Chapter 7 Maintenance Dredging of Coastal Channels of CDC II

7. Maintenance Dredging of Coastal Channels of CDC II

7.1 Operation and Maintenance

7.1.1 Management

1) Overview

The Coastal Dredging and Maintenance Division (CDMD) of the Harbour Department (HD) in the central government and Coastal Dredging Centers (CDC) in provincial areas control the maintenance dredging of coastal and harbour navigation channels in Thailand. The dredging is performed directly by the CDMD and CDCs, in most cases using public sector dredgers. When the need for dredging exceeds HD and CDC's working capacity, the work is carried out by private contractors. Although there are instances in which jobs assigned to private contractors have greatly exceeded the amount of works carried out directly by the government—as with jobs involving major waterways such as Pak Phanang, Pattani, etc.—the amount of dredging done by private contractors in a typical year is generally quite small.

For maintenance of the coastal channels in Southeastern Thailand, CDMD is directly involved in dredging the major channels using hopper dredgers, while CDC II dredges the smaller channels. Although efforts have been made to rationalize the channel maintenance, e.g. constructing training jetties and renewing the equipment for the old dredgers, the management and methods used could not meet appropriate standards of performance.

The observation on the maintenance dredging by JICA Study Team has revealed the need for improvement of the dredging in several aspects since the production rate of each dredger has not reached to its designed capacity.

2) Production Control and Management

(a) Organization

Management and control of maintenance dredging for coastal navigation channels fall under the jurisdiction of the Harbour Department (HD) of the Ministry of Transport and Communications, which organizes and oversees all aspects of the dredging work, including planning, production control, equipment and personnel.

Within the CDMD, the Planning Section carries out dredging planning, while the Marine Engineering Section oversees routine activities relating to the engineering, e.g. designing, building and maintaining of the facilities.

Each of the four CDCs manages dredging works in its area of responsibility to cover the whole nation all together. Cutter suction dredgers and backhoe dredgers are directly operated and maintained by CDCs. The hopper dredgers, on the other hand, which have rapid response capabilities and operate wherever required regardless of CDC boundaries, come under the direct control of HD's Coastal Dredging and Maintenance Division (CDMD).

Figure 7.1.1-1 shows the organization chart of CDMD.

(b) Management by CDMD

Planning

The Planning Section of the CDMD secures budgets required for project implementation of maintenance dredging, and allocates funds to the each CDCs. The section funds the dredging works referring to the past dredging records, and also to requests from CDCs and on the desires of the local communities. The section develops its dredger arrangement plan by calculating periods of dredging of each channel based on dredging volumes of each channel and the dredgers capacity. It then selects dredgers, and determines dredging schedules allowing for scheduled maintenance and weather condition.

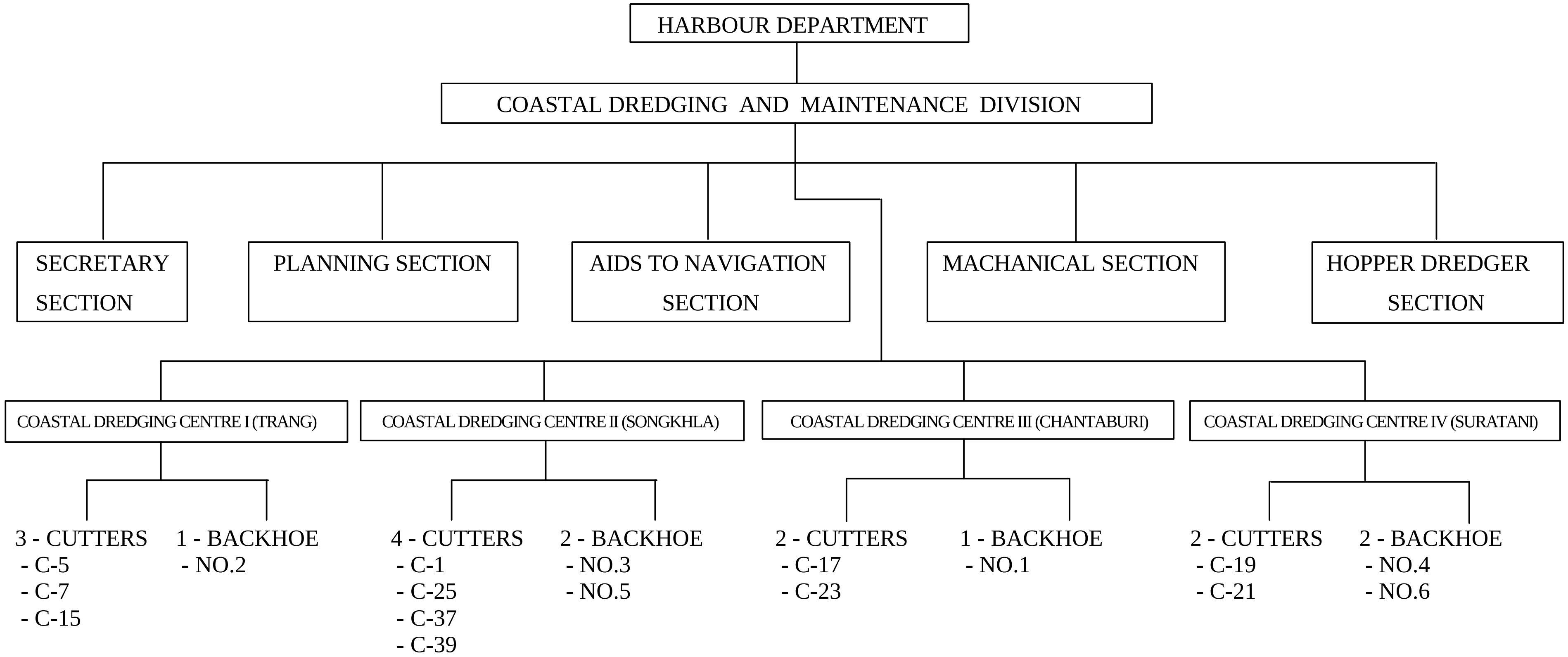
Monitoring and Control

Control over the operation of the dredgers is carried out by the Dredging unit. The Planning Section monitors progress based on daily reports from each dredging unit except Hopper Dredgers.

In controlling the dredging progress, the dredging unit calculates the dredged volume per day by multiplying a standard hourly capacity for each dredger by operated hours. The problem is that this is likely to result in considerable discrepancies between those "reported" dredged sections and the actually dredged sections. So, while this may be based on a long-time practice, it is not an appropriate method to monitor the actual dredged amounts.

All the other aspects (quality, equipment, labor, safety, etc.) are controled by the units except for the hopper dredgers.

Figure 7.1.1-1 Organization of Coastal Dredging and Maintenance Division (CDMD)



Source: HD

(c) Management and Control at CDC II

Production Control

Daily production control at CDC II involves summarizing reports from dredgers on dredging rates, consumption of fuel, lubricating oil and other supplies. Without evaluating the information received, CDC II passes the reports to the Planning Section.

Equipment Control

The major issues with regard to the on-site equipment control are replacing parts of engines and hydraulic units, and repairing snapped wires. Hardly any abration of pumps, cutters and other supplies are observedbecause the dredging is mainly done on soft material. So, replacement of these supplies has not been an issue. However, some of the dredger instruments (dredge pump pressure gauge, vacuum gauge, Diesel engine revolution meter, dredging volume meter, etc.) are no longer usable, making the dredgers incapable of operations; moreover, pumps, cutters and other types of equipment have not been changed or improved as required for on-site conditions as soil character, dredging depth, and transportation distance of the dredged material.

Education and Training

Table 7.1.1-1 shows the number of employees currently working for CDC II. Despite the addition of dredgers, there has been no increase in number of operating crews for the dredgers. The reassignment of the crew from existing vessels meant that these dredgers could no longer be operated for 24 hours, forcing the CDC II to settle for 18-hour operations. This is also contributing to the reduced dredging capabilities.

Till now, CDCs have trained its dredging crews and management staff on the job, and have not provided occupational education and training programs. Therefore, while a crew may be able to operate a hopper dredger and a cutter-suction dredger, they are not sufficiently competent to make judgments whether they are correctly working. Education and training must be provided so that the crew can respond to changes of the site conditions and achieve a maximum production accordingly.

3) Conclusions

The management of channel maintenance dredging on the part of CDMD and CDC II often fails to meet the site conditions under which dredgers are operated. This situation can be attributed to their simplified methods over production control pre-conceived for a long time.

At present, the channels to be maintained are increasing and the maintenance dredging must be handled by a limited number of dredgers. There is a greater need to increase the efficiency of operations. This means that managers and dredging crews have to examine their current practices and establish new norms in managing the dredging operations, particularly for production control.

Table7.1.1 -1 Number of Employees in CDCII

NO	JOB	RATE OF PERSONNELS				TOTAL POSITIONS	TOTAL FULL-TIME POSITIONS
		OFFICIALS		EMPLOYEES			
		TOTAL POSITIONS	FULL-TIME POSITIONS	TOTAL POSITIONS	FULL-TIME POSITIONS		
1	HEAD of the center	1	1	-	-	1	1
2	ADMINISTRATION	5	5	8	7	13	12
3	DREDGING	2	2	-	-	2	2
4	MAINTENANCE	5	4	6	6	11	10
5	CUTTER C-1	5	3	22	20	27	23
6	CUTTER C-3	-	-	6	6	6	6
7	CUTTER C-25	7	7	12	12	19	19
8	TUGBOAT2	-	-	4	4	4	4
9	A CARRIER 401	-	-	2	2	2	2
10	BACKHOE SK-1	-	-	1	1	1	1
11	BACKHOE SK-2	-	-	-			-
	TOTAL	25	22	61	58	86	80

Source: CDC II, HD

7.1.2 Equipment

CDC II has four cutter suction dredgers and two backhoe dredgers, among which the observations and investigations have been carried out on four cutter suction dredgers and one backhoe dredger. The specifications of these dredgers are shown in Tables 7.1.2-1 to 7.1.2-3.

The harbour channel of Songkhla falls within CDC II territorial channel management. This channel has been dredged by hopper suction dredgers of Harbour Department. In order to facilitate better understanding, the general arrangement plans are attached as shown in Figures 7.1.2-1 to 7.1.2-7, as far as plans are available.

The detailed results of investigation of dredging equipment are described below. Unfortunately, when the observation was conducted, the cutter suction dredger C-37 was not in working condition due to a damage of its floating pipeline.

(a) Cutter Suction Dredger C-25

C-25 is a cutter suction dredger has been used for 19 years since it was built in 1982 in Japan. Many parts of steel construction and equipment were found rusted. CDC II should pay more attention to maintain this dredger to be in normal operating condition.

