Table III.1.1-1 Population Projection of Hinterland of Banjarmasin Port

	POPULATION (x 1,000)				
	REAL	PROJECTION			
	1985	1990	1993	1995	2000
1) SOUTH KALIMANTAN	2,000	2,187	2,290	2,362	2,526
2) CENTRAL KALIMANTAN	762	914	1,013	1,085	1,270
3) TOTAL (Annual Growth Rate)	2,762	3,101 (2.34)	3,303 (2.14)	3,447 (2.14)	3,796 (1.95)

In light of the above forecasts, projections of GRDP in South and Central Kalimantan and the hinterland are executed taking into consideration two cases of high and low development as shown in Table III.1.1-2. The GRDP growth rate in the hinterland becomes:

3.9 - 4.9% p.a. in 1985 to 1990,
4.1 - 5.5% p.a. in 1990 to 1995, and
4.9 - 5.7% p.a. in 1995 to 2000,

This projection suggests that the economic growth in the hinterland will be rather steady due mainly to an increase in the export of non-oil products in the South and Central Provinces, which do not depend on oil exports.

Compared with the projections of REPELITA V (Table A III.1-1-2) until 1993, i.e. 5.0, 5.1 and 4.9% p.a. respectively for all Indonesia, South and Central Kalimantan, the forecast of the Study Team was slightly smaller than that of REPELITA V. The differences were 0.1% p.a. for all Indonesia and 0.2% p.a. for the hinterland on average, and this margin of difference can also be judged as acceptable for the purpose of the cargo forecast.

Table III.1.1-2 GRDP Projection (at 1983 Constant prices) in the Hinterland

(Billion Rp.)

			1985	1990	1993	1995	2000
All Indonesia (GDP)			79,911	97,692 (4.1)	112,768 (4.9)	124,090 (4.9)	157,621 (4.9)
South Kalimantan		High	935	1,165 (4.5)	1,360 (5.3)	1,508 (5.3)	1,972 (5.5)
		Low		1,121 (3.7)	1,258 (3.9)	1,358 (3.9)	1,725 (4.9)
Central Kalimantan		H	547	725 (5.8)	864 (6.0)	970 (6.0)	1,299 (6.0)
		L		678 (4.4)	776 (4.6)	849 (4.6)	1,078 (4.9)
HinterLand (G.R.D.P.)	South K. (Share 88%)	H	823	1,025	1,197	1,327	1,735
		L		986	1,107	1,195	1,518
	Central K. (Share 62%)	H	339	450	536	601	805
		L		420	481	526	668
	Total	H	1,162	1,475 (4.9)	1,733 (5.5)	1,928 (5.5)	2,540 (5.7)
		L		1,406 (3.9)	1,588 (4.1)	1,721 (4.1)	2,186 (4.9)

Source: Study team estimation

Note: The share of each province is assumed as equal to the share of population in the province.

( ) indicates annual growth rate of GDP/GRDP

1-2 Future Cargo and Passenger Forecast

1-2-1 Export and Outward Cargoes

(1) Wood Products

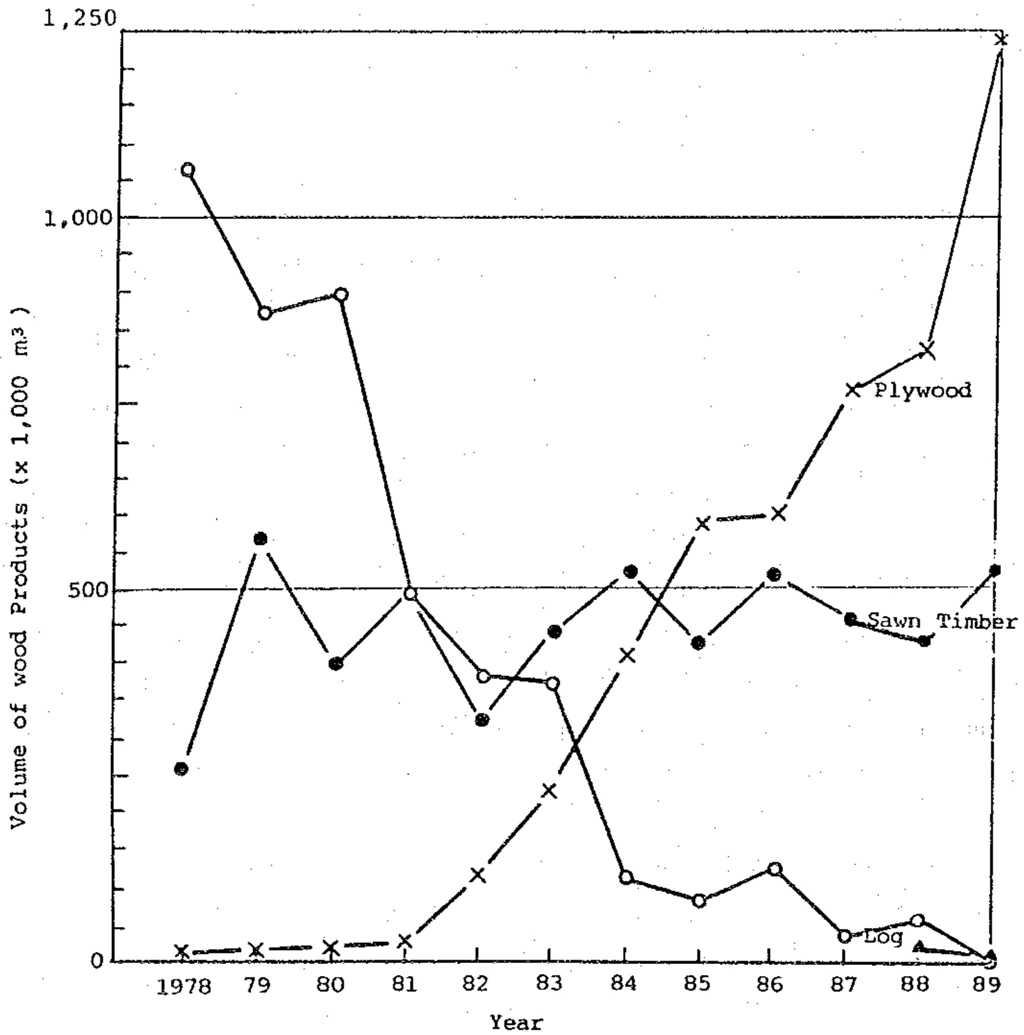
The export and outward volume of wood products from Banjarmasin Port for the past ten years is shown in Fig. III.1.2-1. The structure of commodities has drastically changed as logs which once ranked first have been replaced by plywood while sawn timber has maintained a constant volume and continuously the second rank.

a. Plywood

In 1989, export and outward plywood volume reached respectively 1,220 and 19 thousand m^3, and total 1,239 thousand m^3. This is achieved by 24 hours operation of all the lines of the 13 factories located in Banjarmasin. The total volume coincides with just twice as much as the registered capacity of these factories, i.e. 610 thousand m^3.

Indonesian plywood now holds a share in Japan more than 97% of import and 25% of all consumption, and seems to be able to control her market which is still growing. Since 1987, no license has been issued for the new construction and expansion of the plywood and sawn timber factories. It can be said that the present capacity, or working time and productivity, has been almost fully utilized. In order to develop export further, it is imperative to make new investment for the increase of production and improvement of quality. If a presently 2 lines factory adds another line, the capacity could be increased by 1.7 times. If the number of lines was doubled, the capacity could be 2.3 times larger.

Hence, it is assumed that, for export in 1990, the present capacity will overflow at a level of 1,500 thousand m^3, and after that expansion will be done equivalent to one line addition by 1995, i.e., 8.9% p.a. growth, and 2 lines by 2000, or 5% p.a. growth between 1996 to 2000.



Source: 1978 - 1982 PCI Report
1983 - 1989 Perumpel III

Notes: ▲ Moulding and Dowel

Fig. III.1.2-1 Export and Outgoing Shipment of Wood Products

For outgoing cargo, taking into account the fact that the volume has been stable at a level of about 20 thousand m^3, future volume is forecast as constant 22 thousand m^3.

The result is shown in Fig.III.1.2-2.

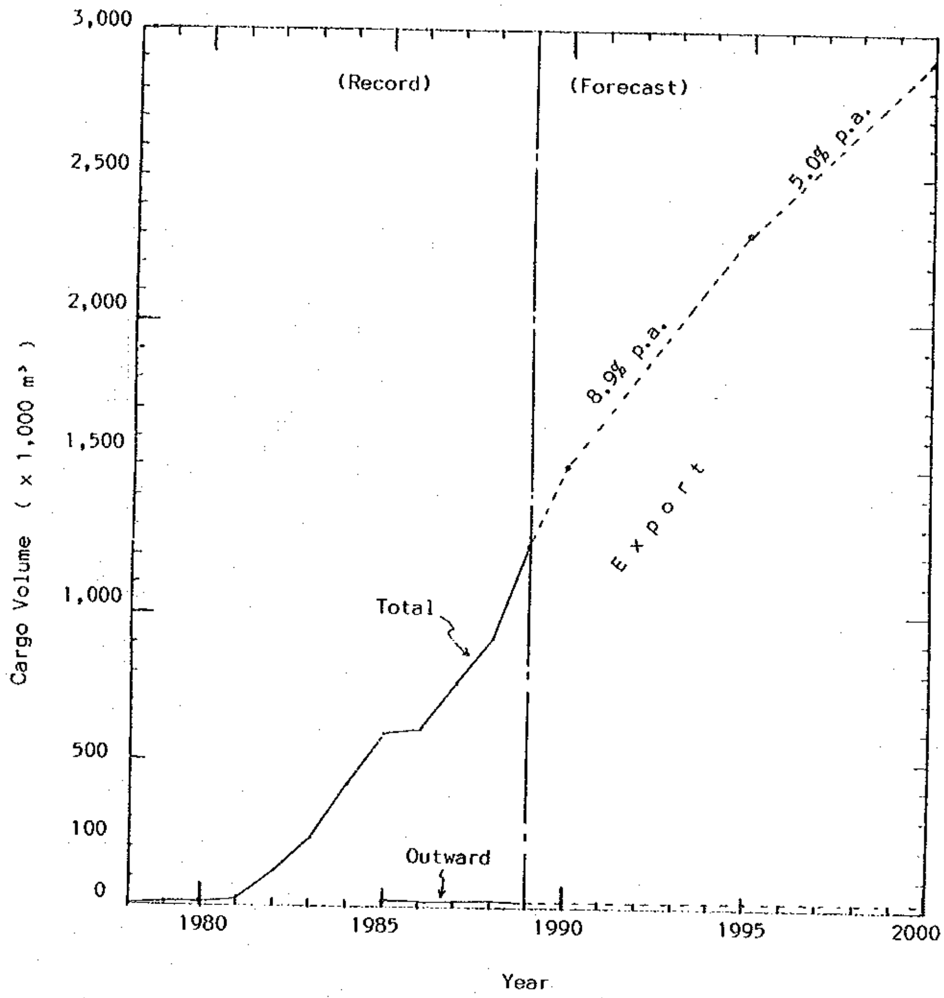


Fig. III.1.2-2 Forecast of Export and Outgoing Plywood

b. Sawn Timber, Moulding and Dowel

On October 10, 1989, the Ministry of Finance made an order (No.1134/KMK013/1989) to levy a very high tax on sawn timber exports, which seems to have the effect of containing sawn timber production and to encourage production of more value-added products such as moulding, dowels, and furniture parts. It may take a considerable time to convert the present sawn timber factory to furniture parts factory.

It is assumed that total volume of sawn timber, moulding and dowel will maintain a constant level in the future. Sawn timber exports will be gradually replaced by moulding and dowel exports which, in turn, will develop following a logistic curve with 5 years to reach half the maximum volume. Outward bound sawn timber will occupy 60% of all wood products in 2000, taking account of the past trend. The result is illustrated in Fig. III.1.2-3.

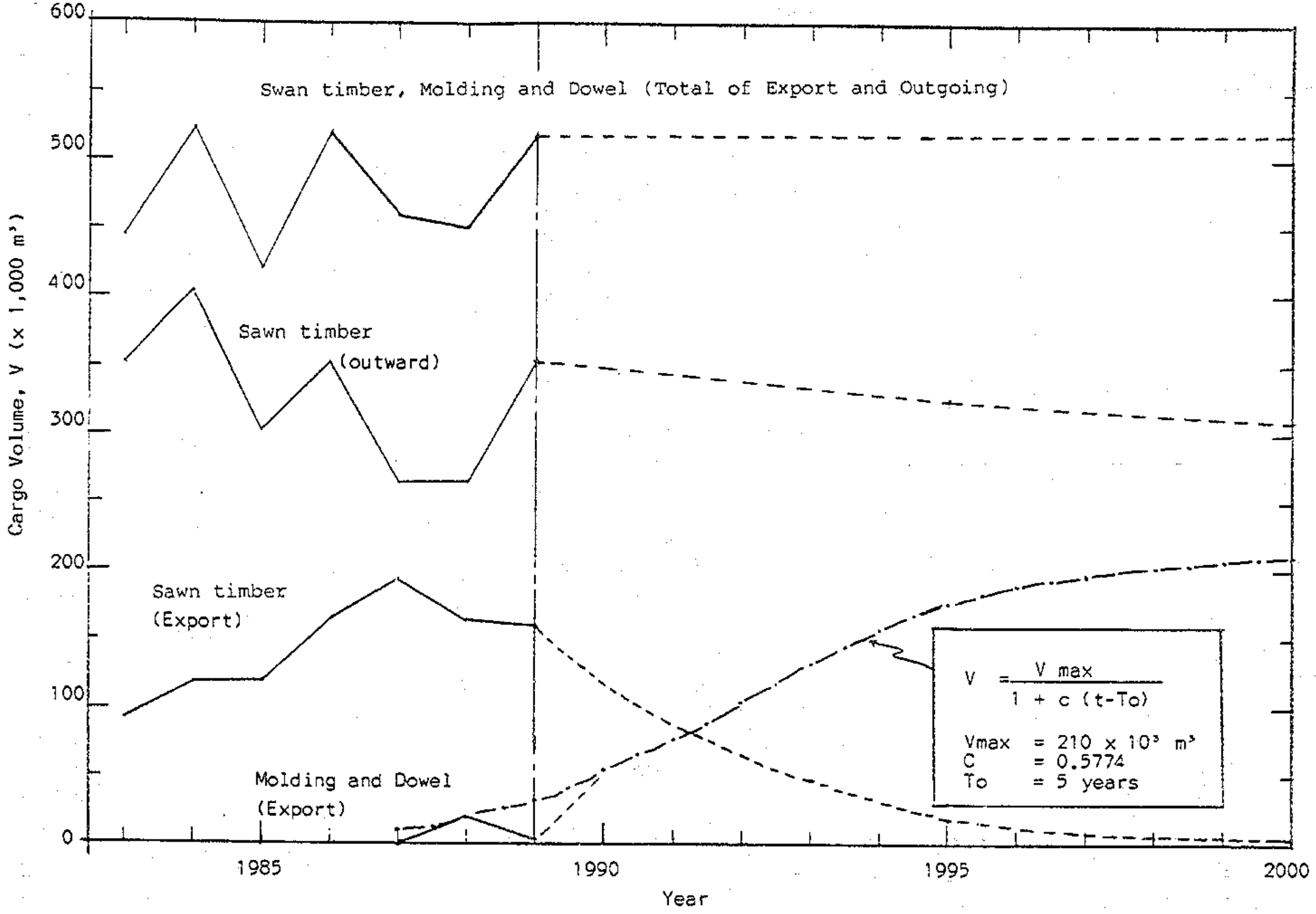


Fig. III.1.2-3 Forecast of Sawn Timber, Moulding and Dowel

(2) Rubber

Rubber exports from Banjarmasin have decreased, but outward bound shipments have increased very much since 1985. This is because of transshipment at Surabaya Port.

It is assumed that the total volume will develop at the rate of the subsectoral growth of horticulture (plantation) given in REPELITA V, i.e. 7.3%, until 1995 and 5.0% p.a. after 1996. Direct exports from Banjarmasin are assumed to be 10% of the total volume.

The result is shown in Fig. III.1.2-4.

(3) Rattan and Rattan Carpet

Direct exports of rattan and rattan carpets from Banjarmasin ended in 1987 and 1989, respectively. Outward bound rattan carpets to Tj. Priok in containers decreased in 1988 and 1989. This is because of over-stocked condition in Japan, i.e., 2 million m^3 equivalent to 1.3 years consumption. Instead, outward bound raw rattan to Surabaya tripled in 1989.

It is assumed that the capacity of raw rattan supply from Sampit, Samarinda, Batricin, etc., is the same as the maximum volume recorded in the past, i.e., 52 thousand m^3. The volume of outward rattan carpets will recover to the past maximum level of 18 thousand m^3 in 1993 and a growth of 6% p.a. after 1994, as IBRD predicted. Then the remaining rattan will be forwarded to Surabaya as shown in Fig. III.1.2-5.

(4) Frozen Shrimp

The future growth rate is supposed to be 6%. p.a., or the same as the figure forecast for all Indonesia by IBRD.

(5) Other Exports

Other Exports include molasses, wood sap, and others. This category is assumed to grow at a rate of 5% p.a. after 1990.

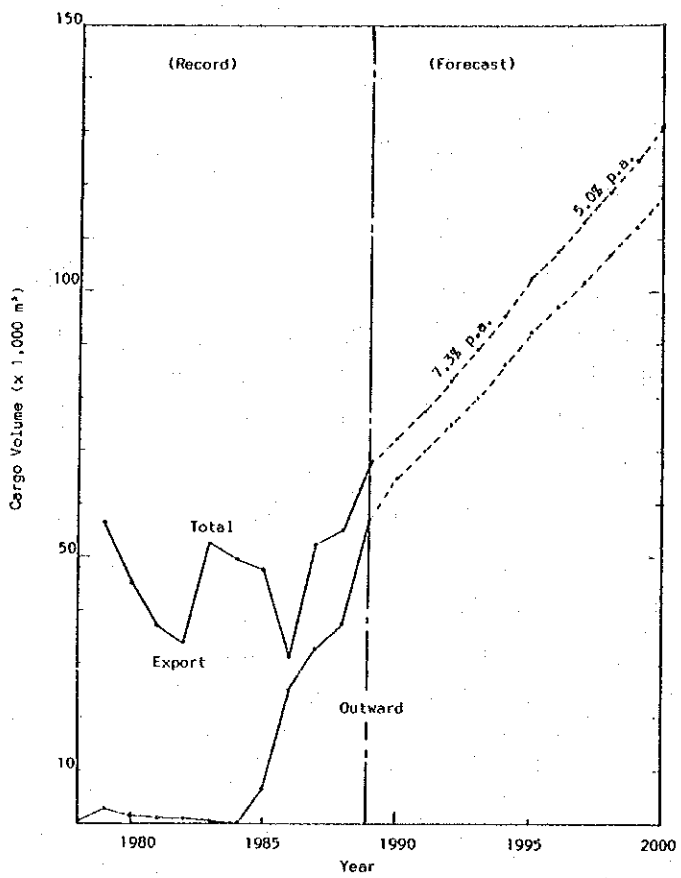


Fig. III.1.2-4 Forecast of Rubber

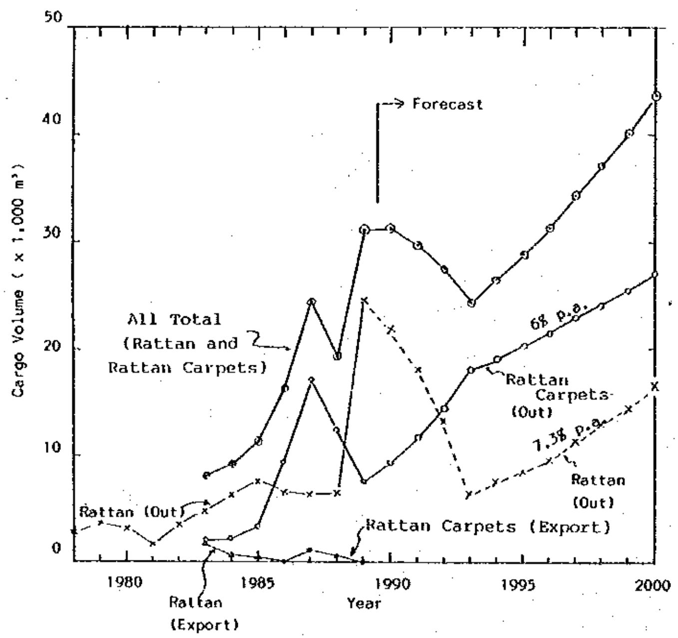


Fig. III.1.2-5 Forecast of Rattan and Rattan Carpets

(6) Chemicals (Outward, Import and Inward)

Chemicals include plywood glue, phenol, melamine, elvanol, etc., which are all for plywood production. Their shipment to/from Banjarmasin involves not only imports from Singapore and Europe and incoming shipments from Tj. Priok and Surabaya, but also outward from 1987.

Until 1987, the import volume of chemicals was 2.5% of plywood production. The formula is now not so simple, and is supposed as a condition of balance of plywood glue volume among import + inward, outward and remaining at Banjarmasin as shown in Fig. III.1.2-6, i.e., imports 3.8%, incoming 23.7% and outward bound 12.5% of the plywood production, P. Other chemicals are assumed to be 6.5% of the plywood production only for incoming shipments.

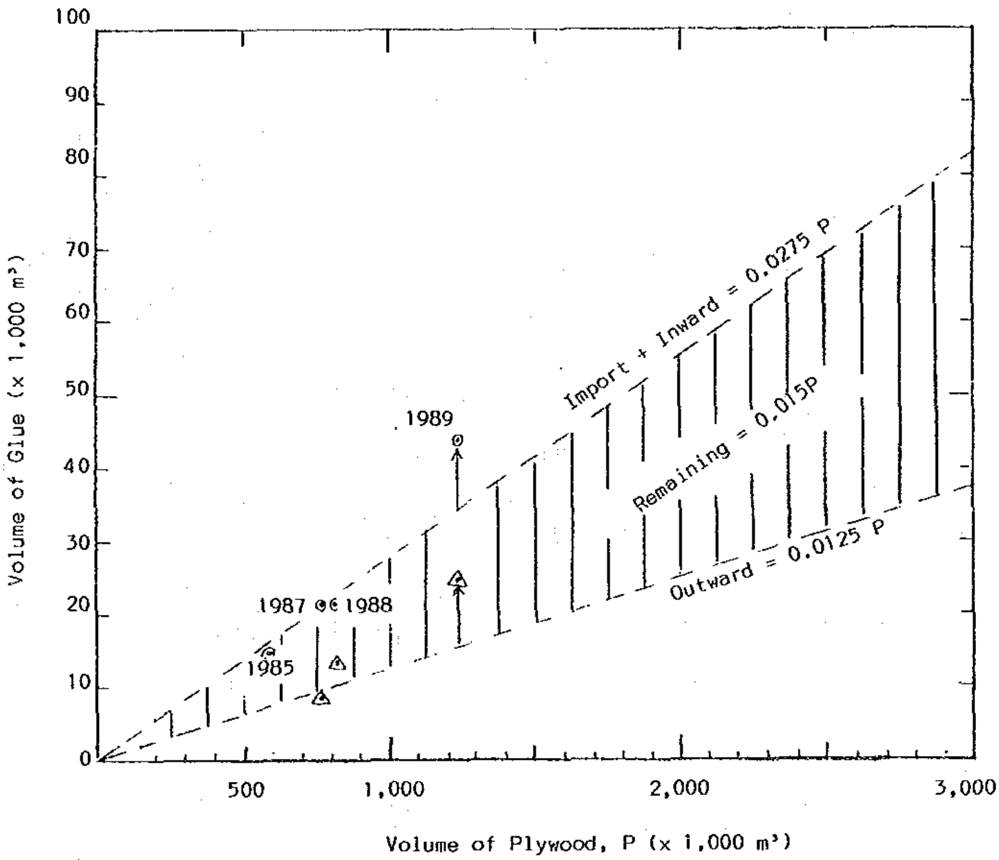


Fig. III.1.2-6 Forecast of Plywood Glue

(7) Petroleum Products (Outward and Inward)

PERTAMINA constructed depots at Pulangpisau in 1989, Kotabaru and Pangkalanbun in 1989, and will built new depots at Palangkaraya and Sampit. Hence, the volume to/from Banjarmasin cannot be expected to increase drastically. It is assumed that the outward bound volume will maintain the present level and incoming volume will increase parallel to the increase of population in the hinterland.

(8) Fertilizer (Outward and Inward)

Inward fertilizer volume has a very good correlation of 0.96 with the GRDP of the foodstuff subsector in the hinterland. Outward is to redistribute it to hinterland area by boat and has a tendency to decrease after 1985.

Future volume of inward is assumed to have a growth rate of 2.9% p.a. by 1993, 3.4% p.a. by 1995 and 4.0% by 2000. Outward volume is assumed to reach and keep to the bottom level of 5,000 tons in 1995 and 2000.

(9) Molasses

Outward bound molasses shipments are assumed to develop at a rate of 3% p.a. until 1993 and 5% p.a. until 2000.

(10) Coal

Shipment of outward bound coal started in 1988 to Gresik from coal mines at Sunkai, Binuang and Cempaka in South Kalimantan. Owing to the completion of a stockyard at Trisakti in 1990, the volume will surely increase in the future.

Taking into account the plan submitted to Perumpel III, it is assumed to develop at a rate of 30,000 t/month by 1995, following a logistic curve, and after that 5% p.a.

(11) Other Outward bound Products

The annual growth rate of this category was 23.3% p.a. until 1988 and 67.6% in 1989. This is due to increases in wood skin (bark), salt fish, rice (tripled), iron scrap, soap (doubled) and others. The trend seems to be sustained because one third is speciality of South Kalimantan.

It is assumed that the growth rate will become smaller following the increase of volume, i.e. 8% p.a. in 1990 to 5% p.a. in 2000.

1-2-2 Imports and Incoming Shipments

(1) Log (Imports, Incoming and Outgoing)

In order to assess the demand and supply for logs, rates of usage to manufacture plywood, sawn timber and moulding/dowel from logs are supposed to be 0.43, 0.50 and 0.40 respectively. Then the local supply of logs can be calculated by dividing their volume by the above rate and adding their converted volume of export and outward minus incoming shipments. The results are presented in Fig. III.1.2-7. It is estimated that the total local supply of logs was around 2,000 thousand m^3 until 1987 and 3,900 thousand m^3 in 1989. Future demand for export and outward wood products is forecast to reach about 8,000 thousand m^3 in 2,000. According to the Forestry Statistics of Indonesia, the maximum annual allowable cut (AAC) is more than 16,000 thousand m^3 in South and Central Kalimantan, which is enough for the above demand.

It is assumed that outgoing log shipments will not take place due to strong local demand, and incoming log shipments will be required to supply unobtainable types of wood from East Kalimantan and Irian Jaya equivalent to 15% of total demand. The question is imports of logs. If we suppose the local supply to be at the most 5,000 thousand m^3, the shortage of 549 and 1,350 thousand m^3 respectively in 1995 and 2000 should be imported, probably from Malaysia. However, difficulty is anticipated from both the economic and environmental points of view in Malaysia. Hence, imports of logs are assumed to not take place.

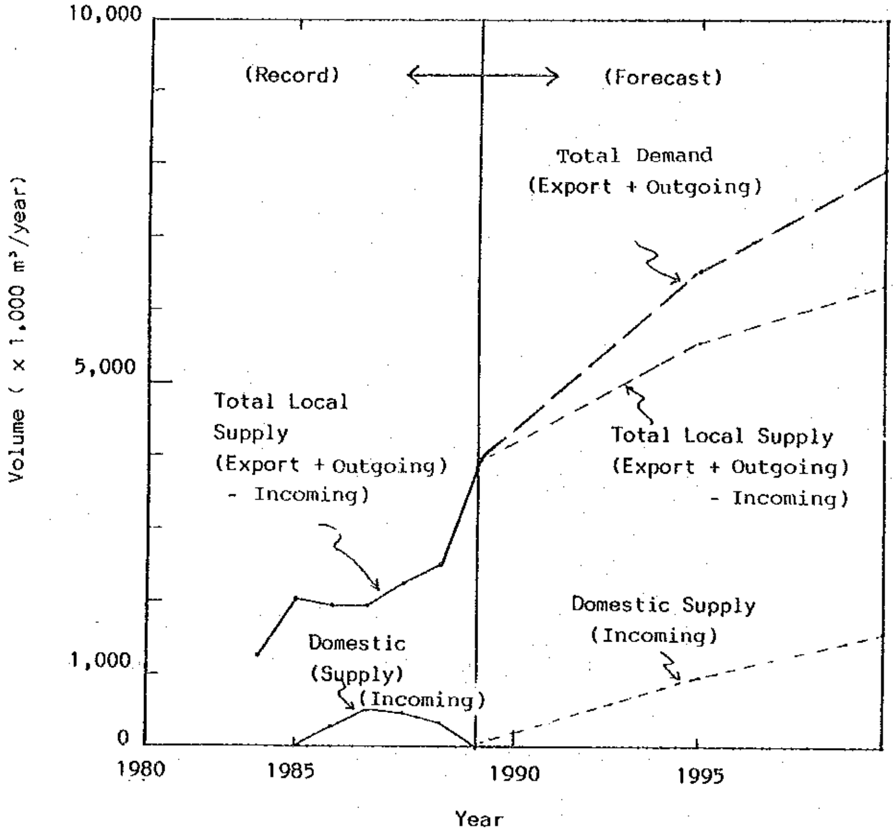


Fig. III.1.2-7 Demand for Logs

(2) Asphalt

The volumes of imports from Singapore and incoming shipments, mainly from Cilacap, fluctuate extremely year by year, as if import was created one year later of increase of demand and inward was to supplement the gap.

It is assumed that total demand will increase at a rate of 5.8% p.a. until 1995, which is equivalent to the expected growth rate of the construction and oil sectors, and 5% p.a. afterward. Import and incoming shipments will account for 60% and 40%, respectively, of the total demand as shown in Fig. III.1.2-8.

(3) Machine and Spare Parts, Heavy Equipment and Car/Vehicles

It is forecast that imports of machines and spare parts will develop at a rate of 8.5% p.a. following the growth rate of the industrial sector. Imports of heavy equipment and incoming shipments of car/vehicles will increase at 7.6% p.a. until 1995, equivalent to the weighted average growth rate of the construction and industrial sectors, and 5% p.a. afterward.

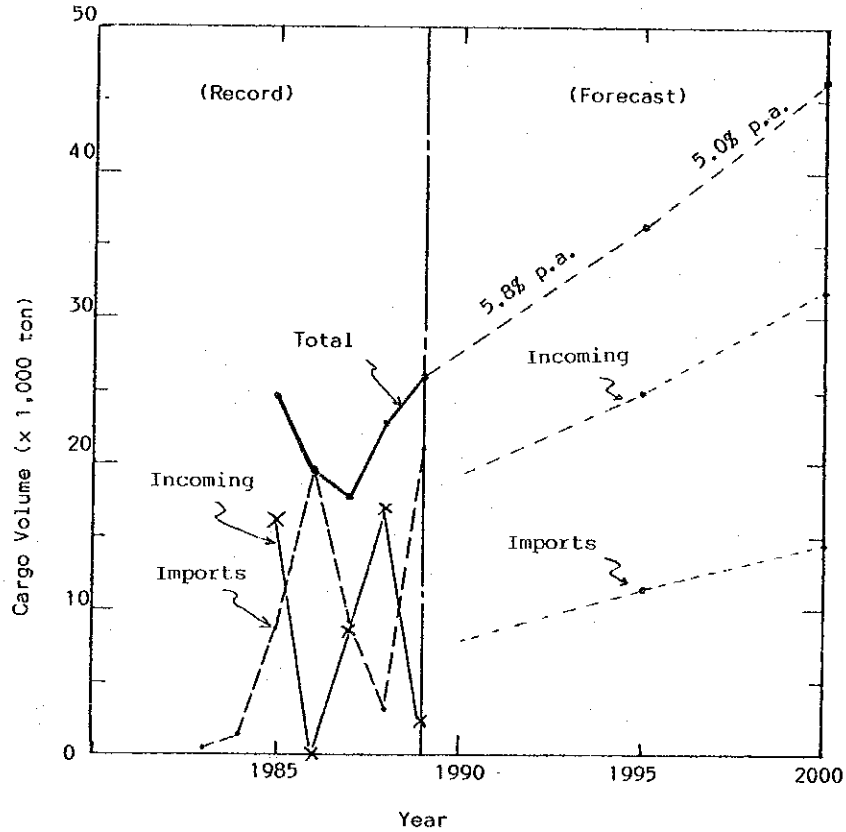


Fig. III.1.2-8 Forecast of Asphalt

(4) Other Imports

A growth rate of 5% p.a. is introduced taking account of the past trend and maximum recorded rates of growth.

(5) Rice, Sugar and Wheat Flour

The incoming shipment volumes of these products in 1989 marked a considerable decrease. However, rice is expected to re-increase as the trend from 1982 to 1986 with a growth rate of 5.0% p.a. Sugar and wheat flour are also supposed to increase at the same rate, based on 1989 and 1988 records, respectively.

(6) Food/Drinks and Tobacco/Cigarette

These products' incoming volumes doubled in 1989 and are expected to decrease in 1990. Considering the past trend and applying the least square method, a growth rate of 10 to 11% p.a. is employed until 1995 and of one 5% p.a. after that.

(7) Cement and Construction Materials

Their correlation with the GRDP of construction sector as well as with that of asphalt was very high. Hence, annual growth rates of 5.8% until 1995 and 5% after that are introduced.

(8) Petroleum Products

It is assumed that the future volume will increase parallel to the increase of population in the hinterland.

(9) Other Incoming Goods

There are many items in this category. Therefore, the least square method is applied to the past records and extrapolated to the future volume, i.e. 8.6% p.a. until 1995 and 5.8% p.a. until 2000.

1-2-3 Passengers

The capacity of the KELIMUTU was already saturated in 1988 and 1989. It is assumed that the capacity will be expanded or new passenger ships introduced following the growth of demand. Then the number of passengers could be considered to be proportional to (a) x (GDP per capita) in principle.

The growth rate of GDP per capita can be calculated by dividing the growth rate of GDP by that of population, i.e., 3.39% p.a. in 1993 and 3.7% p.a. in 2000. The growth rate of passengers is assessed by multiplying it by an elasticity which is not less than 1.0. The elasticity in the past was 1.945, 1.179 and 1.104 in 1987, 1988 and 1989 respectively. It is assumed that the elasticity will decline to 1.000 by 1993.

The result of the forecast is that the expected total number of passengers will be 186,000 in 1993, 198,000 in 1995 and 233,000 persons (psn) in 2000. Of the total number, Martapura Wharf is assumed to handle 30,000 psn, taking the average of the past 4 years, which is shown in Fog. III.1.2-9.

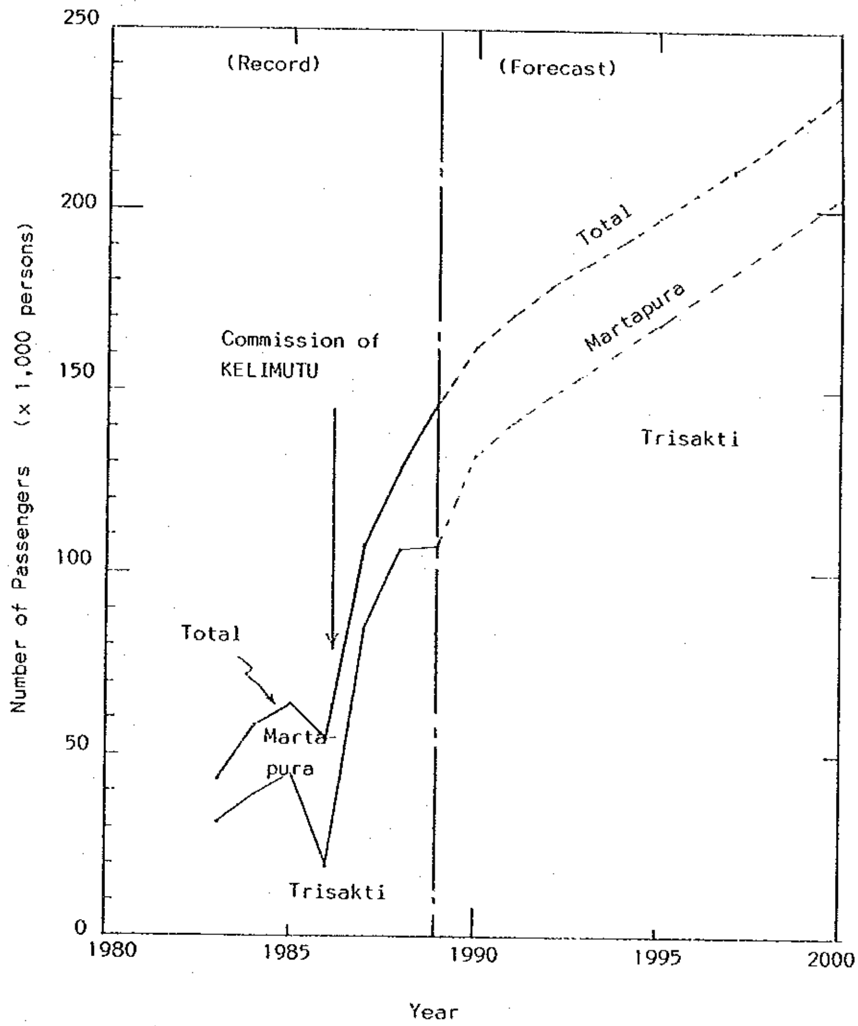


Fig. III.1.2-9 Forecast of Passenger Traffic

1-2-4 Summary of the Cargo Forecast

All the results of the above cargo forecast are summarized in Tables III.1.2-1 and 2 by commodity. The total foreign and domestic trade volume is tabulated in Table III.1.2-3 and illustrated in Fig. III.1.2-10.

Export volume will be 1.80 and 2.24 times in 1995 and 2000, respectively, larger than that in 1989. More than 90% of total exports will comprise plywood. Outward bound cargo will increase by 1.61 times in 1995 and 1.92 times the 1989 level. Coal, sawn timber and rubber will occupy important positions. Their import volume will become 1.70 times and 2.33 times, but the share among total trades will be still very limited. Incoming goods will be the largest category and expand 2.16 times in 1995 and 3.00 times in 2000 over the present level, consisting of consumables and various kind of commodities. In total, the volume is expected to grow by 1.91 times and 2.50 times larger than that in 1989.

