JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE GOVERNMENT OF LAO P.D.R.

# THE STUDY
# ON
# MEKONG RIVERBANK PROTECTION AROUND VIENTIANE MUNICIPALITY
# IN
# THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

# FINAL REPORT
## VOLUME 1
## EXECUTIVE SUMMARY


**DECEMBER 2004**

NIKKEN Consultants, Inc.
NEWJEC Inc.

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# PREFACE

In response to a request from the Government of Lao People's Democratic Republic (hereinafter, Lao P.D.R) the Government of Japan decided to conduct the Study on Mekong Riverbank Protection around Vientiane Municipality in the Lao P.D.R. and entrusted to study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Yasuhiko KATO of NIKKEN Consultants, Ins. (consisting of NIKKEN Consultants, Inc. and NEWJEC Inc.) to Lao P.D.R. five times between December 2001 and December 2004.

In addition, JICA set up an Advisory Committee headed by Mr. Ichiro MORIKAWA, former Director of Foundation of Riverfront Improvement and Restoration between December 2001 and March 2003, and headed by Mr. Masamitsu MIZUNO, Director of Foundation of Riverfront Improvement and Restoration between April 2003 and December 2004. The Committee examined the Study from technical point of view.

The team held discussion with the officials concerned of the Government of Lao P.D.R and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Lao P.D.R. for their close cooperation extended to the Study.

December 2004

Etsuo KITAHARA

Vice-President
Japan International Cooperation Agency

December 2004

Mr. Etsuo KITAHARA
Vice-President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

# LETTER OF TRANSMITTAL

It is with great pleasure that we submit to you the Final Report of the Study on Mekong Riverbank Protection around Vientiane Municipality in the Lao People's Democratic Republic.

The study has been made of formulate a Riverbank Protection Master Plan on the Mekong River around Vientiane City through the execution of the Riverbank Protection Pilot Works introducing Japanese traditional river works. This Report includes all the study results and consists of Summary, Main Report, Manual, Supporting Report and Data Book.

We hope that this Report will be helpful for the riverbank protection in critical areas along the Mekong River around Vientiane City.

We wish to express our deep appreciation and gratitude to the personnel concerned of your Agency, JICA Laos Office, the Embassy of Japan in Lao P.D.R., Ministry of Communication, Transport, Post and Construction, Department of Communication, Transport, Post and Construction of Vientiane City and other authorities concerned of the Lao P.D.R. for the countries and cooperation extended us during our Study.

Very truly yours,

Yasuhiko KATO

Team Leader
for the Study on Mekong Riverbank
Protection around Vientiane Municipality
in the Lao People's Democratic Republic

# COMPOSITION OF FINAL REPORT

## VOLUME 1 EXECUTIVE SUMMARY

## VOLUME 2 MAIN REPORT

## VOLUME 3 MANUAL FOR RIVERBANK PROTECTION

**SECTOR A PLANNING & DESIGN**
**SECTOR B CONSTRUCTION**

## VOLUME 4 SUPPORTING REPORT

**SECTOR A PRESENT CONDITION IN THE STUDY AREA**
**SECTOR B PREPARATORY STUDY FOR PILOT WORKS**
**SECTOR C FIELD SURVEY FOR PILOT WORKS**
**SECTOR D EXECUTION OF PILOT WORKS**
**SECTOR E TEST OF SIMPLE VEGETATION RIVERBANK PROTECTION**
**SECTOR F MONITORING OF PILOT WORKS**
**SECTOR G MONITORING SURVEY FOR PILOT WORKS**
**SECTOR H RIVERBANK PROTECTION MASTER PLAN**
**SECTOR I ENVIRONMENTAL CONSIDERATION**
**SECTOR J TRANSFER OF TECHNOLOGY**

## VOLUME 5 DATA BOOK

The cost estimate in this study is based on the price level at the beginning of February 2004 and the applied foreign currency exchange rates are as stated below:

***EXCHANGE RATE***

| |
|---|
| US Dollar (US$) 1.00 = Lao Kip (Kip) 10,420 |
| Japanese Yen (¥) 100 = Lao Kip (Kip) 9,750 |
| Middle rate as of February 1, 2004 |

# SUMMARY

## 1 INTRODUCTION

1) Objectives of Study

1. To study bank protection works adaptable to the Mekong River and sustainable in Lao P.D.R., introducing river works developed in Japan.
2. To transfer technology to the counterpart personnel through the execution of Pilot Works.
3. To formulate a bank protection master plan for the Mekong River around Vientiane City.

2) Study Area: Mekong riverbank around Vientiane City in Lao P.D.R. (L=approx. 60 km)

3) Period of Study: For 3 years from December 2001 to December 2004

## 2 EXECUTION OF PILOT RIVERBANK PROTECTION WORKS

1) General of the Pilot Works

1. Scheme of execution: Sublet contract with the Study Team for JICA Development Study (Not JICA Grant Aid Project scheme)
2. Design & Supervision: JICA Study Team (in full cooperation with MCTPC/ DCTPC)
3. Contractor: Obayashi Corporation (selected by competitive bidding)
4. Construction Period: January 2003 - May 2003 (5 months)
5. Construction Cost (engineering estimate): US$ 1,259,000 in total
   i. Ban Dongphosi Site US$ 1,088,000 (approx. US$ 1,690/m)
   ii. Wat Chom Cheng Site US$ 49,000 (approx. US$ 200/m)
   iii. Sibounheuang Site US$ 122,000 (approx. US$ 810/m)

2) Work Type of the Pilot Works:

| Site | Work Type | Construction Length |
|---|---|---|
| (1) Ban Dongphosi<br><br>(at Lao National Fuel Company) | 1) Slope protection work<br>(Cobble stone with willow branch work; executed by making gentle slope embankment by backfill of cliffy bank using river sand)<br>2) Foundation work (Riprap work)<br>3) Foot protection work<br>(Soda mattress work; 66 sheets 10m*6m) | 643m |
| (2) Wat Chom Cheng | Wooden pile groynes<br>(6 groynes: L=20 m, interval=40 and 60m)<br>(3 groynes were reinforced by Soda mattresses and riprap on bank for comparison) | 240m |
| (3) Sibounheuang | 1) Slope protection work<br>(Cobble stone with willow branch work; covering lower half of the cliffy bank for cost reduction)<br>2) Foundation work (Riprap work)<br>3) Foot protection work<br>(Soda mattress work; 23 sheets 10m*6m) | 156m |
| | Total | 1,039m |

## 3 RIVERBANK PROTECTION MASTER PLAN

1) Outline of Master Plan

- Target Year: 2020
- Total Project cost (national budget in principle): US$4.89 million
- Total length of 10 Master Plan projects: 7.38 km
  (5 Urgent Projects: 2.70 km and 5 Second Priority Projects: 4.68 km)
- Implementation Schedule: 16-year (2005-2020)

## 2) Basic Features of Master Plan

| Phase | Site Name | Project Name | Location by KM post (km) | | Length | Project Cost | Implementation | Riverbank Protection Type | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From | To | (meter) | (US$1,000) | Fiscal Year | CSWB(A) | CSWB(B) | LH | SF | SM | RG |
| Urgent Projects | Sithantai | Sithantai (1) | 1555+0.00 | 1555+1.28 | 1,280 | 240 | 2006/07-2010/11 | | | | | | ○ |
| | Ban Hom | Ban Hom (1) | 1565+0.38 | 1565+1.14 | 760 | 960 | 2007/08-2011/12 | ○ | | | ○ | ○ | |
| | | Ban Hom (2) | 1565+0.33 | 1565+0.38 | 50 | 65 | 2006/07 | | ○ | | ○ | ○ | |
| | Bo O | Bo O | 1575+0.01 | 1575+0.21 | 200 | 147 | 2005/06-2007/08 | ○ | | ○ | | ○ | |
| | Sibounheuang - Muang Wa | Sibounheuang - Muang Wa | 1587+1.80 | 1589+0.28 | 410 | 286 | 2004/05-2005/06 | ○ | | ○ | | ○ | |
| | Sub-total | | | | 2,700 | 1,698 | | | | | | | |
| 2nd Priority Projects | Sithantai | Sithantai (2) | 1553+0.85 | 1555+0.00 | 2,040 | 382 | 2011/12-2015/16 | | | | | | ○ |
| | Ban Hom | Ban Hom (3) | 1563+2.03 | 1565+0.33 | 760 | 960 | 2012/13-2015/16 | ○ | | | ○ | ○ | |
| | | Ban Hom (4) | 1563+1.15 | 1563+2.03 | 880 | 1161 | 2016/17-2019/20 | ○ | | | ○ | ○ | |
| | Upper Sibounheuang | Upper Sibounheuang (1) | 1590+0.25 | 1591+0.00 | 810 | 555 | 2016/17-2019/20 | ○ | | ○ | | ○ | |
| | | Upper Sibounheuang (2) | 1590+0.02 | 1590+0.21 | 190 | 137 | 2018/19-2019/20 | ○ | | ○ | | ○ | |
| | Sub-total | | | | 4,680 | 3,195 | | | | | | | |
| | Total | | | | 7,380 | 4,893 | | | | | | | |

Note: - Project cost is estimated on the price level at the beginning of February 2004.
- Applied foreign currency exchange rate: US$1=Lao Kip 10,420 (Middle rate on February 1, 2004)
- Project cost does not include price escalation.
- Riverbank Protection Types:

| | | | |
|---|---|---|---|
| CSWB(A) | Cobble Stone with Willow Branch covering lower bank (A) | SF | Stone Foundation |
| CSWB(B) | Cobble Stone with Willow Branch covering whole bank (B) | SM | Soda Mattress |
| LH | Log Hurdle | RG | Riprap Groyne |
| SF | Stone Foundation | | |
| SM | Soda Mattress | | |
| RG | Riprap Groyne | | |

-Bo o site: Design to be prepared by On-going Lao-Flanders River Work Projects of MCTPC in future. Therefore, work type concept of the Master Plan is temporarily applied for the preliminariliy cost estimate at the site instead.

## 3) Basic Principles of Protection Measures of the Master Plan

| Type of Riverbank | Classification of Cliffy riverbanks | Length (km) | Principles of Bank Protection Measures |
|---|---|---|---|
| 1)Cliffy Riverbanks | Existing riverbank protection works | 3.15 (5.3%) | This stretches is to be monitored and rehabilitated if necessary by GOL (O&M). |
| | Objective of M/P (Urgent Projects) | 2.70 (4.6%) | *This stretches is to be implemented by GOL from 2004/2005 to 2011/2012. |
| | Objective of M/P (Second Priority Projects) | 4.68 (7.9%) | *This stretches is to be implemented by GOL from 2011/2012 to 2019/2020.<br>*This stretches would also be protected by people's involvement as the need arises until the start of the Projects by GOL at each sites. |
| | Remaining Stretches including 4 Second Priority Projects to be implemented after 2020/2021 | 8.65 (14.6%) | *This stretches is to be protected by GOL after 2020/2021<br>*This stretches would be protected by people's involvement as the need arises. |
| Sub-total | 19.18 (32.4%) | | |
| 2)Mild-slope riverbanks | 20.71 (35.0%) | | This stretches with no active erosion in general would be protected by people's involvement as the need arises. |
| 3) Riverbanks with sand bar and island | 16.89 (28.5%) | | These stretches would not require specific bank protection activities. |
| 4) Riverbanks with exposed rocks | 2.46 (4.2%) | | |
| Total | 59.24(100%) | | |

# THE STUDY ON MEKONG RIVERBANK PROTECTION AROUND VIENTIANE MUNICIPALITY IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

## FINAL REPORT
## VOLUME 1
## -EXECUTIVE SUMMARY-

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# ABBREVIATIONS

*(1) Organization*

| | |
|---|---|
| Lao P.D.R. | Lao People's Democratic Republic |
| GOL | Government of Lao P.D.R. |
| GOJ | Government of Japan |
| JICA | Japan International Cooperation Agency |
| MCTPC | Ministry of Communication, Transport, Post and Construction |
| DOR | Departments of Roads, MCTPC |
| DCTPC | Department of Communication, Transport, Post and Construction |
| VUDAA | Vientiane Urbane Development and Administration Authority |
| LNMC | Lao National Mekong Committee |
| ADB | Asian Development Bank |
| IUCN | International Union for the Conservation of Nature and Natural Resource |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNDP | United Nations Development Programme |
| UNCHS | United Nations Centre for Human Settlements |
| FITA | Flanders International Technical Agency |
| RTSB | Rancang Timur Sdn. Bhd., Malaysia |

*(2) Place Name, Geographical Name or Project Name*

| | |
|---|---|
| VUISP | Vientiane Urban Infrastructure and Services Project |
| NBCA | National Biodiversity Conservation Area |

# ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd= yard

Area

$cm^2$ = square centimeter
$m^2$ = square meter
ha= hectare
$km^2$ = square kilometer

Volume

$10^6$ = million
$cm^3$ = cubic centimeter
l = litre
kl = kilolitre
$m^3$ = cubic meter
gal = gallon

Weight

Gwh = Gigawatthour
mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb. = pound

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measurement

V = Volt
A = Ampere
hz= Hertz (cycle)
Ghz = Gigahertz
W= Watt
kW = kilowatt
MW = Megawatt
GW = Gigawatt
pr = pair

Other Measures

% = percent
PS = horsepower
o = degree
‘ = minute
“ = second
$10^3$ = thousand
$10^9$ = billion

Derived Measures

$m^3/s$ = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = Kilowatt hour
Mwh = Megawatt hour
Wh/y = Kilowatt-hour per year
kVA = kilovolt ampere
BTU = British Thermal Unit
psi = pound per square inch
Icd = litre per capita per day
Kb/s = Kilovolt/second
Mb/s = Megabit/second

Currency

US$ = US Dollar
Kip= Laotian Kip

# 1 INTRODUCTION

## 1.1 Objectives of Study

The Study aims to conduct the following for the Mekong River around Vientiane City:

1. To study practical bank protection works with lower cost adaptable to the Mekong River and sustainable in Lao P.D.R., introducing river works developed in Japan.
2. To transfer technology related with the above works to the counterpart personnel through the execution of Pilot Works.
3. To formulate a master plan for riverbank protection of the Mekong River around Vientiane City based on the monitoring results of the Pilot Works.

## 1.2 Study Area

The Study Area is the Mekong riverbank around Vientiane Capital City in Lao P.D.R. (L= approximately 60 km) as shown in Figure 1.1.

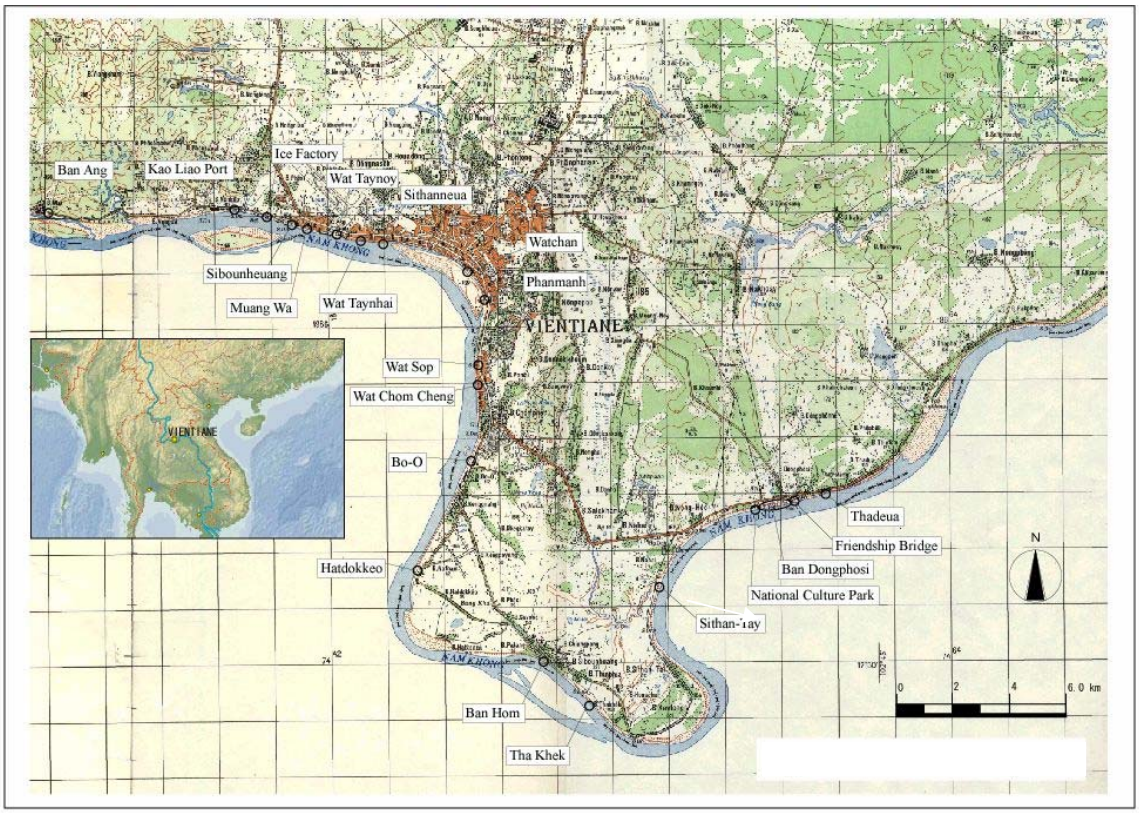



**Figure 1.1 Location of Study Area**

## 1.3 Study Schedule

Overall schedule of the Study from December 2001 to December 2004 and the major contents conducted is as follows:

- 1st year (Dec. 2001-Mar. 2002): Basic study in the Study area
- 2nd year (Oct. 2002- Mar. 2003): Execution of pilot works
- 3rd year (Apr. 2003- Feb.2004)

- Execution of pilot works (Apr- May 2003)
- Monitoring of pilot works (June 2003 -)
- Formulation of Master Plan (Dec.2003- Feb. 2004) <Interim Report in Feb. 2004>

- 4th year (Aug.- Dec. 2004): Monitoring of pilot works <Final Report in Dec. 2004>

# 2 BASIC STUDY

## 2.1 Present Condition in the Study Area

### 2.1.1 Hydro-meteorological Condition

- Annual rainfall: around 1,640 mm in average
  - Rainy season: May to September (1,390 mm in average; 85 % of annual rainfall)
  - Dry season: October to April (250 mm in average; 15 % of annual rainfall)
- Average temperature: 26.3 $^{O}$C
- Annual maximum water level and discharge (1960-2001):
  - 6.67 m - 12.71 m (10.68 m in average)
  - 7,500 m3/s- 22,900 m3/s (16,000 m3/s in average)
- Annual minimum water level and discharge (1960-2001):
  - -0.28 m - 0.93 m (0.43 m in average)
  - 598 m3/s-1,220 m3/s (1,000 m3/s in average)

### 2.1.2 Riverbank Condition around Vientiane City (the Study Area)

#### (1) Characteristics of the Mekong River in the Study Area

- Average riverbed slope: 1/8,100
- Average maximum channel depth: 14.87 m
- Average river width: 856 m (including island), 773 m (excluding islands)
- Riverbed materials: Average of the 60 % grain sizes (d60) are 0.44 mm with the specific gravity at 2.61.

#### (2) Riverbank Condition

- The riverbanks severely eroded in the Study Area forms vertical cliffs mostly as shown in Figure 2.1.
- The riverbanks in the Study Area seem younger and sediment movements are mere active comparing with those in other reaches, since the Study area is located just downstream of the abrupt change of river slope.
- Riverbank generally consists of sandy gravel layer covered with clayey soil (6 m to 8 m deep) on the top. These bank materials are not consolidated and easily be eroded.
- Gabion works are commonly used for bank protection. The existing works are effective to protect the riverbank from erosion, though some works are damaged due to poor foot protection and/or washing away of soil behind the gabion.

