

4 FACILITY DESIGN

4.1 Design Criteria

4.1.1 Design Velocity

As Described in Section 3, the design velocity at each site for the pilot work of bank protection is as summarized below:

Site Name	Design Velocity
(a) Ban Dongphosi Site	3.4 m/sec
(b) Wat Chom Chen Site	2.6 m/sec
(c) Sibounheuang Site	2.6 m/sec

4.1.2 Low Water Level

Low water level with a return period of 5 years at each site is as below:

Site Name	Low Water Level (EL.m)
(a) Ban Dongphosi Site	155.0 m
(b) Wat Chom Chen Site	158.1 m
(c) Sibounheuang Site	158.9 m

4.1.3 Stone Size

a) Rip-rap Stone

Rip-rap stone size is decided by applying the formula*¹⁾ as below:

$$D = K \cdot D_m$$

Where, $K = 1 / [\cos \theta (1 - \tan^2 \theta / \tan^2 \Phi)^{(1/2)}]$

D_m : Average size of rip-rap stone necessary for a horizontal slope
 $= 1 / [E_1^2 \cdot 2g(\rho_s / \rho - 1)] \cdot V_o^2$

V_o : Velocity (m/sec)

ρ_s : Density of stone

ρ : Density of water

θ : Slope of protection work

Φ : Friction angle of submerged stone

E_1 : Coefficient($\cong 1.2$)

*1) U.S.Army Corps of Engineering: Hydraulic Design Criteria, 1970

Relation between velocity and stone size is as shown in Figure 4.1(1).

b) Filling Stone

Filling stone for the Soda mattress and Cobble Stone with Willow Branch Work is decided according to the following relations, considering tractive force of water not exceeding the critical tractive force:

$$\tau_{sd} = \tau_d \cdot \cos(1 - \tan^2 \theta / \tan^2 \Phi)^{(1/2)} \text{ where; } \tau_d :$$

Non-dimensional shear force

(=0.05 based on Shield's experiment)

$$\tau *sd = u^{*2}/(sgD)$$

$$u^* = Vo/ \phi$$

$$\phi = 6.0 +5.75Log_{10}(Hd/ks)$$

From those relations, we get:

$$D \geq Vo^2/((6.0 +5.75Log_{10}(Hd/ks))^2 \cdot \tau *sd \cdot s g)$$

Assuming $ks \doteq D$, and Hd is taken as design water depth, necessary stone size for rip-rap is obtained as shown in Figure 4.1(2). Actual stone size should be 1.3 to 1.5 times of the critical size of stone, considering the incompatibility of stone arrangement and any undulation of the surface might be weak against strong velocity.

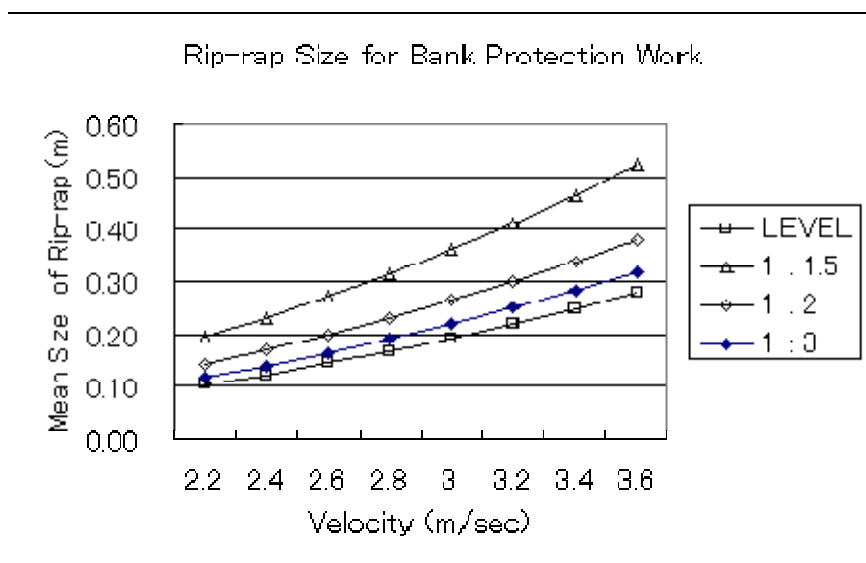


Figure 4.1(1/2) Stone Size for Bank Protection Work

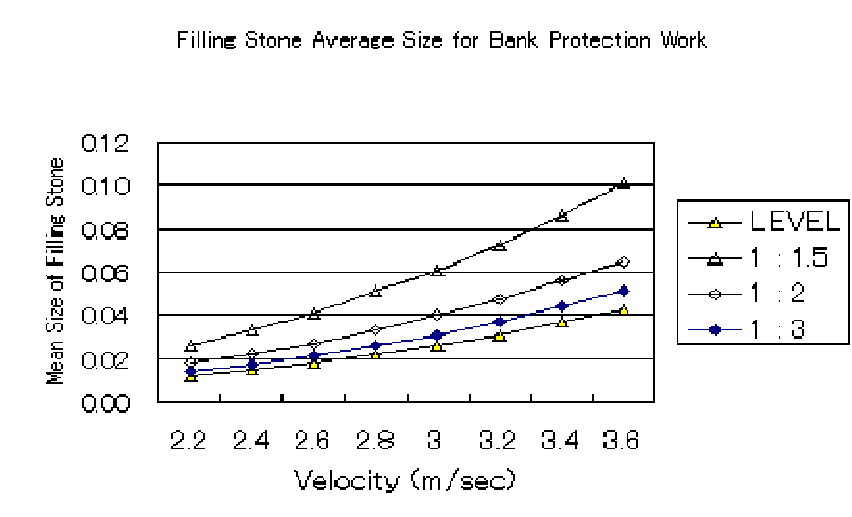


Figure 4.1(2/2) Stone Size for Bank Protection Work

4.2 Selection of Construction Type

Construction type of pilot works of bank protection is selected considering the following items:

- i) Using local construction material as much as possible.
- ii) Using manpower of Lao P.D.R. as much as possible.
- iii) Construction work can be done by people of Lao P.D.R. as much as possible.
- iv) To pay attention to keep riverine environment

Type of the pilot work, therefore, will be one without using imported materials such as wire-meshed basket, geo-textile and cement, and construction work can be done mainly by manual work. Gabion mattress of wire-meshed basket and concrete block will be excluded from the selection of type.

Some of Japanese traditional methods of river works are satisfied with the above criteria, such as Soda mattress, Cobble-stone with Willow Branches Work method, Wooden Pile Dike Groyne, Skeletons, etc. Outlines of each method are as shown in Table 4.1.

Considering features of each type of river bank protection work, the easiness of material supply for the protection work and suitability to the selected site of the bank protection work, candidate types of bank protection work for each site are chosen as shown in Table 4.2.

For each site, the candidate types of riverbank protection work are compared with respect to strength, life time, weight, flexibility, etc., as shown in Table 4.3.

As shown in the table, the most suitable type for each site is as below:

- For Sibounheuang site : Soda Mattress and Cobble Stone with Willow Branch Work
- For Wat Chom Cheng site : Wooden Pile Dike Groyne Work and Soda Mattress Work
- For Ban Dongphosi site : Soda Mattress and Cobble Stone with Willow Branch Work

Table 4.1 Selection of Bank Protection Work Type


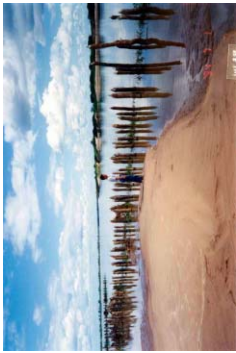



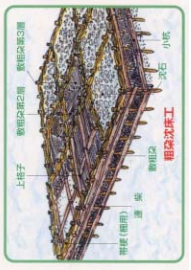
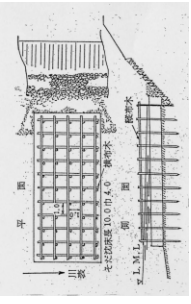
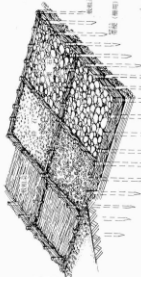
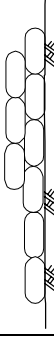
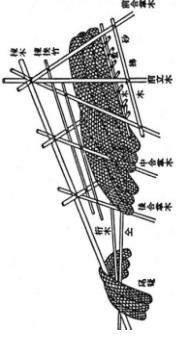
Type of Bank Protection Work	Soda Mattress	Wooden Pile Dike Groin	Pebble Stone with Willow Branch Work	Sand Bag Groin Work	Skelton / Crib Groin Work
Features	<p>Soda Mattress consists of Soda(fascine), Rensai(bunch of fascine), Siki-Soda(fascine flooring), Sigara(hurdle work), and Chinscki(rubble stone). On the lower lattice structure of Rensai with grid space of 1m(Sitagoshi: lower lattice), three layers of Siki-Soda with each layer having perpendicular to the other, in approx. 15 cm thickness is put on. Upper lattice with the similar structure is put on the lower lattice and bound with rope and wooden pile driven at each node of the lattice to fix the structure. Tie-twig hurdle work is made on it. Crushed stones are put on them to set at the site. Almost all materials are produced locally.</p>	<p>Typical permeable dyke groin made of wooden piles spaced in every 1.0~1.2m each other and arranged in more than two rows. Piles are tightened by wooden board laterally and longitudinally or diagonally to connect them. This work is usually applied in mild slope river. For steep slope river also protected, where piles can be driven into the riverbed with sufficient depth of embedment. For the river with sand bed materials, water jet could be used to drive the piles into riverbed. Although less construction cost, necessary attention to the conservation of forest with respect to environmental aspect should be paid.</p>	<p>The structure consists of Siki-Soda on the slope of earth embankment, twig hurdle work on them, made of willow branch, covered by pebble stone and sand with willow plantation on them. After growing up of the willow trees, they give moderate roughness to the flow and act as resistance to protect the structure. Over growing of the willow trees should be stopped by regular cutting maintenance work. Vegetation bank will be realized, to have good environmental aspect. Mild slope river would be preferable for this work, with necessary attention of stability of the slope. This work will be vital for the site, where stone material can be obtained easily and economically.</p>	<p>Mixture of soil and cement with volumetric ratio of 1 : 1 is put in PVC bag. The bags are piled up horizontally to make groin. The bag will be solidified in water and connected with each other to have strength against scouring. All work can be done manually to realize less construction cost. The effect of this method is confirmed in JICA study in Brazil.</p>	<p>Skelton made of wooden log with shapes of as trigonal pyramid or cube are arranged on riverbed / river bank slope in two or three rows perpendicular to river bank as permeable groin. Skeletons are fixed by cylindrical gabions to protect river bank by reducing river flow and expect sand sedimentation between them. Crib work is similar to skeleton work, but filled by pebble stone in it, that is semi-permeable. Those both works are applicable to steep river bed slope, where piling work can not be done because of gravel/pebble stone covering the riverbed.</p>
Sample Picture	 <p>Test Work at Wat Sibounheuang done by I.D.I. Japan</p>	 <p>Pilot work done by JICA Study in Brazil</p>	 <p>Construction site at Chikuma river in Japan</p>	 <p>Construction by JICA Study in Brazil</p>	 <p>At Fuefuki River in Japan (After "Groins in Japan", p153, by Dr. K. Yamamoto, 1996)</p>
Outline of Structure					
Construction Materials	<p>Branch (May Mak Ngoe etc. 12 kinds) Taisha (May Nang Dam etc. 5 kinds) Wooden pile (May Peuy Khao etc., 7 kinds) Crushed stone, pebble stone</p>	<p>Wood(May Nhompa, May Phoung, May Samsa, May Chanpapa, etc., 7 kinds)</p>	<p>Crushed stone, pebble stone in river channel, Willow branch (May Peuy Khao, etc., 7 kinds) Wooden Frame (May Nhompa, May Phoung, May Samsa, May Chanpapa, etc., 7 kinds)</p>	<p>River bed sand, soil cement, PVC bag, Wooden Pile (May Nhompa, May Phoung, May Samsa, May Chanpapa, etc., 7 kinds)</p>	<p>Wooden logs, cylindrical gabions made of bamboo or coated steel wire filled with stones</p>

Table 4.2 Type Selection of Bank Protection Work

Item	Location		
	Sibounheuang Site	Wat Chom Cheng Site	Ban Dongphosi Site
Length of river bank to be protected	150m	200m	650m
Conditions of river bank slope	Vertical cliff of relatively old aged silt layer on the layer of gravel and silt mixture. Lower layer is vulnerable to erosion	Mild slope of newly silt deposits, partly covered by vegetation.	Vertical cliff of relatively new aged silt layer on the layer of gravel and silt mixture. Both layers are vulnerable to erosion
Type of erosion	Falling of cliff material as block undermined through lower layer of gravel and silt forming notches at the foot of slope during flood period.	Sliding of silty deposit on the river bank slope in the recession of flood water.	Falling of cliff material accompanied with set-back of lower layer of gravel and silt that is vulnerable to scoring during flood period.
Point to be emphasized as bank protection measure.	To protect the lower gravel and silt mixture layer	To enhance silt sedimentation on the slope	To protect not only lower gravel and silt mixture layer, but upper silt layer.
Major bank protection work type	Foot protection work and lower part of slope protection	Permeable groin to expect sedimentation by off-setting of fast current and reducing flow speed near the river bank slope.	Foot protection and slope protection work
Candidate type of protection works	1)Soda mattress as foot protection and hurdle work for the slope protection 2)Soda mattress as foot protection and pebble with willow branch for the slope protection 3) Embankment covered by rip-rap stone	1)Wooden Pile Dike Work 2) Skeleton Works 3)Sand bag groin	1)Pebble stone with Willow Branch Work as slope protection and rip-rap stones as foot protection 2) Soda mattress as foot protection and hurdle work as slope protection 3) Pebble stone with willow branch work as slope protection and Soda mattress as foot protection.

Table 4.3 Evaluation of Construction Type for Bank Protection Work

Site Name	Type of Construction Work	Strength	Life time	Weight	Stability	Flexibility	Material retrieving	Construction Technique	Landscape	Riverine Environment	Ecological view	Priority
Sibounheuang Site	Soda Mattress and Wooden Pile Hurdle Work	○	△	○	○	◎	○	△	○	○	◎	2
	Soda Mattress and Pebble Stone with Willow Branch Work	○	○	○	○	◎	○	△	◎	○	◎	1
	Rip-rap	○	○	○	△	○	○	○	○	○	○	3
Wat Chom Cheng Site	Wooden Pile Dike Groin	○	△	○	○	-	◎	○	○	○	○	1
	Skeleton Work	○	△	△	○	○	△	△	△	○	○	3
	Sand Bag Groin	○	○	○	○	○	△	○	△	△	△	2
Ban Dongphosi Site	Pebble Stone with Willow Branch Work	○	○	○	○	◎	○	△	○	○	◎	2
	Soda Mattress and Wooden Pile Hurdle Work	○	△	○	○	◎	○	△	○	○	◎	3
	Soda Mattress and Pebble Stone with Willow Branch Work	○	○	○	◎	◎	○	△	○	○	◎	1

4.3 Design of Pilot Works

4.3.1 Ban Dongphosi Site

Cobble Stone with Willow Branch Work is applied for Ban Dongphosi Site. Considering the characteristics of topography, much amount of embankment is introduced to protect the area, especially around Lao State Fuel Company located in the central part of the site. The slope protection work is supported by foundation work consisting of rip-rap structure and Soda mattress as foot protection work. Both sides of the above part, the slope protection work are economically designed to protect approximately half of the slope covering the foot of the steep cliff to avoid further setback due to undermining of the foot part of the slope with the vegetation growth on the upper natural slope. With partly cutting of the upper part of the slope at unstable slope is necessary to establish naturally stable and vegetation covered slope in a few years after completion of the bank protection work. Transition part is introduced for smooth connecting of the above cross section to avoid possible scoring and/or erosion due to irregularity of streamline.

Design drawings of the bank protection work at Ban Dongphosi Site are as shown in Figure 4.2 – Figure 4.3.

4.3.2 Wat Chom Chen Site

Wooden Pile Dike Groyne Work is applied for the bank protection in front of Wat Chom Cheng Site. Spacing of groynes is set as 40m in the upstream 120m range, and spacing of 60m in the downstream 120m range. Length of the groyne is set as 20m, considering the riverbed cross-section and area to be protected. Spacing of groyne is generally 2 – 3 times of the length of groyne. Each groyne consisting of 3 rows of wooden piles is arranged in a hound's tooth with spacing of 1m. Every other groyne is protected by Soda mattress and rip-rap stones and connected each pile by tie-rod to avoid any damage due to possible local scoring around piles.

Design of the bank protection work at Wat Chom Cheng is as shown in Figure 4.4 – Figure 4.6.

4.3.3 Sibounheuang Site

Cobble Stone with Willow Branch Work is applied at Sibounheuang Site. Considering that the site is just downstream of the test project of Soda mattress and gabion wall work, principle design concept is the same as that, i.e., to protect the foot of slope by foot protection works. The slope protection work is designed to cover the possible notch formation part, that undermines the slope to collapse, and supported by foundation work consisting of wooden pile work and foot protection work by Soda mattress.

Design of the bank protection work at Sibounheuang Site is as shown in Figure 4.7 – Figure 4.8.

