8. OUTER REVETMENT

8.1 Design Standards

Technical Standards and Commentaries for Port and Harbor Facilities (OCDI-2002) have been applied for the design of outer revetment. In the process of the application for using Japanese standards for the design of outer revetment, technical aspects of the current Vietnamese standards have also been fully considered. The following design standards have been also applied as references when more detailed information was required:

- Design Manual for Coastal Facilities (JSCE, 2000)
- Shore Protection Manual (US Army Corps of Engineers, 1984)
- Coastal Engineering Manual (US Army Corps of Engineers, 2004)
- EurOtop Wave Overtopping of Sea Defense and Related Structures Assessment Manual (EA(UK), ENW(NL), KFKI(DE), 2007)
- The Rock Manual (CIRIA, CUR, CETMEF, 2007)
- Design Guideline of Tetrapod (Tetrapod Co., Ltd., 1995)
- RAKUNA-IV (Nikken Kogaku Co., Ltd., 2012)

8.2 Design Conditions

8.2.1 Objective Period to be Considered in the Design of Outer Revetment

Outer revetment is divided into two parts as “Outer Revetment A (L=750m)” and “Outer Revetment B (L=2,480m)” (refer to Figure 8.2.2).

The reclamation for the yard behind outer revetment A will be implemented in the same period of the construction of outer revetment A. On the other hand, the reclamation of the yard behind outer revetment B will be implemented after 5 years from the completion of outer revetment B. Thus, outer revetment B is required as a function of breakwater until the commencement of the reclamation work. And the function as outer revetment for reclamation yard against the wave overtopping is required when the reclamation work will be commenced.

From this point of view, outer revetment A is designed under the external design forcing condition at outer channel side (sea side) as the permanent period condition. On the other hand for outer revetment B, the external design forcing condition at both sides, that is outer channel side (sea side) and inner channel side (lee side), shall be considered on design taking into account of the schedule of the reclamation for the yard. Both of the conditions, which are as breakwater in a short period condition (less than 5 years) and as outer revetment in a permanent period condition, shall be considered in the design.

8.2.2 Natural Condition

The natural condition, which was employed in the SAPROF report and taken into account in the design of the outer revetment, was reviewed considering the latest survey results and newly collected data. Only the summarized results and corresponding justifications are presented in this chapter.

1) Tides

The tide condition presented in the SAPPROF report was given in the TEDI F/S report. According to the F/S report, the design tide condition was determined through extreme probability analysis based on historical water level observation data, which were obtained at Hon

Dau Station from 1974 to 2004. The extreme analysis has been re-conducted in this Study to add the latest five years data from 2005 to 2009. The result shows that mostly the same value as the tide level for 100-years return period (value for 1% probability of exceedance) was obtained. As a result, the same tide values presented in the SAPROF report were employed as the tide condition for the port design.

- HHWL : CD +4.43 m (as 100 years return period or 1% exceeded probability)
- HWL : CD +3.55 m
- MWL : CD +1.95 m
- LWL : CD +0.43 m
- LLWL : CD +0.03 m (observed on January 2, 1991)

(Note: CD refers to Chart Datum, which is nearly the level of the Lowest Astronomical Tide)

2) Offshore Design Waves

Offshore design wave data presented in the SAPROF report are as follows:

- Offshore Wave Height (Ho) : 5.6 m
- Wave Period (To) : 11.6 sec
- Predominant Wave Direction : S to E

(As offshore waves with 50 years return period)

According to the SAPROF report, the differences were observed between the predicted offshore waves based on the extreme wave probability analysis in the previous study results, and that based on the visual observation results obtained at Hon Dau Station from 1956 to 1985. Thus, offshore design wave was re-analyzed in this study through extreme wave probability analysis based on newly collected storm data for more than 50 years. Here, the calculated value was adjusted using the observation data for one year at the offshore area of Hai Phong, which was carried out from 2005 July to 2006 August by TEDI.

The obtained offshore wave conditions are summarized in Table 8.2.1. The details are presented in section 2.4 of Chapter 2.

Table 8.2.1 Offshore Wave Conditions (Refer to Section 2.4 in Chapter 2)

Return Period (years)	H_0 (m)	T_0 (sec)
1	2.30	8.3
5	4.11	11.0
10	4.72	11.8
30	5.59	12.8
50	5.96	13.3
100	6.46	13.8

3) Design Seismic Coefficient for Quay Wall Structure (same as the SAPROF report)

- Horizontal Design Coefficient kh = 0.04
- Vertical Design Coefficient kv = 0.00

Special consideration to TCXDVN leads to the application of Level 3 (kh=0.04 or less) for the projected area among three seismic activity levels in Vietnam. This criteria needs to be paid for in the evaluation of seismic effects on subsoil earth pressures around marine structures and foundation for onshore structures. However, since the regional earthquake activities in and around the project area deemed negligible, possible seismic effects on the structures' stability will be neglected in this Study.

4) Wind Velocity (same as SAPROF report)

- Design Wind Velocity: 60 m/sec
- Wind in Operation: 20 m/sec

5) Subsoil Conditions

The result of soil analysis to be employed to the design of outer revetment is summarized in this part. Detail for the result of soil analysis was presented in section 2.1 of Chapter 2.

It was divided into four blocks as representative soil conditions for each section of the outer revetment as shown in Figure 8.2.1.

- For outer revetment A: ORA-1, ORA-2, ORA-3, ORA-4
- For outer revetment B: ORB-A, ORB-B, ORB-C, ORB-D

Soil conditions analyzed from the latest boring result for each block of outer revetment A and B are shown in Table 8.2.2 through Table 8.2.9.

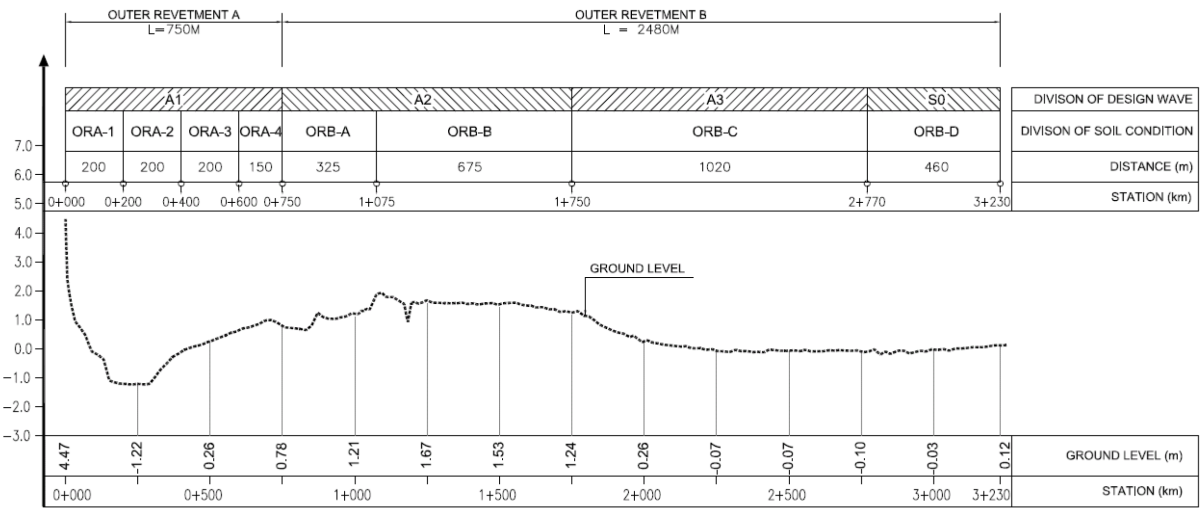


Figure 8.2.1 Division of Representative Soil Property

Table 8.2.2 Soil Properties at the Revetment A (ORA-1)

Soil Parameters	Layer 1b	Layer 2	Layer 3b	Layer 5	Layer 10
Typical Soil Type	CL	CH	CL, SC	CH	
Depth (CD)	-0.5 to -2.0	-2.0 to -8.0	-8.0 to -14.5	-14.5 to -25.5	>-25.5
SPT - N	1	1	5	6	-
γ (kN/m^3)	18.0	17.0	19.0	17.5	-
γ' (kN/m^3)	8.0	7.0	9.0	7.5	-
C_u (kN/m^2)	15	15	25	40	-
ϕ (^{o})	0.0	0.0	0.0	0.0	-
C_c	0.30	0.60	0.25	0.60	-
C_r	0.07	0.12	0.05	0.08	-
C_α (%)	0.4	0.7	0.4	0.8	-
P_c (kN/m^2)	80	80	$\Sigma\gamma'z + 50$	$\Sigma\gamma'z + 75$	-
e_0	1.05	1.45	0.80	1.20	-
C_v (OC) x 10^{-3} (cm^2/s)	1.20	1.00	1.20	2.20	-
C_v (NC) x 10^{-3} (cm^2/s)	1.20	0.60	1.20	0.80	-
C_u/P for NC	0.30	0.30	0.30	0.30	-

Table 8.2.3 Soil Properties at the Revetment A (ORA-2)

Soil Parameters	Layer 2	Layer 3b	Layer 5	Layer 10
Typical Soil Type	CH	CL, SC	CH	
Depth (CD)	-1.0 to -9.0	-9.0 to -14.5	-14.5 to -27.0	>-27.0
SPT - N	1	5	6	-
γ (kN/m^3)	17.0	19.0	17.5	-
γ' (kN/m^3)	7.0	9.0	7.5	-
C_u (kN/m^2)	15	25	40	-
ϕ (^{o})	0.0	0.0	0.0	-
C_c	0.60	0.25	0.60	-
C_r	0.12	0.05	0.08	-
C_α (%)	0.7	0.4	0.8	-
P_c (kN/m^2)	80	$\Sigma\gamma'z + 50$	$\Sigma\gamma'z + 75$	-
e_0	1.45	0.80	1.20	-
C_v (OC) x 10^{-3} (cm^2/s)	1.00	1.20	2.20	-
C_v (NC) x 10^{-3} (cm^2/s)	0.60	1.20	0.80	-
C_u/P for NC	0.30	0.30	0.30	-

Table 8.2.4 Soil Properties at the Revetment A (ORA-3)

Soil Parameters	Layer 1b	Layer 2	Layer 3c	Layer 5	Layer 10
Typical Soil Type	CL	CH	SP, Sp-SC	CH	
Depth (CD)	0.0 to -4.5	-4.5 to -10.0	-10.0 to -12.5	-12.5 to -29.0	>-29.0
SPT - N	1	1	6	6	-
γ (kN/m^3)	18.0	17.0	19.0	17.5	-
γ' (kN/m^3)	8.0	7.0	9.0	7.5	-
C_u (kN/m^2)	15	15	0	40	-
ϕ (^{o})	0.0	0.0	25.0	0.0	-
C_c	0.30	0.60	-	0.60	-
C_r	0.07	0.12	-	0.08	-
C_α (%)	0.4	0.7	-	0.8	-
P_c (kN/m^2)	80	80	-	$\Sigma\gamma'z + 75$	-
e_0	1.05	1.45	-	1.20	-
C_v (OC) x 10^{-3} (cm^2/s)	1.20	1.00	-	2.20	-
C_v (NC) x 10^{-3} (cm^2/s)	1.20	0.60	-	0.80	-
C_u/P for NC	0.30	0.30	-	0.30	-

Table 8.2.5 Soil Properties at the Revetment A (ORA-4)

Soil Parameters	Layer 1a	Layer 1b	Layer 2	Layer 3b	Layer 4	Layer 5
Typical Soil Type	SP, SP-SC	CL	CH	CL, SC	CH, CL	CH
Depth (CD)	+1.0 to -1.0	-1.0 to -5.0	-5.0 to -9.0	-9.0 to -12.5	-12.5 to -14.0	-14.0 to -30
SPT - N	4	1	1	5	10	6
γ (kN/m^3)	18.0	18.0	17.0	19.0	19.0	17.5
γ' (kN/m^3)	8.0	8.0	7.0	9.0	9.0	7.5
C_u (kN/m^2)	0	15	15	25	50	40
ϕ (^{o})	25.0	0.0	0.0	0.0	0.0	0.0
C_c	-	0.30	0.60	0.25	0.35	0.60
C_r	-	0.07	0.12	0.05	0.04	0.08
C_α (%)	-	0.4	0.7	0.4	0.6	0.8
P_c (kN/m^2)	-	80	80	$\Sigma\gamma'z + 50$	$\Sigma\gamma'z + 100$	$\Sigma\gamma'z + 75$
e_0	-	1.05	1.45	0.80	0.85	1.20
C_v (OC) x 10^{-3} (cm^2/s)	-	1.20	1.00	1.20	1.20	2.20
C_v (NC) x 10^{-3} (cm^2/s)	-	1.20	0.60	1.20	0.80	0.80
C_u/P for NC	-	0.30	0.30	0.30	0.30	0.30

*. NC: Normal consolidated State, OC: Over consolidated State, z: depth (m)

Table 8.2.6 Soil Properties at the Revetment B (ORB-A)

Soil Parameters	Layer 1a	Layer 2	Layer 3b	Layer 5	Layer 8c
Typical Soil Type	SP, SP-SM	CH	SM, SC-SM	CL	SM, SC-SM
Depth (CD)	+1.0 to -2.0	-2.0 to -8.0	-8.0 to -13.5	-13.5 to -25.0	>-25.0
SPT - N	6	1	6	5	44
γ (kN/m^3)	18.0	16.5	19.0	17.5	20.0
γ' (kN/m^3)	8.0	6.5	9.0	7.5	10.0
C_u (kN/m^2)	0	10 + 2z	10 + 2z	10 + 2z	0
ϕ (^{o})	25.0	0.0	0.0	0.0	35.0
C_c	-	0.60	0.25	0.55	-
C_r	-	0.06	0.05	0.04	-
C_α (%)	-	0.7	0.4	0.8	-
P_c (kN/m^2)	-	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 50	-
e_0	-	1.05	0.80	1.15	-
C_v (OC) x 10^{-3} (cm^2/s)	-	1.00	1.20	0.30	-
C_v (NC) x 10^{-3} (cm^2/s)	-	0.60	1.20	0.20	-
C_u/P for NC	-	0.25	0.30	0.25	

Table 8.2.7 Soil Properties at the Revetment B (ORB-B)

Soil Parameters	Layer 1b	Layer 2	Layer 3b	Layer 5	Layer LS
Typical Soil Type	SM, SC-SM	CH	SM, SC-SM	CL	-
Depth (CD)	+1.5 to -1.5	-1.5 to -7.5	-7.5 to -9.5	-9.5 to -15.5	>-15.5
SPT - N	5	1	6	5	-
γ (kN/m^3)	18.0	16.5	19.0	17.5	-
γ' (kN/m^3)	8.0	6.5	9.0	7.5	-
C_u (kN/m^2)	10 + 2z	10 + 2z	10 + 2z	10 + 2z	-
ϕ (^{o})	0.0	0.0	0.0	0.0	-
C_c	0.30	0.60	0.25	0.55	-
C_r	0.07	0.06	0.05	0.04	-
C_α (%)	0.4	0.7	0.4	0.8	-
P_c (kN/m^2)	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 50	-
e_0	1.05	1.05	0.80	1.15	-
C_v (OC) x 10^{-3} (cm^2/s)	1.20	1.00	1.20	0.30	-
C_v (NC) x 10^{-3} (cm^2/s)	1.20	0.60	1.20	0.20	-
C_u/P for NC	0.25	0.25	0.30	0.25	-

Table 8.2.8 Soil Properties at the Revetment B (ORB-C)

Soil Parameters	Layer 1b	Layer 2	Layer 3b	Layer 5	Layer 6
Typical Soil Type	SM, SC-SM	CH	SM, SC-SM	CL	CL
Depth (CD)	0.0 to -1.5	-1.5 to -9.5	-9.5 to -12.0	-12.0 to -16.0	>-16.0
SPT - N	5	1	6	5	12
γ (kN/m^3)	18.0	16.5	19.0	17.5	19.0
γ' (kN/m^3)	8.0	6.5	9.0	7.5	9.0
C_u (kN/m^2)	10 + 2z	10 + 2z	10 + 2z	10 + 2z	50
ϕ (^{o})	0.0	0.0	0.0	0.0	
C_c	0.30	0.60	0.25	0.55	0.15
C_r	0.07	0.06	0.05	0.04	0.01
C_α (%)	0.4	0.7	0.4	0.8	0.3
P_c (kN/m^2)	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 25	$\Sigma\gamma'z$ + 50	$\Sigma\gamma'z$ + 100
e_0	1.05	1.05	0.80	1.15	0.80
C_v (OC) x 10^{-3} (cm^2/s)	1.20	1.00	1.20	0.30	0.30
C_v (NC) x 10^{-3} (cm^2/s)	1.20	0.60	1.20	0.20	0.15
C_u/P for NC	0.25	0.25	0.30	0.25	0.30

Table 8.2.9 Soil Properties at the Revetment B (ORB-D)

Soil Parameters	Layer 1a	Layer 2	Layer 3b	Layer 5	Layer 6
Typical Soil Type	SP, SP-SM	CH	SM, SC-SM	CL	CL
Depth (CD)	0.0 to -1.0	-1.0 to -9.5	-9.5 to -11.0	-11.0 to -20.5	>-20.5
SPT - N	6	1	6	5	12
γ (kN/m^3)	18.0	16.5	19.0	17.5	19.0
γ' (kN/m^3)	8.0	6.5	9.0	7.5	9.0
C_u (kN/m^2)	0	10 + 2z	10 + 2z	10 + 2z	50
ϕ (^{o})	25.0	0.0	0.0	0.0	
C_c	-	0.60	0.25	0.55	0.15
C_r	-	0.06	0.05	0.04	0.01
C_α (%)	-	0.7	0.4	0.8	0.3
P_c (kN/m^2)	-	$\Sigma\gamma$'z + 25	$\Sigma\gamma$'z + 25	$\Sigma\gamma$'z + 50	$\Sigma\gamma$'z + 100
e_0	-	1.05	0.80	1.15	0.80
C_v (OC) x 10^{-3} (cm^2/s)	-	1.00	1.20	0.30	0.30
C_v (NC) x 10^{-3} (cm^2/s)	-	0.60	1.20	0.20	0.15
C_u/P for NC	-	0.25	0.30	0.25	0.30

*. NC: Normal consolidated State, OC: Over consolidated State, z: depth (m)

Source: JICA Study Team

8.2.3 Allowance on the Remaining Settlement due to Consolidation

There are no Vietnamese criteria for the allowance on remaining settlement for the revetment after construction. The back yard area behind the outer revetment is planned to utilize as the access road. There are Vietnamese criteria for the allowance on remaining settlement due to consolidation for the road after completion of pavement work (22 TCN 262-2000). Referring to this, the following value was employed as the allowance on remaining settlement due to consolidation for outer revetment.

- Allowance on remaining settlement: 30cm (for 15 years)

8.2.4 Design Wave Height for Outer Revetment

1) Consideration for Existence of Shoal at Outer Revetment

The seabed elevation at the planned outer revetment changes from CD -1.0 m to CD+1.5 m as shown in Figure 8.2.2. Considering the re-evaluated offshore design wave heights shown in Table 8.2.1, the design wave height at outer revetment can be calculated using Goda's wave breaking index. The breaking waves greatly depend on seabed elevation. However, there exists a large-scale shoal at x=800 m to 2,000 m, and the deepest area appeared at onshore area (x=250 m) as shown in Figure 8.2.3 (x: distance from the beginning of outer revetment). The incident waves propagate from offshore to onshore, and if the shoal exists as shown in Figure 8.2.3, the wave height at the onshore side will be affected. If the wave height will be estimated only using the depth at each point individually, the maximum wave will appear at the onshore side for this case without the influence of the existing shoal. Thus, this could cause an overestimate of the design wave height. Taking into abovementioned considerations, the representative seabed elevation (G.L.), which will be used for estimating the design wave height, are set as shown in Table 8.2.10 based on the latest bathymetric data:

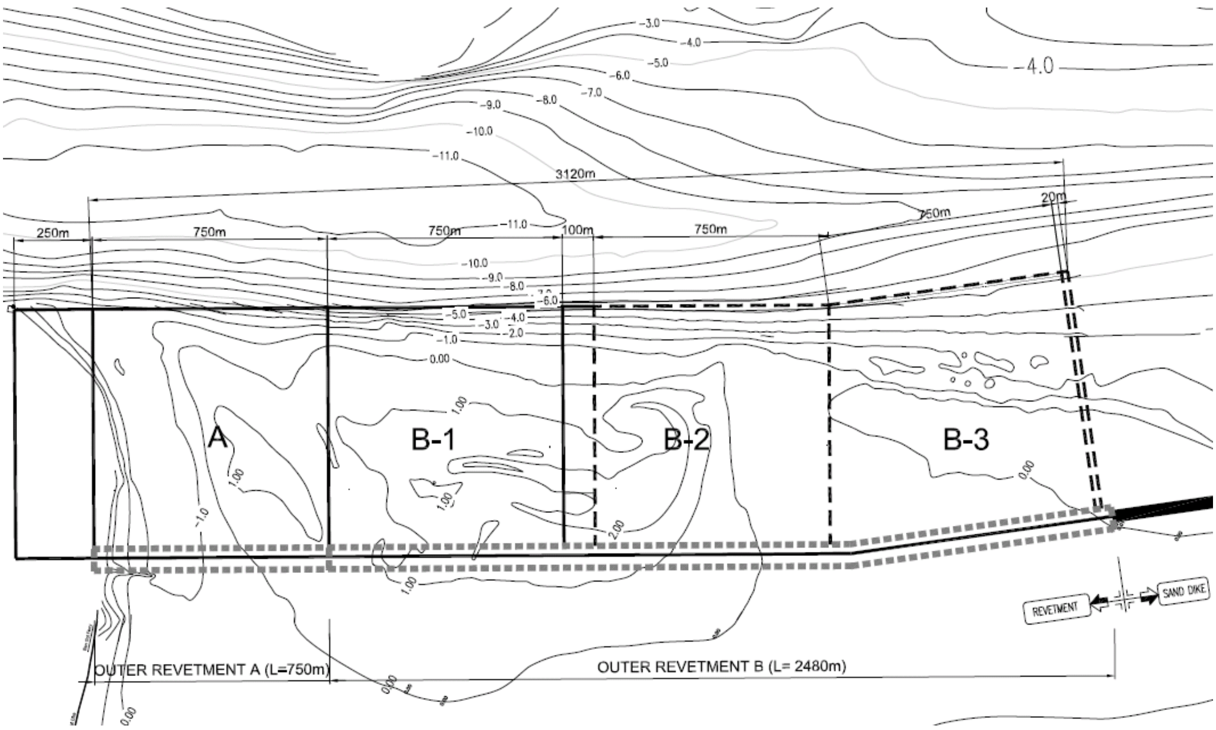


Figure 8.2.2 Seabed Topography around the Outer Revetment

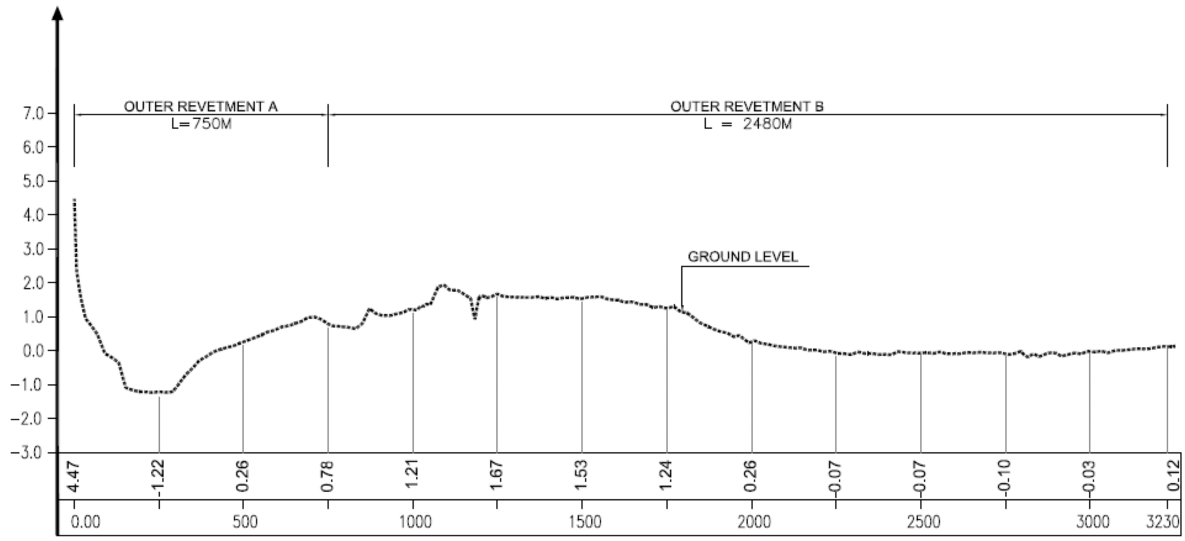


Figure 8.2.3 Seabed Profile Change at the Outer Breakwater in the Longshore Direction

Table 8.2.10 Representative Seabed Elevation for Design Wave Calculation

X (m)	Revetment No.	Cal. Position (Section 2.4 in Chap 2)	Representative Seabed Elevation (CD)
0 ~ 750	A	A1	+0.5
750 ~ 1,750	B-1	A2	+1.0
1,750 ~ 2,500	B-2 and B-3	A3	±0.0
2,500 ~ 3,230	B-3	S0	±0.0

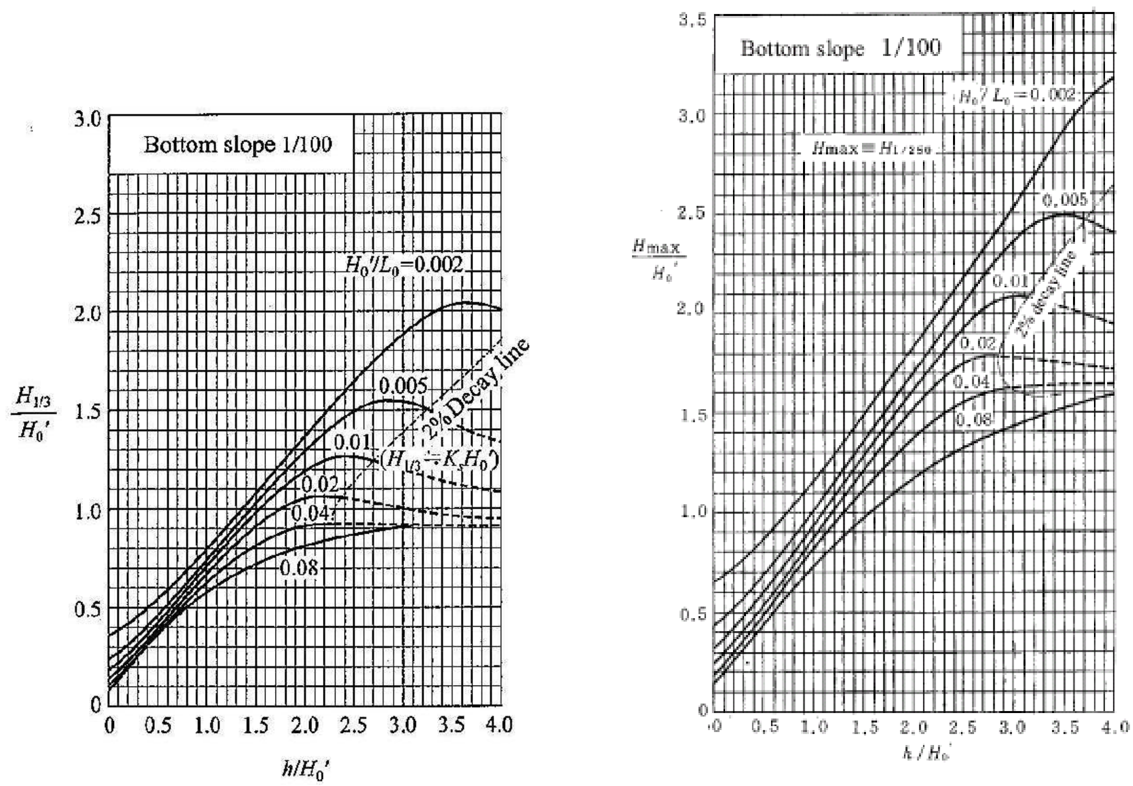
2) Design Wave Height at Outer Channel Side

The design wave height at outer channel side of the outer revetment A (backfill area, L=750m) and B (future backfill area, L=2,480m) was calculated based on the offshore design wave height taking into account of near shore wave deformation such as refraction, diffraction, shoaling and breaking. The near shore wave deformation was calculated by using the numerical computation method presented in section 2.4 in Chapter 2. The depth for each calculation point shown in Table 8.2.10 is shallow and the design wave heights for all points are calculated as breaking waves. For this, Goda’s breaking index (Figure 8.2.4) was adopted using the representative seabed elevation shown in Table 8.2.10.

The incident waves at the outer channel side of the revetment are basically not influenced by the shadow effect due to expansion of the revetment. Thus, 50-years return period was assumed for determination of the design wave height.

The calculation condition and resulting design wave heights with 50-years return period as breaking wave are shown in Table 8.2.11.

As presented later, the wave height with 5-years return period is also required for the design of outer revetment B to study the protection method in a short period (after construction of outer revetment B until conducting of the backfilling). Thus, the wave heights with 5-years return period are also shown in Table 8.2.12.



Source: OCDI (2002)

Figure 8.2.4 Calculation of Wave Height at Outer Revetment A Using Goda’s Breaking Index (s=1/100)

Table 8.2.11 Calculation Condition and Resulting Design Wave Heights (50-years return Period)

X (m)	0 ～ 750	750 ～ 1,750	1,750 ～ 2,770	2,770 ～ 3,230
Revetment No.	A	B-1	B-2 and B-3	B-3
Cal. Point (Section 2.4 in Chap 2)	A1	A2	A3	S0
Offshore Wave Direction	SSW	SSW	SSE	SSE
H_0 (m) (50-years return period)	6.83	6.83	5.78	5.78
H_0' (m)	7.30	7.28	7.43	7.37
Seabed (CD)	0.50	1.00	0.00	0.00
Tide Level (CD)	4.43	4.43	4.43	4.43
h (Tide Level - Seabed)	3.93	3.43	4.43	4.43
h/H_0'	0.54	0.47	0.60	0.60
T_0 (m)	13.3	13.3	13.3	13.3
L_0 (m)	275.9	275.9	275.9	275.9
H_0'/L_0	0.03	0.03	0.03	0.03
H_{max}/H_0'	0.53	0.48	0.58	0.58
$H_{1/3}/H_0'$	0.41	0.37	0.43	0.43
H_{max} (m)	3.9	3.5	4.3	4.3
$H_{1/3}$ (m)	**3.0**	**2.7**	**3.2**	**3.2**
Wave Angle β(deg) *)	32	41	66	68

*) Angle between the wave direction and the perpendicular to the face line of revetment considering 15° safety side

Source: JICA Study Team

Table 8.2.12 Calculation Condition and Resulting Design Wave Heights (5-years return Period)

X (m)	0 ～ 750	750 ～ 1,750	1,750 ～ 2,770	2,770 ～ 3,230
Revetment No.	A	B-1	B-2 and B-3	B-3
Cal. Point (Section 2.4 in Chap 2)	A1	A2	A3	S0
Offshore Wave Direction	SSW	SSW	SSE	SSW
H_0 (m) (50-years return period)	4.72	4.72	4.72	4.72
H_0' (m)	4.56	4.25	4.14	3.62
Seabed (CD)	0.50	1.00	0.00	0.00
Tide Level (CD)	3.92	3.92	3.92	3.92
h (Tide Level - Seabed)	3.42	2.92	3.92	3.92
h/H_0'	0.75	0.69	0.95	1.08
T_0 (m)	11.0	11.0	11.0	11.0
L_0 (m)	188.8	188.8	188.8	188.8
H_0'/L_0	0.02	0.02	0.02	0.02
H_{max}/H_0'	0.70	0.73	0.83	0.92
$H_{1/3}/H_0'$	0.59	0.53	0.64	0.61
H_{max} (m)	3.2	3.1	3.4	3.3
$H_{1/3}$ (m)	**2.7**	**2.3**	**2.6**	**2.2**

Source: JICA Study Team

3) Design Wave Height at Inner Channel Side

As the outer revetment B is required to function as breakwater for five years until backfilling is conducted, the waves which will enforced to the slope at inner channel side up to conducting backfilling shall be considered.

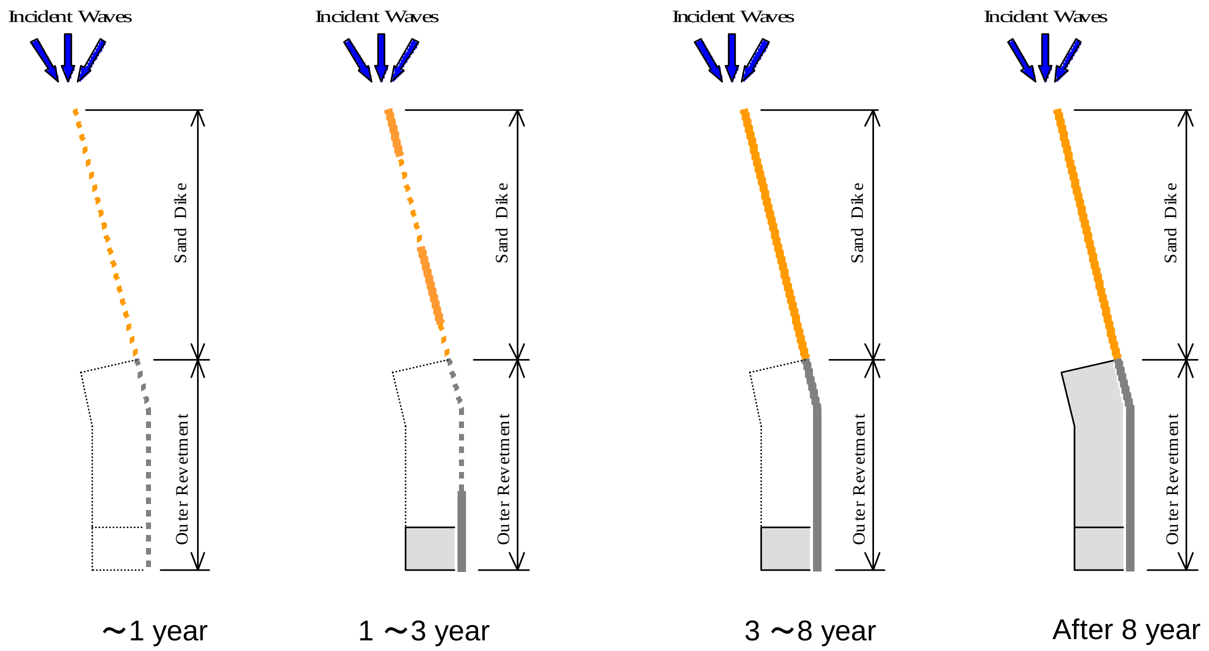
The incident wave height for the outer revetment at inner channel side is influenced by the shadow (diffraction) effect depending on the progress of the extension of outer revetment and sand dike. Thus the identification for the critical wave condition during each construction stage shall be required.

The following construction schedule was presumed as the pre-condition to examine the design wave height at inner channel side.

- Stage-1: Construction period for outer revetment (A, B), sand dike, reclamation inside of outer revetment A: for 3 years
- Stage-2: Construction period for reclamation inside of outer revetment B: for 5 years after completion of Stage-1

Three conditions of the progress for the construction of outer revetment (A, B) and sand dike were considered to compare the enforced waves at the inner channel side (Figure 8.2.5).

- Progress A in Stage-1 (0 ~ 1 year): No construction (without shadow effect)
- Progress B in Stage-1 (1 ~ 3 year): During construction of Stage-1 (with partial shadow effect)
- Progress C in Stage-2 (3 ~ 8 year): During construction of Stage-2 (with full shadow effect)



(1) Progress A (2) Progress B (3) Progress C

Figure 8.2.5 Assumed Construction Progress for Determination of Design Wave Height at Inner Channel Side

It shall be considered the difference of offshore wave height for each return period and shadow effect for each progress. And the most critical wave condition shall be selected as the design waves at inner channel side.

Based on the calculation results of the offshore wave height for each return period and numerical computation for near shore wave deformation, which is presented in section 2.4 of Chapter 2, the wave height at inner channel side for each progress was estimated. To avid the complication, the design wave height at inner channel side was estimated at offshore head part of outer revetment B (Calculation point at S0 in section 2.4 of Chapter 2). Taking into account of the return period for design waves, the HWL was employed as the tide condition for the calculation of near shore wave calculation.

The shadow effect during Progress B will be changed depending on the extension length of revetment and sand dike. Therefore, it was taken the average values between the condition with and without structure as the wave height in Progress B. 3-year period for the offshore waves was taken for Progress A and 5-year period was taken for Progress B and C. Table 8.2.13 shows the selected offshore wave heights (H_0) and calculated equivalent deepwater wave height (H_0’) for each direction and return period. The case of SSE of offshore wave direction in Progress A was selected as the most critical case of wave condition for inner channel side and the critical equivalent deep water wave height (H_0’) was selected.

Table 8.2.14 shows the calculated design wave height at inner channel side for the condition of Progress A based on the calculated equivalent deep water wave height (H_0’) and using the Goda’s breaking index. From the result, $H_{1/3}$=2.4m was obtained as the design wave height at inner channel side.

Table 8.2.13 Offshore Wave heights (H_0) and calculated Equivalent Offshore Wave Height (H_0’) for Each Construction Progress

Progress Case	Progress A			Progress B			Progress C		
	Stage-1 (without shadow effect)			Stage-1 (with partial shadow effect)			Stage-2 (with full shadow effect)		
Presumed Construction Period	0 ～ 1 year			1 ～ 3 year (for 3 year)			3 ～ 8 year (for 5 year)		
Employed Retuen Period for Offshore Wave Height	3 year			5 year			5 year		
Offshore Wave Direction	H_0	Kr for no shadow effect	H_0'	H_0	Kr for partial shadow effect	H_0'	H_0	Kr for full shadow effect	H_0'
E	5.04	0.47	2.39	6.11	0.28	1.72	6.11	0.09	0.55
ESE	4.17	0.74	3.09	5.07	0.44	2.23	5.07	0.14	0.71
SE	3.36	1.14	3.83	4.08	0.64	2.63	4.08	0.15	0.61
SSE	3.33	1.31	**4.35**	4.04	0.72	2.92	4.04	0.14	0.57
S	3.42	1.26	4.29	4.15	0.70	2.90	4.15	0.14	0.58
SSW	3.88	1.07	4.15	4.72	0.56	2.64	4.72	0.05	0.24

Source: JICA Study Team

Table 8.2.14 Calculated Design Wave height at Inner Channel Side (Progress A)

Cal. Point (Section 2.4 in Chap 2)	S0 (Innner Channel Side)					
Offshore Wave Direction	E	ESE	SE	SSE	S	SSW
Incident Wave Angle (deg) (from faceline of revetment)	3	3	9	10	17	29
H_0 (m) (1-years return period)	3.42	2.83	2.28	2.26	2.32	2.64
H_0' (m)	2.39	3.09	3.83	**4.35**	4.29	4.15
Seabed (CD)	0.00					
Tide Level (HWL) (CD)	3.55					
h (Tide Level - Seabed)	3.55	3.55	3.55	3.55	3.55	3.55
h/H_0'	1.49	1.15	0.93	0.82	0.83	0.86
T_0 (m)	8.3					
L_0 (m)	107					
h/L_0	0.03	0.03	0.03	0.03	0.03	0.03
H_0'/L_0	0.02	0.03	0.04	0.04	0.04	0.04
$H_{1/3}/H_0'$	0.90	0.73	0.64	0.55	0.56	0.58
$H_{1/3}$ (m)	2.1	2.3	2.4	**2.4**	2.4	2.4

Source: JICA Study Team

8.3 Review of Previous Design

The previous design presented in the SAPROF report was reviewed based on the re-evaluated design conditions and further technical considerations.

8.3.1 Outer Revetment A

1) Soil Improvement Method

The land reclamation work behind outer revetment A is planned to be carried out in parallel to the construction of the said revetment. Basically, it is preferable to employ the same soil improvement method taking into consideration the continuity of the outer revetment area and the reclamation area, and simplicity of construction method of soil improvement for both areas. In the SAPROF report, it was recommended to adopt the plastic board vertical drain (PVD) method combined with preloading to accelerate the process of consolidation. The stability analysis during the construction period after preloading, which might be the most critical condition on the stability, has checked in section 7.4 of Chapter 7 and confirmed. Thus, the same method of soil improvement, that is the plastic board vertical drain (PVD) method, is employed for outer revetment A.

2) Determination of Crown Height

a) Requirement from Functional Point of View

The crown height of the revetment, which is located at the offshore area, is commonly determined by the rate of wave overtopping, Q ($m^3/s/m$), according to the Japanese and international design standards for revetments faced on seaward. On the other hand in Vietnam, the crown height of a revetment is commonly designed based on the extreme water level, taking into account a certain additional height. Here, the crown height of the revetment is designed using the wave overtopping rate, following international design principle.

Several criteria have been proposed for the permissible rate of wave overtopping, such as permissible rate based on damage level and importance of utilization at hinterland. In the SAORPF report, Q<0.05 (m^3/s/m) was selected as the permissible rate of wave overtopping. Such rate is equivalent to the damage limit rate of overtopping in the case of a revetment with an unpaved apron. This permissible rate is lower than that determined taking into account of a function of the degree of importance of hinterland. The permissible rate of wave overtopping as a function of the degree of importance of hinterland, which was presented in Japanese design standard (OCDI, 2002), is shown in Table 8.3.1.

Table 8.3.1 Permissible Rate of Wave Overtopping as a Function of the Degree of Importance of Hinterland

Areas where there is a high concentration of houses, public facilities etc. behind the seawall, and so it is anticipated that flooding due to overtopping or spray would cause particularly serious damage	About 0.01
Other important area	About 0.02
Other area	0.02 – 0.06

The hinterland of outer revetment will be utilized as port road and public space. Considering this utilization, the value of about 0.02 (m^3/s/m) was taken as target of the permissible rate of wave overtopping for outer revetment.

In SAPROF Report, the rate of overtopping under the design condition was calculated by using Goda's diagram for calculation of wave overtopping. However, this diagram was proposed based on the result of laboratory test for 2-dimentional wave flume. And the wave condition shall be converted to the equivalent deep water wave height (H_0') to apply the 3-dimentional wave field. If the rate of overtopping will be calculated under the re-evaluated wave conditions, it becomes out of the application range for the diagram and it is difficult to calculate. The more suitable calculation formula was newly presented in Euro design manual (EurOtop, 2007). The rate of wave overtopping can be calculated by the wave characteristics just in front of the structure. And the rate for overtopping for permeable type revetment can be predicted more accurately taking into account of the difference of armor materials and effect of wave angle. Thus, the rate of wave overtopping was calculated by using this new formula.

b) Requirement for Construction Method

If the land-work method of construction is adopted for the outer revetment, the crown height of the revetment shall be designed to secure sufficient safety against waves and water level during construction stage. This is also feasible in economic terms. On the other hand, if the offshore-work method is adopted, there is basically no restriction on the construction method. For the construction of the outer revetment, it is required to transport a large quantity of armor and under layer stones, core rubbles and concrete armor blocks fabricated at the temporary yard on land. Furthermore, there is a possibility to construct the outer revetment into several divided sections in order to accelerate the construction schedule. Considering the abovementioned point of view, the offshore-work method of construction is recommended for the outer revetment. For this case, the restriction on crown height is much relieved than that for land-work method.

c) Consideration for Future Settlement

The crown height of the outer revetment shall be determined taking into consideration the future settlement that may be caused due to consolidation of the soil. As presented in section

8.2.3, the value of 30cm was employed as the allowance on the remaining settlement for the revetment after construction. The design crown height will be determined to add the predicted future settlement for consolidation for 15years. Preliminary study for settlement has been carried out in section 7.4 based on the previous soil condition presented in SAPROF Report. The detail analysis for soil stability and settlement based on the latest soil data will be presented in Division III (Detailed Design) and the crown height taking into account of the future settlement will be proposed.

3) Structure Type

As the outer revetment shall be secured with the required function as a permanent protection facility against waves, the same type of revetment, which is armor concrete-type presented in the SAPROF report, is basically recommended. To examine the economic point of view for the armor concrete type, the double-layer and single-layer block types are compared in Section 8.4.

According to the proposed design in SAPROF report, the rubble mound was required to construct after the removal of the preload sand for PVD up to the seabed elevation. Thus, this could incur unnecessary construction costs and time. Furthermore, if reclamation works will be conducted at the same time, the rubble mound will not be necessary on the functional point of view. To save construction costs and time, it shall be considered to minimize the excavation and filling volume for filled reclamation sand and to minimize the material volume for the construction of the outer revetment. The recommended structure type and comparison study are presented in Section 8.4.

4) Toe Protection

In the SAPROF report, placing of concrete block (4 tons) was recommended as toe protection against scouring. Two different reasons are pointed out as the cause of scouring in front of the revetment or seawall. One is due to reflective waves, which are formed in front of the vertical seawall, concrete caisson type revetment, etc. The other is due to liquefaction of fine sand under the placed armor material. The scouring due to reflective waves mainly occurs at the impermeable and steep slope type seawall or revetment. However, scouring due to the latter is mainly anticipated for this case. If so, the placing of the large size armor block on the seabed of fine sand will rather accelerate further settlement of the armor block. As for the provision of toe protection against scouring due to liquefaction of fine sand, it is much effective to adopt such measures using the idea of providing a filter layer at the toe, with sufficient width from the toe end. According to the shore protection design manuals such as those of SPM (1984) and CEM (2004), it is suggested to apply several sizes of quarries as filter layer, with the smaller sizes placed as the bottom layer and bigger ones as the top layer. On the other hand, in case to consider stability of toe protection due to wave condition, The Rock Manual (2007) will be employed to analysis. According to result of stability calculation weight of toe protection armor stone with 300kg same as under layer is sufficient. Details are shown in Figure 8.4.1.

5) Necessity of Geotextile Sheet

It is required to place a geotextile sheet between the reclaimed soil and rubble core to prevent the outflow of soil through the rubble layer.

6) Necessity of Drainage Facility for Wave Overtopping

In the previous design in SAPROF report, it was not considered the drainage for water inflow due to wave overtopping. The drainage facility is necessary to flow out the intrusion of overtopping water. The drainage system will be designed under the condition of determined rate of wave overtopping, Q<0.02 ($m^3/s/m$) as the permissible rate. Detail is presented in Division III (Detailed Design).

8.3.2 Outer Revetment B

1) Soil Improvement Method

Soil improvement is also required at outer revetment B to enhance soil stability. The same method as that for outer revetment A, that is PVD method, was recommended in the SAPROF report. However;

- The total length of outer revetment B is 2,430 m and further reduction of cost and construction period for the revetment is required.
- Outer revetment B will be constructed prior to land reclamation at back yard and five years can be expected as the consolidation period.

Taking into consideration the above conditions which are different from that for outer revetment A, the sand replacement method can serve as alternative soil improvement method for outer revetment B. A comparison study is carried out in Section 8.4.

2) Determination of Crown Height

The same permissible rate of wave overtopping as outer revetment A is required for outer revetment B. The difference on condition of the settlement for consolidation between outer revetment A and B is that the outer revetment B will be constructed prior to 5 years from land reclamation. The predicted settlement for 15 years is considered to determine the crown height at the outer revetment A. For outer revetment B, taking into account of 5 years difference between construction of revetment and reclamation at backyard, the predicted settlement for 20 years are considered to determine the crown height of the revetment. Detail analysis will be presented in Chapter 17.

3) Structure Type

As outer revetment B is required to function as breakwater for five years until backfilling is conducted, the rubble mound type revetment as the same as that proposed in SAPROF report is recommended.

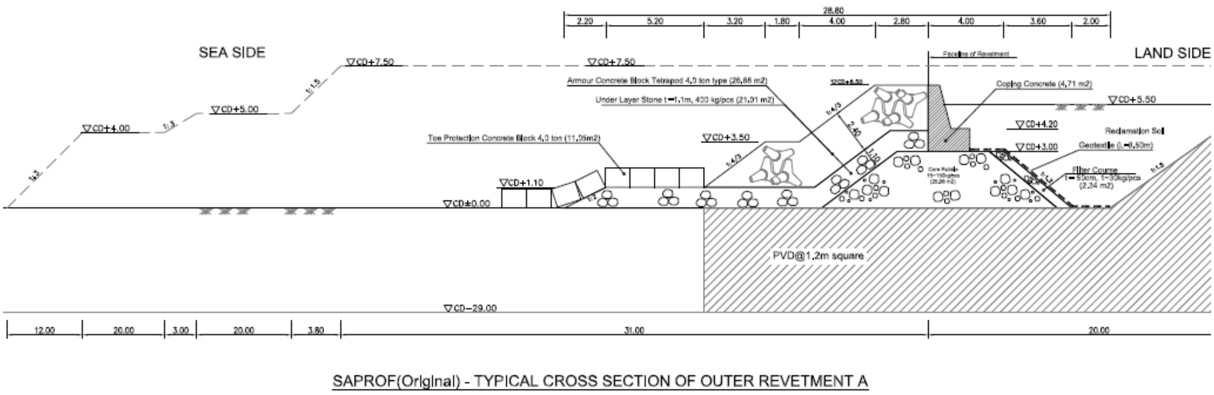
However, the dimension of the revetment, which is crown height, width, slope, etc, shall be re-examined taking into account the wave conditions before and after the backfilling as well as stability analysis of concrete cap.

8.4 Design Principle Based on Comparison Study

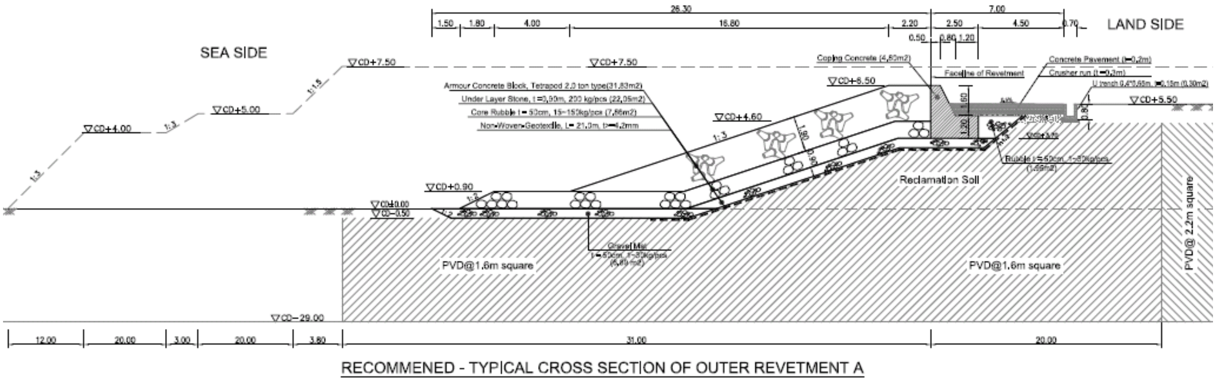
The comparison study was carried out in this section in order to decide on the suitable structure type for outer revetments A and B.

8.4.1 Outer Revetment A

As explained in Section 8.3, the rubble mound is not required if it is assumed that backfilling will be carried out at the same time as the construction of outer revetment. Furthermore, the sand backfill shall be widely excavated during the construction of outer revetment based on the SAPROF design. To minimize the excavation volume of sand backfill as well as eliminate the necessity for rubble mound, an alternative is presented in Figure 8.4.1 (2). The alternative design for outer revetment A aims to eliminate the rubble mound and slope changes from 1:4/3 to 1:3, taking into account the slope stability of backfill soil during construction. The cost comparison between original (SAPROF) design and alternative was carried out. The size and dimension of each structural component, such as crown height, concrete armor block, underlying stones, concrete cap, etc., were decided based on the revised design wave height.



(1) Original Design (SAPROF)



(2) Recommended Design

Figure 8.4.1 Recommended Structure Type for Outer Revetment A

Table 8.4.1 shows the result of cost comparison. The recommended alternative can achieve an 18% reduction of total construction cost of the original design due mainly to the decrease in quantity of rubbles and excavation volume.

Table 8.4.1 Result of Cost Comparison between the Original Design and Recommended Alternative

Original Design (SAPROF)	Recommended Design
100%	82%

As a result, the alternative design was recommended as the structure type for outer revetment A as shown in Figure 8.4.1 (2). The modification points are summarized as follows.

- Change of structure type from rubble mound type to rubble slope protection
- Change of toe protection method from placing of the concrete block at toe part to filling the gravel mat as filter layer to prevent the settlement due to liquefaction of fine sand.
- To add the drainage at lee side of the revetment
- To add the geo-textile sheet under the rubble layer

The detail design for each structure part was presented in Chapter 17.

8.4.2 Outer Revetment B

1) Comparison of Soil Improvement between PVD and Sand Replacement

Soil improvement method was preliminary compared between the PVD method that was recommended in the SAPROF report, and the sand replacement method. The depth and width of sand replacement were estimated based on preliminary soil stability calculation using the software, “SLOPE/W”, to secure a safety factor of S.F.>1.3.

Cost comparison for soil improvement was carried out considering the same structure presented in the SAPROF report. The dimension of the sand replacement was decided from the result of soil stability analysis shown in Figure 8.4.2 and Figure 8.4.3. The required safety factor (SF>1.3) for the case without soil improvement cannot be achieved as shown in Figure 8.4.2. Meanwhile, the dimension of sand replacement was decided to meet the SF>1.3 as shown in Figure 8.4.3.

Table 8.4.2 shows the result of cost comparison for soil improvement. The sand replacement method could reduce construction cost by 20% compared to PVD method. From the result, it is recommended to change the soil improvement method from PVD method to sand replacement method.

Table 8.4.2 Result of Cost Comparison (only for Soil Improvement)

PVD	Sand Replacement
100%	80%

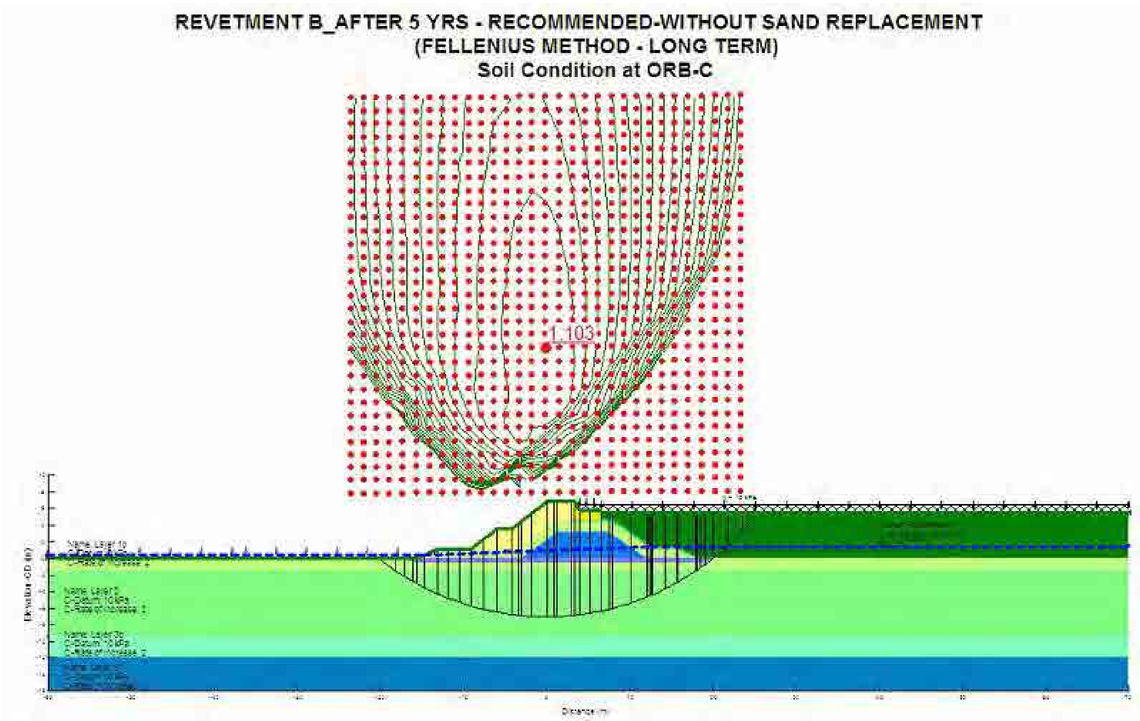


Figure 8.4.2 Calculation Result of Soil Stability Without Soil Improvement

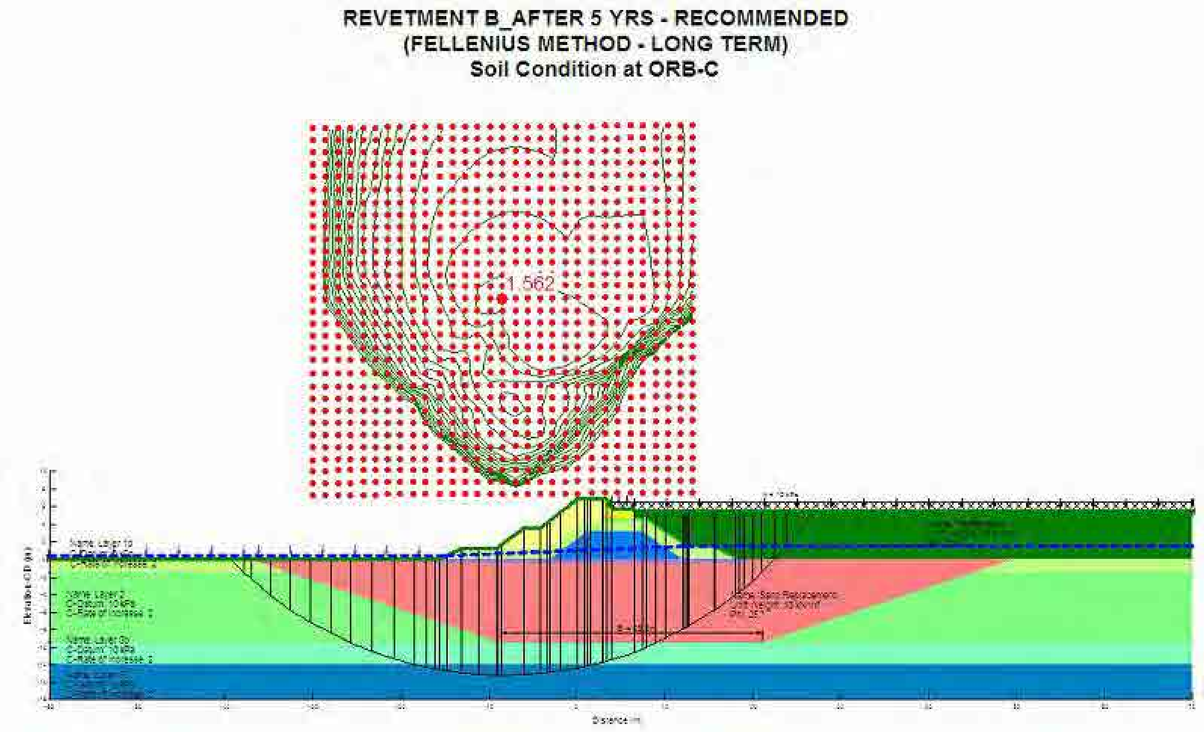


Figure 8.4.3 Calculation Result of Soil Stability with Sand Replacement

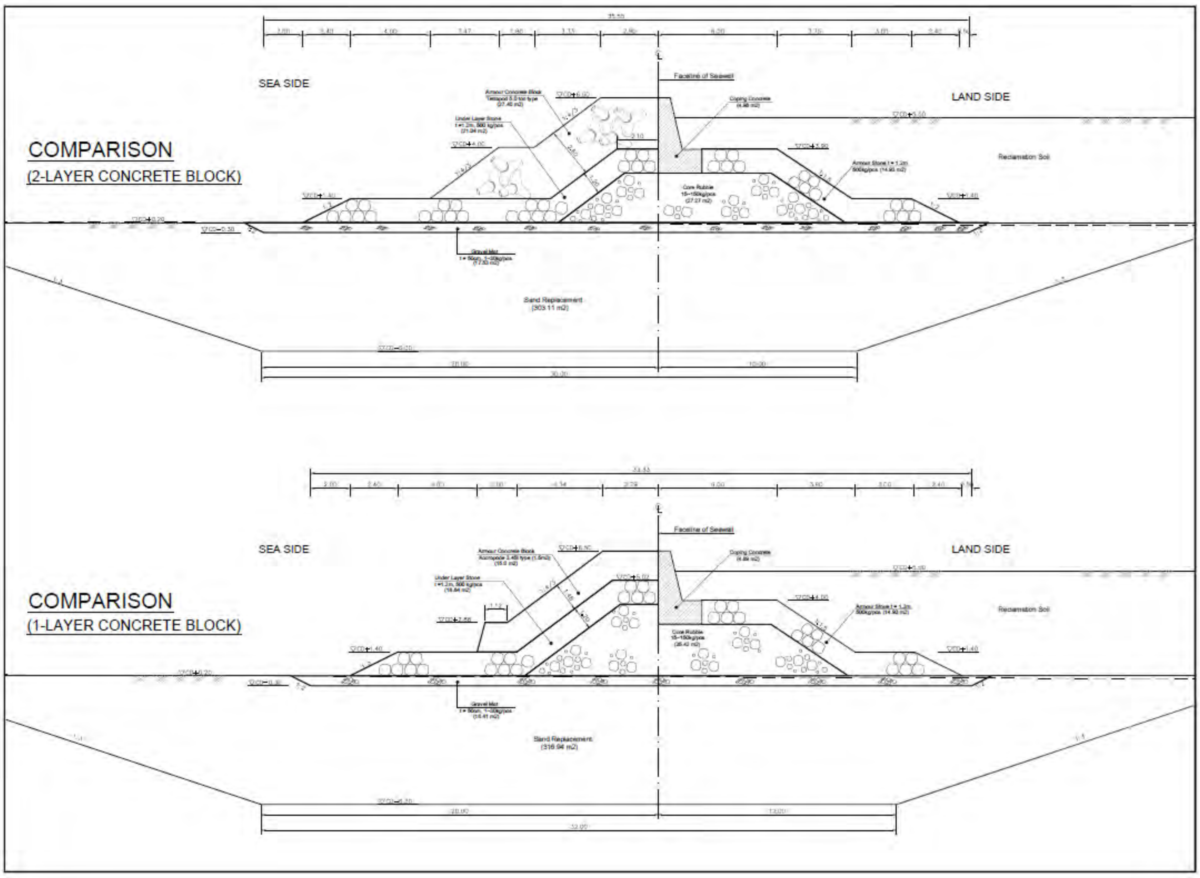
2) Comparison Between Single-layer and Double-layer Armor Concrete Block

The same structure type presented in the SAPROF report was basically recommended as the structure type of outer revetment B, as explained in Section 8.3. In this section meanwhile, the armor materials were compared. If the armor rock is assumed to be employed, the required weight was estimated to be more than 8.3 ton/unit. Thus, the wave dissipating concrete block is recommended as the type of armor material. As for the armor concrete blocks, two types were compared namely, the double-layer and the single-layer type. Tetrapod and Accropode armor concrete blocks were assumed as the double-layer and single-layer armor block type, respectively, as shown in Figure 8.4.4. The block size and dimension of the armor layer were calculated based on the design guideline for each block.

Table 8.4.3 shows the result of cost comparison between the double-layer and single-layer concrete block types. Even though the latter type could reduce the total concrete volume and resulting fabrication cost, its installation is more costly due to the necessity of strictly controlling the placement of the block for ensuring the required interlocking effect. As a result, the cost for the single-layer concrete block increased by 6% of that for the double-layer block.

Table 8.4.3 Result of Cost Comparison between 1-layer and 2-layer Concrete Armor Block

Double-layer Concrete Armor Block (assumed Tetrapod)	Single-layer Concrete Armor Block (assumed Accropode)
100%	106%



(Upper: Double-layer Tetrapod concrete block ; Lower: Single-layer Accropode concrete block)

Figure 8.4.4 Cross Section for Comparison of Different Type of Armor Block

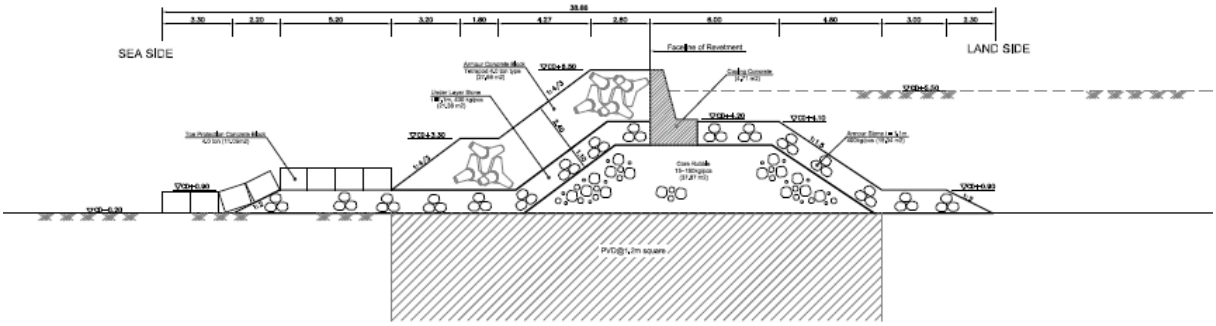
3) Comparison Between Original and Recommend Design

Figure 8.4.5 shows the comparison of typical cross section for outer revetment B between original design (SAPROF) and recommended one. The future image after executing the reclamation work was also presented as a reference.

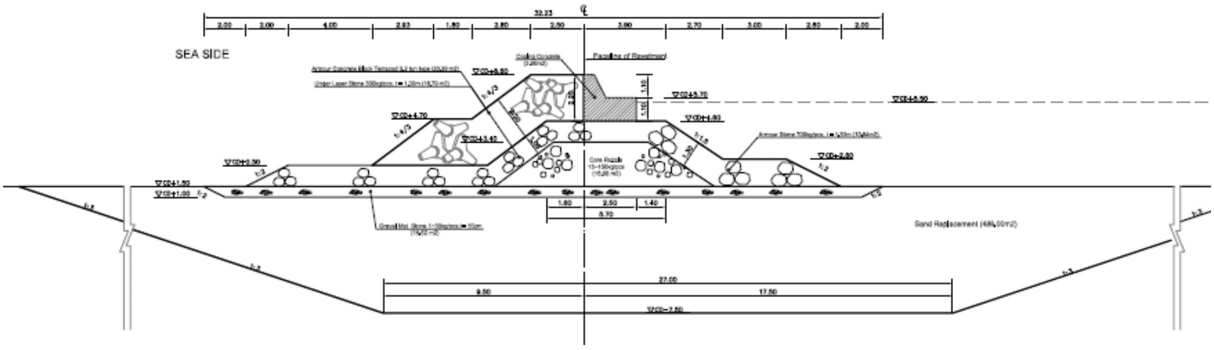
The modification points are summarized as follows.

- Change of soil improvement method from PVD to sand replacement
- Change of toe protection method from placing of the concrete block at toe part to filling the gravel mat as filter layer to prevent the settlement due to liquefaction of fine sand.
- The following construction items shall be considered after executing the reclamation at backyard.
  + Installation of geo-textile sheet with filter course at lee side
  + Concrete pavement at lee side
  + U- trench for drainage system

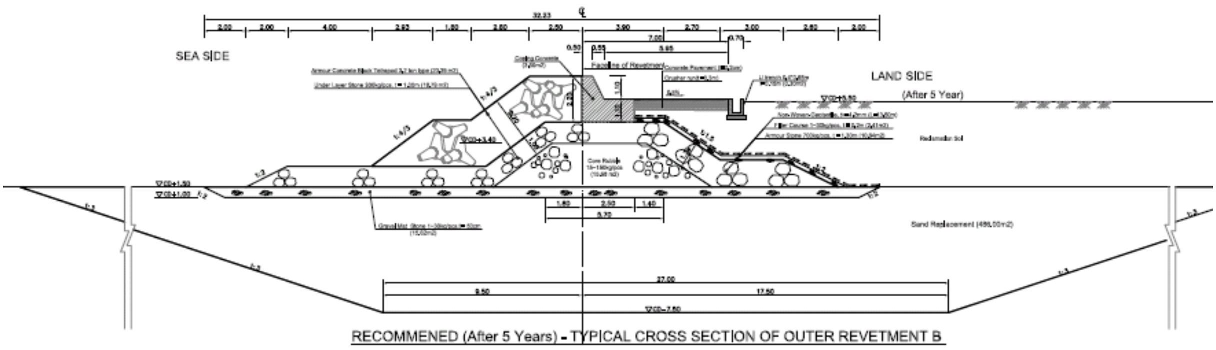
The detail design for each structure part was presented in Chapter 17.



(1) Original Design (SAPROF)



(2) Recommended Design (until Commencement of Reclamation at Backyard)



(3) Image after Reclamation at Backyard (as Reference)

Figure 8.4.5 Recommended Structure Type for Outer Revetment B

9. SAND PROTECTION DYKE

9.1 Design Standards and Conditions

The basic principle concerning the application of design standards for sand protection training dyke is the same as that for breakwater, which was presented in the previous section. Basically, Japanese standard for port and harbor structures, Technical Standards and Commentaries for Port and Harbor Facilities (OCDI-2002), are employed for the design while Vietnamese standard will be used for checking the results, in case that the latter exhibit significant difference with those of the Japanese standard. Following design standards were also applied as references when detailed information was required.

- Design Manual for Coastal Facilities (JSCE, 2000)
- Shore Protection Manual (US Army Corps of Engineers, 1984)
- Coastal Engineering Manual (US Army Corps of Engineers, 2004)
- Design of Vertical Breakwaters (Port and Airport Research Institute, Japan)
- The Rock Manual. The use of rock in hydraulic engineering, 2nd edition (C683, CIRIA, London, 2007)
- Design Guideline of Tetra-pod (Tetra-pod Co., Ltd., 1995)
- RAKUNA-IV (Nikken Kogaku Co., Ltd., 2012)

Because the channel sedimentation volume at the operation stage will affect significantly on the economical efficiency of the project, thus the layout and the length of the sand protection dyke will be carefully studied based on the updated numerical simulation of channel sedimentation, if found necessary.

Natural conditions such as tides, offshore design waves are also the same as that of breakwater, which were presented in the previous section. Because Sand Protection Dyke does not affect directly to the safety of ship navigation and port operation as well as the stability of civil structure, return period of 30 years of offshore design waves is considered for the structural design. H.H.W.L is not considered in the design of the structure for the same reason.

Soil improvement method will be considered in case that the safety factor for sloping stability becomes less than the required value. Although soil settlement of at most around 50cm by the preliminary study will be occurred with or without the soil improvement, soil settlement is not considered for the determination of crown height of the structure at the design stage. As will be mentioned later, crown height of the structure will be determined through the study of numerical sedimentation simulation which has inherently brought certain amount of uncertainty with the results and can be amended through the maintenance work

Damage ratio of wave dissipating block is important factor for the design of coastal structure and no-damage or less than 1 to 3% is usually employed. Sand Protection Dyke is not the structure which has direct influence on the safety of important port structure or important port activities as was mentioned above, damage ratio of up to 3% will be considered. Because of this, periodical checking and necessary maintenance work should be prepared.

9.2 Type of Structure

9.2.1 Previous Study

In the SAPROF study, numerical simulation had been done to reproduce the past channel sedimentation of Lach Huyen Channel for Hai Phong Port and to estimate the possible amount of channel sedimentation with/without the sand protection dyke. Based on the results of these simulation studies, necessity of providing sand protection dyke was confirmed. This structure is intended to serve as wall to confine and stabilize the in/out tidal flow along the access channel waterway, prevent the deposition of channel sedimentation, and function as a sand protection groin to interrupt the sediment transport along the shoreline.

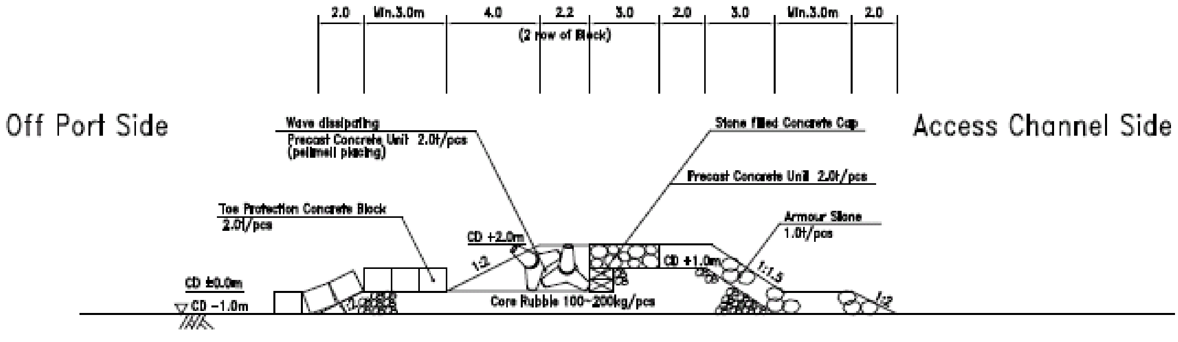
Crown height and the layout of the sand protection dyke were determined by considering the two functions namely, as training wall and groin. Moreover, economic efficiency for the dyke's construction was taken into account.

Hence, sand protection dyke is found necessary, considering a crown height of CD+2.00 m, and installed up to a water depth of CD-5.00 m in the initial stage of the port development. Non-permeable structure of about 3 to 5 m high above the seabed, which will serve as core portion of the sand protection dyke, will also be considered.

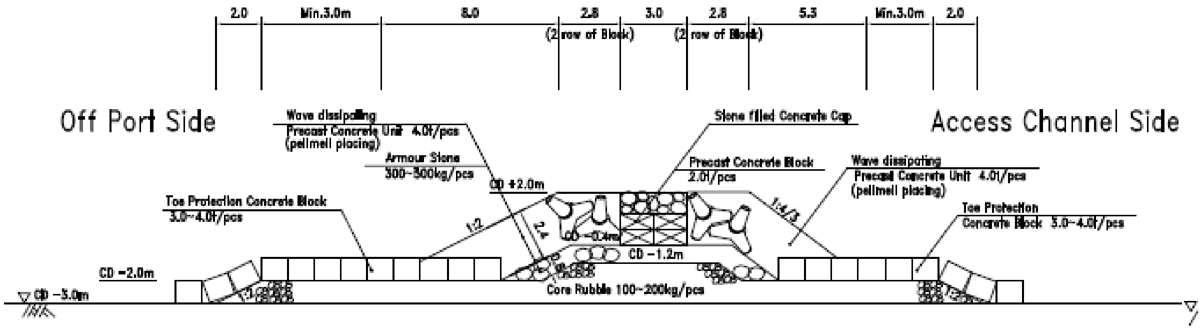
In the SAPROF study, the expected settlement due to consolidation is small. Moreover, maximum allowance of 0.5 m settlement due to consolidation was considered for the determination of the crown height of the sand protection dyke, instead of considering the execution of soil improvement work. This is initiated in order to prevent any settlements after the completion of the work.

Because sand protection dyke works as a breakwater for navigational channel, transmitted wave height through the dyke was studied. Thus, it was concluded that since the crown height of CD+2.00 m was relatively low, reduction of transmitted wave height was not so significant in protecting the navigational channel, particularly when the tide level is at HWL

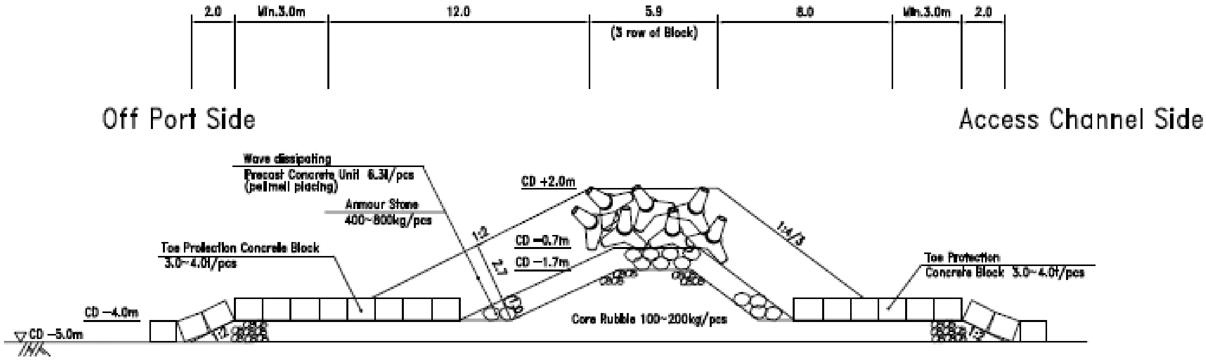
Rubble mounded sloping dyke armored with wave dissipating blocks was proposed in the SAPROF study. Figure 9.2.1 shows the standard cross section of the sand protection dyke designed by the SAPROF study team. The calculated settlement due to consolidation ranges from 30 to 40 cm. Furthermore, soil improvement works was no longer considered after taking into account the bearing capacity of the upper clayey soil.



Section for GL up to CD −1.0m



Section for CD -1.0~-3.0m



Section for GL up to CD -3.0~-5.0m

Figure 9.2.1 Typical Cross Section of Sand Protection Dyke

9.2.2 Alternative Types of Structure

Possible layout plans and the crown height of the Sand Protection Dyke as a countermeasure of navigational channel sedimentation were presented in the previous section and the annual sedimentation volume which correspond to the average annual maintenance dredging volume were also presented.

According to the results of numerical simulation of channel sedimentation shown in Section 5.2, following things have been identified. The difference of sedimentation volume due to the difference of length of Sand Protection Dyke, in other words, difference of the water depth at the tip of the Sand Protection Dyke have been small for the case with energy average wave conditions. On the other hand there have been significant differences for the case with high wave conditions but the difference of expected sedimentation volume was at most 0.3 million m3 which was considered small compared with the increase of the construction cost of Sand Protection Dyke. The alignment of Sand Protection Dyke as a countermeasure was determined to obey the previous study at SAPROF in order not to intervene the future port expansion for terminal area. Based on these considerations, length of Sand Protection Dyke was employed the same length with SAPROF and Crest height of the Sand Protection Dyke will be determined by cost-benefit based analysis.

Figure 9.2.2 shows the layout plans of the Sand Protection Dyke studied in the previous section. Annual sedimentation volume for each possible layout plan has been shown in the table of Section 5.2. In the table, annual sedimentation volume without the existence of countermeasure structure against sedimentation was also presented as a reference in the table.

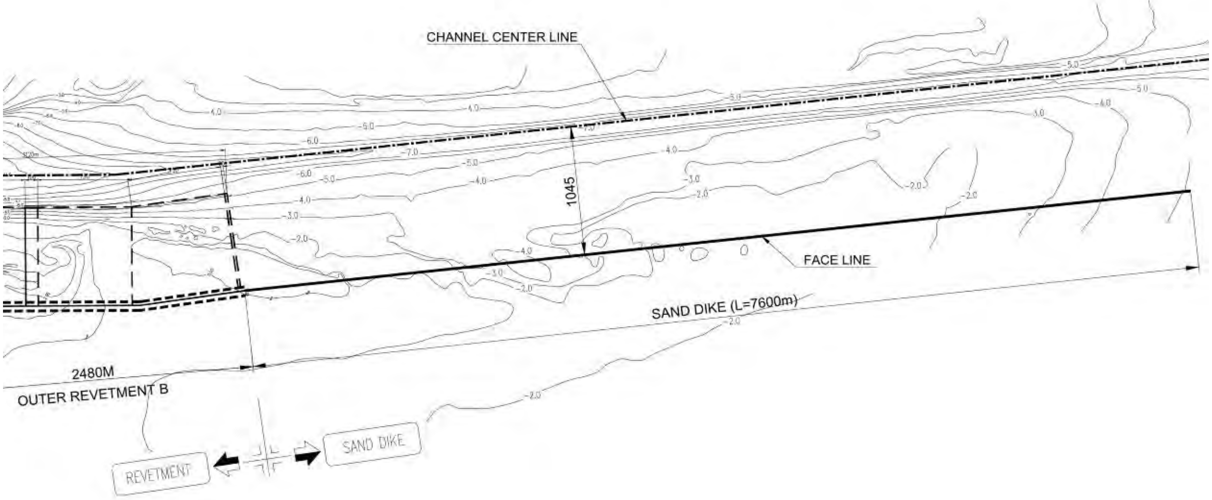


Figure 9.2.2 Seabed Topography around the Sand Protection Dyke

In determining the most suitable type of sand protection dyke structure, gravity-type cellular caisson as well as sloping dyke which was the proposed structure type in SAPROF study were considered. As for the sloping dyke structure, basic ideas of the structural type of revetment such as tow protection were employed. In order for the reduction of construction cost and construction period, cellular caisson type structure instead of cast in concrete structure was used for superstructure. Precast concrete block will be used as an alternative structure of cast-in-concrete capping concrete.

Structure with crown height of C.D.L.+2.00m and G.L.+3.00m has been studied for the comparison of the construction cost in order to confirm the cost-effectiveness of the proposed crown height for Sand Protection Dyke.

Selection of the type of structure and the length of Sand Protection Dyke were based on the total cost of construction of the structure with the consideration of construction period and maintenance dredging cost during the certain period of port operation period. Annual maintenance dredging cost will be calculated by using the annual sedimentation volume shown in the table of Section 5.2. Appropriate crown height of Sand Protection Dyke was obtained through this evaluation study in a latter section.

9.3 Basic Design of Sand Protection Dyke

9.3.1 Design Conditions

Tidal conditions and offshore wave conditions that the dyke is subjected to are the same with those for the breakwater. Design wave heights of H_{max} and $H_{1/3}$ along the alignment of the Sand Protection Dyke were obtained through the wave deformation analysis with the use of Goda’s formula of wave deformation by breaking in Chapter 2, and the results are also shown in the previous Chapter 2 and in Appendix. In this study, return period of 30 years with tidal condition of H.W.L and L.W.L were considered as stated previously in this section.

Subsoil conditions using the data obtained through this study were shown in the Section 2.1. Figure 9.3.1 shows the sea bottom profile along the alignment of Sand Protection Dyke based on the latest bathymetric survey data. Subsoil conditions are used to confirm the safety against slope sliding and to determine the soil improvement method in case of necessity.

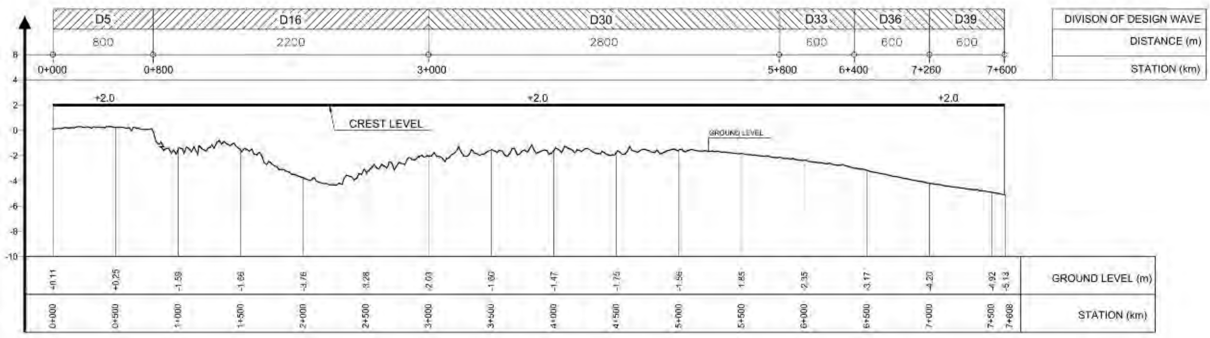


Figure 9.3.1 Seabed Profile along the Alignment of Sand Protection Dyke

9.3.2 Core rubble material

Core rubble mound of 5-150kg/pcs were used in order to keep the structure impermeability which was the fundamental requirement of the structure as a countermeasure for channel sedimentation to protect the transportation through the Dyke structure which were considered as a basic input data for the numerical simulation model of channel sedimentation.

9.3.3 Wave Dissipating Concrete Block and Foot Protection Block

“The Rock Manual - The use of rock in hydraulic engineering, 2nd edition (C683, CIRIA, London, 2007)” were used for the design of the wave dissipating concrete block for determining the dimensions and slope gradient of wave dissipating concrete block with conditions of 3% damage level. According to the consideration of wave deformation analysis in the previous section, incident wave from offshore side and from inner port side should be considered for the design of Sand Protection Dyke and slope gradient of wave dissipating block of 1:2 for both sides were employed.

Because the proposed crown height of Sand Protection Dyke is relatively low, wave overtopping greatly influence the stability of armor layer. Incident wave heights from inner port side are almost as high as that of at the same point from offshore side. Taking into consideration of these effects, same dimensions of wave dissipating concrete block for the armor layer material of offshore side will be employed for the other inner side.

For the determination of weight of wave dissipating concrete block, Hudson formula shown in equation (9-1) was used. In this equation K_D value of 8.3 which correspond to the damage ratio of 3% was used by referring the Rock Manual (2011) in equation (9-2). That means we allow some damage at the time when the incident waves becomes close to or exceed the design wave height and maintenance remedial work should be necessary. Table 9.3.1 through Table 9.3.3 show the calculation results of necessary weight for wave dissipating block and foot protection block at each location along the alignment of Sand Protection Dyke. For obtaining this table, H.W.L. and L.W.L. sea level conditions were taken into consideration.

HUDSON FORMULA:

$$W = \frac{\rho_s H_s^3}{K_D \left(\frac{\rho_s}{\rho_w} - 1 \right)^3 \cot\alpha} \qquad (9\text{-}1)$$

$$N_s = \frac{H_s}{\Delta D_n} = \left(K_D \cot\alpha \right)^{1/3} \qquad (9\text{-}2)$$

Where in:

W: necessary weight of armor concrete block (t)
ρ_s: mass density of armor unit (t/m^3)
ρ_w: mass density of water (t/m^3)
K_D: stability coefficient
α: slope angle
H_s: characteristic wave height (m)
N_s: stability number
Δ: relative buoyant density, $\rho_s/\rho_w - 1$
D_n: equivalent cube length of median armor block.

Table 9.3.1 Results of Calculation of Necessary Weight of Tetra-Pod

Pos	Seabed Level (m)	Wave height $H_{1/3}$ (m)	K_D	Slope	Tetrapod (tons)				
					W (tons)	Type (tons)	Thickness (m)	B (m)	B' (m)
D5	0.0	2.67	8.3	1:2	1.36	**2.0**	1.90	1.60	2.20
D16	-1.0	3.08	8.3	1:2	2.11	**3.2**	2.20	1.80	2.50
D30	-2.0	3.58	8.3	1:2	3.30	**4.0**	2.40	2.00	2.80
D33	-3.0	4.08	8.3	1:2	4.89	**6.3**	2.70	2.30	3.20
D36	-4.0	4.64	8.3	1:2	7.17	**8.0**	3.00	2.50	3.40
D39	-5.0	4.96	8.3	1:2	8.78	**10.0**	3.20	2.70	3.70

Table 9.3.2 Results of Calculation of Necessary Weight of RAKUNA-IV (for reference)

Pos	Seabed Level (m)	Wave height $H_{1/3}$ (m)	K_D	Slope	RAKUNA-IV (tons)				
					W (tons)	Type (tons)	Thickness (m)	B (m)	B' (m)
D5	0.0	2.67	10.8	1:2	1.06	**2.0**	1.80	1.66	1.77
D16	-1.0	3.08	10.8	1:2	1.62	**2.0**	1.80	1.66	1.77
D30	-2.0	3.58	10.8	1:2	2.54	**4.0**	2.20	2.03	2.55
D33	-3.0	4.08	10.8	1:2	3.76	**4.0**	2.20	2.03	2.55
D36	-4.0	4.64	10.8	1:2	5.53	**6.0**	2.55	2.38	2.98
D39	-5.0	4.96	10.8	1:2	6.76	**8.0**	2.80	2.55	3.21

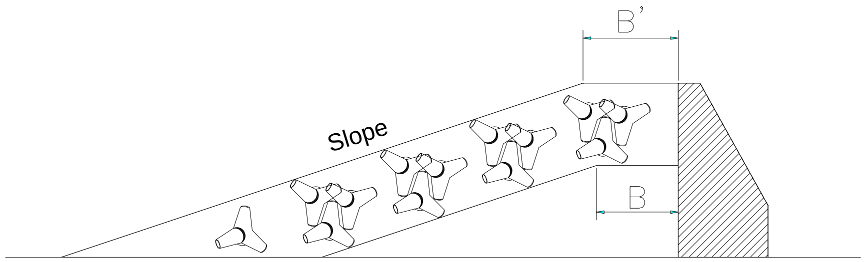


Table 9.3.3 Results of Calculation of Necessary Weight of Foot Protection Block (STONE-BLOCK, for reference)

Pos	Seabed Level (m)	Wave height $H_{1/3}$ (m)	Ns^3	STONE-BLOCK (tons)		
				W (tons)	Type (tons)	Thickness (m)
D5	0.0	2.67	25	0.91	**4.0**	0.84
D16	-1.0	3.08	22	1.59	**4.0**	0.84
D30	-2.0	3.58	30	1.83	**4.0**	0.84
D33	-3.0	4.08	33	2.46	**4.0**	0.84
D36	-4.0	4.64	55	2.17	**4.0**	0.84
D39	-5.0	4.96	90	1.62	**4.0**	0.84

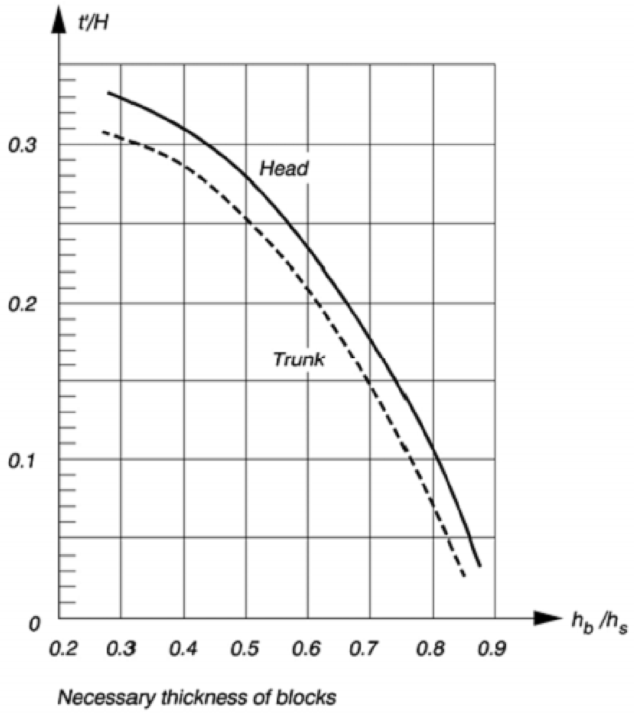
9.3.4 Cellular Caisson

Incident wave force was calculated by Goda's Formula shown in equation (9-3). Friction factor of 0.8 for cellular caisson filled with rock material was used following the Technical Standards and Commentaries for Port and Harbor Facilities (OCDI-2002). Dimension of foot protection concrete block was also determined using the Figure 9.3.2 which was given by Coastal Engineering Manual (US Army Corps of Engineers, 2004). Precast concrete block was used as an alternative structure of cast-in capping concrete. Horizontal dimension of 3.0m x2.0m and maximum height of 2.5m for each cellular caisson was determined by taking into consideration of the easiness of handling and placing the structure at the site. Table 9.3.4 shows the results of calculation of above mentioned dimensions. For obtaining this table, H.W.L. and L.W.L. sea level conditions were taken into consideration.

GODA's Formula: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$ (9-3)

Where in:

P_1: wave pressure at still water level
β: angle between the line normal to the upright wall and the direction of wave approach.
λ: wave modify factor
ρ_0: density of water
g: gravitational acceleration
H_D: wave height



l x b x t'			app. mass t
2.5	1.5	0.8	6
3.0	2.5	1.0	15
4.0	2.5	1.2	25
5.0	2.5	1.4	37
5.0	2.5	1.6	42
5.0	2.5	1.8	48
5.0	2.5	2.0	53
5.0	2.5	2.2	58

Specification of outer block geometries in meters. Hole volume should be app. 10% of total volume.

Figure 9.3.2 Design of foot protection blocks according to Japanese practice

Table 9.3.4 Calculated Results of Dimensions of Cellular Caisson

Alternative	Seabed Elev. (m)	Cellular dimension width (m)	length (m)	height (m)	thickness (m)	Remark
CASE B-1	0.0	3.00	2.00	2.00	0.20	Single layer cellular
	-1.0	3.00	2.00	2.00	0.20	Single layer cellular
	-2.0	3.00	2.00	3.00	0.20	Single layer cellular
	-3.0	3.00	2.00	2.00	0.20	Double layer cellular
	-4.0	3.00	2.00	2.50	0.20	Double layer cellular
	-5.0	3.00	2.00	2.75	0.20	Double layer cellular
CASE B-2	0.0	3.00	2.00	1.50	0.20	Single layer cellular
	-1.0	3.00	2.00	1.50	0.20	Single layer cellular
	-2.0	3.00	2.00	2.50	0.20	Single layer cellular
	-3.0	3.00	2.00	2.50	0.20	Single layer cellular
	-4.0	3.00	2.00	2.50	0.20	Single layer cellular
	-5.0	3.00	2.00	2.50	0.20	Single layer cellular

9.3.5 Superstructure

Cellular caisson structure was also employed for superstructure. Incident wave force was calculated by Goda's Formula which was shown in equation (9-3). Friction factor of 0.8 for cellular caisson filled with rock material was also used following the Technical Standards and Commentaries for Port and Harbor Facilities (OCDI-2002). This friction factor can't apply the bottom of the cellular caisson concrete structure in a strict sense, but the effect is small and the results of safety factor will be checked to have enough safety that can cover the negligence of those factor. Because the wave dissipating concrete block of same weight was placed at both side, weight of those structures were taking into consideration of counter-weight against the sliding due to waves. Friction factor of 0.8 was considered in the calculation of safety factor of superstructure against wave forces. Table 9.3.5 shows the results of calculation of above mentioned dimensions.

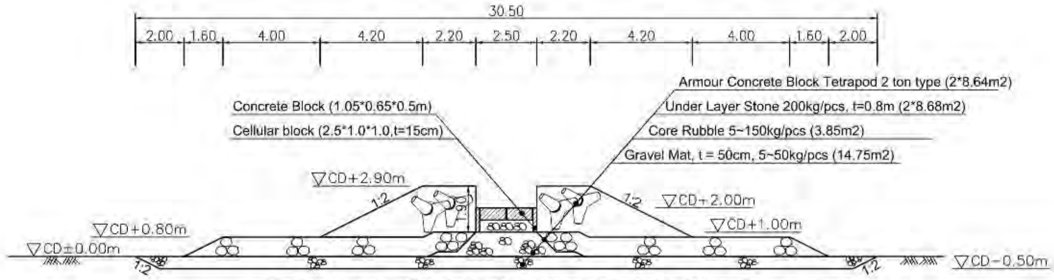
Table 9.3.5 Calculated Results of Dimensions of Cellular Caisson

Alternative	Seabed Elev. (m)	Cellular dimension Width (m)	Length (m)	Height (m)	Thickness (m)
CASE A-1	0.0	2.50	2.00	2.00	0.20
	-1.0	2.50	2.00	2.00	0.20
	-2.0	2.50	2.00	2.20	0.20
	-3.0	3.00	2.00	2.20	0.20
	-4.0	3.00	2.00	2.50	0.20
	-5.0	3.00	2.00	2.50	0.20
CASE A-2	0.0	2.50	2.00	2.00	0.20
	-1.0	2.50	2.00	2.00	0.20
	-2.0	2.50	2.00	2.20	0.20
	-3.0	3.00	2.00	2.20	0.20
	-4.0	3.00	2.00	2.50	0.20
	-5.0	3.00	2.00	2.50	0.20

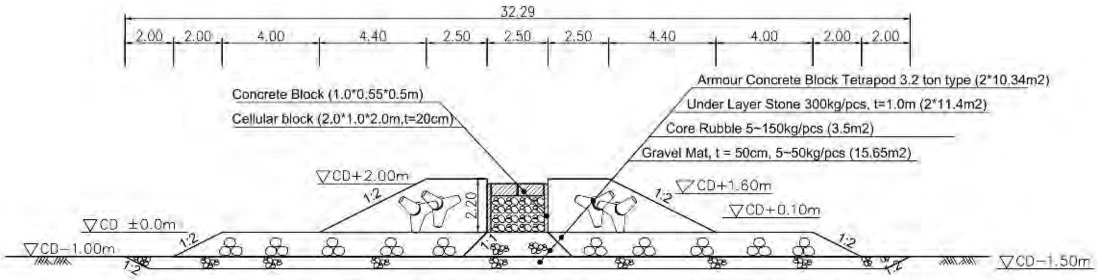
9.3.6 Comparison of the Proposed Alternatives as a Sand Protection Dyke

Typical cross sections of two types of structure with two different crown heights were shown from Figure 9.3.3 to Figure 9.3.6 for each considered water depth. In these figures, Case-A indicate the sloping dyke structure with cellular caisson as a superstructure and Case-B indicate the gravity type cellular caisson structure. Suffix of these case number shows the crown height difference and suffix 1 indicate the structure with crown height of CDL+2.00 and suffix 2 indicate the structure with its crown height of at least 3.00m high from the sea bottom.