In particular, the cutter ladder steel construction and support construction of the swing wire was very rusty, since they were often splashed by seawater. Reinforcement of the ladder construction is urgently required. These constructions are very fundamental not only for hull strength but also for dredging operation.

These construction parts may function as expected in the calm and swell-less seas. However, in the worst case, these steel parts will incur damage or destruction as a result if operation of this dredger continues without repair.

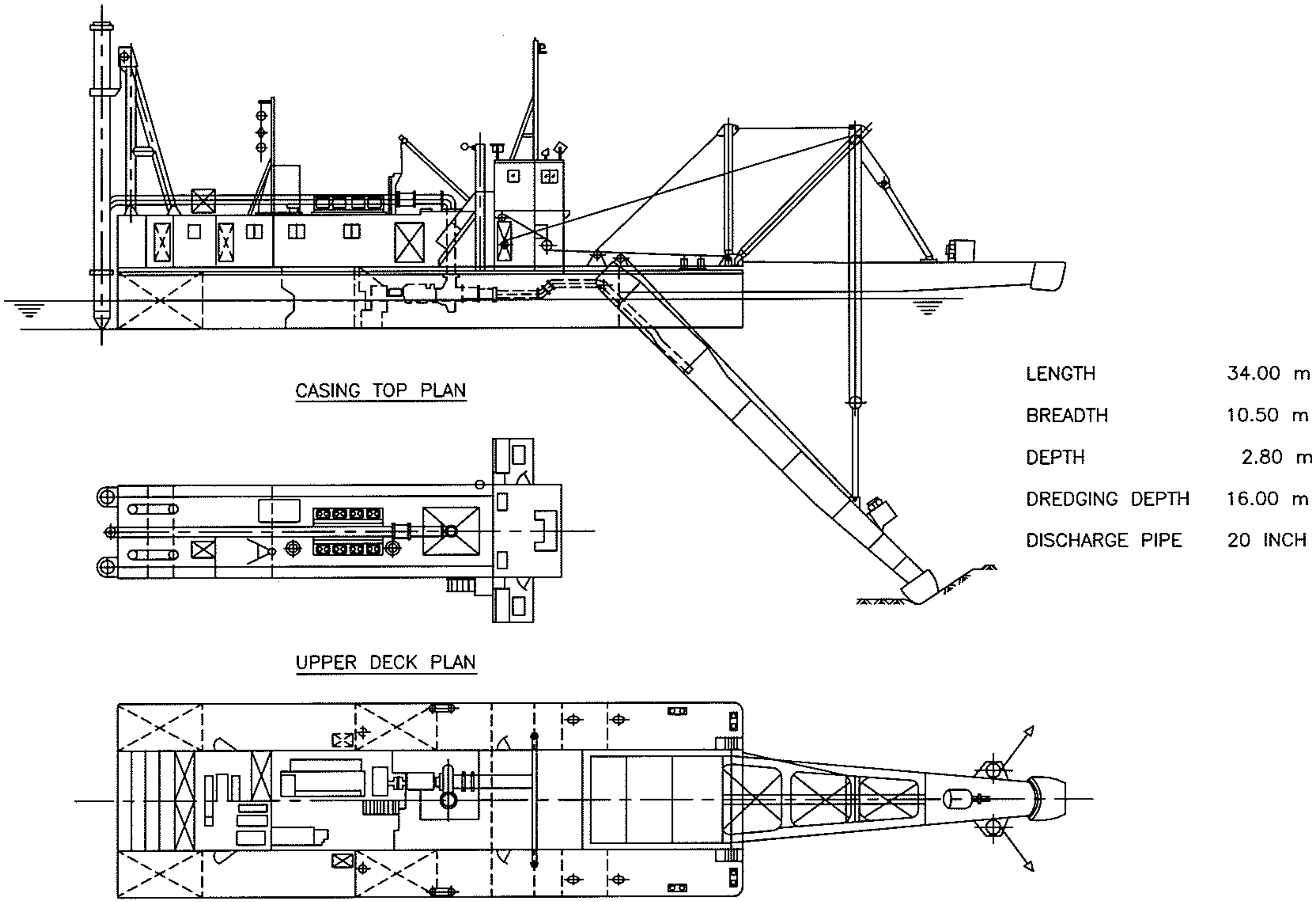


Figure 7.1.2-1 Dredger C-25

Source: HD

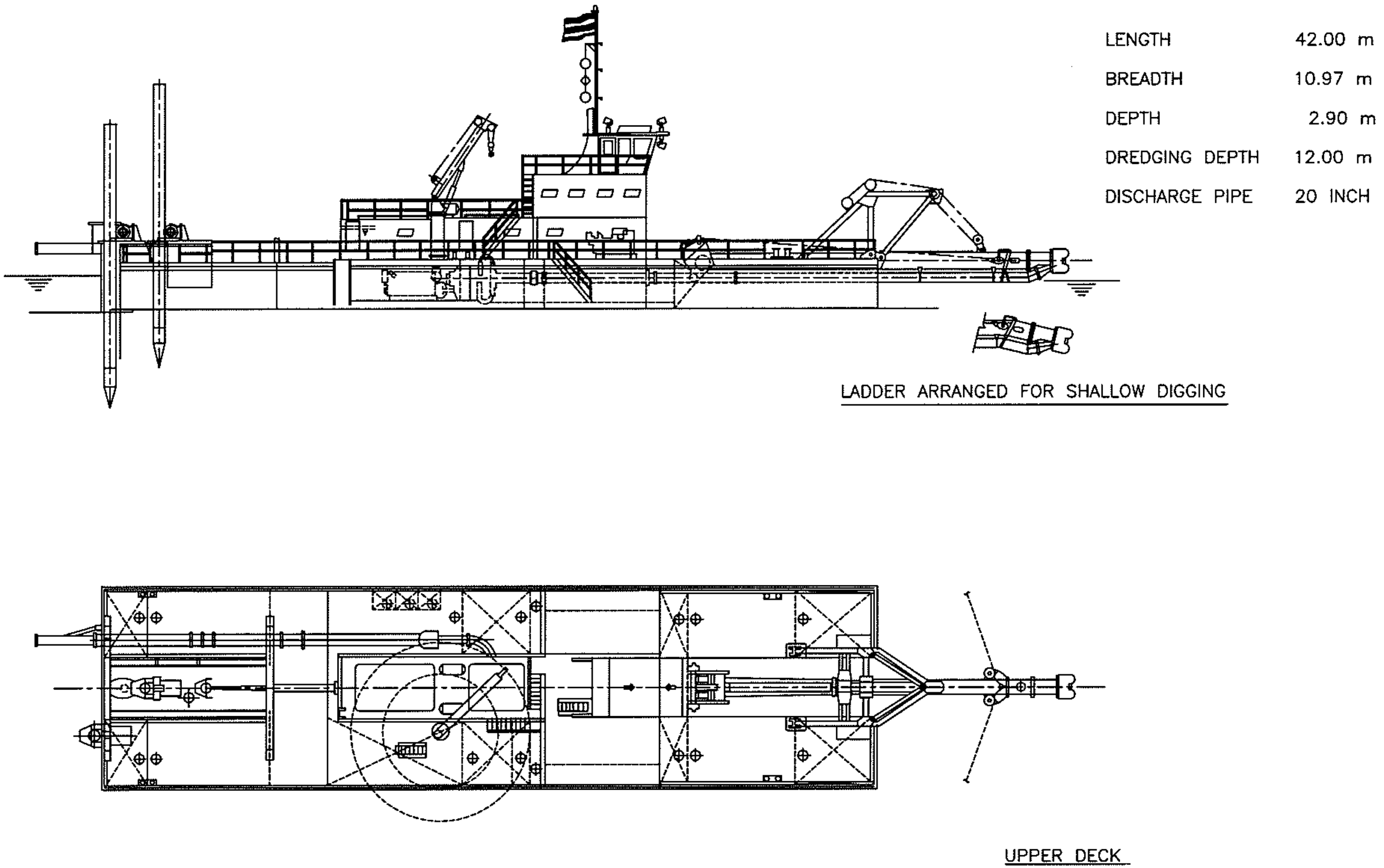


Figure 7.1.2-2 Dredger C-37

Source: HD

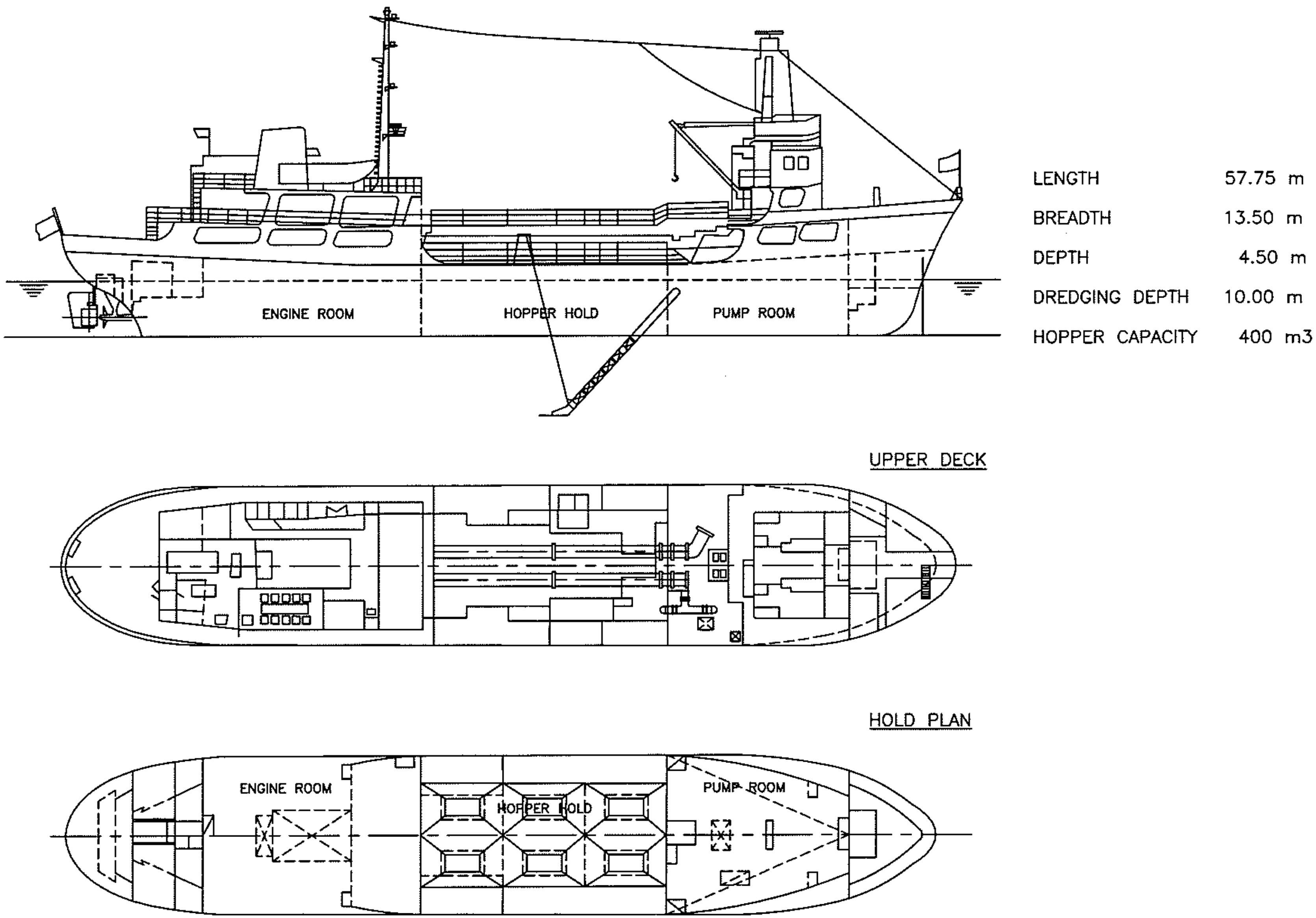
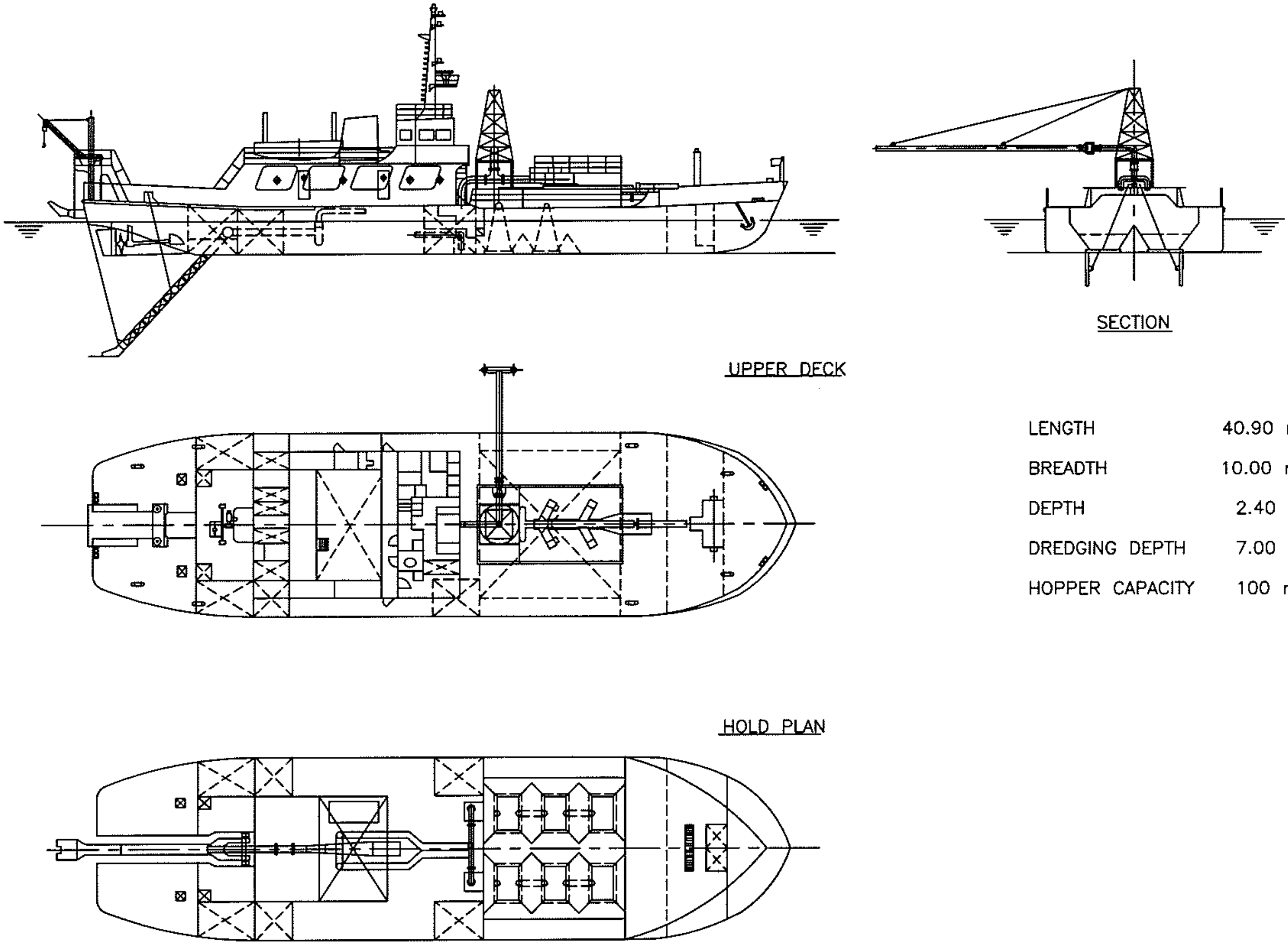