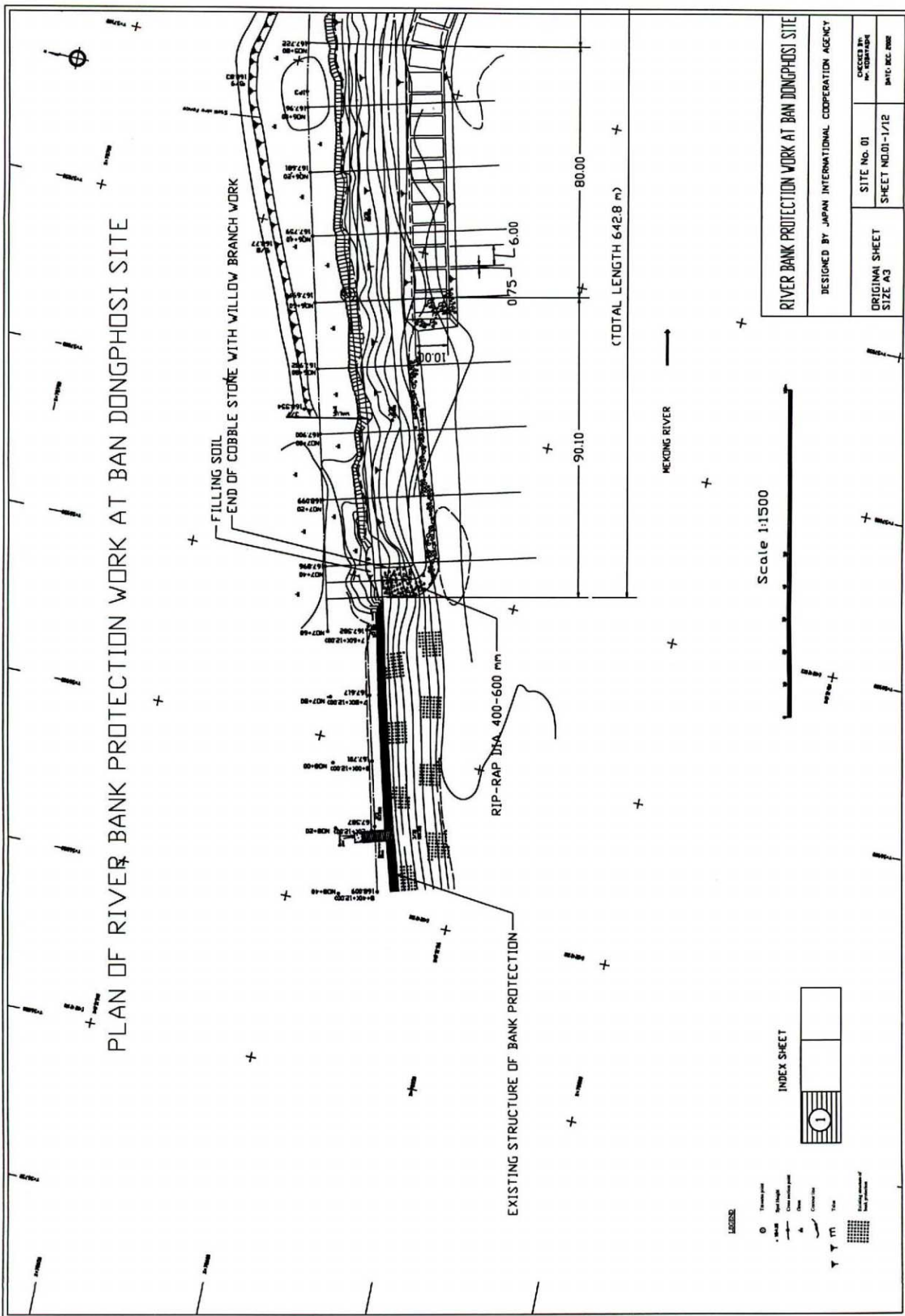


Figure 4.2(1/3) Plan of Riverbank Protection Work at Ban Dongphosi Site

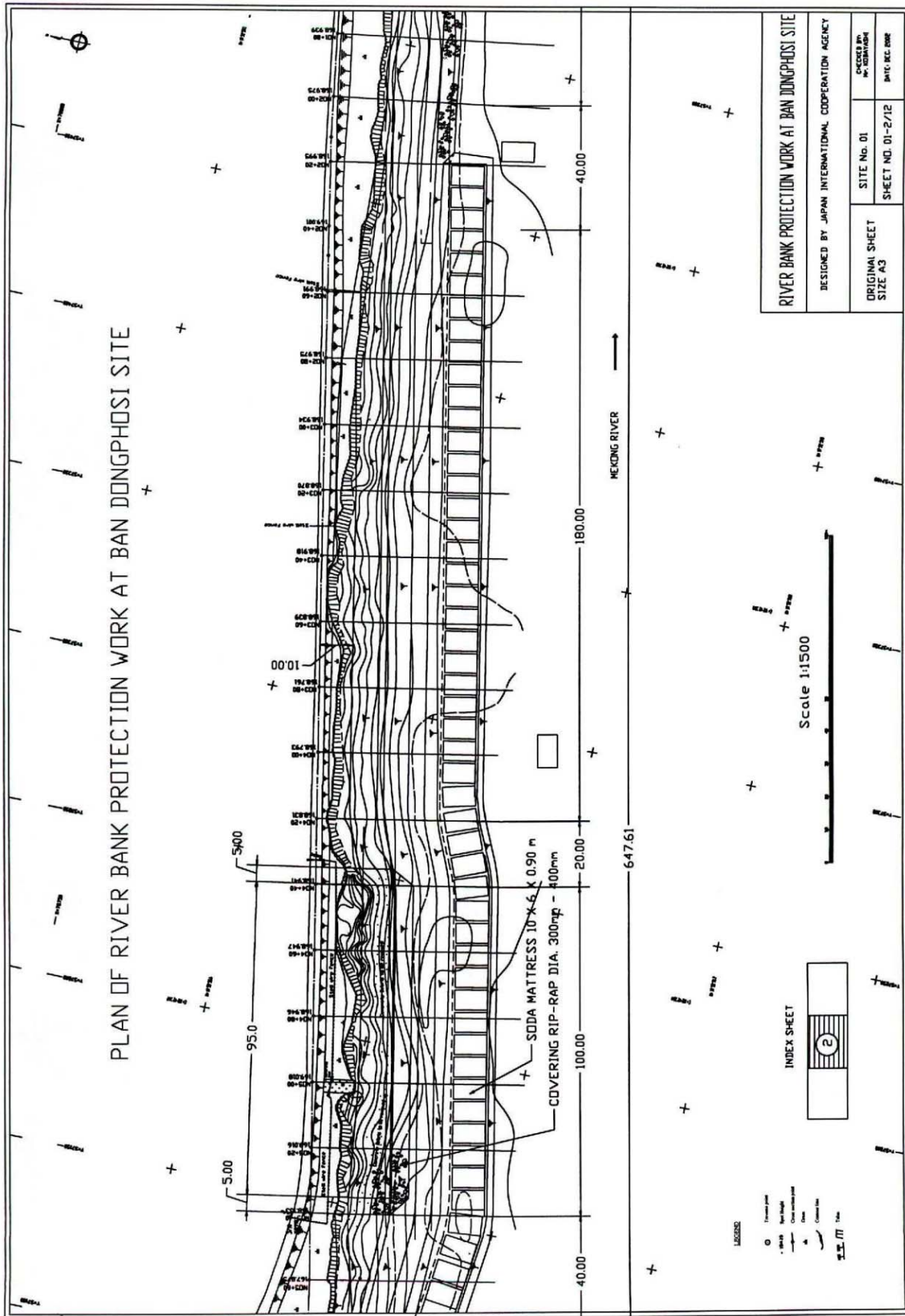


Figure 4.2(2/3) Plan of River Bank Protection Work at Ban Dongphosi Site

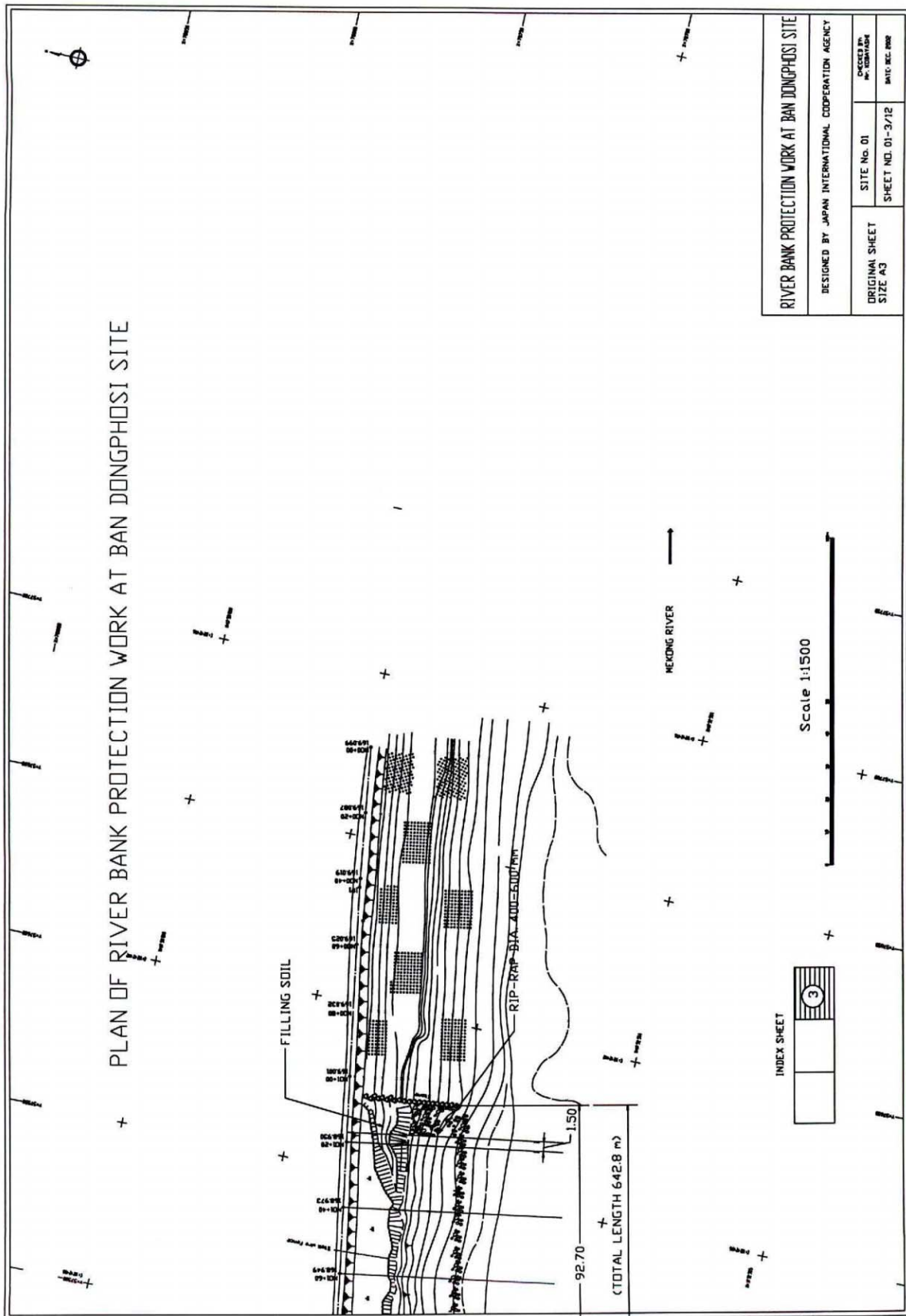


Figure 4.2(3/3) Plan of River Bank Protection Work at Ban Dongphosi Site

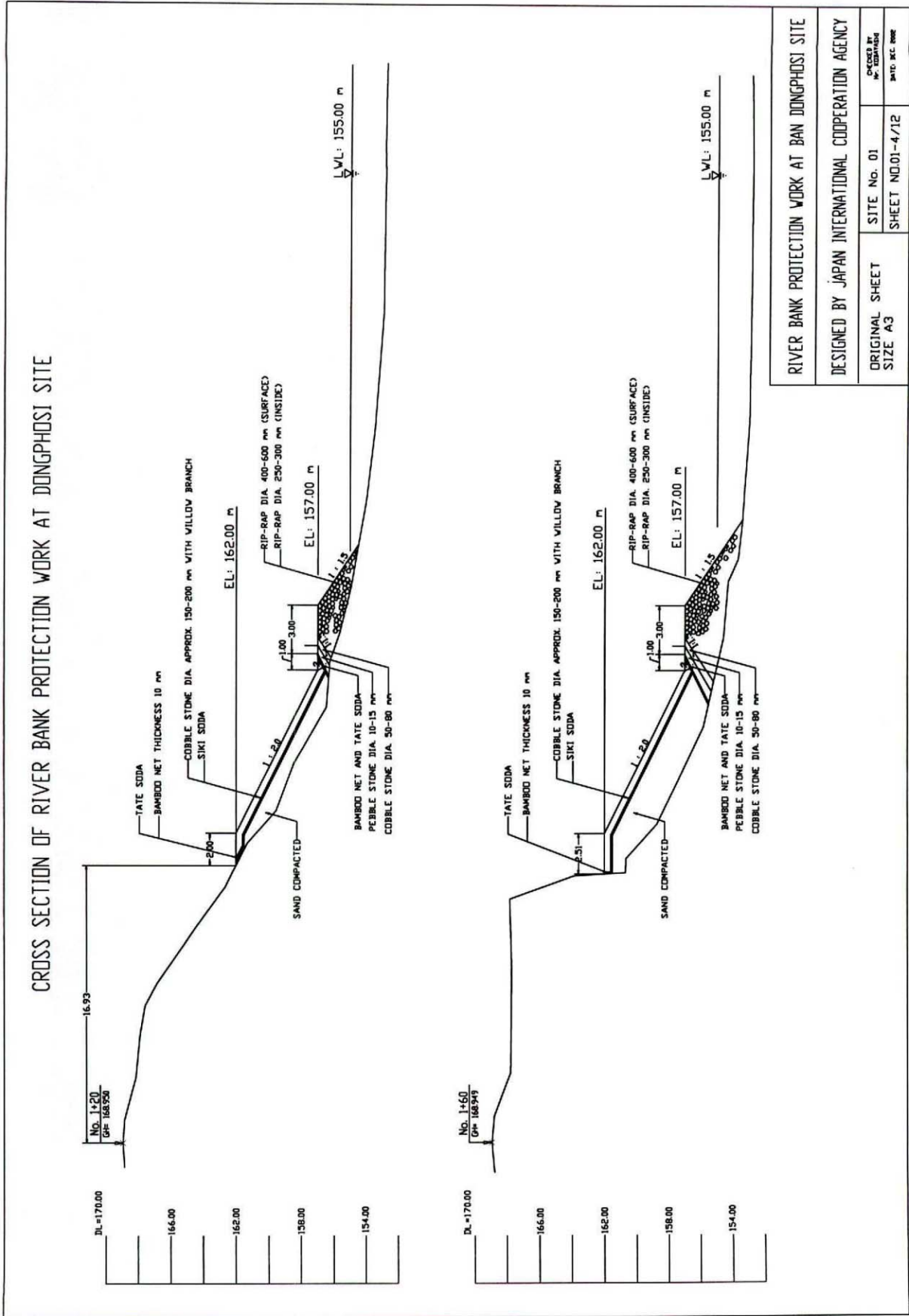


Figure 4.3(1/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

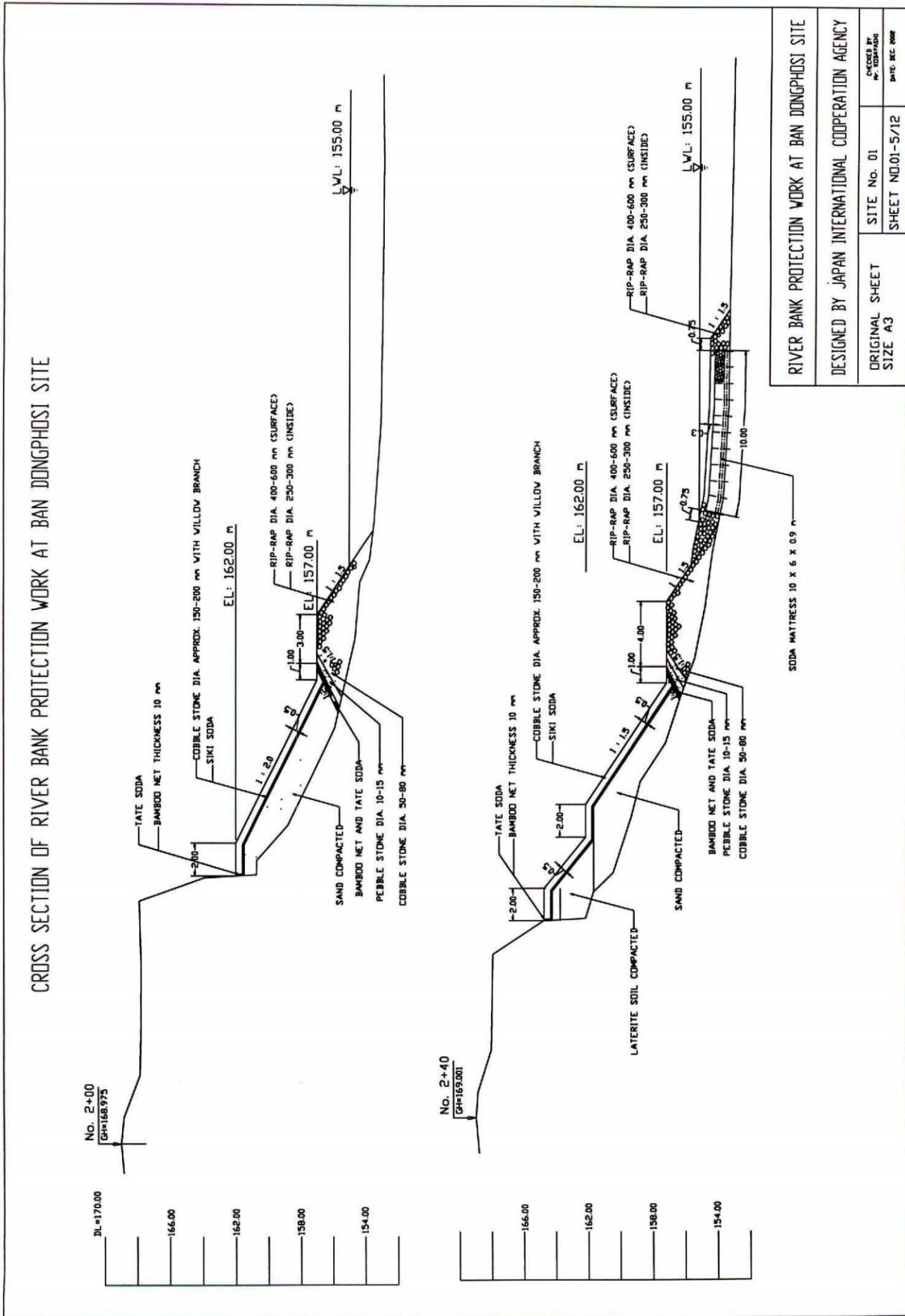


Figure 4.3(2/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

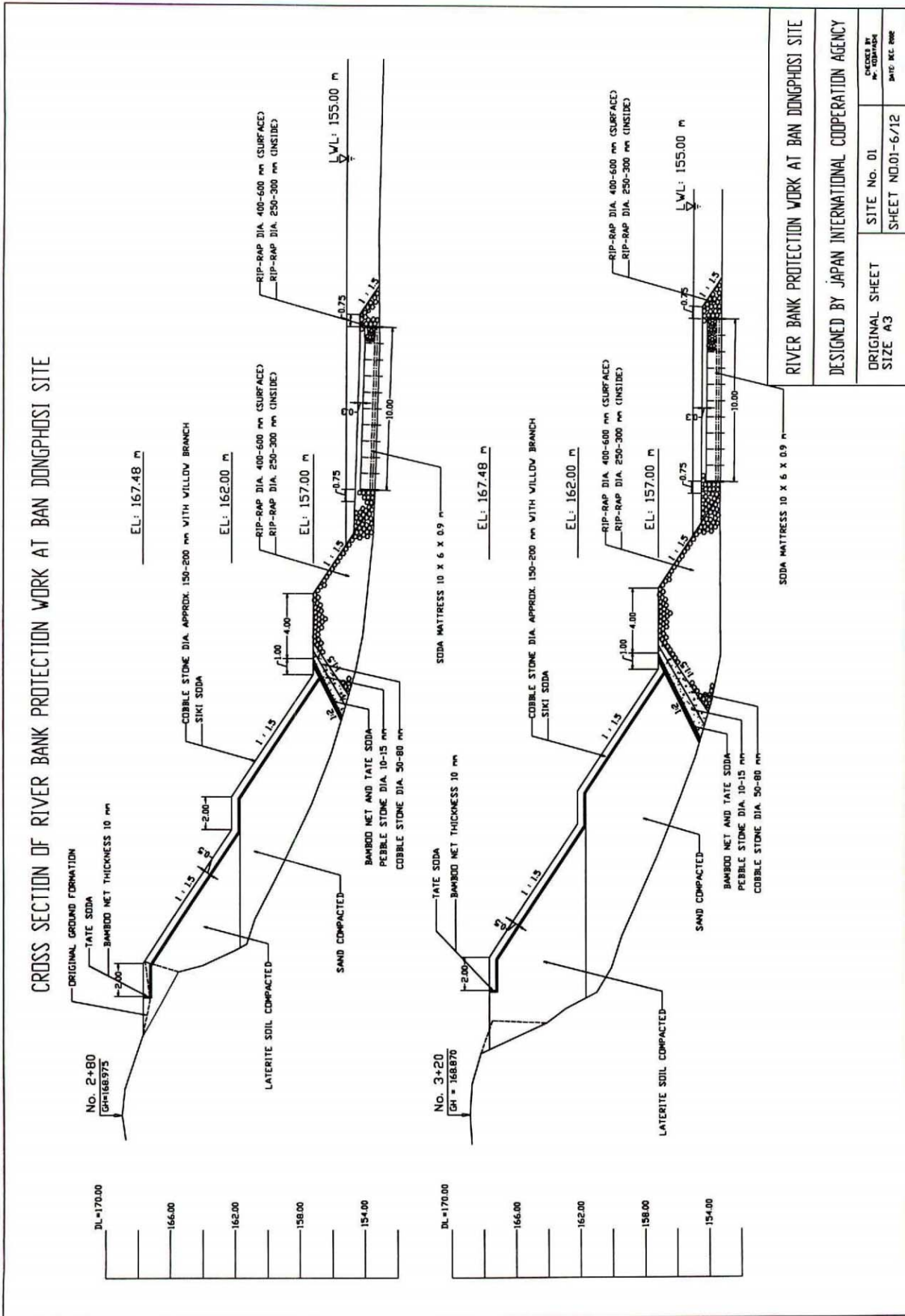


Figure 4.3(3/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

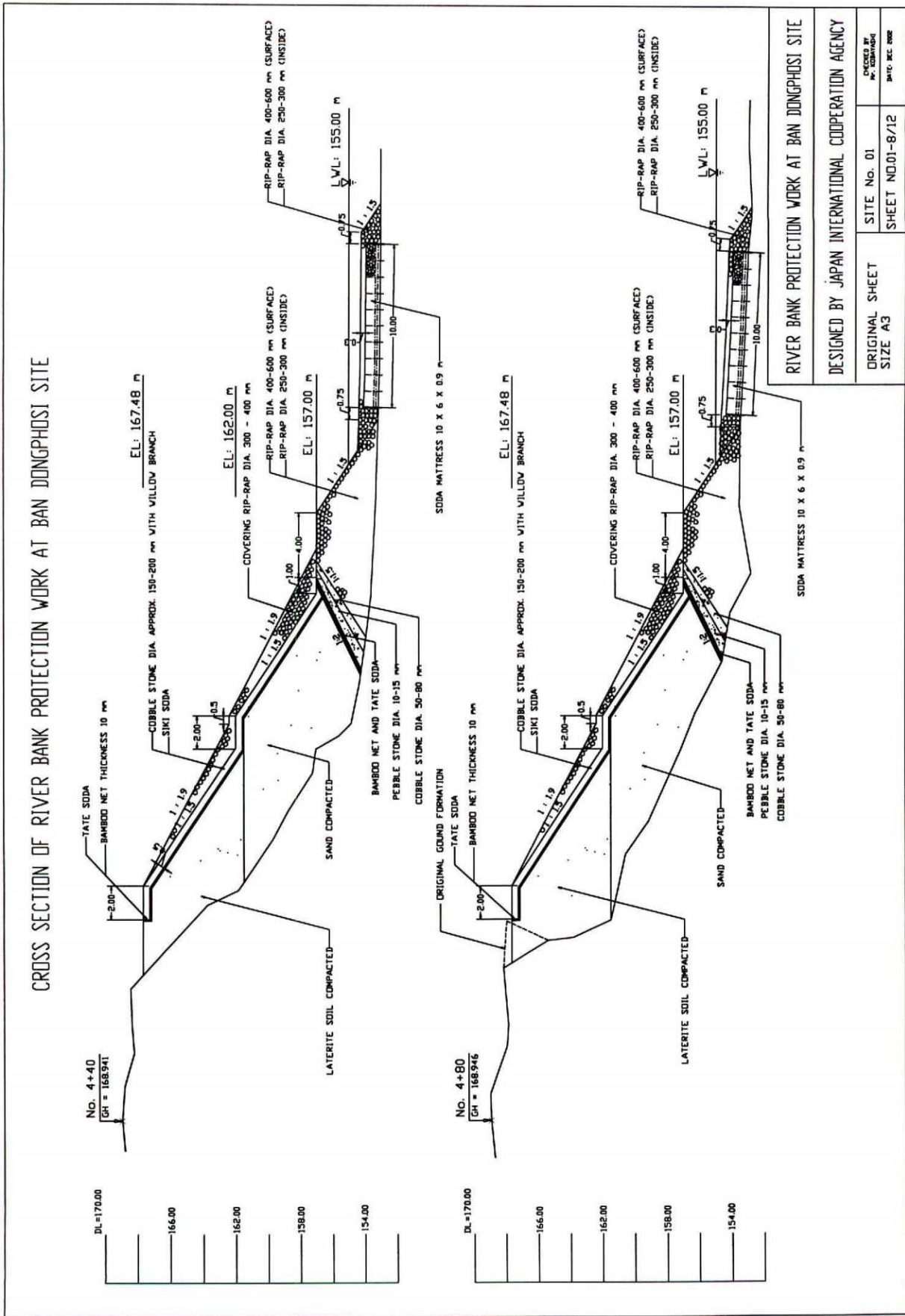


Figure 4.3(5/9) Cross Section of River Bank Protection Work at Ban Dongphoshi Site