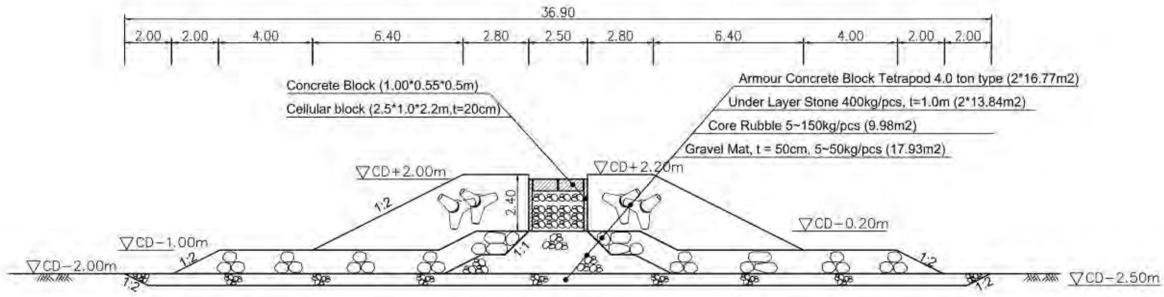
CASE A-1



TYPICAL CROSS SECTION FOR STATION D1 ~ D5



TYPICAL CROSS SECTION FOR STATION D5 ~ D16



TYPICAL CROSS SECTION FOR STATION D16 ~ D30

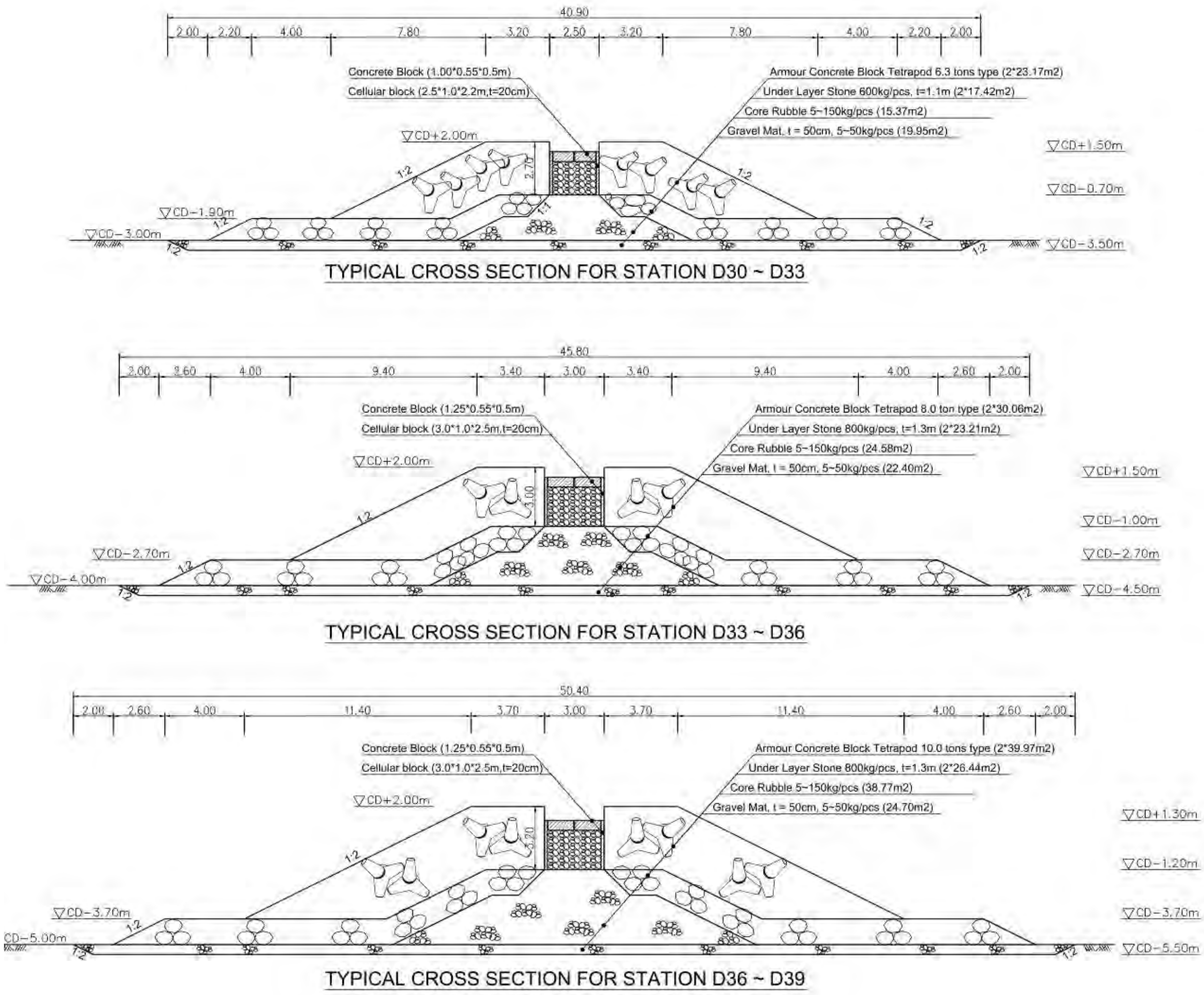
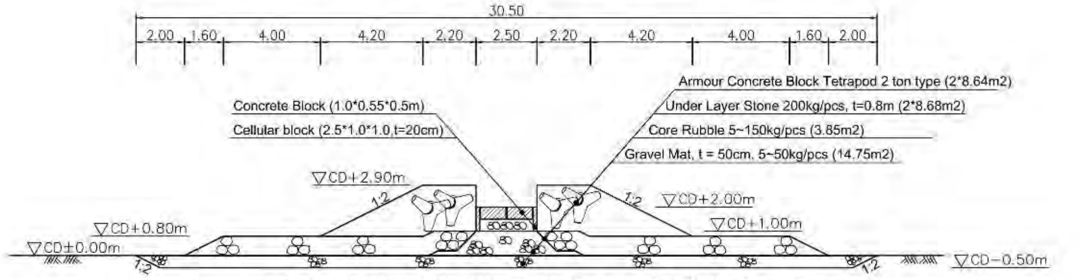
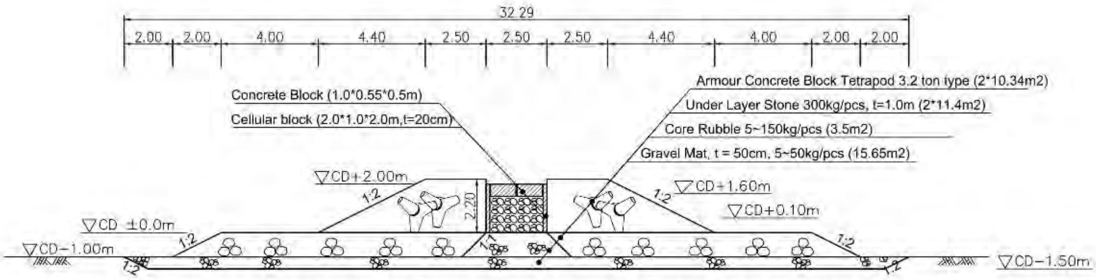


Figure 9.3.3 Typical Cross Section of Proposed Sand Protection Dyke – CASE A-1

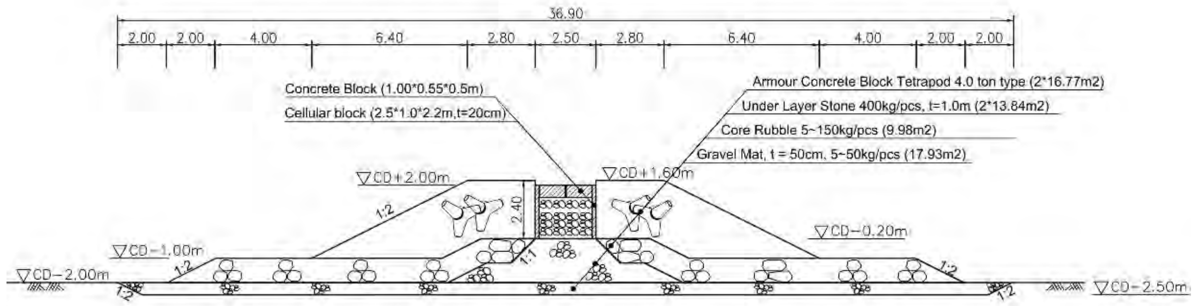
CASE A-2



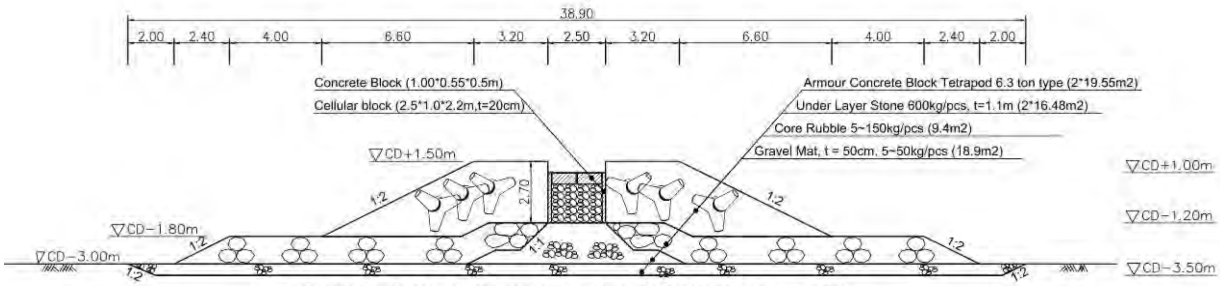
TYPICAL CROSS SECTION FOR STATION D1 ~ D5



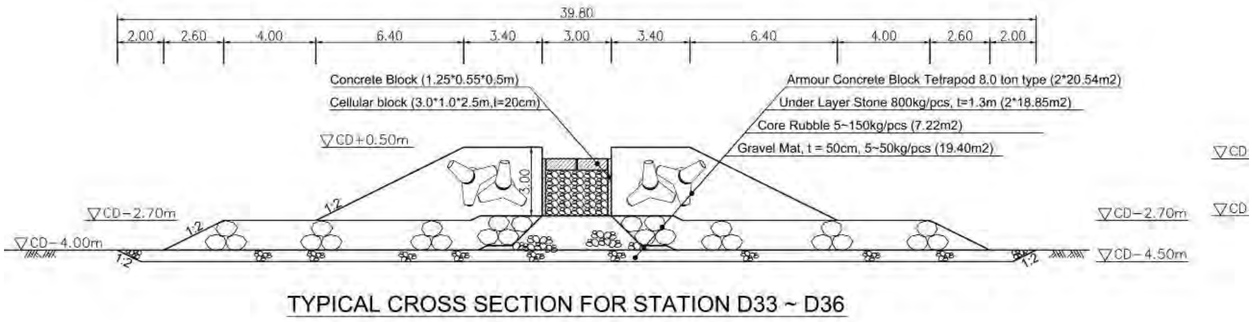
TYPICAL CROSS SECTION FOR STATION D5 ~ D16



TYPICAL CROSS SECTION FOR STATION D16 ~ D30



TYPICAL CROSS SECTION FOR STATION D30 ~ D33



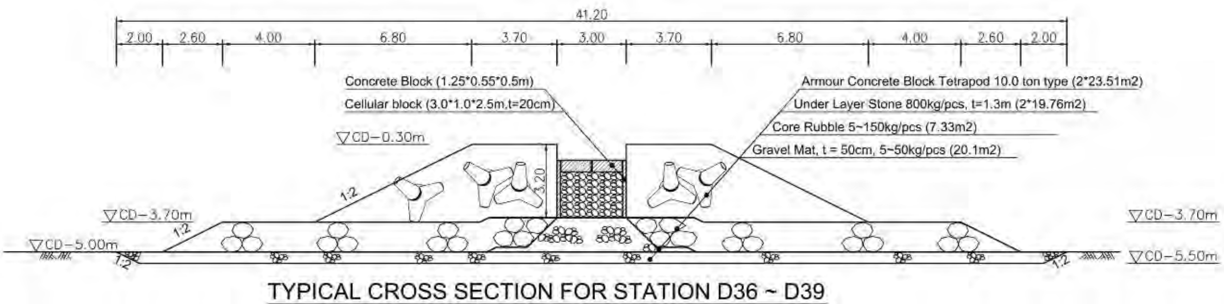
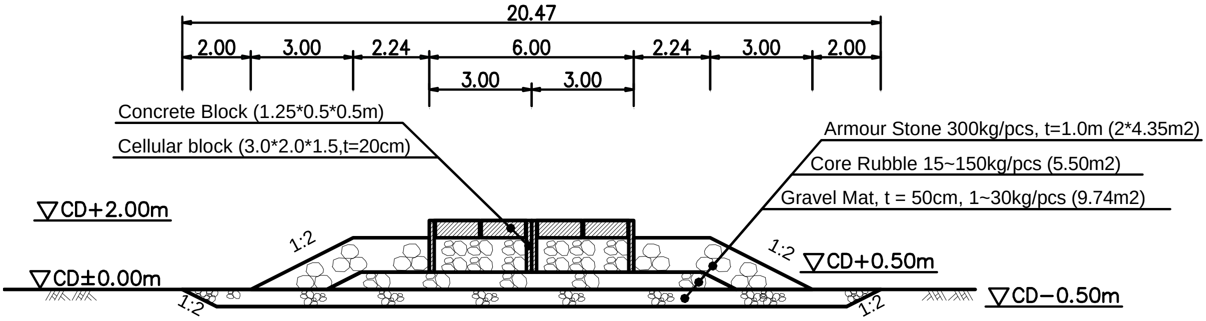
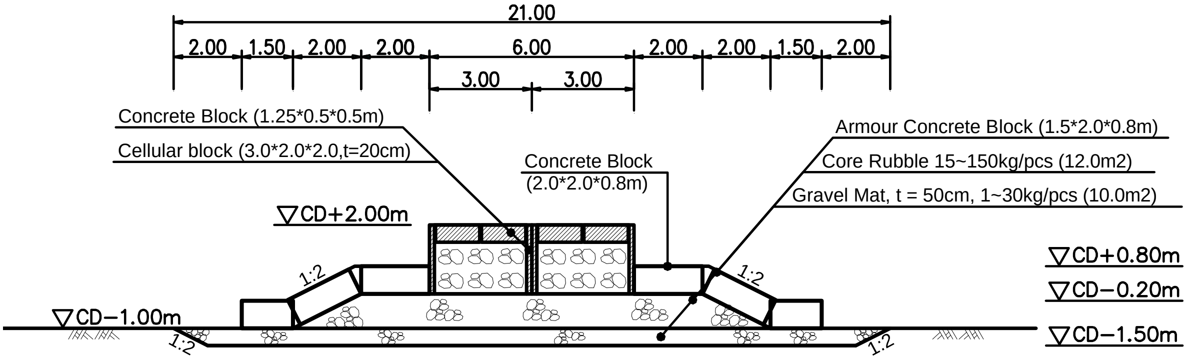


Figure 9.3.4 Typical Cross Section of Proposed Sand Protection Dyke – CASE A-2

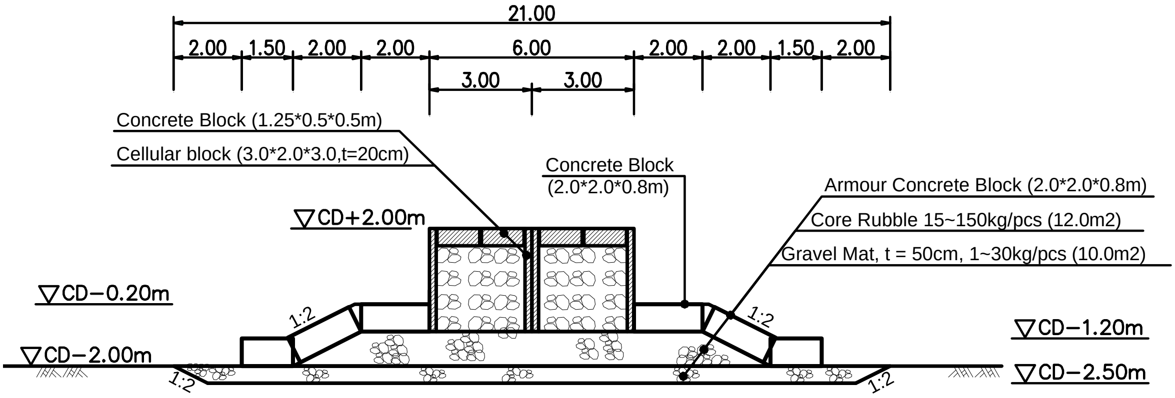
CASE B-1



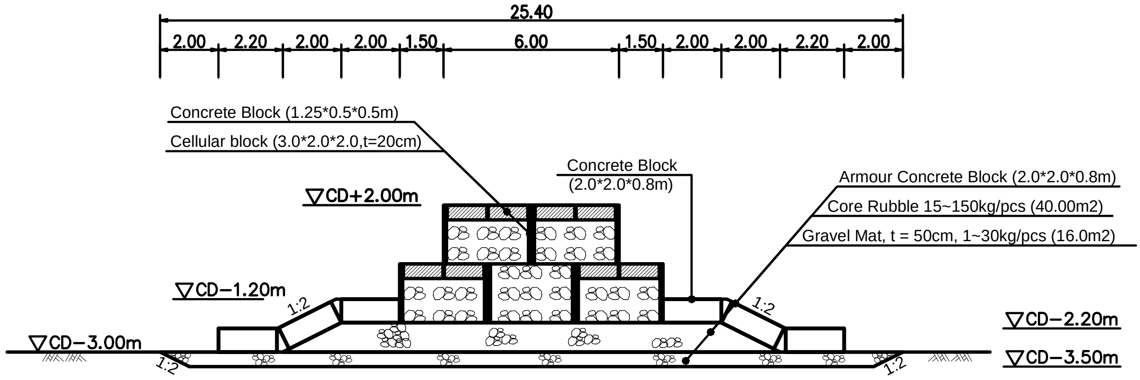
TYPICAL CROSS SECTION FOR STATION D1 ~ D5



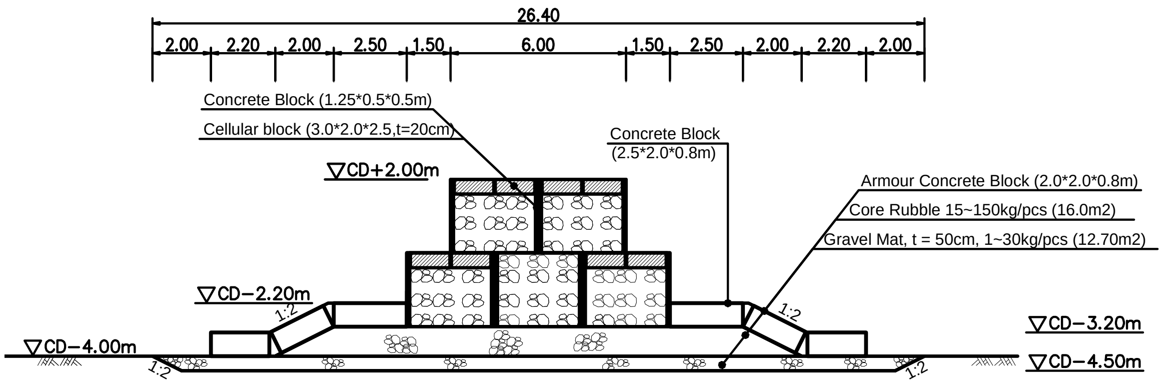
TYPICAL CROSS SECTION FOR STATION D5 ~ D16



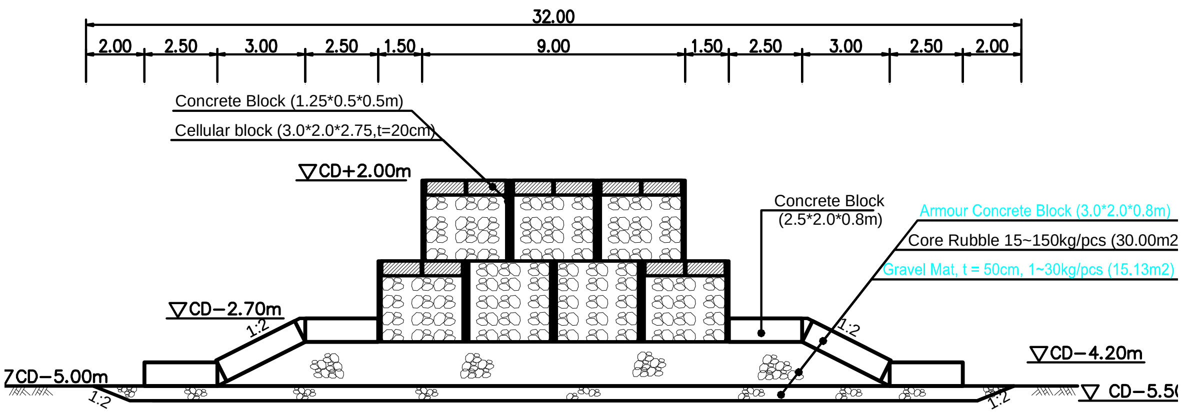
TYPICAL CROSS SECTION FOR STATION D16 ~ D30



TYPICAL CROSS SECTION FOR STATION D30 ~ D33



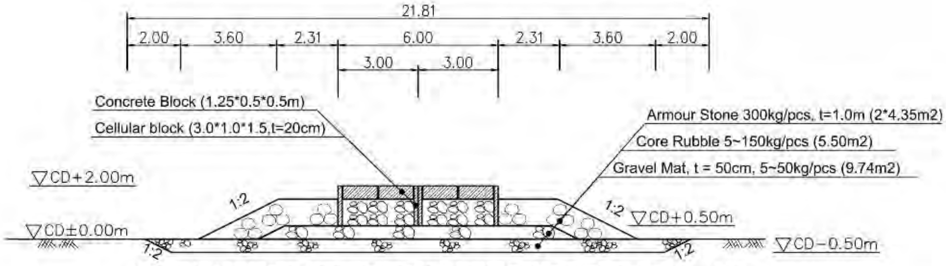
TYPICAL CROSS SECTION FOR STATION D33 ~ D36



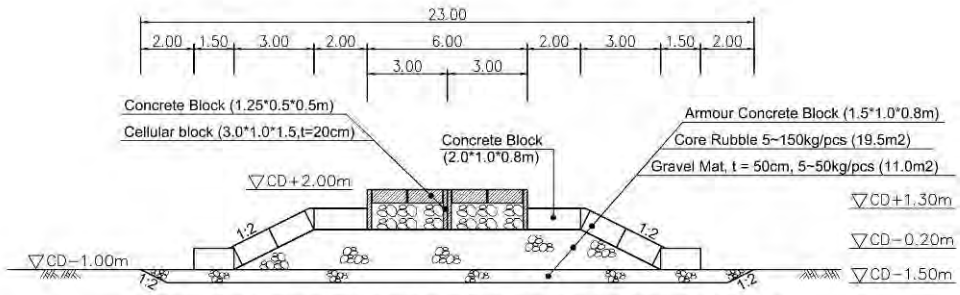
TYPICAL CROSS SECTION FOR STATION D36 ~ D39

Figure 9.3.5 Typical Cross Section of Proposed Sand Protection Dyke – CASE B-1

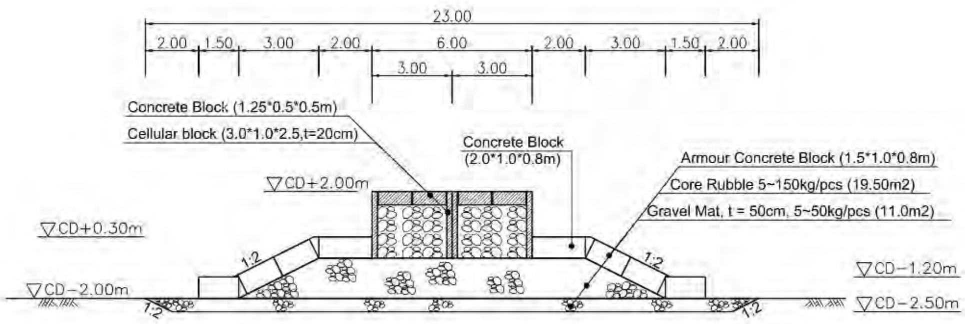
CASE B-2



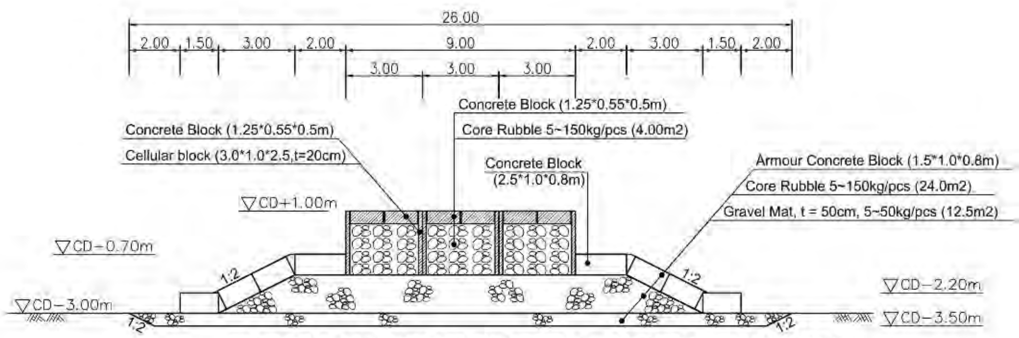
TYPICAL CROSS SECTION FOR STATION D1 ~ D5



TYPICAL CROSS SECTION FOR STATION D5 ~ D16



TYPICAL CROSS SECTION FOR STATION D16 ~ D30



TYPICAL CROSS SECTION FOR STATION D30 ~ D33

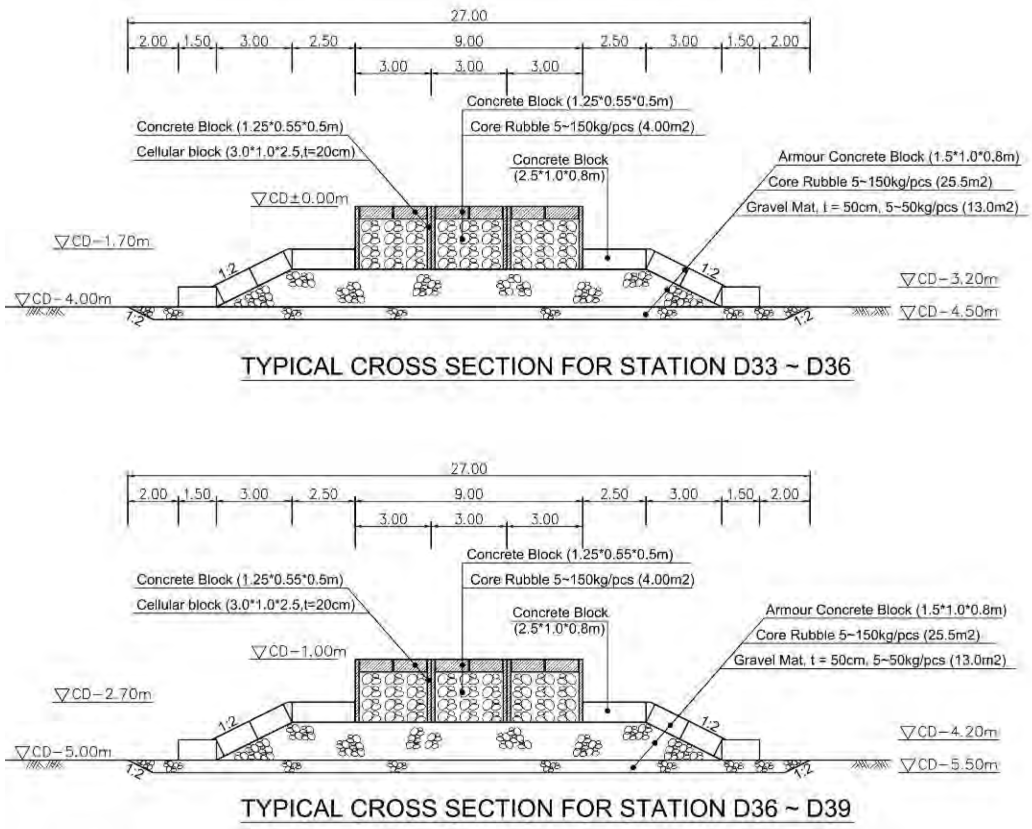
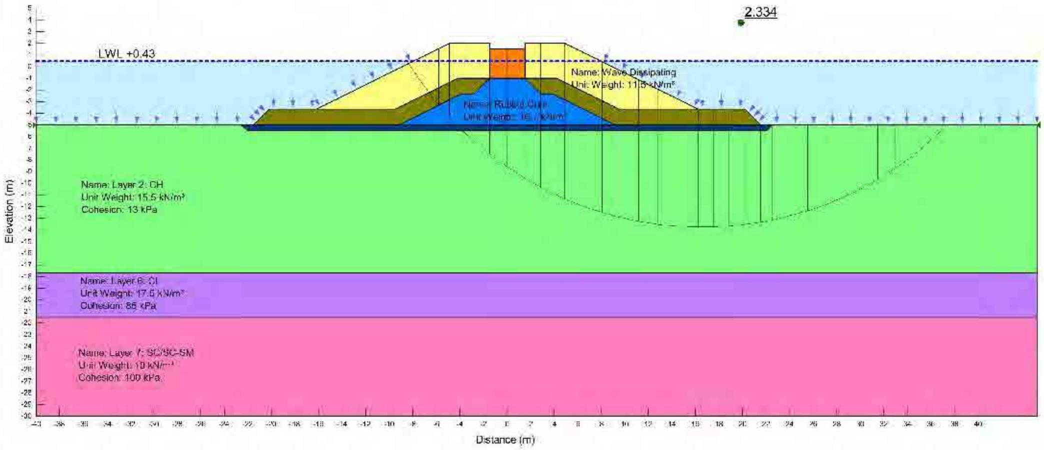


Figure 9.3.6 Typical Cross Section of Proposed Sand Protection Dyke – CASE B-2

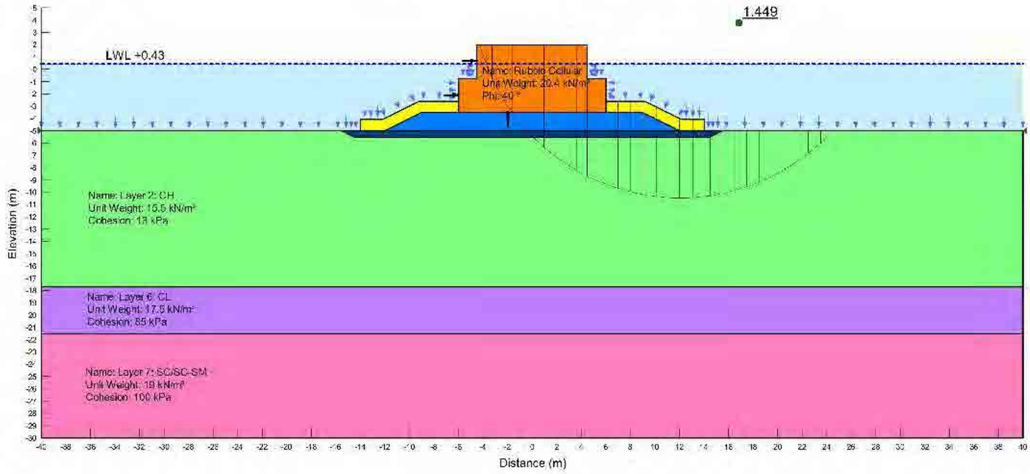
For the design of Sand Protection Dyke, one of the most important things is to ensure the sloping stability. Below result, the most critical section is employed to check the slope stability of structure such as soil conditions of borehole D26 consistent with typical cross section of GL. -5.0 m CD. According to the results shown in Figure 9.3.7, minimum safety factor are 2.110 and 2.771 for those two alternative types of structures. These results showed that there is no necessity for soil improvement work for the Sand Protection Dyke structure which was shown in Figure 9.3.3 to Figure 9.3.6.

After completion of the construction, periodical inspection and maintenance work should be done in accordance with the observation of channel sedimentation. In case actual sedimentation will turn out to surpass the predicted value with unacceptable level, some countermeasures such as the extension of the dyke, raising the crown height, placement of additional simple structure etc. should be carefully studied.

SLOPE STABILITY OF SAND PROTECTION DIKE
CASE A: RUBBLE MOUND CELLULAR COVERS BY TETRAPOD BLOCKS
TYPICAL CROSS SECTION GL.-5.0 (BOREHOLE - D26)



SLOPE STABILITY OF SAND PROTECTION DIKE
CASE B: RUBBLE MOUND CONCRETE CELLULAR
TYPICAL CROSS SECTION (BOREHOLE: D26)



SLOPE STABILITY OF SAND PROTECTION DIKE
ALTERNATIVE: RUBBLE MOUND CONCRETE CELLULAR
TYPICAL CROSS SECTION GL.-5.0 (BOREHOLE - D26)

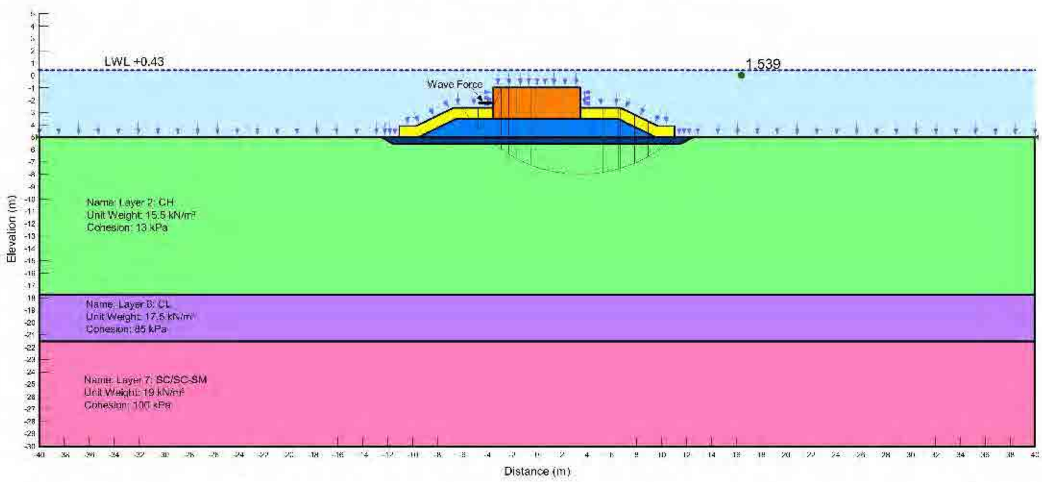


Figure 9.3.7 Calculated Results of Sloping Stability

Although the effect of length and the layout of the Sand Protection Dyke have studied in Chapter 5 and layout plan near navigational channel were intensively studied because this layout shows effective reduction of sedimentation, original layout plan of Sand Protection Dyke at SAPROF was preferred.

In order to confirm the appropriate length of Sand Protection Dyke, predicted sedimentation data with different length of the structure were necessary. Predicted sedimentation for Case03-5m, Case03-10m and Case03-14m in Table 5.10.2 were used to obtain the expected sedimentation for the SAPROF alignment case for which only water depth at the tip of -5m was the only case that have simulated sedimentation data. Ratio between Case03-10m and Case03-14m with Case03-5m were used as the ratio for SAPROF alignment case.

Comparison of the Construction cost for each alternative structure of Sand Protection Dyke was shown in Table 9.3.6. According to these results, Case B-2 shows the lowest construction cost. With the consideration of annual maintenance dredging cost for the Case B-1 and B-2, the length and the crown height of the Sand Protection Dyke will be determined.

Table 9.3.6 Construction Cost of Sand Protection Dyke

Case	Sea bottom depth at the tip (C.D.L -m)	Initial construction cost (billion VND)	Annual sedimentation volume at energy averaged wave conditions ((x10,000 m^3)	*1) Annual sedimentation volume at rough wave conditions ((x10,000 m^3)
Case A-1	-5m -10m	1,690 3,762	103.7 101.2 *2)	158.5 135.7 *2)
Case A-2	-5m -10m	1,539 2,503	129.5 126.4 *2)	154.1 132.0 *2)
Case B-1	-5m	1,584	103.7	158.5
	-10m	3,947	101.2 *2)	135.7 *2)
Case B-2	-5m	1,306	129.5	154.1
	-10m	2,197	126.4 *2)	132.0 *2)
Case 1			160.2	168.0

*1) Annual sedimentation volume for wave conditions of year of 2005.05 to 2006.04
*2) Estimated value using the results for alignment near the channel as explained in the context

Table 9.3.7 shows the construction cost and expected annual maintenance dredging cost for energy average wave conditions (*1)) and energy wave conditions plus “rough wave conditions” that means for actual wave conditions from May 2005 to April 2006 (*2)) which was the most severest sea wave conditions after the opening of Lach Huyen new channel for Hai Phong Port Area. Dredging cost of 10.0 USD/m^3 which was used in the cost estimate for preparing F/R. was used. Accumulated cost for 10 years, 20 years and 30years which include the initial construction cost and maintenance cost were also shown in this table.

According to the result shown in this table, although the case without any countermeasure shows lowest cost at the early stage of port operation, construction of Sand Protection Dyke of Case B-1 with crown height of C.D.L-2.00m shows most cost-effective results in the long run of certain port operation period and will be recommended as the countermeasure against navigational channel sedimentation.

Table 9.3.7 Construction Cost and Expected Sedimentation Volume

Case No.	Crown height	Water depth at the tip	Initial construction cost	Annual Maintenance dredging cost ((x10,000 m^3)	Accumulated cost			Annual wave conditions
					10 years	20 years	30 years	
Case 1	-		0	336	3,360	6,720	10,080	"Energy average wave"
Case B-1	C.D.L.+2.0m	-5m	1,584	218	3,764	5,944	8,124	
Case B-1	C.D.L.+2.0m	-10m	3,947	213	6,077	8,207	10,337	
Case B-2	G.L.+3.0m	-5m	1,306	272	4,026	6,746	9,466	
Case B-2	G.L.+3.0m	-10m	2,197	265	4,847	7,497	10,147	
Case 1	-		0	689	6,890	13,780	20,670	"Energy average wave" + Rough wave condition*1)
Case B-1	C.D.L.+2.0m	-5m	1,584	551	7,094	12,604	18,114	
Case B-1	C.D.L.+2.0m	-10m	3,947	498	8,927	13,907	18,887	
Case B-2	G.L.+3.0m	-5m	1,306	596	7,266	13,226	19,019	
Case B-2	G.L.+3.0m	-10m	2,197	541	7,607	13,017	18,427	

*1) Annual sedimentation volume for wave conditions of year of 2005.05 to 2006.04 (unit: billion VND)

10. LAND RECLAMATION AT PUBLIC RELATED AREA

10.1 Land Reclamation

The Public Related area is used for the port operation and management facilities. Since a high voltage power line tower (see Figure 10.1.1) is located adjacent to the planned Public Related area, the setback layout is recommended through the discussion with EVN Haiphong branch so as not to make any adverse effect to the power line tower during construction.

Figure 10.1.1 High Voltage Power Line Tower

The set backed layout of Public Related area and its expected land-use map is as shown in Figure 10.1.2.

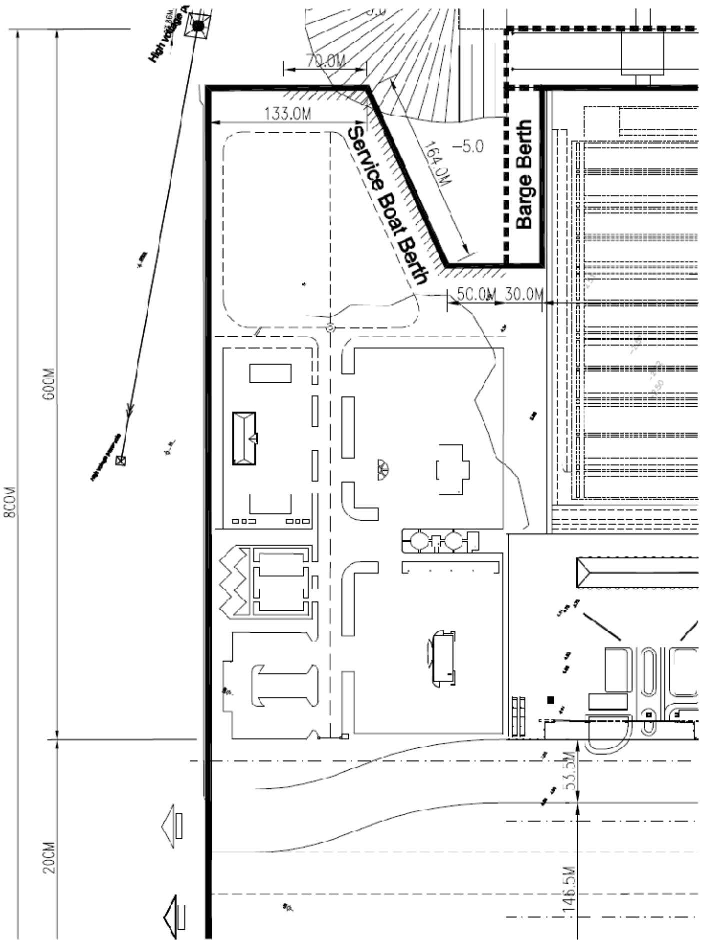


Figure 10.1.2 Expected Land Use Plan of Public Related Area

The finish elevation of reclamation at Public related area in the Component A of the Project is 4.5m CDL. It is proposed that materials for reclamation fill will be sourced from river sand dredging. The reclamation plan is shown in Figure 10.1.3 and typical cross section of reclamation is shown in Figure 10.1.4

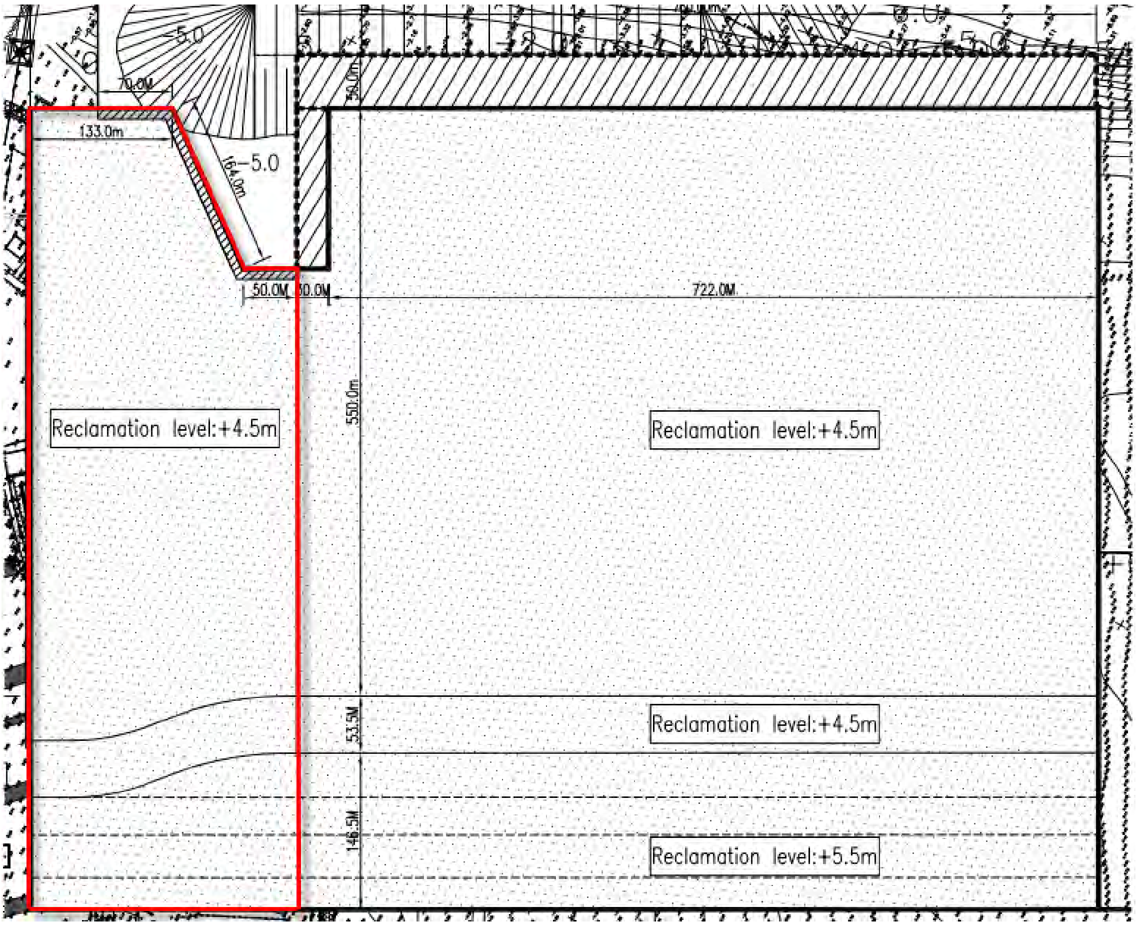
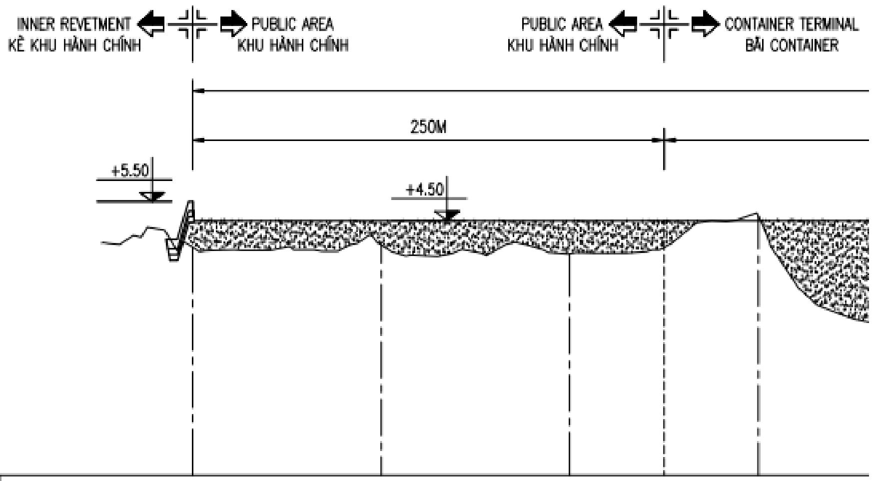


Figure 10.1.3 Plan of Land Reclamation



NATURAL GROUND LEVEL (M) CAO ĐỘ TỰ NHIÊN (M)	3.108	3.209	2.735	4.723
ACCUMULATED DISTANCE (M) KHOẢNG CÁCH CỘNG DỒN (M)	0.0	100.0	200.0	300.0

Figure 10.1.4 Typical Cross Section of Land Reclamation for Public Related Area

10.2 Basic Design of Service Boat Berth

Sheet pile wall construction with provision of earth pressure relieving platform is proposed to be applied in view of weakness of clayey subsoil condition at the site. Sheet piled wall is very rigid structure owing to the soil backfilling immediately behind the sheet pile walls.

10.2.1 Design Condition

The general conditions are discussed in section 7.1.

1) Natural Condition

a) Tidal Condition

High Water Level (H.W.L) : +3.55m CDL

Low Water Level (L.W.L.) : +0.43m CDL

b) Sub soil condition

According to the soil investigation results mentioned in Chapter 2.1, the soil condition applied to Service Boat Berth is block “18” of Figure 10.2.1. The model of soil layer for examination is indicated in Figure 10.2.2 and applied soil parameters of each layer are as shown in Table 10.2.1.

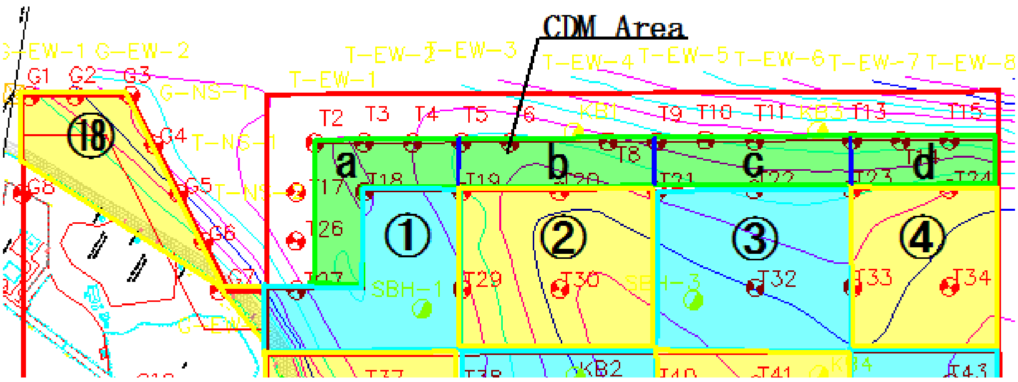


Figure 10.2.1 Plan of Boreholes for Service Boat Berth

Table 10.2.1 Soil Parameters for Service Boat Berth

Layer No.	Typical Soil Type	SPT-N	γ (kN/m3)	γ' (kN/m3)	Cu (kN/m2)	ϕ (°)	Cc	Cr	Ca (%)	Pc (kN/m2)	e0	Cv (OC) x 10^{-3} (cm2/s)	Cv (NC) x 10^{-3} (cm2/s)	Cu/P for NC
1a	SP	4	18.0	8.0	0	25.0	-	-	-	-	-	-	-	-
1b	CL	5	18.0	8.0	15	0.0	0.30	0.07	0.4	80	1.05	1.20	1.20	0.30
2	CH	1	17.0	7.0	15	0.0	0.60	0.12	0.7	80	1.45	1.00	0.60	0.30
3a	SP	4	19.0	9.0	0	25.0	-	-	-	-	-	-	-	-
3b	CL	5	19.0	9.0	25	0.0	0.25	0.05	0.4	$\Sigma\gamma'z$+50	0.80	1.20	1.20	0.30
3c	SP	6	19.0	9.0	0	25.0	-	-	-	-	-	-	-	-
4	CH, CL	10	19.0	9.0	50	0.0	0.35	0.04	0.6	$\Sigma\gamma'z$+100	0.85	1.20	0.80	0.30
5	CH	6	17.5	7.5	40	0.0	0.60	0.08	0.8	$\Sigma\gamma'z$+75	1.20	2.20	0.80	0.30
Fill,Emb.	S	-	18.0	10.0	0	30.0	-	-	-	-	-	-	-	-

*NC: Normal conslidated State OC: Over consolidated State

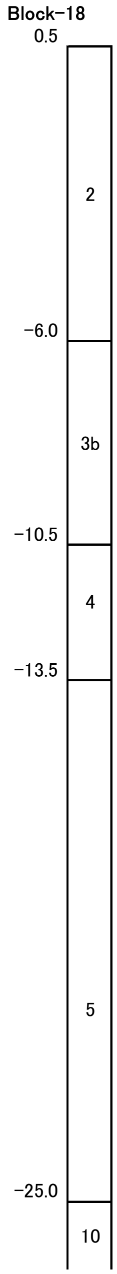


Figure 10.2.2 Model of Soil layer for Examination

c) Residual Water Level

The residual water level behind the earth retaining wall is normally taken as the following formula for the sheet pile structure:

$$RWL = LWL + (HWL – LWL) \times 2/3$$

According to the design condition mentioned in 7.1, the residual water level of +2.51m CDL is derived by the above formula.

2) Structural Condition

a) Cope elevation of steel sheet pile wall

The cope elevation of steel sheet pile wall is taken as +5.50m CDL.

b) Design water depth in front of Service Boat Berth

The design water depth of service boat berth is – 5.0m CDL.

3) Design Vessel

The following size of Tug Boat is considered in designing berth.

Table 10.2.2 Dimension of Tugboat

		2,000PS	3,000PS	4,000PS
Length	Loa	28.1	31.8	36.2
	Lpp	24.2	28.0	31.5
Beam	B	8.2	9.0	9.8
Depth	D	3.5	3.6	4.4
Draft	d	2.7	2.7	3.2
Displacement Tonnage	DT	320	435	544

4) Loading Condition

Applied loading condition is as follows:

- Operational load : $10kN/m^2$
- Seismic load : not considered (According to TCXDVN 375-2006)
- Ship Berthing Condition : Design Vessel of 4,000PS Tugboat
  Ship Approach Velocity 0.3m/s
  Ship Berthing Angle 10°
- Load on Bollard : 150kN Hawser pull capacity
- Filling sand : $\gamma = 18kN/m^3$; $\phi = 30^o$
- Horizontal Displacement : within 30mm

10.2.2 Calculation Result

1) Fender System

Berthing velocity of such design vessel as tugboat is assumed 0.3 m/sec perpendicular to berth cope-line for the design vessels. The corresponding berthing angle to the wharf cope line is taken as 10° at the quarter-point berthing of ship. V-shaped Rubber type of fenders spaced at 6 m will be installed to accommodate smaller sizes of boats.

The following is the summary of the design output and selection of the fender system. The detailed calculation of fender system is shown in Appendix 10-1.

Table 10.2.3 Selection of Fender Size

Size of Ship	Berthing Velocity (m/sec)	Fender Interval (m)	Berthing Energy of Ship (kN-m)	Fender V type H (mm) x Length (m)	Energy Absorption (kN-m)	Fender Reaction (kN)
Japanese Standard						
4,000PS Tugboat	0.3	12.0	24	H400 x 3.0m	44.3 (L=0.9m)	977(L=3.0m)
				H300 x 3.5m	24.2 (L=0.9m)	745.5(L=3.5m)

The rubber type docking fender of V shaped type H300mm x L3.5m are installed at 6 m interval to accommodate service boats used for new port.

Energy Absorption = 26.9kN-m/m x 0.9m (Contact length with ship) x 0.9=24.2 kN-m

Fender Reaction Force = 213kN/m x 3.5m (Full length for ship Contact) =745.5 kN

The reaction force is balanced with active earth pressure by back-filled soil mass working on the back-face of the wall upon ship contact with berth.

2) Mooring Bollard

Mooring bollards of 150 kN Hawser Pull force capacity per unit are provided at an interval 12m along the face-line of berth to accommodate design vessel.

3) Relieving Platform

The summary of the calculation of relieving platform is described bellow. The detailed calculation results are shown in Appendix 10-2 for standard section and in Appendix 10-3 for corner section.

a) Calculation of the bottom level of relieving platform

The bottom elevation of relieving platform was determined so that the active earth pressure of Layer "2" at the rear end of platform does not exceed the passive earth pressure (see Figure 10.2.3).

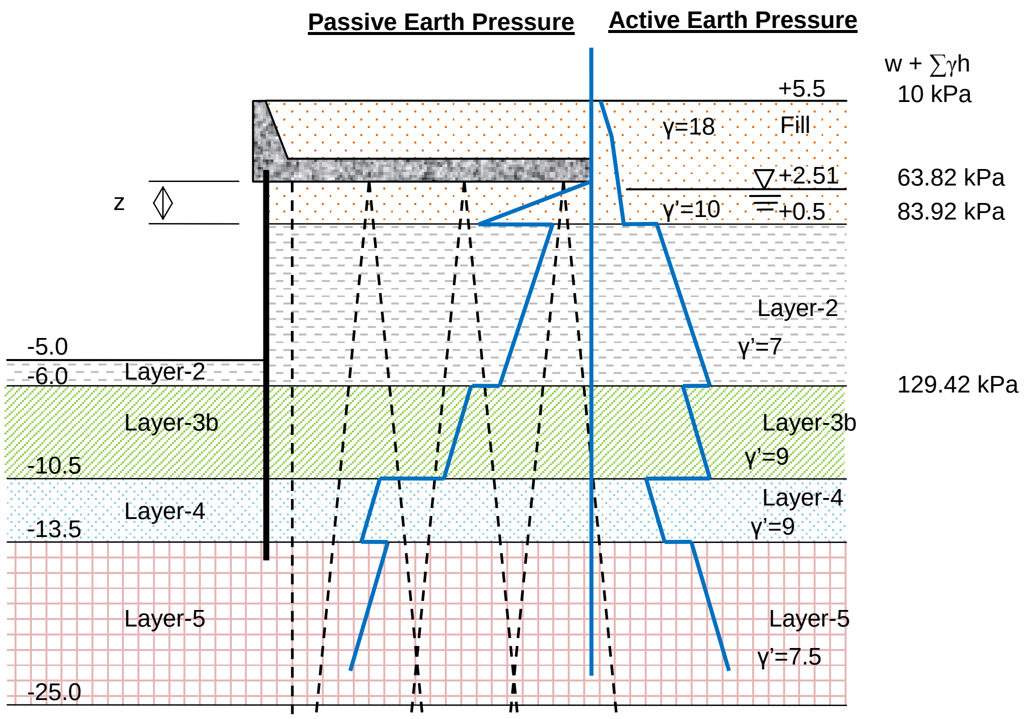


Figure 10.2.3 Diagram of Earth Pressure

At the top surface of Layer-2 (+0.5mCDL)

- Active Earth Pressure : $p_A = w + \Sigma\gamma h - 2C = 83.92$ kPa $- 2\times15$kPa $= 53.92$ kPa
- Passive Earth Pressure : $p_P = \gamma z + 2C = \gamma z + 30$ kPa

Therefore, $p_P - p_A = \gamma z + 30$kPa $- 53.92$ kPa $> 0 \Rightarrow \gamma z > 23.92$ kPa

Since γ= 10 kN/m^3, z > 2.392m ⇒ the bottom elevation requires more than +2.892m CDL

Thus, the bottom elevation of relieving platform is taken as **+3.0m CDL.**

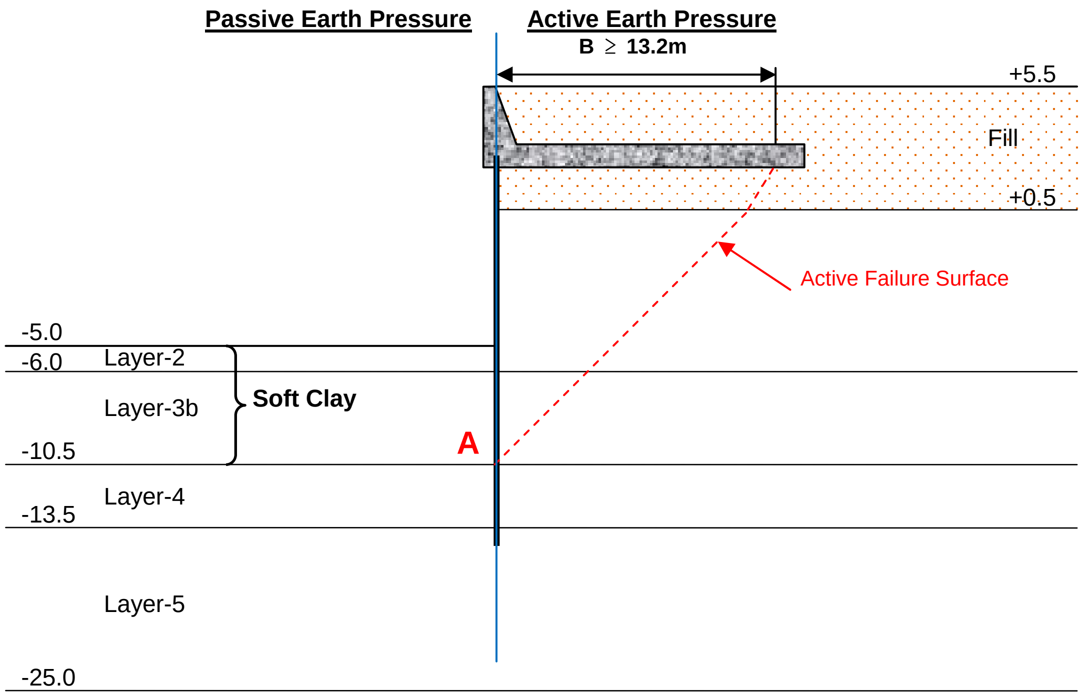
b) Calculation of the width of relieving platform

The width of the relieving platform is determined so that all of the following conditions are satisfied.

- The check of the intersection with the active failure surface
- The stability check against circular slip
- The stability check as the gravity-type wall structure

i) The check of the intersection with the active failure surface

According to the soil investigation results, Layer-2 and Layer-3b are soft soil (Cu<30kPa). The width of the relieving platform was determined so that the platform will intersect the active failure plane drawn from the point A in the figure below. A minimum width of the relieving platform is calculated as 13.2m from the center line of the sheet pile.



ii) The stability check against circular slip

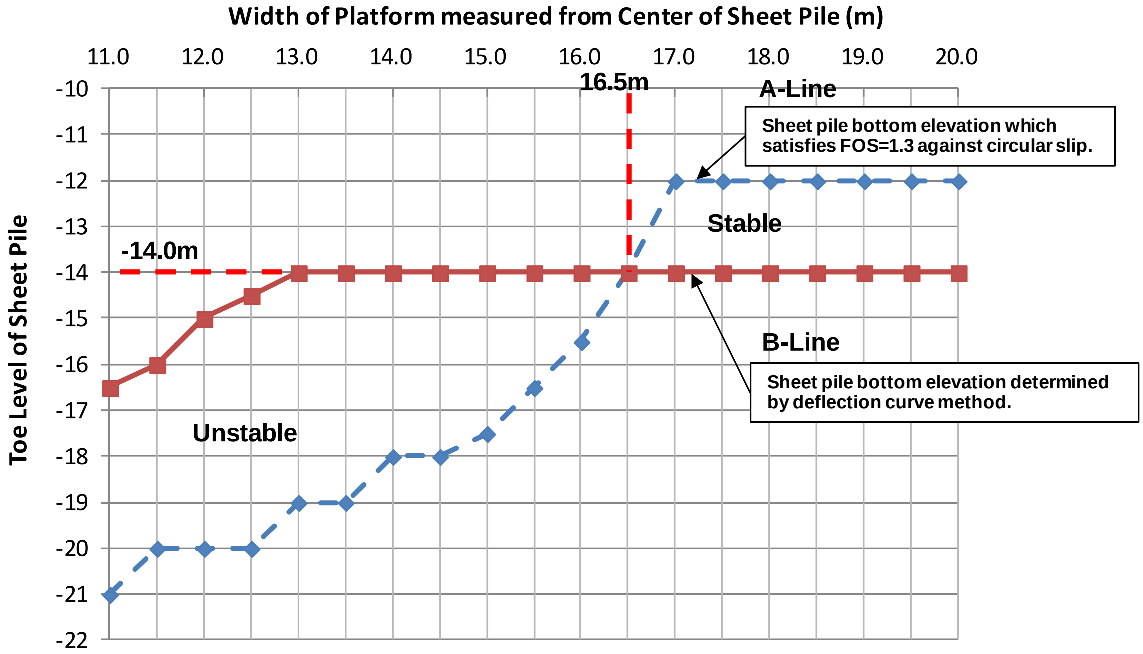
The required factor of safety against circular slip failure is as follow;

Ordinary Case : F.S. ≥ 1.3

Figure below illustrates the relationship between result of circular slip analysis and penetration depth of sheet pile. The relieving platform has effects to reduce the active earth pressure working on sheet pile as well as the driving moment in the circular slip analysis. Generally, wider the platform, shallower the sheet pile tip level.

A-Line is the required tip level of sheet pile satisfying factor of safety against circular slip failure of FS=1.3 under ordinary case, and B-Line denotes the penetration depth determined by deflection curve method.

It is recommended that the embedded depth of sheet pile not be extended more deeply than the required depth determined by the equilibrium of the earth pressure on the sheet pile in hope of avoiding circular slip failure. Therefore, the minimum width of the platform is set as 16.5m which is the intersection of A-Line and B-Line.



iii) The stability check as the gravity-type structure

The stability calculation against sliding and overturning as the gravity-type structure was carried out for the platform width of B=16.5m (measured from center of sheet pile) as obtained in above section.

Applied factor of safety is as follows:

- Against Sliding F.S ≥ 1.2 (Ordinary/Mooring Case)
- Against Overturning F.S ≥ 1.2 (Ordinary/Mooring Case)

The calculation results are summarized as below.

Study Case		Sliding		Overturning	
		F.S	Required	F.S	Required
Ordinary Case	Case-1	1.896	>1.2	1.533	>1.2
	Case-2	1.215		1.546	
Mooring Case	Case-1	1.890	>1.2	1.519	>1.2
	Case-2	1.211		1.531	

4) Embedded length of sheet pile

The summary of the calculation of sheet pile is described bellow. The detailed calculation results are shown in Appendix 10-2 for standard section and in Appendix 10-3 for corner section.

The embedded length and bending moment of the sheet pile was calculated by “Deflection Curve Method” and “Free Earth Support Method”. The factor of safety for the embedded length of sheet pile was adopted as 1.2 for both methods.

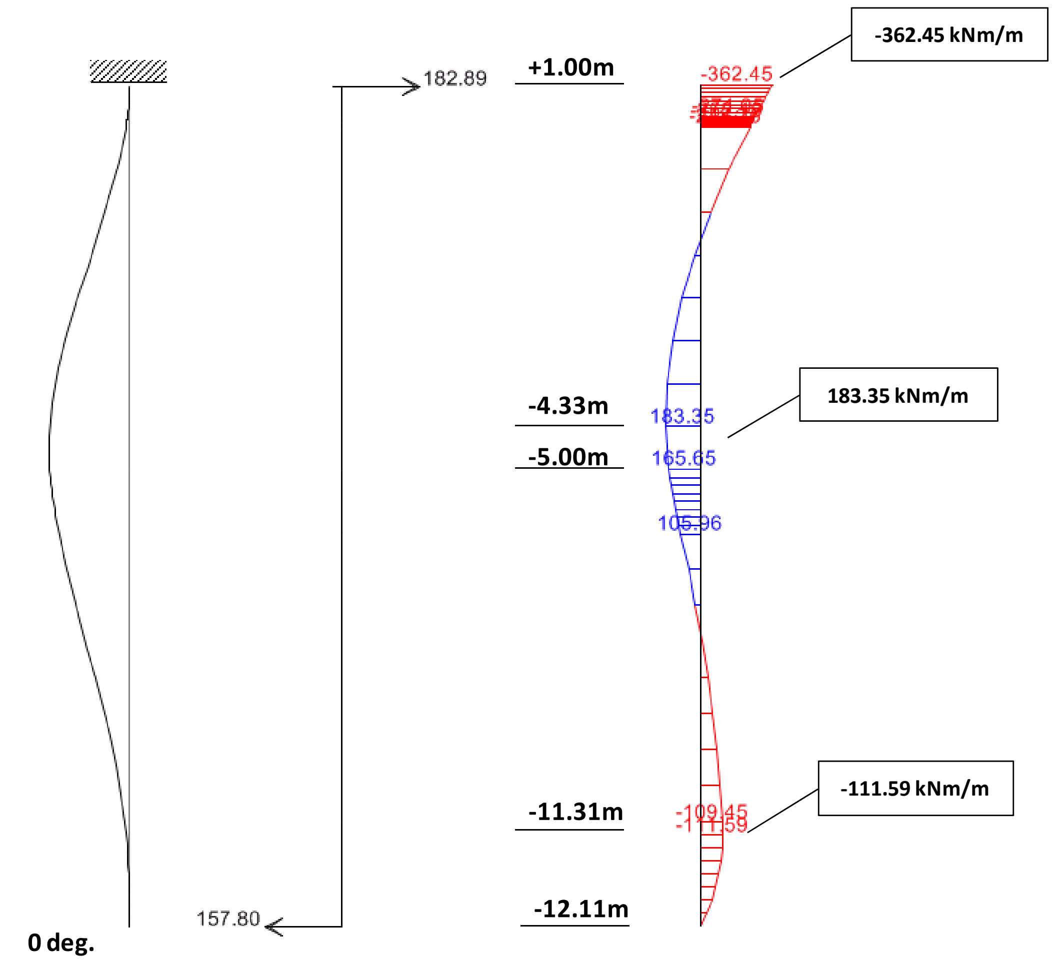
a) Deflection Curve Method

The elastic equations are solved under the external force conditions with the conditions that the displacement and deflection angle is zero at the top and the toe of the sheet pile.

For this purpose, the sheet pile is assumed to be "fix-supported" at the top of sheet pile and "pin-supported" at the tip of sheet pile and the deflection angle at the toe of sheet pile is calculated by varying the embedded length of sheet pile. Once the embedded length of sheet pile with which the deflection angle becomes zero is obtained, it is considered as the minimum embedded length. The embedded length of sheet pile shall be 1.2 times (i.e. factor of safety) of the minimum embedded length.

The analysis was conducted by using the software SAP2000. The result of analysis is shown as below.

- Tip of sheet pile from above result : -12.11 m CDL
- Seabed elevation : -5.000 m CDL
- Embedded length of the sheet pile : L = 1.2 × (-5.00 + 12.11) = 8.532 m
- Tip elevation : D = -5.00 – 8.532 = -13.532 m CDL



Deflection Curve **Reaction Force** **Bending Moment**

b) Free Earth Support Method

The embedded length of the sheet pile is obtained so that the following formula is satisfied.

$$Mp = F.S \times Ma$$

where;

Mp: Moment due to the passive earth pressure about the top of the sheet pile (kN-m/m)
Ma: Moment due to the active earth pressure and the residual water pressure about the top of the sheet pile (kN-m/m)
F.S: Factor of safety (=1.2)

The tip elevation of -11.549m CDL is derived from this equation.

From the both methods above, the required tip elevation of sheet pile of -14.0m CDL is selected.

5) Dimensions of the Service Boat Berth

The calculated dimensions of service boat berth is as shown in the following table and the typical section is shown as

Relieving Platform	Width	16.5m (17.0m from the face line)
	Bottom Elevation	+3.0 m CDL
	Thickness of Slab	1.0m
Sheet Pile	Type	Steel Sheet Pile IV_w
	Material	SY295
	Penetration Depth	-14.0 m CD
Support Pile	Type	PHC Pile Type B
	Dimension	$\phi 600 \times 100$ and $\phi 500 \times 90$
	Pitch of Pile	
	Alongside Berth	4.0m
	Perpendicular to Berth	5.0m + 4.5m + 4.5m
	Numbers of Piles per 1 line	Battered Pile : 3 Vertical Pile : 4

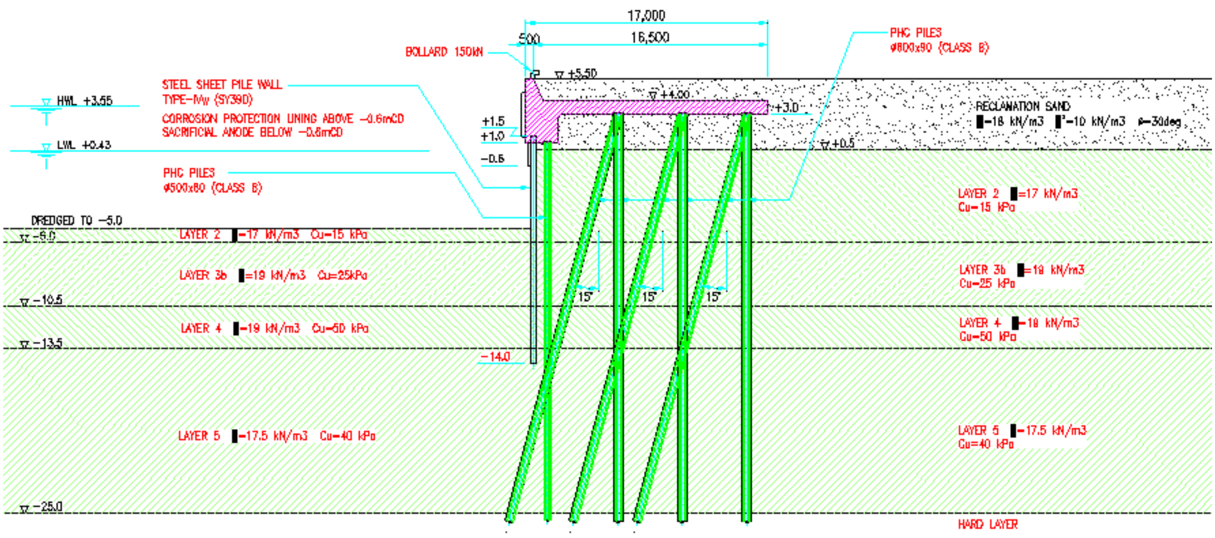


Figure 10.2.4 Typical Cross Section of Service Boat Berth

6) Apron pavement

The apron for service boat berth is 10m in width along to the berth line is paved by use of Interlocking Concrete Block (ICB). The total thickness of pavement is 49cm and the structure consists of the following layers:

- Interlocking Concrete Block (ICB) : 6cm;
- Sand bedding : 3cm
- Cement treated base course : 15cm;
- Sub-base soil Aggregate CBR >30 : 25cm;
- Sub-grade Compacted fill CBR>5

The typical section of the pavement for service boat berth is shown as below figure:

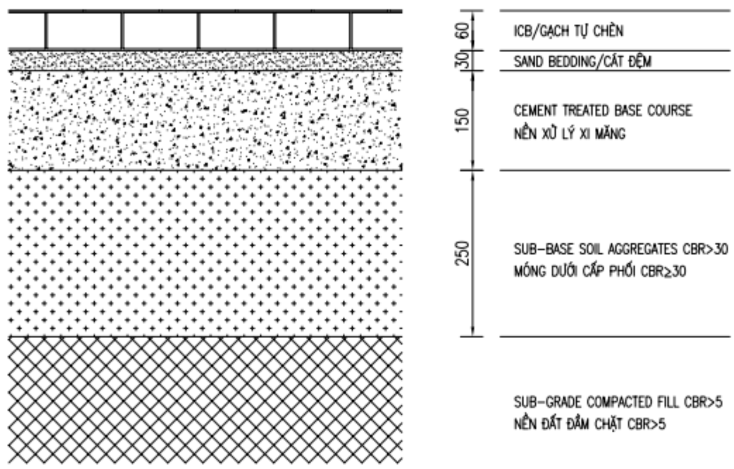


Figure 10.2.5 Typical Section of Pavement for Service Boat Berth

10.3 Basic Design of Revetment

10.3.1 General

Revetment for the Public related area is the revetment located alongside the north side of the Public related area and separates the Port facilities from the existing land of Cat Hai island. Since the revetment is constructed onshore, the size of armor stone for the revetment is commonly-used in the similar structure and should satisfy the circular slip stability of the whole revetment.

The total length of Revetment is 966.5m as indicated in Figure 10.3.1.

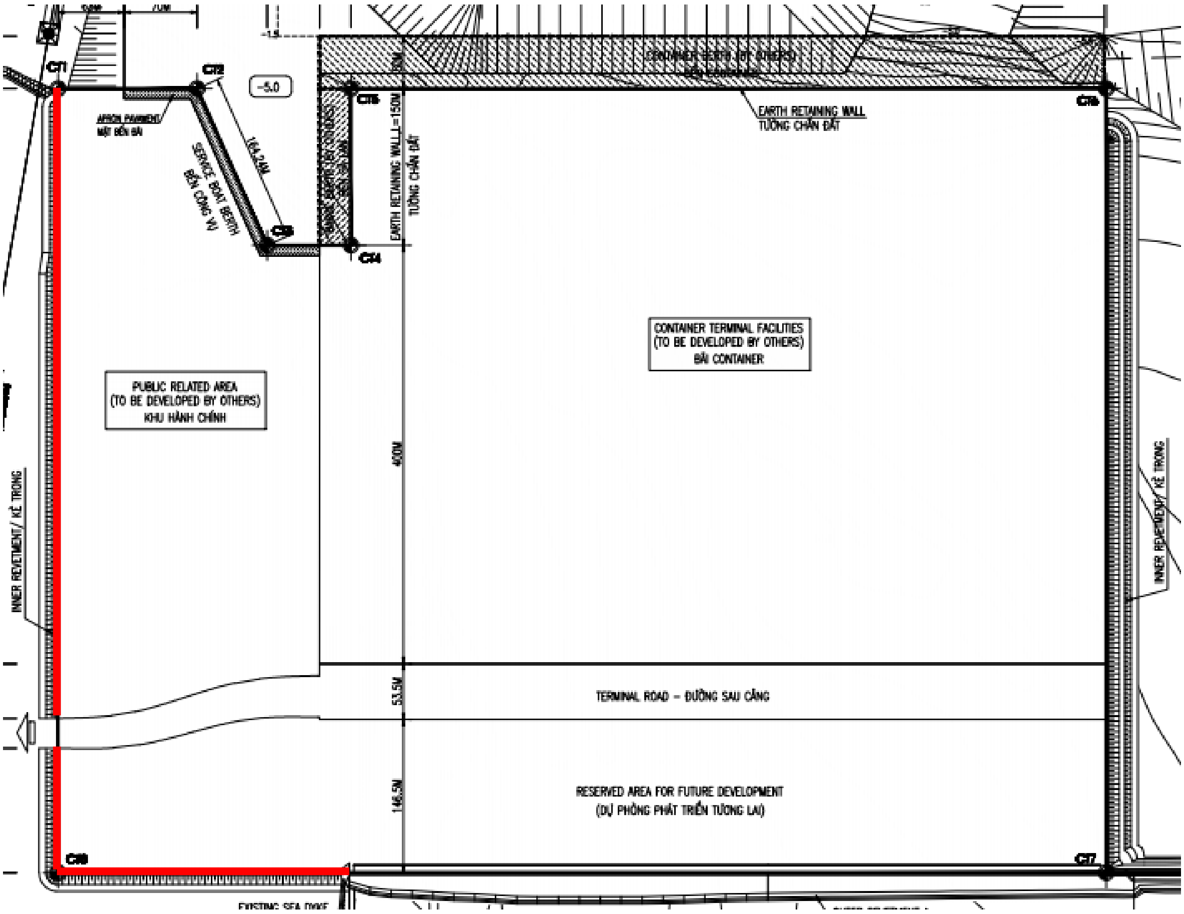


Figure 10.3.1 Location of Revetment of Public Related Area

10.3.2 Typical Section

Typical section of Revetment is as shown in Figure 10.3.2.

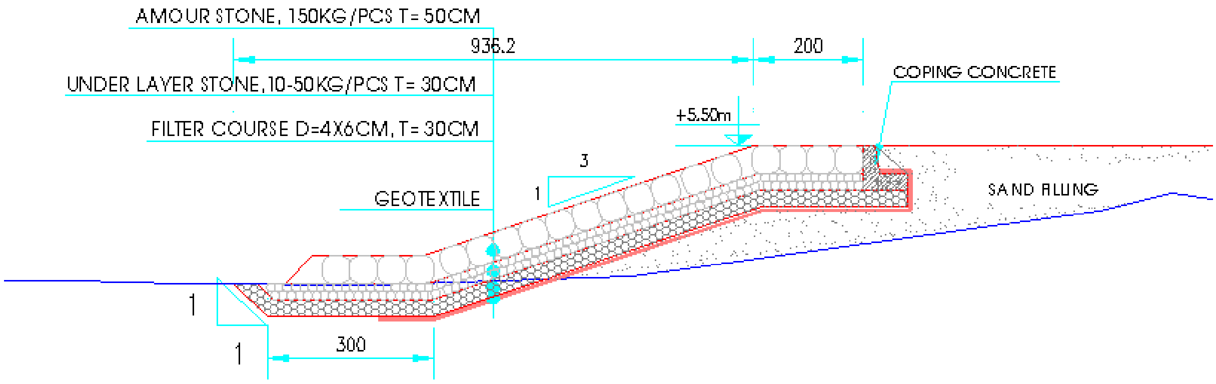


Figure 10.3.2 Typical Section of Revetment of Public Related Area

10.3.3 Design Condition

The applied design conditions for the revetment are summarized as follows:

- Location of revetment : north side and west of the Public related area (onshore)
- Existing ground level : varied from +2.7m CDL to +4.1m CDL
- Soil Improvement Method : no soil improvement will be applied
- Operational load : 10kN/m^2
- Filling sand : γ = 18kN/m^3 ; ϕ = 30^o
- Subsoil Condition : refer to the Bore hole No. G9

The location of bore hole No. G9 is shown as Figure 10.3.3, and the soil layer model of bore hole No. G9 is indicated in Figure 10.3.4. Applied soil parameters of each layer are as shown in Table 10.3.1.

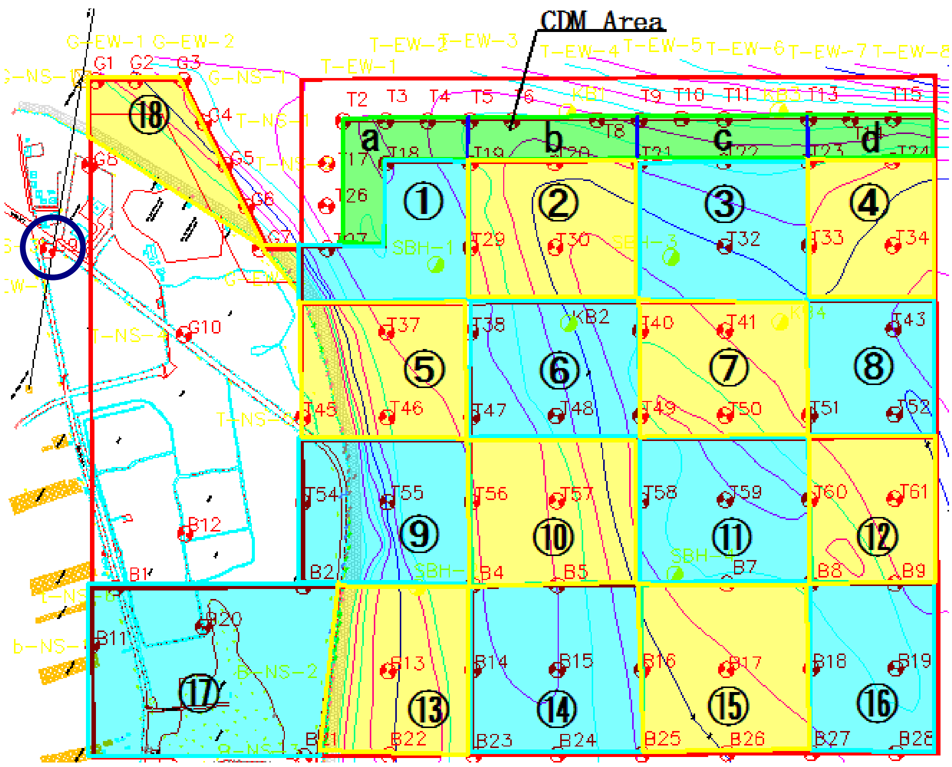


Figure 10.3.3 Location of Borehole for the Calculation of Revetment

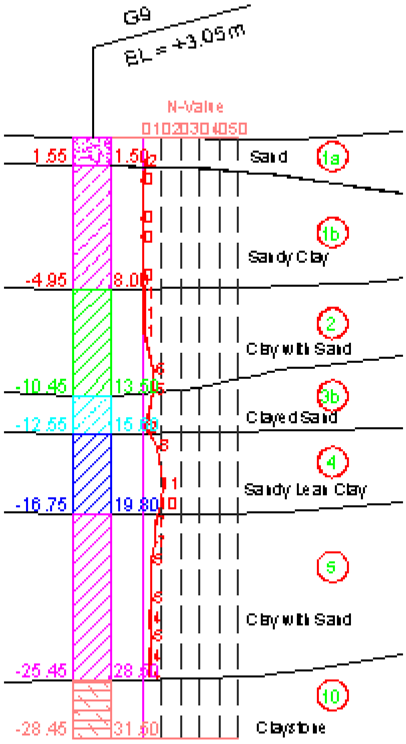


Figure 10.3.4 Soil Layer Model of Bore Hole No. G9

Table 10.3.1 Soil Parameters Design of Revetment

Layer No.	Typical Soil Type	SPT-N	γ (kN/m3)	γ' (kN/m3)	Cu (kN/m2)	φ (°)	Cc	Cr	Ca (%)	Pc (kN/m2)	e0	Cv (OC) x 10^{-3} (cm2/s)	Cv (NC) x 10^{-3} (cm2/s)	Cu/P for NC
1a	SP	4	18.0	8.0	0	25.0	-	-	-	-	-	-	-	-
1b	CL	5	18.0	8.0	15	0.0	0.30	0.07	0.4	80	1.05	1.20	1.20	0.30
2	CH	1	17.0	7.0	15	0.0	0.60	0.12	0.7	80	1.45	1.00	0.60	0.30
3a	SP	4	19.0	9.0	0	25.0	-	-	-	-	-	-	-	-
3b	CL	5	19.0	9.0	25	0.0	0.25	0.05	0.4	Σγ'z+50	0.80	1.20	1.20	0.30
3c	SP	6	19.0	9.0	0	25.0	-	-	-	-	-	-	-	-
4	CH, CL	10	19.0	9.0	50	0.0	0.35	0.04	0.6	Σγ'z+100	0.85	1.20	0.80	0.30
5	CH	6	17.5	7.5	40	0.0	0.60	0.08	0.8	Σγ'z+75	1.20	2.20	0.80	0.30
Fill,Emb.	S	-	18.0	10.0	0	30.0	-	-	-	-	-	-	-	-

*NC: Normal conslidated State OC: Over consolidated State

10.3.4 Slope Stability Calculation

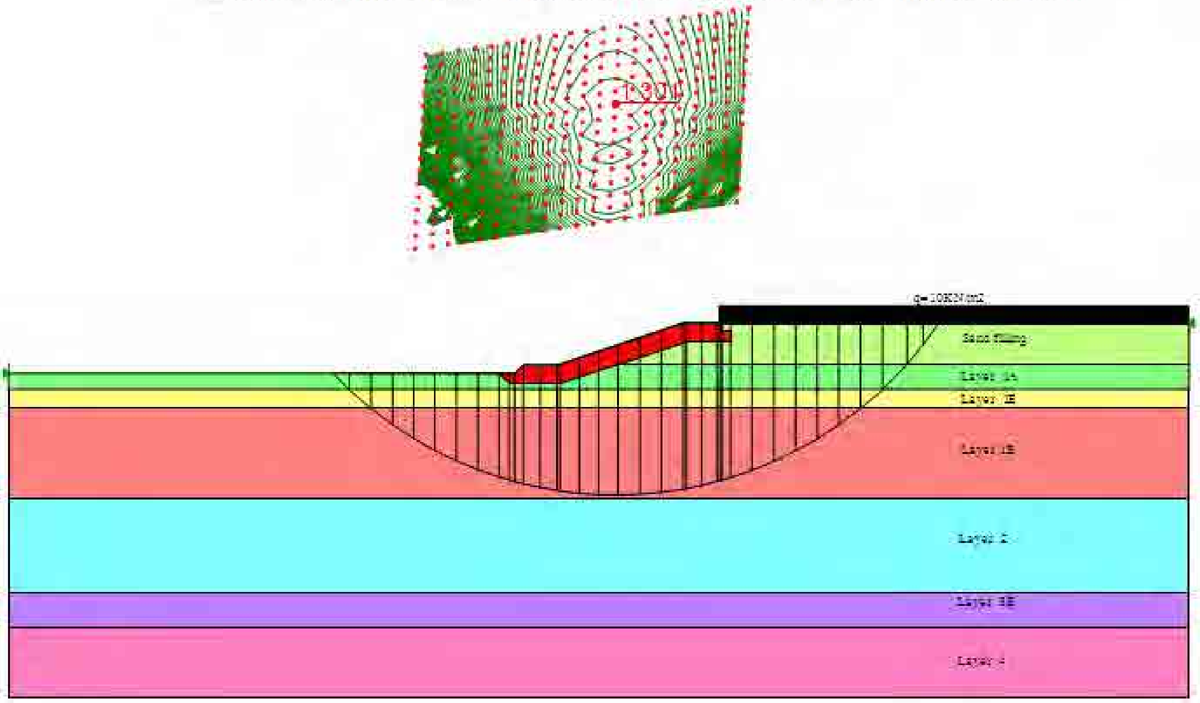
The slope stability of the revetment is examined as follows:

- Required Safety factor for Slope Stability is based on OCDI-2002 :

$$Fsa \geq 1.3$$

- Slope Stability Analysis (Slip Circular Surface Method): using the software: SLOPE/W) with Bishop Method. The result is shown in the figure below:

SLOPE STABILITY OF INNER REVETMNET AT PUBLIC AREA – BISHOP METHOD



The derived safety factor of 1.301 satisfies the required factor of safety against circular slip failure.

11. UTILITIES

11.1 General

Figure 11.1.1 shows the public related facilities area and container terminal of Berth Nos. 1 and 2, which will be constructed by the JV of VINALINES and three Japanese companies.

According to the Record of Discussion with JICA in June 2010, it is understood that “it was thus agreed that, except for the service berth, soil improvement and construction, buildings and utilities in the public related facilities area would not be included in the scope of the ODA loan, as the organization that would use the area would be responsible for such works.

Therefore, it is understood that the electric and water supplies of the service boat berth may be necessary and can be included in the scope of the JICA Detailed Design Study.

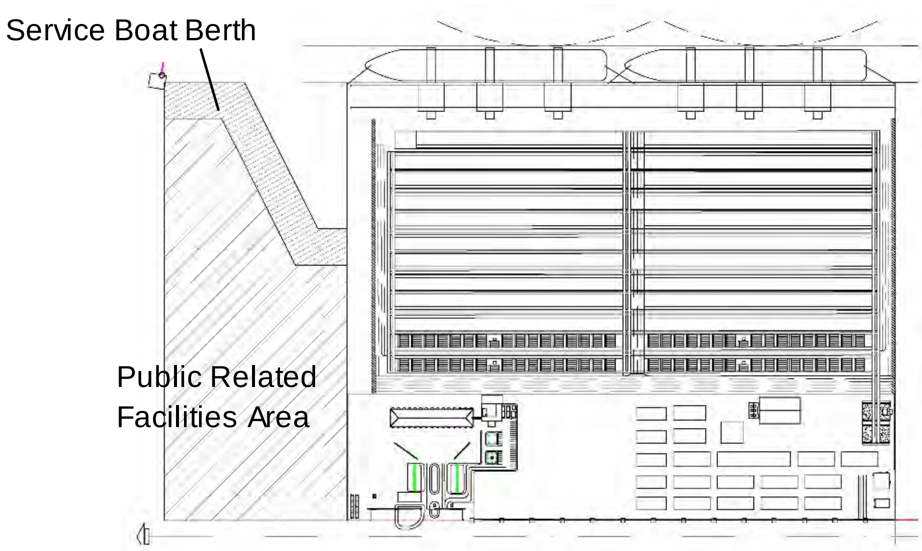


Figure 11.1.1 Public Related Facilities Area and Container Terminal

11.2 Electric Power Supply

11.2.1 Design Standards

The design, manufacture, test and installation of electrical equipment will comply with the latest edition of the standards, codes and regulations, consisting of the following:

- Vietnam Design Standards (TCVN)
- International Electrotechnical Commission (IEC)
- Japanese Industrial Standards (JIS)
- Standards of Japanese Electrotechnical Committee (JEC)
- Standards of the Japanese Electrical Manufacturers Associations (JEM)

Moreover, it is necessary to apply the following codes and regulations in a detailed design of electrical power supply.

- Electricity Law (No.28/2004/QH11)
- Decision from Ministry of Transport (No.1386/QD-BGTVT): Refer to the following Table 11.2.1

Table 11.2.1 Applicable Code & Law for Power Supply Design

II.4	Power supply utility Design - Thunder light protection	Code No.
1	Artificial outdoor lighting for public buildings and urban infrastructure- Design specifications	TCXDVN 333:2005
2	Artificial lighting Standard in building	TCXD 16:1986
3	Natural lighting standard in building	TCXD 29:1991
4	Installation of electric equipment's in dwellings and public building - Design specifications	TCXD 27:1991
5	Thunder light prevention for construction works - Design and construction standards	TCXD 46:1984
6	Complete unit of transformer up to 1000KVA, voltage up to 20KV	TCVN 3715:1982
7	Code of electrical equipment - Part III - Distribution Facilities and Transformer	11 TCN 20:2006
8	Code of electrical equipment - Part IV: Protection and Automation	11 TCN 21:2006

11.2.2 Design Conditions

1) Service conditions

The project area has a hot, humid and tropical atmosphere. Moreover, the surrounding environment has a high degree of salinity.

All electrical equipment, cables, accessories and fittings which form part of the electrical installation shall be fully suitable for use in the following specified service conditions:

(1)	Altitude above mean sea level (approx.):	2.0 m
(2)	Ambient temperature	- maximum: 45 °C - minimum : 5 °C
(3)	Relative humidity	- maximum: 100%
(4)	Climatic atmosphere	: Tropical
(5)	Wind pressure	: Maximum 30m/s
(6)	Earthquake	: The lateral seismic coefficient of 0.03 for equipment is designed because no earthquakes in the past are recorded.
(7)	Salt contamination	: Unless otherwise specified, under the contract, the design for salt contamination of the insulators and bushings shall be applied at 5.0 mg/sq.cm.

2) Design criteria

a) Possible supply from the power company:

Possible supply power by Cat Hai Electricity was 10MVA confirmed in April, 2011 and One (1) Circuit. However, it is assumed it was few as an electric power used with this project. Then, whether the electric power up to which extent can be supplied is confirmed on October 10, and it has been understood that it is one (1) circuit and 20MVA or less.

Therefore, it is a parameter of a possible power supply.

- Possible supply capacity : 20 MVA
- Rated voltage (of supply transformer) : 110 kV/35-10 kV

- Number of phases and wires : Three phases/Three wires
- Rated frequency : 50 Hz
- Braking capacity : 31.5 kA
- Number of circuits : One circuit

b) Demand capacity

Required electric capacity had the approximately 30MVA answer from the container terminal operator.

On the other hand, there is no answer about required electric capacity of the Public related area.

Therefore, installed power capacity was estimated from the terminal area and loading equipment and demand power capacity shown in Table 11.2.2 was assumed.

Table 11.2.2 Estimated Installed Power Capacity and Actual Demand Power

No.	Description	Estimation of installed power capacity [kVA]	Estimation of demand power capacity [kVA]
1	Public related area	760	370
2	Container terminal area	22,100	19,580
	Total	22,860	19,950

Source: JICA Study Team

11.3 Water Supply

11.3.1 Design Standards

Water supply should be planned and designed in accordance with the following Vietnamese regulations:

1) TCXD 33-1985 (MOC) Water Supply-Outside Networks of Construction

2) TCVN 6986-2001 (MONRE) Water Quality Standards for Industrial Effluents Discharged into Coastal Waters Using for Protection of Aquatic Life

11.3.2 Design Conditions

The plan and required water supply volume have been inquired to both the container terminal operator and MPMU II by the Study Team. So far, the reply from container terminal operator has been received. The water supply system in the public related area has not been designed yet. The water supply to the service boat berth is a part of the total water supply system for the public related facilities area, including the water tank and pumping station.

The water supply system in the public related area has not been designed yet in detailed by Vietnamese side. The water supply to the service boat berth is a part of the total water supply system for the public related facilities area, including the water tank and pumping station.

In the Study, the design conditions of the water supply were determined based on the said reply to the queries and previous reports related to the project. After Vietnamese Government will conduct and finalize the design of public related area, a consultant who will be in charge of bidding documents preparation and construction supervision would need to review the design of water supply considering total water supply system for the public related area including the service boat berth.

11.4 Other Utilities

It is understood that the utility facilities in the public related area, except for the abovementioned utilities - waste water treatment, fire fighting, telephone, internet, etc., would be developed by the Vietnamese Government.

It is also understood that any utility facilities inside the fence of the container terminal will be developed by the terminal operator, while those situated up to the fence of the container terminal will be developed by the Vietnamese Government.

11.5 Existing Utility Facilities

11.5.1 Substation in Cat Hai Island

New Supply Substation that exists in the Cat Hai Island shown in Photo 2 is scheduled to supply the electric power to Public related area and Container terminal area. However, the installed capacity of this substation is small in 25MVA. The amount of demand at present is about 3MVA, and capacity to be able to supply about 20MVA in the remainder to another in the future.

In addition, the main transformer secondary voltage is 35/10kV, does not conform to 22kV terminal operators have been demanding.

There needs to be replaced or modified in consultation with the new power company and terminal operator.

The outline of this Substation is as follows.

Table 11.5.1 Outline summary of Cat Hai 110kV supply substation

No.	Item	Description
1.	Name of power supply company	Hai Phong Power Company – Cat Hai Electricity
2.	Name of supply substation	Cat Hai 110kV supply substation
3.	Type of substation	Outdoor conventional type
4.	Type of network line connection	110kV overhead wiring single line receiving system (fed from Hai Phong 110kV supply substation)
5.	Facility capacity	25MVA (Installed transformer capacity: 110/35/10kV, one set)
6.	Possible supply power	20MVA

Source: JICA Study Team

Photo 1 Old Substation in Cat Hai Island

Photo 2 New Substation in Cat Hai Island

11.5.2 Utility Facility in Chua Ve Container Terminal

Two photos of utility facilities in Chua Ve Container Terminal are shown below, as reference for the planning of the utility facility in the service boat berth, even if fire hydrants are not included in the scope of the JICA Detailed Design Study.

Photo 3 Utility Box (Water Supply)

Photo 4 Fire Hydrant

11.6 Utility Supply Demand for Container Terminal Area

11.6.1 Electric Power Supply

Power demand in container terminals, since the peak is expected at 30MVA, has been requested from the terminal operator wants to supply at least 30MVA power.

It is also under consideration and those details such as cargo handling equipment used in the terminal area. Specifically, the power company and how the receiving terminal operator in the future should be determined in consultation

11.6.2 Water Supply

The container terminal operator has provided the information regarding their required volume of water supply as shown below. Also, two calculations of water supply volume are presented. The following values may be useful to compare the required water supply for the container terminal.

Table 11.6.1 Demands for Water Supply (Unit: (m^3/day))

	Container Terminal (Berth No.1&2)	Cai Mep Container Terminal	Hai Phong International Gateway Port
Container Terminal	310.0	108.3	160.0
Vessels	180.0	180.0	300.0
Public Area	-	30.9	180.0 (100.0 for tugboats)
Total	490.0	319.2	640.0

Note1: “Container Terminal (Berth No.1&2)” is the reply from potential Japanese container terminal operator.
Note2: “Cai Mep Container Terminal” is referred to Detailed Design Study Report on Cai Mep-Thi Vai Ports.
Note3: “Hai Phong International Gateway Port” is referred to Report on Adjustment of Investment Project.

11.7 Utility Supply Demand for Public Related Area

Record of Discussion between GOV and JICA exchanged in June 2010 indicates that:

“The both side agreed that the work for the public related facilities would be limited to the most urgent component. It was thus agreed that, except for the service boat berth, soil improvement and construction of building and utilities in the public related facilities area would not be included in the scope of the ODA loan, as organization that would use the area would be responsible for such works. As for the service boat berth, all the necessary work to set up is included in the scope."

Therefore, the JICA ODA loan Project and the scope of JICA DD Study Work covers reclamation, revetment and construction of service boat berth for Public Related Area and, hence, any soil improvement work (except for the service boat berth if necessary), construction of buildings and utility facilities to be developed in public related area are not included in the JICA DD Study work (which shall be planned, designed and constructed by Vietnamese side).

JICA Study Team has issued the letters for clarification on the development plan of Public Related Area in the process of JICA DD work, and the following reply has been obtained from MPMU2 for our request for clarification.

(1) So far, there has been confirmed any untouchable lot or area in the development area for Public Related Area.

(2) Ground elevation (Finish Level) of Public Related Area under the Project is **+4.5m** as stipulated in Decision No. 476/QD-BGTVT on March 15, 2011 of MOT.

(3) Service Boat Berth shall follow Decision No. 476/QD-BGTVT.

(4) Utility supply system belonging to Component A of the Project is as shown in the drawings: 00NX-KT.01, 00NX-CD.01 &02, 00NX-NS.01, 00NX-NCH.01 and 00NX-TN.01 (Article E. Building and Utilities) of the approved revised F/S Report.

As for utility supply to the Public related area, JICA DD Study Team considers:

Water Supply System

(1) Water supply piping work to service boat berth should be developed in the total system of water supply in Public Related Area.

(2) Underground connection piping from the main at access road to the Public Related Area and piping connection from the above connection pipe to underground water supply pipe at service boat berth is not covered in JICA ODA Loan Project since the land is reclaimed to the finished level of CD+4.5m under the Project.

(3) Underground water supply piping and ship hydrant at berth apron area of Service Boat Berth is designed by JICA DD Team and included in JICA ODA Loan Project.

Electric Supply System

(1) Electric supply work to service boat berth should be developed in the total system of electric supply in Public Related Area.

(2) Underground connection cable pit from the main at access road and electric supply cable connection from the above connection pit to service boat berth in Public related is not covered in JICA ODA Loan Project since the land is reclaimed to the finished level of CD+4.5m under the Project

(3) External lighting system (Lighting pole and electric cabling) behind Service Boat Berth area is not included in JICA ODA Loan Project since the land immediately behind the berth area is reclaimed to the finished level of CD+4.5m under the Project.

11.7.1 Electric Power Supply

In this DD Study, a review of electric supply system in Public Related Are in relation to power supply demand to berth apron external lighting system for service boat berth. The followings are the result of the review on electric supply at public related area.

- Substation facilities and required demand power for the Public Relate Area
- Lighting facility for Service boat berth
- Lighting for road
- Power supply wiring of water supply facilities

Design data are used for reference when reviewing the plan SAPROF. Electric supply system in public Related Area and the connection to the main cable is deemed to design and construct by Vietnamese side. External lighting at berth apron area for service boat berth is also designed in details and constructed by the Project Owner.

1) Required demand power and Substation

The electric equipment installed capacity and the demand power capacity of government building, service boat berth, and public road are calculated, and it proposes the table below as a result.

Table 11.7.1 Installed Power Capacity and Demand Power Capacity for Electric Power Supply

Description	Installed Power Capacity [kVA]	Demand Power Capacity [kVA]
Indoor Lighting	703.1	348.8
Exterior Lighting	41.0	12.3
Common Road Lighting	19.4	3.0
Others *	76.5	35.9
Total	840.0	400.0

* Including the additional load due to modification after operation (About 10% of total capacity)

Demand capacity calculated by the Study Team are Installed power capacity= 800kVA, Demand power capacity = 400kVA with expected demand. Power from Cai Hai substation is shown in Figure 11.7.1 (Power Supply Single Line Diagram for Public Related Area) to propose a system is shown outside the scope of the ODA Loan. Outline of Substation for power receiving provided on Public related area is as follows.

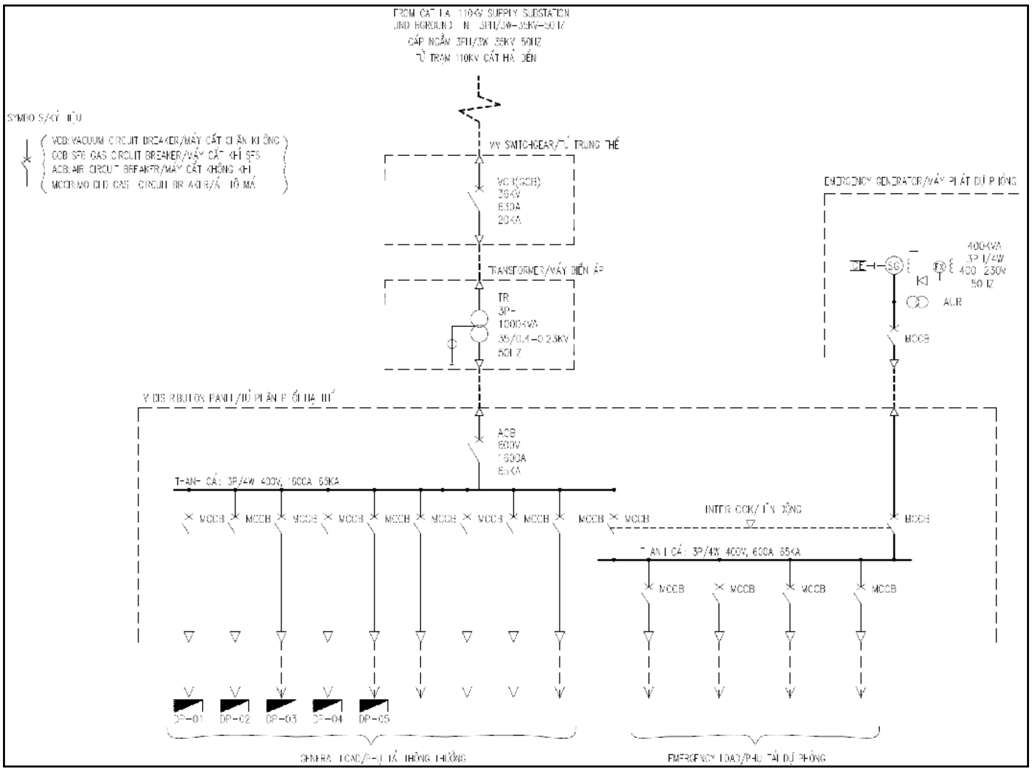


Figure 11.7.1 Power Supply Single Line Diagram for Public Related Area

Calculation results of the above, in the Public Related Area Substation is recommended that it should be installed at least 1000kVA of receiving transformer.

2) Lighting facility for Service boat berth

The service boat berth is provided with lighting to allow night landing on the boat. The Lighting fixtures and wiring shall be as shown in Figure 11.7.2.

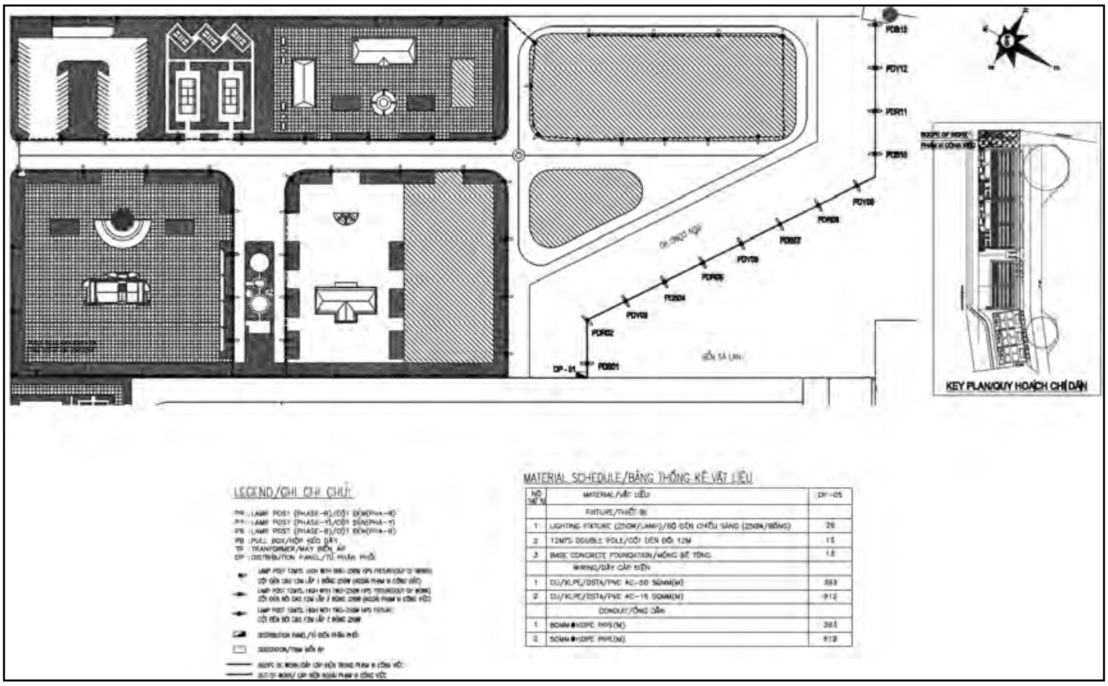


Figure 11.7.2 Lighting Fixtures and Wiring for Service Boat Berth

3) Power supply wiring of Water supply facilities

The electric motor provided in the vicinity of the Water Pump Service boat berth, a power supply from the LV Distribution panel in Substation of Public Related Area. Cable Route the wire as shown in Figure 11.7.3.

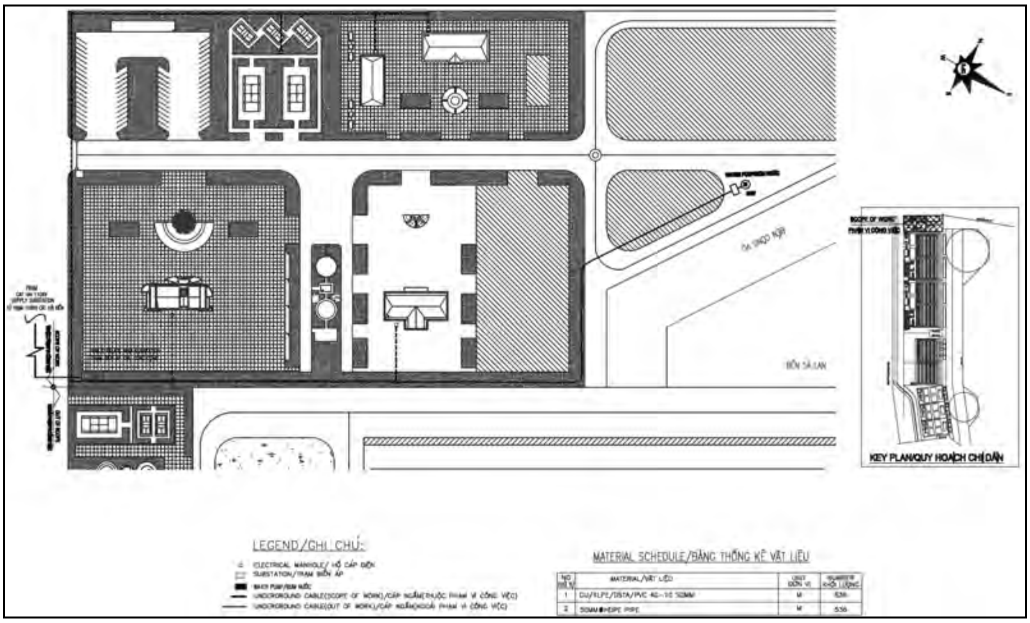


Figure 11.7.3 Power supply wiring of Water supply facilities

11.7.2 Water Supply

The water supply to the service boat berth is a part of the total water supply system for the public related facilities area, including the water tank and pumping station, which are essential even for the design of water supply up to the service boat berth only.

Therefore, the water supply piping to the service boat berth should be well-planned and designed considering the total system of water supply to the public related area, which is to be planned, designed and constructed by the organization which uses such facilities. The underground connection piping from the main at the access road to the outside of the fence of the public related facilities area and the water supply piping at the berth apron are designed by the Study Team and constructed under ODA loan.

Figure 11.7.4 shows the conceptual water supply diagram in the Hai Phong International Gateway Port. The portions in red color are to be designed by the Study and constructed under ODA loan.

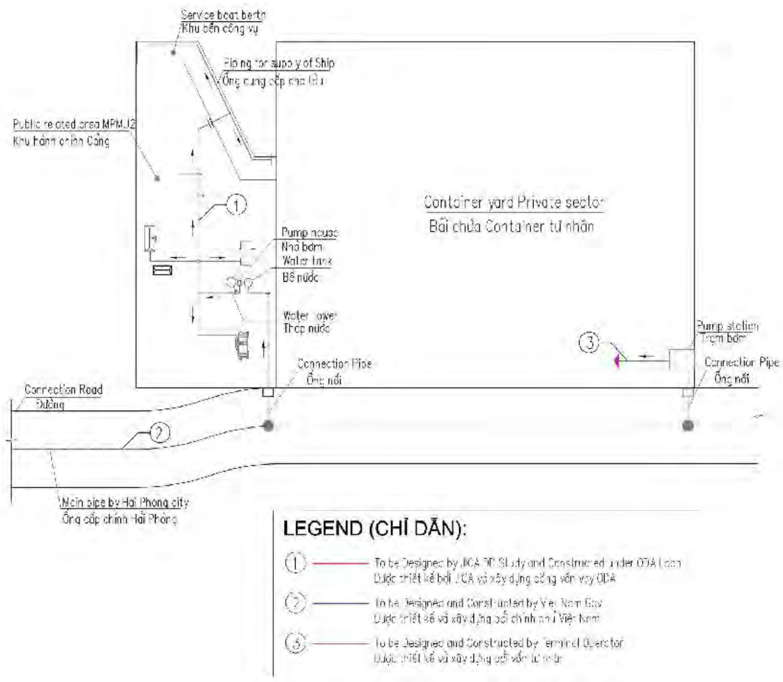


Figure 11.7.4 Conceptual Water Supply Diagram

1) Plan of Branch Pipe to Connection Pit in the Public Related Area

It is expected that the work of water pipe connection between the main pipe and branch pipe is designed in details and constructed by Vietnamese side.

a) General

Figure 11.7.5 shows the plan of branch pipe to the connection pit in the Public Related Area. The length of branch pile from main pipe to the connection pit in the Public Related Area is approximately 15.0m in case that the main pipe will be installed 4.0m away from the boundary line.

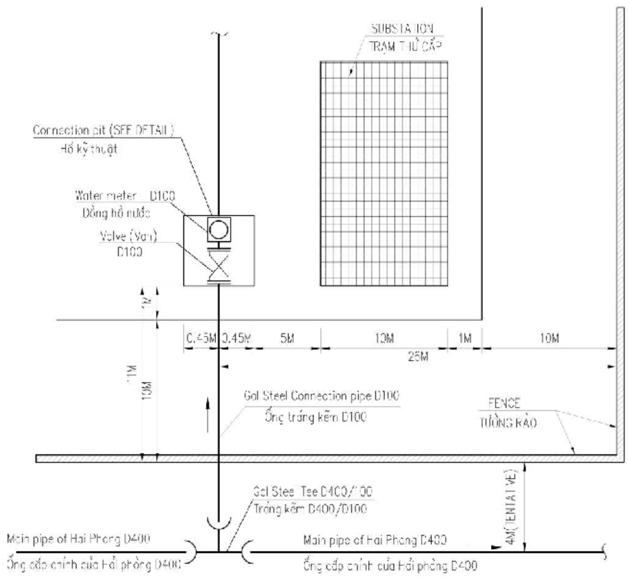


Figure 11.7.5 Plan of Branch Pipe to Connection Pit in the Public Related Area

Two of D400 pipes will be installed along the access road from Hai Phong City to the Project area.

b) Size of Branch Pipe to Connection Pit in the Public Related Area

The Study Team sent the MPMU II an inquiry about the required amount of electric and water supplies. However, the Study Team has not received any reply so far.

Here, the size of branch pipe to the Public Related Area is discussed considering the related study and similar project in Vietnam. The demand for water supply in the Public Related Area is summarized in Table 11.7.2. The demand for water supply to service boats is estimated with $20m^3$ multiplying by 5 ship hydrants.

Table 11.7.2 Demand for Water Supply in Public Related Area (Unit: (m^3/day))

	Estimation of JICA Study Team	Cai Mep Container Terminal	Hai Phong International Gateway Port
Public Area	(waiting for MPMU II's reply)	30.9	80.0
Service Boats	80.0	-	100.0
Total	80.0	30.9	180.0

Note1: "Cai Mep Container Terminal" is referred to Detailed Design Study Report on Cai Mep-Thi Vai Ports.
Note2: "Hai Phong International Gateway Port" is referred to Report on Adjustment of Investment Project.

From the above, a pipe size needs to meet the water supply of 160.0 ~ 180.0 m^3/day. Thus, D100 pipe is selected for the branch pipe to the Public Related Area from the main pipe.

c) Material of Branch Pipe to Connection Pit Public Related Area

Galvanized steel pipe will be applied to branch pipe to the Public Related Area including the service boat berth, because this pipe is popular in Vietnam and has enough size variation.

d) Connection Pit in the Public Related Area

The connection pit between the main pipe and water supply network in the Public Related Area including the service boat berth is planned and designed to check the water supply volume to the Public Related Area and to shut off water pipeline for the convenience of maintenance service.

2) Design of Connection Pit in the Public Related Area

The connection pit between the main pipe and water supply pipe in the Public Related Area are designed with applying common structure and parts in Vietnam. Figure 11.7.6 shows the detail of connection pit between main pipe and water supply pipe in the Public Related Area.

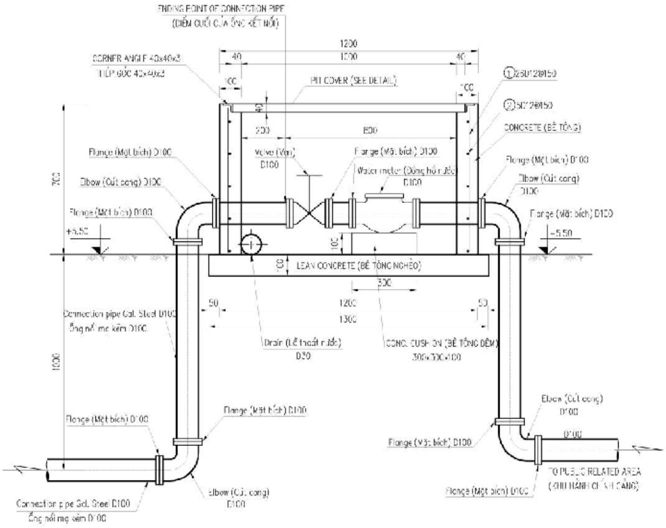


Figure 11.7.6 Detail of Connection Pit between Main Pipe and Water Supply Pipe in the Public Related Area

3) Plan of Water Supply to Service Boat Berth

The water supply network in the Public Related Area was planned in the Revised F/S prepared by TEDI Port. However, the exact location of connection to the service boat berth has not been decided yet. In addition, the berth line of service boat berth has been set back to avoid the base of steel tower for electric power supply. Therefore, the JICA Study Team proposes the location shown in Figure 11.7.7.

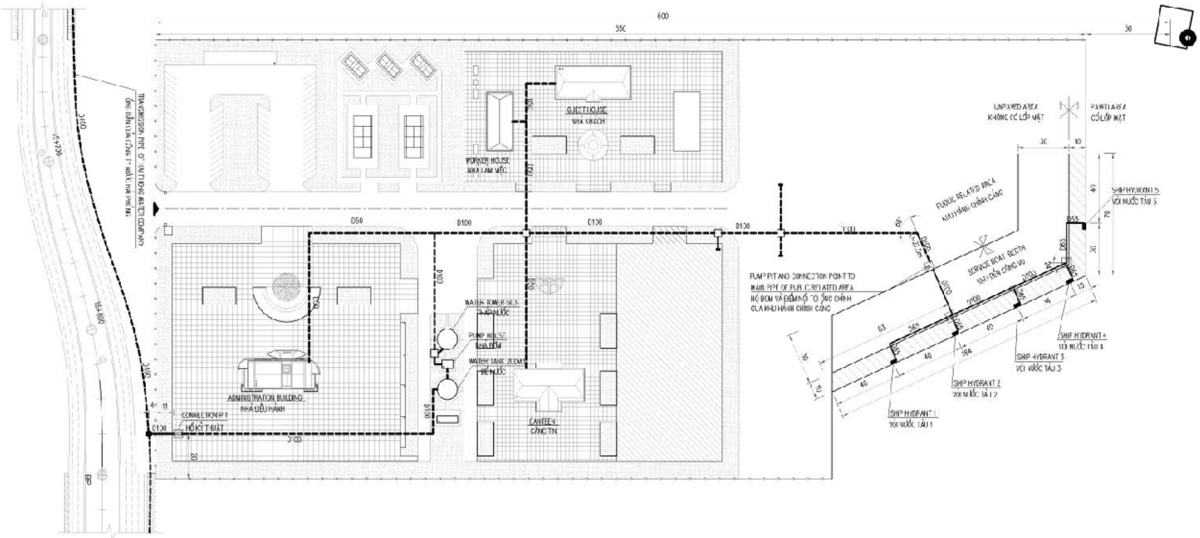


Figure 11.7.7 Proposed Water Supply System to Service Boat Berth

11.8 Utility Supply Demand for Port Development Plan in 2020

As for the future port development, six container berths and three multi-purpose berths were planned for port development plan in 2020. In this section, the future utility demands are discussed below.

11.8.1 Electric Power Supply

Development Plan 2020 (three multi-purpose berth 3-6) has not been decided yet, the power capacity of the container terminal at the time SAPROF scale is assumed about 35MVA.

Cat Hai substation, the new container terminal will be constructed, it is difficult to supply power.