Table III.1.2-1 Projection of Export and Outgoing Cargo Volume

(Thousands of tons/m^3)

Item	Past		Records			Forecast	
	1985	1986	1987	1988	1989	1995	2000
I. Export							
1)Plywood	568.0	581.3	747.9	794.5	1,219.7	2,300	2,900
2)Sawn Timber	119.8	165.4	194.7	163.9	161.1	19	3
3)Moulding & Dowels	-	-	-	21.3	3.3	176	207
4)Rubber	41.5	6.2	18.6	17.4	10.8	10	13
5)Rattan Carpets	-	-	1.1	0.5	0.0	0	0
6)Frozen Shrimp	1.4	2.1	2.6	1.9	3.6	4	6
7)Others	6.6	16.4	1.9	9.7	4.1	14	17
Sub-Total	737.3	771.4	966.8	1,009.2	1,402.6	2,523	3146
II.Outgoing							
1)Plywood	21.3	20.4	20.6	24.8	19.3	22	22
2)Sawn Timber	302.7	353.7	264.5	265.5	353.4	325	310
3)Logs	76.2	124.2	32.9	56.7	-	0	0
4)Rubber	6.3	25.1	33.7	37.6	56.4	92	118
5)Rattan	7.5	6.6	6.3	6.4	24.5	9	17
6)Rattan/Rush Mats	3.3	9.4	17.0	12.4	7.7	20	27
7)Chemicals	6.3	-	8.4	13.4	25.9	29	37
8)Petroleum Products	28.1	7.2	8.5	19.3	10.6	11	12
9)Fertilizer	8.7	6.5	6.1	7.8	5.1	5	5
10)Molasses	-	-	-	9.5	14.8	18	23
11)Coal	-	-	-	0.3	29.5	360	482
12)Others	33.4	38.7	54.4	62.6	104.9	156	200
Sub-Total	487.5	591.8	444.0	516.3	652.1	1,047	1,253
Total	1,224.8	1,363.2	1,410.8	1,525.5	2,054.7	3,570	4,399

Source: Annual Reports, Banjarmasin Office, Perumpel III

Table III.1.2-2 Projection of Import and Incoming Cargo Volume

(Thousands of tons/m^3)

	Past		Records			Forecast	
	1985	1986	1987	1988	1989	1995	2000
1. Import							
1) Chemicals	14.8	12.1	18.3	5.7	7.2	9	11
2) Asphalt	8.6	19.9	9.3	6.0	21.0	11	15
3) Machines $ Spare Parts	1.8	3.5	4.7	9.9	10.5	17	26
4) Heavy Equipment	6.2	5.1	4.9	8.4	0.6	14	20
5) Logs	-	-	-	-	-	(549)	(1,360)
6) Others	2.0	10.1	2.1	1.1	0.1	16	20
Sub-Total	33.4	50.7	39.3	31.0	39.5	67 (616)	92 (1,452)
II. Incoming							
1) Rice	58.1	63.6	83.7	65.6	48.0	99	126
2) Sugar	47.7	49.5	45.0	47.8	22.1	35	47
3) Wheat Flour	29.5	32.0	31.6	33.9	27.2	48	61
4) Fertilizer	46.9	57.4	77.4	80.1	103.6	128	192
5) Cement	61.6	66.4	61.9	77.5	98.2	138	176
6) Asphalt	16.0	-	8.4	16.8	4.9	25	32
7) Chemicals	21.2	-	21.1	18.6	117.8	206	259
8) Food/Drinks	22.2	46.0	17.1	41.2	83.7	105	135
9) Tobacco/Cigarettes	10.5	27.9	26.0	24.6	46.1	68	87
10) Car/Vehicles	8.3	23.9	22.8	19.4	32.2	50	64
11) Construction materials	32.3	18.2	14.2	22.4	72.4	102	130
12) Others	138.8	353.2	319.5	353.3	520.2	855	1,133
Sub-Total(1 - 12)	493.1	738.5	728.7	801.2	1,176.2	1,859	2,442
13) Logs	285.8	498.8	462.9	316.2	1.2	979	1,588
14) Petroleum Products	303.2	243.2	260.6	279.8	276.3	309	340
Sub-Total(1 - 14)	1,082.1	1,480.5	1,452.2	1,397.2	1,453.8	3,147	4,370
Total	1,115.1	1,531.2	1,491.5	1,428.2	1,493.3	3,214	4,462

Source: Annual Reports, Banjarmasin Office, Perumpel III

Table III.1.2-3 Summary of the Projection of Future Cargo at Banjarmasin Port

(Thousands of tons/m^3)

Item	Past Records					Forecast	
	1985	1986	1987	1988	1989	1995	2000
1)Exports	737.3	771.4	966.8	1,009.2	1,402.6	2,523	3,146
2)Imports	33.4	50.7	39.3	31.0	39.5	67	92
Sub-Total	770.7	822.1	1,006.1	1,040.2	1,442.1	2,590	3,238
1)Outgoing	487.5	591.8	444.0	516.3	652.1	1,047	1,253
2)Incoming	1,082.1	1,480.5	1,452.2	1,397.2	1,453.8	3,147	4,370
Sub-Total	1,569.6	2,072.3	1,896.2	1,913.5	2,105.9	4,194	5,623
Total	2,340.3	2,894.4	2,902.3	2,953.8	3,548.0	6,784	8,861

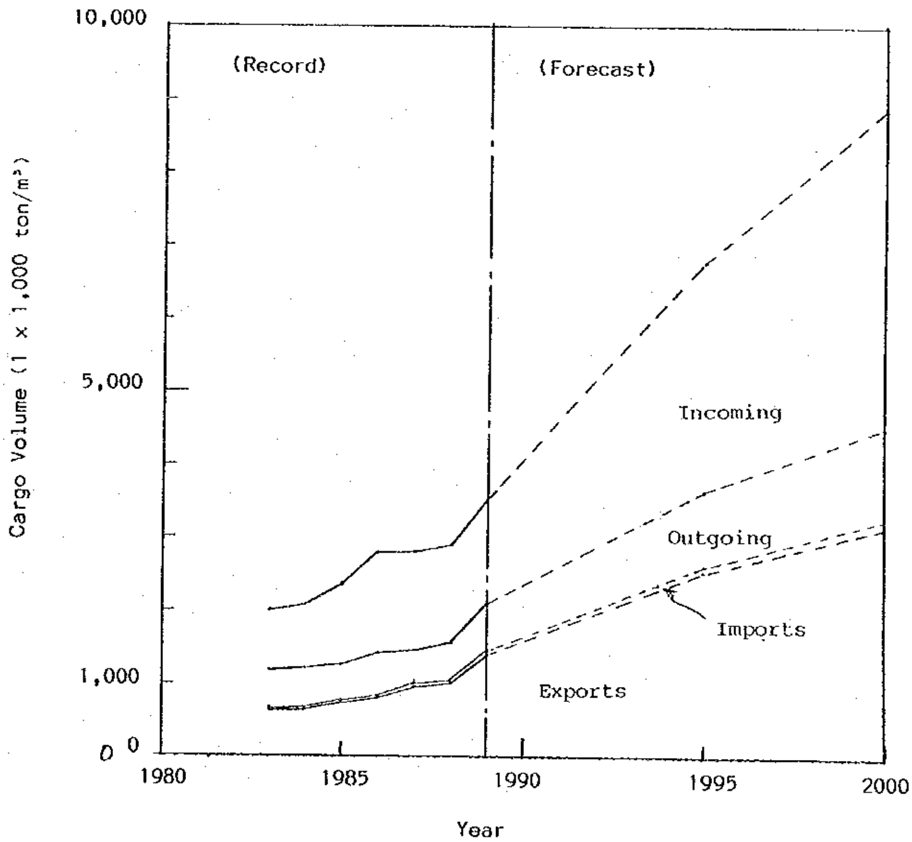


Fig. III.1.2-10 Projection of Cargo Volume at Banjarmasin Port

1-3 Future Vessel Traffic Forecast

1-3-1 Cargo Volume by Ship Type

The future cargo projections in 1995 and 2000 are allocated to different types of vessels, i.e. oceangoing (O.G.), interisland (I.I), local and sailing (Loc. & Sail), special industry (S.I.), and tankers (Tanker). The allocation was made based on the share of each kind of goods presented on Table A III.1.3-1.

1-3-2 Average Ship Size, Payload and Cargo Volume per Ship

The changes of the average ship size (GRT/ship), pay load (tons/GRT) and cargo volume (tons/ship) are illustrated in Fig. III.1.3-1 for the past seven years. Forecast numbers in 1995 and 2000 are also shown in the same Figure.

1-3-3 Forecast of the Number of Ship Calls

Dividing the projected volumes of cargoes by the projected average volume per ship, the number of ship calls is forecast by type of ship in 1995 and 2000.

Similarly, the number of passenger ships is calculated by the projected annual number of passengers and the expected average number of passengers per ship. The latter number is supposed to be 2,500 persons/ship based on past records.

The result is presented in Table III.1.3-1, and illustrated in Fig. III.1.3-2. The forecast total number of ships shown an increase of 53% in 1995 and 68% in 2000 compared with the 1989 figures.

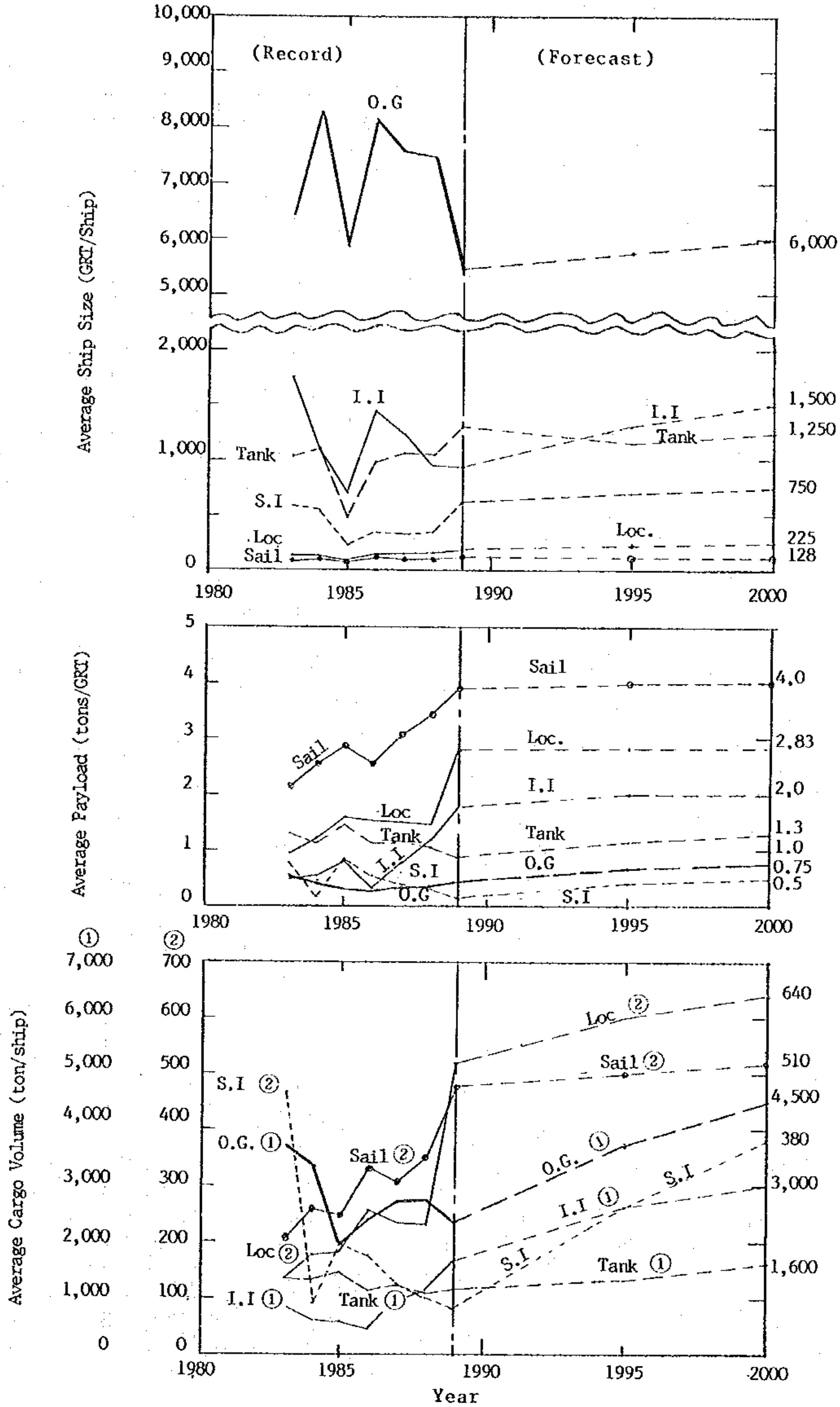


Fig. III.1.3-1 Ship Characteristics and their Forecast

Table III.1.1-3 Forecast of the Number of Ship Calls

Year	Type of Ship	Volume Number (Th. ton) (Th. psn)	Average Volume (Ton/ship) (psn/ship)	Number of ships	
				Annual	Daily
1988 (Actual)	Oceangoing	1,156	2,733	423	1.16
	Interisland	241	1,135	212	0.58
	Local	256	233	1,096	3.00
	Sailing	577	351	1,643	4.50
	Special	445	101	4,411	12.08
	Tanker	280	1,097	255	0.70
	(Sub-Total)	(2,954)	(-)	(8,040)	(22.03)
	Passenger	129	2,486	52	0.14
	Total	-	-	8,092	22.17
1989 (Actual)	Oceangoing	1,442	2,337	617	1.69
	Interisland	321	1,681	191	0.52
	Local	504	518	973	2.67
	Sailing	797	478	1,666	4.56
	Special	208	81	2,565	7.03
	Tanker	276	1,145	241	0.66
	(Sub-Total)	(3,548)	(-)	(6,253)	(17.13)
	Passenger	147	3,128	47	0.13
	Total	-	-	6,300	17.26
1995 (Fore-cast)	Oceangoing	2,780	3,740	743	2.04
	Interisland	706	2,600	271	0.74
	Local	598	600	997	2.73
	Sailing	794	500	1,588	4.35
	Special	1,598	280	5,707	15.64
	Tanker	309	1,300	238	0.65
	(Sub-Total)	(6,784)	(-)	(9,544)	(26.15)
	Passenger	198	2,500	79	0.22
	Total	-	-	9,623	26.36
2000 (Fore-cast)	Oceangoing	3,547	4,500	788	2.16
	Interisland	934	3,000	311	0.85
	Local	779	640	1,217	3.33
	Sailing	933	510	1,829	5.01
	Special	2,327	380	6,124	16.78
	Tanker	340	1,600	213	0.58
	(Sub-Total)	(8,361)	(-)	(10,482)	(28.72)
	Passenger	233	2,500	93	0.26
	Total	-	-	10,575	28.97

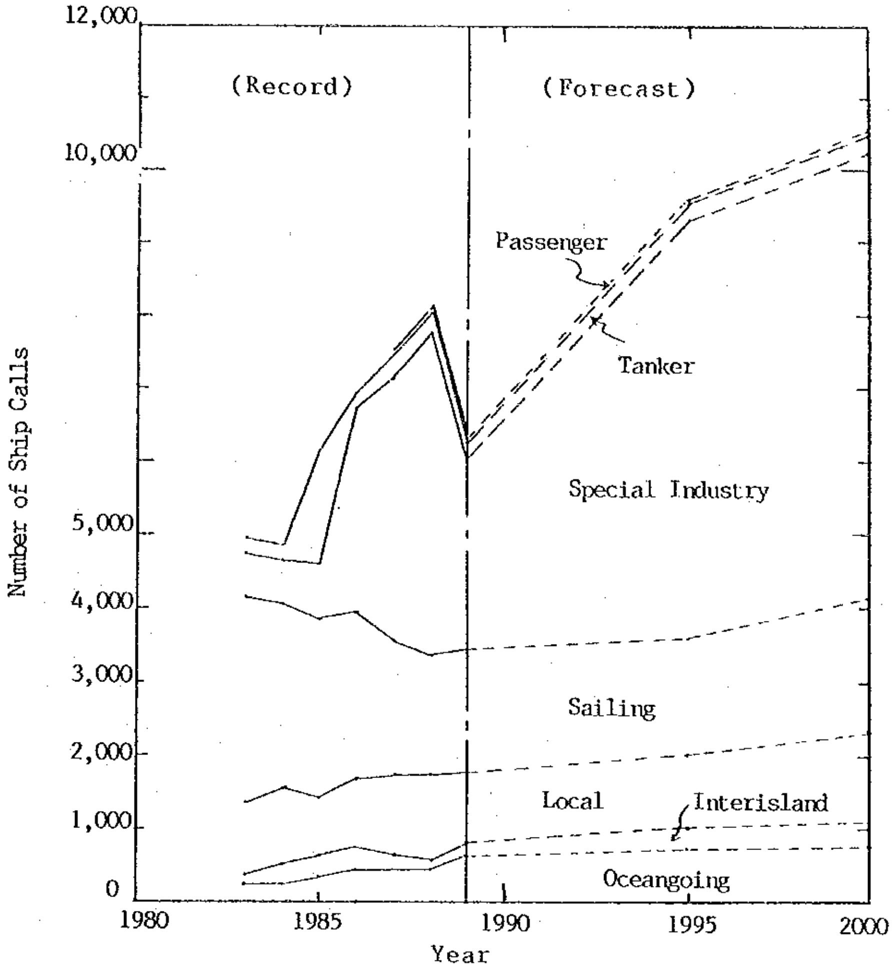


Fig. III.1.3-2 Forecast of the Number of Ship Calls

1-3-4 Some Discussions on Future Vessel Traffic

(1) Containerization

If we assume the following containerization factors in 2000:

Plywood : 50% (Exp), 10% (Out);

Sawn Timber : 30% (Exp), 10% (Out);

Moulding and Dowels : 100% (Exp);

Rubber : 80% (Exp), 10% (Out);

Rattan Carpets : 100% (Out);

Frozen Shrimp : 80% (Exp);

Chemicals : 100% (Imp), 30% (Inw), 5% (Out);

Machines and Spare parts : 100% (Imp);

Food/Drinks : 30% (Inw);

Tobacco/Cigarette : 80% (Inw);
Construction materials : 60% (Inw); and
Others : 20% (Exp), 10% (Out) 90% (Imp), 30% (Inw);

Containerized cargo volume would be approximately 100 thousand TEU for loading and 400 thousand TEU for unloading, except for empty boxes. This is equivalent to 380 voyages per year for a full container ship with a capacity of 230 TEU (6,000 to 10,000 GRT class with a breadth of 20 m and draft of about 8 m).

Development of such containerization has the possibility of being realized given some conditions, such as the existence of specialized container berths and equipment, their efficient operations, a well-maintained channel, and political measures for conventional ships to be replaced, all of which are not easily fulfilled. Hence, the above forecast does not expect such a large-scale containerization, but a limited one, which keeps primarily to the present shipping system.

(2) Coal Barge Traffic

A big project to exploit coal mines near Tanjung in upper South Kalimantan is being carried out. According to the plan of the coal company, barge transport from Kelanis at the middle Barito River to the coal terminal at Pulau Laut will take place with a frequency of 200 to 400 voyages per year (assuming 5,000 to 15,000 DWT barges) by 1993/1994.

If this plan is materialized, the barge traffic become additional one beside the above forecast.

(3) Log Import

As already discussed in 1-2-2(1), the possibility of log imports in the future is disregarded here. If they were to happen, their traffic is purely additional to the above forecast.

(4) Sailing Vessels

According to DGSC's register, in all Indonesia, the number of PL has decreased by about 30% since 1981 until 1987, whereas the number of PLM and KM increased at almost the same rate. In the KANWIL V region where Banjarmasin is included, the number of PLs fell to less than half and the number of PLM more than doubled during the same period. Hence, these small boats can be expected to survive beyond 2000, except possibly for PLs.

(5) Capacity of the Access Channel

It is forecast in Table III.1.3-1 that, in 2000, 29 ships will arrive at Banjarmasin every day. The question is whether the capacity of the access channel is sufficient or not.

Table III.1.3-2 shows the result of the physical capacity analysis. If a minimum sea level of DL+2.0 m and all-day operation is maintained, 70 ships, or 35 ships for each direction, will be able to utilize the one line channel in case B, which is enough to meet the demand.

Table III.1.3-2 Capacity of One Lane Channel

(Channel Length L = 14,300m)

Ship speed (kt)	Length Overall (m)	Sea Level (DL+)	Daytime operation		All-day operation	
			Navigable hours/day	Capacity (Ships/day)	Navigable hours/day	Capacity (Ships/day)
Case - A 5 (Tag and Barge)	100	2.5m 2.0 1.5 1.0	0.5 3.4 7.8 11.2	0 7 77 132	2.3 7.7 16.7 22.1	0 75 221 309
Case - B 7 (6,000 GRT vessels)	130	2.5 2.0 1.5 1.0	0.5 3.4 7.8 11.2	0 16 71 114	2.3 7.7 16.7 22.1	2 70 182 250
Case - C 10 (Passenger Ship)	100	2.5 2.0 1.5 1.0	0.5 3.4 7.8 11.2	0 44 146 255	2.3 7.7 16.7 22.1	19 144 352 477

1-4 Requirements of Channel Dimensions

1-4-1 Principles of the Alignment of the Channel

(1) Small Siltation

Taking account of the past experience and investments, the present alignment shall be considered to be the primary plan. Alternative alignments, however, will also be discussed as far as they have a chance of reducing the siltation rate considerably.

(2) Safety Navigation

The line of the long and narrow channel shall be straight in principle from the viewpoint of navigation safety. The depth and width of the channel should be as small as possible in order to decrease the siltation volume within the limit of navigational safety.

1-4-2 Number of Lanes and Navigation Time

(1) Number of Lanes

The number of lanes will be one, considering the result of the future vessel traffic forecast (Table III.1.3-1), the assessment of channel capacity (Table III.1.3-2), and the need to minimize maintenance dredging.

(2) Night Navigation

Navigation in the channel shall be allowed not only in the daytime but also at night, provided that appropriate measures are taken to improve navigation safety.

1-4-3 Design Ship and Consignment Volume

(1) Design Ship

Currently, the maximum ship size is 16,000 DWT for general cargo ships and 55,000 DWT for bulk carriers. The majority of the bulk carriers are over 17,000 DWT. A summary of the size of presently calling ships is presented in Table III.1.4-1 for these two ship sizes. Container ships are another important ship type to be discussed for the future.

Currently, the national container fleet in Indonesia consists of 27 ships of which 74% are more than 12,000 DWT, which is presented in Table III.1.4-2 and their particulars in Fig. A III.1.4-1. The ship size suitable to Banjarmasin might be less than 10,000 DWT.

Thus,the appropriate design ship may be a general cargo ship with a size of 10,000 DWT which can cover 86.5% of all general cargo ships presently commissioned on the Banjarmasin route. It also covers 6,400 GRT container ships.

(2) Consignment Volume

As Banjarmasin Port may be the last port of call, full load of design ship should be considered for the purpose of planning the channel.

1-4-4 Depth of the Channel

(1) Definition of the Sea Bottom

The result of the site survey shows that the bottom of fluid mud layer of $\gamma t = 1.30\ t/m^3$ after KIRBY and PARKER (1974) is very close to the nautical bottom of $\gamma t = 1.22\ t/m^3$ on the average derived after KERCHAERT ET AL, (1985). The nautical bottom can be considered as the bottom of the channel.

(2) Design Depth of the Channel

An appropriate design depth of the channel is considered to be DL -6.0 m, taking account of the additional tidal level of + 2.0 m for the design ship of 10,000 DWT class general cargo vessels, which has a maximum draft of 7.7 m, and net underkeel clearance of 0.3 m for moderate swell conditions and soft sea bed.

An alternative depth of DL -8.0 m will also be considered to secure high coverage of general cargo ships of about 97% and 10,000 GRT class container ships.

Table III.1.4-1 Size and Coverage of General Cargo Ships and Bulk Carriers in Banjarmasin

Type of Ships	GRT (tons)	DWT (tons)	dmax (m)	Coverage (%)	Required water depth (m)*	Remarks
General Cargo Ships	6,500	10,000	7.8	86.5	6.0	* Taking account of + 2m tidal level
	7,500	12,000	8.2	90.5	6.5	
	11,000	18,000	9.6	97.1	8.0	
	16,000	20,000	10.4	100	9.0	
Bulk Carriers	5,000	8,500	5.0	2.1	3.5	
	10,000	17,000	9.2	2.1	7.5	
	11,000	19,000	9.6	5.0	8.0	
	15,000	27,500	10.7	27.1	9.0	
	20,000 (28,000)	38,000 (47,000)	11.6 (11.6)	69.3 (97.1)	10.0 (10.0)	
	31,000	52,000	12.1	100	11.0	

Table III.1.4-2 Size and Coverge of Container Ship in Indonesia

Type of Ships	GRT (tons)	DWT (tons)	dmax (m)	Coverage (%)	Required water depth (m)*	Remarks
Container Ships	6,400	10,700	7.7	22.2	6.0	
	8,100	15,300	8.2	33.3	6.5	
	10,000	16,000	9.7	59.3	8.0	
	16,000	21,000	10.0	100.0	8.5	

1-4-5 Width of the Channel

According to the Technical Standards for Port and Harbour Facilities in Japan, the minimum width of a one lane channel with ordinary length and under moderate sea conditions shall be more than L/2, where L is the length of the design ship. PIANC has a provision of 5 Bext, where Bext is the extreme breadth of the design ship. As the design general cargo ships have a length of about 130 m and breadth of about 20 m, the channel width shall be no less than 65 to 100 m.

In considering the long distance of the channel, current conditions (surface speed of 1.5 m/sec with an angle of 30 degrees was recorded at Spot No.13,000 on 1 October 1988), the possible drift of barges pulled by tug boats (Fig. III.1.4-1), etc., a width of 100 m is required as the design width. This design condition coincides with the proposals by most of the present channel users.

1-4-6 Slope of the Channel

The slope of the channel shall be decided taking principally into account the slump angle of seabed soils, or the strength of seabed materials within the limits of a stable gradient under the action of current, waves, etc.

The past records of cross - sectional soundings indicated a tendency of stable slope of 1/10 or gentler two to three months after dredging. Another example is a sounding done just after the Semi-capital Dredging (Fig. III.1.4-2) of which the target dredging slope was 1/8. This sounding shows that the average slopes between Spot No.2,000 and 6,000 are around 1/10 and between, No.7,000 to 10,000 around 1/9 to 1/8.

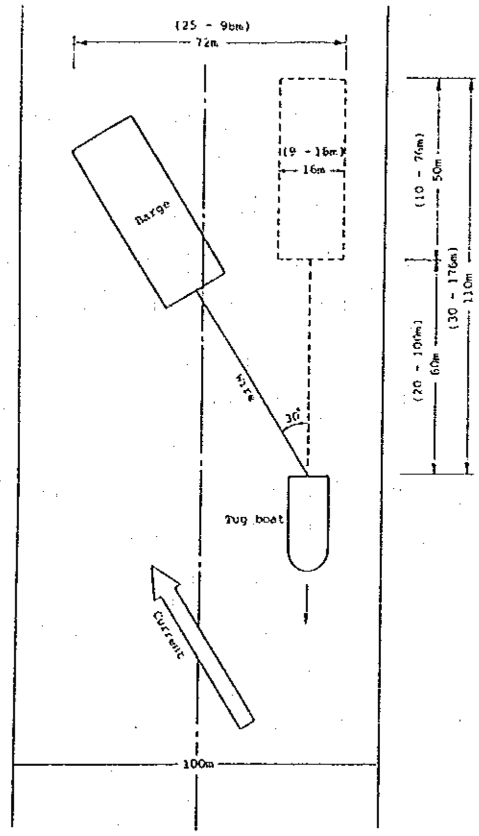
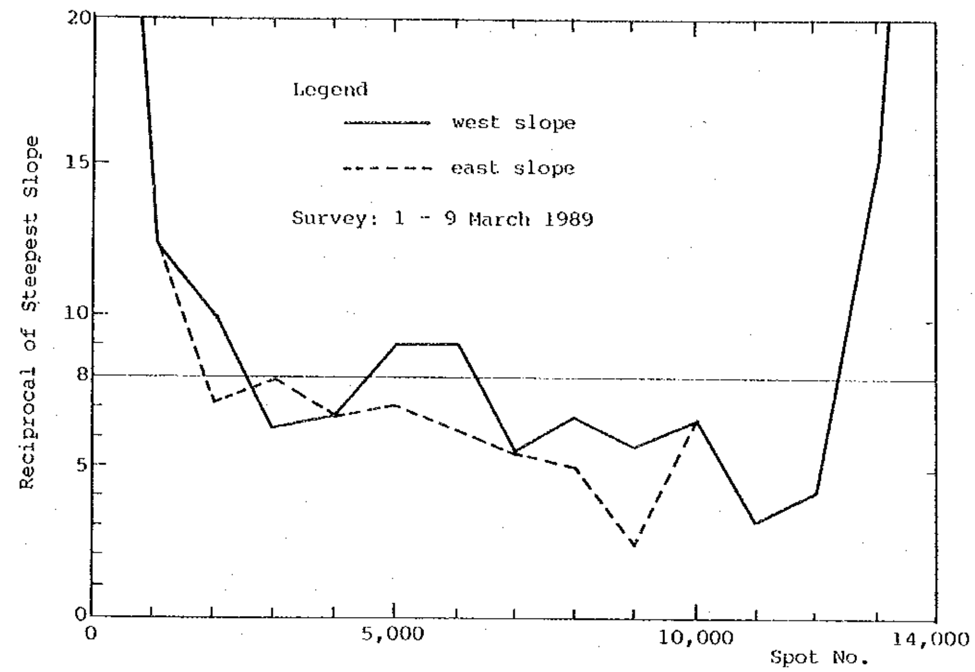


Fig. III.1.4-1 Effect of Current on Drift of Barges

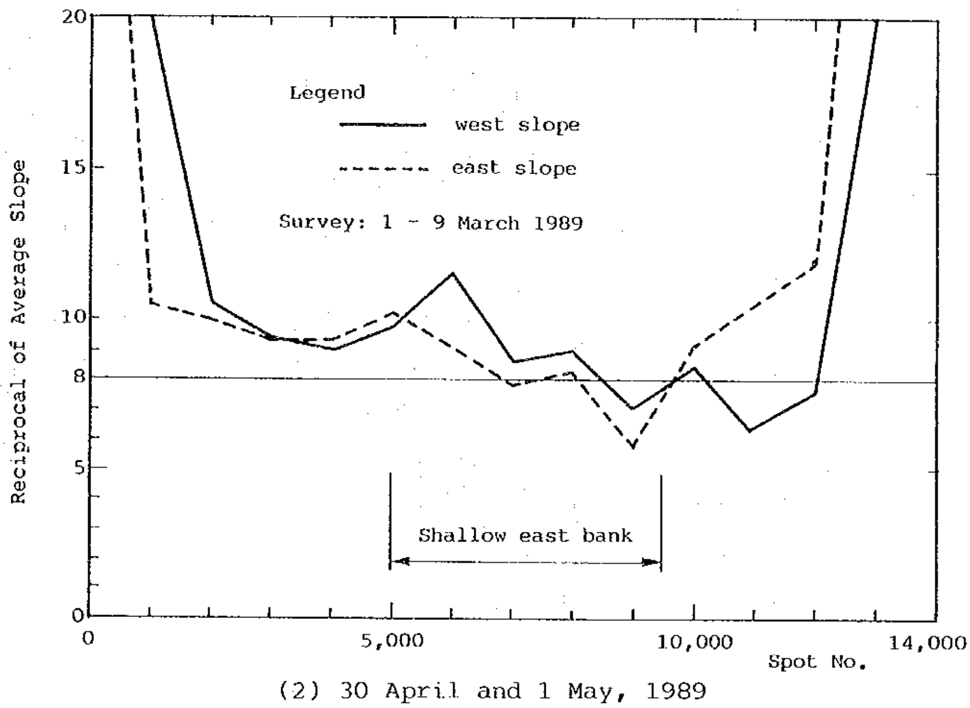
Thus, taking the slumping of the shoulders by currents and waves into consideration, a slope of 1/10 is selected to be the primary slope for the channel planning. A slope of 1/8 can be used locally, if conditions allow it.

1-4-7 Turning Basin in the Channel

In planning the channel alignment, one or two turning basins are expected to be arranged in the channel specifically for improving dredging efficiency.



(1) 11 to 12 October, 1988



(2) 30 April and 1 May, 1989

Fig. III.1.4-2 Slope of Channel Sides just after Semi-capital Dredging

Chapter 2 Alternative Siltation Reduction Plans

2-1 Siltation Phenomena and Causes

(1) Sedimentation due to Saline Wedge

The existence of a saline wedge was confirmed by the field survey. One of the distribution patterns in the channel is shown in Fig. III.2.1-1. It is also observed that there is a very thin, soft and widely spread layer of yellow brown color on the bank.

The saline wedge and broad coverage of the fluid muds on the bottom strongly suggest that flocculation and sedimentation of suspended solids occurs in the river and on the bank. During the rainy season the sediment supply from the river can be 300 kg/sec (density : 60 ppm), as shown in Fig. III.2.1-2, which is equivalent to 788,000 tons per month and can possibly settle on the bank.

(2) Shallow Spit on the West Bank and Dam in the Channel

One of the most prominent phenomena in the channel is the formation of a submerged dam at around Spot No.12,300. This is apparently due to direct/indirect effects of the sandspit on the west bank. There are two saddles of contours in this area. One, at Spot No.11,300, is larger than that at No.12,300. The latter is, however, what has frequently blocked the channel. This could be the result partly of direct intrusion of the sandspit and partly of sedimentation of the larger particles that are scoured at the bottom and side slope of the upper part of the sandspit, judging from the cross sections of the channel, particle size distribution, locus of floats and other evidence.

(3) Erosion by Current

By closely checking the cross section, we find stable seabed areas upstream from Spot No.12,500 and downstream east slope of the channel from No.14,000 until No.11,000. The area are sometimes eroded. This seems to be the effect of strong and sustained downstream cross currents during ebb tide.

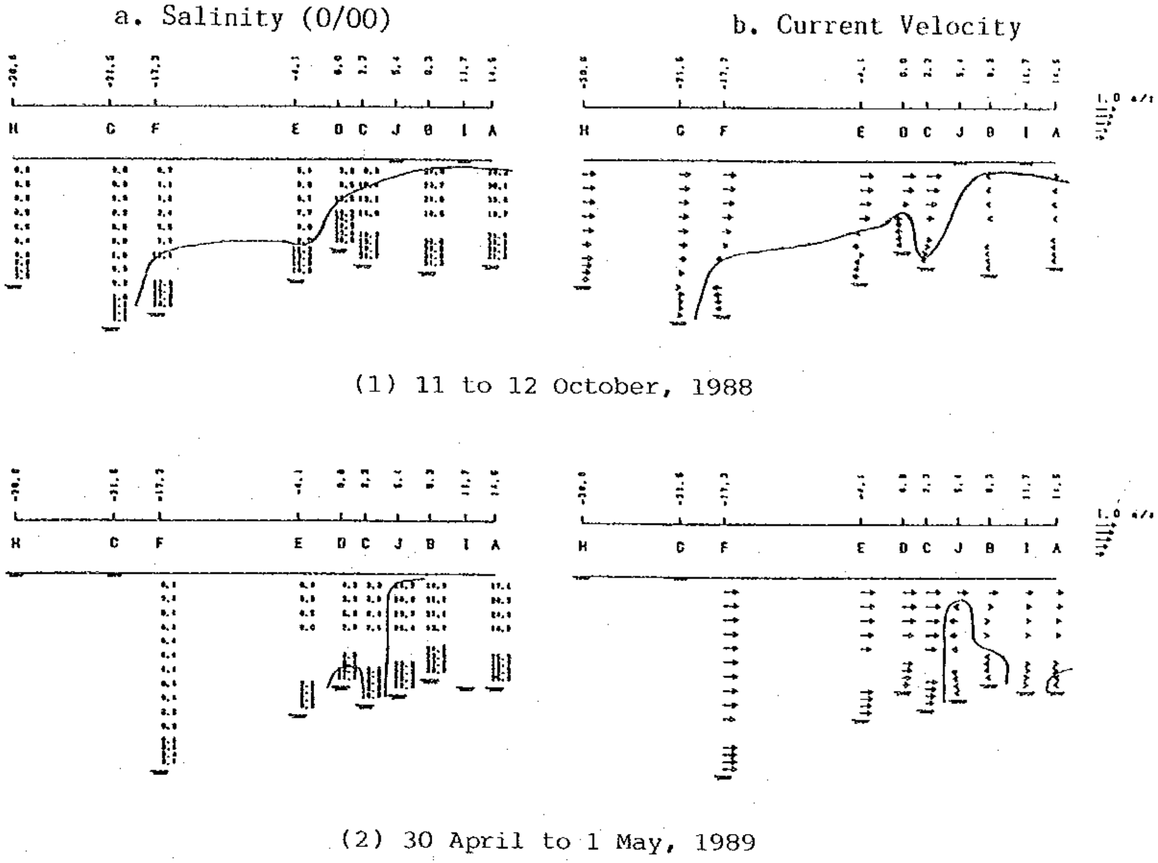


Fig. III.2.1-1 Average Salinity and Average Current

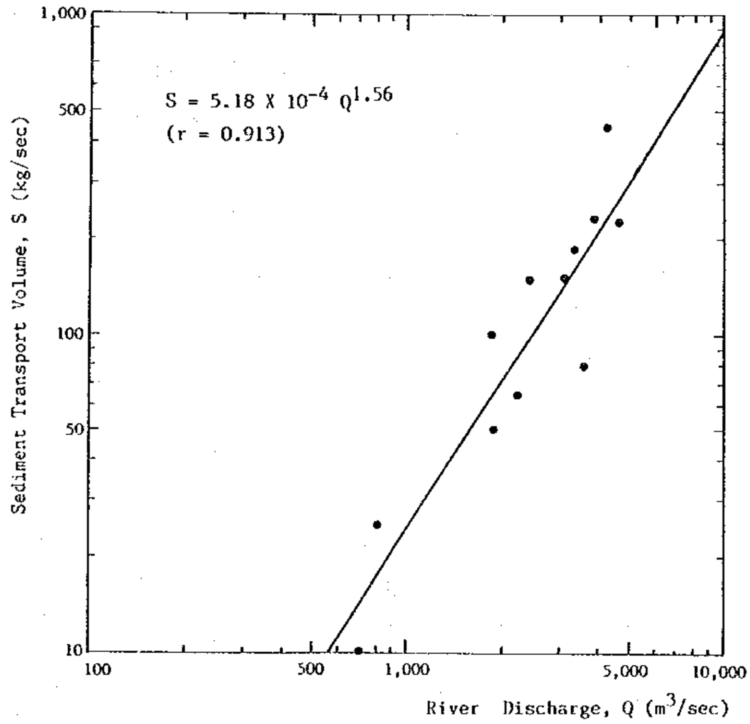


Fig. III.2.1-2 Observed River Discharge and Sediment Transport Volume (Sept. 1988 - Aug. 1989)

(4) Siltation at the Central Portion of the Channel

Between Spot Nos.4,000 and 10,000, the largest siltation occurs in the channel. One of the most significant characteristics is that the sedimentation is normally accompanied by the formation of fluid mud in the channel. The reason for the above phenomena could be explained by the following three phenomena:

a. Siltation of suspended loads and bedloads caused by waves and currents.
b. Siltation of re-suspended solids from both sides of the channel due to the action of tidal current, agitation by waves, current caused by waves and their breaking (radiation stress), etc.
c. Direct flowing in of the fluid mud on the bar due to the action of currents and gravity.

(5) Scouring and Slumping by Waves

By detailed investigation of the changes in past cross sections, we cannot deny the possibility of scouring and slumping of both slopes and sides of the channel on some occasions. These most suspected are Spot Nos.1,000 to 2,100 and 2,600 to 4,000 on the east side; and 1,000 to 2,100 and 3,000 to 4,000 on the west side.