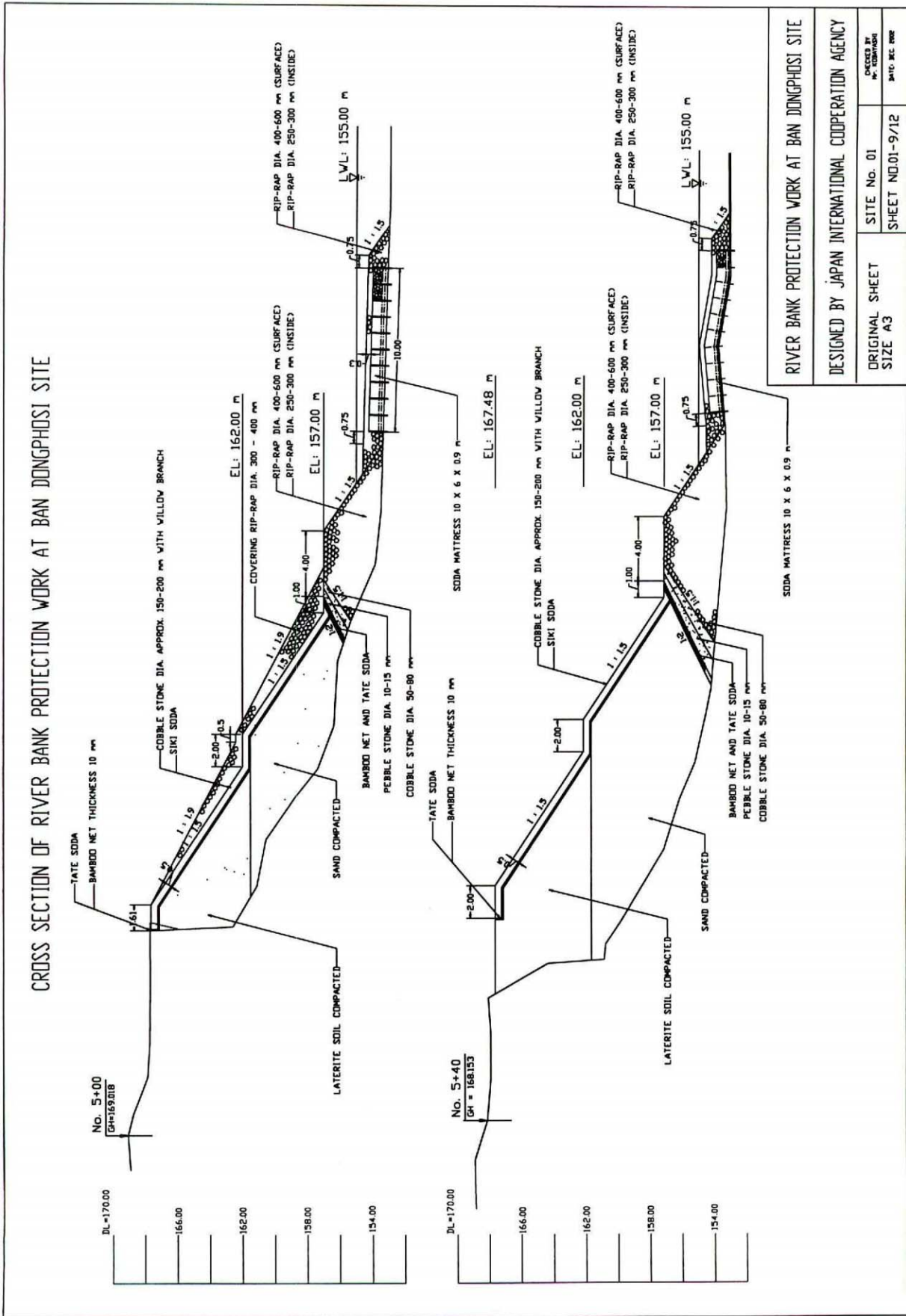


Figure 4.3(6/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

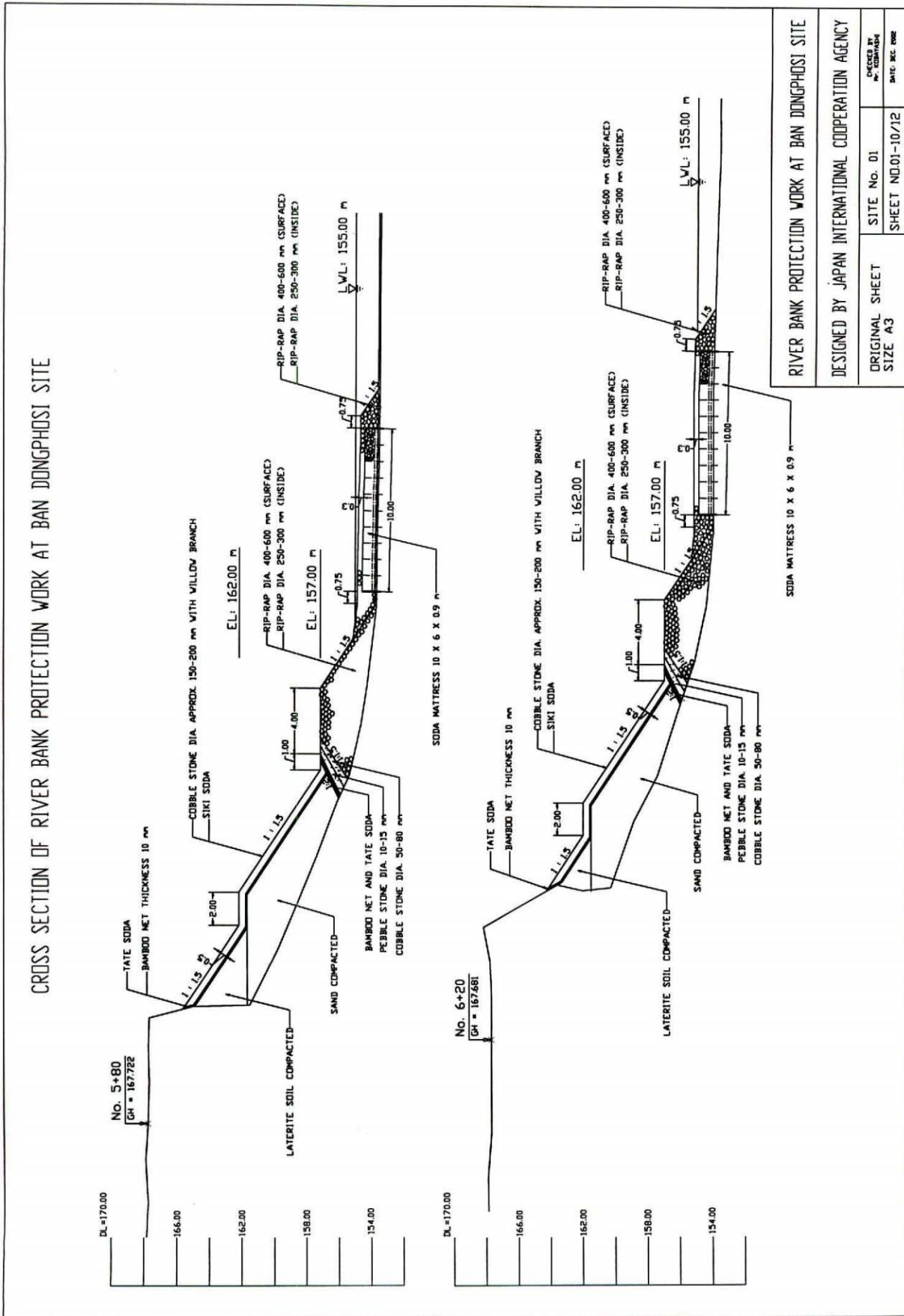


Figure 4.3(7/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

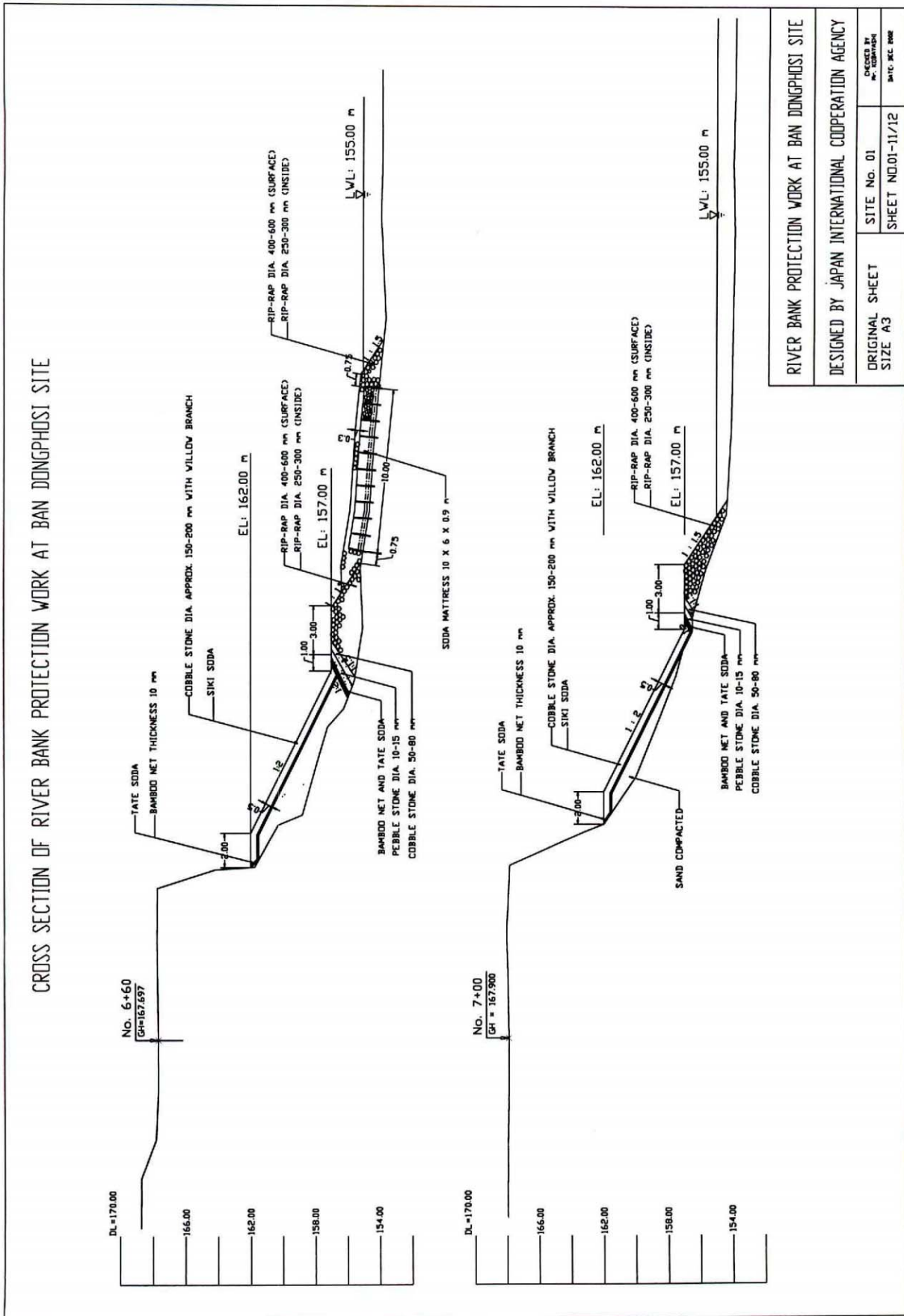


Figure 4.3(8/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

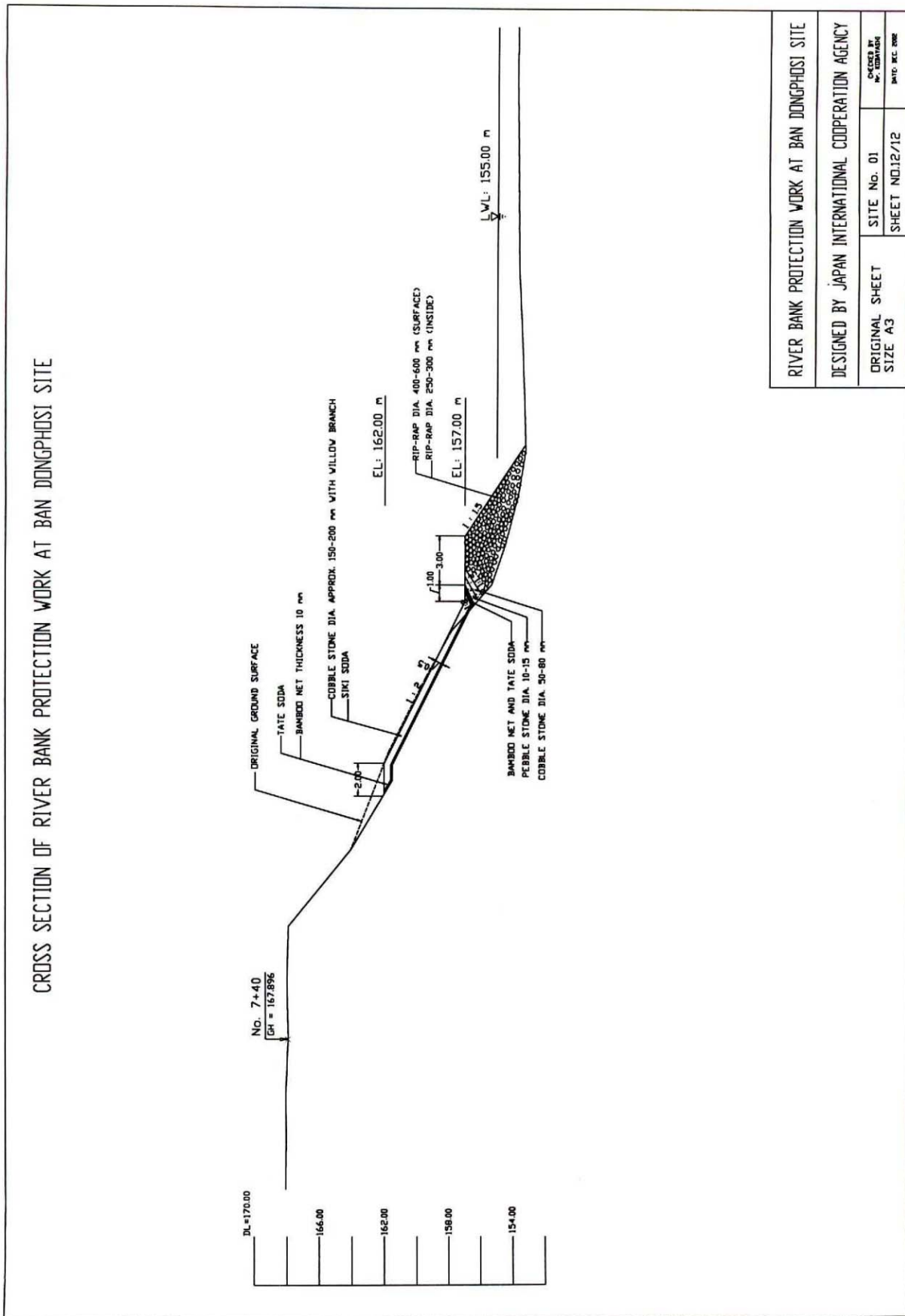
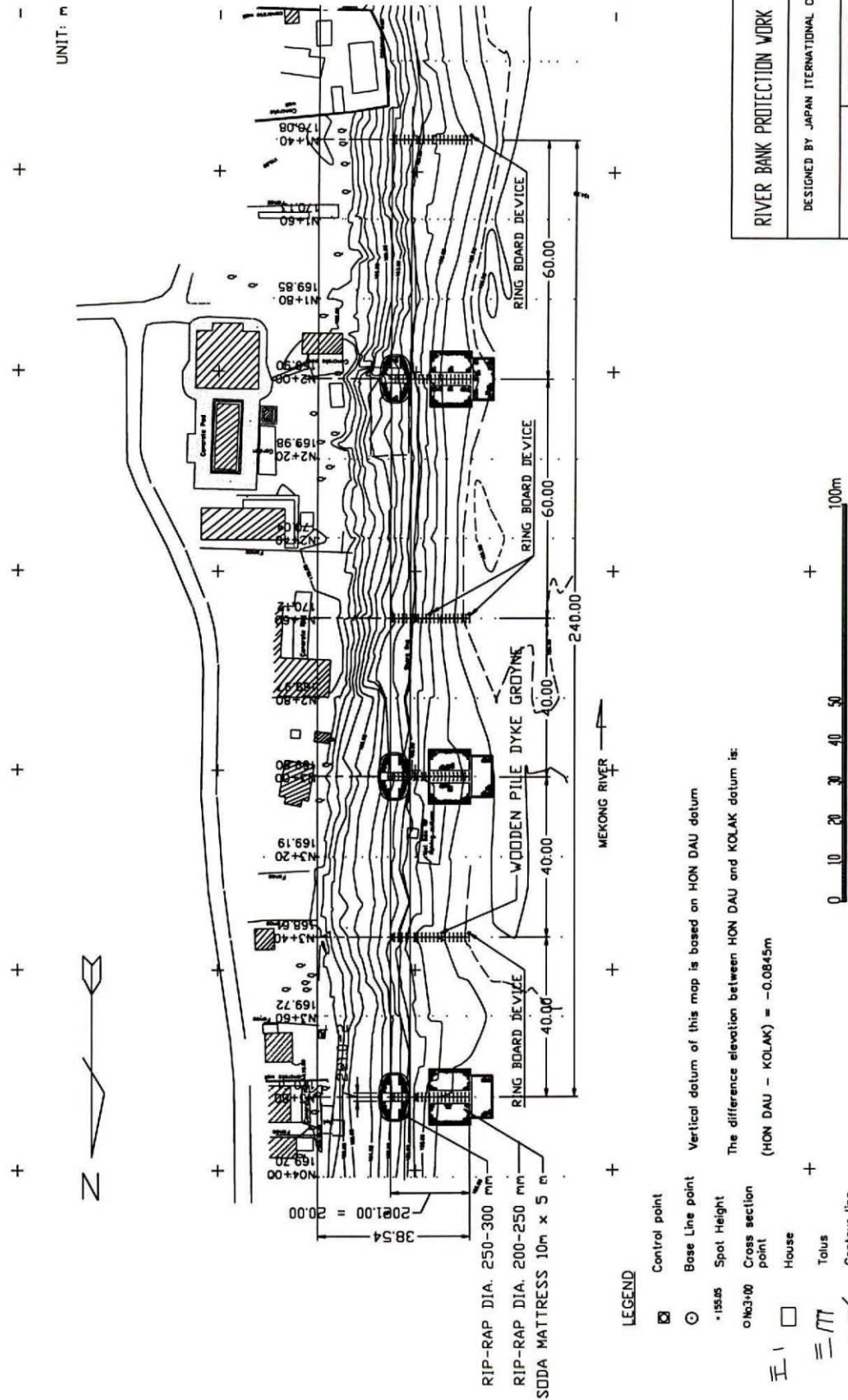


Figure 4.3(9/9) Cross Section of River Bank Protection Work at Ban Dongphosi Site

PLAN OF RIVER BANK PROTECTION WORK AT WAT CHOM CHENG



RIVER BANK PROTECTION WORK WAT CHOM CHENG		