Sithantai

Ban Hom

Bo O

Sibounheuang

**Figure 2.1 Eroded Cliffy Riverbanks in the Study Area**
-Condition in December 2001-

**(3) Riverbank Alignments and Islands**

- Historical change of riverbanks and islands: During past 30 years, changes in riverbanks are not much as a whole, and the islands remained almost at the same location. The riverbank movements are relatively large in the stretch from KM-1574 to KM-1562.
- Course of main flow: The bank erosions in the Study Area are mainly caused by the attacking river flows and the reaches of flow attacks are historically fixed.
- Average intervals of meandering cycle: about 8.5 km (about 10 times of river width)

**(4) Sediment Flow Conditions**

- Dune bed under the frequent flood flow conditions and flat bed under the bankfull flow condition.
- Sediment transport: Suspension not fully developed

**(5) Causes of Bank Erosion**

- Erosion due to scouring at foot of riverbed (The vertical riverbank cliffs would be formed in this manner and most of the eroded river banks in the Study Area are of this type.)
- Erosion due to excess pore pressure during lowering period of river water level
- Erosion due to slope failure

### 2.1.3 Riverbank Condition of Whole Mekong River in Lao P.D.R.

**(1) Southern Part of Whole Mekong River**

(Bolikhamxai, Khammouan, Savannakhet and Champasak Provinces)

- Vertical cliffs of riverbanks commonly seen in the Study Area are seldom found.
- Near Wat Phu remain (World Heritage) in Champasak province (Figure 2.2): A part of the remnants of exterior wall of Wat Phu located at the eroded riverbank is now under constant threat of collapse. Revetment works covering whole river bank is not recommendable in consideration of the conservation and archaeological prospecting of remains. Groin works might be effective to stabilize the bank by accelerating the sedimentation and vegetation at the foot of eroded bank.

**Figure 2.2 Mekong Riverbank near Wat Phu Remain**
- Condition in December 2001-

**(2) Northern Part of Whole Mekong River** (Luang Phabang and Bokeo Provinces)

- In the urban area of Luang Phabang, riverbanks are rather stable and keep some gentle slope and the extent and damage of erosion is relatively small as shown in Figure 2.3.
- In Bokeo province, the riverbanks, most notably existing groin site at Ban Tonpheung form vertical cliffs at many places as shown in Figure 2.4 as can seen in the Study Area.

**Figure 2.3**
Mekong Riverbank
along Luang Phabang City
- Condition in January 2002-

**Figure 2.4**
Mekong Riverbank
in Bokeo Province
- Condition in January 2002-

### 2.1.4 Existing Bank Protection Works

**(1) Around Vientiane City (the Study Area)**

Present condition of the existing bank protection works in the Study Area is summarized as follows and shown in Figure 2.5.

- Bank protection works along the Mekong River around Vientiane City have been implemented since early 1990s.
- Most of the protection works were done by using gabion. As for these works, at many locations, silt deposits with partly covered by vegetation are found. Some of wire nets have been corroded to become thin and partly damaged in a long period after construction.
- At Wat Sibounheuang, a new method using Soda mattress has been tested.
- At Hatdokkeo, gabion at the toe of the slope is damaged and stones in the net-cage are lost, resulting a steep slope of toe without being protected. Existing sand excavation works near the site might have influenced the riverbed degradation in front of the work.

Thadeua

National Culture Park

Hatdokkeo

Wat Sop

Muang Wa

Sibounheuang

**Figure 2.5 Existing Riverbank Protection Works in the Study Area**
-Condition in December 2001-

**(2) Whole Mekong River in Lao P.D.R. (Southern part from Vientiane)**

- At Pakkadan in Bolikhamxai province, four riprap groins have been constructed and two new groins are under construction along the national road No.13 (Figure 2.6). Further extension of groin is planned. With somewhat low elevation of the groin crown, the sedimentation between the groins is realized under the groin level. Slope of the embankment between the groins is suffered from partly collapse due to high velocity in the flood season. Slightly higher groins and/or the combination of slope protection works as riprap works between groins are supposed to be effective.

**Figure 2.6 Riprap Low Groins at Pakkadan**
- Condition in February 2002-

**(3) Whole Mekong River in Lao P.D.R. (Northern part from Vientiane)**

- Around Luang Phabang city, riverbank slope of the Mekong is rather stable except the drainage treatment on the slopes.
- Along Ban Tonephueng in Bokeo province, riprap groin works being executed by GOL with the technical assistance of JICA Expert to MCTPC since 1998 as shown in Figure 2.7. Amount of sedimentation is found between groins, resulting to protect the riverbank slopes. MCTPC constructed 14 groins by 2003 and will continue further extension until 2008, every 2 groins a year.

**Figure 2.7 On-going Riprap Groin Works in Bokeo Province**
- Condition in December 2001-

### 2.1.5 Proposed Plans and Projects in the Study Area

**(1) Bank Protection Plans and Projects**

The following plans and projects relating to river bank protection are reviewed for the basis of the formulation of the Master Plan:

1) Projects by National Budget

GOL has been implementing bank protection works gradually by using very limited national budget. Proposed projects after 2004 are as follows so far:

1. Sibounheuang (L=410 m): to be implemented after 2005 (survey was started from 2004)
2. Ban Hom/Tha Khek: 60 m to be constructed in 2004, construction to be continued

2) Lao-Flanders River Works Project

The outline of the project is as follows:

1. On-going capacity development project at Bo O riverbank site (2002-2004) of MCTPC financially assisted by Flanders International Technical Agency (FITA), the Government of Belgium.
2. Survey for L=200 m is completed and the design of bank protection works using gabion has not been completed; the draft drawing is available.
3. Construction work will be executed by national budget; GOL is requesting FITA for the financial aid, though.

3) Projects by Other Donors

No specific future plans and projects by other donors exist so far except present technical cooperation by JICA and FITA. However, if donor's financial assistance is available in the future, it will help GOL to accelerate the implementation of the Master Plan.

**(2) Related Plans and Projects**

1) Urban Development Project by Reclamation at Watchan

- Modern Home Co. Ltd., Laotian private developer, completed reclamation work (L=840 m) in 2002
- Modern Home Co. Ltd. abandoned original Don Chan Island development owing to financial difficulty.

2) On-going Don Chan Island Development

- Don Chan Island (100ha) will be fully developed and urbanized by Rancang Timur Sdn. Bhd. (RTSB), Malaysia.
- Bank protection of the island will be executed by RTSB.
- Sand mining in the Mekong River for reclamation might cause some impact to riverbank.
    - On-going MRC study "Environmental Risk Assessment between Non Kai and Vientiane" including sediment transport can be utilized in near future.

3) Vientiane Urban Development Master Plan

The draft of revised Vientiane Urban Development Master Plan (URI-MCTPC, 2003) proposed the land use principles of riverine area. The plan has a close relation with the non-structural measures of JICA Master Plan.

4) Vientiane urban infrastructure and service project (VUISP) (VUDAA/ADB, 2001)
Riverbank protection project around Sibounheuang (L=1.06 km) was excluded from the original component.

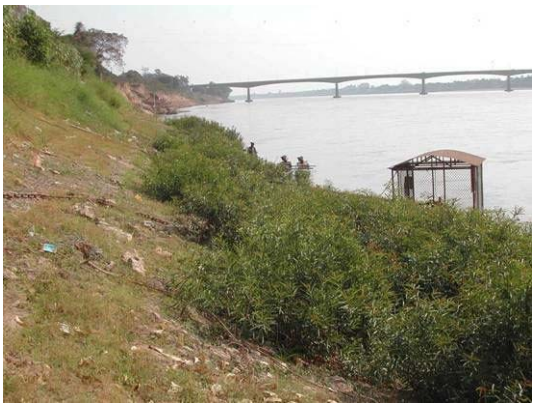
5) Committee for prevention of impacts on river banks and ecology system
- established by Prime Minister's Decree in April 2003 as national level activities including Vientiane
- Setting up of organization and implementation schedule of the committee: now under consideration

### 2.1.6 Riverine Vegetation in the Study Area

**(1) Vegetation on Natural Riverbank**
- Little vegetation grows on the bank forming vertical cliff.
- Vegetation grows on the stable bank with gentle slope.

**(2) Vegetation on Existing Bank Protection Works**
- Growing plants change with the situation of sedimentation.
- The kinds of distributed plant differ in the upper, middle and lower layers of bank.
- Growth of plant is not active for one year after the completion of work

**(3) Willow in the Mekong River**
- Distribution of willow:
  - Many communities of the willow are found at existing bank protection works after 5 years or more from the completion as shown in Figure 2.8.
  - Few willows are found on natural riverbanks
  - Massive communities are found at the sandbar in front of Buddha Park.
- Characteristics of willow:
  - The kind of soil has little influence on the growth of willow.
  - Moisture has strong influence on the growth of willow
  - Community of willow can hold the soil of riverbank



National Culture Park

Mekong Restaurant near KM4

**Figure 2.8 Community of Willow on Existing Bank Protection Works**

### 2.1.7 Basic Environmental Condition in the Study Area

**(1) Natural Environment**

- Protected Area: Phou Phanang and Phou Khao Khoay National Biodiversity Conservation Areas (NBCA)
- Fauna and flora: Natural vegetation areas remain well in and around above NBCAs. There is no natural vegetation along the Mekong riverbank.

**(2) Social Environment**

- Forestry law in Lao P.D.R.:
  - Forest are categorized 1) protected forests, 2) forest reserves, 3) production forests, 4) rehabilitation forests and 5) degraded forests
  - Wood and other forest products can be exploited only from production forests.
- Riverine land use: 1) field, 2) field with trees, 3) residential area, 4) residential area with trees and 5) commercial area

### 2.1.8 Socioeconomic and Financial Conditions

**(1) Socioeconomic Development Plans**

- GOL emphasizes to eliminate the country's poverty by 2020.
- Economic growth target of National Socioeconomic Development Plans: around 7% p.a.

**(2) Financial Conditions**

- GOL finance has highly depended on ODA (3/4 of capital expenditure).
- GOL clearly states to reduce gradually high dependency on ODA.
- Expenditure of MCTPC for riverbank protection has remained less than 1% of the budget for road construction except FY2002/03, when JICA Pilot Works were implemented.
- Cumulative length of existing riverbank protection works in Vientiane City from 1989 up to date: approx. 4,770 m as shown in Figures 2.9 and 2.10.
  - Donor’s financial assistance: 3,240 m (68%) (including JICA Pilot Works: 1,039 m)
  - National budget: 1,530 m (32%)

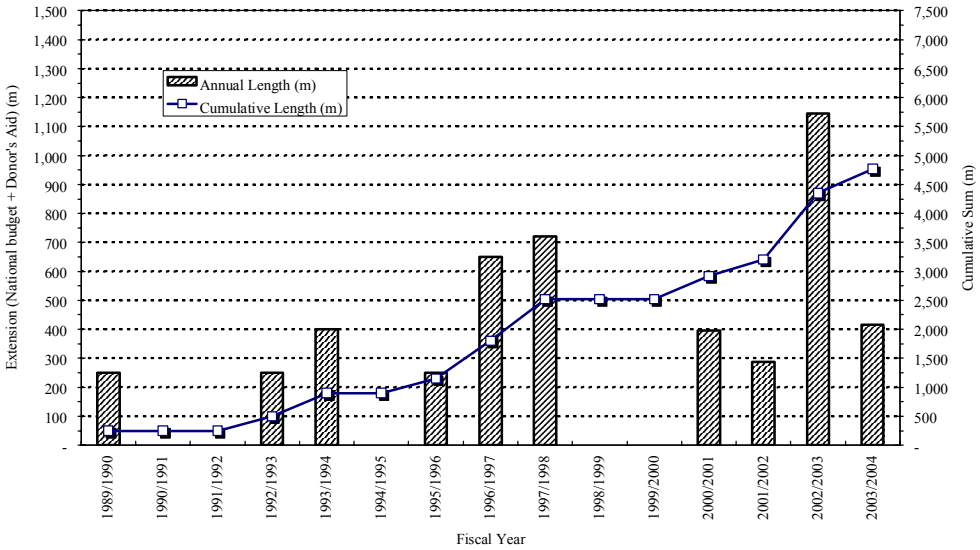



**Figure 2.9 Extension of Existing Bank Protection Works in Vientiane**

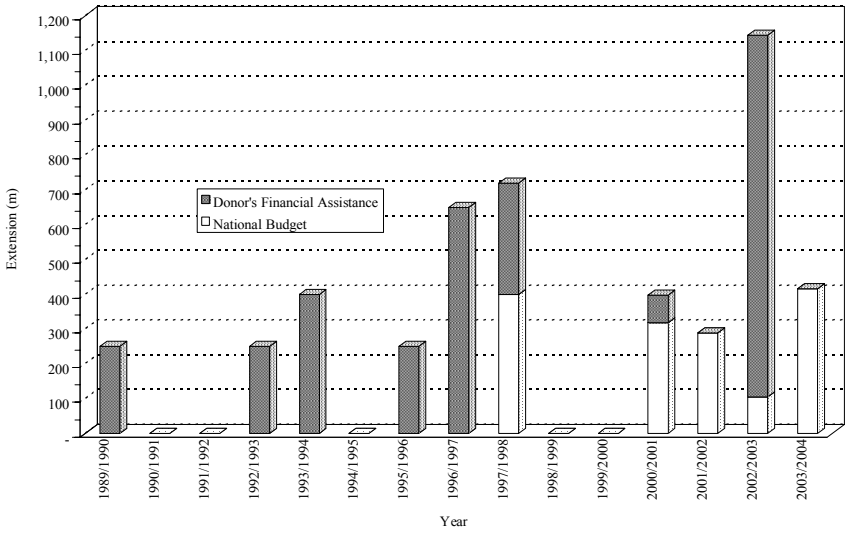



**Figure 2.10 Riverbank Protection Works around Vientiane City by Source of Finance**

## 2.2 Preparatory Study for Pilot Works

### 2.2.1 Selection of Sites for Pilot Works

The following three (3) sites shown in Figure 2.11 are selected for the bank protection Pilot Works (the Pilot Works):

1. Ban Dongphosi site (L=643 m)
2. Wat Chom Cheng site (L=240 m)
3. Sibounheuang Site (L=156 m)

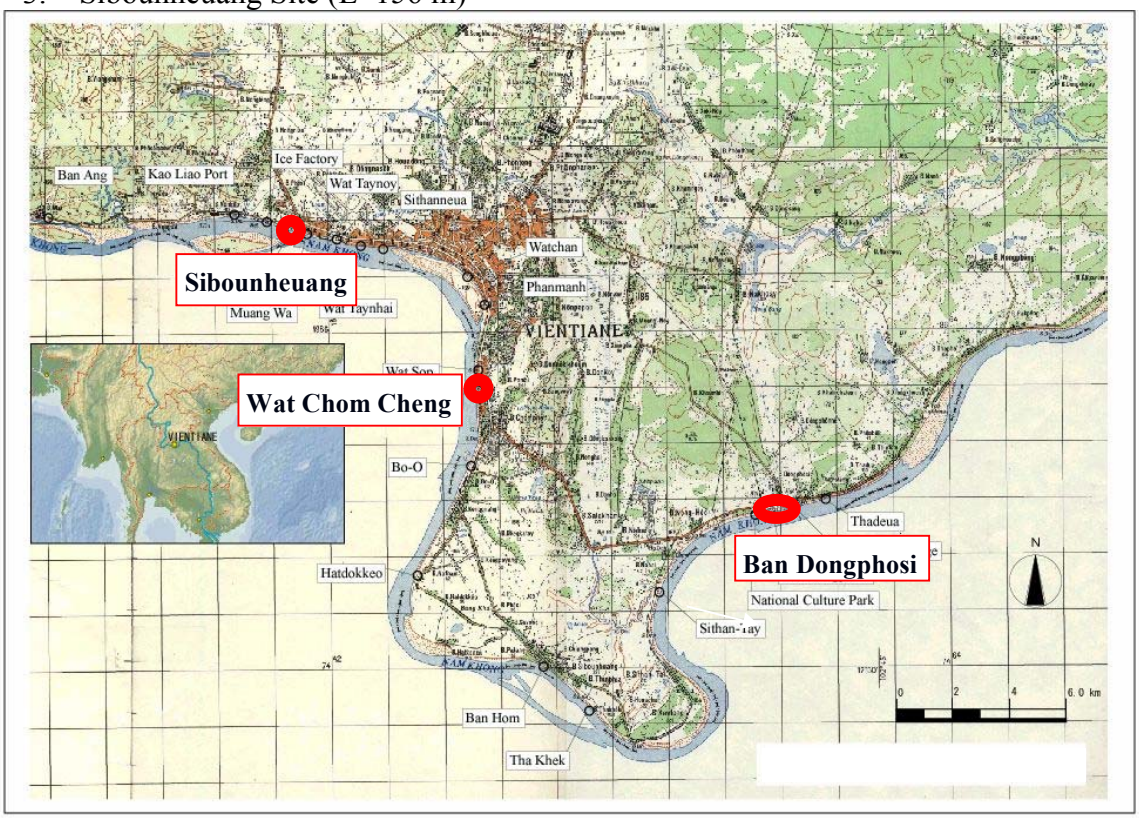



**Figure 2.11 Location of 3 Pilot Work Sites**

### 2.2.2 Site Condition for Pilot Works

Condition of each Pilot Work site in December 2001 is as shown in Figure 2.12. The riverbank type is summarized in Table 2.1.

Ban Dongphosi Site (December 2001)

Wat Chom Cheng Site (December 2001)

Sibounheuang Site (December 2001)

**Figure 2.12 Condition of Pilot Work Sites**

**Table 2.1 Riverbank Type of Pilot Work Site**

| Type of riverbank | Characteristics | Corresponding Pilot Work site ( ): other similar site |
|---|---|---|
| 1 | -bank slope: 45 degree or less<br>-secondary deposits: loose sandy silt/silty sand | **Wat Chom Cheng** (Sithanneua, Watchan, Hatdokkeo) |
| 2 | - bank slope: 65~90 degree<br>-upper layer: dark pale brown, somewhat loose<br>-lower layer: pale reddish brown clay layer, stiff<br>-small holes are observed | (Ice Factory) |
| 3 | - bank slope: 65~90 degree<br>- upper layer: pale reddish brown, stiff clay<br>- lower layer: gravel layer with loose sand where hollows are produced by scouring | **Sibounheuang** (Wat Taynhai) |
| 4 | - upper steep portion: pale gray silty clay, moderate stiff<br>- lower gentle: gravel layer (Vientiane gravel), rather strong resistance against erosion | **Ban Dongphosi** (Sithantai, Thadeua) |

### 2.2.3 Facility Design of Pilot Works

**(1) Design Criteria**

| Site Name | Design flow velocity (m/sec) | Low water level with 5-year return period (El. m) | Stone size |
|---|---|---|---|
| 1. Ban Dongphosi | 3.4 | 155.0 | a) Rip-rap Stone: according to the formula of US Army Corps of Engineering<br>b) Filling Stone: according to a experimental formula |
| 2. Wat Chom Cheng | 2.6 | 158.1 | |
| 3. Sibounheuang | 2.6 | 158.9 | |

**(2) Selection of Construction Type**

| Site Name | Construction type |
|---|---|
| 1. Ban Dongphosi | 1) Riprap work, 2) Soda mattress work and 3) Coble stone with willow branch work |
| 2. Wat Chom Cheng | 1) (partial) Soda mattress work and 2) Wooden pile groin work |
| 3. Sibounheuang | 1) Log hurdle work, 2) Soda mattress work and 3) Cobble stone with willow branch work (covering lower bank) |

**(3) Design of Pilot Works**

The design of the Pilot Works is conducted and the design for Ban Dongphosi site is further reviewed and revised after the historical big flood in August 2002, and is incorporated into the description in Chapter 3.