Figure 7.1.2-3 Dredger H-4

Source: HD



LENGTH	40.90 m
BREADTH	10.00 m
DEPTH	2.40 m
DREDGING DEPTH	7.00 m
HOPPER CAPACITY	100 m3

Figure 7.12-4 Dredger H-6

Source: HD

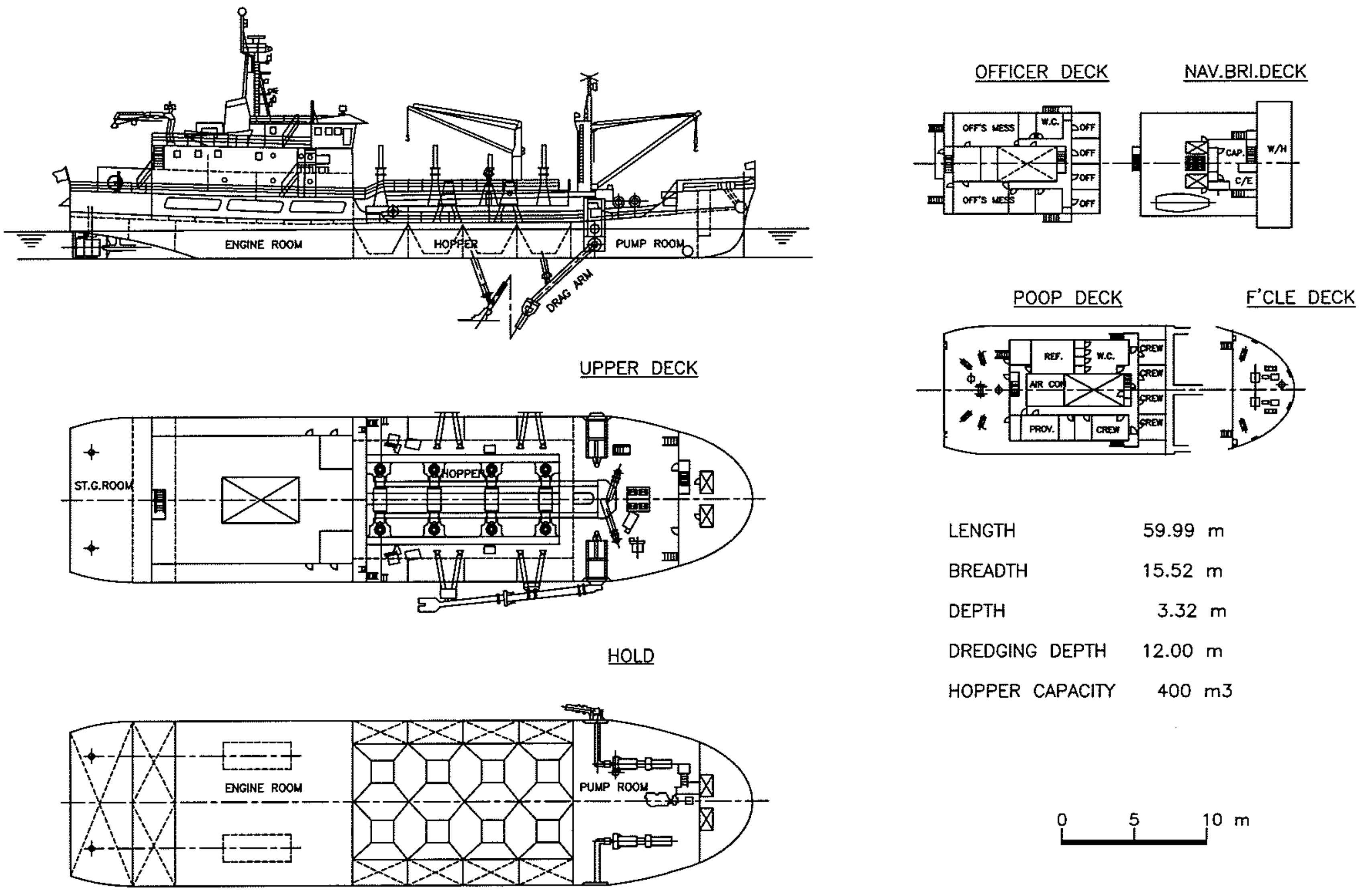


Figure 7.1.2-5 Dredger H-8

Source: HD

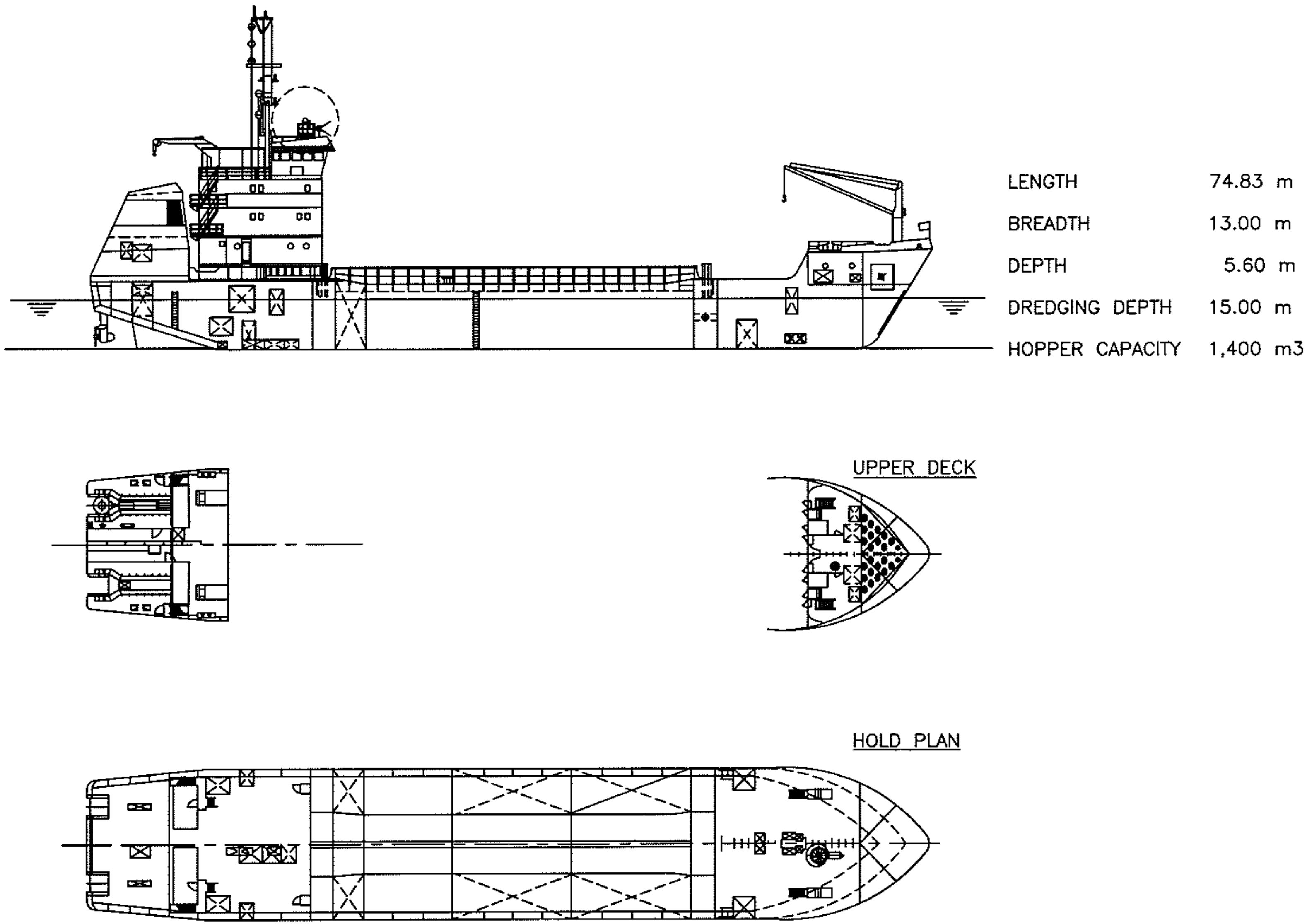


Figure 7.1.2-6 Dredger H-12

Source: HD

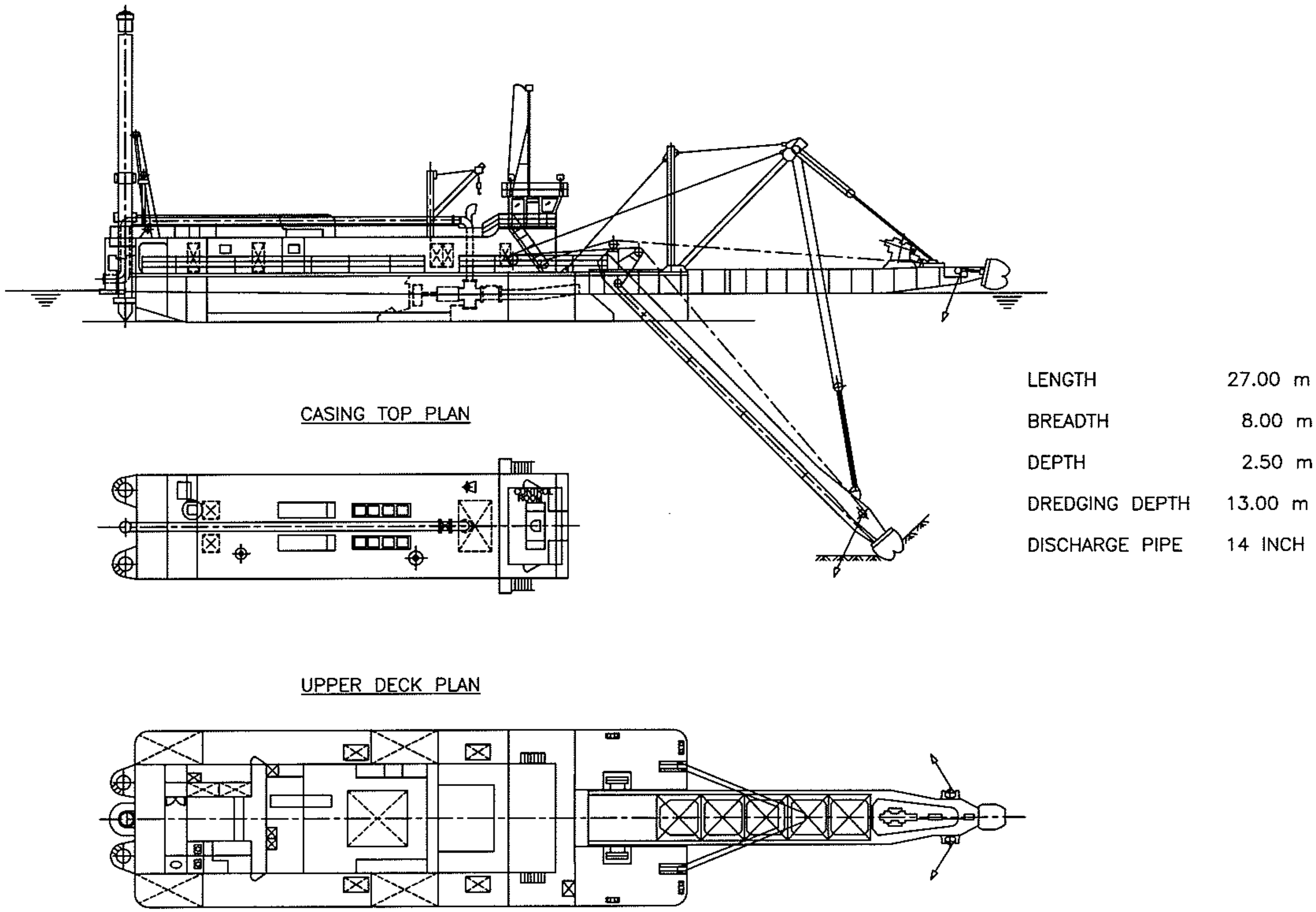


Figure 7.1.2-7 Dredger C-15

Source: HD

Table 7.1.2-1 Specifications of Cutter Suction Dredgers of CDC II (Songkhla)

DESCRIPTION	Dredger C-1	Dredger C-25	Dredger C-37	Dredger C-39
Type	Cutter	Cutter	Cutter	Cutter
Built in	Germany	Japan	Thailand	Thailand
Built when	1964	1982	1997	1997
Registered in	1965	1982	1999	1998
Size: Width(m)	6.50	10.50	10.97	3.56
Length(m)	20.00	34.00	42.00	10.67
Depth(m)	1.90	2.80	2.90	1.08
Water depth required(m)				
Bow	1.30	1.60	1.60	o.61
Stern	1.30	1.60	1.60	0.61
Gross Tonnage(T)	96.01	356.00	424.00	
Length+Cutterhead(m)	30.50	54.00	54.90	10.75
Digging depth(m)	8	16	12	4
Digging capacity (m^3/hr)	100	450	450	50
Sucking pipe (inch)	16	22	22	6
Sending pipe (inch)	14	20	20	4
Type of anchor	2 swings 300kgs	2 swings 1,400kgs	2 swings 1,400kgs	2 swings 190(CAT)
Digging pump engine(HP)	400(man)	1,200(YANMAR)	1,710(CAT)	
Hydraulic pump Engine(HP)	195(CAT)	600(YANMAR)	480(CAT)	
Gen. Pump engine(KVA)	CAT	(YANMAR)	345,77(CAT)	
Generator(KVA)	10	65(YANMAR)	250	
Air pressure engine(HP)		3.5	63.27	
Operating area	Songkhla	Songkhla	Songkhla	Songkhla

Source: CDCII, HD

Table 7.1.2-2 Specifications of Hopper Dredgers of HD

Description	H-2	H-4	H-6	H-8	H-10	H-12
Built in : country	Japan	Japan	Japan	Japan	China	Germany
Built in	1966	1969	1982	1985	1997	1999
Registered in	1966	1969	1982	1985	1998	2001
