Chapter 26 Stabilization Measures of the Navigation Channel

26.1 Numerical simulation model

26.1.1 Characteristics of the simulation model applied

Computer simulation is nowadays a powerful method for analyses in the fields of river hydraulics and morphology, owing to development in computer technology. In other words, numerical simulations could be an effective means to quantitatively analyze and understand phenomena of flow and trend of erosion/accretion, taking place in the present river. It could also be useful as a means to predict the effects of the river stabilization facilities. It cannot be almighty, however, and should be considered as a tool for comprehensive technical judgment supported by other empirical knowledge, survey results, experiments and others.

The simulation procedures are explained in **Appendix 26.1** and the flow chart is presented in **Figure A26.1.1**.

The simulation model applied here has the following characteristics:

1) Theoretical rationality

The phenomena taken account in the model are suitable and enough to discuss the actual phenomena occurring in the river. They include eddies in the current, friction of the bottom, resistance by artificial materials such as groins, buildings, trees, etc.

2) Unsteadiness of the phenomena

Basically the flow and shape in the river is changeable in time domain. The model shall reflect unsteady phenomena. In this context, the model employed here is an unsteady model.

However, calculation of the unsteady conditions is time-consuming. Steady model is also applied for analyzing phenomena in a limited period of time.

3) Re-productivity of flow and change of river shape and profile.

One of the key factors of re-productivity is the coordinate system. In this study a cylindrical coordinate system is introduced, which is a convenient coordinate to represent the curved alignment of the Red River. The coordinate system is as shown in **Figure 26.1.1**.

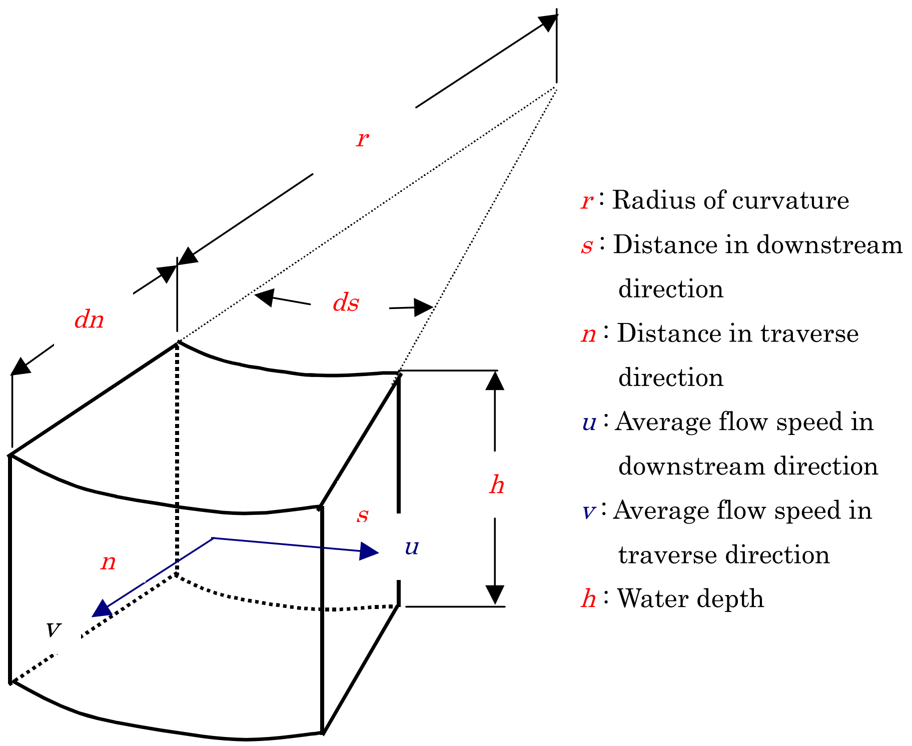


Figure 26.1.1 Two-dimensional Cylindrical Coordinate System

4) Economy of calculations

The dominant factor in computation time is the grid size and its number, which should be minimized while maintaining enough accuracy of the simulations. Another important factor is number of layers to divide the depth of water. In consideration of the actual vertical flow pattern shown in **Figure 14.5.1 (1)**, the division is taken as one, or the model has one layer.

26.1.2 Mathematical model

A detailed description of the model is given in **Appendix 26.1.1**. The following is a fundamental feature of the model.

(1) Basic equations

Basic equations for flow are the equations of motion and continuity for two-dimensional shallow water. They take account of frictional velocity, turbulent eddy viscosity, bottom roughness coefficient by manning, permeability coefficient of resistant materials, etc. Basic equations for sediment transport are equations of motion for bed load and suspended sediment, and equation of continuity. They take account of density, particle size, void ratio of riverbed materials, friction of and shear force on riverbed, diffusion of suspended particles, etc.

(2) Boundary conditions

1) Current field

The model field has the configuration shown in **Figure A26.1.2**, which is constructed based on the topographic and bathymetric map preparation in January 2002 by the Study Team. It consist of 58,598 (166 x 353) grids with *d*s of 40 m -140 m, their average of 100 m, and *d*n of 10 m -40 m, depending on local curvatures and width of the river.

For calculation of the flow in the Red River during the dry season, the boundary conditions on the water level and the discharge volume are given as shown in **Table 26.1.1**. The Manning roughness coefficient on the riverbeds is taken as n_m = 0.025 for the wet riverbed, 0.030 for dry riverbed in the dry season, and 0.40 on the bank.

Table 26.1.1 Boundary Conditions (Dry Season)

Location	Water Level (m)		Discharge (m^3/sec)		Remarks
	Dry Season	Flood Season	Dry Season	Flood Season	
No. 1: Upstream end	(4.44)	(10.42)	1,750	10,445	Giay Pump Station
No. 5: Duong bifurcation	3.39	9.33	(510)	(2,596)	In the Duong River
No.10: Downstream end	2,34	8.18	(1,240)	(7,849)	Below Thanh Tri Meandering

Source) JICA Study Team

2) Parameters on sedimentation

Following Parameters related to sediments are introduced:

Riverbed material: d = 100 μm to 200 μm (d50)
Suspended material: d = 5 μm
Upper boundary: d = 57.8 to 374.4 mg/l after discharge and density
Lower boundary: d = 36.4 to 334.0 mg/l after measured SS at Khuyen Luong

Detailed conditions of numerical simulations are summarized in **Appendix 26.3**.

26.2 Analysis on stability of the present river channel

26.2.1 Purpose of analysis

The analyses here aim at, after confirmation of enough accuracy of re-production of the present current field, examination of the effect of extreme cases, which are possible deviations of current directions at the Thang Long Bridge, and a cut of Tu Lien-Tung Ha Sand Bars.

26.2.2 Re-production of the present conditions

(1) Current field

The result of calculation of the flow under the present conditions in the dry and rainy seasons is shown in **Figure 26.2.1 (1)** and **(4)**, respectively, which is shown by flow vectors. The figures indicates the following features:

1) The pattern of flow vectors coincides well with the distribution of measured velocity and the route of Talweg.
2) The simulated flow direction at Thang Long Bridge is 83 to 91 degrees clockwise from the North. It is well in accord with the actual direction of about 83 degrees, or about 7 degrees anticlockwise from the perpendicular direction of Thang Long Bridge.
3) The simulated velocities agree well with the measured ones, average velocity of 3 depths, as shown in **Figure 26.2.2 (1)**.

Thus, the simulated flow can be said to represent the present current field very well.

For reference, the ratio of current speeds without and with the existing groins is shown in **Figure 26.2.1 (2)**, and the ratio between Present Conditions in flood and dry seasons in **Figure 26.2.1 (5)**, respectively. The effect of the groins is clearly indicated in the figure.

(2) Riverbed field

Comparison of Suspended Solids (SS) is made between the simulated and measured values in dry and flood seasons, and the result is shown in **Figure 26.2.2 (2)**. The re-productivity of SS can be considered pretty well.

The result of simulation on erosion/accretion on the present riverbed is shown in **Figure 26.2.1 (3)** for the dry season. Change of the riverbed is small in the dry season.

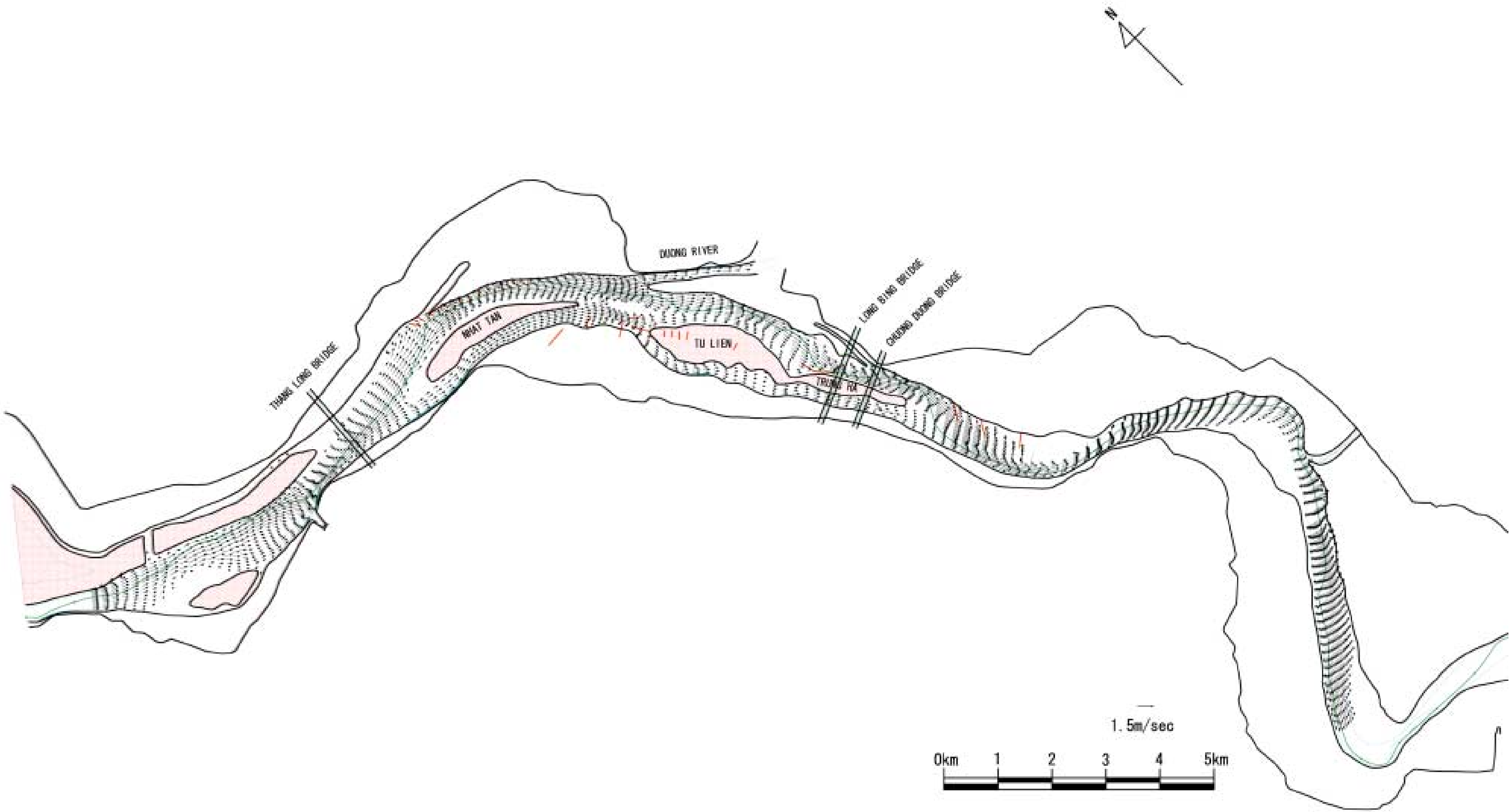


Figure 26.2.1 (1) Current Vectors (Dry Season: Present Conditions with Existing Groins)