In the future, to expand the Cat Hai substation, there is a need to provide a new substation or another.

11.8.2 Water Supply

Two of D400 pipes will be installed for water supply from Hai Phong City to the Project area along the access road and bridge. Though the water supply demands for future development plan 2020 (Berths 3~6 and three multi-purpose berths) have not been decided yet, it is checked preliminary with using the estimated water supply demand by berth length based on that of Berth 1&2.

The result of future demands for water supply is summarized in Table 11.8.1.

Table 11.8.1 Future Demands for Water Supply

	Berth Length (m)	Water Supply Demand (m^3/day)
Public Related Area	-	180
Berth 1&2	750	490
Berth 3&4	750	490*1
Berth 5&6	750	490*1
Multi-purpose Berths (3 berths)	750	490*1
TOTAL	3,000	2,140

Note1: estimated water supply demand by JICA Team

It is understood that two of D400 pipes will be enough for total future demands of water supply for port development plan 2020.

12. CHANNEL DREDGING AND DREDGED SOIL DISPOSAL

12.1 Channel Dredging

12.1.1 General

As the Lach Huyen navigation channel (hereinafter called the Channel) has to be dredged giving priority to the existing ship traffic of the present channel, the JICA Study Team carried out an alternative study on the channel dredging plan to consider how the dredging works can be implemented while maintaining work efficiency and maritime safety for both commercial ship traffic and construction vessel activities. The major points envisioned in this Chapter as Basic Design study are summarized as follows:

(1) To provide priority to the present channel traffic of the existing channel.

(2) To ensure maritime safety for existing ship passage in the Channel and the construction works

(3) To select the most effective solution on the dredging plan for the Channel regarding the dredging period and cost.

(4) To determine the order and sequence of dredging by cross section of Channel dredging to minimize disturbance of existing channel traffic during the construction period.

(5) To give priority to the dredging order for the turning basin area where the private sector will construct the container berth facility.

12.1.2 Configuration of the existing channel and volume to be dredged

1) Longitudinal stations of the Channel

The longitudinal location of the Channel is designated in 3 ways from different beginning points to Stations as summarized in following Table. In the Basic Design (B/D) Study, the landside end of the Channel will be Sta. 0 +000, and the seaside entrance of the Channel at the water depth of approximately CD-14 m will be Sta. 17 +400.

Table 12.1.1 Summary of Channel Stations

Starting Point	At the land side end of the channel	Widening point of the channel from 160m to 210m	Existing “0” Buoy as entrance of existing channel	At the entrance of the Project channel at -14m depth
Basic Design Study: The most landside end of the navigation channel as “0” Point	0km+000	9km+950	15km+808	17km+400
Existing stations Hai Phong Port as “0”	27km+000	36km+948	42km+800	44km+393
Offshore “0” buoy as “0” used by VMSC-North	15km+808	5km+858	0km+000	NA

2) Principal dimensions and alignment of the Channel

The general layout plan of the Channel and principal dimensions and centerline alignment of the Channel are shown in Figure 12.1.1 and Figure 12.1.2 and in the following Table 12.1.2.

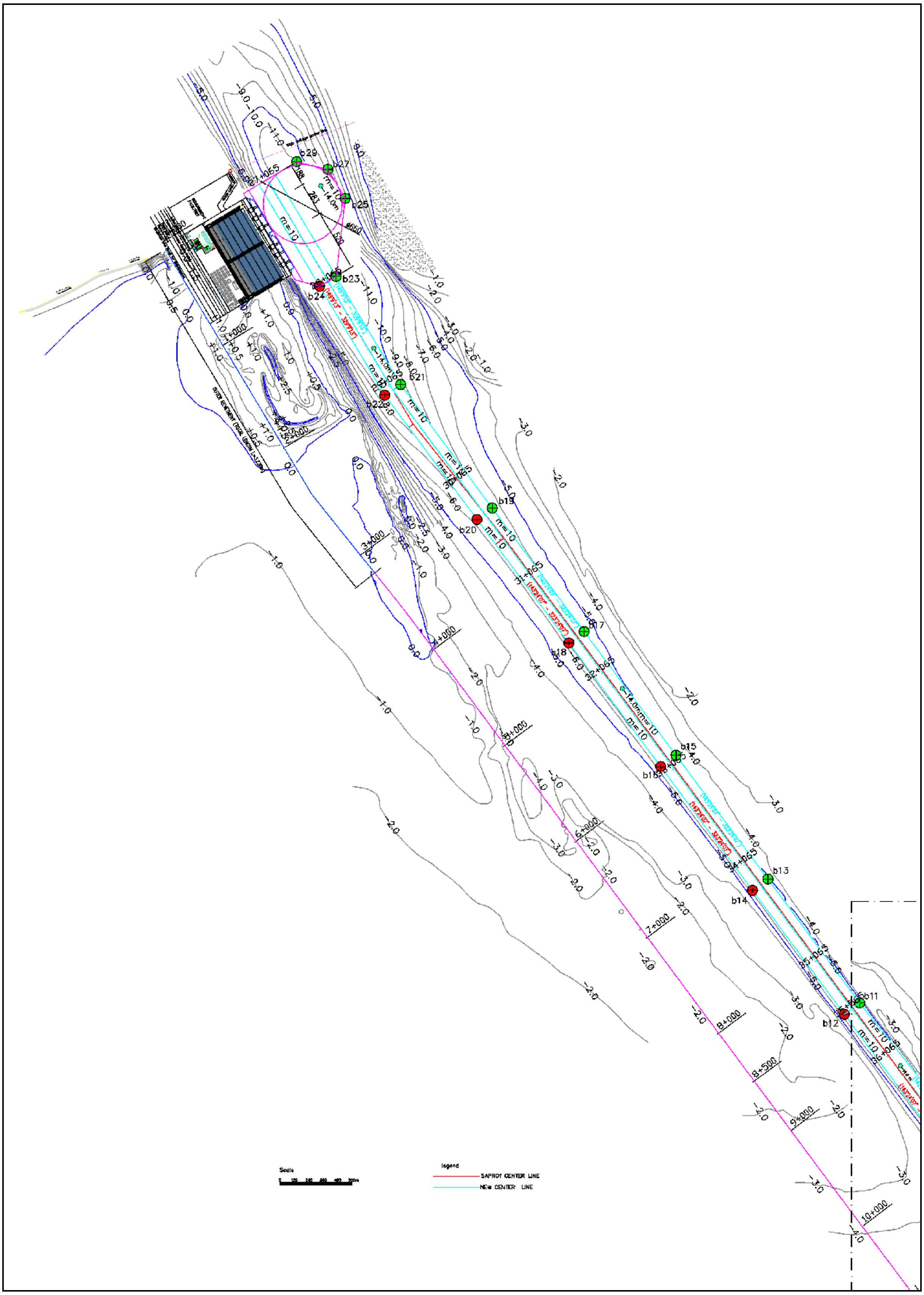


Figure 12.1.1 Channel Layout (1) (for Basic Design)

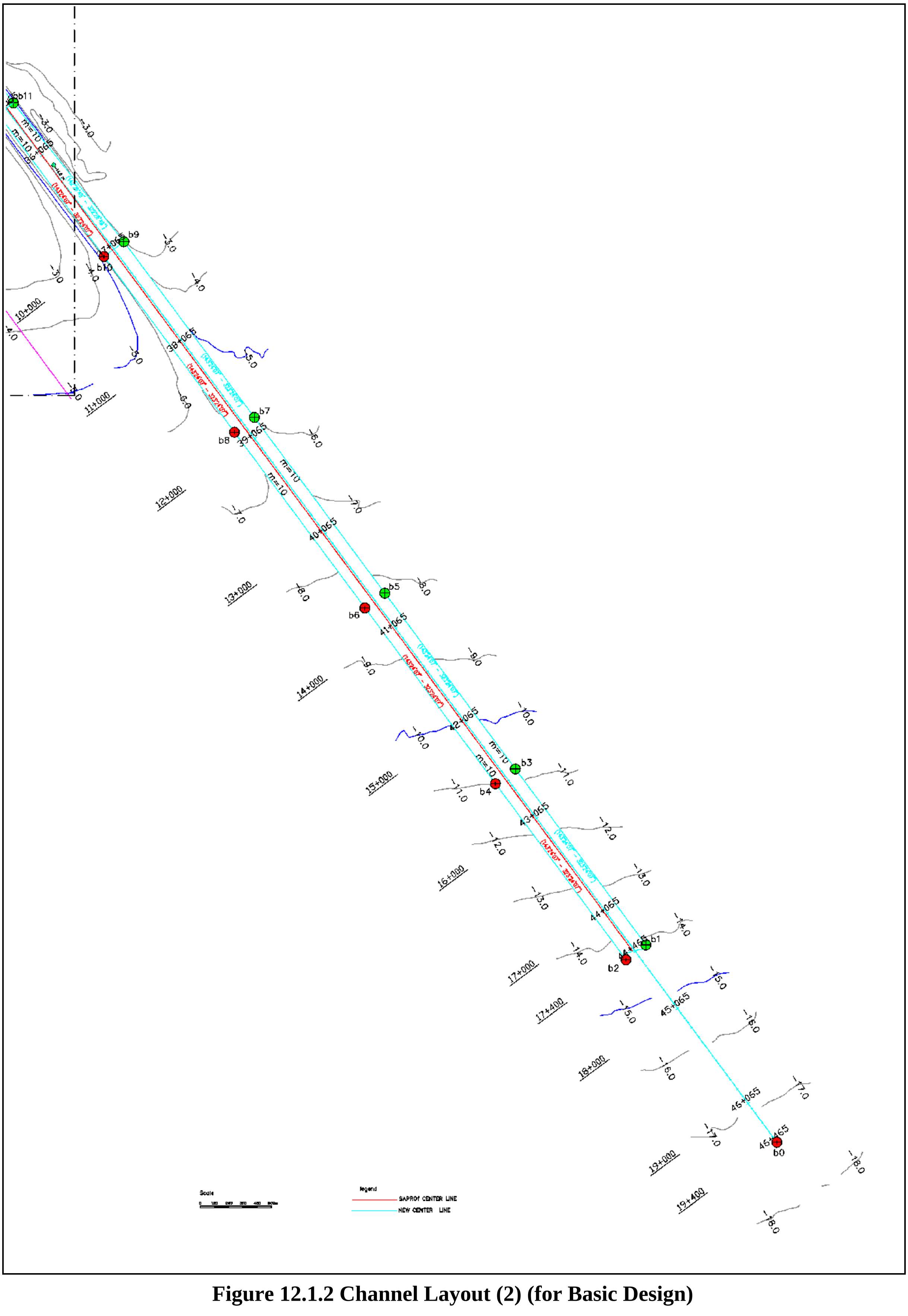


Figure 12.1.2 Channel Layout (2) (for Basic Design)

Table 12.1.2 Principle Dimension of Proposed Navigation Channel and Turning Basin (for B/D)

	Station	Width (Diameter for Basin)	Water Depth (CD)	Side Slope	Bearing direction
Channel	0+000 to 2+050	160 m	-14m	1:10	149 ° 9’13” - 329 ° 9’13” (Decision: 149°14’)
	2+050 to 9+950	160 m	-14m	1:10	143 ° 24’7” - 323 ° 24’7” (Decision 143 ° 24’)
	9+950 to 17+400	210 m	-14m	1:10	143 ° 24’7” - 323 ° 24’7”
Turning Basin	0+000 to 0+660	660 m	-14m	1:10	NA
Note: Channel/Basin dimensions and bearing direction are subject to the revision by JICA Team					

3) Existing configuration of the Channel

In spite of the fact that no maintenance dredging has been done since the completion of the existing Lach Huyen channel initial dredging works were completed under Hai Phong Port Project 2 in 2005, the water depth along the channel center is around CD -7 m. The Lach Huyen channel is located between sand bars along the east and west sides of the channel where the water depth varies from CD +2 m to only CD -2 to 3 m. The lengths of the sand bars are approximately 10 km from Sta. 0+000 to Sta. 10+000 on both sides of the channel. The sand bars work like a barrier of navigable water and the area for the dredging work is limited. Some large size working boats, such as TSHD (Trailing Suction Hopper Dredger) and hopper barges cannot turn within the Channel area. The TSHD and hopper barges are therefore required to go up to the landside end of the channel where a wide basin is located and turn their head seaside. The large size TSHDs, which have a maximum draft of 10 m, cannot work in the existing channel area until the dredging work has been completed by another type of dredger and an appropriate depth is secured.

Notes 1/ Small volume (approx. 52,000 m^3) of maintenance dredging at Lach Huyen channel was done in late 2011.
2/ CD: Chart Datum

12.1.3 Dredging volume

The dredging volume for the above mentioned principal dimensions of the Channel was calculated based on the result of the hydro-survey conducted by the JICA team. The breakdown of the total dredging volume in two study periods of SAPROF in 2009 and DD in 2011 are compared in the following Table. The additional volume due to the extra depth of the Channel and sedimentation during the channel dredging are added as a part of the dredging volume. The dredging volume determined in this dredging plan is the total volume based on the DD survey, i.e. 31,865,986 m^3.

The abovementioned volumes were reviewed based on the results of the siltation study in the Detailed Design (D/D).

Table 12.1.3 Summary of Dredging Volume (for B/D)

Item	Dredging volume(m^3)			Remarks
	As per the survey by SAPROF Study/2009	As per the survey by DD Study/2011	Balance	
Main channel dredging	29,037,883	28,603,386	(434,497)	for Basic Design
Extra volume due to the extra depth of the channel	1,262,600	1,262,600	0	0.4 m thickness below designated channel water depth
Extra volume due to the sedimentation during the channel dredging	2,000,000	2,000,000	0	The volume is subject to the result of the sedimentation study
Total	32,300,483	31,865,986	(434,497)	

The main Channel dredging volume is calculated at each longitudinal Station at 1 km intervals and by cross-sectional segment areas for the purpose of the dredging plan study. The cross-sectional segment Nos. are shown in Figure 12.1.3.

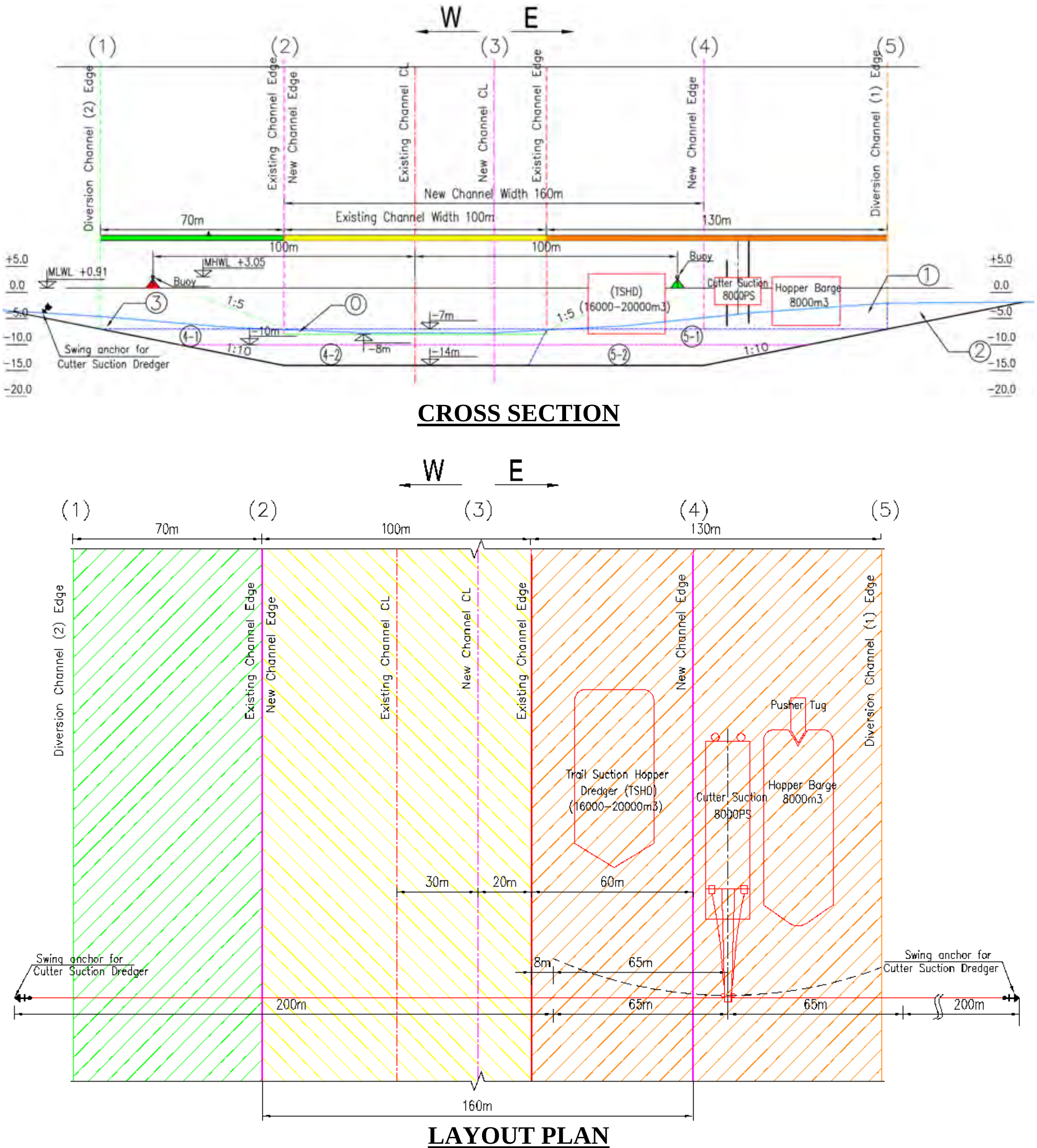
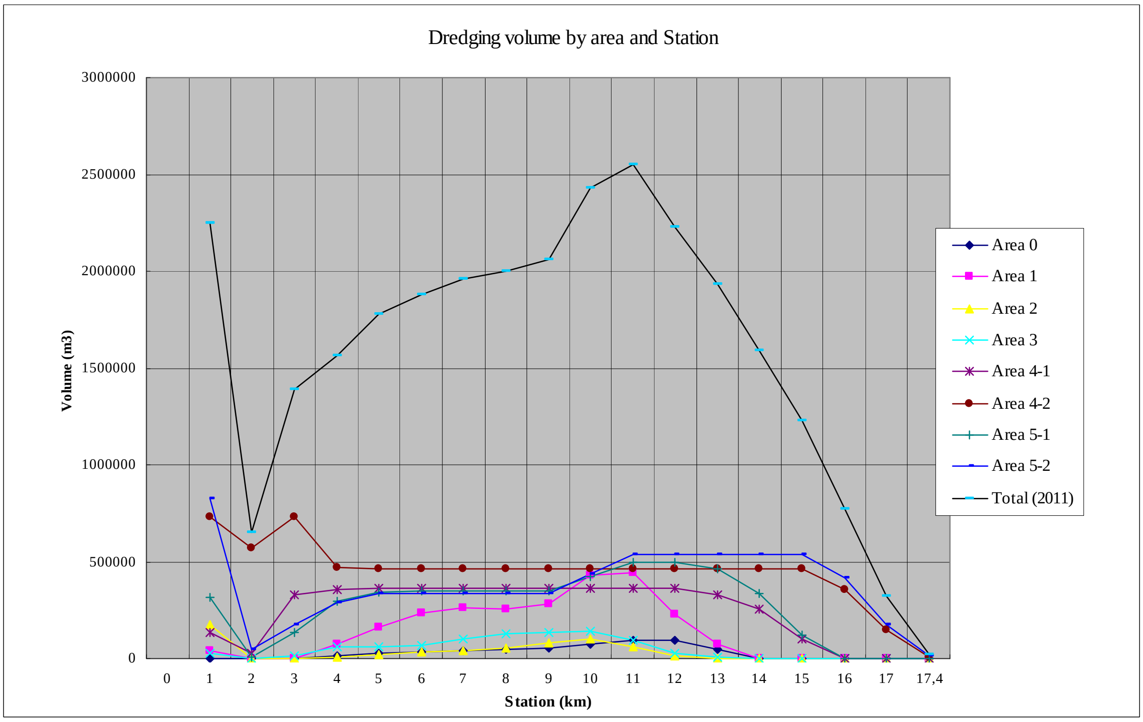


Figure 12.1.3 Typical Cross Section of the Channel and Dredging Procedure which will use Diversion Channel within the Cross Section of the Channel

Table 12.1.4 Dredging Volume Distribution by Longitudinal Stations and by Cross-Sectional Segment Areas (for B/D)

Longitudinal Stations		Cross sectional segment areas									Longitudinal Sub Total	
		Area 0	Area 1	Area 2	Area 3	Area 4-1	Area 4-2	Area 5-1	Area 5-2	Total		
0											0 to 3 km	
1		0	41,321	175,430	23,661	135,742	731,285	315,821	826,260	2,249,520		
2		0	0	0	0	23,559	572,671	5,200	48,830	650,260		
3		913	2,808	296	13,916	330,708	731,910	135,706	173,588	1,389,844		4,289,624
4		10,351	72,492	8,492	63,179	354,723	471,771	293,917	291,429	1,566,354	3 to 9 km	
5		24,750	164,200	21,400	63,650	359,950	464,000	343,200	336,000	1,777,150		
6		36,900	238,250	34,300	66,450	359,550	464,000	346,950	336,000	1,882,400		
7		43,550	261,400	42,650	103,150	361,650	464,000	346,650	336,000	1,959,050		
8		49,150	257,600	53,700	130,800	363,000	464,000	346,650	336,000	2,000,900		
9		51,350	279,550	79,450	136,900	363,000	464,000	347,000	336,000	2,057,250		11,243,104
10		73,950	432,800	97,650	142,550	363,000	464,000	422,000	436,000	2,431,950	9 to 11km	
11		92,050	441,150	62,900	92,450	363,000	464,000	497,000	536,000	2,548,550		4,980,500
12		92,500	231,350	16,050	29,300	363,000	464,000	497,000	536,000	2,229,200	11 to 13km	
13		49,500	75,400	3,100	9,400	331,800	464,000	460,950	536,000	1,930,150		4,159,350
14		0	0	0	0	253,800	464,000	333,950	536,000	1,587,750	13km & off shore side	
15		0	0	0	0	103,500	464,850	121,500	537,050	1,226,900		
16		0	0	0	0	0	356,000	0	414,450	770,450		
17		0	0	0	0	0	146,350	0	177,550	323,900		
17,4		0	0	0	0	0	9,141	0	12,667	21,808		3,930,808
Sub total	0 to 13 km	524,964	2,498,320	595,418	875,406	4,072,682	6,683,636	4,358,043	5,064,108	24,672,577		
	13 km to off	0	0	0	0	357,300	1,440,341	455,450	1,677,717	3,930,808		
Total		524,964	2,498,320	595,418	875,406	4,429,982	8,123,977	4,813,493	6,741,825	28,603,385		28,603,385



Note: Dredging volume is subject to revision based on the confirmatory survey by JICA Team (for B/D)

12.1.4 Type of Dredger

In order to complete the dredging works for the volume of 32 million m^3 in three (3) years time, the average daily productivity should be more than 35,000 m3, or when considering the stoppage due to several working conditions, the dredging fleet(s) should have peak productivity of 50,000 to 60,000 m^3 per day.

Taking the conditions such as, (1) parallel works with existing ships passage, (2) narrow and shallow existing channel, and (3) distance to the dumping site, working conditions for dredgers should be secured to ensure safety for existing ship passage and dredging work vessels and the dredging fleet should be organized to perform with the highest productivity. The outline specifications for each type of dredger are shown in the following Table. The major pros and cons by type of dredger are summarized hereunder:

1) Trailing Suction Hopper Dredger (TSHD):

Depending on the conditions, the productivity of TSHD will be the highest of all dredgers. For the Lach Huyen channel however, a TSHD cannot turn around within the channel area. Thus, the TSHD will consume time for the dumping cycle to travel between the dredging site and the dumping area.

The minimum working water depth for a TSHD will be approximately 10 m for a 16,000 m^3 hopper and 6 m for a 3,500 m^3 hopper. In order to let the TSHD work, pre-dredging will be needed to secure the required depth. Dumping the dredged soil on a coastal area is not practical for TSHD.

2) Cutter Suction (Pump) Dredger (CSD):

Ordinarily, a CSD is used with in combination with discharge pipes to send the dredged soil to a distant place. In the case of an 8,000 ps CSD, discharge pipe of approximately 3 or 4 km in length is required. Depending on the distance, the power of the discharge pump will be consumed for sending soil instead of for dredging itself. Instead of this discharging pipe system, direct discharge to the hopper barges will allow the CSD to achieve the highest productivity because the power can be used only for dredging. However, the ordinary type of CSD with a discharge pipe system has a discharge pump with a high hydraulic head (high pressure), which is not compatible with a direct discharge system. The low hydraulic head type pump dredger with a large discharge volume is most suitable for the purpose. Compared to the TSHD, the CSD can continue dredging work for the entire day. The hopper barges will receive dredged materials by turning without requiring extra stand-by or dumping time for the dredger.

For the existing Lach Huyen channel dredging under the Hai Phong 2 project, the CSD was found to be highly productive.

The CSD dredges by swinging the cutter head using anchors deployed on its starboard (right) and port (left) sides. For an 8,000 ps class CSD, the swinging range will be approximately 130 m and 200 m for anchor range, which requires 265 m water area on each side of the CSD (see Figure 12.1.3 for the anchor arrangement of CSD). Although the CSD has the highest productivity, it is dependent on an area with wide working space.

3) Grab Dredger (GD)

Compared to the above two types of dredgers, the productivity of a GD is 1/2 or 1/3. However, a GD has the advantage of being able to work by using spuds without extending anchors and it can work within the Channel cross sectional area simultaneously to commercial ship passage. The dredged soil of a GD is less disturbed than that of TSHD and CSD hence, it is relatively suitable for reclamation material. The dredged soil however, is not self-flowing (spreading) at dumping site due to the low water content (less disturbed) of soil. If the GD dredged soil is used for coastal dumping, a soil distributer, such as a pneumatic pump distribution system or barge unloaded ship (s), must be implemented and this requires a high cost.

4) Small size dredger

The productivity of the small size dredgers, such as a TSHD (3,250 m^3 type) or a GD (2 m^3 type), are 10 to 20% of that of the large type dredgers. In order to perform with the same productivity, the required number of fleet will be 5 to 10 times of large-size dredgers. For example, for a small GD, 50 to 100 working boats must be deployed in the dredging area to achieve the same productivity. From a safety point of view, it is not practical to use small GDs as the major dredging fleet.

The outline specifications and particulars of main dredgers are summered in the Tables below.

Table 12.1.5 Outline specifications of main dredgers

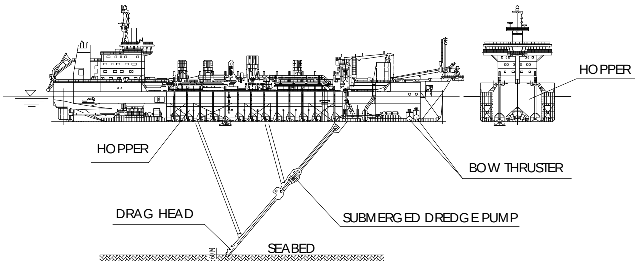
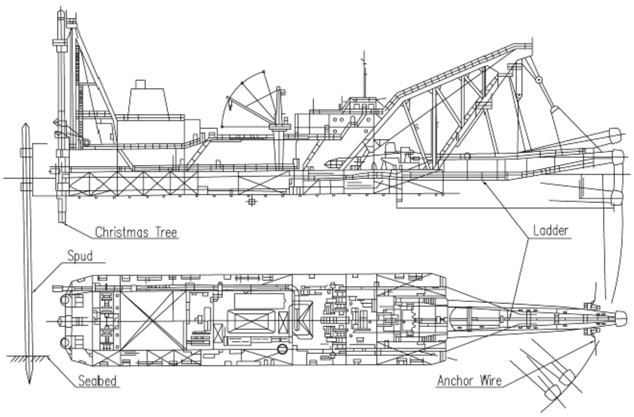
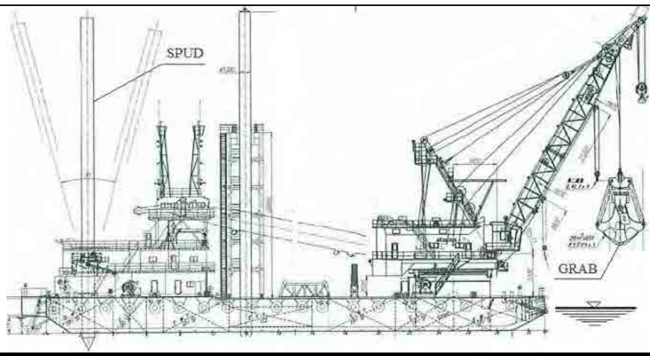
Type	Illustration	Dimension (m) Length (LOA)	 Width (B)	 Depth (D)	 Draft (d)
TSHD: Trailing Suction Hopper Dredger (Hopper Capacity: 16,500 to 20,000 m^3)		157.0 to 167.0	28.0 to 31.0	12.5 to 15.5	10.5 to 11.0
CSD: Cutter Suction Dredger (Main Pump 7,000 to 10,000 Ps)		131.0 (including ladder)	19.4	6.1	4.53
Grab Dredger (Grab Bucket 20 to 26 m^3)		60.0	24.0	4.0	2.0

Table 12.1.6 Particulars of relevant type of dredgers

Item		Type of dredger		
		TSHD	CSD	GD
size	Hopper	>16,000 m3		
	power		8,000 ps	
	Grab bucket			23 m3
Max depth to operate (m)		60	32	60
Min. depth to operate (m)		11	5.7	3
Max. Wave height to operate (m)		3	2	1.5
Max swell height to operate (m)		2	1	1
Max. cross current to operate (knots)		3	2	1.5
Max. soil shear strength (kN/m2)		75	500	300
Cruising speed (knots)		16	−	−
Dredging speed (knots)		2 to 4	−	−
Swinging range of cutter head (m)		−	130	−
The way to fix own working position		self propelled and by side thrusters	swinging anchors at both side of ladder head and spuds or Christmas tree anchors at opposite side of ladder	Fixing own position by spuds at opposite side of the grab
Soil dumping method		Carrying the dredged soil in bottom dumping hopper in the own hull and plying to dumping site	Discharging the dredged soil to hopper barge along side the CSD. The CSD can continue dredging for whole working day.	Discharging the dredged soil to hopper barge along side the GD. The GD can continue dredging for whole working day.
Notable particulars		1) Self-propelled and less affected by existing ship traffic 2) Intermittent dredging works since TSHD itself has to ply between dredging and dumping sites. 3) Can not dredge above the level of CD -10 m due to the own deep draft. 4) Practically not possible to dump at coastal dumping site due to the deep draft. 5) Can not turn around within the channel area due to the own ship hull length (approx 160 m) and has to go up to the turning area at the end of the channel for each cycle time.	1) The highest productivity among other type of dredger, but depend on the working condition such as working area and stand by time 2) Less affected by the stiff cohesive soil (N value is around 20) which is found at lower part of dredging section (CD-12 to 14 m or below) at several points along the Channel alignment.	1) GD can dredge by itself at the dredging site without disturbing the existing ships traffic. 2) The productivity is lower than that of CSD and TSHD thus comparatively high cost. 3) The dredged soil is less disturbed (less water content) than that of hydraulic pump system dredger such as TSHD and CSD. As for the reclamation material, GD produce better soil. The coastal dumping will, therefore, be hard due to the stiffness of the dredged soil which is not self spread material at dumping site and soil spreading means will be required at dumping site.. 4) Heavy type grab is required for stiff cohesive soil. (right type clam shell is not suitable)
				

Source 1) BS 6349-5
2) Brochure Contractors
3) The Japan Work Vessel Association

12.1.5 Dredging Methodology

The potential methods for Channel dredging are summarized in the following ways:

(1) CSD (8,000 ps) – Hopper barges (5,000 to 8,000 m^3)– offshore dumping

(2) TSHD (16,000 m^3 or bigger) – offshore dumping (for the portion under -10 m)

(3) GD – Hopper barges (1,300 to 1,500 m^3) - offshore dumping

(4) CSD – Hopper barges (5,000 to 8,000 m^3) - coastal dumping by secondary cutter suction dredger (4,000 ps)

(5) GD – coastal dumping – to distribute the solid dredged material, a pneumatic distribution or barge unloader system is required and incurs a high cost.

(6) Coastal dumping by TSHD is not practical due to the deep draft of TSHD for both large and small dredgers.

The combinations of dredging fleet and relevant descriptions are shown in the following Table 12.1.7. The applicable cases are discussed in Section 12.1.8. The major methodology of coastal dumping and discharge at Cat Hai and South Dinh Vu discussed hereunder is by Method 4 CSD or GD. The major contents of the Table 12.1.7 are enumerated hereunder:

1. Off shore dumping is most productive (Methods 1 to 3)
2. TSHD can not dredge and dump at shallow area due to low productivity (Methods 2,7 & 8)
3. Secondary cutter suction is double handling (dredging) of discharged soil (Method 4)

12.1.6 Dumping Sites

Three dumping sites, Offshore, at Cat Hai and at Dinh Vu, and six approaches to the dumping sites were compared as shown in Figure 12.1.4 and Table 12.1.8. The Offshore dumping site is a 5 km x 5 km area with a minimum water depth of -20 m. The distance from the center of the Channel to the Offshore dumping area is 16 km while the distances to the Cat Hai east south and west approaches and Dinh Vu east are 7km, 13 km and 22 km respectively.

The size of the hopper barge as a carrier of dredged material for a CSD (8,000 ps) will be 5,000 m3. To allow the barges access to the Cat Hai dumping site, an approach trench and dumping basin will be required near the coastal dumping site. For the Cat Hai south approach, an approach channel of more than 10 km will be needed. The Nam Trieu channel, which has a shallow water depth of -1.5 m, cannot be used as an approach channel.

The schematic plans of coastal dumping basin and secondary dredgers with discharge pipes are also shown in the corner of the same Figure 12.1.4.

Of the six coastal dumping approaches, Cat Hai east approach is the shortest distance from Lach Huyen Channel and the shortest length of approach trench. The east approach will be, therefore, the lowest cost and the most effective (high productivity) for the coastal soil discharge works. In order to shorten the secondary discharge pipe length from dumping basin to disposal area, east dumping basin is preferable to locate at southwest side of the terminal area with approach trench crossing the outer revetment but subject to the further confirmation on the construction planning of outer revetment and sand protection dike.

The size of dumping basin is so determined as to have the capacity to receive 3 to 4 days channel dredging volume and to avoid the temporarily discharged soil over-flowing out to the channel area under the temporary dumping works by hopper barges and secondary dredging by 4,000 ps CSDs.

Table 12.1.7 Comparison of dredging methodology

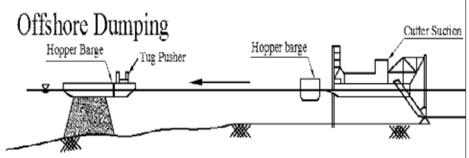
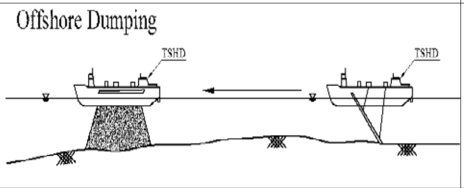
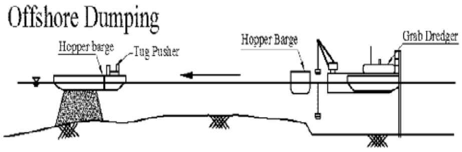
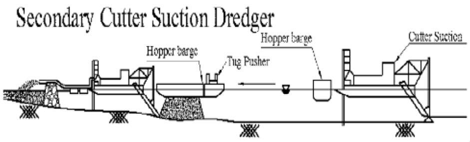
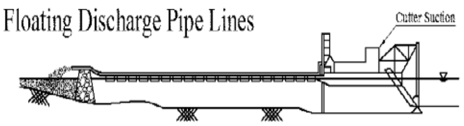
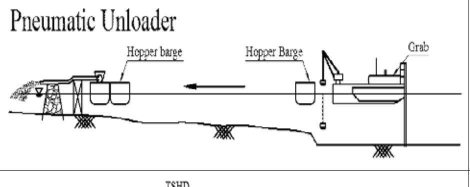
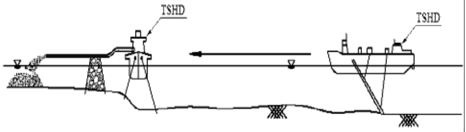
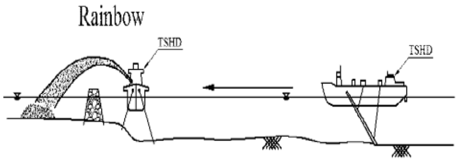
Method No.	Sketch	Composition of main Dredgers	Dumping site	Descriptions
1		Cutter Suction Pump Dredger (CSD) with hopper barges	Offshore	* CSD (>8,000 ps) with the pump of low hydraulic head and large discharge volume which will achieve the highest productivity by allowing CSD continuous operation whole time of the day. * Hopper barge and pusher tug boats with proper size (5,000 to 8,000 m3) and number (3 to 4 units/CSD fleet) will be required so that dredged soil will be continuously received and disposed by barges. * Anchor wires have to be deployed for swinging of ladder head of the CSD.
2		Trailing Suction Hopper Dredger (TSHD)	Offshore	* Large size TSHD dredger (>16,500 m3 hopper size) * Intermittent operation for dredged soil dumping by TSHD itself plying between dredging and dumping sites. * Large TSHD can work at water depth of -10m or below. * Can not approach shallow dumping area. Practically offshore dumping is most effective usage.
3		Grab Dredger (GD) with hopper barges	Offshore	* Large size GD (>23m3) with 3 units of hopper barges (>1,300 m3) and pusher tug boats per each GD fleet * Less productivity than CSD and TSHD resulting high cost. * Self standing by its' own spuds so that less influence to existing marine traffic and safety.
4	 Note: The coastal dumping and discharge at Cat Hai and South Dinh Vuh is by Method 4 by CSD or GD	CSD with hopper barges	Cat Hai	* CSD (>8,000 ps) with the pump of low hydraulic head and large discharge volume . * Hopper barge and pusher tug boats with proper size (5,000 to 8,000 m3) for dumping soil to Cat Hai. * Access trench and dumping basin are required to allow hopper barge at shallow sea water area at Cat Hai * The access trench and dumping basin should be maintained the water depth below -3 to -5m until the Channel dredging works are completed. * 3 units of CSD (>4,000 ps) with discharge pipe and floaters are required for secondary discharging to disposal area. * Revetment temporary passage within the dumping site and spillways are to be prepared before starting dumping at Cat Hai.
5		CSD with discharge pipes on floaters	Cat Hai	* CSD (>8,000 ps) with discharge pipes and floaters to make direct dumping to Cat Hai. * The productivity of the CSD will be much lower than that of CSD with direct discharge to hopper barge. * The effective distance from dredging point to dumping site is 2 to 3km of which 1 to 2km will be consumed for passing the terminal area. * In case that the diversion channel is within the cross-section of the Channel, the discharge pipe will be limited by existing ship passage.
6		GD with hopper barges and pneumatic un-loader./Barge unloader ship	Cat Hai	* The Channel area is consisting of cohesive soil. The soil dredged by GD will be still plastic. The distribution of the dredged soil will be required some mechanical system such as a pneumatic unloader or barge unloading ship(s). * The cost of pneumatic distributor/barge unloading ship will be high.
7		TSHD discharge by own pumps through discharge pipes nearby the disposal area	Cat Hai	* Due to shallow water depth TSHD can not approach to dumping site at Cat Hai, or otherwise deep approach trench will be required. * TSHD will have to consume time to discharge soil at Cat Hai.
8		TSHD discharge by free throwing "Rainbow" nearby the disposal area.	Cat Hai	* Same as above and much less range of soil distribution by rainbow. Note: Rainbow means the direct free throwing discharge by using TSHD discharge pump

Table 12.1.8 Comparison of dumping sites

Location of dumping site			Cat Hai					Off shore	Dinh Vu	
			Approach					Off shore	Approach	
			East 1/			South	West	area below -20 m	East	South
Total distance from center		km	7	7	7	13	22	16	22	17
Size of hopper barge		m3	5,000	1,300	3,500 TSHD	5,000	5,000		5,000	5,000
Trench	Length	km	1.2	1.2	1.2	8	2		3	11
	Width	m	50	50	40	50	50		50	50
	Depth	m (CD)	-5.5	-4.5	-4.5	-5.5	-5.5		-5.5	-5.5
	Side slope		1:5	1:5	1:5	1:5	1:5		1:5	1:5
	Volume	m3	332,200	246,800	246,700	2,215,000	1,048,000		1,059,400	-
Dumping basin	Length	m	1,200	1,200	1,000	1,200	1,200		1,200	1,200
	Width	m	200	200	200	200	200		200	200
	Depth	m (CD)	-9.00	-9.00	-8.50	-9.0	-9.0		-9.0	-9.0
	Side slope		1.5	1.5	1:5	1:5	1:5		1:5	1:5
	Volume	m3	2,763,500	2,763,500	2,164,000	2,763,500	2,763,500		3,150,000	-
Turning basin	Length	m	1,200	1,200	1,000	1,200	1,200		1,200	1,200
	Width	m	200	200	100	200	200		200	200
	Depth	m	-5.5	-4.5	-4.5	-5.5	-5.5		-5.5	-5.5
	Volume	m3	1,605,500	673,800	562,300	1,605,500	1,605,500		2,214,800	-
Total soil volume	Trench	m3	332,200	246,800	246,700	2,215,000	1,048,000		1,059,400	-
	Basin	m3	4,369,000	3,437,300	2,726,300	4,369,000	4,369,000		5,364,800	-
	maintenance (assumption)	m3	769,100	590,500	519,400	2,652,000	1,484,900		1,595,900	-
	Total	m3	5,470,300	4,274,600	3,492,400	9,236,000	6,901,900		8,020,100	-

Note 1/ For 3,500 TSHD, the size and volume of trench and basin are minimal for reference.

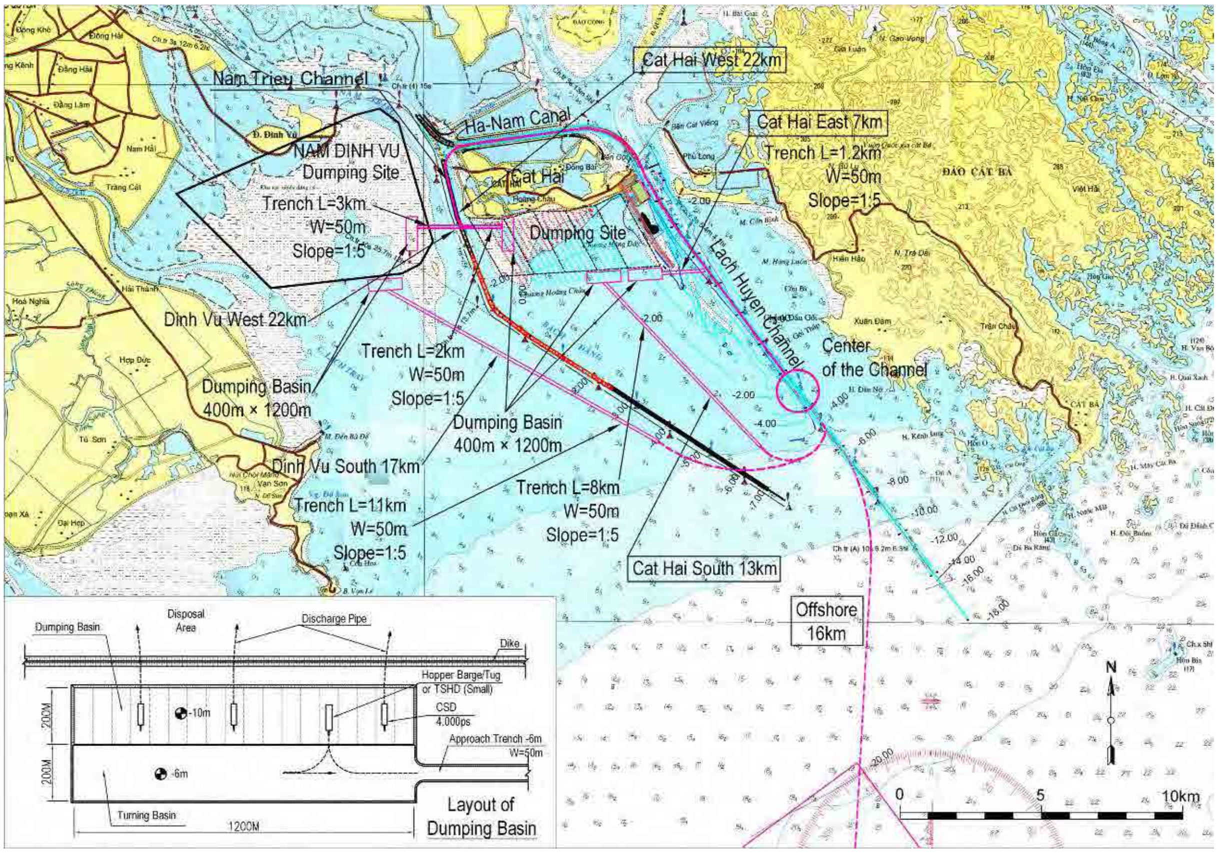


Figure 12.1.4 Comparative dumping sites of dredged soil

12.1.7 Conditions and Efficiency of Dredging Work

The efficiency of the dredging works was determined in different way according to the type of dredger. The major points that affect efficiency are as follows:

(1) Hardness of the dredging soil, which will be represented by N-value (SPT: Standard Penetration Test). In this BD study stage, an N-value “5” was considered as the average hardness.

(2) Work efficiency depends on the thickness of the dredging layer.

(3) Work efficiency depends on the configuration of the dredging area.

(4) Work efficiency depends on the cross-sectional shape of the dredging area.

(5) Work efficiency depends on the oceanographic conditions.

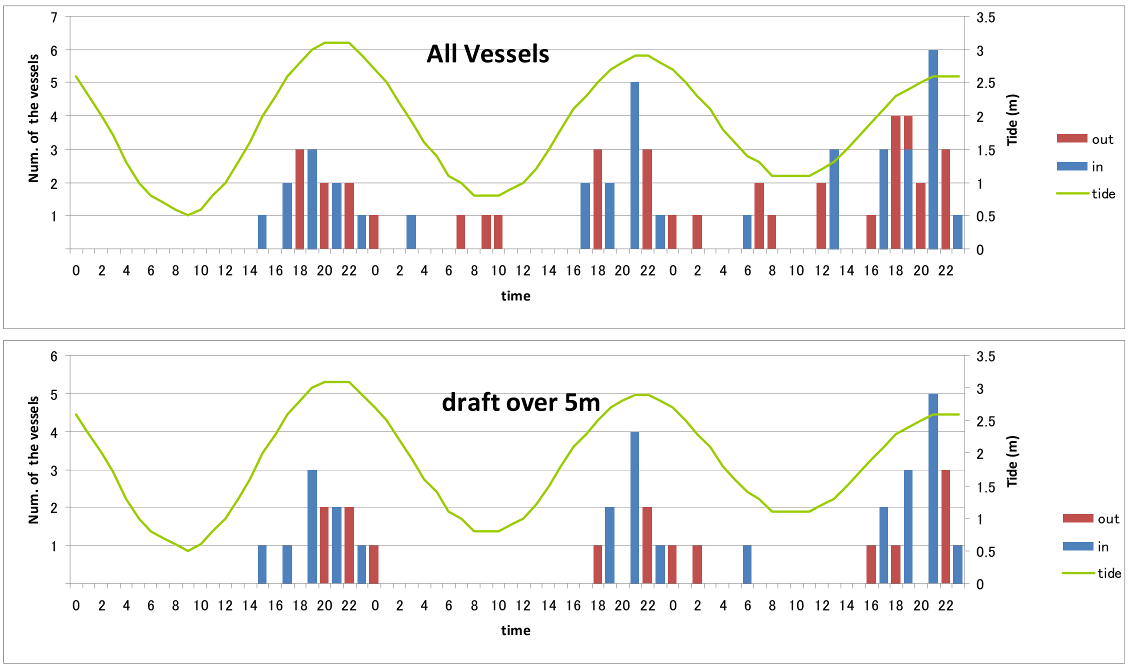
(6) Work efficiency depends on the time for mitigation measures for turbidity and environmental related arrangement.

(7) Distance between the dredging site and dumping site, particularly for TSHD.

(8) Ratio for idling time.

(9) And, stand-by time duration per day for existing ship traffic, which will be given priority.

For the existing ship traffic, Figure 12.1.5 shows the record of the ships passing the existing Lach Huyen channel for 3 consecutive days from May 25th, 2011 as a typical example of maritime conditions. As can be seen from the Figure, ships move in and out of the channel depending on the tidal level curve indicated with the green line, but also at almost every hour of the day. Regardless of the size of the passing ships, the dredging works of CSD will be affected because of the need for stoppage to let ships pass. In the case of GD, which has to deploy more than 15 major working boats along the channel, effects on safety aspects must also be considered. For the TSHD, because the dredger itself has to go back and forth between dredging site and dumping site, some waiting time must be considered.



Source: VMS1 May 25th to 27th, 2011

Figure 12.1.5 Record of ships passing Lach Huyen channel

The detailed work efficiency and productivity of the dredgers by type are summarized in the following Table 12.1.9 through Table 12.1.11 for CSD, GD and TSHD respectively. Alternative cases of the study are discussed in Section 12.1.8. For study of the most productive CSD, working with a diversion channel within the cross-sectional area of the Channel, two alternative cases with 6 hours (Case A3-1) and 10 hours (Case A3-2) of stand-by time are determined.

Table 12.1.9 Dredging works efficiency (1)

Type of dredger			CSD (Cutter Suction Dredger)							
Power			D 8,000 ps			D 8,000 ps			D 4,000 ps	
Discharge method			Direct discharge to hopper barge						Discharge pipes	
Classification of the soil			cohesive soil							
Dredging position			Lach Huyen Channel			Lach Huyen Channel, Thin layor			Approach trench and dumping basin	Secondary discharge tocoastal damping site
Daily stand-by time		hr	0	6	10	0	6	10	0	0
Average N-value			5	5	5	5	5	5	5	0
Distance of discharge		km	0	0	0	0	0	0	3.2	2.0
Basic capacity of the dredger	q	m3/hr	2,800	2,800	2,800	2,800	2,800	2,800	694	1,036
Work efficiency (Dredging)	E1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Work efficiency (Thickness of layor)	E2		1.0	1.0	1.0	0.7	0.7	0.7	0.9	1.0
Work efficiency (Configuration of the dredging area)	E3		0.9	0.9	0.9	1.0	1.0	1.0	0.9	1.0
Work efficiency (Cross section)	E4		1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0
Work efficiency (Oceanographical Conditions)	E5		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Work efficiency (Other condition: turbid control etc.)	E6		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Ratio for idling	E7		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Working hour per day	T	hr	16	16	16	16	16	16	16	16
Daily stand-by hours		hr	0	6	10	0	6	10	0	0
Daily stand-by ratio	Sr		0	0.25	0.42	0	0.25	0.42	0	0
Daily productivity: Q=(q x E1 x E2 x E3 x E4 x E5 X E6 x T)X(1-Sr)		m3 /day	29,400	22,050	17150	21,230	15,920	12,380	6,190	12,080

Source: 1) Port and harbors construction cost estimation standards (2010, Japan)
2) Cost Standards for dredging equipment, 2005, R.N.Bray
3) Hearing to marine contractors

Table 12.1.10 Dredging works efficiency (2)

GD (Grab Dredger)			
Type of dredger			GD
Grab size			23m3
Discharge method			Hopper barge
Classification of the soil			Cohesive soil
Dredging position			Lach Huyen channel
Basic capacity of the dredger	q	m3/hr	787
Work efficiency (Thickness of layor)	E1		0.85
Work efficiency (Oceanographical Conditions)	E2		0.95
Work efficiency (Water depth)	E3		1
Ratio for idling	E4		0.9
Working hour per day	T	hr	16
Daily stand-by hours		hr	0
Daily stand-by ratio	Sr		0
Daily productivity: Q=(q x E1 x E2 x E3 x E4 x T)X(1-Sr)	Q	m3/day	9150

Table 12.1.11 Dredging works efficiency (3)

TSHD (Trailing Suction Hopper Dredger)									
			16,000 m3	3,500 m3				1,500 m3	Remarks
Daily stand-by time		hr	0	0	0	6	10	0	
Hopper size		m3	16,000	3,500	3,500	3,500	3,500	1,500	
Effective soil ratio			0.4	0.4	0.4	0.4	0.4	0.4	
Effective soil volume	(1)	m3	6400	1400	1400	1400	1400	600	
Dumping site			Off shore		Cat Hai	Off shore			
Distance to dumping site		nm	14	14	6	14	14	14	14 nm including dist. to turning
of which dist. Within the channel		nm	8	8	6	8	8	8	
Speed within the channel		knot	8	8	8	8	8	8	
Running time within the channel		hr	1	1	0.8	1	1	1	
Distance of outer sea		nm	6	6	0	6	6	6	
Speed outer sea		knot	14	14	14	14	14	14	
Running time outer sea		hr	0.43	0.43	0.00	0.43	0.43	0.43	
Running time round trip		hr	2.86	2.86	1.65	2.86	2.86	2.86	
Dredging time		hr	3.00	3.00	3.00	3.00	3.00	3.00	
Dumping time		hr	0.50	0.50	0.75	0.50	0.50	0.50	
Waiting time for existing ships		hr	1.00	1.00	1.00	1.00	1.00	1.00	
Total cycle time		hr	7.36	7.36	6.40	7.36	7.36	7.36	
Daily working time		hr	24	24	24	24	24	24	
Number of daily trip	(2)	times	3.26	3.26	3.75	3.26	3.26	3.26	
Work efficiency (Oceanographical Conditions)	(3)		0.9	0.9	0.9	0.9	0.9	0.9	
Ratio for idling	(4)		0.9	0.9	0.9	0.9	0.9	0.9	
Day off ratio	(5)		0.9	0.9	0.9	0.9	0.9	0.9	
Daily stand-by hours		hr	0	0	0	6	10	0.0	
Daily stand-by ratio	Sr		0	0	0	0.25	0.42	0.0	
Daily productivity: Q=(1) x (2) x (3) x (4) x (5)x(1-Sr)		m3/day	14,660	3,210	3,680	2,400	1,870	1,380	

12.1.8 Comparative Study Cases and Diversion Channels

To achieve safety and the lowest cost solution, comparative study Cases as summarized in Table 12.1.12 were determined.

Cases 1, 3, 4, 5, 7, 8 and 12 include a diversion channel in the cross-sectional area of the Channel (indicated as “Inside”), while Cases 2, 6, 9, 10 and 11 are considered with the diversion channel “Outside” of the Channel cross-sectional area. Although the additional dredging volume for the outside diversion channel will be approximately 3 to 4 million m3, which is 10 to 15% of the total main Channel dredging, the total cost will be less than that of the former Cases, which have the diversion channel within the Channel area and are less productive and more costly due to the high unit cost of basic dredging by the type of dredger.

In the Cases 1 to 6, coastal dumping of dredged soil is determined, while Cases 7 to 10 shows off shore dumping and Case 11 and 12 are for the combination of off shore dumping until such time that the bund (dike) of the dumping site and approach trench for the hopper barges are ready and coastal dumping will follow.

The relevant productivity, work duration and dredging cost for each case are determined in Sections 12.1.9 and 12.1.10.

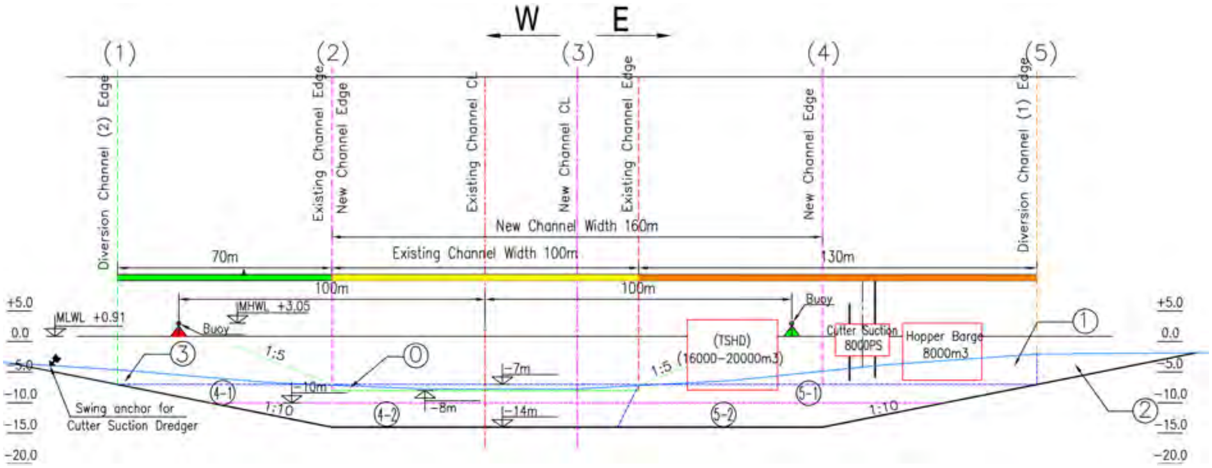
Some other alternative cases as indicated in the following Table are also shown in Sections 12.1.9 and 12.1.10 for reference.

The typical cross sections and layout plans of each study Case are shown in Figure 12.1.6 to Figure 12.1.15.

Table 12.1.12 Comparative Case Study on Channel Dredging

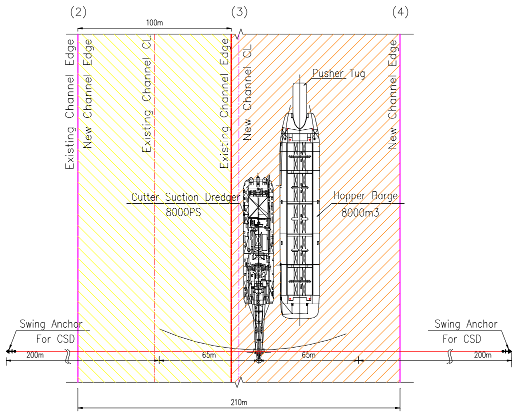
	Case No.	Ref. No.	Dumping site: Dinh Vu	Dumping site: Cat Hai	Dumping site: Off shore	Dumping site: Combination	Diversion Channel: Inside	Diversion Channel: Outside	Combination of dredger: CSD 8,000 ps /5,000 m3 barges	Combination of dredger: CSD 8,000 ps /1,300m3 barges	Combination of dredger: TSHD >16,000 ps	Combination of dredger: GD 23 m3	Combination of dredger: TSHD 3,500 m3	Combination of dredger: CSD 4,000 ps for dumping site	General description	Case of (B/D Report)
	1	A3	○				Inside		○ offshore			◎	○	○	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Dinh Vu (East)	A1-5
	2		○					Outside	◎				○	○	With outer (east) diversion channel by CSD and 5,000 hopper barges dumping all at Dinh Vu (east)	B1-4
	3			○			Inside		-		-	◎	○	○	Within the Channel by GD dumping all at Cat Hai (East)	A1-3
	4	A4		○			Inside		○ offshore		-	◎	○	○	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Cat Hai (East)	A1-4
	5			○			Inside						◎	○	Within the Channel by TSHD (small) dumping all at Cat Hai (East)	A1-6
	6			○				Outside	◎		-	-	○	○	With outer (east) diversion channel by CSD and 5,000 hopper barges dumping all at Cat Hai (east)	B1-3
	7				○		Inside		○ offshore		◎	◎	○	-	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) and dumping off shore	A1-2
	8				○		Inside		○ offshore		◎	-	◎	-	Within the Channel by Large and small TSHD, and CSD (Sta 13 km and offshore), dumping offshore	A2-2
	9				○			Outside	◎		-	-	○	-	With outer (east) diversion channel by CSD and 5,000 hopper barges dumping offshore,	B1-2
	10				○			Outside		◎	-	-	○	-	With outer (east) diversion channel by CSD and 1,300 m3 hopper barges dumping offshore	B2-2
	11			○	○	Combined		Outside	◎		-	-	○	○	With outer (east) diversion channel by CSD dumping at Cat Hai and offshore,	B1-1
	12-1			○	○		Inside		○ offshore			◎	○	○	Within the Channel by GD and CSD (Sta 13 km and offshore) dumping Cat Hai and offshore	A1-1
	12-2			○	○		Inside		○ offshore		◎	◎	○	○	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping Cat Hai and offshore	
Alternative cases	13			○	○		Inside		○ offshore		◎		◎	○	Within the Channel by large/small TSHD, and CSD (Sta 13 km and offshore) dumping Cat Hai and offshore	A2-1
Alternative cases	14			○	○			Outside	◎				○	○	With outer diversion channel by CSD and 1,300m3 hopper barges dumping Cat Hai and offshore	B2-1
Alternative cases	15				○		Inside		◎				○		Within the Channel by CSD with standby time (6hours/day) dumping offshore	A3-1
Alternative cases	16				○		Inside		◎				○		Within the Channel by CSD with standby time (10 hours/day) dumping offshore	A3-2
Alternative cases	17				○			Outside	◎						The Channel itself shifted east outside by CSD dumping at off shore	B-3
Alternative cases	18				○			Outside	◎				○		With west diversion channel by CSD and 1,300 m3 hopper barges dumping offshore. 1/	B-4
Alternative cases	19	C1	○	○	○	Combined	Inside		○ offshore			◎	○	○	Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 1 Package	A1-6
Alternative cases	20	C2	○	○	○		Inside		○ offshore			◎	○	○	Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 2 Packages	A1-7
Alternative cases	21	A1'	○		○		Inside		○ offshore			◎	○	○	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping at Dinh Vu (East) and Offshore	A1-5'
Alternative cases	22	A2'		○	○		Inside		○ offshore			◎	○	○	Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Cat Hai (East) and Offshore	A1-4'

Note: 1/ Subject to effectiveness of buffer trench to minimize possible sedimentation in the Channel and maintenance dredging to be confirmed by sedimentation study.

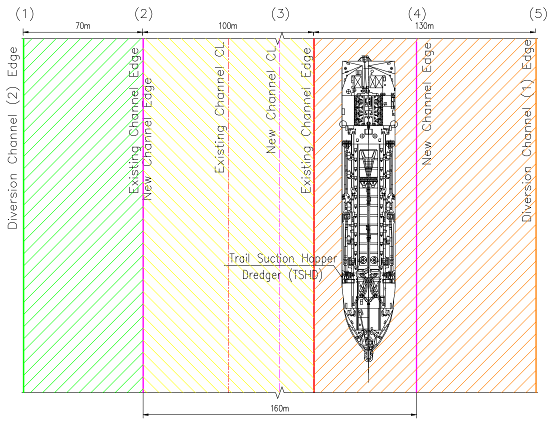


CROSS SECTION

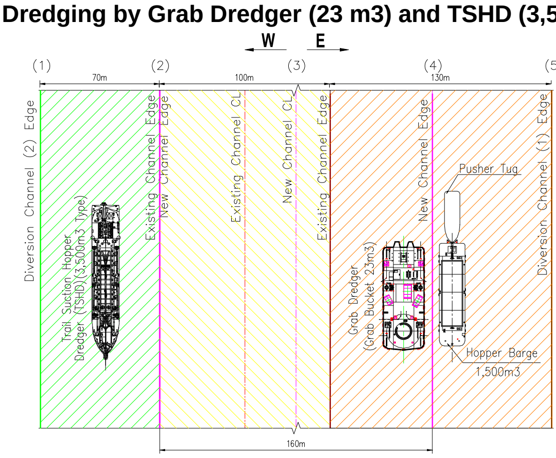
Dredging by CSD 8,000 PS with Hopper Barge



Dredging by > 16,000 m3 TSHD below level -10,0m



Dredging by Grab Dredger (23 m3) and TSHD (3,500 m3)



LAYOUT PLAN

Figure 12.1.6 Cases 1,3,4,5,7,8,12,13,15 and 16 Typical Cross Section of the Channel and Dredging Procedure which will use Diversion Channel within the Cross Section of the Channel

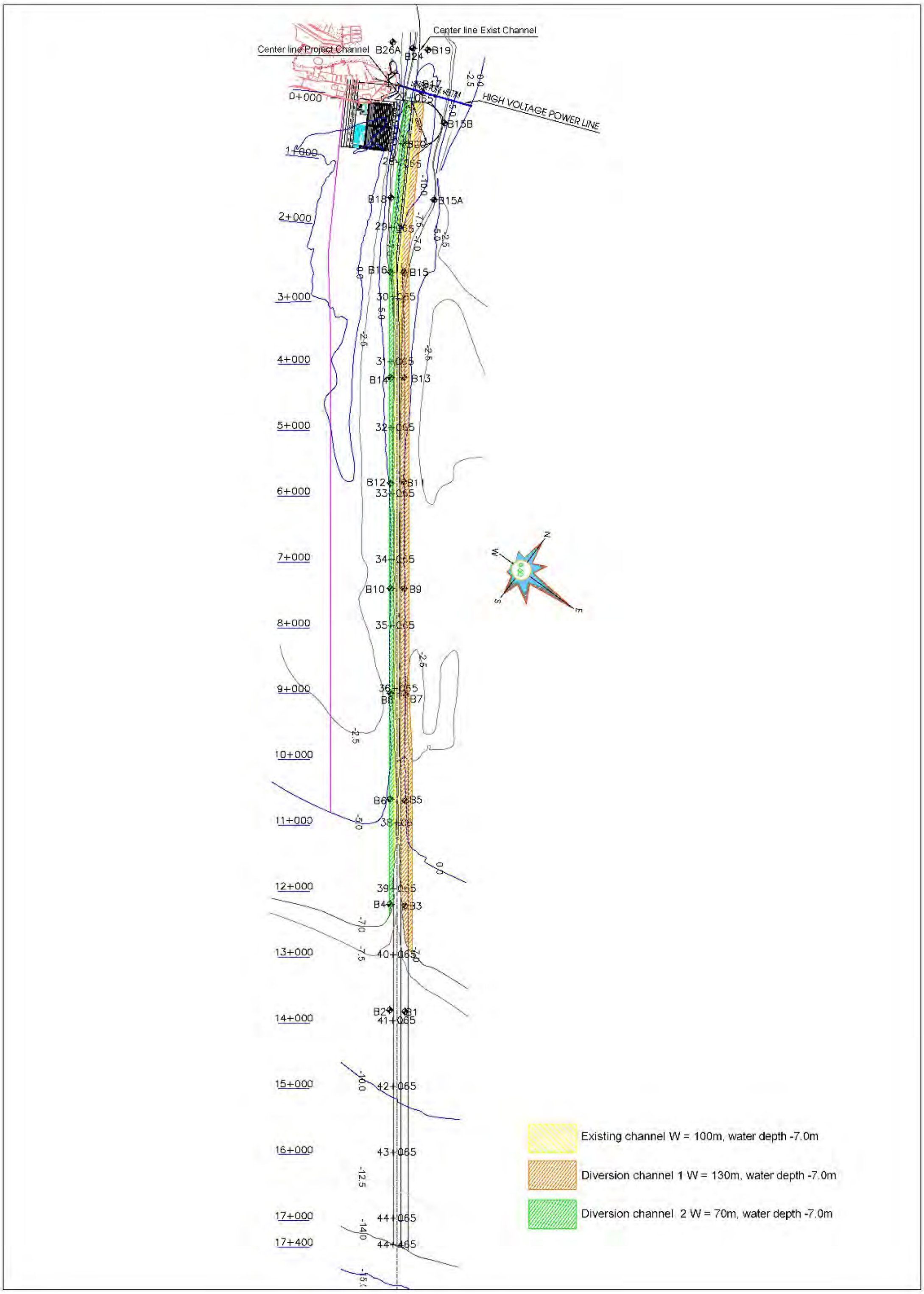


Figure 12.1.7 Cases 1,3,4,5,7,8,12,13,15 and 16 Diversion Channel within the Cross Section Area of the Channel

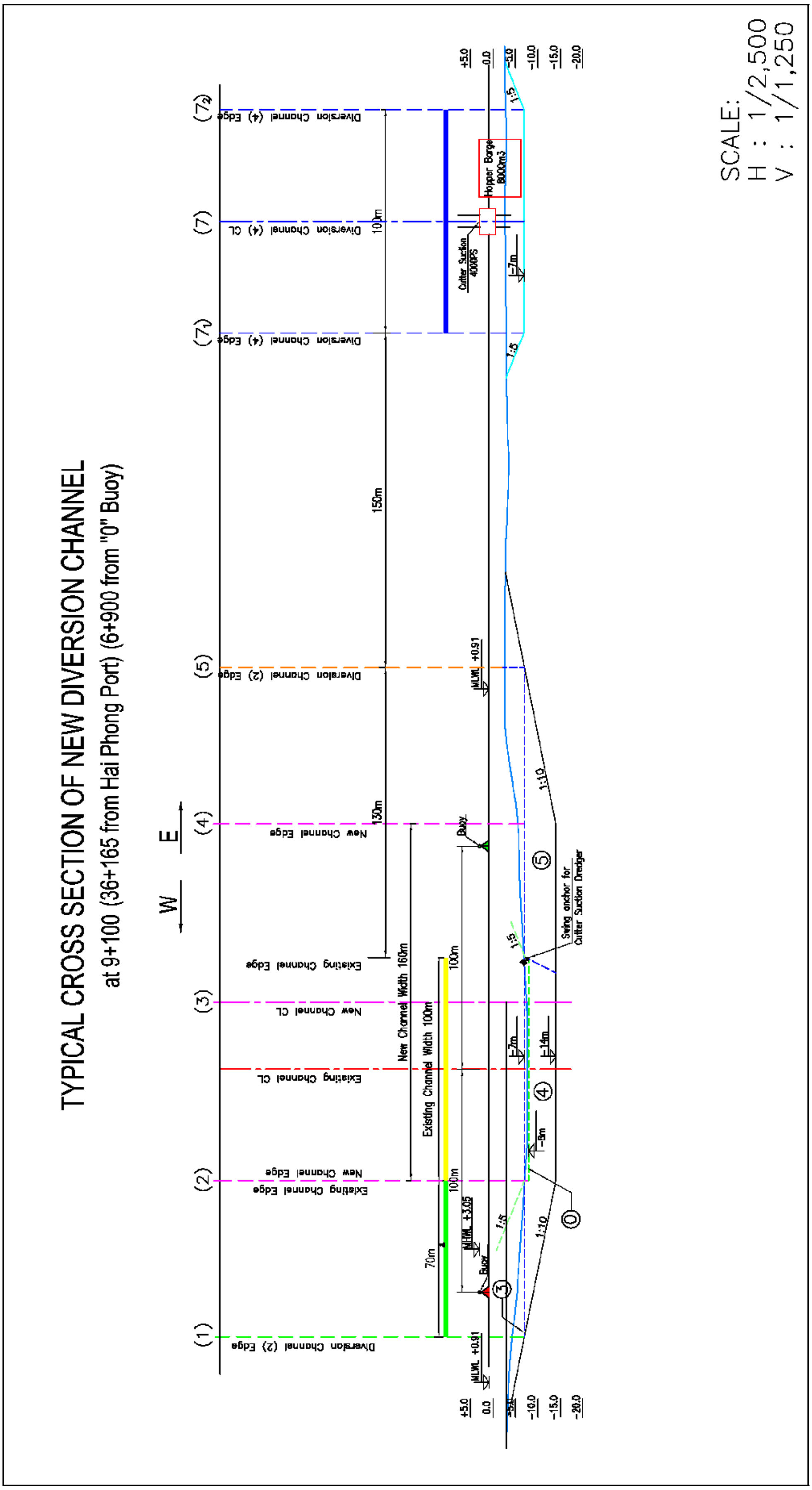


Figure 12.1.8 Cases 2,6,9,10, 11 and 14 Typical Cross Section of East Side Diversion Channel

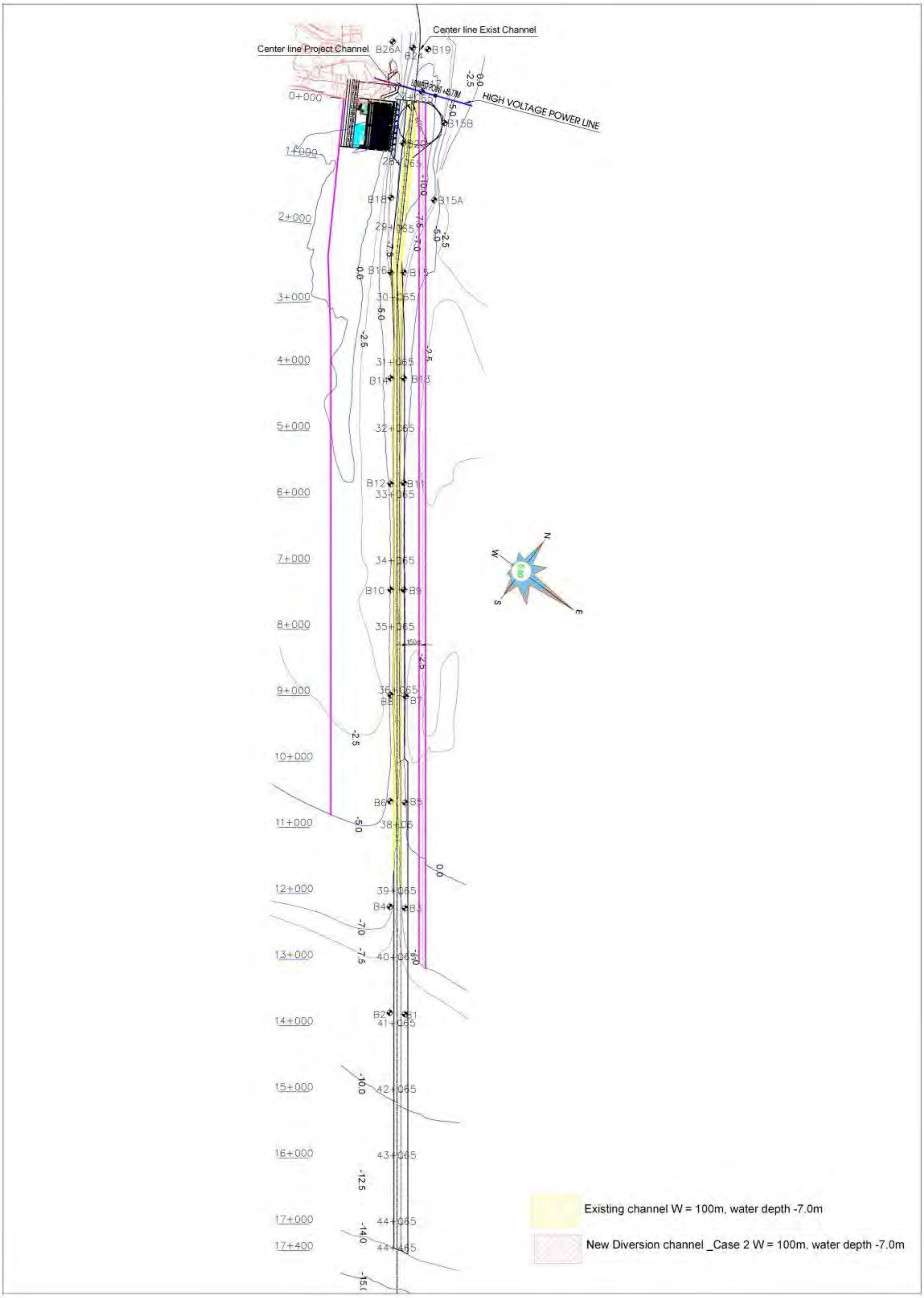


Figure 12.1.9 Cases 2, 6, 9, 10, 11, and 14 General Layout Plan of East Side Diversion Channel

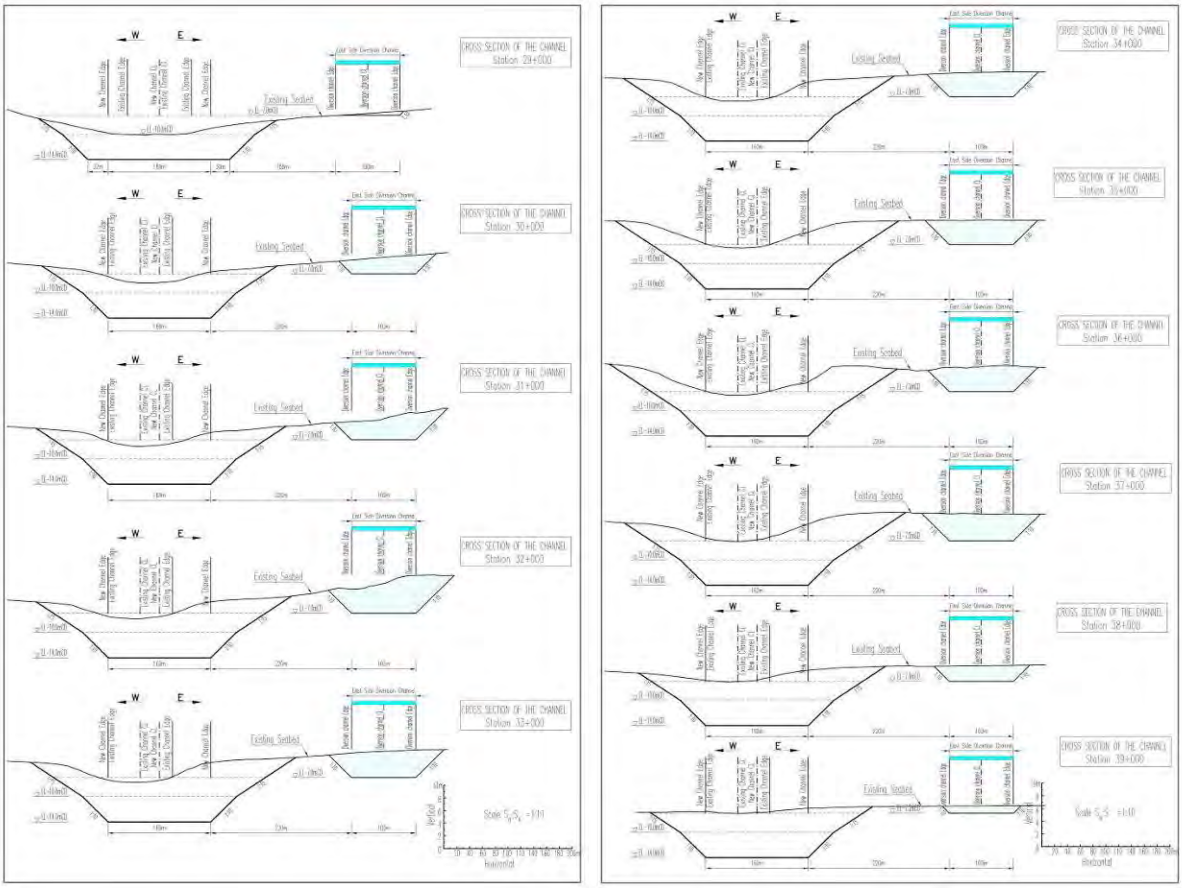


Figure 12.1.10 Cases 2, 6, 9, 10, 11, and 14 Cross Sections of East Side Diversion Channel

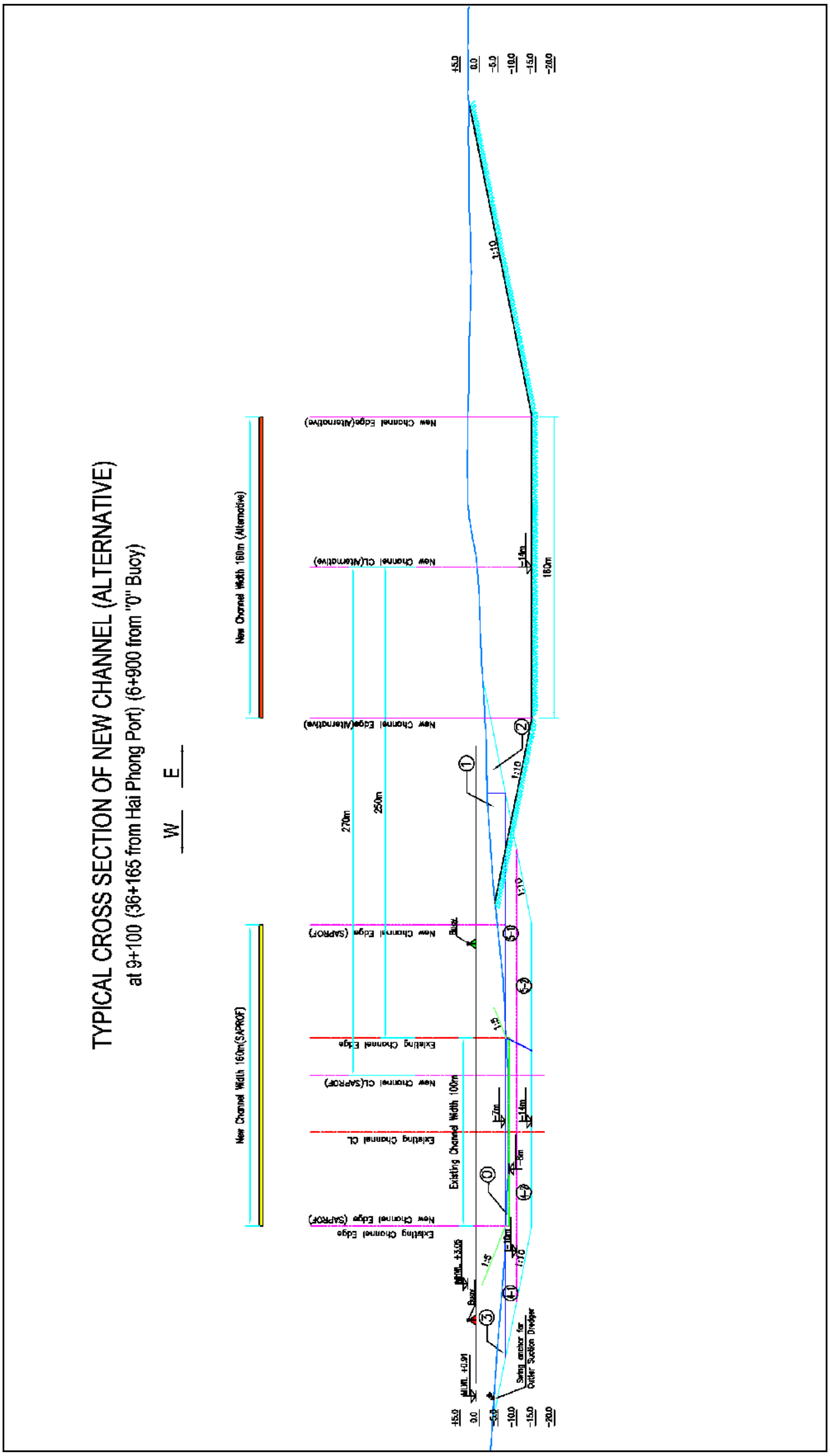


Figure 12.1.11 Alternative Case 17 Typical Cross Section of the Channel shifted 270m East Side

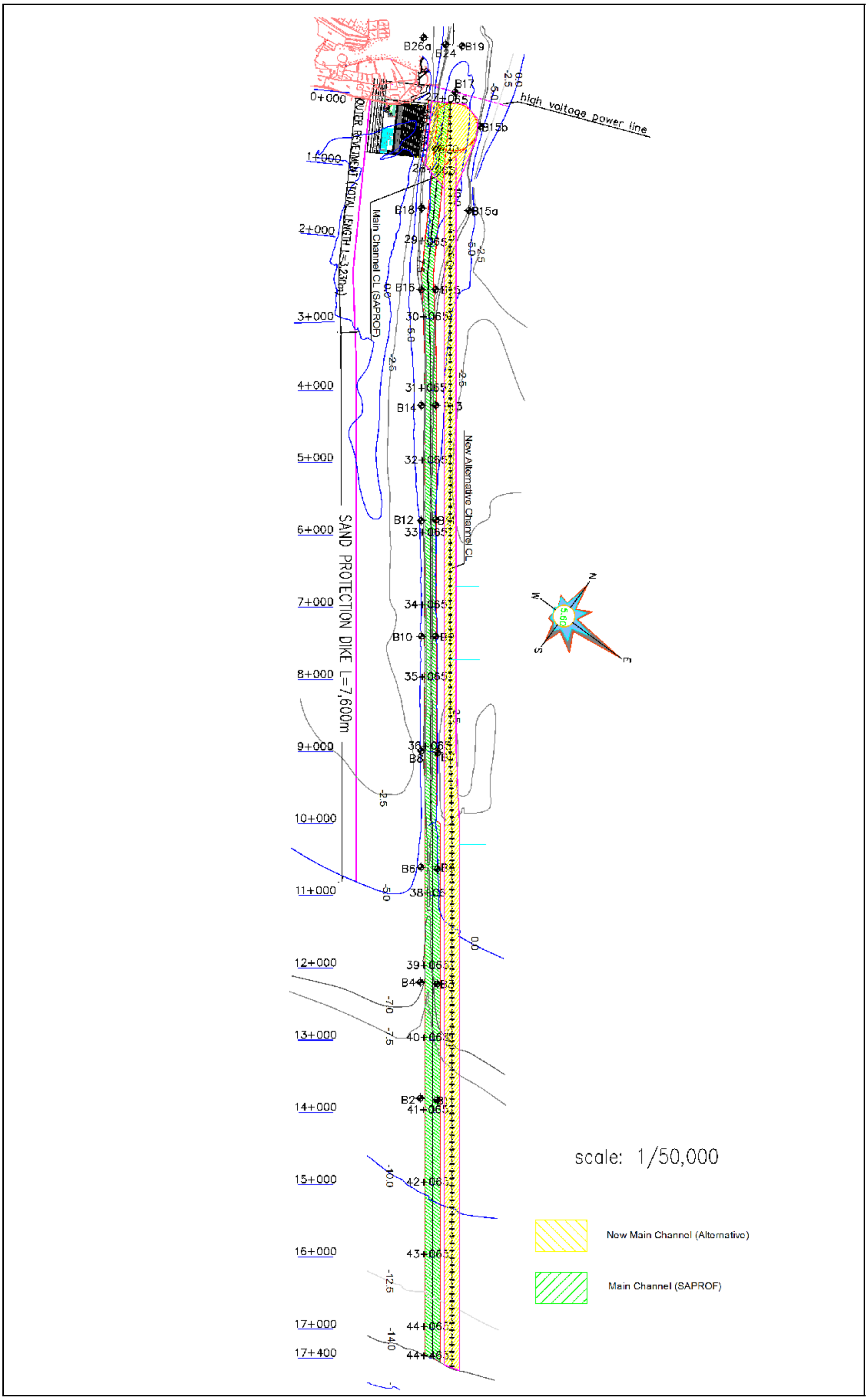


Figure 12.1.12 Alternative Case 17 General layout plan of the Channel shifted 270m east side

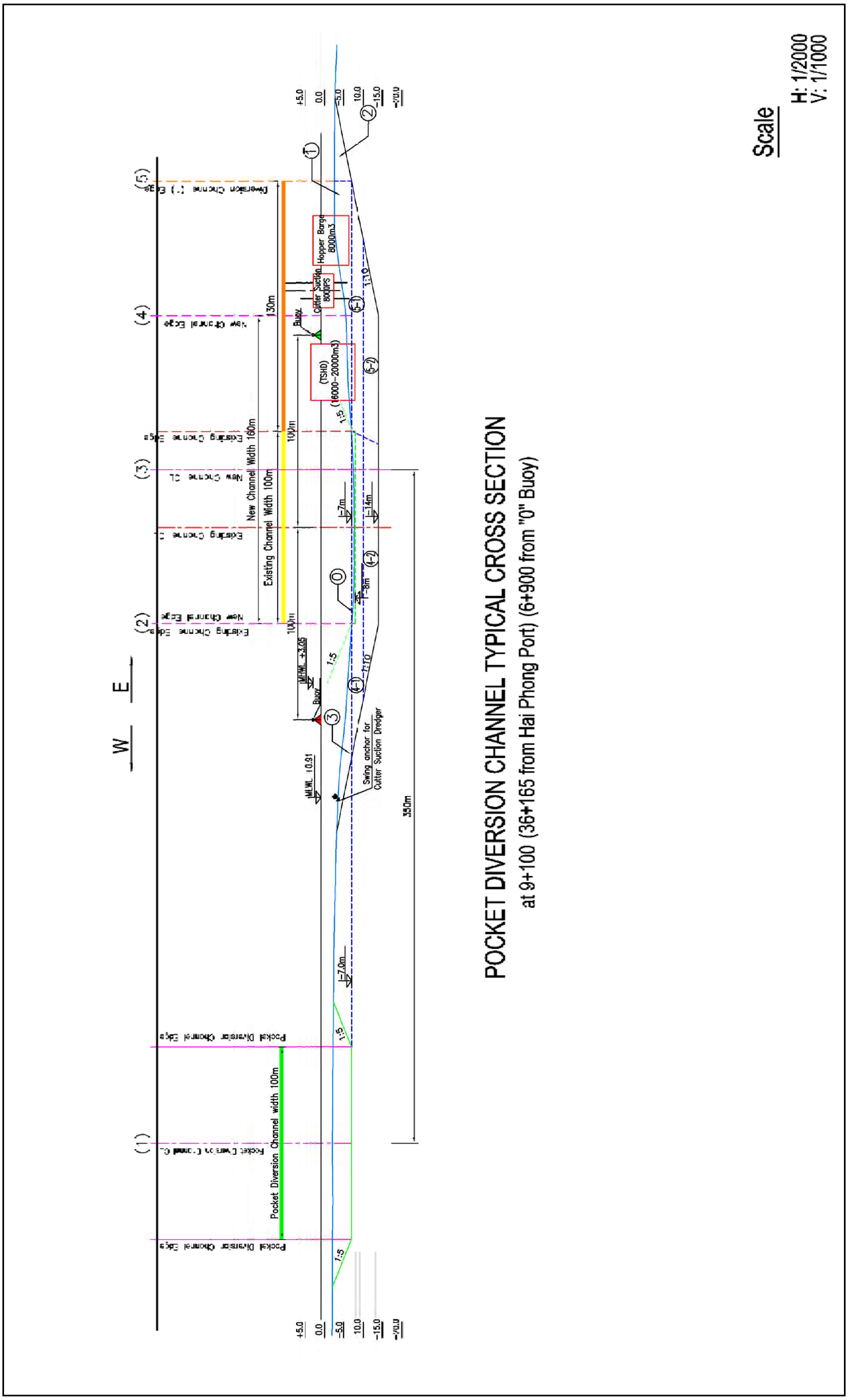


Figure 12.1.13 Alternative Case 18 Typical Cross Section of West Side Pocket Diversion Channel

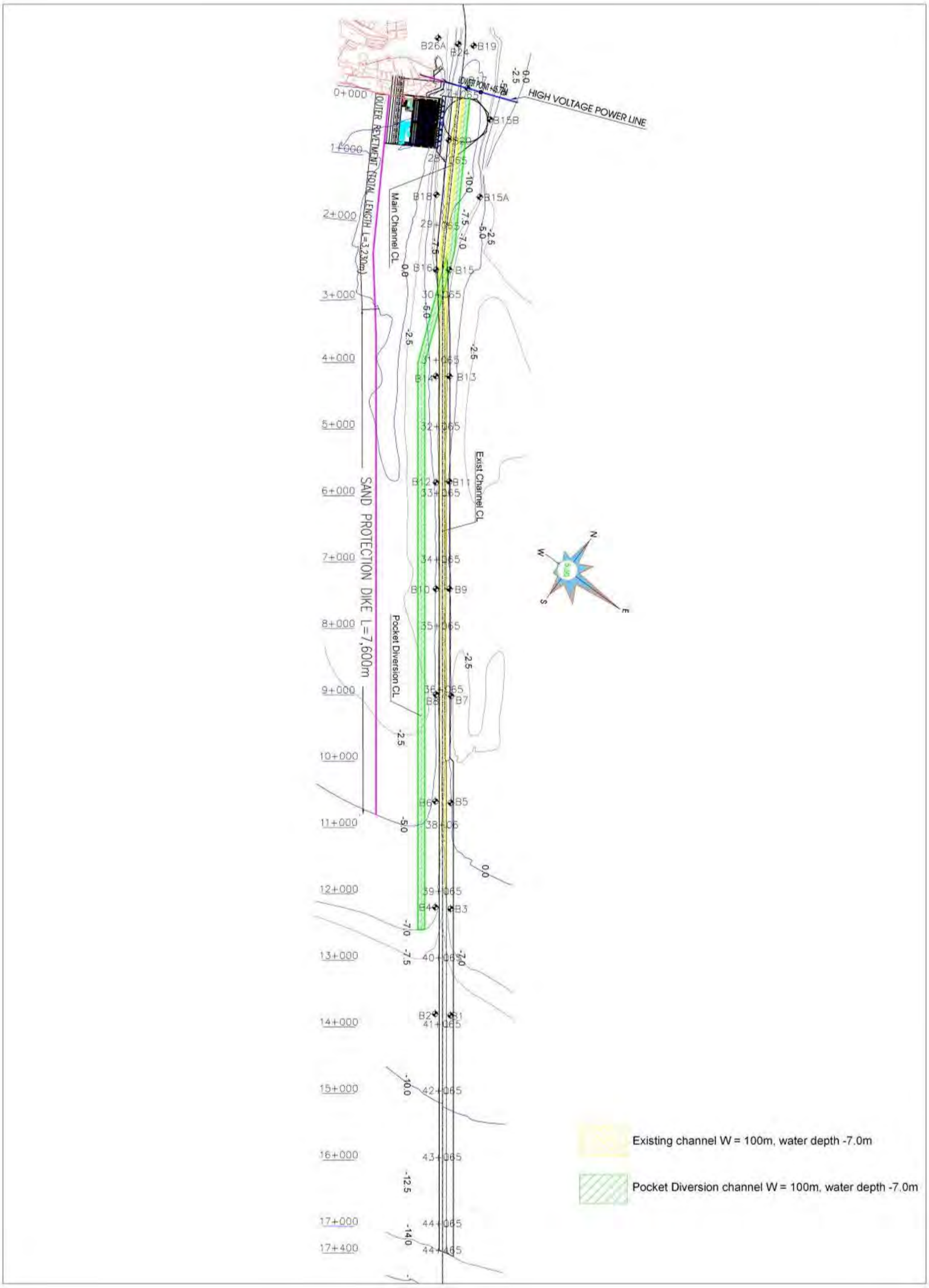


Figure 12.1.14 Alternative Case 18 General Layout Plan of West Side Pocket Diversion Channel

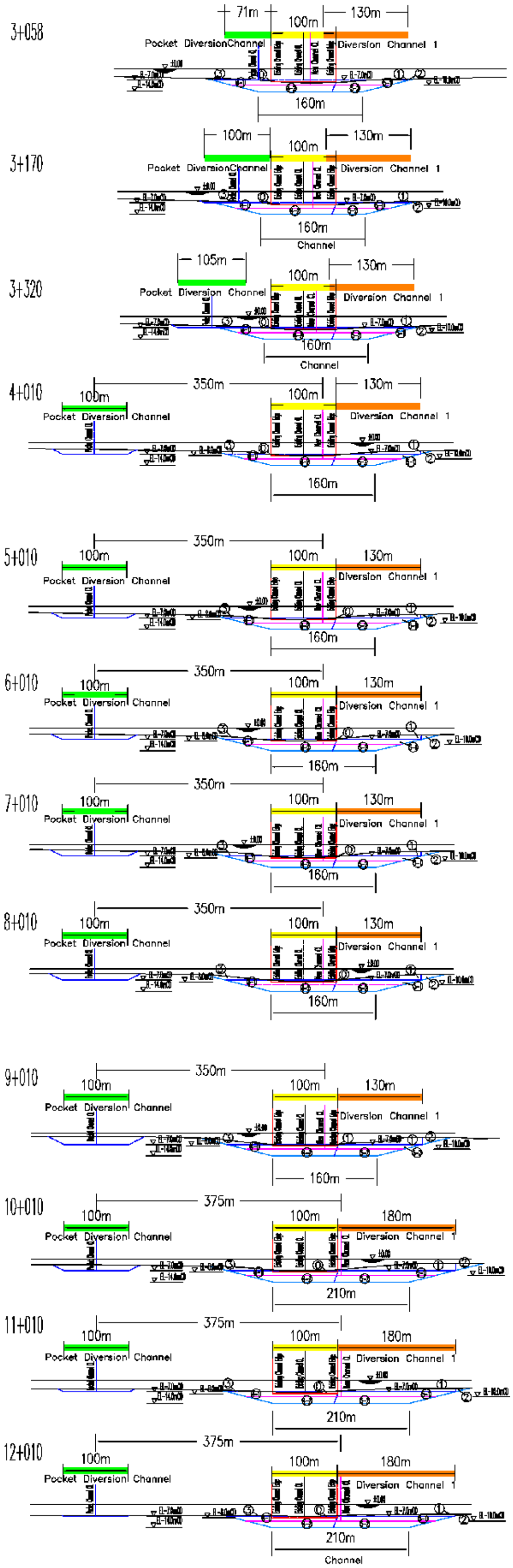


Figure 12.1.15 Alternative Case 18 Cross Sections of West Side Pocket Diversion Channel

12.1.9 Comparison of Dredging Methodology by Productivity of Dredgers and Work Schedule

A suitable combination of dredging equipment for each dredging study Case is determined in Table 12.1.13. The “Cross-sectional area” in the first column on the left side means the designated dredging cross-sectional segment as indicated in Figure 12.1.6. The 2^{nd} to 4^{th} columns show the volume to be dredged as indicated in Section 12.1.3. An individual major dredger is designated for each dredging segment as shown in the 5th column with relevant productivity and the required number of the dredging fleet in the 7th column. Thereafter, the required working duration by number of days for each dredging segment and time bar charts with the critical path of dredging works are shown. The timing and number of channel diversions on the existing ship traffic and prior arrangement of navigational buoy relocations are shown with a triangle mark under each bar chart table.

For the combination of alternative study cases, refer to Table 12.1.12.

Cases 1 to 6 show that all the dredged soil is to be dumped at Dinh Vu or Cat Hai after the dike is completed; hence, construction of the dike becomes a critical requirement and the total construction period becomes long.

A series of Cases indicated with “Inside” shows the dredging methodology with a diversion channel within the Channels cross sectional area. Cases 11, 12-1 and 12-2 indicated as “Combined” show the dumping at combination of Cat Hai and off-shore. The dredged soil will be dumped at an offshore dumping area until the perimeter dike of the dumping site is completed. After the dike is completed, dumping will be done at Cat Hai.

In Table 12.1.13, Cases 9 and 11 are showing the longitudinal order of dredging segregated by Station number. In Case 11, the volumes to be dumped at offshore and Cat Hai sites are shown separately by each segment.

Cases 15 and 16 were prepared to determine the reduction of productivity of the CSD (Cutter suction Dredger) with stand-by time supposed to be caused by commercial ship traffic in the Channel.

The series of cases 19 to 22 were made to confirm the cost and time scale of the combined dumping sites of Dinh Vu and Cat Hai simultaneously.