Hopper capacity: m^3	380	400	100	400	800	1400
Size : m						
- width	13.50	13.50	10.00	15.52	14.00	13.00
- length	57.75	57.75	40.90	59.99	65.00	74.83
- depth	4.50	4.50	2.40	3.32	4.75	5.60
Draft at no load : m			0.88			2.74
Draft at full load : m	3.50	3.50	1.40	2.30	4.10	4.40
Drag arm length : m	13.55	13.55	10.35	13.55	14.80	20.40
- maximum	10.00	10.00	7.00	12.00	12.00	15.00
Pump : Hp	350	350	95	420	375	599
Pump capacity : m^3/hrs	2,500	2,500	1,000	2,550	3,000	2,600
Number of dredging pump	2	2	1	2	2	2
Navigation engine : Hp	510 x 2	510 x 2	600 x 2	1400 x 2	1608 x 2	1059 x 2
Speed at full load : knots	9.75	9.75	9.00	10.70	10.00	10.35
Complement : persons	45	44	12	40	34	34
- officer	6	6	4	6	12	16
- crew	39	38	8	34	22	18
Operating area	Gulf of Thailand Andaman sea	Gulf of Thailand	Gulf of Thailand	Gulf of Thailand	Mouth of Chaophraya	Songkhla

Source: HD

Table 7.1.2-3 Specifications of Backhoe of CDC II (Songkhla)

DESCRIPTION	BACKHOE SK-1	BACKHOE SK-2
Type	Backhoe	Backhoe
Source	Metromachinery company Ltd.	Metromachinery company Ltd.
Year bought	1993	1993
Year registered	20 December 1993	1993
Size	Jib 18.34m Depth distance 14.625m Capacity 0.55m^3	Jib 18.450m Depth 14.895m Capacity 0.55m^3
Engine capacity	Diesel 6 cylinders 4 strokes with turbocharger water cooled system CATTERPILLA flywheel net 148HP at 2200 rpm	Diesel 6 cylinders 4 strokes with turbocharger water cooled system CATTERPILLA flywheel net 153 HP at 1950 rpm
Operating area	CDC II (Songkhla)	CDC II (Songkhla)

Source: CDC II, HD

As for the reinforcement, it will be necessary to renew rusty parts of spud-supporting construction. Also, some on-deck piping and swivel joints of dredge discharge pipe should be repaired to prevent leakage.