## 2.3 Field Survey for Pilot Work Design

### 2.3.1 Topographic Survey

Cross sections and topographic maps (1:500) were prepared with a quantity as shown below:

| Site Name | Work Item | |
|---|---|---|
| | Cross Section Survey | Mapping |
| 1. Ban Dongphosi | 43 lines | 42,000 $m^2$ |
| 2. Wat Chom Cheng | 21 lines | 24,000 $m^2$ |
| 3. Sibounheuang | 16 lines | 15,000 $m^2$ |

### 2.3.2 Velocity Measurement

Velocity measurements were carried out to obtain vertical/ plan distribution of current speed with a quantity as follows:

| Site Name | Quantity |
|---|---|
| 1. Ban Dongphosi | 9 lines x 20 points/line = 180 points |
| 2. Wat Chom Cheng | 3 lines x 20 points/line = 60 points |
| 3. Sibounheuang | 3 lines x 20 points/line = 60 points |

### 2.3.3 Geotechnical Investigation

- (1) Soil Investigation: Investigation items are as follows:
  1. Boring (115m in total) and in-situ tests, and
  2. Various laboratory tests for clayey and sandy soil.
- (2) Rock Piece Test: Rock piece tests of 20 samples at prospective quarry sites were conducted to know the basic properties of rock used for the bank protection materials.

### 2.3.4 Supporting Investigation for Initial Environmental Examination

Social/Natural environmental survey was conducted to obtain basic environmental data/information related to the Study Area including three (3) Pilot Work sites.

# 3 EXECUTION OF PILOT WORKS

## 3.1 General

### 3.1.1 Outline

The Pilot Works at three (3) sites, namely, Ban Dongphosi, Wat Chom Cheng and Sibounheuang Sites were completed by the Study Team in May 2003. General of the work is as follows:

6. Scheme of execution: Sublet contract with the Study Team for JICA Development Study (Not JICA Grant Aid Project scheme)
7. Design & Supervision: JICA Study Team (in full cooperation with MCTPC/ DCTPC)
8. Contractor: Obayashi Corporation (selected by competitive bidding including local contractors)
9. Construction Period: January 2003 - May 2003 (5 months)
10. Construction Cost (engineering estimate): US$ 1,259,000 in total
    i. Ban Dongphosi Site US$ 1,088,000 (approx. US$ 1,690/m)
    ii. Wat Chom Cheng Site US$ 49,000 (approx. US$ 200/m)
    iii. Sibounheuang Site US$ 122,000 (approx. US$ 810/m)

### 3.1.2 Upgrading of Specification at Ban Dongphosi Site

#### (1) Riverbank Erosion at Pilot Work Sites by August 2002 Flood

A historical big Mekong flood in August 2002 before the execution of the Pilot Works caused severe riverbank erosion in many Mekong stretches around Vientiane City as follows:

- The flood is the historical second biggest (H max = 170.64 m, MSL)
  <cf. the biggest in 1966 (H max = 170.75 m, MSL)>
- Ban Dongphosi: The average setback width eroded by the flood is around 2.3 m (1.2~2.9m)
  <cf. average setback width in ordinary year: around 0.5 m>
- Wat Chom Cheng: The riverbank was not eroded so much
- Sibounheuang:
  - Several limited points were eroded with the width of 3-5 m locally
  - However, the bank was not eroded so much generally (harder bank soil than that at Ban Dongphosi)

#### (2) Upgrading of Specification

At Ban Dongphosi site, the original facility design in March 2003 was upgraded as follows after August 2002 flood taking into account the importance of oil stockpiling base located extremely close to the eroded vertical cliffy banks:

- Additional backfill corresponding to the riverbank setback (average width = 2.3 m)
- Partial reinforcement by stone covering (L=100 m at the front of oil stockpiling base)

### 3.1.3 Collection Sites of Construction Materials

Construction materials for the Pilot Works are collected at the sites as shown in Figure 3.1.

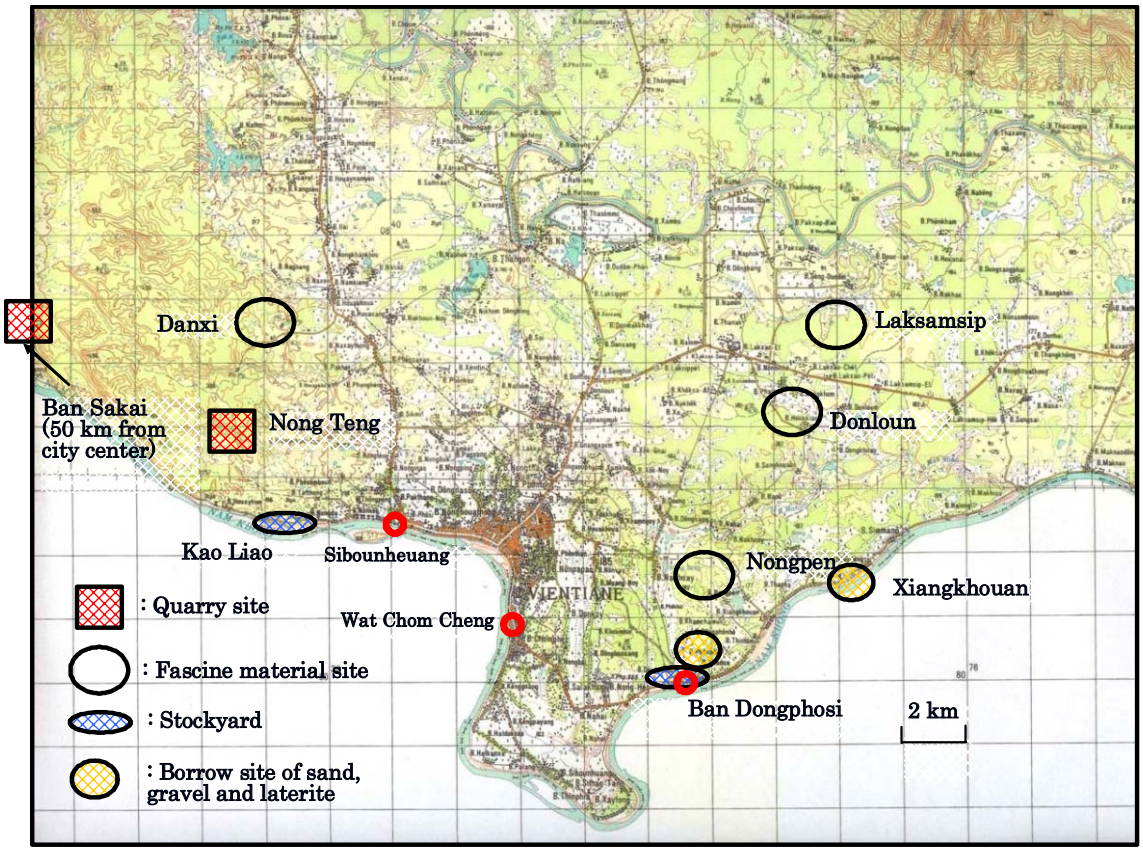



**Figure 3.1 Location of Material Collection Sites**

## 3.2 Execution of Pilot Work at Ban Dongphosi Site

### 3.2.1 Outline

The pilot work at the site was completed in May 2003. After completion, willows will grow and will cover the surface of the slope. The photos before and after the execution are as shown in Figure 3.2. The outline of the work is summarized in Table 3.1.

Before construction (October 2002)

Just after construction (May 2003)

After rainy season (January 2004)

**Figure 3.2 Completed Pilot Work at Ban Dongphosi Site**

**Table 3.1 Outline of Pilot Work at Ban Dongphosi Site**

| |
|---|
| 1. Total length of execution: 643 m |
| 2. Riverbank type:<br>a) upper steep portion: pale gray silty clay, moderate stiff<br>b) lower gentle portion: gravel layer (Vientiane gravel), rather strong resistance against erosion |
| 3. Design criteria:<br>a) design flow velocity: 3.4 m/sec<br>b) low water level with 5-year return period: 155.0 m, MSL |
| 4. Construction type:<br>a) Foundation work (rubble deposition)<br>b) Foot protection work (Soda Mattress work)<br>c) Slope protection work (Cobble stone with willow branch work) |
| 5. Main points to note:<br>a) Much amount of backfill is introduced to protect important properties, especially around the oil stockpiling base of Lao State Fuel Company.<br>b) The slope protection work for peripheral part of the Company is designed to protect the foot of the steep cliff to avoid further setback due to undermining of the slope and to establish naturally stable slope with vegetation.<br>c) The following upgrading of facility design is newly introduced after August 2002 flood<br>• additional backfill corresponding to the riverbank setback eroded by the flood with an average width of 2.3 m<br>• partial reinforcement by stone covering at the front of oil stockpiling base (L=100 m)<br>d) After completion, willows will grow and will cover the surface of the slope. |
| 6. Work items:<br>a) preparatory works<br>• temporary works and facilities<br>• collection and transportation of materials<br>b) foundation riprap works<br>• stone dike (crushed stone of dia. 250mm-600mm): 12,300m3<br>• stone dike (gravel of dia. 50mm under): 1,800m3<br>c) foot protection works by Soda Mattress<br>• assembling of mattress (66 sheets: 10m*6m*0.9m)<br>• installation of mattress (crushed stone of dia. 250mm-600mm):5,200m3<br>d) earth works (backfill and embankment by river sand): 45,000m3<br>e) slope protection works<br>• cobble stone with willow branch works (A=13,700 m2)<br>• partial reinforcement by stone covering (L=100 m, V=1,400 m3)<br>f) finishing works, and<br>g) inspection of completion by the Study Team |
| 7. Construction period: January 2003 - May 2003 |

### 3.2.2 Drawings

Drawings of the work are as shown in Figure 3.3.

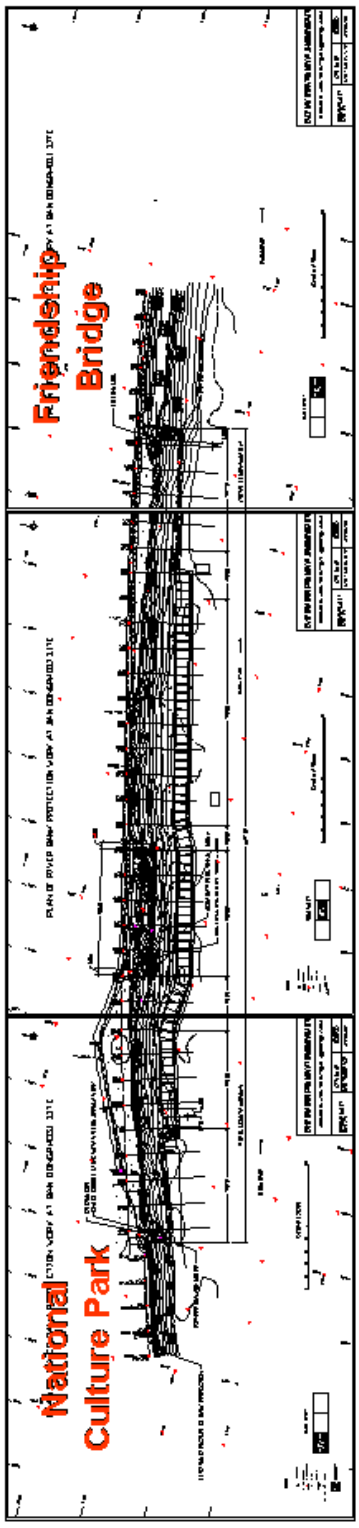



**Figure 3.3 (1/3)**
**Drawings of Ban Dongphosi Site**

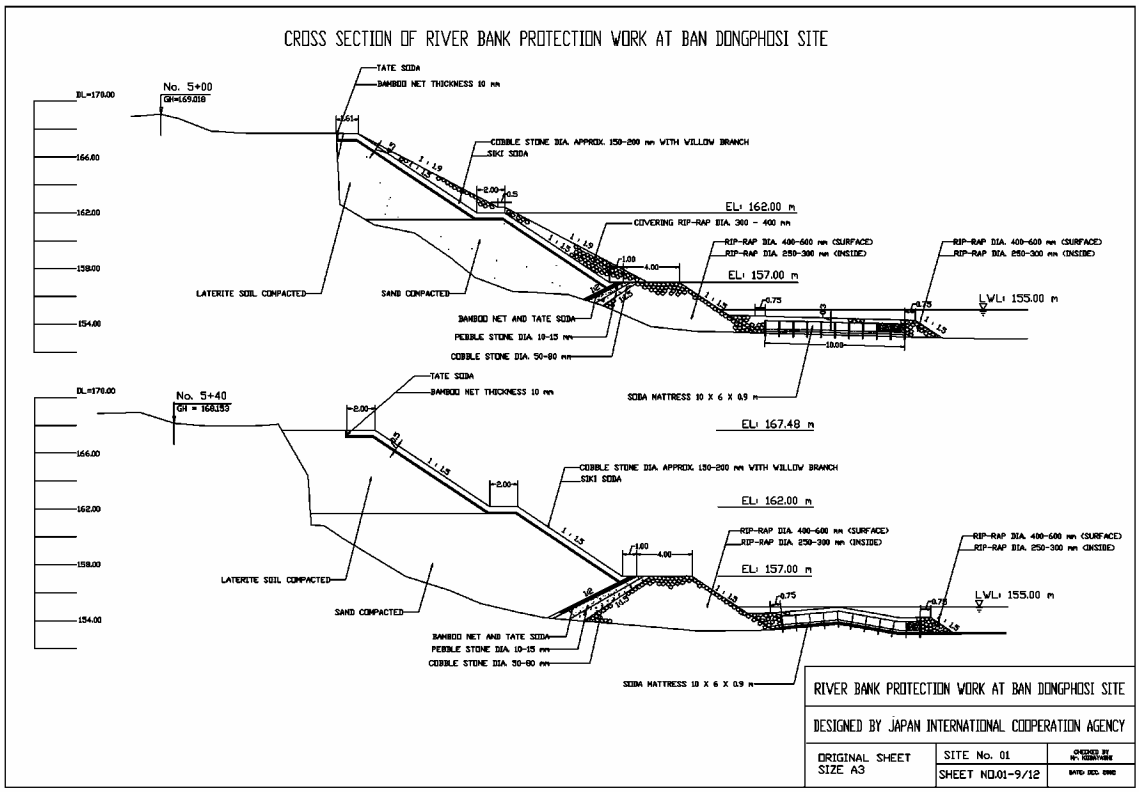



**Figure 3.3 (2/3) Drawings of Ban Dongphosi Site**

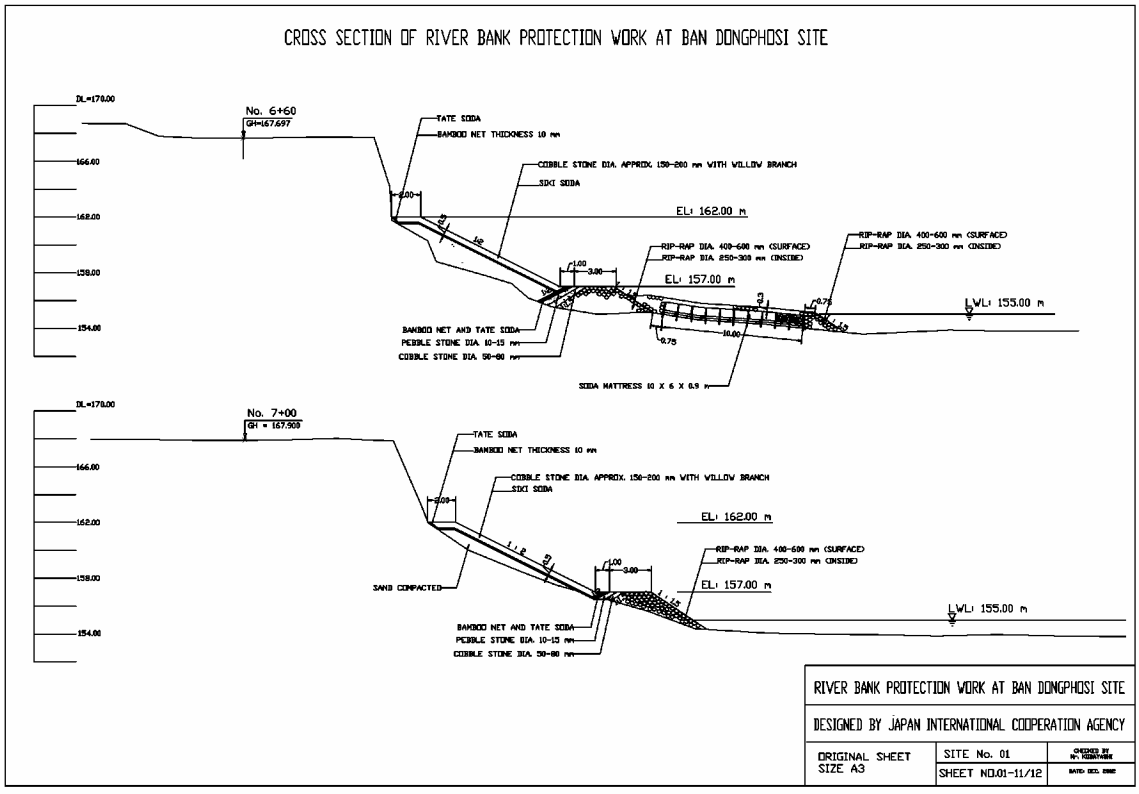



**Figure 3.3 (3/3) Drawings of Ban Dongphosi Site**

## 3.3 Execution of Pilot Work at Wat Chom Cheng Site

### 3.3.1 Outline

The pilot work at the site was completed in May 2003 based on the original design established in March 2002. The photos are as shown in Figure 3.4. The outline of the work is summarized in Table 3.2.

Before construction (February 2002)

Just after construction (May 2003)

After rainy season (December 2003)

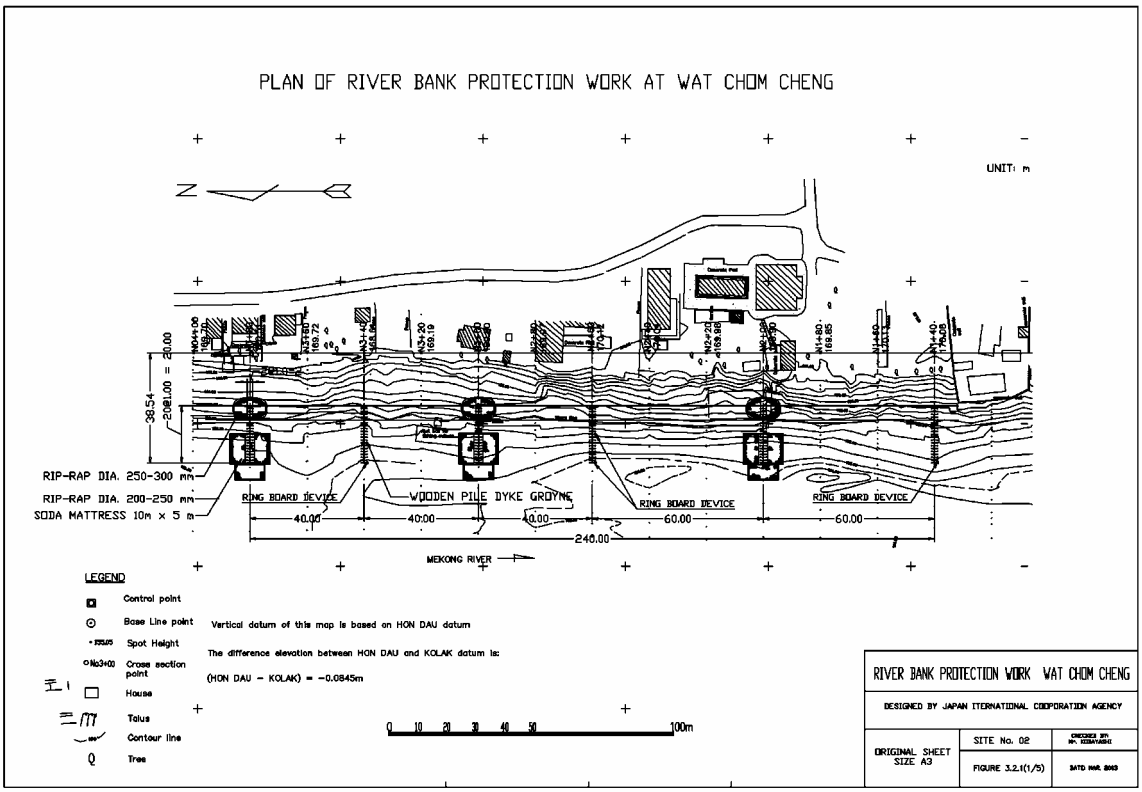
**Figure 3.4 Completed Pilot Work at Wat Chom Cheng Site**

**Table 3.2 Outline of Pilot Work at Wat Chom Cheng Site**

| |
|---|
| 1. Total length of execution: 240 m |
| 2. Riverbank type:<br>a) bank slope: 45 degree or less<br>b) secondary deposits: loose sandy silt/silty sand |
| 3. Design criteria:<br>a) design flow velocity: 2.6 m/sec<br>b) low water level with 5-year return period: 158.1 m, MSL |
| 4. Construction type:<br>a) Foot protection work (wooden pile groin work, Soda Mattress)<br>b) Slope protection work (wooden pile groin work) |
| 5. Main points to note:<br>a) Number of groin: 6 (3 of them are reinforced by Tie-beam, Soda Mattress and riprap)<br>b) Spacing of groins: 40 m (upper stretch), 60 m (downstream stretch)<br>c) Length of the groin: 20m<br>d) 3 rows of wooden piles is arranged in a hound's tooth with spacing of 1m |
| 6. Work items:<br>a) preparatory works<br>• temporary works and facilities<br>• collection and transportation of materials<br>b) groin works<br>• log pilling (378 wooden piles (L=6m))<br>• assembling of soda mattress (9 sheets: 10m*5m*0.9m)<br>• installation of soda mattress<br>c) finishing works, and<br>d) inspection of completion by the Study Team |
| 7. Construction period: January 2003 - May 2003 |

### 3.3.2 Drawings

Drawings of the work are as shown in Figure 3.5.