DESIGNED BY JAPAN INTERNATIONAL COOPERATION AGENCY		
ORIGINAL SHEET SIZE A3	SITE No. 02	CHECKED BY: M. UEMAYASHI
	FIGURE 3.2.1(1/5)	DATE: MAR. 2003

Figure 4.4 Plan of River Bank Protection Work at Wat Chom Cheng Site

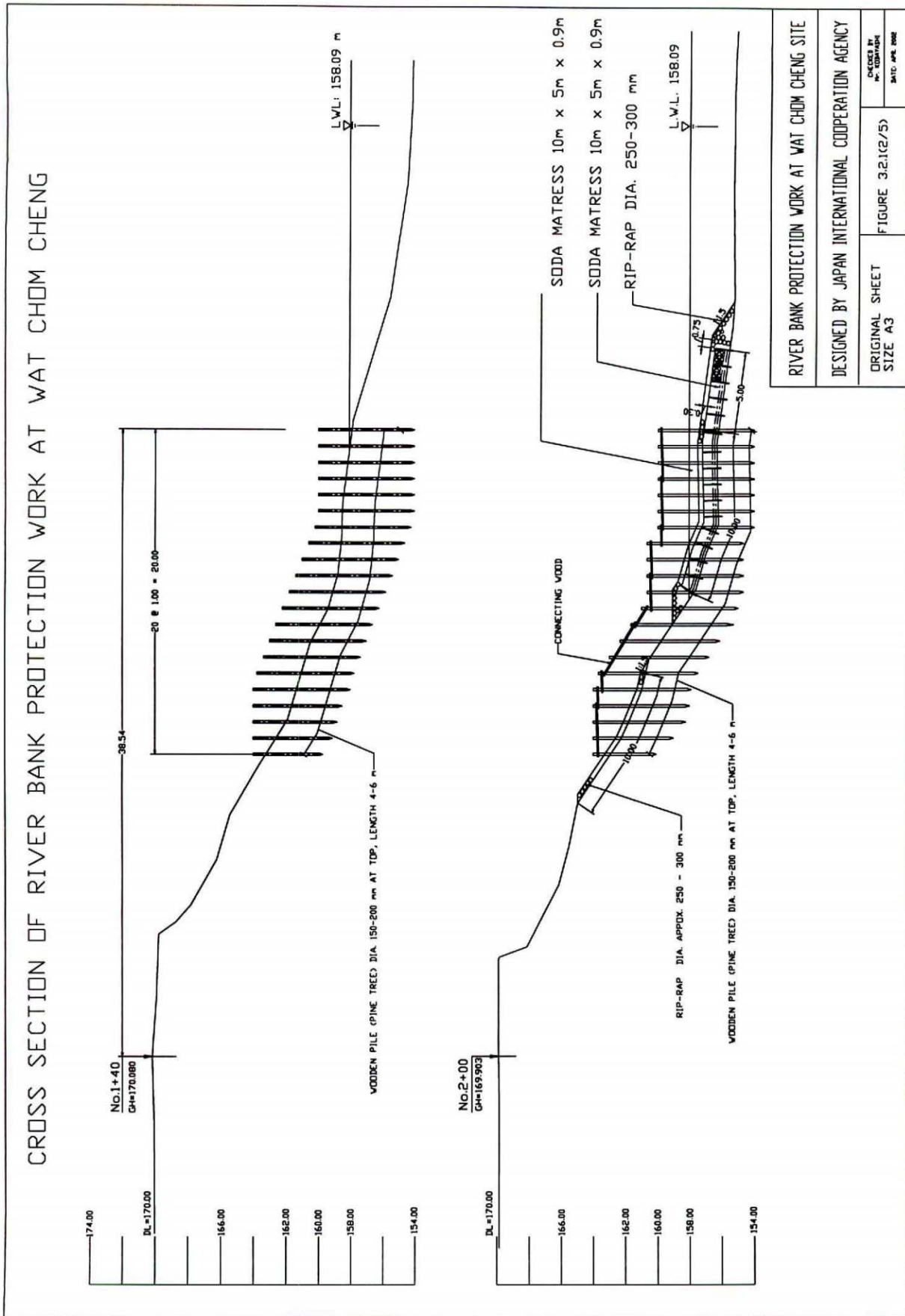


Figure 4.5(1/3) Cross Section of River Bank Protection Work at Wat Chom Cheng Site

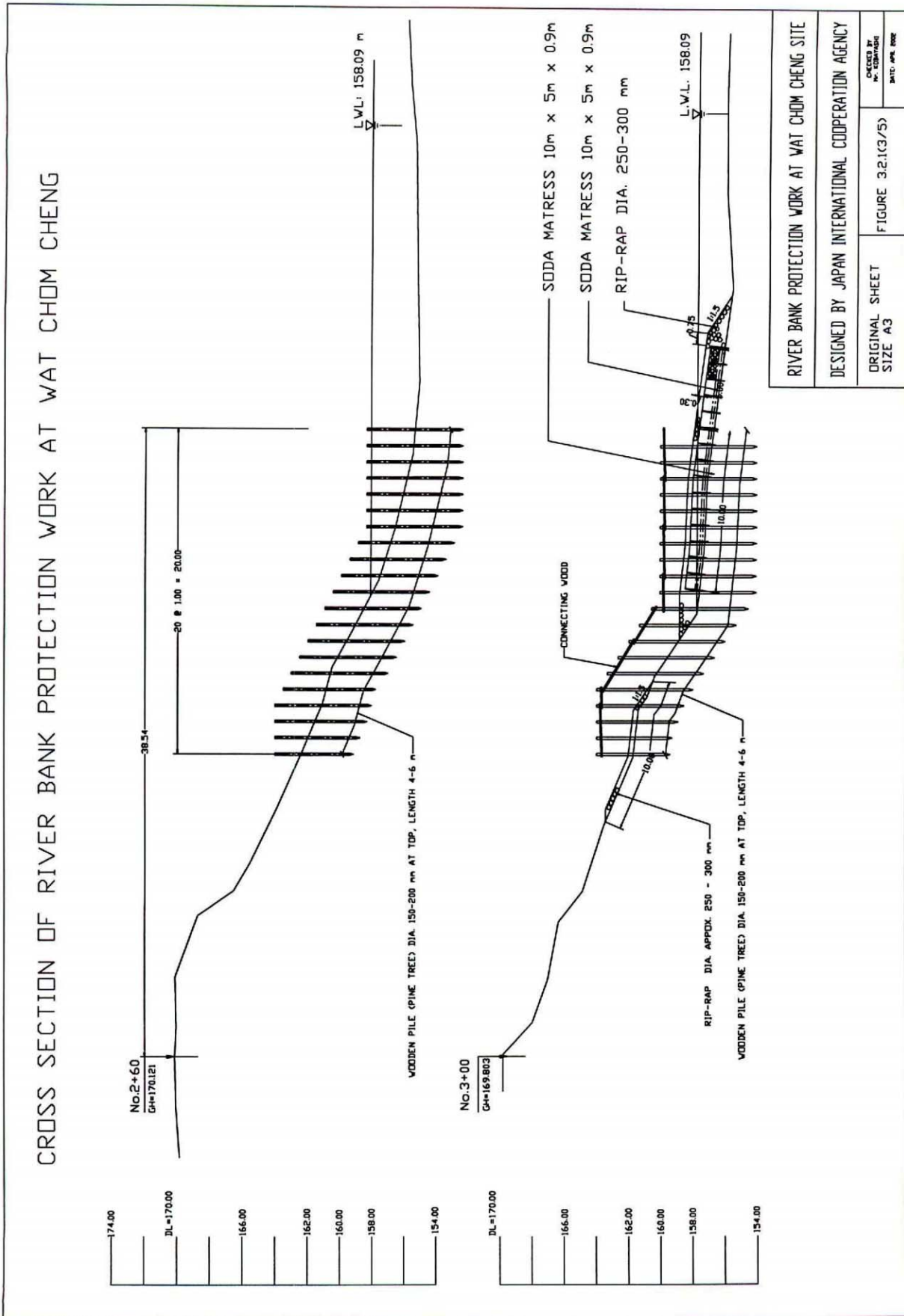


Figure 4.5(2/3) Cross Section of River Bank Protection Work at Wat Chom Cheng Site

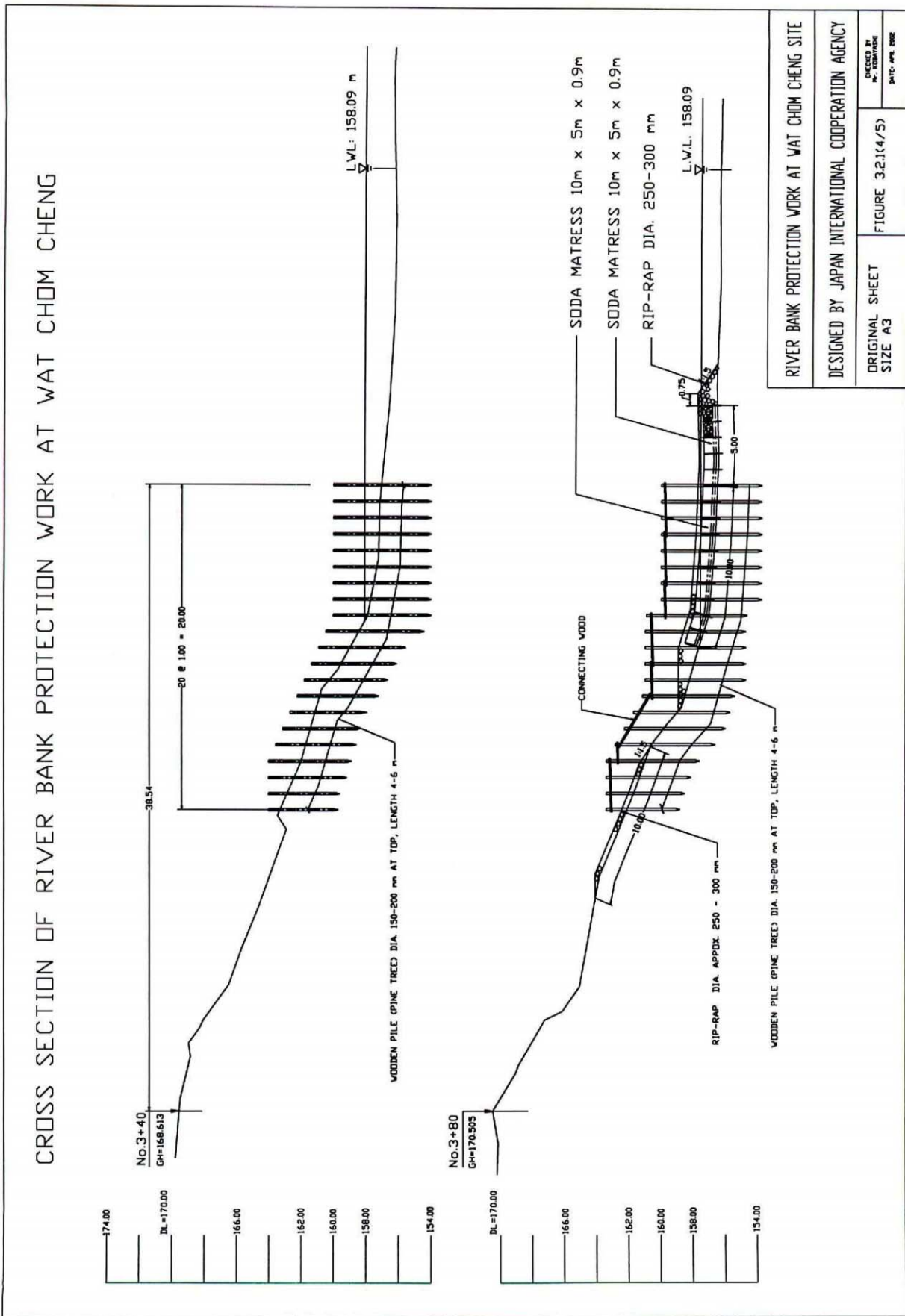


Figure 4.5(3/3) Cross Section of River Bank Protection Work at Wat Chom Cheng Site