Source) JICA Study Team

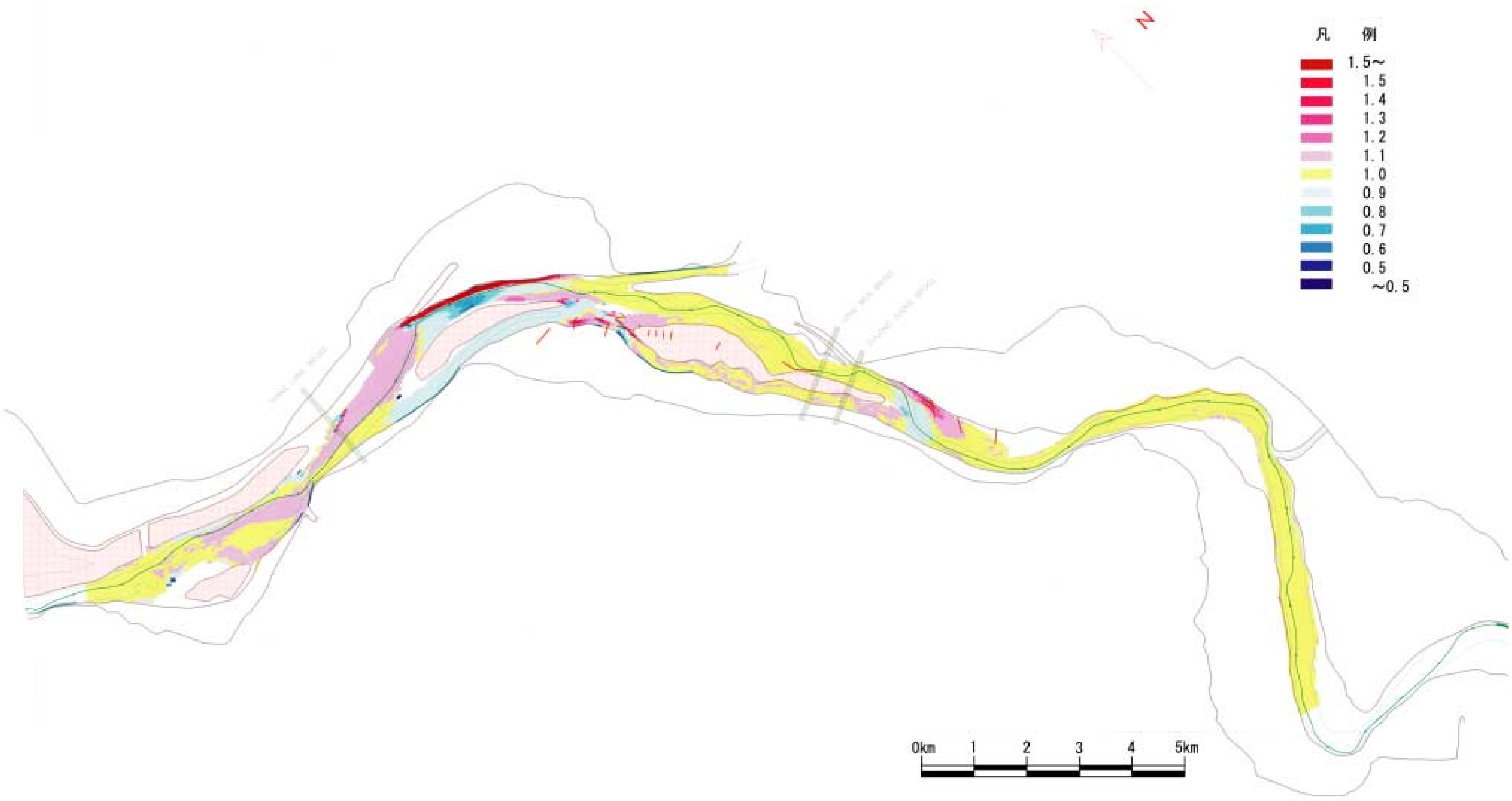


Figure 26.2.1 (2)　Ratio of Current Speeds (Dry Season: Present Conditions with Existing Groins / without Existing Groins)

Source)　JICA Study Team

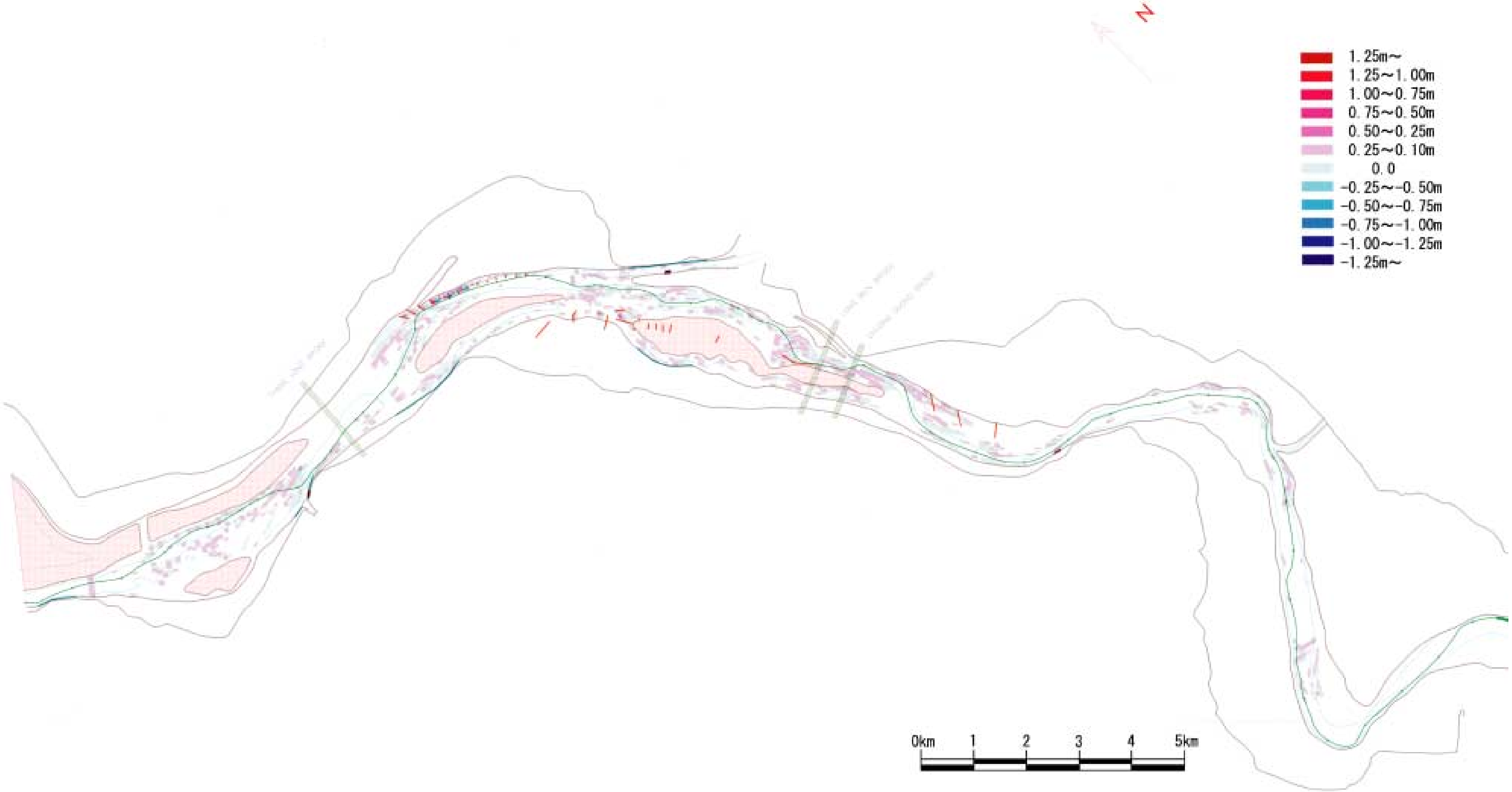


Figure 26.2.1 (3) Change of Riverbed (Dry Season: Present Conditions with Existing Groins)

Source) JICA Study Team

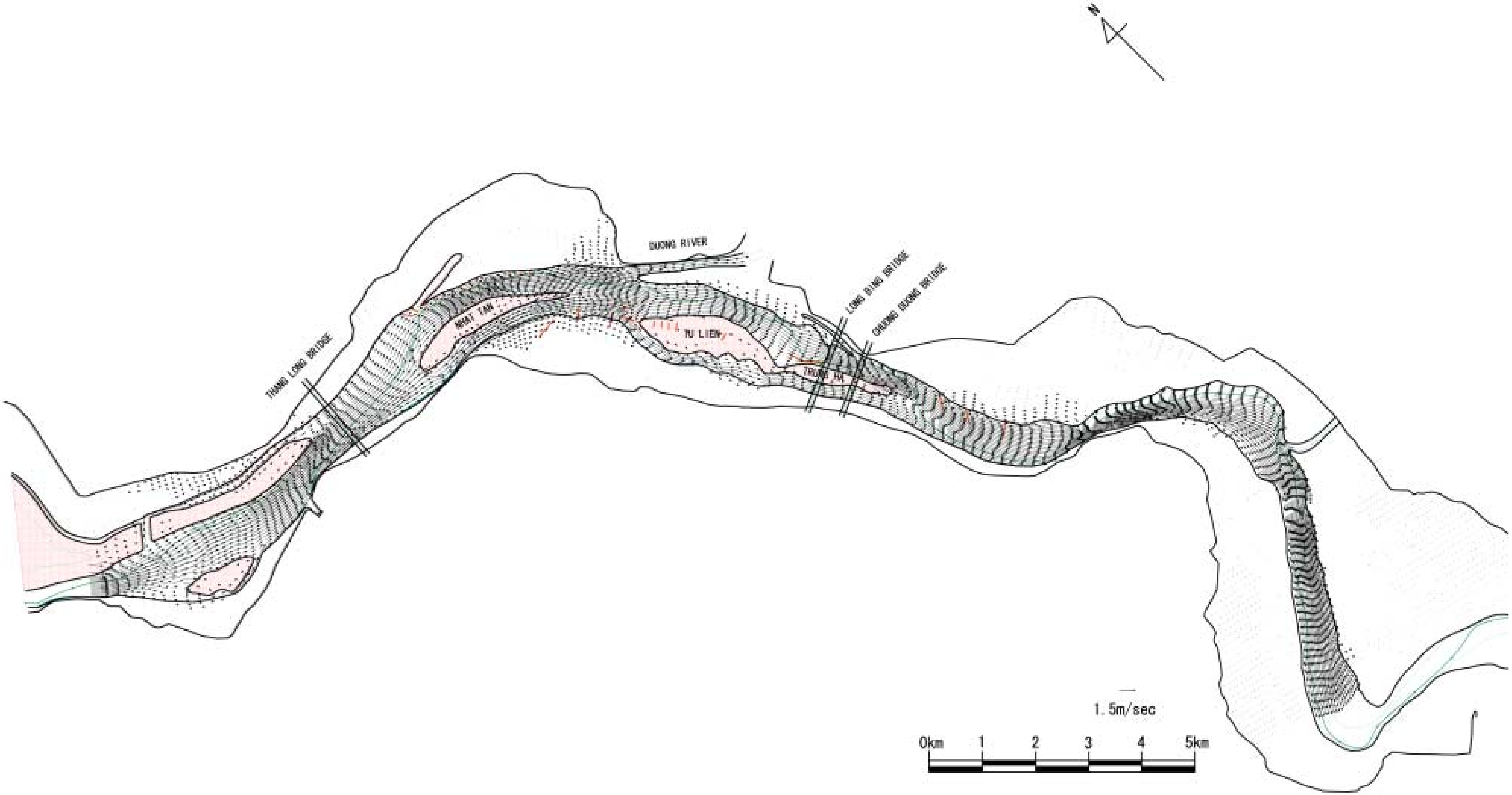


Figure 26.2.1 (4) Current Vectors (Dry Season: Present Conditions with Existing Groins)