Leakage was found in the engine room. It is recognized by the trace of mud that leakage of muddy water occurs at the joint and bend of the dredge soil pipe.

As for the gauge meter equipment, only the engine revolution meter is functioning to indicate the operating conditions. Other indicators such as the temperature meter of exhaust gas and delivery pressure meter of the pumps in the engine room are broken or out of order.

Apart from the above matters, some safety equipment is found insufficient or in an inadequate arrangement.

(b) Cutter Suction Dredger C-37

C-37 is a cutter suction dredger which is designed by Ellicott, USA, and built at Prakan Shipyard, Thailand. This is still a new dredger, built two years ago, and is observed to be almost in good condition in all parts. When observation was made, this dredger was not working as the discharge floating pipeline was broken and under repair. Therefore, observation was not made under working conditions.

(c) Cutter Suction Dredger C-39

C-39 is a cutter suction dredger which was built in Thailand three years ago. The dredger was operated smoothly and is in good condition in almost all parts, as it is a comparatively new dredger. This dredger is a small type with a 4 inch discharge pipe, and considered as a most suitable for the dredging work at a shallow channel.

Occasionally, some leakage happens at the joint where the discharge pipe connects to the dredge pump. The leakage can be prevented by tightening the joint. However, this kind of trouble is avoidable by replacing a joint packing.

(d) Cutter Suction Dredger C-1

C-1 is a cutter suction dredger built in Germany 35 years ago.

When observation was made, the dredge pump engine and generator engine have already been replaced to new ones, two or three years ago.

The hydraulic and pump systems also function well and no vital damage has been found so far.

This dredger is considered as a suitable for the dredging work at shallow water. However, CDC II is currently not operating this dredger, reportedly because of budget constraints.

(e) Backhoe Dredger

Although observation was made from the shore, the backhoe dredger seemed to operate smoothly, and a new backhoe of crawler type was mounted on the barge. There is no particular trouble at present.

7.1.3 Maintenance

(a) General

The cutter suction dredger C-25 does not seem to be well maintained. Similar lack of maintenance is supposedly taking place for other dredgers. As the cutter suction dredger C-25 has problems due to aging, similar problems may occur for the cutter suction dredger C-37 and C-39 in several years. The current maintenance situation of the dredging equipment is described below, item by item.

(b) Repair Works

There is a tendency for repair measures to be taken only after troubles happen. It seemed that equipment or parts of equipment are almost not attended to and not periodically inspected until they are worn out. Therefore, when troubles or problems occur, enormous time and labor are needed for repair and big losses are likely to result.

Specific defects and damages found on board the dredgers are as follows:

- Leakage at the bend and joint of the dredge pipe
- Loss or damage of indicators for the engine and auxiliary machinery operation, dredge pump operation, etc
- Corrosion of the main vital steel construction, such as cutter ladders, spud supports, operation wire sheave supports, etc
- Inadequate life saving equipment, such as inflatable life raft or fire fighting equipment
- Partially removed handrail on the upper deck

Most of the defects and damages on the on-board equipment items are adjusted or repaired by a specialized workshop. The crew temporarily takes care of small troubles such as water leakage of the dredge pipes and supposedly repairs rubber joints of the floater pipelines at site since many of such worn items were found on the deck.

(c) Inspection

As for inspection procedure, details were not clarified due to the limited time of observation. However, it was apparent that on-board crew has not periodically executed inspection. If this is due to insufficient skills of the crew, training or education program should be organized.

(d) Facility of Inspection and Repair

Inspection and repairs of the cutter suction dredgers are made at Prakan Shipyard. Meanwhile, Bangkok Dockyard Co. is the regular repair facility for a self-propelled ship like a hopper suction dredger. These two shipyards did not have sufficient facilities for the required services, but seemed well accustomed to repairing and maintaining dredgers. Their brief description follows below.

Prakan Shipyard:	Movable truck cranes are employed at berth for installation of steel blocks and equipment. The shipyard took two years to complete C-37 dredger. Repairing and maintenance work was slow due to insufficient repair facilities and workers.
Bangkok Dockyard Co.:	This is the regular repair factory for self-propelled ships equipped with two graving docks and one slipway. Crawling cranes are employed for repair work. All levels of repair works are performed to some extent at the dockyard shop, from inspection to overhaul of equipment

7.1.4 Actual Observation of Dredging of Navigational Channels

1) Cutter Suction Dredger C-25 and C-37

Observation reveals that the water velocity of the discharge pipeline is generally too large. The following is the actual observation by the JICA Study Team.

Cutter Suction Dredger C-25
The JICA Study Team measured the water velocity in the discharge pipeline at Pak Phanang. It was 7.0 m/sec on February 20 and 8.1 m/sec on April 30. When measured, the length of the pipeline was 200 m, which is the maximum length without extra floaters.

On February 20, after measurement of the velocity, reducing the pump revolution from 400 rpm to 300 rpm was attempted to further reduce the water velocity. However, the attempt was abandoned since abnormal vibration and noise had occurred.

On the same day, the team sampled the soil-contained-water with a mess cylinder at the outlet of the discharge pipeline. The mud content in the discharge water was less than 3 %.

Also, the team conducted simple sounding with a handy echo-sounder. C-25 was excavating the channel from –3 m down to –5 m. The spud positioning took 24 minutes. As the swing of C-25 is 60 m, the output of excavation was computed to be about 300 m^3 per hour (60 m width x ((-3) – (-5)) depth x (60 minutes / 24 minutes) x 1m advance / positioning).

The engine revolution, pump pressure and suction vacuum were observed as follows:

	Engine Revolution	Pump Pressure	Suction Vacuum
February 20:	400 rpm	1.8 kg / cm^2	250 mmHg
April 30:	420 rpm	1.8 kg / cm^2	350 mmHg

The cutter of C-25 is designed for effective excavation about 10 m below the water surface. At Pak Phanang, however, the seabed was about 2 to 3 m below the water surface. The excavated soil depth was only 2 to 4 m. Nevertheless, since the dredger repeats excavation of the seabed by each layer of 40 to 50 cm thickness, the performance has been highly ineffective. The cutter head should have been placed at the designed channel bottom.

It was reported to the team that the seabed surface was rather hard to excavate because it was covered with sand. Generally speaking, the soils to be dredged by CDC II are of alluvial origin. They are debauched from rivers and accumulate in the seabed. Therefore, when the excavation commences from a deep position, alluvial soils can generally be excavated easily.

Cutter Suction Dredger C-37

The team measured the water velocity in the discharge pipeline at Sichon on March 1. It was 2.9 m/sec, which was too small. When measured, the pipeline was composed of 22 inch diameter pipes of 162 m length and 14 inch diameter pipes of 18 m length. The outlet of the discharge was elevated to 5 m above the seawater. The smaller pipes were supposedly used to elevate the outlet across the rock mound of the jetty. From a hydrodynamic point of view, these smaller pipes behaved as a reducer of the pipeline by creating larger resistance in the pipeline.

Engine revolution, pump pressure and suction vacuum were as follows:

	Engine Revolution	Pump Pressure	Suction Vacuum
March 1:	740 rpm	1.4 kg / cm^2	140 mmHg

The team measured the water velocity in the discharge pipeline at Khanom on May 4. It was 8 m/sec, which was too large. When measured, the pipeline was composed of 22 inch diameter pipes of 200 m. length which was supposedly the maximum length at that time because about 100 m length of its pipeline had been left at Sichon after it capsized in a rough sea. Water was discharged at the seawater level. No reducer was observed.

The cutter C-37 is also designed for effective excavation at about 10 m below the water surface. The planned elevation of the channel seabed was 6 m below the water surface. Soil thickness to be excavated was only 1 m. At each advance of the dredger, excavation repeated from the seabed surface and downwards for each 30 cm depth, layer by layer. The cutter head should have been placed at the designed channel bottom attacking one layer.

In addition, cutter C-37 has a special design to perform excavation at shallower and deeper depths by turning the ladder head upside down. This technique can be utilized for shallow excavation at Pattani, Pak Phanang, Sichon, Tha Sala and Khanom.

2) Trailer Suction Hopper Dredger H-10

The team observed dredging operation of Trailer Suction Hopper Dredger H-10 on February 26 at Songkhla. H-10 has a hopper capacity of 800 m^3. The observation is briefly summarized below:

First Trip:

Excavation was conducted along the navigation channel. The dredged materials were sandy.

From 8:50 a.m. to 9:00 a.m., within 10 minutes, the hopper of 800 m^3 was fulfilled with water. This supposed that the hourly pump capacity is 4,800 m^3.

At 9:10 a.m. H-10 started to move to the disposal site.

The loading of the soils into the hopper could not be visually confirmed. Sounding with a bamboo stick did not confirm the existence of the soils in the hopper. The team asked if the hopper was full of soils. The answer was, nevertheless, positive.

Second Trip

Excavation was conducted in front of the quay. The dredged materials were muddy.

At 9:50 a.m., H-10 lowered the suction pipe. Excavation commenced.

At 10:00 a.m., within 10 minutes after commencement, the hopper was fulfilled with muddy water. It started to move to the discharge site. The water in the hopper was very muddy and supposedly contained maximum volume of mud. No more loading of mud seemed possible.

Third Trip:

Excavation was conducted along the navigation channel again. The dredged materials were sandy.

10:40 a.m. H-10 lowered the suction pipe. Excavation commenced.

At 10:49 a.m., the hopper was fulfilled with water and started to move to the disposal site. The loading of the soils into the hopper could not be visually confirmed.

At disposing, the team requested to drain the hopper by gradually lowering the vertical drainpipe so that the water could be drained from the surface and sands could be seen. When about 500 m^3 of water was in the hopper, sands could not be seen yet. When the bottom was almost visible some time after commencement of dumping through the bottom splits, sands could be seen after all. The team again asked if the hopper was full of soils. The answer was again positive.

From the above observation, the team is of the opinion that confirmation should be made whether the hopper is fully loaded with soil.