The scouring and slumping result in eventually the overall siltation even in these areas.

(6) Gentle Siltation

The area offshore from No.2,000 is deeper and suffers from rather steady siltation. Both sides of the channel have almost even depth. Disregarding the fluid mud, the bottom has a stable depth and its longitudinal slope is 1/1,000 to 1/1,300.

Siltation in this area might be due to the following phenomena:

a. Sedimentation of particles from both sides of the channel due to moderate current,

b. Effect of erosion and slumping of the above (5),

c. Flowing down of fluid mud from the upstream channel, and

d. others.

In summary, the above characteristics of siltation are presented in Fig.III.2.1-3.

Lastly, an important feature which should not be disregarded is the long-term coastal process, i.e., the formation of the shallow coastline and spits on the west of the river mouth. This might be due to the settling of sediments directly flowing from the river, the large clock-wise movement of sediments on the bank and the eastward longshore drift of sediments.

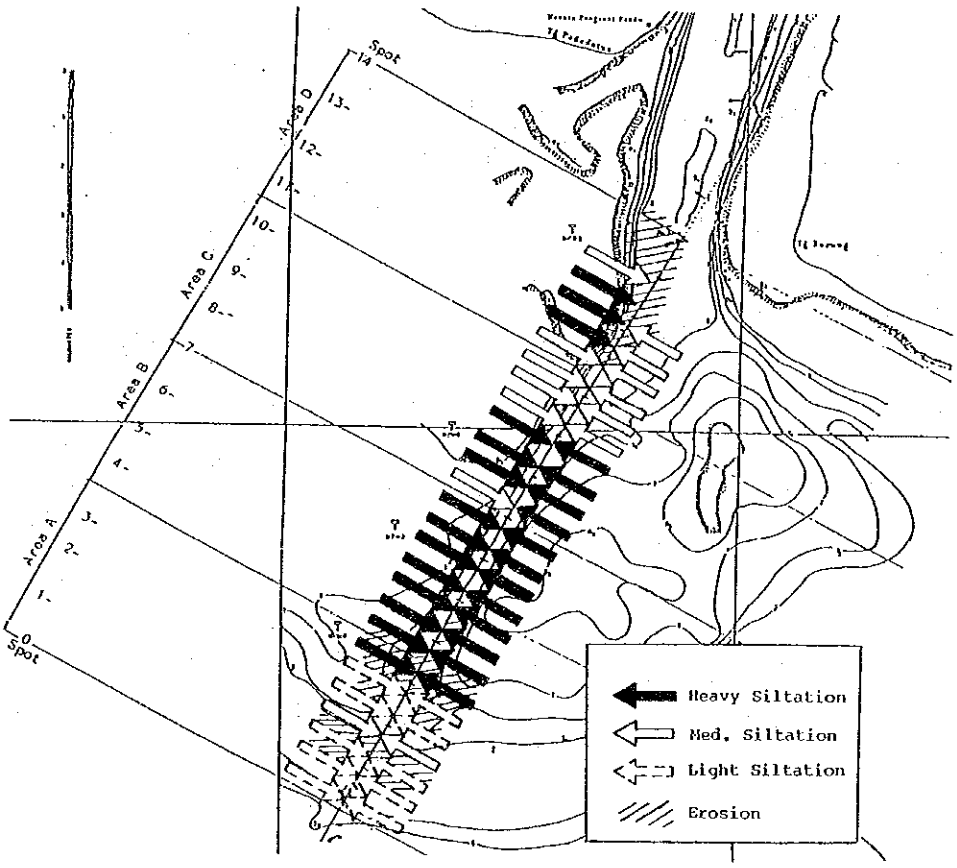


Fig. III.2.1-3 Expected Siltation along the Channel

2-2 Points of Countermeasures

Bearing in mind the above discussions, the major aims and purposes of siltation against anticipated countermeasures can be divided into the following four areas:

A. Prevention of erosion and siltation by ebb current and waves; West bank from Spot Nos.9,000 to 14,000, amongst from Nos.9,900 to 13,000, and both sides from Nos.2,500 to 5,000. It might not be practical or economical, however, to prevent erosion by waves through artificial means,

B. Prevention of erosion and small-scale siltation: East bank from No.9,500 to 10,000,

C. Prevention of large-scale siltation: West bank from No.5,000 to 9,000 and east bank from No.5,000 to 9,500, and

D. Prevention of small-scale siltation: Both sides from Nos.0 to 2,500,

E. Prevention of longshore sediment movement off the west coast.

It should be noted that the division of the above aims and Spot numbers is rather simplified and not definite, which will be scrutinized later by means of the hydraulic model tests and numerical simulations.

2-3 Alternative Plans for the Present Channel

In considering the results of the above analyses, the following are selected as probable countermeasure plans to reduce siltation for the present alignment of the Banjarmasin channel. It should be noted that the abbreviations of HM and NM to be used below are referred to as Hydraulic Model tests and Numerical Model simulations respectively.

2-3-1 Present Condition (HM: Case C, NM: Case I)

As the base case, we consider the present channel with a planned water depth of DL, -6 m and a width of 40 m (HM) and 60 m (NM) without any facility. The actual U-shaped cross-section such as that in April 1989 may constitute this condition. (Fig. III.2.3-1).

2-3-2 No Facility Plans

(1) Principal Plan (HM: Case D-1, NM: Case II)
This is the principal case based on the channel planning with a water depth of DL -6 m and width of 100 m. The cross section is trapezoidal in shape. (Fig. III.2.3-2)

(2) Enlargement Plan (NM: Case IX)
Based on the channel planning, the depth and width will be enlarged up to -8 m and 120 m respectively (Fig. III.2.3-2).

(3) Trap Plan (HM: Case D-8, NM: Case VIII)
As a large influence is expected from the west bank, a trap zone or an expansion of the channel width from 100 m to about 170 m is considered in this case. The widened area could form a berm, if the main channel is overdredged for maintenance purpose, or if the berm is dredged with a minimum depth for dredging, e.g. DL -5.5 m. (Fig. III.2.3-3)

2-3-3 Training Wall Plans

(1) Short Training Wall Plan (HM: Case D-7)
To prevent the direct intrusion of the sandspit on the west bank and sedimentation of eroded bed material, a structure such as a training wall and branch walls on the west side of the channel might be effective. This is expected to have an effect on stopping the formation of the dam around Spot No.12,300. But it might accompany a change of coastal process in the area and might result in unforeseen phenomena. (Fig. III.2.3-4)

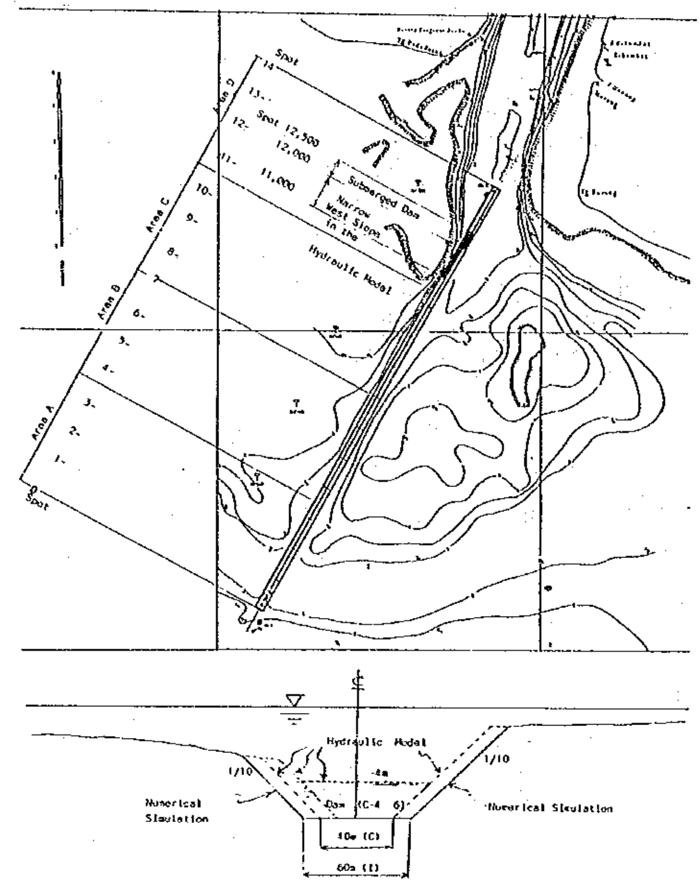


Fig. III.2.3-1
Present Condition
(Hydraulic Model C
Numerical Simulation I)

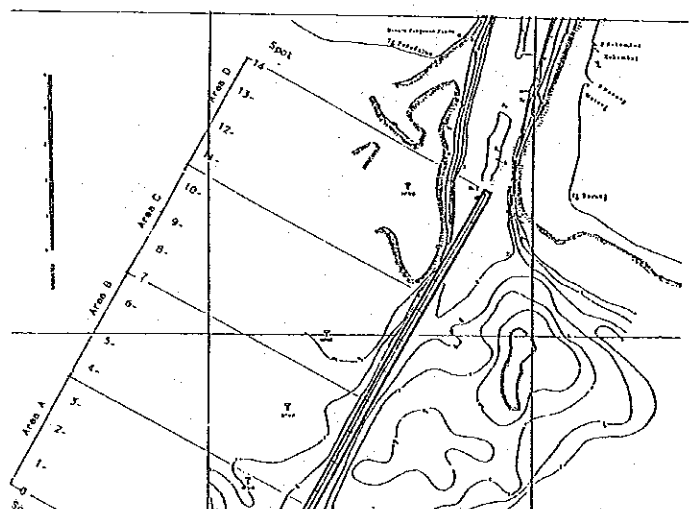


Fig. III.2.3-2
Principal Plan
(Hydraulic Model D-1
Numerical Simulation II)
and
Expansion Plan
(Numerical Simulation IX)

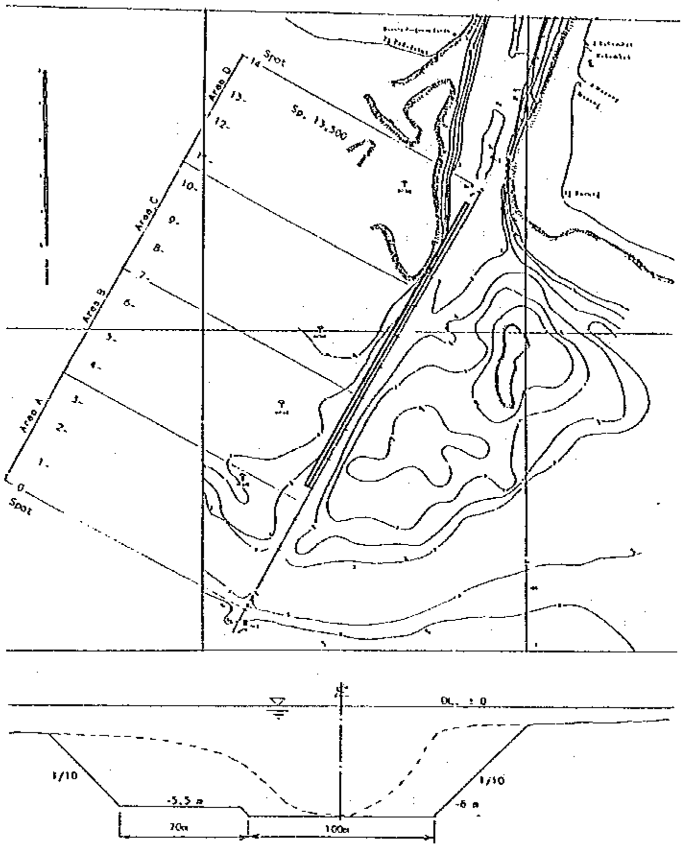


Fig. III.2.3-3
Trap
(Hydraulic Model D-8
Numerical Simulation VIII)

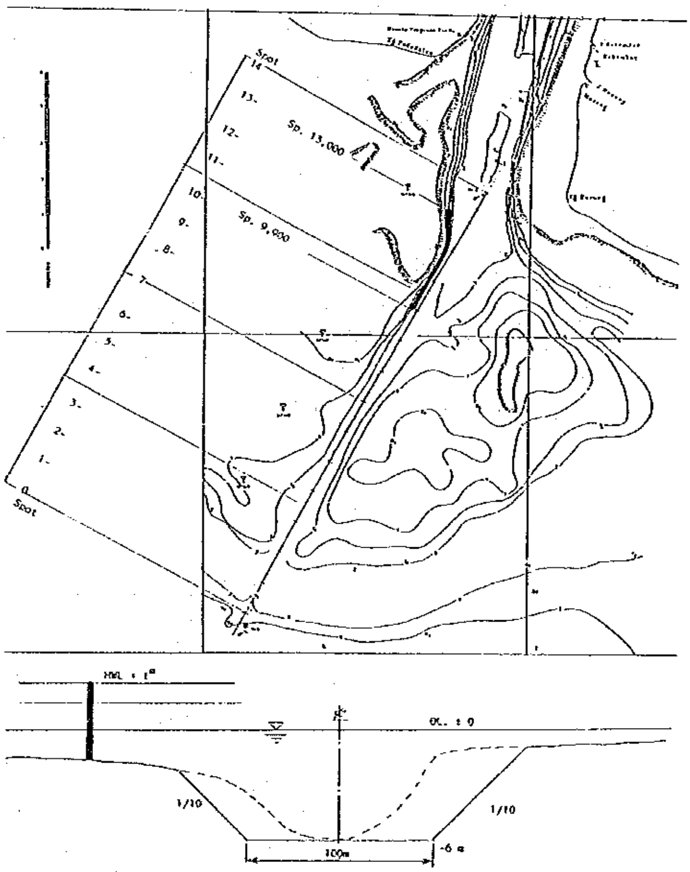


Fig. III.2.3-4
Training Wall
(Hydraulic Model D-7)

(2) Extended Training Wall Plan

This case is the extension of the training wall to cover the east face of the whole sandspit. The upper extended portion could be a submerged training wall, taking into consideration its effect on the total coastal process.

2-3-4 Long Jetty Plan (HM: Case D-2)

To prevent longshore sediment movement, a long jetty with a length of about 6 km could be planned originated from the corner of the west bank at the river mouth. (Fig. III.2.3-5)

2-3-5 Submerged Wall Plans

(1) Short Submerged Wall Plan (HM: Case D-4 and D-5, NM: Case III)

This is to prevent major siltation in the central portion of the channel (Spot No. 3,000 - 9,000) by means of submerged walls with a height of 1 m or 2 m on both sides of the channel. (Fig. III.2.3-6)

(2) Extended Submerged Wall Plan (HM: Case D-3, NM: Case IV)

The above submerged walls are extended both upstream and downstream (Spot Nos.2,000 - 10,500) to cover a larger central area of the channel. (Fig. III.2.3-6)

(3) Long Submerged Wall Plan (NM: Case V, VI and XI)

Long submerged walls with a height of 1 m or 1.5 m above the seabed cover most of the channel length (Spot No.2,000 to 13,000).

In the case of 100 m channel width, distance between walls is 210 m (Case VI') or 270 m (Case V and VI). (Fig. III.2.3-7)

In the case of 60 m channel width (Case XI), the distance between walls is set to be 180 m and height to be 1.5 m. (Fig. III.2.3-8)

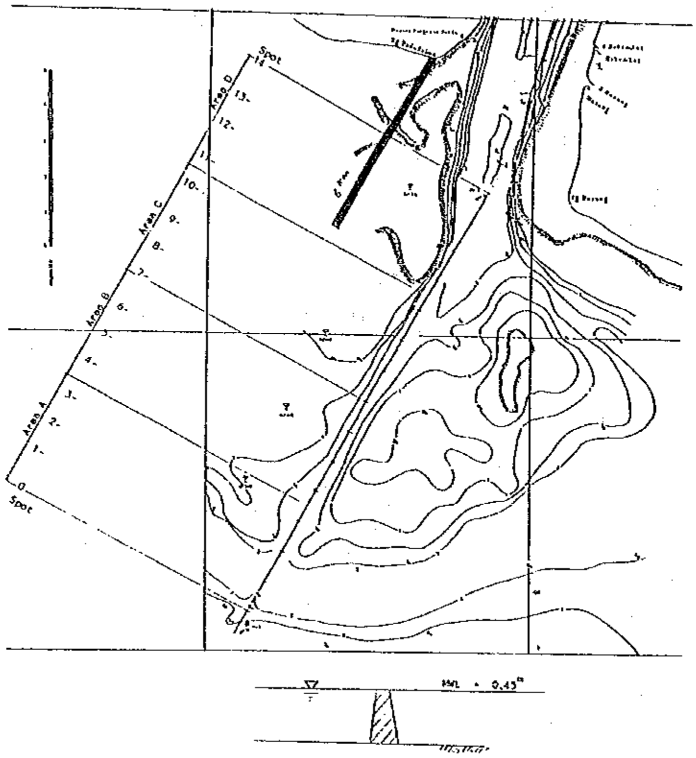


Fig. III.2.3-5
Long Jetty
(Hydraulic Model D-2)

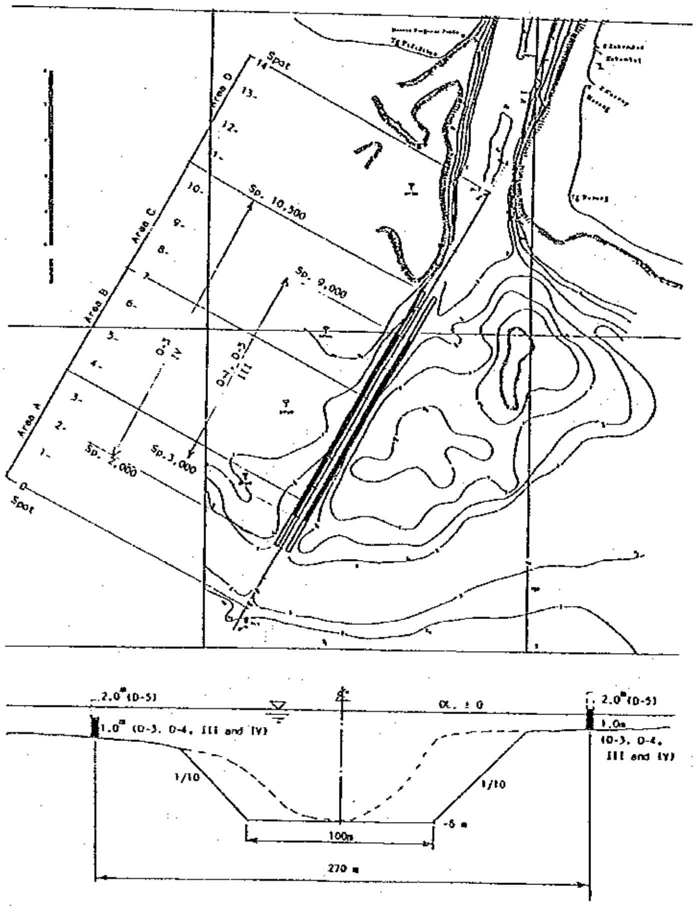


Fig. III.2.3-6
Short and Extended
Submerged Walls
(Hydraulic Model D-3, D-4 and D-5
Numerical Simulation III and IV)

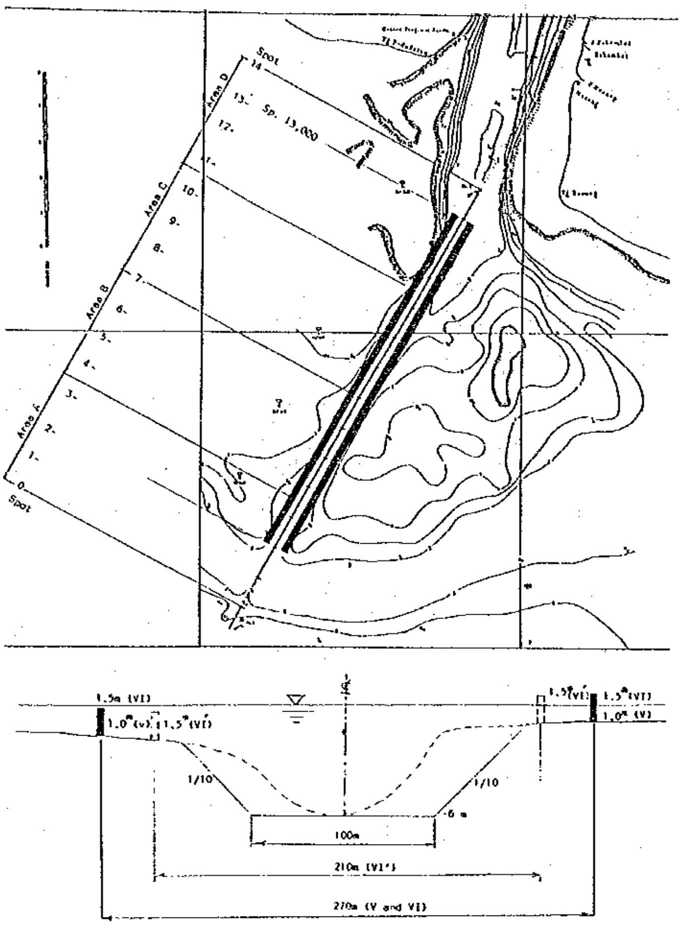


Fig. III.2.3-7
Long Submerged Walls
(Numerical Simulation V and VI)

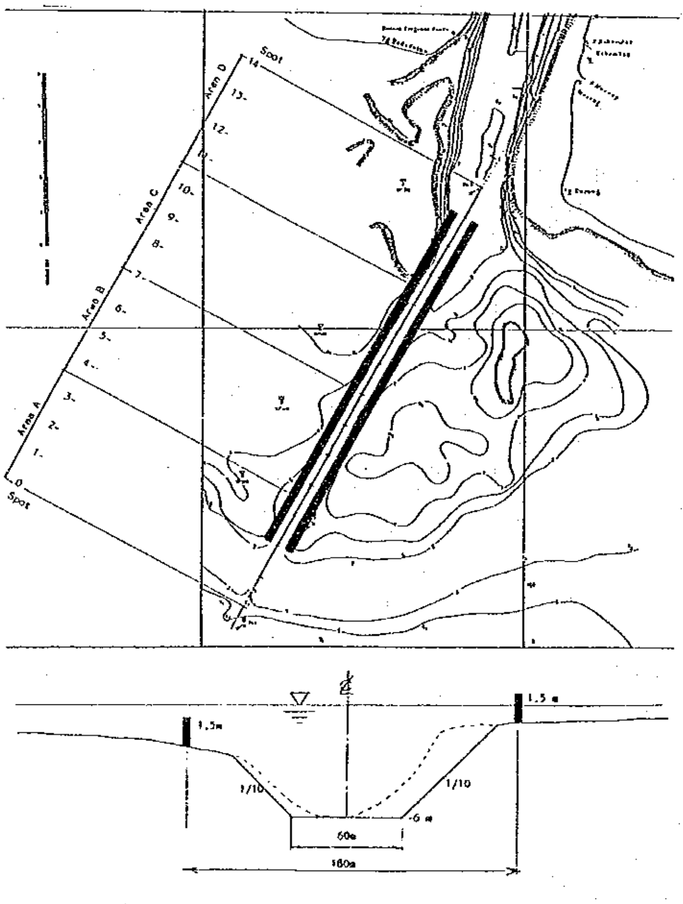


Fig. III.2.3-8
Present Condition + Submerged Walls
(Numerical Simulation XI)

(4) Non-continuous Submerged Wall Plan (HM: Case D-11, NM: Case XII)
The central portion of the Long Submerged Wall Plan is removed. (Fig. III.2.3-9)

(5) Submerged Walls' Stage Plan (HM: Case F-1 and F-2)
Either eastern wall or both eastern and western walls of the upstream portion of the Non-continuous Submerged Wall Plan is removed to represent under-construction stages. (Fig. III.2.3-10)

2-3-6 Comprehensive Protection Plan

(1) Training Wall and Submerged Wall Plan (NM: Case VII)
This is a combination of the above corresponding cases. (Fig. III.2.3-11)

(2) Long Jetty and Submerged Wall Plan (HM: Case D-6)
Long Jetty and Submerged Walls are combined in this case. (Fig. III.2.3-12)

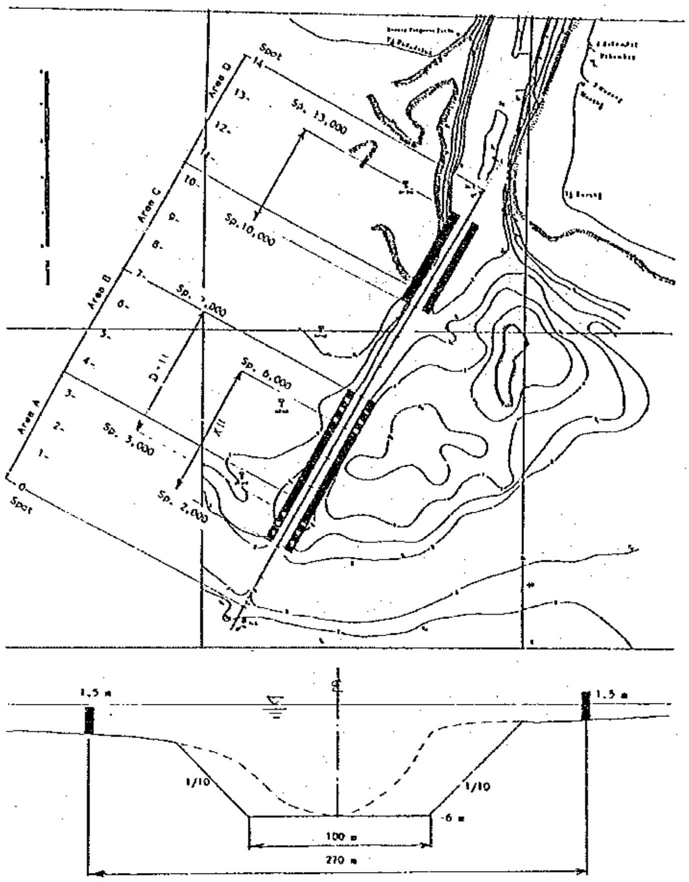


Fig. III.2.3-9
Non-continuous Submerged Walls
(Hydraulic Model D-11
Numerical Simulation XII)

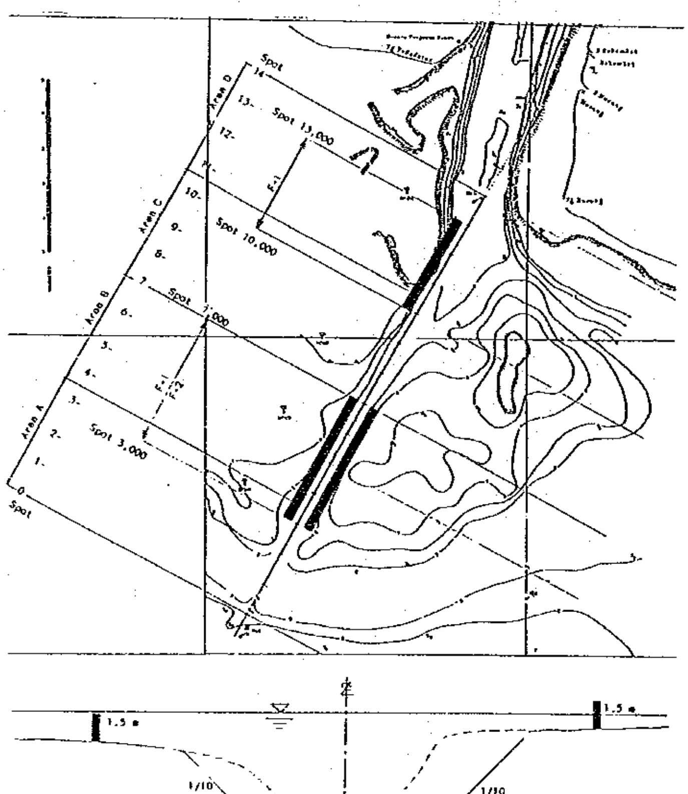


Fig. III.2.3-10
Submerged Wall's Stage Plans
(Hydraulic Model F-1
and F-2)

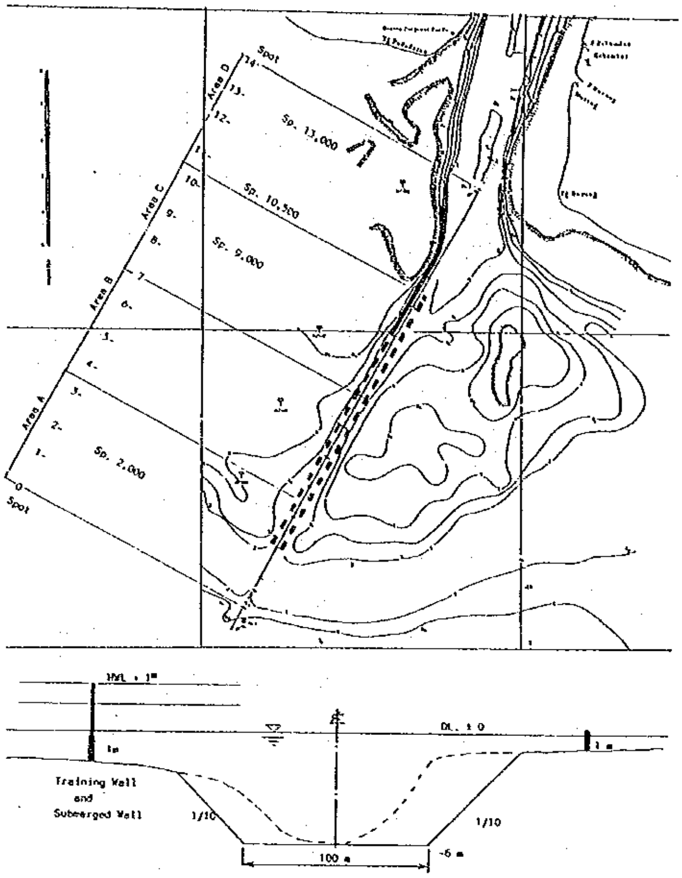


Fig. III.2.3-11
Training Wall +
Submerged Walls
(Numerical Simulation VII)

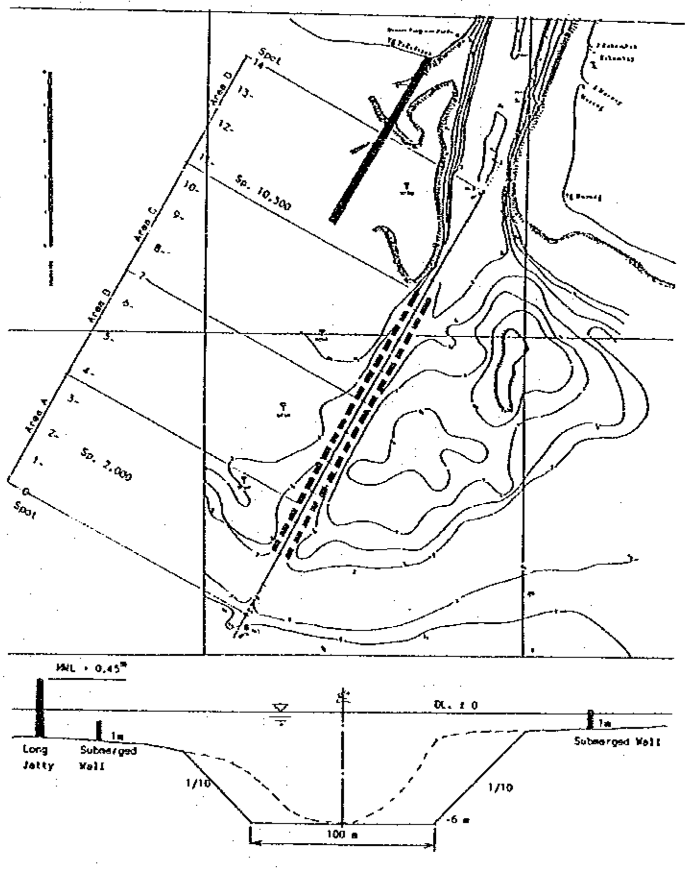


Fig. III.2.3-12
Long Jetty + Submerged
Walls
(Hydraulic Model D-6)

2-4 Relocation Plans of the Access Channel

A channel, in general terms, should be oriented in a direction parallel to that of strong currents in order to secure bed shear and safer navigation. In the case of the Banjarmasin Channel, the eastern half of the east bank has a flow pattern of this kind, as Fig. III.2.4-1 shows. The diamond marks in the figure indicate the main axis of the current.

Thus, although the water depth in the area is partly very shallow, it might be possible to select some alternative locations, such as the following two cases, as representative plans.

(1) New N-S Alignment (HM: Case D-9, NM: Case X)
A new channel with a depth of DL -6 m and a width of 100 m will be oriented to the south or to the direction of 29 degrees at the bend without any facility. (Fig. III.2.4-2)

(2) New SSE Alignment (HM: Case D-10)
The direction will be further turned by 48 degrees to orient the channel approximately SSE direction without any facility. (Fig. III.2.4-2)

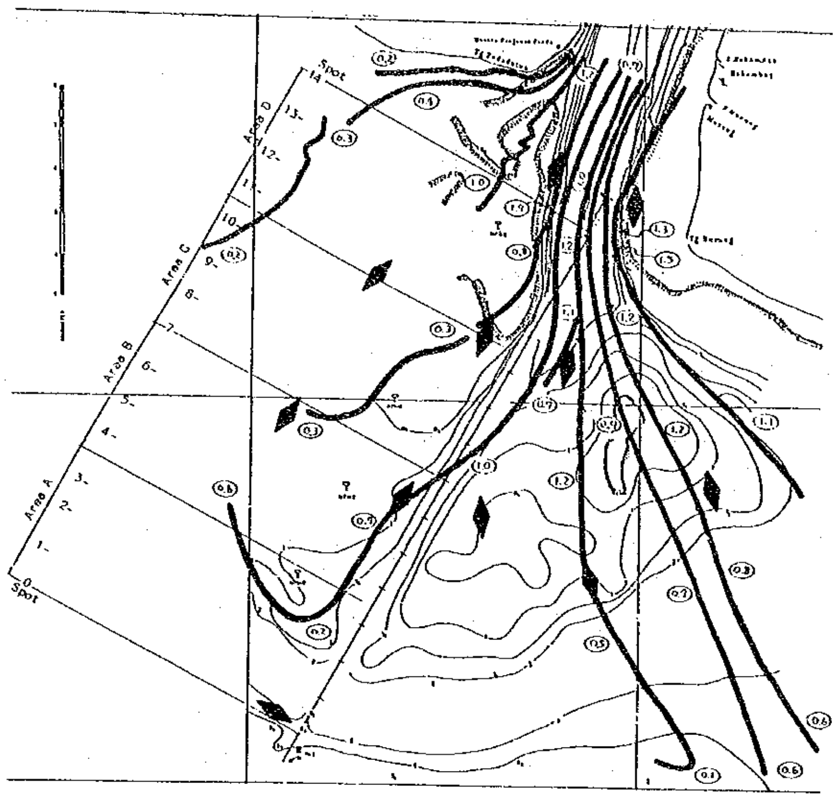


Fig. III.2.4-1 Loci of Ebb Current (30 Sept. - 2 Oct. 1988)

Notes: Diamond mark ; Main axis of currents

Number in circle ; Surface current speed (m/sec)

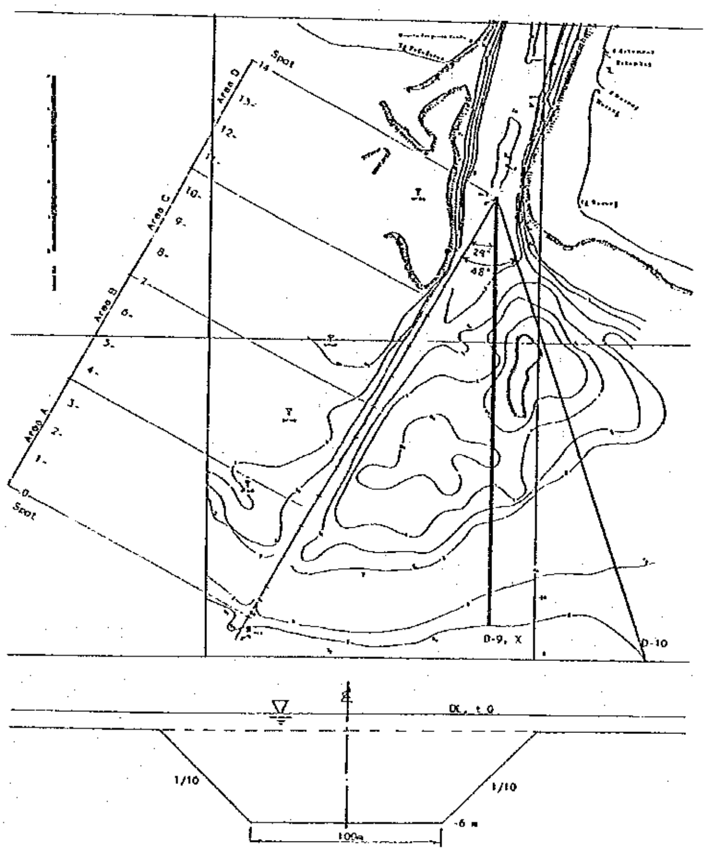


Fig. III.2.4-2

New Alignment

(Hydraulic Model D-9 and D-10

Numerical Simulation X)

Chapter 3 Improvement of Navigational Safety and Countermeasures for Navigational Aids

3-1 Improvement of Navigational Safety

3-1-1 Navigational Problems of the Existing Access Channel

(1) Navigational Problems

Navigational problems in the existing access channel can be broadly classified into 4 categories as follows:

1) mixed traffic of ocean-going vessels and small vessels
2) poor maneuverability for tugs and barges
3) rather strong cross currents
4) insufficient width and depth of the access channel

All of these factors are assumed to be interrelated to some extent, and insufficient maintenance of the access channel can be undoubtedly recognized as a major navigational problem.

- Mixed traffic of ocean-going vessels and smaller vessels

  Mixed traffic consisting of a wide variety of ship types and sizes is inevitable based upon the fact that Banjarmasin Port imports various kind of cargoes by ocean-going vessels, interisland vessels, local vessels, tankers, sailing vessels and specialized vessels.

  A large number of barges, Rakyat and Lokal, are utilized as advantageous means of transport and this situation is envisaged to continue in the foreseeable future.

  Generally, slow-moving tugs and barges in a long tow do not allow ocean-going vessels to pass or overtake them safely when they navigate with the cross currents which exist in almost the full width of the channel.

- Poor maneuverability of tugs and barges

  Tugs and barges, Lokal and Rakyat have and will play an important role in cargo transportation because of their shallow draft and low transportation cost.

This transportation system can be considered as one of the most economical and practical solutions suitable to the transport circumstances specific to Banjarmasin Port.
Tugs and barges carrying cargo to/from the port or the sea use the existing access channel where unfavorable cross currents exist. The access channel is narrower than that in the Barito River.

- Insufficient Channel Dimensions

From observation trips aboard vessels and discussion with users (pilots and masters of vessels), from studying comparable models and from comparison with other navigation channels, the Banjarmasin access channel is certainly too narrow.
Such a narrow and insufficient maintenance channel may result in poor maneuverability of large ships and there may ultimately be collisions, groundings, etc., involving small ships. The existing access channel is even narrower and shallower than the designed one due to insufficient maintenance dredging.