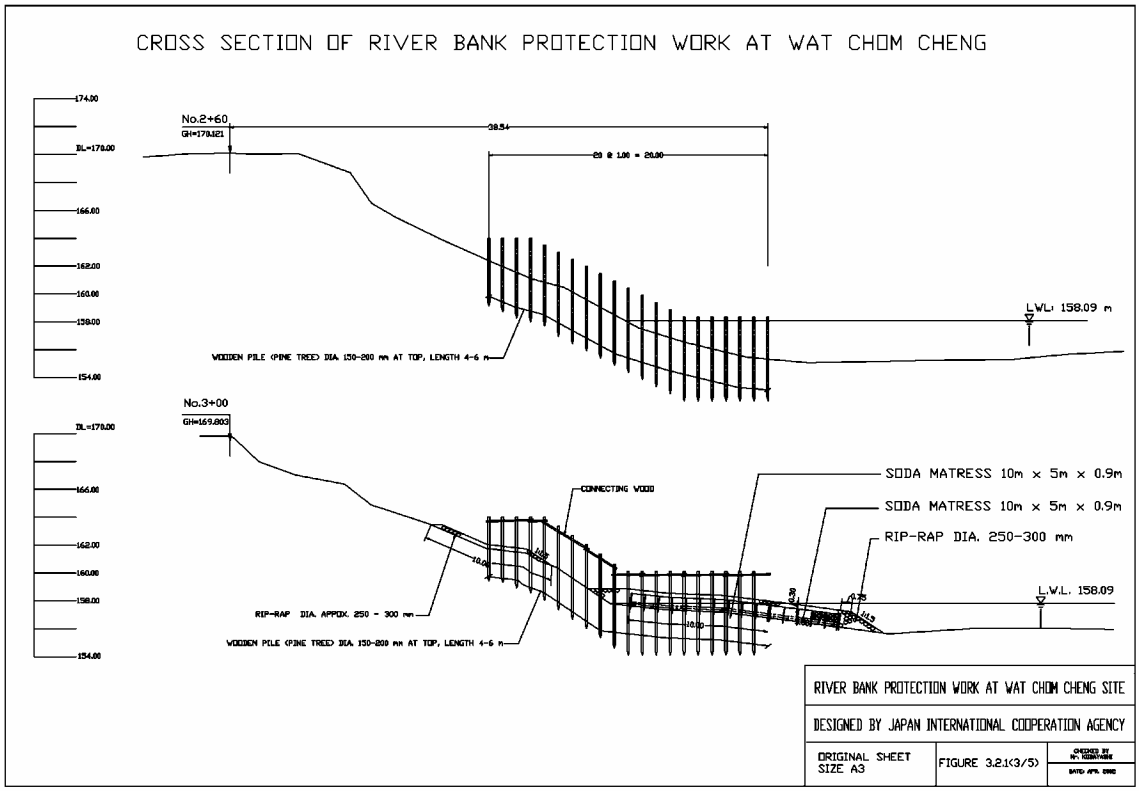




**Figure 3.5 Drawings of Wat Chom Cheng Site**

## 3.4 Execution of Pilot Work at Sibounheuang Site

### 3.4.1 Outline

The pilot work at the site was completed in April 2003 based on the original design established in March 2002. The photos before and after the execution are as shown in Figure 3.6. The outline of the work is summarized in Table 3.3.

Before construction (December 2001)

Just after construction (April 2003)

After rainy season (December 2003)

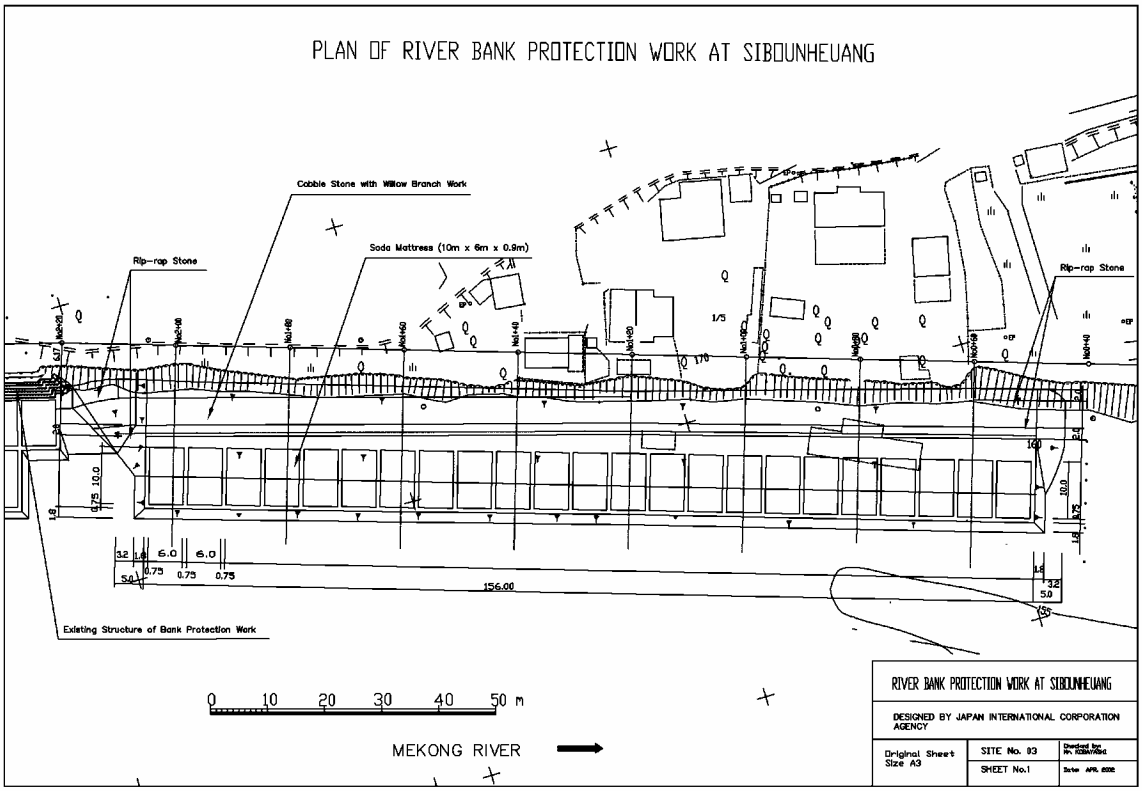
**Figure 3.6 Completed Pilot Work at Sibounheuang Site**

**Table 3.3 Outline of Pilot Work at Sibounheuang Site**

| |
|---|
| 1. Total length of execution: 156 m |
| 2. Riverbank type:<br>a) bank slope: 65~90 degree<br>b) upper layer: pale reddish brown, stiff clay<br>c) lower layer: gravel layer with loose sand where hollows are produced by scouring |
| 3. Design criteria:<br>a) design flow velocity: 2.6 m/sec<br>b) low water level with 5-year return period: 158.9 m, MSL |
| 4. Construction type:<br>a) Foundation work (log hurdle work),<br>b) Foot protection work (Soda Mattress work), and<br>c) Slope protection work (earthwork, Cobble stone with willow branch work). |
| 5. Main points to note:<br>a) The principle design concept is the same as IDI Japan's test project, i.e., to protect the foot of slope by foot protection work<br>b) The slope protection work is designed to cover the possible notch formation part to avoid undermining. |
| 6. Work items:<br>a) preparatory works<br>• temporary works and facilities<br>• collection and transportation of materials<br>b) foundation work (log hurdle works)<br>• 77 primary wooden log piling (L=3m, 2 m interval)<br>• 760 secondary (short) wooden log piling (L=1.5 m, 0.2 m interval)<br>c) earth works (embankment)<br>d) foot protection works (Soda Mattress: 23 sheets, 10m*6m*0.9m)<br>• assembling of mattress<br>• installation of mattress<br>• rubble deposition (V=2,400 m3)<br>e) slope protection works for lower bank (cobble stone with willow branch works)<br>• crushed cobble (V=200m3)<br>• Siki soda, Taisya, Kogui, willow branch (A=1,100m2)<br>f) finishing works, and<br>g) inspection of completion by the Study Team |
| 7. Construction period: January 2003 - April 2003 |

### 3.4.2 Drawings

Drawings of the work are as shown in Figure 3.7.



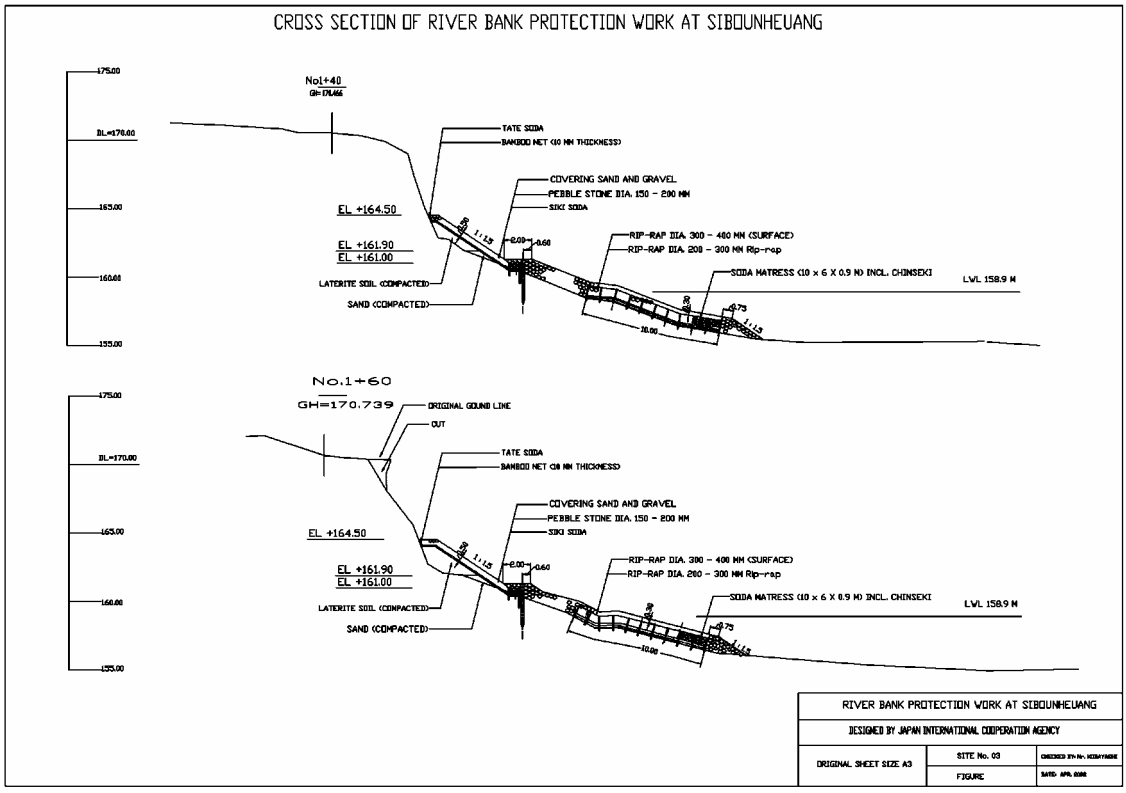




**Figure 3.7 Drawings of Sibounheuang Site**

## 3.5 Preliminary Environmental Impact Assessment

EIA is not required officially for the Pilot Works, however, Pre-EIA for the Works was conducted in January - February 2003. Pre-EIA proves that the pilot works have no serious environmental impact potentially as follows, since the works are conducted to create favorable river environment:

1. During construction stage: Some check items are B (low negative impact) or C (unknown impact), however, most of check items are D (no impact).
2. Operation/maintenance stage: All check items are D (no impact)

# 4 TEST OF SIMPLE VEGETATION RIVERBANK PROTECTION WORKS

## 4.1 Outline

High-cost riverbank protection works is unrealistic measures for the banks forming continuous vertical cliffs with low important riverine area. Simple vegetation riverbank protection works might be the possible measures to fix such bank soil where some sedimentation is found in the dry season. The implementation cost of the vegetation works is extremely low, though it requires several years before the work effects.

## 4.2 Execution of Test Works

The outline of the test work is as follows and the related location is shown in Figure 4.1:

- Location: 1) Nongheo (60 x 8 m) and 2) Chom Cheng (24 x 6 m)
- Construction Period: Jan. 2003 - May 2003
- Planting willow species: 1) Khai Nun and 2) Kok Khai
- Material collection site:
  - Willow material: Culture park and near Japanese ambassador house
  - Soda material: Danxi and Nongpen
- Planting method: 1) bundled tree works, 2) Soda-net works, 3) cutting works and 4) seedling works

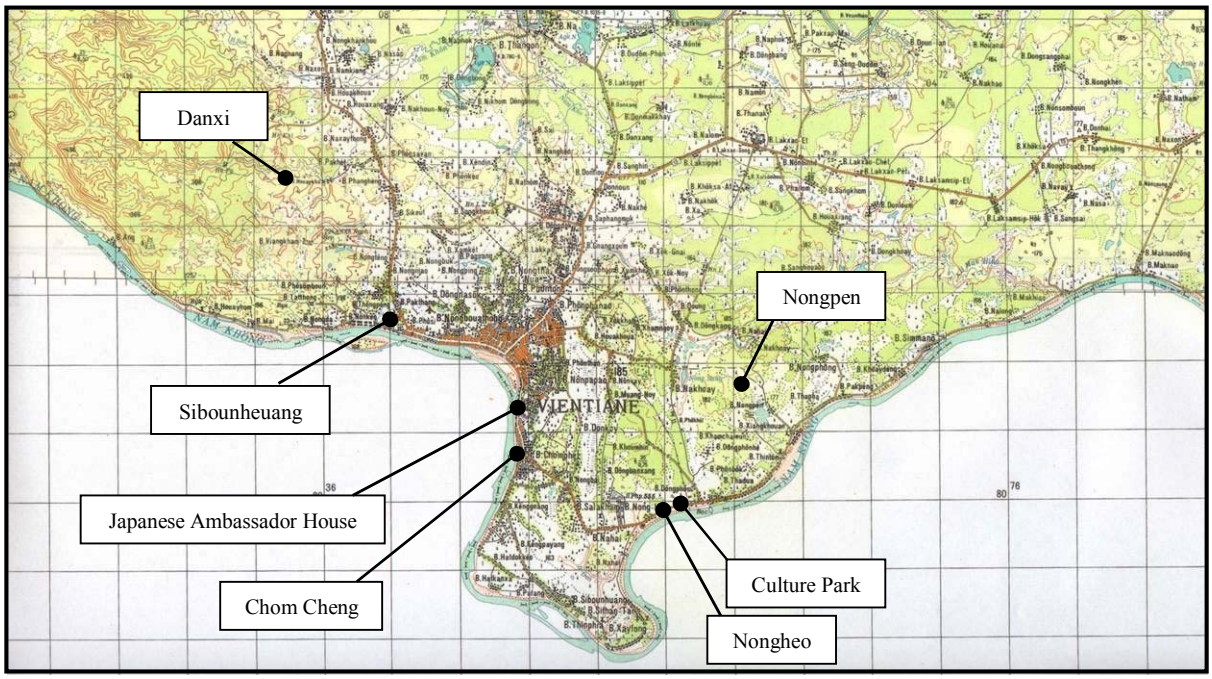



**Figure 4.1 Location of Test Works and Relating Sites**

## 4.2 Monitoring of Test Works

The result of the test work is as follows, further monitoring is required, though:

- The test work seems effective judging from the survival rate, growth performance and root growth performance (Figure 4.2).
  - 1) Bundled tree works, 2) Soda-net works and 3) seedling works are available for willow growing.
  - 1) Cutting works are available if watering could be continuously done for a month after planting.
- In order to ensure the success, it is necessary to grow more to form willow community.

It is important for willow planting as follows:

- To plant willow deeply by stump directly planting and by using Soda-net
- To cover bundle tree with sufficient soil and enough watering just after planting
- To plant at the edge of water during the dry season as water level goes down

Upstream side at Nongheo site

Downstream side at Nongheo site

Chom Cheng site

**Figure 4.2 Situation of Planted Willow Survived**
-December 2003, after the high water period-

# 5 MONITORING OF PILOT WORKS

## 5.1 Pilot Works

### 5.1.1 Monitoring Survey for Pilot Works

**(1) Cross-sectional Survey**

- Period (3times): February 2002, June 2003, January 2004 (cf. completion of the Pilot Works: May 2003)
- Quantity of the survey is as follows:

| Location of survey | Unit | Quantity | Remark |
|---|---|---|---|
| 1) Ban Dongphosi Site | Line | 43 | pitch=20m, line length=50m |
| 2) Wat Chom Cheng Site | | 21 | |
| 3) Sibounheuang Site | | 16 | |

**(2) Velocity measurement**

- Period (6times): January/October 2002, June/September 2003 and January/August 2004 (cf. completion of the Pilot Works: May 2003)
- Quantity of the survey is as follows:

| Location of Measurement | Quantity |
|---|---|
| a) Ban Dongphosi Site | 9 lines x 20 points/line = 180 points |
| b) Wat Chom Cheng Site | 3 lines x 20 points/line = 60 points |
| c) Sibounheuang Site | 3 lines x 20 points/line = 60 points |

### 5.1.2 Topographic Condition

The Pilot Works are proved effective for the bank condition at each site in view of the topographical monitoring including visual observation.