3) Other Dredgers

Cutter Suction Dredger C-1

This is reportedly due to lack of budget for fuel and non-availability of crew. Some members of C-1 crew had been shifted to C-37. The JICA Study Team on May 1 made observation on Cutter Suction Dredger C-1 moored at HD berth at Pattani. The dredger is currently not operating.

Visual measurement of the dimensions of its ladder and cutter, C-1 was supposedly designed for rather shallow water about 3 to 4 m below the water surface. There were no significant damages observed on the mechanical systems of pump, hydraulic pressure pipeline and generator.

From the fact that C-1 is not operating, the team conjectured that HD had preferred a larger dredger like C-37 that, HD might have thought, could be operational in the monsoon rough sea. C-1, a rather small dredger, obviously cannot work at a rough sea. Then, when C-37 tried dredging operation at Sichon this year in rather rough seas owing to the north-east winds, waves prohibited its operation and its floating pipeline capsized. The trial implies that even C-37 failed to operate in a rough monsoon sea.

Cutter Suction Dredger C-39

The team observed Cutter Suction Dredger C-39 operating at Lam Pam on February 23. The team measured the water velocity of the discharge pipeline, suction vacuum and engine revolution. They were 6.3 m/s, 9 inch Hg (230 mmHg) and 1570 rpm (1600 rpm at maximum) respectively.

The captain informed the team that he usually operated C-39 with 1400 rpm of engine revolution. (At this revolution, the water velocity will be about 5 m/s.) On this day, he intentionally increased the engine revolution since it was required to splash the dredged soils a longer distance.

Backhoe Dredgers

HD has two backhoe dredgers. The team observed one backhoe dredger operating at Takhria on February 23. As HD informed the team that the backhoe dredgers were operating at Takhria, Sala Tham, Ban Mai, Chiang Phong, Mahakan Ok, Ban Ku Khud, all on the inland waters, the team made a round trip observation by boat on March 28.

The team observed one backhoe dredger excavating the channel at Chiang Phong to the dimensions of 15 m width and 1.5 m depth. The dredger has a long arm for excavation and disposal. Therefore, the disposal is limited within the reach of the arm. It can excavate the soils with tree roots and boughs, and boulders that are obstacles for a cutter suction dredger. In this regard, the backhoe dredgers are appropriate for maintaining inland water channels, especially when disposal can be done within the reach of its arm.

7.2 Recommended Improvements in Maintenance Dredging

7.2.1 Management Issues and Improvements

1) Management Issues

For many years, management and planning of dredging work have been based on the inaccurate figures calculated through the above methods, and as a consequence, management and planning have not been in agreement with actual operational performance.

Below are several circumstances that can be seen as factors behind the current operational status.

1. An appropriate level of technical training has not been provided to crew because of the lack of competent dredging engineers. (Lack of training)
2. Even though operational supervisors are responsible for collecting operational data, they are not familiar with management methodology, so they are unable to actually evaluate the data, and to reflect them towards the next operation. (Lack of ability of data analysis)
3. Dredging crews lack skills in appropriately responding to various problems onboard and unable to quickly find countermeasures, resulting in poor operational efficiency. (Lack of crew's skill)
4. Equipment cannot be effectively modified to meet the changes of dredging conditions because of the lack of competent equipment technicians. (Lack of technical knowledge)
5. The absence of fundamental site data for managing the status of each channel prevents the Planning Section from being able to suitably plan operations. (Lack of management ability)

2) Organizational and Managerial Improvements

The dredging done by CDC II at the channels under its jurisdiction is mainly of soft material and, in normal situations, it should have been completed with a great deal of efficiency and a minimal need to replace supplies. However, because the entire bottom of the channels is soft mud, the surrounding mud soon begins to flow into the newly dug channels, making it difficult to maintain the vertical sections. Thus the CDC II is forced to repeat maintenance dredging each year. Training jetties are being built in some cases to deal with this phenomenon, but they have occasionally led to the secondary damage of coastal erosion. Construction of training jetties has to be re-examined.

From the standpoint of organizational structure, it seems fair to say that CDMD is functioning effectively, with the required Planning and Management, Technology, and Dredging divisions all in place. Nonetheless, in the current survey, it has become clear from cases of inappropriate dredging that were seen at various sites that the organization faces a number of operational problems. In addition to a lack of technical skills on the part of persons operating the dredgers, these inefficiencies spring largely from a shortage of supervisory capability on the part of the Hopper Dredger and the CDCs, which are responsible for overseeing the actual dredging. The problem appears to stem from the organizational equality of those who should be able to provide direct guidance and instruction to those requiring it; i.e., the Planning Section and Marine Engineering Section, which are the key centers for dredging technology, exist in organizational parity with the Hopper Dredger and CDCs. To solve this issue, there is a pressing need to take steps to improve the quality of engineers in the Hopper Dredger and CDCs, and at the same time a need to strengthen the central government’s ability to support these measures. For the time being, our judgment of the study team is that, through coordinated efforts among existing sections, committees should be organized to take steps to improve capacity and to oversee and provide guidance for dredging engineers.

Because of the simplicity of the dredging, the tendency is to take a lax approach both to operating dredgers and to constructing structures like jetties and groins. Observation made it clear that the CDMD and CDC II face the following major problems and that immediate improvement is required.

(a) Progress Control

Control over the operation of the dredgers is carried out by the Planning Section, which monitors progress based on daily reports sent to it by each dredging unit except for Hopper Dredgers. The Planning Section also monitors and controls consumption of fuel and supplies on these daily reports.

The management of channel dredging at CDC II is based primarily on progress control and material control. Each dredging unit submits daily reports to the Planning Section except the crews of Hopper Dredgers.

CDC II compiles the reports that the dredgers provide daily on dredging volumes, advanced distances, and materials used (fuel, lubricating oil, etc.). CDC II then submits the compiled reports to the Planning Section of CDMD. In doing so, CDC II does not conduct its own analysis. On the contrary, CDC II leaves dredging operations entirely in the hands of the crew operating the dredgers. It provides no special guidance to the crew.

The dredging volume cited in daily reports is not of the amounts actually dredged. Instead, each dredging unit deals with this reporting by multiplying the preconceived hourly capacity for each dredger by hours of operation. In fact, actual dredged volume was quite smaller than reported volume.

Regarding the progress control of the Hopper Dredgers, constant efforts to improve the production are required: e.g., by carrying out appropriate management practices, adopting measures to increase dredging capacity, and being consistently alert to new ways of enhancing dredging precision.

(b) Material Control

Although daily reports allow the agencies to track how much of the main consumables for dredgers are being used (fuel, lubricating oil, and hydraulic oil), they are involved merely in compiling the data and do not judge the appropriateness of the amounts being used. The dredger was observed transporting an excessive amount of water, resulting in an excessive consumption of fuel. The percentage of fuel consumed by a dredger for any given amount of material dredged provides a standard of judgment regarding appropriateness of operations. Both CDMD and CDC II should incorporate control methods that effectively utilize the data.

(c) Equipment Control

Dredgers are regularly serviced and receive sufficient maintenance that enables them to function without problems. However, both CDMD and CDC II do not appear to make sufficient efforts to improve and effectively utilize dredging equipment. Major dredging equipment such as pumps and cutters should be adapted to the-site conditions. Valuable instruments used in the control of operations were broken and left unattended, indicating that the need for instruments relating to efficiency was not being appreciated.

In particular, the following improvements need to be made urgently.

(1) Adjusting cutting angle to soil

To increase the dredging capabilities of cutter suction dredgers, the cutting angle to soil needs to be maintained at around 25 degrees at all times. It can be obtained by converting the base for the cutter driving gear for C-25 and by readjusting the front end of the ladder for C-37.

(2) Changing the shape of cutters

Being able to choose a cutter shape that is suitable for type of silt being dredged is required to increase suction capacity. In the C-25, the current configuration allows silt to flow away from the suction mouth during dredging operations. Thus, the shape of the cutter needs to be altered so that it causes the silt to move toward the suction mouth.

(3) Lowering head transformation of dredging pumps

The dredging pump must be operated in a way that enables the sediment flowing through disposal pipeline to travel at a speed that is appropriate for the type of sediment being transported. In addition to adjusting the engine's revolutions, the diameter of the impellers needs to be shortened, since in the dredging done in this area, the dredged material only has to be transported a short distance.

(4) Adjustment of drag heads

The suction capacity of drag heads used on hopper dredgers can be increased by adjusting the contact pressure to the bottom soil in accordance with the type of soil being dredged. In addition to assuring that dredging operations run smoothly at all times by keeping the front end of the head in proper contact with the soil, in some cases a counterweight needs to be attached.

So long as HD dredgers are government property, it will not be possible to make arbitrary changes to shapes, structures, and so on. However, because dredgers are a form of production equipment, situations will arise in which such improvements must be made. Thus, operational measures need to be developed that will enable improvements of dredging equipment and components to be smoothly carried out.

(d) Education and Training of Dredger Crews

The efficiency of dredgers greatly depends on the skills of the person operating the vessel. A new dredger will fail to reach prescribed capacity if operated by an incompetent operator. Based on observations of the way that dredgers were being piloted in CDC II, it became evident that operator did not adequately respond to changes of the dredging conditions. When operators repeat the same operation without understanding what has to be done in response to the changes of soil, depth, or delivery distance, it is difficult to improve the efficiency of the activity.

It will be important, therefore, to provide operators along with their technical supervisors with thorough basic technologies of cutter suction dredgers and hopper dredgers. It will also be necessary to carry out an educational and training program for that purpose as soon as possible.

(e) Promotion of Information Technology

Information technology is making rapid inroads in Thailand, as it is elsewhere. New information systems are being incorporated into various operations within HD. There is a need to build a database that will enable those involved to organize information and control the vast number of channels along the country's coast, and also to monitor the operational status of the many dredgers at work in order to manage them in an appropriate way.

(1) A database to support the management of channels would have to include the following.

a. Name of channel

b. Channel specifications (length, width, depth)

c. Location maps

d. Depth sounding maps

e. Appurtenant channel facilities (specifications, structural drawings, locations)

Training Jetties

Offshore breakwaters

Wharves

Piers

f. Data on channel utilization

Using ships（Type, Gross tonnage, Numbers）

g. Natural conditions affecting channel

Waves

Tides

Currents

Wind velocity, wind direction

Rainfall

Siltation（Thickness, volumes）

Volumes of drift sand

h. Annual Record of dredging work

Years in which work completed

Dredging locations

Amount of sediment dredged

I. Dredging volumes

Budgets

(2) Facilities required hereafter for management of dredging work

a. GPS surveying system

Surface surveying of channel

Positioning of dredger

Hopper dredger track record

b. Multi-narrow beam depth surveying system

This will make it possible to identify locations at sea and survey sea depths rapidly and accurately, while also permitting users to readily convert data on sea depth into various kinds of maps (cross sectional maps, grid system sounding maps, air view maps, route maps, etc.). This will enable those managing the work to stay on top of work progress even from a long distance, and to send work instructions directly to dredgers from a central location.