Source) JICA Study Team

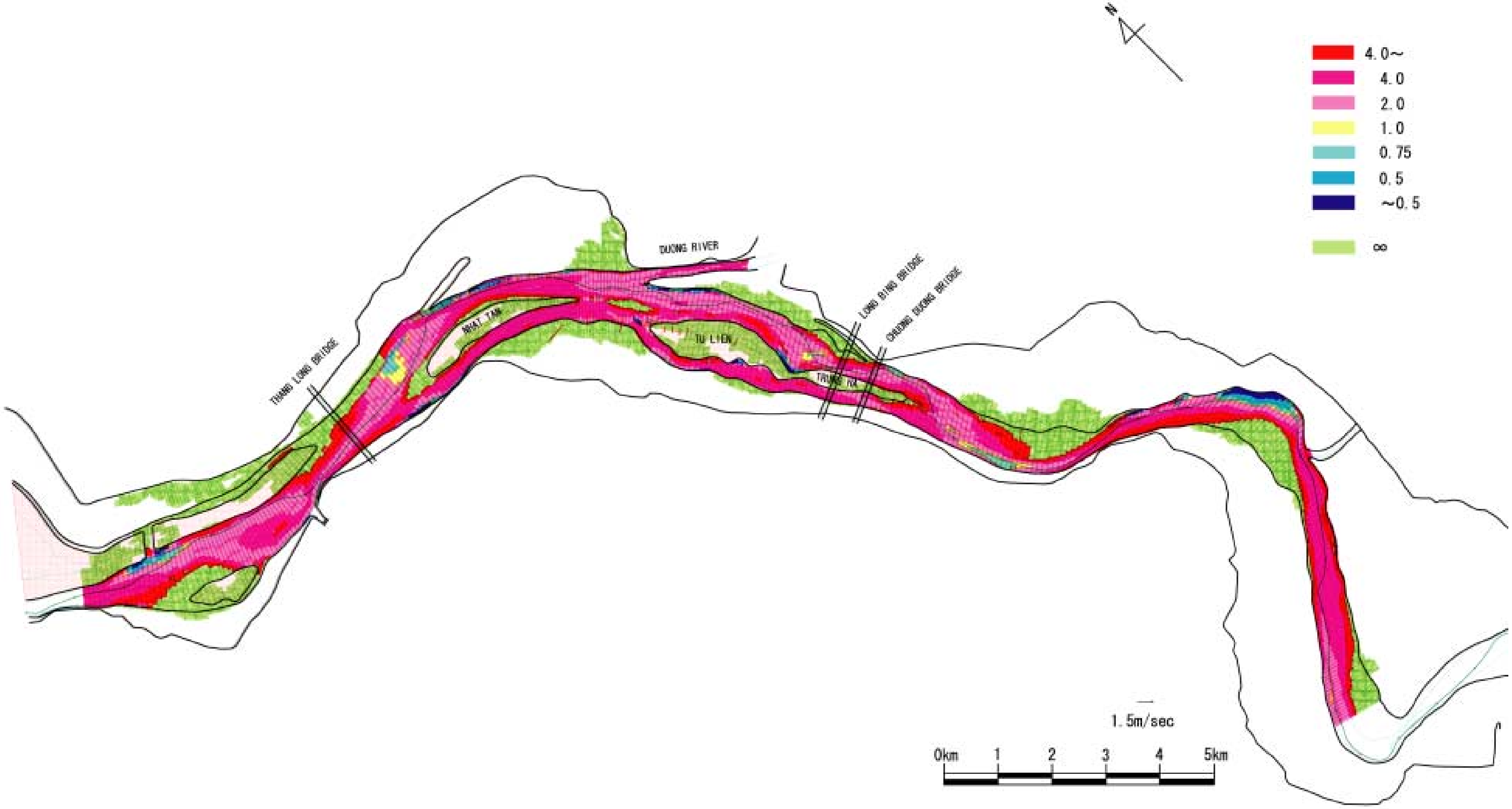
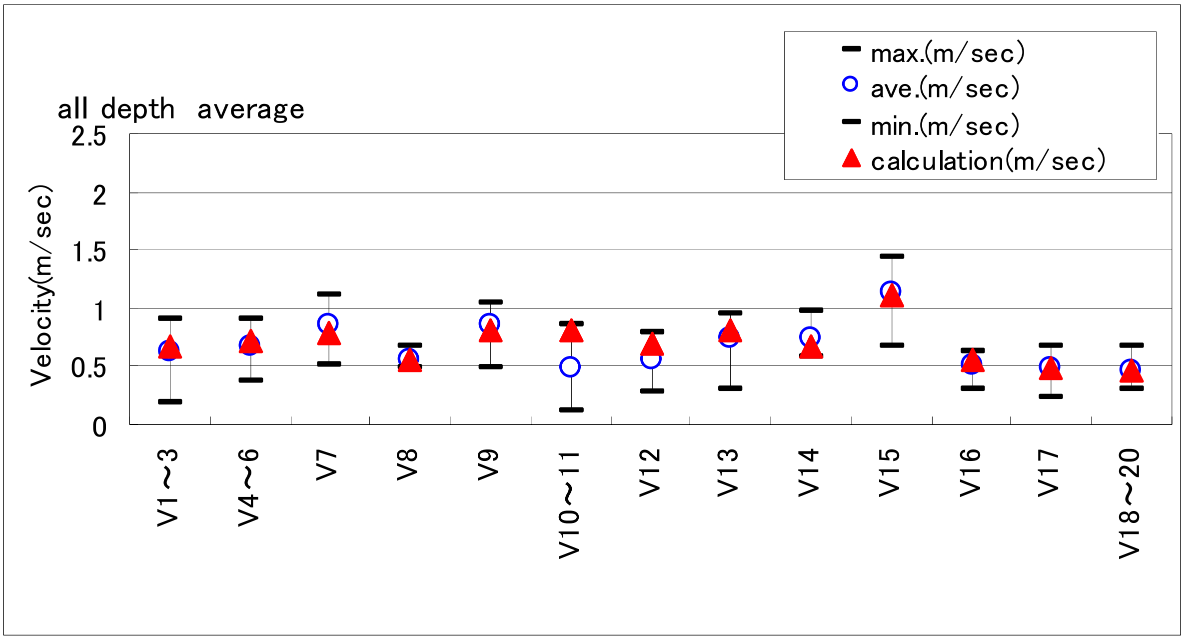
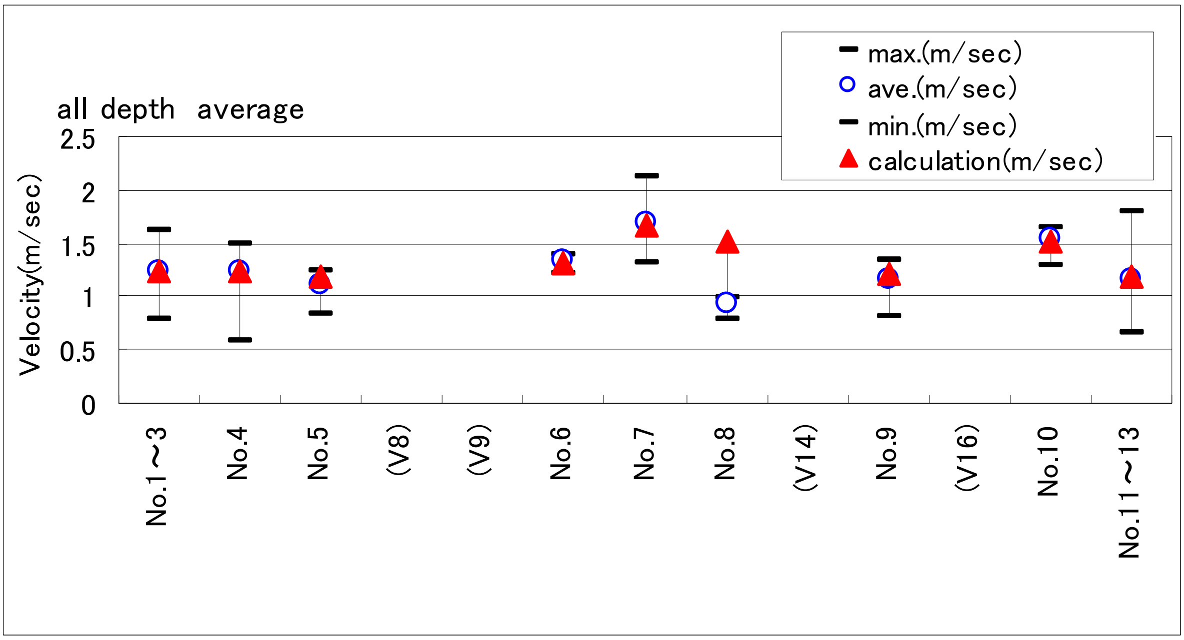


Figure 26.2.1 (5) Ratio of Current Speeds (Flood Season: Present Conditions in Flood Season / Dry Season)