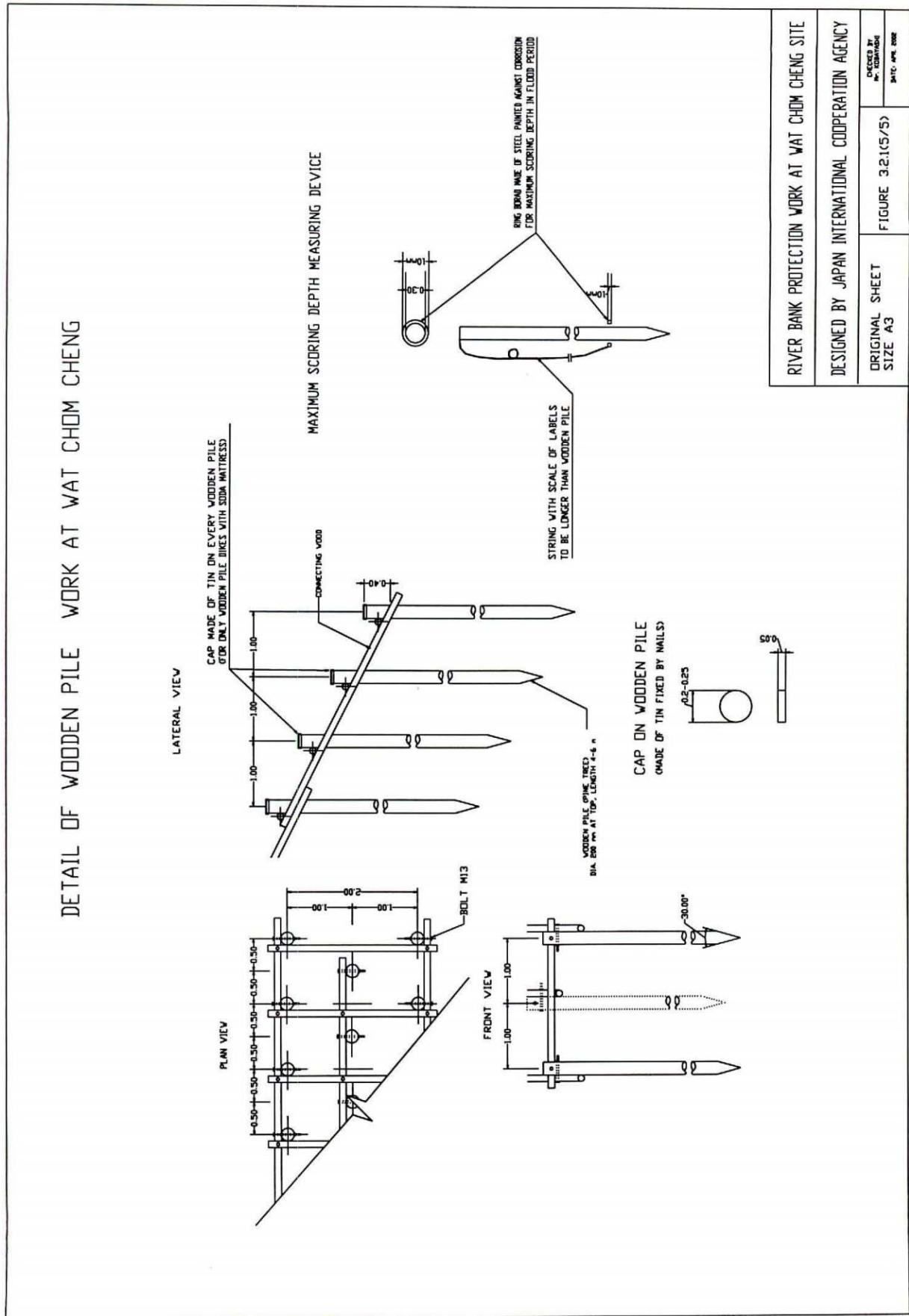


Figure 4.6 Detail of Wooden Pile Work at Wat Chom Cheng Site

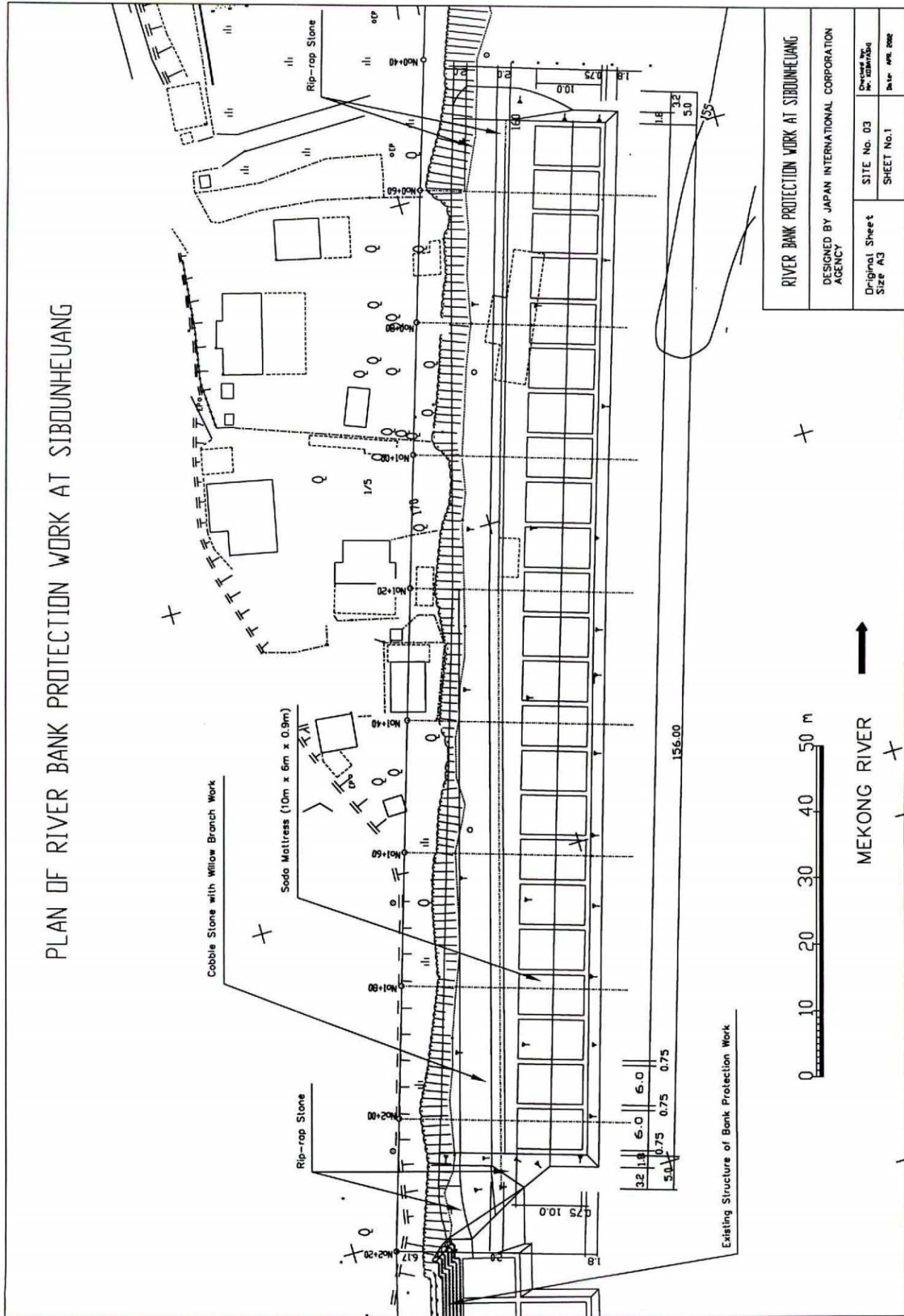


Figure 4.7 Plan of River Bank Protection Work at Sibounheuang Site

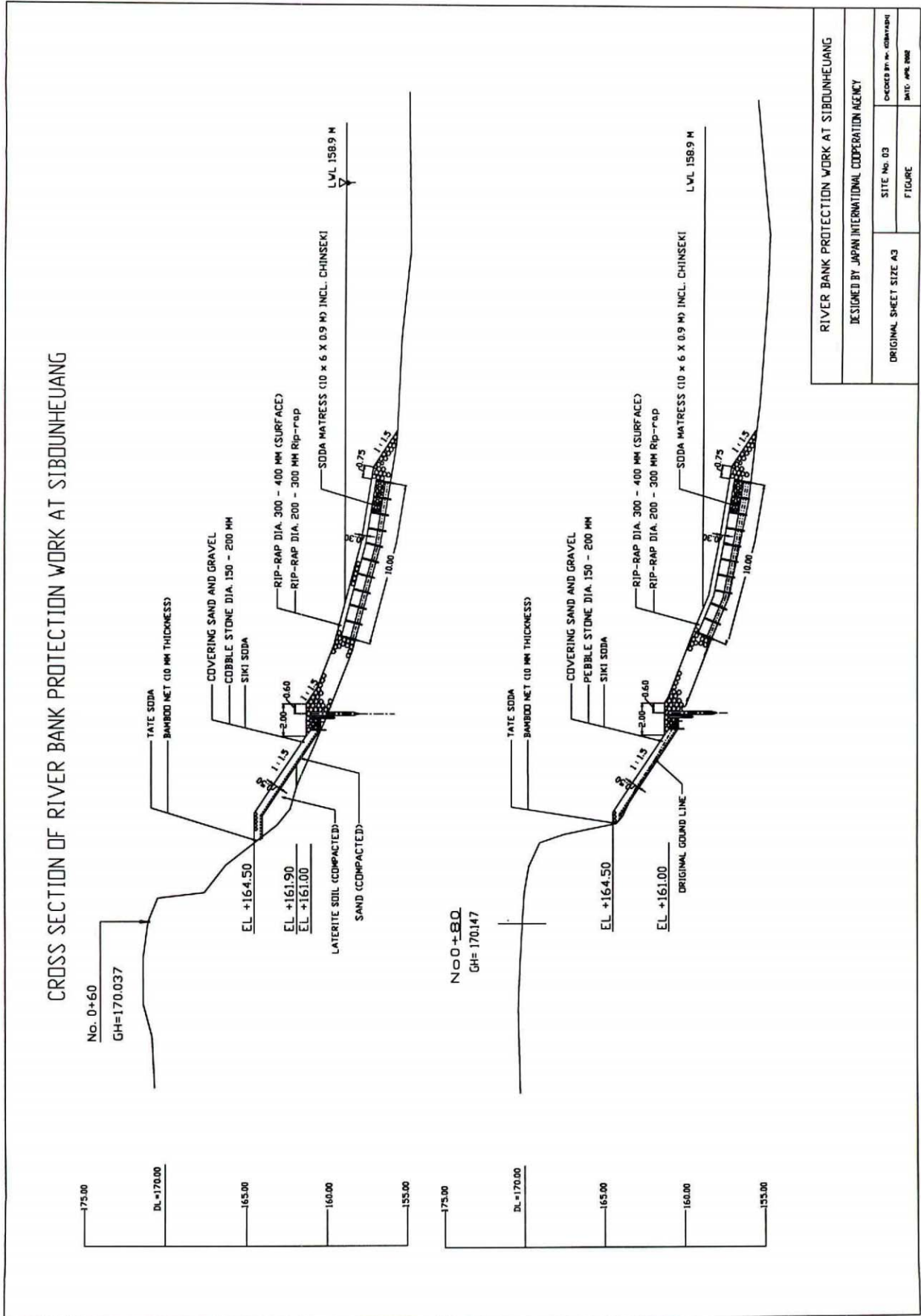


Figure 4.8(1/5) Cross Section of River Bank Protection Work at Sibounheuang Site

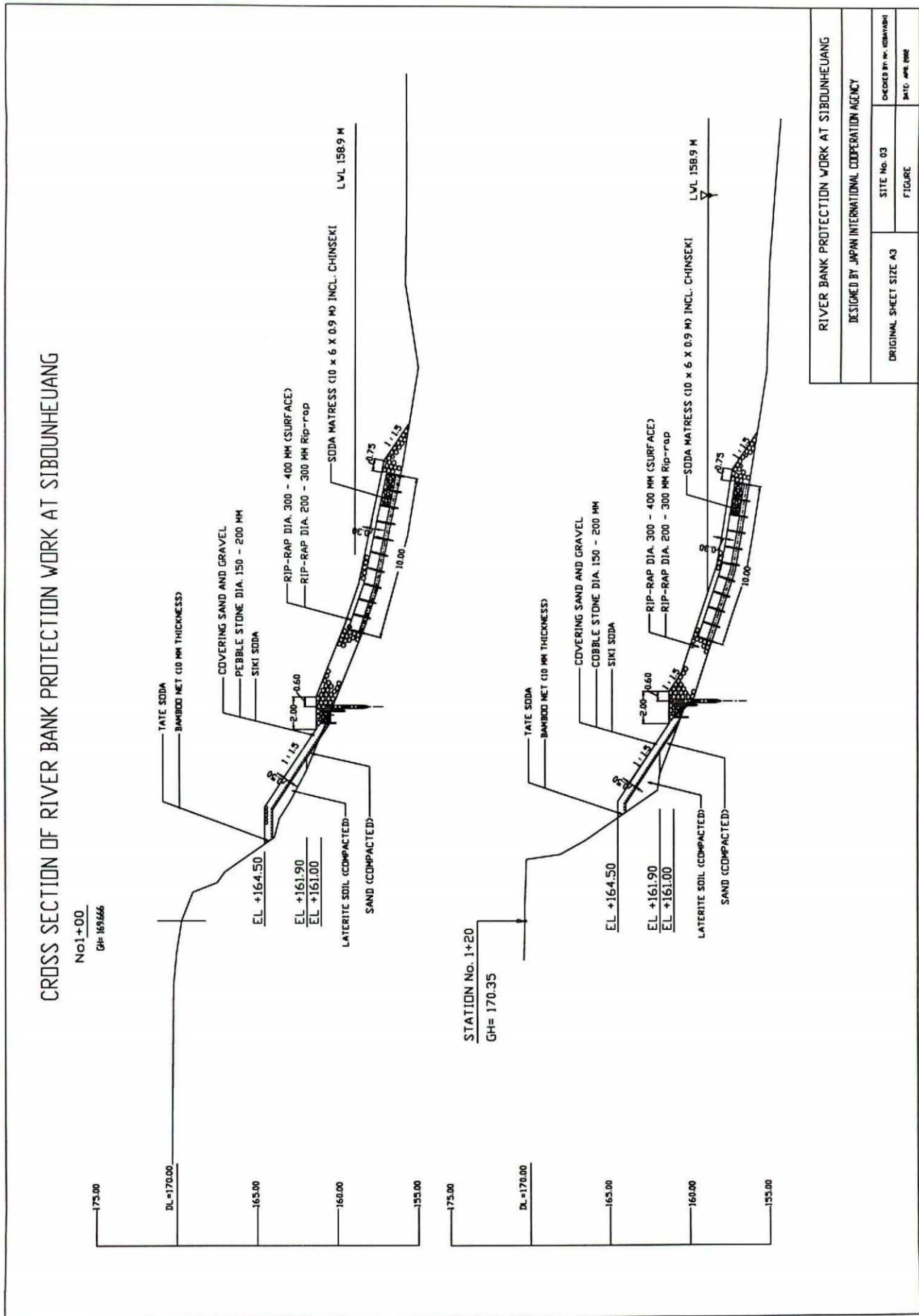


Figure 4.8(2/5) Cross Section of River Bank Protection Work at Sibounheuang Site

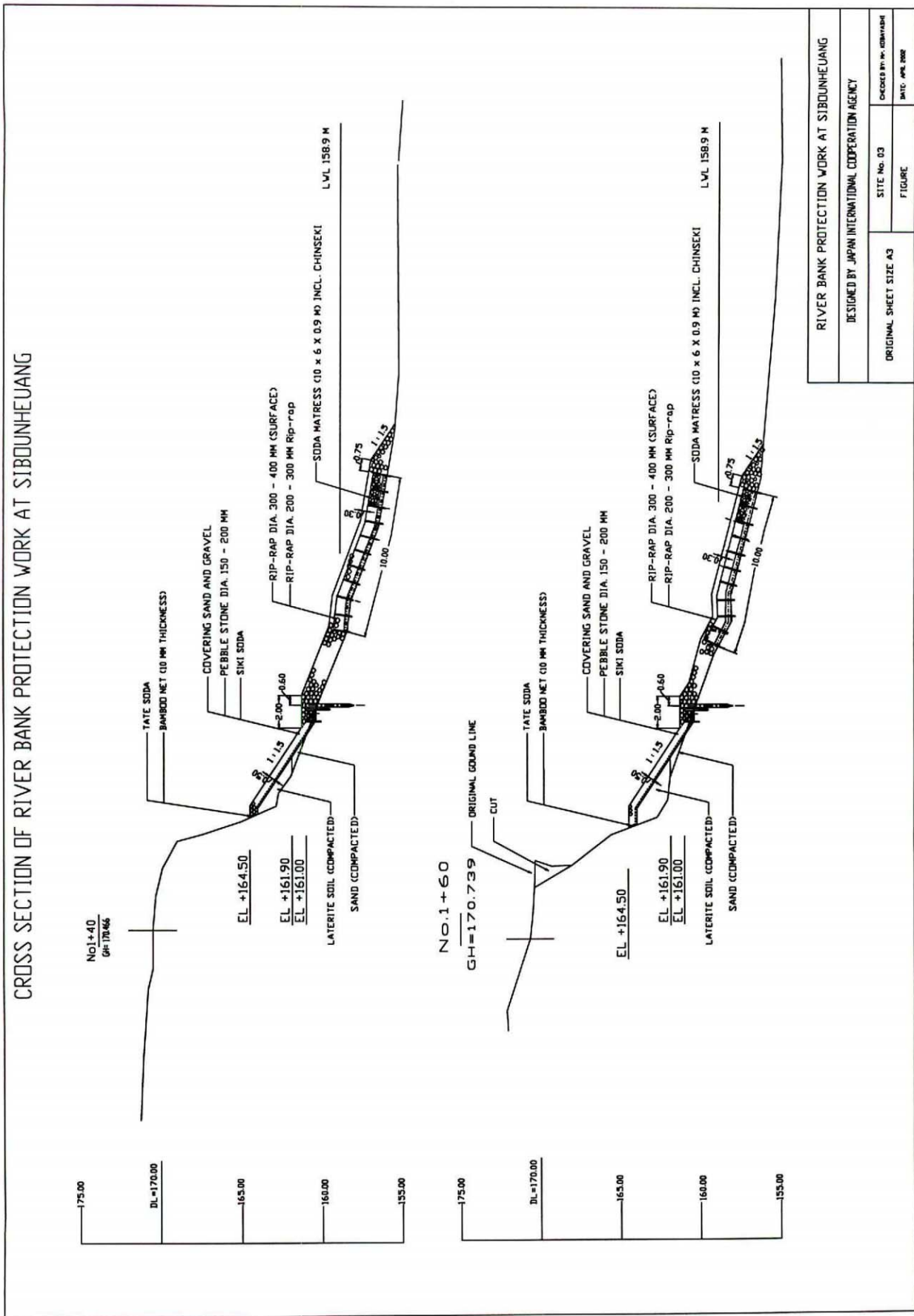


Figure 4.8(3/5) Cross Section of River Bank Protection Work at Sibounheuang Site

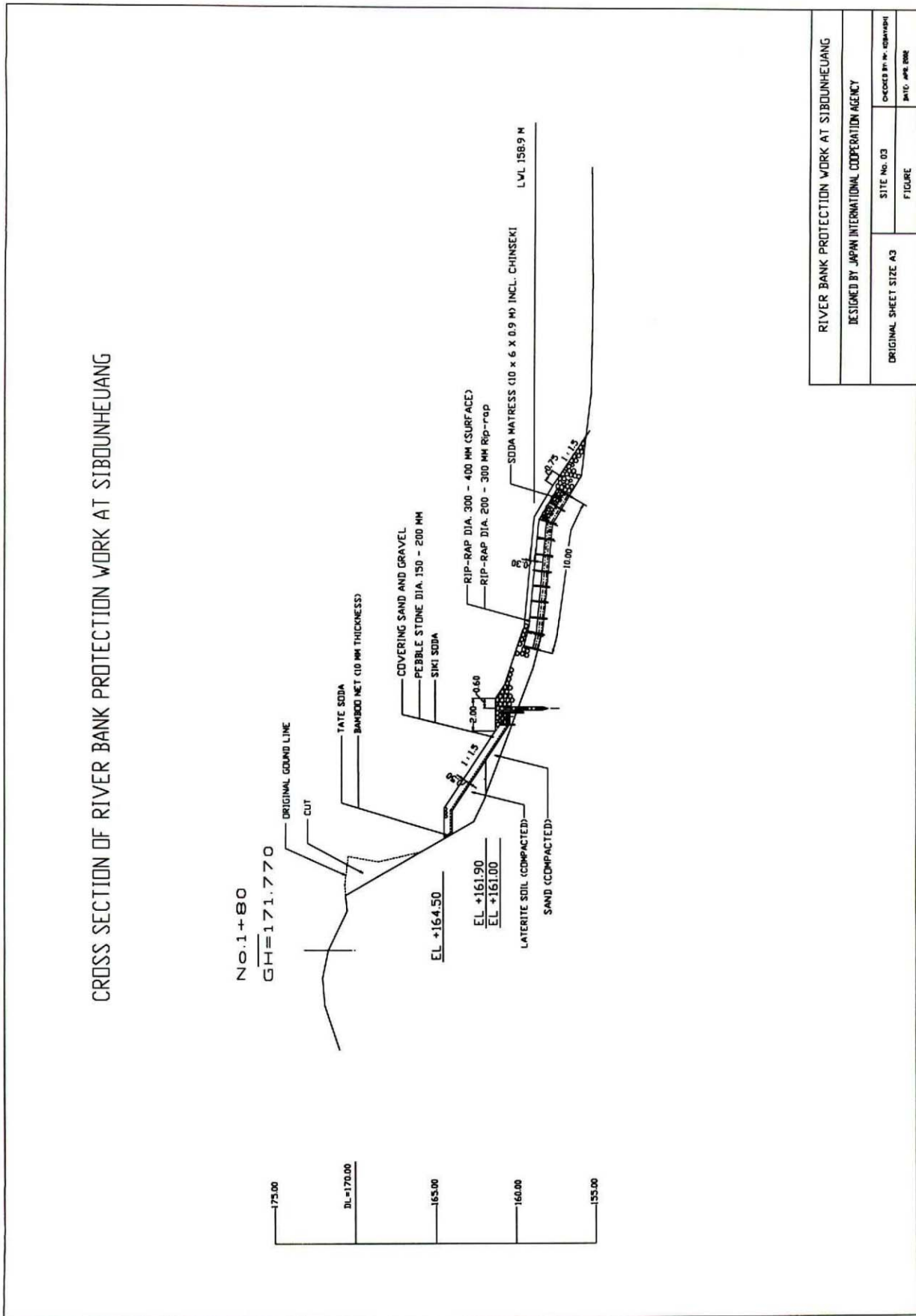


Figure 4.8(4/5) Cross Section of River Bank Protection Work at Sibounheuang Site

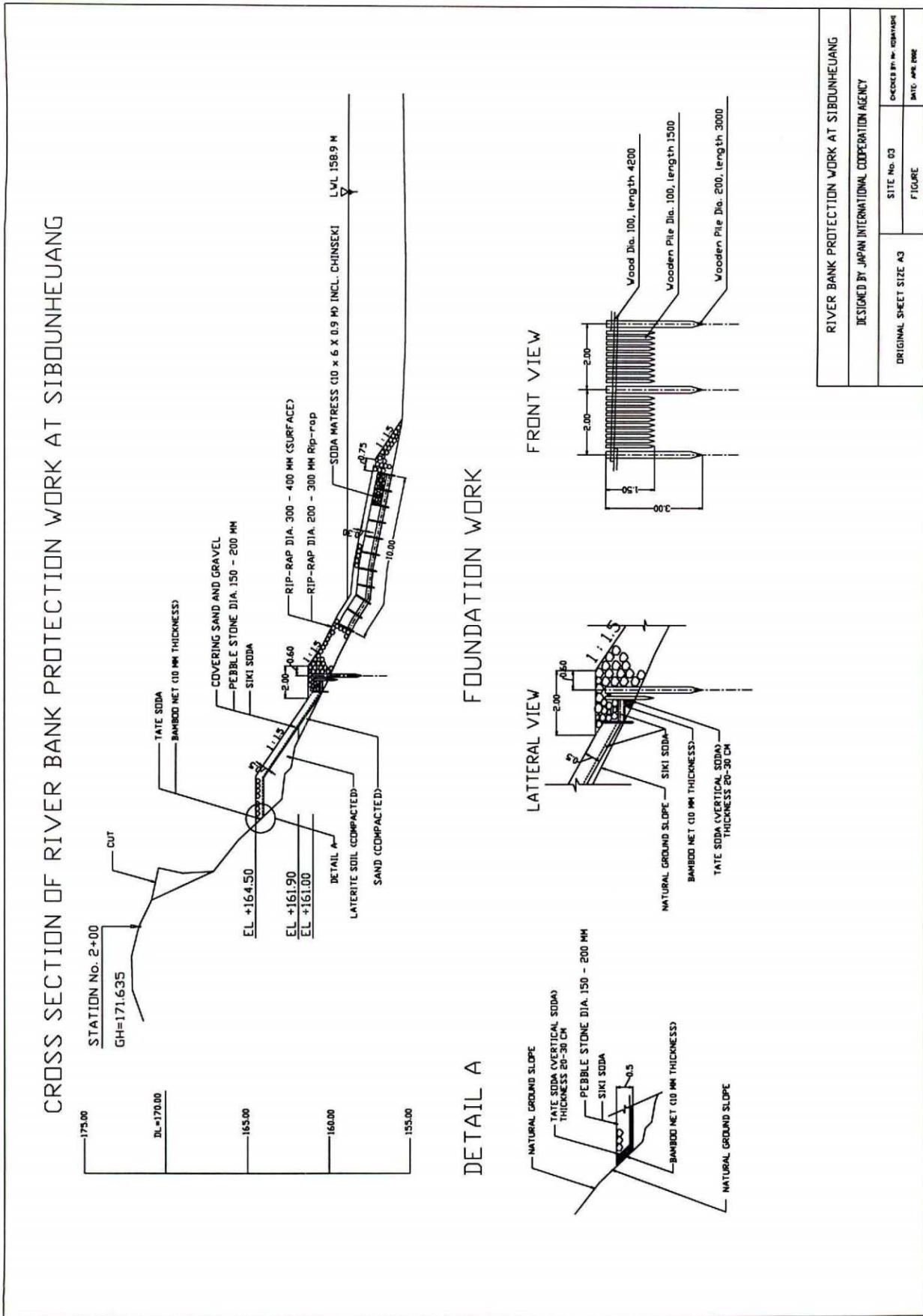


Figure 4.8(5/5) Cross Section of River Bank Protection Work at Sibounheuang Site

5 MONITORING PROGRAM

Monitoring survey shall be executed to confirm the effect of the pilot works, and to be reflected to the bank protection master plan. The monitoring program consists of 1) Topographic and hydraulic condition and 2) Vegetation condition. In preparing the monitoring program, it was kept in mind that the results of pilot works would be reflected to the bank protection master plan and the plan and design manual for counterpart personnel.

5.1 Topographic and Hydraulic condition

The monitoring program for the topographic and hydraulic condition is as shown in Table 5.1.

Table 5.1 Monitoring Program

Monitoring Items	Site	Nos	Interval	2001	2002		2003		2004	
				Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
Cross-sectional surveying	All Sites	2				—		—		
River water stage	All Sites		Everyday	—————						
Flow velocity and direction	All Sites	6		—	—	—	—	—	—	
Scoring depth	Wat Chom Cheng	2				—		—		

5.1.1 Topographic Survey

The change in the local scour in the vicinity of the tip of countermeasure, especially Soda Mattress bank protection work and Cobble Stone with Willow Branch bank protection work, the transformation of countermeasure, the situation of bank erosion and deposition at the upstream installation parts shall be understood by the topographical survey within the range up to about 1.5m in depth and the comparison in the time series of the sounding result.

The transformation and the inclination of the piles of Pile Dike work shall be measured by the topographical survey. It is expected to cause the local scour of the foundation of the pile in the vicinity of the tip of the Pile Dike work for the flood period. To examine the local scour depth, a doughnut of the steel-made and the rust proofing painting with the rope for the measurement shall be additionally set on the initial riverbed at the position of the piles, and devised by several places to be able to measure the vertical position according to the length of the rope for the measurement at the dry season of next year.

5.1.2 River Water Stage and Flow Velocity and Direction

The change of water level and discharge shall be understood based on the data of the water level and discharge gauging station of Vientiane KM4.

In addition, horizontal and vertical distribution of flow velocity and direction around the pilot works in the time of a different water level, that is, the dry season and the rainy season, before and after the construction of the bank protection works, shall be measured to grasp the change in a local flow field in the effect of the flow velocity decrease and the effect of shifting the current direction etc. The daily water level of each construction site other than Sibounheuang Site shall be observed with the water gauges, which were set by the study team. The water level of Sibounheuang Site shall be referred to the data measured by the existing water gauge.

5.1.3 Scoring Depth

By means of ring-board with stirrings set at the bottom of wooden pile of Wooden Pile Dike Groyne Work at Wat Chom Cheng. Location of setting is approximately four points, at the tip of groyne without Soda mattress. Two of them are in longitudinal direction and remaining is in lateral direction. Length of string will be measured just after completion of construction and once in every dry season in 2 years after that.

5.2 Vegetation condition

The monitoring program for vegetation condition is as shown in Table 5.2. The monitoring will be at four (4) categories: 1) The project sites (3 sites), 2) Existing project site (4sites), including at Wat Sibounheuang site, where the test project was conducted by IDI-Japan, Thadeua site, National Culture Park, and another site constructed about 3years ago, 3) Natural bank slope (4 sites), including a site where erosion occurs, but no bank protection work has been constructed, a site where slope is covered by vegetation, and a site where willow communities grows on sand bar, from where willow trees will be collected for the pilot project, and 4) Soda materials supply area.(2 sites), including the site for the test project at Wat Sibounheuang done by IDI-Japan, and a site for the pilot project.

The program is planned in the aim of comparison study of planting method and timing:

Planting method : Direct cutting / Using stumps prepared in poly-pot

Planting timing: During construction period (March 2003) /Just before rainy season (May-June, 2003) / End of rainy season (November – December, 2003)

Monitoring items are as below:

Growth situation of willow at Pilot works sites and existing bank protection sites:

- Measurement of germinating willow (Numbers, Size) /- Photographing

Growth situation of tree at site where soda material was / will be gathered:

- Measurement of germinating willow (Numbers, Size) / - Photographing

Distribution of vegetation and Flora at Pilot works site, existing bank protection sites, and natural bank slope site(s):

- Preparation of vegetation distribution map

- Preparation of vegetation distribution cross section

- Photographing
- Preparation of plant kind list

Photograph will be taken in consideration of the followings:

The passing age situation change in the brushwood mountain where the process of the brushwood production, the collection, and the reproduction is repeated shall be recorded in the photograph. The passing age situation change in the quarry shall be recorded in the photograph.

In Soda Mattress bank protection work and Cobble Stone with Willow Branch bank protection work, it is expected that germination and growing after the construction are generated because unseasoned wood is used. Therefore, changing in vegetation on each construction site shall be observed and recorded, and the appearance in the future is presumed. In Cobble Stone with Willow Branch bank protection work, the growing situation such as invasion of the sprout and the root from immediately after planting to the following rainy seasons, and the number of remaining and the growing situations after these rainy seasons shall be understood.