- (1) Ban Dongphosi site
  - Amount of sedimentation is found on the work.
  - No remarkable changes of the work are found except:
    - ✧ two (2) local scoring spots at the toe of the slope
    - ✧ local gaps between Soda mattress and riprap foundation work
  - As for the foot protection work, supply of ripraps will be effective if further deformation of the foundation work is detected through successive monitoring works.
- (2) Wat Chom Cheng site
  - Amount of sedimentation is found between groynes especially at just downstream of the groynes. No remarkable changes of the wooden piles are observed.
  - Slight inclination of wooden piles of a groyne is found presumably due to soil mass movement
  - Maximum local scouring depth: approx. 0.6 m in 2003
  - Appropriate interval of groynes will be 3 times of groyne length.
- (3) Sibounheuang Site
  - Amount of sedimentation is found on the work. No remarkable changes of the work are found.
  - Upper natural bank seems to relatively stable to have some vegetation growth on it.

### 5.1.3 Hydraulic Condition

Change in Flow velocity and direction after the Construction of the Works is summarized as follows:

- Flow velocities have become relatively small, especially at Wat Chom Cheng site due to the effect of groynes.
- Flow directions have become relatively uniform due to the effect of straightened topography.
- Main current has shifted offshore judging from velocity concentration ratio analyzed.

### 5.1.4 Vegetation Condition at Pilot Work Sites

- Execution of planting willow on the slope protection work at Ban Dongphosi Site
  - Planting method: 1) seedling in small plastic bucket, 2) stump directly planting and 3) seed sowing (Figure 5.1)
  - Willow species: 1) Khai Nun and 2) Kok Khai
- Period : Jul. 2003 - Jun. 2004
- Result: Survival rate: seedling (32.8%), stump directly (2.4%) and seed sowing (0%)

## 5.2 Vegetation Condition at Related Sites

- (1) Riverine Vegetation Survey
  - Location: 3 existing riverbank protection works and 1 natural riverbanks
  - Period: February - March 2003, December 2003 and May 2004
- Result: There were similar vegetation, annual community and gramineae community, at middle and upper layer in existing bank protection sites and natural slope. There were gramineae community and willow community at the lower layer of riverbank.
- (2) Soda Materials Collection Site for Pilot Works
  - The vegetation completely recovered as before collection at each site in a year

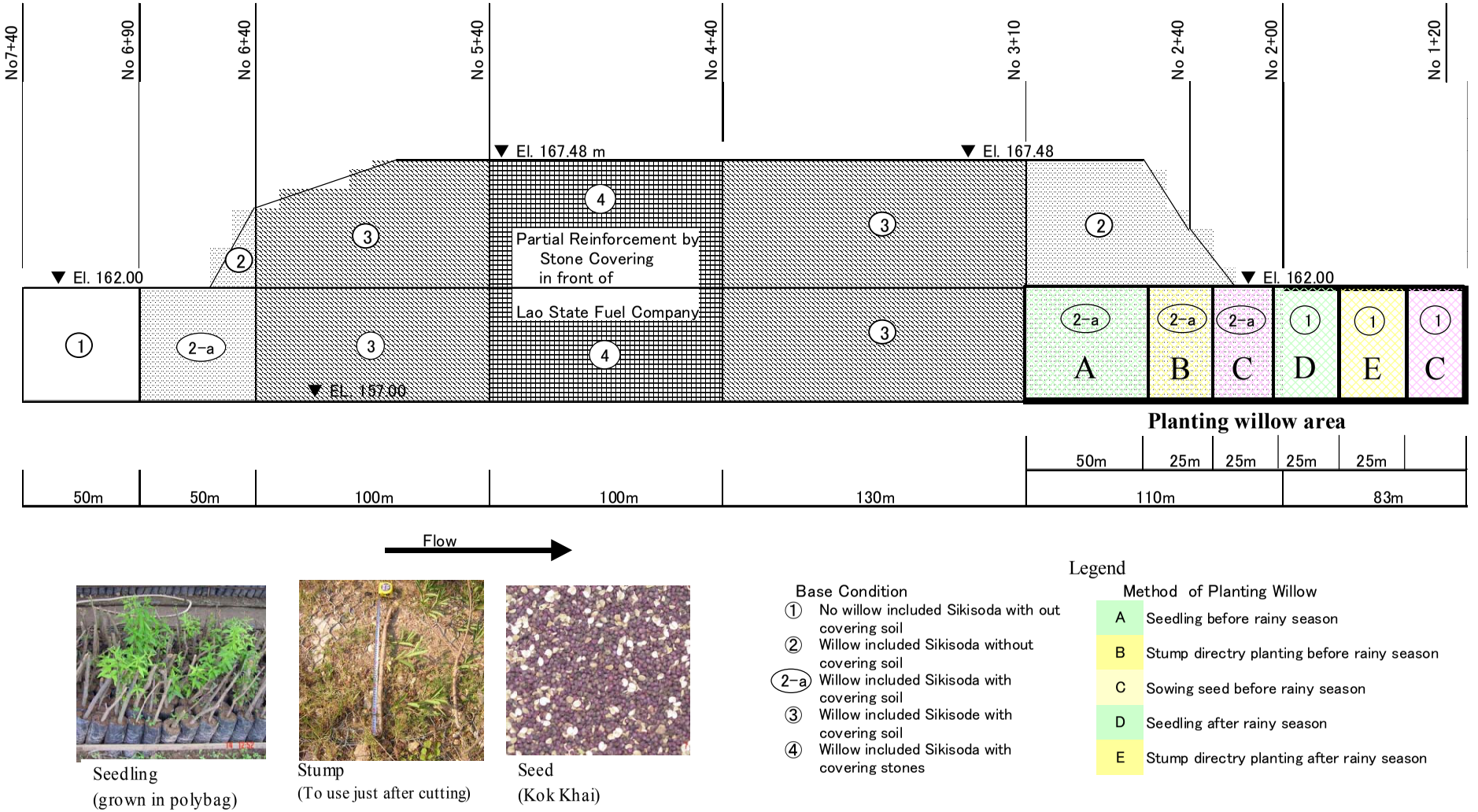



**Figure 5.1 Willow Planting Design at Ban Dongphosi Site**

# 6 RIVERBANK PROTECTION MASTER PLAN

## 6.1 Basic Framework and Principles of Master Plan

### 6.1.1 General

The Master Plan is the principles and guideline for the Mekong bank protection activities around Vientiane City:

1. to be implemented by the Government of Lao P.D.R. (GOL) by themselves using national budget in principle after 2005, and
2. introducing traditional river works of Japan in principle.

### 6.1.2 Basic Framework and Principles

The following are the basic planning frame of the Master Plan.

- Target year: 2020 corresponding to National Poverty Eradication Programme (NPEP) (GOL, 2003).
- Objective Area: Mekong riverbank around Vientiane City with L=approx. 60 km (Thadeua - Ban Ang)
- Planning Methodology:
  - Selection of high priority stretches: selected from cliffy riverbanks
  - Implementation schedule: 1) design, 2) cost estimate and 3) implementation schedule by 2020 are preliminarily prepared for the Objective Stretches to be protected, which is selected from the High Priority Stretches.
  - The extension of the Objective Stretches is determined by the followings:
    - ✧ Setting up of sustainable organization and institution
    - ✧ Type of work & cost applied to each Objective Stretches
      (low cost type is proposed according to required safety level of each site)
    - ✧ Sustainable & achievable budgetary allocation
    - ✧ Minimum resettlement (JICA Pilot Works completed with no resettlement.)
    - ✧ Resident's Participation
- Sustainable Supply of Materials
  - Soda materials: Sustainable supply with proper forest preservation proved possible through the experience of Pilot Work in 2003.
  - Quarry:
    - ✧ The following three (3) quarries have been utilized for bank protection works in recent years in the Study Area:
      - ➢ Ban Sakai permanent site (the only site under operation, 50 km from Vientiane, lime stone)
      - ➢ Nong Teng temporary site(utilized for JICA Pilot Works, sand stone)
      - ➢ Tat Thong temporary site (utilized for GOL recent works, sand stone)
    - ✧ Development of new quarry exclusive for bank protection: low feasibility in view of project scale and limited usage of sand stone
    - ✧ Selection of quarry is the option of local contractors in principle in future.
- Coordination with Relating Projects (refer to Section 2.1)
  - On-going and proposed bank protection plan/projects are principally:
    - ✧ incorporated into the Master Plan as it is, and
    - ✧ consist of a part of the Master Plan with high priority.

## 6.2 Mechanism of Bank Erosion

### 6.2.1 Geomorphologic Background

Materials forming the river channel of the Mekong River come from mainly two different sources as follows:

- Vientiane Gravel:
  - A fan-deposit transported from the Himalayas by the Mekong River during the Glacier Age.
  - The gravel would hardly be transported by the present flood flows
- Silty Sand:
  - A recent alluvial deposit of the Mekong River with the thickness 6 to 15 m.
  - The silty sand is transported by the present river flows as suspended loads.

Riverbed during the flood:

- is basically formed with the gravel
- the depth to the gravel layer is a ruling factor of depth of the river

### 6.2.2 Changes in Plan-form and Riverbank Erosion

- Changes in Plan Form of River (during past 30 years, 1961/62-1991/1992)
  - 5 islands in the Mekong River remained at almost the same places:
  - Tam Island expanded 3 to 4 times, which caused severe bank erosion at Ban Hom.
  - As for islands in the upper reaches, their sizes are almost the same.
- Recent Bank Erosion
  - The Study Area experienced historical 2nd biggest flood in August 2002.
  - Riverbanks suffering from active erosions are the cliffy banks of 1) Nahai to Sithantai, 2) Thakhek to Wat Chomthong, 3) Hatdokkeo to Bo O, and 4) Wat Muang Wa to Mekong Breeze Hotel.
  - Erosion is most active from Thakhek to Wat Chomthong, where the bank was eroded by about 25 m in 2003 and about 35 m since 2001.
  - These erosions mostly took place during the recession period of floods.
- Forecast of Progress of Erosion:
  - It is difficult to forecast because of limited data available, the following could be clarified:
    - ✧ Sites of riverbank erosion would not change so much in future, judging from small change in river plan-form in the past.
    - ✧ Recent active erosions take place in the cliffy riverbanks.

### 6.2.3 Types of Riverbanks and Coping Measures to Erosion

The riverbanks in the Study Area can be classified into four types for bank protection purpose as shown in the table below:

- Objective stretch: L= 59.24 km (Thadeua to Wat Thampha)
- 5 km from Ban Ang to Wat Thampha: not important in view of bank protection

**Classification of Types of Riverbank**

| Type | Length (Km) | Characteristics in view of bank protection |
|---|---|---|
| 1) Cliffy riverbanks | 19.18 (32%) | erosion prevails and is in most critical erosion condition with almost vertical slope with little vegetation |
| 2) Mild-slope riverbanks | 20.71 (35%) | in the condition between erosion and sedimentation and in favorable state as a whole with vegetation |
| 3) Riverbanks with sand bar and island | 16.89 (29%) | This stretches would not require specific bank protection works |
| 4) Riverbanks with exposed rocks | 2.46 ( 4%) | |
| Total | 59.24 | |

- Coping Measures for Erosion
  - Bank protection works of the Mekong River consist of following component works in general:
    - ✧ 1) foot protection works, 2) foundation works and 3) slope protection works
  - Various types of works can be conceived for the bank protection.
  - Type of works for the bank protection measure should be selected considering the type of riverbank and expected safety level as well as availability of construction materials and fund.
  - Types of riverbank and advisable combinations of the component works are summarized in the table below for reference.

**Types of Riverbank and Protection Measures**

| Items | Type-C1 bank | Type-C2 banks | Type-C3 bank |
|---|---|---|---|
| Physical Conditions | | | |
| Shape of bank | Cliffy bank | | |
| Bank materials | Silty sand (gravel bed is not seen above water surface) | Silty sand on loose gravel bed | Silty sand on consolidated gravel bed |
| River flows | Facing or contacting to the main flow of the Mekong R. | | |
| Mechanism of Bank Erosion/Failure | Scour of bank toe and erosion of slope due to attacks of river flows. | Scour of loose gravel bed at the toe of slope and erosion of slope due to attacks of river flows. | Erosion of bank slope due to attacks of river flows. |
| Typical Riverbanks in Study Area | - Upstream reaches of Ice Factory<br>- Ban Hom | - Hatdokkeo to Bo O<br>- Wat Muang Wa to Sibounheuang. | - Ban Dongphosi to Sithantai, though Type-C2 banks are found in places. |
| Coping Measures | - To protect foot of bank-slope from scour.<br>- To protect bank-slope from erosion.<br>- To reduce flow velocity near riverbank. | | - To protect bank-slope from erosion.<br>- To reduce flow velocity near riverbank. |
| Advisable Protection Works | | | |
| Important protection sites of higher safety | Cobble stone w/willow branch (LS&US)<br>+ Riprap or log-hurdle foundation + Soda mattress | Cobble stone w/willow branch (LS&US)<br>+ Riprap or log-hurdle foundation + Soda mattress | Cobble stone w/willow branch (LS&US)<br>+ Riprap foundation + Soda mattress |
| Other protection sites | 1) Cobble stone w/willow branch (LS)<br>+ Riprap or log-hurdle foundation + Soda mattress<br>2) Riprap groyne | 1) Cobble stone w/willow branch (LS)<br>+ Riprap or log-hurdle foundation + Soda mattress<br>2) Riprap groyne | Riprap groyne |

## 6.3 Selection of Objective Banks for Protection

### 6.3.1 Selection of High Priority Stretches for Protection

High Priority Stretches (L=8.77 km) are nominated for the Master Plan to be implemented by the year 2020 through a series of screening as shown below:

Unit: km

| No | Site Name | Initial Screening (General Bank Condition) | | | Secondary Screening (Vulnerability to erosion) | Tertiary Screening (Social Importance) |
|---|---|---|---|---|---|---|
| | | Cliffy bank | Existing work | Passed | Passed | Passed |
| 1) | Ban Dongphosi - Sithantai | 7.51 | 1.50 | 6.01 | 3.32 | 3.32 |
| 2) | Ban Hom | 2.61 | 0.16 | 2.45 | 2.45 | 2.45 |
| 3) | B. Hatdokkeo - u/s Bo O | 5.12 | 0.63 | 4.49 | 1.51 | 0.97 |
| 4) | Muang Wa -Kaoliao Port | 3.94 | 0.86 | 3.08 | 2.03 | 2.03 |
| | Total length | 19.18 | 3.15 | 16.03 | 9.31 | 8.77 |

### 6.3.2 Arrangements for Implementation

For the implementation of the works by the year 2020, the nominated High Priority Stretches (L=8.77 km) are further divided into two project groups as shown below, i.e.,

- Urgent Projects (L=2.70 km) to be implemented immediately considering seriousness of erosion and possible damage under the present conditions, and
- Second Priority Projects (L=6.07 km) to be implemented after the completion of the Urgent Projects.

| Site Name | Location by KM post | High Priority Stretches nominated for M/P | Length (meter) | Priority | |
|---|---|---|---|---|---|
| | | | | Urgent | 2nd Priority |
| Sithantai | From 1553+0.85km<br>To 1555+1.28km | Sithantai (1)<br>Sithantai (2) | 1,280<br>2,040 | √ | <br>√ |
| Ban Hom | From 1563+1.15km<br>To 1565+1.14km | Ban Hom (1)<br>Ban Hom (2)<br>Ban Hom (3)<br>Ban Hom (4) | 760<br>50<br>760<br>880 | √<br>√ | <br><br>√<br>√ |
| Hatdokkeo | From 1571+0.97km<br>To 1571+1.74km | Hatdokkeo | 770 | | √ |
| Bo O | From 1575+0.10km<br>To 1575+0.21km | Bo O | 200 | √ | |
| Sibounheuang - Muang Wa | From 1587+1.80km<br>To 1589+0.28km | Sibounheuang - Muang Wa | 410 | √ | |
| Upper Sibounheuang | From 1589+0.56km<br>To 1591+0.00km<br>excluding existing BP | Upper Sibounheuang (1)<br>Upper Sibounheuang (2)<br>Upper Sibounheuang (3)<br>Upper Sibounheuang (4)<br>Upper Sibounheuang (5) | 810<br>190<br>350<br>40<br>230 | | √<br>√<br>√<br>√<br>√ |
| Total | | | 8,770 | 2,700 | 6,070 |

## 6.4 Preliminary Design of Bank Protection Facilities

As for 4 sites including the proposed Urgent Projects, namely 1) Sithantai, 2) Ban Hom, 3) Sibounheuang-Muang Wa and 4) Bo-O, preliminary design of the riverbank protection facility is carried out for three (3) sites except for Bo-O.

**Design of Bo O site:** Out of 4 sites, design of Bo O site by conventional gabion type is to be prepared by "Lao-Flanders River Works Project" of MCTPC with the assistance of the Government of Belgium (GOB) and is incorporated into the Master Plan as it is.

### 6.4.1 Condition of Objective Sites

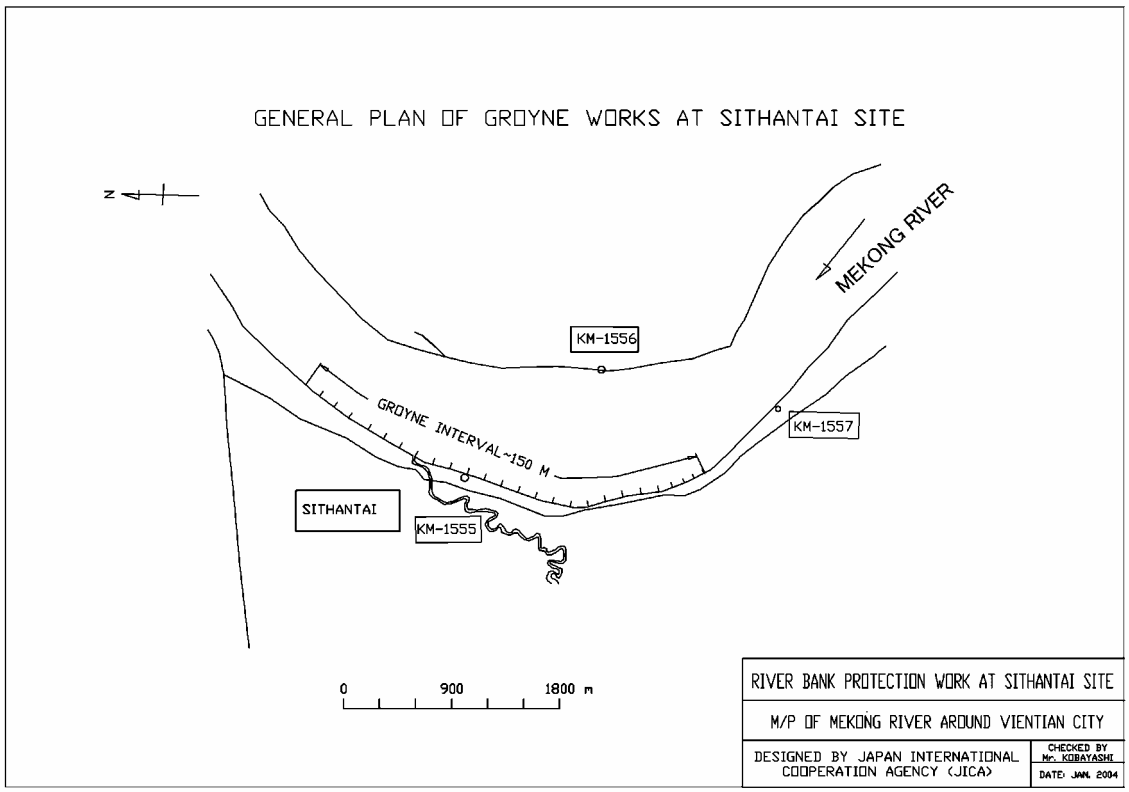
Condition of 3 sites is summarized as below:

| Item | Site Name | | |
|---|---|---|---|
| | 1) Sithantai | 2) Ban Hom | 3) Sibounheuang-Muang Wa |
| Total length | 3,320m | 2,450m | 410m |
| Conditions of river bank slope | Upper vertical cliff and lower slopes of relatively new aged silt layer on the layer of gravel and silt mixture. Both are vulnerable to erosion | Vertical high cliff of relatively new aged silt layer on the layer of gravel and silt mixture. Both are vulnerable to erosion | Vertical cliff of relatively old aged silt layer on the layer of gravel and silt mixture. Lower layer is vulnerable to erosion |
| Type of erosion | Falling of cliff material accompanied with setback of lower layer of gravel and silt that is vulnerable to scoring during flood period. | | Falling of cliff material as block undermined through lower layer of gravel and silt forming notches at the foot of slope during flood period. |
| Protection principle | To reduce erosion at lower gravel and silt mixture layer. | To protect not only lower gravel and silt mixture layer, but upper silt layer. | To protect the lower gravel and silt mixture layer |