Source) JICA Study Team



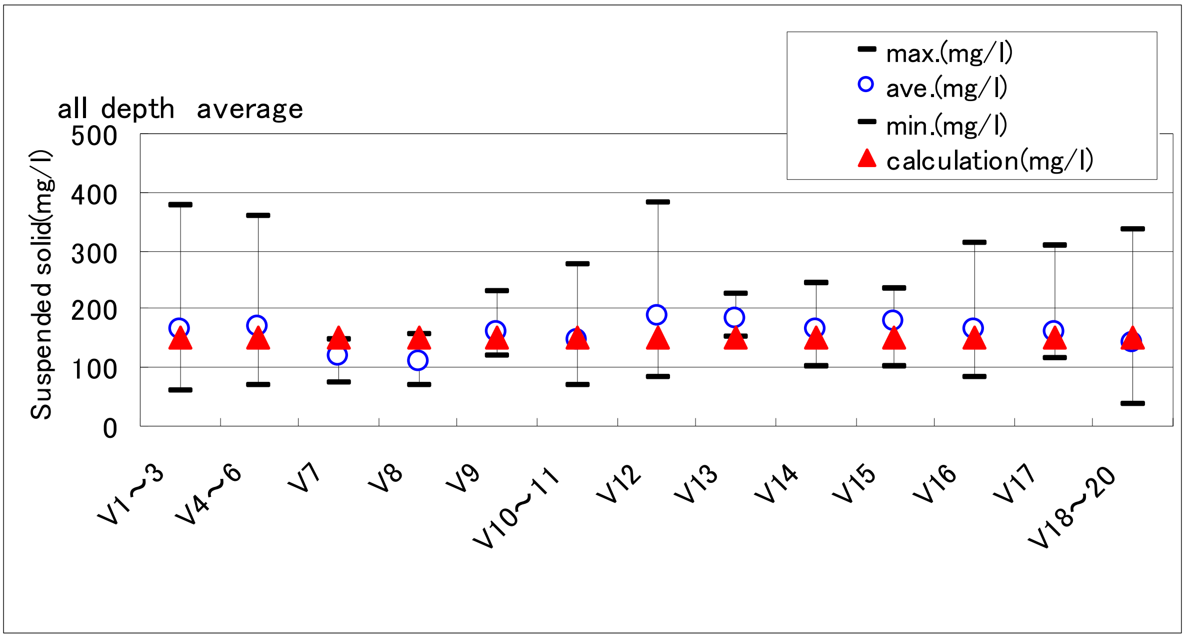
1) Dry Season



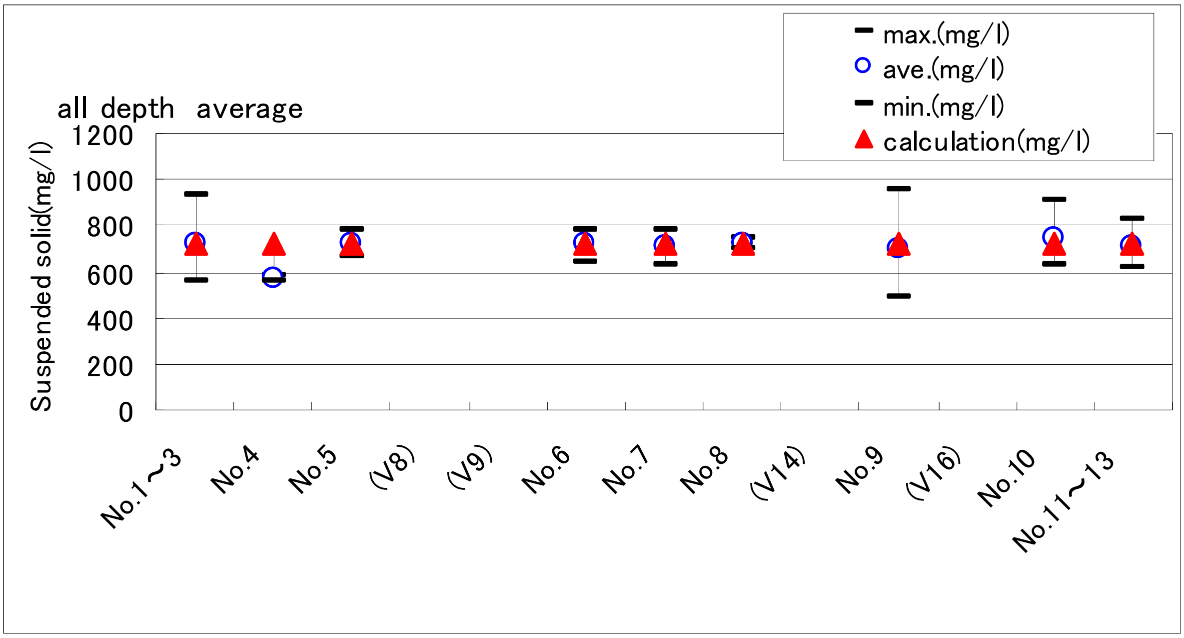
2) Flood Season

Source) JICA Study Team

Figure 26.2.2 (1) Comparison of Simulated and Measured Present Current Velocities



1) Dry Season



2) Flood Season

Source) JICA Study Team

Figure 26.2.2 (2) Comparison of Simulated and Measured Present SS

26.2.3 Prediction of extreme phenomena by computer simulations

The present alignment of mainstream in the Red River can be considered relatively stable under the present configuration of the River. Here changes of flow conditions are forced artificially in the model in order to examine what could happen by such drastic changes in the future.

(1) Deviations of upstream current direction

The angle of current direction at Thang Long Bridge is an important index of impact of flows to the present morphology in the upstream and downstream portions.

Two extreme cases are created, one is to deviate the current direction at Thang Long Bridge toward the right bank and the other is to orient toward the left bank. The results of these simulations are given in **Figure 26.2.3** and **Figure 26.2.4**, respectively. In these figures, **(1)** shows the current vectors. **(2)** indicates the ratio of current speeds in the deviated cases against the present flow, where increase in the speed is shown in red color and decrease in the speed is in blue color.

In the case of **(1)**, the current speed at the right side of Nhat Tan Sand Bar increases 1.5 times to twice as large as the present one.

In the case of **(2)**, the current speed at the left-side of Nhat Tan Sand Bar, or in front of the place of Tam Xa Groin Group, increases twice to three times higher than that of the present current speed.

These results imply a possibility of large-scale change of the present morphology, if such current deviation were realized.

(2) Cut of Tu Lien-Trung Ha Sand Bar

There is a place in between Tu Lien and Trung Ha Sand Bars where the width became quite narrow between 1999 and 2002, or substantially in the past two years. Worry is the effect of change in case that the sand bars is cut by some causes.

The current fields is calculated for two cases of the cut, and the results are shown in **Figure 26.2.5 (1)** and **(2)** for Case A, and **Figure 26.2.6 (1)** and **(2)** for Case B.

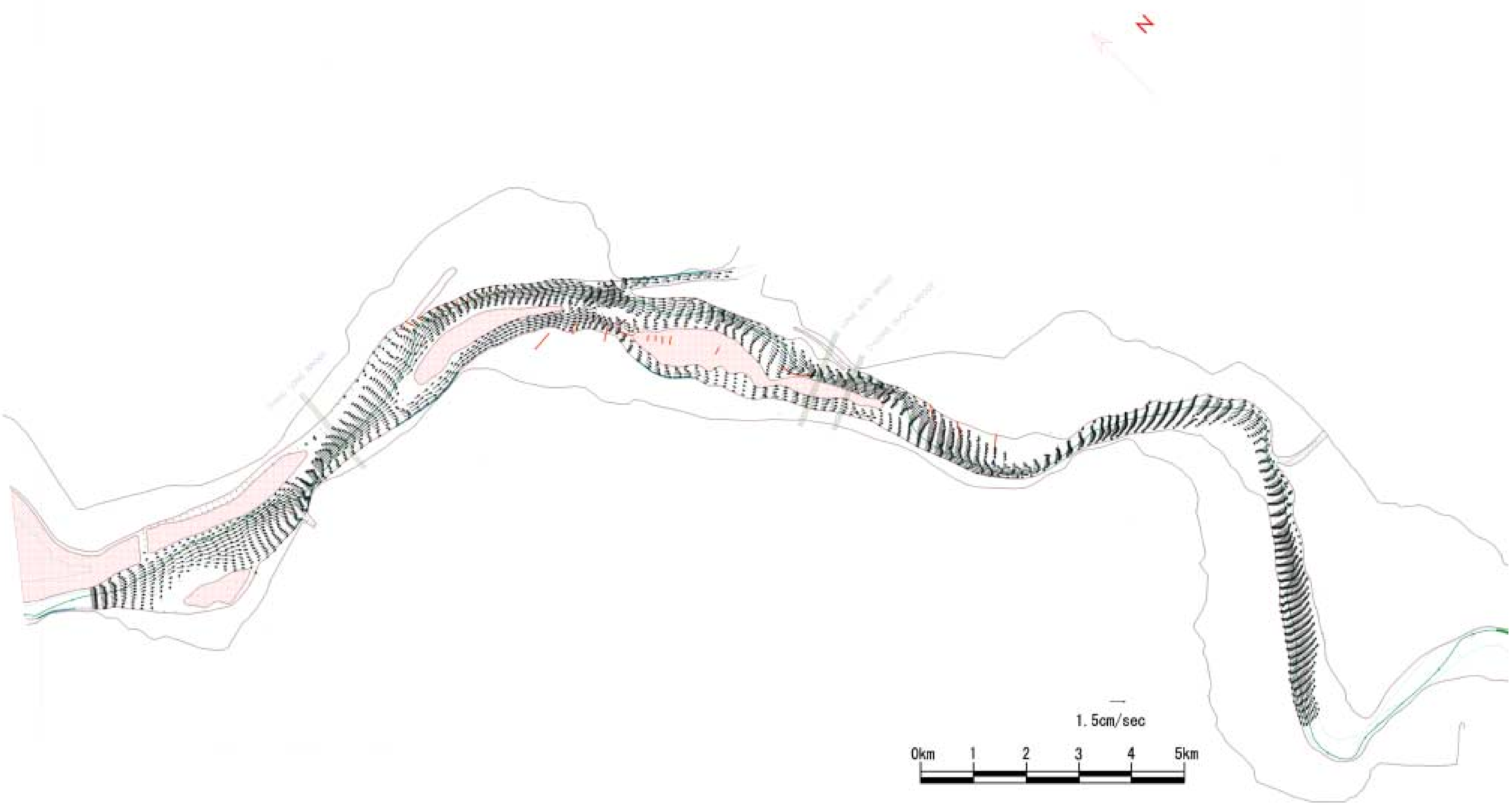


Figure 26.2.3 (1) Current Vectors (Dry Season: Deviation of Direction to the Right at Thang Long Bridge)

Source) JICA Study Team

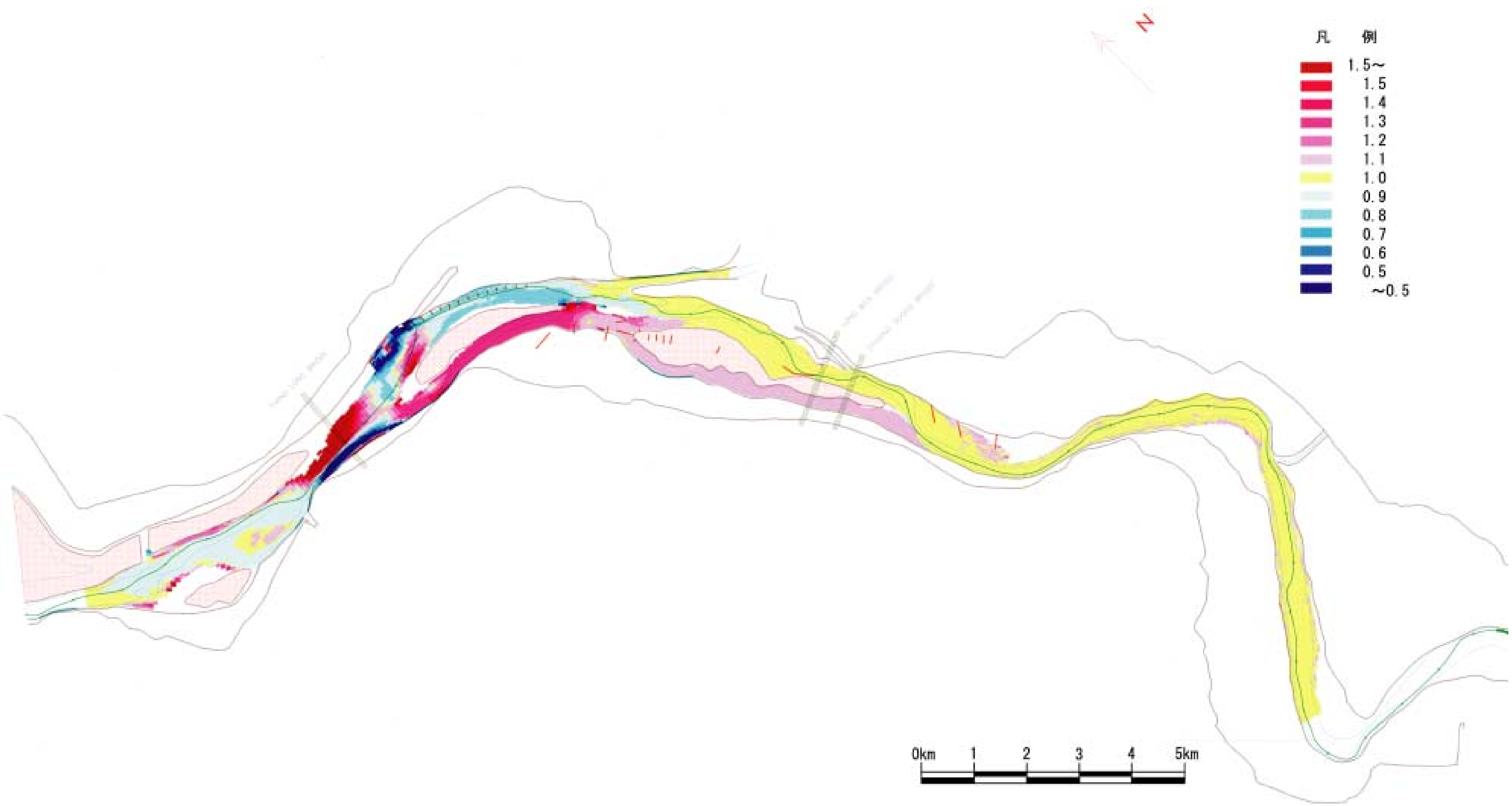


Figure 26.2.3 (2) Ratio of Current Speeds (Dry Season: Deviation of Direction to the Right at Thang Long Bridge / Present Condition with Existing Groins)