The planting plan at Ban Dongphosi Site is as shown in Figure 5.1.

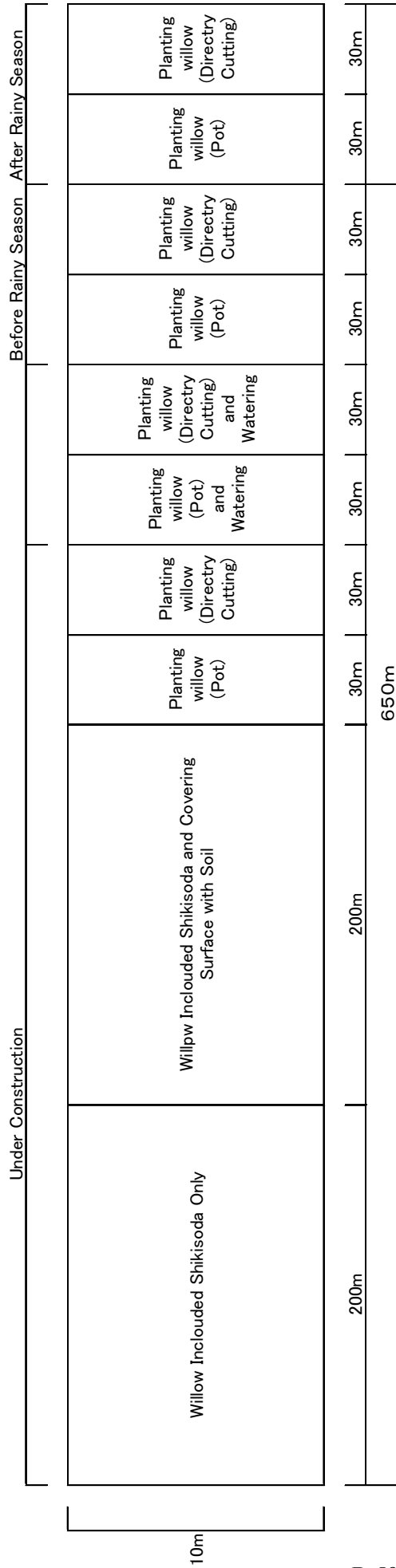


Figure 5.1 Planting Plan at Ban Dongphosi Site

6 CONSTRUCTION PLAN

6.1 Construction Method

6.1.1 Bank Protection Type

The bank protection type at three (3) sites for the Pilot Works under the Study are mainly composing of the rubble deposition work used commonly in Mekong and various Japanese traditional river works such as the piling spur dike, soda mattress, log hurdle and riprap with willow fascine.

The protection type for the Pilot works is summarized in Table 6.1

Table 6.1 Bank Protection Type of Pilot Works

Site Name	Ban Dongphosi	Wat Chom Cheng	Sibounheuang
Foot Protection Work	Soda Mattress System Rubble Deposition	Type A: Soda Mattress System Piling Spur Dike Type B: Piling Spur Dike	Soda Mattress System Rubble Deposition
Slope Protection Work	Log Hurdle Riprap with Willow (fascine)	Piling Spur Dike	Riprap with Willow (fascine)

The construction method for the bank protection is described below.

6.1.2 Soda Mattress System

Soda Mattress System consists of Soda(Fascine) , Rensai(Tie-twigs array), Sitagousi, Temporary Kogui, Siki-Soda, Uegousi, Kogui, Sigara gaki, Piling, transportation and installation works. The concept of each works is summarized in the table below.

Table 6.2 Description of Soda Mattress System

Soda Works Item	Description
Rensai works (Tie-twigs array)	On the processing stand for Rensai work, The Soda is spread, and excessively thick and bent ones are removed. The butt ends of Sodas at both ends will be directed to each end of the stand. Sodas in middle will be arranged so that all butt ends are directed in one direction. Soda must be tightened, adding Soda of good quality, to make it 15cm in diameter. Then it must be tightened at 20cm intervals by double whips.
Sitagousi assembly works (Bottom grid array)	Rensai will be arranged in array (crosswise at 1m intervals) so that butt ends are directed to the upstream and the bank. The arranged Rensai in top and bottom are tightened by straw ropes.
Temporary Kogui works (Short pile)	After Sitagousi assembly, Kogui will be temporally driven at crossing points of Sitagousi, and straw ropes, whips, and sling wires are temporally fixed with Kogui.
Siki-Soda works	After Sitagousi work, a layer of bundled, not-tightened soda will be laid on the Sitagousi for the first layer, and unfastened bundles of soda will be laid for second and third layers. For each layer, butt ends of soda will be laid in parallel or perpendicular to the river. Adjacent layers are in right angle, making the third layer in same direction as the first layer.
Uegousi assembly works (Top grid)	After Uegousi is arranged in same method as the Sitagousi, they are tightened by straw ropes, which have been set beforehand at the Sitagousi.
Kogui works (Short pile)	Kogui will be driven into Uegousi to make their heels 35cm above the Uegousi crown. Before installing soda mattress, they will be driven to make their heels 6cm above Sigara-gaki crown
Sigara-gaki works (Hurdle)	Sigara-gaki is to weave taisya between Kogui and Kogui. First Sigara to be weaved is Crosswise Sigara (right angles to water flow) and the second is outside Sigara, starting from center of downstream side, and the last is Lengthwise Sigara (the same direction as water flow). They will be driven to be about 15cm in height by a wooden hammer, and be tightened by iron wire.
Piling	After completion of assembly, they will be piled at temporary stockyard by a crane. They will be piled in no more than three layers.
Transportation	Soda mattresses will be loaded on a transport ship by a crane, and be transported to the construction site.
Installation	Approximate location of the Soda mattresses will be marked by, for example, floats, and exact locations are directed using survey instruments. After installation of Soda-mattresses, rubble stones will be placed onto them.

Various works in the Soda Mattress System constructed in Mekong at Sibounheuang under IDI Japan are illustrated in Figure 6.1.



1) Arrange the tie-twig so that they form a square 1 m length fascine grid or lattice beam structure



2) After assembly, the short pile will be temporarily droved at crossing points



3) Use only adhesive and flexible wood for cross twigs



4) Lift and transport the finished mattress using a crane



5) Submerge the mattress in the previously designate river position.



6) Lift and place cobble stone with a crane

Figure 6.1 Work Flow of Soda Mattress System

6.1.3 Log Hurdle Work

Log hurdle work is composed of primary log piling, secondary (short) piling, wailing by log waling and cobble place.

The primary log piling is set 2 m interval by man-power. After piling logs and waling log are clamped with bolts, secondary short logs piling are set behind the waling log. Behind the secondary piling logs, the cobble stones are placed as backfill.

6.1.4 Riprap with Willow Fascine

After smoothing the embankment slope, the Siki-Soda (fascine) with a length of 1.2 – 1.8 m are spread, setting the root side toward upstream. After piling short wood with an interval of 50 cm, the frame is set with B:2.0 m * L:2.0 m and the hurdle made of Taisya (small tree trunk with a flexibility) with a height of 15-20 cm is filling by cobble. For the short pile and Taisya, the willow branches are used. The willows are spread in the Siki-Soda.

6.1.5 Log Piling

For the piling less than 3 m of the log length, the manpower should be commonly adopted. In addition, the piling work by the simple water jet power using water pump or the backhoe is also available for incoherent soil condition. The piling by the puncher or the crane is adapted to the completed bank protection project in Mekong at Ban Vangpho.

6.2 Material Procurement

6.2.1 Specification of Materials

The specification of main materials used for the various works categorized for the Pilot Works is listed in Table 6.3.

For Japanese traditional river works, Japanese standard is arranged for the local material to be procured in the market or on the site.

The river sand, gravel, laterite soil and the crushed stone produced on sites, using as the embankment and deposition are similar to local standard, used for the bank protection project completed in the past.

The name of trees used for Soda Mattress system are described in the Section 6.2 of Sector A.