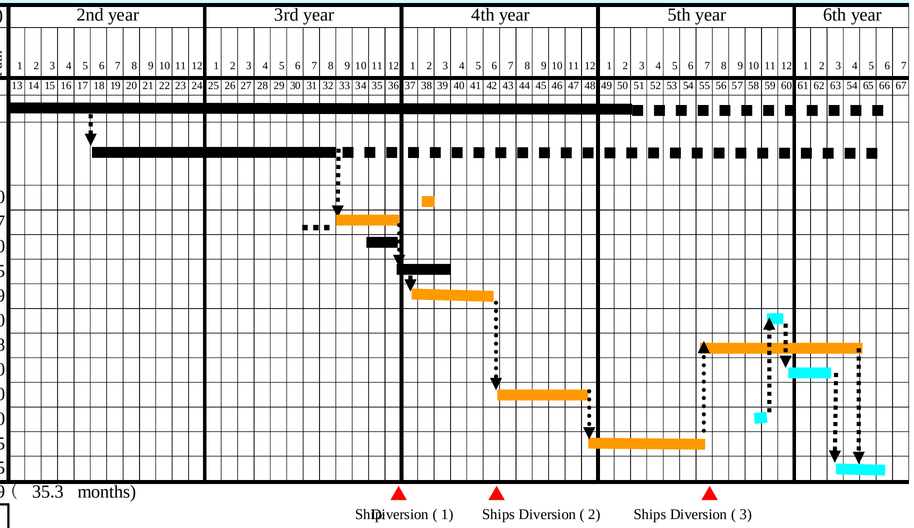
Table 12.1.13 Comparison of dredging methodology by productivity of dredgers and dredging work schedule

Case 1 (Ref. No. A3) Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Dinh Vu (East) (A1-5)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1500	
Trench/ dumping basin	6,424,200	1,595,900	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	432	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	CSD 8,000 ps	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	Grab Dredger 23m3	9,150	3	278	278
13km to of	1,440,341	260,350	1,700,691	CSD 8,000 ps	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to of	455,450	31,846	487,296	CSD 8,000 ps	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	Grab Dredger 23m3	9,150	3	215	215
13km to of	1,677,717	276,948	1,954,665	CSD 8,000 ps	21,230	1	92	45
Total	35,027,585	4,858,500	39,886,085	(uncl. Trench)	he Channel Dredging Works Total			1059 (35.3 months)

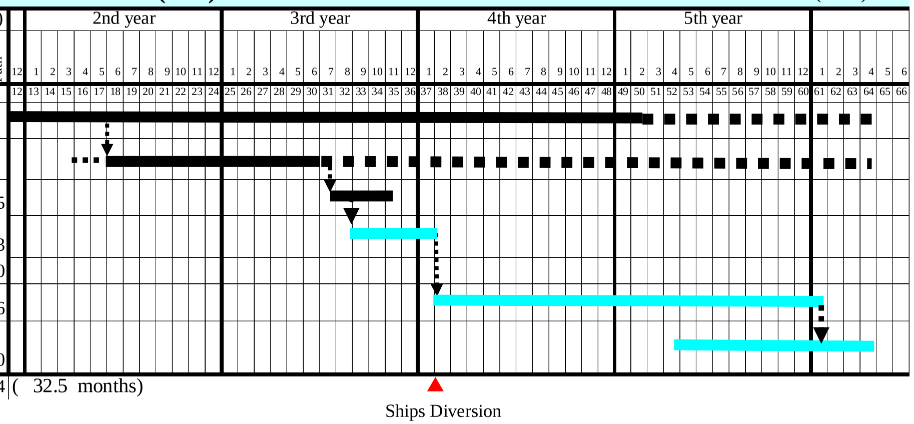
Sub total GD	25,767,383
Sub total TSHD 3,500m	1,573,667
Sub total CSD	12,545,035

Sub total offshore	0
Cat Hai	39,886,085



Case 2: With outer (east) diversion channel by CSD and 5,000 hopper barges dumping all at Dinh Vu (east) (B1-3)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1500	
Trench/ dumping	6,424,200	1,595,900	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and	6,190	3	432	
Diversion Channel	865,089		865,089	TSHD, 1,500m3	1,380	6	104	45
	3,460,355		3,460,355	CSD 8,000 ps	21,230	1	163	163
		129,763	129,763	TSHD, 3,500m3	3,210	1	40	0
0 to 5	19,627,235	2,238,750	21,865,985	CSD 8,000 ps	29,400	1.1	676	676
Finish dredging	8,976,150	1,023,850	10,000,000	CSD 8,000 ps	21,230	1	471	90
Total	32,928,829	4,988,263	44,341,292	(uncl. Trench)	he Channel Dredging Works Total			974 (32.5 months)



(Table 12.1.13 cont'd)

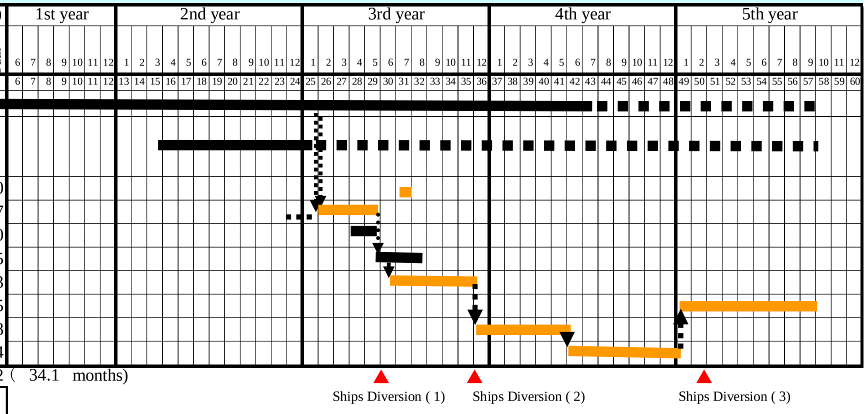
Case 3 Within the Channel by GD dumping all at Cat Hai (East)

(A1-3)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1290	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,680	3	58	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,680	3	85	15
4-1	4,429,982	309,752	4,739,734	Grab Dredger 23m3	9,150	3	173	173
4-2	8,123,977	1,199,343	9,323,320	Grab Dredger 23m3	9,150	4	255	255
5-1	4,813,493	336,568	5,150,061	Grab Dredger 23m3	9,150	3	188	188
5-2	6,741,825	1,102,701	7,844,526	Grab Dredger 23m3	9,150	4	214	214
Total	33,304,585	4,031,700	37,336,285	(uncl. Trench)	The Channel Dredging Works Total		1022	(34.1 months)

Sub total GD	30,292,318
Sub total TSHD 3,500m3	1,573,667
Sub total CSD	5,470,300

Sub total	offshore	0
	Cat Hai	37,336,285



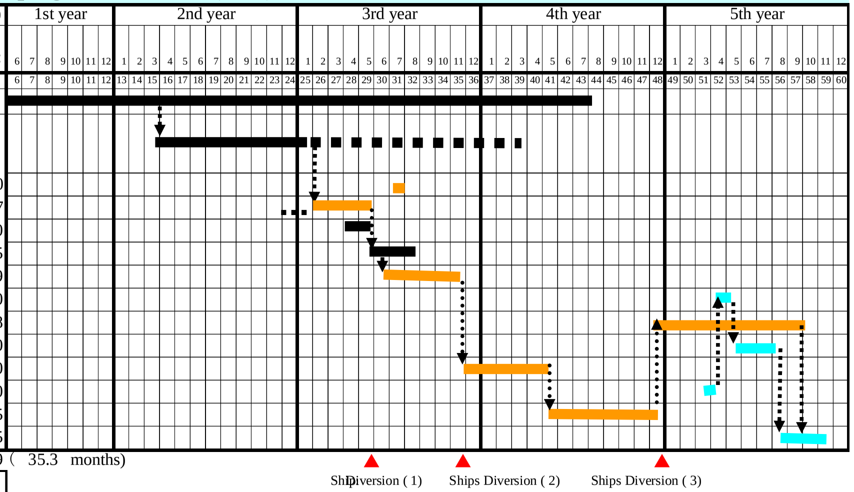
Case 4 (Ref. No.A-4) Within the Channel by GD and CSD (Sta 13 km and offshore) dumping all at Cat Hai (East)

(A1-4)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1260	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,680	3	58	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,680	3	85	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	Grab Dredger 23m3	9,150	3	278	278
13km to of	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to of	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	Grab Dredger 23m3	9,150	3	215	215
13km to of	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	45
Total	33,304,585	4,031,700	37,336,285		The Channel Dredging Works Total		1059	(35.3 months)

Sub total GD	25,767,383
Sub total TSHD 3,500m3	1,573,667
Sub total CSD	9,995,235

Sub total	offshore	0
	Cat Hai	37,336,285

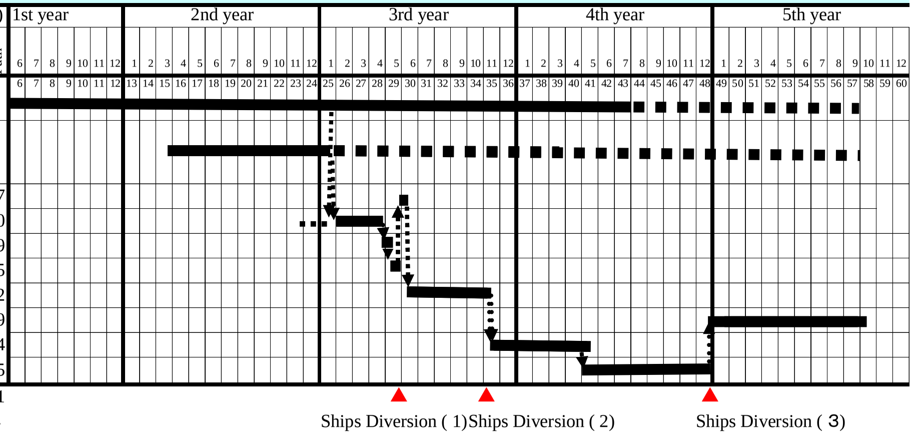


(Table 12.1.13 cont'd)

Case 5: Within the Channel by TSHD (small) dumping all at Cat Hai

(A1-6)

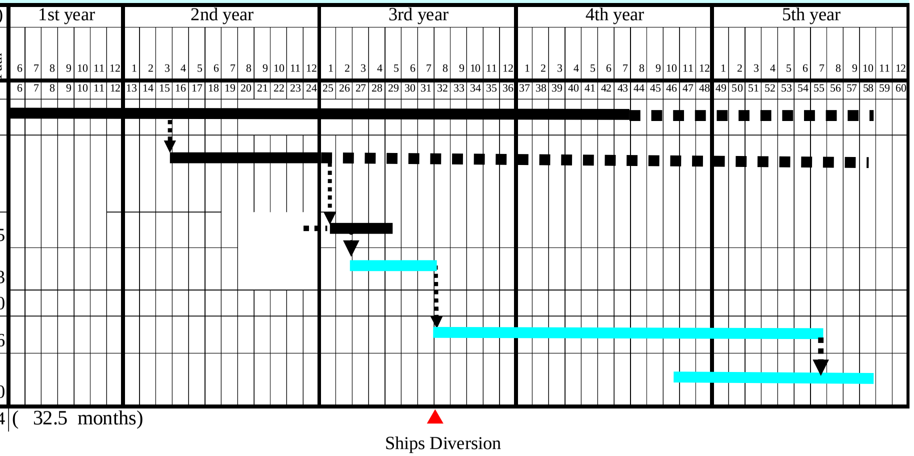
Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1290	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0	524,964	31,525	556,489	TSHD, 3,500m3	3,680	9	17	17
1	2,498,320	150,029	2,648,349	TSHD, 3,500m3	3,680	9	80	140
2	595,418	35,756	631,174	TSHD, 3,500m3	3,680	9	19	19
3	875,406	52,570	927,976	TSHD, 3,500m3	3,680	9	28	15
4-1	4,429,982	266,028	4,696,010	TSHD, 3,500m3	3,680	9	142	142
4-2	8,123,977	1,119,159	9,243,136	TSHD, 3,500m3	3,680	9	279	279
5-1	4,813,493	289,059	5,102,552	TSHD, 3,500m3	3,680	9	154	154
5-2	6,741,825	1,036,159	7,777,984	TSHD, 3,500m3	3,680	9	235	235
Total	33,304,585	3,749,385	37,053,970	(incl. Trench)	'he Channel Dredging Works Total			1001
							months	33.4



Case 6: With outer (east) diversion channel by CSD and 5,000 hopper barges dumping all at Cat Hai (east)

(B1-3)

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1260	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
Diversion Channel	865,089		865,089	TSHD, 1,500m3	1,380	6	104	45
	3,460,355		3,460,355	CSD 8,000 ps	21,230	1	163	163
		129,763	129,763	TSHD, 3,500m3	3,210	1	40	0
0 to 5	19,627,235	2,238,750	21,865,985	CSD 8,000 ps	29,400	1.1	676	676
Finish dredging	8,976,150	1,023,850	10,000,000	CSD 8,000 ps	21,230	1	471	90
Total	32,928,829	4,161,463	41,791,492	(incl. Trench)	'he Channel Dredging Works Total			974



(Table 12.1.13 cont'd)

Case 7 Within the Channel by GD TSHD and CSD (Sta 13 km and offshore), dumping off shore

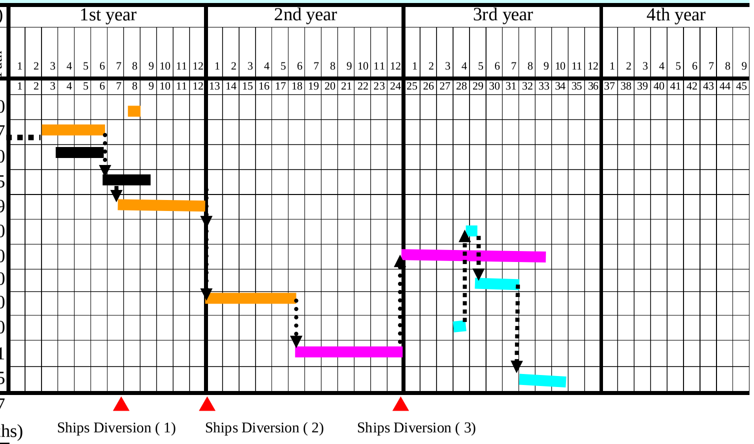
(A1-2)

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to of	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to of	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to of	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	45
Total	28,603,385	3,262,600	31,865,985	The Channel Dredging Works Total				1027

(34.2 months)

Sub total GD	12,254,894
Sub total TSHD 3,500m	1,573,667
Sub total TSHD 16,000m	13,512,489
Sub total CSD	4,524,935

Sub total offshore	31,865,985
Cat Hai	0



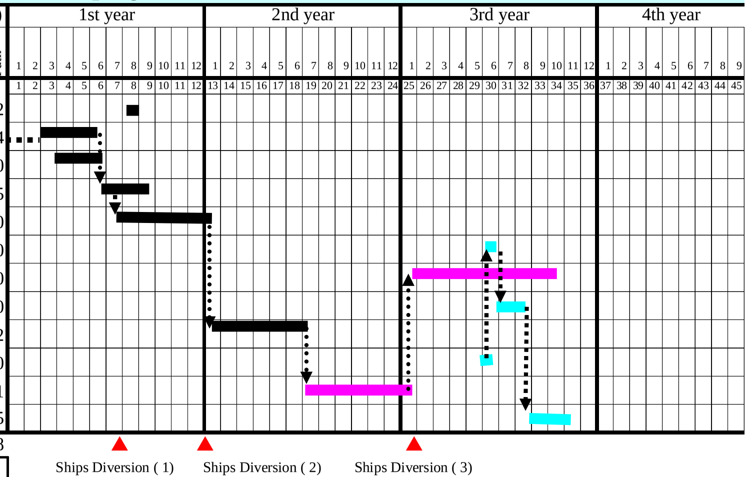
Case 8 :Within the Channel by Large and small TSHD, and CSD (Sta 13 km and offshore), dumping offshore

(A2-2)

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
0	524,964	36,706	561,670	TSHD, 3,500m1	3,210	8	22	22
1	2,498,320	174,687	2,673,007	TSHD, 3,500m2	3,210	8	104	164
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	8	25	0
3	875,406	61,210	936,616	TSHD, 3,500m4	3,210	8	36	15
4-1	4,072,682	284,769	4,357,451	TSHD, 3,500m5	3,210	8	170	170
13km to of	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to of	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	TSHD, 3,500m3	3,210	8	182	182
13km to of	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to of	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	15
Total	28,603,385	3,262,600	31,865,985	The Channel Dredging Works Total				1028

Sub total TSHD 3,500m	13,828,561
Sub total TSHD 16,000m	13,512,489
Sub total CSD	4,524,935

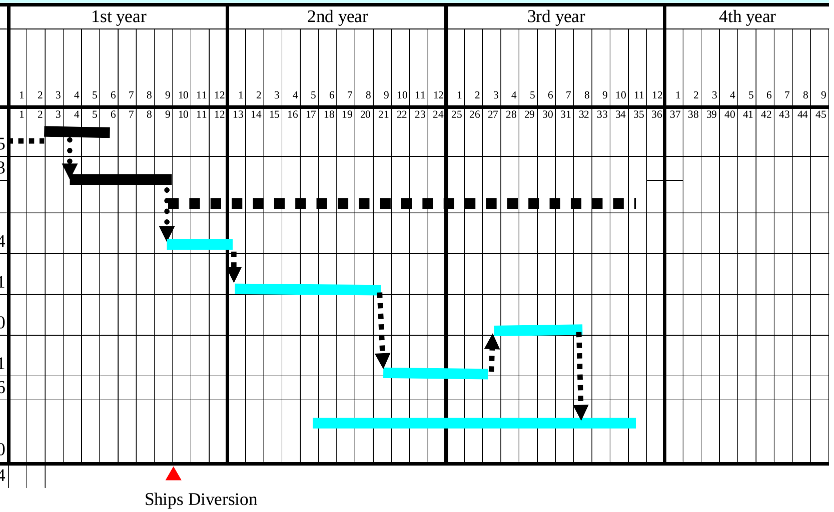
Sub total offshore	31,865,985
Cat Hai	0



(Table 12.1.13 cont'd)

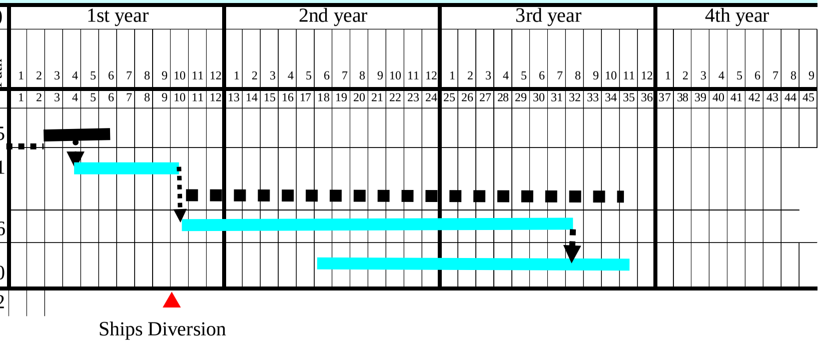
Case 9: With outer (east) diversion channel by CSD and 5,000 hoppwer barges dumping offshore, (B1-2)

Cross sectional Area	Long. Section Sta No	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Sub Total	Thin layer for finish Dredge	Gross Total	Type of Dredger	Productivity m3/day /fleet	No of fleet	Duration: for each work	Critical Path
Diversion Channel		865,089		865,089		865,089	TSHD1,500	1,380	6	104	105
		3,460,355		3,460,355		3,460,355	,	21,230	1	163	163
			129,765	129,765		129,765	TSHD3,500	3,210	1	40	
Main Channel Cross section segment 0 to 5	Sta 0+000 to Sta 3+000	4,289,624	489,289	4,778,913	1,724,138	3,054,775	Cutter Suction, 8,000ps,	29,400	1	104	104
	Sta 3+000 to Sta 9+000	11,243,104	1,282,427	12,525,531	3,448,276	9,077,255		29,400	1.28	241	241
	Sta 9+000 to Sta 11+000	4,980,500	568,093	5,548,593	1,149,425	4,399,168		29,400	1	150	150
	Sta 11+000 to Sta 17+400	8,090,158	922,791	9,012,949	3,678,161	5,334,788		29,400	1	181	181
	Sub total	28,603,386	3,262,600	31,865,986	10,000,000	21,865,986				676	676
	Thin Layer				10,000,000	10,000,000	Cutter Suction 8,000ps	21,230	1	471	90
Grand Total		32,928,830	3,392,365	36,321,195	10,000,000	36,321,195	The Channel Dredging Works			Total	1,034



Case 10: With outer (east) diversion channel by CSD and 1,300 m3 hopper barges dumping offshore (B2-2)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Diversion Channel	865,089		865,089	TSHD, 1,500m3	1,380	6	104	105
	3,460,355		3,460,355	Cutter Suction, 8,000ps,	19,110	1	181	181
		129,765	129,765	TSHD, 3,500m3	3,210	1	40	
0 to 5	19,627,235	2,238,750	21,865,985	Cutter Suction, 8,000ps,	26,450	1.3	636	636
Finish dredging	8,976,150	1,023,850	10,000,000	Cutter Suction, 8,000ps,	19,110	1	523	90
Total	32,928,829	3,392,365	36,321,194	The Channel Dredging Works Total				1012



Sub total TSHD1,500	865,089
Sub total TSHD 3,50(	129,765
Sub totalTSHD 16,00	0
Sub total CSD	35,326,340

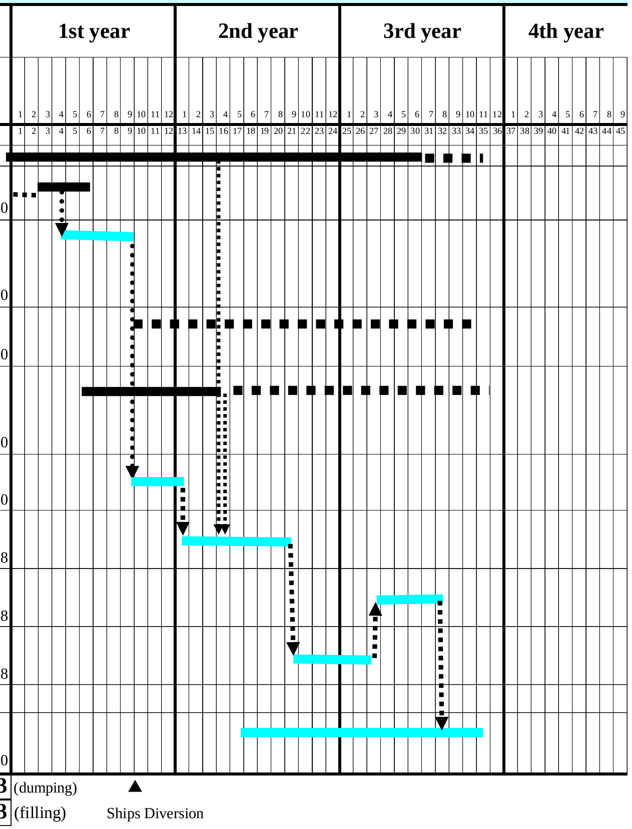
Sub total offshore	36,321,194
Cat Hai	0

(Table 12.1.13 cont'd)

Case 11: With outer (east) diversion channel by CSD dumping at Cat Hai (east) and off shore

(B1－1)

Cross sectional Area	Long. Section Sta No	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Sub Total	Dredging Volume (m3): Thin layer for finish Dredge	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day /fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path	Dumping site: Off shore	Dumping site: Cat Hai
Preparatory works for Cat Hai dumping area including revetment spilway silt fence and etc.													
Diversion Channel		865,089		865,089		865,089	TSHD 1,500m3	1,380	6	104	105	865,089	0
		3,460,355		3,460,355		3,460,355	CSD8,000ps	21,230	1	163	163	3,460,355	0
			129,765	129,765		129,765	TSHD 3,500m3	3,210	1	40		129,765	0
Trench/ dumping basin		4,701,200	769,100	5,470,300	NA	5,470,300	CSD8,000ps /1300 m3 Barges	19,110	1	286	0	5,470,300	0
Main Channel	Sta 0+000 to Sta 3+000	4,289,624	489,289	4,778,913	1,724,138	3,054,775	CSD, 8,000ps,	29,400	1	104	104	3,054,775	0
	Sta 3+000 to Sta 9+000	11,243,104	1,282,427	12,525,531	3,448,276	9,077,255		29,400	1.28	241	241	4,538,628	4,538,628
	Sta 9+000 to Sta 11+000	4,980,500	568,093	5,548,593	1,149,425	4,399,168		29,400	1	150	150	0	4,399,168
	Sta 11+000 to Sta 17+400	8,090,158	922,791	9,012,949	3,678,161	5,334,788		29,400	1	181	181	0	5,334,788
	Sub total	28,603,386	3,262,600	31,865,986	10,000,000	21,865,986				676	676		
	Thin Layer				10,000,000	10,000,000	CSD 8,000ps	21,230	1	471	90	4,000,000	6,000,000
Grand Total		37,630,030	4,161,465	41,791,495	10,000,000	41,791,495			Total		1,034	**21,518,912**	**20,272,583** (dumping)
				(Incl. Trench)			The Channel Dradging WorksTotal			(	**34.5**	**months)**	**18,512,583** (filling)



Volume (m3)		
	TSHD 1,500m3	865,089
	TSHD 3,500 m3	129,765
	CSD 8,000 m3	40,796,641
	Total	41,791,495

(Table 12.1.13 cont'd)

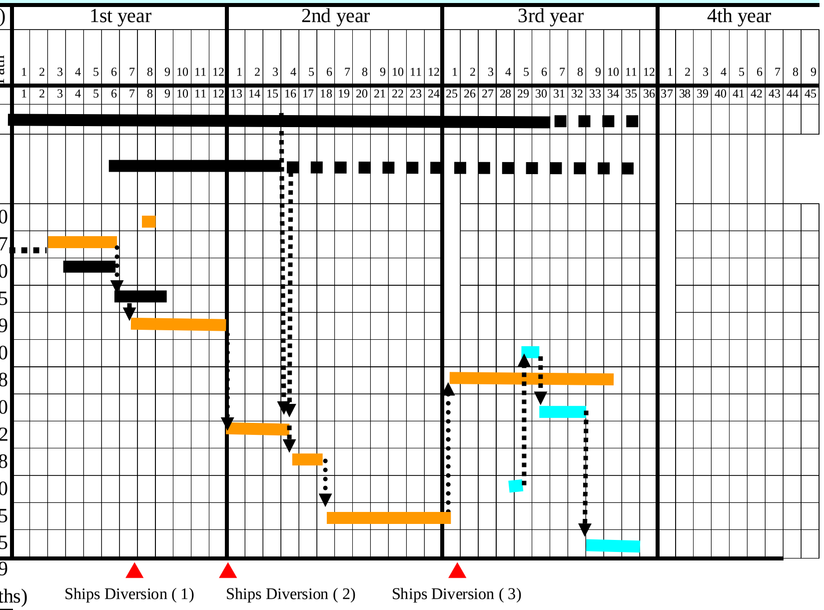
Case 12-1 Within the Channel by GD and CSD (Sta 13 km and offshore) dumping at Cat Hai (East) and off shore (A1-1)

Cross sectional Area	Dredging Volume (m3) Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day) for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.								
Trench/ dumping basin	4,701,200	769,100	5,470,300	CSD8,000ps /1300 m3 Barges	19,110	1	286	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	CSD 8,000 ps	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	Grab Dredger 23m3	9,150	3	278	278
13km to of	1,440,341	260,350	1,700,691	CSD 8,000 ps	21,230	1	80	0
5-1	4,358,043	304,722	2,797,659	Grab Dredger 23m3	9,150	3	102	102
			1,865,106	Grab Dredger 23m3	9,150	3	68	68
13km to of	455,450	31,846	487,296	CSD 8,000 ps	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	Grab Dredger 23m3	9,150	3	215	215
13km to of	1,677,717	276,948	1,954,665	CSD 8,000 ps	21,230	1	92	45
Total	33,304,585	4,031,700	37,336,285	(incl. trench)	'he Channel Dredging Works Total			1059
							(35.3	months)

Sub total	GD 23 m3	25,767,383
Sub total	TSHD 3,500m	1,573,667
Sub total	CSD	9,995,235 (incl. trench)

Sub total	offshore	17,433,754
	Cat Hai	19,902,531

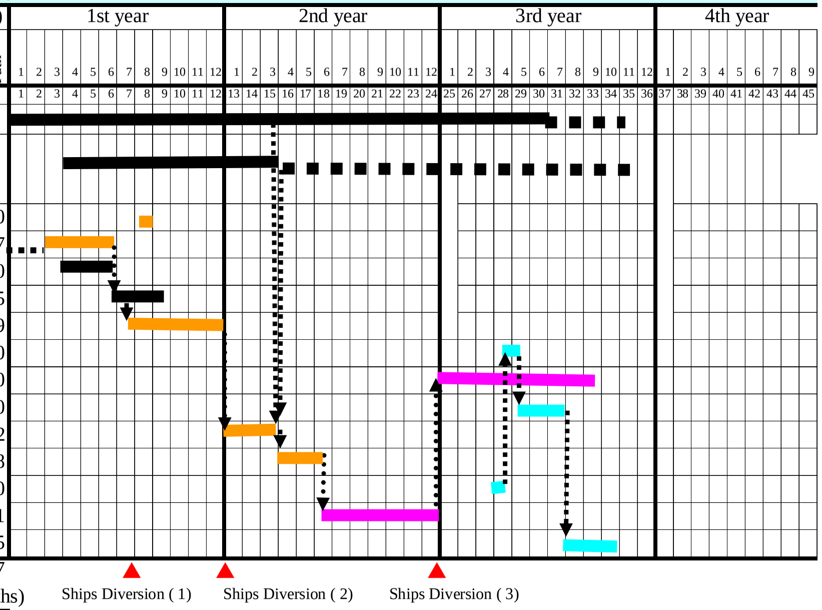
(dumping) 18,142,531) m



(Table 12.1.13 cont'd)

Case 12-2 Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping at Cat Hai (East) and off shore (A1-1)

Cross sectional Area	Dredging Volume (m3) Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day) for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.								
Trench/ dumping basin	4,701,200	769,100	5,470,300	CSD8,000ps /1300 m3 Barges	19,110	1	286	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	CSD 8,000 ps	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to of	1,440,341	260,350	1,700,691	CSD 8,000 ps	21,230	1	80	0
5-1	4,358,043	304,722	2,797,659	Grab Dredger 23m3	9,150	3	102	102
			1,865,106	Grab Dredger 23m3	9,150	3	68	68
13km to of	455,450	31,846	487,296	CSD 8,000 ps	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to of	1,677,717	276,948	1,954,665	CSD 8,000 ps	21,230	1	92	45
Total	33,304,585	4,031,700	37,336,285	(incl. trench)	'he Channel Dredging Works Total			1027
					(		34.2	months)



Sub total GD 23 m3	12,254,894
Sub total TSHD 3,500m	1,573,667
Sub totalTSHD 16,000m	13,512,489
Sub total CSD	9,995,235

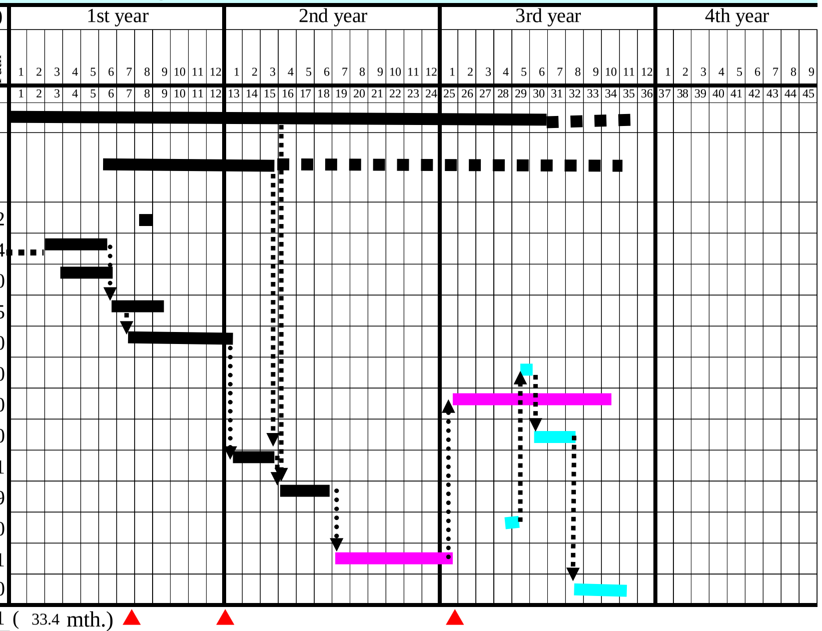
Sub total	offshore	30,946,244
	Cat Hai	6,390,041

(dumping) 4,630,041 m3

(Table 12.1.13 cont'd)

Case 13 :Within the Channel by Large and small TSHD, and CSD (Sta 13 km and offshore), dumping at Cat Hai (East) and off shore (A2-1)

Cross sectional Area	Dredging Volume (m3) Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day) for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.								
Trench/ dumping basin	4,701,200	769,100	5,470,300	CSD8,000ps /1300 m3 Barges	19,110	1	286	
0	524,964	36,706	561,670	TSHD, 3,500m1	3,210	8	22	22
1	2,498,320	174,687	2,673,007	TSHD, 3,500m2	3,210	8	104	164
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	8	25	0
3	875,406	61,210	936,616	TSHD, 3,500m4	3,210	8	36	15
4-1	4,072,682	284,769	4,357,451	TSHD, 3,500m5	3,210	8	170	170
13km to of	357,300	24,983	382,283	CSD 8,000 ps	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to of	1,440,341	260,350	1,700,691	CSD 8,000 ps	21,230	1	80	0
5-1	4,358,043	304,722	2,331,383	TSHD, 3,500m3	3,210	8	91	91
			2,331,383	TSHD, 3,500m3	3,210	8	19	19
13km to of	455,450	31,846	487,296	CSD 8,000 ps	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to of	1,677,717	276,948	1,954,665	CSD 8,000 ps	21,230	1	92	60
Total	33,304,585	4,031,700	37,336,285	(incl. trench)	'he Channel Dredging Works Total		1001	(33.4 mth.)



Sub total TSHD 3,500m	13,828,561
Sub totalTSHD 16,000m	13,512,489
Sub total CSD	9,995,235

Sub total	offshore	30,479,967
	Cat Hai	6,856,318

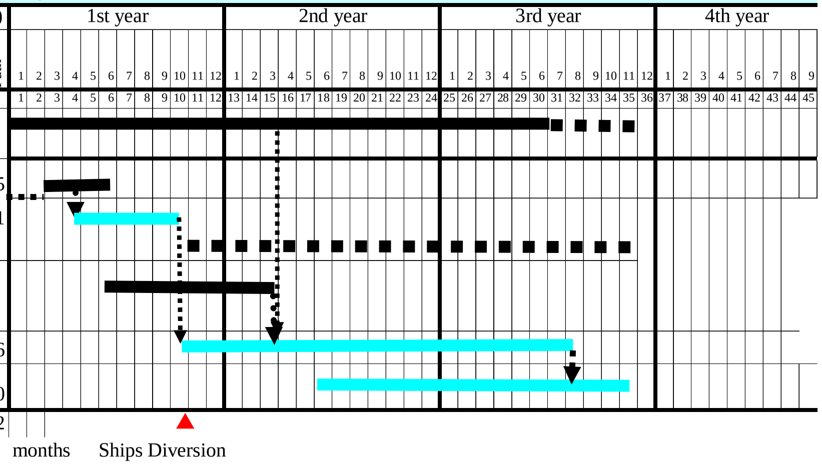
Ships Diversion (1) Ships Diversion (2) Ships Diversion (3)

(dumping) 5,096,318 8,235,235 m3(filling)

(Table 12.1.13 cont'd)

Case 14: With outer (east) diversion channel by CSD and 1,300 m3 hopper barges dumping at Cat Hai and off shore (B2-1)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.								
Diversion Channel	865,089		865,089	TSHD, 1,500m3	1,380	6	104	105
	3,460,355		3,460,355	CSD 8,000 ps	19,110	1	181	181
		129,765	129,765	TSHD, 3,500m3	3,210	1	40	
Trench/ dumping basin	4,701,200	769,100	5,470,300	CSD8,000ps /1300 m3 Barges	19,110	1	286	
0 to 5	19,627,235	2,238,750	21,865,985	CSD 8,000 ps	26,450	1.3	636	636
Finish dredging	8,976,150	1,023,850	10,000,000	CSD 8,000 ps	19,110	1	523	90
Total	37,630,029	4,161,465	41,791,494	(incl. trench)	The Channel Dredging Works Total			1012



33.7 months

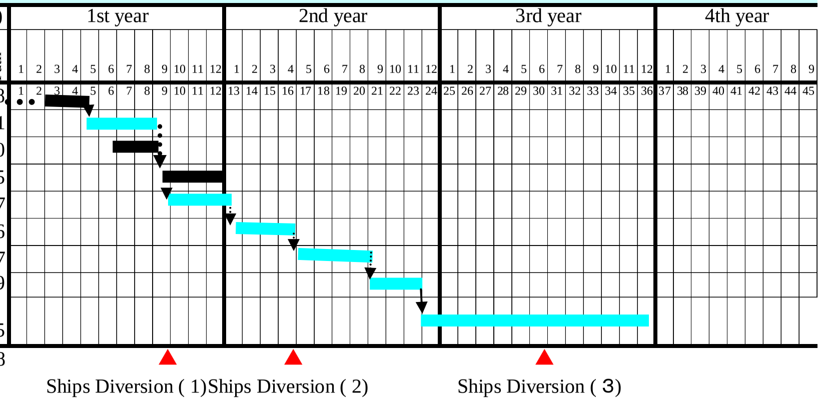
Sub total TSHD1,500	865,089
Sub total TSHD 3,500m	129,765
Sub total CSD	40,796,640
totl	41,791,494

Sub total	offshore	15,327,123
	Cat Hai	26,464,371

(dumping) 24,704,371 m3(filling)

Case 15 : Within the Channel by CSD (Stand-by 6hrs/day), dumping offshore (A3-1)

Cross sectional Area	Dredging Volume (m3): Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Critical Path
0	524,964	36,706	561,670	TSHD, 3,500m3	2,400	3	78	138
1	2,498,320	174,687	2,673,007	Pump Dredger, 8,000ps,	22,050	1	121	121
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,429,982	309,752	4,739,734	Pump Dredger, 8,000ps,	22,050	2	107	107
4-2	8,123,977	1,199,343	4,661,660	Pump Dredger, 8,000ps,	22,050	2	106	106
5-1	4,813,493	336,568	5,150,061	Pump Dredger, 8,000ps,	22,050	2	117	117
5-2	6,741,825	1,102,701	3,922,263	Pump Dredger, 8,000ps,	22,050	2	89	89
Finish dredging			8,583,923	Pump Dredger, 8,000ps,	15,920	1.4	385	385
Total	28,603,385	3,262,600	31,865,985	The Channel Dredging Works Total				1078



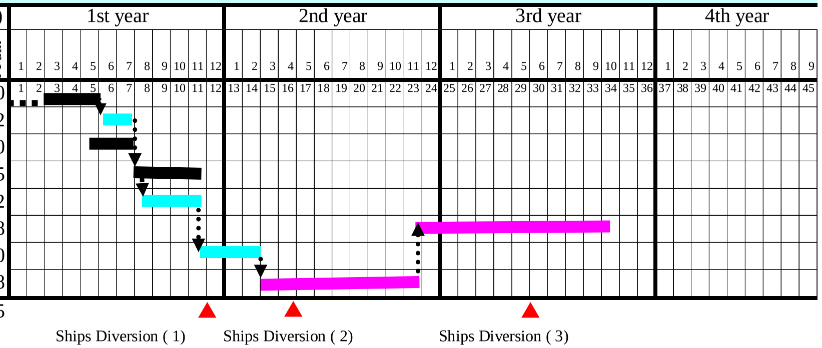
Sub total CSD	29,730,648
TSHD	2,135,337

(Table 12.1.13 cont'd)

Case 16 : Within the Channel by CSD (Stand-by 10hrs/day) and TSHD, dumping offshore (A3-2)

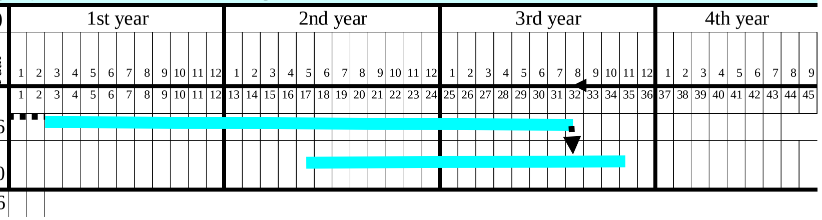
Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
0	524964	36,706	561,670	TSHD, 3,500m3	1,870	3	100	160
1	2,498,320	174,687	2,673,007	Pump Dredger, 8,000ps,	17,150	3	52	52
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,429,982	309,752	4,739,734	Pump Dredger, 8,000ps,	17,150	3	92	92
4-2	8,123,977	1,199,343	9,323,320	TSHD>16,000m3 (thin layer	14,660	2	318	318
5-1	4,813,493	336,568	5,150,061	Pump Dredger, 8,000ps,	17,150	3	100	100
5-2	6,741,825	1,102,701	7,844,526	TSHD>16,000m3 (thin layer	14,660	2	268	268
Total	28,603,385	3,262,600	31,865,985	The Channel Dredging Works Total				1005

Sub total CSD	12,562,802
TSHD3,500	2,135,337
TSHD16,000	17,167,846



Case 17: Lach Huyen Channel is shifted to east outside of the existing channel, dredging by CSD and dumping at off shore. (B-3)

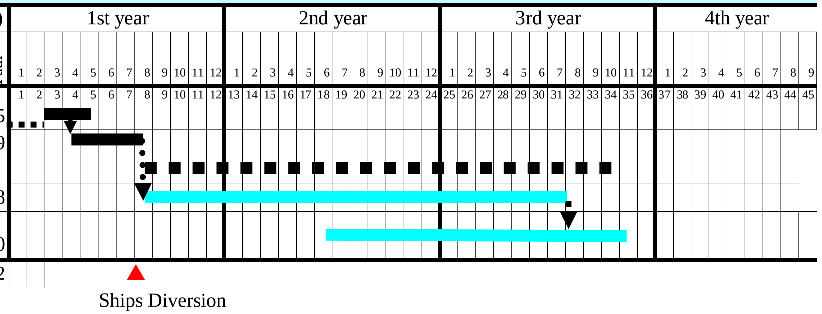
Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
0 to 5	28,797,757	2,472,046	31,269,803	Cutter Suction, 8,000ps,	29,400	1.2	886	946
Finish dredging	9,209,446	790,554	10,000,000	Cutter Suction, 8,000ps,	21,230	1	471	90
Total	38,007,203	3,262,600	41,269,803	The Channel Dredging Works Total				1,036



Case 18 With outer (west) diversion channel by CSD and 1,300 m3 hopper barges dumping offshore (B-4)

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Diversion Channel	629,286		629,286	TSHD, 1,500m3	1,380	6	76	105
	2,517,144		2,517,144	Cutter Suction, 8,000ps,	21,230	1	119	119
		629,286	629,286	TSHD, 3,500m3	3,210	1	196	
0 to 5	19,627,235	2,238,750	21,865,985	Cutter Suction, 8,000ps,	29,400	1.1	708	708
Finish dredging	8,976,150	1,023,850	10,000,000	Cutter Suction, 8,000ps,	21,230	1	471	90
Total	31,749,815	3,891,886	35,641,701	The Channel Dredging Works Total				1022

Sub total CSD	34,383,129
TSHD	1,258,572



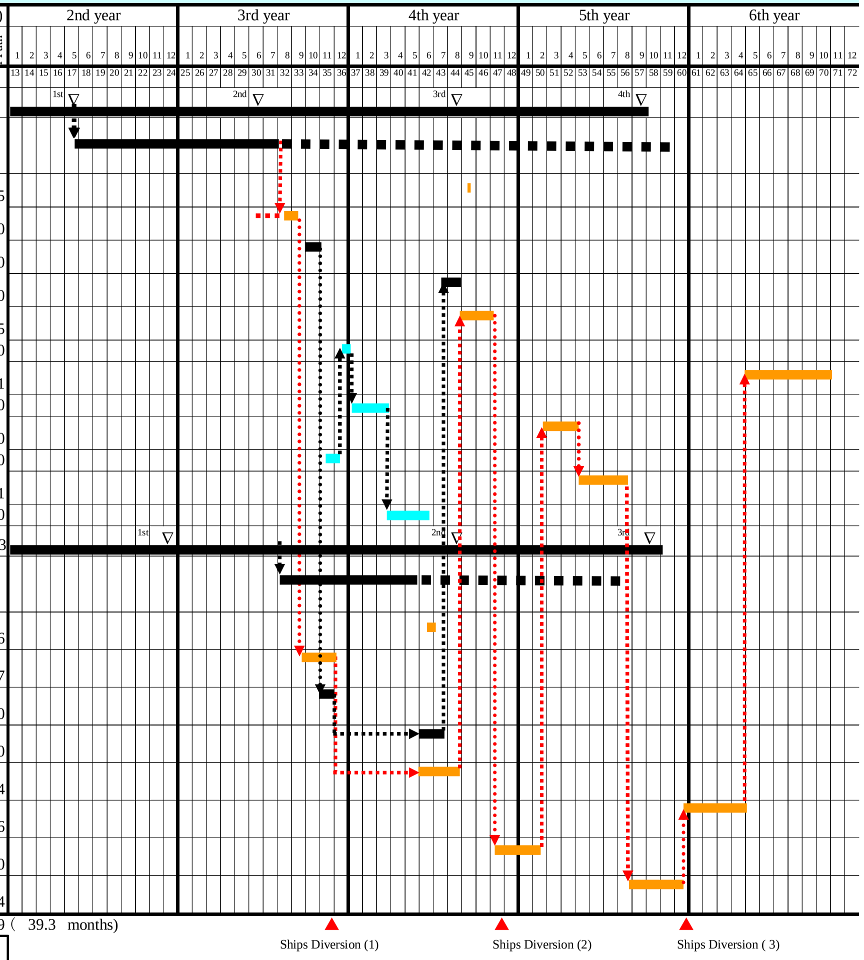
(Table 12.1.13 cont'd)

Case 19 (Ref. No.C1) Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 1 Package (A1-6)

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Preparatory works for Dinh Vu dumping area including perimeter dyke spillway silt fence and etc.							1712	
Trench/ dumping basin	6,424,200	1,595,900	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	432	
0 (Km0-Km7)	116,464	8,143	124,607	Grab Dredger 23m3	9,150	3	5	5
1 (Km0-Km7)	780,470	54,572	835,042	Grab Dredger 23m3	9,150	3	30	90
2 (Km0-Km7)	282,568	19,758	302,325	TSHD, 3,500m3	3,210	3	31	0
3 (Km0-Km7)	334,006	23,354	357,361	TSHD, 3,500m3	3,210	3	37	0
4-1 (Km0-Km7)	1,925,882	134,661	2,060,543	Grab Dredger 23m3	9,150	3	75	75
Km13 to off	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2 (Km0-Km7)	3,899,636	526,641	4,426,277	Grab Dredger 23m3	9,150	3	161	161
Km13 to off	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1 (Km0-Km7)	1,787,443	124,981	1,912,424	Grab Dredger 23m3	9,150	3	70	70
Km13 to off	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2 (Km0-Km7)	2,348,108	418,155	2,766,263	Grab Dredger 23m3	9,150	3	101	101
Km13 to off	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	0
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1733	693
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0 (Km7-Km13)	408,500	28,563	437,063	Grab Dredger 23m3	9,150	3	16	16
1 (Km7-Km13)	1,717,850	120,115	1,837,965	Grab Dredger 23m3	9,150	3	67	67
2 (Km7-Km13)	312,850	21,875	334,725	TSHD, 3,500m3	3,680	3	30	0
3 (Km7-Km13)	541,400	37,856	579,256	TSHD, 3,500m3	3,680	3	52	0
4-1 (Km7-	2,146,800	150,108	2,296,908	Grab Dredger 23m3	9,150	3	84	264
4-2(Km7-Km13)	2,784,000	412,352	3,196,352	Grab Dredger 23m3	9,150	3	116	116
5-1 (Km7-	2,570,600	179,741	2,750,341	Grab Dredger 23m3	9,150	3	100	100
5-2 (Km7-	2,716,000	407,597	3,123,597	Grab Dredger 23m3	9,150	3	114	114
Total	39,728,785	5,627,600	45,356,385		The Channel Dredging Works Total		1179	(39.3 months)

Sub total GD	25,767,383
Sub total TSHD 3,500m	1,573,667
Sub total CSD	18,015,335

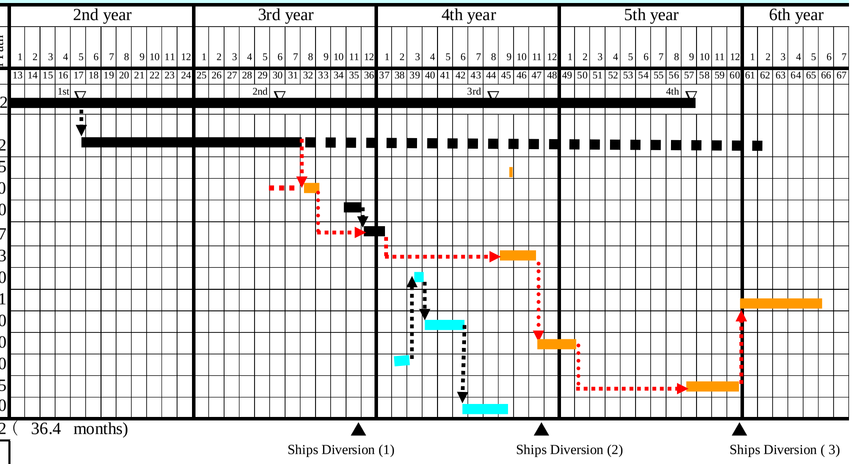
Sub total		
	offshore	4,524,935
	Dinh Vu	20,435,122
	Cat Hai	20,396,328

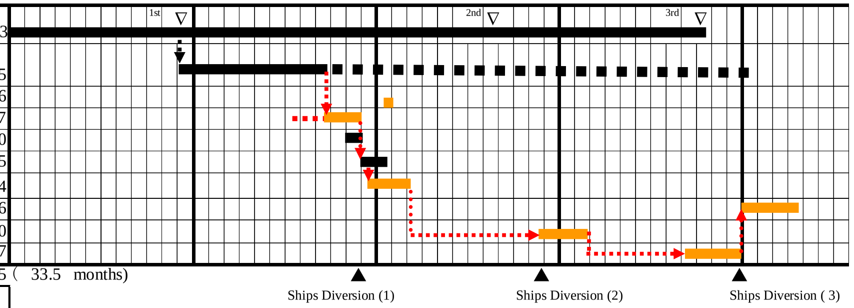


(Table 12.1.13 cont'd)

Case 20 (Ref. No. C2) Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 2 Packages (A1-7)

Dividing Package	Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration: for each work	Duration: Critical Path
1st Package	Preparatory works for Dinh Vu dumping area including perimeter dyke spilway silt fence and etc.							1712	502
	Trench/ dumping basin	6,424,200	1,595,900	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and	6,190	3	432	432
	0 (Km0-Km7)	116,464	8,143	124,607	Grab Dredger 23m3	9,150	3	5	5
	1 (Km0-Km7)	780,470	54,572	835,042	Grab Dredger 23m3	9,150	3	30	90
	2 (Km0-Km7)	282,568	19,758	302,325	TSHD, 3,500m3	3,210	3	31	0
	3 (Km0-Km7)	334,006	23,354	357,361	TSHD, 3,500m3	3,210	3	37	127
	4-1 (Km0-Km7)	1,925,882	134,661	2,060,543	Grab Dredger 23m3	9,150	3	75	303
	Km13 to off	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
	4-2 (Km0-Km7)	3,899,636	526,641	4,426,277	Grab Dredger 23m3	9,150	3	161	161
	Km13 to off	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
	5-1 (Km0-Km7)	1,787,443	124,981	1,912,424	Grab Dredger 23m3	9,150	3	70	70
	Km13 to off	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
	5-2 (Km0-Km7)	2,348,108	418,155	2,766,263	Grab Dredger 23m3	9,150	3	101	335
	Km13 to off	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	0
	Total	21,829,585	3,500,293	25,329,878	The Channel Dradging WorksTotal			1092	(36.4 months)
			Sub total GD	12,125,157		Sub total offshor		4,524,935	
			Sub total TSHD 3,500	659,686		Dinh V		20,804,943	
			Sub total CSD	12,545,035					
2nd Package	Preparatory works for Cat Hai dumping area including perimeter dyke spilway silt fence and etc.							1733	693
	Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and	6,190	3	295	295
	0 (Km7-Km13)	408,500	28,563	437,063	Grab Dredger 23m3	9,150	3	16	16
	1 (Km7-Km13)	1,717,850	120,115	1,837,965	Grab Dredger 23m3	9,150	3	67	127
	2 (Km7-Km13)	312,850	21,875	334,725	TSHD, 3,500m3	3,680	3	30	0
	3 (Km7-Km13)	541,400	37,856	579,256	TSHD, 3,500m3	3,680	3	52	15
	4-1 (Km7-Km13	2,146,800	150,108	2,296,908	Grab Dredger 23m3	9,150	3	84	84
	4-2(Km7-Km13)	2,784,000	412,352	3,196,352	Grab Dredger 23m3	9,150	3	116	116
	5-1 (Km7-Km13	2,570,600	179,741	2,750,341	Grab Dredger 23m3	9,150	3	100	100
	5-2 (Km7-Km13	2,716,000	407,597	3,123,597	Grab Dredger 23m3	9,150	3	114	547
	Total	17,899,200	2,127,307	20,026,507	The Channel Dradging WorksTotal			1005	(33.5 months)
			Sub total GD	13,642,226		Sub total offshor		0	
			Sub total TSHD 3,500	913,981		Cat Ha		20,026,507	
			Sub total CSD	5,470,300					





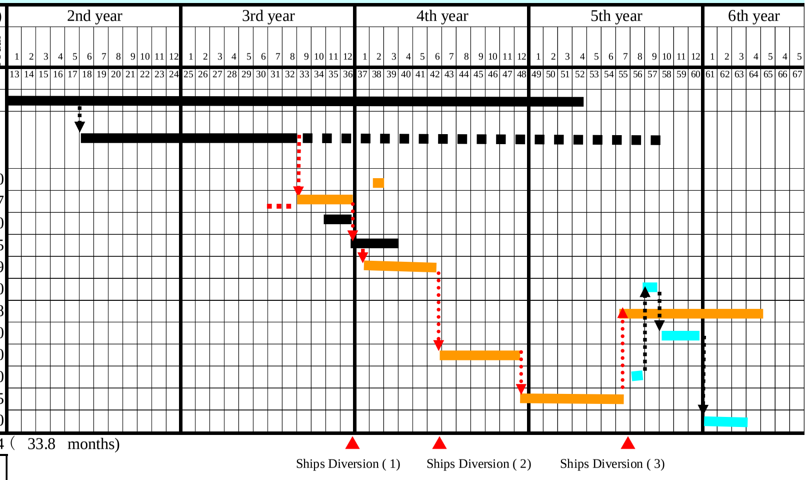
(Table 12.1.13 cont'd)

Case 21 (Ref. No. A1') Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping at Dinh Vu (East) and Offshore (A1-5')

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Preparatory works for Dinh Vu dumping area including perimeter dyke spillway silt fence and etc.							1590	
Trench/ dumping basin	6,424,200	1,595,900	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	432	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	Grab Dredger 23m3	9,150	3	278	278
13km to of	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to of	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	Grab Dredger 23m3	9,150	3	215	215
13km to of	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	0
Total	35,027,585	4,858,500	39,886,085		The Channel Dredging Works Total			1014 (33.8 months)

Sub total GD	25,767,383
Sub total TSHD 3,500m	1,573,667
Sub total CSD	12,545,035

Sub total	offshore	4,524,935
	Cat Hai	35,361,150

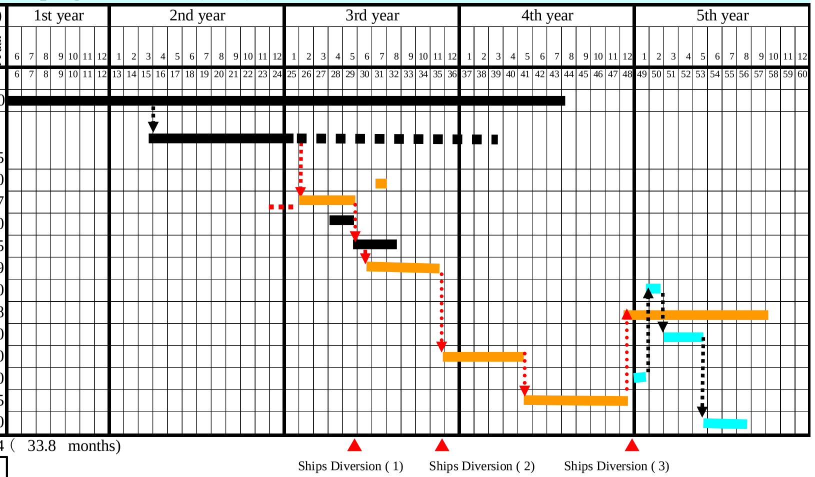


Case 22 (Ref/ No. A2') Within the Channel by GD and CSD (Sta 13 km and offshore) dumping at Cat Hai (East) and Offshore (A1-4')

Cross sectional Area	Dredging Volume (m3): Net Volume	Dredging Volume (m3): Extra vol for extra depth and Siltation	Dredging Volume (m3): Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day): for each work	Duration (day): Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spillway silt fence and etc.							1260	450
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	295
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,680	3	58	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,680	3	85	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to of	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	Grab Dredger 23m3	9,150	3	278	278
13km to of	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to of	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	Grab Dredger 23m3	9,150	3	215	215
13km to of	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	0
Total	33,304,585	4,031,700	37,336,285				Total	1014 (33.8 months)

Sub total GD	25,767,383
Sub total TSHD 3,500m	1,573,667
Sub total CSD	9,995,235

Sub total	offshore	4,524,935
	Cat Hai	32,811,350



12.1.10 Comparison of Cost by Study Cases

Cost estimation was prepared for comparison of each study case by item of cross-sectional area and type of dredger as shown in following Table 12.1.14. The unit costs are estimated based on the following standards and references:

(1) Japanese port and harbors construction cost estimation standard (2010)

(2) Price table of construction equipment (Japan, 2009)

(3) Cost standards for dredging equipment 2005, R.N. Bray

(4) Vietnamese cost estimation manuals and standards.

All costs indicated are direct costs.

Table 12.1.14 Comparison of cost by study cases

Case 1 (Ref. No. A3) Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Dinh Vu (East) (A1-5)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	837	6,712,823,700
0	561,670	Grab Dredger 23m3	1,200	674,004,510
1	2,673,007	Grab Dredger 23m3	1,200	3,207,608,420
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,357,451	Grab Dredger 23m3	1,200	5,228,941,479
13km to off shore	382,283	Pump Dredger, 8,000ps,	950	363,168,904
4-2	7,622,629	Grab Dredger 23m3	1,200	9,147,154,489
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	950	1,615,656,742
5-1	4,662,765	Grab Dredger 23m3	1,200	5,595,318,223
13km to off shore	487,296	Pump Dredger, 8,000ps,	950	462,931,087
5-2	5,889,860	Grab Dredger 23m3	1,200	7,067,832,524
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	950	1,856,931,810
Total	39,886,085			43,998,596,205
Discharge at Dinh Vu	29,705,985	Cutter Suction, 4,000ps,	419	12,446,807,715
Total coastal filling	37,726,085		Total cost	**56,445,403,920**

Case 2: With outer (east) diversion channel by CSD and 5,000 hoppwer barges dumping all at Dinh Vu (east) (B1-4)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	Cutter Suction, 8,000ps,	950	3,287,337,440
	129,763	TSHD、3,500 m3	1,313	170,379,239
Approach trench/ dumping basin	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	837	6,712,823,700
0 to 5	21,865,985	Cutter Suction, 8,000ps,	771	16,858,674,435
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	950	9,500,000,000
Total	44,341,292			**37,782,728,485**
Discharge at Dinh Vu	34,161,192	Cutter Suction, 4,000ps,	419	14,313,539,582
Total coastal filling	42,181,292		Total cost	**52,096,268,067**

(Table 12.1.14 Cont'd)

Case 3 Within the Channel by GD dumping all at Cat Hai (East) (A1-3)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0	561,670	Grab Dredger 23m3	981	550,998,687
1	2,673,007	Grab Dredger 23m3	981	2,622,219,884
2	637,051	TSHD, 3,500m3	1,143	728,148,944
3	936,616	TSHD, 3,500m3	1,143	1,070,552,040
4-1	4,739,734	Grab Dredger 23m3	981	4,649,679,338
4-2	8,692,020	Grab Dredger 23m3	981	8,526,871,667
5-1	5,781,361	Grab Dredger 23m3	981	5,671,515,207
5-2	7,844,526	Grab Dredger 23m3	981	7,695,479,516
Total	37,336,285			36,094,106,383
Discharge at Cat Hai	30,105,985	Cutter Suction, 4,000ps,	419	12,614,407,715
Total coastal filling	35,576,285		Total cost	**48,708,514,098**

Case 4 (Ref. No. A-4) Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping all at Cat Hai (A1-4)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0	561,670	Grab Dredger 23m3	981	550,998,687
1	2,673,007	Grab Dredger 23m3	981	2,622,219,884
2	637,051	TSHD, 3,500m3	1,143	728,148,944
3	936,616	TSHD, 3,500m3	1,143	1,070,552,040
4-1	4,357,451	Grab Dredger 23m3	981	4,274,659,659
13km to off shore	382,283	Pump Dredger, 8,000ps,	848	324,176,032
4-2	7,622,629	Grab Dredger 23m3	981	7,477,798,795
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	848	1,442,186,229
5-1	4,662,765	Grab Dredger 23m3	981	4,574,172,647
13km to off shore	487,296	Pump Dredger, 8,000ps,	848	413,226,907
5-2	5,889,860	Grab Dredger 23m3	981	5,777,953,089
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	848	1,657,555,974
Total	37,336,285			35,492,289,987
Discharge at Cat Hai	30,105,985	Cutter Suction, 4,000ps,	419	12,614,407,715
Total coastal filling	35,576,285		Total cost	**48,106,697,702**

Case 5 Within the Channel by TSHD (small) dumping all at Cat hai (East) (A1-6)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0	561,670	TSHD, 3,500m3	1,143	641,989,296
1	2,673,007	TSHD, 3,500m3	1,143	3,055,247,020
2	637,051	TSHD, 3,500m3	1,143	728,148,944
3	936,616	TSHD, 3,500m3	1,143	1,070,552,040
4-1	4,357,451	TSHD, 3,500m3	1,143	4,980,566,759
13km to off shore	382,283	TSHD, 3,500m3	1,143	436,949,534
4-2	7,622,629	TSHD, 3,500m3	1,143	8,712,664,650
13km to off shore	1,700,691	TSHD, 3,500m3	1,143	1,943,890,164
5-1	4,662,765	TSHD, 3,500m3	1,143	5,329,540,607
13km to off shore	487,296	TSHD, 3,500m3	1,143	556,979,192
5-2	5,889,860	TSHD, 3,500m3	1,143	6,732,110,480
13km to off shore	1,954,665	TSHD, 3,500m3	1,143	2,234,182,167
Total	37,336,285			41,001,461,955
Discharge at Cat Hai	30,105,985	Cutter Suction, 4,000ps,	419	12,614,407,715
Total coastal filling	35,576,285		Total cost	**53,615,869,670**

(Table 12.1.14 Cont'd)

Case 6: With outer (east) diversion channel by CSD and 5,000 hoppwer barges dumping all at Cat Hai (east) (B1-3)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	Cutter Suction, 8,000ps,	837	2,896,317,302
	129,763	TSHD、3,500 m3	1,313	170,379,239
Approach trench/ dumping basin	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0 to 5	21,865,985	Cutter Suction, 8,000ps,	698	15,262,457,530
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	848	8,480,000,000
Total	41,791,492			**32,641,308,843**
Discharge at Cat Hai	34,561,192	Cutter Suction, 4,000ps,	419	14,481,139,582
Total coastal filling	40,031,492		Total cost	**47,122,448,425**

Case 7 Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) and dumping off shore (A1-2)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
0	561,670	Grab Dredger 23m3	1,091	612,782,433
1	2,673,007	Grab Dredger 23m3	1,091	2,916,250,655
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,357,451	Grab Dredger 23m3	1,091	4,753,979,295
13km to off shore	382,283	Pump Dredger, 8,000ps,	837	319,970,919
4-2	7,622,629	TSHD>16,000 m3	971	7,401,572,507
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	837	1,423,478,624
5-1	4,662,765	Grab Dredger 23m3	1,091	5,087,076,818
13km to off shore	487,296	Pump Dredger, 8,000ps,	837	407,866,653
5-2	5,889,860	TSHD>16,000 m3	971	5,719,054,484
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	837	1,636,054,658
Total	31,865,985			32,344,311,362
			Total cost	**32,344,311,362**

Case 8 :Within the Channel by Large and small TSHD,and CSD (Sta 13 km and offshore), dumping offshore (A2-2)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
0	561,670	TSHD, 3,500m1	1313	737,473,268
1	2,673,007	TSHD, 3,500m2	1313	3,509,658,213
2	637,051	TSHD, 3,500m3	1313	836,447,562
3	936,616	TSHD, 3,500m4	1313	1,229,776,753
4-1	4,357,451	TSHD, 3,500m5	1313	5,721,333,469
13km to off shore	382,283	Pump Dredger, 8,000ps,	837	319,970,919
4-2	7,622,629	TSHD>16,000m3	971	7,401,572,507
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	837	1,423,478,624
5-1	4,662,765	TSHD, 3,500m3	1313	6,122,210,689
13km to off shore	487,296	Pump Dredger, 8,000ps,	837	407,866,653
5-2	5,889,860	TSHD>16,000m3	971	5,719,054,484
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	837	1,636,054,658
Total	31,865,985			35,064,897,799
			Total cost	**35,064,897,799**

Case 9: With outer (east) diversion channel by CSD and 5,000 hoppwer barges dumping offshore, (B1-2)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	Cutter Suction, 8,000ps,	837	2,896,317,302
	129,763	TSHD、3,500 m3	1,313	170,379,239
0 to 5	21,865,985	Cutter Suction, 8,000ps,	698	15,262,457,530
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	837	8,370,000,000
Total	36,321,192		Total	27,952,667,743
			Total cost	**27,952,667,743**

(Table 12.1.14 Cont'd)

Case 10 : With outer (east) diversion channel by CSD and 1,300 m3 hopper barges dumping offshore (B2-2)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	Cutter Suction, 8,000ps,	928	3,211,209,626
	129,763	TSHD、3,500 m3	1,313	170,379,239
0 to 5	21,865,985	Cutter Suction, 8,000ps,	757	16,552,550,645
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	928	9,280,000,000
Total	36,321,192			30,467,653,181
			Total cost	**30,467,653,181**

Case 11 With outer (east) diversion channel by CSD and 5,000 hoppwer barges dumping at Cat Hai (east) and off shore, (B1-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	CSD, 8,000ps,	837	2,896,317,302
	129,763	TSHD、3,500 m3	1,313	170,379,239
Approach trench/ dumping basin	5,470,300	CSD, 8,000ps, 1,300 m3 barge	928	5,076,438,400
0 to 5	21,865,985	CSD, 8,000ps,	698	15,262,457,530
Finish dredging	10,000,000	CSD, 8,000ps,	837	8,370,000,000
Total	41,791,492			**33,029,106,143**
Discharge at Cat Hai	18,512,583	Cutter Suction, 4,000ps,	419	7,756,772,277
Total coastal filling	18,512,583		Total cost	

Case 12-1 Within the Channel by GD and CSD (Sta 13km and offshore) dumping at Cat Hai (East) and off shore (A1-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	CSD, 8,000ps, 1,300 m3 barge	928	5,076,438,400
0	561,670	Grab Dredger 23m3	1,091	612,782,433
1	2,673,007	Grab Dredger 23m3	1,091	2,916,250,655
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,357,451	Grab Dredger 23m3	1,091	4,753,979,295
13km to off shore	382,283	CSD, 8,000ps,	848	324,176,032
4-2 (Cat Hai)	7,622,629	Grab Dredger 23m3	981	7,477,798,795
13km to off shore	1,700,691	CSD, 8,000ps,	848	1,442,186,229
5-1offshore	2,797,659	Grab Dredger 23m3	1,091	3,052,246,091
5-1 Cat Hai	1,865,106	Grab Dredger 23m3	981	1,829,669,059
13km to off shore	487,296	CSD, 8,000ps,	848	413,226,907
5-2 (Cat Hai)	5,889,860	Grab Dredger 23m3	981	5,777,952,660
13km to off shore	1,954,665	CSD, 8,000ps,	848	1,657,555,974
Total	37,336,285			37,400,486,845
Discharge at Cat Hai	18,142,531	Cutter Suction, 4,000ps,	419	7,601,720,489
Total coastal filling	18,142,531		Total cost	**45,002,207,334**

Case 12-2 Within the Channel by GD, TSHD and CSD (Sta 13km and offshore) dumping at Cat Hai (East) and off shore (A1-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	CSD, 8,000ps, 1,300 m3 barge	928	5,076,438,400
0	561,670	Grab Dredger 23m3	1,090	612,220,763
1	2,673,007	Grab Dredger 23m3	1,090	2,913,577,648
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,357,451	Grab Dredger 23m3	1,090	4,749,621,844
13km to off shore	382,283	CSD, 8,000ps,	848	324,176,032
4-2	7,622,629	TSHD >16,000 m3	971	7,401,572,507
13km to off shore	1,700,691	CSD, 8,000ps,	848	1,442,186,229
5-1offshore	2,797,659	Grab Dredger 23m3	1,090	3,049,448,432
5-1 Cat Hai	1,865,106	Grab Dredger 23m3	981	1,829,669,059
13km to off shore	487,296	CSD, 8,000ps,	848	413,226,907
5-2	5,889,860	TSHD >16,000 m3	971	5,719,054,484
13km to off shore	1,954,665	CSD, 8,000ps,	848	1,657,555,974
Total	37,336,285			37,254,972,595
Discharge at Cat Hai	4,630,041	Cutter Suction, 4,000ps,	419	1,939,987,179
Total coastal filling	4,630,041		Total cost	**39,194,959,774**

(Table 12.1.14 Cont'd)

Case 13:Within the Channel by Large and small TSHD,and CSD (Sta 13 km and offshore), dumping at Cat Hai (East) and off shore (A2-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Trench/ dumping basin	5,470,300	CSD, 8,000ps, 1,300 m3 barge	928	5,076,438,400
0	561,670	TSHD, 3,500m1	1313	737,473,268
1	2,673,007	TSHD, 3,500m2	1313	3,509,658,213
2	637,051	TSHD, 3,500m3	1313	836,447,562
3	936,616	TSHD, 3,500m4	1313	1,229,776,753
4-1	4,357,451	TSHD, 3,500m5	1313	5,721,333,469
13km to off shore	382,283	CSD, 8,000ps,	848	324,176,032
4-2	7,622,629	TSHD>16,000m3	971	7,401,572,507
13km to off shore	1,700,691	CSD, 8,000ps,	848	1,442,186,229
5-1offshore	2,331,383	TSHD, 3,500m3	1313	3,061,105,345
5-1 Cat Hai	2,331,383	TSHD, 3,500m4	1314	3,063,436,727
13km to off shore	487,296	CSD, 8,000ps,	848	413,226,907
5-2	5,889,860	TSHD>16,000m3	971	5,719,054,484
13km to off shore	1,954,665	CSD, 8,000ps,	848	1,657,555,974
Total	37,336,285			40,193,441,870
Discharge at Cat Hai	5,096,318	Cutter Suction, 4,000ps,	419	2,135,357,242
Total coastal filling	5,096,318		Total cost	**42,328,799,112**

Case 14: With outer (east) diversion channel by CSD and 1,300 m3 hopper barges dumping at Cat Hai and off shore (B2-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	865,089	TSHD, 1,500 m3	1,449	1,253,513,671
	3,460,355	CSD, 8,000ps,	928	3,211,209,626
	129,763	TSHD、3,500 m3	1,313	170,379,239
Approach trench/ dumping basin	5,470,300	CSD, 8,000ps, 1,300 m3 barge	928	5,076,438,400
0 to 5	21,865,985	CSD, 8,000ps,	757	16,552,550,645
Finish dredging	10,000,000	CSD, 8,000ps,	928	9,280,000,000
Total	41,791,492			**35,544,091,581**
Discharge at Cat Hai	24,704,371	Cutter Suction, 4,000ps,	419	10,351,131,449
Total coastal filling	24,704,371		Total cost	**45,895,223,030**

Case 15 : Within the Channel by CSD (Stand-by 6hrs/day), dumping offshore (A3-1)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
0	561,670	TSHD, 3,500m3	1751	983,484,914
1	2,673,007	Pump Dredger, 8,000ps,	931	2,488,569,533
2	637,051	TSHD, 3,500m3	1313	836,447,562
3	936,616	TSHD, 3,500m3	1313	1,229,776,753
4-1	4,739,734	Pump Dredger, 8,000ps,	931	4,412,692,624
4-2	4,661,660	Pump Dredger, 8,000ps,	931	4,340,005,460
5-1	5,150,061	Pump Dredger, 8,000ps,	931	4,794,706,791
5-2	3,922,263	Pump Dredger, 8,000ps,	931	3,651,626,853
Finish Dredging	8,583,923	Pump Dredger, 8,000ps,	1,115	9,571,074,145
Total	31,865,985		Total	32,308,384,635
			Total cost	**32,308,384,635**

Case 16 : Within the Channel by CSD (Stand-by 10hrs/day) and TSHD, dumping offshore (A3-2)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
0	561,670	TSHD, 3,500m3	2,249	1,263,196,785
1	2,673,007	Pump Dredger, 8,000ps,	1,197	3,199,589,399
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,739,734	Pump Dredger, 8,000ps,	1,197	5,673,461,945
4-2	8,692,020	TSHD>16,000m3 (thin layer)	971	8,439,951,467
5-1	5,781,361	Pump Dredger, 8,000ps,	1,197	6,920,289,197
5-2	7,844,526	TSHD>16,000m3 (thin layer)	971	7,617,034,261
Total	31,865,985			35,179,747,370
			Total cost	**35,179,747,370**

(Table 12.1.14 Cont'd)

Case 17: Lach Huyen Channel is shifted to east outside of the existing channel, dredging by CSD and dumping at off shore. (B-3)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
0 to 5	31,269,803	Cutter Suction, 8,000ps,	698	21,826,322,494
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	837	8,370,000,000
Total	41,269,803			30,196,322,494
			Total cost	**30,196,322,494**

Case 18: With outer (west) diversion channel by CSD and 1,300 m3 hopper barges dumping offshore (B-4)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Diversion Channel	629,286	TSHD, 1,500 m3	1,449	911,835,414
	2,517,144	Cutter Suction, 8,000ps,	837	2,106,849,528
	629,286	TSHD,3,500 m3	1313	826,252,518
0 to 5	21,865,985	Cutter Suction, 8,000ps,	698	15,262,457,530
Finish dredging	10,000,000	Cutter Suction, 8,000ps,	837	8,370,000,000
Total	35,641,701			27,477,394,990
			Total cost	**27,477,394,990**

Case 19 (Ref. No.C1) Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 1 Package (A1-6)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin at Dinh	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	837	6,712,823,700
Approach trench/ dumping basin at Cat	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0 (Km0-Km7)	124,607	Grab Dredger 23m3	981	122,239,884
0 (Km7-Km13)	437,063	Grab Dredger 23m3	981	428,758,855
1 (Km0-Km7)	835,042	Grab Dredger 23m3	1,200	1,002,050,813
1 (Km7-Km13)	1,837,965	Grab Dredger 23m3	1,200	2,205,558,185
2 (Km0-Km7)	302,325	TSHD, 3,500m3	1,313	396,953,102
2 (Km7-Km13)	334,725	TSHD, 3,500m3	1,313	439,493,969
3 (Km0-Km7)	357,361	TSHD, 3,500m3	1,143	408,463,219
3 (Km7-Km13)	579,256	TSHD, 3,500m3	1,143	662,089,219
4-1 (Km0-Km7)	2,060,543	Grab Dredger 23m3	981	2,021,392,884
4-1 (Km7-Km13)	2,296,908	Grab Dredger 23m3	981	2,253,266,854
4-1 (Km13 - offshore)	382,283	Pump Dredger, 8,000ps,	848	324,176,032
4-2 (Km0-Km7)	4,426,277	Grab Dredger 23m3	1,200	5,311,532,044
4-2 (Km7-Km13)	3,196,352	Grab Dredger 23m3	981	3,135,621,244
4-2 (Km13 - offshore)	1,700,691	Pump Dredger, 8,000ps,	848	1,442,186,047
5-1 (Km0-Km7)	1,912,424	Grab Dredger 23m3	1,200	2,294,909,291
5-1 (Km7-Km13)	2,750,341	Grab Dredger 23m3	981	2,698,084,486
5-1 (Km13 - offshore)	487,296	Pump Dredger, 8,000ps,	848	413,226,907
5-2 (Km0-Km7)	2,766,263	Grab Dredger 23m3	1,200	3,319,515,345
5-2 (Km7-Km13)	3,123,597	Grab Dredger 23m3	981	3,064,248,901
5-2 (Km13 - offshore)	1,954,665	Pump Dredger, 8,000ps,	848	1,657,556,064
Total	45,356,385			44,892,788,145
Discharge at Cat Hai	13,166,028	Cutter Suction, 4,000ps,	419	5,516,565,833
Discharge at Dinh Vu	10,255,022	Cutter Suction, 4,000ps,	419	4,296,854,100
Dinh Vu filling	18,275,122			
Cat Hai filling	18,636,328			
Offshore dumping	4,524,935		Total cost	**54,706,208,077**

(Table 12.1.14 Cont'd)

Case 20 (Ref. No. C2) Within the Channel by GD and TSHD dumping at Dinh Vu (East) (from Sta 0 to 7 km), Cat Hai (East) (from Sta 7 to 13 km), and by CSD (from Sta 13 km to offshore) dumping offshore- 2 Packages (A1-7)

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin at Dinh	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	837	6,712,823,700
dumping basin at Cat Hai	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0 (Km0-Km7)	124,607	Grab Dredger 23m3	1,200	149,528,910
0 (Km7-Km13)	437,063	Grab Dredger 23m3	981	428,758,855
1 (Km0-Km7)	835,042	Grab Dredger 23m3	1,200	1,002,050,813
1 (Km7-Km13)	1,837,965	Grab Dredger 23m3	981	1,803,043,816
2 (Km0-Km7)	302,325	TSHD, 3,500m3	1,313	396,953,102
2 (Km7-Km13)	334,725	TSHD, 3,500m3	1,143	382,590,713
3 (Km0-Km7)	357,361	TSHD, 3,500m3	1,313	469,214,529
3 (Km7-Km13)	579,256	TSHD, 3,500m3	1,143	662,089,219
4-1 (Km0-Km7)	2,060,543	Grab Dredger 23m3	1,200	2,472,651,846
4-1 (Km7-Km13)	2,296,908	Grab Dredger 23m3	981	2,253,266,854
4-1 (Km13 - offshore)	382,283	Pump Dredger, 8,000ps,	848	324,176,032
4-2 (Km0-Km7)	4,426,277	Grab Dredger 23m3	1,200	5,311,532,044
4-2 (Km7-Km13)	3,196,352	Grab Dredger 23m3	981	3,135,621,244
4-2 (Km13 - offshore)	1,700,691	Pump Dredger, 8,000ps,	848	1,442,186,047
5-1 (Km0-Km7)	1,912,424	Grab Dredger 23m3	1,200	2,294,909,291
5-1 (Km7-Km13)	2,750,341	Grab Dredger 23m3	981	2,698,084,486
5-1 (Km13 - offshore)	487,296	Pump Dredger, 8,000ps,	848	413,226,907
5-2 (Km0-Km7)	2,766,263	Grab Dredger 23m3	1,200	3,319,515,345
5-2 (Km7-Km13)	3,123,597	Grab Dredger 23m3	981	3,064,248,901
5-2 (Km13 - offshore)	1,954,665	Pump Dredger, 8,000ps,	848	1,657,556,064
Sub total (1st package)	25,329,878			25,966,324,631
Sub total (2nd package)	20,026,507			19,006,345,187
Discharge at Cat Hai	12,796,207	Cutter Suction, 4,000ps,	419	5,361,610,796
Discharge at Dinh Vu	10,624,843	Cutter Suction, 4,000ps,	419	4,451,809,137
Dinh Vu filling	18,644,943		Total cost (1st Package)	**30,418,133,768**
Cat Hai filling	18,266,507		Total cost (2nd Package)	**24,367,955,983**
Offshore dumping	4,524,935		Total	**54,786,089,751**

(Table 12.1.14 Cont'd)

Case 21 (Ref. No. A1') Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) dumping at Dinh Vu (East) and Offshore **(A1-5')**

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	8,020,100	Cutter Suction, 4,000ps, with discharge pipes and floater	837	6,712,823,700
0	561,670	Grab Dredger 23m3	1,200	674,004,510
1	2,673,007	Grab Dredger 23m3	1,200	3,207,608,420
2	637,051	TSHD, 3,500m3	1,313	836,447,562
3	936,616	TSHD, 3,500m3	1,313	1,229,776,753
4-1	4,357,451	Grab Dredger 23m3	1,200	5,228,941,479
13km to off shore	382,283	Pump Dredger, 8,000ps,	848	324,176,032
4-2	7,622,629	Grab Dredger 23m3	1,200	9,147,154,489
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	848	1,442,186,229
5-1	4,662,765	Grab Dredger 23m3	1,200	5,595,318,223
13km to off shore	487,296	Pump Dredger, 8,000ps,	848	413,226,907
5-2	5,889,860	Grab Dredger 23m3	1,200	7,067,832,524
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	848	1,657,555,974
Total	39,886,085			43,537,052,803
Discharge at Dinh Vu	25,181,050	Cutter Suction, 4,000ps,	419	10,550,859,821
Coastal filling	33,201,150			
Offshore dumping	4,524,935		Total cost	**54,087,912,624**

Case 22 (Ref/ No. A2') Within the Channel by GD and CSD (Sta 13 km and offshore) dumping at Cat Hai (East) and Offshore **(A1-4')**

Cross sectional Area	Dredge /discharge volume (m3)	Type of Dredger	Unit cost (JPY)	Cost (JPY)
Approach trench/ dumping basin	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	837	4,578,641,100
0	561,670	Grab Dredger 23m3	981	550,998,687
1	2,673,007	Grab Dredger 23m3	981	2,622,219,884
2	637,051	TSHD, 3,500m3	1,143	728,148,944
3	936,616	TSHD, 3,500m3	1,143	1,070,552,040
4-1	4,357,451	Grab Dredger 23m3	981	4,274,659,659
13km to off shore	382,283	Pump Dredger, 8,000ps,	848	324,176,032
4-2	7,622,629	Grab Dredger 23m3	981	7,477,798,795
13km to off shore	1,700,691	Pump Dredger, 8,000ps,	848	1,442,186,229
5-1	4,662,765	Grab Dredger 23m3	981	4,574,172,647
13km to off shore	487,296	Pump Dredger, 8,000ps,	848	413,226,907
5-2	5,889,860	Grab Dredger 23m3	981	5,777,953,089
13km to off shore	1,954,665	Pump Dredger, 8,000ps,	848	1,657,555,974
Total	37,336,285			35,492,289,987
Discharge at Cat Hai	25,581,050	Cutter Suction, 4,000ps,	419	10,718,459,821
Coastal filling	31,051,350			
Offshore dumping	4,524,935		Total cost	**46,210,749,807**

12.1.11 Summary of Comparative Studies on the Channel dredging

The combination of dredgers for each study case together with the dredging volume by respective type of dredgers are summarized with dredging work duration, and the cost in the Table 12.1.15 below. On the lowest line of the Table, an unit direct cost of each case is shown for cost comparison indices.

The findings of the comparative study discussed in the previous sections are summarized hereunder:

1) The compatibility of each type of dredger is dependent on several factors of the working conditions, i.e.

- **TSHD** can work alone by a self-propelling system and will not disturb the existing ship traffic in the channel. However, the TSHD has a restricted minimum working water depth of -10 m and -6 m for the large and small units respectively due to its deep draft. Turning within the channel area is not possible due to the hull length (160 m: large unit) and it has to turn in the turning basin area. Coastal dumping in a shallow water area is logistically not possible, particularly for the large TSHD. For the small TSHD, coastal dumping is dependent on the depth of the dumping basin, which should be deeper than -7 m plus allowance for the pile height of the dumped soil. Ordinarily, TSHD has high productivity, but due to the distance to the dumping site and the additional distance to the turning site at the landside end of the Channel, the intermittent timing will lower the productivity.
- **CSD** has the highest productivity and therefore the least cost of dredging among others, but it is subject to securing adequate space for expanding the swinging anchors. The achievement of high performance and the least cost output will depend on the free possession of the channel dredging site by provision of a diversion channel for existing ships passage along the outside of the existing channel. In this Study, direct dumping to the barges alongside the dredger has been considered so that the power of the dredger will be used solely for the dredging works. The dredger will be used continuously for the entire working period by turning the dredged soil into the hopper barges coming one after the other, which in turn, will convey it to the dumping site. CSD has the ability to dredge against stiff cohesive soil with an N-value of more than 10 to 15, which was found in a recent soil investigation at several points along the Channel alignment.
- **GD** has a self-standing system and is fixed at the dredging site by using spuds. Therefore, the GD can work without disturbing the existing ship traffic within the cross-sectional area of the Channel. The productivity of the GD is lower than that of the CSD and TSHD and it has a higher cost. As for the stiff cohesive soil dredging, the GD can perform well by using a heavy bucket. The soil dredged by the GD is not disturbed (not mixed much with water) and is relatively suitable for reclamation material. The nature of the GD dredged soil however, is not self-flowing (spreading) at the coastal dumping site. Some means of soil distribution within the dumping site will be required, otherwise the dumped soil will need to be crushed and mixed with water for hydraulic distribution.

Table 12.1.15 Summary of dredging volume by dredger and costs

Case			1	2	3	4	5	6	7	8	9	10	11	12-1	12-2	13	14	15 *	16 **	17	18
			A1-5	B1-4	A1-3	A1-4	A1-6	B1-3	A1-2	A2-2	B1-2	B2-2	B1-1	A1-1		A2-1	B2-1	A3-1	A3-2	B-3	B-4
Dumping site			Dinh Vu		Cat Hai				Off shore				Combined					Offshore			
Location of Diversion channel (Inside (In) or Outside (Out) of the Channel)			In	Out	In	In	In	Out	In	In	Out	Out	Out	In	In	In	Out	In	In	Out	Out
Combination of dredgers (volume million m3)	CSD 8,000 ps/5,000 m3 hopper barges	million m3	4.52	35.33		4.52		35.33	4.52	4.52	35.33		35.33	4.52	4.52	4.52		29.73	12.56	41.27	34.38
	CSD 8,000 ps/1,300m3 hopper barges	million m3										35.33					35.33				
	TSHD >16,000 ps	million m3							13.51	13.51					13.51	13.51			17.17		
	GD 23 m3	million m3	25.77		30.29	25.77			12.25					25.77	12.25						
	TSHD 3,500 m3/1,250m3	million m3	1.57	0.99	1.57	1.57	31.87	0.99	1.57	13.83	0.99	0.99	0.99	1.57	1.57	13.83	0.99	2.14	2.14		1.26
	CSD 4,000 ps for dumping basin and trench	million m3	8.02	8.02	5.47	5.47	5.47	5.47													
	CSD 8,000 ps for dumping basin and trench	million m3											5.47	5.47	5.47	5.47	5.47				
	Total Volume	million m3	39.89	44.34	37.34	37.34	37.34	41.79	31.87	31.87	36.32	36.32	41.79	37.34	37.34	37.34	41.79	31.87	31.87	41.27	35.64
Volume breakdown	Approach trench/dumping basin	million m3	8.02	8.02	5.47	5.47	5.47	5.47					5.47	5.47	5.47	5.47	5.47				
	Main Channel	million m3	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	31.87	41.27	31.87
	Diversion Channel	million m3		4.46				4.46			4.46	4.46	4.46				4.46				3.78
	Total Volume	million m3	39.89	44.34	37.34	37.34	37.34	41.79	31.87	31.87	36.32	36.32	41.79	37.34	37.34	37.34	41.79	31.87	31.87	41.27	35.64
	of which for coastal filling	million m3	37.73	42.18	35.58	35.58	35.58	40.03	0	0	0	0	18.51	18.14	4.63	5.10	24.70	0	0	0	0
Dredging Period (months)	Preparation works	Months	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Dredging works including Div. channel	Months	33.3	32.5	32.1	33.3	31.6	32.5	32.2	32.3	32.5	31.7	32.5	33.3	32.2	31.4	31.7	33.9	31.5	32.5	32.1
	Total duration	Months	35.3	34.5	34.1	35.3	33.6	34.5	34.2	34.3	34.5	33.7	34.5	35.3	34.2	33.4	33.7	35.9	33.5	34.5	34.1
Dredging cost (bill. Yen)	Main Channel (incl. div. channel.)	Bill. JPYen	37.29	31.07	31.52	30.91	36.42	28.06	32.34	35.06	27.95	30.47	27.95	32.32	32.18	35.12	30.47	32.31	35.18	30.20	27.48
	Extra cost (Trench, 2nd. Discharge)	Bill. JPYen	19.16	21.03	17.19	17.19	17.19	19.06	0	0	0	0	12.83	12.68	7.02	7.21	15.43	0	0	0	0
	Total Cost	Bill. JPYen	56.45	52.10	48.71	48.11	53.62	47.12	32.34	35.06	27.95	30.47	40.79	45.00	39.19	42.33	45.90	32.31	35.18	30.20	27.48
		Unit cost1/ PY/m	1,771	1,635	1,529	1,510	1,683	1,479	1,015	1,100	877	956	1,280	1,412	1,230	1,328	1,440	1,014	1,104	948	862

Notes 1. Diversion Channel : "Inside" means the diversion channel within the cross sectional area of the Channel
2. Diversion channel: "Outside" means the parallel diversion channel east outside of the cross sectional area of the Channel. (Case 18 is West diversion channel)
3. CSD: Cutter Suction Dredger, TSHD: Trailing Suction Hopper Dredger, GD: Grab Dredger
4 All costs are direct cost, not including the cost for coastal dumping/filling site including perimeter/intermediate dykes, spillway, arrangement of discharge pipes, environmental mitigation, and navigation safety measures (marine pilots, safety patrol boats, navigation buoys/marks and the relocation on cross-sectional/longitudinal directions), .
5. Unit cost is average unit cost for the volume of the main Channel 31,865,985 m3
6. Dredging period is not including the preparation period of coastal dumping site and stand-by time for pilot/navigation buoys/marks arrangement
7. Case 15*: Standby time 6 hours/day. Case 16**: Standby time 10 hours/day

2) Productivity of dredging works by type of dredgers:

The dredging productivity (m^3/day/dredger) is estimated considering work efficiency, hardness of seabed soil, distance to the dumping site, working hours per day, standby hours, etc. for the relevant type of dredgers as summarized in Table 12.1.16. The CSD shows the highest productivity (indicated with color) among the others except for some of the standby cases without an outer diversion channel.

Table 12.1.16 Summary of productivity of dredging works

Working conditions of dredgers	Diversion channel	Thickness of dredging layer	Productivity (m3/day)			
			TSHD		CSD	GD
			16,000 m3	3,500 m3	8,000 ps	23 m3
With the provision of diversion channel	Outside of the Channel	Ordinary	-	3,210	29,400	9,150
Without diversion channel (in case 6 hours stand-by time a	Inside		14,660	2,400	22,050 (Stand-by 6 hours/day)	9,150
Without diversion channel (in case10 hours stand-by time a	Inside		14,660	1,870	17,150 (Stand-by 10 hours/day)	9,150
Thin layer dredging for finishing works (with diversion	Outside of the Channel	Thin	-	-	21,230	-
Thin layer dredging for finishing works (in case 6	Inside		14,660	-	15,920 (Stand-by 6 hours/day)	-
Thin layer dredging for finishing works (in case10	Inside		14,660	-	12,380 (Stand-by 10 hours/day)	-

3) Time duration of dredging works

Basically, all comparative study cases will be completed within the 3-year construction period, except for the case that requires completion of the perimeter dike of the coastal dumping area. Upon completion of the dike, the soil dumping works therein will begin.

4) Dredging works with diversion channel within the cross-sectional area of the Channel

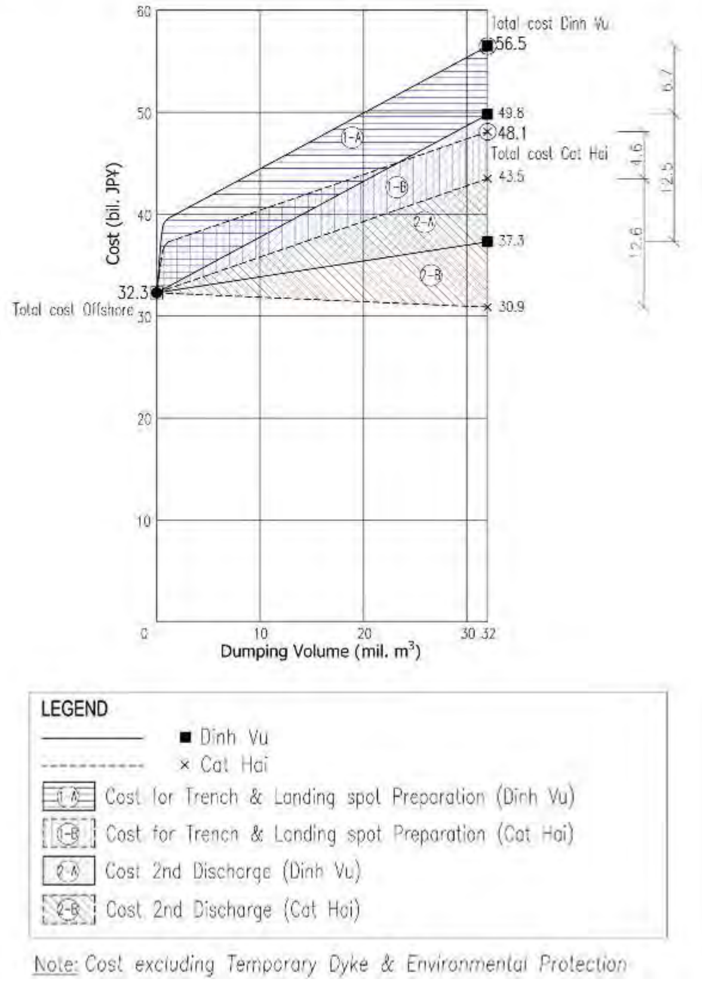
For the comparative cases with a diversion channel within the cross-sectional area of the Channel, the dredging methodology using a CSD is not practical because the productivity of the CSD will worsen and safety for the marine traffic and the dredging work itself will be difficult to secure. In this case, either GD or TSHD will be used instead.

5) Dumping sites

Regarding the dredged soil dumping site, offshore dumping is the most economical. As for coastal dumping, the dredged soil will be transferred to the dumping site by hopper barges. The dredged soil will be discharged from a temporary dumping basin to the final coastal dumping area by using secondary cutter suction dredgers. In order to enable the secondary discharge, an access trench and dumping basin near the coastal dumping site will be required. Due to the shallow water depth of the existing seabed at the coastal dumping site, the dredging volume is estimated to be approximately 5 million m^3 or more and the relevant funds and time for the additional dredging will be needed. The costs for the dike and the distribution of the dredged soil in the dumping site are expected to be shouldered by local funds of the GOV.

In response to the request of MOT/TAC/VINAMARINE, the relation between the cost and dumping volume at “Cat Hai”, “Dinh Vu” and “Off-shore” were indicated in Figure 12.1.16. This shows big cost portion shared by temporary access trench and dumping basin dredging and also for the cost of the secondary discharge of the soil to Cat Hai and/or Dinh Vu reclamation sites.

RELATIONSHIP BETWEEN COST AND DUMPING VOLUME



Case	Ref. No	Dumping site	Dredging Volume (mil. m3)						Cost (bil. JPY)				Construction Period (Year)
			Channel			Approach/Dumping Basin		Total	Channel	Trench & 2nd Discharge	Peripheral Dyke	Total	
			Inner	Middle	Outer	Dinh Vu (E)	Cat Hai (E)						
C1 (1-Package)	A1-6	S Dinh Vu IZ	12.4			8.0		20.4	15.0	11.0	4.1	30.1	5.7
S.D.Vu /C.Hai / Off.		Cat Hai South		14.9			5.5	20.4	14.8	10.1	5.2	30.1	
3-Dumping Site		Offshore			4.5			4.5	3.8			3.8	
In Combination		Total						**45.4**	**33.6**	**21.1**	**9.3**	**64.0**	
C2 (2-Package)	A1-7	S Dinh Vu IZ	12.8			8.0		20.8	15.4	11.0	4.1	30.5	5.5
S.D.Vu /C.Hai / Off.		Cat Hai South		14.6			5.5	20.0	14.4	10.1	5.2	29.8	
3-Dumping Site		Offshore			4.5			4.5	3.8			3.8	
In Combination		Total						**45.4**	**33.7**	**21.1**	**9.3**	**64.1**	
A1'	A1-5'	S Dinh Vu IZ		27.3		8.0		35.4	33.0	17.3	12.0	62.3	5.3
S Dinh Vu/ Offshore		Cat Hai South											
2-Dumping Site		Offshore			4.5			4.5	3.8			3.8	
In Combination		Total						**39.9**	**36.8**	**17.3**	**12.0**	**66.1**	
A2'	A1-4'	S Dinh Vu IZ											4.7
Cat Hai/ Offshore		Cat Hai South		27.3			5.5	32.8	27.1	15.3	11.0	53.4	
2-Dumping Site		Offshore			4.5			4.5	3.8			3.8	
In Combination		Total						**37.3**	**30.9**	**15.3**	**11.0**	**57.2**	
A3	A1-5	S Dinh Vu IZ			31.9	8.0		39.9	37.3	19.2	13.0	69.5	5.4
S Dinh Vu		Cat Hai South											
1-Dumping Site		Offshore											
		Total						**39.9**	**37.3**	**19.2**	**13.0**	**69.5**	
A4	A1-4	S Dinh Vu IZ											4.8
Cat Hai		Cat Hai South			31.9		5.5	37.3	30.9	17.2	12.0	60.1	
1-Dumping Site		Offshore											
		Total						**37.3**	**30.9**	**17.2**	**12.0**	**60.1**	

Note: Construction Cost excluding Peripheral Dyke at Dumping Site (S Dinh Vu IZ or Cat Hai) and Other Dumping Soil Distribution Cost within Dumping Site

For Reference

A1	A1-2	S Dinh Vu IZ											2.9
Offshore		Cat Hai South											
1-Dumping Site		Offshore			31.9			31.9	32.3	-	-	32.3	
		Total						**31.9**	**32.3**	**-**	**-**	**32.3**	

Figure 12.1.16 Relation between cost and dumping volume

6) Findings

Diversion channel outside of the sectional area of the Channel

(1) Among the three major types of dredgers, CSD (Cutter Suction Dredger) has the highest productivity and the cheapest cost of dredging. TSHD (Trail Suction Hopper Dredger) and GD (Grab Dredger) are following to CSD.

(2) The productivity of CSD, however, will be reduced, in the limited working area because of that CSD requires wide space to deploy anchor wires.

(3) Cases 15 (A3-1) and 16 (A3-2) were prepared to confirm the influence of stand-by time of CSD for 6 and 10 hours respectively and compared to the productivity of TSHD and GD.

(4) As a result, by 6 hours stand-by time a day, CSD is still highest productivity. But by 10 hours stand by time a day, TSHD took position of CSD for the area deeper than -10m below seawater level.

(5) Considering the existing “Record of ships passing Lach Huyen channel” shown in Figure 12.1.5 commercial ship traffic will be continued for more than half of the day, and assumed that the stand-by time of CSD will be longer than 10 hours.

(6) In order to realize the CSD as a cheapest solution, an outside diversion channel was determined in Cases 2, 6, 9, 10 and 11.

(7) As a result of the comparative study, it was revealed that the additional cost of outside diversion channel is less than that of high productivity of CSD compared to another type of dredgers. In other word, the total cost by using CSD including the cost of diversion channel will be less than other type of dredgers without diversion channel.

Diversion channel within the sectional area of the Channel

(8) MOT, showed the desire by “Decision” and the letter of VINAMARINE indicated in Section 12.1.12 that the outer diversion channel will increase dredging volume and TSHD or GD in the diversion channel within the Channel is preferable. As for the safety of navigation in the Channel during the construction period will be secured by MOT.

(9) Those Cases of Inside diversion channel with TSHD and GD were, therefore, determined.

Costal dumping

(10) As shown in Cases 7 to 9, off-shore dumping is the most practical.

(11) In order to achieve the MOT’s desire, however, many cases of coastal dumping were determined to maximize the volume of Coastal dumping thorough the diversion channel within the cross sectional area of the Channel.

(12) Assuming the perimeter dyke for coastal filling site will be able to start the initial receiving of the dredged soil by 1.5 years, the total duration will be 4.5 years until completion of the Channel dredging works with 3 years of net dredging work period.

(13) If the total period of the dredging works was required to complete within three years including construction period of the perimeter dyke, a 47 to 54 % of the total dredging volume will be obliged to dump offshore in the first dredging period (1.5 years) until the perimeter dyke was completed. (see Cases 11 and 12-1 in Table 12.1.15)

(14) Above dredging volume is including the volume of approach trench and temporary dumping basin estimated to be 5.5 million m^3 which is much bigger than the volume of outside diversion channel (4.5 million m^3).

Among the comparative study Table below shows the potential cases.

Cases 1 and 4 show dumping all dredged soil to Dinh Vu and Cat Hai. The construction time and cost will be 66 and 59 months with 56 and 48 billion JP Yen respectively, while in Case 7 by off-shore dumping much less cost and time period. Cases 12-1 and 12-2 show combined dumping at Cat Hai and off-shore. This will achieve the dredging works by 34 months with less cost.

Table 12.1.17 Summary of case study for the dredging works

Case	Position of diversion channel		Dumping site			Major Dredger				Dredging Cost (Bill JPY)			Construction Period (Month) (Critical Path of Dredging Works)				Number of ships traffic diversion ▲
	Inside	Outside	Dinh Vu	Cat Hai	Off shore	CSD 8,000 ps	TSHD >16,000 ps	GD 23 m^3	TSHD 3,500 m^3	Main Channel	Extra Cost	Total	Dyke	Trench Dumping Basin	Channel Dredging	Total	
1	○		○			○		◎	○	37.3	19.2	56.4	18	15	33	66	3
4	○			○		○		◎	○	30.9	17.2	48.1	15	11	33	59	3
6		○		○		◎			○	28.1	19.1	47.1	15	11	32	58	1
7	○				○	○	◎	◎	○	32.3	0.0	32.3	0	0	34	34	3
9		○			○	◎			○	28.0	0.0	28.0	0	0	35	35	1
11		○		○	○	◎			○	28.0	12.8	40.8	0	0	34	34	1
12-1	○			○	○	○		◎	○	32.3	12.7	45.0	0	0	35	35	3
12-2	○			○	○	○	◎	◎	○	32.2	7.0	39.2	0	0	34	34	3

For the Cases 1, 4, 7 and 12 which are with the diversion channel inside the Channel, a great care should be taken for maritime safety during the construction period by deploying maritime pilots, safety control and patrol vessels. In addition, both frequent rescheduling of existing ship passage and relocation of navigation aid buoys are indispensable. These incidental expenses are not yet included in this comparative cost estimation.

For the series of Cases 6, 9 and 11 a diversion channel outside of the Channel cross-sectional area is proposed. In spite of the additional dredging volume of the diversion channel, which is approximately 15% of that of the main Channel dredging, the total productivity will be improved and the work efficiency will be increased by more than 15 % of those Cases within the Channel and therefore, showing high productivity, low cost, less construction duration, high safety for maritime traffic and less influence on the Hai Phong port activity. In addition, the parallel diversion channel will be able to be used as a separate water passage for those ships calling at the existing group of Hai Phong ports even after completion of the Project and will improve the overall operation efficiency of the Lach Huyen new terminal.

12.1.12 Reference Correspondence

Case A3-1 and Case A3-2

Proposed methodology of Dredging with the diversion channel within the cross sectional area of main channel: For reference only

(1) Outline of the navigation channel and the dredging works.

The new Lach Huyen navigation channel dredging work was planned as shown in Fig 1 “Channel typical cross section” which indicates a cross section at Sta 36 + 165 (distance from Hai Phong Port), Sta 6+900 (distance from “0” Buoy) or Sta 9+100 (distance from land side end of new channel) at 160 m channel width portion as described below.

(note: As for the distance of channel ,see channel layout plans shown in Figs 12. bbb to ddd. Hereinafter the distance from Hai Phong Port is indicated.)

The dimension of new channel is 160 m wide at -14 m water depth below CD (chart datum) from Sta 27+065 to Sta. 37+000 and 210 m wide from Sta. 37+000 to Sta.44+400. The total length of the Channel is 17.4 km. The side slope of the channel is 1 to 10.

Since the dredging work will be done simultaneously to the existing channel ships navigation passage, a detouring channel was provided within the cross sectional area of new navigation channel which is indicated with orange color in Fig.12.aaa.

The existing channel is 100 m wide at CD-7.0 m with total length of approximately 12 km from Sta 27+000 to Sta 39+000. This water depth of CD-7.0 m is tentatively designated as the target depth for detouring channel. The zone of the existing channel is shown with yellow color in Fig 12.aaa.

The layout plan of the above existing and detouring channel are shown in Figs. 12 bbb to ddd. which indicate the alignment of the channels with similar color of yellow and orange respectively.

The dredging work will be carried out by using Cutter Suction Pump Dredger (hereinafter called as Pump Dredger) for the channel cross sectional area above CD-10m and by Trail Suction Hopper Dredger (hereinafter called as TSHD) below CD-10m.

(2) Cross section of the channel

Fig 1 is a typical cross section which shows:

- Existing seabed with blue line,
- The existing channel (100m width with the tentative target water depth of CD-7.0m) at yellow zone,
- The Project channel (160 to 210m width, CD-14 m depth) with bold black line,
- The typical dimensions of several types of dredgers by orange rectangular,
- Position of existing green and red buoys,
- Numbers 0 to 5 in circle which indicates the sequence of the dredging works, and
- Position of swing anchors for Pump dredger,

(3) Dredging methodology

The proposed dredging methodology is enumerated hereunder:

Step 1 Prior to the dredging works, the existing Green Buoys will be transferred along the east side edge of existing channel (between yellow and orange area).

Step 2 The orange zone and eastside slope will be dredged by Pump dredger (the areas ① and ② in Fig.1 up to CD-7.0m or below.

- At first the pump dredger will deploy anchors with wire rope 200 m away at left and right sides of her cutter head. (see Fig. 12.aaa)
- By means of the anchors, the pump dredger will swing cutter head on the seabed and suck the seabed soil through suction pipes and discharge the dredged soil mixed with seawater to the Hopper Barge which is moored alongside of the Pump Dredger. The above mentioned wire ropes of swinging anchors will be placed perpendicular to the channel center line and across it. (see Fig 12.aaa)
- Whenever the commercial ships are passing the existing channel, the anchor wire will be loosen and slacked down onto the seabed to let ships pass above wire rope.
- Prior to the dredging works on the orange zone, the seabed of the existing channel (yellow zone) will be deepened to CD-8.0m (the area "0" in Fig 12.aaa) so that under keel clearance for commercial ships will be secured and the dredgers' anchor wire will have enough room to slack-down on the seabed.
- The dredging works for orange zone will be continued for entire length from Sta 27+000 to Sta. 39+000 to secure the detouring channel first.

Step 3 The green buoys will be shifted to east edge (right side on Fig. 1) of orange zone (position (5)) and the red buoys to west edge of orange zone to indicate the fairway of detouring channel, as shown in Fig 12.aaa..

Step 4 The commercial ships navigation will be shifted to orange zone.

Step 5 Green zone and yellow zone will be dredged by pump dredger up to CD-10m and by TSHD below CD-10m.

Step 6 The dredging works of above step 5 will be continued for entire length of the detouring channel from Sta. 29+500 to Sta. 39+000. (See Figs 12. bbb to ddd)

Step 7 The green buoys will be shifted to the east edge (right side on Fig. 12.aaa) of yellow zone and the red buoys to west edge of green zone as shown in Fig 1, to indicate the fairway of secondary detouring channel.

Step 8 The commercial ships navigation will be shifted to green and yellow zones

Step 9 The Orange zone will be dredged by pump dredger up to CD-10m and by TSHD below CD-10m.

Step 10 As for the offshore area beyond Sta 39+000 and up to Sta 44+400, the dredging works will be done simultaneously with above dredging.

Step 11 Completion of the Channel dredging works.

(4) Special Notes

- The dredging works by either pump dredger or TSHD will be made for 24 hours of the day continuously. The productivity of the dredger will be depending on how many hours they could work in one day. The probable stand-by time due to the ships passing the existing channel should be limited as short as possible for the viewpoint of the dredging works efficiency. For example, if the dredging works was stopped 6 hours in a day (24 hours), the work productivity will be reduced by 1/4. In other word, the dredging cost will go up by 25%.
- In order to minimize the stand-by time of the dredger, the commercial ships passage should be done by grouping (fleet).
- In order to minimize the shifting time of swing anchor, the anchor wire will be slack-down on the seabed while commercial ships are passing beside the dredging work site.
- Special safety measures such as safety watch boat(s), temporary buoys, stand-by tug boat(s) for emergency, and any other precautionary safety preventive measures should be provided.
- Close coordination between the MSC1, the dredging works contractors, and all other concerned agencies is indispensable to minimize stand-by time and safety measures.

Case A3-1 and Case A3-2

Reply of MPMUII on the proposed methodology in the previous pages   For reference only

VINAMARINE
MPMU II
No. 227/BQLDAHHII-KH
V/v: Lach Huyen Channel Dredging Methodology

SOCIALIST REPUBLIC OF VIETNAM
Independence – Freedom – Happiness
Hai Phong, June 03, 2011

To: JICA DD Study Team

First of all, MPMU II would like thanks for active cooperation of JICA DD Study Team.

We received the your Letter on Lach Huyen Channel Dredging Methodology. After studying your planned dredging methodology, we would like have following comments.

(1) Characteristics of Lach Huyen Channel:

This is existing national access channel to Hai Phong Port, having large number of in/out ships, accordingly, the dredging works should not disturb existing channel operation.

(2) Planned Dredging Methodology

You are planning to use cutter suction dredger (CSD) to dredge until CDL -10.0m and trail suction hopper dredger to dredge below CDL -10.0m. Based on our experience of dredging in Vietnam, your planned methodology is appropriate for dredging new channel. However, as for the existing channel, like Lach Huyen channel's case, it is not so suitable because of followings;

- If CSD is used to dredge until CDL -10.0m, crossing anchored wire over the channel is required, and the wire will be loosen and slacked down onto the seabed whenever commercial ships are passing the existing channel. Since large number of ships go in/out Hai Phong port, so the anchored wire should be loosen many times in one day, and accordingly, the actual working times of CSD will be much less, leading to low productivity of dredger.
- Crossing anchored wire over the channel may cause influence to navigation safety of commercial ships on the channel as well as the safety of dredgers. The existing channel is national channel, having international navigation aids, so, moving green buoys for dredging activities and dredging diversion channel will need the cost, and project cost will be higher accordingly, and will make ships control and coordination be complicated due to frequent channel diversion.
- Using CSD to dredge whole channel until CDL -10.0m requires 24h/24h monitoring and control station to keep navigation safety on the dredging site, this will make project cost higher.

With above-mentioned considerations, in order to keep planned schedule, quality of work, safety and economically efficiency, MPMU II would like to suggest JICA DD Study Team to consider other dredging methodology so as to match with local conditions of Lach Huyen channel (for example, to use trail suction hopper dredger with crab dredger which have suitable specifications and capacity with project site soil conditions and topographical conditions.

Sincerely thank you.

Recipients:
- As above mentioned
- VINAMARINE (reporting)
- Filing in MPMU II (KH, KT, HC)

On behalf of Director
Deputy Director
Tran Anh
Signed and Sealed

12.2 Dredged Soil Disposal

12.2.1 Background of Study on Dredged Soil Disposal

1) SAPROF Study

The dredging work of access channel for Lach Huyen Port Construction Project was planned to start from the middle of 2012 and completed by the middle of 2015. But, according to Nam Dinh Vu Investment, the project owner of the industrial zone, the reclamation work of South Dinh Vu Industrial Zone (SDIZ) development plan was originally scheduled to start from May 2010, and completed by early 2013. Therefore, if the reclamation of SDIZ will complete as their original schedule, new dumping area deemed to be required from the year 2013.

Considering the above reclamation schedule of Nam Dinh Vu Investment, it may be more economical if offshore dumping site with sufficient seabed depth is available. Therefore, it is recommended in the SAPROF Study that the possibility of EIA approval for such offshore dumping site should be studied during detail design stage (page 16-4 of the final SAPROF report) with careful consideration of the environmental impacts. With the sufficient studies and appropriate counter measures to reduce the environmental impacts, it deemed possible to acquire the approval of the EIA and permission of the dump (page 22-4 of the final report).

Comments and Recommendation are given in JICA SAPROF Study conducted in 2009-2010 as follows:

- Dredged soil not suitable as for reclamation material
- Dumped in the area Dinh Vu South IZ designated by Hai Phong PC
- Recommended to study possibility of EIA approval for Offshore Dumping

Therefore, the Project cost by SAPROF Study was estimated under the following conditions:

- Dredged soil is planned to dispose in Dinh Vu South IZ without any pre- or post-soil improvement for use of reclamation.
- Any necessary temporally dyke for receiving dredged soil disposal is assumed to be constructed under the responsibility of Hai Phong City PC or Dinh Vu South IZ developer.
- The construction cost of temporary dyke and any work related to the reclamation is not included in the JICA Project.

Through discussion between JICA mission and Vietnamese Government, it was agreed that:

1) JICA could not include construction of the dyke in the scope of the Project
2) MOT will take responsibilities to follow up actions taken by Hai Phong City PC in order to prepare the temporary dyke based on the work time schedule of the Project
3) JICA expects that the commitment by Hai Phong City PC or guarantee by MOT on temporary dyke construction will be given by June 30, 2010
4) As regards alternative site for future logistic park development area proposed by Vietnamese side, its feasibility must be firstly studied at detailed design stage.

But, at present, there has not been given any commitment or guarantee from Vietnamese side on the preparation of temporary dyke construction for Dinh Vu South IZ.

2) Review of SAPROF Study by Vietnamese Side (Review F/S Report by TEDI)

The review report refers Dinh Vu South IZ which is originally allocated by Hai Phong PC to dump the channel dredged soil (Alternative 1). But it is also proposed that the dredged soil is disposed at the adjacent area west of the outer breakwater of Lach Huyen International Gateway Port Construction Project, which is located at Cat Hai Island south coastal area and opposite to SDIZ through Nam Trieu (Alternative 2) and the recommendation is given as follows:

- Since the Alternative 2 dumping site is located near Lach Huyen Channel that will be dredged, pumping method by cutter suction dredger can be used.
- The area is surrounded by existing revetment of Cat Hai island shore in the North and outer revetment of Lach Huyen Port terminal in the East which can be utilized as the revetment for the disposal site.
- Furthermore, the cost of outer revetment of Lach Huyen Port terminal can be reduced because the disposed soil functions as the revetment.
- In addition, the disposal area can form a land for future development for Hai Phong City.

The dredging costs including disposal is estimated to be VND 5.400 billion for alternative1 while VND 4.600 billion for alternative 2.

3) MOT Decision

Meanwhile, the following two (2) sites have been already approved as Dumping Site for Channel Dredged Soil by MOT Decision No.476/QD-BGTVT.

- Site A: Dinh Vu South IZ
- Site B: Cat Hai South Offshore (Behind Breakwater at Lach Huyen Port)

4) Re-evaluation by JICA DD Study

Based on the TOR for JICA DD Study, comparative study is carried out to select best suitable disposal site for dredged soil. Four (4) possible/potential disposal areas for the channel dredged soil are considered including the following two (2) alternative sites in addition to the already approved dumping site by MOT Decision.

- Logistic Park
  In the view of effective use of the dredged soil, logistic park area behind Lach Huyen port where future development is planned shall be studied as a disposal site.
- Offshore Dumping (Site)
  In case when the disposal is done at the area designated by MOT decision, the additional construction cost of embankment as well as additional construction period is likely to be required. There is also a concern that most of the dredged soil is soft clay which is unsuitable for reclamation and makes the use of land difficult without proper soil improvement. Considering the above, "Offshore Dumping" is proposed as another alternative plan

Table 12.2.1 Four (4) - Possible/Potential Sites for Dredged Soil Disposal for Selection

Site	Area	EIA	Description
Plan A	Southern Dinh Vu IZ	approved	Approved by MOT Decision
Plan B	Cat Hai South Offshore	Not yet submitted	- ditto -
Plan C	Offshore for Future Logistic Park	Not yet submitted	Suggested by VN side at JICA SAPROF
Plan D	Offshore area (20-25m water depth)	Not yet submitted	Recommended for further study by JICA SAPROF

JICA Study Team evaluates its potentiality in view of economic and technical aspect in construction (construction time schedule, construction cost, construction method) and environmental consideration for possible approval for EIA.