Source) JICA Study Team

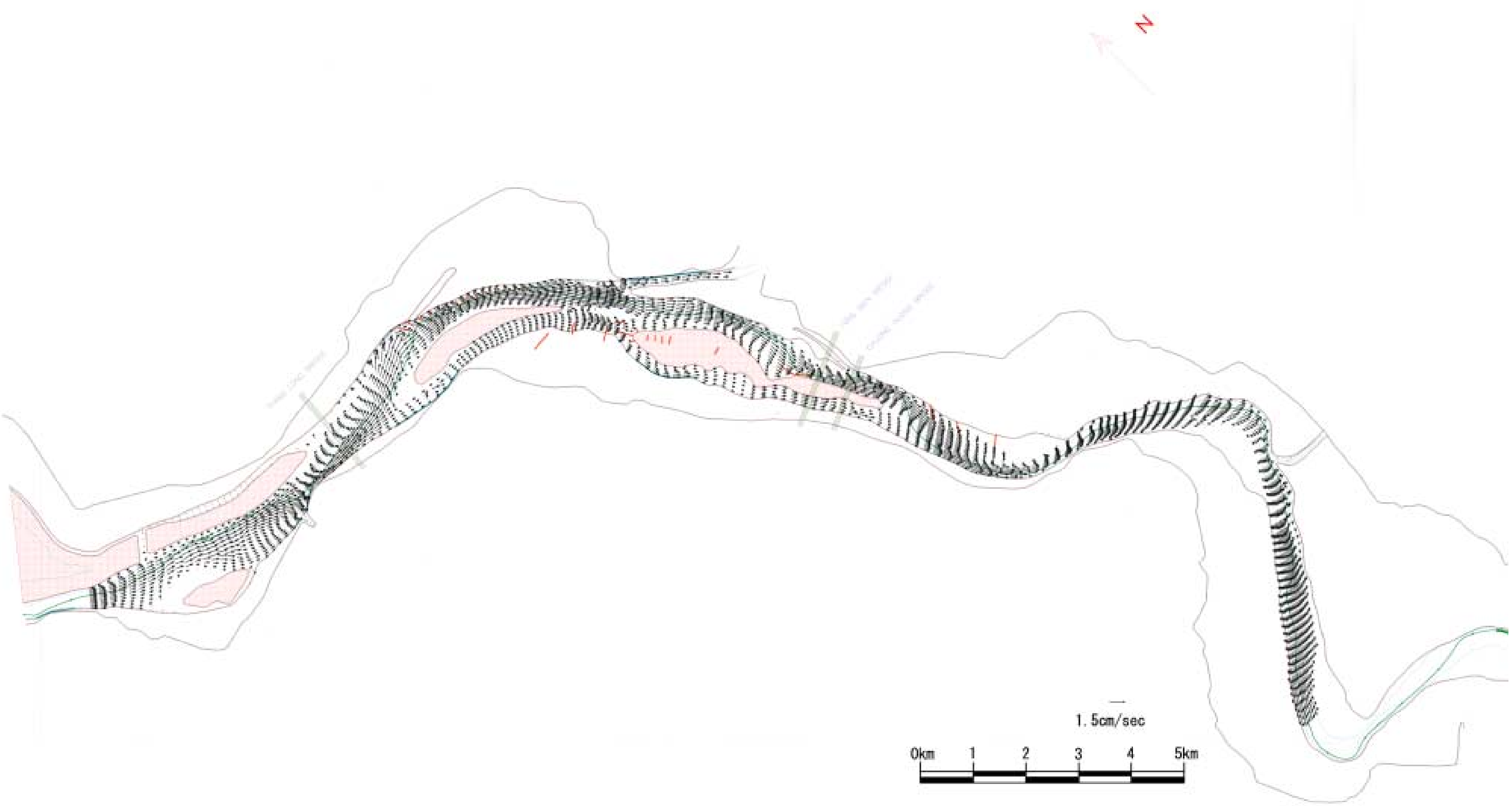


Figure 26.2.4 (1) Current Vectors (Dry Season: Deviation of Direction to the Left at Thang Long Bridge)

Source) JICA Study Team

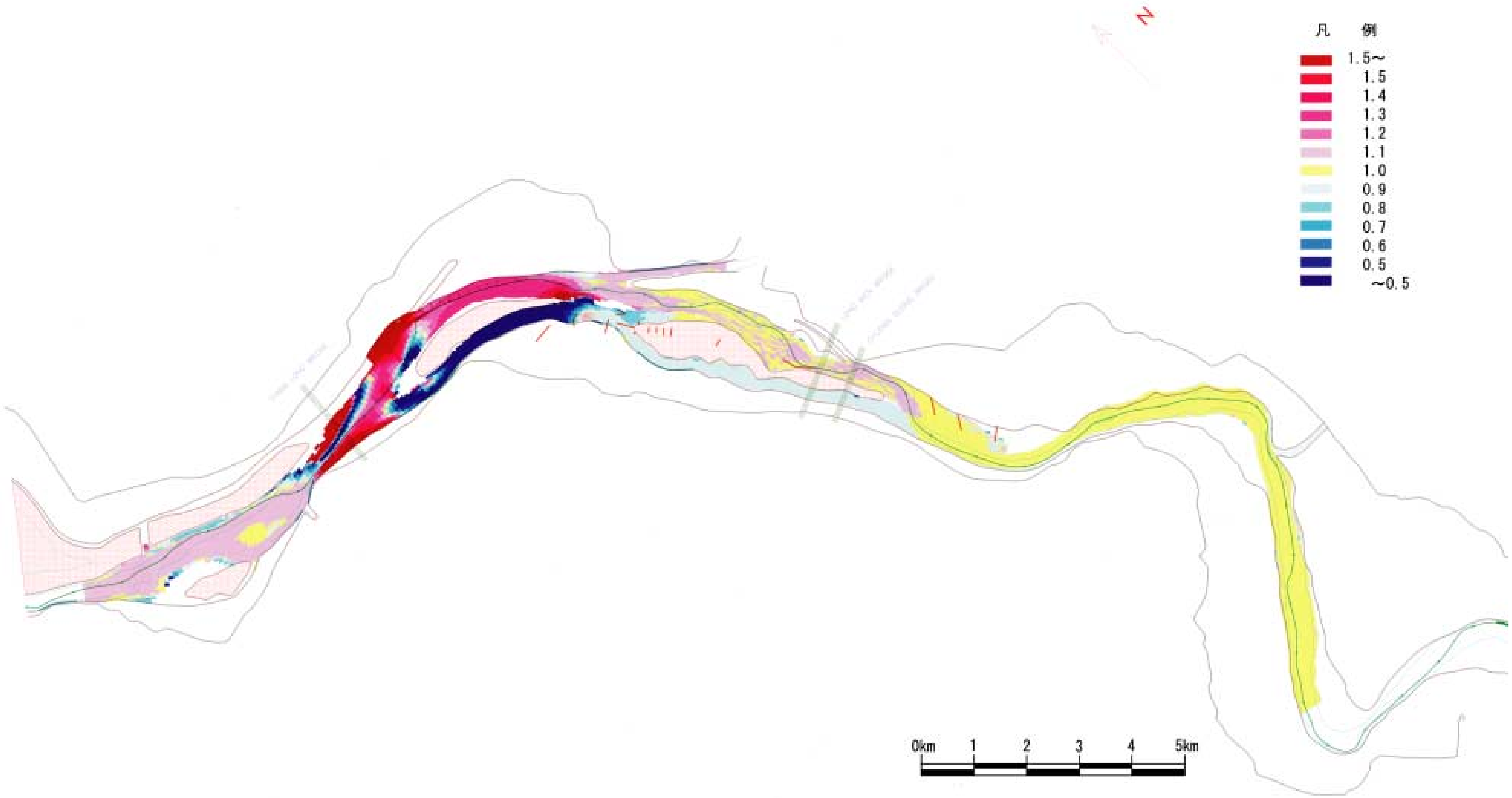


Figure 26.2.4 (2) Ratio of Current Speeds (Dry Season: Deviation of Direction to the Left at Thang Long Bridge / Present Condition with Existing Groins)