### 6.4.2 Preliminary Design

Outline of the design for 3 sites is as shown below. General layout and typical cross section are as shown in Figure 6.1.

| Site Name | Type of Construction Work |
|---|---|
| 1) Sithantai | Riprap groyne work<br>(L=50 m, Interval=150 m, Height=4.5m - 2.0 m) |
| 2) Ban Hom | <Type A> (low dense riverine land use)<br>1) Slope protection work (Cobble stone with willow branch work covering lower half of the cliffy bank for cost reduction)<br>2) Foundation work (Riprap work)<br>3) Foot protection work (Soda mattress work "in every others" for cost reduction) |
| | <Type B> (in front of Wat Thong that)<br>1) Slope protection work (Cobble stone with willow branch work)<br>2) Foundation work (Riprap work)<br>3) Foot protection work (Soda mattress work) |
| 3) Sibounheuang-Muang Wa | 1) Slope protection work (Cobble stone with willow branch work)<br>2) Foundation work (Log-hurdle work)<br>3) Foot protection work (Soda mattress work) |



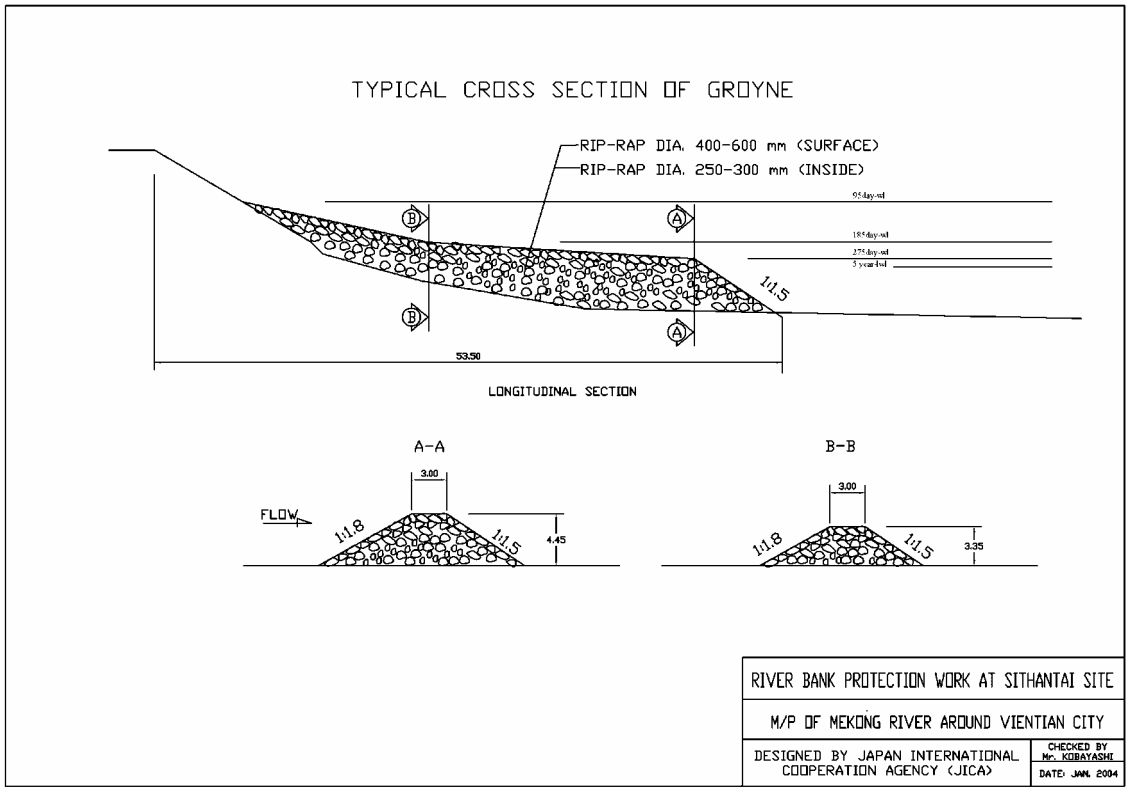




**Figure 6.1 (1/4) Preliminary Design of Riverbank Protection Works**
(Sithantai Site)

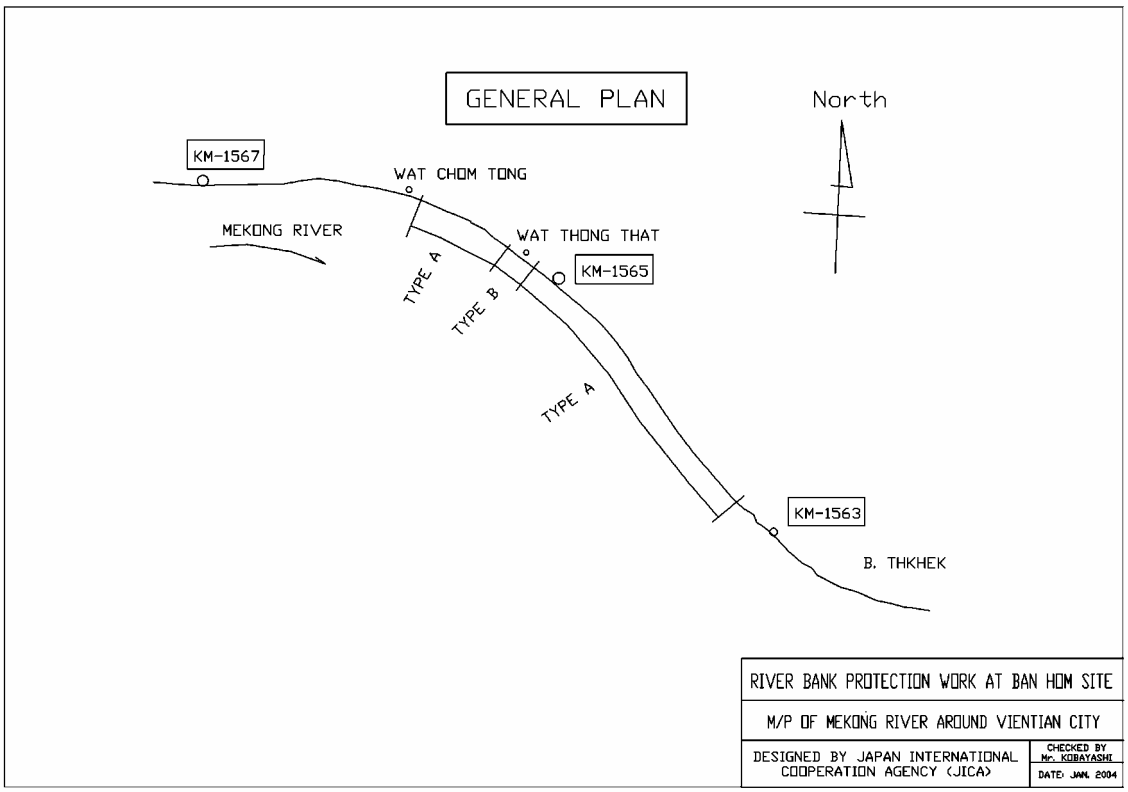
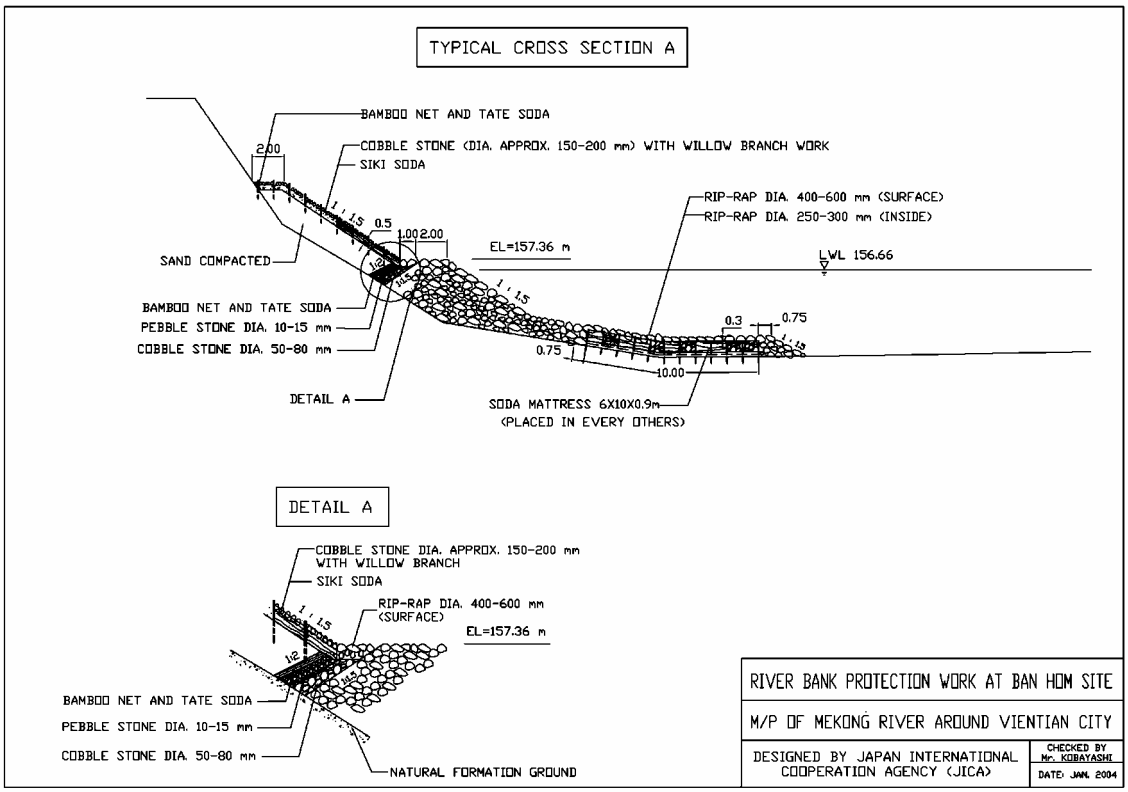
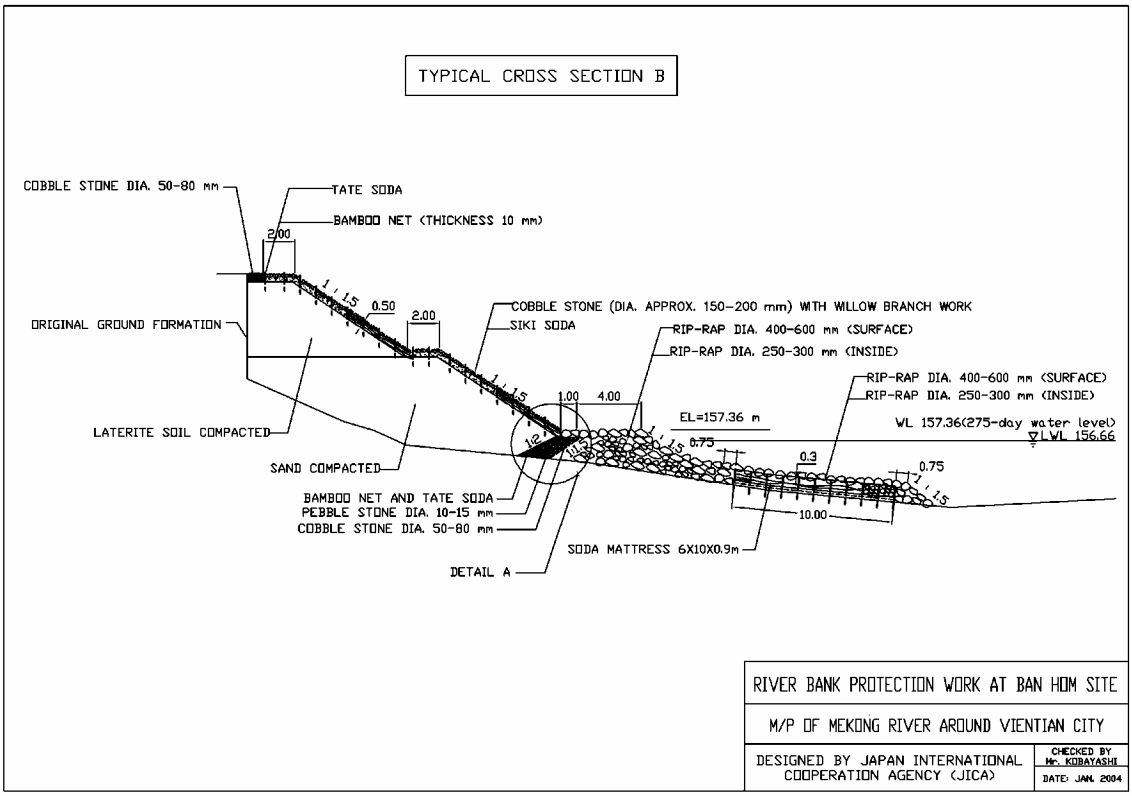



**Figure 6.1 (2/4) Preliminary Design of Riverbank Protection Works**
(Ban Hom Site (1/2))




Cross-Section (Type A)




Cross-Section (Type B)

**Figure 6.1 (3/4) Preliminary Design of Riverbank Protection Works**
(Ban Hom Site (2/2))

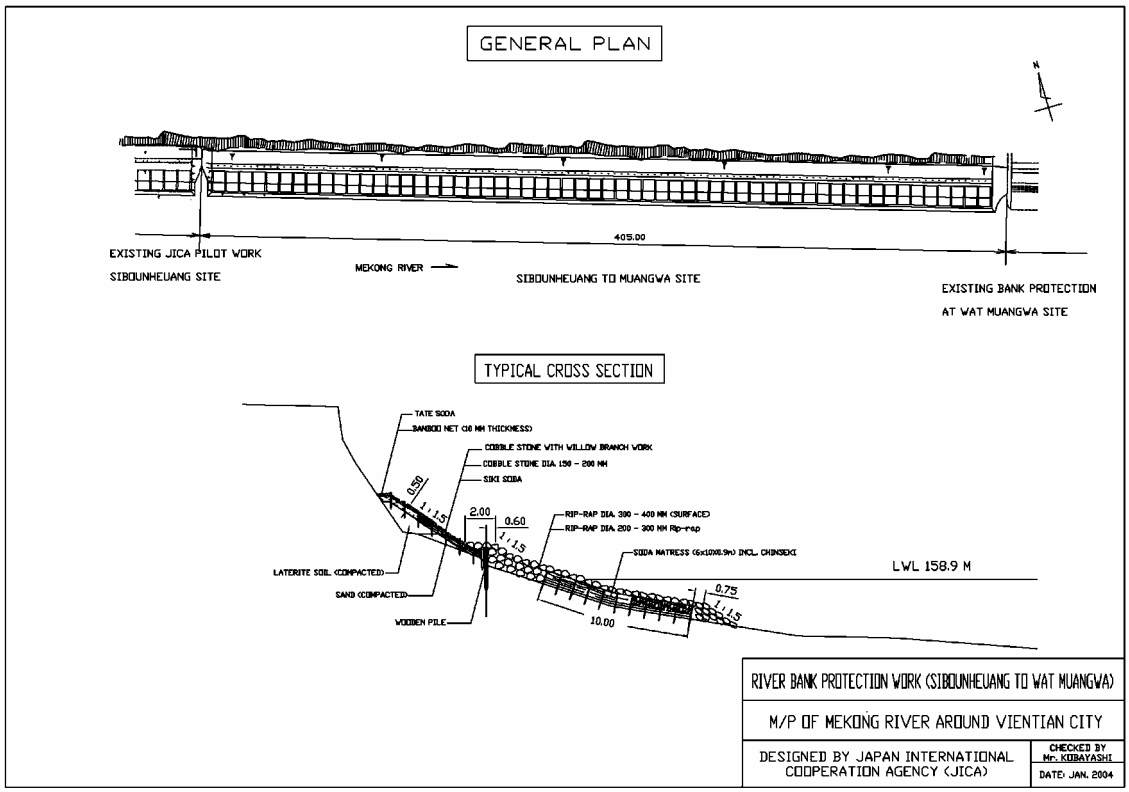



**Figure 6.1 (4/4) Preliminary Design of Riverbank Protection Works**
(Sibounheuang - Muang Wa Site)

## 6.5 Institution and Organization

### 6.5.1 Set up of New Permanent Organization

The Study office in MCTPC is temporarily one on a project basis and will be closed after the Study completion in December 2004. "Mekong Riverbank Protection Unit (tentative name)" as new permanent organization for riverbank protection should be established in MCTPC:

- to realize sustainable implementation of the project proposed by the Master Plan, and
- as the preparation to receive possible future donor's technical assistance after year 2005 to assist the implementation.

### 6.5.2 Human Resources Arrangement

Proper human resources arrangement to the New Organization is one of the crucial preconditions for the success of sustainable implementation of the Master Plan projects. Present MCTPC counterpart personnel for the Study shall be the core of the New Organization especially in the early stage of the implementation.

### 6.5.3 Human Resources Development

Continuous human resources development is also the essentials to transfer knowledge on river bank protection from one generation to the next in GOL. The following activities by MCTPC will be necessary for the human resources development:

- Proper arrangement of new employees to the New Organization
- Practical training of the new employees
- Development of the teaching material for the training
- Various public education to disseminate the information on the importance of the river bank protection and for future recruitment as follows:
  - Receiving the trainee from various educational institutions to New Organization
  - Making lectures and having seminar at various educational institutions and relating agencies by the New Organization staff and the experts of donors

## 6.6 Non-structural Measures of the Master Plan

### 6.6.1 Public Awareness Campaign

- Launching a campaign by GOL to educate the population of Vientiane City on the importance:
  - to protect riverbank from erosion, and
  - to create environmental friendly riparian zone by nature-oriented works.
- Public relations using media (newspaper/TV) should be continued and expanded.
- Prior to the construction of the Master Plan projects, GOL should ask representatives of local residents at each project site to understand the contents and importance of the works.

### 6.6.2 People's Involvement

- It is virtually impossible for GOL to protect throughout the Cliffy riverbanks (16.03 km) owing mainly budgetary limitation; length of Master Plan projects is 7.38 km in total (refer to Section 6.9).
- An approach "planting willow" is also essential by simple vegetation work only by manpower of local residents introducing Soda technique.
- GOL support and train local community leaders, provide guidance and information

### 6.6.3 Riparian Land Use Regulation

- in accordance with the principles proposed by revised "Vientiane Urban Development Master Plan" (URI-MCTPC, 2003) as follows:
  - Construction of new building & heavy weight facilities is not allowed in principle except for light weight public facilities.
  - Present resident can live as usual except for GOL require resettlement for bank protection works.
    - ✧ Target of JICA Master Plan = 0 resettlement
  - Temple and cultural assets should be preserved as it is.
- Riverbank area (L=20 km) along city center is categorized as riverside area in above plan.

### 6.6.4 Preservation and Planting of Riparian Trees

- The riparian trees should be preserved as much as possible
  - unless caused negative impact to riverbank stability
  - for example, trees hanging down from the edge of riverbank.
- Shade of trees can protects bank soil from drying and helps plant grows on the bank.
- Planting trees on riverbank is recommended.
- Future ideal riverbank image: attractive greenbelt for local residents & foreign tourist.