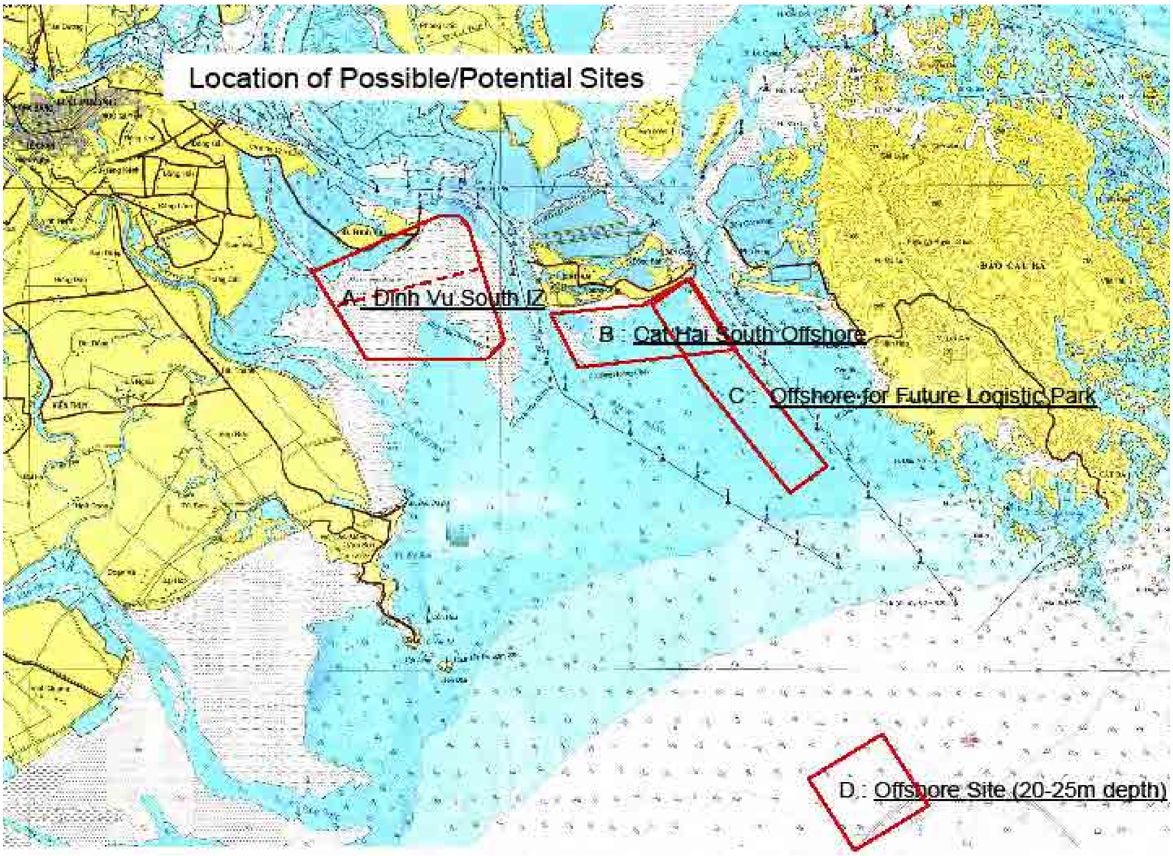


Figure 12.2.1 Locations of Possible/Potential Sites

12.2.2 Dredged Soil Material

A suitable material for reclamation is the sandy soil which has high permeability and the particle size of around 0.1mm to 1.0mm. Sand mixed with gravel is also suitable.

When using the soft dredged soil as a reclamation material, soil improvement or dehydration before reclamation, or soil improvement after the reclamation is necessary.

The result of soil investigation along Lach Huyen channel indicates that the sea bottom sediment to be dredged is mostly clayey soil but its consistency may differ from very soft to stiff with SPT N-value 0-5 at upper layer. Therefore, dredgeability of Lach Huyen access channel dredging is likely to be good but it is not suitable soil for reclamation. In addition, the dredging in Lach Huyen Port project is planned to be partially done by Cutter Suction Dredger (CSD), and secondary dumping into dumping site is carried out by CSD as well. Therefore, the dredged material will be discharged into reclamation area as the mixture of clay balls and slurry. Due to the large volume of soft soil with high content of moisture, it is not practical to be used the channel dredged soil as reclamation material.

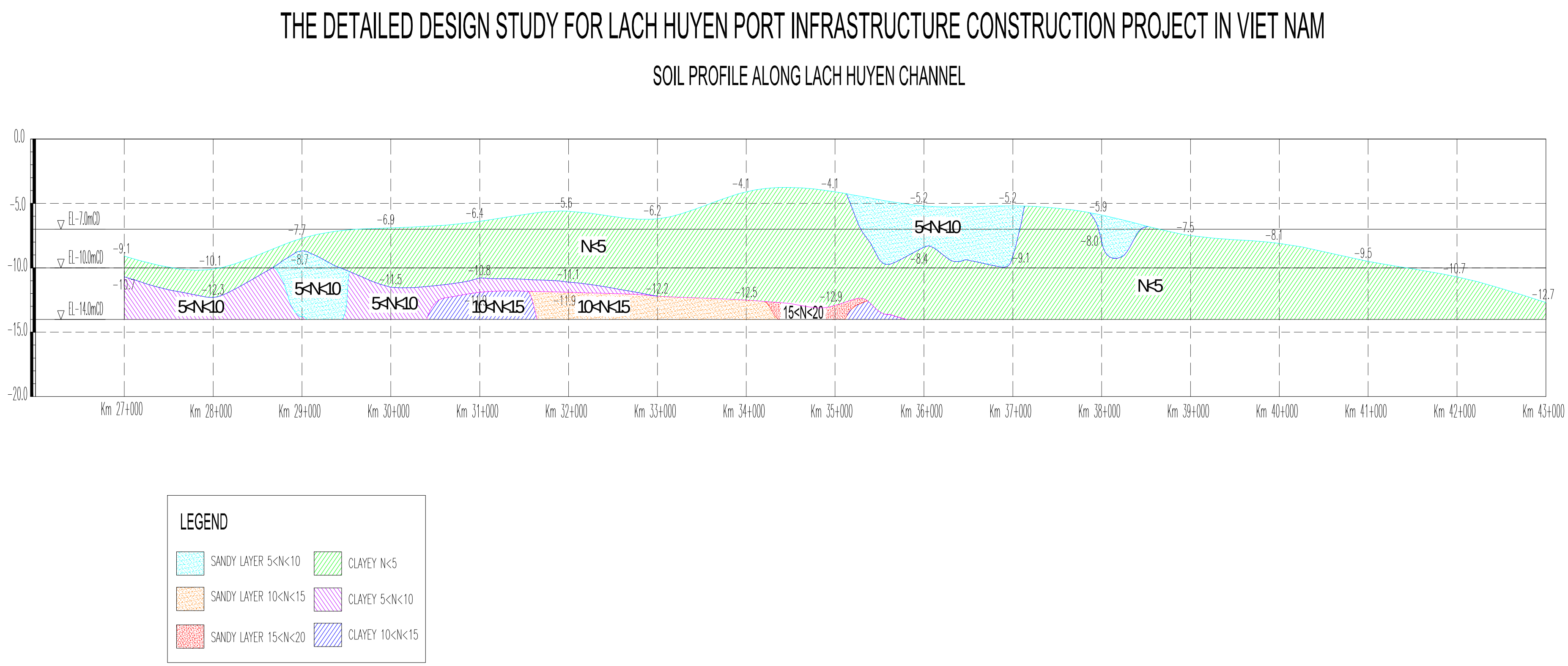


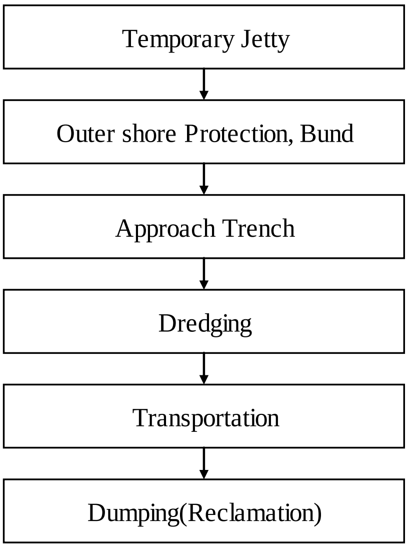
Figure 12.2.2 Subsoil Profile Along Channel

12.2.3 Study Condition

1) Dredging and Disposal Method

Construction (process) flow of the disposal of dredged soil is shown in Figure 12.2.3.

PLAN A, B, C



1) Temporary Jetty: Materials etc. Shallow draft quay & Yard

2) Temporary Jetty: Materials etc. Shallow draft quay & Yard

3) Approach Trench: Dredging for Hopper Barge

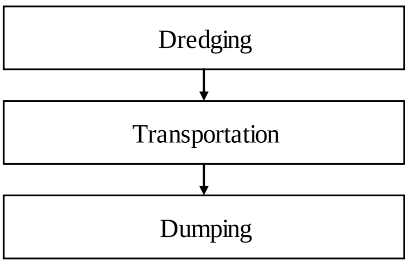
4) Dredging: Channel Dredging for Lach Huyen Port (-14M)

5) Transportation: From Channel to Dumping Area

6) Dumping: Secondary Pumping by CSD

7) Reclamation: Dredged soil executed in the Outer shore protection. (above 1)~2) is Vietnamese Portion)

PLAN D



1) Dredging: Channel Dredging for Lach Huyen Port (-14M))

2) Transportation: From Channel to Offshore Dumping Area

3) Dumping: Direct Dumping by barge & TSHD

Figure 12.2.3 Construction (Process) flow Chart

・Outline of the Construction Flow (Plan A.B.C)

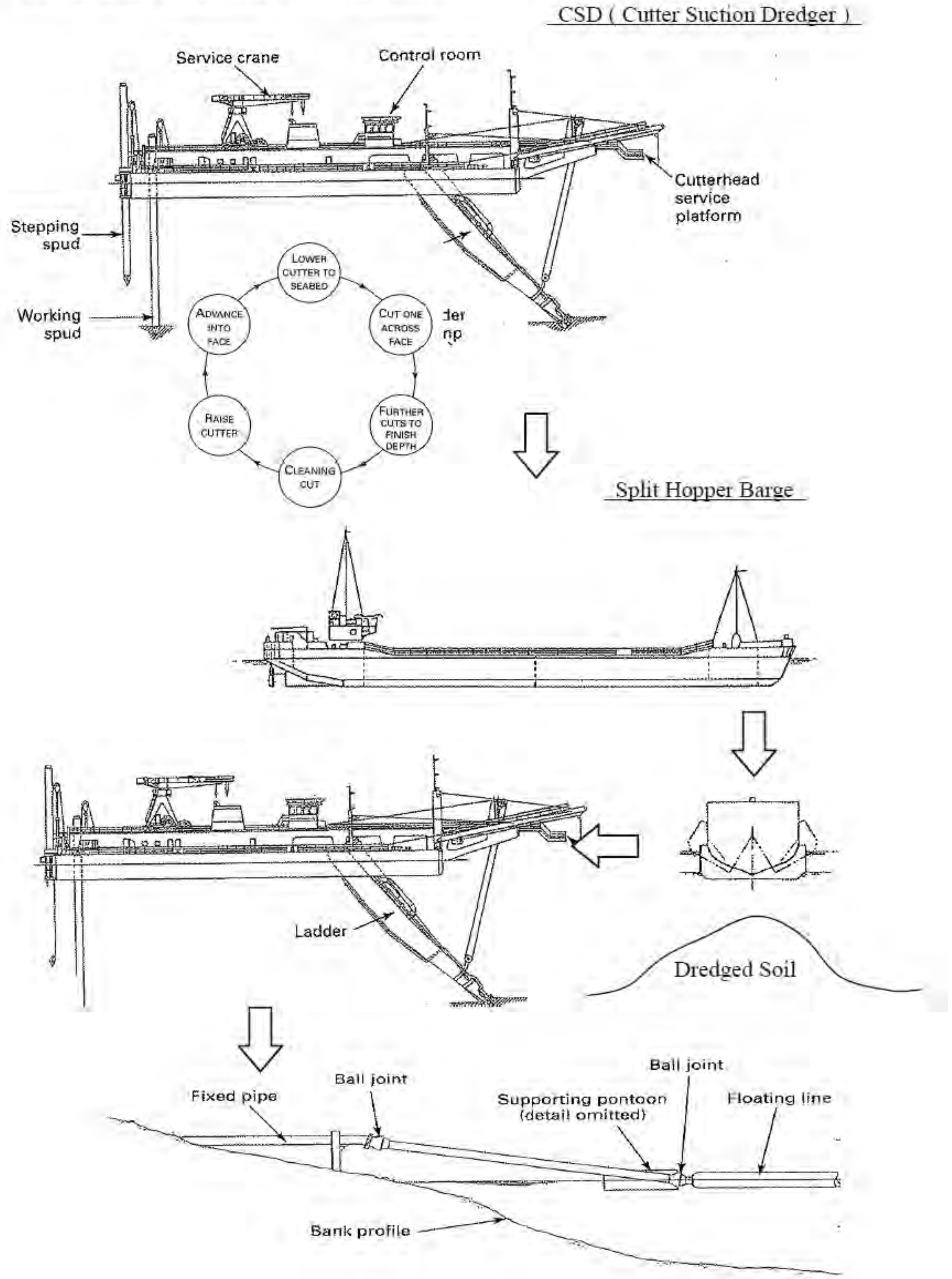


Figure 12.2.4 Flow Chart of the construction Procedure (Plan A, B, C)

• Outline of the Construction Flow (Plan D)

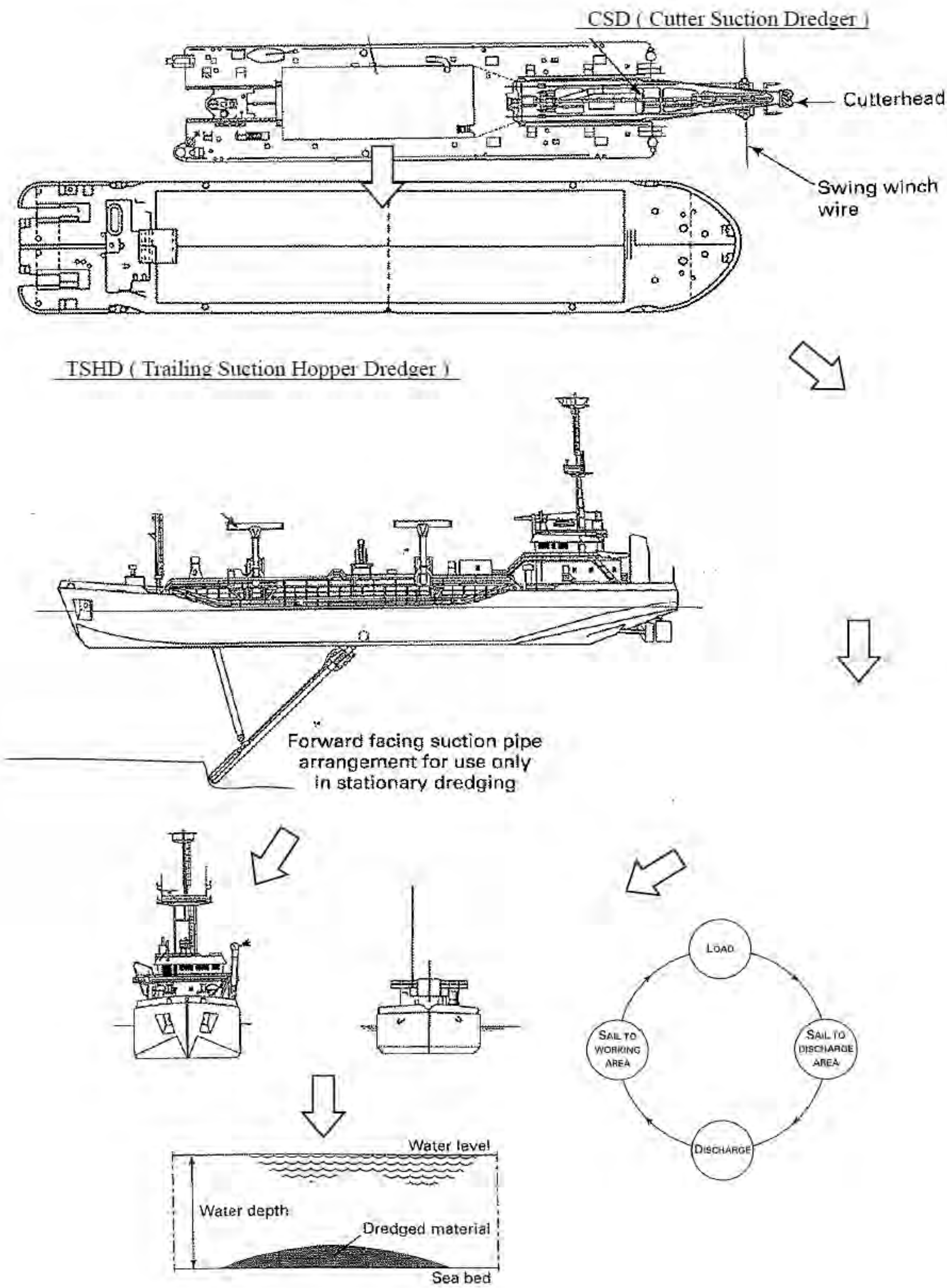


Figure 12.2.5 Flow Chart of the construction Procedure (Plan D)

2) Amount of Dredged Soil Dumping

When the design depth of the channel is -14mCD, the volume of dredging soil is 32,000,000 m^3 (SAPROF net.). When CSD and TSHD are used, the actual dredging volume is estimated to be

1.5 times of the design in consideration of the expansion ratio (dilatability). When grab dredger is used, it is 1.05 times.

3) Channel Dredging Period

The period of Channel dredging is estimated to be roughly 30 to 36 months.

4) Cost sharing of Disposal area

The construction of the outer revetment and any work related for reclamation by dredged soil at Plan A, B and C is a responsibility of Vietnamese side and it should be completed before the start of dredging work.

5) Soil improvement work for use as reclamation

Soil improvement work for the purpose of effective use of the dredged soil (pre and post, solidification, dehydration) is not covered in this study.

12.2.4 Outline of Evaluation

1) Southern Dinh Vu IZ (Plan A)

South Dinh Vu IZ is the disposal site adopted by SAPROF Study for which current EIA has been already approved by MONRE. Reclamation is scheduled and being implemented by the development Investor. Dinh Vu South is planned to be used for industrial zone development. Currently, the development investor is carrying out the reclamation with the purchased river sand, and environmental pollution problems have not been reported so far. Therefore, the construction of the outer revetment prior to the reclamation is not planned at the moment.

JICA Study Team obtained the outline of the development plan through hearing to Industrial Zone Developer as follows:

Table 12.2.2 Hearing survey result from IZ Developer (Site A)

1	Construction Time Schedule: The reclamation work is now undergoing and is re-scheduled to complete in 2017. Total reclamation is estimated about 54 million m^3 and 1.5million m^3 has been reclaimed at present for 100Ha area.
2	Construction of Embankment: So far, the construction of outer revetment prior to the reclamation is not planned and the embankment for reclamation is carried out in parallel with the progress of reclamation work.
3	Soil for Reclamation: The purchased river sand material is used for reclamation. So far, technical specification of reclamation material is not available for South Dinh Vu IZ Project.
4	Acceptance of Lach Huyen Channel Dredged Material: 1) Depending upon the quality of the dredged soil but suitable material complying Vietnamese standards for filling except for those of more than 10% of organic content is acceptable for reclamation. 2) Dredged soft clay with applying soil improvement method may be acceptable if the cost of such soils is reasonable. 3) Mud or soft clayey soil may be dumped for reclamation only for such designated area as future green areas.

So far, Commitment by Hai Phong PC or Southern Dinh Vu IZ owner has not been given to construct the temporary peripheral dyke for receiving dredged soil in time based on the construction time schedule of the Lach Huyen Project.

Soils suitable for fill materials for reclamation will be well-graded, free-draining sand with a particle size distribution in the range of 0.1 to 0.6mm. Since the dredged soil from Lach Huyen channel is mostly very soft muddy clayey soil mixed with much water through dredging operation by cutter suction dredger or other means, the dredged soil from access channel is not suitable for the use of reclamation unless such soil is subjected to proper soil improvement method for land reclamation which is decisively costly.

It will be concluded that,

(1) The soil dredged from Lach Huyen Channel will be unacceptable to the Dinh Vu

(2) South IZ Developer in technical view of judgment.

(3) There is no space other than very limited narrow areas for future green zone to reclaim the area within Dinh Vu IZ by the use of the dredged soil from Lach Huyen Channel Dredging which is mostly clayey soils mixed with much water through dredging operation.

(4) Dinh Vu South IZ shall be ready to receive very soft muddy soil for land reclamation through construction of necessary embankment, dumping channel dredged soil into Dinh Vu South IZ cannot be commenced which will cause serious delay in the construction schedule of the Project.

(5) Environmental Consideration

(6) EIA has already been approved by MONRE in October 2008.

(7) Construction Plan

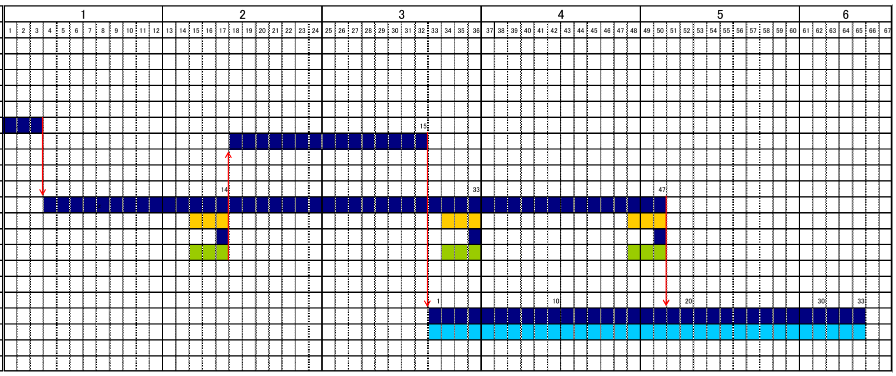
The possible dredging methods are as follows:

- Depending upon the depth of dredging, CSD (Cutter Suction Dredger) or Grab Dredger and/or TSHD (Trailing Suction Hopper Dredger dredges the channel seabed.
- The dredged soil by CSD or Grab is loaded directly into SHB and transported to landing spot for reclamation by the tugboat. It returns to the dredging site after each dumping.
- Landing of temporally dumped soil at landing spot is dredged by another CSD and discharged into reclamation area through discharge pipeline.

(8) Construction period: 65.0 months

Table 12.2.3 Time Schedule (Site A)

	Description	Unit	Quantity	Year / month
1	**Dredging**			
-1	Temporary Facility	Ls	1.0	
	1)Temporary Yard	m2	40,000.0	3.0
	2)Approachi trench	m3	8,480,000.0	15.0
-2	Dumping Yard	Ls	1.0	
	1)Shore protection &Bund	m	38,330.0	46.8
	2)Dreding Pipe	m	29,250.0	9.0
	3)Outret(Discharge)	m	750.0	3.0
	4)Geotextile	m2	38,330.0	9.0
-3	Dredging Work	Ls	1.0	
	1)Dredging Work	m3	31,870,000.0	33.3
	2)2nd Discharge	m3	31,870,000.0	33.3



Source: JICA Study team
Note: Above schedule indicates a case that soil disposal for approach trench is planed to dump at Southern Dinh Vu IZ.

(9) Construction Cost of Revetment: 12.93 bill. JPYen

Table 12.2.4 Construction Cost of Outer shore Protection & Bund (Site A)

Item		Length	Unit Price	Cost	Remark
Category	Type	(m)	(JPYen/m)	(JP Yen)	
Dyke	a	5,800.0	88,689.3	514,398,207	(average)
Outer Revetment (Seawall)	b	0.0		0	
Outer Revetment	c	10,330.0	831,301.6	8,587,345,906	(average)
Bund	d	22,200.0	172,383.3	3,826,909,645	(average)
TOTAL		38,330.0	337,298.6	12,928,653,758	(reference)

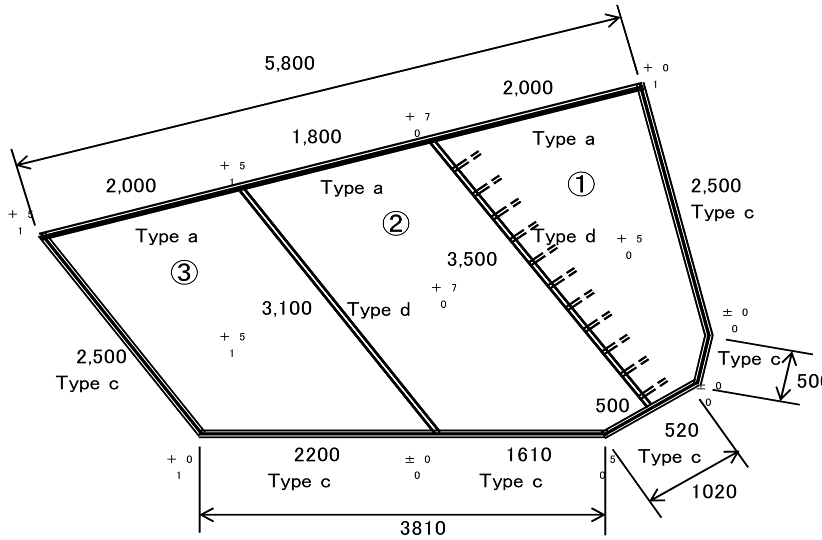


Figure 12.2.6 Reclamation Plan at Southern Dinh Vu IZ area

Dredged Soil Disposal Cost (1 VND = 0.00528Yen)

Construction Cost of Disposal site

a.	Temporary / Ancillary works	JPY 684,000,000 (Yen)
b.	Outer shore Protection, Bund	JPY 12,929,000,000 (Yen)

Dumping Cost of Dredged Soil

a.	Transportation Cost (silt protector)	JPY 1,237,000,000 (Yen)
b.	Secondary Discharge at Dumping.	JPY 12,550,000,000 (Yen)

2) Cat Hai South and Future Logistic Park Development Area (Plan B and C)

It is shallow sea area which extends from Nam Trieu estuary to the south of Cat Hai Island, and the seabed shows above water during low tide. Site Plan B (Cat Hai South) is designated as a disposal area by MOT Decision (March, 2011), and Haiphong PC has approved as well. EIA has not been applied for MONRE approval. About six months are required for the application and approval. It is necessary to carry out the monitoring on environmental impacts on surrounding water area caused by water contamination diffusion during dredging and land reclamation by secondary discharging into reclamation area of channel dredged soil. So far, there is neither decisive land-use development plan nor design for Cat Hai South reclamation except for development concept plan in relation to Cat Hai Economic Zone Development Plan.

Site Plan C is located in the West of Lach Huyen port container terminals and shallow seabed shows above water during low tide. At the time of previous studies in June 2009 and July 2010, reclamation of this area was proposed by Vietnamese side in order to develop a Logistic Park. The approval of development by MOT and Hai Phong PC is required as well as EIA by MONRE. When the Logistic Park area is developed, the soil improvement work for reclaimed soil by channel dredging as well as the existing subsoil is necessary.

Since the site locates immediately behind the outer revetment of the Project, the outer revetment of the Lach Huyen Port for the Project will be subject to the structure change due to the construction of the dumping area. However, the construction of revetment for the disposal area becomes the critical path and it needs to be constructed according to the progress of dredging and reclamation.

The dredging and dumping will be carried out in the following method:

- In the channel dredging, the dredged soil is loaded directly into SHB (Split Hopper Barge) by CSD (Cutter Suction Dredger) or Grab Dredger.
- The barge is towed to the temporary dumping basin by tugboat, and the soil is dumped.
- The dumped soil is again dredging by another CSD and pumped into the disposal area by discharge pipeline.

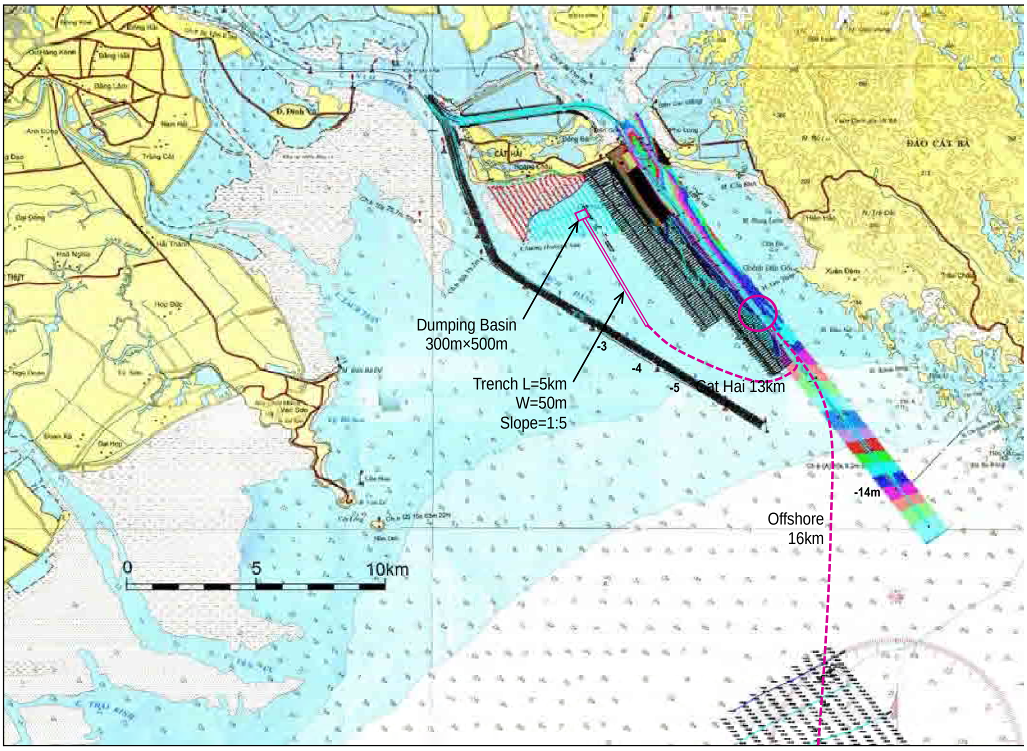


Figure 12.2.7 Construction plan

But, soil dredged by Cutter Suction Pump Dredger or other means is very soft clayey soils mixed with much water through dredging operation. In case of these two disposal sites, the peripheral embankment need to be constructed and be suitably protected from offshore sea wave actions (the same type of sea wall structure). The construction of the peripheral dyke is costly and requires relatively long period for completion. Dumping site may be divided into several sections with provision of parting walls so that dredged soil dumping could be commenced in advance before the whole completion of peripheral embankment.

In addition, temporary access passage for dredged soil transportation by barge needs to be constructed for discharging dredged soil into dumping site. The dredging of temporary passage way is costly and time spending as well.

Table 12.2.5 Summary of Concern (Site B/C)

(1)	The construction of peripheral embankment is required in view of protection of marine environment during dumping operation.
(2)	The Peripheral embankment is of seawall type of construction properly protected from offshore wave actions
(3)	The temporary passage way is mandatory to be dredged for barge transportation for discharging dredged soil into reclamation area.
(4)	The construction cost of temporary passage way for barge transportation is costly. (About ¥ 5 bill.)
(5)	The construction of the embankment may require additional financial arrangement by Vietnamese government own budget
(6)	The Project Time Schedule is seriously delayed.
(7)	Any land use development after reclamation must be very difficult

The distance of the dredged soil transportation is shorter compared to the Southern Dinh Vu IZ area, which will reduce the transportation cost of channel dredged soil for disposal.

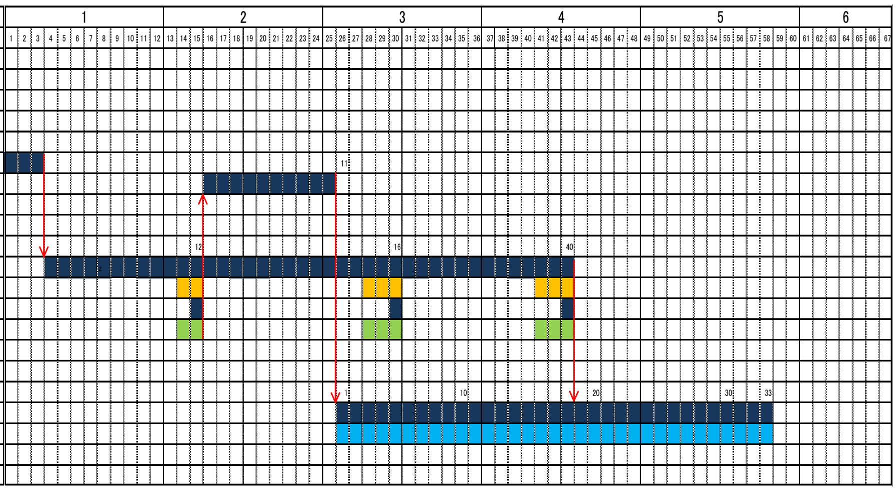
In addition, the cost of the outer revetment for the Lach Huyen port may be reduced because the disposal area and its revetment functions as outer revetment for the port. However, the construction of revetment for the disposal area becomes the critical path and it needs to be constructed according to the progress of dredging and reclamation.

a) Plan B: Cat Hai South

i) Construction period: 58.0 months

Table 12.2.6 Time Schedule (Site B)

	Description	Unit	Quantity	Year / month
1	**Dredging**			
-1	Temporary Facility	Ls	1.0	
	1)Temporary Yard	m2	40,000.0	3.0
	2)Approachi trench	m3	5,911,600.0	10.5
-2	Dumping Yard	Ls	1.0	
	1)Shore protection &Bund	m	32,550.0	39.8
	2)Dreding Pipe	m	23,400.0	8.0
	3)Outret(Discharge)	m	450.0	3.0
	4)Geotextile	m2	32,550.0	8.0
-3	Dredging Work	Ls	1.0	
	1)Dredging Work	m3	31,870,000.0	33.3
	2)2nd Discharge	m3	31,870,000.0	33.3



Source: JICA Study team
Note: Above schedule indicates a case that soil disposal for approach trench is planed to dump at Cat Hai south.

Dredged Soil Disposal Cost (1 VND = 0.00528Yen)

<u>Construction Cost of Disposal site</u>

a.	Temporary / Ancillary works	JPY 684,000,000	(Yen)
b.	Outer shore Protection, Bund	JPY 11,903,000,000	(Yen)

<u>Dumping Cost of Dredged Soil</u>

a.	Transportation Cost (silt protector)	JPY 1,237,000,000	(Yen)
b.	Secondary Discharge at Dumping.	JPY 12,610,000,000	(Yen)

ii) Construction Cost of Revetment: 11.90 bill. JPYen

iii) Construction Plan of Outer Revetment

The following is the preliminary design of outer revetment for reclamation area at Cat Hai South.

Table 12.2.7 Construction Cost of Outer shore Protection & Bund (Site B)

Item		Length	Unit Price	Cost	Remark
Category	Type	(m)	(JPYen/m)	(JP Yen)	
Dyke	a	6,050.0	113,198.1	684,848,326	(average)
Outer Revetment (Seawall)	b	2,200.0	703,753.8	1,548,258,466	(average)
Outer Revetment	c	7,800.0	858,773.2	6,698,431,244	(average)
Bund	d	16,500.0	180,111.5	2,971,840,492	(average)
TOTAL		32,550.0	365,695.2	11,903,378,528	(reference)

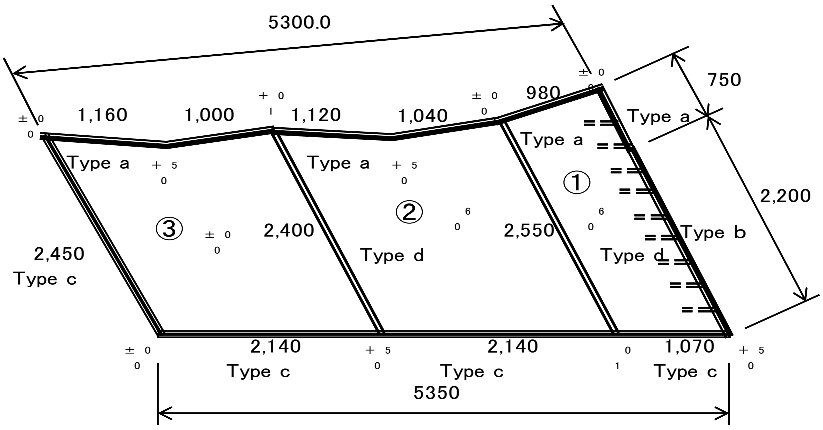


Figure 12.2.8 Outer Revetment Plan at Cat Hai Southern area

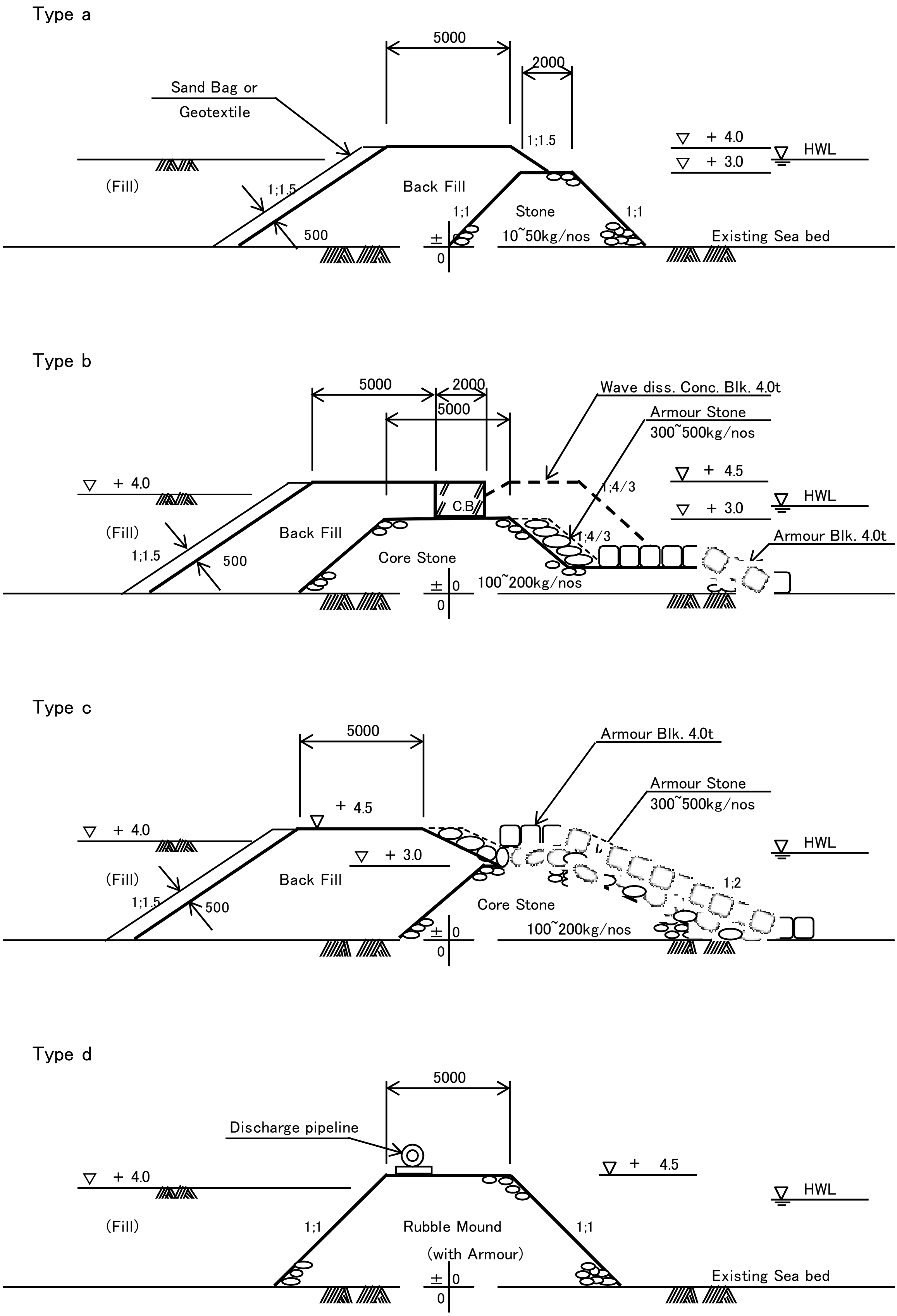


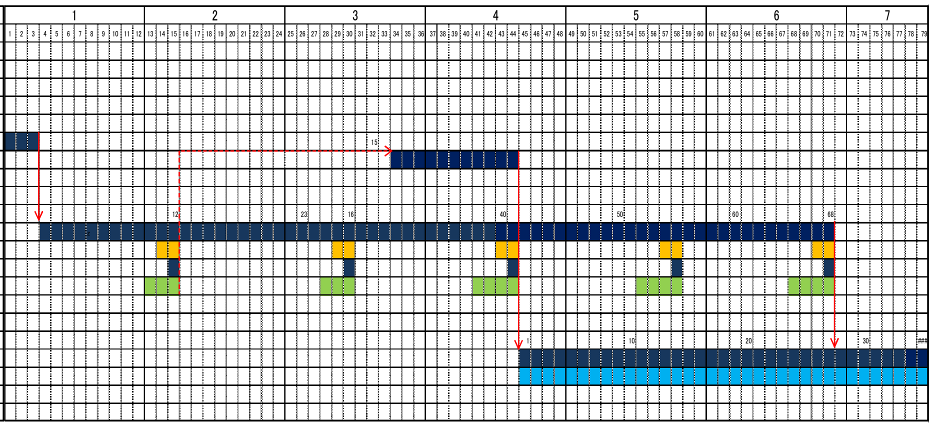
Figure 12.2.9 Typical Section of the Revetment

b) Plan C: Logistic Park (Lach Huyen port area)

i) Construction period: 79.0 months

Table 12.2.8 Construction schedule (Plan C)

	Description	Unit	Quantity	Year / month
1	**Dredging**			
-1	Temporary Facility	Ls	1.0	
	1)Temporary Yard	m2	40,000.0	3.0
	2)Approachi trench	m3	5,911,600.0	10.5
-2	Dumping Yard	Ls	1.0	
	1)Shore protection &Bund	m	37,100.0	67.6
	2)Dreding Pipe	m	19,350.0	10.0
	3)Outret(Discharge)	m	750.0	5.0
	4)Geotextile	m2	283,500.0	13.0
-3	Dredging Work	Ls	1.0	
	1)Dredging Work	m3	31,870,000.0	34.4
	2)2nd Discharge	m3	31,870,000.0	34.4



Source: JICA Study team
Note: Above schedule indicates a case that soil disposal for approach trench is planed to dump at Cat Hai south.

ii) Construction Cost of Revetment: 24.64 bill. JPYen

Dredged Soil Disposal Cost (1 VND = 0.00528Yen)

<u>Construction Cost of Disposal site</u>

a.	Temporary / Ancillary works	JPY 684,000,000	(Yen)
b.	Outer shore Protection, Bund	JPY 24,636,000,000	(Yen)

<u>Dumping Cost of Dredged Soil</u>

a.	Temporary Cost (Silt Protector)	JPY 1,237,000,000	(Yen)
b.	Secondary Discharge at Dumping.	JPY 14,480,000,000	(Yen)

3) Offshore area (From Lach Huyen port area 20-25kmSSE, offshore area)

JICA Study Team selected possible/potential offshore dumping site at a distance 10km (13Km at the center) west from Cat Ba archipelagoes. Sea bed depth is -20mCD or deeper. So far, dredging cost is estimated JP ¥ 28.0 ~ 35.0 bills. and the dredging and disposal of dredged soil required 33 months (excluding preparation work).

The dredging methods are as follows:

- Depending upon the depth of dredging, CSD (Cutter Suction Dredger) or Grab Dredger and/or TSHD (Trailing Suction Hopper Dredger dredges the seabed.
- When CSD or Grab dredger is used, the dredged soil is loaded directly into SHB and the barge is towed to offshore dumping site by the tugboat for disposal. When TSHD is used, the soil is loaded into own hopper and sails to the offshore dumping area by itself.
- After dumping dredged soil SHB or TSHD returns to the dredging site.

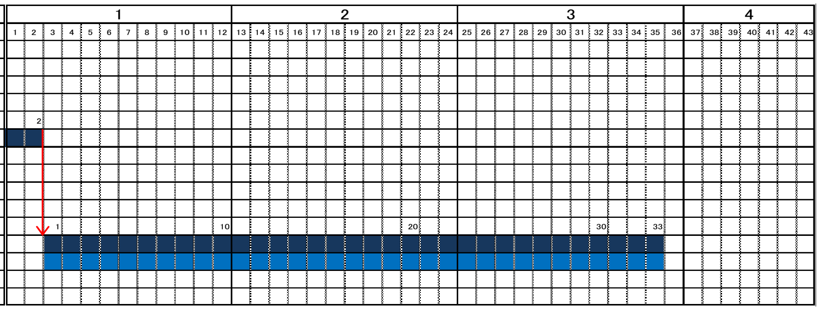
a) Environmental Consideration

About six months are required for the application to and approval by MONRE. It is necessary to carry out the monitoring on the impacts on ecosystem and natural environment by water contamination due to dredging and offshore dumping operation.

b) Construction period: 35.0 months

Table 12.2.9 Time Schedule (Site D)

	Description	Unit	Quantity	Year / month
1	Dredging			
−1	Temporary Facility	Ls	1.0	
	1)Temporary Work	Ls	1.0	2.0
−2	Dumping Yard	Ls	0.0	
−3	Dredging Work	Ls	1.0	
	1)Dredging Work	m3	32,000,000.0	33.0
	2)Transportation Work	m3	32,000,000.0	33.0



As explained in EIA, Offshore Dumping is least risk to impact on invaluable marine ecology.

"Offshore Dumping" of the dredged soil is practical way for disposing dredged soil and most feasible for the Project in technical and economical view in construction as far as the impact on environment at and around the site shall be minimized.

c) Construction Cost of Revetment: Nil

Dredged Soil Disposal Cost (1 VND = 0.00528Yen)

Construction Cost of Disposal site

a.	Temporary / Ancillary works	– Nil –
b.	Outer shore Protection, Bund	– Nil –

Dumping Cost of Dredged Soil

a.	Temporary Cost (Silt Protector)	JPY 2,553,000,000 (Yen)
b.	Dumping Cost	– Nil –

4) Environmental Consideration

In case of disposal of channel dredged soil into Alternative site B, C and D, about six months are required for the application and approval of EIA. It is necessary to carry out the monitoring of ecosystem, pollution in natural environment, water contamination diffusion as well as the consideration to the fisheries and tourism. The following table shows the comparison for the environmental consideration.

Table 12.2.10 Summary of Environmental Consideration

	Site	subject
SS dispersion simulation	**A**	Dispersion pattern is considered as same as for Cat Hai southern area.
	B/C	Sediment dispersion will be significantly large due to excessive work load and discharge of turbid water from effluent outlet.
	D	Sediment dispersion will spread widely in east-west direction from dumping center.
Biological Environment	**A**	Insufficient information to describe
	B/C	Field survey results indicate that the near shore areas have higher ecological value compared to the offshore area.
	D	Field survey results indicate that the offshore area has lower ecological value compared to the near shore areas.
Social Environment	**A**	Insufficient information to describe
	B/C	Results of SS dispersion simulation indicate that disposal in the near shore area could have significant impacts on tourism through elevated levels of SS.
	D	Results of SS dispersion simulation indicate that disposal in the offshore area will have less impacts (on tourism) compared to disposal in the near shore areas.

The preliminary simulation carried out in this detail design study shows that the soil diffusion caused by dredged soil disposal is limited within the vicinity nearby the disposal area (see Figure 12.2.10, Figure 12.2.11 and Figure 12.2.12).

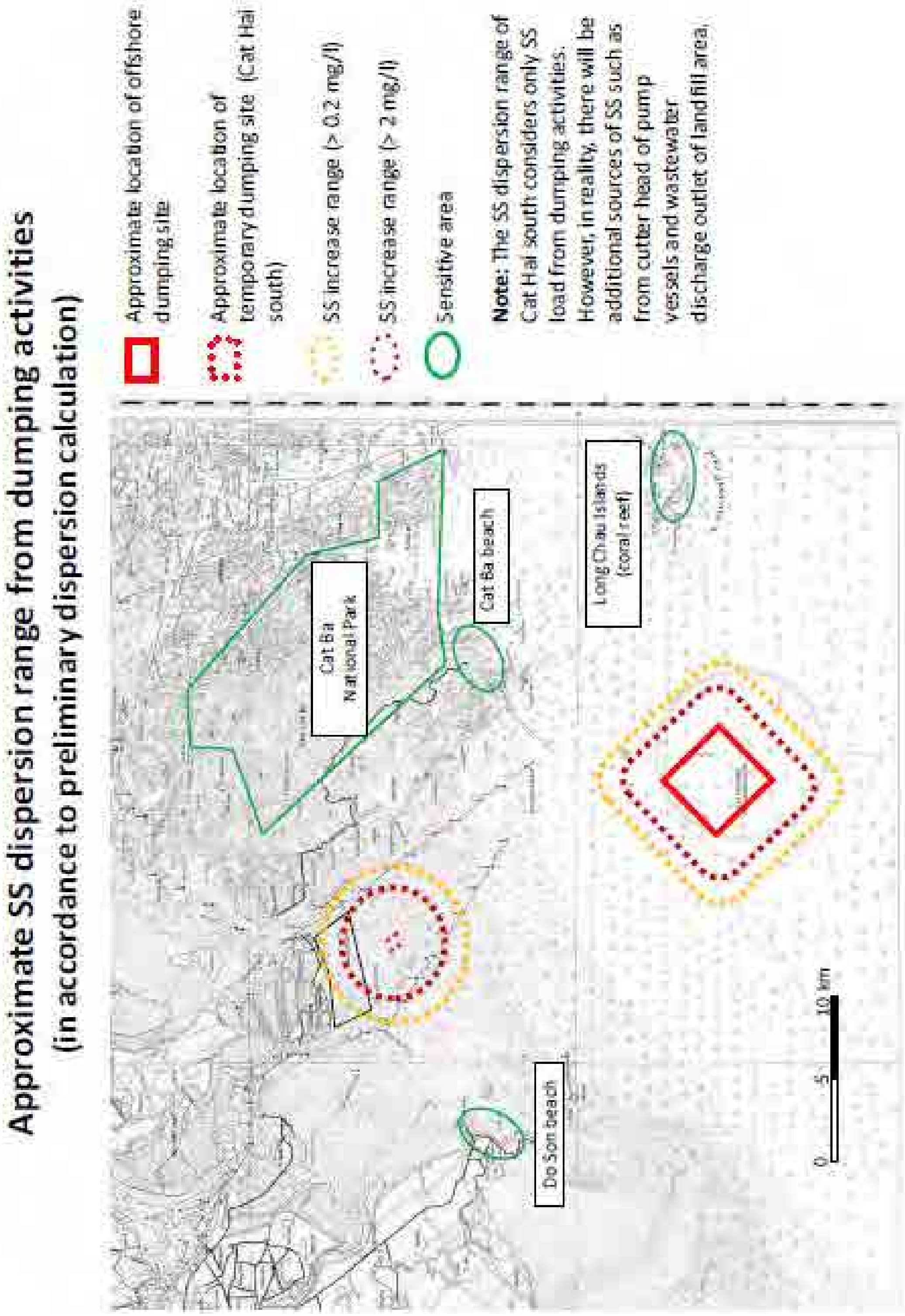
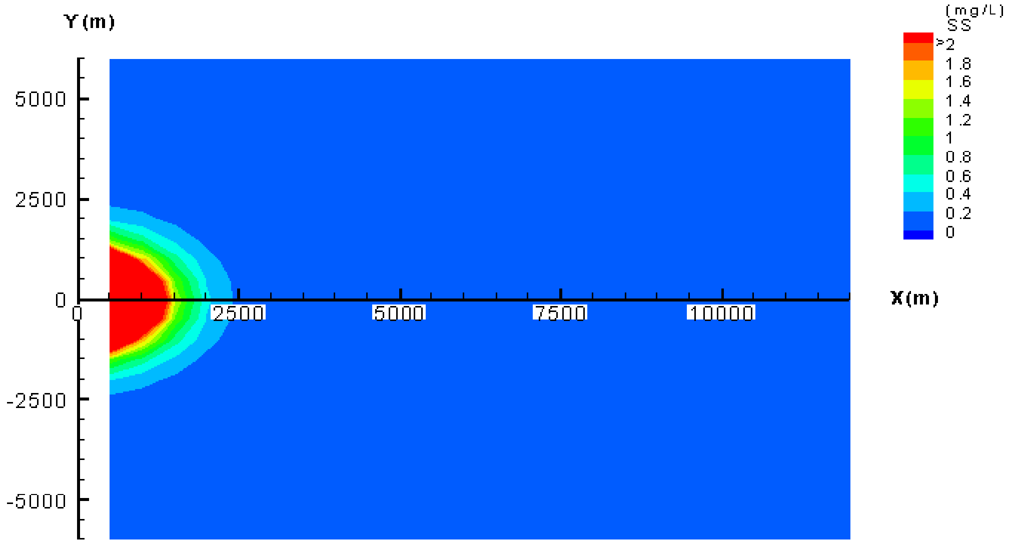
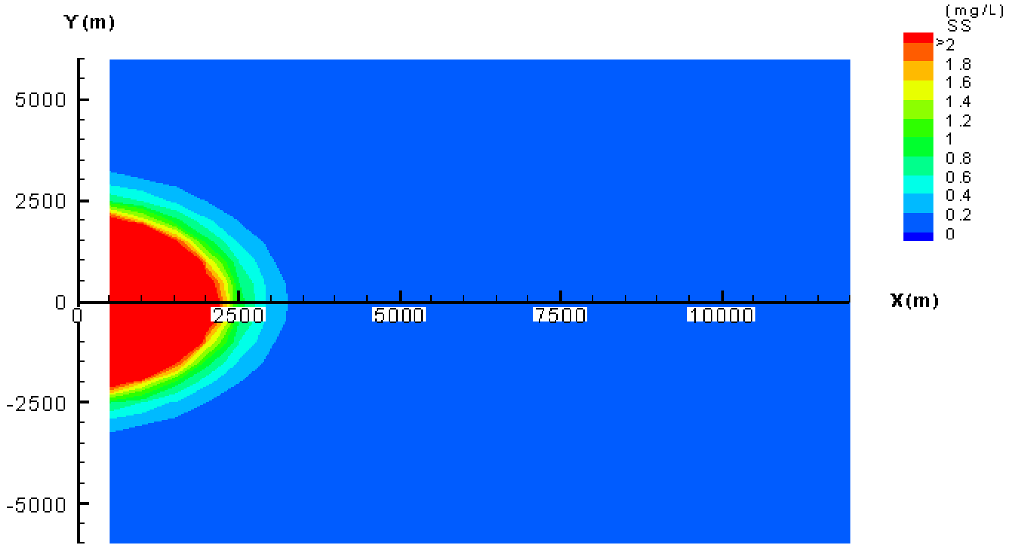


Figure 12.2.10 Approximate SS Dispersion

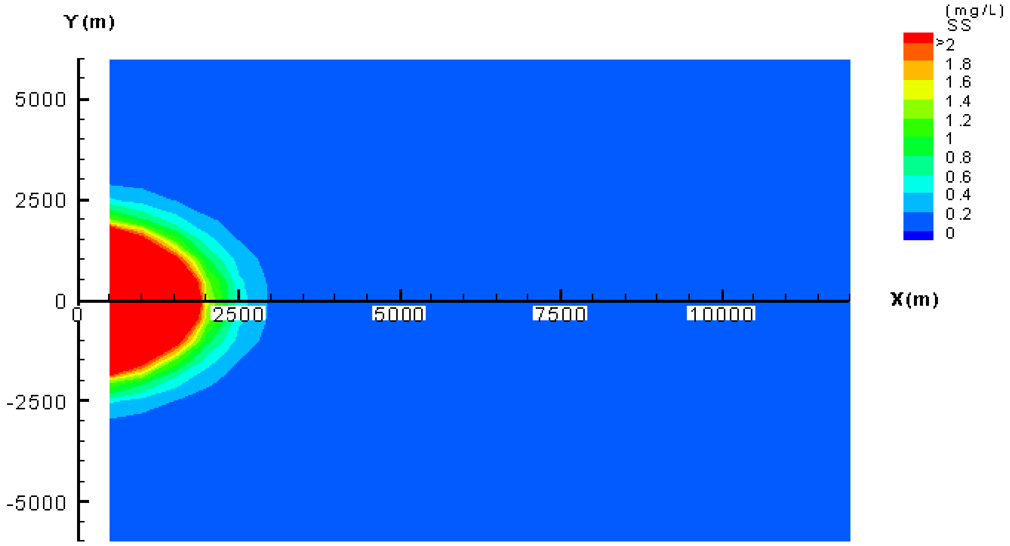


Case 1 Current speed: 0.4 m/s (max. speed recorded at St. V4 of SAPROF),
Diffusion speed: 100 m2/s, Dumping volume: 3,000 m^3/h

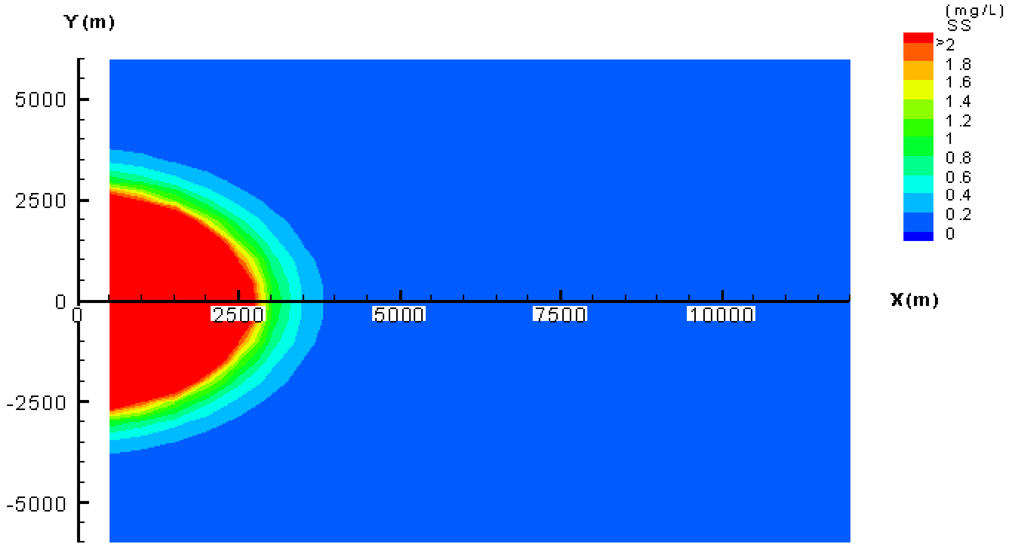


Case 2 Current speed: 0.065 m/s (average speed recorded at St. V4 of SAPROF),
Diffusion speed: 16 m2/s, Dumping volume: 3,000 m^3/h

Figure 12.2.11 Results of Preliminary SS Dispersion Calculation (1/2)



Case 3 Current speed: 0.4 m/s (max. speed recorded at St. V4 of SAPROF),
Diffusion speed: 100 m2/s, Dumping volume: 10,000 m^3/h



Case 4 Current speed: 0.065 m/s (average speed recorded at St. V4 of SAPROF),
Diffusion speed: 16 m2/s, Dumping volume: 10,000 m^3/h

Note: Does not consider sedimentation process
Does not consider effects of wave
Considers only single layer
Particle size: data of offshore boring site (SAPROF)

Figure 12.2.12 Results of Preliminary SS Dispersion Calculation (2/2)

5) Summary and Conclusion

a) Overall Evaluation

i) Economic efficiency

When only the costs of construction are compared among the four Plans, Plan D of the offshore dumping method is the most economical.

ii) Construction period

As for Plan A and Plan B, the construction of outer embankment for the disposal area must be completed before dredging starts. Otherwise, the Project will seriously delay for the commencement of Container Terminal operation which is scheduled to start within the year 2015.

In Plan C, the outer revetment and the sand protection dyke have to be constructed concurrently, and shortening the construction period will be unrealistic. The Project will seriously delay for the commencement of Container Terminal operation.

iii) Environment and others

The existing material in the planned dredging area is categorized as soft clayey soil. As it turns into weak soil (with high void ratio) during dredging operation by CSD (Cutter Suction Dredger), it is not suitable for reclamation material. Therefore, if the dredged soil has to be used as landfill material, the soil stabilization and soil improvement work will become inevitable in order for the required physical character and mechanical strength of soil to be secured (Additional costs is expected to come out sometime after completion of the project).

On the other hand, reclamation may create natural resource such as mangrove forest along the shore lines. This will bear some benefit in consequence and has favorable aspect than offshore dumping which does not create any natural resource.

b) Specific Remarks for Each Alternative Site

Site A : Southern Dinh Vu IZ

Preparation of Temporary Dyke is accordance with the plan and the schedule of the Lach Huyen Project.

- Commitment by Hai Phong City PC or Guarantee by MOT to be confirmed as agreed with JICA Mission on June 2010.
- Dredged material without such measures as to improve soil by Pre - or post soil improvement shall be accepted by Private Developer for use as land reclamation.
- Unless the embankment shall be constructed in advance before the commencement of JICA Project, the Project Time Schedule will be seriously delayed.
- Any works related to reclamation shall be borne by Private Developer.

Site B/C: Offshore for Cat Hai South/Future Logistic Park

- The embankment and other work related to reclamation shall be executed by Vietnamese own budget.
- Construction of the perimeter dyke for receiving dredged soil shall be done in time for the construction scenario of the Project. Unless the embankment shall be constructed in advance before the commencement of JICA Project, the Project Time Schedule will be seriously

delayed.

- The construction of temporary passage way for barge and disposal operation is estimated very Costly.
- The Land Owner or User accepts very weak clayey soil because the dredged material must be very weak cohesive soil unsuitable for reclamation.
- Dumping in the near shore areas are likely to have significant impacts on natural, biological and social environment, as dumping activities and wastewater discharge from the landfill area will generate significant amounts of SS.

Site D : Offshore Dumping Site

- Most practical way in view of economy and time schedule in construction.
- Least risks to impact on invaluable marine ecosystem.
- Minimum requirements to guarantee income & livelihood restoration for Project affected people.
- Relatively simple & easy counter measures to control SS dispersion.
- Dumping in the offshore areas are likely to have relatively less significant impacts on natural, biological and social environment compared to dumping in the near shore areas, thus is recommended from an environmental perspective.

c) Summary of Construction Cost

Table 12.2.11 Summary of Construction Cost

(1VND = 0.00528 YEN)

Items			Unit	Quantity	Amount	Dredging & Reclamation			Dredging & Dumping	Remark
						A. Southern Dinh Vu IZ	B. Cat Hai island Southern Sea	C. Logistic Park	D. Offshore area	
Disposal Site Construction	1	Temp. Jetty	m2	40,000.0	VND	129,545,454,545	129,545,454,545	129,545,454,545		200m*200m
					(YEN)	684,000,000	684,000,000	684,000,000		
	2	Shore Protection & Bund	m	(*Remark)	VND	2,448,674,242,424	2,254,356,060,606	4,665,909,090,909		A = 38330m, B = 32550m,
					(YEN)	12,929,000,000	11,903,000,000	24,636,000,000		C = 37100m
Dredging soil Disposal	3	Temp. Cost (Silt Protector)	m	(*Remark)	VND	234,280,303,030	234,280,303,030	234,280,303,030	483,522,727,273	A/B/C=(3000m+1800m)*2,
					(YEN)	1,237,000,000	1,237,000,000	1,237,000,000	2,553,000,000	D = 5000m*4
	4	Approach trench	m3	(*Remark)	VND	1,344,696,969,697	937,500,000,000	937,500,000,000	0	A =8480000m3,
					(YEN)	7,100,000,000	4,950,000,000	4,950,000,000	0	B/C = 5,222000m3
	5	Dredging	m3	31,870,000.0	VND	7,062,500,000,000	5,871,212,121,212	5,293,560,606,061	5,293,560,606,061	
					(YEN)	37,290,000,000	31,000,000,000	27,950,000,000	27,950,000,000	
	6	Dumping	m3	31,870,000.0	VND	2,376,893,939,394	2,388,257,575,758	2,742,424,242,424	0	Secondary Discharge at
					(YEN)	12,550,000,000	12,610,000,000	14,480,000,000	0	dumping
Sub Total	I	Vetnam Portion			VND	6,534,090,909,091	5,943,939,393,939	8,709,659,090,909	0	
					(YEN)	34,500,000,000	31,384,000,000	45,987,000,000	0	
	II	JICA Loan			VND	7,062,500,000,000	5,871,212,121,212	5,293,560,606,061	5,777,083,333,333	
					(YEN)	37,290,000,000	31,000,000,000	27,950,000,000	30,503,000,000	
Total (I + II)					VND	13,596,590,909,091	11,815,151,515,152	14,003,219,696,970	5,777,083,333,333	
					(YEN)	71,790,000,000	62,384,000,000	73,937,000,000	30,503,000,000	
Reduced amount ※					VND	0	637,310,606,061	1,784,469,696,970	0	
					(YEN)	0	3,365,000,000	9,422,000,000	0	
Grand Total					VND	13,596,590,909,091	11,177,840,909,091	12,218,750,000,000	5,777,083,333,333	
					(YEN)	71,790,000,000	59,019,000,000	64,515,000,000	30,503,000,000	
Reclaimed area			m2			14,865,000.0	24,103,000.0	10,595,000.0	0.0	

※ Cost reduced (depends on a structural change) by constructing disposal site shore protection.

Plan A

A. Southern Dinh Vu IZ		milion VND
Temp. Jetty		129,545
Shore Protection		2,448,674
Temp. Cost		234,280
Approach trench		1,344,697
Dredging		7,062,500
Dumping		2,376,894
	Ⅰ.Vetnam	6,534,091
	Ⅱ.JICA	7,062,500
	T.（Ⅰ+Ⅱ）	13,596,591
	Reduce	0
	Grand T.	13,596,591
(A−D)/Reclaimed area	(VND/m2) =	526,035
(G.T−Ⅱ)/Reclaim. area	(VND/m2) =	439,562
G.T/Reclaimed area	(VND/m2) =	914,671

Plan B

B. Cat Hai island Sout.		milion VND
Temp. Jetty		129,545
Shore Protection		2,254,356
Temp. Cost		234,280
Approach trench		937,500
Dredging		5,871,212
Dumping		2,388,258
	Ⅰ.Vetnam	5,943,939
	Ⅱ.JICA	5,871,212
	T.（Ⅰ+Ⅱ）	11,815,152
	Reduce	637,311
	Grand T.	11,177,841
(B−D)/Reclaimed area	(VND/m2) =	224,070
(G.T−Ⅱ)/Reclaim. area	(VND/m2) =	220,165
G.T/Reclaimed area	(VND/m2) =	463,753

Plan C

C. Logistic Park		milion VND
Temp. Jetty		129,545
Shore Protection		4,665,909
Temp. Cost		234,280
Approach trench		937,500
Dredging		5,293,561
Dumping		2,742,424
	Ⅰ.Vetnam	8,709,659
	Ⅱ.JICA	5,293,561
	T.（Ⅰ+Ⅱ）	14,003,220
	Reduce	1,784,470
	Grand T.	12,218,750
(C−D)/Reclaimed area	(VND/m2) =	607,991
(G.T−Ⅱ)/Reclaim. area	(VND/m2) =	653,628
G.T/Reclaimed area	(VND/m2) =	1,153,256

i) (A-D)/Reclaimed area (VND/m^2)

This unit cost is calculated as the cost difference between Plan A (original) and Plan D divided by the area of reclamation, which indicates the additional cost per square meter required in case when the construction of disposal site is included in the project.

ii) (Grand Total – JICA Loan)/Reclaimed area (VND/m^2)

This unit cost is calculated as the cost difference between Grand Total and JICA Loan divided by the area of reclamation, which indicates the unit cost per square meter in case when the reclamation cost is not included in the project cost (included in Vietnamese portion).

iii) Grand Total/Reclaimed area (VND/m^2)

This unit cost is calculated for simple cost comparison among Plan A, Plan B and Plan C. The Grand Total of the each Plan is the all of the cost in relation to the dredging and reclamation including additional/reduced cost borne by design change etc.

Table 12.2.12 Comparative Evaluation

Items							
1	Study condition	・Amount of Dredging Soil	1) Amount of Dredging Soil when sea route depth is assumed to be -14M V＝32,000,000 m3 （SAPROF Net） 2) As for the amount of the dredging soil, when CSD and TSHD are used, it is 1.5 times the amount of the dredging soil in consideration of the system change rate (dilatability). Moreover, it is 1.05 times at the glove ship.				
		・Dredging Period	1)The period of construction is assumed 2015 from 2013. Dredging is estimated roughly 30 to 36months.			(CSD: Cutter Suction Dredger, TSHD: Trailing Suction Hopper Dredger, GD: Grab Dredger)	
2	Outline of Disposal Area	Location	A. Southern Dinh Vu IZ Region	B. Cat Hai island Southern Sea Region	C. Logistic Park	D. Offshore area	Combined B/C+ D
		・Location of Possible/ Potential Sites					
		・Outline	・Reclamation is scheduled by the development Investor, and planned to be completed in 2017.They use river sand. Outer embankments are built to suit the progress of the landfill.	・Shallow sea area that extends to Nam Trieu estuary, south of Cat Hai island. It becomes a tidal flat at low water.	・Western hinterland container terminals, the tide was low tide and tidal flat areas.	・Offshore area is located from Cat Ba island and the small islands to about 10km west. Sea bed is gentle and depth is -20M or more.	・See B/C & D (combined)
		・Original Ground level	CDL. -0.5M～+0.8M	CDL. -1.0M～+0.5M	CDL. -2.8M～+0.5M	CDL. -20.0M～-25.0M	CDL. -20.0M～-25.0M & '-2.0M～+0.5M
		・Area / Ground level	S = 14,865,000 m2 / H =＋ 4.0m	S = 14,102,000 m2 / H =＋ 4.0m	S = 10,595,000 m2 / H =＋ 4.0m	S = 25,000,000 m2 / H = － 20m ～－ 25m	S = 25,000,000 / 2,520,000 m2 / H = 20m ～－ 25m / +4.0m
		・Capacity	V = 48,841,245 m3	48,576,002 m3	V = 48,404,686 m3	V = 75,000,000 m3	V = 75000000 / 9,995,000 m3
		・Land-use Plan on disposal area	・Plans to develop Industrial Zone. IZ Developer only suitable materials for reclamatio could be acceptable.	・Soil improvement work is unnecessary when there is no development plan.	・When the Logistic Park is developed, the soil improvement work including the existing ground is necessary.	・There is no plan concerning effective use for the Offshore area.	・See B/C & D (combined)
3	Disposal Site Construction	・Construction cost (bilion YEN)	1) Temporary Jetty 6.84 2) Outer Shore Protection & Bund 129.29	1) Temporary Jetty 6.84 2) Outer Shore Protection & Bund 119.03	1) Temporary Jetty 6.84 2) Outer Shore Protection & Bund 246.36	1) Temporary Jetty Nil 2) Outer Shore Protection & Bund Nil	1) Temporary Jetty 6.84 2) Outer Shore Protection & Bund 47.33
		・Construction period	1) Temporary works (3.0 months) 2) Start of Dredging works (From beginning) (18.0 months) （Construction period) (65.0 months)	1) Temporary works (3.0 months) 2) Start of Dredging works (From beginning) (16.0 months) （Construction period) (58.0 months)	1) Temporary works (3.0 months） 2) Start of Dredging works (From beginning) (34.0 months） （Construction period) (79.0 months）	1) Temporary works (Nil ） 2) Start of Dredging works (From beginning) (2.0 months） （Construction period) (35.0 months）	1) Temporary works (3.0 months） 2) Start of Dredging works (From beginning) (2.0 months） （Construction period) (35.0 months）
		・Remarks	1) Construction cost not included in the Projyect cost by SAPROF study	1) Construction cost not included in the Projyect cost by SAPROF study 2) Shore protection A&B and Sand dike should be change the design, because of adiacent to the Disposal area.	1) Construction cost not included in the Projyect cost by SAPROF study 2) Shore protection A&B and Sand dike should be change the design, because of adiacent to the Disposal area.		1) Construction cost not included in the Projyect cost by SAPROF study 2) Shore protection A&B and Sand dike should be change the design, because of adiacent to the Disposal area.
4	Dredging soil disposal cost	・Construction cost (bilion YEN)	1) Temporary Cost (Silt protector) 12.37 2) Secondary Discharge at Dumping 125.50	1) Temporary Cost (Silt protector) 12.37 2) Secondary Discharge at Dumping 126.10	1) Temporary Cost (Silt protector) 12.37 2) Secondary Discharge at Dumping 144.80	1) Temporary Cost (Silt protector) 25.00 2) Secondary Discharge at Dumping Nil	1) Temporary Cost (Silt protector) 20.67 2) Secondary Discharge at Dumping 41.88
		・Disposal cost	relatively high	relatively high	relatively high	reasonable	relatively high
5	Environmental consideration	・Permits	1) EIA requirement confirmed (MONRE: Oct.2008) 2) MOT & HPPC approved (Decision 476 QD-BGTVT)	1) EIA requirement Need EIA approval (6month to obtain) 2) MOT & HPPC approval(roughiy 3-6manths,then EIAapproval)	1) EIA requirement Need EIA approval (6month to obtain) 2) MOT & HPPC approval(roughiy 3-6manths,then EIAapproval)	1) EIA requirement Need EIA approval (6month to obtain) 2) MOT & HPPC approval(roughiy 3-6manths,then EIAapproval)	1) EIA requirement Need EIA approval (6month to obtain) 2) MOT & HPPC approval(roughiy 3-6manths,then EIAapproval)
		・SS dispersion simulatio	・SS dispersion simulation is not carried out. However, dispersion pattern is considered as same as for Cat Hai southern area..	・According to SS dispersion simulation, sediment dispersion will be significantly large due to excessive work load and discharge of turbid water from effluent outlet.	・SS dispersion simulation is not carried out. However, dispersion pattern is considered as same as for Cat Hai southern area..	・According to SS dispersion simulation, sediment dispersion will spread widely in east-west direction from dumping center.	・See B/C & D (combined)
		・Biological Environment	・Insufficient information to describe	・Field survey results indicate that the nearshore areas have higher ecological value (e.g. higher species diversity and abundance, presence of nursery ground) compared to the offshore area. ・ Results of SS dispersion simulation indicate that disposal in the nearshore area could have significant impacts on valuable marine habitats.		・Field survey results indicate that the offshore area has lower ecological value (e.g. lower species diversity and abundance) compared to the nearshore areas. ・ Results of SS dispersion simulation indicate that disposal in the offshore area will have less impacts on valuable marine habitats compared to disposal in the nearshore area.	・See B/C & D (combined)
		・Social Environment	・Insufficient information to describe	・ Impact could be significant as the adjacent area is a primary fishing area for Cat Hai and Cat Ba fishermen. ・ Livelihood recovery program shall be considered and approved by the affected people and implemented before the construction. ・ Impact could be significant as the coastal water is the only source of both aquaculture and salt production. Contamination of coastal water shall be avoided. ・ Counter measures for avoiding degradation of water quality shall be considered. In case of no economical and technical measures, livelihood recovery program shall be considered and approved by PAP and implemented before the construction. ・ Results of SS dispersion simulation indicate that disposal in the nearshore area could have significant impacts on tourism through elevated levels of SS.		・ Impact should be less significant compared to the nearshore area, as the adjacent area is not a primary offshore fishing area. ・ Results of SS dispersion simulation indicate that disposal in the offshore area will have less impacts compared to disposal in the nearshore areas. ・ Results of SS dispersion simulation indicate that disposal in the offshore area will have less impacts on tourism compared to disposal in the nearshore areas.	・See B/C & D (combined)
		・conclusion	・Insufficient information to describe	・ Dumping in the nearshore areas are likely to have significant impacts on natural, biological and social environment, as dumping activities and wastewater discharge from the landfill area will generate significant amounts of SS. ・ While dumping in the nearshore areas are not recommended from an environmental perspective, if unavoidable, effective countermeasures must be implemented to minimize impacts (e.g. installation of silt curtain, control of wastewater discharge, implementation of livelihood recovery programs).		・Dumping in the offshore areas are likely to have relatively less significant impacts on natural, biological and social environment compared to dumping in the nearshore areas, thus is recommended from an environmental perspective. ・ Nevertheless, certain impacts are likely and hence effective countermeasures must be implemented to minimize sediment dispersion (e.g. installation of silt curtain).	・See B/C & D (combined)
6	Evaluation	・Evaluation comment of total Cost (Dredging to Dumping)	・Not applicable unless the commitment for recieval of very soft muddy dredged soil	・Not practical the time extension of construction required unless the dumping site shall be ready for dredged soil dumping before the commencement of the port portion construction.	・Not practical the time extension of construction required unless the dumping site shall be ready for dredged soil dumping before the commencement of the port portion construction.	・Best Solution and recommended	・Not practical the time extension of construction required unless the dumping site shall be ready for dredged soil dumping before the commencement of the port portion construction.
		・Comprehensive evaluation	・The construction cost and the construction period are compared, and the environmental impact is considered, most effective method is to the Offshore dumping of dredged soil. It is also possible to turn on a part of the dredged soil to Idea B, if the disposal area is maintained by Vietnam portion. However, it is necessary to have completed the shore protection etc. before it begins to construct this project in that case.				
			Not Applicable	**Not Practical**	**Not Practical**	**Recommended**	**Not Practical**

12.2.5 Dumping Site In Combination (Offshore and Cat Hai South Area)

The study is carried out for channel dredged soil disposal into two (2) sites in combination, i.e. land filling into Cat Hai area (Alternative Site) and Offshore dumping area (Alternative D). The study covers an examination on dredge plan (schedule) and construction cost.

1) Outline of Disposal Plan

The sequence of channel dredged soil disposal is considered as follows.

- Dumping at Offshore Dumping until completion of the Dyke at Cat Hai South reclamation area
- Disposal for reclamation at Cat Hai South Area after completion of the Peripheral Dyke at Cat Hai South Area

Since it is assumed that Outer Revetment A & B (breakwater) locating the west of access road area for container terminal construction of the Project will form a part of the peripheral dyke at Cat Hai south reclamation area, the cost reduction in construction cost for Outer Revetment is considered.

The possible dredging method is the combined method of dredging and disposal method for alternative plan B (Cat Hai South) and D (Offshore Dumping) as described in Sub Section12.2.3.

2) Dredging Plan & Cost

The Dredging Plan (Within the Channel) of Case A1-1 and A2-1 are as shown below. Dredging by Grab Dredger (23m^3) and Trailer Suction Dredgers (TSHD> 1600m^3) of Case A1-1 or TSHD of Case A2-1 is used for channel dredging and the dredged soil is disposed at Offshore Dumping site until completion of the Dyke at Cat Hai South reclamation area. Once the dyke shall be completed, channel is dredged by Cutter Suction Dredge (8000ps) and dumped by barge at dumping basin. Discharging of the dredged soil into Cat Hai area is carried out by use of Cutter Suction Dredger (CSD 4000ps).

- Gross total of Dredging Volume; Vg=37,336,000 m^3 (Net Volume; Vn=33,304,000 m^3)
- Offshore Dumping Volume; Vo=27,341,000 m^3 (73.2%)
- Land Reclamation Volume for Cat Hai South; Vc=9,995,000 m^3 (28.2%)

Table 12.2.13 Schedule of Case A1-1

Case A1-1 Within the Channel by GD TSHD and CSD (Sta 13 km and offshore) and dumping at Cat Hai (East) and off shore

Cross sectional Area	Dredging Volume (m3) Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day) for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spilway silt fence and etc.							540	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0	524,964	36,706	561,670	Grab Dredger 23m3	9,150	3	20	20
1	2,498,320	174,687	2,673,007	Grab Dredger 23m3	9,150	3	97	157
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	3	66	0
3	875,406	61,210	936,616	TSHD, 3,500m3	3,210	3	97	15
4-1	4,072,682	284,769	4,357,451	Grab Dredger 23m3	9,150	3	159	159
13km to off	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to off	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	Grab Dredger 23m3	9,150	3	170	170
13km to off	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to off	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	45
Total	33,304,585	4,031,700	37,336,285				Total	1027
							(34.2 months)	

Sub total GD	12,254,894
Sub total TSHD 3,500m3	1,573,667
Sub totalTSHD 16,000m3	13,512,489
Sub total CSD	9,995,235

Sub total offshore	27,341,050
Cat Hai	9,995,235

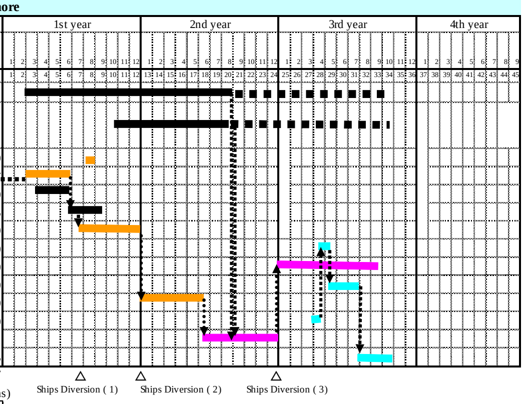


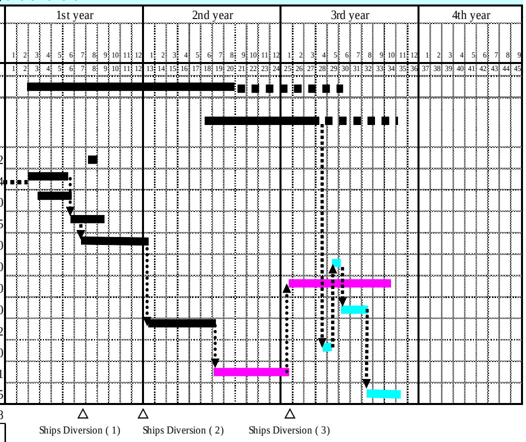
Table 12.2.14 Schedule of Case A2-1

Case A2-1 :Within the Channel by Large and small TSHD,and CSD (Sta 13 km and offshore), dumping at Cat Hai (East) and off shore

Cross sectional Area	Dredging Volume (m3) Net Volume	Extra vol for extra depth and Siltation	Gross Total	Type of Dredger	Productivity m3/day/fleet	No of fleet	Duration (day) for each work	Critical Path
Preparatory works for Cat Hai dumping area including perimeter dyke spilway silt fence and etc.							540	
Trench/ dumping basin	4,701,200	769,100	5,470,300	Cutter Suction, 4,000ps, with discharge pipes and floater	6,190	3	295	
0	524,964	36,706	561,670	TSHD, 3,500m1	3,210	8	22	22
1	2,498,320	174,687	2,673,007	TSHD, 3,500m2	3,210	8	104	164
2	595,418	41,633	637,051	TSHD, 3,500m3	3,210	8	25	0
3	875,406	61,210	936,616	TSHD, 3,500m4	3,210	8	36	15
4-1	4,072,682	284,769	4,357,451	TSHD, 3,500m5	3,210	8	170	170
13km to off	357,300	24,983	382,283	Pump Dredger, 8,000ps,	21,230	1	18	0
4-2	6,683,636	938,993	7,622,629	TSHD>16,000m3	14,660	2	260	260
13km to off	1,440,341	260,350	1,700,691	Pump Dredger, 8,000ps,	21,230	1	80	0
5-1	4,358,043	304,722	4,662,765	TSHD, 3,500m3	3,210	8	182	182
13km to off	455,450	31,846	487,296	Pump Dredger, 8,000ps,	21,230	1	23	0
5-2	5,064,108	825,752	5,889,860	TSHD>16,000m3	14,660	2	201	201
13km to off	1,677,717	276,948	1,954,665	Pump Dredger, 8,000ps,	21,230	1	92	15
Total	33,304,585	4,031,700	37,336,285				Total	1028

Sub total TSHD 3,500m3	13,828,561
Sub totalTSHD 16,000m3	13,512,489
Sub total CSD	9,995,235

Sub total offshore	27,341,050
Cat Hai	9,995,235



a) Case A1-1

Till the 20 month for completion outer dyke construction at Cat Hai south reclamation area, GD or TSHD is used for channel dredging and the dredged soil is dumped at offshore. In the 21-27th month period, it is possible to dump channel dredged soil into Cat Hai south reclamation area by the use of CSD and barge. For construction cost, see Table 12.2.15 & Table 12.2.16 below.

Table 12.2.15 Total Cost of Case A1-1

・Combined Plan Cost (A1−1)

a) Cat Hai（Pump Dredger 8000ps + Barge + Unloader 4000ps)
b) Offshore Dumping（TSHD)
b)' Offshore Dumping（Grab Dredger 23m3 + Barge)

Silt Protectors *1: ¥1.2bill/3　　*2:¥2.5bill/3*2　　Temp. & Others : 1000m*¥60000/m

Dredging Volume terms	m3	Unit Cost (JPY/m3) Dredging	Transport	Dumping	Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
a)	9,995,000	645	203	419	12,663,665,000	4,733,300,000	400,000,000	60,000,000	17,856,965,000	1,787	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	925,000,000	0	18,168,298,000	1,204	TSHD,*2
b)'	12,255,000	653	432	5	13,357,950,000	0	742,000,000	0	14,099,950,000	1,151	Grab+Barge,*2
Total	37,336,000				43,264,913,000	4,733,300,000	2,067,000,000	60,000,000	50,125,213,000	1,343	(34.2 months)

Table 12.2.16 Total Cost of Case A1-1’

・Combined Plan Cost (A1−1')

a) Cat Hai（Pump Dredger 8000ps + Barge + Unloader 4000ps)
a)' Cat Hai（Grab Dredger 23m3 + Barge + Unloader 4000ps)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Grab Dredger 23m3 + Barge)

Silt Protectors *1: ¥1.2bill/2　　*2:¥2.5bill/2　　Temp. & Others : 2000m*¥60000/m

Dredging Volume terms	m3	Unit Cost (JPY/m3) Dredging	Transport	Dumping	Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
a)	9,995,000	645	203	419	12,663,665,000	4,022,400,000	440,000,000	89,000,000	17,215,065,000	1,722	Pump+Barge+Unloader,*1
a)'	3,493,000	653	328	419	4,890,200,000	1,407,900,000	160,000,000	31,000,000	6,489,100,000	1,858	Grab+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	788,000,000	0	18,031,298,000	1,195	TSHD,*2
b)'	8,762,000	653	432	5	9,550,580,000	0	462,000,000	0	10,012,580,000	1,143	Grab+Barge,*2
Total	37,336,000				44,347,743,000	5,430,300,000	1,850,000,000	120,000,000	51,748,043,000	1,386	(34.2 months)

b) Case A2-1

In case A2-1, TSHD is used for channel dredging for offshore dumping. After completion of outer peripheral dyke at Cat Hai South reclamation area, CSD (8000ps) is planned to use for channel dredging for disposal at Cat Hai South area. For construction cost, see Table 12.2.17 below.

Table 12.2.17 Total Cost of Case A2-1

・Combined Plan Cost (A2-1)
a) Cat Hai（Pump Dredger 8000ps + Barge + Unloader 4000ps）
b) Offshore Dumping（TSHD）
b)' Offshore Dumping（Pump Dredger 8000ps + Barge ）

Silt Protectors *1: ¥1.2bill/3 *2:¥2.5bill/3*2 Temp. & Others : 1000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	9,995,000	645	203	419	12,663,665,000	4,733,300,000	400,000,000	60,000,000	17,856,965,000	1,787	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	925,000,000	0	18,168,298,000	1,204	TSHD,*2
b)'	12,255,000	645	432	5	13,259,910,000	0	742,000,000	0	14,001,910,000	1,143	Pump+Barge,*2
Total	37,336,000				43,166,873,000	4,733,300,000	2,067,000,000	60,000,000	50,027,173,000	1,340	(34.5 months)

c) Offshore Dumping Plan for Comparison

Offshore Dredging Plan does not require the dredging of the trench and dumping basin

Vg '= 31,866,000 m^3 in total gross (Vn' = 28,604,000 m^3 net volume)

Table 12.2.18 Total Cost of Case A1-1(V=0)

・Combined Plan Cost (A1-1)
a) Offshore Dumping (Pump Dredger 8000ps + Barge)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Grab Dredger 23m3 + Barge)

(A1V= 0) Silt Protectors *2: ¥2.5bill

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	4,525,000	645	432	5	4,896,050,000	0	355,000,000	0	5,251,050,000	1,160	Pump+Barger,*1
b)	1,574,000	1138	0	5	1,799,082,000	0	123,000,000	0	1,922,082,000	1,221	TSHD,*2
b)'	25,767,000	653	432	5	28,086,030,000	0	2,022,000,000	0	30,108,030,000	1,168	Grab+Barge,*2
Total	31,866,000				34,781,162,000	0	2,500,000,000	0	37,281,162,000	1,170	(34.5 months)

In comparison of a dredging plan, both Combined Plan and Offshore Dumping plan are completed within 35.0 months. However, in comparison of the construction cost in Case A1-1, Combined Plan is 1.34 times higher compared with Offshore Dumping Plan.

Even if prospective cost saving of 3.37 billion yen for the construction of outer shore protection is deducted, the revised total cost of Case A1-1 is 46.66 billion yen, which is still 1.25 times higher than the total cost of Offshore Dumping Plan.

3) Peripheral Dyke Constructions Cost

Dyke construction for Cat Hai South reclamation area may change with the required volume of channel dredged soil to receive. For this reason, a trial calculation is carried out for three cases of 1/3, 1/2 and 2/3 of the amount of Dredging Volume (gross quantity Vg=37,336,000 m^3).

It is assumed that peripheral dyke in Cat Hai is carried out in line with Outer Revetment A & B (breakwater) for the Project along access road behind container terminal area which is extended to 3.2 km offshore to form peripheral dyke of Cat Hai Island south reclamation area.

The following table shows the difference in volume of reclamation filling into Cat Hai and the Volume of Offshore Dumping for each case.

Table 12.2.19 Summary of Dredging and Dumping Volume

・Combined Plan (A1-1)　　Cat Hai + Offshore Dump

Category		terms	1/3		1/2		2/3		1/1		0	
			(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)
1	Cat Hai		12,445,000	33.3	18,670,000	75.0	24,890,000	66.7	37,336,000	100	0	0
3	Offshore Dump	3 = 4 − 1	24,891,000	66.7	18,666,000	50.0	12,446,000	33.3	0	0	31,866,000	100
4	Total volum (gross)		37,336,000								31,866,000	

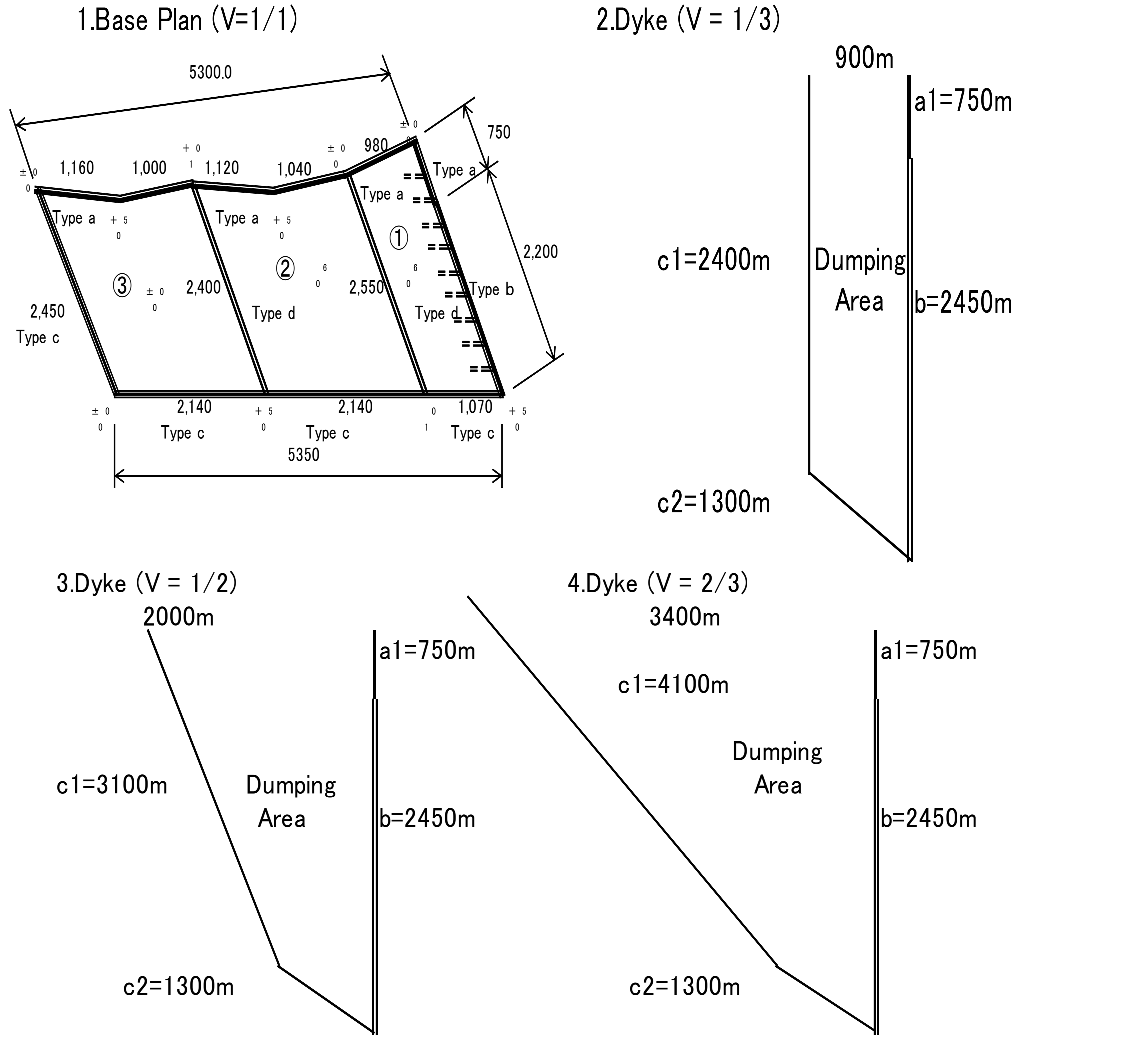


Figure 12.2.13 Plan of Dyke

The table below shows the cost estimation for each Case based on the amount of Dredging Volume. These trial calculations include cost for dredging, transportation, dumping (filling), Dyke (revetments) construction, silt protectors, temporary works, and all other costs.

Table 12.2.20 Summary of Cost Comparison Case A1-1

・Combined Plan (A1−1) Cat Hai + Offshore Dump

a) Cat Hai (Pump Dredger 8000ps + Barge + Unloader 4000ps)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Grab Dredger 23m3 + Barge)

(A1−1)

	Category	terms	1/3		1/2		2/3		1/1−1		1/1−2		0			
			(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)
1	Cat Hai		12,445,000	33.3	18,670,000	75.0	24,890,000	66.7	37,336,000	100	37,336,000	100	0	0		
3	Offshore Dump	3 = 4 − 1	24,891,000	66.7	18,666,000	50.0	12,446,000	33.3	0	0	0	0	31,866,000	100		
4	Total volum (gross)		37,336,000										31,866,000			

・Combined Plan Cost (A1−1) Cat Hai + Offshore Dump

	Category	terms	1/3	1/2	2/3	1/1−1	1/1−2	0	
			12,445,000 (m3)	18,670,000 (m3)	24,890,000 (m3)	37,336,000 (m3)	37,336,000 (m3)	31,866,000 (m3)	
1	Cat Hai	(JPY)	20,961,115,000	29,805,190,000	38,832,130,000	64,479,433,000	65,081,258,000	0	
3	Offshore Dump		29,597,748,000	22,395,498,000	15,895,778,000	0	0	37,281,162,000	
4	Total Cost (JPY)		50,558,863,000	52,200,688,000	54,727,908,000	64,479,433,000	65,081,258,000	37,281,162,000	
Cost ratio (vs offshore)			1.36	1.40	1.47	1.73	1.75	1.0	
Construction schedule			34.5	40.0	46.0	58.5	52.0	34.5	

Table 12.2.21 Summary of Cost Comparison Case A2-1

・Combined Plan (A2−1) Cat Hai + Offshore Dump

a) Cat Hai (Pump Dredger 8000ps + Barge + Unloader 4000ps)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Pump Dredger 8000ps + Barge)

(A2−1)

	Category	terms	1/3		1/2		2/3		1/1−1		1/1−2		0−1		0−2	
			(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)	(m3)	(%)
1	Cat Hai		12,445,000	33.3	18,670,000	75.0	24,890,000	66.7	37,336,000	100	37,336,000	100	0	0	0	0
3	Offshore Dump	3 = 4 − 1	24,891,000	66.7	18,666,000	50.0	12,446,000	33.3	0	0	0	0	31,866,000	100	31,866,000	100
4	Total volum (gross)		37,336,000										31,866,000			

・Combined Plan Cost (A2−1) Cat Hai + Offshore Dump

	Category	terms	1/3	1/2	2/3	1/1−1	1/1−2	0−1	0−2
			12,445,000 (m3)	18,670,000 (m3)	24,890,000 (m3)	37,336,000 (m3)	37,336,000 (m3)	31,866,000 (m3)	31,866,000 (m3)
1	Cat Hai	(JPY)	20,961,115,000	29,805,190,000	38,832,130,000	61,052,422,000	60,588,092,000	0	
3	Offshore Dump		29,519,308,000	22,366,858,000	15,895,778,000	0	0	38,646,813,000	38,156,495,000
4	Total Cost (JPY)		50,480,423,000	52,172,048,000	54,727,908,000	61,052,422,000	60,588,092,000	38,646,813,000	38,156,495,000
Cost ratio (vs offshore)			1.35	1.40	1.47	1.64	1.63	1.04	1.02
Construction schedule			34.5	40.0	46.0	65.5	61.5	34.5	33.5

4) Evaluation

In comparison of a construction cost, Case A2-1(1/3) is the lowest, and all works can be completed within 35.0 months in both Case A2-1(1/3) and case A1-1 (1/3). But, Combined Plan (1/3) is high 1.35 or more times as compared with Offshore Dumping Plan.

With Combined Plan, even if it reduces the prospective amount cost of 3.37 billion yen of outer shore protection, it is estimated as 47.12 billion yen which is 1.26 or even higher than Offshore Dumping Plan.

When trial calculation from Dredging Plan (35.0 months) and Construction Cost is compared with the Combined Plan, Case A2-1of dumping into Cat Hai South of about 100,000 m^3 (28%) and others to Offshore Dumping is the lowest construction cost. In this case, the construction cost from the dredging to the dumping for reclamation is estimated about 50.03 billion yen, and the prospective amount of cost deduction (Outer Revetment A & B) is estimated about 46.66 billion yen.

On the other hand, a construction cost for all Offshore Dumping Plan is estimated at about 37.28 billion yen, at present, the lowest construction costs. In addition, the environmental impact deems low in view of contamination diffusion and other aspect. Consequently, Plan D (offshore dumping) is recommendable.

For detailed breakdown cost, see the following Attachments.

Table 12.2.22 Cost Comparison Case A1-1 (1/3~2/3,1/1)

・Combined Plan Cost (A1-1)
a) Cat Hai (Pump Dredger 8000ps + Barge + Unloader 4000ps)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Grab Dredger 23m3 + Barge)

(A1V=1/3) Silt Protectors *1: ¥1.2bill/3 *2:¥2.5bill/3*2 Temp. & Others : 1000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	12,445,000	645	203	419	15,767,815,000	4,733,300,000	400,000,000	60,000,000	20,961,115,000	1,684	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	1,012,000,000	0	18,255,298,000	1,210	TSHD,*2
b)'	9,805,000	653	432	5	10,687,450,000	0	655,000,000	0	11,342,450,000	1,157	Grab+Barge,*2
Total	37,336,000				43,698,563,000	4,733,300,000	2,067,000,000	60,000,000	50,558,863,000	1,354	(34.5 months)

(A1V=1/2) Silt Protectors *1: ¥1.2bill/2 *2:¥2.5bill/2*1 Temp. & Others : 2000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	18,670,000	645	203	419	23,654,890,000	5,430,300,000	600,000,000	120,000,000	29,805,190,000	1,596	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	1,010,000,000	0	18,253,298,000	1,210	TSHD,*2
b)'	3,580,000	653	432	5	3,902,200,000	0	240,000,000	0	4,142,200,000	1,157	Grab+Barge,*2
Total	37,336,000				44,800,388,000	5,430,300,000	1,850,000,000	120,000,000	52,200,688,000	1,398	(40.0 months)

(A1V=2/3) Silt Protectors *1: ¥1.2bill/3*2 *2:¥2.5bill/3*2 Temp. & Others : 3000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	24,890,000	645	203	419	31,535,630,000	6,316,500,000	800,000,000	180,000,000	38,832,130,000	1,560	Pump+Barge+Unloader,*1
b)	12,446,000	1138	0	5	14,225,778,000	0	1,670,000,000	0	15,895,778,000	1,277	TSHD,*2
b)'	0	653	432	5	0	0	0	0	0		Grab+Barge,*2
Total	37,336,000				45,761,408,000	6,316,500,000	2,470,000,000	180,000,000	54,727,908,000	1,466	(46.0 months)

Table 12.2.23 Cost Comparison Case A2-1 (1/3~2/3,1/1)

・Combined Plan Cost (A2-1)

a) Cat Hai (Pump Dredger 8000ps + Barge + Unloader 4000ps)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Pump Dredger 8000ps + Barge)

(A2V=1/3) Silt Protectors *1: ¥1.2bill/3 *2:¥2.5bill/3*2 Temp. & Others : 1000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	12,445,000	645	203	419	15,767,815,000	4,733,300,000	400,000,000	60,000,000	20,961,115,000	1,684	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	1,012,000,000	0	18,255,298,000	1,210	TSHD,*2
b)'	9,805,000	645	432	5	10,609,010,000	0	655,000,000	0	11,264,010,000	1,149	Pump+Barge,*2
Total	37,336,000				43,620,123,000	4,733,300,000	2,067,000,000	60,000,000	50,480,423,000	1,352	(34.5 months)

(A2V=1/2) Silt Protectors *1: ¥1.2bill/2 *2:¥2.5bill/2*1 Temp. & Others : 2000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	18,670,000	645	203	419	23,654,890,000	5,430,300,000	600,000,000	120,000,000	29,805,190,000	1,596	Pump+Barge+Unloader,*1
b)	15,086,000	1138	0	5	17,243,298,000	0	1,010,000,000	0	18,253,298,000	1,210	TSHD,*2
b)'	3,580,000	645	432	5	3,873,560,000	0	240,000,000	0	4,113,560,000	1,149	Pump+Barge,*2
Total	37,336,000				44,771,748,000	5,430,300,000	1,850,000,000	120,000,000	52,172,048,000	1,397	(40.0 months)

(A2V=2/3) Silt Protectors *1: ¥1.2bill/3*2 *2:¥2.5bill/3*2 Temp. & Others : 3000m*¥60000/m

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	24,890,000	645	203	419	31,535,630,000	6,316,500,000	800,000,000	180,000,000	38,832,130,000	1,560	Pump+Barge+Unloader,*1
b)	12,446,000	1138	0	5	14,225,778,000	0	1,670,000,000	0	15,895,778,000	1,277	TSHD,*2
b)'	0	645	432	5	0	0	0	0	0		Pump+Barge,*2
Total	37,336,000				45,761,408,000	6,316,500,000	2,470,000,000	180,000,000	54,727,908,000	1,466	(46.0 months)

Table 12.2.24 Cost Comparison Case A1-1,2-1 (V=0)

・Combined Plan Cost (A1-1)
a) Offshore Dumping (Pump Dredger 8000ps + Barge)
b) Offshore Dumping (TSHD)
b)' Offshore Dumping (Grab Dredger 23m3 + Barge)

(A1V= 0) Silt Protectors *2: ¥2.5bill

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	4,525,000	645	432	5	4,896,050,000	0	355,000,000	0	5,251,050,000	1,160	Pump+Barger,*1
b)	1,574,000	1138	0	5	1,799,082,000	0	123,000,000	0	1,922,082,000	1,221	TSHD,*2
b)'	25,767,000	653	432	5	28,086,030,000	0	2,022,000,000	0	30,108,030,000	1,168	Grab+Barge,*2
Total	31,866,000				34,781,162,000	0	2,500,000,000	0	37,281,162,000	1,170	(34.5 months)

・Combined Plan Cost (A2-1)
a) Offshore Dumping (Pump Dredger 8000ps + Barge)
b) Offshore Dumping (TSHD)

(A2V= 0-1) Silt Protectors *2: ¥2.5bill

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	4,525,000	645	432	5	4,896,050,000	0	400,000,000	0	5,296,050,000	1,170	Pump+Barger,*1
b)	27,341,000	1138	0	5	31,250,763,000	0	2,100,000,000	0	33,350,763,000	1,220	TSHD,*2
Total	31,866,000				36,146,813,000	0	2,500,000,000	0	38,646,813,000	1,213	(34.5 months)

(A2V= 0-2) Silt Protectors *2: ¥2.5bill

Dredging Volume		Unit Cost (JPY/m3)			Sub Total	Dyke	Silt Protectors	Temp. & Others	Total	Unit Price (JPY/m3)	Remark
terms	m3	Dredging	Transport	Dumping							
a)	12,563,000	645	432	5	13,593,166,000	0	983,000,000	0	14,576,166,000	1,160	Pump+Barger,*1
b)	19,303,000	1138	0	5	22,063,329,000	0	1,517,000,000	0	23,580,329,000	1,222	TSHD,*2
Total	31,866,000				35,656,495,000	0	2,500,000,000	0	38,156,495,000	1,197	(33.5 months)

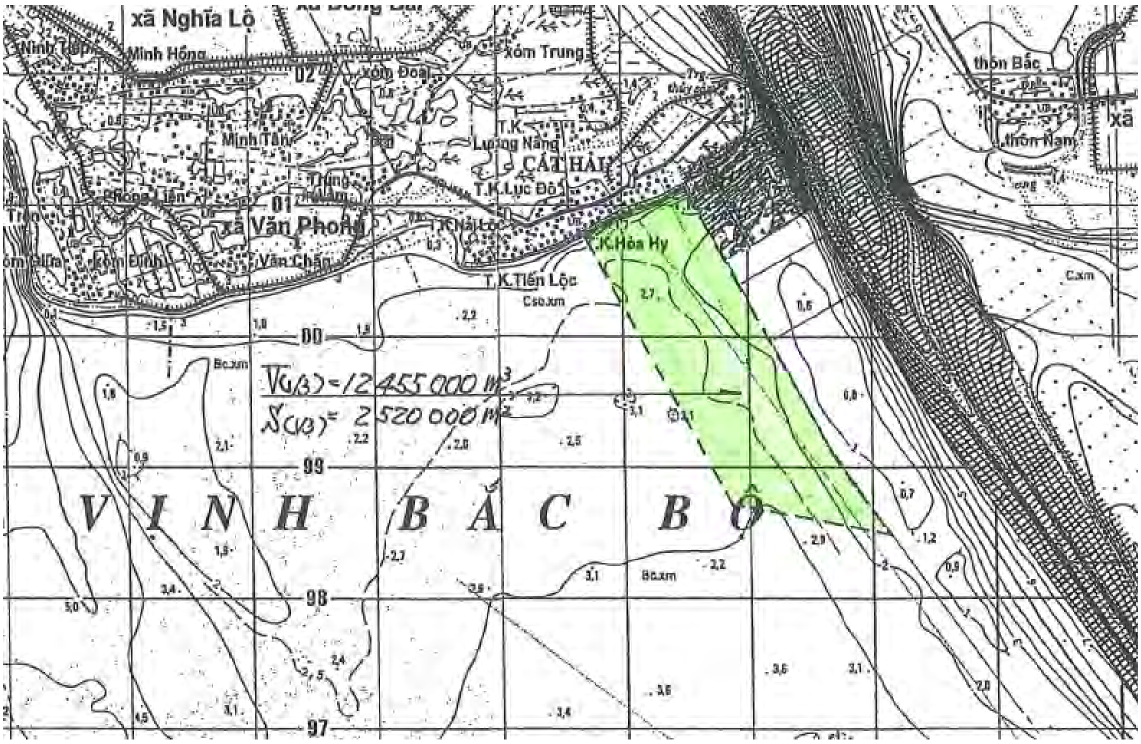


Figure 12.2.14 Combined Dumping Plan of (1/3)

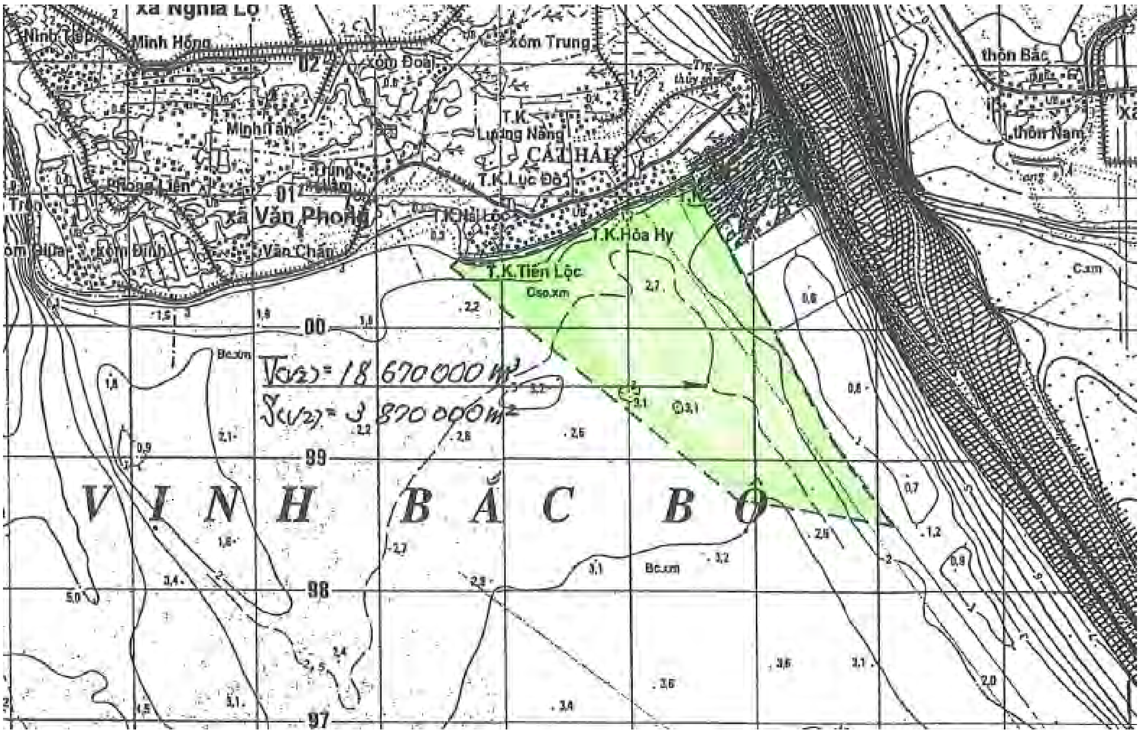


Figure 12.2.15 Combined Dumping Plan of (1/2)

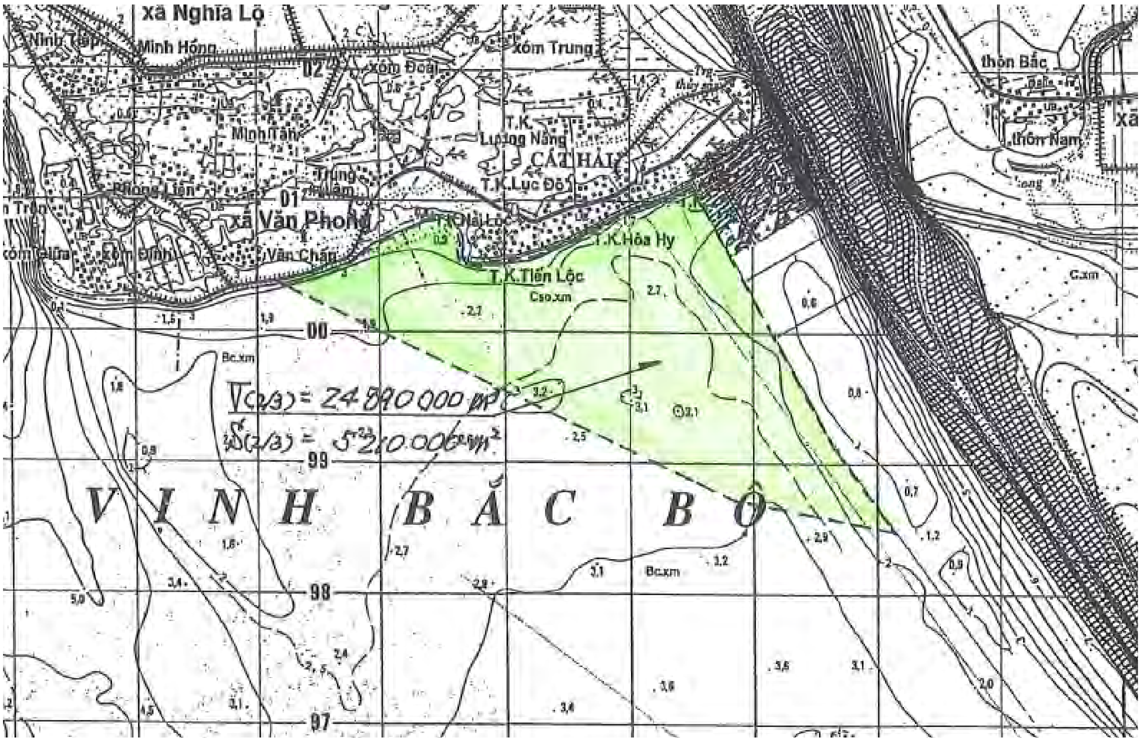


Figure 12.2.16 Combined Dumping Plan of (2/3)

12.2.6 Comparison Study on Dredged Soil Dumping Sites of South Dinh Vu IZ and/or Offshore Area

1) Preliminary Comparison Study

a) Dredging Volume

Total dredging volume of Lach Huyen Channel is estimated at 37.7 million m^3 which includes 6.1 million m^3 of sedimentation during 3 years of channel dredging period.