Source) JICA Study Team

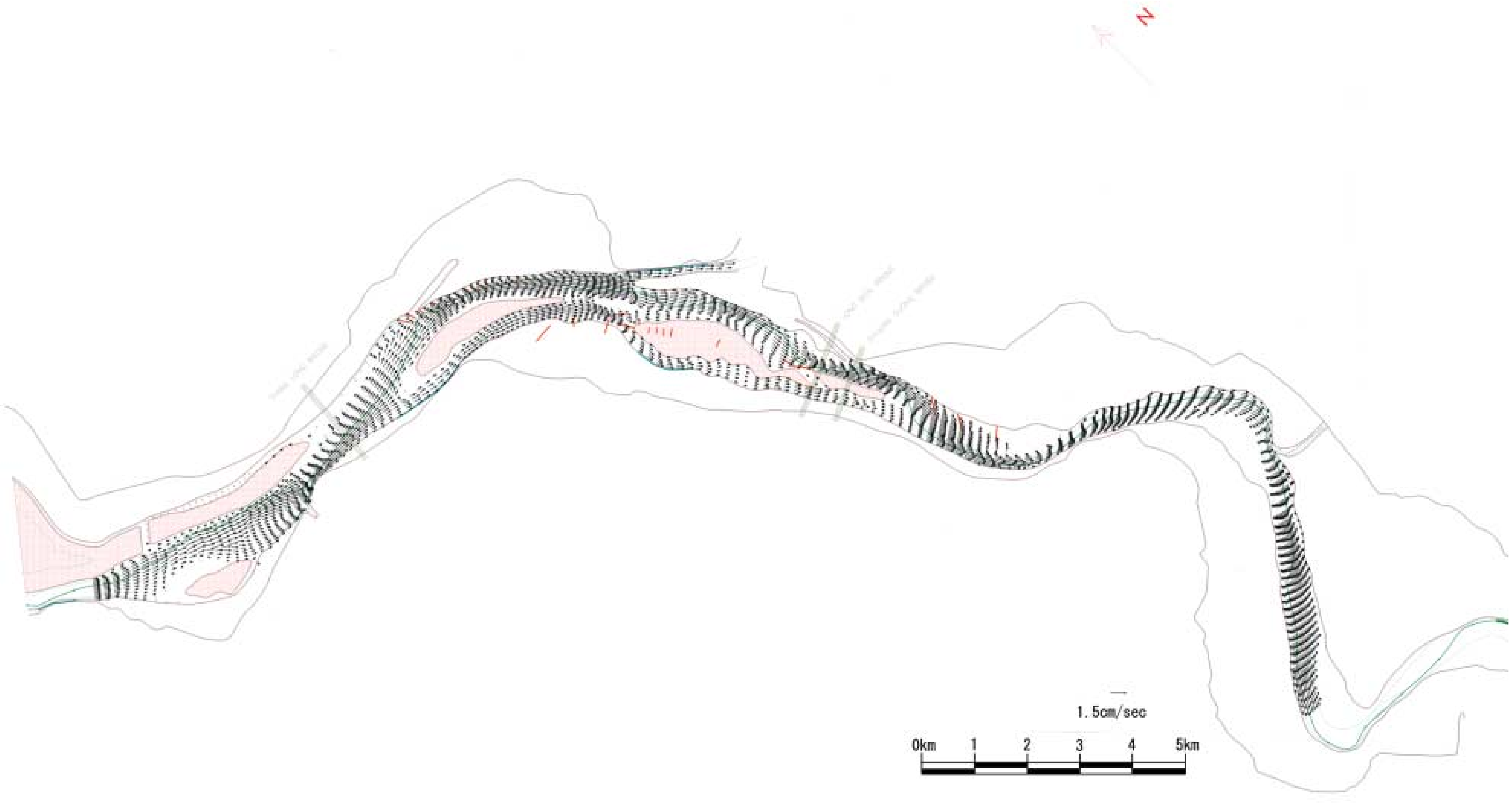


Figure 26.2.5 (1) Current Vectors (Dry Season: Cut of Sand Bar – Case A)

Source) JICA Study Team

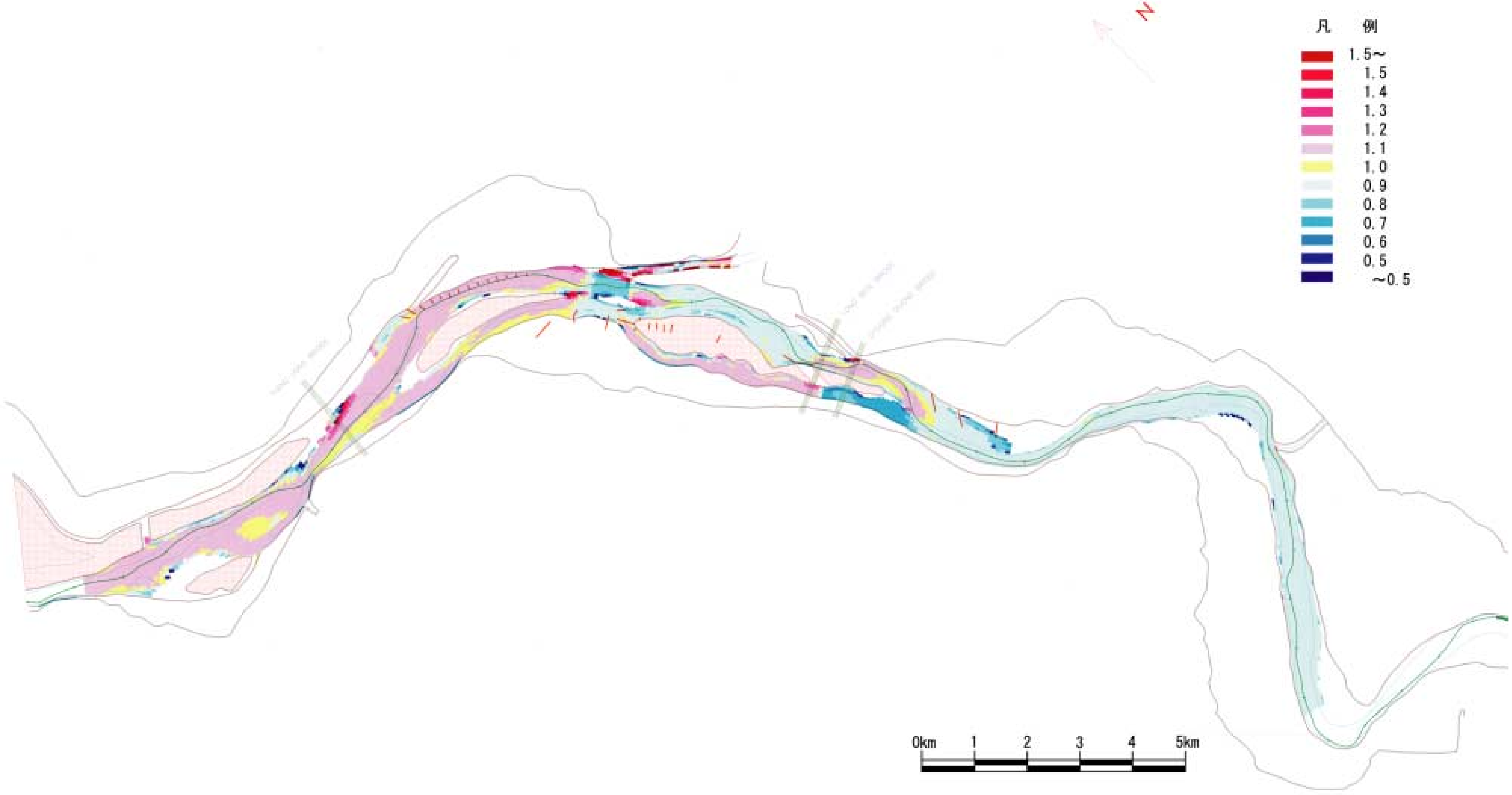


Figure 26.2.5 (2)　Ratio of Current Speeds (Dry Season: Cut of Sand Bank Case A / Present Condition with Existing Groins)

Source)　JICA Study Team

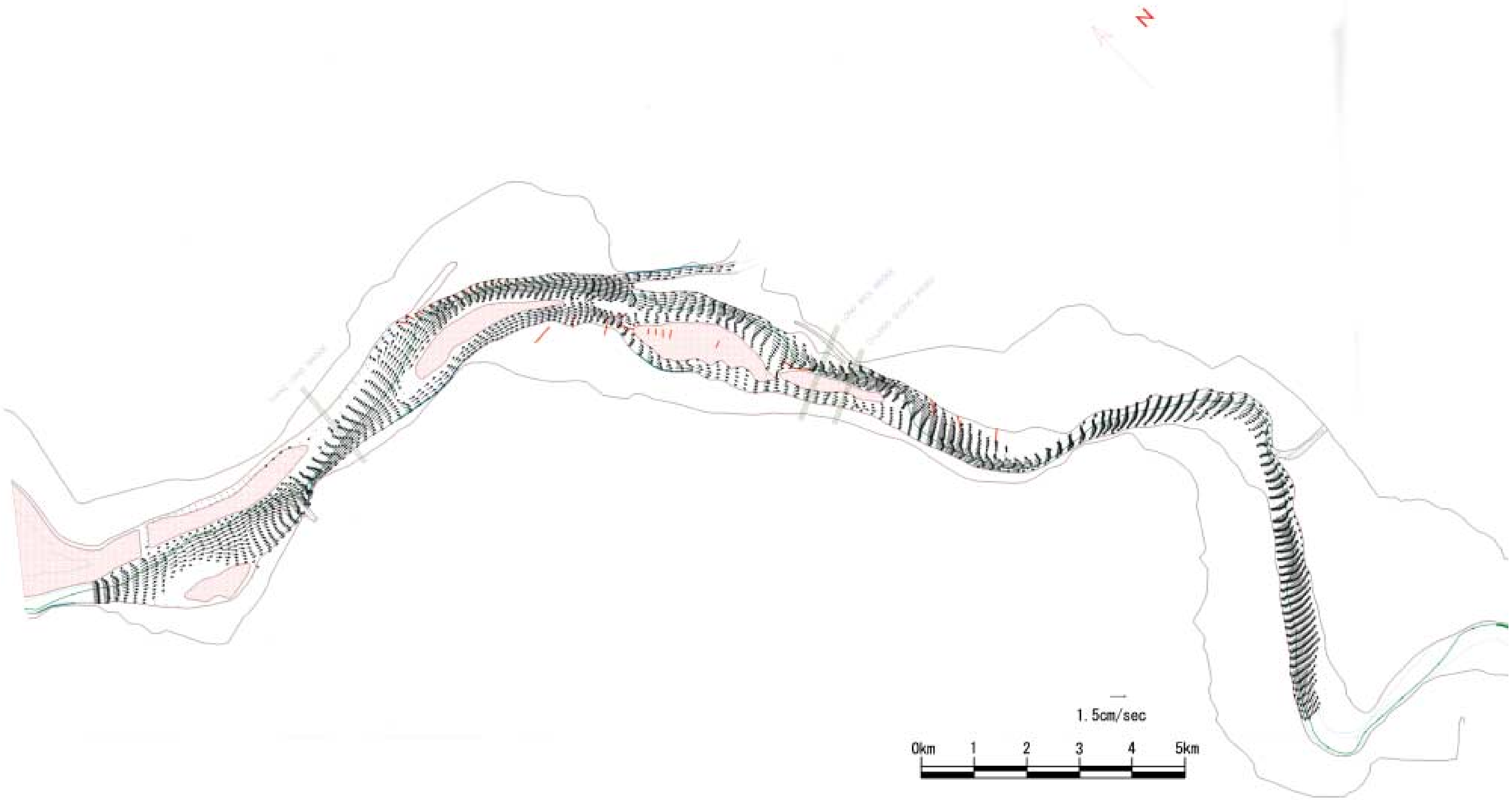


Figure 26.2.6 (1) Current Vectors (Dry Season: Cut of Sand Bar – Case B)