3) Recommendations for Long-term Improvement

(a) Introduction of New Depth-sounding Technology

Currently, marine charts used for navigational purposes are required to show depth that has been measured by standard-frequency echo sounding devices. Therefore, unless special measures are devised, navigation by ships in areas of siltation will be impossible.

To resolve this dilemma, channel managers must find ways of confirming the extent of floating mud in these areas by using depth-specific densimetry, echo depth sounders that do not detect floating mud, or other means. After establishing standards that indicate the depths at which navigation is not impeded, they must increase the rate of utilization of channels and harbors by continually monitoring conditions in all navigational channels.

The dredging of these channels will be carried out on the basis of dredging plans that deal only with sediment that has been measured on the basis of these standards. Navigation channel managers would then establish dredging cycles of one, two or three years, etc. on the basis of the amounts of sedimentation measured, and adopt annual dredging plans for all channels on the basis of these cycles.

Adopting this method would permit the passage of large vessels that have heretofore been prevented from entering harbors and would result in major improvements in the efficiency of harbor and channel utilization.

(b) Dredging Methods to Deal with Sediments

The introduction of new depth-sounding technology would make it possible to distinguish between floating mud and sediment. This in turn would permit navigation channel managers to discontinue use of the traditional hopper dredgers and cutter suction dredgers, which had been employed to deal primarily with floating mud. And by making the elimination of sediment the new objective of dredging and adjusting work methods accordingly, navigation channel managers would be given a means of increasing the efficiency of dredging.

(i) Improving dredging methods through use of hopper dredgers

Up till now, in channel dredging using hopper dredgers in CDCII, there has been almost no work done on sediment. Instead dredging has focused entirely on floating mud, which does not produce results. This has been primarily due to a lack of adequate knowledge regarding channel dredging among navigation channel managers, work supervisors and ship operators. It is particularly important to note that, when using hopper dredgers to remove sediment, operators must make sure that mud is being sucked up and loaded into the hopper through a process of bringing the draghead repeatedly into contact with the surface of the sediment and dragging it. In addition, in order to increase the efficiency of dredging, it will be important to increase the ratio of dredging hours to total work hours and to carry out dredging work with the aim of increasing the amounts of material dredged daily.

Some of the hopper dredgers that are currently in use have major pieces of dredging equipment and tools that are not in operating condition, including dragheads. Servicing or replacing all such equipment will be an essential requirement for engaging in sediment dredging.

(ii) Improving dredging methods through use of cutter suction dredgers

The cutter suction dredgers owned by HD have heretofore been involved principally in the dredging of small channels. Although steps are being taken to adapt them to projects involving both shallow waters and short-distances, as recommended by the present survey, there is a need to deal urgently with a number of other vital issues that are designed to improve operations dealing with sediment—namely, the previously cited issue of pumps for short-distance dredging, and the production of new cutters, or conversion of existing cutters, for use in shallow water dredging.

(iii) Improving dredging methods through use of other types of dredgers

For berth and channel-maintenance dredging involving limited areas, neither the hopper dredger nor the cutter dredger may be the suitable vessel for the task. In this case managers could decide that it would be appropriate to assign in their place a self-navigating grab hopper dredger that has the mobility to adapt to these situations. Because this vessel could be used to deal not only with localized dredging of sedimentation but also to dredge areas left unfinished by other vessels or to even out areas that have previously been dredged, we believe that one such vessel should be placed in service within the area covered by CDCII's jurisdiction.

(c) Dredging Management Methods

Until now, the construction management (process management, materials management) of dredging projects executed by each CDC has been centralized under HD. But because HD has had its hands full just trying to compile information, it has not made appropriate judgments on the content of the work being performed, nor has it involved itself in providing guidance to those on site. Consequently its efforts have not resulted in improved efficiency or lower costs.

If work methods change hereafter to a focus on removing sediment, it would require channel managers to replace traditional methods of control based on "apparent" amounts of dredged material with methods that account for "actual" amounts. Consequently, after developing dredging plans based on accurate assessments of the amount of sedimentation in channels prior to the commencement of dredging, channel managers will have to monitor daily operations by comparing these amounts with actual progress achieved at dredging sites.

The use of these methods will enable managers to know precisely how far dredging has progressed and to respond promptly with guidance to those on site on the basis of an early recognition of problems. This, in turn, will make it possible to reduce the amount of time required for dredging.

Because this approach would also provide clear indications of the amounts of material (fuel oil etc.) being used per unit of dredged sediment, managers will be able to determine whether power on dredging vessels is being used appropriately or not and also be able to provide guidance aimed at operating vessels more efficiently.

Not only will this permit an improvement in the efficiency of each vessel but it will also enable a shortening of dredging periods and a reduction of costs for the entire fleet.

7.2.2 Operational Issues and Improvements

1) Dredging Records of Navigational Channels

(a) General

a. Dredging Responsibility

According to CDMD of HD in their Implementation Annual Report for 2000, CDC responsibilities by total material dredging volume are outlined in Table 7.2.2-1. The study area which is CDC II located around Songkhla is shown to cover 6 million m^3 or 23.4% of the total.

Table 7.2.2-1. Summary of CDC Dredging Responsibilities

Section	Location	Big Channel (m^3)	Medium Channel (m^3)	Small Channel (m^3)	Total (m^3)	Percentage
CDC I	Trang	2,451,840	2,735,880	441,280	5,629,000	21.9%
CDC II	Songkhla	4,227,500	1,382,570	414,300	6,024,370	23.4%
CDC III	Chanthaburi	1,961,200	3,423,900	1,823,000	7,208,100	28.0%
CDC IV	Surat Thani	3,100,100	1,196,700	754,250	5,051,050	19.6%
Center	Bangkok	1,830,000			1,830,000	7.1%
	Grand Total				25,742,520	

Source: Implementation Annual Report (Fiscal year 2000), CDMD, HD

b. 44 Channels in CDC II

CDC is responsible for all dredging maintenance work. The 44 channels in CDC II are listed in Table 7.2.2 -2. Channels have been classified by LLW depth such that six are considered as Big (LLW depth 3.0 to 9.0 m.) covering 4.22 million m^3 dredging volume, 18 as Medium (LLW depth 1.5 to 2.0 m.) covering 1.38 million m^3 dredging volume and 20 as Small (LLW depth primarily 1.5 m) covering 0.41 million m^3 dredging volume. This data will be rearranged by type of dredging equipment used.

Table 7.2.2-2 Channel Description under HD Responsibility for CDC II

Channel Type - Name	Province	channel size (m)			average	volume of	type of	remark
		width (m)	length (km)	depth LLW (m)	siltation (m/year)	material (m^3/year)	material at sea base	
1. Big 6 channels								
Khanom outer channel	Nakhon Si Thammarat							
- outer channel part 1		80	0.745	5.0	1.0	200,000	mud-sand	
- outer channel part 2		180	0.382	4.5	1.0	171,000	sand	
- outer channel part 3		140	0.237	3.0	1.0	150,000	mud-sand	
Pak Phanang	Nakhon Si Thammarat	60	27.00	4.0	0.65	1,008,000	mud-sand	adjust to 5.0 m.
Songkhla	Songkhla							
- deep sea port		120	6.00	9.0	1.5	977,500	sand	
- inner channel		250	5.00	5.0	0.5	496,000	mud-sand	
Pattani	Pattani	60	4.00	5.0	1.5	675,000	mud	
Narathiwat	Narathiwat	60	4.00	4.0	0.5	300,000	sand	
Ko lok	Narathiwat	180	1.35	3.0	0.3	100,000	sand	depth from MSL
	Total of material					**4,227,500**		
2. Medium 18 channels								
Khanom inner channel	Nakhon Si Thammarat	40	2.80	2.0	1.0	115,000	mud-sand	
Sichon	Nakhon Si Thammarat	40	1.00	2.0	1.5	123,750	sand	
Khlong Tung Ca (Ban Tepa)	Nakhon Si Thammarat	30	1.00	2.0	0.6	15,120	sand	
Tha Mak	Nakhon Si Thammarat	30	0.60	2.0	1.0	12,000	sand	
Pak Duad	Nakhon Si Thammarat	30	0.80	2.0	0.8	15,200	sand	
Tha Sala	Nakhon Si Thammarat	40	0.80	2.0	1.5	82,500	sand	
Pak Phaying	Nakhon Si Thammarat	40	4.50	2.0	0.5	165,000	mud-sand	
Pak Phun	Nakhon Si Thammarat	40	3.50	2.0	0.6	138,000	mud-sand	
Pak Paya	Nakhon Si Thammarat	30	1.79	1.7	1.0	80,000	mud-sand	
Pak Nakhon	Nakhon Si Thammarat	40	3.70	2.0	0.6	150,000	mud-sand	
Nathap	Songkhla	40	0.80	2.0	1.5	82,500	sand	
Thepa	Songkhla	40	1.00	2.0	1.5	106,500	sand	
Sakhom	Songkhla	40	0.70	2.0	1.5	82,500	sand	
Ban Ku Khud-Ban Laem Vang	Songkhla	30	1.85	1.5	1.5	108,000	mud-sand	new channel
Sai Buri	Pattani	40	1.00	2.0	0.5	34,000	sand	
Panare	Pattani	30	0.40	1.5	1.0	12,000	mud-sand	
Tawa (Nong Jig)	Pattani	30	0.35	1.5	1.5	11,000	sand	
Tak Bai	Narathiwat	40	0.60	2.0	1.5	49,500	sand	
	Total of material					**1,382,570**		

Source: Implementation Annual Report (Fiscal year 2000), CDMD, HD

Table 7.2.2-2 Channel Description under HD Responsibility for CDC II (cont'd)

Channel Type - Name	Province	channel size (m)			average	volume of	type of	remark
		width (m)	length (km)	depth LLW (m)	siltation (m/year)	material (m^3/year)	material at sea base	
3. Small 20 channels								
Lake Songkhla (Thale Noi)		20	10.00	2.0	0.5	160,000	mud-water plant	
Chalae	Songkhla							new channel
Khlong Mahakan	Songkhla							new channel
Khlong Chiang Phong	Songkhla							new channel
Ban Mai	Songkhla							new channel
Sala Tham	Songkhla							new channel
Hua Pa	Songkhla							new channel
Khlong Sam Rong	Songkhla	6	10.0	1.5	1.0	75,000	mud-sand	
Bang Lieng	Songkhla							new channel
Bang Rapa	Pattani	20	0.1	1.5	1.0	2,100	sand	
Ban Sai Samor	Pattani	15	0.4	1.5	1.0	5,200	sand	
Tan Yong Phao	Pattani	20	0.9	1.5	1.0	21,000	sand	
Bang Maruad	Pattani	20	0.8	1.5	1.0	21,000	sand	
Ta Lo La Veng	Pattani	30	0.5	1.5	1.0	20,000	sand	
Khlong Gor Tor	Pattani	30	0.7	1.5	1.0	20,000	mud-sand	
Laem Ta Chee	Pattani	20	0.9	1.5	1.0	25,000	sand	
Khlong Tu Yong	Pattani	20	0.7	1.5	1.0	30,000	mud	
Rusamilae	Pattani	30	0.9	1.5	1.0	27,000	sand	
Kae Kae	Pattani							new channel
Khlong Kok Kean	Narathiwat	20	10.0	1.5	1.0	8,000	mud-sand	
Total material						**414,300**		
Grand total CDC II						**6,024,370**		

Source: Implementation Annual Report (Fiscal year 2000), CDMD, HD

c. Main Coastal Channels

The study focused its attention on seven channels based on the size of vessels plying its waters, depth of the channel and high amount of activity (no. of vessels). These are discussed below.