It is estimated that the dredging material contains approx. 4.2 miilion m^3 of sandy soil which is suitable for land reclamation and occupies about 14% of main channel dredging volume. However, the sandy soil is not located in one place but scattered in many places in the channel and whole volume of sandy soil couldn't be practically utilized for reclamation. In this study, therefore, it is assumed that 3.2 million m^3 of sandy soil which is equivalent to about 8% of total dredging volume of 37.7 million m^3 is available for land reclamation.

b) Study case

In this preliminary comparison study, following **6 cases** are considered. The cases are selected focusing to the rate of volume for reclamation and the most suitable equipment is considered to use for each case.

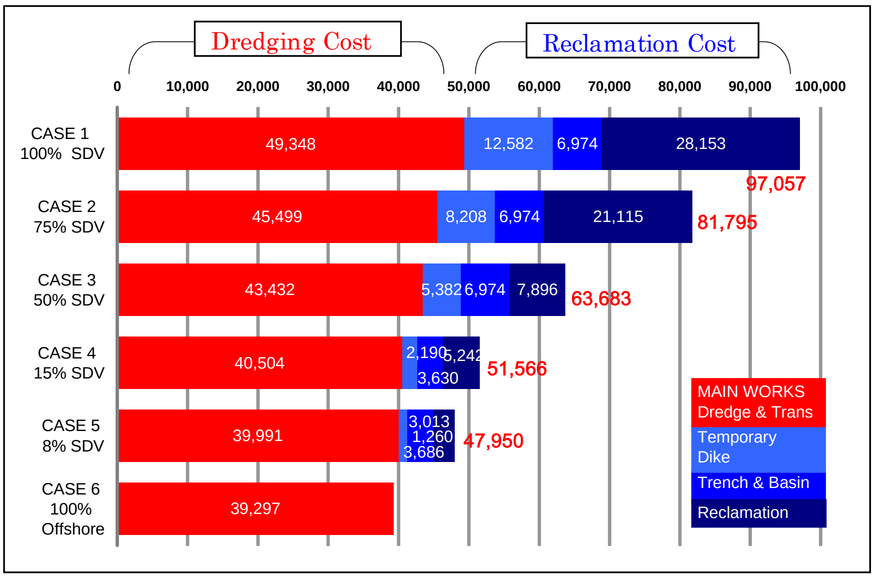
Table 12.2.25 Study Case

Case	Reclamation Volume (Mil. m^3)		Method (Equipment)		
	Description	Volume	Dredging	Transport	Reclamation
1	100% SDVIZ (Mud & Sand)	37.7	GD 23m^3	H.B. 1,300m^3	CSD 8,000PS
2	75% SDVIZ (Mud & Sand)	28.1	GD 23m^3	H.B. 1,300m^3	CSD 8,000PS
3	50% SDVIZ (Mud & Sand)	18.8	GD 23m^3	H.B. 1,300m^3	CSD 4,000PS
4	15% SDVIZ (Mud & Sand)	5.5	GD 23m^3	H.B. 1,300m^3	BUD 2,500PS
5	8% SDVIZ (Sand Only)	3.2	GD 23m^3	H.B. 1,300m^3	BUD 2,500PS
6	All Off-shore Dumping	-	All Offshore Dumping		

c) Cost Estimate

The result of cost estimation is summarized as follows.

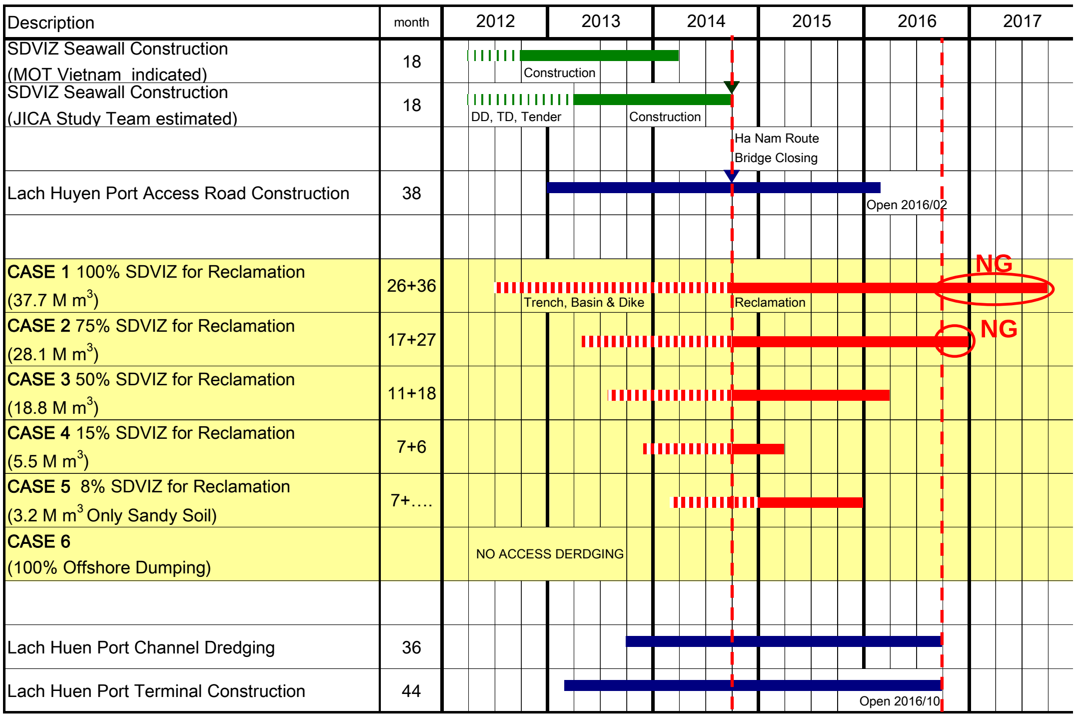
Table 12.2.26 Summary of Cost Estimate (Unit: Million JPY)



d) Construction Schedule

The schedule of each case is plotted on the following time chart. From this table, the use of 50% or less volume for SDVIZ seems suitable if we consider the estimated future progress of SDVIZ seawall construction.

Table 12.2.27 Time Schedule of Each Case



e) Preliminary Evaluation

- **Case 6** of Off-shore dumping of the dredged material is **primary recommended** as cost is the minimum. In addition, most of dredged material is silt/clay which is not suitable material for land reclamation. The developer shall suffer from additional cost and time for soil improvement.
- **Case 5** of only sandy material be provided to SDVIZ is **secondary recommended** in view of reclamation cost as well as further expenditure for soil improvement is not required.
- **Case 1 and 2** of the use of 100% or 75% dredged material for SDVIZ reclamation are **not practical** from viewpoints of both very high cost and schedule.
- **Case 3** of the use of 50% or less dredged material for SDVIZ seems **possible** from viewpoint of time schedule of relevant projects, if Vietnam Government will arrange a certain project fund.
- **Case 2-6** require approval on EIA for off-shore dumping. **Case 1-5** require revision of approved EIA of SDVIZ reclamation project.

2) Secondly (Conclusive) Comparison Study

a) Purpose of Case Study

As the result of above preliminary comparison study, MOT acknowledged the difficulty of utilization of soil over 50% of total dredging volume taking cost and schedule into account and requested JICA to make further comparison study on the following 2 options:

- **Option 1**: 50% South Dinh Vu IZ Reclamation and 50% Offshore Dumping
  Volume: 18.9 million m^3 SDVIZ
  18.9 million m^3 Offshore
  Distance: 22 km
- **Option 2**: 100% Offshore Dumping
  Volume: 37.7 million m^3
  Distance: 17 km

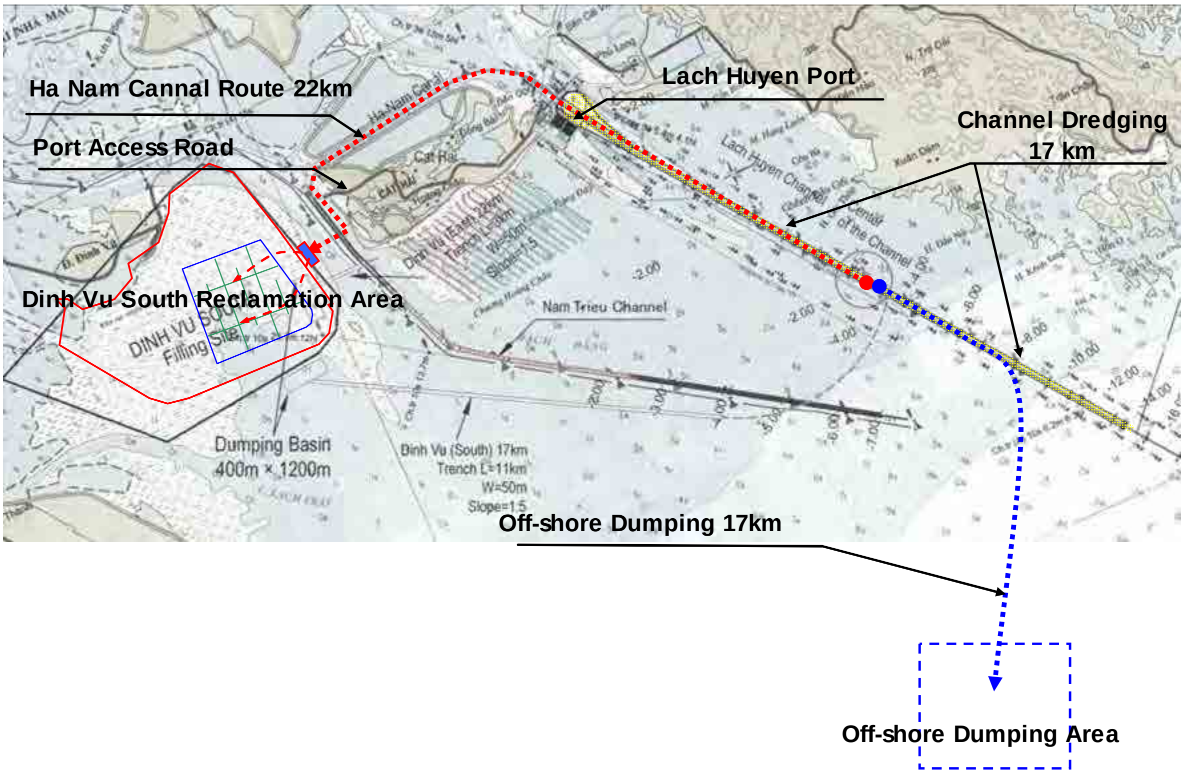


Figure 12.2.17 Location of Reclamation Site and Dumping Site

b) Method and Cost of Reclamation for Option 1

i) Method of Reclamation

The following combination of equipment for alternative reclamation methods are considered. The variety of Vietnam equipment were reviewed for effective use of local market.

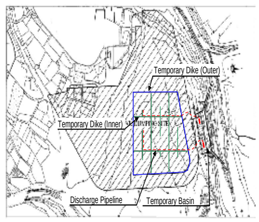
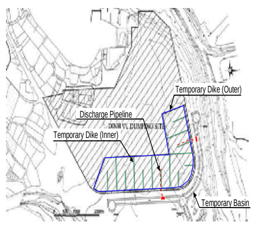
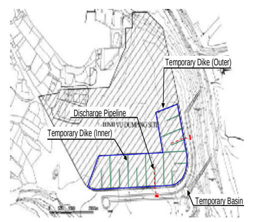
Table 12.2.28 Combination Alternatives of Equipment for Reclamation

Legend: Foreign Equip. / Vietnam Equip.

Dredging		Transport.		Reclamation
GD 23 m^3	→	HB 5,000m^3	→	CSD 4,000PS
TSHD 3,500m^3	→	TSHD 3,500m^3	→	TSHD 3,500m^3
GD 23 m^3	→	HB 5,000 m^3	→	BUD 2500PS
GD 23 m^3	→	SB 1,000 m^3	→	SB 1,000m^3

The following table shows the comparison and evaluation of applicability of each equipment.

Table 12.2.29 Comparison of Alternative Reclamation Equipment

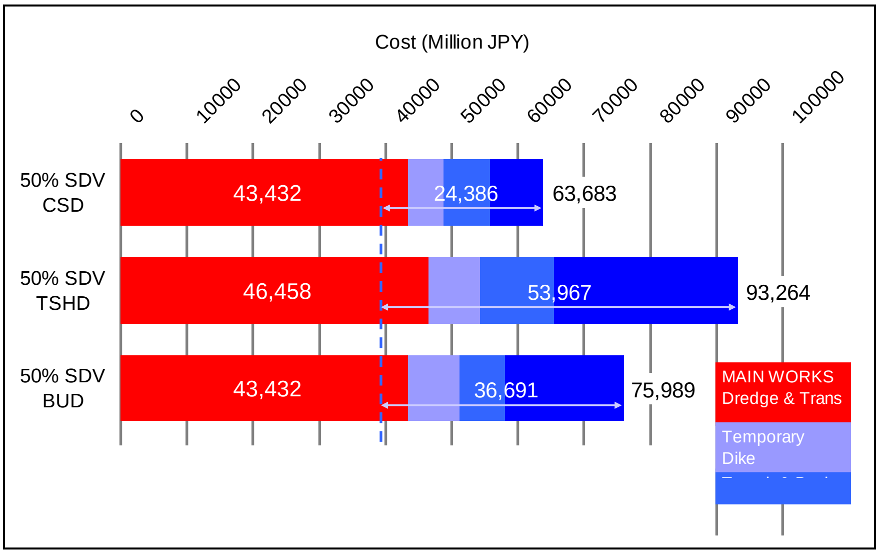
Reclamation Equipment	CSD 4,000PS	TSHD 3,500m^3	BUD 2,500PS	SB 1,000m^3
Local/Foreign	Local	Local	Foreign	Local
Advantage	・suitable for large volume ・high efficiency ・long distant discherge (2.5km)	・self- dredge and self-discharge ・temporary dumping is not required	・temporary dumping is not required ・turbidity dispersal is reduced	・light draft (2~2.5m) can reduce the access trench dredging ・many units are available in Vietnam
Risk	・temporary dumping basin shall be dredged ・fluid discharge may cause turbidity disparsal	・height of ship is high (23m), and it cannot pass under Lach Hyuen accsess bridge ・short distant discharge (1km)	・cost is high ・available equipment is limited (approx. 3 units available in Japan) ・short distant discharge (1km)	・small size hopper does not match the size of grub bucket dredger ・only loose sand material can be applied ・short distant discharge (~0.5km~)
Reclamation Image				not suitable for large scaled project as the risks mentioned above
Evaluation	applicable	applicable	applicable	not applicable

Local sand barge has strong advantage of light draft which allows smaller trench dredging but it is not adopted for further consideration, since application is not suitable because of smaller power and miss-match against scheduled dredging equipment. Nevertheless its utilization should be left for the choice of dredging contractor.

ii) Cost Comparison

The cost is estimated as follows. As known from the comparison table, the case using Cutter Suction Dredger (CSD) for reclamation is the cheapest as we adopted in the above preliminary comparison study.

Table 12.2.30 Cost Comparison for Alternative Reclamation Methods



c) Cost Estimate

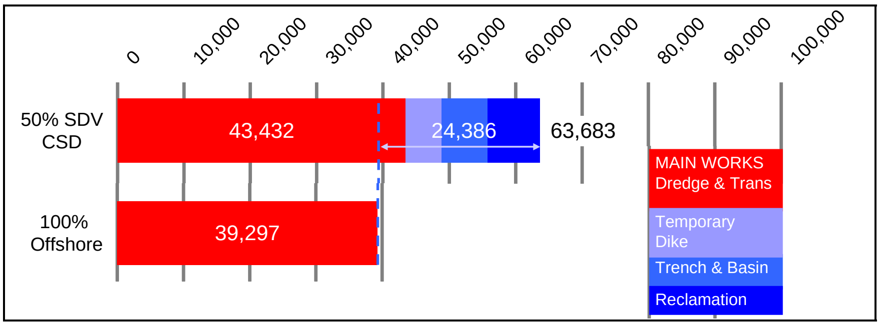
i) Dredging Cost

Dredging and reclamation/dumping costs for Option 1 and 2 are estimated as follow. Option 1 requires additional direct construction cost of 24.4 Bill. JPY（6,000 Bill. VND）more than Option 2.

Table 12.2.31 Comparison of Dredging and Reclamation/Dumping Costs

Dumping Site		Option 1 50% SDVIZ + 50% Offshore Dumping	Option 2 100% Offshore Dumping
1	Dredging Main Channel & Transport	¥43.43 billion	¥39.30 billion
2	Trench & Temporary Basin Dredging	¥6.97 billion	0
3	Secondary Discharge	¥7.90 billion	0
4	Temporary Dyke Construction	¥5.38 billion	0
	Total	¥63.68 billion	¥39.30 billion

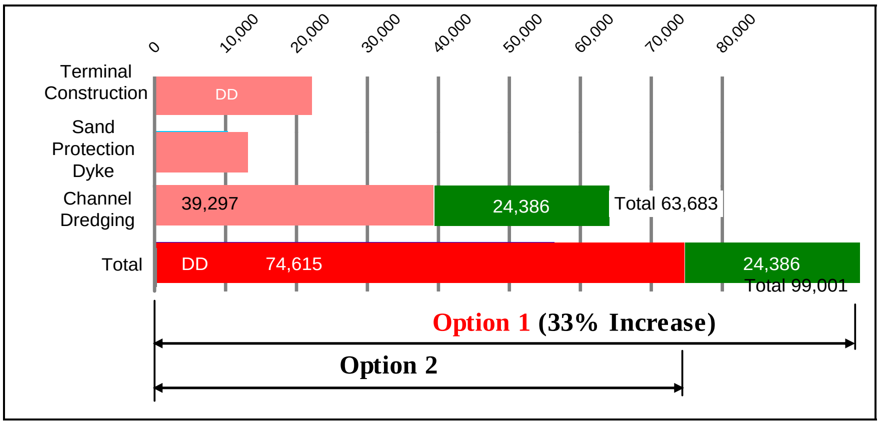
Table 12.2.32 Difference of Costs between 2 Options (million¥)



ii) Impact on Total Construction Cost

The additional direct construction cost of ¥24,386 million for Option 1 will be higher than the construction cost of Lach Huyen container terminal reclamation and soil improvement cost and will increase the total project cost by 33% than Option 2 which is significant impact on project implementation.

Table 12.2.33 Comparison of Total Project Costs (million¥)



d) Construction Schedule

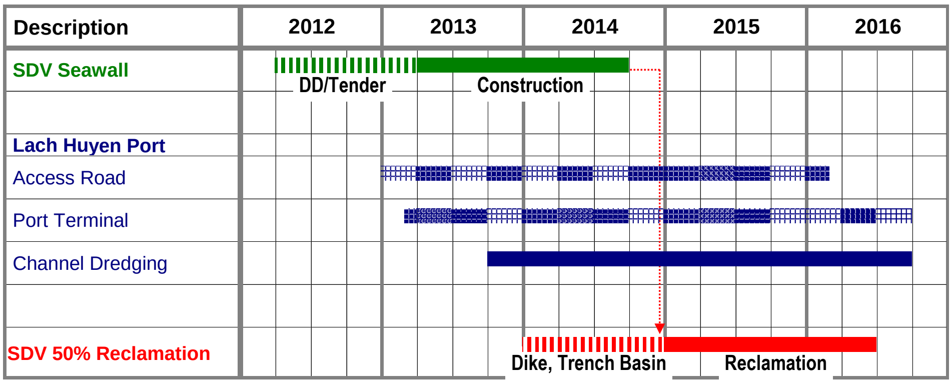
Expected dredging period of channel for 37.7 mil m^3 is 36 months which is established considering the target port opening time.

Option 1

Required reclamation period of SDVIZ for 18.9 mil m^3 is estimated as follow:

Preparation Works (Trench & Basin Dredging, Dike Construction, Etc)	:12 months
Transport and Reclamation 50% (18.9 Mil. m3)	:18 months
Total	**:30 months**

Table 12.2.34 Construction Schedule of Option 1 (SDVIZ 50% Reclamation)



As known from above bar-chart, Option 1 (50% reclamation to SDVIZ) is possible to be complete within the expected total dredging period of 36 months.

e) Topics of the Case Study

i) Quality of Material

<u>Sand or Mud</u>

As explained in 12.2.6 1)a) above, the soil type of Lach Huyen Channel is mostly mud which contains more than 50% of fine particles. Generally, muddy soil should be avoided for reclamation because it requires further soil improvement which is costly and time consuming. Common procedure to use the land reclaimed by mud is as follow;

- Leave surface hardened (5-7 years)
- Geotextile sheet and sand mat placement
- Sand drain/PVD installation and surcharge (1 year)

In addition, prior to discharge the muddy soil into reclamation area, the temporary inner dykes should be arranged for laying discharge pipeline which also causes high reclamation cost.

The land which requires early use such as industrial zone or public facilities is normally reclaimed by sandy soil. Sandy soil is suitable for land reclamation, because;

- Reclaimed land can be used immediately after reclamation
- Temporary dykes can be reduced, i.e., unit cost can be reduced
- Turbidity dispersal is smaller by quick settling

However, the volume of sandy soil in Lach Huyen channel area is not much, estimated at 3.2 million m^3 only.

<u>Example in Thailand</u>

Leam Chabang Port in Thailand was developed in the coastal area reclaimed by dredged soil from channel and basin. The dredged materials were mostly sandy soil and used for terminal land reclamation but included about 2.0 million m^3 of muddy soil which was judged as not suitable for immediate use and deposited future development area (blue colored triangle area in Figure 12.2.18. Phase 1 development of Laem Chabang Port was completed in 1990 and commenced Phase 2 development in 1998. However, the deposited poor soil was not improved naturally during last 8 years and the soil improvement method was studied and reached to the conclusion that the deposited mud should be replaced by the sandy soil. The deposited mud must be removed again to another silt pond.

If Option 1 is adopted, it is worried whether or not such a similar problem will occur in SDVIZ.

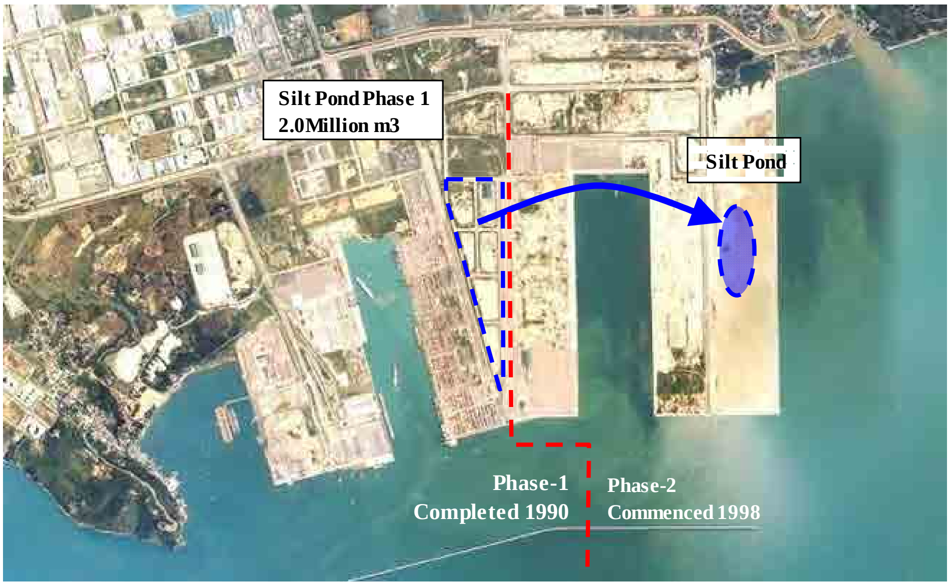
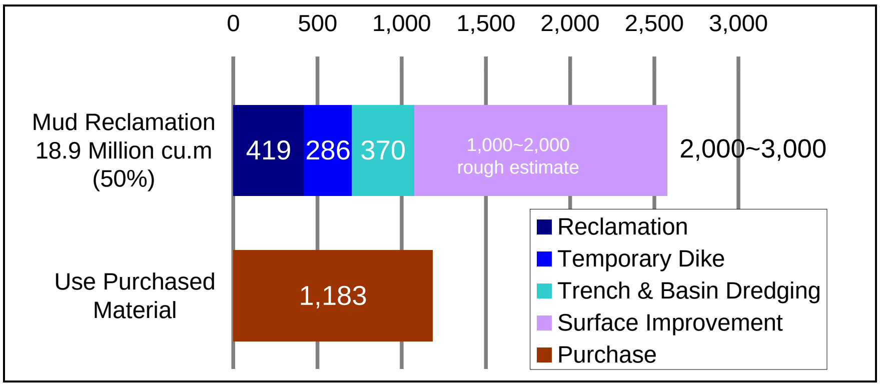


Figure 12.2.18 Laem Chabang Port in Thailand

ii) Unit Cost of Reclamation

Unit cost of SDVIZ reclamation using muddy soil from Lach Huyen Channel and using sandy soil purchased from market are compared as follow.

Table 12.2.35 Comparison of Unit Cost of Reclamation (JPY/m^3)



The unit cost of mud reclamation of SDVIZ is consists of costs for trench and basin dredging, temporary dyke construction, discharging and surface improvement for the reclamation volume of 18.9 million m^3. On the other hand, the unit cost of purchased sand reclamation is applied the same land reclamation unit cost of Lach Huyen Container Berth No.1 & 2.

As known from above comparison, Use of Lach Huyen dredged material is more costly than purchased sand with market price.

Therefore, it is recommended to dump 100% dredged material to offshore and reclaim South Dinh Vu IZ by purchased sandy soil.

It should be noted that if the dredged soil from Lach Huyen Channel is suitable for reclamation, we would have proposed to reclaim future port development land along Lach Huyen Channel, that will be cheaper than the offshore dumping cost since transport distance is shorter, but we didn't, because the dredged soil is not suitable for reclamation.

f) Environmental Impact

SS (Suspended Solid) diffusion simulation was conducted for offshore dumping and SDV reclamation to assess the environmental impact by dredged soil dumping. The cases of simulation analysis were following:

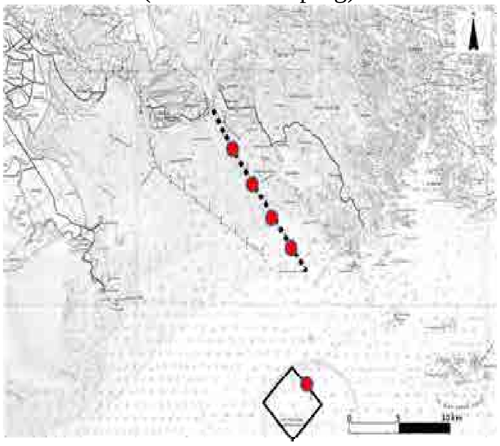
Case 1: 100% Offshore Dumping without mitigation measure
Case 2: 100% SDV Reclamation without mitigation measure
Case 3: 100% Offshore Dumping with silt curtain for channel dredging
Case 4: 100% SDV Reclamation with silt curtain for channel dredging, temporary basin and drainage effluent outlet from embankment
Case 5: 50% Offshore Dumping with silt curtain for channel dredging + 50% SDV Reclamation with silt curtain for channel dredging, temporary basin and drainage effluent outlet from embankment

The results of simulation are obtained as shown in Figure 12.2.19 and Figure 12.2.20. As known from these figures, countermeasures to SS dispersion such as silt curtain will effectively work to reduce the impact by dredging/dumping activities. Therefore, Case 3 to 5 shall be considered for further study.

According to the simulation results of Case 3, 4 and 5, biological and socially sensitive area such as Ha Long Bay, Cat Ba beach area, Do Son beach area, Long Chau Islands will not be affected directly by Case 3: offshore dumping, however the SS dispersion of Case 4 and 5: reclamation at SDV might reach to Do Son beach area. Based on the above SS diffusion simulation results, offshore dumping is recommendable.

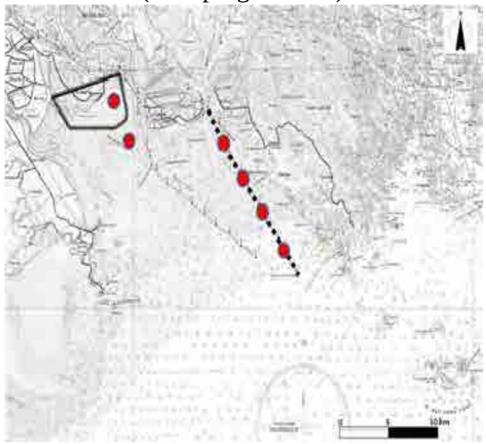
Case 1 : 100% Offshore Dumping (without silt curtain)	**Case 2** : 100% SDV Dumping (without silt curtain)
(Offshore dumping)	(Dumping at SDV)

Case 1 (Offshore dumping):



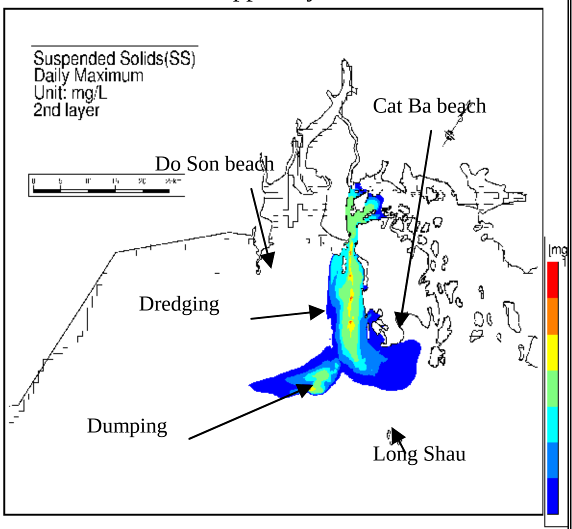
●: Load generation point

Case 2 (Dumping at SDV):

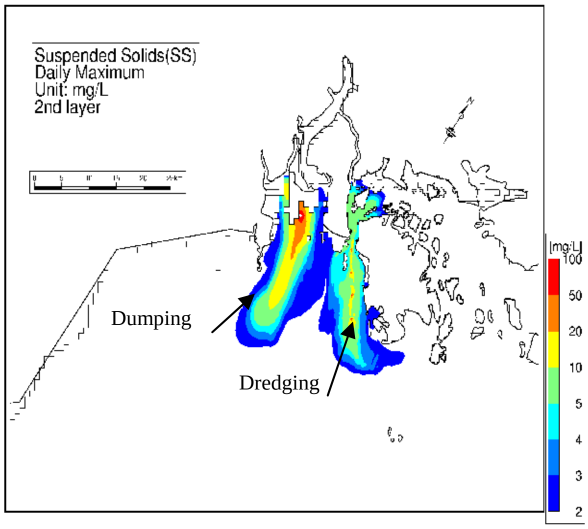


●: Load generation point

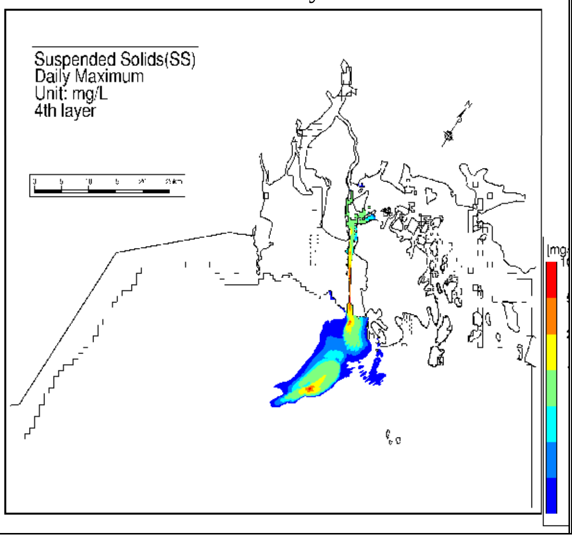
Upper layer (Case 1)



Upper layer (Case 2)



Lower layer (Case 1)



Lower layer (Case 2)

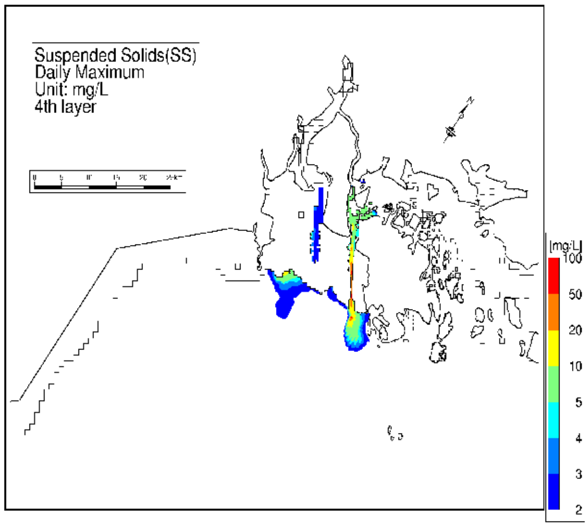


Figure 12.2.19 SS Diffusion Simulation Result of Case 1 and Case 2

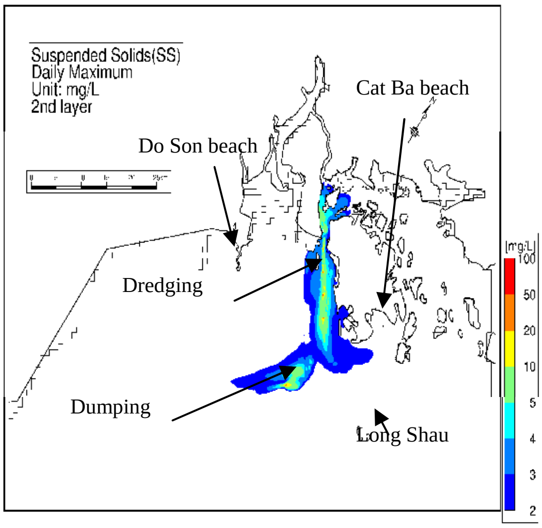
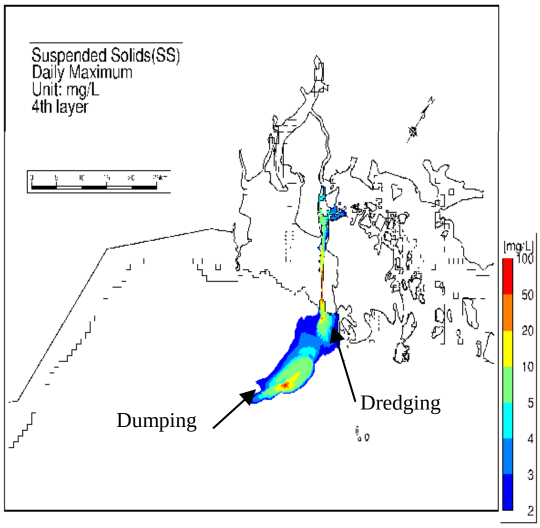
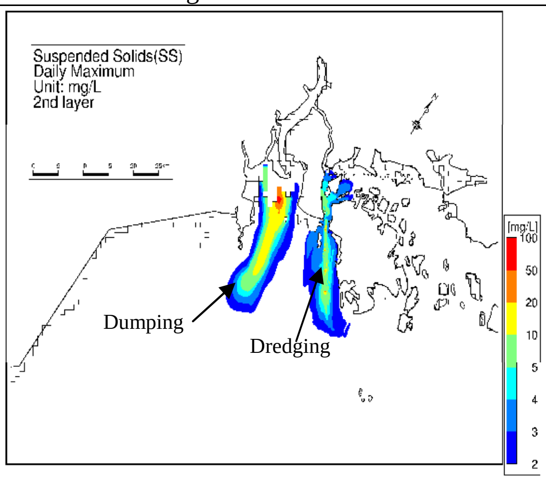
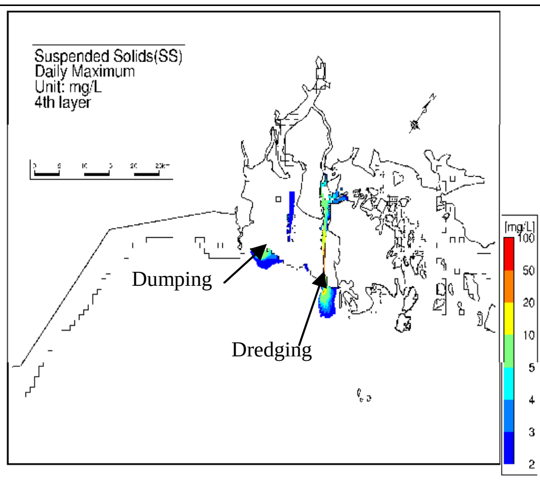
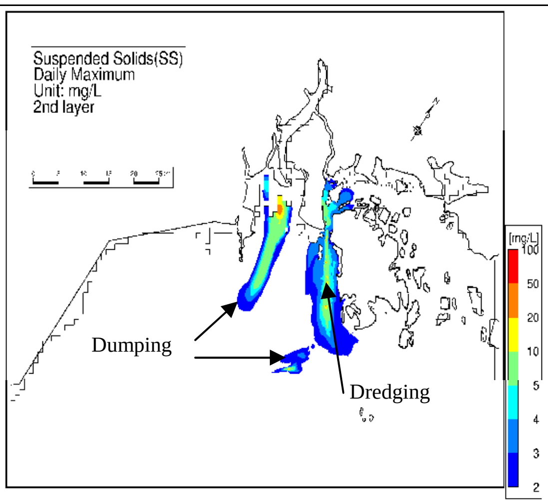
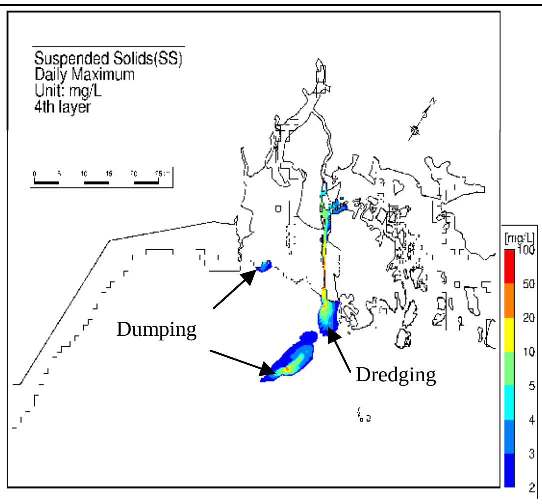
<table>
<tr><th></th><th>Upper layer</th><th>Lower layer</th></tr>
<tr><td></td><td colspan="2">Case 3 : 100% Offshore Dumping (with silt curtain for dredging)</td></tr>
<tr><td>100% dumping at offshore</td><td>
</td><td>
</td></tr>
<tr><td></td><td colspan="2">Case 4 : 100% SDV Dumping (with silt curtain for dredging, dumping basin and drainage effluent outlet from embankment)</td></tr>
<tr><td>100% dumping at SDV</td><td>
</td><td>
</td></tr>
<tr><td></td><td colspan="2">Case 5: 50% SDV+50% Offshore Dumping(with silt curtain for dredging, dumping basin and drainage effluent outlet from embankment of SDV)</td></tr>
<tr><td>50% offshore + 50% SDV</td><td>
</td><td>
</td></tr>
</table>

Figure 12.2.20 SS Diffusion Simulation Results of Case 3, 4 and 5

g) Conclusion

- 100% offshore dumping is better option.

  Reason: a) Dredged soil is not suitable for reclamation
  b) Project cost is lower (6,000 billion VND cheaper)
  c) Environmental impact is smaller

- 50% SDVIZ dumping is technically possible, however,

  Risk: a) Cost of surface soil improvement is high
  b) Coordination of schedule with IZ developer will be difficult
  c) Additional L/A is required
  d) Additional EIA is necessary

12.3 Suspended Solid Dispersion

Numerical simulations were carried out in order to study the influence of the suspended solid (SS) / turbidity, which is generated by dredging of sea route and dumping of the dredged materials, to surrounded area.

12.3.1 Outline

1) Target Area

Target area of the simulation study is shown in Figure 12.3.1.

2) Work Flow

Work flow of this study is shown in Figure 12.3.2.

Map source: Google earth

Figure 12.3.1 Target Area of the Simulation Study

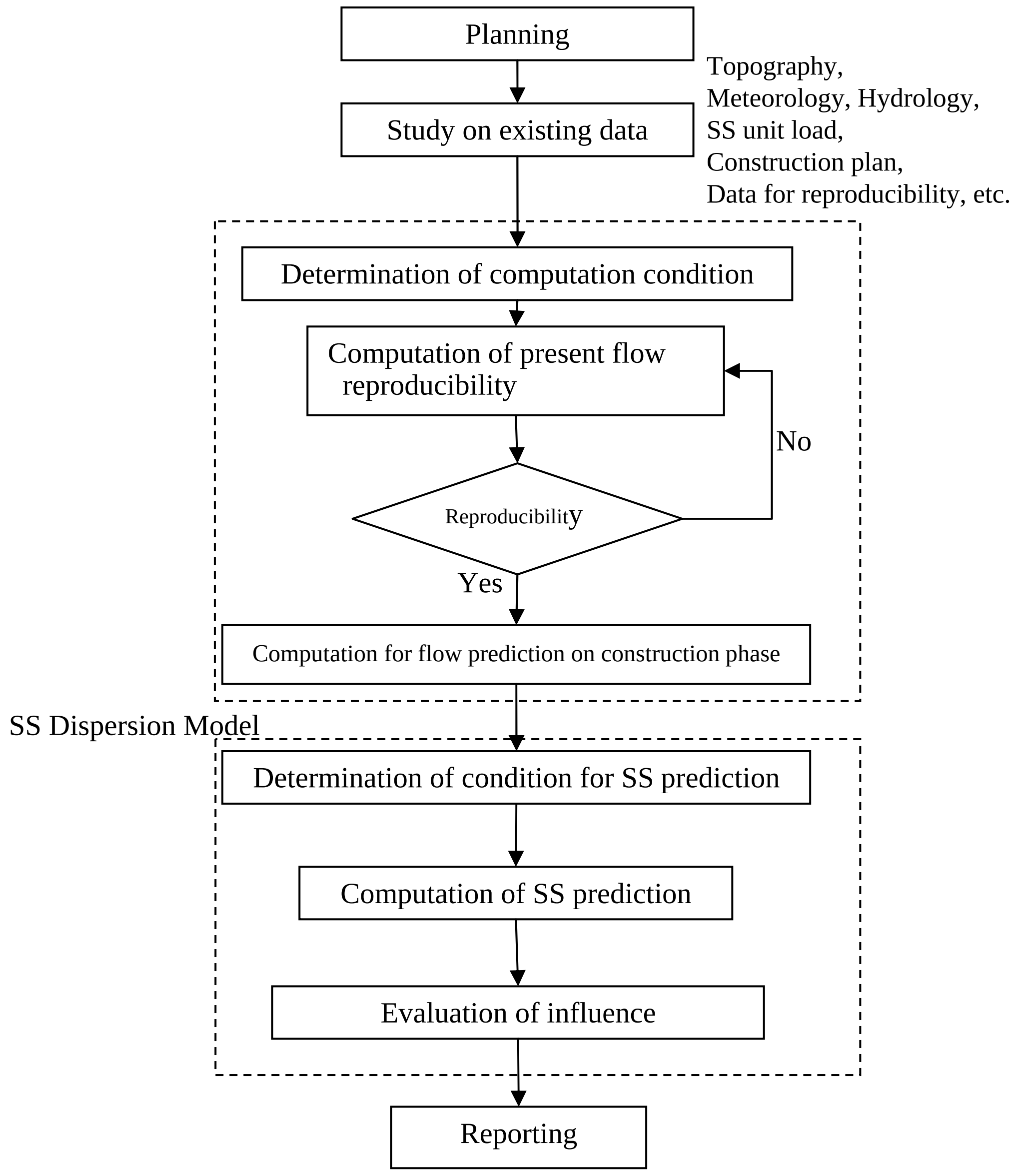


Figure 12.3.2 Work Flow

12.3.2 Study on Existing Data

Prior to conducting hydrodynamic and SS dispersion simulation, existing data such as meteorological and hydrological conditions were studied.

Obtained data is summarized in Table 12.3.1.

Table 12.3.1 Obtained Existing Data

Category	No.	Data	Utilized information
Assessment	1-1	MINISTRY OF TRANSPORT VIETNAM MARITIME ADMINISTRATION, MARITIME PROJECT MANAGEMENT UNIT II OF JAPAN INTERNATIONAL COOPERATION AGENCY (2010.5): SUPPLEMENTAL REPORT ENVIRONMENTAL IMPACT ASSESSMENT - HAI PHONG INTERNATIONAL GATEWAY PORT (LACH HUYEN GATEWAY PORT) CONSTRUCTION PROJECT (2010-2015).	Meteorological Condition, Tide level, Flow, Density distribution in sea area
	1-2	JICA: THE PREPARATORY SURVEY ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION IN VIET NAM, Final Report, July 2010	ditto
Field Survey	2-1	ORIENTAL CONSULTANST CO., LTD (2009.12):THE PREPARATORY SURVEY ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION IN VIET NAM REPORT ON HYDROGRAPHIC SURVEY VOLUME I: BATHYMETRIC SURVEY	Bathymetry survey results
	2-2	ORIENTAL CONSULTANST CO., LTD (2010.1):THE PREPARATORY SURVEY ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION IN VIET NAM REPORT ON CURRENT SURVEY	Flow measurement results
Study paper	3-1	D. S. van Maren (2004): Morphodynamics of a cyclic prograding delta: the Red River, Vietnam. Netherlands Geographical Studies 324, Royal Dutch Geographical Society / Faculty of Geosciences, Utrecht University.	Fresh water inflow
	3-2	Thao, N. T. P., M. V. D. Wegen and D. Roelvink (2008) : MORPHOLOGICAL BEHAVIOUR OF NAM TRIEU ESTUARY – VIETNAM. COPEDEC VII, 2008, Dubai, UAE.	ditto
Manual	4-1	Ministry of Land, Infrastructure and Transport: Guideline for prediction of impact by turbidity on port construction, April 2004	Basic Idea for SS dispersion
Other	5-1	Matsumoto, K., T. Takanezawa, and M. Ooe (2000) : Ocean Tide Models Developed by Assimilating TOPEX/POSEIDON Altimeter Data into Hydrodynamical Model: A Global Model and a Regional Model Around Japan, Journal of Oceanography, 56, 567-581.	Tide in open sea

12.3.3 Simulation Models

The simulation models used in this study consists of two models, hydrodynamic model and SS dispersion models. Hydrodynamic model computes reproducibility of flow and predicts the flow change caused by construction, while SS dispersion model predicts the change of SS distribution based on the flow change prediction.

1) Selection of the Models and the Structure

Based on the following consideration, the models and the structure were determined.

a) Characteristics of the Target Area

Turbidity generated by dredging or dumping is generally spreading with diffusing by the water flow in the area. The water flow in the target area of this study is considered the mixture of tidal current, density flow caused by inflow of fresh water from the rivers and wind-driven current that is important factor in the shallow area such as tidal flat. The depth of the target area is comparatively shallow and tidal flats are widely spread repeating the ebb away and submerging by the transition of tide..

b) Outline of Applied Numerical Models

Following two (2) models are used to express the characteristics of the target area described above.

Hydrodynamic Model	: Vertical multilayer level model which considers ebb away and submerge of tidal flat by tide transition, tidal current, density flow and wind-driven current.
SS Dispersion Model	: A model which considers process of advection, diffusion and sedimentation of suspended solid. Water level, direction and speed of the flow which is calculated by the hydrodynamic model are used for computation input conditions.

Nesting method is used to express the complicated topography of the target area and to effectively compute. Appropriate mesh size is used to express in detail in the port and sea route area connecting different mesh size for outer area to compute simultaneously for intimate prediction of influence by the construction.

General idea of the multilayer level model is shown in Figure 12.3.3.

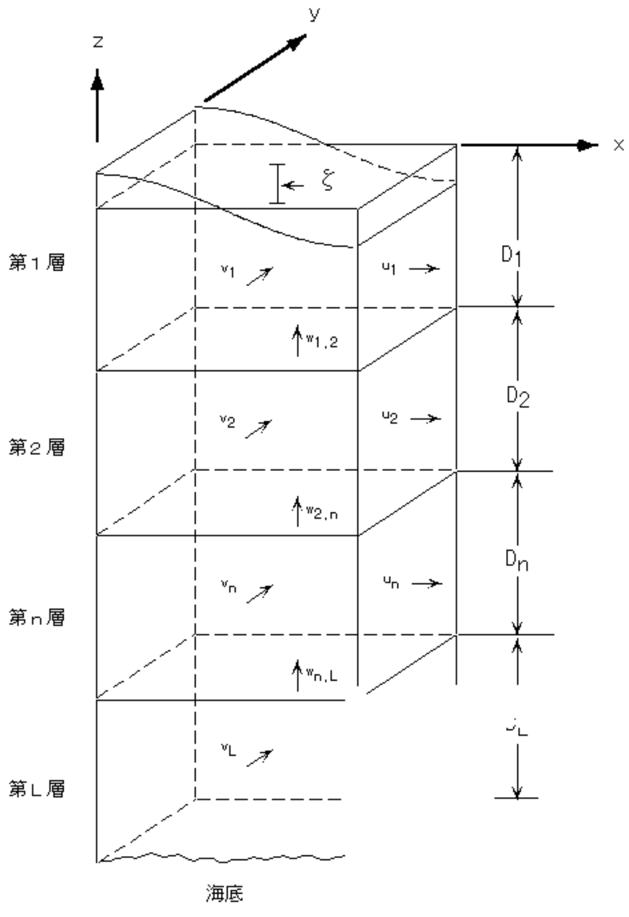


Figure 12.3.3 General Idea of Multilayer Level Model

c) Structure of the Numerical Models

Basic structure of the models is shown in Figure 12.3.4.

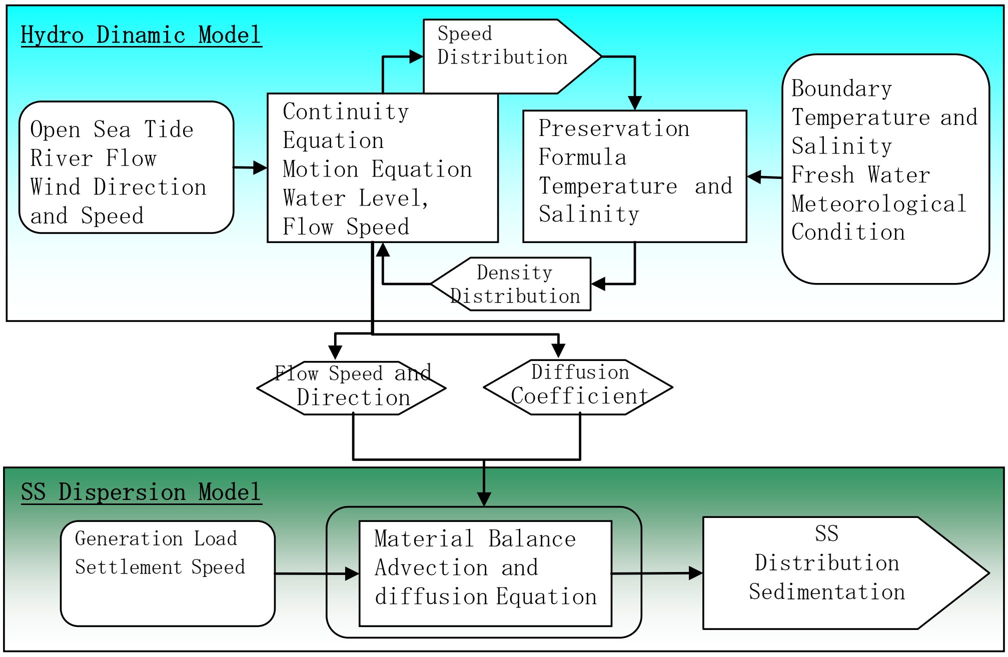


Figure 12.3.4 Basic Structure of the Models

d) Basic Equations and Consideration

i) Hydrodynamic Model

The hydrodynamic model is a numerical model which ciphers the basic equations of fluid dynamics (Motion Equation, Continuity Equation and Preservation Formula of Temperature and Salinity) by differencing.

Details are discussed in APPENDIX 12-1.

Followings are considered upon computation.

- Two seasons, dry and wet season, are considered because flow field might be changed due to the difference of river flow volume and wind condition.
- Average meteorological and hydrological conditions are setup to predict average flow field in dry and wet season by time-homogeneous computation.

ii) Suspended Solid (SS) Dispersion Model

SS dispersion model uses advection and diffusion equation as a basic formula and considers settlement process of dispersion materials in conservative system.

Details are described in APPENDIX 12-1.

Followings are considered upon computation.

- Comprehensive SS dispersion in the target area is considered based on the reality of multiple execution way of construction, different work load and simultaneous execution at different locations.
- Relative concentration of SS contributed by construction is considered.

12.3.4 Computation Condition for Primary Simulation

Primary simulation was carried out with following conditions to study the area of SS dispersion.

1) Hydro Dynamic Model

a) Data from Field Survey

Field survey data listed in Table 12.3.2 are used for computation.

Although May through October is categorized as Wet season and November through April is categorized as Dry season, high season for rain and river flow in Lach Huyen area is from July to September. Thus other data available through internet was also used to consider the difference between Dry and Wet season.

Table 12.3.2 Obtained Existing Data

Item	Wet Season	Dry Season	Date of Data
Topography	X		Data is available in the Lach Huyen area, every 2-3 months from May 2005 to May 2011
Tide level	X		November 2009, May 2011
Temperature, Salinity	X		May 2006, May 2011
Fresh Water Inflow	X		September 1999, May 1999
Meteorological Condition	X	X	Averaged monthly data from 1975 to 2005
Flow	X	X	November 2009, May 2011

b) Computation Area and Mesh

Computation area is shown in Figure 12.3.5.

Minimum computation mesh size is set as 100m in order to express the geometry of sea route and port berth. The mesh size is bigger in outer area based on the Nesting method, and the biggest mesh size is 900m. The computation area covers candidate dumping areas with 100m mesh size.

c) Vertical Layers Partition

Vertical layer partition is as follows.

First Layer: Sea surface to 2.0m (below surface)
Second Layer: 2.0 - 4.0m
Third Layer: 4.0 - 6.0m
Fourth Layer: 6.0 - 8.0m
Fifth Layer: 8.0 - 10.0m
Sixth Layer: 10.0 - 12.0m
Seventh Layer: Deeper than 12.0m

Vertical layer partition is important on computation of hydrodynamic and SS dispersion, considering topography and depth in the target area. Based on the following conditions, depth layer less than 10m below surface is recognized as important part and divided every 2m.

- The depth of the sea route is 7 – 8m
- Shallow area is one of candidates for dumping site
- Although the depth of candidate site for offshore dumping is deeper than 20m, dispersion of

turbidity may spread from surface to bottom layer. Thus influence in the surface part, where the flow speed is higher than in the bottom layer, is considered significant and the part is divided into small part.

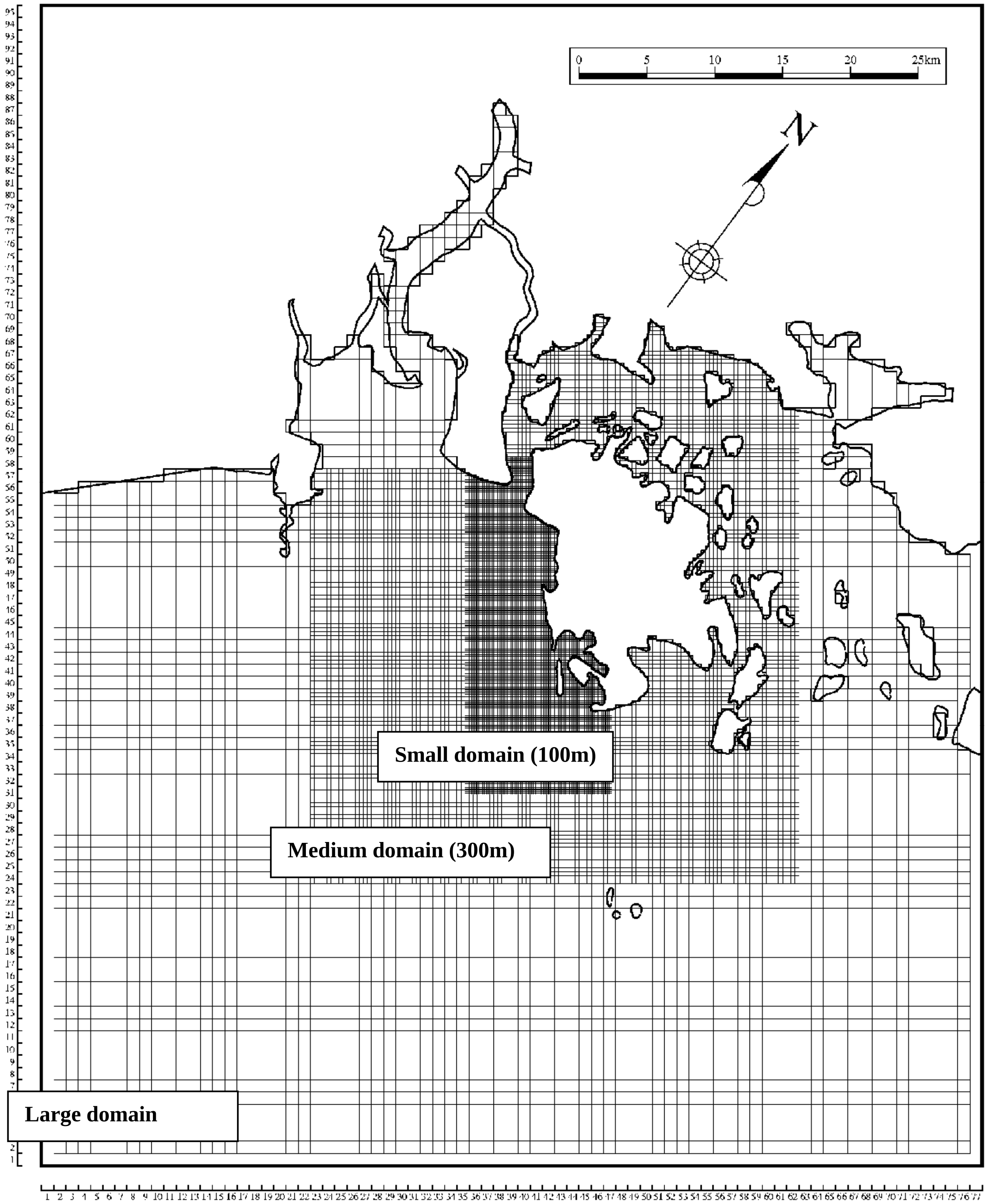


Figure 12.3.5 Computation Area and Mesh Partition

d) Seafloor Topography

Data for seafloor topography was generated using data from commercial sea chart and the data from previous study[1].

The topography in each domain is shown in Figure 12.3.6, Figure 12.3.7 and Figure 12.3.8 respectively.

e) Tide Level

Flow in the target area caused by water level changes at boundary of the target area was computed. Amplitude and tide lag of predominant tidal components (K1 and O1) based on the Global Ocean Tide Model (Matsumoto et al. (2000)[2]) are referred.

Position of open boundary and used parameters at open boundary is shown in Figure 12.3.9 and Table 12.3.3 respectively.

f) Water Temperature and Salinity

Water temperature and salinity for initial value and open boundary points were determined referring the survey data in May 2006[3]. In the survey, water temperature and salinity were measured at 3 layers in 5 locations at the south of Cat Hai Island. Determined values are shown in Table 12.3.4.

Another survey data carried out in May 2011 will be used instead of this data.

[1] ORIENTAL CONSULTANST CO., LTD (2009.12):THE PREPARATORY SURVEY ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION IN VIET NAM REPORT ON HYDROGRAPHIC SURVEY VOLUME I: BATHYMETRIC SURVEY

[2] Matsumoto, K., T. Takanezawa, and M. Ooe (2000) : Ocean Tide Models Developed by Assimilating TOPEX/POSEIDON Altimeter Data into Hydrodynamical Model: A Global Model and a Regional Model Around Japan, Journal of Oceanography, 56, 567-581.

[3] MINISTRY OF TRANSPORT VIETNAM MARITIME ADMINISTRATION,MARITIME PROJECT MANAGEMENT UNIT II OF JAPAN INTERNATIONAL COOPERATION AGENCY : SUPPLEMENTAL REPORT ENVIRONMENTAL IMPACT ASSESSMENT - HAI PHONG INTERNATIONAL GATEWAY PORT (LACH HUYEN GATEWAY PORT) CONSTRUCTION PROJECT (2010-2015).

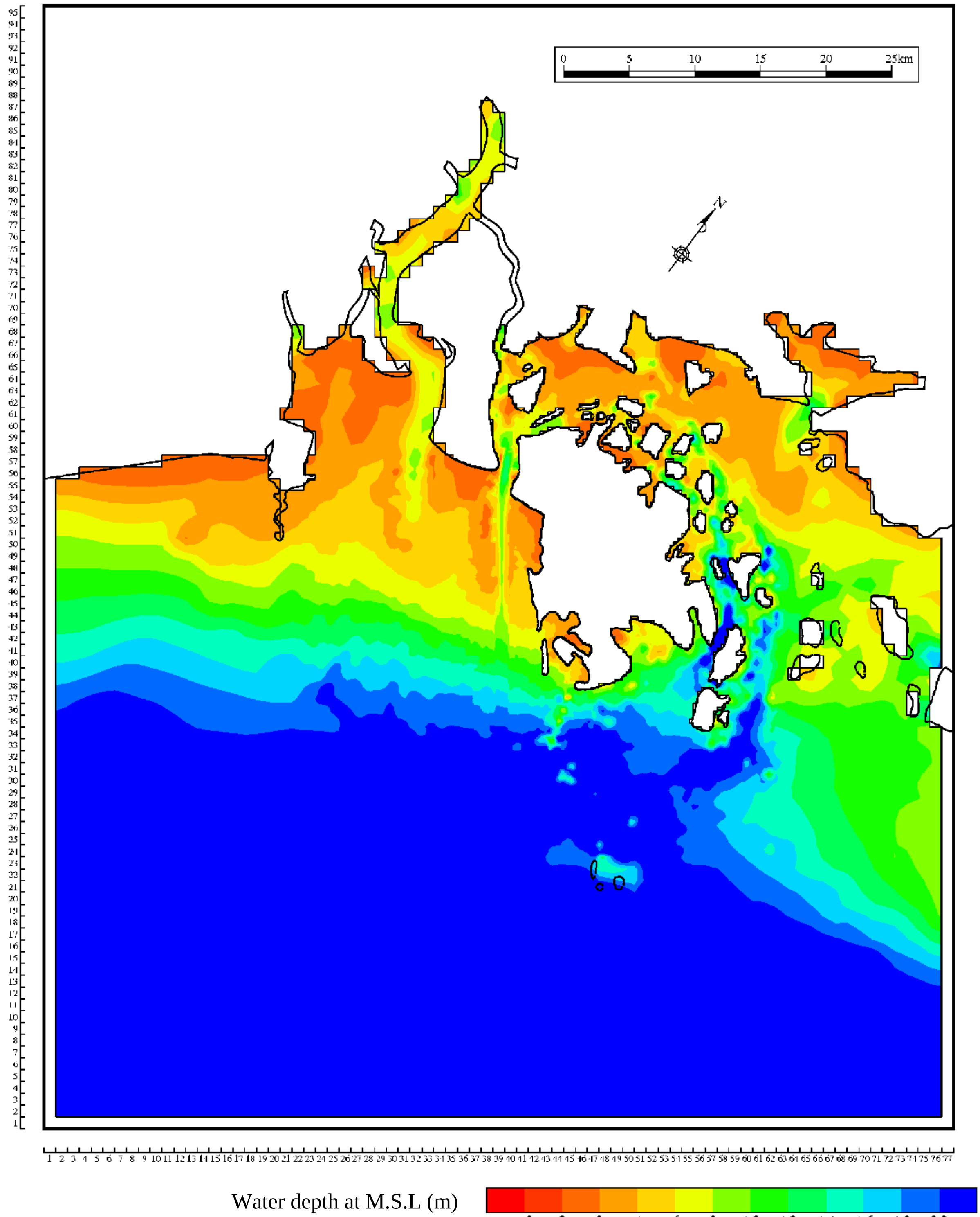


Figure 12.3.6 Seafloor Topography in Large Domain (Mesh Size: 900m, 300m, 100m, Present Condition)

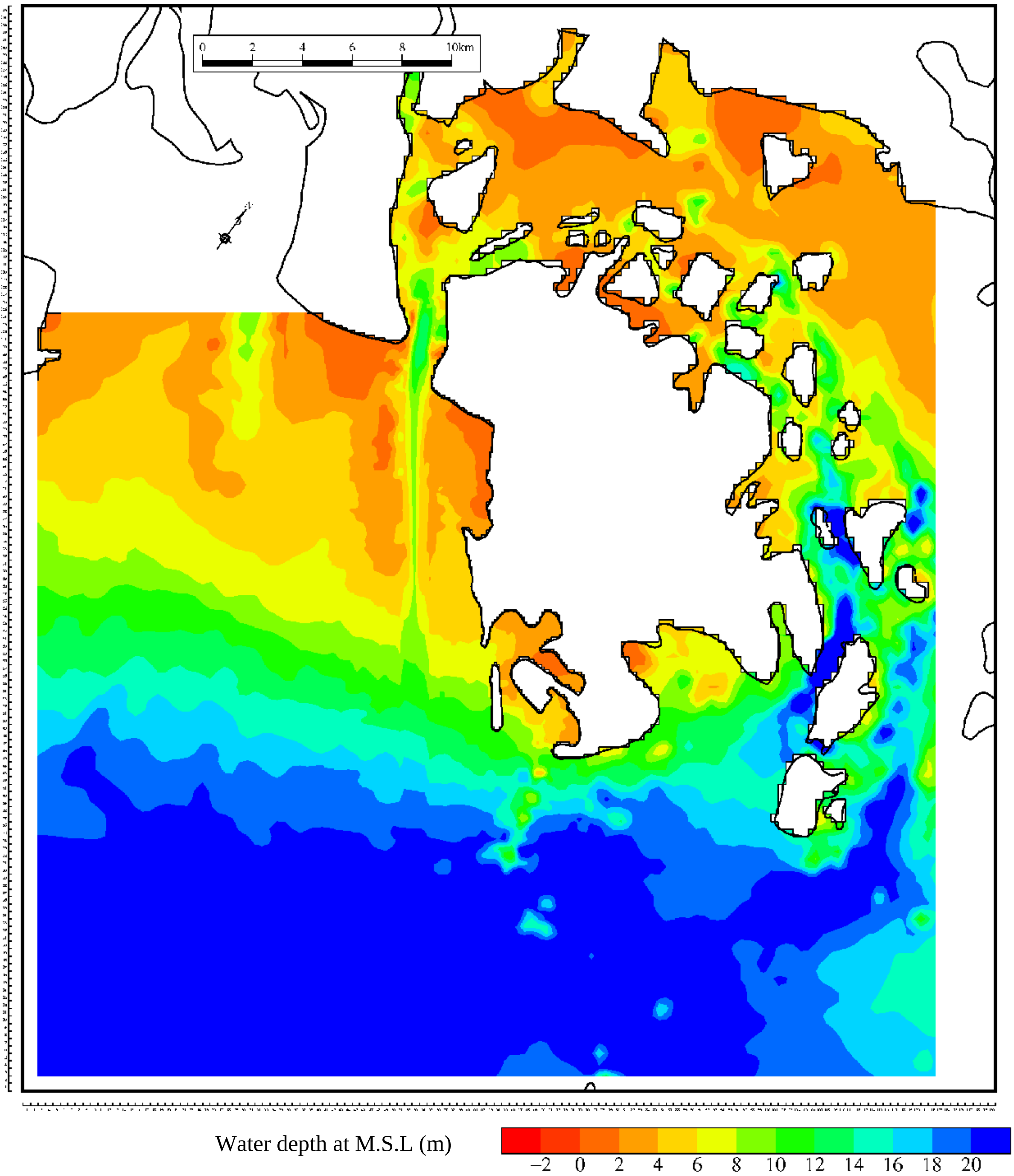


Figure 12.3.7 Seafloor Topography in Medium Domain (Mesh Size: 300m, 100m, Present Condition)

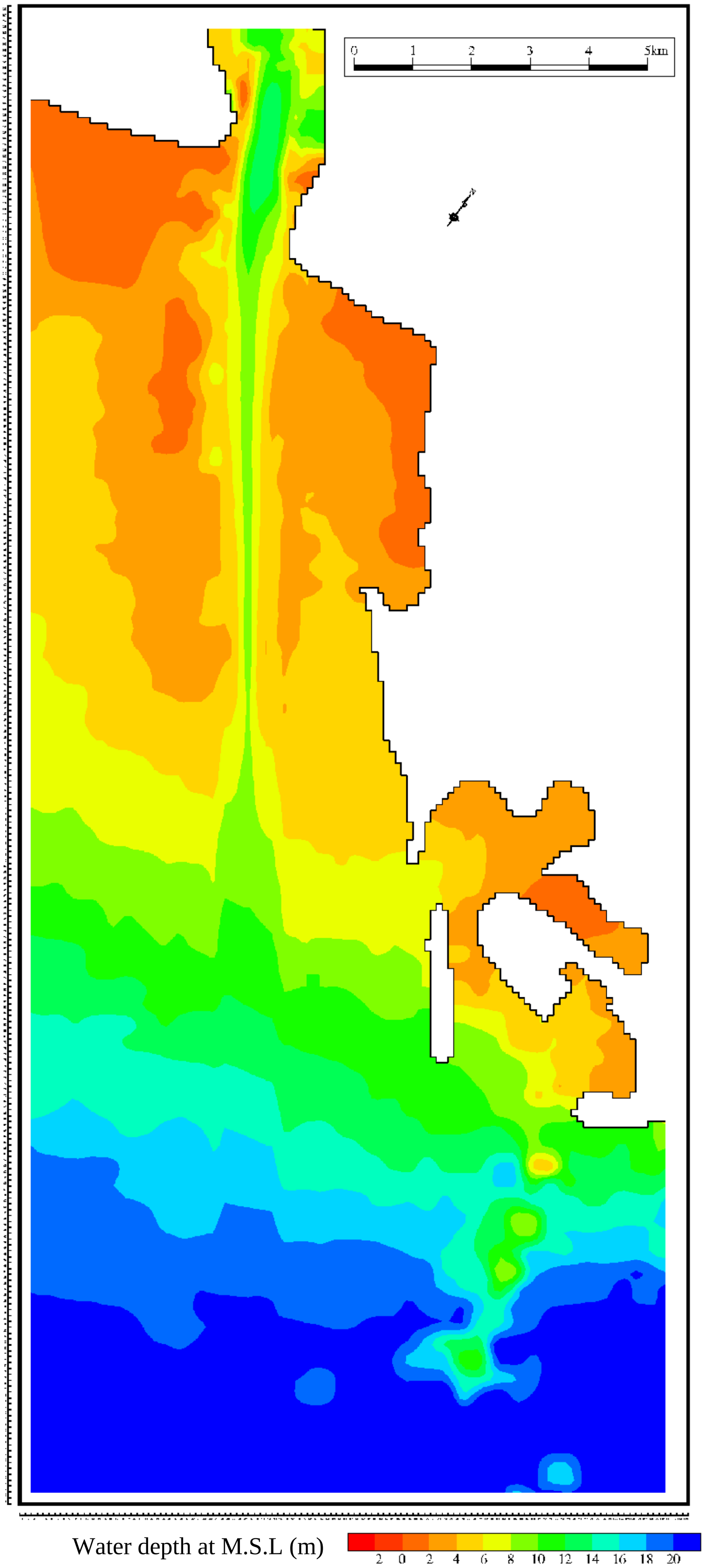


Figure 12.3.8 Seafloor Topography in Small Domain (Mesh Size: 100m, Present Condition)

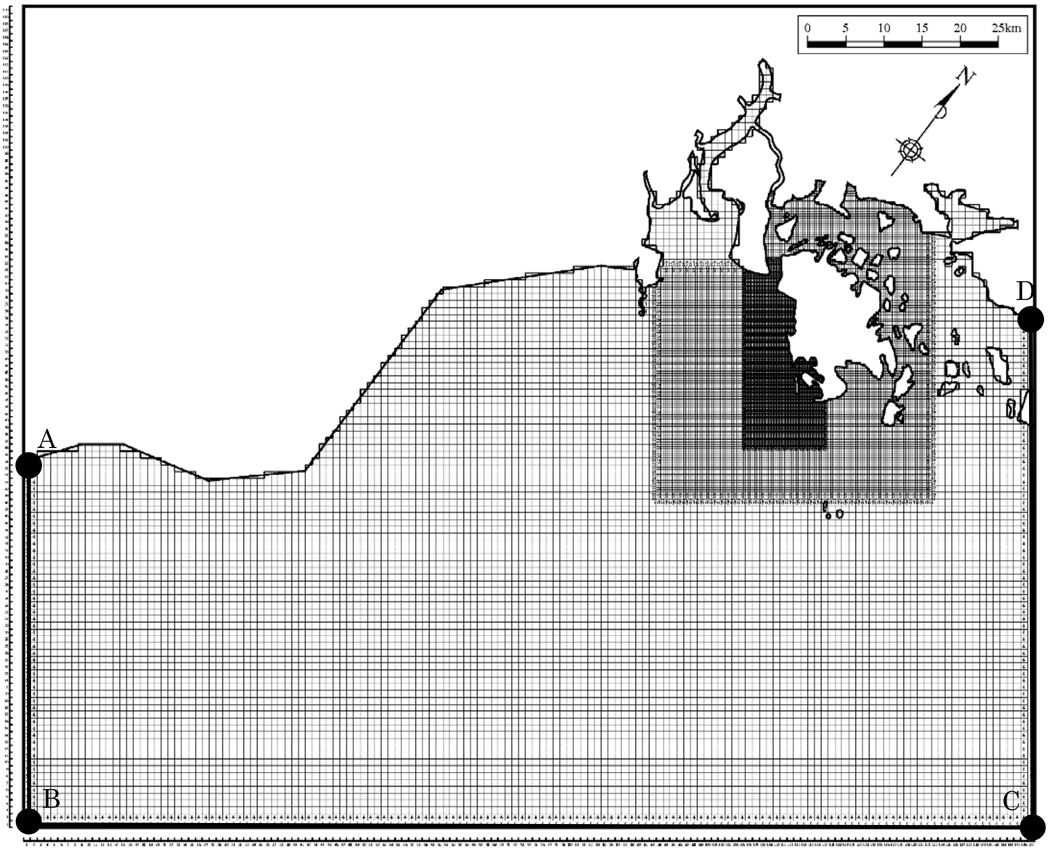
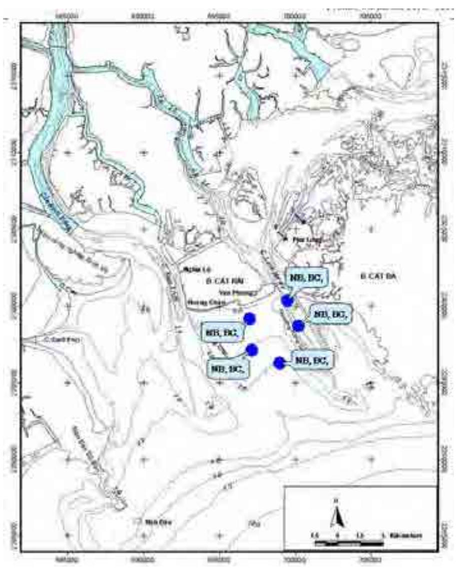


Figure 12.3.9 Location of Open Boundary

Table 12.3.3 Parameters Used for Tide Computation at Open Boundary

	Amplitude	Tide Lag	Averaged Water Level
A	140 cm	0.0^{o}	2cm
B	140 cm	0.0^{o}	2cm
C	158 cm	1.0^{o}	0cm
D	158 cm	1.0^{o}	0cm

Table 12.3.4 Boundary Values



	Layer depth(m)	Temperature (deg)	Salinity (psu)
1st Layer	1	26.60	27.20
2nd Layer	3	26.20	27.20
3rd Layer	5	25.85	27.20
4th Layer	7	25.55	27.20
5th Layer	9	25.25	27.20
6th Layer	11	24.95	27.20
7th Layer	13	24.65	27.20

g) Fresh Water Inflow

Fresh water inflow volume was determined as 6,000 m^3/s in wet season and 1,600 m^3/s in dry season respectively based on the averaged flow volume in 1960 -1998 at Son Tay in the Red River – Thai Binh water system introduced by Maren (2004)[4]. And flow volume form each river was calculated using distribution ratio (Maren, 2004).

Determined fresh water inflow volumes are shown in Table 12.3.5. Figure 12.3.10 shows the location of Son Tay.

Thao et al.(2008)[5] states that 80% of annual volume flows in wet season, which assists the determination volume above.

Table 12.3.5 Fresh Water Inflow Volume (m^3/s)

Season	Lach Huyen (5%)	Nam Trieu (10%)	Lach Tray (5%)	Total
Wet	300	600	300	1,200
Dry	80	160	80	320

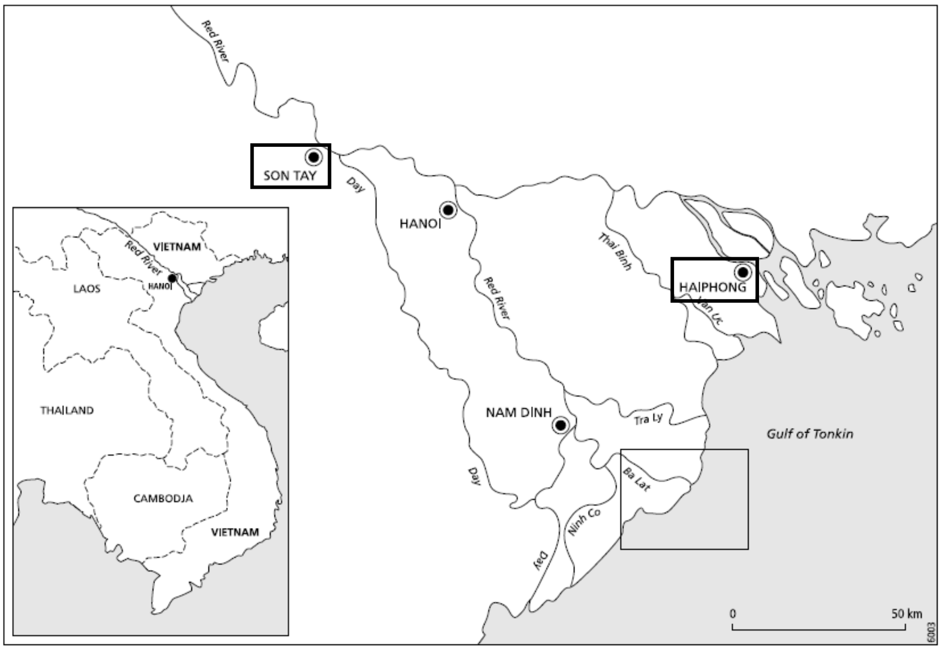


Figure 12.3.10 Observation Point for Fresh Water Flow (Son Tay)

h) Meteorological Data

Meteorological data was determined based on the monthly averaged data from 1975 to 2005[6].

Wind direction and speed was determined from the data at Bai Chay in Ha long city, amount of global solar radiation was determined from the data at Phu Lien in Hai Phong city and other

[4] D. S. van Maren (2004) : Morphodynamics of a cyclic prograding delta: the Red River, Vietnam. Netherlands Geographical Studies 324, Royal Dutch Geographical Society / Faculty of Geosciences, Utrecht University.

[5] Thao, N. T. P., M. V. D. Wegen and D. Roelvink (2008) : MORPHOLOGICAL BEHAVIOUR OF NAM TRIEU ESTUARY – VIETNAM. COPEDEC VII, 2008, Dubai, UAE.

[6] JICA: THE PREPARATORY SURVEY ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION IN VIET NAM, Final Report, July 2010

parameters were determined from the data at Cat Hai respectively.

Determined data is shown in Table 12.3.6 and Figure 12.3.11.

Table 12.3.6 Meteorological Data

Parameter	Wet Season	Dry Season
Temperature (^oC)	28.0	20.3
Precipitation (mm/day)	8.8	1.1
Humidity (%)	83.8	82.2
Global Solar Radiation (kcal/cm2/month) **	11.4	6.5
Cloudiness (10munites observation)	6.4	7.3
Main Wind Direction (8 directions) *	SE	N
Averaged Wind Speed of Main Wind Direction (m/s) *	3.8	3.6
Averaged Wind Speed (Scalar Average of all wind direction, m/s)*	3.6	3.1

* Bai Chai, Ha Long City
** Phu Lien, Hai Phong
*** Data of other parameters are from Cat Hai.

Figure 12.3.11 Meteorological Data Observation Point

i) Integration Time

Integration time was set as 20 days until fresh water inflow from the rivers and sea water density influenced by heat balance between sea surface and atmosphere is stable. And the last 24 hours are used for analysis.

j) Other Parameters

Other parameters which is used for hydrodynamic computation is listed in Table 12.3.7.

Table 12.3.7 Parameters Used for Hydrodynamic Computation

Parameter	Value
Integration Time Step	$\Delta t < \dfrac{\Delta s}{\sqrt{2 \cdot g \cdot h_{\max}}}$ Δs: Mesh Size(m) g: Gravitation Acceleration (m/s^2) h_{max}: Maximum Depth in Computation Area(m) Computation stability is determined by the above equation. 18 seconds for 900m mesh, 6 seconds for 300m mesh and 2 seconds for 100m mesh are set respectively considering computation stability.
Sea Surface Friction Coefficient	Seas surface friction is effect of momentum sifting from wind to sea water by friction. $\tau_a = C_d \cdot \rho_a \cdot W^2$ τ_a: Sea Surface Stress (dyne/cm^2) ρ_a: Atmosphere Density(g/cm^3) C_d: Sea Surface Friction Coefficient(=0.0013) W: Wind speed Vector(cm/s)
Horizontal Eddy Kinematic Viscosity Coefficient (A_M) Horizontal Eddy Diffusion Coefficient(A_H)	Empirical Formula by Smagorinsky(1963)[7] is used. $A_{M,H} = C_{M,H}(\Delta x \times \Delta y)\left[\frac{1}{2}\left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2 + \left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right]^{1/2} + A_{MB,HB}$ $C_{M,H}$:0.1, $A_{MB,HB}$:10^4 cm^2/s
Vertical Eddy Kinematic Viscosity Coefficient (K_M) Vertical Eddy Diffusion Coefficient (K_H)	Stratification function by Pacanowski and Philander(1981)[8] is used. Minimum value is set as 1.0(cm^2/s), maximum value is set as 100.0(cm^2/s). $K_M = \dfrac{K_{M0}}{(1+\alpha R_i)^n} + K_{MB}$ $K_H = \dfrac{K_M}{(1+\alpha R_i)^n} + K_{HB}$ $R_i = \dfrac{-\frac{g}{\rho}\left(\frac{\partial \rho}{\partial z}\right)}{\left(\frac{\partial U}{\partial z}\right)^2}$ K_{MB}: Vertical Eddy Kinematic Viscosity Coefficient at back ground(=1.0 cm^2/s) K_{HB}: Vertical Eddy Diffusion Coefficient at back ground (=1.0 cm^2/s) K_{M0}: 100.0 cm^2/s α : 5 n : 2 z : Vertical coordination value above datum U : Horizontal speed(cm/s)
Coriolis Parameter	Apparent force by the earth rotation which influence to moving object is shown by following equation. f=2ωsinφ f : Coriolis parameter (1/s) ω : Angular velocity of the earth rotation(2π/(23.93×3600)) φ : Latitude (=20.5°)

2) Suspended Solid Dispersion Model

a) Selection of Computation Condition

i) Computation Area, Mesh Partition and Vertical Layer Partition

Same conditions as the Hydrodynamic Model are used.

ii) Initial Condition and Boundary Value of concentration for Suspended Solid

Initial condition and boundary value (background value) for concentration of Suspended Solid are set as 0 mg/L to evaluate the diffusion area and concentration caused by the construction.

---

7 J.Smagorinsky(1963) : General Circulation Experiments with the Primitive Equations Ⅰ. The Basic Experiment, Monthly Weather Review, 91, 99-164.

8 R. C. Pacanowski and S. G. H. Philander(1981):Parameterization of Vertical Mixing in Numerical Models of Tropical Oceans. J. Phys. Oceanogr.,11,1443-1451.

iii) Diffusion Coefficient

Same value of the Horizontal and Vertical Eddy Diffusion Coefficients in the Hydrodynamic Model are used.

iv) Grain Size of Dredged Soil for Computation

Previous survey data of grain size test in borehole experiment[9] was used for grain size of dredged soil for computation. Sampling points and layers are uniformly distributed horizontally along with the sea route and vertically (from bottom surface to 7.0m below bottom).

All available data is averaged to obtain the composition shown in Table 12.3.8 and grain size distribution curve shown in Figure 12.3.12 was generated.

Table 12.3.8 Composition of Grain Size

	Grain Size	Composition
Sand	0.5-0.25 mm	9.0%
	0.25-0.10 mm	19.6%
	0.10-0.05 mm	14.1%
Silt	0.05-0.01 mm	12.7%
	0.01-0.005 mm	8.2%
Cray	<0.005 mm	36.4%

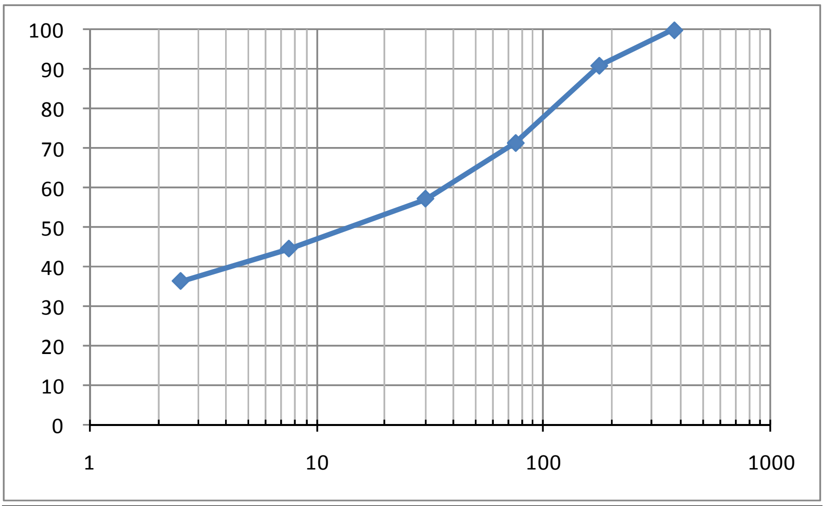


Figure 12.3.12 Grain Size Distribution Curve

Using this data and Stokes' sedimentation equation, sedimentation speed is determined.

v) Prediction Cases for Simulation of Suspended Solid Dispersion

Prediction cases are summarized in Table 12.3.9. Five (5) cases were computed based on the construction plan.

Unit load of suspended solid depends on the dredging/dumping way. A guideline for prediction of suspended solid dispersion[10] is referred to determine the unit load. Unit load in

[9] Lach Huyen Gateway Port – Hai Phong Investment of Construction Project, MPMU1, 2006

[10] Guideline for Prediction of Influence of Suspended Solid on Port Construction, April 2004, Ministry of Land,

the table is obtained averaging each unit load for fine particle fraction of the target dredging/dumping way in the guideline.

Table 12.3.9 Prediction Case

Case	Dredging						Dumping				
	Vessel	Amount (m^3/day/ vessel)	Unit Load (t/m^3)		Depth (m)	Soil Contain	Vessel	Site	Frequency (times/day) x vessels	Amount (m^3/time/ vessel)	Unit Load (t/m^3)
			Cutter Head	Over Flow							
1	TSHD* x 10	3,210	1.92×10^{-3} at bottom	7.68×10^{-3} at -5m	-7 -> -10	40%	TSHD x 10	Offshore	3 x 10	1,070	22.72×10^{-3}
2	TSHD x 2	14,660	1.92×10^{-3} at bottom	7.68×10^{-3} at -5m	-10 -> -14	40%	TSHDx2	Offshore	3 x 2	4,887	22.72×10^{-3}
3	Pump x 2	25,300	4.26×10^{-3} at bottom	-	-7 -> -14	20%	Hopper barge	Offshore	3 x 7	1,205	5.33×10^{-2}
4**	Pump x 2	25,300	4.26×10^{-3} at bottom	-	-7 -> -14	20%	Hopper Barge	Cat Hai***	3 x 7	1,205	5.33×10^{-2}
	Pump x 3	12,000	2.11×10^{-3} at bottom	-	-5	20%	Pump	Cat Hai ***	1 x 3	48,000 m^3/day/ Vessel ****	22.72×10^{-3} ****
5	Grab	9,150	1.53×10^{-2} all layer	-	-7 -> -10	50%	Hopper Barge	Offshore	5 x 4	915	5.33×10^{-2}

*TSHD: Trailing Suction Hopper Dredger
**This case consists of two phases, dredging/dumping at temporal dumping site and secondary dredging for dumping to regular damping site.
***Temporal dumping site is located at 3km offshore of Cat Hai Island, and regular dumping site is located at south of Hat Hai Island.
****Amount and unit load are the values of discharged turbid water from dumping site through effluent outlet.

Pattern diagrams of each case are shown in Figure 12.3.13.

Source of suspended solid load of dredging in Case 1 and 2 is expressed as line, while other sources are expressed as point based on the type of works.

The length of load source in Case 1 is shorter than that in Case 2 based on the planned dredging depth.

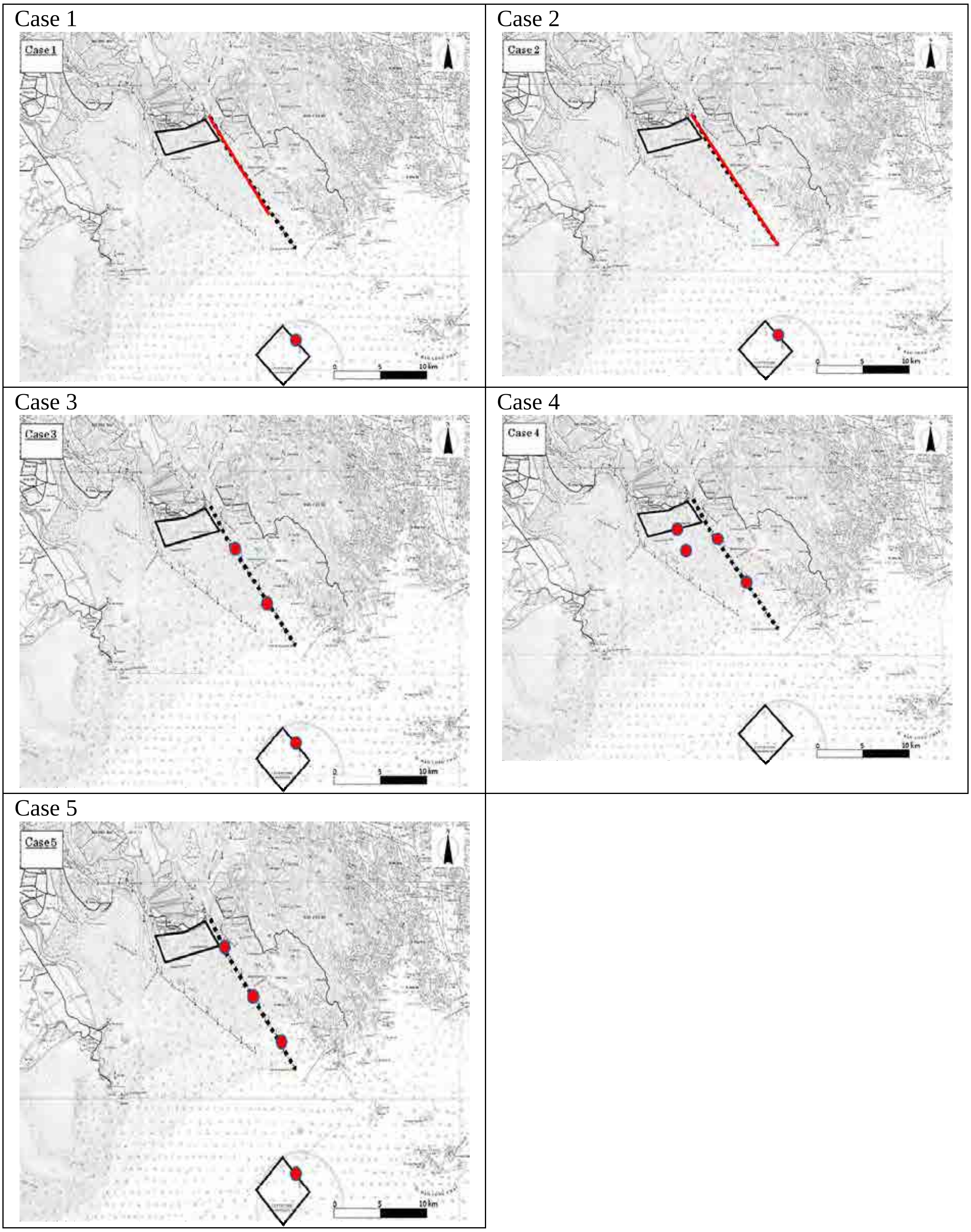


Figure 12.3.13 Pattern Diagram of Computation Case

b) Model for SS Dispersion

Dispersion of Suspended Solid (SS) defers depending on the dredging/dumping way.

Table 12.3.10 summarizes the basic idea of SS dispersion.

Table 12.3.10 Models for SS Dispersion

Dredging	TSHD	SS is generated at bottom by drilling cutter and at several m above bottom from overflow water discharge pipe.
	Pump	SS is generated at bottom by sucking cutter.
	Glove	SS is generated at all layers by gloving at bottom, drawing-up of the glove at middle layer and leakage of dredged materials at surface.
Dumping	TSHD Hopper barge	SS is generated at all layers by dumping from the bottom of the vessel.

12.3.5 Computation Condition for Detailed Study

Based on the result from the primary simulation, countermeasures for SS dispersion and method for dredging and dumping were discussed to conduct the detailed study using simulation model (See Chapter 21 for the details).

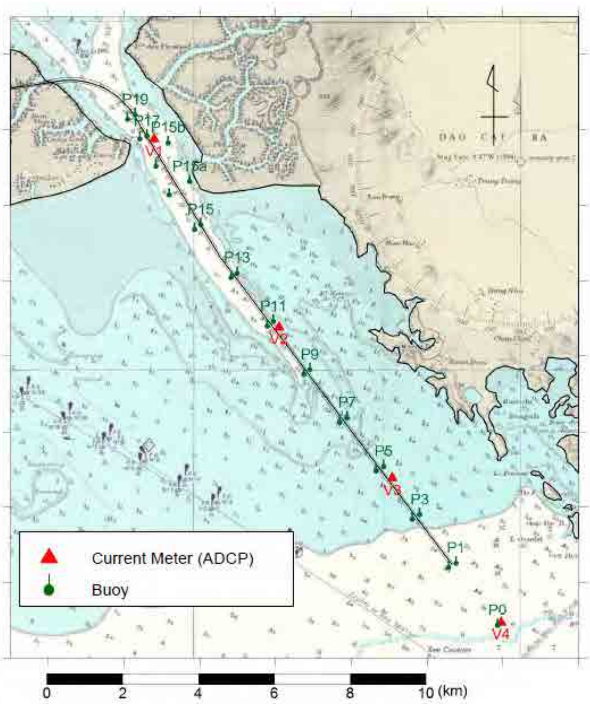
12.3.6 Confirmation of Reproducibility of the Hydrodynamic Model

1) Used Survey Data

Reproduction period is from November 2009 to December 2009, when field survey was conducted on SAPROF study.

Reproduction parameters are tidal current ellipse and residual flow.

Survey points are shown in Figure 12.3.14.



Coordinate System : VN2000-105° 45'

East	North	Name	Depth m CD
620585	2301881	V1	-9.77 m CD
623743	2297059	V2	-3.83 m CD
626820	2292833	V3	-4.56 m CD
629550	2288929	V4	-10.66 m CD

Source: JICA, The Preparatory Survey on Lach Huyen Port Infrastructure Construction in Viet Nam, Final Report, July 2010

Figure 12.3.14 Location of Flow Survey (Nov., 2009 – Dec., 2009)

2) Reproducibility of Tidal Current Ellipse

Comparison of tidal current ellipse between survey data and computation result is shown in Figure 12.3.15.

NNW to SSE tidal current direction is distinguished except St. V4 in both results. The comparison shows the characteristics that current speed at St. V1 is greater than at St. V3 and vertical strength of the current speed.

Although computation result shows a bit greater speed than observation data at St. V4, it is considered that the computation result shows the good reproducibility.

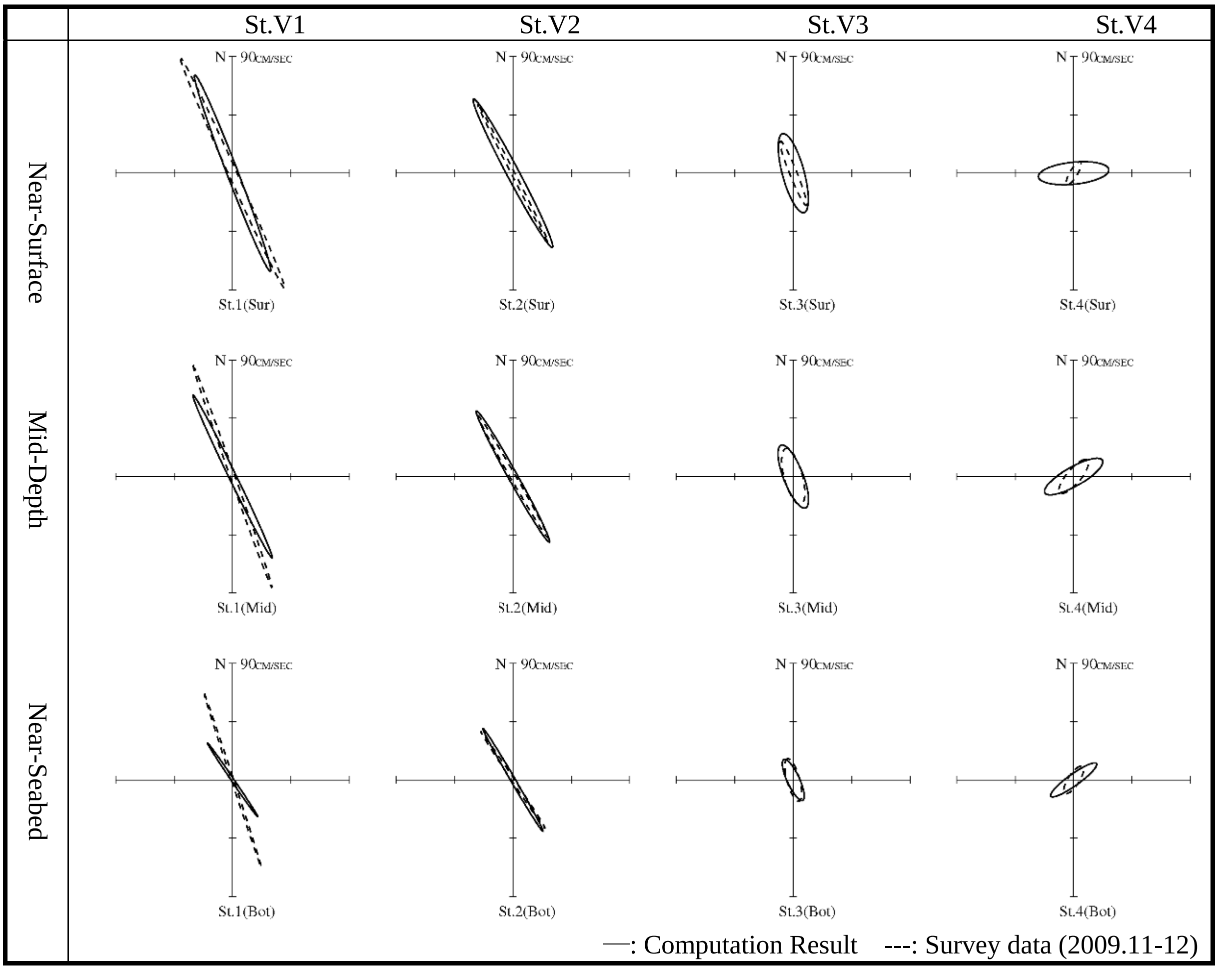


Figure 12.3.15 Comparison of Tidal Current Ellipse between Survey Data and Computation Result

3) Reproducibility of the Residual Current

Residual current is averaged flow in a random period. Survey data from November 10th 2009 to December 11th 2009 (every 10minutes observation) was averaged and 24 hours computation data (every 1 hour) was averaged.

Comparison of the residual current between survey data and computation result is shown in Figure 12.3.16.

Although different direction of residual current is found at some locations and layers, it is considered that computation result shows comparatively good reproducibility.