### 6.6.5 Monitoring and Maintenance System

- Early diagnosis is of great importance in riverbank protection.
- Regular visual inspection of natural riverbank and existing protection works in a dangerous condition
- Regular monitoring and maintenance of the Pilot Works by GOL after 2005
  - Period: 5 years after the completion in 2003, i.e. 2008, until the vegetation and sedimentation on the works is stabilized
  - The monitoring is essential:
    - ✧ to detect damaged portion and rehabilitate in earliest stage
    - ✧ to localize traditional river works of Japan to Lao P.D.R.
  - Wat Chom Cheng Site (real test work): inspection is continued without any rehabilitation work unless unforeseen erosion
- Monitoring cross-sectional survey on riverbed fluctuation
  - Objective: to reflect the result for the design of the projects by GOL
  - Location: Sithantai, Ban Hom and Sibounheuang - Muang Wa site
  - Program: 1time at each site (3-4 surveys during the rainy season)

## 6.7 Preliminary Estimation of Project Cost

### 6.7.1 Material and Equipment

- 1) Specification of materials (as shown in the table below), 2) procurement, 3) equipment: in accordance with these applied for the Pilot Works. (All material and equipment can be procured in Laos.)

| Item | Specification | Unit |
|---|---|---|
| **Soda Mattress** | | |
| Soda | Length: 2.7m, 45cm rise peripheral: 60cm<br>200cm rise peripheral:55cm | bundle |
| Taisya | Length:2.7m, φ2～3cm at butt end<br>φ1.0 cm at 2.7m rise, 25 twigs per bundle | bundle |
| Kogui (Short Pile) | Length: 1.2m,φ3～5cm at butt end | pieces |
| Rubble stones | φ400～200 mm, φ150～50 mm | $m^3$ |
| Straw rope | φ10 mm | m |
| Zinc-coated whip | 10# & 12# | m |
| **Log Hurdle Work** | | |
| Wooden pile | Length:3 – 4.0 m, tip end:φ15 cm (primary pile)<br>Length:3.5m, tip end:φ9cm (secondary pile) | piece |
| Bolt | L=30 cm, d=13 mm | unit |
| Nail | L=15 cm | kg |
| Back rubble stone | φ150～50 mm | $m^3$ |
| **Embankment Work** | | |
| River sand & Gravel | Procured from pit in the Mekong river | $m^3$ |
| Laterite | Procured from borrow area | $m^3$ |
| **Foundation Riprap Work** | | |
| Rubble | φ200～150 mm (riprap), φ400～200 mm (deposition) | $m^3$ |
| Bamboo net | B=2.5 m L=1.0 m | $m^2$ |
| **Slope Protection Work** | | |
| Soda | L=3.0 m, S=0.7 m | bundle |
| Taisya | L=3.0 m, 1 bundle =25 unit | bundle |
| Kogui (Short Pile) | L=1.2 m, φ=4 cm | unit |
| Willow | L=1.2 m, S=0.9 m (collected from the Mekong River) | bundle |
| Pebble | φ=150 – 200 mm | $m^3$ |
| **Piling (Groyne) Work** | | |
| Wooden pile | Length:4.0 – 6.0 m, tip end>φ15 cm | piece |
| Tie-beam | L=3.2 m, tip end>φ9cm | piece |
| Bolt | L=30 cm, d=13 mm | piece |

- Unit cost (material, equipment rental, major work) for the cost estimate is in accordance with these utilized for the Pilot Works in 2003 inprinciple.

### 6.7.2 Pleliminary Project Cost

Bank protection type and estimated project cost at 14 projects nominated for the Master Plan is as shown below:

| Phasing by Priority | Urgent Projects | | | | | Second Priority Projects | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stretch No. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Project Name | Sithantai | Ban Hom | | Bo O | Sibounheuang-Muang Wa | Sithantai | Ban Hom | | Hatdokkeo | Upper Sibounheuang | | | | |
| Project No. | (1) | (1) | (2) | Bo O | Sibounheuang-Muang Wa | (2) | (3) | (4) | Hatdokkeo | (1) | (2) | (3) | (4) | (5) |
| Stretch Length (meters) | 1280 | 760 | 50 | 200 | 410 | 2040 | 760 | 880 | 770 | 810 | 190 | 350 | 40 | 230 |
| Bank Protection Type | | | | | | | | | | | | | | |
| CSWB-Work (A) | | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | ○ | ○ |
| CSWB-Work (B) | | | ○ | | | | | | | | | | | |
| LH-Work | | | | ○ | ○ | | | | | ○ | ○ | ○ | ○ | ○ |
| SF-Work | | ○ | ○ | | | | ○ | ○ | | | | | | |
| SM-Work | | ○ | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | ○ | ○ |
| RG-Work | ○ | | | | | ○ | | | ○ | | | | | |
| Unit: US$ | | | | | | | | | | | | | | |
| Construction Cost (A) | 228,410 | 914,000 | 61,360 | 139,070 | 272,110 | 363,070 | 914,000 | 1,105,690 | 141,730 | 528,310 | 129,570 | 233,940 | 34,690 | 163,410 |
| Administration Cost (B) | 11,420 | 45,700 | 3,060 | 6,950 | 13,600 | 18,150 | 45,700 | 55,280 | 7,080 | 26,410 | 6,470 | 11,690 | 1,730 | 8,170 |
| Project Cost (US$) | 240,000 | 960,000 | 65,000 | 147,000 | 286,000 | 382,000 | 960,000 | 1,161,000 | 149,000 | 555,000 | 137,000 | 246,000 | 37,000 | 172,000 |

NOTE: CSWB-Work (A): Cobble Stone with Willow Branch Work, Type (A)
CSWB-Work (B): Cobble Stone with Willow Branch Work, Type (B)
LH Work: Log Hurdle Work
SF-Work: Stone Foundation Work
SM-Work: Soda Mattress Work
RG-Work: Riprap Groyne Work

**Bo O project:** the design is to be prepared by on-going Lao-Flanders River Works Project of MCTPC with the assistance of the GOB. Therefore, work type concept of the Master Plan is temporarily applied for the cost estimate instead.

## 6.8 Alternative Study

### 6.8.1 Work Type Alternatives

Work type is selected considering the following criteria; some of Japanese traditional river works satisfied the criteria:

- using local construction material/ manpower as much as possible
- construction can be done by the manpower of Laotian as much as possible
- pay attention to keep and/or create better riparian environment
- without using imported materials; gabion mattress and concrete block are excluded from the selection

"Priority 1" shown below is selected as the most suitable work type for each sites by comparing candidate types with respect to various factors such as strength, easiness of material collection, construction cost, etc. The preliminary design is conducted according to this result.

| Site Name | Candidate Type of Construction Work | Priority |
|---|---|---|
| Sithantai | Cobble stone with willow branch work + Riprap foundation + Soda mattress work | 2 |
| | Wooden pile groyne work | 3 |
| | Riprap groyne work<br>(main river flow is shifted away from the riverbank with low cost at low dense riverine land use) | 1 |
| Ban Hom | Cobble stone with willow branch work + Log-hurdle work + Soda mattress work | 3 |
| | Cobble stone with willow branch work + Riprap foundation + Soda mattress work<br>(less impact to the opposite bank , Don Tam island (Thai territory), comparing with groyne type) | 1 |
| | Riprap groyne work | 2 |
| Sibounheuang -Muang Wa | Cobble stone with willow branch work + Log-hurdle work + Soda mattress work<br>(similar work type with that the adjacent JICA Pilot Work) | 1 |
| | Cobble stone with willow branch work + Riprap foundation + Soda mattress work | 2 |
| | Riprap groyne work | 3 |

### 6.8.2 Financial Alternatives

"Alternative 3" is selected as the most appropriate plan from the table shown below:

| | Unit | Alternative 1 | Alternative 2 | **Alternative 3** | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|
| 1.Base Year Budget (FY2003/04) | M Kip | 2,800<br>Calculated budget to complete all the priority stretches by 2020 | 2,300<br>MCTPC's investment plan for riverbank protection around Vientiane City in FY2003/04. | 2,300<br>MCTPC's investment plan for riverbank protection around Vientiane City in FY2003/04. | 2,300<br>MCTPC's investment plan for riverbank protection around Vientiane City in FY2003/04. | 1,000<br>Actual average investment by national budget for ban protection around Vientiane City for last 4 years. |
| 2. Budget in the 1st Year of the M/P (FY2004/05) | M Kip | 3,000<br>7% increase from FY2003/04 | 2,450<br>6.5% increase from FY2003/04 based on NPEP | 2,445<br>6.3% increase from FY2003/04 | 2,392<br>4% increase from FY2003/04 | 1,063<br>6.3% increase from FY2003/04 |
| 3. Growth rate of budget from FY2004/05 to FY2019/20 | % | 7<br>Economic development target of the country for 2020 stated in National Poverty Eradication Programme (NPEP) | 7 | 6.3<br>Average annual economic growth rate for the last 10 years | 4<br>The lowest annual economic growth rate for the last 10 years | 6.3<br>Average annual economic growth rate for the last 10 years |
| 4. Project Cost | US$1,000 | 5,497 | 5,176 | **4,893** | 3,634 | 1,698 |
| 5. Length of BP | km | 8.77 | 7.77 | **7.38** | 5.95 | 2.70 |
| 1) Urgent project | km | 2.70 | 2.70 | **2.70** | 2.70 | 2.70 |
| 2) 2nd priority proj. | km | 6.07 | 5.07 | **4.68** | 3.25 | 0.00 |

The remaining 4 Second Priority Projects, Hatdokkeo and Upper Sibounheuang (3), (4) and (5) are to be implemented after FY 2020/2021

## 6.9 Proposed Master Plan

The outline of the proposed Master Plan (Financial Alternative 3) is as follows:

- Total Project cost (national budget in principle): US$4.89 million (Alternative 3)
- Total length of 10 Master Plan projects: 7.38 km
  - Five (5) Urgent Projects: 2.70 km
  - Five (5) Second Priority Projects: 4.68 km
- Implementation Schedule: 16-year (2005-2020)

- The basic features and the general layout of the Master Plan are as shown in Figure 6.2 and as follows:

| Phase | Site Name | Project Name | Location by KM post (km) | | Length | Project Cost | Implementation | Riverbank Protection Type | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From | To | (meter) | (US$1,000) | Fiscal Year | CSWB(A) | CSWB(B) | LH | SF | SM | RG |
| Urgent Projects | Sithantai | Sithantai (1) | 1555+0.00 | 1555+1.28 | 1,280 | 240 | 2006/07-2010/11 | | | | | | ○ |
| | Ban Hom | Ban Hom (1) | 1565+0.38 | 1565+1.14 | 760 | 960 | 2007/08-2011/12 | ○ | | | ○ | ○ | |
| | | Ban Hom (2) | 1565+0.33 | 1565+0.38 | 50 | 65 | 2006/07 | | ○ | | ○ | ○ | |
| | Bo O | Bo O | 1575+0.01 | 1575+0.21 | 200 | 147 | 2005/06-2007/08 | ○ | | ○ | | ○ | |
| | Sibounheuang - Muang Wa | Sibounheuang - Muang Wa | 1587+1.80 | 1589+0.28 | 410 | 286 | 2004/05-2005/06 | ○ | | ○ | | ○ | |
| | Sub-total | | | | 2,700 | 1,698 | | | | | | | |
| 2nd Priority Projects | Sithantai | Sithantai (2) | 1553+0.85 | 1555+0.00 | 2,040 | 382 | 2011/12-2015/16 | | | | | | ○ |
| | Ban Hom | Ban Hom (3) | 1563+2.03 | 1565+0.33 | 760 | 960 | 2012/13-2015/16 | ○ | | | ○ | ○ | |
| | | Ban Hom (4) | 1563+1.15 | 1563+2.03 | 880 | 1161 | 2016/17-2019/20 | ○ | | | ○ | ○ | |
| | Upper Sibounheuang | Upper Sibounheuang (1) | 1590+0.25 | 1591+0.00 | 810 | 555 | 2016/17-2019/20 | ○ | | ○ | | ○ | |
| | | Upper Sibounheuang (2) | 1590+0.02 | 1590+0.21 | 190 | 137 | 2018/19-2019/20 | ○ | | ○ | | ○ | |
| | Sub-total | | | | 4,680 | 3,195 | | | | | | | |
| | Total | | | | 7,380 | 4,893 | | | | | | | |

Note:- Project cost is estimated on the price level at the beginning of February 2004.
- Applied foreign currency exchange rate: US$1=Lao Kip 10,420 (Middle rate on February 1, 2004)
- Project cost does not include price escalation.
- Riverbank Protection Types:

| | | | |
|---|---|---|---|
| CSWB(A) | Cobble Stone with Willow Branch covering lower bank (A) | SF | Stone Foundation |
| CSWB(B) | Cobble Stone with Willow Branch covering whole bank (B) | SM | Soda Mattress |
| LH | Log Hurdle | RG | Riprap Groyne |
| SF | Stone Foundation | | |
| SM | Soda Mattress | | |
| RG | Riprap Groyne | | |

-Bo o site Design to be prepared by On-going Lao-Flanders River Work Projects of MCTPC in future.
Therefore, work type concept of the Master Plan is temporarily applied for the preliminariliy cost estimate at the site instead.

- Basic principles of protection measures of the Master Plan are as follows:

| Type of Riverbank | Classification of Cliffy riverbanks | Length (km) | Principles of Bank Protection Measures |
|---|---|---|---|
| 1)Cliffy Riverbanks | Existing riverbank protection works | 3.15 (5.3%) | This stretches is to be monitored and rehabilitated if necessary by GOL (O&M). |
| | Objective stretches for Urgent Projects of M/P | 2.70 (4.6%) | *This stretches is to be implemented by GOL from 2004/2005 to 2011/2012. |
| | Objective stretches for Second Priority Projects of M/P | 4.68 (7.9%) | *This stretches is to be implemented by GOL from 2011/2012 to 2019/2020.<br>*This stretches would also be protected by people's involvement as the need arises until the start of the Projects by GOL at each sites. |
| | Remaining Stretches including 4 Second Priority Projects to be implemented after 2020/2021 | 8.65 (14.6%) | *This stretches is to be protected by GOL after 2020/2021<br>*This stretches would be protected by people's involvement as the need arises. |
| Sub-total | 19.18 (32.4%) | | |
| 2)Mild-slope riverbanks | 20.71 (35.0%) | | This stretches with no active erosion in general would be protected by people's involvement as the need arises. |
| 3) Riverbanks with sand bar and island | 16.89 (28.5%) | | These stretches would not require specific bank protection activities. |
| 4) Riverbanks with exposed rocks | 2.46 (4.2%) | | |
| Total | 59.24(100%) | | |

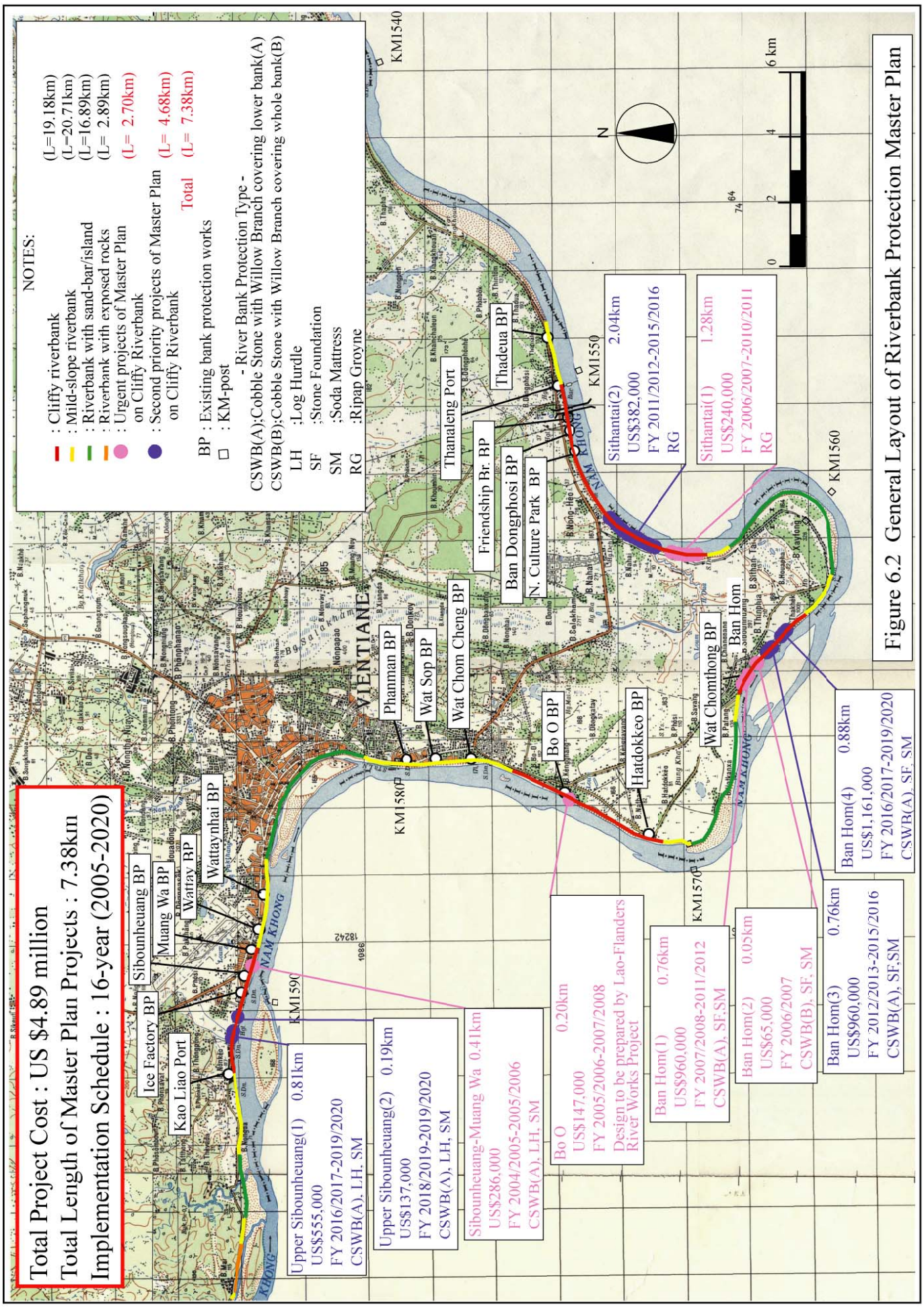



Figure 6.2 General Layout of Riverbank Protection Master Plan

- As a selection guideline of the M/P construction method, the combination of construction methods and its reason for application in consideration of mechanism of bank erosion and situation of the property distributed on eroded riverbanks is shown in the following table:

| Property and land use situation on cliffy bank | Typical M/P project sites | Mechanism of bank erosion | Construction method combination and the reason for application | | | Note |
|---|---|---|---|---|---|---|
| | | | Foot protection work | Foundation work | Slope protection work | |
| High density of properties (important property, such as factory, national road, temple and public facilities) | -Wat Thong That (Ban Hom)<br>-Bo O temple | Falling of cliff material accompanied with setback of lower layer of gravel and silt that is vulnerable to scoring during flood period | Soda mattress work<SM><br><br>[Reason]<br>-Executable by using only local material and equipment<br>-Mattress are so flexible, that they can change the form and follow the riverbed changes<br>-Environmental friendly by using natural material | Riprap work <SF><br><br>[Reason]<br>To protect foot of slope firmly united with foot protection work | Cobblestone with willow branch work <CSWB(B)> (covering whole bank to secure high safety level taking the importance of property into consideration)<br>[Reason]<br>-Executable by using only local material and equipment<br>-Adaptable to gentle slope river as the M/P area<br>-Environmental friendly by using natural material | -Applied for the Pilot Woks for oil stockyard at Ban Dongphosi<br>-Design at Bo O temple was already prepared using conventional gabion with the assistance of the Government of Belgium |
| Middle density of properties (Although private houses in urban area is distributed, there are relatively little important properties) | -Bo O<br>-Sibounheuang ~Muang Wa<br>-Upper Sibounheuang | Falling of cliff material as block undermined through lower layer of gravel and silt forming notches at the foot of slope during flood period | | Log hurdle work<LH><br><br>[Reason]<br>lower cost by using less riprap than stone foundation | Cobblestone with willow branch work <CSWB(A)> (covering lower half of the cliffy bank to lower construction cost in consideration of the balance between safety level and density of property)<br><br>[Reason]<br>-as above<br>-capable of stabilizing upper cliffy bank by prevention of scouring based on covering lower bank | Applied for the Pilot Works at Sibounheuang |
| Low density of properties (peripheral part of important facilities, or farmland with low dense distribution of houses) | Ban Hom | Falling of cliff material accompanied with setback of lower layer of gravel and silt that is vulnerable to scoring during flood period | Soda mattress work<SM> (installed in every others for cost reduction taking the balance of safety level and the property density into consideration)<br><br>[Reason]<br>as above | Stone foundation work<SF><br><br>[Reason]<br>difficulty of construction because of the relation between bank topography and river water level | | -Applied for the Pilot Works at peripheral part of Ban Dongphosi site<br>-Applied as alternative of riprap groyne to avoid the influence of groyne to opposite bank due to narrow river width |
| | Sithantai | | Riprap groyne work<RG> | | | This method was not tested in the Pilot Works. |

## 6.10 Project Evaluation

### 6.10.1 Economic Evaluation

The riverbank protection along the Mekong River is given the status of an indispensable public investment to conserve national land, to maintain the border, and to protect Buddhist temples which is an integral part of people's life.