Source) JICA Study Team

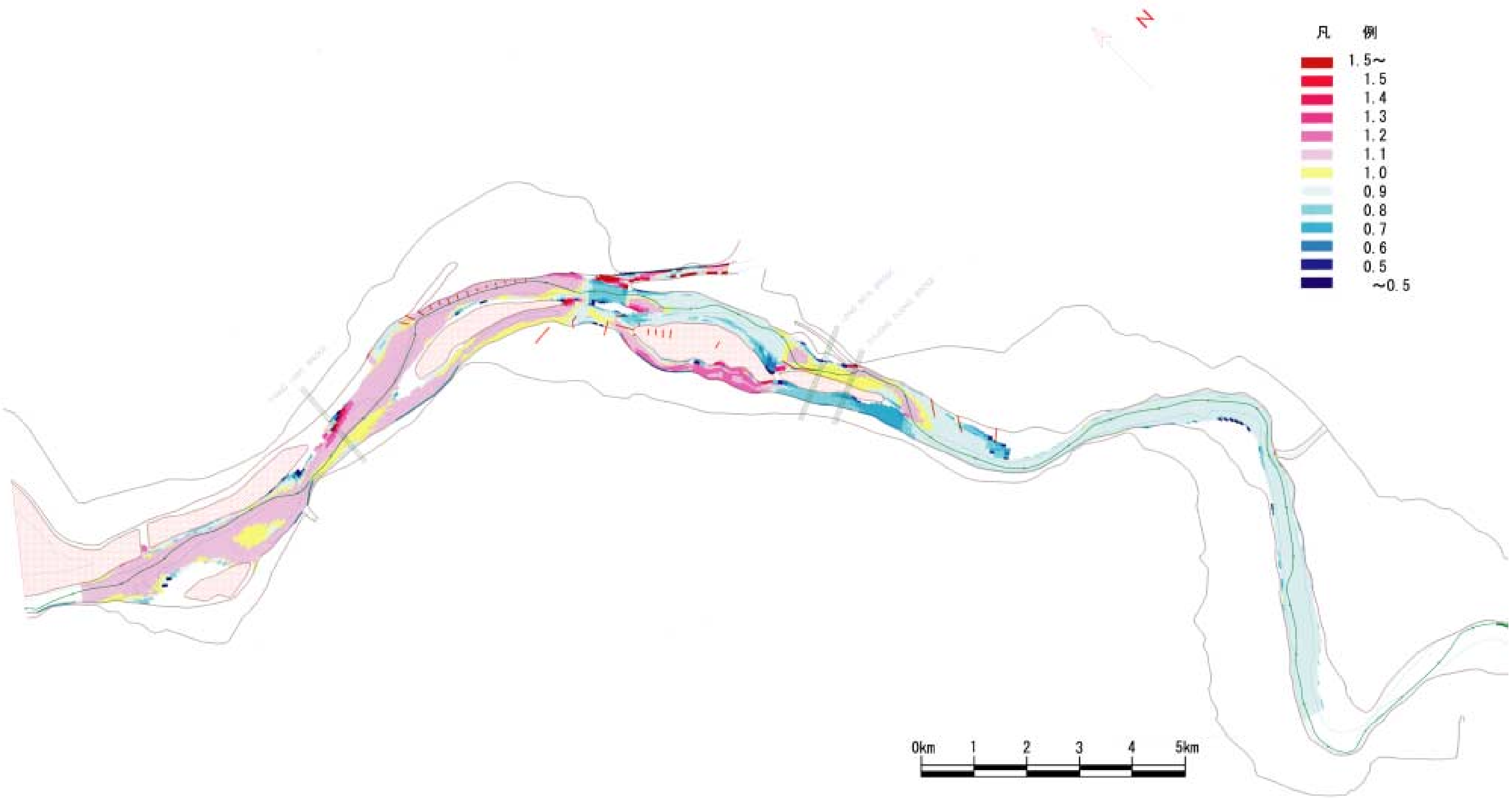


Figure 26.2.6 (2) Ratio of Current Speeds (Dry Season: Cut of Sand Bank Case B / Present Condition with Existing Groins)

Source) JICA Study Team

The phenomena accompanied with the cut of the sand bar can be described, referring to **Figure 26.2.7**, as follows:

The current speed at the left side of Tu Lien-Trung Ha Sand Bar is higher than that at the right side. It results in higher water level at the right side than the left side. Then the current through the cut flows from the right side to the left side.

As the effects of this newly created current, the following phenomena are accompanied:

1) Current speed at the downstream portions on the right decreases,
2) Current speed at the upstream portion on the right increases, because the flow is given an impetus due to 1),
3) Current speed on the left of Tu Lien Sand Bar becomes slower, which results in an increase in the water level,
4) The higher water level at the entrance of the Duong River increases discharge into the River, and
5) As a whole, current speed above the Duong Bifurcation increases, and the current speed down the Bifurcation decreases.

This change of current field could cause a certain change of profile of the river banks and sand bars during the rainy season, possibly erosion in the upstream portion and accretion of the down stream portion.

A result of simulations on erosion/accretion of the riverbed is shown in **Figure 26.2.8** for Case A in the dry season. The degree of erosion/accretion is not large, because of a small volume of river discharge. The trend of accretion can be read at Thuong Cat above Thang Long Bridge, at the mouth of the Duong River, the left side of Tu Lien-Trung Ha Sand Bar, Thach Cau Bank, etc.

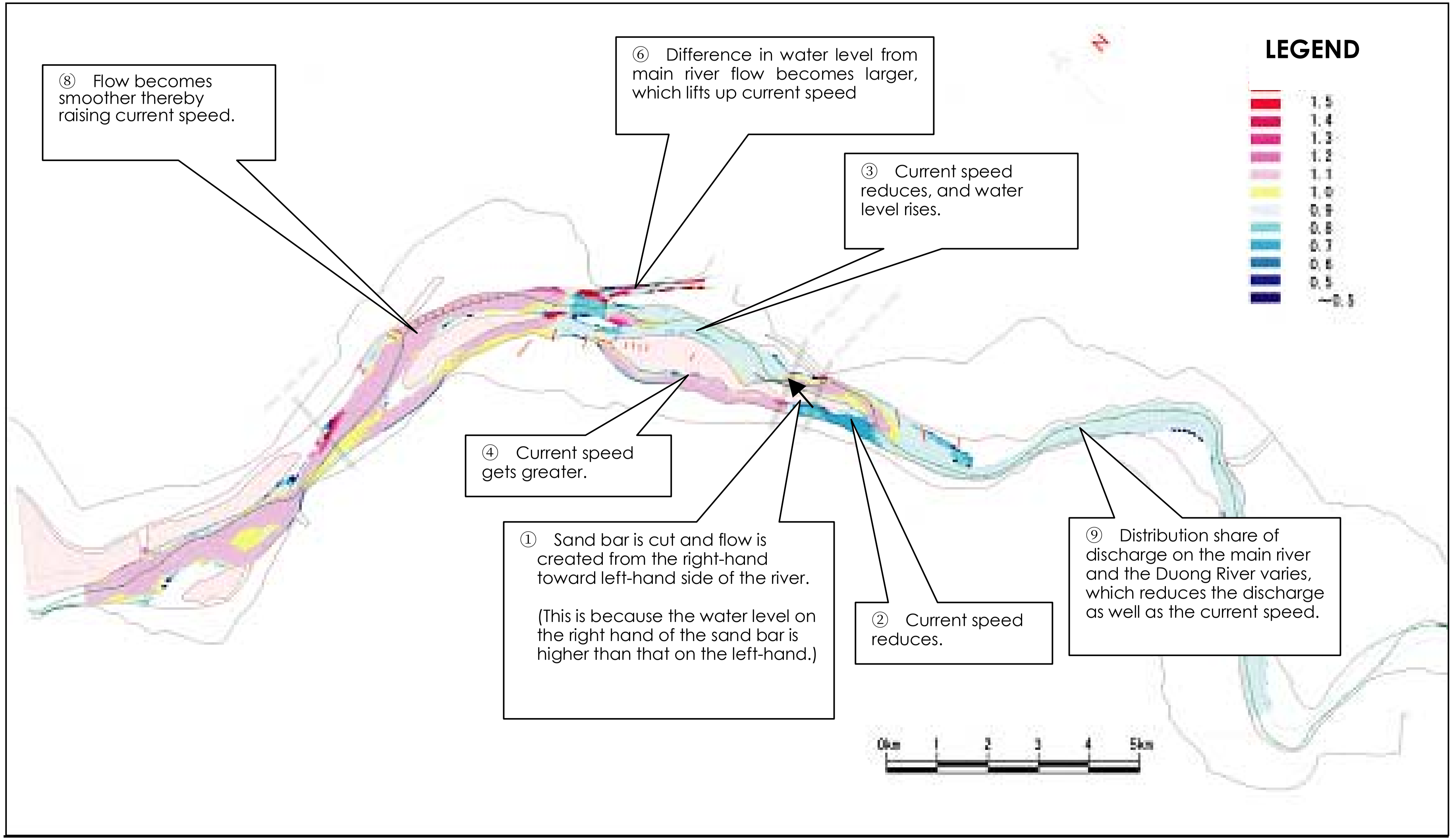


Figure 26.2.7 Effects of a Cut at Tu Lien-Trung Ha Sand Bar on Current Field

Source) JICA Study Team

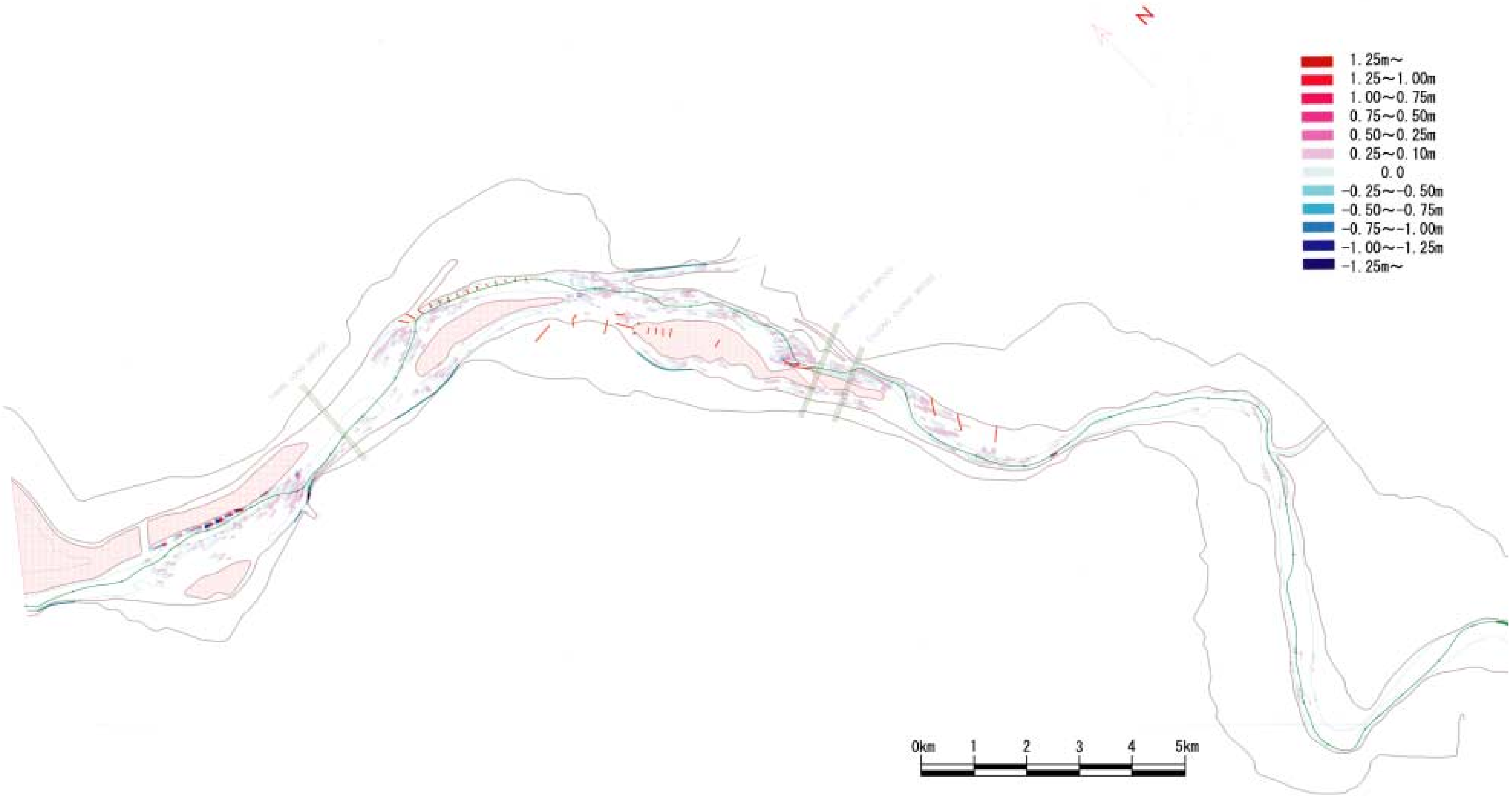


Figure 26.2.8 Effects of a Cut at Tu Lien-Trung Ha Sand Bar on Riverbed Field

Source) JICA Study Team

26.3 Channel dredging plan

26.3.1 Capital dredging volume

The channel alignment along the present Talweg and planned Sinusoid with a planned width of 150 m is superimposed on the Water Depth Map based on the survey in January 2002. Then, areas shallower than the planned water depth, i.e. 2.5 m at the upstream portion of Hanoi Port, are identified. For the down stream portion of Hanoi Port, areas shallower than 3.6 m in the center lanes and 2.5 m at the side lanes are identified.