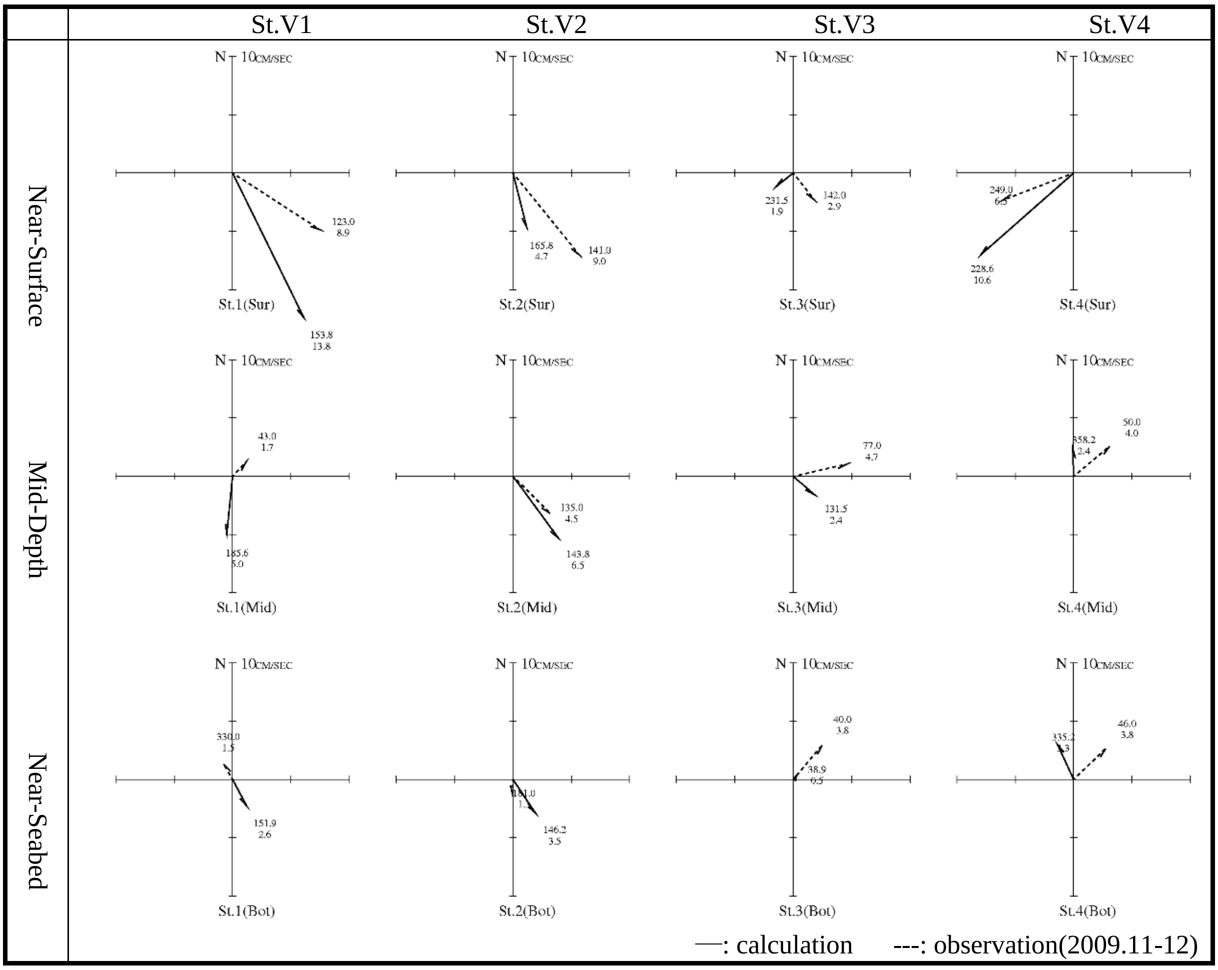
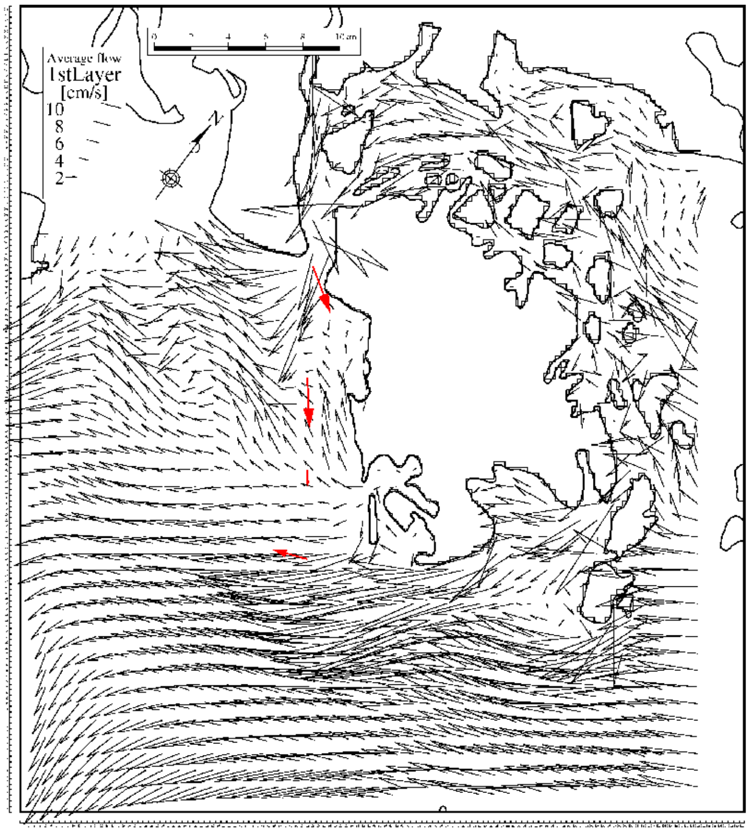


Figure 12.3.16 Comparison of the Residual Current between Survey Data and Computation Result

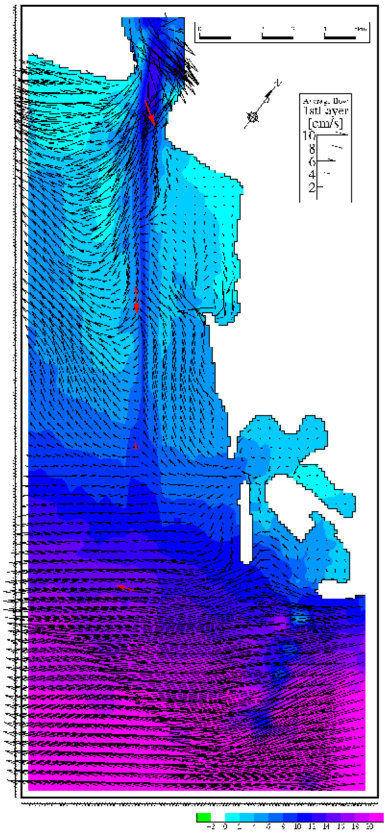
Horizontal distribution of residual currents at the 1st layer by computation for present condition is shown in Figure 12.3.17. Other figures at deeper layers are shown in APPENDIX 12-1.

Strong southern current is shown at the channel between the Cat Hai Island and the Cat Ba Island. Westward current dominates at offshore area and flow pattern changes at the south edge of the Cat Ba Island.

Same tendency is seen at 2nd and 3rd layers (2-6m below M.S.L.), while compensation flows (N to NE direction) for 1st layer is seen at deeper than 4th layer (6-8m below M.S.L.).



(Medium Domain, 300m mesh, 1st layer)



(Small Domain, 100m mesh, 1st Layer)

→: computation, →: observation (2009.11-12)

Figure 12.3.17 Residual Current on Computation at Present Condition

12.3.7 Distribution of Tidal Current by Computation at the Present Condition

Tidal current distributions by computation for present condition at 1st layer are shown in Figure 12.3.18 for dry season and Figure 12.3.19 for wet season, respectively. Comparison between computation result and survey result in wet season is not studied.

Distribution of tidal current in dry season shows east current at flood tide and west current at ebb tide. Current at Lach Huyen sea route shows the flow alongside with the sea route, northward at flood tide and southward at ebb tide. Current speed exceeds 100cm/s at some locations in the sea route.

Distribution of tidal current in wet season shows same pattern in dry season at Lach Huyen sea route. Flow pattern at offshore of the Cat Ba Island is different from the one in dry season.

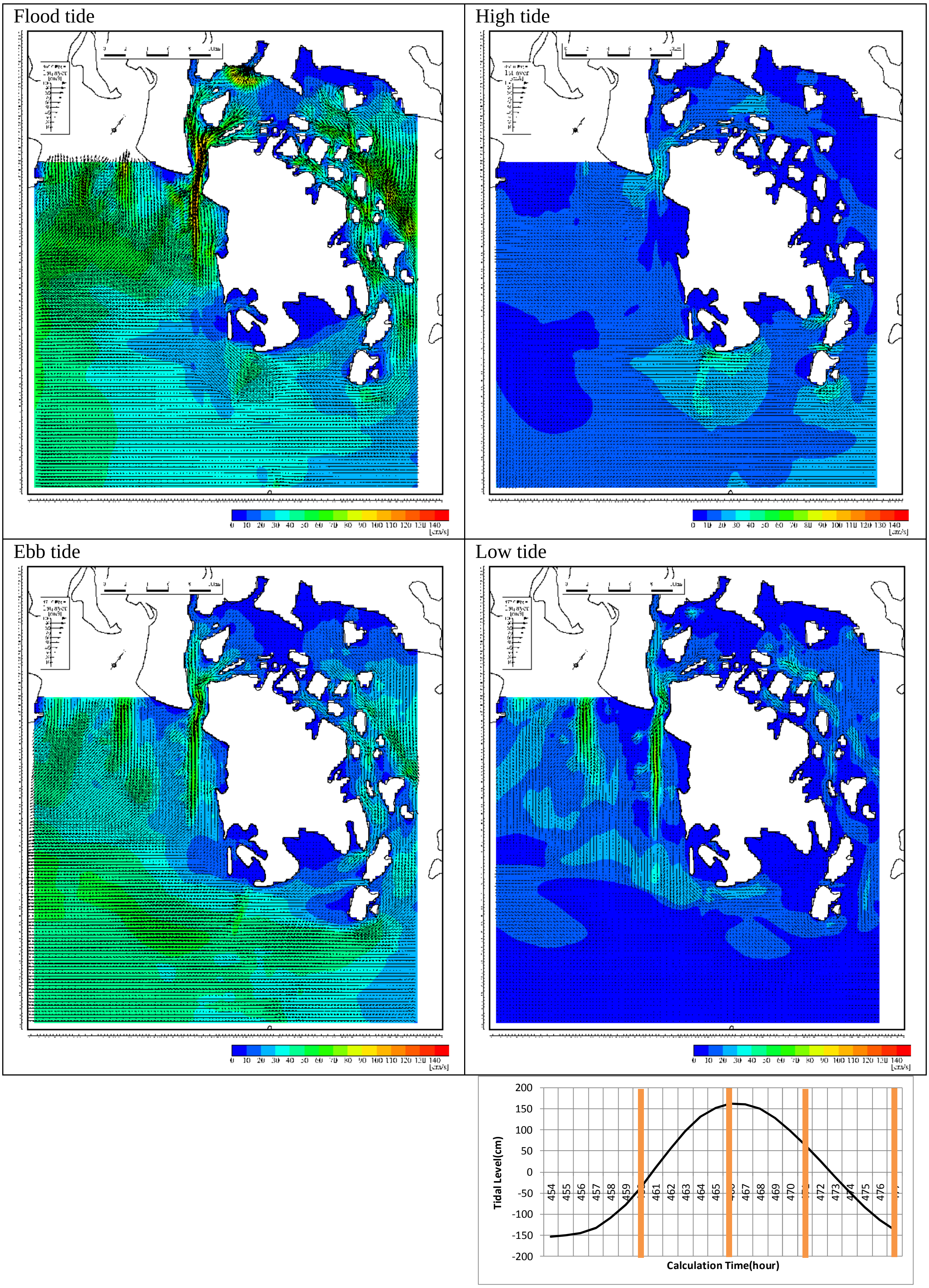


Figure 12.3.18 Distribution of Tidal Current by Computation at Present Condition (Dry Season: 1st Layer=M.S.L. +2m)

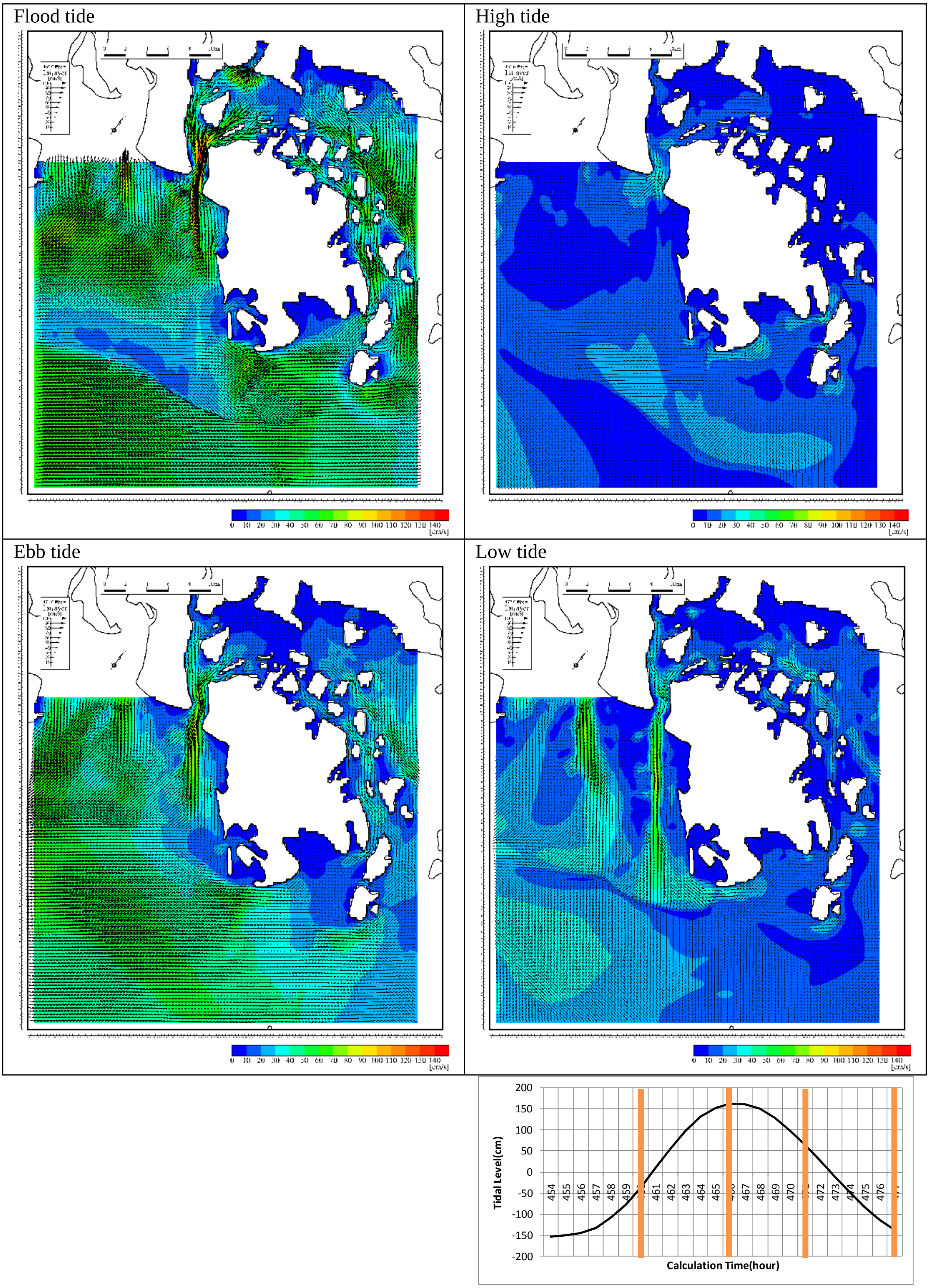


Figure 12.3.19 Distribution of Tidal Current by Computation at Present Condition (Wet Season: 1st Layer=M.S.L. +2m)

12.3.8 Distribution of Salinity and Tidal Current at Present Condition

Distributions of salinity and tidal current distributions by computation for present condition at 1st layer are shown in Figure 12.3.20 for dry season and Figure 12.3.21 for wet season, respectively. Comparison between computation result and survey result in wet season is not studied.

It is understand that strong density front is formed at offshore of the Cat Ba Island in wet season, causing different flow pattern from dry season.

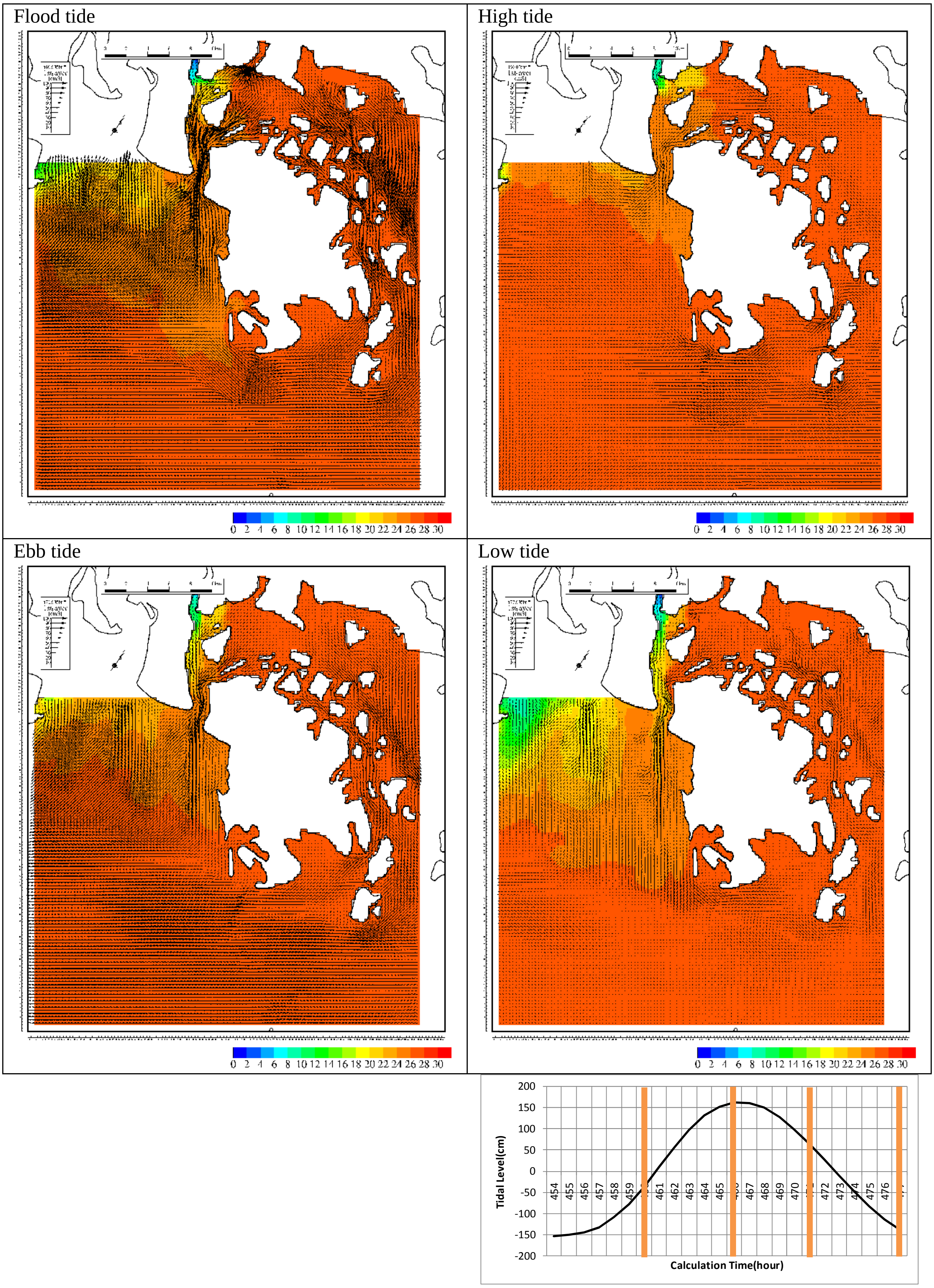


Figure 12.3.20 Distribution of Salinity and Tidal Current by Computation at Present Condition (Dry Season: 1st Layer=M.S.L. +2m)

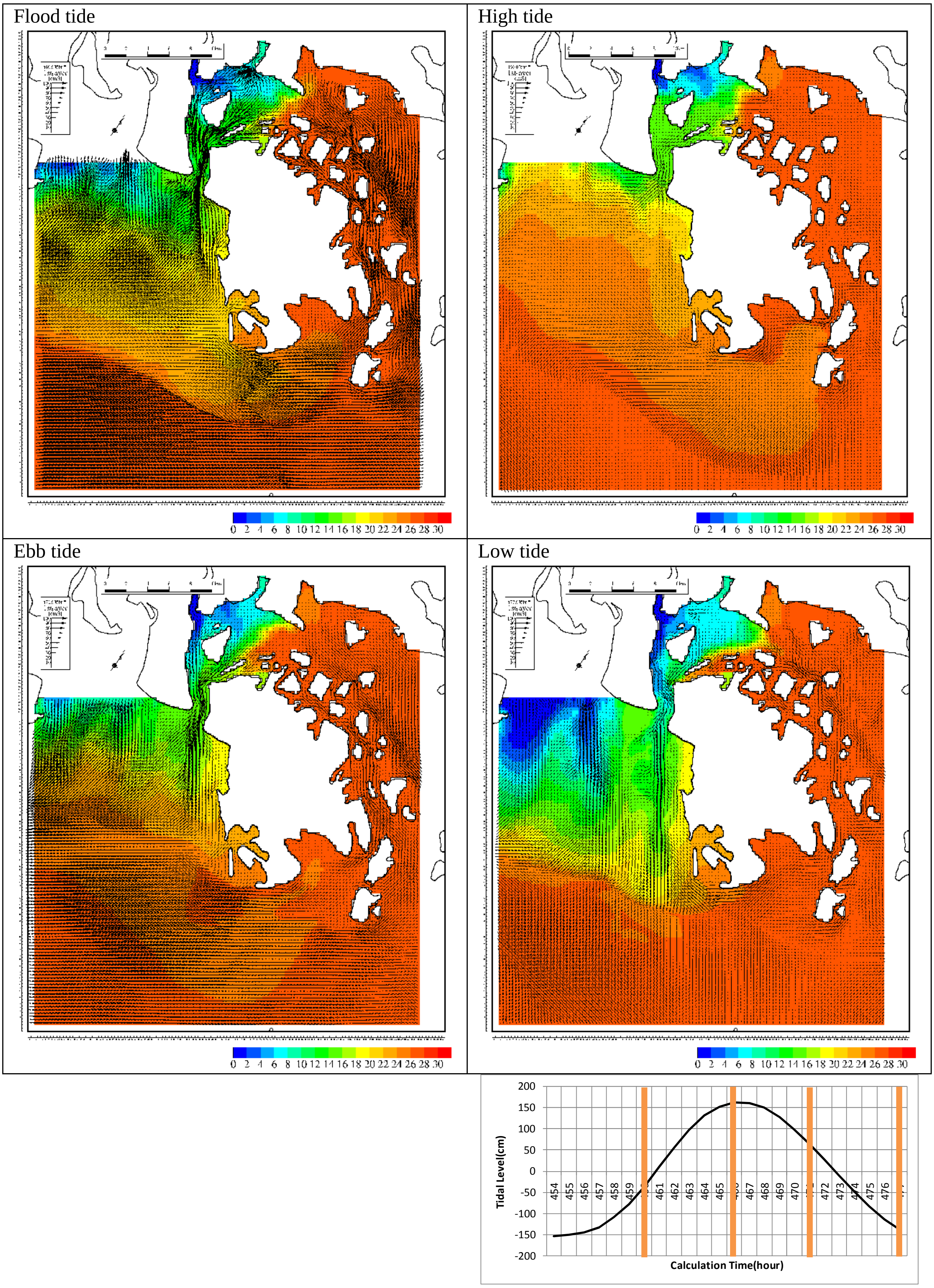


Figure 12.3.21 Distribution of Salinity and Tidal Current by Computation at Present Condition (Wet Season: 1st Layer=M.S.L. ±2m)

12.3.9 Suspended Solid Dispersion on Primary Simulation

1) SS Load

Used unit load and calculated SS load based on the construction plan is summarized in Table 12.3.11.

Generally SS load by dumping is much significant than that by dredging.

Table 12.3.11 Summary of SS Load

Case	Work Type	Vessel Type	Size	Existing Unit Laod (t/m3)×10^{-3}	75% Particle Size	Used Unit Load (t/m3)× 10^{-3}	Unit Work Load (m3/day/vessel)	Number of Vessel	Total Work Load (m3/day)	SS Load (t/day)	Work Hour
1	Dredging	TSHD	2400PS	1.92	90.05	2.13	8025	10	80250	170.9	24
	Overflow	TSHD	2400PS	7.68	90.05	8.52	8025	10	80250	683.7	24
	Dumping	TSHD	2400PS	22.72	68.6	33.12	8025	10	80250	2657.9	24
2	Dredging	TSHD	5884kW (8000PS)	1.92	90.05	2.13	36650	2	73300	156.1	24
	Overflow	TSHD	5884kW (8000PS)	7.68	90.05	8.53	36650	2	73300	625.2	24
	Dumping	TSHD	5884kW (8000PS)	22.72	68.6	33.12	36650	2	73300	2427.7	24
3	Dredging	Pump	8000PS	4.26	80.32	5.3	126500	2	253000	1340.9	24
	Overflow	Hopper Barge	–	–	–	–	–	–	–	–	–
	Dumping	Hopper Barge	500m3	53.32	76.34	69.85	35000	6	210000	14668.5	24
4	Dredging	Pump	8000PS	4.26	80.32	5.3	126500	2	253000	1340.9	24
	Overflow	Hopper Barge	–	–	–	–	–	–	–	–	–
	Dumping	Hopper Barge	500m3	53.32	76.34	69.85	35000	6	210000	14668.5	24
	Dredging	Pump	4000PS	4.26	80.32	5.3	60000	3	180000	954.0	24
	Overflow from Dumping Site	–	–	–	–	–	–	–	–	8329.2	24
5	Dredging	Grab	25m3	15.29	82.37	18.56	18300	3	54900	1018.9	16
	Dumping	Hopper Barge	500m3	53.32	76.34	69.85	4575	12	54900	3834.8	16

2) SS Dispersion

Out of all outputs by computation in the large domain, the 2^{nd} layer (2-4m below surface) and the 7^{th} layer (12m below surface to sea bottom) of daily maximum value in each case are selected as the representative layers for dredging and dumping respectively, and are shown in Figure 12.3.22 and Figure 12.3.23.

Daily maximum value, here, means the broadest SS dispersion in a day.

All outputs of medium domain and large domain are stored in APPENDIX 12-1.

In this simulation, any countermeasures for SS dispersion are not considered.

Human-induced 2mg/L load is used in Japan as a threshold value to evaluate the influence to sea area by artificial activity[11].

Difference of SS dispersion depending on work type is discussed in the following section based on this threshold value.

[11] Quality Standard for Fishery Water, 2005, Japan Fisheries Resource Conservation Association

a) Dredging (Case 1, 2, 3 and 5)

SS dispersion contour by dredging spreads along side of sea route in all cases. Especially at deeper layer, 2mg/L contour is limited in sea route.

SS dispersion pattern in any case shows similar tendency, spreading southward along with sea route.

The area of Case 5 (Grab Dredger) is a little bit wider than that of Case 1 and 2 (Trailing Suction Hopper Dredger), following Case 3 (Cutter Suction Dredger).

Between the similar construction way, Case 1 and Case 2, area of 2mg/L contour in Case 1 is wider than that in Case 2. It is considered the number of vessel (TSHD) contribute the SS dispersion (10 vessels in Case 1 while 2 bigger vessels in Case 2).

b) Dumping (Case 1, 2, 3 and 5: Offshore dumping, Case 4: Coastal area dumping)

SS dispersion pattern of offshore dumping (Case 1, 2, 3 and 5) is similar in any case, showing 15km spread in east-west direction at the 7th layer (12m below surface to sea bottom), while dispersion at upper layer (e.g. 2^{nd} layer: 2-4m below surface) is limited.

Coastal area dumping (Case 4), however, shows the significant SS dispersion covering tourism area such as Do son and Cat Ba.

Comparing with Case 3 and 4, same dredging method and different dumping location, SS dispersion in Case 4 is incredibly huge.

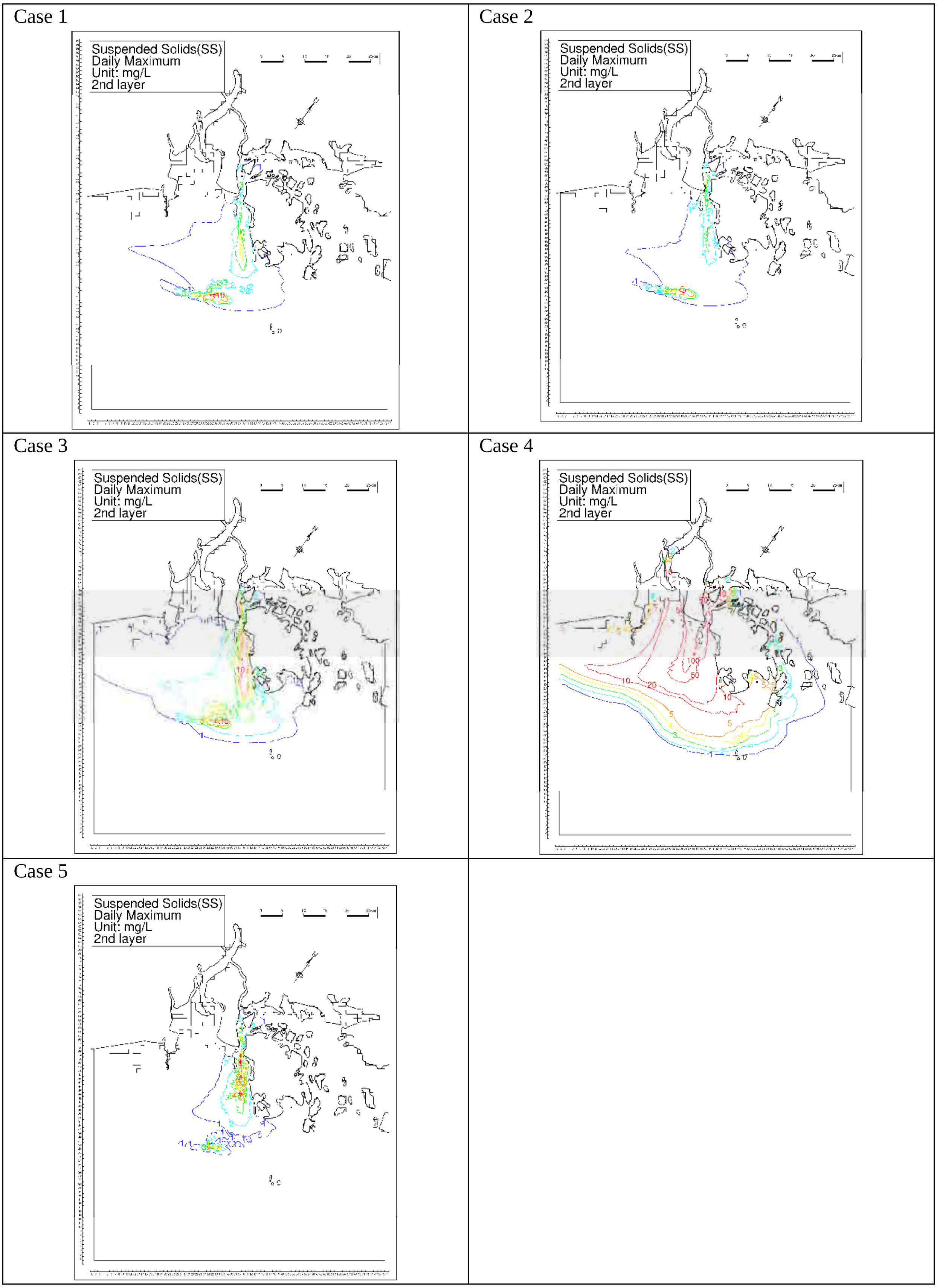
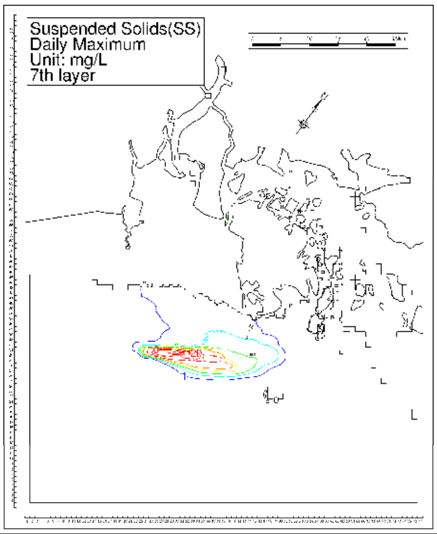
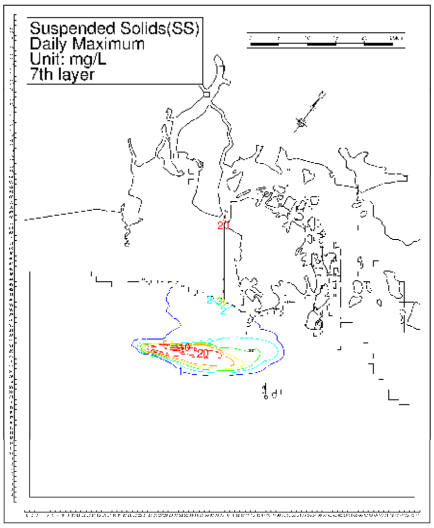


Figure 12.3.22 SS Dispersion Prediction (2-4m below surface, Large Domain, Daily Maximum)

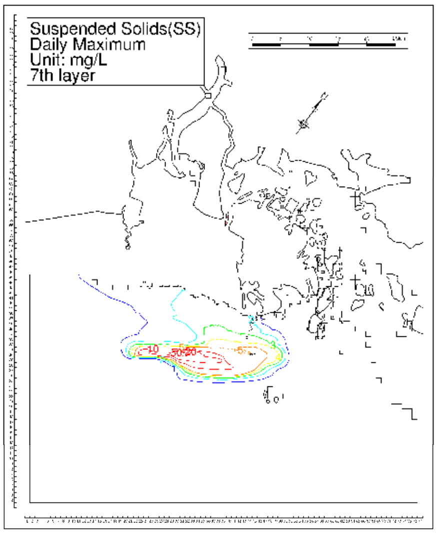
Case 1



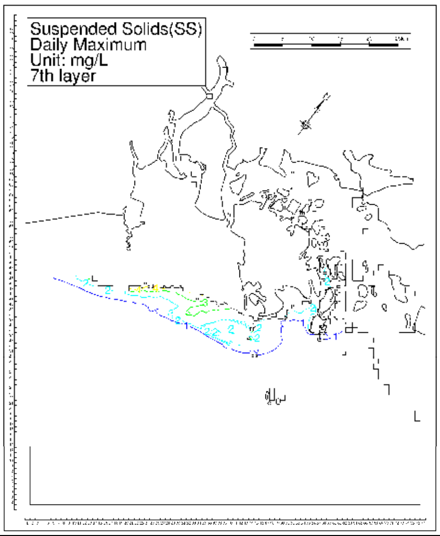
Case 2



Case 3



Case 4



Case 5

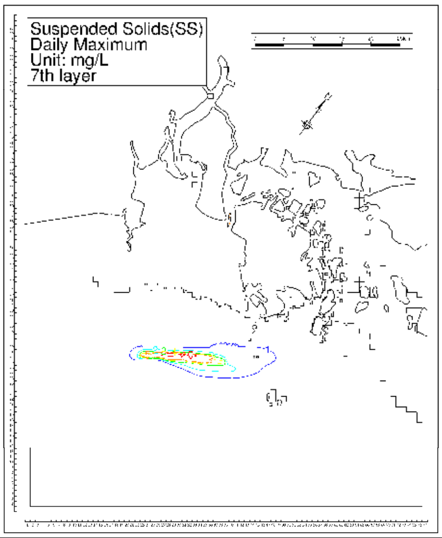


Figure 12.3.23 SS Dispersion Prediction (12m below surface to sea bottom, Large Domain, Daily Maximum)

12.3.10 Additional Study for SS Dispersion

Additional study for SS dispersion was carried out as follows.

- Case 6-11: to know the difference between offshore dumping and dumping at south of Cat Hai Island.
- Case 12-18: to know the difference between offshore dumping and dumping at South Dinh Vu Industrial Zone (SDVIZ).

The results from Case 12 to Case 18 are described in this section. Refer to Section 21 of the Final Report and its Appendix 21-1 for the results from Case 6 to Case 11.

1) Target Area

Target area was broadened form the previous simulation due to unexpected wider area of SS dispersion caused by near-shore dumping (refer to Section 21 of the Final Report and its Appendix).

2) Parameters

Some of input parameters were updated using the results from the field survey conducted on this project (refer to Section 21 of the Final Report and its Appendix).

DD survey data for grain size test in borehole experiment[12] was used for grain size of dredged soil for simulation. Sampling points and layers are uniformly distributed horizontally along with the sea route and vertically. All available data was averaged to obtain the composition shown in Table 12.3.12 and grain size distribution curve shown in Figure 12.3.24 was generated.

Table 12.3.12 Composition of Grain Size

	Grain Size	Composition
Sand	4.750-9.500 mm	0.2%
	2.000-4.750 mm	0.0%
	0.850-2.000 mm	0.6%
	0.425-0.850 mm	1.3%
	0.250-0.425 mm	0.2%
	0.075-0.250 mm	13.4%
Silt	0.005-0.075 mm	34.3%
Cray	<0.005 mm	50.0%

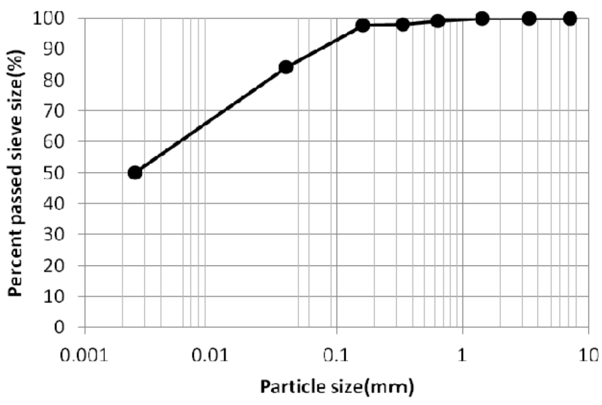


Figure 12.3.24 Grain Size Distribution Curve

[12] Soil Investigation Report for Port Portion - Part B-, Volume 2.3: The Appendices of Navigation Channel Area, August 2011, Portcoast

Using this data and Stokes' sedimentation equation, sedimentation speed was determined. Unit load of suspended solid generation depends on the dredging/dumping method. A guideline[13] for prediction of suspended solid dispersion in Japan was referred to determine the unit load, averaging each unit load for fine particle fraction of the target dredging/dumping method in the guideline. (See 12.3.10 3) b) for the details.)

3) Case 12-18

a) Simulation Scenarios

Following scenarios were used for the simulation of SS (Suspended Solid) dispersion. Other conditions are the same as previous simulation study. Flow regimen in rainy season, which river flow would strongly influence at upper layer, was used for hydrodynamics.

Each figure shows the widest distribution of SS in a day after the SS generated by dredging and dumping activity reaches to saturated concentration.

The details of each scenario are:

Case 12:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge and <u>without</u> silt curtain frame surrounding the grab
Dumping:	offshore site
Comparison:	with Case 5 (3 vessels of 23m^3 grab dredger, offshore dumping)

Case 13:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge and <u>without</u> silt curtain frame surrounding the grab
Dumping:	near shore site (SDVIZ) secondary dredging and reclaiming by 3 vessels of 4,000PS CSD (Cutter Suction Dredger) after dumping at temporary dumping basin by hopper barges
Comparison:	with Case 12 (see above)

Case 14:

Dredging:	2 vessels of 8,000PS CSDs, without overflow from hopper barge and <u>without</u> silt curtain frame surrounding the grab
Dumping:	near shore site (SDVIZ) secondary dredging and reclaiming by 3 vessels of 4,000PS CSDs after dumping at temporary dumping basin by hopper barges
Comparison:	with Case 4 (2 vessels of 8,000PS CSDs, dumping at Cat hi south with secondary dredging and reclaiming by 3 vessels of 4,000PS CSDs after dumping at temporary dumping basin by hopper barges)

[13] Guideline for Prediction of Influence of Suspended Solid on Port Construction, April 2004, Ministry of Land, Infrastructure, Transport and Tourism, Japan

Case 15:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge, and with silt curtain frame surrounding the grab
Dumping:	offshore site
Comparison:	with Case 12 (see above)

Case 16:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge, and with silt curtain frame surrounding the grab
Dumping:	near shore site (SDVIZ) secondary dredging and reclaiming by 3 vessels of 4,000PS CSDs after dumping at temporary dumping basin by hopper barges
Comparison:	with Case 15 (see above)

Case 17:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge, and with silt curtain frame surrounding the grab
Dumping:	near shore site (SDVIZ) dumping directly by unloader from hopper barge
Comparison:	with Case 16 (see above)

Case 18:

Dredging:	4 vessels of 23m^3 grab dredger, without overflow from hopper barge, and with silt curtain frame surrounding the grab
Dumping:	offshore site and near shore site (SDVIZ) secondary dredging and reclaiming by 3 vessels of 4,000PS CSDs after dumping at temporary dumping basin by hopper barges
Comparison:	with Case 12 and Case 16 (see above)

Table 12.3.13 summarizes the scenarios.

Table 12.3.13 Computation Scenario

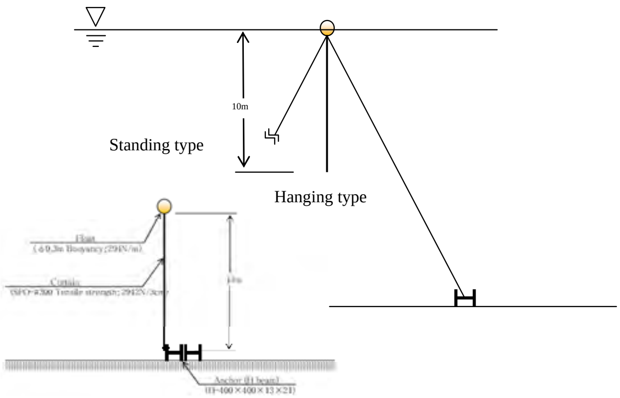
Case	Dredging			Dumping			Season	Comparison with
	Vessel	Overflow	Silt Protector	Location	Embankment	Silt Protector		
Case 12	4 GDs	No	No	Offshore	-	No	Wet	Case 5
Case 13	4 GDs	No	No	Near shore SDVIZ*1	Yes	No	Wet	Case 12
Case 14	2 CSDs	No	No	Near shore SDVIZ*1	Yes	No	Wet	Case 4
Case 15	4 GDs	No	Yes	Offshore	-	No	Wet	Case 12
Case 16	4 GDs	No	Yes	Near shore SDVIZ*1	Yes	Yes	Wet	Case 15
Case 17	4 GDs	No	Yes	Near shore SDVIZ*2	Yes	Yes	Wet	Case 16
Case 18*3	4 GDs 3 CSDs	No	Yes	Offshore	-	No	Wet	Case 12
				Near shore SDVIZ*1	Yes	Yes	Wet	Case 16

Note: Case number is consecutive number from previous simulation.
BDS: Basic Design Study
*1: Secondary discharge by 4,000 ps CSD (3 units)
*2: Secondary discharge by direct dumping from barge using unloader.
*3: Dumping volume is 50% of total volume each for offshore dumping and near shore dumping respectively.

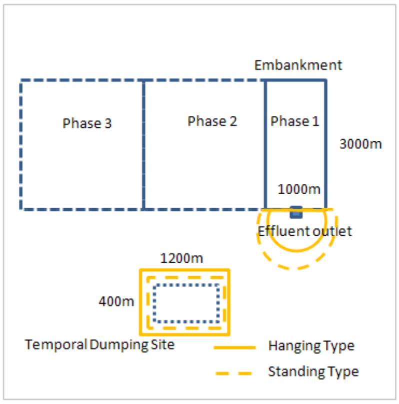
Following conditions were used as countermeasures for SS (see Figure 12.3.25):

Dredging:	A frame with hanging silt curtain is installed to the dredger. Dredging is performed in the frame. 80% vertical coverage of the silt curtain is used. The rest of the depth (20%) is uncovered by the silt curtain. 40% SS removal ratio of the silt curtain is used (Case 15 and 16).
Offshore dumping:	No countermeasure to SS is undertaken (Case 12, 15 and 18).
Near-shore dumping:	Revetments are constructed before dumping. Temporal dumping basin is surrounded by silt curtain with 100% vertical coverage. Outlet of dumping revetment is surrounded by silt curtain with 100% vertical coverage. 40% SS removal ratio of the silt curtain is used (Case 16).
Others:	SS dispersion on dredging at temporal sea route to Din-Vu south is not considered. Simultaneous dumping at offshore and near-sore is not considered.

Dredging frame with silt curtain (silt curtain frame)
Source: Guideline for prediction of SS dispersion[14].



Silt protector/curtain



Installment of silt curtains

Source: Taiyo Kogyo Corporation

Figure 12.3.25 Countermeasures to SS Dispersion

b) SS Load

SS generation load depends on construction method, such as grab dredging, cutter suction dredging and dumping by hopper barge, construction capability of the vessel and grain size of dredging/dumping material. The guideline for simulation of SS dispersion in Japan[14] lists a lot of such information based on the experimental constructions carried out in Japan to obtain such parameters and suggests proper unit load on each construction method.

In this study, the unit loads listed in the guideline were averaged to use in the simulation model, because the grain size compositions in the guideline does not much with the grain size composition in the target area of the project.

And obtained unit load is used to calculate daily SS generation load, which is used as the input data of the simulation. Table 12.3.14 summarizes each unit load and daily load of construction method. For the simulation at different dumping site, sum of SS generation loads as follows was used as the input data:

Offshore dumping:	a + b
Dumping at SDVIZ:	a + b + c + d
50% offshore dumping + 50% dumping at SDVIZ:	(a + b) / 2 + (a + b + c + d) / 2

where:
- a: SS load by dredging
- b: SS load by dumping
- c: SS load by dredging at temporal dumping basin
- d: Discharge from revetment

[14] Guideline for Prediction of Influence of Suspended Solid on Port Construction, April 2004, Ministry of Land, Infrastructure, Transport and Tourism, Japan

Table 12.3.14 SS Generation Load

Work Type		Vessel Type	Guideline		Calculated unit load based on the actual particle size	Work Load (m3/day/vessel)	Number of Vessel	Total Work Load (m3/day)	Daily SS Generation Load (t/day)	Working Hour
			Capability	Unit Load(t/m3) $\times 10^{-3}$						
Case 4	Derdging at sea route	CSD	8000PS	4.26	5.3	**126500**	2	253000	1340.9	24
	Dumping at temporal basin	Hopper barge	500m3	4.94	8.43	**35000**	6	210000	1770.3	24
	Secondary dredging	CSD	4000PS	4.26	5.3	**60000**	3	180000	954.0	24
	Overflow from barge	Hopper barge	–	7.68	8.53	–	–	253000	2158.1	24
	Dsicharge from revetment	–	–	–	–	–	–	–	1282.8	24
Case 5	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	3	54900	1018.9	16
	Dumping at offshore	Hopper barge	500m3	4.94	8.43	**4575**	12	54900	462.8	16
Case 12	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	73200	1358.6	16
	Dumping at offshore	Hopper barge	500m3	15.79	22.26	**4575**	16	73200	1629.4	16
Case 13	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	73200	1358.6	16
	Dumping at temporal basin	Hopper barge	500m3	15.79	22.26	**4575**	16	73200	1629.4	16
	Secondary dredging	CSD	4000PS	4.26	5.3	**60000**	3	180000	954.0	24
Case 14	Dredging at sea route	CSD	8000PS	4.26	5.3	**126500**	2	253000	1340.9	24
	Dumping at temporal basin	Hopper barge	500m3	15.79	22.26	**35000**	6	210000	4674.6	24
	Secondary dredging	CSD	4000PS	4.26	5.3	**60000**	3	180000	954.0	24
	Overflow from barge	Hopper barge	500m3	15.79	22.26	**35000**	6	210000	4674.6	24
	Dsicharge from revetment	–	–	–	–	–	–	–	7728.6	24
Case 15	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	73200	1358.6	16
	Dumping at offshore	Hopper barge	500m3	15.79	22.26	**4575**	16	73200	1629.4	16
Case 16	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	73200	1358.6	16
	Dumping at offshore	Hopper barge	500m3	15.79	22.26	**4575**	16	73200	1629.4	16
	Secondary dredging	CSD	4000PS	4.26	5.3	**60000**	3	180000	954.0	24
Case 17	Dredging at sea route	GD	25m3	15.79	22.26	**18300**	4	73200	1629.4	16
	Dsicharge from revetment	–	–	–	–	–	–	–	2265.6	24
Case 18	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	36600	679.3	16
	Dumping at offshore	Hopper barge	500m3	15.79	22.26	**4575**	16	36600	814.7	16
	Dredging at sea route	GD	25m3	15.29	18.56	**18300**	4	36600	679.3	16
	Dumping at temporal basin	Hopper barge	500m3	15.79	22.26	**4575**	16	36600	814.7	16
	Secondary dredging	CSD	4000PS	4.26	5.3	**60000**	3	90000	477.0	24

*1) To determine this value, following leteratures were refered.
Hazen's theory regarding ideal sedimentation basin (extrusion effluent model)
Guideline for designing of waterworks facility, 1990, Japan Water Works Association
Manual for prediction of influence of turbidity by dredging/reclamation, March 1982, Ministry of Transportation, Japan

Equation:

$$SSd = SSg \times (1 - r)$$

where:
SSd: Daily SS generation load (t/day)
SSg: SS generation load (t/day)
r: Removal ratio: 0.717

$$r = v_c / v_0$$

where:
Vc: Settlement sped of cray (m/day): 0.43
V0: Water moving speed: Q/A (m/day): 0.6
Q: Dumping volume (m3/day): 180000
A: Area of dumping site (m2): 300000

$$SSg = Dv \times \rho_t \times C_m / 100$$

where:
Dv: Dredging volume (m3/day): 90000
ρ_t : Wet density
Cm: Mud content (%): 20

$$D_v = C_p \times G_c / 100$$

where:
Cp: Dredging cpacity: m3/day): 180000
Gc: Grainsize composition of cray (%): 50

$$\rho_t = \frac{(1 + \omega / 100)\rho_w}{\rho_w / \rho_s + \omega / S}$$

where:
ω : Water content (%): 89%
ρ_w : Water density (g/cm3): 1.02
ρ_s : Density of soil perticles: 2.68
S: Saturation degree (%): 100

c) Results

All outputs by simulation are stored as Appendix 12-2. Followings are comparison studies based on the simulation outputs. Human-induced 2mg/L load is used in Japan as a threshold value to evaluate the influence to sea area by artificial activity[15].

i) SS dispersion by the difference of number of grab dredgers (GDs): Figure 12.3.26

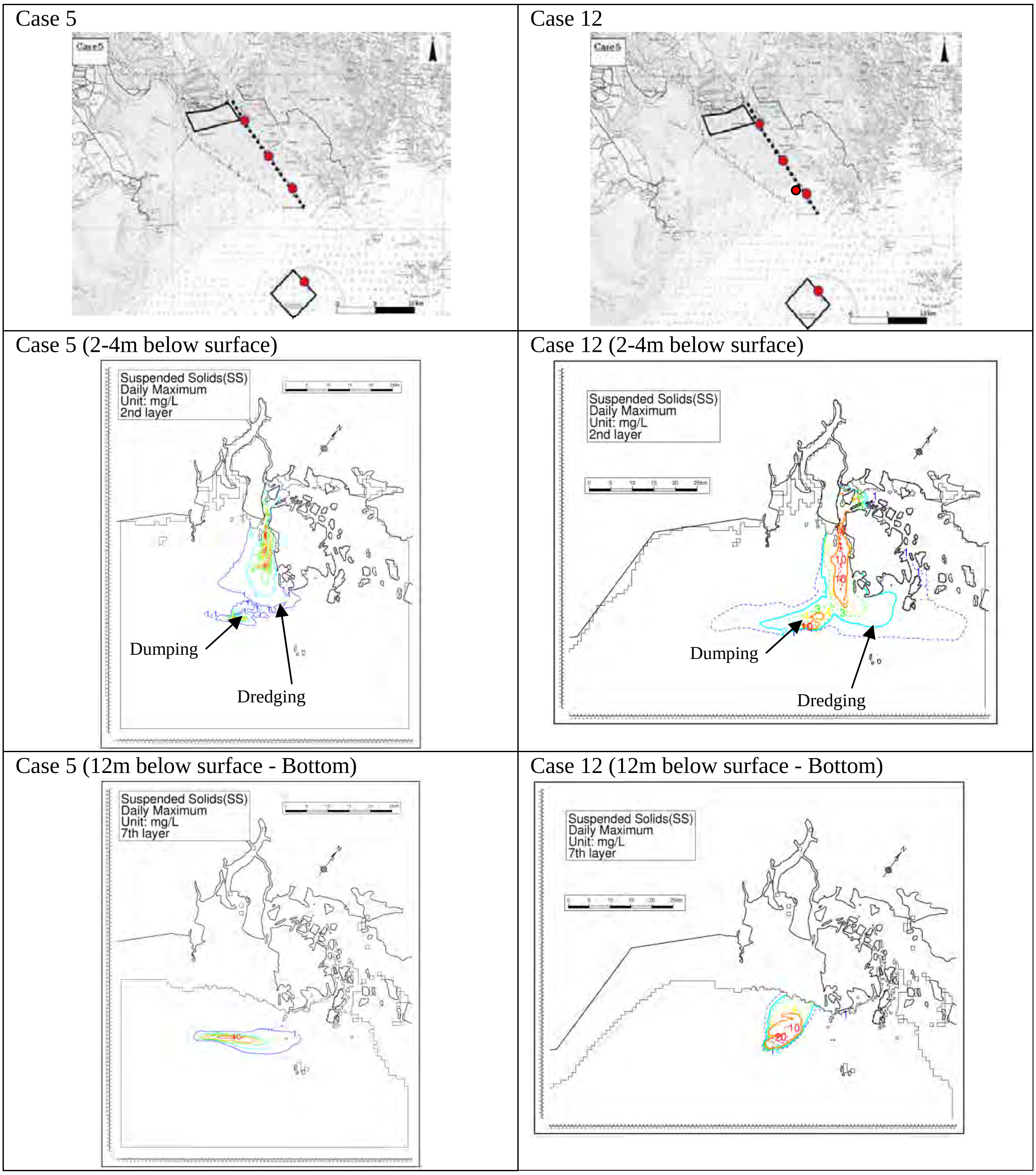
SS dispersion between Case 5(Dredging: 3 GDs, Dumping: offshore) and Case 12 (Dredging: 4 GDs, Dumping: offshore) was compared.

Light-blue-solid-line in the figure shows 2mg/L increment of SS compared to no-construction condition, which is the threshold value for influence to marine biota by human activity regulated in the standard for fishery water in Japan[15].

SS dispersion area by dredging with 4 vessels of grab dredgers (Case 12) is greater than that by dredging with 3 vessels of grab dredgers (Case 5) and dispersion at surface layer (2-4m below surface) overlaps with dispersion by offshore dumping. The line reaches to the south of Cat Ba. The area of dispersion in the lower layer (12m below surface – Bottom) is limited due to smaller influence of water current.

Hydro regimen in dry season is used for Case 5, because the available data was limited when computation for Case 5 was conducted. Hydro regimen in wet season, which greatly affects the SS dispersion pattern, was used for Case 12. Therefore, SS dispersion pattern in wet season at lower layer between both cases differ, while the pattern at upper layer is not remarkable due to greater influence by river discharge.

[15] Quality Standard for Fishery Water, 2005, Japan Fisheries Resource Conservation Association



Note: Hydro regimen in dry season is used in Case 5, while wet season is used in Case 12.

Figure 12.3.26 Simulation Result (Case 5, Case 12: Large domain, Daily maximum)

ii) SS dispersion by the difference of dumping location with grab dredging: Figure 12.3.27

SS dispersion between Case 12 (Dredging: 4 GDs, Dumping: offshore) and Case 13 (Dredging: 4 GDs, Dumping: SDVIZ) was compared.

Revetment for the dumping area at SDVIZ is considered on computation, while measures for discharges from outlet of dumping site are not considered. Figures at 6-8m below surface were used as lower layer for the comparison, because evaluation at shallower layer for near shore dumping is considered important.

At upper layer, SS dispersion area by dredging and dumping overlaps at south of Cat Hi and high turbid area (red and yellow contours in the figure) shows tendency to spread along with river flow from SS generation points (dredging and dumping). Contour line of 1mg/L (dotted line in the figures) spreads towards East till south of Cat Ba and towards West till offshore of Do Son. Same tendency is shown at lower layer, but the area is smaller than that at upper layer.

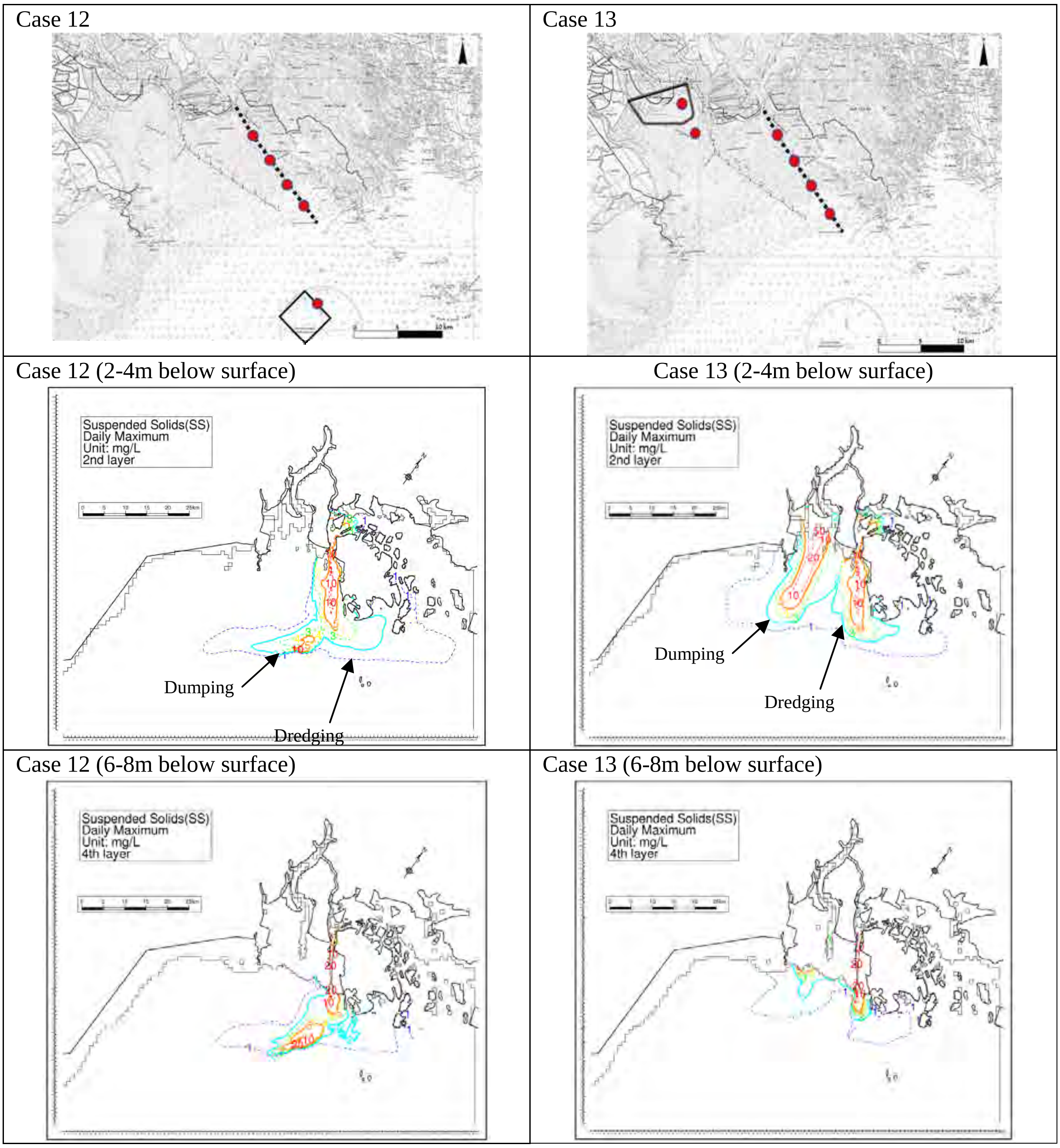


Figure 12.3.27 Simulation Result (Case 12, Case 13: Large domain, Daily maximum)

iii) SS dispersion by the difference of dumping location with cutter suction dredging (CSD): Figure 12.3.28

SS dispersion between Case 4 (Dredging: 2 CSDs, Dumping: Cat Hi south) and Case 14 (Dredging: 2 CSDs, Dumping: SDVIZ) was compared.

Revetment for the dumping area at dumping site is considered on computation, while measures for discharges from outlet of dumping site are not considered. Figures at 6-8m below surface were used as lower layer for the comparison, because evaluation at shallower layer for near shore dumping is considered important. Both cases show overlapped SS dispersion area by dredging and dumping.

The area of SS dispersion in Case 14 is smaller that in Case 4. The contour line of 2mg/L in Case 4 reaches to the east side of Cat Ba, while the line in Case 14 stays at south of Cat Ba. This is considered because the flow rate at west side water channel of Cat Hi is smaller than that at east side and this leads to the limitation of SS dispersion by the dumping at SDVIZ. However, the contour line of 10mg/L (red line) in Case 14 reaches to Do Son, tourism area. The dispersion pattern at bottom layer is similar to the pattern at upper layer.

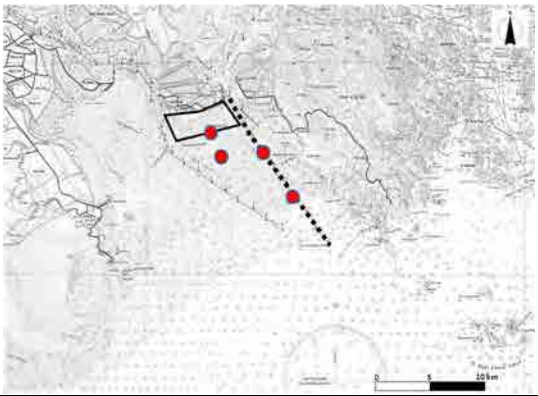
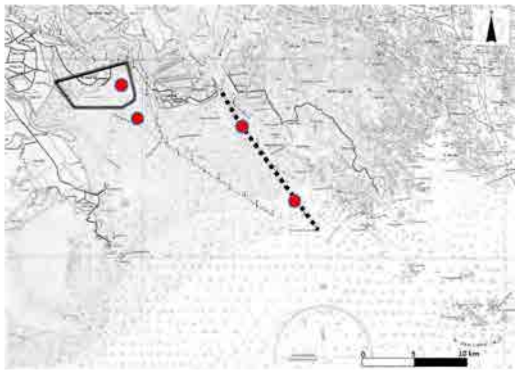
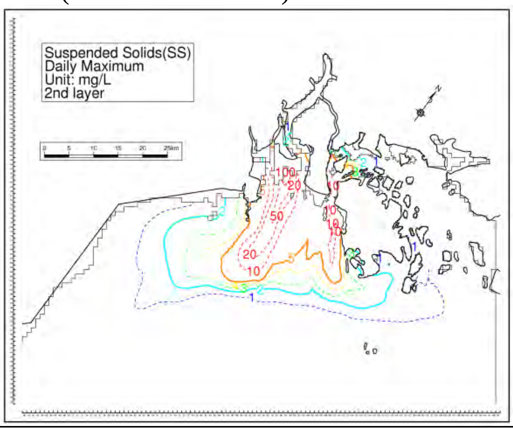
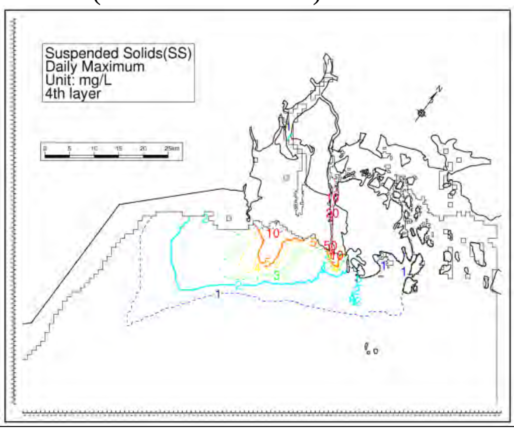
Case 4 	Case 14 
Case 4 (2-4m below surface) 	Case 14 (2-4m below surface) 
Case 4 (6-8m below surface) 	Case 14 (6-8m below surface) 

Figure 12.3.28 Simulation Result (Case 4, Case 14: Large domain, Daily maximum)

iv) Study on countermeasures for SS dispersion: Figure 12.3.29

SS dispersion between Case 12 (Dredging: 4 GDs without silt curtain frame, Dumping: offshore) and Case 15 (Dredging: 4 GDs with silt curtain frame, Dumping: offshore) was compared. Refer to Figure 12.3.25 and its explanation for the details of the countermeasures.

The area of 2mg/L contour line (light blue) in Case 15 is smaller compared to that in Case 12. The area of 10mg/L contour line (red) is also smaller in Case 15 than in Case 12, suggesting the positive effect of countermeasure to SS dispersion.

The SS dispersion area at upper layer (2-4m below surface) by dredging overlaps the area by dumping at offshore. The SS dispersion pattern at bottom layer (12m below surface to bottom) does not differ from the upper layer, suggesting the influence of SS dispersion from the bottom layer of the silt curtain frame.

The area by the offshore dumping can be estimated from the difference of contour lines in Case 12 and Case 15: that is 16km at E-W direction and 12km N-S direction at upper layer, 10km at E-W direction and 12km N-S direction at lower layer.

v) SS dispersion by the difference of dumping location with grab dredging with SS dispersion counter measures: Figure 12.3.30

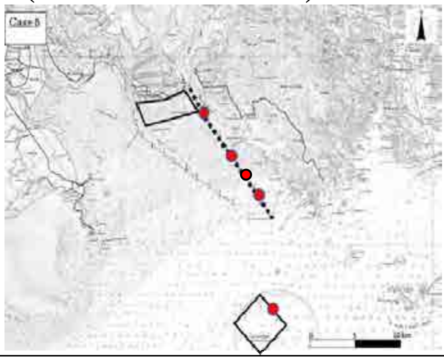
SS dispersion between Case 15 (Dredging: 4 GDs, Dumping: offshore) and Case 16 (Dredging: 4 GDs, Dumping: SDVIZ) was compared. As countermeasures to SS dispersion, silt curtain frame for dredging and silt curtains for dumping site at SDVIZ are considered (refer to Figure 12.3.25 and its explanation for the details of the countermeasures). Figures at 6-8m below surface were used as lower layer for the comparison, because evaluation at shallower layer for near shore dumping is considered important.

SS dispersion patterns caused by dredging and dumping respectively at upper layer in Case 16 show the tendency to spread along with the water flow from the river system. The area in Case 16 is greater than that in Case 15, suggesting the greater impact by near shore dumping than offshore dumping.

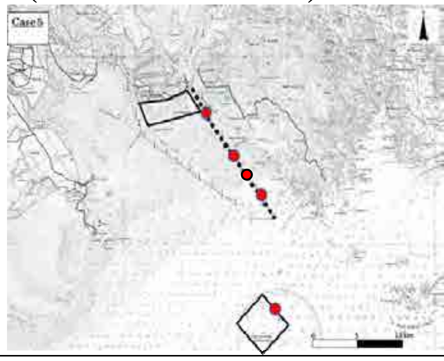
At lower layer, SS dispersion area by near shore dumping in Case 16 is limited and it is smaller than that by offshore dumping in Case 15.

SS dispersion area by near shore dumping can be estimated as 10km E-W direction and 26km at N-S direction at upper layer and 8km at E-W direction and 19km at N-S direction at lower layer.

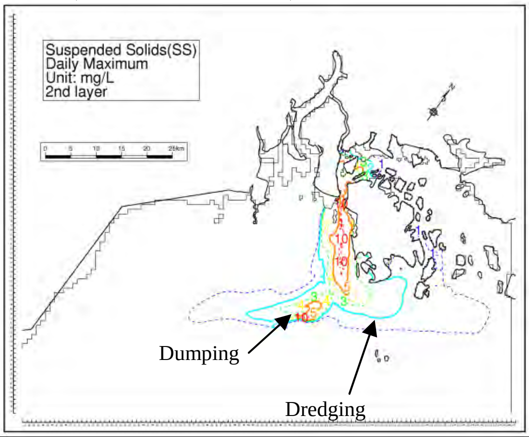
Case 12 (without silt curtain frame)



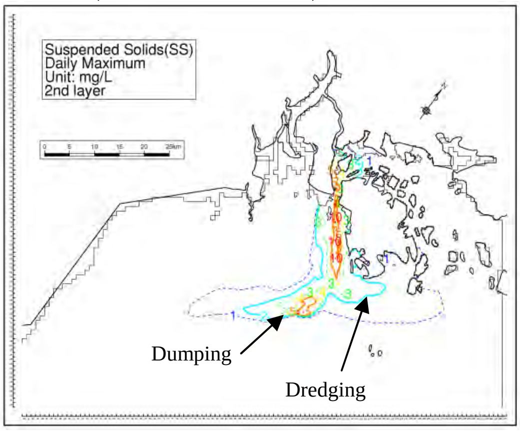
Case 15 (without silt curtain frame)



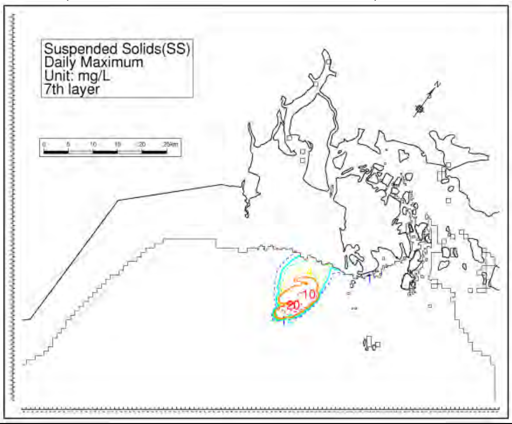
Case 12 (2-4m below surface)



Case 15 (2-4m below surface)



Case 12 (12m below surface - Bottom)



Case 15 (12m below surface - Bottom)

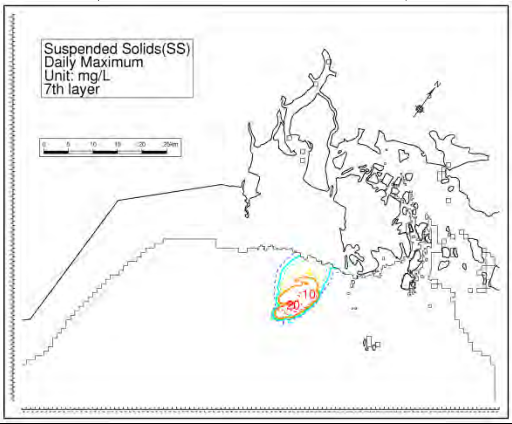
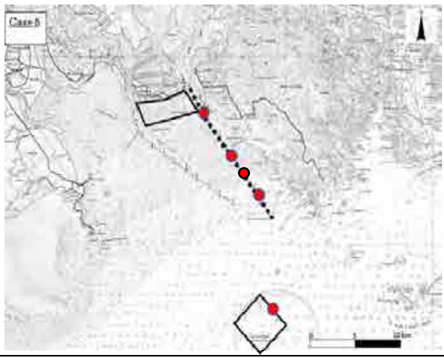
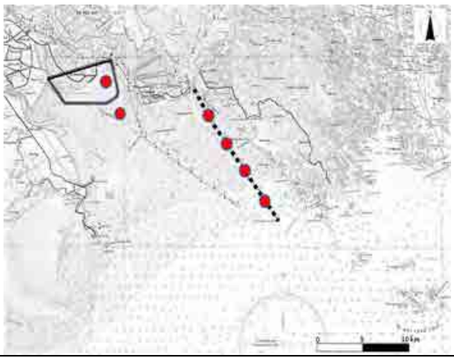


Figure 12.3.29 Simulation Result (Case 12, Case 15: Large domain, Daily maximum)

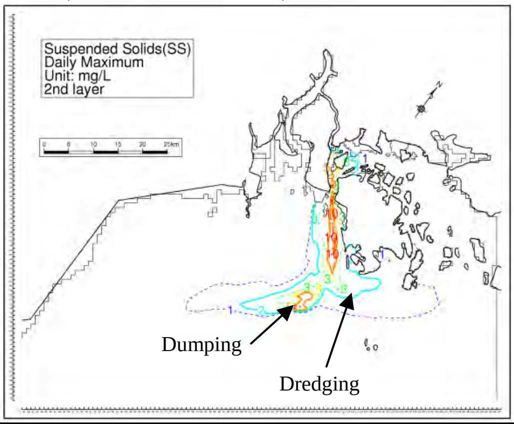
Case 15



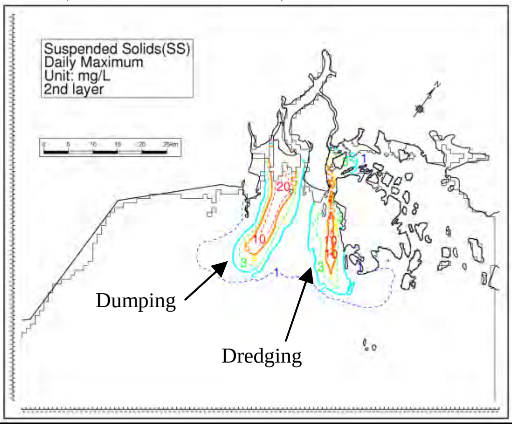
Case 16



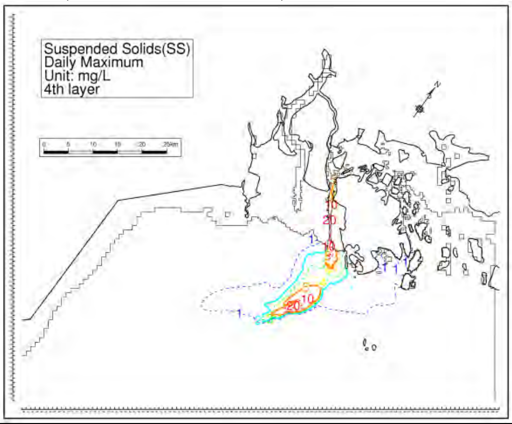
Case 15 (2-4m below surface)



Case 16 (2-4m below surface)



Case 15 (6-8m below surface)



Case 16 (6-8m below surface)

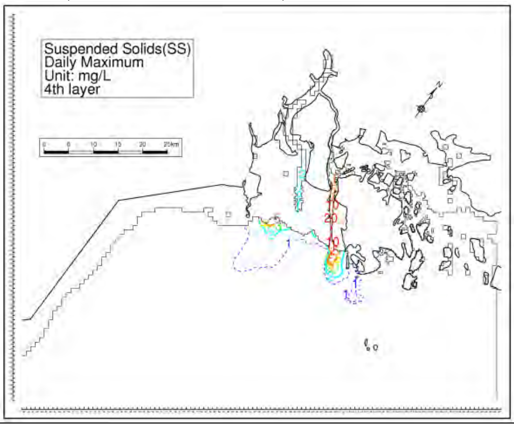


Figure 12.3.30 Simulation Result (Case 15, Case 16: Large domain, Daily maximum)

vi) SS dispersion by the difference of dumping methods: Figure 12.3.31

SS dispersion between Case 16 (Dredging: 4 GDs, Dumping: SDVIZ with secondary dredging with 3-3,000ps-CSDs) and Case 17 (Dredging: 4 GDs, Dumping: SDVIZ with direct dumping from hopper barges) was compared.

Revetment for the dumping area at SDVIZ is considered in both cases on computation and counter measure to SS dispersion for discharges from outlet is also considered. As a measure for Case 16, temporary dumping basin is surrounded by silt curtain (refer to Figure 12.3.25 and its explanation for the details of the countermeasures).

SS dispersion area in Case 17 is smaller compared to that in Case 16 at upper layer. This suggests that the counter measure for the SS dispersion caused by discharges from outlet of the revetment is effective. 10mg/L contour line in both cases, however, reaches to the tourism area, Do Son.

SS dispersion pattern at lower layer is similar to that at upper layer and the contour line of 2mg/L is close to Do Son area.

SS dispersion area by near shore dumping can be estimated as 10km E-W direction and 24km at N-S direction at upper layer and 8km at E-W direction and 18km at N-S direction at lower layer.

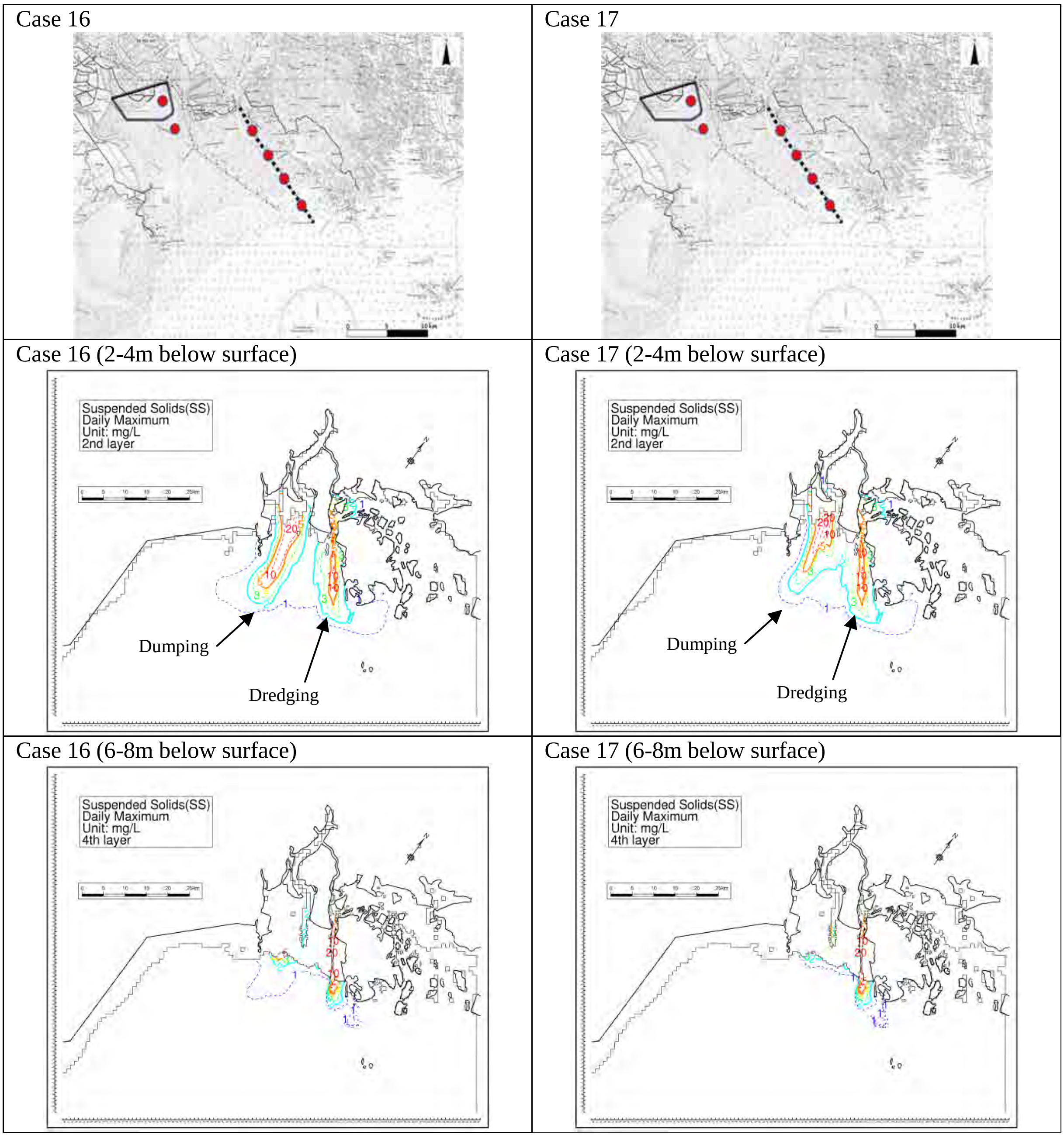


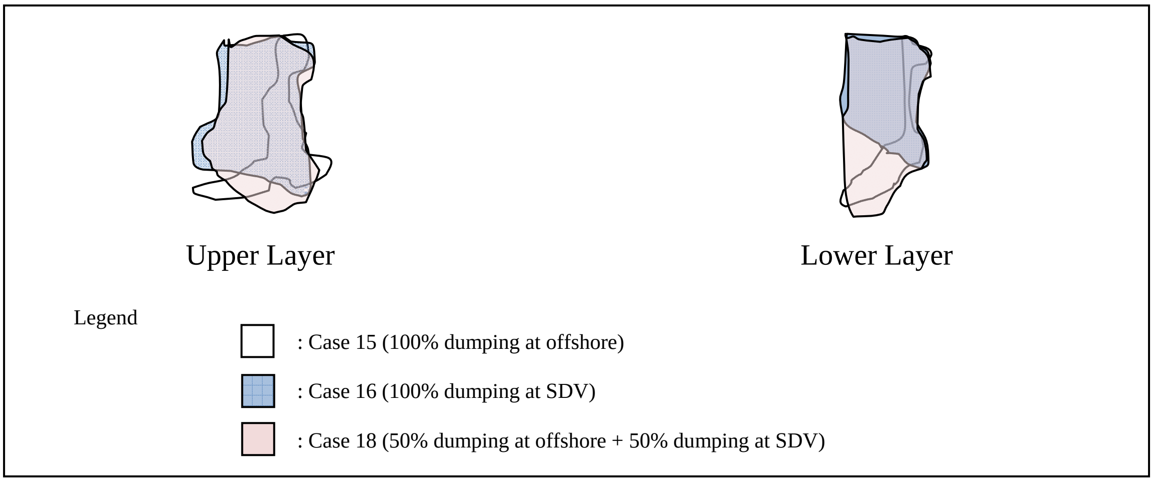
Figure 12.3.31 Simulation Result (Case 16, Case 17: Large domain, Daily maximum)

vii) Comparison and combination of offshore dumping and dumping at SDVIZ: Figure 12.3.32 and Figure 12.3.33

Comparison study between offshore dumping and dumping at SDVIZ was carried out. The summary is as follows. Refer to Appendix 12-3 for the details of the study.

SS dispersion area by combination of different dumping site (e.g. 50% of dumping at offshore and 50% of dumping at SDV) was also studied, and shown in Figure 12.3.33 comparing with Case 15 (100% of dumping at offshore) and Case 16 (100% of dumping at SDV). Mitigation measures in all cases are considered. Figure 12.3.32 compares the comprehensive affected area by each dumping location.

The total area itself by combination dumping is smaller than that by other dumping location; however, comprehensive affected area by combination dumping is larger than that by dumping at single location. Combination of dumping sites remains possibility of impact to Do Son area although the area is smaller than that by 100% dumping at SDV. Thus it can be concluded that 100% dumping at offshore is an ideal option.



SS dispersion area of each simulation case was comprehensively traced and lapped over.

Figure 12.3.32 Comparison of Comprehensive Affected Area between Dumping Sites

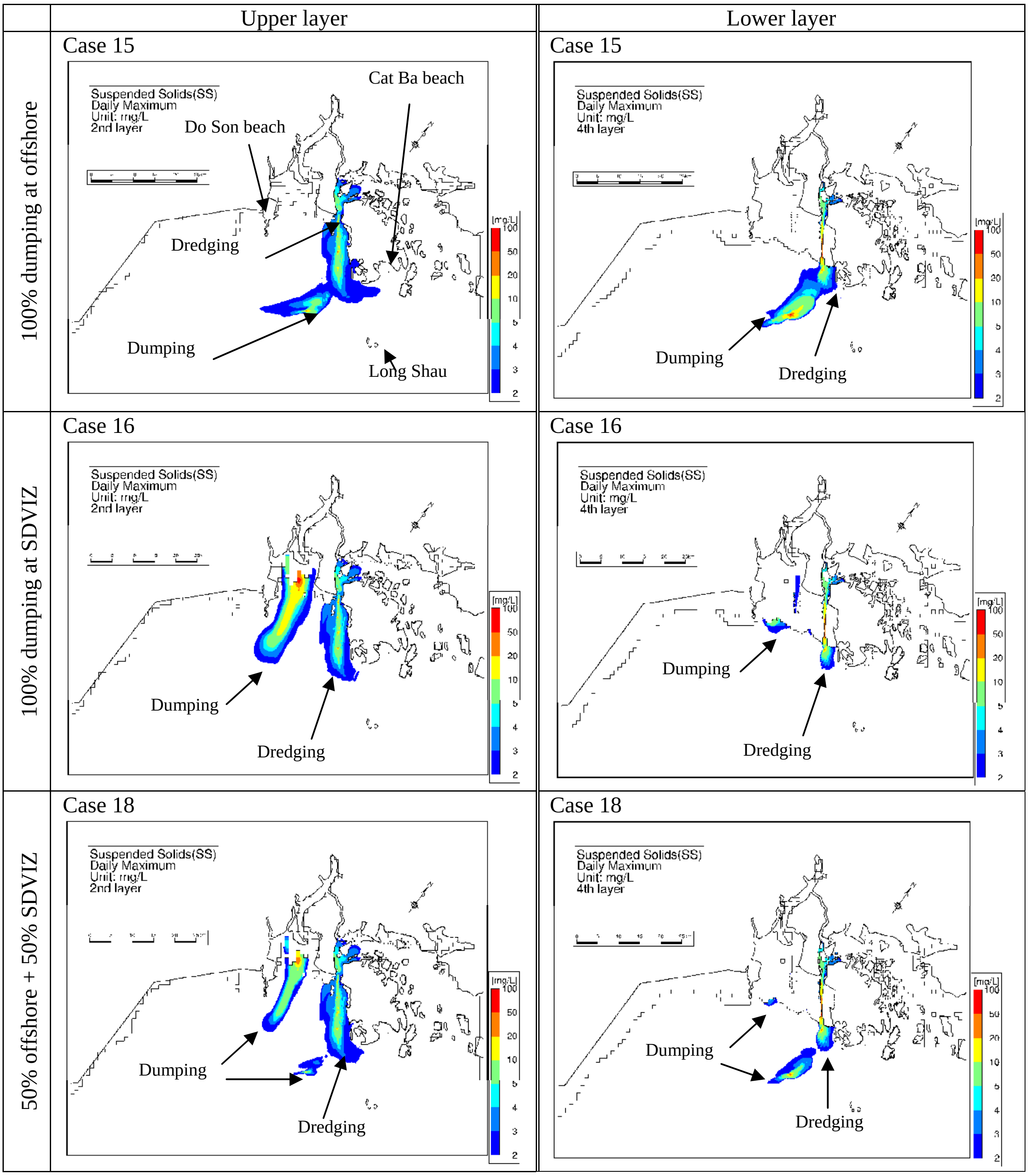


Figure 12.3.33 Simulation Result (Case 15, Case 16 and Case 18: Large domain, Daily maximum)

viii) Conclusion

The summary of this study is as follows.

- Additional simulation was conducted: to know the difference between offshore dumping and dumping at south of Cat Hai Island and: to know the difference between offshore dumping and dumping at South Dinh Vu Industrial Zone (SDVIZ).
- Near-shore dumping may cause more significant impacts on coastal tourism.
- According to the simulation results, biological and socially sensitive area such as Ha Long Bay, Cat Ba beach area, Do Son beach area, Long Chau Islands will not be affected directly by offshore dumping, however the SS dispersion by dumping at SDVIZ might reach to Do Son beach area.
- Based on the findings listed above, offshore dumping is preferable.
- By the combination of dumping at different location, such as 50% of dumping at offshore and 50% of dumping at SDVIZ, the affected area will be broader than that by dumping at single location.
- Countermeasures to SS dispersion such as silt protector/curtain will effectively work to reduce the impact by dredging/dumping activities.
- Countermeasure for offshore dumping is not considered this time as installation of silt curtain is considered difficult due to deeper depth and weather condition.
- Comparing the SS dispersion pattern between offshore dumping and near-shore dumping, the area by near-shore dumping is greater than that by offshore dumping in upper layer. This is because the influence of discharge from outlet of dumping revetment is great.

Although countermeasure for SS dispersion such as slit curtain was considered in this study, SS is not perfectly controlled due to insufficient SS removal rate (40% was used this time).

Other approach for SS control such as frequent monitoring to control construction load (dredging and dumping volume) might be necessary on actual construction activity.

Even though offshore dumping is likely to have naturally, biologically and socially less impact, continuous monitoring and measures to control SS generation/dispersion during the construction phase are highly recommended (see Chapter 21 for the details of environmental monitoring plan).

13. PRELIMINARY CONSTRUCTION PLAN

13.1 Scope of Construction

The construction works required for the implementation of the Lach Huyen Port Project are divided into the following Facilities and Works:

No.	Facilities	Works	Unit	Quantity
1	Port and Terminal			
1-1		Revetment (Berth Line)	M	750
1-2		Outer Revetment-A	M	750
1-3		Reclamation	M3	2,201,525
1-4		Soil Improvement	M2	552,327
2	Channel Protection			
2-1		Sand Protection Dyke	M	7,600
2-2		Outer Revetment-B	M	2,480
3	Port Service			
3-1		Service Boat Berth	M	347
3-2		Port Service Road	M	1,000
4	Channel Dredging		M3	37,979,707

Indicated works and quantities are estimated in the SAPROF Study and will be reviewed in the Detail Design stage. In above Facilities and Works, execution method of the "Channel Dredging" is mentioned in the Chapter-8 [Channel Dredging Plan] of this report.

Container Berth structure and Terminal structure are belong to the Private sector Project and execution method for the Private sector Project is not mentioned in this Report.

Tentative Construction Method and Work Schedule of above Facilities are mentioned in this Section. These methods are to be foundations of the Cost Estimation for the Project.

13.2 General Conditions of the Site

Location, Access, Natural condition and Social condition are studied in this Section. Work Method, Procedure, used equipment and activity ratio of each Work Item are to be estimated based on the General Condition of the Site.

13.2.1 Location and Access

The Project site is located along the existing channel at the Lach Huyen. Lach Huyen Port is located east coast of the Cat Hai Island which is connected with Hai Phong city by the Ferry Boat only, now. It takes about two hours from Hai Phong City center to the Work site by car and Ferry boat, and three hours by a passenger boat.

Therefore, manpower, equipment and materials shall be mobilized by the waterway until completion of the Access Bridge and Access Road.

Ready mixed concrete and Asphalt concrete (if necessary) shall be fabricated in the work site at the time due to the lifetime of these law materials.

13.2.2 Rainfall

The Project area is characterized as a monsoon climate with a dry season from November of May and a rainy season from June to October. Average monthly number of rainstorm day in Cat Hai is 44.3 days according to The Preparatory Survey on Lach Huyen Port Infrastructure Construction in July 2010.

Table 13.2.1 Average Monthly Number of Rainstorm Day

(Days)

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Cat Hai	0.00	0.29	3.29	3.43	4.57	9.29	7.43	8.14	5.43	2.00	0.43	0.00	44.3

Source: The Preparatory Survey on Lach Huyen Port Infrastructure Construction in July 2010
Original Data from the North-East Meteorological Station, 1975-2006

13.2.3 Typhoon

Lach Huyen area and its vicinity are occasionally subjected to typhoons. The strongest (measured) winds induced by typhoons reached 51m/sec on August 21, 1977.

Cat Hai area was attacked by typhoon at 0.92 times per annum on average according to the observation in the second half of 20th century. Most of the typhoon in this area was observed from June to September.

13.2.4 Wind

Generally, the winds in Hai Phong area are gentle. Winds of 1-4m/sec account for about 60% and over 10m/sec account for about 2%.

According to the wind data observed 3-years period from 2006 to 2008, predominant wind directions range from East to South (about 45% of occurrence) and North (about 13% of occurrence) of the whole wind.

13.2.5 Tide

The Tidal Level prediction at Hon Dau is given in the TEDI F/S Report as follows. The tidal range is from +0.43m Chart Datum (lowest water level) to +3.55m (highest water level).

One tide per day:	H.H.W.L	+4.43m
	H.W.L	+3.55m
	M.H.W.L	+3.05m
	M.W.L	+1.95m
	M.L.W.L	+0.91m
	L.W.L	+0.43m
	L.L.W.L	+0.03m

13.2.6 Waves

Some of the works, especially the dredging of the channel and Public Facilities may be affected by the wave conditions.

Hon Dau Station records (3-year period from 2006 to 2008) shows the wave height more than 1.0m occupied 8.59% of occurrence and 60% of waves come from directions from East to South.

13.2.7 River Currents

River currents have been measured during a Russian led study in 1963-64 and later studies. The main target for these measurements has been to determine the discharge volume for estimation of the sedimentation, and the measurements have been carried out at the estuaries of the river systems. However, from the Russian study it may be deducted that the outgoing river currents can reach 0.8-1.0m/s, whereas the ingoing currents are up to 0.4-0.6m/s. The maximum currents are in the rainy season.

The river currents will naturally mostly affect the dredging works and operations with floating equipment at the berth structure.

13.2.8 Channel Traffic

The number of vessels calling Hai Phong Port exceeds 1,300 per year. All these vessels are using the approach channel on arrival and departure and they must follow the marked and dredged channel. The traffic is to some extent concentrated in high water periods. In addition to this traffic pattern is seen a huge number of barges, in a range of sizes up to a few hundred tons. The barges are either self-propelled or pushed or towed by tugboats. Barges may be tied together in groups up to 4. Whereas the larger vessels calling the Port navigate in the approach channel, the barges may use the river system joining the Cam River and they may – due to the shallow draft – at times navigate at the limit or outside the dredged channel.

13.2.9 National Holidays

There are following national holidays in Viet Nam and holidays for the foreign companies, which are considered to be unworkable days.

-	New Year Day:	1st January	1 day
-	Chinese New Year Day:	Jan to Feb	4 days
-	Kings Birthday	10th March of Lunar	1 day
-	Independence Day	30th April	1 day
-	May Day	1st May	1 day
-	National Day	2nd September	1 day

13.2.10 Workable days and Activity Ratio

Taking the above natural conditions and national Holidays into consideration, the following days are considered to be unworkable.

(1) On-land General Works:

-	Rainfall	12 %
-	Typhoon	1 %
-	Wind	2 %
-	National Holidays	13 days
-	Sunday	53 days

(2) Marine Works (excluding dredging and tidal works):

-	Rainfall	12 %
-	Typhoon	1 %
-	Wind	2 %
-	Wave	9 %

- River Currents	5 %
- Channel Traffic	20 %
- Tide	10 %
- National Holidays	13 days
- Sundays	53 days

Based on above unworkable days, Tidal condition, River current, and Channel Traffic condition, following Activity Ratio of the Works are considered. In this area, weather condition between rainy season and dry season is not so different that activity ratio of rainy season and dry season shall be calculated together.

<Work Item>	**<Activity Ratio>**
- Temporary Yard land work:	0.71
- Temporary Jetty:	0.61
- DMM marine work:	0.72
- Piling work (marine):	0.52
- Seabed Excavation:	0.70
- Stone Backfill:	0.73
- Sand Bag Dyke Fabrication:	0.58
- Installation of Geotextile:	0.52
- Installation of Filter Stone:	0.73
- Installation of Armor Stone:	0.73
- Installation of Rubble Stone:	0.73
- Leveling of Filter Stone:	0.73
- Leveling of Armor Stone:	0.73
- Leveling of Rubble Stone:	0.73
- Reclamation under the water:	0.73
- Reclamation above the water:	0.81
- ALiCC method:	0.71
- PVD method:	0.71
- Sub-grade works:	0.71
- Base Course and Sub Base works:	0.71
- Prime Coat and Tack Coat works:	0.71
- Asphalt Concrete works:	0.71
- Traffic Sign:	0.71
- Fabrication of Tetrapod:	0.71
- Installation of Tetrapod:	0.64
- Fabrication of Concrete Block:	0.71
- Installation of Concrete Block:	0.64
- Building Works:	0.71
- Dredging works:	0.64
- Utility and Accessory:	0.71
- Other Civil Works:	0.71
- Other Marine Works:	0.64

13.2.11 Working Time

Working time is estimated eight hours per day for the normal work items due to the safety and quality control reason. However, Concrete Block Fabrication Work, Reclamation Work and Dredging Works may be carried out with two or three shift per day to save construction period.

13.3 Construction Sites

13.3.1 Port and Terminal

The construction site is located besides Cat Hai island around the existing channel which connecting the Hai Phong Port and sea channel (Figure 13.3.1).

Access to the site from the seaside is possible all along the site and it is assumed that the Contractor will construct a temporary wharf to be used for unloading of his equipment and construction material. The full length of the existing channel face along the site will eventually be part of the yard area, so careful planning is required by the contractors to avoid moving the temporary wharf.

The access to the site from landside is limited. Traffic from Hai Phong City area to the site is interrupted by existing river and any vehicle is required to use car ferry to cross the river until completion of the Access Bridge and Causeway.

The existing channel is in operation throughout the construction period, and the Contractor must make planning so the channel operations are not disturbed.

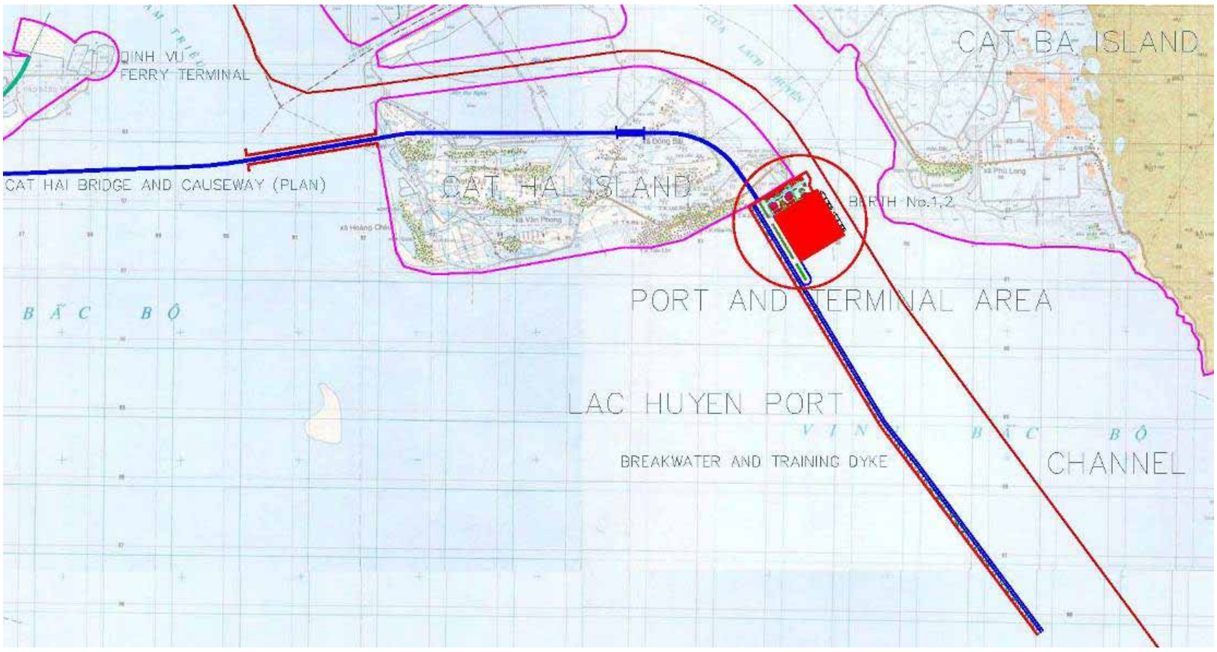


Figure 13.3.1 Construction Area of Port and Terminal

13.3.2 Channel Protection

The construction site for the Channel Protection is located besides Cat Hai Island around the existing channel with 7.0km from Port and Terminal location (Figure 13.3.2).

Access to the site from seaside is possible all along the site but from landside is limited caused by the existing river same as Lach Huyen area.

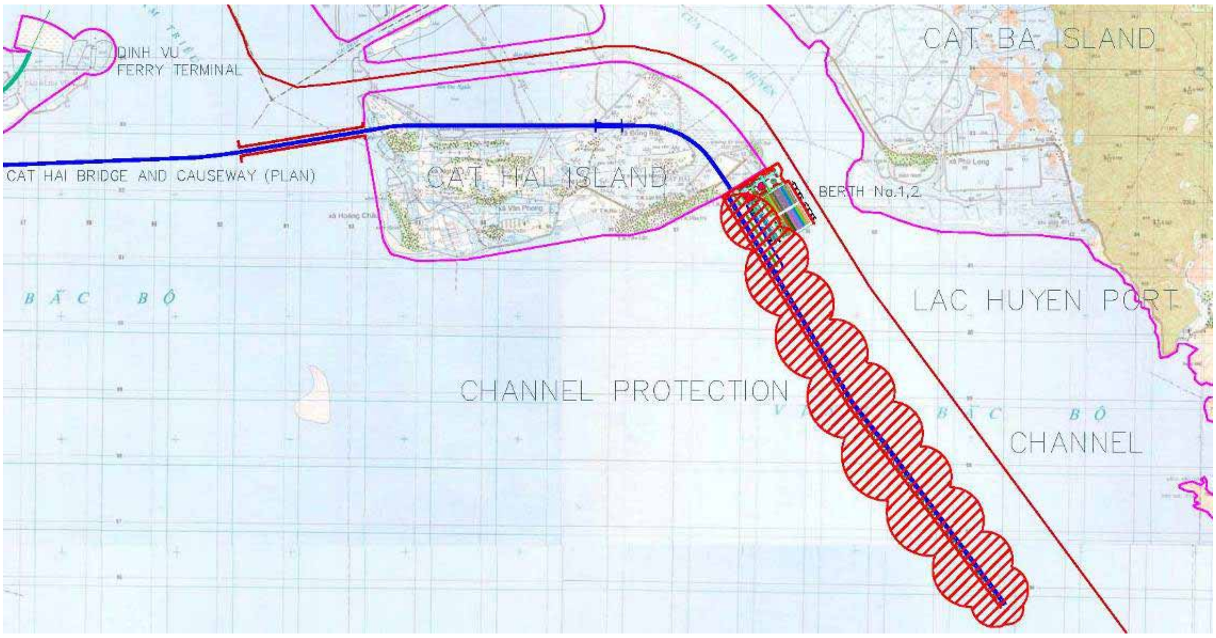


Figure 13.3.2 Construction Area of Channel Protection

13.3.3 Port Service

The construction site for the Service Berth is located between Cat Hai Island and the new Container Terminal (Figure 13.3.3).

The construction site for the Port Service Road is located behind the new Container Terminal (Figure 13.3.4).

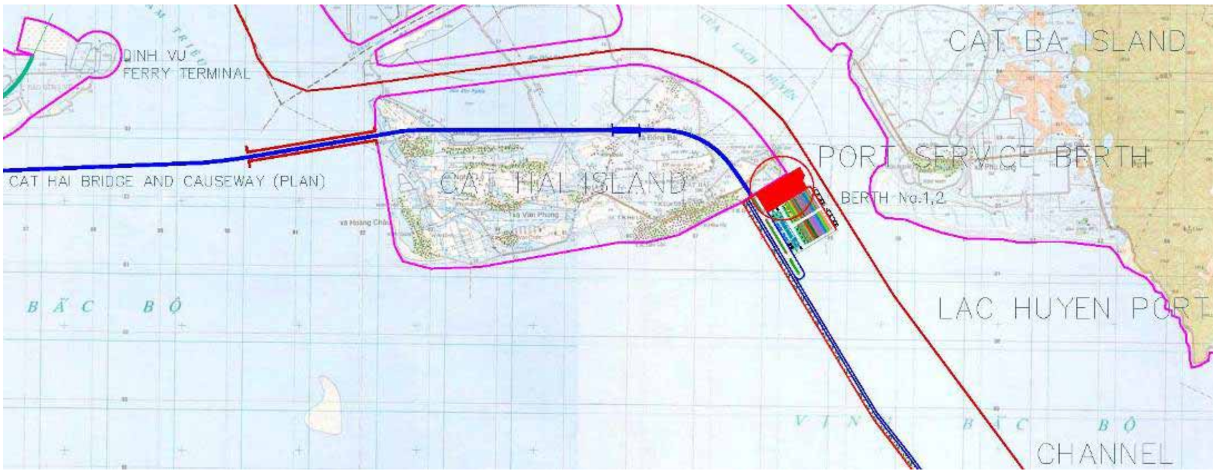


Figure 13.3.3 Construction Area of Service Berth

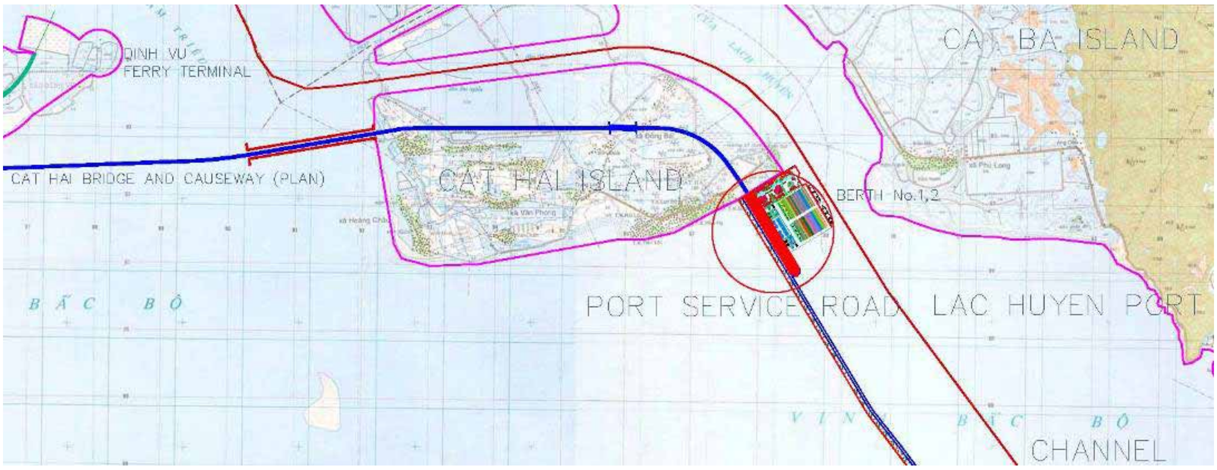


Figure 13.3.4 Construction Area of Port Service Road

13.4 Material Availability

In general is it envisaged that the bulk of the construction material is available form existing sources and storages, so that no new quarries need be opened for this project. The construction material for this project is envisaged achieved from local sources or imported as briefly described in the following:

13.4.1 Reclamation Sand

1) Description

Reclamation Sand is mainly used for the Port and Terminal Works. The kind of Reclamation Sand is called "Black Sand" which diameter is around 0.1 mm and dark collar. The dredged material is not suitable for reclamation.

2) Source and Capacity

The source of reclamation sand is mainly available in back-river of Kinh Thay River and Thai Binh River, which is 70 Km far from construction site. Reclamation sand mines are allocated sporadically in flood plain of the rivers. Even the reserve of each mine is not high, there are advantages in sand extraction and transportation in water way, which is because Kinh Thay River and Thai Binh River are main waterway transportation line into Hong River Delta Area. There are Dai Dong mine (in Thai Binh River) and Cong Hoa mine (in Kinh Thay River) which has reserve over 6 million m^3.

It was confirmed that there is a licensing system for sand mining in Vietnam by the previous investigation in SAPROF study. As a continuation of the SAPROF study, JICA study team conducted hearing investigations to major sand suppliers in Hai Duong city. A major licensed supplier, who has 4 licenses in Hai Duong city and his on-going major contract is to provide reclamation sand in the volume of 10 million m^3 in 20 months, that is 17,000m^3 per day, for a construction of new highway No. 5 from Ha Noi to Hai Phong city, said that the surroundings of acquiring new license and renewal license is getting difficult because of mainly for environmental protection aspect especially from early this year. Although Lach Huyen Project does not require so huge volume like above-mentioned project, it also needs big amount, 10,000 m^3 per day constantly by reason of the aspects of work magnitude and restricted construction term. Therefore, in Detail Design stage, further examination and investigation of sand procurement are necessary and the results have to be reflected on the cost estimation. In case of exploring further procurement sources, it is necessary to note that the recent surging diesel price influences transportation cost that rises in proportion to the distance from the site.

3) Transportation

Normally, Reclamation sand is transported by Flat Barge, Sand Barge or Dump Truck according to the site condition in Vietnam. When project site is near river or sea, Flat Barge or Sand Barge is used due to the lower cost. Sand Barge has engine pump for loading and unloading sand in the own body. When Flat Barge is used for transportation, pump barge is used for unloading sand. Unloaded sand can be transported longer than 1.0km by sand pump and plastic tube.

13.4.2 Sand for Concrete

1) Description

Sand for concrete might be used not only for the Concrete Works, but for the Sand Mat at the Soil Improvement Works. The kind of this Sand is called “Yellow Sand” which diameter is from 0.5 mm to 2.5 mm and collar is yellow or gray.

2) Source and Capacity

The source of sand for concrete is mainly available in Lo River, Phu Tho Province, there is only 200 Km by waterway from the sand source to construction site. These mines may supplies 8 to 10 barges (400m^3 in each barge) per day for the construction.

3) Transportation

Normally, Fine Aggregate is transported by Flat Barge, Sand Barge or Dump Truck according to the site condition in Vietnam. When project site is near river or sea, Flat Barge or Sand Barge is used due to the lower cost. This kind of sand can be transported not longer than 200m by sand pump and plastic tube.

Clamshell is usually used for loading and unloading sand to the Barge and Dump Truck is used for the secondary transportation.

13.4.3 Rock for Revetment, Armor and Rubble

1) Description

Rock and stone material for revetments and dike construction is available from local sources. Although Hai Phong is located in a river delta, there are rock hills scattered around the city and vast areas of mountains to the north.

2) Source and Capacity

Rock resource is mainly allocated in Thuy Nguyen, Hai Phong City, and Yen Hung, Quang Ninh Province. Mines in Thuy Nguyen, Hai Phong, are considered to have good quality, large reserve, which is about 10 million m^3 as the one in Phi Liet. These mines may supply large block rock to construct dykes, revetments. Furthermore, these mines located at near rivers and have advantages in waterway transportation. Rock mines in Yen Lap, Yen Hung, Quang Ninh Province have reserve over 6 million m^3, and near construction site but the transportation by waterway has limitation due to dried and narrowed river in the area.

3) Transportation

Filter Stone, Rubble Stone and Armor Stone is produced in stone quarry and transported by Dump Truck or Barge. When transportation distance is long, or project site is in the river or sea, stone is transported to the Barge by Dump Truck and transported to the site. Manpower or

Backhoe is usually used for loading and unloading stone to/from Barge.

13.4.4 Aggregate for Foundation and Concrete

1) Description

In the Hai Phong Area, crushed stone is normally used as the Aggregate for Foundation and Course Aggregate for Concrete. Thus, Aggregate is produced in the Stone quarry.

2) Source and Capacity

Aggregate for Foundation and Concrete have large amount in Minh Duc, Thuy Nguyen. There are at least 10 rock manufacturer companies in this area which have available crushing and screening equipments with standard sizes, using to produce foundation and concrete. Each production line can supply 200m^3 technical rocks per day.