3-1-2 Improvement of Navigational Safety

From the viewpoint of navigational safety the following measures should be carried out in conjunction with each other:

(1) Regular maintenance survey and dredging of the access channel
(2) Necessity of navigational control
(3) Optimum arrangement and maintenance of navigational aids
(4) Communication system
(5) Other Back-up systems

1) Regular maintenance survey and dredging
It is certain that the record of ships transitting the access channel will have a significant impact on the future number of ships using the channel.
2) Virtually all major ports in the world require frequent dredging on a regular basis to accommodate ships engaged in domestic and international commerce.
3) It is not only during the actual transit of the access channel that ships are at risk, but also in the fore and rear approaches to the access channel, where the far approaches are concerned,

navigational aids and ships' position are a great concern of the masters of the ships approaching the entrance of the access channel.

4) The axis line of the access channel should follow the natural streamline of the river as much as possible.

5) Access channel to Banjarmasin Port
According to the results of our field survey, the access channel is not well-maintained through the year.

Dredging should be basically carried out to maintain sufficient depth and width in the port and the access channel to ensure smooth and safe navigation year round, irrespective of tide conditions.
The importance of this cannot be overemphasized, as it directly affects the permissible draft and size of ships sailing in and out of the port, which in turn has enormous bearing on the economics of shipping companies and the port itself.

3-1-3 Upgrading of Navigational Regulations and Controls

The present navigational regulations should be upgraded to ensure greater navigational safety, and a monitoring and navigational control system utilizing radar should be considered.

(1) Radar Control System

A radar control system is a shore-based facility aimed at increasing navigational safety.

Generally a ship is capable of avoiding collision and grounding through its own resources. Nevertheless, sometimes shore-based navigational services are required to assist ships in water areas where there are navigational obstacles such as bars, wrecks in narrow channels and in circumstances where visibility is reduced. Using this system, radar operators on duty will be able to obtain information about inbound and outbound vessels such as speed, course, positions, closest point of approach to other vessels, and so forth. Chart information should also be shown on the radar scope, so radar operators will be able to make sure whether the vessels are proceeding along the buoyed channel.

But any new system will require a large initial investment. Considerable running expenses and safety must also be given top priority. Therefore, it is important to carry out investigations and studies before the introduction of a new system. Judging from current accident reports, most vessels involved in various accidents are local sailing ships and towing barges. These vessels generally have no communication networks. Thus, at this point it seems useless to establish such an expensive new system in the Port of Banjarmasin. According to the analysis of marine accidents following installation of radar control systems in several ports around the world, the number of reported accidents has been reduced to about one-quarter of the level before introduction of the systems.

(2) Port Traffic Signals

The signals have been recommended by the IMO for use in ports which intend to either install new signals or to modernize existing equipment. It is intended that the rules for port traffic signals shall be followed to control traffic movements in ports and port approaches.

However, where no other conflicting rules exist, the appropriate authority may also use them to control ships traffic in other situations; for instance, at locks or movable bridges. In view of the availability of modern technology, only lights are used. The basis of the system is that there are:

- Main messages, which should be displayed through simple signals easy for the mariners to commit to memory.
- Additional information. For instance, for ports with a complex layout, or complicated traffic situations, which can be displayed through the use of auxiliary signals exhibited together with the main ones.

A modern international system of port traffic signals at present is not used at the Port of Banjarmasin, so, there are the same problems as with a radar control system.

(3) Monitoring and Advising by Patrol Boat

Monitoring and advising operations by speed patrol boats is quite useful for the safety of navigation in and around the access channel. It is also important to rehabilitate and maintain patrol boats as an operational condition.

(4) Telecommunications

A telecommunications system is imperative for safe navigation and is effective only when all the vessels are equipped with wireless equipment such as VHF, SSB, etc. So, installation of the above instruments should be required or advised.

(5) Special Rules for Towing Vessels and Fishing Boats

The present navigational regulations and acts are applicable to the navigation in the water area of Banjarmasin Port and the access channel.

But judging from the results of the field survey, the following restrictions on towing and micellaneous vessels should be considered:

- the distance between the bow of the towing vessel and the after-end of the last towboat shall not exceed 100 meters
- the towboats shall not be more than two abreast
- the Harbour Master may, if necessary, strengthen the restrictions outlined in the preceding paragraph
- Sailing vessels shall not sail in a zigzag fashion within the access channel and Banjarmasin Port
- Fishing vessels shall keep out of the way of power driven vessels in the access channel

3-2 Proposed Countermeasures for Navigational Aids

(1) Navigational Aid Requirements

The navigational aids required at a given port vary widely. The aids needed for deep-water ports situated close to the ocean will differ from those for ports with long approach channels or these situated some miles up a river or an estuary. Deep-water ports need major landfall aids of either the visual, acoustic or electronic type, or all three. On the other hand, ports with long channels also require many short-range and minor navigational aids such as buoys, beacons and radar aids.

The requirements in each case must be established by detailed consultation with those using the port. In particular, the views of pilots and masters of vessels conducting trading activities at the port must be taken into account. Other important groups of users may include fishermen and pleasure craft owners. Long-range aids such as Loran C, Decca Navigator, Omega and Satellite are used in special water areas. Short and medium-range navigational aids available fall into 3 categories; visual, acoustic and radio. In the Port of Banjarmasin, traffic is generally rather light, but there is a narrow 14km-long access channel in the outer bar.

(2) Damage to Navigational Aids

According to the report of damage to navigational aids in 1986 and 1987, lights were extinguished more than 115 times (including 11 times for leading lights). Almost all these accidents were caused by insufficient maneuvering of vessels, current, insufficient maintenance of the channel as well as the way allocation and maintenance of the navigational aids were carried out. Most marine accidents likely occured with tugs and barges when sailing out at ebb tide. Due to their generally slow sailing speed, these vessels tend to sail out with the ebb current.

(3) Improvement and Upgrading of Navigational Aids

Navigational aids are aimed at securing navigational safety as well as improving traffic efficiency. In planning the construction and operation of optimum navigational aids, the following points should be given thorough consideration:

1) they should be installed at a place where necessary for safe navigation and be clearly identified
2) they should be operated with utmost accuracy and reliability
3) the intervals between buoys shall be 1km to 3km, depending on the conditions
4) they should be internationally standardized

Three categories of navigational aids, such as light, sound and radio wave signals are considered useful in the Banjarmasin access channel.

- Pair buoy system

  The channel-marking buoys along the existing access channel are installed according to a single buoy system in which one buoy is installed on either side of the channel. In a single buoy system, there is a tendency to lead ships toward the mark, while a pair buoy system allows uniform utilization of the full width of a channel. This can also result in more accurate positioning of dredging work. Therefore it is recommended that a pair buoy system replace the present single buoy system.
- Synchronized lighting system

  A synchronized lighting system of channel marking buoys in which all the buoys flash in a synchronized manner is very helpful in recognizing the entire layout of a channel at a long distance and has been increasingly used because it is easy to install its plug-in apparatus and antenna.
- Automatic lamp changer

  An automatic lamp changer is a unit that revolves on a socket base automatically and replaces a burned-out bulb with a spare bulb by placing the latter into the focus position. This system offers economical and reliable operation of lighted buoys.
- Solar battery system

  This system consists of a solar battery and a storage battery. A solar battery converts solar energy to electric energy by using semiconductors. An economical and reliable maintenance operation can be achieved by using this system.

- Leading lights

  The access channel's existing leading lights and its day marks are inconspicuous, so it is necessary to make the light more visible distance than at present and install radar beacon.

- Radar reflector

  A radar reflector can be attached to a channel marking buoy to give a clearer reflection to a radar signal.

- Radar transponder

  A radar transponder can be attached to a outer fairway buoy. This apparatus functions in almost the same way as a radar reflector, but gives an amplified responding signal when answering a radio wave transmitted from a ship.

Chapter 4 Effective Management and Operation for Dredging

4-1 Organization

The maintenance dredging of the navigation channel is under the control of the MOC, and so many other organizations are also involved with the planning and execution of the maintenance dredging such as DGSC, KANWIL DEPHUB, Perumpel and Perumpen.

These organizations have changed their functions and structure. KANWIL DEPHUB has become a unit of MOC and is subordinated and accountable to the Ministry. In a rationalization effort, the number of directorates at Perumpel and Perumpen has been reduced from four to three.

The main responsibilities and conditions of each organization are shown in Table II.4.2-1 and Fig. A II.4.2-1.

The budget and volume of maintenance dredging at Banjarmasin has remained more or less constant. The total budget of maintenance dredging in Indonesia has remained almost constant. However, its budget was covered by funds of the President's office, Perumpel and foreign countries as follows:

Table III.4.1-1 Dredged Volume and Budget

	1984/1985	1985/1986	1986/1987	1987/1988	1988/1989
Total Volume(m^3)	13,030,400	11,416,534	6,967,773 (4,850,000)	4,624,618 (2,575,382)	8,661,291 (3,000,000)
Total Budget ('000Rp)	6,960,350	6,116,970	3,880,301 (2,907,020)	3,359,793 (3,427,528)	8,964,556 (2,919,200)
Banjarmasin (m^3)	2,300,000	1,920,000	2,822,600 (750,000)	1,577,000	(3,000,000)
Banjarmasin ('000Rp)	1,988,916	967,240	1,679,447 (892,825)	1,140,440	(2,919,200)

Source: DGSC

Note: 1) ( ) figures include funds form the President's office, Perumpel and foreign countries.

Considering the budgetary restraints, the related organizations should strongly express the necessity for proper maintenance dredging to the Central Government in order to ensure the safe navigation of channels from the viewpoint of the national economy.

Perumpen was established to set up dredging programs and for physical execution of all dredging work.
The management and operation of Perumpen is summarized in Fig. A III.4.1-1 and Table A III.4.1-1, which show the actual procedure for conducting each activity. The necessary documents for each activity total about 41 forms. Almost all the forms must be approved by the head office before execution.

It is necessary to establish a monitoring system. As a result of the establishment of a monitoring system, it will become possible to grasp the exact conditions at the dredging site and analyze the dredging works precisely.

4-2 Maintenance and Supply of Equipment

The maintenance and repair of dredgers has been increasing, as shown in Table III.4.2-1. However, regular maintenance docking of some hopper dredgers has not been carried out and average number of floating repairs was only 2.7 times per dredger due to efforts to increase productivity (See Table A III.4.2-1).

Table III.4.2-1 Number of Maintenance and Repair of Dredging Fleet 1986-1987

	1986					1987				
	Dock	E.D	FR	RR	Total	Dock	E.D	FR	RR	Total
Dredger	15	2	2	8	27	12	7	61	110	190
Bucket	2			1	3			3	2	
Cutter	3		1		4	2	1	18	11	
Grab	1			5	6	2		5	18	
Hopper	9	2	1	2	14	8	6	35	79	
Tug Boat	23	1			24	31		9	25	65
Barge	19	1		12	32	21		3	11	35
Total	57	4	2	20	83	64	7	73	146	290

Source: Perumpen

Note: E.D Emergency docking
FR Floating repair
RR Running repair

If the maintenance of dredgers is not carried out systematically, the dredger will age rapidly.

The schedule of maintenance docking should be kept according to the regulations and the maintenance planning. Regular inspection and floating repairs have been decided upon by Perumpen and should be carried out regularly.

The planning maintenance system (TSAR) is well known in Indonesia, and was adopted for the some Perumpen dredgers. However, this system requires a large stock of spare parts, and cannot work if spare parts are not held in stock.

The procurement of spare parts and materials and the execution of major repairs are often delayed due to lack of funds, a long decision making-process and other reasons.

Major contracts must be awarded by tender, and expenditures over 100 million Rupiah must be approved by the MOC. Approval takes one month at least.

Procurement at Perumpen has been executed via the head office and thus requires much time.

It is necessary to speed up the procurement process and to introduce a computer system for maintenance and repairs, including the management of spare parts.

4-3 Personnel and Training

The personnel of Perumpen is shown in Table II.4.1-1. And most of the personnel are concentrated at the head office and Tanjung Priok because only six years have passed since Perumpen was established in 1984.

The crew composition for each dredger differs, even though some dredgers have the same capacity, as shown in Table A III.4.3-1.

However, at present, Perumpen has set the following standard crew composition:

Table III.4.3-1 Standard Crew Composition

Type of Dredger	Number of Crow
4,000 m^3 Hoppers	35 persons
3,000 m^3 Hoppers	33 persons
2,000 m^3 Hoppers	32 persons
1,000 m^3 Hoppers	22 persons
30 Inch Cutters	23 persons
24 Inch Cutters	23 persons
22 Inch Cutters	20 persons
7.5 Cu.Y Grabs	12 persons
700 Lit. Bucket	11 persons

Source: Perumpen

It is necessary to consider the total number of crew because crew members may take holidays for 7 days every 3 months.

At present, some of the electronic equipment on the dredgers are broken. Broken indicators have not been repaired, and the positioning systems have not been operated regularly due to a lack of electronic engineers. It is necessary to employ electronic engineers as soon as possible.

The MOC has been holding training programs at the Sea Communication Center every year using funds from the government budget and other sources. However, there have been no training programs for the management, engineering and the related organizations of dredging.

The training program of Perumpen consisted only of on-the-job training in the past. However, at present, the training program is being carried out using foreign funds, as shown in Fig. A III.4.3-1.

It is necessary to proceed with such large-scale training. This is necessary not only for the personnel of Perumpen but also for the personnel of related organizations.

4-4 Dredging Budget and Unit Price

Requests for maintenance dredging are sent to the MOC or DGSC from many organizations.

The basic dredging program is considered at the planning of PELITA (National Development Program). However, the annual dredging program is decided according to REPELITA (Rolling Plan for Development Program).

The dredging program in PELITA V is shown in Table A III.4.4-1.

The dredging in PELITA IV and its execution are as follows:

Table III.4.4-1 Dredging Program and Execution in PELITA IV

	1984/1985	1985/1986	1986/1987	1987/1988	1988/1989
(Plan)					
Budget('000Rp)	9,542,207	6,437,182	10,366,030	9,689,730	9,574,500
Volume (m^3)	16,570,543	11,614,535	13,872,684	13,471,500	11,765,000
Locations	18	14	15	14	17
(Execution)					
Budget('000Rp)	6,960,350	6,116,970	6,787,321*	5,214,731*	8,909,315
Volume (m^3)	13,030,400	11,416,534	11,817,773	7,200,922	8,661,291
Locations	14	14	7	5	16

Source: DGSC
Note: *Estimation

According to the dredging program in PELITA V, the average dredging volume and budget for one year are 14.9 million m^3 and 14,847 million Rupiah, respectively, and the number of locations is 13 - 19.

There was a large difference in the dredging budget and volume between the planning and execution in PELITA IV.

It is necessary to secure the funds for execution of maintenance dredging in PELITA V for the safe navigation of channels.

The unit price of dredging is determined between the MOC and the DGSC according to the basic estimation of Perumpen, which is reviewed every years as shown in Table II.4.2-2.

The unit price consists of the average unit price of dredgers and additional costs: survey, mobilization/demobilization, tax, interest, insurance, etc. (See Table A III.4.4-2 and Table A III.4.4-3).

However, there are many factors that influence the estimation of dredging cost which vary based on the conditions at each site.

The dredging cost should be estimated considering the estimated output and calculated working time of the dredger at each dredging site.

Chapter 5 Effective Technology for Dredging

The major problems of maintenance dredging in the channel at Banjarmasin at present are the large dredging requirements and the difficulty of maintaining the design profile. In this chapter, effective technology is studied considering both a long time span aiming around the year 2000 and the present circumstances. Of course, the technology considered under the present circumstances is incorporated into the technology which is planned for the long term.

5-1 Planning

5-1-1 Long-term Viewpoint

(1) Judgement of Dredging Depth

All navigation channels in the world are maintained to enable ships to sail safely. So, the most important factor is to know the nautical depth. The depth of channels in Japan is measured by an echo-souder using frequencies between 100 kHz to 200 kHz. In the access channel in Banjarmasin, fluid mud sometimes appears, especially when dredging is not executed. The influence of this fluid mud on the safety of navigation and its behaviour are not fully known by current field survey results. During the JICA field survey to determine the depth of the sea bottom, there was a case in which the fluid mud layer disappeared from the record of the echo-sounder just by the sailing of tugboats. And through several field surveys, it was found that the depth of the sea bottom measured by lead was sometimes deeper than that measured by an echo-sounder at 33 kHz. At the most, the difference was one meter. In order to know the accurate depth of the sea bottom, sounding by dual frequencies such as 210 kHz and 33 kHz is always necessary and a cross check should be made by lead in case of the appearance of fluid mud. Dredging depth can be evaluated by the analysis of these data.

(2) Dredging Requirements by Area and by Soil Condition

Dredging requirements are the first and the most fundamental data for planning. In order to make proper planning, the dredging requirements by area and by soil conditions are necessary. Based on this information, the execution methods are decided.

Soil conditions affect the various dredging operations, and the dredging execution method depends on the soil conditions. Especially, the concentration ratio depends on the soil conditions. This means that the in situ dredged volume measured by the hopper volume will change by this condition. Furthermore, the application of agitation dredging is also decided by soil conditions, especially particle size. The general characteristics of soils and rocks for dredging purposes are explained in Table A III.5.1-1 of the appendices for reference.

(3) Procedures for Future Dredging Planning

Standard procedures for planning dredging by trailing suction hopper dredgers are summarized in Table III.5.1-1. Maintenance dredging itself should be regularly executed as in channels and basins throughout the world. The required frequency will be decided by the dredging requirement.

5-1-2 Under the Present Circumstances

All points stated in the above subparagraph are also applied in this section for effective measures under the present circumstances. Only the notable points are stated below.

(1) Important Data for Planning

As maintenance dredging should be carried out regularly, the understanding of the latest conditions of the channel and the character of the channel are indispensable. These data are obtained only through regular monitoring and this work should be considered as one part of the dredging project. Monthly monitoring is not undertaken at Banjarmasin. The accumulation of past dredging records and the analyses of these data are the first step for

Table III.5.1-1 Dredging Planning Procedure for Training Suction Hopper Dredger

Investigation items	Contents of investigation	Elements decided	Dredging capacity	Execution planning
Soil conditions	Grain size distribution Soil classification N value or Compressive strength Water content	Dredging speed Stress on bottom Pump quantity Concentration ratio	Dredging hours Turning hours Sailing hours Dumping hours Cycle time Loaded volume per cycle	Capacity per cycle Necessary cycle numbers Necessary operation hours Necessary operation days
Dredging conditions	Possibility of overflow Possibility of agitation	Loading efficiency Dredging hours		
Sounding record of dredging area	Topography Shape of sea bottom Dredging volume	Order of dredging Dredging distance Way of turning		
Dumping conditions	Dumping Distance between dredging area and dumping area	Dumping hours Sailing hours		
Conditions of dredging area, dumping area, and navigation area	Frequency of sailing vessels Navigation rules	Working efficiency	Intermission hours	
Meteorological and marine phenomena	Frequency by wave height Period by wave height Wave direction Frequency by wind velocity Wind direction	Working efficiency		

planning. Analyses should be done both from general and specific points of view. These analyses can easily be done using the computers installed at Perumpen and the DGSC. Statistical analyses are preferable when using a computer. For example, useful indicators such as mean values and standard deviations are easily calculated. Various graphs are immediately illustrated and those graphs are useful for understanding.

(2) Procedures for Planning

There is no particular procedure for planning different from the procedure stated in the previous subparagraph. Even now the procedure for planning should be done as shown in Table III.5.1-1. The standard planning procedure is explained in Fig. A III.5.1-1 of the appendices.

5-2 Execution and Control of Dredging

5-2-1 Long-term Viewpoint

(1) Type of Dredger

The use of trailing hopper suction dredgers has been recommended for maintenace dredging in the access channel of Banjarmasin Port in all the papers written about a suitable maintenace dredging system in this channel. We also think that this type of dredger is the most suitable judging from the various conditions of the channel. It is also useful to use an automated dredger with high speed and better turning.

(2) Future Dragheads and Attachments

The draghead is the most crucial part for dredging efficiency and sometimes small attachments such as knives improve the output. As illustrated in Fig.III.5.2-1, in future, dragheads could be expanded outward near the sea bottom, and the total width could be two or three times the present one. Ultimately dragheads could have a width similar to the width of the dredger, as shown in Fig.III.5.2-2.

The dredging efficiency inevitably decreases towards the latter stages of the work. One method is to use a levelling blade to prevent the dropping of dredging efficiency to a minimum level. The levelling blade is to be fixed to both sides of the draghead, as shown in Fig.III.5.2-3.

A spade recently made in Japan shows good results in a wide rage of soil conditions. The spade was originally designed for dredging hard material and shows good results compared with conventional dredging for hard material using edges with water jets. The spade is shown in Fig.III.5.2-4. The shape of this spade is quite different from the edges fixed to the dragheads of Perumpen's dredgers.

(3) Execution Methods by Trailing Suction Hopper Dredger

Ideally the channel in Banjarmasin should be maintained by regular dredging by one trailing suction hopper dredger. The bigger the hopper's capacity, the greater the output. This is confirmed by the fact that IRIAN JAYA was more efficient than HALAMAHERA in the semi- capital dredging. Therefore, dredging by one bigger dredger seems to be a better method within a suitable draft.

The dredging operation by a trailing suction hopper dredger in this channel has three steps. These are preparation for dredging, dredging and dumping. The details of each operation are shown in Fig.III.5.2-5.

(4) Application of Agitation Dredging

Judging from the analyses of the dredging record of the semi-capital dredging commenced on the 20th of June, 1988, agitation dredging seems to be effective.

Underwater movement of sediment consists of three stages of erosion, transport and sedimentation. Investigations were carried out by Hjulstrom to find a correlation between particle size and velocities required for the these three stages and the result is as shown in Fig. III.5.2-6. Very high velocities are needed to start the erosion process. These velocities do not occur frequently in nature. The

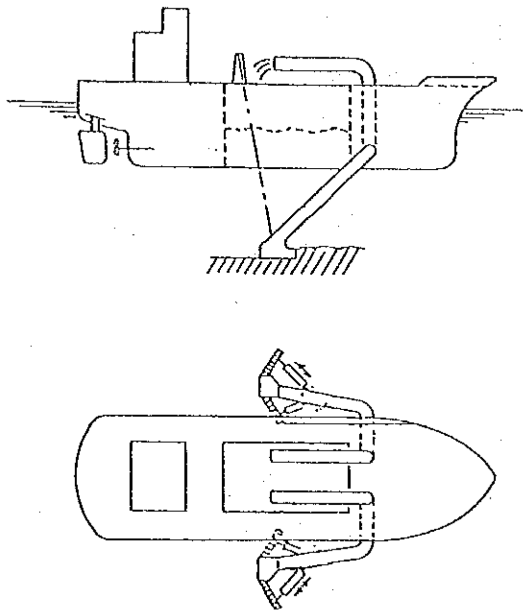


Fig. III.5.2-1 Image of Expanding Draghead

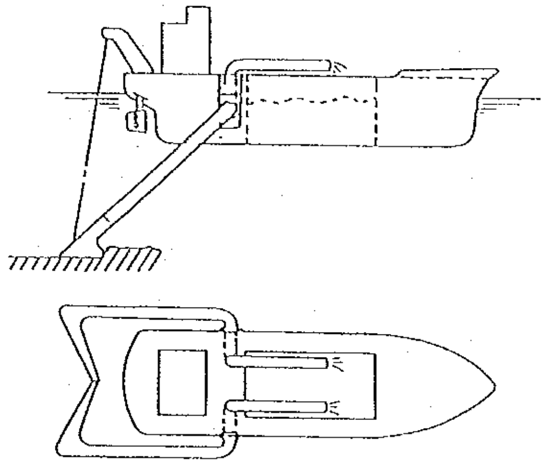


Fig. III.5.2-2 Image of Wide Draghead

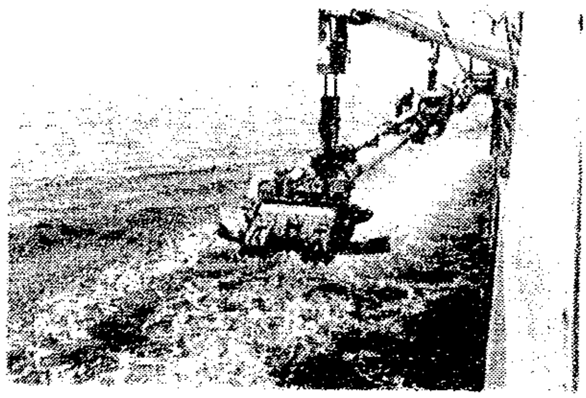


Fig. III.5.2-3 Draghead with Levelling Blade

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

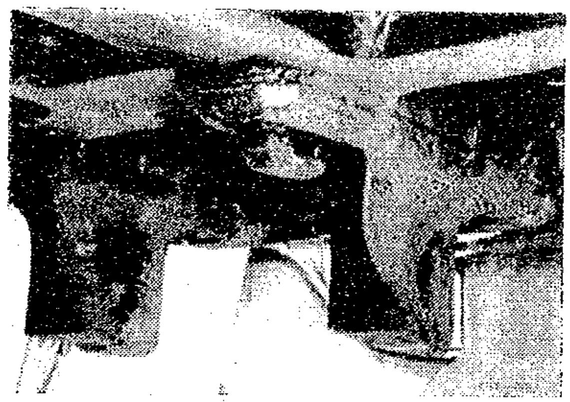


Fig. III.5.2-4 Draghead with Spade

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

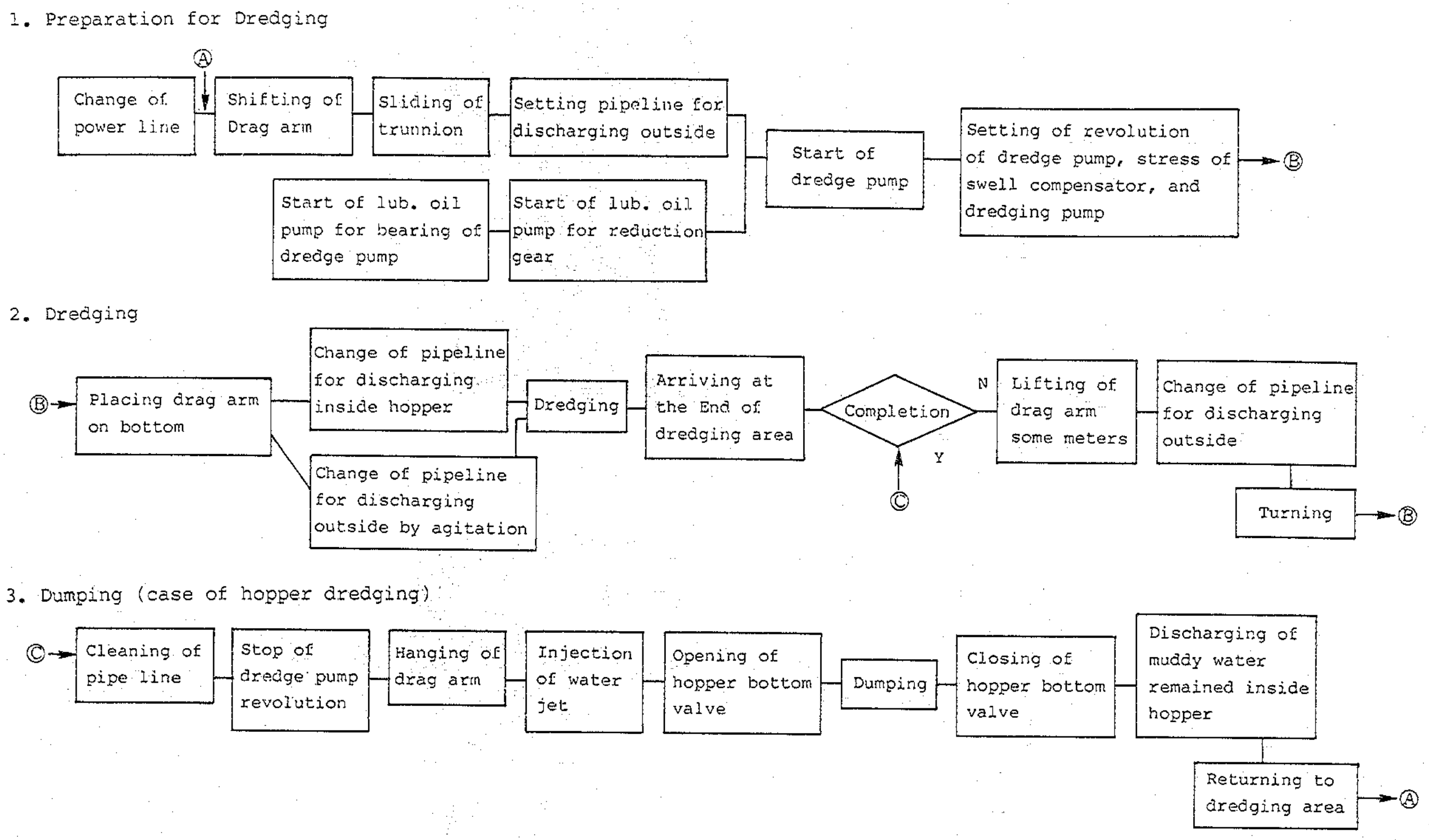


Fig. III.5.2-5 Dredging Execution Flow by Tailing Suction Hopper Dredger erosion and re-dispersion however can be stimulated artificially and that in fact forms the basis for agitation dredging. Some agitation devices are explained and these are shown in Table III.5.2-1.

Table III.5.2-1 Agitation Dredging Methods

No.	Methods
1	Hydraulic rake
2	Mud wheel
3	Airlift methods
4	Jet pumps
5	Use of propellers
6	Underwater scraper/dozer/plough

Source: ESCAP Report "Agitation Dredging A Low Cost System" in 1985

The average mean grain size obtained by the General Survey and Monthly Survey ranges between 0.0145 mm and 0.043 mm. This is defined as silt from the point of grain size. Judging from the graph of Fig.III.5.2-6, if the velocity is over 20 cm/sec, the particles will be transported from the safety point of view. The results of the JICA Surveys are as follows;

- The stream flows southward from three hours until six hours after high tide and from eight hours to two hours before low tide.
- The velocity is mainly between 20 cm/sec and 50 cm/sec.

Based on these findings, agitation dredging might be effective around one-third of the day, theoretically.

There is one more graph useful in considering agitation dredging. Using Rubey's formula for particle settlement, the relation between particle size and sedimentation velocity is shown as illustrated in Fig.III.5.2-7. The figure is in an ordinary case in that specific gravity is 2.65 and water temperature is 25°C. The average specific gravity measured by the JICA field survey is around 2.60. The water temperature is mainly around 28°C,based on the JICA field survey. These differences are small, and thus Fig.III.5.2-7. can be used roughly as one of guidelines for agitation dredging in the channel.

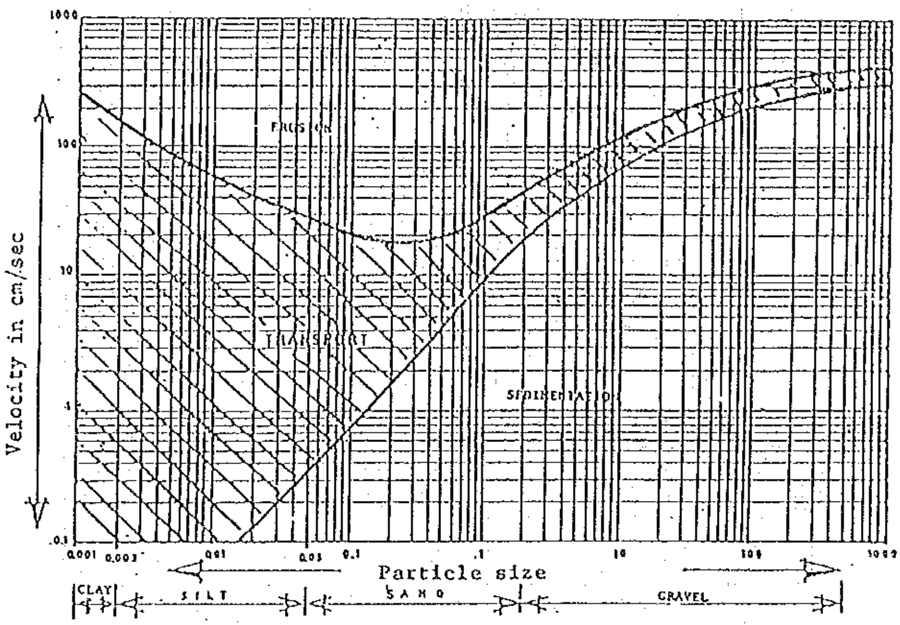


Fig. III.5.2-6 Hjullstorm Diagram

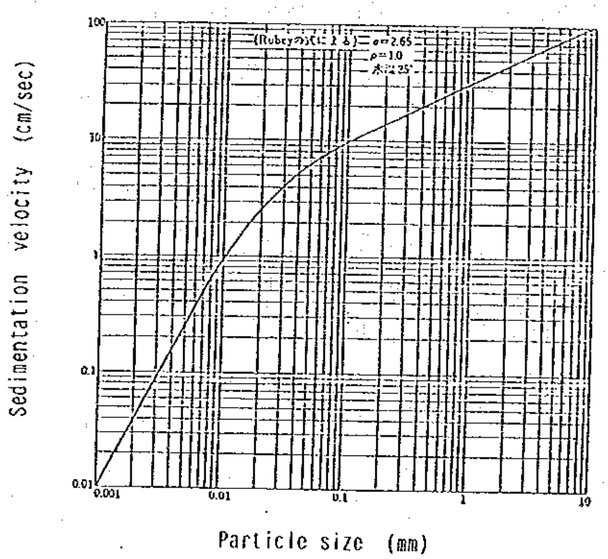


Fig. III.5.2-7 Particle Size and Sedimentation Velocity

Note: (1) This figure is based on Rubey's formula.

(2) Specific gravity is 2.65 and water temperature is 25°c.

The present agitation in the channel has been carried out by side casting by trailing suction hopper dredgers through short pipes less than 15m in length. The discharged material drops into the channel. It seems that agitation dredging will be more effective if the reaching distance is extended further.

(5) Installation of Draghead Position Indicator

The present positioning system of a dredger indicates the position of the dredger and does not show the dredging location. Therefore, a draghead position indicator is necessary to make dredging more efficient. This indicator is being used in some countries. Here, we explain the system installed in a Japanese trailing suction hopper dredger. This system consists of five units, and the main equipment is listed in Table III.5.2-2. Fig.III.5.2-8 shows the system.

Based on opinions from dredging crew, some modifications have been made and the dredging efficiency is being improved by this system.

From the point of efficient execution and its control, use of this draghead position indicator is one of the best methods. This system will reduce the required numbers of bathymetric surveys.

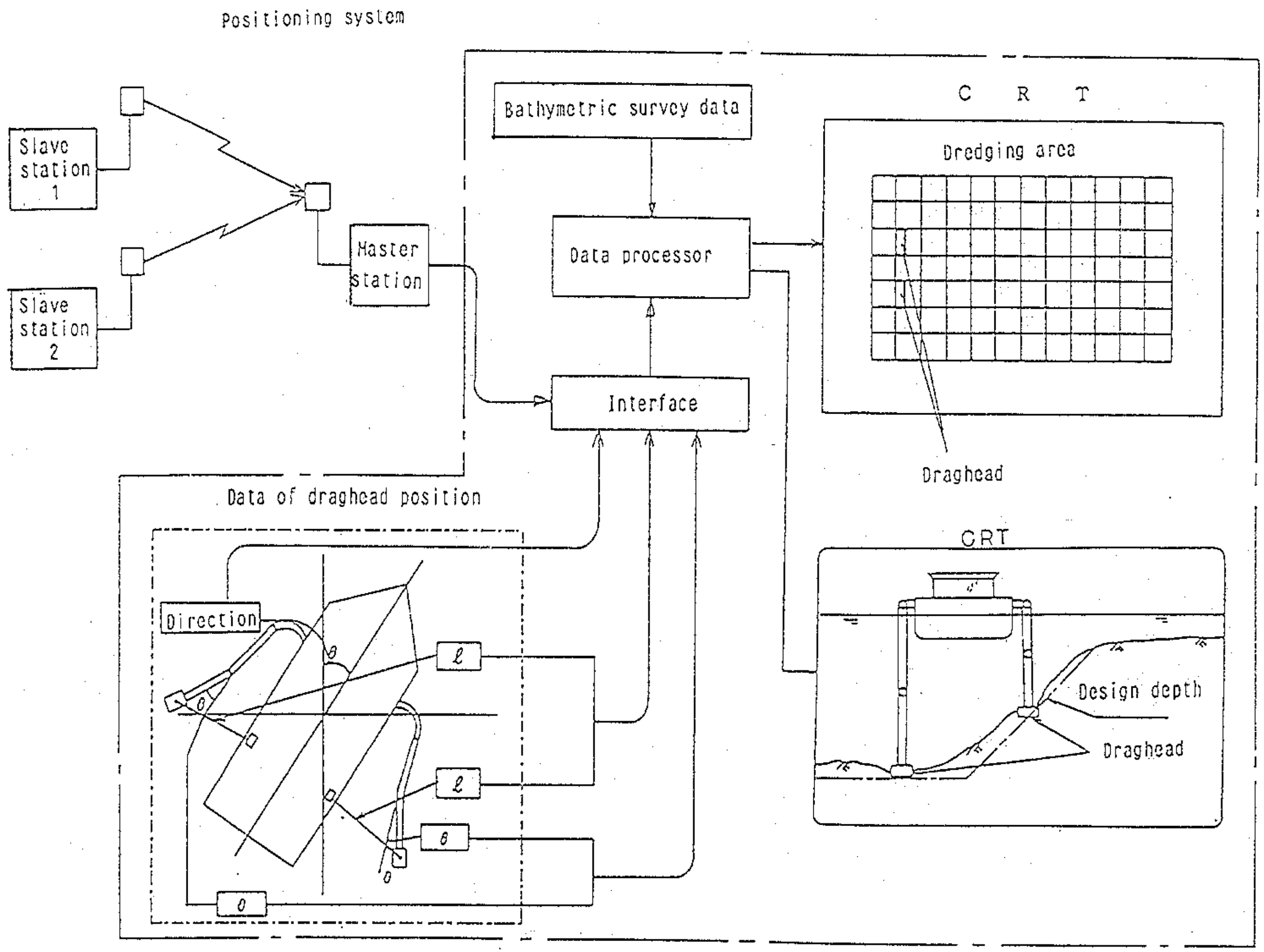


Fig. III.5.2-8 Draghead Position Indicator System

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

Table III.5.2-2 Main Equipment List for Draghead Position Indicator

No.	Equipment	Quantity
I	Ship Positioning System	
	1 Master station antenna	1
	2 Master station	1
	3 Slave station antenna	2
	4 Slave station	2
	5 XY plotter	2
II	Ship Direction System	
	1 Gyro compass	1
	2 Direction transducer	1
III	Measurement of Angle of Drag Arm	
	1 Angle transducer	2
	2 Wire length transducer	2
IV	Draghead Depth Indicator	
	1 Pressure gauge	2
V	Data Display Unit	
	1 Display unit	1
	2 Operation unit	1
	3 Color printer	1

Source: Port and Harbor Research Institute, Ministry of Transport of Japan

(6) Rationalization of Echo Sounding

The control of the progress and quality of dredging execution is mainly carried out by echo soundings all over the world. Recently, dual frequencies have been used in the channel. The results vary case by case. The record measured by 33kHz is usually deeper than the record by 210 kHz. However, it sometimes occurs that there is no difference between these dual frequencies. During the JICA field survey it was found that the depth of the sea bottom measured by lead is commonly deeper than that measured by echo-sounder using 33kHz. Following these findings, the depth of sea bottom composed of soft material might be measured by an echo-sounder using a lower frequency. If there is a difference between the records by dual frequency, a cross-check should be carried out using lead. This kind of effort should be continued and the best frequency for the channel should be selected through many experiences on site. In Europe, the layer with a density of 1.20 ton/m^3 is defined as the Nautical Depth in fluid mud areas and whether to dredge or not is decided using this definition. Instruments for measuring density are developed using radio isotopes and/or supersonic waves. In any case, a cross-check is necessary.