The areas where the present water depth is inadequate along Talweg are shown in **Figure. 26.3.1.** There are 13 places where the depth is not enough. The volume of shallow bed above the planned depths is roughly estimated. It is summarized in **Table 26.3.1.** The net volume amounts to an order of 0.76 million m^3.

If dredging work is carried out along the present Talweg with an over-dredging tolerance depth of 50 cm and tolerance width of 2m, the required total capital dredging becomes approximately 0.94 million m^3.

Table 26.3.1 Estimated Volume of Capital Dredging along Talweg

Name of location	Area (m^2)	Net volume (m^3)	Over-dredge volume (m^3)	Total Volume (m^3)
Thuy Phuong	54,900	10,400	16,470	26,870
Phu Thuong	45,000	3,000	13,500	16,500
Tu Lien	95,900	32,600	28,770	61,370
Trung Ha-Bo De	219,000	380,700	65,700	446,400
Thach Cau	104,900	205,400	31,470	236,870
Duyen Ha	42,200	123,700	12,660	136,360
Van Phuc	20,600	8,600	6,180	14,780
Total	**582,500**	**764,400**	**174,750**	**939,150**

Source) JICA Study Team

Similarly, the capital dredging volume is estimated for the channel alignment along the Basic Sinuosity shown in **Figure 26.3.2**. The result is presented in **Table 26.3.2**.

The volume to be dredged is 3.7 million m^3 for the Short-term Plan until 2010. If the Long-term Plan is considered for lower segment from Hanoi Port, dredging volume amounts to 5.0 million m^3.

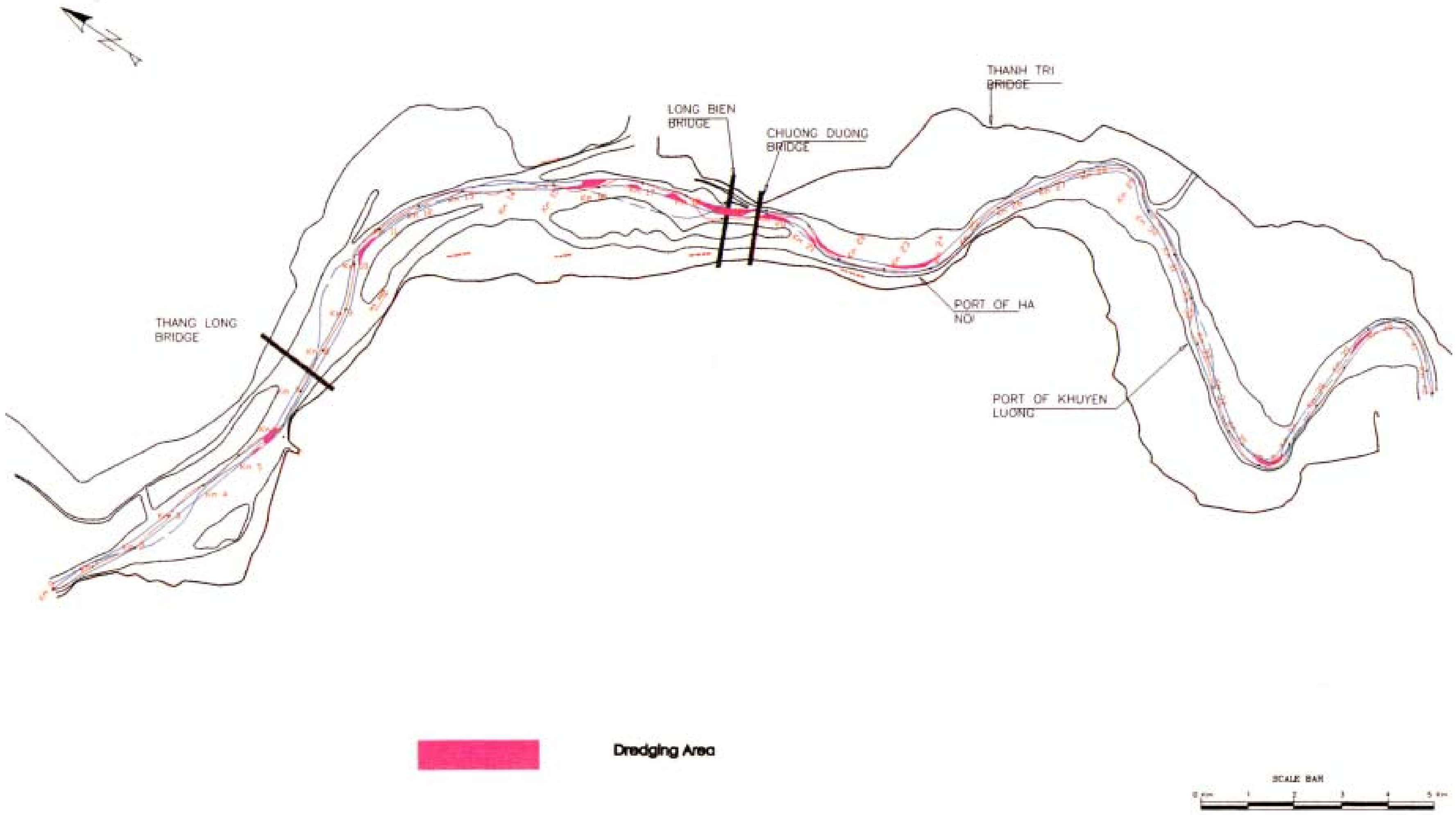


Figure 26.3.1 Areas of Capital Dredging along Talweg

Source) JICA Study Team

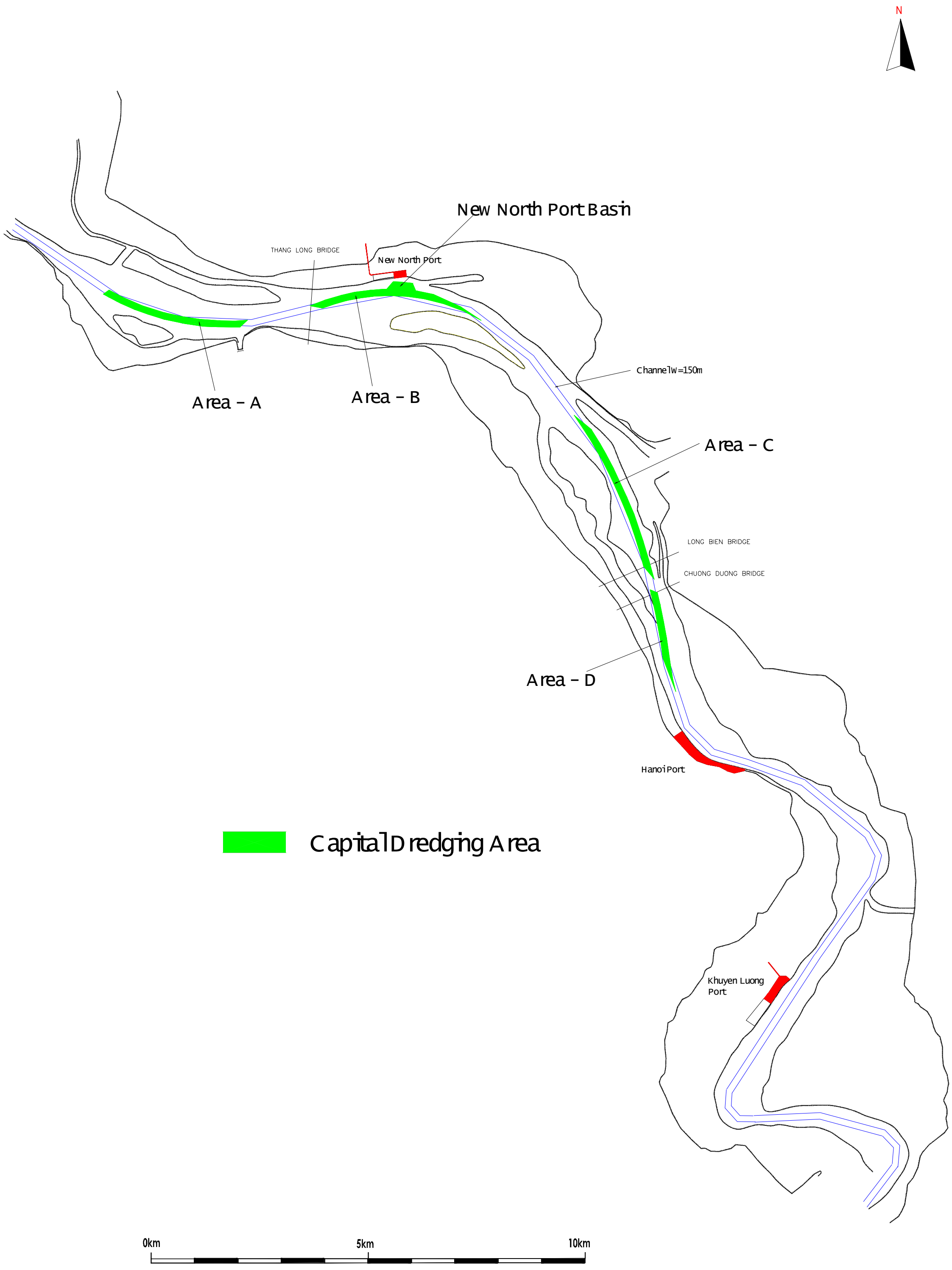


Figure 26.3.2 Areas of Capital Dredging along the Basic Sinusity

Source) JICA Study Team

Table 26.3.2 Estimated Volume of Capital Dredging along Basic Sinuosity

Name of location	Length (m)	Net volume (m^3)	Over-dredge volume (m^3)	Total Volume (m^3)
Area-A	3,300	944,500	172,300	1116,700
Area-B	3,300	725,300	167,000	892,300
Area-C	3,800	408,300	181,600	590,000
Area-D (2010)	1,900	805,200	105,300	910,500
New North Port	550	128,600	29,500	158,100
Total (2010)	**12,850**	**3,011,900**	**655,700**	**3,667,500**
Area-D (2020)	1,900	1,184,600	113,600	1,298,200
Total (2020)	**14,750**	**4,196,500**	**769,300**	**4,965,700**

Source) JICA Study Team

26.3.2 Maintenance dredging volume

Estimate of maintenance dredging volume is difficult at this stage, because of ambiguity accompanied by change of morphology due to construction of channel stabilization facilities.

This subject will be touched upon later in **26.9.2**.

26.3.3 Dredging plan

A list of dredgers available in Viet Nam is summarized in Table **A26.3.1**. The types of dredgers suitable to river channels are River Suction Hopper Dredgers, River Backhoe Dredgers and River Cutter Suction Dredgers.

The most practical choice for capital dredging may be the River Cutter Suction Dredgers. Closing the one side of the channel, the dredger can operate and dig the riverbed and discharge the soils on the nearby river banks and sand bars. Method of accumulating the soils and releasing water should be carefully planned in view of the last disposal of the soil and environmental impact of discharging the overflow water.

During the maintenance stage, the most suitable dredger may be a Suction Hopper Dredger attended by Self-propelled Barges. The Barges can dump the dredged soils at deep waters located at downstream.