>
<td>TBM #07M</td>
<td>Casted by Concrete</td>
<td>05/May/2009</td>
</tr>
<tr>
<td>TBM #03M</td>
<td>Casted by Concrete</td>
<td>05/May/2009</td>
</tr>
<tr>
<td>TBM #03N</td>
<td>Casted by Concrete</td>
<td>05/May/2009</td>
</tr>
<tr>
<td>TBM #01M</td>
<td>Casted by Concrete</td>
<td>05/May/2009</td>
</tr>
<tr>
<td>TBM #01N</td>
<td>Casted by Concrete</td>
<td>05/May/2009</td>
</tr>
</tbody>
</table>
Figure 1.2-5  Location of Temporary Benchmarks
(3) Center Line Survey

Figure 1.2-6  Result of Center Line Survey
1.2.3 Study on Meteorology, Hydraulics and Hydrology

(1) Data Collection and Analysis

Main data collected and analyzed are shown in

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
<th>Duration</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Min. – Max. (Prey Veng)</td>
<td>2001 - 2008</td>
<td>16°C - 40°C</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Annual rainfall (Prey Veng)</td>
<td>2001 - 2008</td>
<td>1306 mm</td>
</tr>
<tr>
<td></td>
<td>Number of rainy days (Prey Veng)</td>
<td>2001 - 2008</td>
<td>117 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>24 days (Nov-Apr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>93 days (May-Oct)</td>
</tr>
<tr>
<td>Wind</td>
<td>Max (Prey Veng, Phnom Penh)</td>
<td>2001 - 2008</td>
<td>18 m/s</td>
</tr>
<tr>
<td></td>
<td>Max (Kampong Cham)</td>
<td>1986 - 2008</td>
<td>28 m/s</td>
</tr>
<tr>
<td></td>
<td>Direction (Prey Veng)</td>
<td>2001 - 2008</td>
<td>S-W (Apr-Oct)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N-E (Nov-Mar)</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Monthly average (Prey Veng)</td>
<td>2001 - 2008</td>
<td>77.8% – 86.5%</td>
</tr>
<tr>
<td>Flood Record</td>
<td>Interview, water level (Neak Loung)</td>
<td>1988 - 2008</td>
<td>Year 96, 00, 01, 02</td>
</tr>
<tr>
<td>Earthquake Record</td>
<td>Data of USGS</td>
<td>1973 - 2008</td>
<td>No record</td>
</tr>
<tr>
<td>Water Level</td>
<td>100 years return period (Bridge Section)</td>
<td>1988 - 2008</td>
<td>H.W.L. = 7.93 m</td>
</tr>
<tr>
<td></td>
<td>20 years return period (Bridge Section)</td>
<td></td>
<td>L.W.L. = 0.43 m</td>
</tr>
<tr>
<td>Velocity / Discharge</td>
<td>FS: Cross section averaged flow velocity Discharge</td>
<td>2002 - 2004</td>
<td>0.5 - 1.6 m/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,000 - 33,000 m^3/s</td>
</tr>
<tr>
<td></td>
<td>BD: Measured velocity Discharge</td>
<td>2008</td>
<td>0.46 - 2.24 m/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,000 – 24,000 m^3/s</td>
</tr>
</tbody>
</table>

(2) River Bank Erosion

Large scale of erosion at the east side of Phnon Knong Island is confirmed through the survey as shown in Figure 1.2-7.

![Figure 1.2-7 Bank Erosion at the East Bank of Phnon Knong Island](image)

The slope of the banks 1km upstream/downstream are slower than that at the bridge site. If the channel shape is assumed to be stabilized with these gradients, the width of erosion is estimated to be 115m ~ 255m as shown in Figure 1.2-8.
Figure 1.2-8 Gradients of River Bank Upstream and Downstream of the Site