5-2-2 Under the Present Circustances

(1) Dragheads and Attachments to Dragheads

(a) Spade for Hard Material

In the case of dredging hard material in Japan, a draghead with a rotary cutter or edges together with a water jet has been tried. But these methods are often not so effective.

The spade is redesigned and refined based on trials, and thus dredging efficiency is improved. The spade has been used for three years and it is found that the spade is useful not only for hard material but also for a wide range of soil conditions. The water jet is used together with the spade for hard material. In the case of soft material, the use of water jet should be decided after some trials. A sketch of the spade is illustrated in Fig.III.5.2-9 and a photograph of it is shown in Fig.III.5.2-10. The spade might be effective in the channel and the best shape of the spade should be decided after some trials in this channel. One of the reasons that the dredging efficiency of IRIAN JAYA was better than HALMAHERA in the semi-capital dredging was that the edge of the draghead of IRIAN JAYA was better than that of HALMAHERA.

(b) Levelling Blade for Better Completion

As already stated, the levelling blade is designed to be used in the final stage of the project. The aim of the blade is levelling the sea bottom and cutting high spots during dredging. The effect of the blade is the reduction of dredging hours by the levelling of dredged areas and to level shallow places. The blade was planned to be fixed to the side face of the draghead. A sketch of the draghead with this blade is illustrated in Fig.III.5.2-11 and a photograph of it is shown in Fig.III.5.2-12. The result of the experimental dredging with the levelling blade showed that the dredging hours were reduced by around 30% and the over dredged volume was reduced by about 35%. Moreover, a levelling effect was found. On the contrary, the generating power for propulsion and dredge pump output increased by about 6%.

In the final stage of the project, there may be cases where only levelling without dredging is satisfactory. For such cases, one method is to fix the sweeping blade, as shown in Fig.A III.5.2-1. The width of the blade is limited by the hangar space of the draghead on deck.

(c) Employment of New-type Draghead for Soft Mud Layers

A front-open type draghead has been developed as one of the effective methods of removing soft mud layers at the sea bottom in Japan. The aim of this draghead is to dredge a thin layer less than 20 cm with high concentration. This type of draghead is shown in Fig.A III.5.2-2 through Fig.A III.5.2-4. The stabilizer with an area of 7 m^2 is used to gain constant cutting depth without over-cutting by the use of a swell compensator. This type of draghead sucks soils from the front, so a control unit to keep the suction mouth at proper position meeting the change of the sea bottom is installed. Furthermore, a mud detector that detects soft mud layers directly by an ultrasonic system is used. This type of draghead is designed to dredge a thin layer of soft mud of around 50 cm efficiently.

(2) Optimal Utilization of Equipment

Some points stated in the long-term execution methods can also be utilized under the present circumstances. Regular dredging by a bigger dredger seems to be a suitable method. Furthermore, the efficiency will surely be improved by application of agitation dredging and setting of the turning basin as described below.

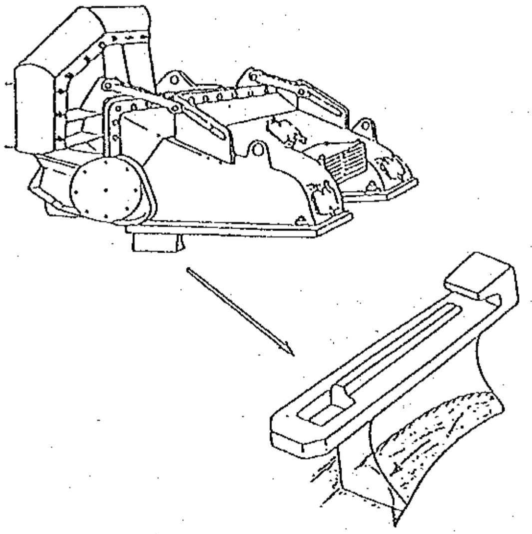


Fig. III.5.2-9 Sketch of Spade

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

Fig. III.5.2-10 Photograph of Spades

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

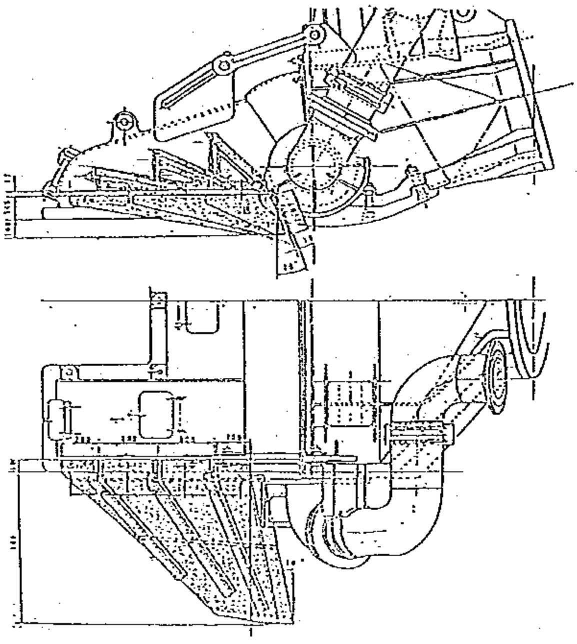


Fig. III.5.2-11 Sketch of Draghead with Levelling Blade

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

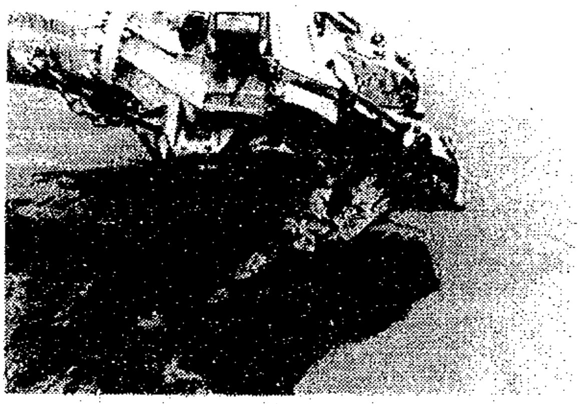


Fig. III.5.2-12 Photograph of Draghead with Levelling Blade

Source: Port and Harbor Research Institute, Ministry of Transport of Japan.

In order to fully utilize the dredging capacity, the following operations will be necessary. In the initial stage, high output is the target. It is better to increase the rotations of the dredge pump and to place the dragheads deeper more than during the middle and later stages. During the middle stage, the rotation of the dredge pump will be slightly reduced and the setting of dragheads will be within around 30 cm below the bottom. In the final stage, the rotation of the dredge pump will be kept low and the stress of dragheads on the bottom will be slightly lower than usual. A levelling blade will be used. The above operation should be revised through experiences on site.

(3) Effects of Agitation Dredging

Judging from the results of the semi-capital dredging in the initial stage, an agitation dredging system seems to be effective. The estimated dredged volume calculated from the difference between the pre-dredge survey made during the middle of June 1988 and the progress survey from the 1st of July to the 7th of July is 428,000 m^3. At the initial stage, HALMAHERA, with a 2,900 m^3 hopper capacity, carried out both ordinary dredging and agitation dredging. The period of agitation dredging was from the 20th of June to the 5th of July and this period corresponds to the above survey period. The in situ dredged volume measured from the hopper volume was 118,877 m^3 during this period. As for agitation dredging, if it is assumed that 2,900 m^3 of material including water is removed in 30 minutes, then the dredged volume from the 20th of June to the 5th of July is:

$$(8{,}085/30) \times 2{,}900 \times 0.4 = 312{,}620 \ m^3$$

where 8,085 is the total dredging hours. Therefore, the total dredged volume is roughly estimated at 430,000 m^3, which is almost same as the calculated volume based on the hydraulic surveys. Agitation dredging has been executed near the center line of the channel. It can be said that agitation dredging is effective at least at the area near the center line of the channel in a short period.

(4) Making the Turning Basin

Preparing a turning basin in this narrow channel is the best way to reduce cycle time and non-productive time. At present there are only a few chances for dredgers, especially dredgers with 2,900 m^3 or 4,000 m^3 hopper capacity, to turn in the channel due to the draft and length of dredgers and the channel condition. Based on the results of the semi-capital dredging, the reduction of cycle time is estimated.

In case of one turning basin, the middle of the channel will be the best. If turning basins are located at two places, the middle of area B and the middle of area C will be the best combination.

The ratio of saved sailing distance to total sailing distance is 14.2 % for one turning basin amd 18.6 % for two turning basins.

Thus dredging efficiency will be improved by preparation of a turning basin. The plan is shown in Fig.V.2.1-1 of PART V.

(5) Trials of Some Dragheads

It is important to emphasize the necessity of trials on site in different ways. Experimentation is the first approach to better dredging execution. Perumpen should plan the items to be developed every year and these developments can be achieved by repeated trials on site.

(6) A New Dumping Site

Based on the observation of buoy tracking in the channel by the JICA study team in the channel, it seems that the flow runs southward duing ebb tide. If dredgers dump the dredged material at the east of the channel near the river mouth, the dumped material might be carried away by this southward stream. But this method should be tested by trials on site, etc. Similar to agitation dredging, this method will be effective within the limited hours during the ebb tide.

(7) Specific Gravity of Sea Bottom

An image of the loaded hopper is illustrated in Fig.III.5.2-13.

Using this figure, in situ dredged volume (Vb) is calculated as follows:

$$(V-Vb) \times pw + Vb \times r = D$$

$$Vb = (D - V \times pw)/(r - pw)$$

$$Vb = V(D/V - pw)/(r - pw)$$

where,

D = Displacement tonnage of the dredger

By measuring draft and using a curve of the displacement of the dredger, D is easily obtained.

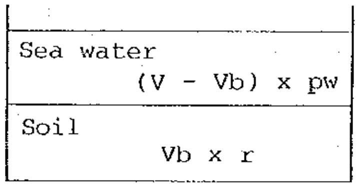


Fig. III.5.2-13 Image of Hopper Loaded

In the above formula, the problem is the estimation of the in situ wet bulk density of the soil. In the semi-capital dredging, the value is set based on the results of the soil investigation executed by PCI during July of 1988. The values are 1.412, 1.411, 1.466, and 1.441 respectively for areas A, B, C, and D. In order to know the effect of differences in the wet bulk density of soil, the calculation is made and the result is shown in Table III.5.2-3. The difference of 0.05 in wet bulk density represents a difference of around 10% of the dredged volume calculation. In case the setting value of wet bulk density is lower than the actual one, the dredged volume is overestimated.

Table III.5.2-3 Change of Dredged Volume by Different In Situ Wet Bulk Density of Soil

r (ton/m3)	1.30	1.35	1.40	1.45	1.50	1.55	1.60
Index of dredged volume (%)	100	85	73	65	58	52	48

Note: The value of r of 1.30 is set as the standard.

(8) Accurate Echo Sounding

All the points stated in echo sounding for the long-term viewpoint are applied to the present situation. A mini-ranger system or tris-ponder system is the best survey method in this long channel. It was pointed out during the semi-capital dredging that the centerline of the channel drawn by the results of the progress surveys by Perumpen fluctuated. This error is due to the horizontal difference. One method to reduce this horizontal error is to place marker poles along the channel and to mark the chart of the echo-sounder when the survey boat crosses between these marker poles. The locations of the poles would be around 200 meters away from the center line of the channel on both sides and the pitch between the two poles would be about 200 meters.

Accurate sounding by echo-souder in the channel depends on the frequency of sonic waves. Echo sounding by dual frequency should be continued and the best frequency will be found through many data.

Conventional soundings by lead are often necessary to check some aspects. Special types of lead should be used to check the surface of soft material. One example is the circular type lead. This type of lead is widely used for the sounding of dredging works of soft materials in Japan. The following Fig.III.5.2-14 is sketch of the circular lead and its weight is 2.1kg.

As the channel is located at the river mouth and has a lengh of 14 km, two tide poles should be set along the channel. Correction of tide for echo-sounding results should be based on the record of tide level at the Pilot Station and these new tide poles in case that there are a big difference in these three locations.

High humidity and temperature hinder this system, so an air condi-tioner should be installed in the survey boat. Frequent charging of the batteries of reference stations is necessary at present, so a heavy duty battery charger will be necessary. Moreover, a stronger anchoring system is necessary to cross check the results of echo sounding by lead.

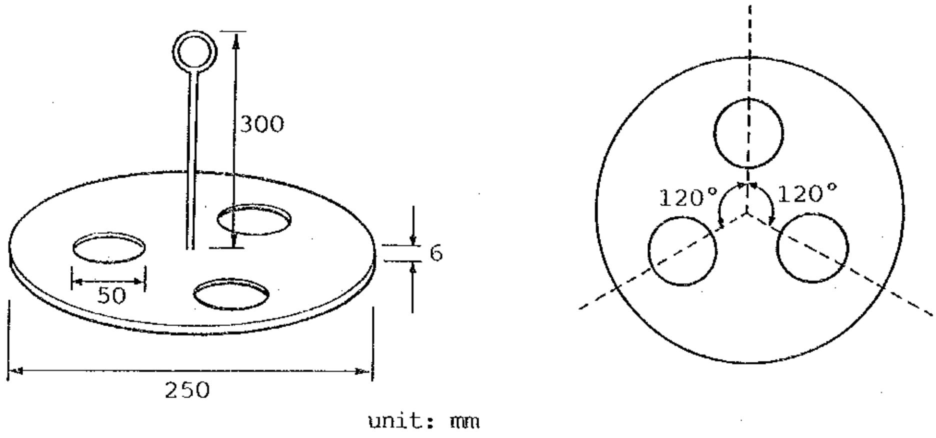


Fig. III.5.2-14 Example of Lead for Soft Material

5-3 Maintenance and Repairs

5-3-1 Long-term Viewpoint

(1) Home Docking System

A home docking system is being discussed by the ministries of Communications and Industry. The idea is good and idling time due to tendering procedures will be reduced. The problem is setting standard unit prices and the sharing of jobs between shipyards and Perumpen. The ideal situation is that vessels be maintained and repaired by the staff of Perumpen as much as possible.

(2) Maintenance and Inspection Standards

In 1978 an Investigation Research Committee was set up in Japan to study the maintenance and inspection standards for dredgers. The members are from leading ship-builders, machinery manufactures, dredging companies and the Ministry of Transport. Though their investigation was based on dredgers in Japan, the standards will contribute to the maintenance and repairs by Perumpen. An outline of this study is summarized in the following section about trailing suction hopper dredgers.

Standards for drag arm assembly are as shown in Table III.5.3-1 and the related parts are shown in Fig. A III.5.3-1 of the appendices. Standards for drag heads are given with reference to the California type. As for the trunnion system, standards are listed in Table III.5.3-2 and a drawing of it is shown in Fig. A III.5.3-2.

Standards for drag arm hoisting equipment are stated in the following Table III.5.3-3, and the parts are shown in Fig. A III.5.3-3. Concerning the hopper door system, those standards are listed in Table III.5.3-4.

Table III.5.3-1 Drag Arm Assembly

Parts			Inspection Item	Allowable Limit
Drag head	Body		Wear and damage	Wear: Up to 50% of original thickness; no crack permitted
	Grate		Wear	Up to 50% of original thickness
	Jet pipe		Wear and corrosion	Wear: Up to 30% of original thickness; no water leakage permitted
	Jet nozzle		Wear	No outlet deformation permitted wear by 30% of overall length
	Digging teeth	Body	Wear	Wear: Up to 50% of original height
		Adaptor	Wear and corrosion	No clearance in the engagement
	Shaft	Body	Wear and bend	Wear; Up to 85% of original thickness or diameter; no bends allowed
		Bearing	Wear	Up to 70% of original thickness
		Bearing bush	Wear	Up to 30% of original thickness
	Heel pad		Wear	Up to 50% of original thickness
	Great fasteners (bolts and nuts)		Wear and deformation	Wear: Up to 50% of bolt head height; no anomalous deformation
Drag arm	Body		Wear and corrosion	Wear: Up to 50% of original thickness
	Rubber packing		Deterioration and damage	No detrimental deterioration or no damage
	Flange fasteners (bolts and nuts)		Fatigue	Up to 10% in elongation of bolt
Rubber joint			Deterioration and damage	No exposure or no cracking of inside canvas
Ball joint	Body		Wear	Up to 50% of original thickness
	Hinge pin		Wear	Up to 10% of original thickness
Hinge piece	Body		Corrosion and wear	Wear: Up to 20% of original thickness; no cracking permitted
	Hinge pin		Wear	Up to 10% of original diameter

Note: A drawing is shown in Fig. A III.5.3-1

Source: Studies on Maintenance and inspection Standards for Dredgers prepared by the Japan Workvessel Association.

Table III.5.3-2 Trunnion System

Parts		Inspection Item	Allowable Limit
Trunnion elbow	Body	Wear	Up to 30% original thickness
	Holder	Wear	Up to 5mm of clearance
	Bolts and nuts for holder	Fatigue	Up to 10% in bolt elongation
Sliding trunnion		Wear at wedge	Up to 5mm of original thickness
Trunnion holder	Body	Wear	Up to 5mm in clearance
	Bolts and nuts	Fatigue	Up to 10% in bolt elongation
Packing for mud pipe		Damage	No serious wear or no damage

Note: Drawing is shown in Fig. A III.5.3-2

Source: Studies on Maintenance and Inspection Standards for Dredgers prepared by Japan Workvessel Association.

Table III.5.3-3 Drag Arm Hoisting Equipment

Parts			Inspection Item	Allowable Limit
Trunnion, intermediate joint and drag head lifting device	Lifting post		Corrosion Damage	Up to 30% of original thickness No depressions more than 50mm long by 2mm deep No crack or no damage at the welded parts
			Deformation and deflection	Deflection in any direction: within 1.5mm + $\frac{\text{Length, mm}}{1,000}$
	Lifting jib	Body		
		Shaft for footing	Wear Deformation and deflection Damage	Up to 10% of original diameter No detrimental deformation or no deflection No detrimental damage
		Foot bearing	Wear Damage	Up to 10% of original diameter No detrimental wear No crack or no damage at the welded parts
		Sheave shaft	Wear Deformation and deflection	Up to 2% of original No detrimental deformation or no deflection
		Sheave bearing	Wear Deformation Noise	Up to 2% of original diameter No bearing seizure or no deformation No abnormal running noise

Note: Drawing is shown in Fig. A III.5.3-1

Source: Studies on Maintenance and Inspection Standards for Dredgers prepared by Japan Workvessel Association.

Table III.5.3-4 Hopper Door System

Parts			Inspection Item	Allowable Limit
Hopper door system	Hopper door or conical valve	Body	Corrosion Wear Deformation Damage	Up to 30% of original thickness Up to 30% of original thickness Water tight No rack at the welded parts
		Hinge pin	Wear	Up to 5% of original diameter; No missing lock pin; no slackened nut
		Hinge bush	Wear	Up to 20% of original thickness
	Rod	Body	Wear and corrosion Deformation Damage	Up to 30% of original thickness No trouble in open-close operation No crack in welded parts
		Lifting pin	Wear and corrosion	Up to 10% of original diameter
		Turn-buckle	Corrosion	No detrimental corrosion
	Rod bearing bush		Wear Corrosion Damage	Up to 20% of original Up to 20% of original thickness No trouble in open-close operator
	Cotter		Deformation	No trouble in engagement and no disengagement

Notes : (1) The hopper door is available in the flap type and conical type. Investigation was carried out in these two types.

(2) The hopper door rods of steel pipe make are taken up here.

Source: Studies on Maintenance and Inspection Standards for Dredgers prepared by Japan Workvessel Association.

(3) Aiming at Preventive Maintenance

If there is no failure in design, the cause of breakdown is due to misoperation or some other failure. And if there is no mistake in operation, the breakdown is due to other failure and thus indirectly induced. If the cause is found, countermeasures can be considered. This means that preventive maintenance can be possible. The standards for maintenance and inspection stated in the section were set up adopting reasonable and practical values which are not too strict and not too lax backed-up by ample data and experiments. It is recommended that Perumpen establish similar standards meeting the present dredging fleet and use their own standards for preventive maintenance.

5-3-2 Under the Present Circumstances

(1) Preparation of History Sheets for Dredgers

As the first step to effective technology for maintenance and repairs, all records of maintenance and repairs of each dredger are arranged and should be written in history sheets such as a chart for a patient. The study team could not obtain any past record of maintenance and repairs of each dredger in detail from Perumpen and there may be no history sheets.

(2) Understanding of Maker's Instruction Manual

It is correct that dredging crew have been carrying out inspections and maintenance and repairs following instruction manuals. Inspection should be done using all five senses. While the dredging crew are cleaning some equipment, they have many chances to note defects such as vibration, leakage of oil, strange smells, noises, and high temperature. This action is one of preventive maintenance.

5-4 Others

5-4-1 Integrated Maintenance Dredging System

At the end of 1988, a meeting for a new maintenance dredging system, called as an integrated maintenace dredging system, was held at Bogor near Jakarta and attended by staff from the DGSC, Perumpel, Perumpen, project managers and deputy project managers. The new system is to be applied only to channels and basins where regular dredging is necessary, and maintenance dredging at other places is based on the present guidelines. This new system was scheduled to come into force on the first day of 1989. However, it has not yet been applied.

The key points of the new system are;

- The system technically and administratively can be carried out to guarantee the depth of navigation channels and basins as designed for one year throughout Indonesia at locations requiring regular maintenance dredging.

- The system can be applied if the DIP budget is planned integrally by combining the total volumes from all locations into one package to guarantee the depth of channels and basins in one year.
- Annual maintenance dredging volume will be decided by the DGSC, Perumpel, and Perumpen.
- Perumpen will decide the time of dredging, method of work, schedule and equipment.

As a concept, integrated maintenance dredging aiming to keep navigation channels and basins in safe conditions for sailing for one year throughout Indonesia is one of the best ideas. However, each channel and basin has its own characteristics, so that special conditions of contracts are also important. Though there are some difficulties, the new system is worth trying and must be developed step by step.

PART Ⅳ EFFECTS OF SILTATION COUNTER—MEASURES IN THE ACCESS CHANNEL

Chapter 1 Hydraulic Model Tests

1-1 Purposes

The location of the access channel at the river mouth in Banjarmasin along with the sea bottom topography around the channel made the study very complicated. On top of this, any analysis of the current characteristics in and around the channel required that the tides, river discharge and salinity conditions be taken into consideration.

The accuracy of current analysis under the conditions adopted largely influenced the prediction of siltation for countermeasures to reduce the amount of maintenance dredging.

The hydraulic model testing was therefore utilized to examine the current characteristics and salinity conditions around the channel to ensure accuracy, and the test results reflected in a numerical simulation to predict the siltation phenomena.

The direct purposes of the hydraulic model tests can be summarized as:

(1) Reproduction of the present current conditions,
(2) Prediction of future current conditions for major channel improvement plans, and
(3) Rough estimate of the degree of siltation for the major plans by means of tracer tracking tests.

1-2 Hydraulic Model

1-2-1 Facilities and Equipment

(1) Test Facilities

The test facilities were constructed in a test basin of width 50m, length 40m and depth 1.5m in the Nippon Tetrapod Hydraulic Laboratory. An outline of the facilities and equipment is shown in Table IV.1.2-1 and Fig. IV.1.2-1.

Table IV.1.2-1 Facilities and Functions

Facilities	Functions
Tide Generator	Reproduction of Tidal Action (Amplitude; 1.5cm, Period; 14 min 24 sec)
Fresh Water Supply Installation	River Discharge Control (Maximum Discharge 12 liters/sec)
Salt Water Installation	Salt Water Making and Salinity Control
Control System	Total Control System to Adjust Test Conditions

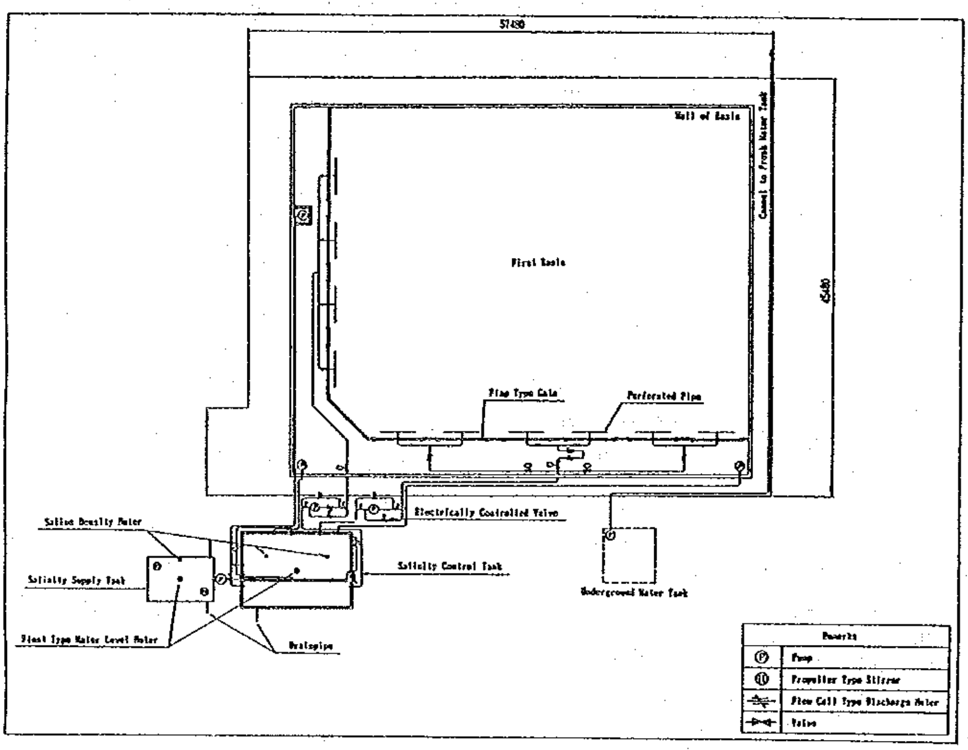


Fig. IV.1.2-1 Outline of Facilities and Equipment

(2) Measurement Items and Equipment

Measurement items and equipment used in the hydraulic model tests are shown in Table IV.1.2-2.

Table IV.1.2-2 Measurement Equipment

Item	Measurement Location	Equipment (No. of Items)
(a) Tide	About 10 Locations	Servo Type Wave Gauges (10)
(b) Current Velocity	About 20 Locations (2 Layers in Deep Areas)	Electro Magnetic Current Meters (13)
(c) Salinity	Same Locations as (b)	Salinometers (10)
(d) Tracer Observation	In and Around the Channel	Video Image Processing System and Salinometers
(e) Float Observation	All the Bank Area	Video Image Processing System
(f) Others		Data Recorder

(3) Measurements Points

Measurements of water level, currents, and salinity were made at the points presented in Figs. IV.1.2-2 and IV.1.2-3 for the present conditions and the countermeasure plans.

Tracer experiments were conducted by injecting blue-dyed salt water of concentration 5% from 34 points surrounding the channel, and by measuring the chlorine concentration at 9 locations, each with 7 measurement points of different depths as shown in Fig. IV.1.2-4. The volume of salt water from 1 and 2 was double that of the other points.

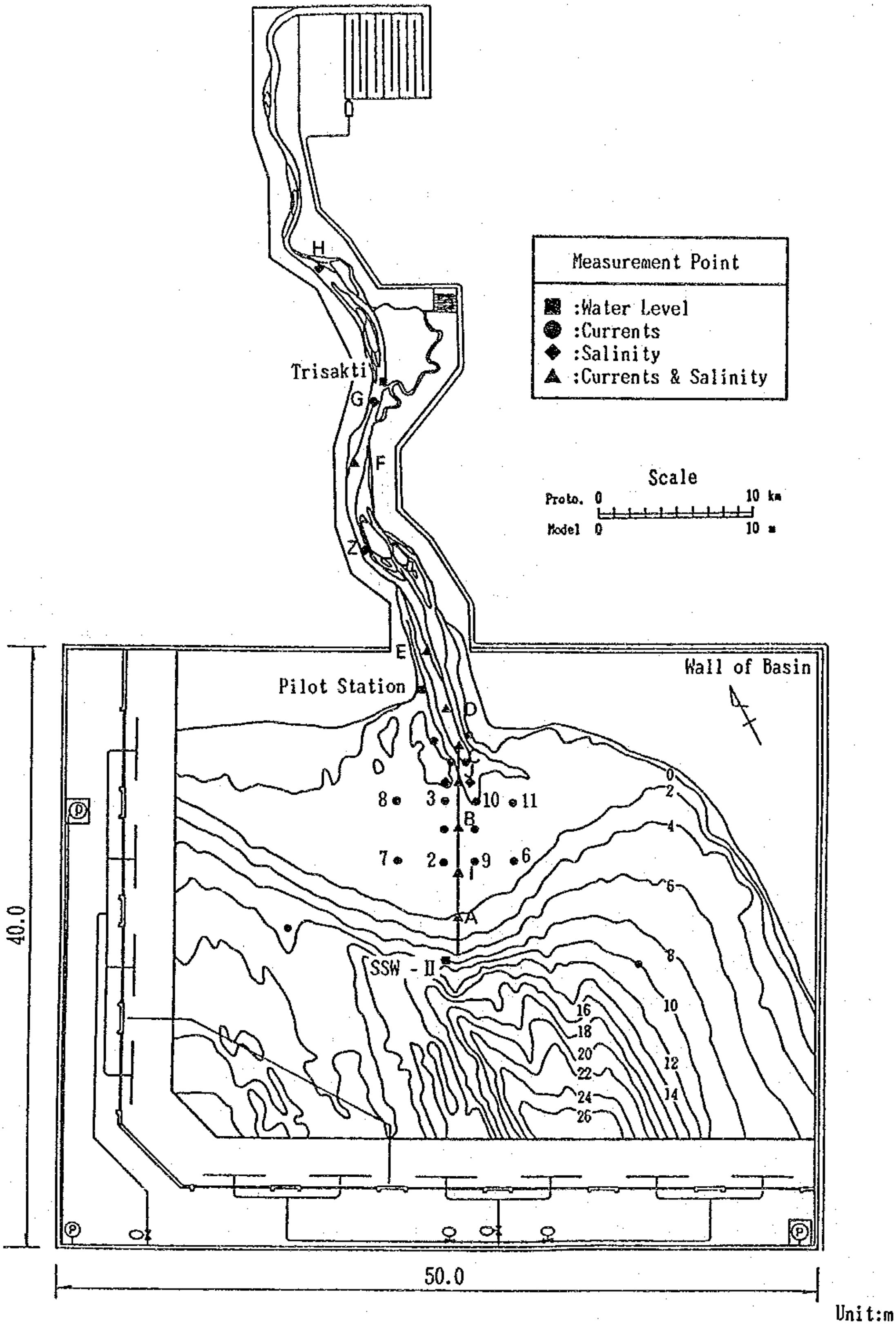


Fig. IV.1.2-2 Distribution of Measurement Points

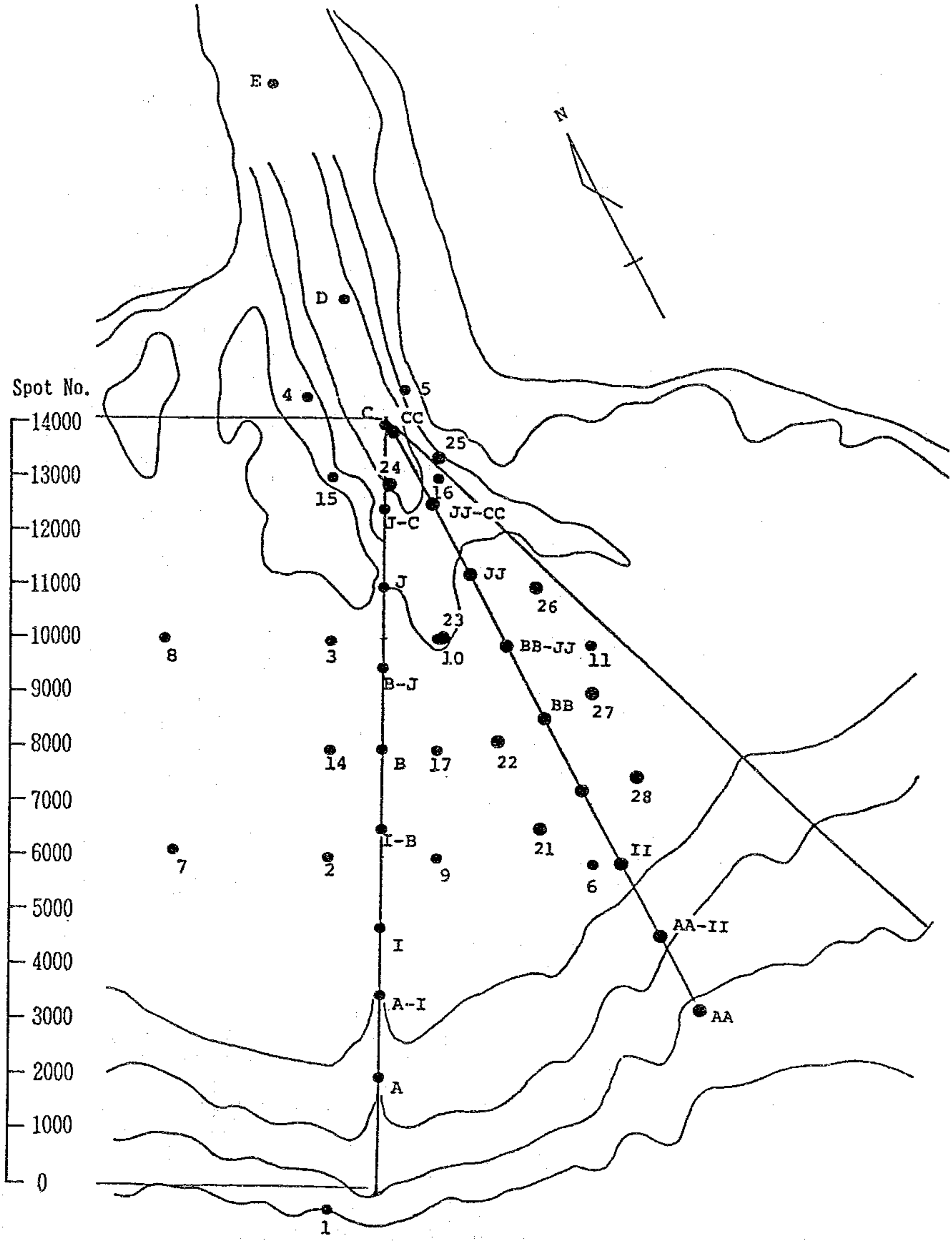


Fig. IV.1.2-3 Access Channel of Banjarmasin Port and Distribution of Current Measurement Points

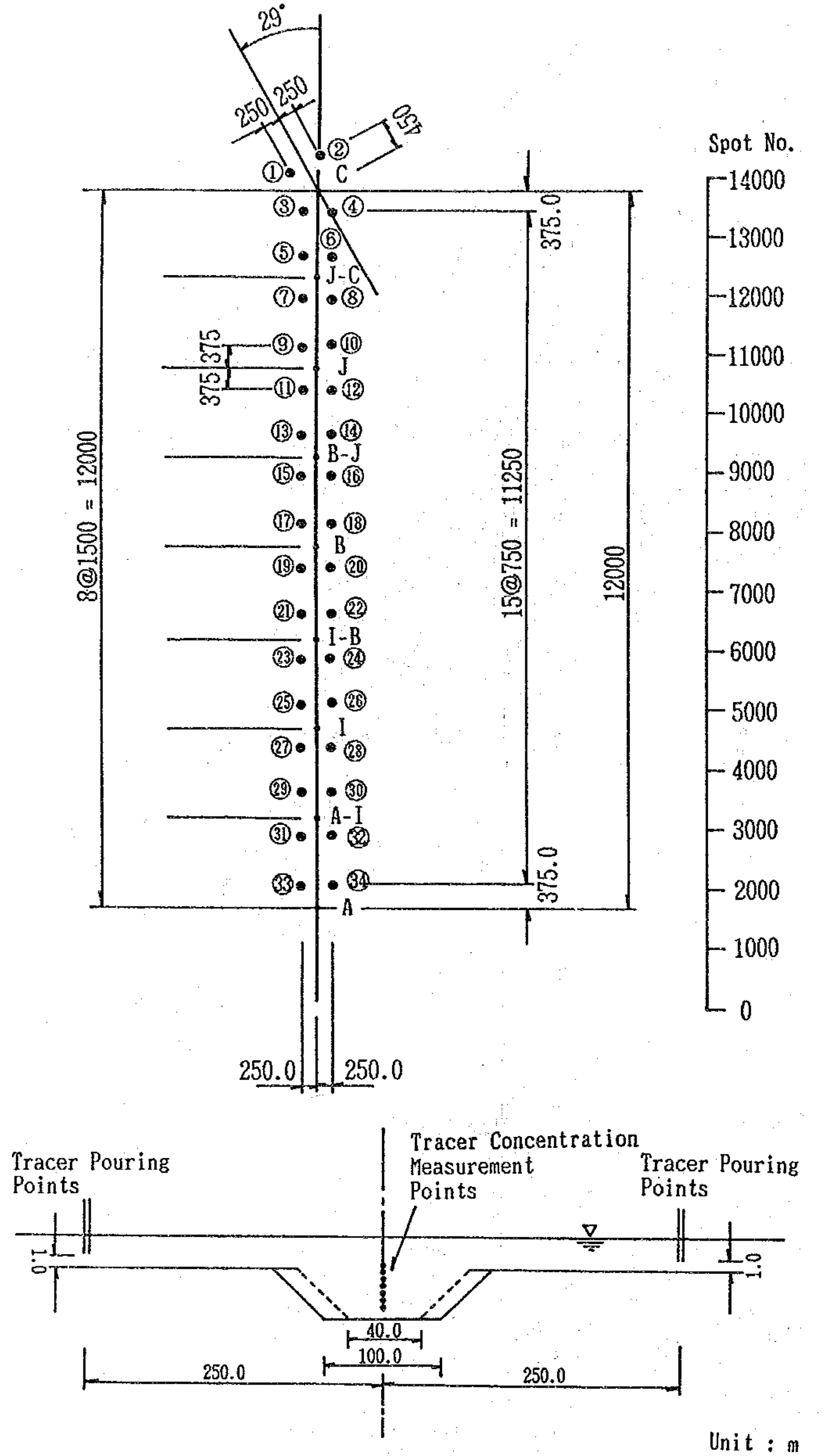


Fig. IV.1.2-4 Tracer Pouring and Concentration Measurement Points

1-2-2 Model Scale and Parameters

The horizontal and vertical scales of the model were decided on as 1/1,000 and 1/100 respectively, after taking into consideration the area to be modeled, the tide variation, river discharge and other factors such as accuracy of the model test. The model layout is shown in Fig. IV.1.2-5.