The Master Plan projects have direct economic benefit to save US$9.9 million or 66% comparing with that by the conventional gabion works for GOL. Average construction costs of the works proposed in the Master Plan and conventional gabion works implemented around Vientiane City is as follows:

| | Construction Method | Average Construction Cost (US$/meter) |
|---|---|---|
| 1. | Conventional Gabion Works implemented around Vientiane City | 2,000 |
| 2. | Work Types proposed in the Master Plan | |
| (1) | Riprap groyne work (L=50m, interval=150m) | 190 |
| (2) | 1) Cobble stone with willow branch work covering whole bank, 2) stone foundation and 3) soda mattress | 1,300 |
| (3) | 1) Cobble stone with willow branch work covering lower bank, 2) stone foundation and 3) soda mattress (in every other) | 1,290 |
| (4) | 1) Cobble stone with willow branch work covering lower bank, 2) log hurdle work and 3) soda mattress | 700 |
| 3. | JICA Pilot Works (Reference) | |
| (1) | Ban Dongphosi Site <1) Cobble stone with willow branch work covering whole bank, 2) stone foundation and 3) soda mattress> | 1,690 |
| (2) | Wat Chom Cheng Site <Wooden pile groyne work> | 200 |
| (3) | Sibounheuang Site <1) Cobble stone with willow branch work covering lower bank, 2) log hurdle work and 3) soda mattress> | 810 |

The Master Plan projects will create new job opportunities equivalent to cash income of US$77,000 during construction works as follows:

| | New Job Opportunity (man-day) | | |
|---|---|---|---|
| | Urgent Projects | 2nd Priority Proj. | Total |
| 1. Skilled labor | 2,200 | 4,000 | 6,200 |
| 2. Unskilled labor | 8,800 | 16,000 | 24,800 |
| Total | 11,000 | 20,000 | 31,000 |

### 6.10.2 Initial Environmental Examination

IEE of 4 sites including the Master Plan project sites proves that the projects have no serious environmental impact potentially as follows, since the projects create better riparian environment:

- During construction stage: Most of check items are evaluated D (no impact).
- Operation/maintenance stage: Most of check items are evaluated D (no impact)

### 6.10.3 Overall Evaluation

The proposed Master Plan is evaluated feasible, sustainable and appropriate from the technical, financial, economical and environmental viewpoint.

## 6.11 Implementation Schedule

The proposed implementation schedule and investment & budgeting plan of the Master Plan is presented in Figure 6.3 and Table 6.1, respectively.

| Project | Length (m) | Implementation (meters) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2004/05 | 2005/06 | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 |
| **I. Implementation** | | | | | | | | | | | | | | | | | |
| **1. Urgent Projects** | | | | | | | | | | | | | | | | | |
| (1) Sithantai (1) | 1,280 | | | 250 | 250 | 260 | 260 | 260 | | | | | | | | | |
| (2) Ban Hom (1) | 760 | | | | 110 | 160 | 160 | 160 | 170 | | | | | | | | |
| (3) Ban Hom (2) | 50 | | | 50 | | | | | | | | | | | | | |
| (4) Bo O | 200 | | 60 | 70 | 70 | | | | | | | | | | | | |
| (5) Sibounheuang-Muang Wa | 410 | 200 | 210 | | | | | | | | | | | | | | |
| Sub-total of 1 | 2,700 | 200 | 270 | 370 | 430 | 420 | 420 | 420 | 170 | - | - | - | - | - | - | - | - |
| **2. Second Priority Projects** | | | | | | | | | | | | | | | | | |
| (6) Sithantai (2) | 2,040 | | | | | | | | 400 | 400 | 400 | 400 | 440 | | | | |
| (7) Ban Hom (3) | 760 | | | | | | | | | 190 | 190 | 190 | 190 | | | | |
| (8) Ban Hom (4) | 880 | | | | | | | | | | | | | 220 | 220 | 220 | 220 |
| (9) Hatdokkeo | | To be implemented after FY2020/21 | | | | | | | | | | | | | | | |
| (10) Upper Sibounheuang (1) | 810 | | | | | | | | | | | | | 200 | 200 | 200 | 210 |
| (11) Upper Sibounheuang (2) | 190 | | | | | | | | | | | | | | | 90 | 100 |
| (12) Upper Sibounheuang (3) | | To be implemented after FY2020/21 | | | | | | | | | | | | | | | |
| (13) Upper Sibounheuang (4) | | | | | | | | | | | | | | | | | |
| (14) Upper Sibounheuang (5) | | | | | | | | | | | | | | | | | |
| Sub-total of 2 | 4,680 | - | - | - | - | - | - | - | 400 | 590 | 590 | 590 | 630 | 420 | 420 | 510 | 530 |
| Total (1+2) | 7,380 | 200 | 270 | 370 | 430 | 420 | 420 | 420 | 570 | 590 | 590 | 590 | 630 | 420 | 420 | 510 | 530 |
| **II. Maintenance works** | | | | | | | | | | | | | | | | | |

**Figure 6.3 Implementation Schedule of Master Plan**

**Table 6.1 Investment and Budgeting Plan of Master Plan**

| Project | Total Cost (US$1,000) | Length (m) | Annual Investment (US$1,000) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2004/05 | 2005/06 | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 |
| I. Investment Plan | | | | | | | | | | | | | | | | | | |
| 1. Urgent Projects | | | | | | | | | | | | | | | | | | |
| (1) Sithantai (1) | 240 | 1,280 | - | - | 47 | 47 | 49 | 49 | 48 | - | - | - | - | - | - | - | - | - |
| (2) Ban Hom (1) | 960 | 760 | - | - | - | 139 | 202 | 202 | 202 | 215 | - | - | - | - | - | - | - | - |
| (3) Ban Hom (2) | 65 | 50 | - | - | 65 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (4) Bo O | 147 | 200 | - | 44 | 51 | 52 | - | - | - | - | - | - | - | - | - | - | - | - |
| (5) Sibounheuang-Muang Wa | 286 | 410 | 140 | 146 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sub-total of 1 | 1,698 | 2,700 | 140 | 190 | 163 | 238 | 251 | 251 | 250 | 215 | - | - | - | - | - | - | - | - |
| 2. Second Priority Projects | | | | | | | | | | | | | | | | | | |
| (6) Sithantai (2) | 382 | 2,040 | - | - | - | - | - | - | - | 75 | 75 | 75 | 75 | 82 | - | - | - | - |
| (7) Ban Hom (3) | 960 | 760 | - | - | - | - | - | - | - | - | 240 | 240 | 240 | 240 | - | - | - | - |
| (8) Ban Hom (4) | 1,161 | 880 | - | - | - | - | - | - | - | - | - | - | - | - | 290 | 290 | 290 | 291 |
| (9) Hatdokkeo | | | To be implemented after FY2020/21 | | | | | - | - | - | - | - | - | - | - | - | - | - |
| (10) Upper Sibounheuang (1) | 555 | 810 | - | - | - | - | - | - | - | - | - | - | - | - | 137 | 137 | 137 | 144 |
| (11) Upper Sibounheuang (2) | 137 | 190 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 65 | 72 |
| (12) Upper Sibounheuang (3) | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (13) Upper Sibounheuang (4) | | | To be implemented after FY2020/21 | | | | | - | - | - | - | - | - | - | - | - | - | - |
| (14) Upper Sibounheuang (5) | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sub-total of 2 | 3,195 | 4,680 | - | - | - | - | - | - | - | 75 | 315 | 315 | 315 | 322 | 427 | 427 | 492 | 507 |
| Sub-total (1+2) | 4,893 | 7,380 | 140 | 190 | 163 | 238 | 251 | 251 | 250 | 290 | 315 | 315 | 315 | 322 | 427 | 427 | 492 | 507 |
| 3. Maintenance & repair | | | 20 | 20 | 21 | 22 | 22 | 22 | 22 | 24 | 28 | 28 | 28 | 28 | 35 | 35 | 35 | 35 |
| Total (1+2+3) | | | 160 | 210 | 184 | 260 | 273 | 273 | 272 | 314 | 343 | 343 | 343 | 350 | 462 | 462 | 527 | 542 |
| II. Budgeting Plan (Million Kip) | | | 2,445 | 2,599 | 2,763 | 2,937 | 3,122 | 3,319 | 3,528 | 3,750 | 3,986 | 4,237 | 4,504 | 4,788 | 5,090 | 5,411 | 5,752 | 6,114 |
| (Equiv. US$1,000) | | | 235 | 249 | 265 | 282 | 300 | 319 | 339 | 360 | 383 | 407 | 432 | 460 | 488 | 519 | 552 | 587 |
| Balance by Fiscal Year (US$1,000) | | | 75 | 39 | 81 | 22 | 27 | 46 | 67 | 46 | 40 | 64 | 89 | 110 | 26 | 57 | 25 | 45 |

Basic Condition of Estimation:

1) Each project is implemented by one contract even the project is implemented over several years.
2) Increase of work volume due to progress of riverbank erosion is assumed to be covered by physical contingency.
3) The budget for riverbank protection around Vientiane City in FY2004/05 is estimated by 6.3% increase from 2,300 million Kip, investment plan of MCTPC for riverbank protection in Vientiane City for FY2003/04.
4) The budget for riverbank protection around Vientiane City is assumed to increase 6.3% per annum in accordance with the average economic growth rate for the last 10 years.
5) Price escalation are not included in neither investment plan nor budgeting plan.
6) Applied foreign exchange rate: US$1 = 10,420 Kip (February 1, 2004).
7) As maintenance and repairing cost, 0.5% per annum of the project cost is assumed after completion of the facilities.
8) As maintenance and repairing cost of the existing riverbank protection facilities, US$20,000 per annum is assumed.
9) The proposed annual budget plans still have some balance even after implementation of the proposed projects so that unexpected urgent projects can be implemented.

# 7 PREPARATION OF MANUAL FOR RIVERBANK PROTECTION

- Objective: a complement of the Master Plan
- User: working-level Laotian engineer of GOL
- Contents: basic principles for bank protection works, technical standards and criteria as follows:

Sector A: Planning & Design

1 Planning
2 Design

Sector B: Construction

1 Introduction
2 Execution of Pilot Work at Ban Dongphosi Site
3 Execution of Pilot Work at Wat Chom Cheng Site
4 Execution of Pilot Work at Sibounheuang Site
5 Construction Data

# 8 TRANSFER OF TECHNOLOGY

## 8.1 Technology Transfer Seminar

- Date and venue:
  - 1st Seminar: October 4, 2002 at Lao Plaza Hotel, Vientiane
  - 2nd Seminar: October 12, 2004 at Novotel, Vientiane
- Objective: to exchange technical ideas and to transfer technology on riverbank protection
- Contents: various bank protection-related themes by Laotian and Japanese presenters and free discussion sessions
- Number of Participants: around 80-100

## 8.2 Indoor and Field Session

- Indoor session in MCTPC in January 26, 2004: presentation and discussion on the process & results of the Study
- Field session at Nongheo site in February 10, 2004: demonstration of simple vegetation riverbank protection works by a Soda technique experts of the Study Team

## 8.3 Technical Guidance for Soda Technique

- Conducted by Soda (fascine) technique experts of the Study Team
- Period: February and March 2003
- Location: the construction site of the Pilot Works
- Items: 1) Soda Mattress work and 2) Cobble stone with willow branch work

## 8.4 Counterpart Training in Japan

- Trainee and period:
  - Mr. Viengsavanh PHASAVATH, MCTPC (2002/08/15 - 2002/09/28)
  - Mr. Somchith SITHIPHONG, DCTPC (2002/08/26 - 2002/09/28)
- Main training items:
  - Learning Soda technique, traditional river works in Japan by outdoor training in Niigata, Japan
  - Learning traditional/ modern river works in Japan by indoor lecture and field tour

## 8.5 Transfer of Technology to Counterpart

The contents and result of the technology transfer to the MCTPC counterpart (C/P) through the teamwork with the Study Team are shown in Table 8.1. It is considered that in general good result was obtained. However, in view of the challenge described in Table 8.1, in order for Lao side to be able to implement the M/P project independently in the future, continuous Japanese technical cooperation will be desired for several years.

## Table 8.1 Transfer of Technology to Counterpart

| | Contents | Result | Future Challenge |
|---|---|---|---|
| Study and Planning | A series of basic study and planning work relating to the Master Plan | C/P understood the procedure and outline of work required for M/P planning. | -Future M/P revision by themselves<br>-Systematic study of river engineering |
| | Preparation of manual for riverbank protection | C/P understood the contents of the manual. | The revision and the Laotian translation by themselves |
| | Field investigation for the design of the M/P project | C/P carried out topographical survey by themselves under conditions similar to the Pilot Work (Sibounheuang – Muang Wa Site). | Investigation for other M/P project sites with some unknown factor |
| | Explanation of contents of the Study and the Pilot Works to the agencies concerned | -C/P prepared PowerPoint materials (Laotian) by themselves and performed effective presentation at the technology transfer seminar and the MCTPC departmental meeting.<br>-C/P carried out the explanation to related research group and the seminar for provincial MCTPC with the assistance of JICA experts. | C/P plans and organized seminars for public relations of the M/P projects. |
| Design | Preparation of the plan of bank protection facilities by CAD | C/P created the plan of simple bank protection works by themselves, and assisted the Study Team (when basal condition was ready). | Design under conditions with some unknown factor |
| | Design of the M/P projects | C/P designed a M/P project by themselves under conditions similar to the Pilot Work (Sibounheuang – Muang Wa Site). | Design for other M/P project sites with some unknown factor |
| Construction | Acquisition of Soda technique required for execution of traditional river works of Japan | C/P mastered collection of Soda material, and the assembling of Soda mattress to some extent through on-the-job training in Japan. | Spread, tradition and localization of Soda Technique |
| | Acquisition of bank protection works through execution of the Pilot Works | -C/P understood detailed process of bank protection works practically by teamwork with the Study Team.<br>-C/P assisted the supervision by the Study Team.<br>-C/P conducted quality control of Soda material based on training experience in Japan. | Sustainable implementation of the M/P project by themselves |
| | Acquisition of simple vegetation bank protection works | C/P understood the construction process practically by teamwork with the Study Team. | Spread and support of the construction by C/P to riverine local community |
| Monitoring and Maintenance | Periodical visual inspection of the completed Pilot Works | C/P carried it out and reported the result to the Study Team by e-mail. | Correspondence at the M/P project site with some unknown factor |
| | Arrangement with the chart of monitoring result (change in water level and topography) of the Pilot Works | C/P arranged the result with charts (MS Excel, AutoCAD) by themselves. | |
| | Acquisition of data of automatic water gauge | C/P performed the computer processing by themselves. | |
| | Installation of staff gauge and observation of daily water level | C/P have observed the water level and repaired the gauge after damaged, which was originally installed by the Study Team. | |
| Organization and Institution | The necessity for permanent organization establishment for the M/P implementation | C/P recognizes necessity and is working towards setting up the organization. | Setting up a permanent organization for riverbank protection |
| Human Resources Development | Explanation to the public of the contents of the Study and the Pilot Works | C/P gave lectures on the Study content to the trainee of faculty of technology, National university of Laos on their own. | ・Giving lectures at the university<br>・Continuous acceptance of the trainee<br>・Enlightenment of local residents |

# 9 RECOMMENDATION

## (1) Set Up of Organization and Institution

It is strongly recommended that GOL implement the following as an absolutely necessary condition to implement the bank protection projects of the Master Plan by GOL using national budget in principle:

1. Setting up "Mekong Riverbank Protection Unit (tentative name)" (New Unit) as a new permanent organization in MCTPC,
2. Proper human resources arrangement to the New Unit,
3. Budget allocation for riverbank protection certainly based on the annual investment schedule of the Master Plan, and
4. Continuous human resources development.

## (2) Review and Revision of the Master Plan

It is advisable that the Master Plan be reviewed and revised by GOL if necessary in 2010 and 2015, in accordance with 5-year Socio-economic development plans, taking the following factors in consideration:

1. Financial factors (Unforeseen change in financial condition of GOL), and
2. Technical factors.
   a) The result of the long-term monitoring of the Pilot Works
   b) Unforeseen change in the conditions of riverbank erosion

## (3) Avoidance of Resettlement on Construction Work

It is recommendable to avoid negative social environmental impact such as resettlement as much as possible on the construction of the bank protection works proposed by the Master Plan. (JICA Pilot Works required no resettlement.)

## (4) Facility Design and Cost Estimate to be conducted by GOL

The facility design and the cost estimate in the Master Plan are the preliminarily ones to conduct overall planning targeting the year 2020. On the commencement of each projects of the Master Plan by GOL, it is essential for GOL to conduct the detail design and the cost estimate by conducting topographic and hydrological surveys at each site.

## (5) Status of On-going Bo O project in the Master Plan

Design of "Lao-Flanders river works project" at Bo O site is underway by MCTPC with the assistance of the Government of Belgium (GOB), which is one of the Urgent Project sites of JICA Master Plan. The project is incorporated into the JICA Master Plan as it is in principle and is given high priority in the Master Plan. However, the design has not been completed and accordingly no definite cost estimate is available so far. It is noted that Japanese traditional river works proposed by the Master Plan is temporarily applied for the preliminarily cost estimate at the site in this Study instead. The cost in the Master Plan shall be reviewed by MCTPC in future upon the definite cost based on the final design is determined by the river works project.

## (6) Collection of Available Quarry Information

The cost of crushed stone from quarry constitutes large percentage of the total cost of bank

protection works. It is obvious that the development of the new quarry around Vientiane exclusive for bank protection is not virtually feasible in view of lithology (sand stone) and the project scale of the Master Plan. Therefore, the selection of quarry will be the option of local contractors as before in principle on the construction of the projects of the Master Plan. It is advisable to secure available quarries information for sustainable implementation of the Master Plan projects.

**(7) Maintenance of the Pilot Works**

As for Ban Dongphosi and Sibounheuang Sites, the maintenance work of the Pilot Works after 2005 shall be conducted under the responsibility of GOL, the owner of the Works as one of the regular maintenance activities based on the budget allocation of the Master Plan.

As for Wat Chom Cheng Site, the work is implemented as "essential test work" and accordingly the inspection should be continued without any rehabilitation work unless serious negative influence to local residents happens by unforeseen erosion.