Table 6.3 Specification of Main Material used for Pilot Works

Item	Specification	Unit
Soda Mattress		
Soda	Length: 2.7m, 45cm rise peripheral 60cm 200cm rise peripheral...55cm	bundle
Taisya	Length:2.7m, ϕ 2~3cm at butt end ϕ 1.0cm at 2.7m rise 25 twigs per bundle	bundle
Kogui	Length: 1.2m, ϕ 3~5cm at butt end	Pieces
Rubble stones	ϕ 400~200 mm ϕ 150~50 mm	m ³
Straw rope	ϕ 10 mm	m
Zinc-coated whip	#10	m
Zinc-coated whip	#12	m
Siki-Soda (1layer)		
		Unit
Soda	Length: 2.7m, 45cm rise peripheral 60cm 200cm rise peripheral 55cm	bundle
Kigui	Length:2.5m, tip end: ϕ 12cm	Piece
Tie-beam	Length:3.5m, tip end: ϕ 9cm	Piece
Soda-bundle	(ϕ 300 6 layer)	bundle
Back rubble stone	ϕ 100~50 mm	m ³
Straw rope	ϕ 10 mm	m
Zinc-coated whip	#10	m
Zinc-coated whip	#12	m
Log Hurdle Work		
		Unit
Pile (Kogui)	Length:3 – 4.0 m, tip end: ϕ 15 cm	Piece
Wailing log	Length:3.5m, tip end: ϕ 9cm	Piece
Short pile	(ϕ 300 6 layer)	bundle
Bolt	L=30 cm, d=13 mm	Unit
Nail	L=15 cm	Kg
Back rubble stone	ϕ 150~50 mm	m ³
Embankment Work		
		Unit
River sand & Gravel	Collected in Mekong	m ³
Laterite	Collected on Site	m ³
Rubble (Rip rapping)	ϕ 200~150 mm	m ³
Rubble (Deposition)	ϕ 400~200 mm	m ³
Bamboo net	B=2.5 m L=1.0 m	M2
Slope Protection Work		
		Unit
Soda	L=3.0 m, S=0.7 m	Bundle
Taikyou	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	Bundle
Cobble	ϕ =150 – 200 mm	m ³
Piling Work		
		Unit
Wooden Pile	Length:4 – 6.0 m, tip end> ϕ 15 cm	Unit
Tie-beam	L=3.2 m, tip end> ϕ 9cm	Unit
Bolt	L=30 cm, d=13 mm	Kg

6.2.2 Procurement

Soda fascine should be collected near the site (Ban Dongphosi) or the local village at Ban Naxone and Ban Thanghong along No 13 Road.

The woods for the log hurdle work, log piling and riprap work with willow fascine may be supplied in market. KM 5 Wood Product Factory procure the woods from Luang Phabang Province.

The crushed stone for rip rapping, deposition work etc. is procured under State Company only in Vientiane Province at Ban Sakai.

The Laterite soil is collected at the borrow site near Ban Dongphosi. The river sand and gravel is collected in Mekong at Xiangkhouan.

The metal material such as zinc-coated whip, bolt, nail is easily procured by the suppliers in Vientiane city.

6.3 Equipment Procurement

The main equipments in the completed riverbank protection projects are summarized in Table 6.4.

Among these projects, the floating dock, barge, and crane were utilized for the place of Soda Mattress system at Shi Bounhuang. In addition, the Soda Mattress system at Tha Khek site were placed by the similar equipment.

Table 6.4 Main Equipments in 4 Projects

Project Name	Tha Deua Phase II	Phanmanh Phase II	Wattay	Shi Bounhuang
Bank Length (m)	250	63	250	80.25
Construction Year	1992-1993	2001-2001	1995-1996	2000-2001
Main Protection Work	Gabions Wall	Reno Mattress Embankment/Riprap	Reno Mattress Gabions Wall	Soda Mattress Gabions Wall Tie-twigs Hurdle
Main Equipment	Rough Terrain Crane Bulldozer Motor Grader Motor Excavator & Loader Truck and Crane Damp Track	Bulldozer Wheel Loader Backhoe Loader Roller Compacter Tracto Graderr Tanker DumpTrack	Excavator Bulldozer Motor Grader Roller Compacter Water Tank Dump Track Plate Compacter	Rough Terrain Crane Crawler Crane Floating Dock Material Barge Wheel Loader Backhoe Dump Track

For the Pilot Works, the equipments listed in the Table should be utilized due to similar bank protection work.

The damaged concrete wall is still spread at the construction site of Ban Dongphosi. Specially, the concrete breaker for the clearing work shall be required.

According to the contractor survey, the mentioned major equipments almost are owned by the contractor. Rental service of the equipment also is commonly in Vientiane market.

6.4 Preliminary Cost

6.4.1 Unit Cost

Unit cost survey has conducted through the interview from the local contractors and various tender document in the bank protection work in Mekong River, as listed below.

Table 6.5 Unit Cost of Material and Equipment Rental

	Description	Applicable	unit	unit price (us \$)
1	Rubble Stone including Transportation from Sakai-VT	> 500 mm	m3	20~26
		300-500 mm	m3	20~26
		< 300 mm	m3	20~26
2	Clean Sand		m3	8~12
3	Transportation (L=30-40 Km)	10T Dump	Per Day	100~130
4	Unit crane		Per Day	100~140
5	Floating Dock		per Month	3000~3700
6	Barge		per Month	3000~4000
7	Tag Boat		Per Day	450~600
8	River sand and gravel		m3	4~7
9	Piling of Wood	5 m Depth=2-3m	10 unit	20~30

Table 6.6 Unit Cost of Major Work

	Description	unit	unit price (us \$)
1	Common Excavation	m3	1.0~1.47
2	Supply and fill laterite	m3	4.02~4.50
3	Supply and fill gravel	m3	4.02~4.92
4	Supply and fill gravel below water	m3	10~15
5	Assemble, place Reno mattress	Unit	2~8
6	Supply and place rock	m3	27~31
7	Supply and place Geotextile	m2	1~3
8	Gabion Rockfill	m3	30~38
9	Supply and riprap (ϕ =12-20 cm)	m3	18~26
10	Log piling (l=3-5m, ϕ =5-10 cm)	Unit	3~7

6.4.2 Quantity

Based on the preliminary design, the main item of the construction quantities at three (3) sites are summarized in Table 6.7.

The total quantities of the main item for the Pilot Works tentatively are calculated below.

Description	Unit	Quantity
Soda Fascine	bundle	55,400
Log Pile (ϕ =4-20 cm)	unit	99,700
Embankment Laterite and Gravel	m3	39,100
Crushed Stone	m3	20,900

Table 6.7 Preliminary Quantities for 3 Pilot Works

Ban Dongphosi		Wat Chom Cheng		Sibounheuang	
Description	Unit	Quantity	Description	Unit	Quantity
1 Preparatory Works			1 Preparatory Works		
1.1 Establishment of access	LS		1.1 Establishment of access	LS	
1.2 Clearing of stockpile area, contractor's area	m2		1.2 Clearing of stockpile area, contractor's area	m2	
1.3 Clearing of construction site	m2		1.3 Clearing of construction site	m2	
1.4 Establishment of site office, workshop etc.	LS		1.4 Establishment of site office, workshop etc.	LS	
2 Earthworks			2 Earthworks		
2.1 Cut to waste of unsuitable material	LS		2.1 Cut to waste of unsuitable material	m3	
2.2 Cut and trimming to form	m3		2.2 Cut and trimming to form	m3	
2.3 Supply and place laterite/gravel	m3		2.3 Supply and place laterite/gravel	m3	
2.4 Supply and place Bamboo net	m2		2.4 Supply and place Bamboo & Tate-Soda	m2	
2.5 Tate-Soda	m2				
3 Foot Protection Works			3 Foot Protection Works		
3.1 Assemble, place and Soda mattress (Size 10 m*10 m*0.9 m)	unit		3.2 Assemble, place and Soda mattress	unit	
3.2 Supply and place rubble in Soda mattress	m3		3.3 Supply and place rubble in Soda mattress	m3	
3.3 Supply and place rubble on Soda mattress	m3		3.4 Supply and deposition rubble on Soda	m3	
3.4 Supply and deposition rubble for Toe	m3				
4 Slope Protection Works			4 Log Hurdle Works		
4.1 Supply and place cobble	m3		4.1 Supply, assemble and place log	unit	
4.2 Supply and place log	bundle		4.2 Supply, assemble and place Tate-Soda	bundle	
4.3 Supply and place soda (fascine)	bundle		4.3 Supply, assemble and place Bamboo	m2	
4.4 Supply and place willow (fascine)	bundle		4.4 Bolt	unit	
4.5 Supply and place Taikyo	bundle		4.5 Supply and deposition rubble	m3	
5 Finishing Works			5 Slope Protection Works		
5.1 Planting	m2		5.1 Supply and place cobble	m3	
6 Repair road	m2		5.2 Supply and place log	bundle	
6.1 Kerb	m		5.3 Supply and place soda (fascine)	bundle	
7 Quality Control			5.4 Supply and place willow (fascine)	bundle	
7.1 Testing	LS		5.5 Supply and place Taikyo	bundle	
8 Contingency			6 Finishing Works		
8.1 Detour road or steps	LS		6.1 Planting	m2	
			6.2 Repair road	m2	
			6.3 Kerb	m	
			7 Quality Control		
			7.1 Testing	LS	
			8 Contingency		
			8.1 Detour road or steps	LS	

6.5 Implementation Schedule

6.5.1 Local Contractor

Table 6.8 lists the contractor with the experience of the bank protection works in Vientiane City.

For the bank protection using the Soda mattress, Engineering Construction Company has sufficient experience to procure the soda fascine, assemble the mattress and set the mattress using a crane and dock under IDI Project.

In addition, D.M. Construction Co., Ltd has also the bank protection work (Jan. to April, 2001) at Tha Khek, using the soda mattress.

Table 6.8 Contractor with Bank Protection Works in Vientiane City
(1989-2001)

	Project Name	Length(m)	Beginning	Completion	Contractor
1	Thadeua Phase I	250	1989	1990	Communication Construction Company Km 18
2	Thadeua Phase II	250	1992	1993	Road and Bridge Company
3	Tana Laeng	400	1993	1994	John Holland Company
4	Wattay	250	1995	1996	IBANETSU Company
5	Ice Factory Kaoliao	140	1995	1996	Savannaked irrigation Company
6	Tha Watmuangwa	250	1996	1997	IBANETSU Company
7	Hatdokkeo	400	1996	1997	Savannaked irrigation Company
8	Vat Sop	320	1997	1998	CTC Company
9	National Culture Park	400	1997	1998	High Land Road and Bridge Company
10	Phanmanh Phase I	47	2000	2000	State Survey Design, Water Way Construction Company
11	Khuy Daene Mane Phase I	55	2000	2000	SVS Construction Company
12	Ban Home Phase I	65	2000	2000	K SC Construction Company
13	Hatdokkeo	30	2000	2000	LKC Construction Company
14	Ban Vang Pho	120	2000	2000	K SC Construction Company
15	Sibounheuang	83	2000	2001	Obayashi, Engineering Construction Company
16	Phanmanh Phase II	63	2001	2001	SVS Construction Company
17	Khoy Daene Mane Phase II	55	2001	2001	SVS Construction Company
18	Ban Home Phase II	100	2001	2001	KSC Construction Company
19	National Culture Park	20	2001	2001	LKC Construction Company
20	Ban Vang Pho Phase II	50	2001	2001	KSC Constructions Company
	Total	3348			

The contractors with the experience of Mekong River bank protection construction should be nominated for three (3) pilot works.

6.5.2 Procedure to Tender

The finance source for the pilot works is granted by JICA. The Study Team has an attorney from JICA for the evaluation/selection of the contractors and the contract.

The procedure of the contract for the pilot works is belows;

- (1) Preparation of the tender document
- (2) Approval from JICA Headquarter for the tender document
- (3) Nomination of the contractors in the short list.
- (4) Bid quotation submitted by the bidders
- (5) Evaluation and selection by the Study Team
- (6) Approval from JICA Headquarter for the selection and the contract

For the tender document, the expressions shall be defined as below.

Table 6.9 Definition for Tender Document

	Item	Description
1	Employer	JICA Study Team on Mekong Riverbank Protection around Vientiane Municipality
2	Finance	Japan International Cooperation Agency (JICA)
3	Project	Construction of the bank protection in Mekong River at Ban Dongphosi, Wat Chom Cheng and Sibounheuang
4	Tender Document	Invitation to bid, instruction to bidders, condition of contract, technical specification and bid forms
5	Bidder	Partnership, corporation, association, firm or joint venture submitting to the Employer or his authorized representative
6	Bid	Quotation submitted by the Bidders
7	Price	The sums referred to in the contract shall include all costs for Project
8	Effective Date Contract	Date of signing the contract by the Employer and contractor
9	Completion Period	Mentioned date in the specifications and tender document
10	Certification	The Employer issues after the inspection by the Contractor to obtain the satisfaction of the Employer or his authorized representative.

6.5.3 Implementation Schedule

Under the budget program of JICA, there are some restrictions for the execution of the Pilot Works.

- 1) Study Team shall enter into Lao PDR on the beginning of October 2002.

- 2) It takes approximately one (1) month for the preparation and approval of the tender and bid.
- 3) The construction work will commence on the beginning of November 2002.
- 4) Three (3) Pilot Works shall be completed until the end of March 2003.

Based on the estimated preliminary quantity and above-mentioned restrictions, the implementation schedule is tentatively drawn in Fig. 6.2

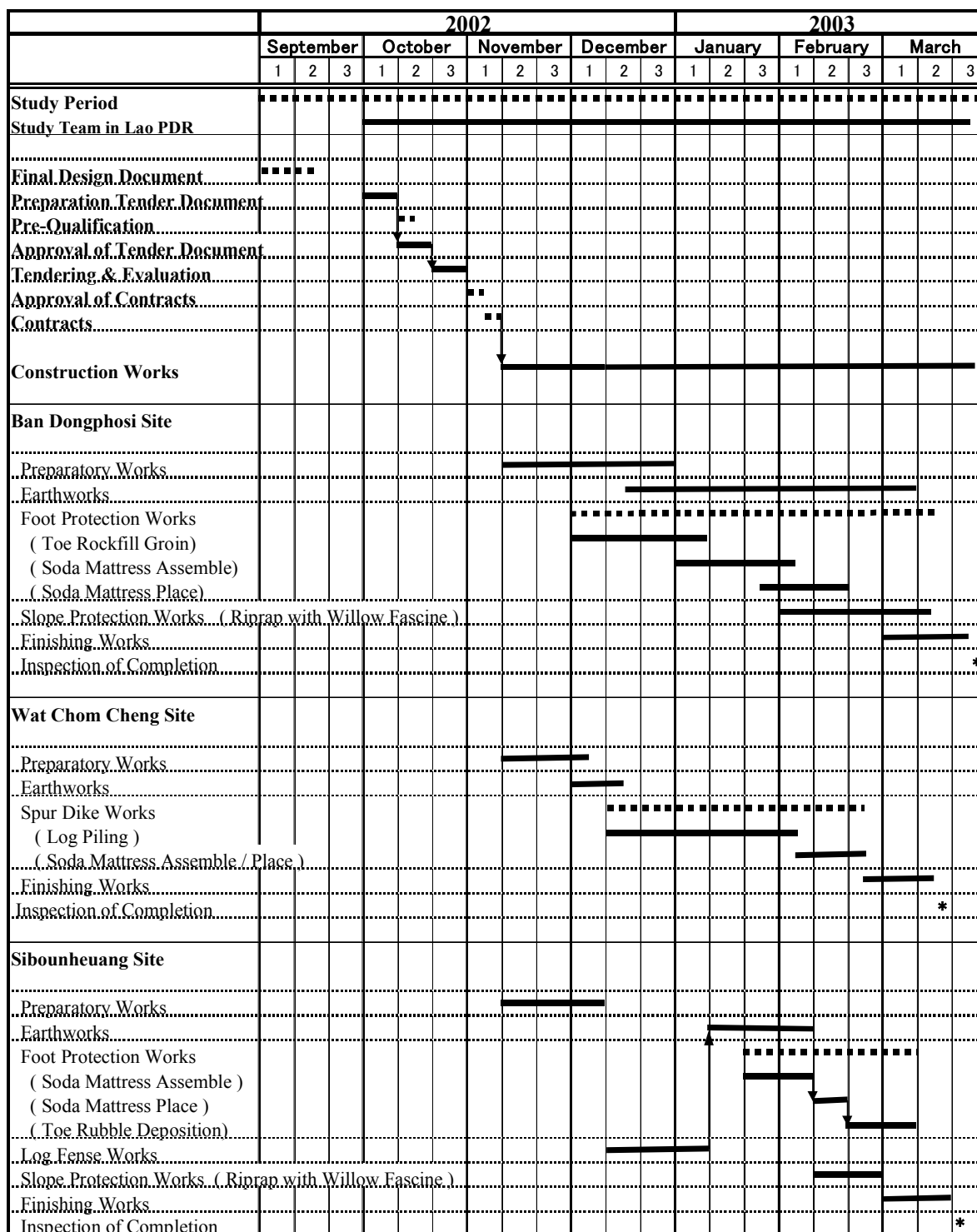


Figure 6.2 Implementation Schedule for 3 Pilot Works

SECTOR C

FIELD SURVEY FOR PILOT WORKS

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

**FINAL REPORT
VOLUME 4
-SUPPORTING REPORT-**

SECTOR C

FIELD SURVEY FOR PILOT WORKS

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SECTOR C

FIELD SURVEY AND INVESTIGATION FOR PILOT WORKS

This Sector describes general result of the field survey and investigations conducted by local contractors for the pilot works to be executed by the Study Team in 2nd Work in Lao P.D.R. This includes topographic survey (cross-section and mapping), geotechnical investigation, velocity measurement and environmental survey.

1 TOPOGRAPHIC SURVEY

1.1 Cross Sectional Survey

1.1.1 General

The profile and cross-sectional survey were carried out at pilot work sites along the Mekong Riverbank in Vientiane City. The coverage of the survey work for riverbank protection was determined based on the consultation between the Study Team and MCTPC. It was divided into the following three sites; Ban Dongphosi, Wat Chom Cheng and Sibounheuang. The survey work was conducted by a local contractor under the supervision of the Study Team.

1.1.2 Method

The metric system was used as the system of measurement. The horizontal location was determined by National coordinate datum (Ellipsoid: Krassovsky Projection: UTM). The elevation was measured as the elevation above the mean sea level (Hon Dau Vietnam).

All control points were observed by GPS (Global Positioning System) and those points were transformed into National coordinates. The monument of the centerline for the cross section was measured by the double running method using the first class level and each point was connected to the national Bench Mark. The cross-sectional survey was conducted using a total station, aluminum staff and a lead weight.

1.1.3 Quantity of Works

Quantity of works is as shown below:

Work Item	Unit	Quantity
1. Ban Dongphosi		
- GPS control point survey	point	2
- Plastic post Monumentation	point	43
- Cross-sectional survey	line	43
2. Wat Chom Cheng		
- GPS control point survey	point	2
- Plastic post Monumentation	point	21
- Cross-sectional survey	Line	21
3. Sibounheuang		
- GPS control point survey	point	2
- Plastic post Monumentation	point	16
- Cross-sectional survey	line	16

The skeleton map for cross-sections and GPS control points at three pilot work sites are shown in Figures 1.1.

1.1.4 Result

The drawings of cross sections are prepared with the vertical scale of 1:100 and horizontal scale of 1:100. The final results are 3 sets of the drawings.

1.2 Mapping

1.2.1 Outline

The objective area is the pilot work sites. All maps are prepared with a scale of 1:500 with an intermediate contour of 1m and a supplementary contour of 0.5m. The survey work was conducted by a local contractor under the supervision of the Study Team during the period from January to February 2002.

Work Item	Unit	Quantity
1. Ban Dongphosi		
- Topographic map	m ²	42,000
2. Wat Chom Cheng		
- Topographic map	m ²	24,000
3. Sibounheuang		
- Topographic map	m ²	15,000

1.2.2 Method

The metric system was used as the system of measurement. The horizontal location was determined by National coordinate datum (Ellipsoid: Krassovsky Projection: UTM). The elevation was measured as the elevation above the mean sea level (Hon Dau Vietnam). The topographic survey was carried out based on the ground survey method using the total station system.