Hydraulic parameters of the model were calculated from those of the prototype based on the Froude Similitude Law as shown in Table IV.1.2-3.

Table IV.1.2-3 Parameters of Model and Prototype

Item	Prototype	Scale	Model
Horizontal Length		Lr=1/1,000	
Vertical Length		Hr=1/100	
Channel Length	14.5 km	Lr	14.5 m
Channel Depth	6.0 m	Hr	6.0 cm
Tidal Range	2.0-3.0 m	Hr	2.0-3.0 cm
Tidal Period	24 hours	$Tr=Lr/Hr^{1/2}$	14 min 24 sec
Current Velocity	1.0 m/sec	Ur=Lr/Tr	10 cm/sec
River Discharge	12,000m^3/sec	$Qr=Lr^2xHr/Tr$	12 liter/sec

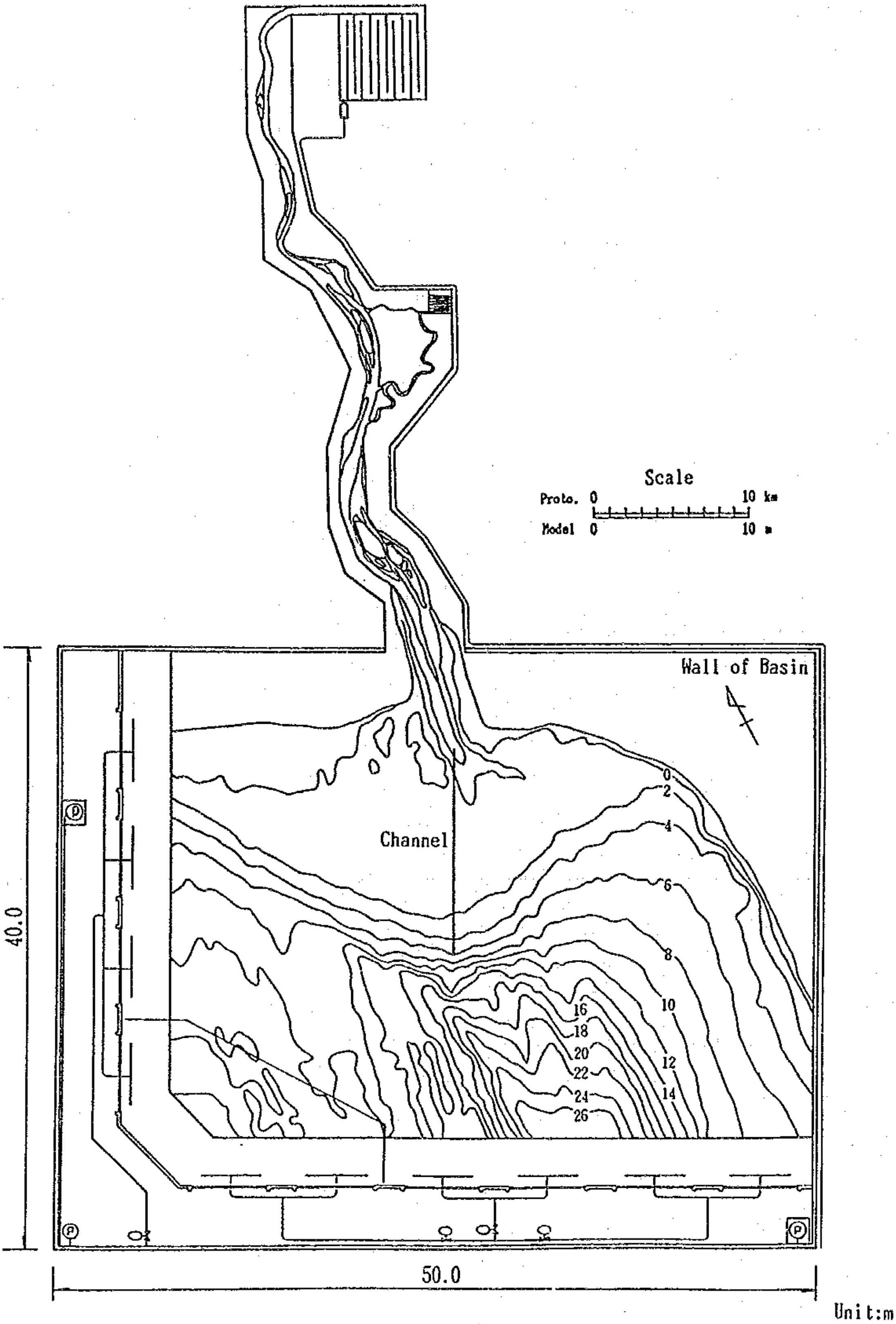


Fig. IV.1.2-5 Arrangement of Model

1-3 Test Cases

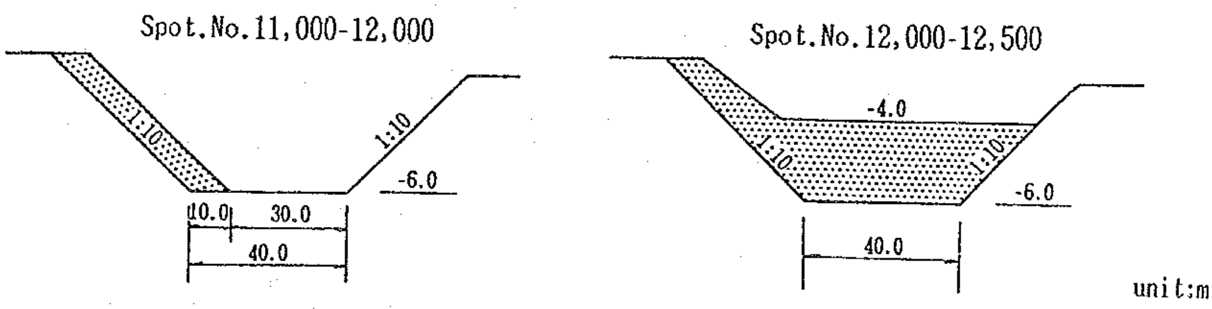
1-3-1 Present Conditions

(1) Cross Sections

Reproduction of the present conditions was undertaken for the intermission period of dredging, i.e., March to May 1989. The cross section of the channel selected was primarily -6m in depth and 40m in width, with the variations shown in Fig. IV.1.3-1:

a. Narrow upper channel (30m in width between Spot No.11,000 and 12,000), and

b. A dam at the upper channel (Spot No.12,000 to 12,500).



a. Narrow Upper Channel   b. A Dam at the Upper Channel

Fig. IV.1.3-1 Cross Sections for the Present Channel

(2) River Discharge and Tides

The average river discharge was 3,500 m^3/sec during the intermission period of dredging. In addition to this, discharges of 1,500 m^3/sec and 5,000 m^3/sec were selected to represent the dry and rainy seasons respectively.

The representative tide for the reproduction tests was decided using major components, i.e., K_1 and M_2.
The cases for the present conditions can be summarized in Table IV.1.3-1.

Table IV.1.3-1 Test Cases for the Present Condition

Case No.	River Discharge	Current Measurement	Float Tracking	Siltation Tracing	Remarks
C-1	3,500 m^3	0	0	-	Without a dam
C-2	1,500	0	0	0	
C-3	5,000	0	0	0	
C-4	1,500 m^3	0	-	0	With a dam
C-5	5,000	0	-	0	
C-6	3,500	0	-	-	

1-3-2 Improvement Plans

Various improvement plans were examined for the cases shown in Table IV.1.3-2.

Table IV.1.3-2 Test Cases for Improvement Plans

Case No.	Classification	Tide	Salt-water	River Discharge (m^3/sec)	Channel Depth and Width	Layout	Crown Height	Measurement	Float Tracking	Tracer Tracing
D1-1 D1-2 D1-3	Principal Plan	○	○	1500 5000 3500	-6m, 100m	—	—	Current Salinity	○	○
D2-1 D2-2	Long Jetty	○	○	1500 5000	-6m, 100m	Length:6km	MWL+0.45m	Current Salinity	○	○
D3-1 D3-2	Submerged Wall (3)	○	○	1500 5000	-6m, 100m	(West, East) Spot No. 2,000-10,500	1.0m above Sea Bed	Current Salinity	—	○
D4-1 D4-2	Submerged Wall (1)	○	○	1500 5000	-6m, 100m	(West, East) Spot No. 3,000-9,000	1.0m above Sea Bed	Current Salinity	○	○
D5-1 D5-2	Submerged Wall (2)	○	○	1500 5000	-6m, 100m	(West, East) Spot No. 3,000-9,000	2.0m above Sea Bed	Current Salinity	○	—
D6-1 D6-2	Jetty + Submerged Wall	○	○	1500 5000	-6m, 100m	Length:6km Submerged Wall (3)	MWL+0.45m 1.0m above Sea Bed	Current Salinity	—	○
D7-1 D7-2	Training Wall	○	○	1500 5000	-6m, 100m	(West) Spot No. 9,900-13,000	HWL+1.0m	Current Salinity	○	○
D8-1 D8-2	Trap	○	○	1500 5000	-6m, 170m	(West) Spot No. 4,000-13,500	—	Current Salinity	—	○
D9-1 D9-2 D9-3	New N-S Alignment (29°)	○	○	1500 5000 3500	-6m, 100m	—	—	Current Salinity	○	○
D10-1 D10-2	New Alignment (48°)	○	○	1500 5000	-6m, 100m	—	—	Current Salinity	○	○
E1-1 E1-2 E1-3	Non Continuous Submerged Wall	○	○	1500 5000 3500	-6m, 100m	(West, East) Spot No. 3,000-7,000 Spot No. 10,000-13,000	1.5m above Sea Bed	Current Salinity	○	○
E2-1 E2-2	Stage Plan (1)	○	○	1500 5000	-6m, 100m	(West, East) Spot No. 3,000-7,000 (West)Spot No. 10,000-13,000	1.5m above Sea Bed	Current Salinity	○	○
E3-1 E3-2	Stage Plan (2)	○	○	1500 5000	-6m, 100m	(West, East) Spot No. 3,000-7,000	1.5m above Sea Bed	Current Salinity	○	○

Note (West, East) : West and East Side of the Channel, (West) : West Side of the Channel

1-4 Results of Tests

1-4-1 Reproduction and Analyses of Present Conditions

(1) Tides

A comparison of the tides under the present conditions was made. Fig. IV.1.4-1 shows the actual conditions at the Pilot Station and those in the model. The curves agree with each other fairly well, although the time lag as the falling tide approaches the mean sea level is slightly off.

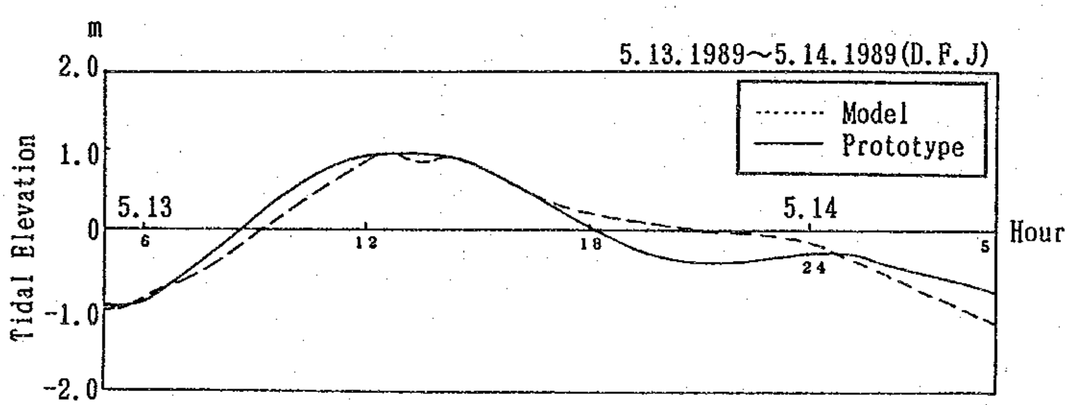


Fig. IV.1.4-1 Reproduction of Tides

(Prototype is actual tides at the Pilot Station, and Model contains K_1 and M_2 tidal component)

(2) Currents

a. Currents in the Channel

Changes of current speed for one cycle at the site and in the model were compared and are shown in Fig. IV.1.4-2 for Point J in the channel. They correspond quite well, except for the current in the surface layer during the falling tide. This reflects the effect of the limit of tidal reproduction.

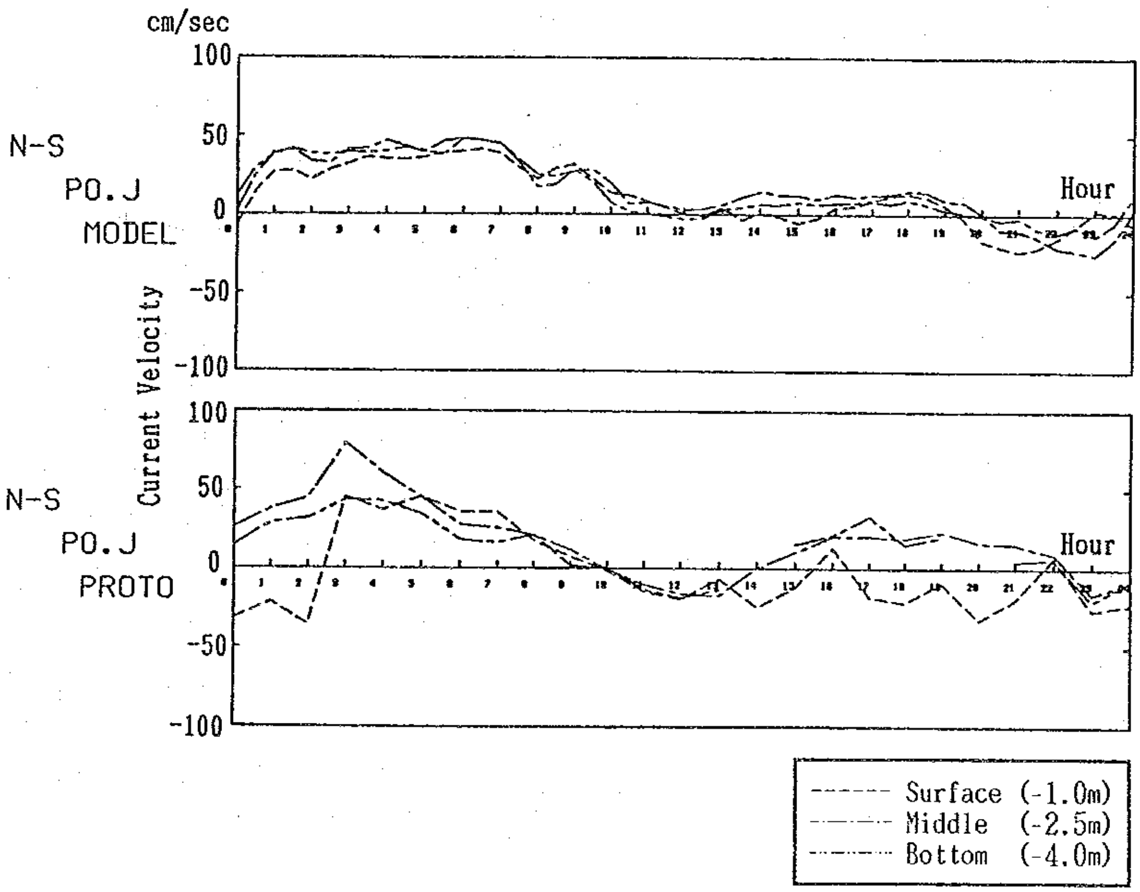


Fig. IV.1.4-2 Reproduction of Currents in the Channel (N-S Component at Point J under Discharge 3,500m^3/sec)

b. Current Ellipses on the Bank

An example of current ellipses on the bank is introduced in Fig. IV.1.4-3 both for those observed at the site and those reproduced in the model. The patterns agree with each other fairly well. Similarity of axes and roundness of ellipses at the four points, neighboring the channel center are rather poor, although the clockwise movements of current directions are well reproduced.

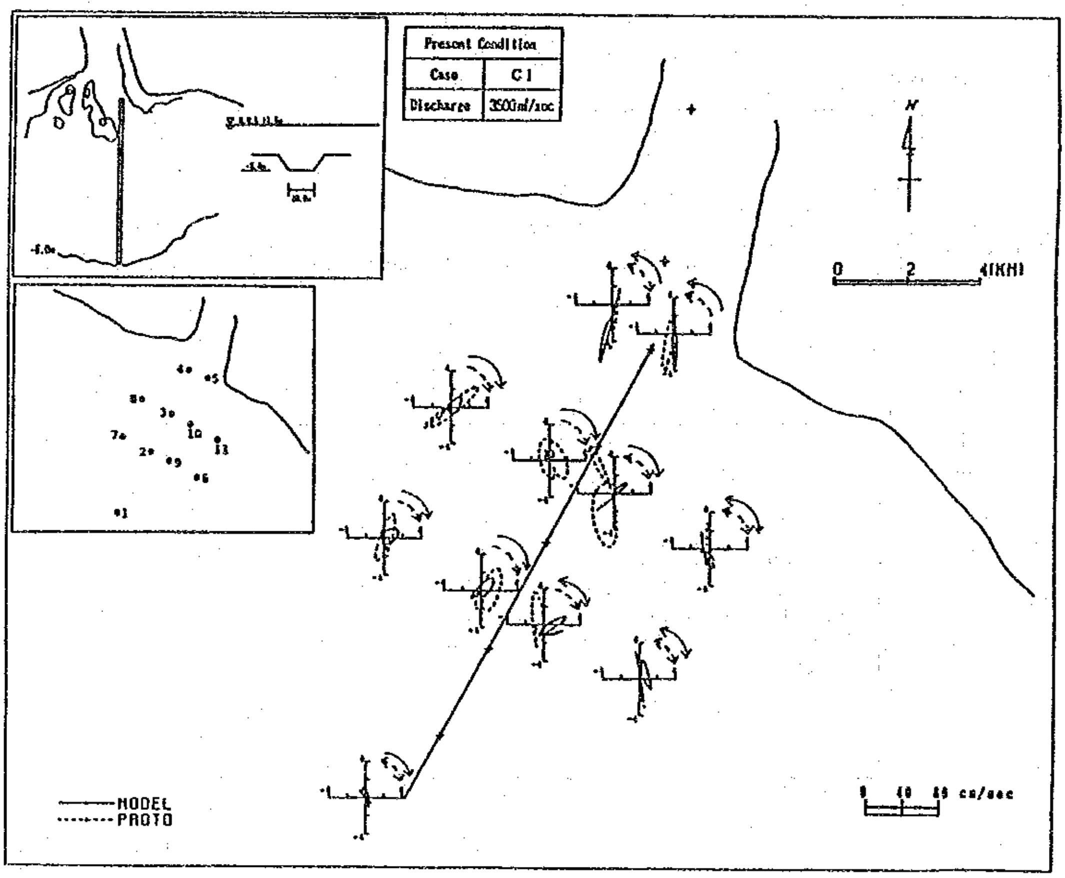


Fig. IV.1.4-3 Reproduction of Current Ellipses
(Present Conditions under a Discharge 3,500m^3/sec)

c. Surface Flow Pattern on the Bank

The surface current vectors measured at various points on the bank in the model are illustrated in Fig. IV.1.4-4 for the times of maximum flood and ebb currents. The latter corresponds very well to the results obtained in the float tracking surveys on the site as already presented in Fig. II.2.3-3. The current velocities during the ebb tide also coincide sufficiently between the model tests and field survey as shown in Fig. IV.1.4-5. The characteristics are, during ebb current, deviation in the main stream to the center of the east bank and the existence of a recrossing current over the channel in the offshore area. During flood currents, the current vectors are toward the river mouth and, generally, in a clockwise direction.

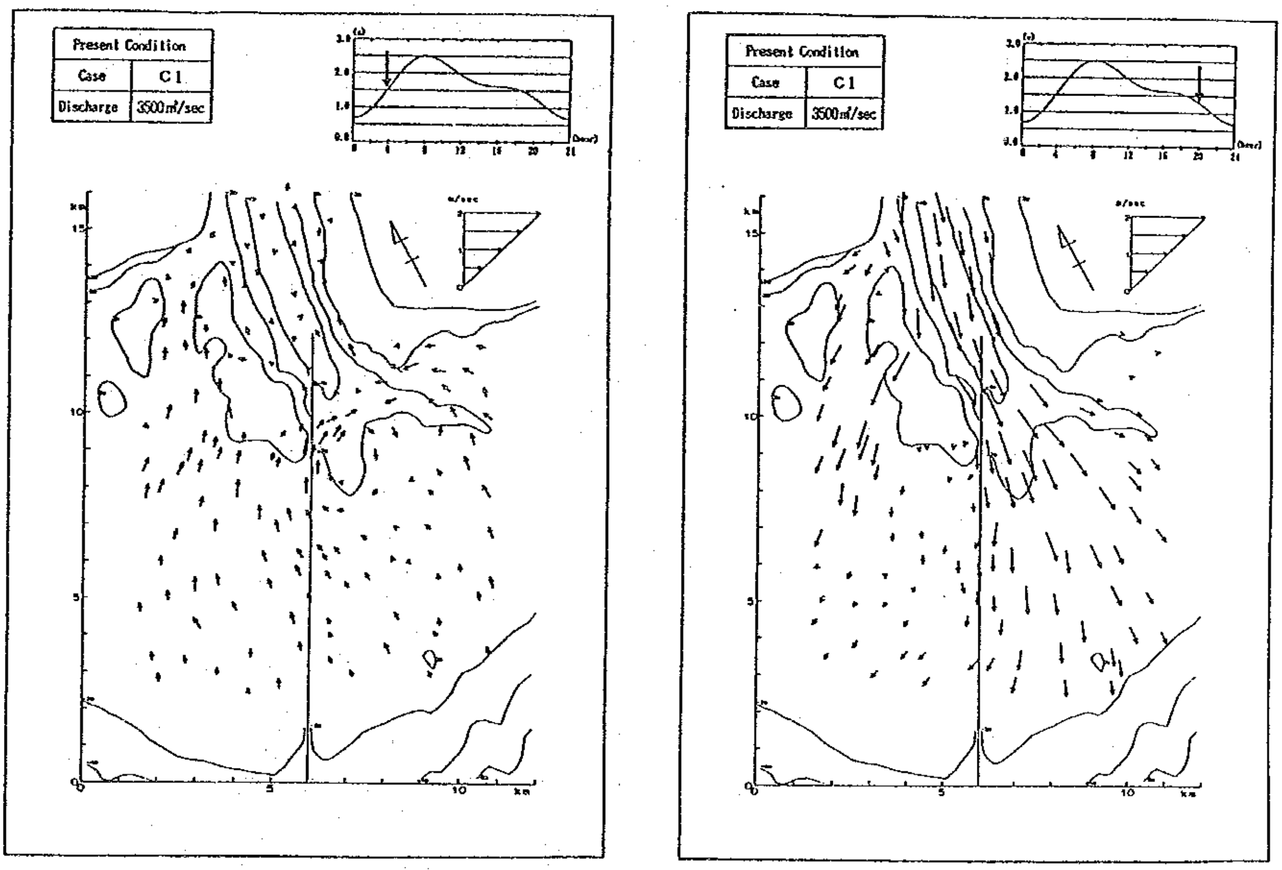


Fig. IV.1.4-4 Surface Flow Pattern for Present Conditions

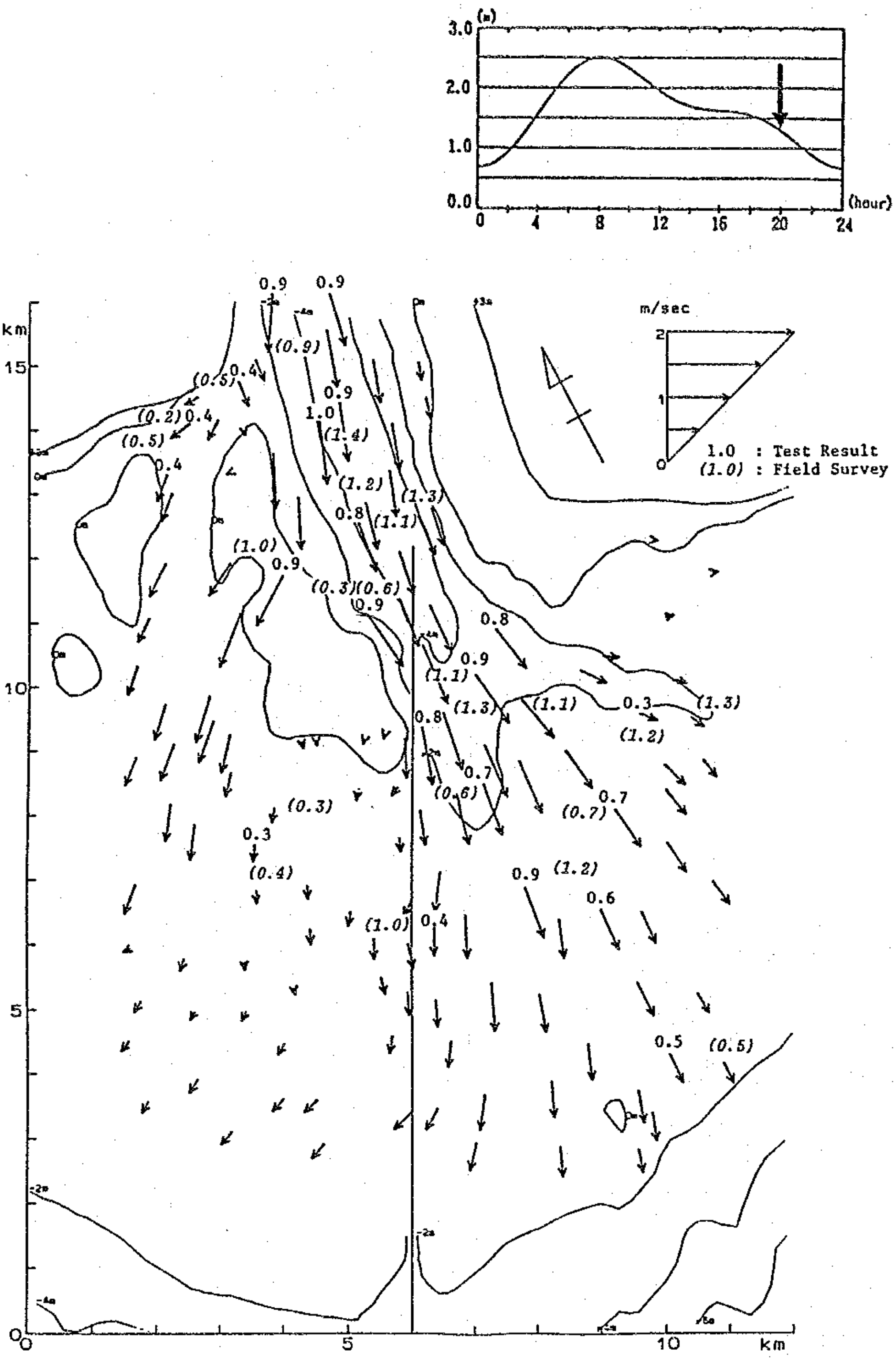
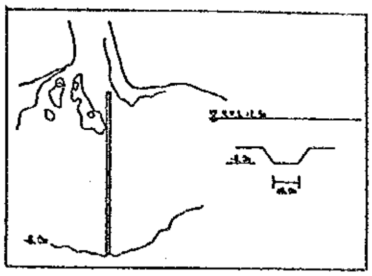


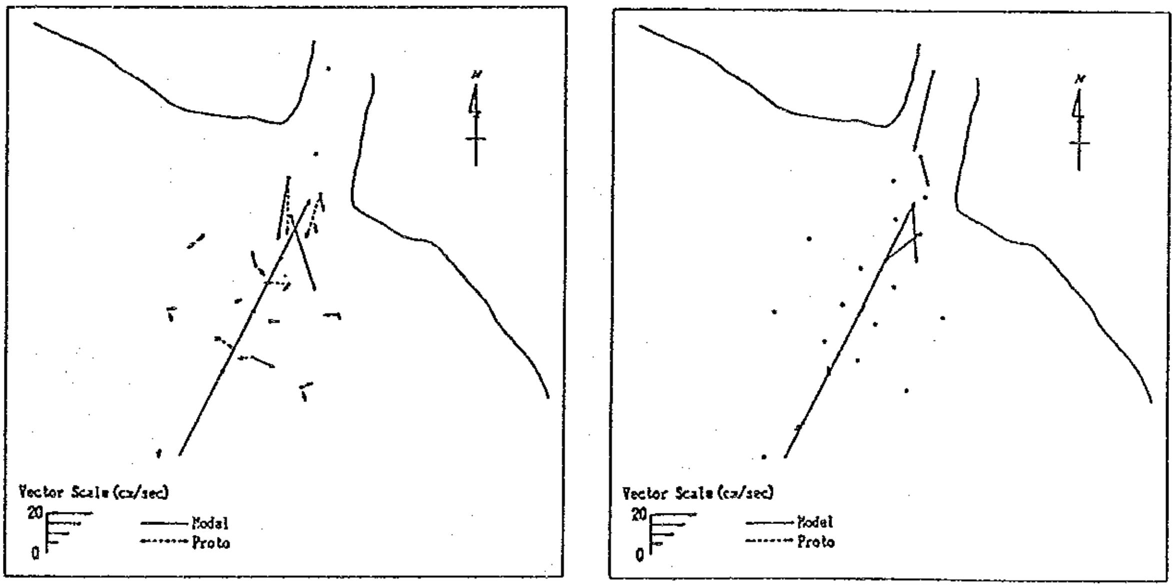
Fig. IV.1.4-5 Surface Current Velocity in the Field and Test

d. Average Velocity

The average current velocities in the model over one tidal cycle were calculated and compared with those observed at the site. The results are in Fig. IV.1.4-6. The agreement on the bank is not always very good. One of the most interesting facts is that the directions of the current at Points B and J in the channel are to the upstream. This coincides with the result of the site survey introduced in the results of the field survey.



Present Condition	
Case	C1
Discharge	3500m³/sec



a. On the bank

b. In the Channel

Fig. IV.1.4-6 Average Velocity Distribution
(Case C-1, Discharge 3,500m^3/sec)

(3) Salinity Change and Saline Wedge

Model experiments were performed with salt water in the sea and fresh water from the river. The resultant salinity changes are examined and an example is introduced in Fig. IV.1.4-7. The effect of salt water is broader in terms of duration of time for the model than for the site, specifically in the upper and middle layers.

Fig. IV.1.4-8(1) shows details on the relative water depth when 10°/oo and 20°/oo salinities were observed in the field survey for various locations. The tip of the saline wedges reach as far as location F and even H in the dry season and location C up to E in the rainy season.

The results of the model tests are shown in Fig. IV.1.4-8(2). The model test saline wedges obtained coincide well with field data.

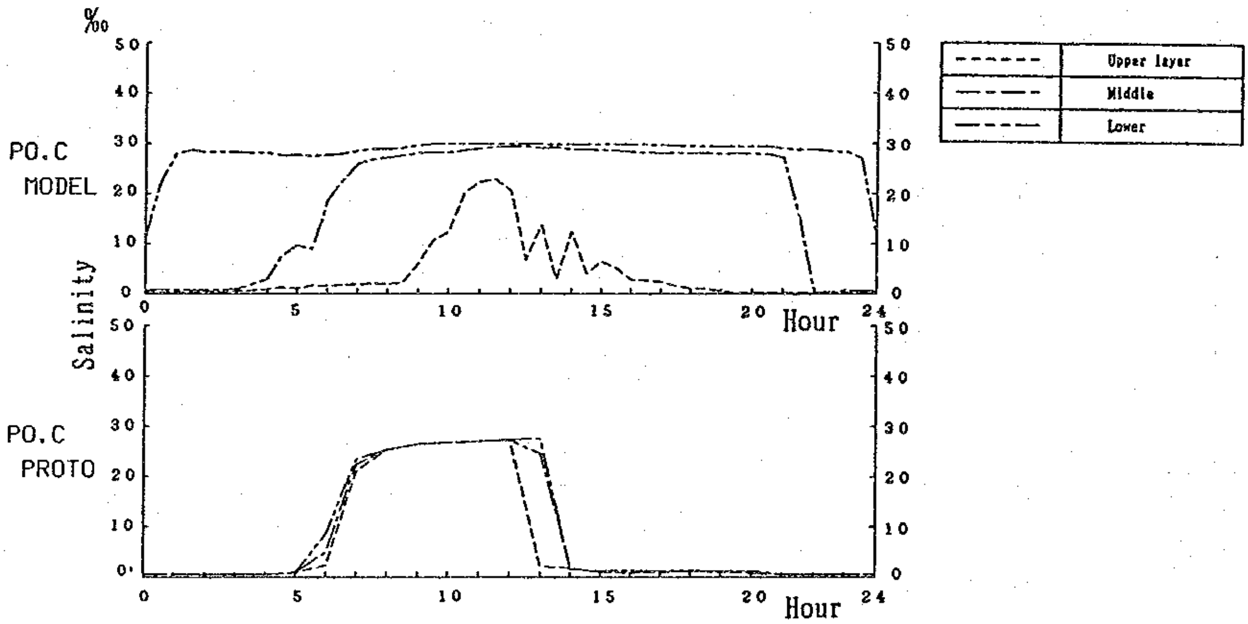
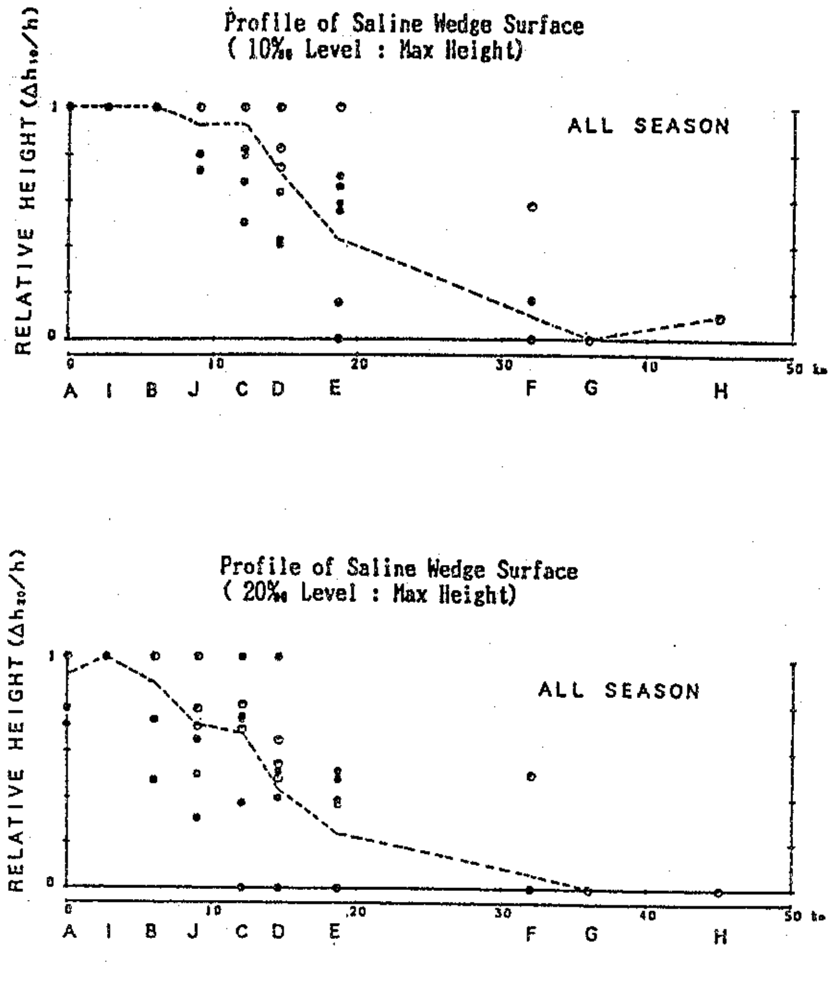
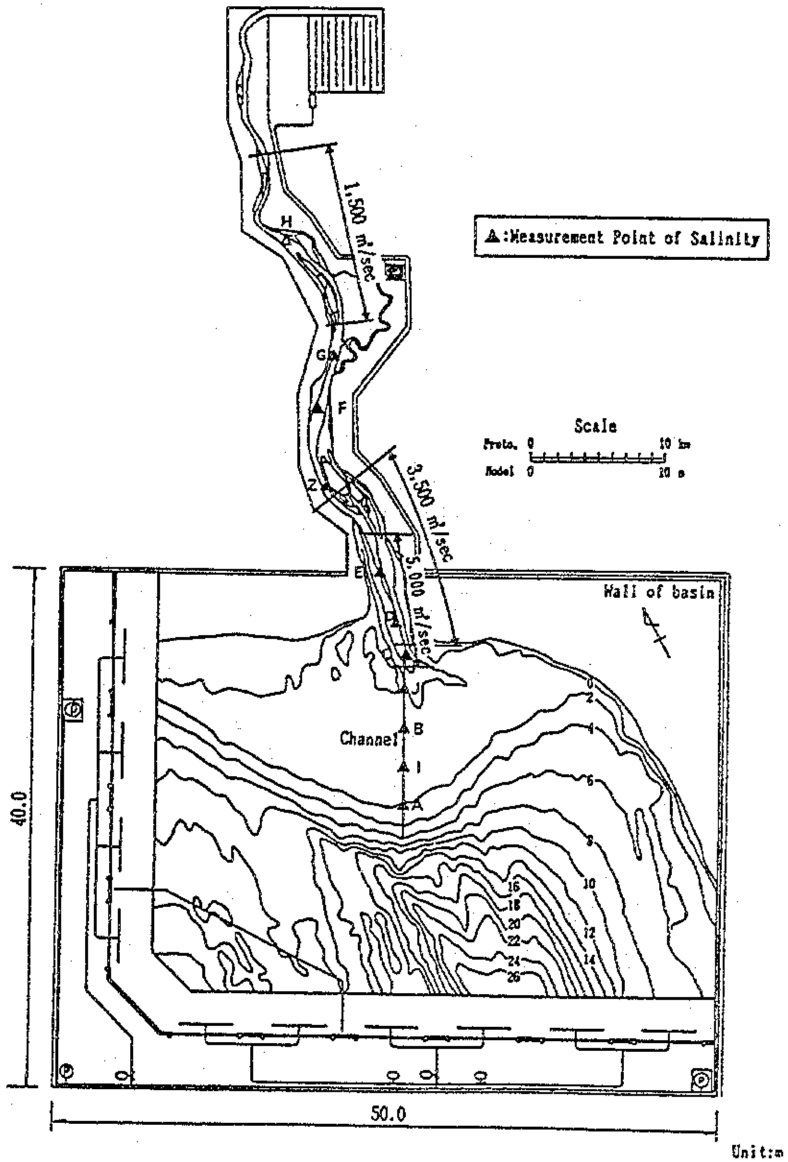


Fig. IV.1.4-7 Reproduction of Salinity Change
(at Point C under Discharge 3,500m^3/sec)



(1)Prototype



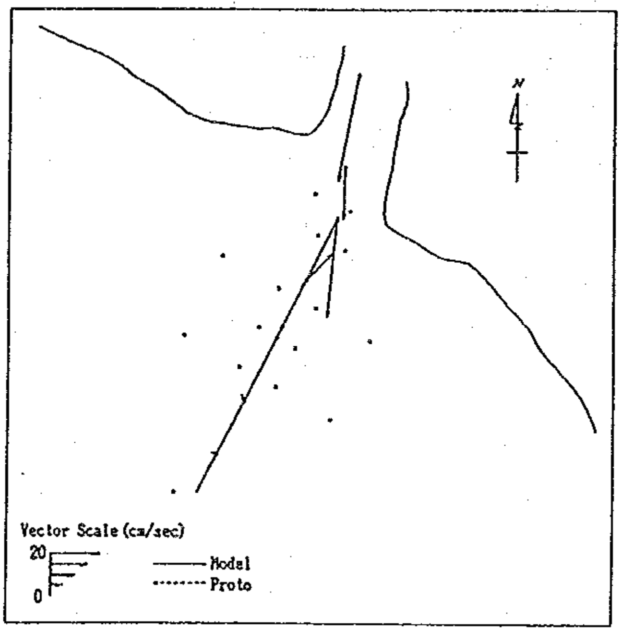
(2)Model

Fig. IV.1.4-8 Results of Saline Wedge Measurement

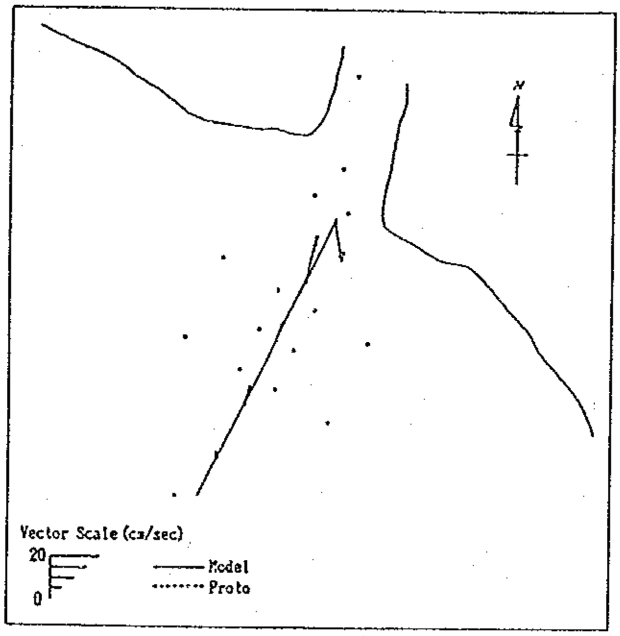
(4) Effect of a Dam on the Current in the Channel

It was anticipated that, once a dam had formed in the vicinity of Spot No.12,300 in the channel, conditions of flow and siltation behind the dam would be affected to a certain extent. Here, the effect of such the dam is evaluated in terms of change in average velocity in the channel. The result is presented in Fig. IV.1.4-9 for cases of discharge of 5,000 m^3/sec with and without the dam.