3) Transportation

Aggregate is produced in stone quarry. Aggregate is transported by Dump Truck or Material Barge. Clamshell or Backhoe is usually used for loading and unloading Aggregate to/from Barge.

13.4.5 Cement

1) Description

There are a number of cement factories nearby Hai Phong, so cement is easily available locally. Two types of cement called PCB30 and PCB40 are normally used for concrete works. Workability, price and quality is different each other.

2) Source and Capacity

Companies, which can supply cement in the area, are Ching Phong Company, Hai Phong Cement Company, and Hoang Thach Cement Company. Other cement companies are Thang Long Company, Ha Long Cement Company, total capacity of these companies is about 8 million tons per year. Cement is transported easily through 30 Km from Hai Phong Cement Company and Ching Phong Company to construction site by waterway transportation. When cement is transported from Hoang Thach Cement Company to construction site, it must be transported in land-way (about 40 Km) to Hai Phong City, and the next 60 Km to the construction site.

3) Transportation

Cement is transported by Truck if they are packed in bag. When required cement is not little, tank truck is used for transportation.

13.4.6 Ready Mixed Concrete

1) Description

Ready mixed concrete is produced by the Concrete Batching Plant or Concrete Drum Mixer. Concrete Batching Plant is suitable for supplying huge quantity of concrete. When Concrete Drum Mixer is used for Producing concrete, all materials as Cement, Aggregates, Water and Admixture shall be stocked at placing site.

2) Source and Capacity

In Hai Phong city, there are some concrete mixing plants near construction site, as follows:

No.	Name of company	Address	Concrete mixing plant		
			$45m^3/h$	$60m^3/h$	$120m^3/h$
1	Thang Long Mechanic & Construction Enterprise	57 Luong Khanh Thien Street, Hai Phong City		1	1
2	Bach Dang 5 Construction Company	Dinh Vu Island, Hai Phong City	1	1	
3	Thai Son Construction Trading Joint Stock Company	Dinh Vu IZ, Hai An, Hai Phong City		2	
4	Hai Phong Construction Trade Joint Stock Company	No. 152 Hoang Van Thu Street, Hong Bang, Hai Phong City	1		1

3) Transportation

Ready mixed concrete is usually transported by agitator truck. Capacity of the truck is 4ton or 10ton. Transportation time is limited due to the setting time of the ready mixed concrete.

13.4.7 Reinforcement Bar

1) Description

Steel reinforcement bars are in general available from local sources. SD295, SD345 and SD390, etc is available in Viet Nam as same as Japan.

2) Source and Capacity

In Hai Phong Area, there are about 20 steel manufacture enterprises, which designed capacity is 4.5 million tons per year, among them, 2.3 million tons is steel billet. Some information about manufacturers is as follows:

- **Vinakansai**, at Km 18 National Road No. 5, An Hai, Hai Phong; Capacity: 250,000 tons of construction steel per year.
- **Vinasteel**, at Km 9, Vat Cach, Quan Toan, Hong Bang District, Hai Phong. Capacity of steel rolling plant is 180,000 tons/year, main product is Hot rolled steel from 10mm to 41mm. This steel type meets International and Vietnamese quality requirements.

3) Transportation

Reinforcing Bar is transported by Barge, Trailer Truck, Flat bed Truck in accordance with site condition and required quantity. Crane, Backhoe or manpower is used for loading and unloading Re-Bar to/from Barge or Truck.

13.4.8 Structural Steel

1) Description

The major quantity of steel is for the steel piles and the steel sheet piles, which all will be imported. Steel for smaller structural items, such as fence and navigation aids, is available locally. Cutting, bending and welding works are possible in Vietnam.

2) Source and Capacity

Cuu Long Steel Factory in Km 9, National Road No. 5, Quan Toan, Hong Bang District, Hai Phong. Capacity of the factory is 160,000 tons/year.

3) Transportation

Structural Steel is transported by Barge, Trailer Truck, Flat bed Truck in accordance with site condition, required quantity and each size of the structure. Crane or Backhoe is normally used for loading and unloading steel structure to/from Barge or Truck.

13.4.9 Asphalt Concrete

1) Description

Asphalt Concrete is made by sand, Aggregate and Asphalt milk. Asphalt Batching Plant is necessary for producing Asphalt Concrete.

2) Source and Capacity

No.	Company Name	Address	Plant			
			48 t/h	64 t/h	100 t/h	120 t/h
1	Hoang Truong Production Company	Pham Van Đong Street	1	1		1
2	Hai Phong Land-way Company	Pham Van Dong Street		1	1	1

3) Transportation

Asphalt Concrete is made in the Asphalt Batching Plant and transported by Dump Truck, normally. Asphalt Concrete is covered by plastic sheet to keep temperature during the transportation. Transportation time is limited due to the setting time of the Asphalt Concrete.

13.4.10 Concrete Pile

1) Description

Concrete Pile as PC Pile and PHC Pile are made by concrete, Re-Bar, steel plate and PC wire. They are fabricated at the Factory due to the requirement of fabrication system and equipment. RC Pile is made by concrete, Re-Bar and steel plate. RC Pile is made at the temporary yard or at the Factory.

2) Source and Capacity

In Hai Phong, there are companies supply concrete piles, which are:

- Bach Dang 5 Precast Concrete Company, Dinh Vu IZ, Hai An, Hai Phong
- Minh Duc Concrete Company, Minh Duc Town, Thuy Nguyen, Hai Phong

3) Transportation

Length of PC Pile or PHC Pile is normally 5.0m to 20m, diameter is 50cm to 80cm, and unit weight is 300kg/m to 800kg/m. they are transported by trailer truck, Flat bed truck or material barge. Loading and unloading works require the heavy equipment as mobile crane.

13.4.11 Steel Pipe Pile (SPP)

1) Description

SPP is used for the foundation of wharf and Revetment structure such as SPP wall. There is no factory of the SPP in Vietnam, so far. Therefore, SPP or SPP wall should be imported from Japan, Singapore, Thailand or other country which has suitable SPP factories.

2) Source and Capacity

SPP shall be imported from foreign country.

3) Transportation

Length of SPP is limited by the factory condition and transporting condition. When vessel is used for import, length of SPP is normally 12m to 20m. In the construction stage, SPP shall be transported by the trailer truck or material barge. When design length of SPP is longer than original length, they shall be spliced at the splicing yard and transported by material barge or spliced at the driving position.

13.5 Equipment Availability

The used equipments for the construction are envisaged achieved from local sources or imported as briefly described in the following:

13.5.1 Crane Barge

1) Description

Crane Barge is used for the lifting works in the marine works including Piling work and dredging work. This Barge can not shift by herself. Tug Boat is necessary for shifting and moving. Some of the Crane Barge has Stud system to keep position of the Barge.

2) Source and Capacity

Crane Barge consists of two types as separate type and fixed type. Separate type of Crane Barge is composed of Flat Barge and Crawler Crane from 50ton to 150ton. Crane is fixed on the Barge at the fixed type. Separate type is available in Viet Nam however most of fixed type is imported from abroad. Crane Barge with 50tons crane is popular in Viet Nam and not difficult to mobilize, however, availability of Crane Barge with bigger than 100tons crane is depending on their schedule.

Crane Barge 50t

Crane Barge 300t

13.5.2 Material Barge

1) Description

Material Barge is used for the transporting material as Sand, Stone, Piles and Concrete Structures. This Barge requires Tug Boat for shifting and moving.

2) Source and Capacity

Capacity of 600tons to 2,000tons of Material Barge is popular in Viet Nam and available from local sources. However, huge size of barge as 5,000tons or bigger shall be imported from foreign countries.

Material Barge 600t

13.5.3 Piling Barge

1) Description

Piling Barge is used for the Piling Works. This Barge is composed of the Flat Barge, Piling Rig and Hammer. This Barge requires Tug Boat for shifting and moving.

2) Source and Capacity

There are some Piling Barges in Viet Nam which are made in Viet Nam and imported from foreign countries. Availability of these Barges is depending on their schedule. Capacity of the Piling length of each Pile is less than 40m and weight of each pile is less than 30tons in general.

Piling Barge

Piling Barge

13.5.4 Sand Pump Barge

1) Description

There are mainly two kinds of Sand Pump Barge in Viet Nam. Sand Barge with Pump is one of them. Sand is loaded and unloaded with water by her pump.

The other type is Sand Pump Barge which is composed by small Barge and Pump only. When sand is transported by Material Barge, this Sand Pump Barge shall unload sand by her Pump.

Sand Pump Barge can not shift or move by herself. Tug Boat is required to move this type of Barge.

2) Source and Capacity

Sand Barge with Pump and Sand Pump Barge is popular and available in Viet Nam with suitable numbers. Sand Barge with Pump can deliver sand from 200m^3 to 800m^3 by her own engine. Unloading ability is 50m^3/h to 100m^3/h according to the Pump size and Sand condition.

Sand Pump Barge can not transport material. Sand Pump of this Barge is bigger than that of Sand Barge with Pump. Ability of the Pump is 150m^3/h to 240m^3/h in accordance with site condition.

Sand Barge with Pump

Sand Pump Barge

13.5.5 DMM Barge

1) Description

DMM Barge is used for the Cement Deep Mixing Method (DMM) for the seabed. This Barge is composed by Flat Barge, Rig, Auger and Cement Plant. Cement is used for the material. Tug Boat is required for the shifting and moving.

2) Source and Capacity

Small sizes of the DMM Barge as capacity of one Rig or two Rigs with depth of maximum 30m are available in Viet Nam. However, DMM Barge with six Rigs or with depth of more than 30m should be mobilized from foreign countries.

Even small capacity of DMM Barge is not so popular in Viet Nam that availability shall be depending on their schedule.

DMM Barge (Local)

DMM Barge (Foreign)

13.5.6 PVD Machine

1) Description

PVD Machine is used for the driving of PVD in the PVD method of Soil Improvement Work. This machine is composed by Base Machine, Leader, Casing and Piling Power Plant.

Crawler Crane or Backhoe is used for the Base Machine. Vibro Hammer or Hydraulic Motor is used for the driving power plant.

2) Source and Capacity

PVD method and PVD machine is popular in Viet Nam. PVD machine is available from local sources. However, PVD machine with large ability as driving depth of deeper than 30m should be transported from foreign countries. There are some foreign companies which can carry out PVD work with large equipment.


PVD Machine (20m)


PVD Machine (40m)

13.5.7 Excavator

1) Description

Excavator is one of the most useful equipment in the construction site which can carry out excavation, filling, transportation, and lifting, leveling, breaking, and piling works. Base type of Backhoe is caterpillar and normal arm type. And there are long arm type, wheel type, Floating type and underwater type.

2) Source and Capacity

Backhoe is popular equipment in Viet Nam and available. Standard type and wheel type is easy to be mobilized, long arm type is available but not many, Floating type is small number in Viet Nam, and underwater type should be mobilized from Japan. Capacity of 0.4m^3 to 1.0m^3 of Backhoe is popular in Viet Nam and bigger than 1.6m^3 is difficult to find.


Excavator (0.7 m^3)


Excavator (0.7 m^3)

13.5.8 Bulldozer

1) Description

Bulldozer is used for earth works as surface soil removal, leveling and compaction work.

2) Source and Capacity

Bulldozer is popular in Viet Nam and available from local sources. Bulldozer has a capacity from D2 to D6 and all type is available from local companies.

Bulldozer (D5)

13.5.9 Dump Truck

1) Description

Dump Truck is used for transportation of the Sand, Soil, Stone or other materials. This truck can dump up materials by himself.

2) Source and Capacity

Dump Truck is popular in Viet Nam and available from local sources. Dump Truck has types of 5.0m^3, 10.0m^3 and 15.0m^3 of loading and all type is available from local companies.

Dump Truck (10 m^3)

Dump Truck (15 m^3)

13.5.10 Roller

1) Description

Roller is used for the compaction of Sub-Grade, Sub-Base, Base-Course, and Asphalt Concrete.

2) Source and Capacity

Many kinds of Roller is available in Viet Nam as Handy 1.0ton type, compaction 4.0ton, Steel 10ton, Tire 10ton, etc.

Compaction Roller (4t)

Tire Roller (10t)

13.5.11 Asphalt Finisher

1) Description

Asphalt Finisher is used for the installation of the Asphalt Concrete Pavement.

2) Source and Capacity

Asphalt Finisher is popular in Viet Nam and available from local sources.

Asphalt Finisher

Asphalt Finisher

13.5.12 Concrete Pump Truck

1) Description

Concrete Pump fixed type or Concrete Pump Truck is for the placing concrete. This pump transport ready mix concrete from agitator truck to the placing location.

2) Source and Capacity

Concrete Pump Truck is popular in Viet Nam and available from local sources. There are some types of concrete pump as 30m^3/h, 60m^3/h and 100m^3/h.

Concrete Pump Truck (60m^3/h)

Concrete Pump (Fix type)

13.5.13 Grab Dredger

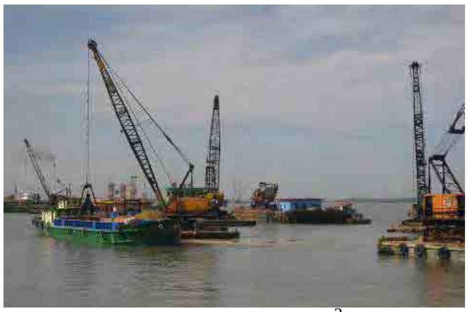
1) Description

Grab Dredger is used for the Dredging work. This Dredger is Cram shell type and it requires dumping barge for disposal of the dredged material. Grab Dredger requires Tug Boat for shifting and moving.

2) Source and Capacity

There are many Grab Dredgers which are used for the Dredging works and maintenance works in Viet Nam. Grab size of 2.0m^3 is popular and available in local sources easily.

Grab Dredger (5.0m^3)



Grab Dredger (2.0m^3)

13.5.14 Other Equipments

1) Description

Most of Equipments for Earth Works are available in Viet Nam. Large size of Crane as bigger than 200tons, Floating Equipment as Concrete Plant Barge or Soil Improvement Barge and Special Equipments are difficult to be found in Viet Nam.

13.6 Temporary Works

13.6.1 Temporary Yard

Prior to the construction of permanent structures, temporary yard should be constructed for the following works:

- Fabrication and stockpile of the Concrete Blocks
- Temporary stockpile of the main materials as Stone, Re-Bar, PVD, SSP, and SPP
- Splicing work of SSP, SPP

Temporary Road, Stockpile Yard, Fabrication Yard, and administrating area are to be located in the Temporary Yard.

Temporary Jetty with suitable loading and unloading crane is required for transporting above materials from Temporary Yard to Site.

Temporary Yard shall be prepared and arranged by the Contractor in accordance with his Construction Planning. Tentative plan of the Temporary Yard is studied for the estimation of the Project schedule in this Report.

In this tentative plan, Temporary Yard is to be constructed near the Dinh Vu Ferry Terminal.

1) Location and area of the Temporary Yard

a) Location

There are some alternatives for the Temporary Yard near the construction site. Dinh Vu area is recommended due to the following reasons:

- Easy access from Hai Phong City
- Availability of Concrete Batching Plant and Asphalt Mixing Plant
- Short distance from site

When the Temporary Yard is constructed near the Dinh Vu Ferry Terminal, some reclamation work will be required.

Map and Photo of Dinh Vu Area is shown below.

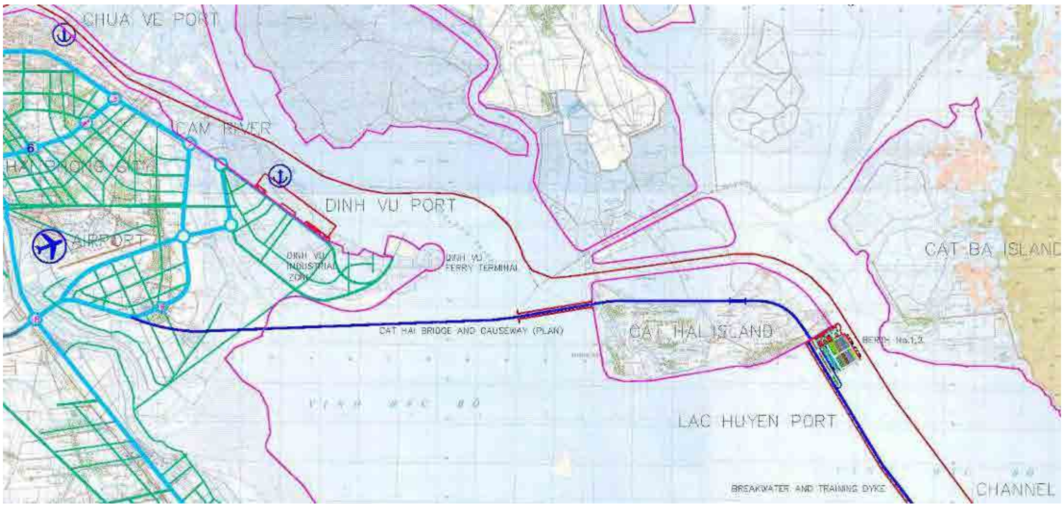


Figure 13.6.1 Map of Dinh Vu Area

Figure 13.6.2 Photo of Dinh Vu Area

b) Area

Tentative Plan of the Temporary Yard is shown in the Figure 13.6.3 [Sketch of Temporary Yard]. According to this plan, recommended area of the Temporary Yard is summarized as follow.

No.	Name of Area	Purpose	Area (m^2)
1	Temporary Road	For transporting	15,000
2	Fabrication Yard	For Concrete Blocks	23,000
3	Stockpile Yard	For Concrete Blocks	12,000
4	Splicing Yard	For SSP, PHC pile and SPP	1,000
5	Temporary Jetty	For transporting	3,000
6	Administrating area	For controlling	6,000
		Total	60,000

These areas are calculated based on the following preliminary conditions.

- Required supply number of the Tetrapod: 70 nos/day
- Required supply number of the Cellular Block: 15 nos/day
- Required supply number of the Concrete Block: 60 nos/day
- Required supply number of the Armor Block: 90 nos/day
- Required number of splicing SSP: 10 nos/day
- Required number of splicing SPP and PHC Pile: 10 nos/day

The capacity and area of the temporary yard will be revised based on the results of Detail Design Study.

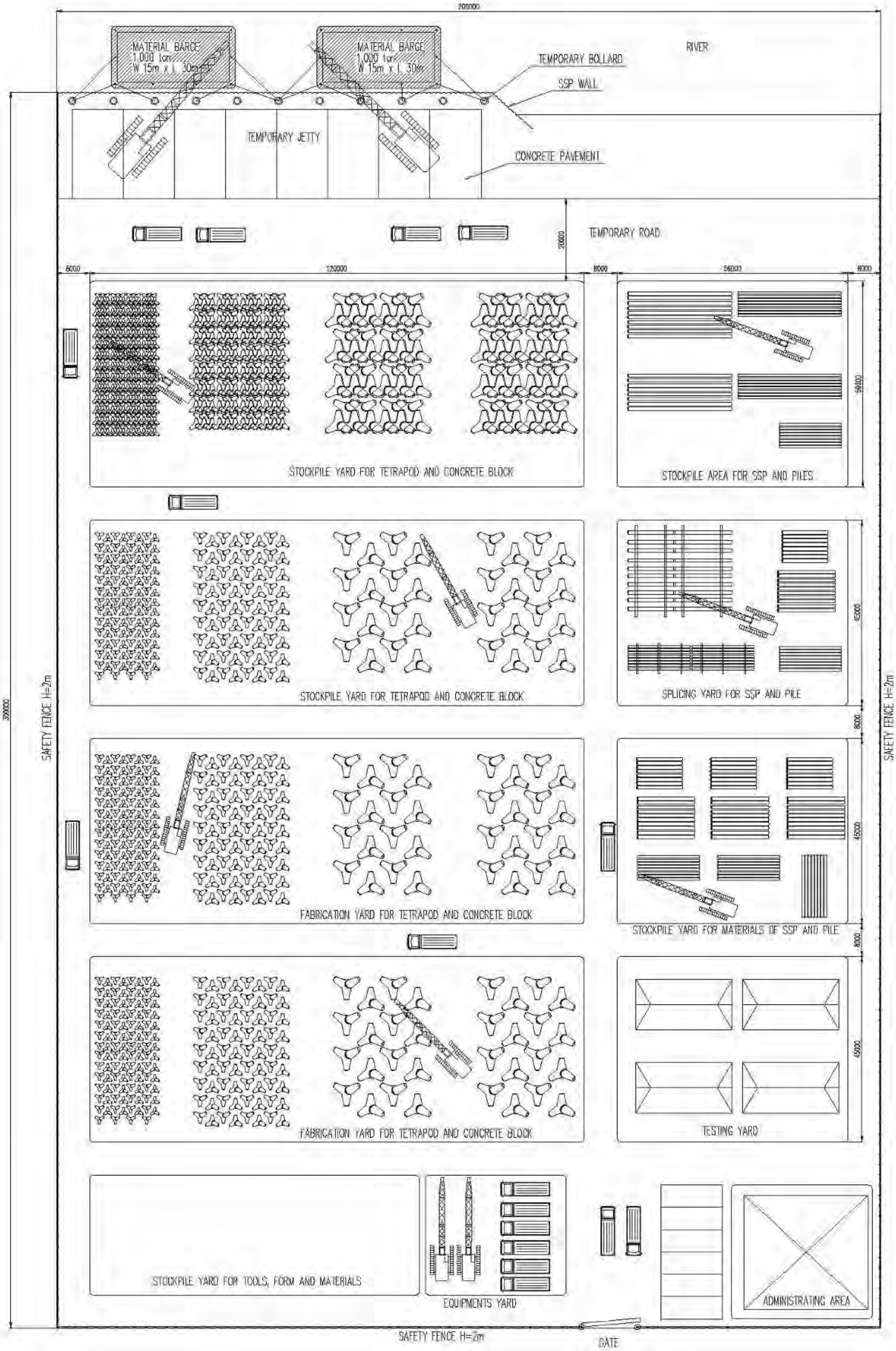


Figure 13.6.3 Sketch of Temporary Yard

2) Reclamation

Reclamation sand (called Black sand) shall be transported by the sand barge and pumped up to the planned area by sand pump barge. Edge of the yard shall be protected by sand bags and rubble stone against the wave. Designed elevation supposed to be +4.5m which is 1.0 m above the H.W.L. Filled sand shall be compacted by the compaction machine and soil improvement is not required.

3) Temporary Gate, Road and Fence

Temporary Gate and Fence shall be constructed for the safety of Temporary Yard when reclamation is completed. Type of Fence shall be the wire mesh and height of fence shall be 2.0m as indicated in the reference drawing.

All works shall be carried out by the manpower and Backhoe.

For the activities in the Temporary Yard including the installation of the Fence, temporary road shall be constructed in the Temporary Yard. Subgrade shall be compacted by compaction roller and base gravel (0 – 40mm) shall be installed and compacted with 300mm thickness.

4) Fabrication Yard and Stockpile Yard

Stockpile Yard shall be covered by the base gravel (0 – 40mm) with 200mm thickness to prevent dust and for easy movement of the equipment.

Splicing Yard and Fabrication Yard of the Concrete Block shall be covered by base gravel (0 – 40mm) with 200mm thickness and surface concrete with 100mm thickness to keep quality of the splicing and concrete block.

Gravel shall be leveled by Bulldozer and compacted by compaction roller. Concrete shall be installed by mixing truck and leveled by manpower.

5) Temporary Jetty

Temporary Jetty for loading of the blocks, piles and materials shall be constructed in the riverside of the Temporary Yard. Width, length and height of the temporary jetty shall be considered based on the loading equipment.

Revetment of the temporary jetty shall be made by Steel Sheet Pile (SSP). Inside of the Revetment shall be filled with sand. And surface of the temporary jetty shall be covered with base gravel (0 – 40mm) with 300mm thickness and covering concrete with 200mm thickness for the stability of the loading equipment.

SSP shall be installed by Vibro Hammer attached with Backhoe.

13.6.2 Temporary Access Road for the Site

Port Facility works as Revetment, Reclamation and Soil Improvement Works does not require the temporary access road. All works shall be carried out by Floating Equipment or carried out on the filled sand.

Sand Protection Dyke shall be constructed by Floating Equipment as Crane Barge, Backhoe Barge and Material Barge. So, access road for the construction site is not required.

Other works does not require the temporary access road, too.

13.6.3 Temporary Jetty for the Port Facility Works

Heavy earth equipments for the Soil Improvement, Service Berth and Service Road shall be mobilized to the work site by Barge because some of them are too heavy for the Ferry Boat to be transported.

There are some existing jetties in the Cat Hai Island however existing road to the site is too narrow for the transportation of the Heavy Equipments. Construction of the Temporary Jetty on the reclamation area is recommended.

Reference sketch of the Temporary Jetty is shown in Figure 13.6.4.

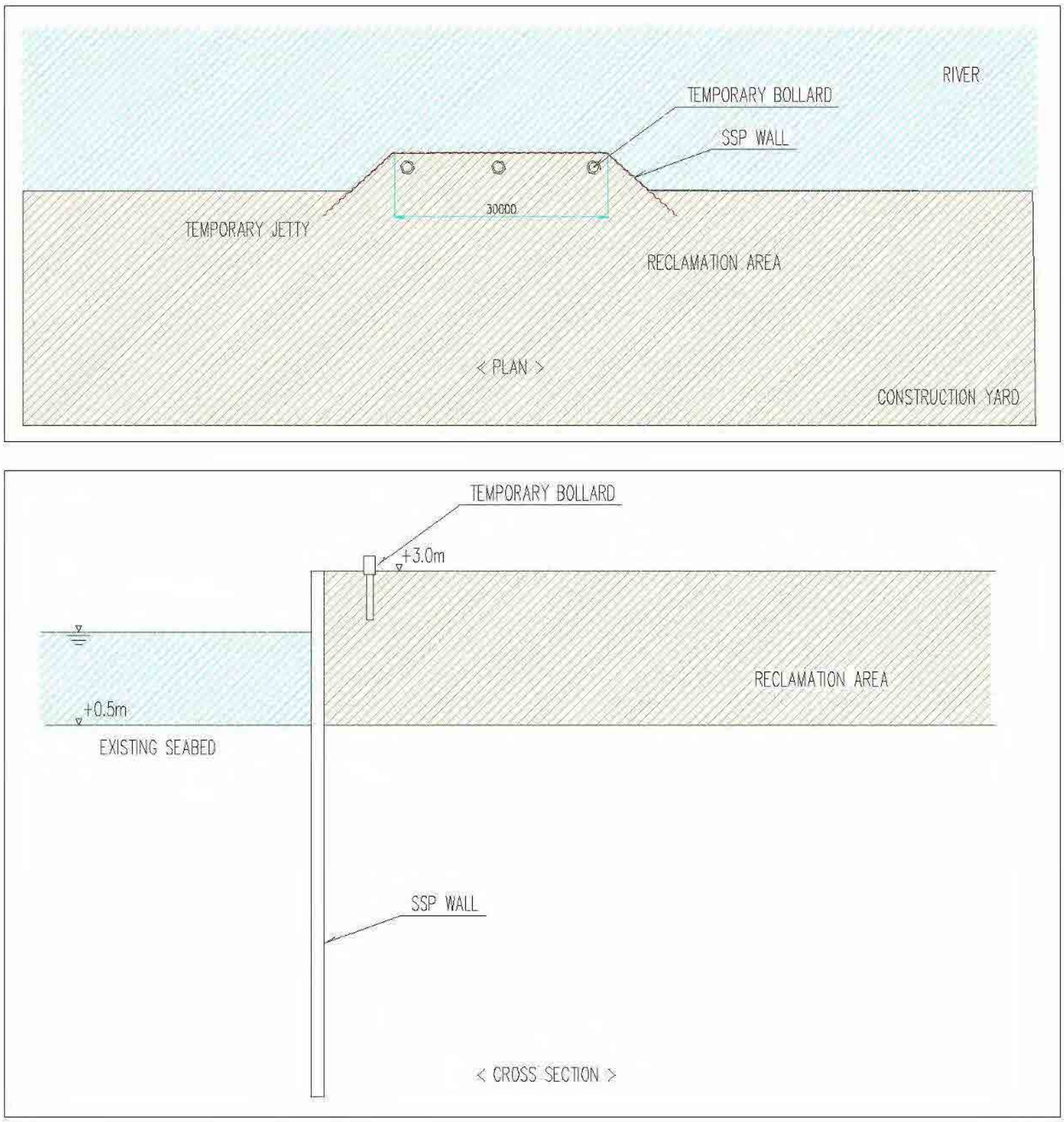


Figure 13.6.4 Sketch of Temporary Jetty

Temporary Jetty shall be located in the Reclamation Area. Location shall be selected with consideration of the Work sequence and schedule.

13.6.4 Safety Fence, Safety Buoy and Gate of Site

Temporary Safety Facility as Safety Fence, Buoy and Gate are included in the Safety Works.

Work site shall be separated by the Safety Fence and Safety Gate from public area and other construction project site. Safety Fence shall be enough strong against the wind and manpower.

Safety Buoy shall be installed to indicate working site of marine works as Reclamation and Sand Protection Dyke to avoid marine accident.

Reference location of the Temporary Fence, Buoy and Gate is shown in Figure 13.6.5.

Detail location in accordance with the Vietnamese Law shall be mentioned in the Section 13.7 [Construction Safety].

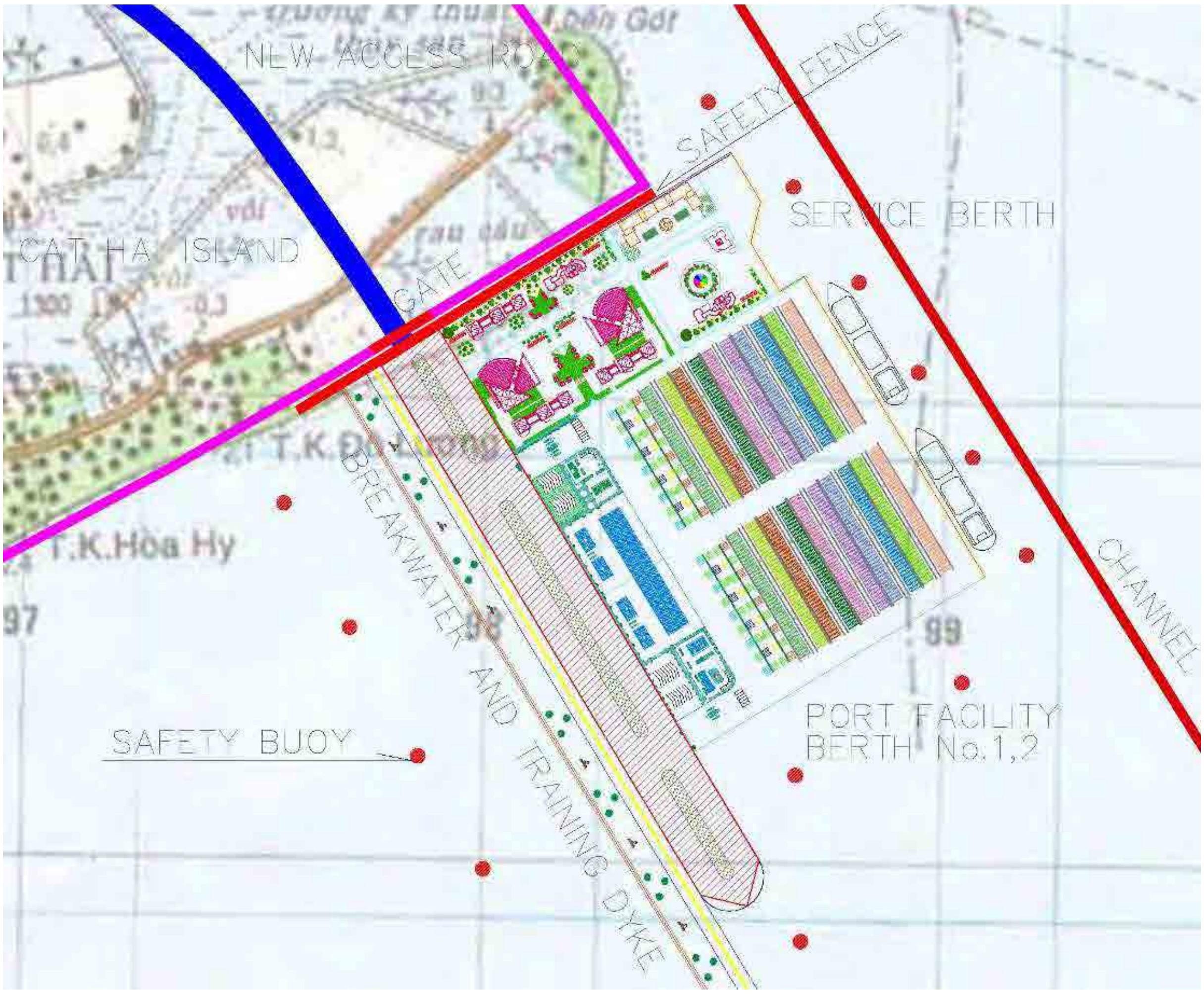


Figure 13.6.5 Location of Temporary Fence, Buoy and Gate

13.7 Construction Safety

13.7.1 General

Safety in any Construction Work is the most important and serious matter for all of the concerned organizations and individuals involved. To this end, a key phrase of "Safety First" is, in most of construction offices, always used to remind that Safety has the utmost priority than any other things in any kind of work.

In spite of such wishes of all the concerned to complete a construction project with "No Accident", this has not been yet completely achieved as some serious accident cases in construction projects were annually reported somewhere in a country. This may reveal that it is not easy to perfectly eliminate from the construction projects any violations/ negligence of the basic requirements of Laws and Regulations related to the Construction Safety and/or insufficient Safety Arrangement & Management due to an attempt to complete a project in a more economical or harried way.

Moreover, in order to achieve a None-accident construction project, it is not sufficient enough to simply conduct safety arrangement and provisions according to the requirements of related Laws and Regulations, but essentially necessary to establish such segment that reviews and enforce the project from safety view points throughout a project implementation based on due considerations and analysis of any possible risks & effective preventions, which may most of part be foreseeable from the site conditions/ environment, complexity and scale of the project, workers skilled level, planned equipment, etc.

In this Section, an effective safety plan for the project implementation will be discussed and recommended, being composed of the below divided Items, with due consideration of Project Component, respective Work Plans, Site conditions as well as Related Laws/ regulations in the Country for targeting to achieve a None-Accident Project;

(1) Laws, regulations and other legal documents related to Construction safety

(2) Basic Concept for Construction Safety

(3) Safety Management Plans in the Project

Among the above, Safety Management Plans in the Project will be further detailed in the Detailed Design prepared according to the detailed Construction Plans.

13.7.2 Laws, Regulations and Other legal documents related to Construction Safety

1) Legal Documents related to Safety and Hygiene in Vietnam

When construction work is implemented in Vietnam, the following legal documents shall be referred to and follow such requirements stipulated in the documents. All parties engaged shall study carefully the latest issues of the documents related to the safety including new issues before the implementation of the Project;

(1) Labor Code of Vietnam (2002)

(2) Decree of Government No 12/CP dated 26 January 1995 On the promulgation of Social Security Regulations

(3) Decree of Government No 110/2002/ND-CP On amending and supplementing some articles of the Governmental Decree No 06/CP dated 20 January 1995 regulating in details some articles of the Labor Code on Labor Safety and Hygiene

(4) Joint Circular No. 01/2007/TTLT/ BLDTBXH-BCA –VKSNDTC, Guidance on the coordination to settle occupational accidents causing deaths, occupational accidents with criminal signs

(5) Joint Circular No. 10/2006 TTLT-BLDTBXH –BYT Amending and supplementing Point 2, Item II of the Joint Circular No. 10/1999 guiding the implementation of the regime of allowances in kind to employees exposed to dangerous and hazardous working conditions

(6) Joint Circular No 14/2005/TTLT/BLDTBXH-BYT-TLDLDVN Guidelines for declaration, investigation, report, recording statistics and periodic report on occupational accidents

(7) Joint Circular No 29/2000/TTLT-BLDTBXH-BYT stipulating the list of jobs and occupations prohibited to HIV/AIDS carriers

(8) Joint Circular No 10/1999/TTLT-BLDTBXH-BYT instructing the implementation of providing allowance in kind for workers who are directly working in contact with harmful and dangerous elements

(9) Joint Circular No 09/TT-LB Stipulating harmful working conditions and list of occupations in which employment of young workers is prohibited

(10) Joint Circular No 03/TT-LB Stipulating harmful working conditions and list of occupations in which employment of female is prohibited

(11) Circular No. 04/2008/ TT-BLDTBXH Guidance on procedures for registration and verification of machines, equipment and materials subject to strict occupational safety requirements

(12) Circular No 37/2005/TT-BLDTBXH Guidelines for occupational safety and health training

(13) Circular No 23/2003/TT-BLDTBXH Regulating and providing guidance on application and appraisal procedures of machinery, equipment, materials, and substances with strict occupational safety, hygiene and health requirements

(14) Circular No 16/2003/TT-BLDTBXH Guidelines for the implementation of regulations on time of work, time of rest for employees having seasonal jobs and export processing jobs according to orders

(15) Circular No 10/2003/TT- BLDTBXH Instructing the implementation of compensation to the victims of occupational accidents and diseases.

(16) Circular No. 22/2010/TT-BXD of MOC on construction safety

In addition to the legal documents, the following Vietnamese Standard, wherever applicable as related, shall apply in the implementation of the Project;

Table 13.7.1 Related Vietnamese Standards

No.	VN	EN
1	**TCVN 2287:1978** Hệ thống tiêu chuẩn an toàn lao động - Quy định cơ bản	Labour safety standards system - Basic rules
2	**TCVN 2288:1978** Các yếu tố nguy hiểm có hại trong sản xuât- Phân loại	Dangerous and harmful effects to production process - Classification
3	**TCVN 2289:1978** Quá trình sản xuất- Yêu cầu chung về an toàn	Manufacturing processes - General safety requirements
4	**TCVN 2290:1978** Thiết bị sản xuất - yêu cầu chung về an toàn	Manufacturing equipment - General safety requirements
5	**TCVN 2291:1978** Phương pháp bảo vệ người lao động	Means of labor protection - Classifications
6	**TCVN 2292:1978** Công nghệ sơn - Yêu cầu về an toàn	Painting works - General safety requirements
7	**TCVN 2293:1978** Gia công gỗ_ Yêu cầu chung về an toàn	Wood processing - General safety requirements
8	**TCVN 3146:1986** Công việc hàn điện - Yêu cầu chung về an toàn	Electric welding works - General safety requirements
9	**TCVN 3147:1990** Quy phạm an toàn trong công tác xếp dỡ – Yêu cầu chung	Safety code for loading and unloading works. General requirements
10	**TCVN 3254:1985** An toàn cháy - Yêu cầu chung	Fire safety - General requirements
11	**TCVN 3255:1986** An toàn nổ - Yêu cầu chung	Explosion safety- General requirements
12	**TCVN 3288:1979** Hệ thống thông gió- Yêu cầu chung về an toàn	Ventilation systems - General safety requirements
13	**TCVN 4086:1985** An toàn điện trong xây dựng - Yêu cầu chung	Electrical safety in construction - General requirements
14	**TCVN 4244:1986** Quy phạm kỹ thuật an toàn thiết bị nâng	Code for the safe technique for crane – equipment
15	**TCVN 4431:1987** Lan can an toàn - Điều kiện kỹ thuật	Protective inventory safeguards - Technical condition
16	**TCVN 4586:1997** Vật liệu nổ công nghiệp – Yêu cầu an toàn về bảo quản, vận chuyển, và sử dụng	Industrial explosion materials. Safety rules for storage, transportation and use
17	**TCVN 4730:1989** Sản xuất gạch ngói nung - Yêu cầu chung về an toàn	Production of clay bricks and tiles - General safety requirements
18	**TCVN 5178:1990** Quy phạm kỹ thuật an toàn trong khai thác và chế biến đá lộ thiên	Technical safety regulations for open pit mining and processing
19	**TCVN 5308:1991** Quy phạm kỹ thuật an toàn trong xây dựng	Code of Practice for building safety technique
20	**TCVN 5738:1993** Hệ thống báo cháy - Yêu cầu kỹ thuật	Fire detection and alarm system - Technical requirements
21	**TCVN 5744:1993** Thang máy - Yêu cầu an toàn trong lắp đặt và sử dụng	Lift - Safe requirements for installation and use

No.	VN	EN
22	**TCVN 5863:1995** Thiết bị nâng - Yêu cầu an toàn trong lắp đặt và sử dụng	Lifting appliances - Safety requirements for installations and use
23	**TCVN 5864:1995** Thiết bị nâng - Cáp thép,Tang,Ròng rọc,Xích và đĩa xích. Yêu cầu chung	Lifting appliances - Wire ropes, drums, pulleys, chains and chain wheels – safety requirements.
24	**TCVN 5866:1995** Thang máy - Cơ cấu an toàn cơ khí	Lifts – Safety mechanisms
25	**TCVN 5867:1995** Thang máy - cabin - đối trọng - ray hướng dẫn. Yêu cầu an toàn	Elevator - Cabins, counterweights, guide rails - Safety requirements
26	**TCVN 6154:1996** Bình chịu áp lực - Yêu cầu kỹ thuật an toàn và thiết kế,chế tạo - Phương pháp thử	Pressure vessels - Safety engineering requirement of design, construction, manufacture - Testing methods
27	**TCVN 6155:1996** Bình chịu áp lực - Yêu cầu kỹ thuật an toàn lắp đặt,sửa chữa,sử dụng	Pressure vessels – Safety engineering requirements of erection, use, repair.
28	**TCVN 6156:1996** Bình chịu áp lực - Yêu cầu kỹ thuât an toàn về lắp đặt,sử dụng,sửa chữa - Phương pháp thử	Pressure vessels - Safety engineering requirements of erection, use, repair. Testing method
29	**TCXDVN 394:2007** Thiết kế lắp đặt trang thiết bị điện - Phần an toàn điện	Electrical Installation of Buildings – Protection for Safety
30	**TCXDVN 66:1991** Vận hành khai thác hệ thống cấp thoát nước - Yêu cầu an toàn	Operation of water supply and drainage systems - Safety requirements

Referring to the above documents, it should be noted that all the concerned parties in a project have respective roles and statutory responsibilities under the *Circular No.22/2010/TT-BXD OF DECEMBER 3, 2010: On labor safety in work construction*, even though the contract documents generally stipulate that the Contractor is wholly and solely responsible for the construction safety.

By the Circular, the following responsibilities of the Employer and the Engineer are summarized;

Responsibility of the Employer

i) Set-up of a full-time or part-time division for examining the observance of labor safety.
ii) Selection of a capable contractor suitable to the jobs.
iii) Suspend, request to take remedies and/or stop the construction, when the contractor's violations of labor safety rules are detected, and/or failed to remedy.
iv) Coordination (with the contractor) in taking handling measures in case of labor incidents or accidents, and concurrently report on the labor safety situation to functional agencies under the labor law.

Responsibility of the Engineer

i) Supervise contractor's observance of approved construction and safety measures and compliance with technical regulations on construction safety.
ii) Notify the Employer of dangers which might affect construction safety in order to take remedies and change construction measures as appropriate.
iii) Examine and report to the Employer for handling violations, stop construction and request remedies when the contractor violates safety rules.

Further, the following points should also be added to the responsibility of both entities which may be likely to happen;

i) Not to make any construction plans and designs which may be difficult to meet construction safety rules under the laws and regulations.
ii) Not to force the contractor to carry out or continue to works under hazardous or dangerous conditions (including abnormal weather and climate conditions).

13.7.3 Basic Concept for Construction Safety

The first step to achieve a non-accident construction project is to recognize and declare the importance of the safety and to do so, and make sure that all of the involved organizations and individuals are of same consensus that **"Construction Safety is the matter of all the parties concerned"**.

Thereafter, it may become a not-so-difficult matter to further proceed into the next steps as follows;

i) To establish a safety committee in the project to jointly review, approve, inspect and monitor all the construction safety aspects throughout the project implementation.
ii) To establish detailed and practical safety management and action plan(s) by reviewing and improving such statement prepared by the contractor(s). The plans shall include an analysis on possible accident risks of each work component, countermeasures to prevent or reduce such risks and the action plan in case of emergencies.
iii) To implement the established and agreed action plans necessary for construction safety.

Among the above steps to be taken in the construction safety aspect, the following points will be further discussed hereinafter as an essential and important;

i) Establishment of Project Safety Committee
ii) Accident Risk Analysis and Prevention Plan (including contingency plans)

1) Establishment of Project Safety Committee

Since the Construction Safety is the utmost importance and concerns of all the parties involved, it should be so arranged that a Safety Committee being composed of the Employer, the Contractor and the Engineer, for the Project is established, and Tasks and Responsibilities are to be clearly defined and agreed by all the parties.

The Safety Committee will conduct, at least the following activities;

i) Review and approve the Safety Management Plan and the detailed safety measures/ arrangement plans for each work component submitted by the Contractor.
ii) Regularly hold a safety meeting and conduct a safety patrol (at least once a month).
iii) Time to time Monitor and Inspect construction activities, and give advices/ instructions to the contractor any improvement in the safety aspects wherever and whenever deemed necessary.
iv) With the dedication of such power, suspend or stop any work or activity which is deemed to be a dangerous or risky act in terms of safety.
v) Organize and Conduct necessary trainings on safety to construction managers and superintendent staff.
vi) Establish and conduct Emergency communications and reporting in case of accidents.

The Project Safety Committee will be established in an earliest possible manner after the construction contract(s) have been finalized.

2) Accident Risk Analysis and Prevention Plan

In preparing a construction safety plan, the contractor is requested to make an accident risk analysis and its prevention plan.

Such analysis and prevention plan shall discuss the following items and matters;

i) Itemization of main work activities for each work component, including main equipment to be used in the activities
ii) Describe possible or foreseeable risks for each work activity, or as a whole work component, considering the particularity/nature of each activity and working conditions.
iii) Assessment/ evaluation of risks by means of ranking of the risks, being categorized into three to five respectively, in terms of:
- Magnitude/ seriousness of damage and influence, once occurs
- Probability estimate
- Effectiveness (or Easiness/Difficulty) in arranging the prevention measures

iv) Prevention plan and Contingency plan when occurred.

13.7.4 Safety Management Plan

A Safety Management Plan shall be prepared by the contractor prior to the work commencement, and submit for the review, comment and approval by the Safety Committee as discussed in the previous Sub-Section.

1) Minimum contents of the Safety Management Plan

The Plan shall, at least, contain the following items;

i) Organization of the contractor on Safety Aspects.
ii) Philosophy with overview of the works and general plans/ procedures for safety arrangement, monitoring, inspection and maintenance, including required safety related facilities/provisions under the project and covering whole the project implementation duration.
iii) Procedures for the protection for Fire, Explosion and dangerous material handling including its storage.
iv) UXO detection and settlement procedure, if required.
v) Training plan of workers on safety.
vi) Marine work safety procedure including work stoppage criteria.
vii) Contingency plan against accidents, adverse weather/climate conditions and other emergency cases including Emergency Communication procedure.
viii) General consideration and procedure for safe evacuation in case of natural disasters or a sort of Force Majeure.

Following to the conclusion and approval of the above Safety Management Plan, the contractor will further develop and prepare the detailed safety plan for each work component of the project for the review and approval of the Safety Committee.

2) Measures to be considered in case of Accidents

Article 10 of the CIRCULAR No.22/2010/TT-BXD also stipulates the following actions to be taken by the parties concerned in case of any labor safety-related or work-related incident/ accident;

i) By any measure give first aid or emergency to the worker(s) injured by the accident, and transfer to a health establishment for treatment;

ii) Promptly report the accident to relevant management agencies for examination and inspection under regulations to identify causes of the incident and accident;

iii) Declare, investigate, make records and statistics and report the process of handling incidents and settlement of the incident in case of labor accidents.

iv) After marking and obtaining approval of a competent agency, the construction work can be continued, with assessment and confirmation of the stability and safety of the work/ job in case of work-related incidents.

From the above, it is essential to provide the following arrangement to cope with emergency incidents;

- First Aid tools, equipment and facilities
- Arrangement of Clinic Facilities/ Emergency hospital(s) for treatment
- Establishment and Assurance of Emergency Communication System
- Regular education and training of Action in case of Emergency incidents/accidents.

A sample prepared for an Emergency Communication Chart is shown in Figure 13.7.1.

EMERGENCY COMMUNICATION CHART (SAMPLE) FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJECT

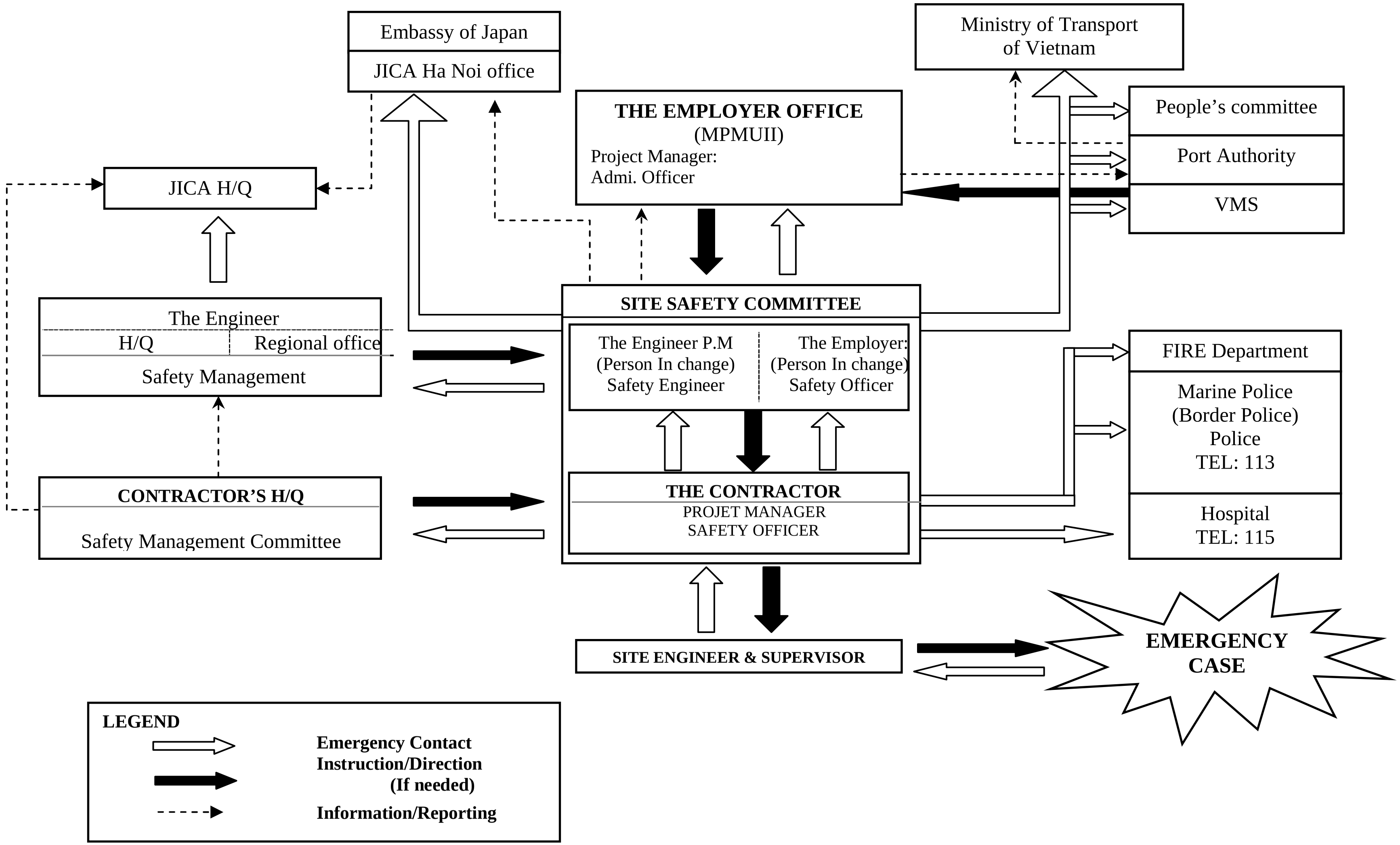


Figure 13.7.1 Emergency Communication Chart

14. PRELIMINARY COST ESTIMATION

14.1 Premises of Cost Estimates

14.1.1 Cost Estimations Standards in Vietnam

1) Decrees/ Circulars related to Cost Estimates in Vietnam

There are various Decrees/ Circulars related to cost estimates for construction works issued by the government of Socialist Republic of Vietnam and Ministry of Construction in Vietnam. Adopted standards, Lows, Decrees and Circulars for the preliminary cost estimation as of June 2011 are listed in the following table.

Table 14.1.1 Decrees/ Circular related to Cost Estimates in Vietnam (as of June 2011)

No	Name of document
1	Construction Law No. 16/2003/QH11 dated 26 December 2003.
2	Law No. 38/2009/QH12 dated 19 June 2009 amending and supplementing a number of articles of the Laws concerning capital construction investment.
3	Decree No. 131/2006/ND-CP dated 09 November 2006 of the Government on Issuance of Regulation on Management and Utilization of Official Development Assistance
4	Decree No. 12/2009/ND-CP dated 10 February 2009 of the Government on Management of Construction Investment Projects (CIPs)
5	Decree No. 83/2009/ND-CP dated 15 October 2009 of the Government on Amending and supplementing a number of Articles of Decree No. 12/2009/ND-CP dated 10 February 2009 of Government on Management of Construction Investment Projects.
6	Decree No. 112/2009/ND-CP dated 19 December 2009 of the Government on Management of work Construction Investment expenses
7	Decree No. 209/2004/ND-CP dated 16 December 2004 of Government on quality management of construction works.
8	Decree No. 49/2008/ND-CP dated 18 April 2008 of the Government on Amending and supplementing a number of Articles of Decree No. 209/2004/ND-CP dated 16 December 2004 of the Government on quality management of construction works.
9	Decree No. 123/2008/ND-CP dated 08 December 2008 of the Government detailing and guiding the implementation of a number of articles of the Low on Value-Added Tax.
10	Circular No. 04/2010/TT-BXD dated 26 May 2010 of the Ministry of Construction on guiding the marking and Management of work Construction Investment expenses
11	Circular No. 129/2008/TT-BTC of December 26, 2008, guiding the implementation of a number of articles of the Value-Added Tax Law and guiding the implementation of the Government's Decree No. 123/2008/ND-CP of December 8, 2008, detailing and guiding the implementation of a number of articles of the Value-Added Tax Law
12	Decree No. 87/2010/ND-CP of August 13, 2010, detailing a number of articles of the Law on Import Duty and Export Duty
13	Construction Quantum - Construction Part in the announcement of the document No. 1776/BXD-VP dated 16 August 2007 of the Ministry of Construction.
14	Construction Quantum - Installation Part in the announcement of the document No. 1777/BXD-VP dated 16 August 2007 of the Ministry of Construction.

15	Construction Quantum - Survey Part in the announcement of the document No. 1779/BXD-VP dated 16 August 2007 of the Ministry of Construction.
16	Construction Quantum on Sea and Inland following Decision No. 19/2000/QD-BXD dated 19 October 2000 of the Ministry of Construction.
17	Scene of Mines Quantum following document No. 1487/2007/BXD-KTTC dated 12 July 2007 of the Ministry of Construction.
18	Decision No. 957/QD-BXD dated 29 September 2009 of the Ministry of Construction in the announcement of the Consultant and Management of work Construction Investment expenses.
19	Circular No. 109/2000/TT-BTC dated 13 November 2000 of the Ministry of Finance guiding appraise fee.
20	Circular No. 19/2011/TT-BTC dated 14 February 2011 of the Ministry of Finance decision for liquidation of Capital Investment
21	Decision 33/2004/QD-BTC dated 12 April 2004 of the Ministry of Finance guiding insurance fee of the construction and installation.

Source: JICA D/D Study Team

2) Unit Price

The following table shows a list for calculation of unit price for Lach Huyen Port Infrastructure Project issued by the government of the Socialist Republic of Vietnam, Ministry of Construction in Vietnam and Hai Phong city.

Table 14.1.2 Unit Price Documents

No	Name of document
22	Decree No. 205/2004/ND-CP dated 14 December 2004 of the Government on decision salary grade systems in Vietnamese
23	Decree No. 107/2010/ND-CP dated 29 October 2010 of the Government on decision minimum wage with the Vietnamese labor working in the foreign-Invested enterprise.
24	Decision No. 131/QD-UBND dated 26 January 2011 of Hai Phong Committee on contraction equipment unit price (working shift) in Hai Phong province
25	Decision No. 410/QD-BXD dated 31 March 2010 of the Ministry of Construction in the announce construction price index.
26	Decision No. 196/QD-BXD dated 23 February 2011 of the Ministry of Construction in the announce construction price index.
27	Material unit price Quotation of Hai Phong City Constructional - Financial Service at the present;

Source: JICA D/D Study Team

a) Unit Price of Construction Material

For the purpose of preliminary cost estimates in Basic Design stage, unit prices of construction materials were investigated as of May 2011based on Material unit price Quotation issued by Hai Phong City. Also, to review cost estimates at SAPROF study, those prices are compared to the prices as of May 2010, which is the time of project cost estimation in SAPROF study.

Table 14.1.3 Unit Price of Construction Material

Unit: VND

No.	Material Items	Investigation Results							
		Source location	Unit	Productivity	Distance from Hai Phong center	Material Unit Price at Mar.2010 (No. 41/2010/ CBG-SXD dated 26 May 2010	Material Unit Price at Mar.2011 (No. 44/2011/ CBG-SXD dated 13 Apr. 2011	Balance (Escalation)	Escalation Factor
1	2	3	4	5	6	7	8	9=8-7	10=8/7
1	Filling sand	Cong Hoa mine, Dai Dong mine - Hai Duong Province (Material Unit Price at the Site_Included supply and transportation)	m3	1000m3/day	70 km	107,438	125,000	17,562	1.16
2	Coarse sand	- Viet Tri city - Vinh Phu Province (Supply Material at the site)	m3	many	200 km	330,000	275,000	-55,000	0.83
		- Yen Lap - Quang Ninh Province (Supply Material at the site)	m3	many	60 km	154,000	198,000	44,000	1.29
3	Rubble stone, Armour Stone	Thong Nhat mine, Kinh Mon mine - Hai Duong province, Phi Liet, Minh Duc mine - Hai Phong city (At the site)	m3	500m3/day	40 km	165,000	187,000	22,000	1.13
4	Crushed stone	Thong Nhat mine, Kinh Mon mine - Hai Duong province, Phi Liet, Minh Duc mine - Hai Phong city (Supply material at the site)	m3	500m3/day	40 km				
	0.5 x 1 cm		m3			242,000	253,000	11,000	1.05
	1 x 2		m3			242,000	253,000	11,000	1.05
	2 x 4		m3			220,000	253,000	33,000	1.15
	4 x 6		m3			198,000	209,000	11,000	1.06
5	Cement	Chin-Fong factory - Hai Phong city; Hai Phong factory - Hai Phong city (at the Hai Phong center)	ton	PCB40_many	25 km - 30 km	950,000	1,040,000	90,000	1.09
			ton	PCB30_many		920,000	1,010,000	90,000	1.10
6	Re-bar, steel prod.		ton						
	D 10	Viet - Uc, See - Steel factory - Hai Phong city (at the factory)	ton	many	30 km	14,575,000	18,315,000	3,740,000	1.26
	D12		ton			14,520,000	18,150,000	3,630,000	1.25
	D14-32		ton			14,410,000	18,040,000	3,630,000	1.25
	Plate steel	Hai Phong city	ton	many	30 km	13,772,000	18,150,000	4,378,000	1.32
	Shaped steel		ton			13,772,000	18,150,000	4,378,000	1.32
7	Concrete Pile	Dinh Vu Industrial Park	m	many	20 km				
	Pile 400x400		m			550,000	600,000	50,000	1.09
	Pile 500x500		m			790,000	850,000	60,000	1.08
8	Concrete Batching Plant	Thanh Hung concrete station - Hai Phong city; Dinh Vu Industrial Park	m3	50m3/h	30 km				
	M200					800,800	986,150	185,350	1.23
	M250					840,400	1,029,710	189,310	1.23
	M300					882,200	1,074,480	192,280	1.22
	M350					931,700	1,145,870	214,170	1.23
	M400					992,200	1,245,200	253,000	1.25
9	Asphalt	Hoang Truong concrete station - Hai Phong city	ton	25m3/h	30 km				
	Cooarse Asphalt		ton			1,120,000	1,240,000	120,000	1.11
	Semi-Coarse Asphalt		ton			1,180,000	1,295,000	115,000	1.10
	Fine Asphalt		ton			1,260,000	1,390,000	130,000	1.10
10	Form wood	Hai Phong city	m3	many	30 km	2,970,000	2,970,000	0	1.00
11	Fuel	Hai Phong city	liter	many					
	Mogas 92		liter	many	30 km	16,990	21,300	4,310	1.25
	Gasoil 0.05S		liter	many	30 km	14,600	21,100	6,500	1.45
	Kero		liter	many	30 km	15,000	20,800	5,800	1.39

Source: JICA D/D Study Team

As a result of our investigation, almost all of the construction material prices rise within the range from 10 to 20%, particularly diesel cost rises by over 40%. According to Monthly Price Index (MPI) issued by Hai Phong city as of May 2011 compared to May 2010, Consumer Price Index (CPI), construction material price index, and diesel price index rise by 20%, 19% and 47% respectively, and these trends are almost same as our investigation results.

Normally, unit price indexes of construction materials in Vietnam are updated in every month, therefore, material prices for Detailed Design stage will be updated.

With regard to material prices procured from Japan, steel sheet piles, steel pipe piles, tie-rods and other structural steels, these are stable compared to the prices in SAPROF study, therefore, these are not changed for preliminary cost estimation.

b) Unit Price of Construction Labor

Unit prices of construction labors were investigated as of May 2011based on Decree No. 205/2004/ND-CP dated 14 December 2004 of the Government on decision salary grade systems in Vietnamese and Decree No. 107/2010/ND-CP dated 29 October 2010 of the Government on decision minimum wage with the Vietnamese labor working in the foreign-Invested enterprise. Also, to review cost estimates at SAPROF study, those prices are compared to the prices as of May 2010, which is the time of project cost estimation in SAPROF study.

Unit prices of construction labors in Vietnam are categorized into three (3) Groups. Basically, Group I means for building construction, Group II means for road construction, and Group III means for port and bridge construction and each group is divided into seven (7) grades, and furthermore, each grade is divided into nine (9) smaller levels. In this report, only major labor wages in each three group are shown in the following tables respectively.

Table 14.1.4 Unit Price of Construction Labor (Group I: Building Construction)

No.	Labor Items	Decree 98/2009/ND-CP dated 30 Oct.2009 of Government	Decree 107/2010/ND-CP dated 29 Oct.2009 of Government	Balance	Escalation Factor
1	2	3	4	5=4-3	6=4/3
I	Minimum Wage (per month)	1,040,000	1,170,000	130,000	1.125
II	Sumary of Main Grade Wages (Group I_per month)				
1	Grade 1	2,239,120	2,519,010	279,890	1.125
2	Grade 2	2,606,032	2,931,786	325,754	1.125
3	Grade 3	3,038,464	3,418,272	379,808	1.125
4	Grade 4	3,549,520	3,993,210	443,690	1.125
5	Grade 5	4,152,304	4,671,342	519,038	1.125
6	Grade 6	4,873,024	5,482,152	609,128	1.125
7	Grade 7	5,711,680	6,425,640	713,960	1.125

Source: JICA D/D Study Team

Table 14.1.5 Unit Price of Construction Labor (Group II: Road Construction)

No.	Labor Items	Decree 98/2009/ND-CP dated 30 Oct.2009 of Government	Decree 107/2010/ND-CP dated 29 Oct.2009 of Government	Balance	Escalation Factor
1	2	3	4	5=4-3	6=4/3
I	Minimum Wage (per month)	1,040,000	1,170,000	130,000	1.125
II	Sumary of Main Grade Wages (Group II_per month)				
1	Grade 1	2,396,368	2,695,914	299,546	1.125
2	Grade 2	2,776,384	3,123,432	347,048	1.125
3	Grade 3	3,235,024	3,639,402	404,378	1.125
4	Grade 4	3,759,184	4,229,082	469,898	1.125
5	Grade 5	4,388,176	4,936,698	548,522	1.125
6	Grade 6	5,108,896	5,747,508	638,612	1.125
7	Grade 7	5,973,760	6,720,480	746,720	1.125

Source: JICA D/D Study Team

Table 14.1.6 Unit Price of Construction Labor (Group III: Port and Bridge Works)

No.	Labor Items	Decree 98/2009/ND-CP dated 30 Oct.2009 of Government	Decree 107/2010/ND-CP dated 29 Oct.2009 of Government	Balance	Escalation Factor
1	2	3	4	5=4-3	6=4/3
I	Minimum Wage (per month)	1,040,000	1,170,000	130,000	1.125
II	Sumary of Main Grade Wages (Group III_per month)				
1	Grade 1	2,632,240	2,961,270	329,030	1.125
2	Grade 2	3,064,672	3,447,756	383,084	1.125
3	Grade 3	3,562,624	4,007,952	445,328	1.125
4	Grade 4	4,152,304	4,671,342	519,038	1.125
5	Grade 5	4,846,816	5,452,668	605,852	1.125
6	Grade 6	5,672,368	6,381,414	709,046	1.125
7	Grade 7	6,628,960	7,457,580	828,620	1.125

Source: JICA D/D Study Team

As a result of our investigation, all of the construction labor wages rise by 12.5%. Unit price indexes of construction labors in Vietnam are updated in every October, therefore, Labor prices for Detailed Design stage will be updated.

c) Unit Price of Construction Equipment

Unit prices of construction equipment were investigated as of May 2011based on Decision No. 131/QD-UBND dated 26 January 2011, Contraction equipment unit price (working shift) in Hai Phong province with considering present fuel cost and operator wage. Also, to review cost estimates at SAPROF study, those prices are compared to the prices as of May 2010, which is the time of project cost estimation in SAPROF study. In this chapter, only main items are listed in the following table.

As a result of our investigation, almost all the prices of construction equipment except marine equipment rise within the range from 10 to 20%. Considering the situation in which the price of the fuel rises by 40%, these equipment costs are relatively reasonable. However, marine equipment like dredgers depends on higher proportions of fuel expenses, therefore, the prices rise by more than 20%, some of them are over 30%.

Recently, unit price indexes of construction equipment in Vietnam are updated in every year therefore, if it is updated in the time of cost estimation in Detailed Design stage, the results will take into consideration for final cost estimation.

Table 14.1.7 Unit Price of Construction Equipment

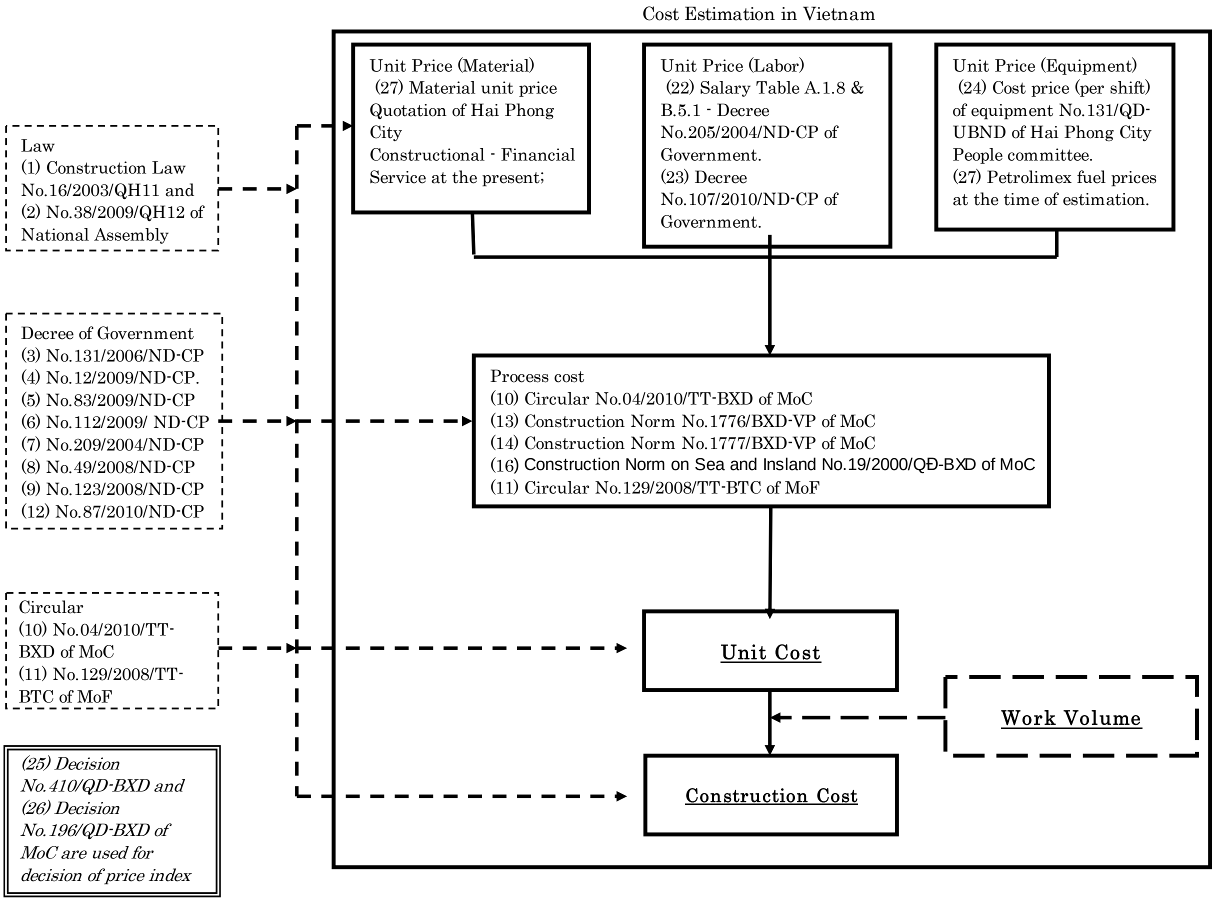
No.	Name of equipment	Unit Price of Construction Equipment -Working shift (2010) 3	Unit Price of Construction Equipment -Working shift (2011) 4	Balance (Escalation) 5=4-3	Escalation Factor 6=4/3
1	Excavator 1.0 m^3	2,623,895	3,273,973	650,079	1.248
2	Excavator 2.0 m^3	4,723,576	5,822,446	1,098,869	1.233
3	Excavator 3.5 m^3	7,680,745	9,369,984	1,689,239	1.220
4	Grab crane 2.30 m^3	5,871,357	7,258,243	1,386,887	1.236

5	Back hoe 1.0 m^3	1,450,404	1,789,119	338,715	1.234
6	Back hoe 2.3 m^3	3,005,028	3,801,124	796,096	1.265
7	Bulldozer 110 cv	1,736,825	2,156,169	419,344	1.241
8	Bulldozer 320 cv	4,990,847	6,085,111	1,094,265	1.219
9	Tamping roller 8.5 ton (steel wheel)	805,467	1,014,485	209,018	1.259
10	Truck 10.0 ton	1,294,349	1,623,017	328,668	1.254
11	Dump truck 10.0 ton	1,641,954	2,105,913	463,959	1.283
12	Agitator truck 6.0 m^3	1,891,919	2,302,760	410,841	1.217
13	Water tank truck 6.0 m^3	1,041,945	1,269,917	227,972	1.219
14	Truck crane 16.0 ton	2,308,740	2,753,438	444,698	1.193
15	Crawler crane 40.0 ton	4,249,392	4,844,309	594,918	1.140
16	Winch 3.0 ton	177,766	204,501	26,735	1.150
17	Concrete mixer 250L	209,307	237,777	28,469	1.136
18	Concrete pump truck 50 m^3/h	3,773,975	4,350,371	576,395	1.153
19	Concrete pump machine 60-90 m3/h	2,415,560	2,639,742	224,182	1.093
20	Concrete vibrator 1,5KW	151,016	175,777	24,761	1.164
21	Asphalt station 60T/h (216T/shift)	10,619,603	11,646,930	1,027,327	1.097
22	Bitumen pump 190CV	2,793,700	3,341,114	547,414	1.196
23	Asphalt finish 100T/h	3,347,565	3,881,592	534,028	1.160
24	Bitumen boil machine 500 liter	235,077	266,154	31,078	1.132
25	Water pump 50CV, Electric	376,121	429,850	53,730	1.143
26	Water pump 150CV, diesel	1,478,045	1,971,905	493,861	1.334
27	Air Compressor 75 m^3/h	282,548	352,021	69,473	1.246
28	Air Compressor 1200 m^3/h	2,267,137	2,875,911	608,773	1.269
29	Welding machine 23kw	226,467	263,067	36,600	1.162
30	Welding machine (water)	1,107,076	1,220,270	113,194	1.102
31	Cutter steel 1,7KW	154,729	179,255	24,526	1.159
32	Air-compressor hammer 3,0m^3/ph	167,653	195,023	27,370	1.163
33	Bending machine 5KW	151,963	177,055	25,093	1.165
34	Diesel pile hammer 3,5T	3,659,712	4,312,685	652,974	1.178
35	Diesel pile hammer 4,5T	4,080,781	4,775,550	694,769	1.170
36	Vibrating hammer 50KW	579,769	662,180	82,411	1.142
37	Vibrating hammer 170KW	952,639	1,083,113	130,474	1.137
38	Pilling rig <=3,5T	4,866,005	5,611,804	745,799	1.153
39	Pilling rig <=7,5T	13,229,637	15,181,386	1,951,749	1.148
40	PVD Driver	1,805,934	2,548,656	742,722	1.411
41	Solution mixer 1000L	318,313	356,205	37,892	1.119
42	Barge 200T	842,366	895,956	53,590	1.064
43	Barge 400T	1,221,583	1,296,030	74,446	1.061
44	Barge 1000T	2,127,778	2,252,066	124,288	1.058
45	Pontoon 250T	223,331	235,614	12,283	1.055
46	Tug boat 360CV	4,817,621	6,506,022	1,688,402	1.350
47	Tug boat 600CV	7,289,688	9,968,525	2,678,837	1.367
48	Tug boat 1200CV	20,556,494	26,785,285	6,228,792	1.303
49	Cutter suction 1200CV	30,341,332	38,087,235	7,745,903	1.255
50	Cutter suction 4170CV	109,691,720	135,164,685	25,472,964	1.232
51	Trailing suction hopper dredger 5945CV	124,271,305	163,975,079	39,703,774	1.319

Source: JICA D/D Study Team

3) Flow chart of Cost Estimation method in Vietnam

Basic principle of cost estimation method in Vietnam is shown in the following Figure.



Note: Number shown in ( ) is related to the Table 14.1.1.
Source: JICA Study Team

Figure 14.1.1 Flow Chart of Cost Estimation Method in Vietnam

14.1.2 Basic Condition of Cost Estimation

In order to calculate preliminary cost estimation in Basic Design stage, the following conditions are taken into consideration.

1) Exchange Rate

Exchange rate for the cost estimation is set in the following.

- VND 1 = JPY 0.0039
- USD 1 = JPY 80.89

Above-mentioned exchange rates are based on the official exchange rate by JICA.

2) Assumed Price Escalation Rate

Assumed price escalation rates for both local and foreign currency portions are set by the ones used in the SAPROF study. Price escalation is calculated for both local and foreign currency portion based on the project implementation schedule.

- Foreign currency portion: 3.1 % per annum
- Local currency portion : 10.3% per annum
- Base year used in cost estimation: May 2011

3) Physical Contingency (5%)

A rate of physical contingency is set as 5 % which is same as the one used in the SAPROF study. Physical contingency is obtained by multiplying the rate by the total of:

- Construction Cost
- Price Escalation

4) Consulting Service

Consulting service is calculated based on the schedule of necessary man-power. Consulting service includes price escalation and physical contingency.

5) Land Acquisition Cost

Land acquisition cost is considered in the cost estimation. Updating the cost is going on, therefore, for the preliminary cost estimation in Basic Design stage, the amount is extracted from the result in the SAPROF study tentatively.

6) Assumed Administration Cost (5%)

Assumed administration cost is set 5% as is the case with SAPROF study. Administration cost is obtained by multiplying the rate by the local currency portion of:

- Construction cost
- Price escalation
- Physical contingency
- Consulting service
- Land acquisition cost

7) Value Added Tax (10%)

Value added tax (VAT) is set 10%. VAT is calculated by multiplying the rate by the total of:

- Construction cost
- Price escalation
- Physical contingency
- Consulting service

8) Imported Tax (10%)

Imported tax is set 10%. Import tax is applied only to the materials that are procured by the foreign country portion, and used for the permanent structure for the Project. The detail of this taxation is based on Decree on Custom Valuation of Imported and Exported Goods issued by the government of socialist republic of Vietnam (No. 40-2007-ND-CP, March 2007). In this study, it is calculated by multiplying the rate by the total of:

- Construction cost (foreign currency portion)
- Price escalation (foreign currency portion)
- Physical Contingency (foreign currency portion)

9) Interest during Construction (Assumed STEP Loan Scheme)

Since the Project is assumed to be funded by Japanese ODA Loan under the Special Terms for Economic Partnership (STEP), the following interests are considered during construction:

- For Construction cost 0.2% per annum
- For Consultancy service 0.01% per annum

The interest during construction is estimated based on the disbursement schedule.

10) Commitment Charge (0.1% per annum)

Commitment charge is the charge for holding available undisturbed balance of a loan commitment after effective date of Loan Agreement (L/A). It is a fixed-rate charge of 0.1 % a year calculated on the basis of undisturbed balance.

11) Expenses

According to the cost estimation method in Vietnam, there are four (4) kinds of expenses. Three of four are applied to the stage of unit cost calculation:

- Other direct expenses: 2.0 % of sum of unit prices
- General expenses: 5.5% of sum of unit prices including other direct expenses
- Pre-Determined taxable income: 6.0% of sum of unit prices considered general expenses

The last expense is that the cost of setting up tents at site which meet a part of site management cost in the standard of Japanese cost estimation, and normally in Vietnam, it is applied 1.0% of sum of construction cost excluding VAT to each package.

12) Conditions for STEP application

The Project is considered to be funded by Japanese ODA loan under the Special Terms for Economic Partnership (STEP). Although STEP application has advantages other than low interest rate, such as:

- Flexibility of the timing of processing
- Available for Grant Assistance for Detailed Design
- Support to feasibility study by JICA and JETRO.

it is also requires the following conditions:

a) Procurement Conditions

- Prime contractors are tied to Japanese firms. Joint ventures (JV) with recipient countries are also admitted on condition that Japanese firm is a leading partner and the total share of work of Japanese partners is more than 50 %.
- Sub-contractors are untied and opened to all countries.

b) Country of Origin of Goods Procured under STEP

- Total cost of goods procured from Japan shall be no less than 30% of the total amount of contract(s) (except consulting services) financed by STEP loan.
- Each contractor should submit a declaration letter for the portion of goods procured from Japan

In the cost estimate, the following construction works / materials are considered to be procured from Japan:

- Channel dredging
- Steel Sheet Pipe Pile, Steel Sheet Pile, Tie Rod, Structural Steel,
- Cement Deep Mixing Method including ALiCC method.
- Mooring Bollards for the quay wall of public facility area
- Rubber Fenders for the qua wall of public facility area
- Light Beacons

As for the percentage of Japan portion, the total of construction cost, price Escalation and physical contingency should be no less than 30% of the total project cost.

13) Contract Package

It is recommended that the Project is divided into four packages as a conclusion of Basic Design stage. The packaging is:

- Package 6: Infrastructure Construction Behind the Container Terminal
- Package 8: Channel Dredging and Disposal Works Part A
- Package 9: Channel Dredging and Disposal Works Part B
- Package 10: Breakwater and Sand Protection Dyke Works

Therefore, preliminary const estimation is computed based on this packaging plan.

14) Major Points for Preliminary Cost Estimation

As assumptions, major points for preliminary cost estimation are set in the following.

- There is no change about channel dredging plan and method compared with SAPROF study
- There is no change about structural designs for training dyke, revetment, breakwater, service road, service berth, reclamation and related soil investigation compared with SAPROF study
- There is no change about construction term. However, in consideration of the case where the construction delay is generated as described in Chapter 13, expected completion time is set in the middle of 2016 tentatively for the calculation of disbursement in this preliminary const estimation.
- Influence in prices compared with the results of SAPROF study is considered.
- Influence of the exchange fluctuation from the time of SAPROF study is considered. For reference, both exchange rates in the SAPROF study and in this Basic Design stage are shown in the following.

	Exchange rate between VND and JPY	Exchange rate between USD and JPY
SAPROF Study (as of May 2010)	VND 1 = JPY 0.00528	USD 1 =JPY 89.60
BD stage in this study (as of June 2011)	VND 1 = JPY 0.0039	USD 1 =JPY 80.86

14.2 Cost Estimates for Each Package of Construction

Based on the recommended packaging in the previous chapter 13, preliminary cost estimation for each package is calculated. The summary of each package is shown in the following table.

Table 14.2.1 Summary of Cost Estimates for Each Package of Construction

Package	Work Items	Construction Cost in JPY	(%)
Package 6:	Infrastructure Construction Behind the Container Terminal	17,777,191,322	31%
Package 8, 9:	Channel Dredging and Disposal Works	31,528,136,911	54%
Package 10:	Breakwater and Sand Protection Dyke Works	8,848,466,632	15%
	Total Construction Cost	58,153,794,866	100%

Source: JICA Study Team

14.2.1 Infrastructure Construction Behind the Container Terminal

For the preliminary cost estimation in this report, the design, construction method and related temporary work plan of Revetment, Breakwater, Service Road, Service Berth, Reclamation and Soil Improvement is based on the result of SAPROF study. However, comprehensive examination with considering construction cost, construction schedule, the results of soil investigation (presently under going) and procurement condition of materials is going on for Detail Design stage. Therefore, the cost shown hereunder is subject to change in DD stage. The result of construction cost for Infrastructure Construction Behind the Container Terminal (Revetment, Breakwater, Service Road, Service Berth, Reclamation and Soil Improvement) at the Basic Design stage is shown in the following table.

Table 14.2.2 Preliminary Cost Estimation for Infrastructure Construction Behind the Container Terminal (Package 6)

Construction Cost		Unit	Quantity	Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		Remarks
				Unit Price	Amount	Unit Price	Amount	
Package 6: Infrastructure Construction Behind the Container Terminal								
Temporary Works								JICA Portion
a	Cost of Setting Up Tents at Site	L.S.	1.0	-	32,219,991,952	-	-	
b	Temporary Yard	m2	28,000.0	5,066,485	141,861,576,072	-	-	
Container Terminal				-	114,942,415,140	-	2,366,063,804	JICA Portion
a	Berth Structure	L.S	1.0	N.A.	-	-	-	*Private Portion*
b	Earth Retaining Wall	m	750.0	149,407,591	112,055,692,926	3,047,698	2,285,773,465	
c	Earth Retaining Wall for Barge Berth	m	180.0	16,037,346	2,886,722,214	446,057	80,290,339	
Reclamation				-	579,028,564,150	-	-	JICA Portion
a	Terminal Area	m3	2,955,483.0	195,917	579,028,564,150	-	-	
Soil Improvement				-	1,474,892,902,509	-	2,244,694,011	JICA Portion
a	Terminal Area	m2	366,625.0	1,898,979	696,213,150,903	5,052	1,852,019,740	
b	Barge Berth Area	m2	5,000.0	9,964,510	49,822,550,016	78,535	392,674,271	
c	Inner Revetment	m2	4,550.0	4,308,578	19,604,032,050	-	-	
d	Outer Revetment A	m2	13,104.0	3,852,164	50,478,759,098	-	-	
e	Outer Revetment B	m2	52,459.0	7,750,722	406,595,113,464	-	-	
f	Access Road	m2	192,900.0	1,307,306	252,179,296,979	-	-	
Port Protection Facilities				-	696,884,973,946	-	-	JICA Portion
a	Inner Revetment	m	750.0	39,325,798	29,494,348,241	-	-	
b	Outer Revetment-A	m	720.0	206,622,485	148,768,189,012	-	-	
c	Outer Revetment-B	m	2,510.0	206,622,485	518,622,436,693	-	-	
Access Road behind Port				-	60,570,509,446	-	-	JICA Portion
a	Access Road	m	1,000.0	60,570,509	60,570,509,446	-	-	
Public Related Facilities (CIQ)				-	153,818,253,980	-	474,978,677	JICA Portion
a	Reclamation	m3	344,131.0	195,917	67,421,020,121	-	-	
b	Dredging	m3	103,897.0	237,143	24,638,493,909	-	-	
c	Quay wall	m	375.0	124,549,222	46,705,958,434	1,266,610	474,978,677	
d	Soil Improvement	m2	23,600.0	1,079,070	43,486,522,451	-	-	
	Total				**3,254,219,187,196**		**5,085,736,492**	
	Total IN JPY						**17,777,191,322**	

Source: JICA Study Team

14.2.2 Channel Dredging and Disposal

For the preliminary cost estimation in this report, channel dredging and disposal plan is based on the result of SAPROF study. The plan is that the channel dredging spans 17.4km and dredged soil is temporary disposed at the south front of Dinh Vu industrial park after barge transportation of which distance 15km on average. After temporary disposal, the dredged soil is pumped and carried inside of the park.

The total dredging volume is quite huge, 32,000,000m^3 and the percentage of this channel dredging in the Lach Huyen port project is very high, reaches almost 60%. Therefore, the dredging method including disposal plan of dredged material affect the cost estimation materially. Major valuable factors of cost estimation for channel dredging and disposal plan are as follows:

1) Location of dumping site for dredged soil

Dumping on Land or Off Shore Dumping

In case of considering dumping on land, costs for additional revetment, piping for dredged material & related facilities, and additional dredging for making access channel especially in case of dumping at shallow area like south Cut Hai, are need to be considered. On the other hand, in case of off shore dumping, transportation distance for dredged materials influences the cost estimation.

2) Dredging Method Considering Present Ship Navigation

Widening of Present Navigation Channel or Construction of Diversion Channel

In case of widening present navigation channel, dredging work will be ineffective cause of considering present ship navigation. On the other hand, not to disturb present ship navigation and to enhance dredging work efficiency, construction of diversion channel needs to be examined. In this case, cost for additional dredging need to be considered.

3) Component of dredging fleets

Because the total dredging volume is larger than that of the construction period, daily required dredging volume becomes huge. In case of procurement of big capacity cutter suction dredger like 8,000ps class, dredging efficiency will be higher. In case of smaller dredger, many dredging fleets need to be procured. Considering site conditions and above-mentioned factors, further examination regarding component of dredging fleets is required.

4) Influence of Sedimentation Simulation

Sedimentation simulation is under going. The result of simulation will affect to the cost estimation.

5) Dredging Period

Above-mentioned valuable factors influence to dreading period and it affects cost estimation materially.

Considering above-mentioned valuable factors for cost estimation, the cost estimation for dredging and disposal plan is easily changed. For Detailed Design Stage, Presently JICA study team is going on further examination and discussion with counterpart in Vietnam. Therefore, the result will be reflected to the cost estimation in Detail Design stage. The present result of construction cost for dredging and disposal plan at the Basic Design stage is shown in the following table.

Table 14.2.3 Preliminary Cost Estimation for Dreading and Disposal Plan (Package 8, 9)

Construction Cost		Unit	Quantity	Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		Remarks
				Unit Price	Amount	Unit Price	Amount	
Package 8, 9: Channel Dreading and Disposal								JICA Portion
a	Cost of Setting Up Tents at Site	L.S.	1.0	-	28,632,657,230	-	-	
b	Temporary Yard	m2	8,000	5,066,485	40,531,878,878	-	-	
c	Channel Dreading	m3	32,300,860	218,472	2,822,733,844,161	1,045	20,249,733,228	VN40:JP60
d	Wharf Slope Dredging	m3	567,514	N.A.	-	-	-	*Private Portion*
e	Berth Box	m3	54,553	N.A.	-	-	-	*Private Portion*
f	Between Channel and Berth Box	m3	98,142	N.A.	-	-	-	*Private Portion*
Total					**2,891,898,380,269**		**20,249,733,228**	
Total IN JPY							**31,528,136,911**	

Source: JICA Study Team

14.2.3 Breakwater and Sand Protection Dyke

For the preliminary cost estimation in this report, the design, construction method and related temporary work plan of training dyke is based on the result of SAPROF study. However, comprehensive examination with considering construction cost, construction schedule, the results of sedimentation simulation (presently under going) and procurement condition of materials is going on for Detail Design stage. Therefore, the cost shown hereunder is subject to change in Detail Design stage. The result of construction cost for sand protection dyke at the Basic Design stage is shown in the following table.

Table 14.2.4 Preliminary Cost Estimation for Training Dyke (Package 10)

Construction Cost		Unit	Quantity	Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		Remarks
				Unit Price	Amount	Unit Price	Amount	
Package 10: Breakwater and Sand Protection Dyke								JICA Portion
a	Cost of Setting Up Tents at Site	L.S.	1.0	-	22,417,405,373	-	-	
b	Temporary Yard	m2	32,000.0	5,066,485	162,127,515,510	-	-	
c	Training Dike-1	m	3,110.0	140,859,943	438,074,423,914	-	-	
d	Training Dike-2	m	3,290.0	354,588,368	1,166,595,731,935	-	-	
e	Training Dike-3	m	1,200.0	395,612,409	474,734,891,015	-	-	
f	Light Beacon for Training Dyke	nos	4.0	51,993,724	207,974,894	4,562,664	18,250,656	
Total					**2,264,157,942,641**		**18,250,656**	
Total IN JPY							**8,848,466,632**	

Source: JICA Study Team

14.3 Summary of Project Cost Estimate

As a final result regarding preliminary cost estimation in Basic Design stage, summary of whole project cost is estimated. The total construction cost is computed as:

VND 15,091,966,702,145 for local currency portion, and,

JPY 30,786,176,599 for foreign currency portion

As the result, the total amount in the VND currency is:

VND 22,985,858,137,667

It is equivalent to:

JPY 89,644,846,737

The next table shows the comparison between above-mentioned results and the results of SAPROF study.

Table 14.3.1 Cost Comparison Table

	SAPROF (May 2010)		BD Study (June 2011)	
	VND	JPY	VND	JPY
Project Cost	12,311,714,105,952	26,456,809,413	15,091,966,702,145	30,786,176,599
Change Ratio	1	1	1.23	1.16
Total in JPY Equivalent		91,462,659,892		89,644,846,737
Change Ratio		1		0.98
Exchange Rate	1VND=0.00528		1VND=0.0039	

Source: JICA Study Team

Disbursement schedule as a result of Basic Design stage is shown in the following table.

Table 14.3.2 Disbursement Schedule

	2011 (Cost Estimate)		2,012		2,013		2,014		2,015		2,016		2,017		Total	
1. Base Cost	Local VND	Foreign JPY	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign
0 Temporary Facility	427,791,025,015	0	0	0	385,011,922,514	0	0	0	0	0	42,779,102,502	0	0	0	427,791,025,015	0
1 Container Terminal	114,942,415,140	2,366,063,804	0	0	114,942,415,140	2,366,063,804	0	0	0	0	0	0	0	0	114,942,415,140	2,366,063,804
2 Cannel Dredging and Disposal	2,822,733,844,161	20,249,733,228	0	0	806,495,384,046	5,785,638,065	806,495,384,046	5,785,638,065	806,495,384,046	5,785,638,065	403,247,692,023	2,892,819,033	0	0	2,822,733,844,161	20,249,733,228
3 Training Dyke	2,079,405,046,863	0	0	0	594,115,727,675	0	594,115,727,675	0	594,115,727,675	0	297,057,863,838	0	0	0	2,079,405,046,863	0
4 Reclamation	579,028,564,150	0	0	0	289,514,282,075	0	289,514,282,075	0	0	0	0	0	0	0	579,028,564,150	0
5 Port Protection Facilities	696,884,973,946	0	0	0	199,109,992,556	0	199,109,992,556	0	199,109,992,556	0	99,554,996,278	0	0	0	696,884,973,946	0
6 Soil Improvement	1,474,892,902,509	2,244,694,011	0	0	0	0	294,978,580,502	448,938,802	589,957,161,004	897,877,604	589,957,161,004	897,877,604	0	0	1,474,892,902,509	2,244,694,011
7 Access Road behind Port	60,570,509,446	0	0	0	0	0	24,228,203,778	0	24,228,203,778	0	12,114,101,889	0	0	0	60,570,509,446	0
8 Public Related Facilities (CIQ)	153,818,253,980	474,978,677	0	0	0	0	61,527,301,592	189,991,471	61,527,301,592	189,991,471	30,763,650,796	94,995,735	0	0	153,818,253,980	474,978,677
9 Navigational Aids	207,974,894	18,250,656	0	0	0	0	0	0	0	0	207,974,894	18,250,656	0	0	207,974,894	18,250,656
Sub-total			0	0	2,389,189,724,006	8,151,701,870	2,269,969,472,225	6,424,568,338	2,275,433,770,651	6,873,507,140	1,475,682,543,223	3,903,943,028	0	0	8,410,275,510,105	25,353,720,376
Total	8,410,275,510,105	25,353,720,376	0	0	2,389,189,724,006	8,151,701,870	4,659,159,196,231	14,576,270,208	6,934,592,966,882	21,449,777,348	8,410,275,510,105	25,353,720,376	0	0	8,410,275,510,105	25,353,720,376
2. Price Escalation			Local 10.3%	Foreign 3.0%	Local 10.3%	Foreign 3.1%	Local 10.3%	Foreign 3.1%	Local 10.3%	Foreign 3.1%	Local 10.3%	Foreign 3.1%	0	0	Local 10.3%	Foreign 3.1%
Price escalation per year *2	Infration		0	0	517,519,996,927	513,239,301	776,147,342,241	616,198,280	1,092,520,988,492	892,772,950	933,504,406,411	643,809,224	0	0	3,319,692,734,072	2,666,019,756
*1 + *2	Disbursement		0	0	2,906,709,720,933	8,664,941,171	3,046,116,814,466	7,040,766,618	3,367,954,759,144	7,766,280,090	2,409,186,949,634	4,547,752,252	0	0	11,729,968,244,177	28,019,740,132
3. Phisical Contingency 5%	for the potion of Interest	*3	0	0	25,875,999,846	25,661,965	38,807,367,112	30,809,914	54,626,049,425	44,638,647	46,675,220,321	32,190,461	0	0	165,984,636,704	133,300,988
	for the portion of Base cost	*4	0	0	119,459,486,200	407,585,093	113,498,473,611	321,228,417	113,771,688,533	343,675,357	73,784,127,161	195,197,151	0	0	420,513,775,505	1,267,686,019
	for the potion of Disbursement	*5 = *3 + *4	0	0	145,335,486,047	433,247,059	152,305,840,723	352,038,331	168,397,737,957	388,314,005	120,459,347,482	227,387,613	0	0	586,498,412,209	1,400,987,007
Sub-total (1+2+3)		6 = *1+*2+*5	0	0	3,052,045,206,980	9,098,188,230	3,198,422,655,189	7,392,804,949	3,536,352,497,101	8,154,594,095	2,529,646,297,116	4,775,139,865	0	0	0	0
JPY Equivalent				0		21,001,164,537		19,866,653,305		21,946,368,833		14,640,760,424		0	0	**77,454,947,099**

* Assumption: Disbursement is continued up to the middle of 2016.
Sorce: JICA Study Team

As for the percentage of Japanese procurement as foreign currency portion in the total of project cost, it is calculated for:

- Construction cost
- Price escalation
- Physical contingency

The calculation result for the percentage of Japanese procurement is shown in the following table.

Table 14.3.3 Percentage of Japanese procurement

Item		VND	JPY	Remarks
Construction Cost		8,410,275,510,105	25,353,720,376	
Proce Escalation		3,319,692,734,072	2,666,019,756	
Phisical Contingency		586,498,412,209	1,400,987,007	
	Total	12,316,466,656,386	29,420,727,139	=(1)
	Total in JPY		77,454,947,099	=(2)
Percentage of JPY currency Portion			**37.98%**	=(1) / (2)

Source: JICA Study Team

The breakdown of preliminary cost estimation for whole project compared with the result of SAPROF study is shown in the following table.

Table 14.3.4 Breakdown of Preliminary Project Cost Estimation

Exchange Rate (as of Mar 2010) 1 USD= JPY 89.60; 1 VND= JPY 0.00528

Exchange Rate (as of June 2011) 1 USD= JPY 80.86; 1 VND= JPY 0.00390

No.	Item	Unit	Quantity	A. SAPROF STUDY					B. BASIC DESIGN STAGE (REVIEWED AS MAY 2011)					BALANCE (B - A)				Remarks
				Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		Total Amount	Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		Total Amount	Local Currency Portion (in VND)		Foreign Currency Portion (in JPY)		
				Unit Price	Amount	Unit Price	Amount	(in JPY)	Unit Price	Amount	Unit Price	Amount	(in JPY)	Unit Price	Amount	Unit Price	Amount	
I	**Construction Cost**																	
1	**Package 8, 9: Channel Dreading and Disposal**				***2,093,062,015,200***		***16,473,438,600***	***27,524,806,040***		***2,891,898,380,269***		***20,249,733,228***	***31,528,136,911***		***798,836,365,069***		***3,776,294,628***	JICA Portion
a	Cost of Setting Up Tents at Site	L.S.	1.0		0		0	0		28,632,657,230		0	111,667,363		28,632,657,230		0	
b	Temporary Yard	m2	8,000.0	4,356,402	34,851,216,000	0	0	184,014,420	5,066,485	40,531,878,878	0	0	158,074,328	710,083	5,680,662,878	0	0	
c	Channel Dreading	m3	32,300,860.0	159,300	2,058,210,799,200	850	16,473,438,600	27,340,791,620	218,472	2,822,733,844,161	1,045	20,249,733,228	31,258,395,220	59,172	764,523,044,961	195	3,776,294,628	VN40:JP60
d	Wharf Slope Dredging	m3	567,514.0	N.A.	0	0	0	0	N.A.	0	0	0	0	N.A.	0	0	0	*Private Portion*
e	Berth Box	m3	54,553.0	N.A.	0	0	0	0	N.A.	0	0	0	0	N.A.	0	0	0	*Private Portion*
f	Between Channel and Berth Box	m3	98,142.0	N.A.	0	0	0	0	N.A.	0	0	0	0	N.A.	0	0	0	*Private Portion*
2	**Package 10: Breakwater and Sand Protection Dyke**				***1,945,858,786,886***		***18,126,764***	***10,292,261,159***		***2,264,157,942,641***		***18,250,656***	**8,848,466,632**		***318,299,155,755***		***123,892***	JICA Portion
a	Cost of Setting Up Tents at Site	L.S.	1.0		0		0	0		22,417,405,373		0	87,427,881	0	22,417,405,373		0	
b	Temporary Yard	m2	32,000.0	4,356,402	139,404,864,000	0	0	736,057,682	5,066,485	162,127,515,510	0	0	632,297,310	710,083	22,722,651,510	0	0	
c	Training Dike-1	m	3,110.0	119,133,461	370,505,063,710	0	0	1,956,266,736	140,859,943	438,074,423,914	0	0	1,708,490,253	21,726,482	67,569,360,204	0	0	
d	Training Dike-2	m	3,290.0	307,135,810	1,010,476,814,900	0	0	5,335,317,583	354,588,368	1,166,595,731,935	0	0	4,549,723,355	47,452,558	156,118,917,035	0	0	
e	Training Dike-3	m	1,200.0	354,387,901	425,265,481,200	0	0	2,245,401,741	395,612,409	474,734,891,015	0	0	1,851,466,075	41,224,508	49,469,409,815	0	0	
f	Light Beacon for Training Dyke	nos	4.0	51,640,769	206,563,076	4,531,691	18,126,764	19,217,417	51,993,724	207,974,894	4,562,664	18,250,656	19,061,758	352,955	1,411,818	30,973	123,892	
3	**Package 6: Infrastructure Construction Behind the Container Terminal**				***2,610,356,499,442***		***4,922,555,845***	***18,705,238,162***		***3,254,219,187,196***		***5,085,736,492***	**17,777,191,322**		***643,862,687,754***		***163,180,647***	JICA Portion
3-1 a	Cost of Setting Up Tents at Site	L.S.	1.0		0		0	0		32,219,991,952		0	125,657,969		32,219,991,952		0	
b	Temporary Yard	m2	28,000.0	0	0	0	0	0	5,066,485	141,861,576,072	0	0	553,260,147	5,066,485	141,861,576,072	0	0	
3-2	**Container Terminal**				***79,073,459,100***		***2,350,001,970***	***2,767,509,834***		***114,942,415,140***		***2,366,063,804***	**2,814,339,224**		***35,868,956,040***		***16,061,834***	JICA Portion
a	Berth Structure	L.S	1.0	N.A.	0	0	0	0	N.A.	0	0	0	0	N.A.	***0***	0	***0***	*Private Portion*
b	Earth Retaining Wall	m	750.0	103,054,818	77,291,113,500	3,027,009	2,270,256,750	2,678,353,829	149,407,591	112,055,692,926	3,047,698	2,285,773,465	2,722,790,668	46,352,773	34,764,579,426	20,689	15,516,715	
c	Earth Retaining Wall for Barge Berth	m	180.0	9,901,920	1,782,345,600	443,029	79,745,220	89,156,005	16,037,346	2,886,722,214	446,057	80,290,339	91,548,556	6,135,426	1,104,376,614	3,028	545,119	
3-3	**Reclamation**				***600,087,179,286***		***0***	***3,168,460,307***		***579,028,564,150***		***0***	2,258,211,400		***-21,058,615,136***		***0***	JICA Portion
a	Terminal Area	m3	2,955,483.0	203,042	600,087,179,286	0	0	3,168,460,307	195,917	579,028,564,150	0	0	2,258,211,400	-7,125	-21,058,615,136	0	0	
3-4	**Soil Improvement**				***1,004,710,309,560***		***2,100,315,625***	***7,405,186,059***		***1,474,892,902,509***		***2,244,694,011***	**7,996,776,331**		***470,182,592,949***		***144,378,386***	JICA Portion
a	Terminal Area	m2	366,625.0	1,261,246	462,404,314,750	4,665	1,710,305,625	4,151,800,407	1,898,979	696,213,150,903	5,052	1,852,019,740	4,567,251,029	637,733	233,808,836,153	387	141,714,115	
b	Barge Berth Area	m2	5,000.0	3,373,909	16,869,545,000	78,002	390,010,000	479,081,198	9,964,510	49,822,550,016	78,535	392,674,271	586,982,216	6,590,601	32,953,005,016	533	2,664,271	
c	Inner Revetment	m2	4,550.0	2,324,418	10,576,101,900	0	0	55,841,818	4,308,578	19,604,032,050	0	0	76,455,725	1,984,160	9,027,930,150	0	0	
d	Outer Revetment A	m2	13,104.0	2,094,872	27,451,202,688	0	0	144,942,350	3,852,164	50,478,759,098	0	0	196,867,160	1,757,292	23,027,556,410	0	0	
e	Outer Revetment B	m2	52,459.0	5,019,258	263,305,255,422	0	0	1,390,251,749	7,750,722	406,595,113,464	0	0	1,585,720,943	2,731,464	143,289,858,042	0	0	
f	Access Road	m2	192,900.0	1,161,762	224,103,889,800	0	0	1,183,268,538	1,307,306	252,179,296,979	0	0	983,499,258	145,544	28,075,407,179	0	0	
3-5	**Port Protection Facilities**				***667,429,847,900***		***0***	***3,524,029,597***		***696,884,973,946***		***0***	2,717,851,398		***29,455,126,046***		***0***	JICA Portion
a	Inner Revetment	m	750.0	40,162,324	30,121,743,000	0	0	159,042,803	39,325,798	29,494,348,241	0	0	115,027,958	-836,526	-627,394,759	0	0	
b	Outer Revetment-A	m	720.0	193,692,006	139,458,244,320	0	0	736,339,530	206,622,485	148,768,189,012	0	0	580,195,937	12,930,479	9,309,944,692	0	0	
c	Outer Revetment-B	m	2,510.0	198,346,558	497,849,860,580	0	0	2,628,647,264	206,622,485	518,622,436,693	0	0	2,022,627,503	8,275,927	20,772,576,113	0	0	
3-6	**Access Road behind Port**				***62,027,985,000***		***0***	***327,507,761***		***60,570,509,446***		***0***	236,224,987		***-1,457,475,554***		***0***	JICA Portion
a	Access Road	m	1,000.0	62,027,985	62,027,985,000	0	0	327,507,761	60,570,509	60,570,509,446	0	0	236,224,987	-1,457,476	-1,457,475,554	0	0	
3-7	**Public Related Facilities (CIQ)**				***197,027,718,596***		***472,238,250***	***1,512,544,604***		***153,818,253,980***		***474,978,677***	**1,074,869,868**		***-43,209,464,616***		***2,740,427***	JICA Portion
a	Reclamation	m3	344,131.0	203,042	69,873,046,502	0	0	368,929,686	195,917	67,421,020,121	0	0	262,941,978	-7,125	-2,452,026,381	0	0	
b	Dredging	m3	103,897.0	223,127	23,182,225,919	0	0	122,402,153	237,143	24,638,493,909	0	0	96,090,126	14,016	1,456,267,990	0	0	
c	Quay wall	m	375.0	237,948,361	89,230,635,375	1,259,302	472,238,250	943,376,005	124,549,222	46,705,958,434	1,266,610	474,978,677	657,131,915	-113,399,139	-42,524,676,941	7,308	2,740,427	
d	Soil Improvement	m2	23,600.0	624,653	14,741,810,800	0	0	77,836,761	637,830	15,052,781,516	0	0	58,705,848	13,177	310,970,716	0	0	
	Total of Construction Cost				**6,649,277,301,528**		**21,414,121,209**	**56,522,305,361**		**8,410,275,510,105**		**25,353,720,376**	**58,153,794,866**		**1,760,998,208,577**		**3,939,599,167**	
II	**Price Escalation (Foreign 3.1% Local 10.3%)**				**2,687,374,729,306**		**2,423,685,463**	**16,613,024,034**		**3,319,692,734,072**		**2,666,019,756**	**15,612,821,419**		632,318,004,766		242,334,293	
III	**Physical Contingency (5%)**				**466,832,601,542**		**1,191,890,334**	**3,656,766,470**		**586,498,412,209**		**1,400,987,007**	**3,688,330,814**		119,665,810,667		209,096,673	
	Percentage of Japan Portion						**32.59%**	**76,792,095,865**				**37.98%**	**77,454,947,099**					
IV	**Consulting Service**				**58,071,069,646**		**645,546,327**	**952,161,575**		**58,071,069,646**		**645,546,327**	**872,023,498**		**0**		**0**	
V	**Land Acquisition Cost**				**7,481,807,000**		**0**	**39,503,941**		**7,481,807,000**		**0**	**29,179,047**		**0**		**0**	
VI	**Administration Cost**				**493,451,875,451**		**0**	**2,605,425,902**		**619,100,976,652**		**0**	**2,414,493,809**		**125,649,101,200**		**0**	
VII	**VAT**				**1,472,429,118,172**		**0**	**7,774,425,744**		**2,008,383,861,463**		**0**	**7,832,697,060**		**535,954,743,291**		**0**	
VIII	**Import Tax**				**476,795,603,307**		**0**	**2,517,480,785**		**82,462,330,998**		**0**	**321,603,091**		**-394,333,272,309**		**0**	
IX	**Interesting During Construction**				**0**		**467,740,070**	**467,740,070**		**0**		**492,424,559**	**492,424,559**		**0**		**24,684,489**	
X	**Commitment Charge**				**0**		**313,826,010**	**313,826,010**		**0**		**227,478,574**	**227,478,574**		**0**		**-86,347,436**	
	Total Project Cost				**12,311,714,105,952**		**26,456,809,413**	**91,462,659,892**		**15,091,966,702,145**		**30,786,176,599**	**89,644,846,737**		**2,780,252,596,192**		**4,329,367,186**	
					—①		—②			-③		—④						
		Total Amount in VND			**17,322,473,464,409**					**22,985,858,137,667**					**5,663,384,673,258**			
		Total Amount in JPY					**91,462,659,892**					**89,644,846,737**					**-1,817,813,155**	
							—⑤					—⑥						

Note:

Above-mentioned Total as SAPROF results are slightly different from the ones shown in SAPROF report. The reasons are:

1. In the SAPROF report, the items of New navigation channel buoy, Replacement of existing buoy, and Pilot assistance system were taken into consideration. However, these are confirmed as out of scope of JICA portion.

2. There is a calculation error in small digit numbers.

Result :

Variation in Total of VND Portion (= ③ / ①)	**1.23**
Variation in Total JPY Portion (= ④ / ②)	**1.16**
Variation in Total Project Cost with Considering Exchange Rate (JPY: = ⑥ / ⑤)	**0.98**