1.2.3 Result

The final result is a topographic map with a scale of 1:50

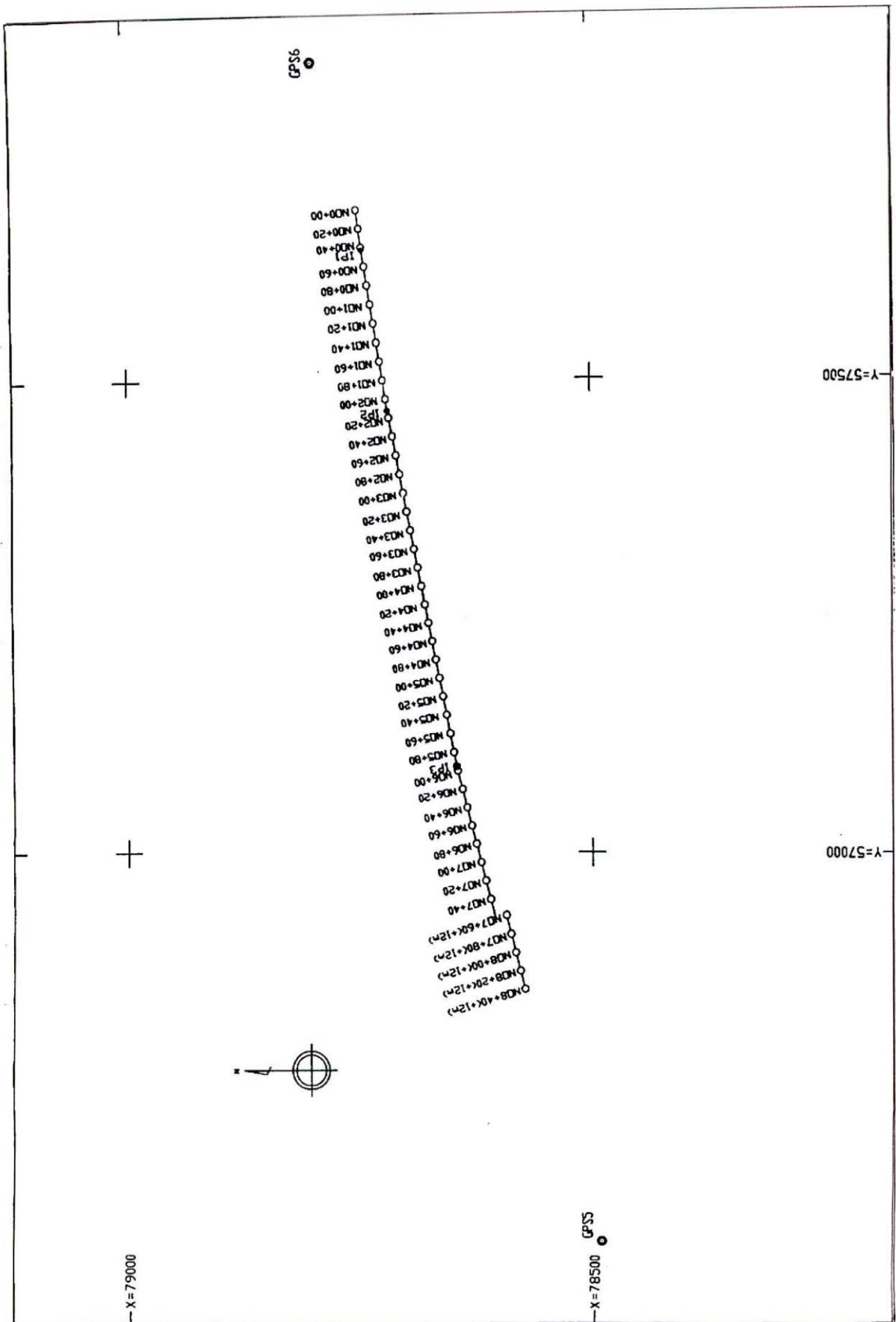


Figure 1.1(1/3) Sketch Map for GPS and Cross-section Point (Ban Dongphosi Site)

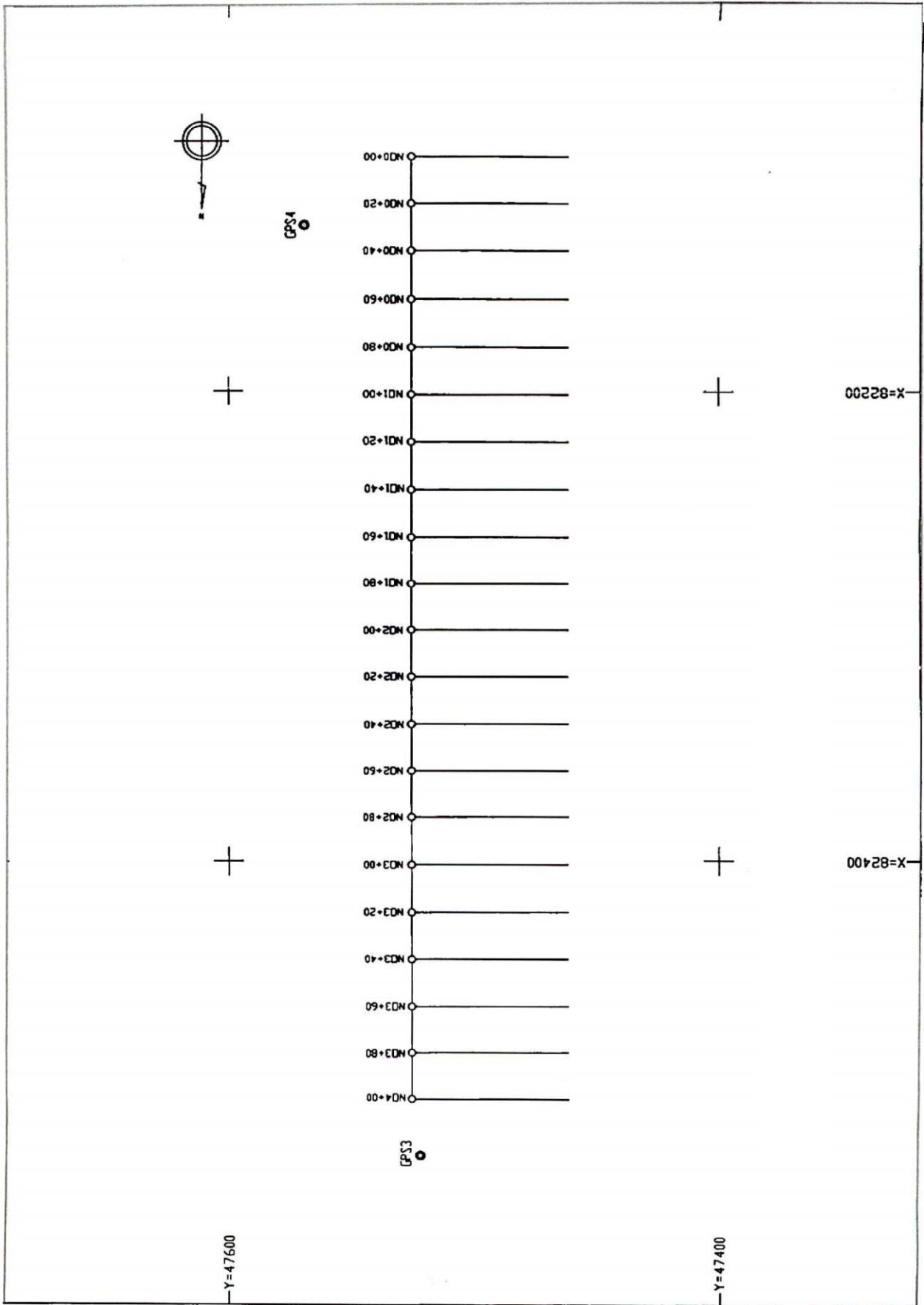


Figure 1.1(2/3) Sketch Map for GPS and Cross-section Point (Wat Chom Cheng Site)

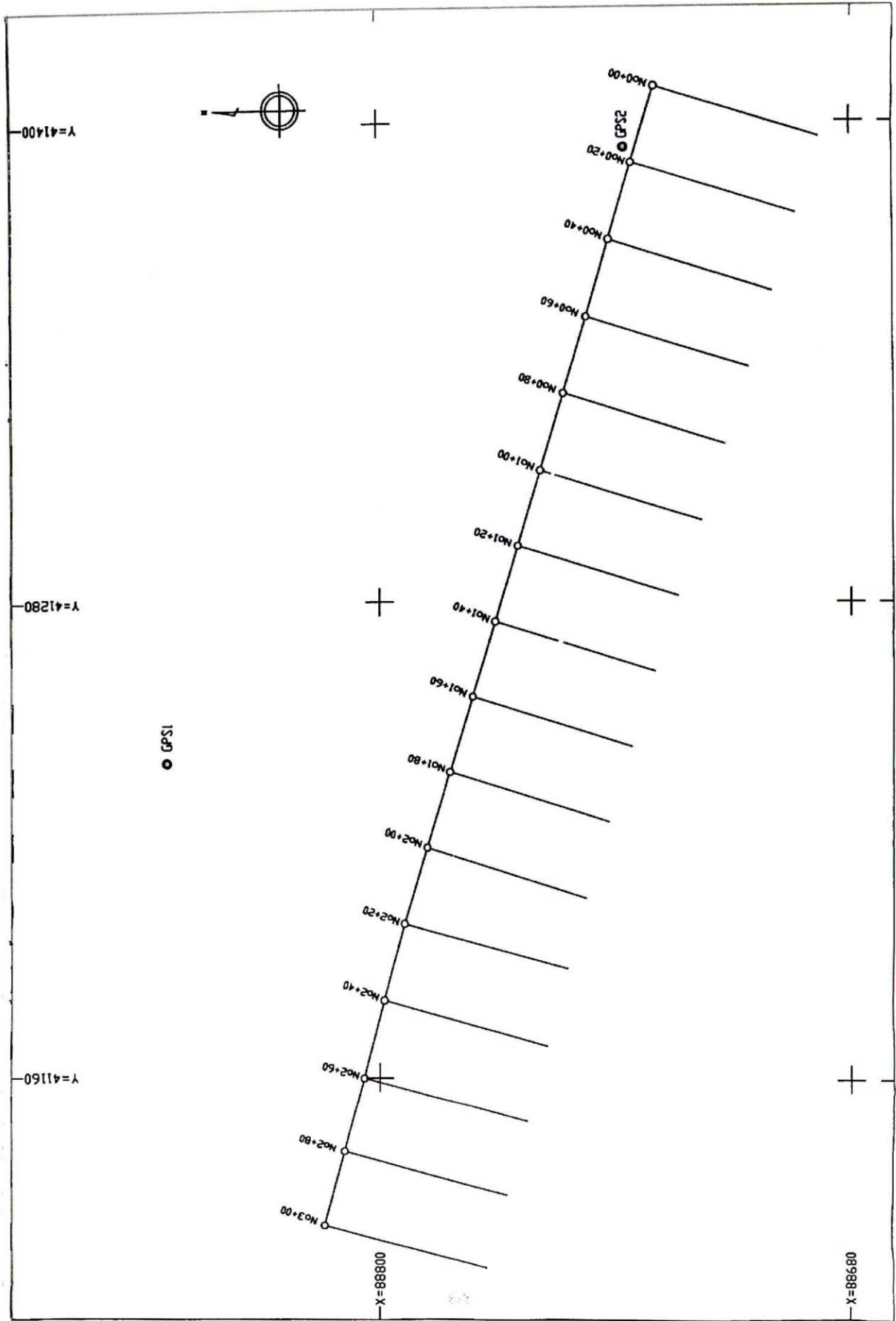


Figure 1.1(2/3) Sketch Map for GPS and Cross-section Point (Wat Chom Cheng Site)

2 GEOTECHNICAL INVESTIGATION

2.1 Soil Investigation

The purpose of boring on the riverbank (hereafter called onshore boring) and on the river course (hereafter called offshore boring) is to obtain geological information for the sites where the countermeasures against bank erosion are planned.

The geological investigation works consist of two parts; one is boring with in-situ test, sampling and laboratory test, and the other is the laboratory test of rock pieces sampled at the candidate quarry sites.

The boring locations are located at three (3) sites, namely Sibounheuang Site (2 borings: S-1 and S-2), Wat Chom Chen Site (2 borings: C-1 and C-2) and Ban Dongphosi Site (5 borings: D-1 and D-2, D-3, D-4 and D-5). Sibounheuang and Wat Chom Chen Sites consist of one survey section each, while Ban Dongphosi Site consists of 3 sections (D-1~D-2, D-3, D-4 ~D-5). Therefore, total survey sections come to five in numbers.

On each site/section, borings with in-situ test and soil sampling for laboratory test were conducted. The quantities are summarized in Table 2.1.

The borings consist of one onshore and one offshore boring except the D-3 section where only an onshore boring was done. The onshore boring was conducted on the left bank of the Mekong River, while offshore borings were done on the river course about 20m off the shoreline, using a pontoon.

All cores were collected and carefully stored in core boxes at the corresponding depths of core boxes except the portions taken out for laboratory test.

2.2 Rock Investigation

Rock piece test at the laboratory was carried out to know the basic properties of rocks to be used for the bank protection materials against river erosion. The rock materials were extracted from the prospective candidate sites of quarries. The candidate quarry sites and the rocks from which test pieces were produced were as follows;

The test pieces were 20 in number. They were tested for the following items;

- ① Unit weight : 20 in number
- ② Specific gravity : 20 in number
- ③ Absorption : 20 in number
- ④ Uni-axial compression test : 20 in number.

Table 2.1 Boring and Sampling

Location		Boring		SPT (number)	Disturbed Sample	Undisturbed Sample	
Shores	On/Off shore	Name	Length (m)			Point	Sample Number
Sibounheuang Site	On-shore	S-1	15	15	8	3	3 for uniaxial 3 for triaxial
	Off-shore	S-2	10	10	5	2	2 for uniaxial 2 for triaxial
Wat Chom Cheng Site	On-shore	C-1	15	15	8	3	3 for uniaxial 3 for triaxial
	Off-shore	C-2	10	10	5	2	2 for uniaxial 2 for triaxial
Ban Dongphosi Site	On-shore	D-1	15	15	8	3	3 for uniaxial 3 for triaxial
	Off-shore	D-2	10	10	5	2	2 for uniaxial 2 for triaxial
	On-shore	D-3	15	15	8	3	3 for uniaxial 3 for triaxial
	On-shore	D-4	15	15	8	3	3 for uniaxial 3 for triaxial
	Off-shore	D-5	10	10	10	5	2 for uniaxial 2 for triaxial
Total 5 sections		9	115	115	60	23	

3 VELOCITY MEASUREMENT

3.1 General

Current measurements were carried out to obtain current speed and direction in/around three pilot work sites along the Mekong River near Vientiane City for the design of bank protection work.

The objective sites and the work quantities of the survey are shown in Table 3.1. The survey works were conducted by a local contractor under the supervision of the Study Team.

3.2 Method

1. Using the established Base Line and Bench Mark points along the riverbank, which are prepared by the topographic survey conducted by the Study Team (refer to Section 4.1).
2. The temporal water level gauge is established.
3. The three or nine measuring lines perpendicular to the Base Line are made by using total station method (EDM). The distance, elevation of Zero of gauge and temporal Bench Mark points down to the measuring line are transferred from the given Bench Mark.
4. Cable way to the standing boat for hanging measuring boat was erected.
5. The measuring points on the cable way are marked by colored tape according to the distance of 2,3,5,10,10,10 and 10 meter respectively.
6. During the field measurement, river water level was measured.

(Current Measurement Work)

7. The “**A. OTT**” Current meter type C31 with one-meter queue was prepared for measurement of current speed and direction at the same time.
The direction of flow was recorded by measuring the angle from the North to the measured flow direction.
8. For each vertical at the depth of 0.2h, 0.6h and 0.8h, in which h denotes water depth at the location of measurement, water depth, current speed, and direction were measured. At each measurement point, water depth, current speed, and direction were measured 2 times and repeated immediately if both result showed any remarkable difference.

3.3 Quantity of Works

Quantity of works is as shown in Table 3.1.

Table 3.1 Quantity of Velocity Measurement works

Work Item	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

3.4 Result

Final results are as follows:

- a) Results of measurement in tabulated form and figures, that show:
 - Location of each measurement
 - Vertical distribution of current speed
 - Plan distribution of current speed and direction
- :1set
- b) Technical evaluation
- :1set

4 SUPPORTING INVESTIGATION FOR INITIAL ENVIRONMENTAL EXAMINATION

4.1 General

The objective of the survey is to obtain basic environmental data concerning the Study. The results of the survey are utilized for the initial environmental examination (IEE) and scope of the EIA study that will be conducted in 2nd Work in Lao P.D.R. The environmental survey works consist of the following:

- (1) Survey for social environment around Vientiane municipality
- (2) Survey for natural environment around Vientiane municipality
- (3) Survey for fishery resources along Mekong River

4.2 Survey for Social Environment around Vientiane City

Survey Area: In and around Vientiane City

Information Sources and Methodology:

Relevant document, interview to relevant organizations and previous studies

Survey Items:

- (1) Rights to the use of water, Right of common
The laws and regulations on right to the use of water and common, including the customary laws were surveyed.
- (2) Resettlement procedure
Resettlement procedure caused by public works was surveyed. The problems on resettlement were also surveyed.
- (3) Land use, Ruins and cultural properties, Industrial structure
The land use, ruins and cultural properties, industrial structure in the study areas were surveyed.
- (4) Attitude of local people to riverbank utilization
Information on the riverbank utilization by the local people were gathered and summarized.
- (5) Present situation of forest utilization by local people
Information on the forest utilization by the local people were gathered and summarized.

4.3 Survey for Natural Environment around Vientiane City

Survey Area: In and around Vientiane City

Information Sources and Methodology:

Relevant document, interview to relevant institutions and previous studies

Survey Items:

- (1) Water Quality
Characteristics of the water quality were surveyed. Required data was obtained from relevant institutions and previous studies.
- (2) Vegetation
Aspects of the vegetation including endangered species were surveyed. The required data was obtained from relevant institutions and previous studies.
- (3) Fauna
Aspects of the fauna including endangered species, mainly terrestrial life, were surveyed. The required data was obtained from relevant institutions and previous studies.
- (4) Protected Area or Forest
Outline of the protected areas were surveyed. Maps indicating locations of the protected areas was prepared based on the 1/100,000 topographic maps. Required data was obtained from relevant institutions.
- (5) Geological features
Aspects of the geological features were surveyed. The required data was obtained from relevant institutions and previous studies.
- (6) Ecosystem
Characteristics of the ecosystem were surveyed. Required data was obtained from relevant institutions, previous studies and field observation.

4.4 Survey for Fishery Resources along Mekong River

Survey Area: In and around Vientiane City

Information Sources and Methodology:

Interview to relevant organizations and fisher persons, relevant document and previous studies

Survey Items:

- (1) Aquatic Life
Aspects of the aquatic life including endangered species were surveyed. Required data was obtained from relevant institutions, previous studies and field observation.
- (2) Present Condition of Fishery
Outline of the fishery, such as the main catch species, transition of catch quantity by species, fishing methods, fishing spots and number of fisher persons, were surveyed. Required data was obtained from interview to the fisher persons and fisher person's association, field observation and existing studies.