It became clear that, after the formation of a dam, the down-stream current speed at Point C (or at the inlet of the channel) would decrease quite a deal, and the upstream currents at other points in the channel would increase considerably.



a. Without a dam (Case C-3)



b. With a dam (Case C-5)

Fig. IV.1.4-9 Effect of a Dam on the Average Velocity in the Channel (Discharge 5,000m^3/sec)

(5) Tracer Concentration in the Channel

The concentration of accumulated tracer in the channel was measured for the with- and without- dam cases, and the results are shown in Fig. IV.1.4-10.

The concentration becomes highest at Point I-B(or near Spot No.6,500) and lowest at both ends of the channel in the without- dam case. When a dam was placed at Spot No.12,000 to 12,500, the concentration at downstream Point J (Spot No.11,000) increased noticeably and marked the highest level.

This result clarified the situation of sedimentation observed downstream of the dam during the field survey.

One of the most characteristic results of the model experiments was that the concentration decreased with increase in the river discharge. This phenomenon occurred because of the nature of the model tests which were undertaken in a flow domain without any waves and with a tracer which is salt water of the same concentration i.e. 5% for both cases.

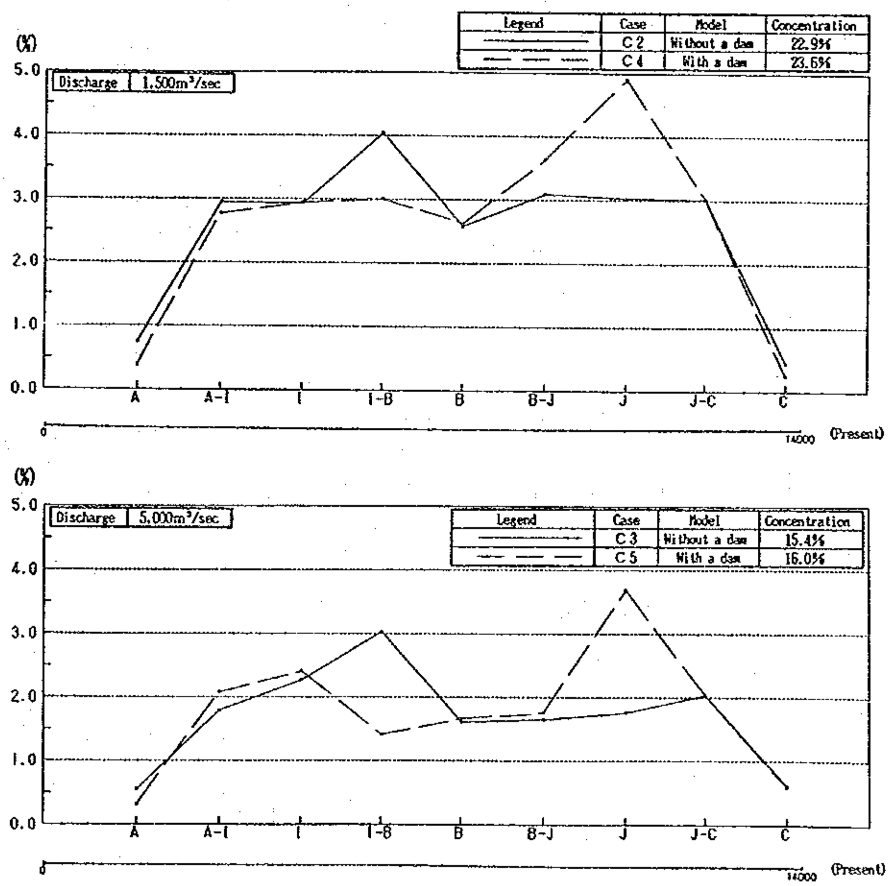


Fig. IV.1.4-10 Concentration of Tracer in the Channel

1-4-2 Results of Test on Improvement Plans

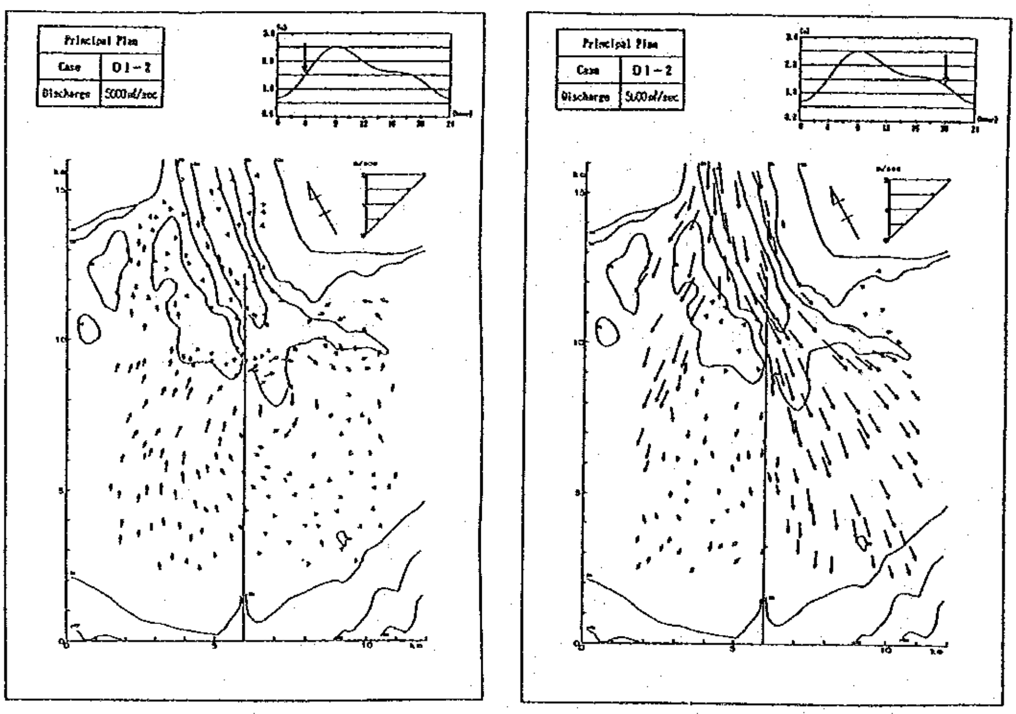
(1) Flow Pattern

The surface flow patterns measured in the model are presented in Fig. IV.1.4-11.

In the case of the Principal Plan with an expanded width of 100m, there was no substantial difference of pattern from the present conditions on the bank.

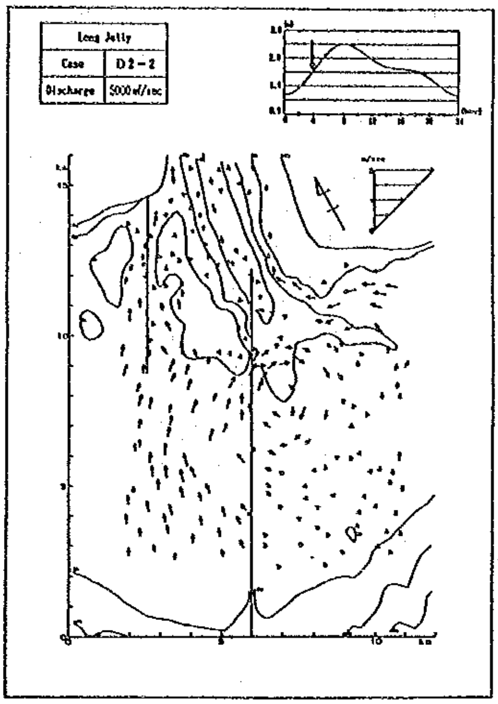
In the case of the long jetty, the direction of currents during falling current was streamlined along the jetty. The current speeds in the downstream area on the west bank increased considerably, compared with cases under present conditions. In addition, the currents in the shadowed area to the west of the jetty became stagnated.

In the case of the short submerged wall with a height of 1m, there was no significant difference from the present conditions on the bank.

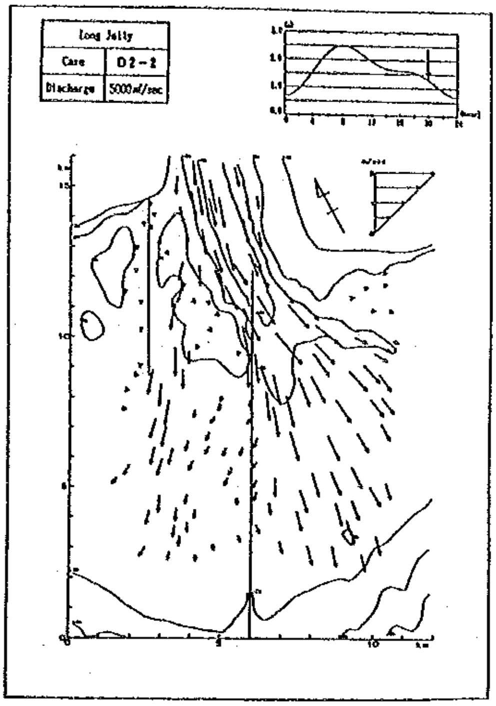


a. Flood Current b. Ebb Current

Fig. IV.1.4-11 (1) Surface Flow Pattern (Principal Plan)

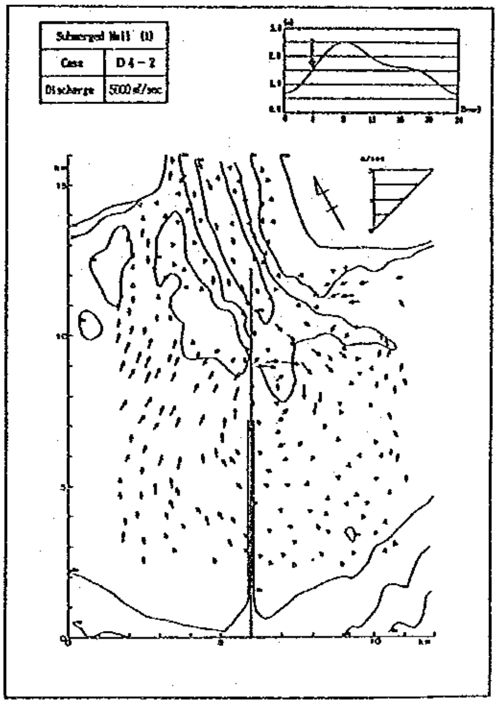


a. Flood Current

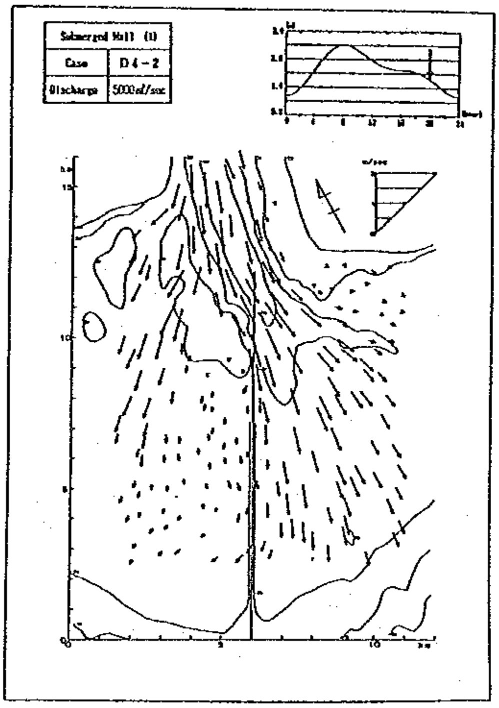


b. Ebb Current

Fig. IV.1.4-11 (2) Surface Flow Pattern (Long Jetty)



a. Flood Current

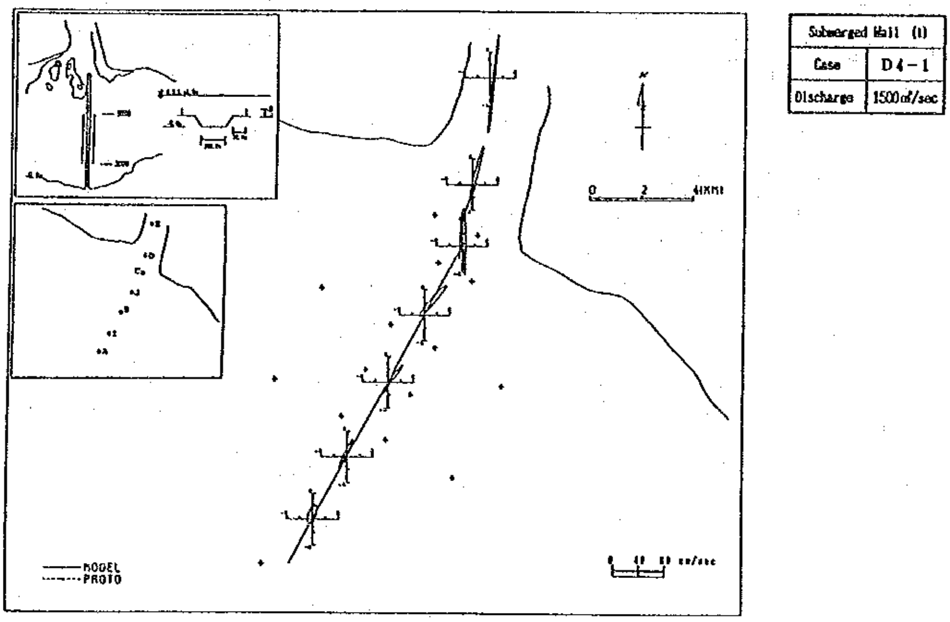


b. Ebb Current

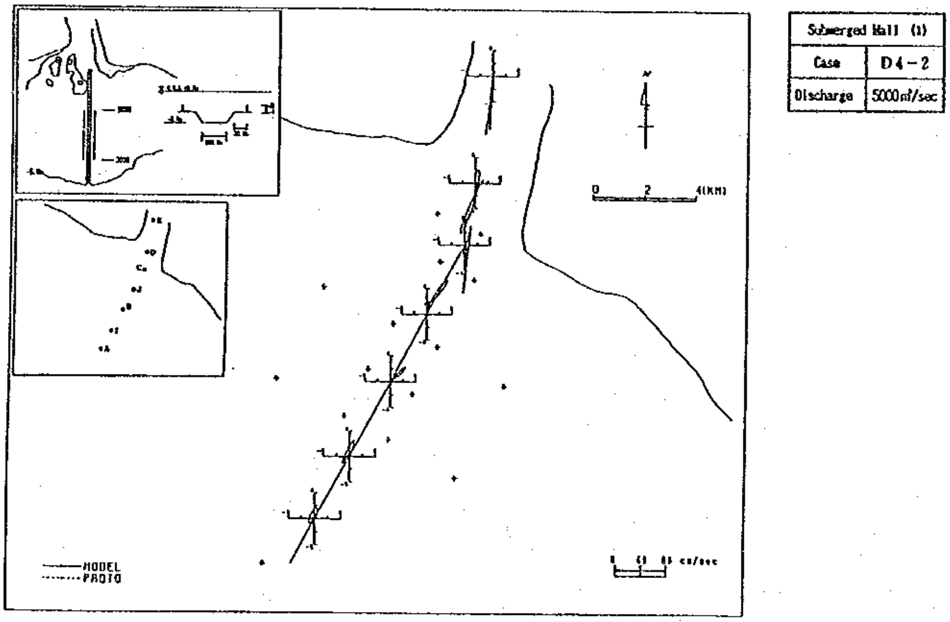
Fig. IV.1.4-11 (3) Surface Flow Pattern (Submerged Wall (1))

(2) Current Ellipses in the Channel

When submerged walls were installed on both sides parallel to the channel, the current directions in the part surrounded by the walls were well-confined in the direction of the channel. This was confirmed by the results in Fig. IV.1.4-12.



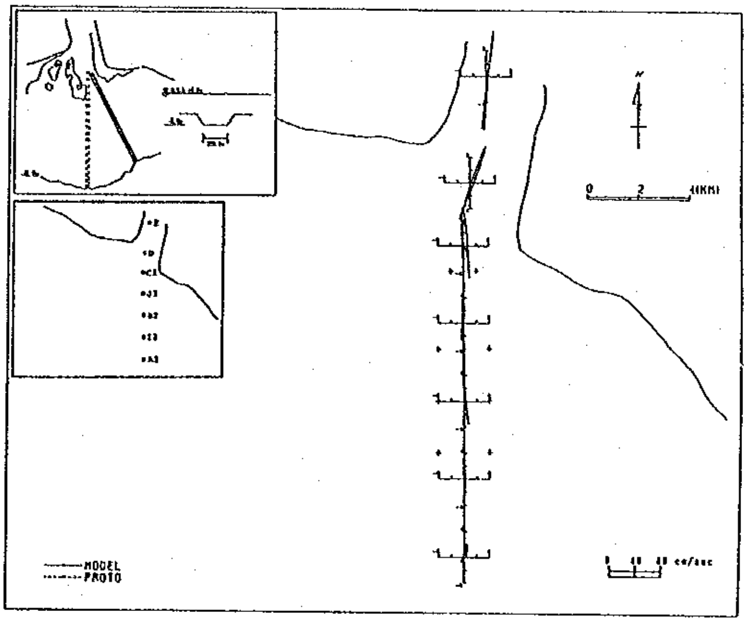
a. Discharge 1,500m^3/sec (Case D4-1)



b. Discharge 5,000m^3/sec (Case D4-2)

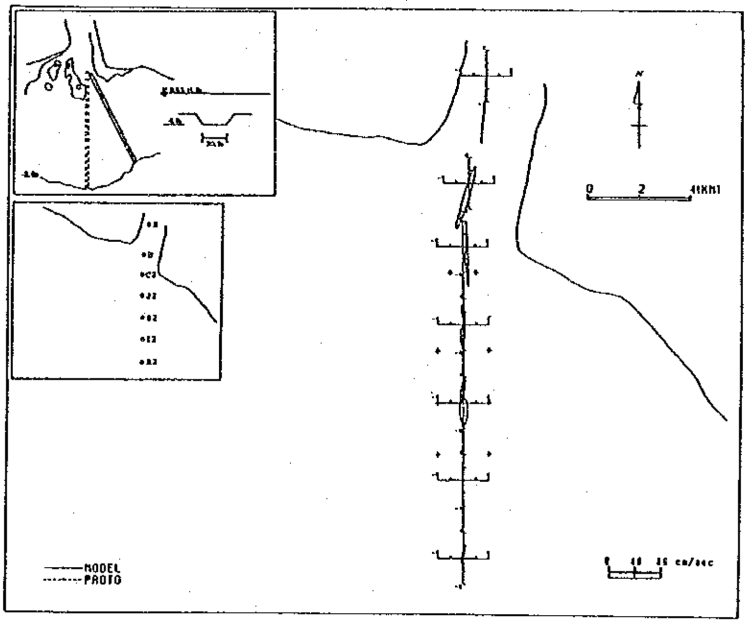
Fig. IV.1.4-12(1) Current Ellipses in the Channel (Submerged Wall (1))

The current ellipses in the new aligned N-S channel were also predominantly parallel to the channel direction as seen in Fig. IV.1.4-12(2). This was as expected when the relocation plans in Fig. III.2.4-2 were proposed.



New N-S Alignment 29°	
Case	D9-1
Discharge	1500m³/sec

a. Discharge 1,500m^3/sec (Case D9-1)



New N-S Alignment 29°	
Case	D9-2
Discharge	5000m³/sec

b. Discharge 5,000m^3/sec (Case D9-2)

Fig. IV.1.4-12(2) Current Ellipses in the Channel(New Alignment (1))

(3) Average Currents

The results of the average current vector distribution measurements are illustrated in Fig. IV.1.4-13.

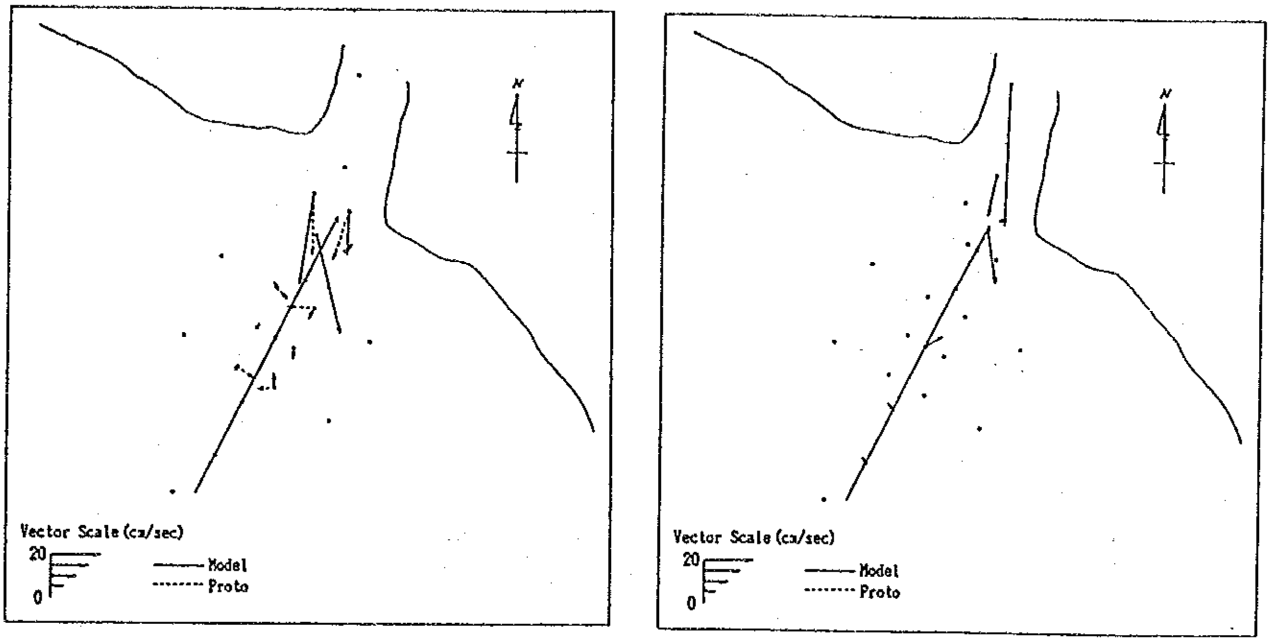
In the channel, the upstream average currents always appeared at Points J and B. Once structures such as the long jetty and submerged wall were introduced, the average current at Point I also turned to the upstream direction.

In the cases of submerged walls, long jetty + submerged walls (3), training wall and trap, the average current directions and velocities were all upstream and similar in magnitude.

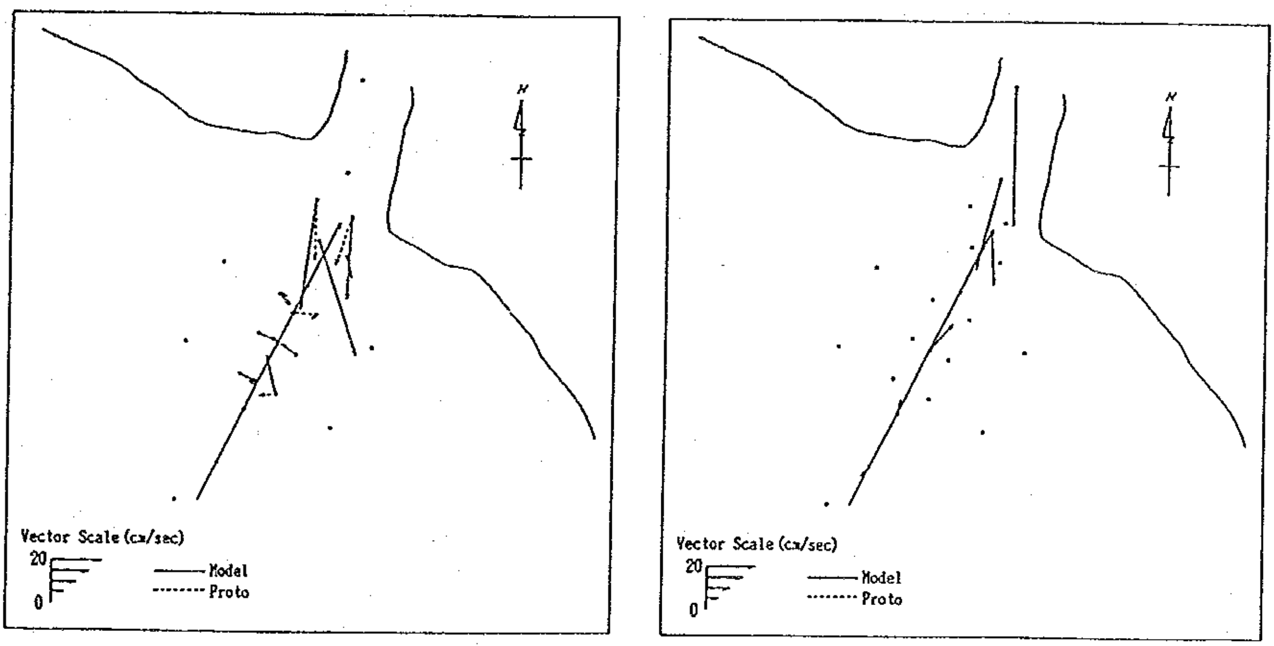
In the area neighboring the channel, there was no significant change in the pattern from the construction of countermeasure structures, except for the case of the jetty in where the directions tended toward the channel.

A special case was the new alignment. Again the directions of average currents were all upstream except for the inlet or Point CC. The magnitudes were rather small compared with the other cases for the present channel conditions.

The differences in average current resulting from structure type are shown in Fig. IV.1.4-14 with respect to the upper, middle and bottom layers.

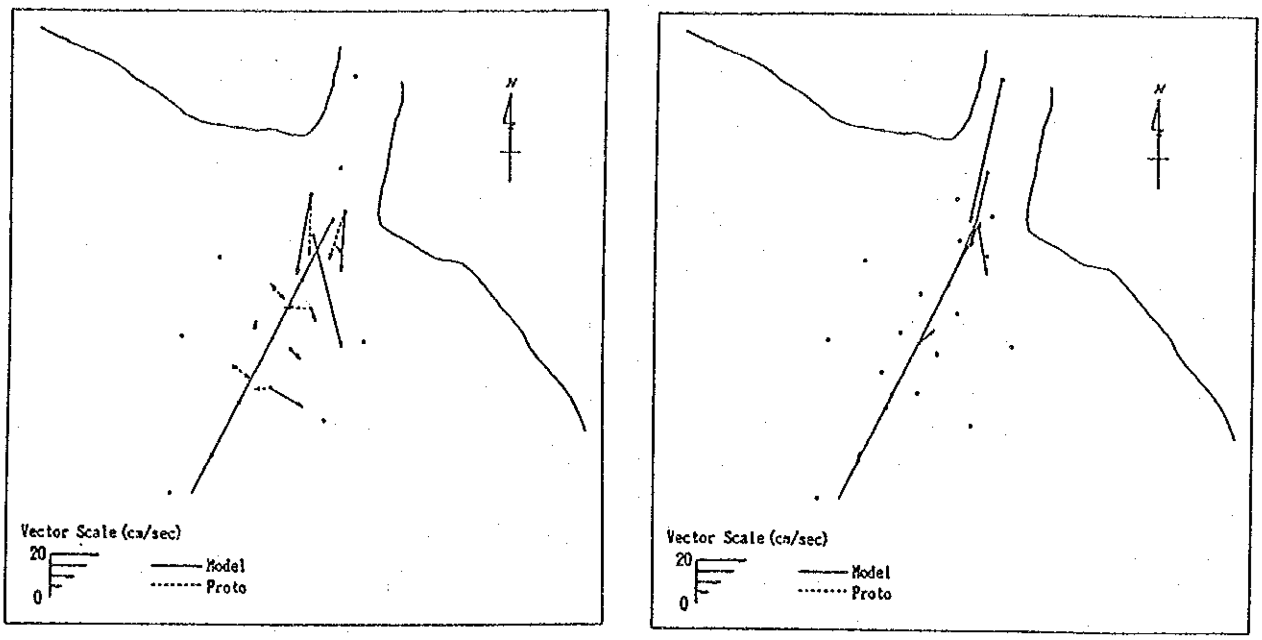


a. Principal Plan (Case D1-2)

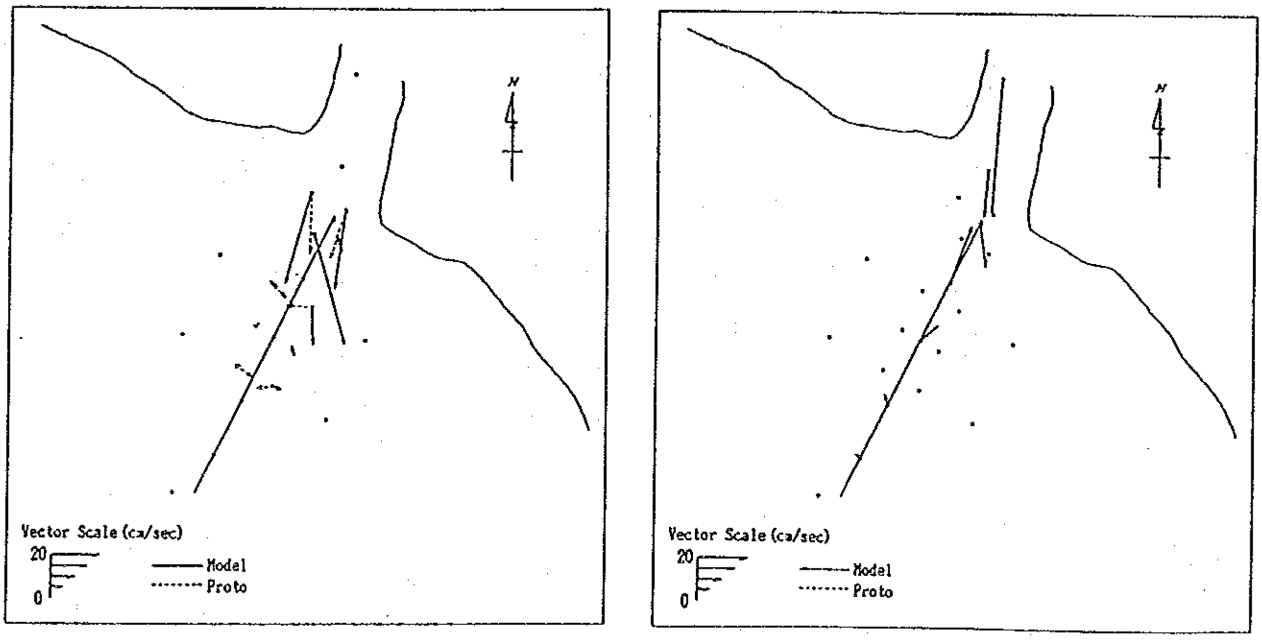


b. Long Jetty (Case D2-2)

Fig. IV.1.4-13(1) Average Current Vector (Discharge 5,000m^3/sec)

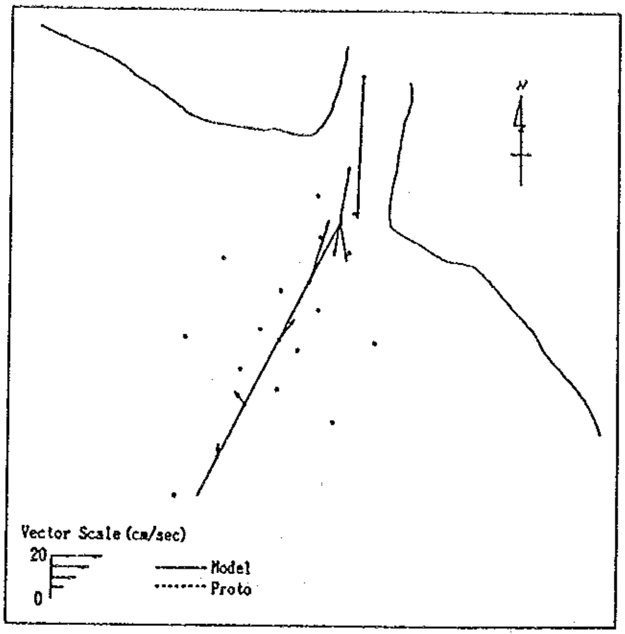


a. Long Submerged Wall (Case D3-2)

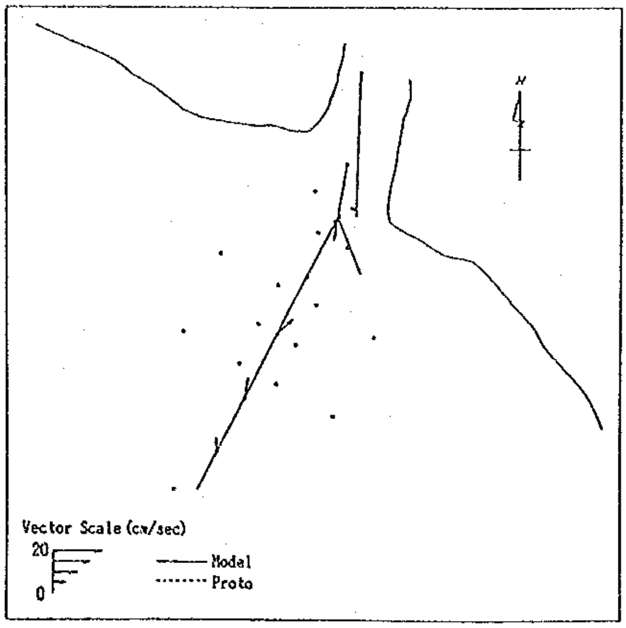


b. Short Submerged Wall (Case D4-2)

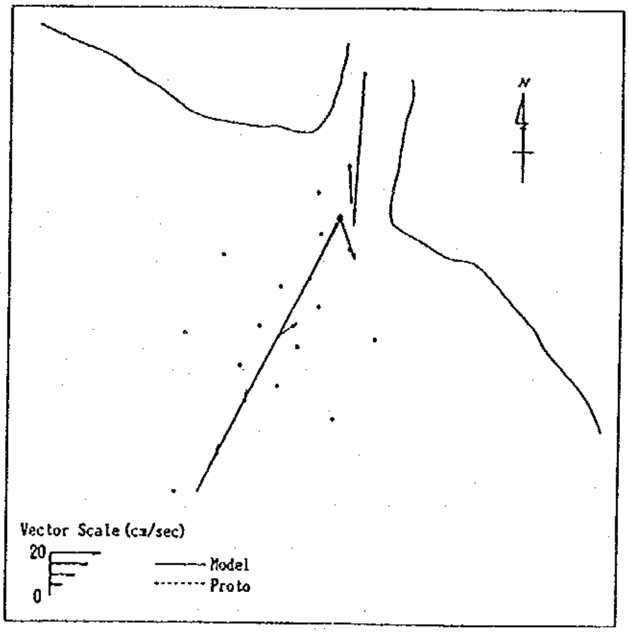
Fig. IV.1.4-13(2) Average Current Vector (Discharge 5,000m^3/sec)



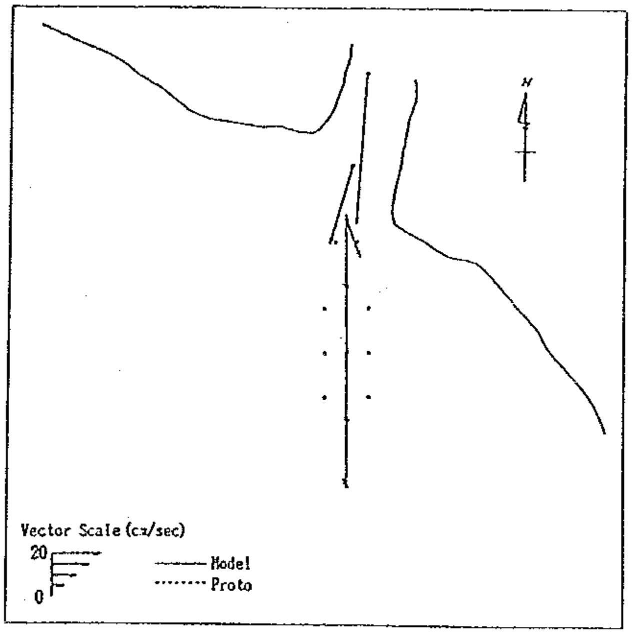
a. Jetty + S.W.(3) (Case D6-2)



b. Training Wall (Case D7-2)



c. Trap (Case D8-2)



d. New Alignment (Case D9-2)

Fig. IV.1.4-13(3) Average Current Vector (Discharge 5,000m^3/sec)

Under the present conditions, the directions of the average current at Points I, B, J and C were all toward the upstream direction (plus current in the figure), except for that found in the surface layer at Point C or the inlet. At Point A or the outlet, the directions were all to the offshore, and the deeper the layer, the higher the speed was.

In the channel, upstream average currents always appeared at Point J and B. The upstream current was especially strong at Point J. The average currents at Point A and I located in the offshore area were weak approaching zero. In the case of the submerged wall, the average currents at Points A and I were among the smallest. It is interesting that the pattern of the New Alignment showed a slightly lower velocity than that of the Principal Plan for the present channel.

(4) Concentration of Tracer in the Channel

The concentration of the tracer measured in the Principal Plan

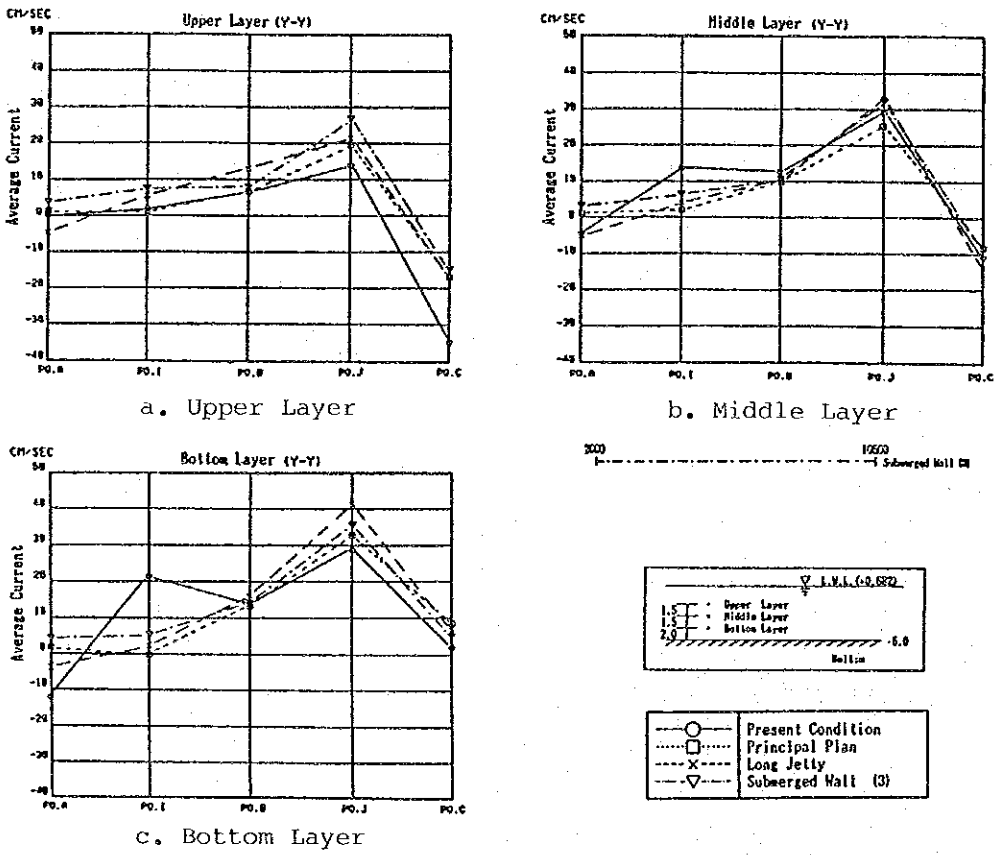
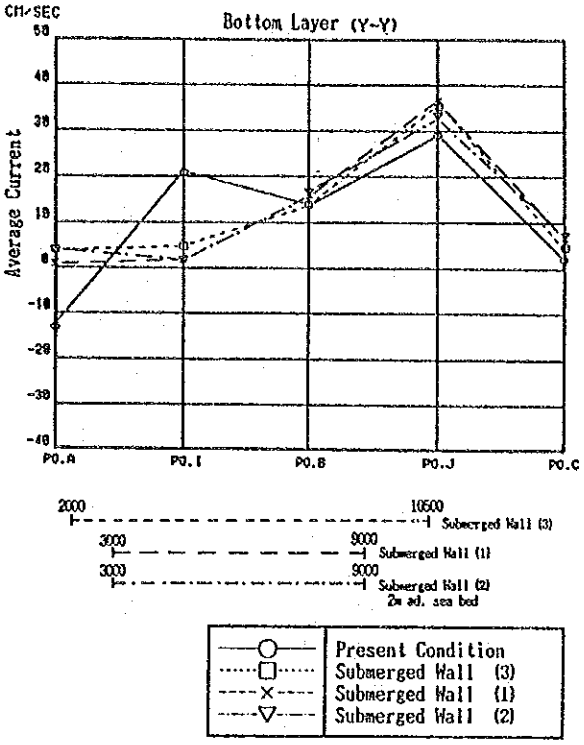
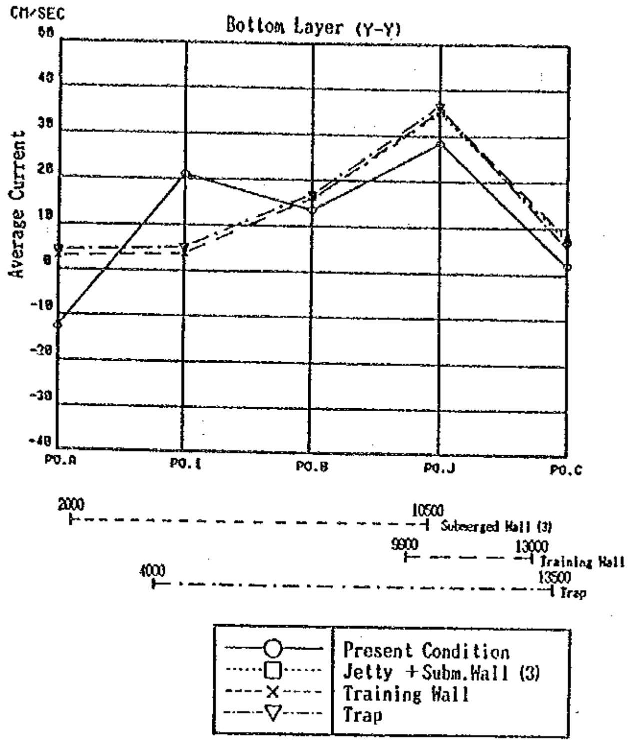
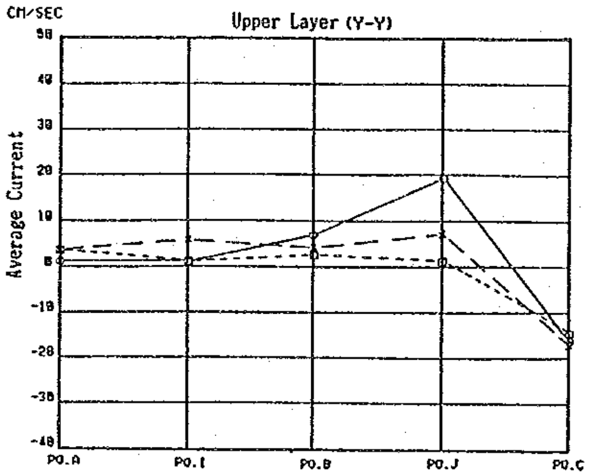


Fig. IV.1.4-14(1) Change of Average Current in the Channel
(Discharge 5,000m^3/sec)

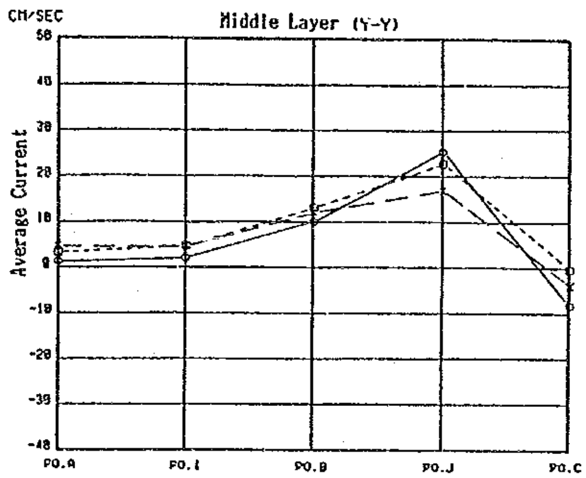




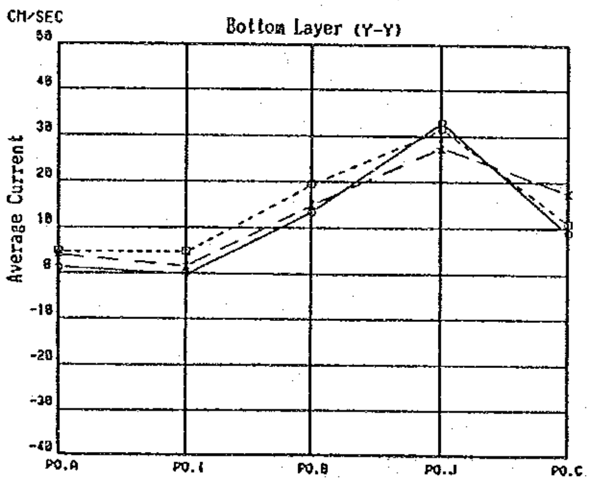
Bottom Layer



a. Upper Layer



b. Middle Layer



c. Bottom Layer

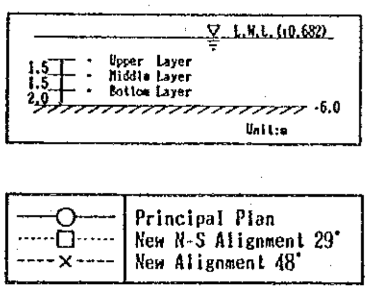


Fig. IV.1.4-14(2) Change of Average Current in the Channel

(Discharge 5,000m^3/sec)

(widened channel) is shown in Fig. IV.1.4-15(1) together with the present channel concentration. As the values shown in the figure are tracer concentration per unit area, the total concentration accumulated in the channel should be discussed taking the channel width into account. The channel width of the Principal Plan was 2.5 times the present channel width adopted in the model test. The measured concentration of the Principal Plan therefore should be multiplied by 2.5 to effectively compare the total concentration with the present channel. This leads to a sedimentation volume for the Principal Plan of about 1.1 times the present volume as shown in the figure.

A comparison is made in Fig. IV.1.4-15(2) on the differences in concentration of tracer accumulated in the channel among the cases for the Principal Plan and submerged walls.

First, it is significant that there was a decrease in concentration after constructing the submerged wall compared with the Principal Plan. On top of this, the walls eliminated the most important phenomenon in the present conditions, i.e., the extraordinary accumulation of tracer at Point I-B.

Second, the overall concentration distribution decreased with increase in river discharge for all the cases. This reflects the nature of the flow-domain experiment and salt water tracer as well as the constant tracer injection rate.

A similar comparison is presented in Figs. IV.1.4-15(3) and (4) for the other countermeasures such as the Long Jetty, Training Wall and Trap plans. Each plan showed a considerable decrease of concentration at Point I-B although this increased at Point A-I. In the Trap plan, the widened area which would function as a sedimentation trap was taken into account when comparing the effectiveness with other countermeasures.

The results for the cases of New Alignment (1) and (2) are shown in Fig. IV.1.4.-15(5). One of the most interesting results was the case of New Alignment(1) of which the concentration distribution was among the smallest.

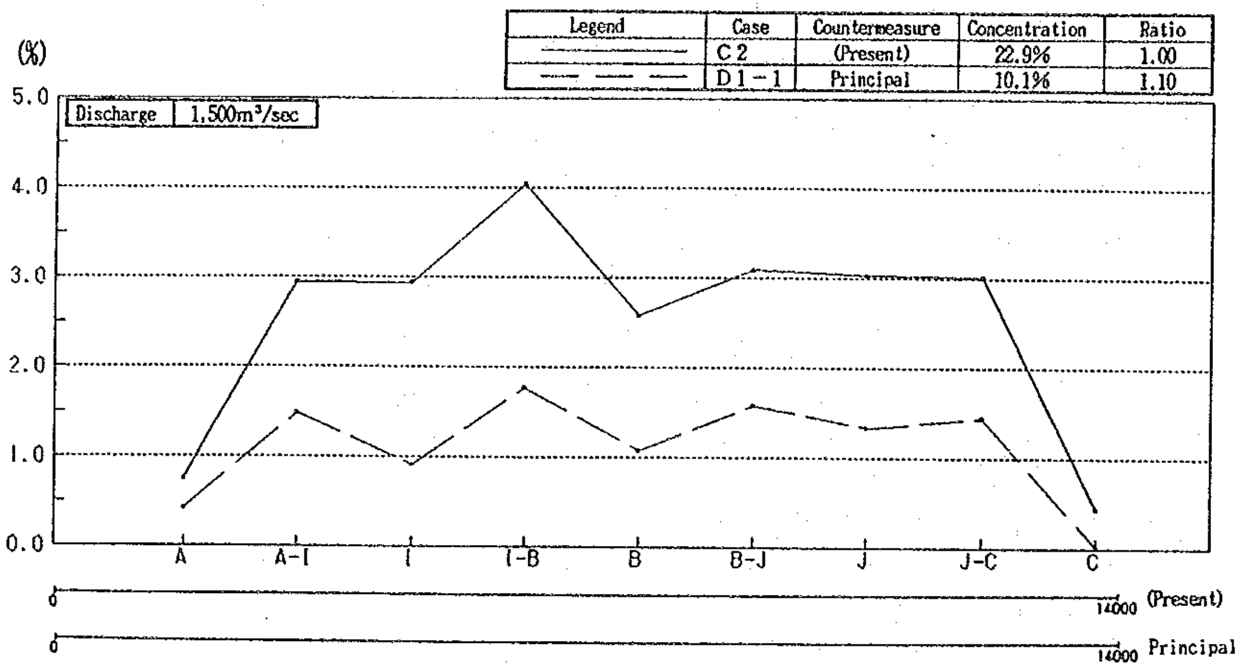
As the results of tracer experiments depended largely on the sea bottom topography surrounding the access channel, future changes in the sea bottom had to be considered especially with regard to the New Alignment.

The stage construction plans for the Submerged Wall Plan were examined and the results are shown in Fig. IV.1.4-15(6).

Additional tests were carried out for the average river discharge(3,500m^3/sec) in order to obtain supplementary data to examine the relationship between the tracer concentration and river discharge. The test results are shown in Fig. IV.1.4-15(7). Tracer concentrations in the channel were reduced inversely proportion to the river discharge indicating that the larger the river discharge, the less the tracer concentration accumulated in the channel. This changed linearly with river discharge and was the result of the characteristics of the tracer behavior under current action together with constant supply method. The tracer was subject to diffusion due to the turbulent current as it was supplied in the sea bottom of the model. On top of this, different sediment loads occurred depending on the river discharge in the field.

The results obtained in the model tests proved useful in examining the relative effectiveness of the countermeasure structures in comparisons with the Principal Plan for the same river discharge and assisted estimation of the siltation volume.

The non-continuous submerged wall reduced the amount of tracer in the channel to 0.73, 0.61 and 0.3 for 1,500, 3,500 and 5,000m^3/sec river discharge respectively compared with the Principal Plan. It was noticed that the larger the river discharge was i.e. the faster the current velocity, the higher the submerged wall effectiveness became. The test results showed that the reduction rate of tracer concentration by the non-continuous submerged wall was about 60% in comparison with the Principal Plan in the average situation.



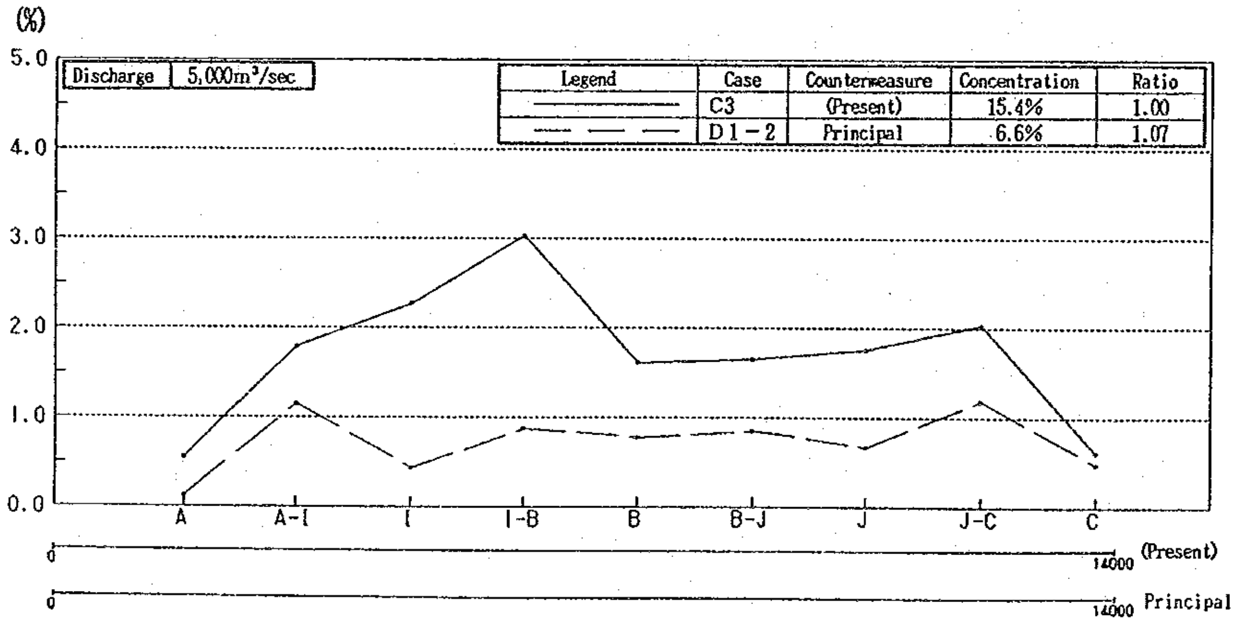
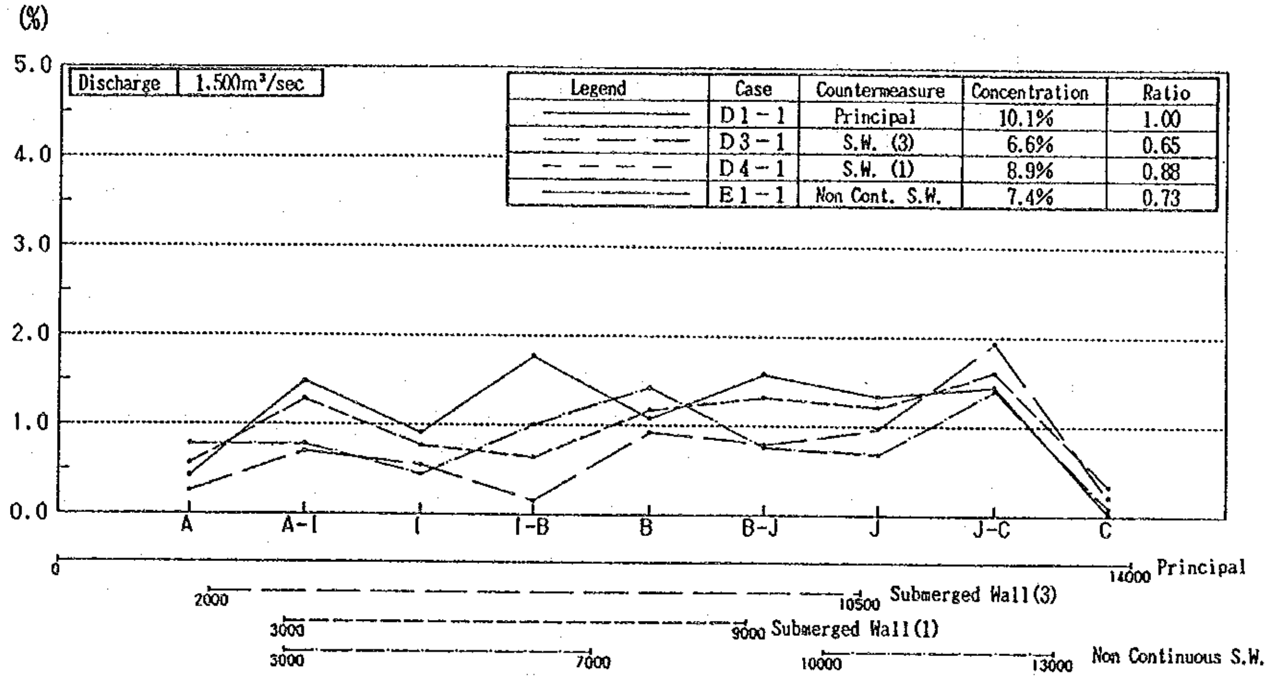
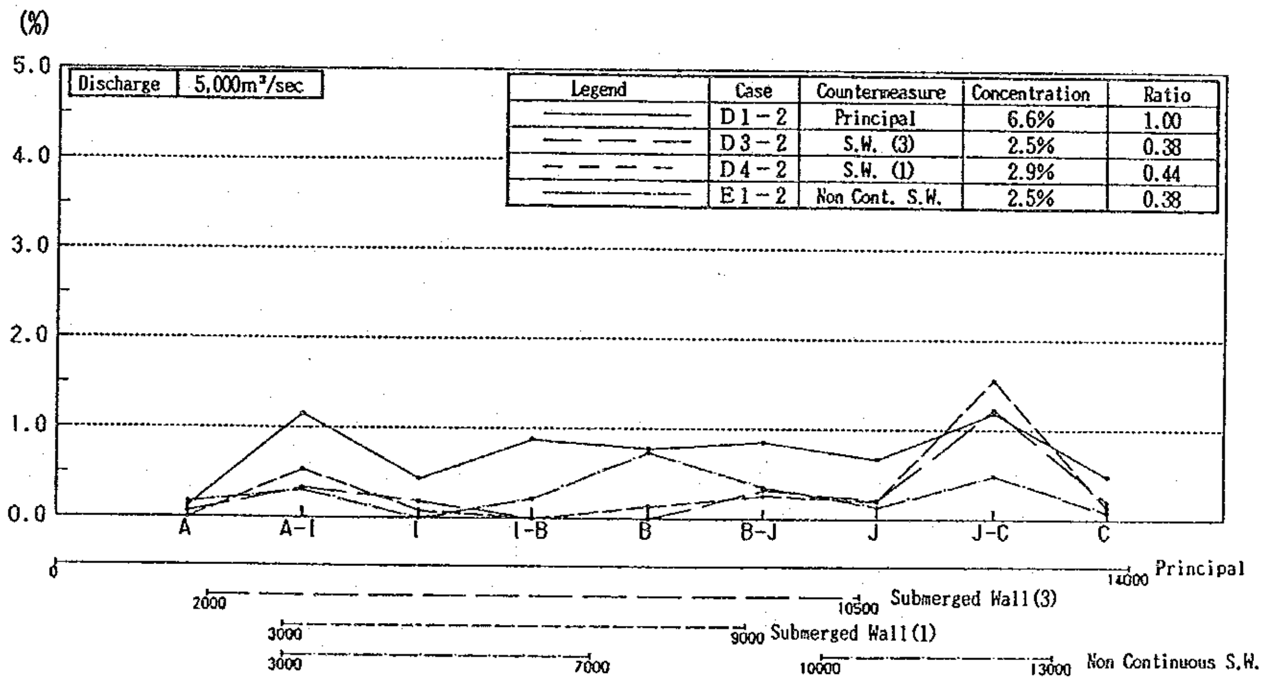


Fig. IV.1.4-15(1) Concentration of Tracer in the Bottom Layer of the Channel

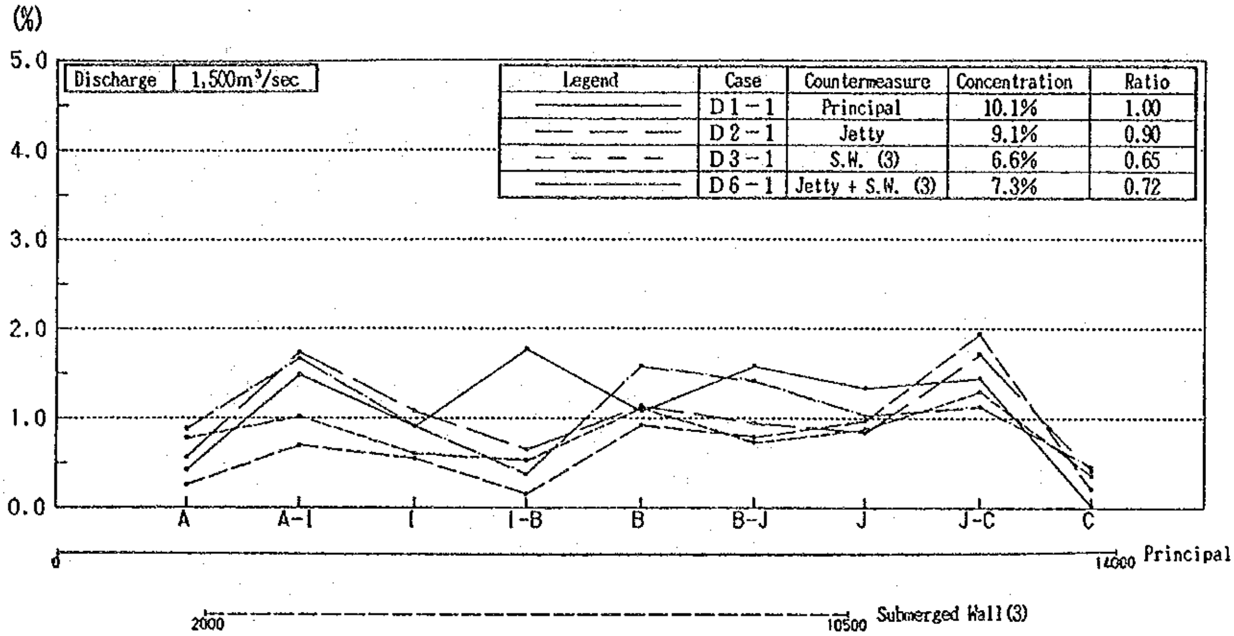


Legend	Case	Countermeasure	Concentration	Ratio
————	D1−1	Principal	10.1%	1.00
— — —	D3−1	S.W. (3)	6.6%	0.65
− − − −	D4−1	S.W. (1)	8.9%	0.88
—·—·—	E1−1	Non Cont. S.W.	7.4%	0.73



Legend	Case	Countermeasure	Concentration	Ratio
————	D1−2	Principal	6.6%	1.00
— — —	D3−2	S.W. (3)	2.5%	0.38
− − − −	D4−2	S.W. (1)	2.9%	0.44
—·—·—	E1−2	Non Cont. S.W.	2.5%	0.38

Fig. IV.1.4-15(2) Concentration of Tracer in the Bottom Layer of the Channel



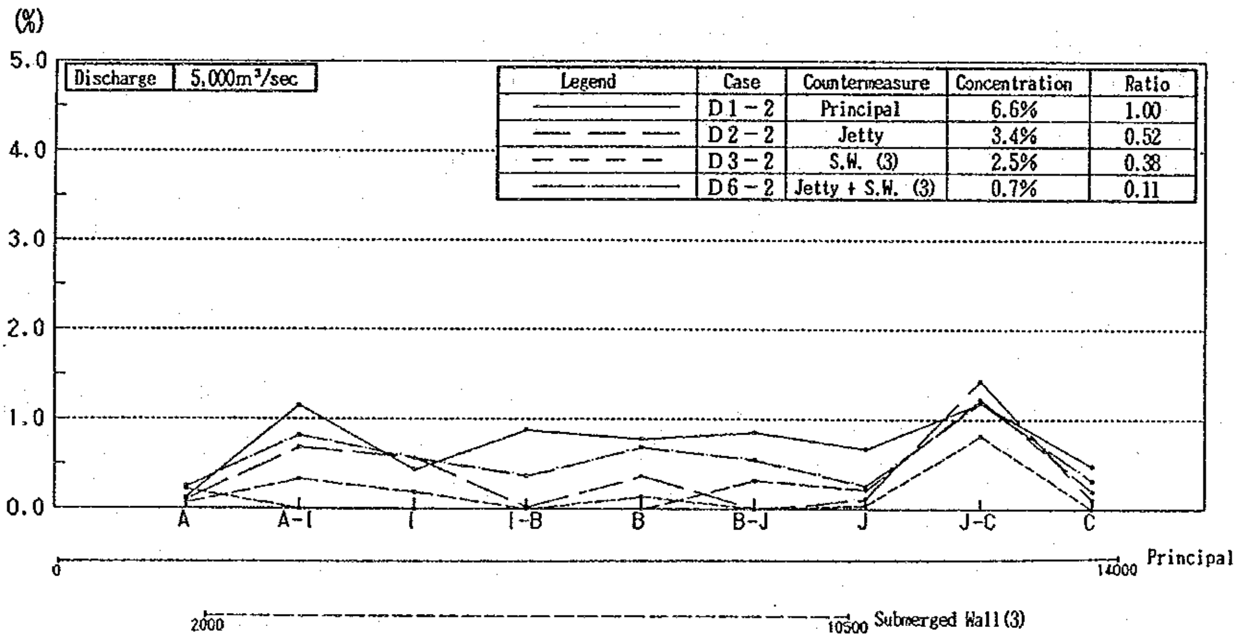
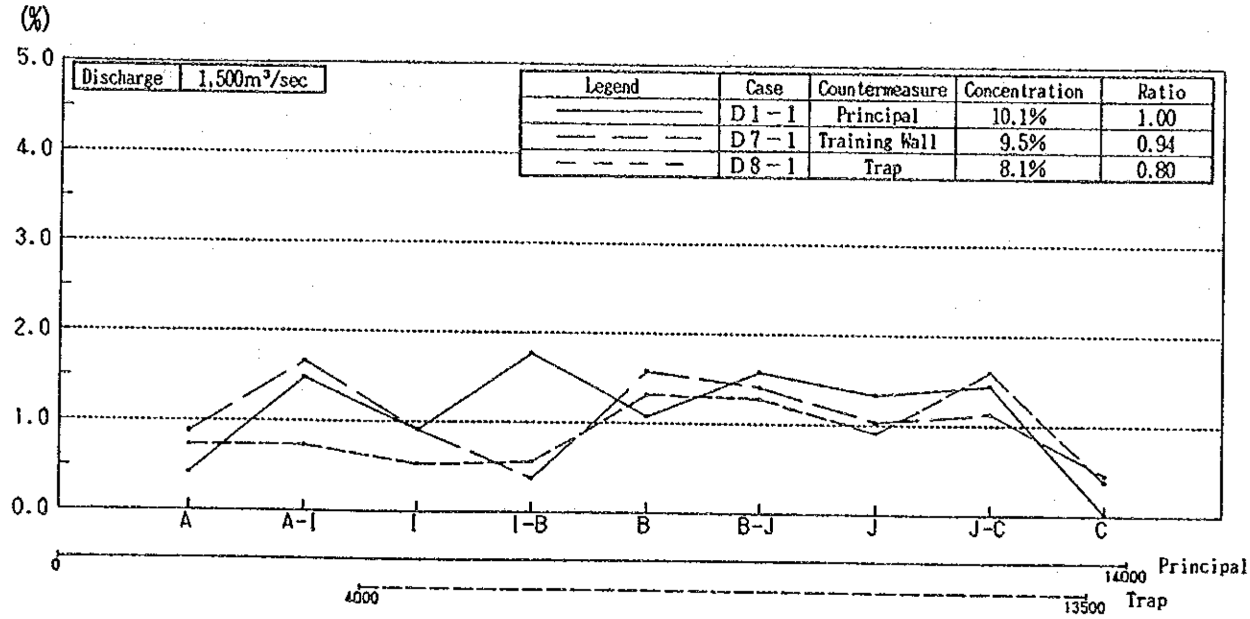


Fig. IV.1.4-15(3) Concentration of Tracer in the Bottom Layer of the Channel



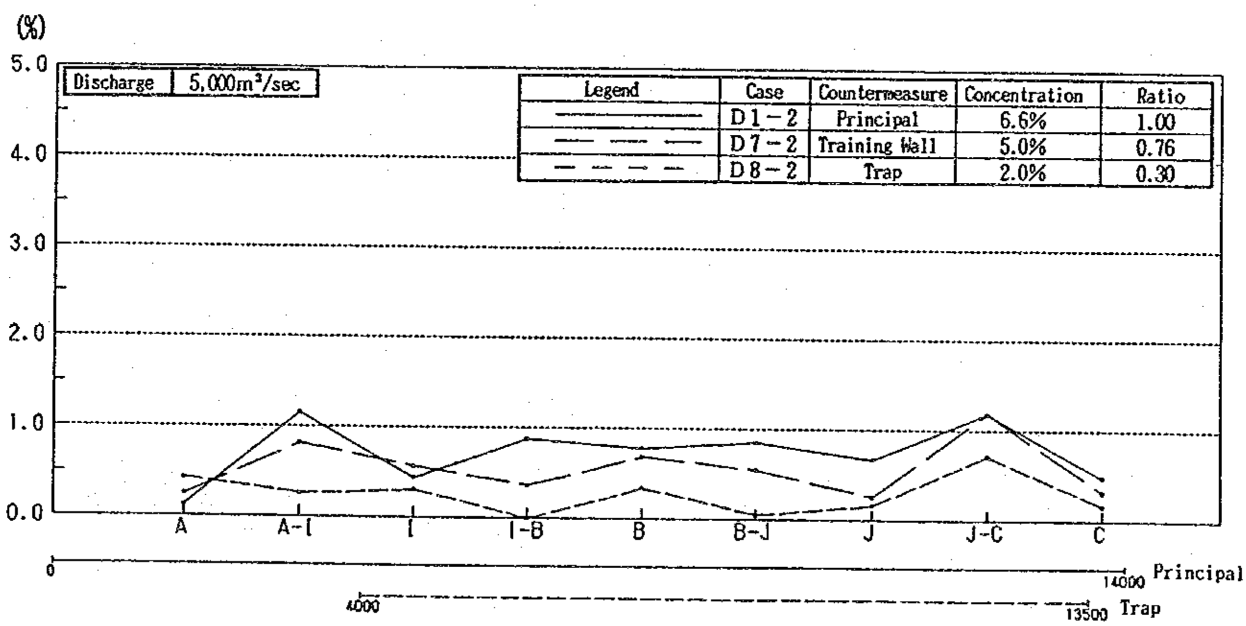
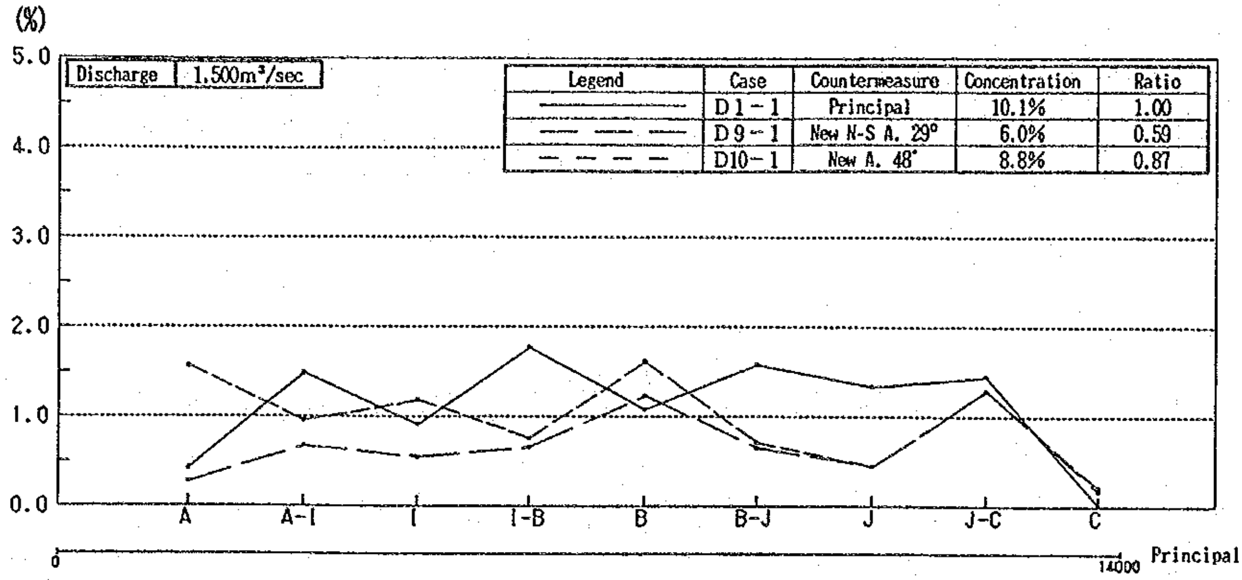


Fig. IV.1.4-15(4) Concentration of Tracer in the Bottom Layer of the Channel



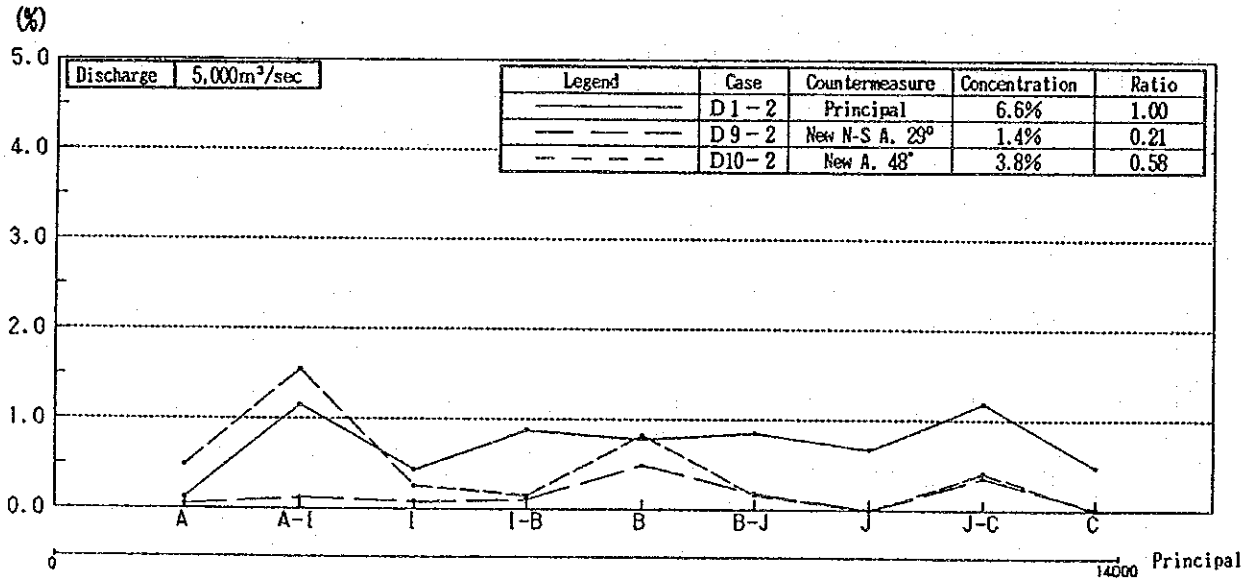


Fig. IV.1.4-15(5) Concentration of Tracer in the Bottom Layer of the Channel