1. Songkhla channel is deepest of the 44 channels. Its design depth is –9 m. International container vessels use Songkhla port and it is the only international seaport in the southern Thailand on the Gulf of Thailand. Inland of this port are fishing ports used by large and medium size fishing boats.

2. Khanom channel services oil carrying vessels for the power station in its environs. Upstream are many fishing ports and port markets.

3. Pattani channel serves sea traffic. It has a large fishing complex and wharf for big and medium fishing boats along the right bank of river. The port design depth is –5 m.

4. Pak Phanang channel is 27 km long from estuary to offshore. Design depth is –4 m. PTT oil tankers use the channel to charge oil tanks for the city. The estuary has a fishing port but the number of fishing boats averages only 5-6 vessels per day and not many boats use the market.

5. Sichon, Tha Sala and Sai Buri channels are smaller with a design depth of only –2 m. Many middle size fishing boats use these waters and there is a very active fishing complex.

d. Dredging Equipment

Further to the discussion in Section 7.1.2, the type and specification of dredging equipment is outlined in the Harbor Dept Annual Report on implementation of dredging work and presented in Table 7.2.2-3. There are 7 dredgers operating under CDCII management as follows:

Table 7.2.2-3 Summary of Dredger Equipment Type

		Diameter of suction pipe	Diameter of delivery pipe	Dredging Capacity
Cutter Suction Dredger	C-1	16"	14"	100 m^3/hrs
	C-25	22"	20"	450 m^3/hrs
	C-37	22"	20"	350 m^3/hrs
	C-39	6"	4"	36 m^3/hrs
Backhoe		Arm length	Depth	Bucket Capacity
	No.3 (SK-1)	18.4 m	14.6 m	0.75 m^3
	No.5 (SK-2)	18.4 m	14.6 m	0.75 m^3
Hopper Dredger	H-12	Hopper capacity: 400 m^3		

Source: Annual Implementation Report (Fiscal year 2000), CDMD, HD

The Cutter Suction Dredges are of various discharge pipe diameters: two large (20”), one small (14”) and one mini pipe (4”). The Backhoes have 2-bucket capacity of 0.75 m^3. The Hopper Dredger has a 1 hopper capacity of 1400 m^3. It was just assigned this year and is made in Germany.

(b) Outputs and Expenses of Dredgers

Expense and dredged volume are data recorded in the Annual Implementation Report of the Coastal Dredging and Maintenance Division (CDMD) of the Harbour Department (HD), Ministry of Transport and Communications. According to this report, dredging work is divided into two types: Dredging by CDC II equipment and Dredging by Contractors. The data from 1996-2000 is presented in the following Tables.

Table 7.2.2-4 Summary of Budget and Volume for Dredging Work on CDC II Channels

(a) Dredging by CDC II Equipment				
Year	Budget (baht)	Volume (m^3)	Number of channel	
1996	14,026,264	2,016,138	10	
1997	19,890,676	2,434,969	10	
1998	25,315,246	2,438,736	16	
1999	23,660,520	2,046,528	15	
2000	26,538,011	4,548,094	26	
Total (a)	**109,430,717**	**13,484,465**		
(b) Dredging by Contractor				
Contract Yr	Budget (baht)	Volume (m^3)	Channel name	Contractor
1996	6,899,796	108,000	Ku Khud-Laem Vang	Thai Sellveg Engineering
1996	19,999,000	338,100	Pak Phaying	Italian-Thai Development
1997	3,279,000	62,800	Ban Tan Yong Phao	Italian-Thai Development
1997	90,170,000	1,656,628	Pak Phanang	Italian-Thai Development
1998	1,820,000	260,500	Khlong Kok Kean	PSI Engineering
1998	6,899,500	105,000	Ku Khud-Laem Vang	Italian-Thai Development
Total (b)	**129,067,296**	**2,531,028**		

Source: Annual Implementation Report (Fiscal year 1996-2000), CDMD, HD

Table 7.2.2-6 Dredging by Contractor

Fiscal year	1996	1997	1998	1999	2000
Period	1 Oct 96 - 30 Sep 97	1 Oct 97 - 30 Sep 98	1 Oct 98 - 30 Sep 99	1 Oct 99 - 30 Sep 00	1 Oct 00 - 30 Sep 01
Channel	**Ku Khud-Laem Vang**	**Ban Tan Yong Phao**	**Ku Khud-Laem Vang**	No engaging	No engaging
Sign	30 Sep 1996	15 Aug 1997	29 Sep 1998	contractor	contractor
Working period	15 Oct 96 - 12 Apr 97	14 Sep 97 - 13 Mar 98	14 Oct 98 - 10 Feb 99	in CDC II area	in CDC II area
Contractor	Thai Sellveg Engineering	Italian-Thai Development	Italian-Thai Development		
Budget : Baht	6,899,796.00	3,279,000.00	6,899,500.00		
Volume : m^3	108,000	62,800	105,000		
Distance : m	1,850	1,650	-		
Contract period	180 days	6 months	4 months		
Channel	**Pak Phaying**		**Khlong Kok Kean**		
Sign	30 Sep 1996		25 Aug 1998		
Working period	15 Feb 97 - 22 Aug 98		23 Sep 98 - 22 Sep 99		
Contractor	Italian-Thai Development		PSI Engineering		
Budget : Baht	19,999,000.00		18,200,000.00		
Volume : m^3	338,100		260,500		
Distance : m	5,500		44,500		
Contract period	360 days		12 months		
Channel		**Pak Phanang**			
Sign		14 Aug 1997			
Working period		13 Sep 97 - 12 Sep 99			
Contractor		Italian-Thai Development			
Budget : Baht		90,170,000.00			
Volume : m^3		1,656,628			
Distance : m		27,000			
Contract period		24 months			

Source: Annual Implementation Report (Fiscal Year 1996 - 2000), CDMD, HD

2) HD Conclusions and Countermeasures

HD focuses on the fact that the capacity of equipment is insufficient to dredge the large volume of siltation in the many channels of CDC II. In their Comment in September 2001, they state that the yearly dredging volume is 6.10 million m^3 and hence they conclude that the capacity of dredging equipment is insufficient since it can only handle 3.5 million m^3. However, the equipment capacity has not been verified.

In the following table, the dredged volume from Section 7.2.2, 1) has been rearranged by dredger type.

Table 7.2.2-7 Dredged Volume by Equipment 1996-2000

Unit: m^3

Equipment	1996	1997	1998	1999	2000
Hopper	1,372,830	1,398,400	1,042,500	1,038,710	2,790,800
20" Cutter	358,890	472,500	553,770	433,560	867,225
14" Cutter	144,458	351,327	459,568	296,880	478,600
BackHoe	139,960	212,742	382,898	277,378	411,469

Source: Annual Implementation Report (Fiscal Year 1996 - 2000), CDMD, HD

Based on this data, the following Figure 7.2.2-1 shows that the dredged volume doubled in 2000 primarily due to an increase in the number of Hoppers.

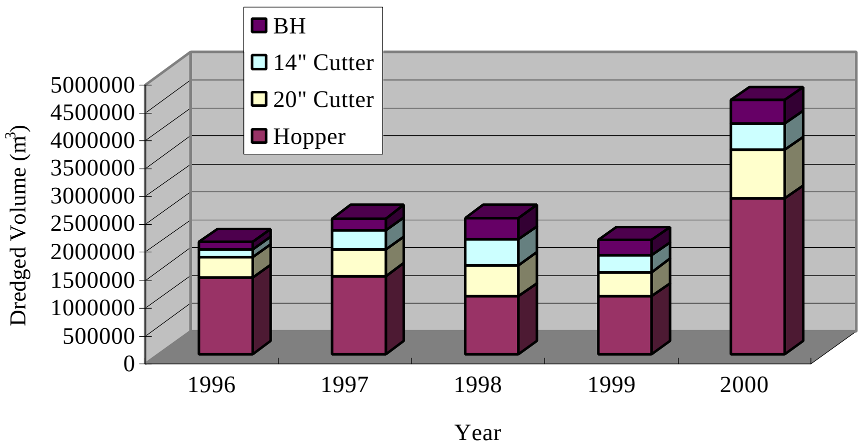


Figure 7.2.2-1 Dredged Volume by Kinds of Dredger, 1996 to 2000

Source: Annual Implementation Report (Fiscal Year 1996 - 2000), CDMD, HD

To solve the problem of insufficient capacity of dredgers, HD started using C-25 and C-37 Cutter Suction Dredges with a 20” pipe where before they had used a only 14” inch pipe dredger (C-1). This is viewed as increasing efficiency and decreasing unit cost since the volume of work is larger and yet the operating crew remains the same.

3) JICA Findings

(a) Expense and Volume recorded in HD

Expenses and volume for only maintenance dredging in Fiscal year 1996 to 2000 have been examined and computed. As a result, expenses for both Pak Phanang and Songkhla channel maintenance turned out 75% of total. In volume, maintenance dredging for both Pak Phanang and Songkhla channels turned out (see Table 7.2.2-8 and Figure 7.2.2-2). In conclusion, although there are 44 channels in CDC II, the improvement of channel maintenance of the two channels, Pak Phanang and Songkhla will mostly contribute to the performance of CDCII. The study, therefore, focused on these two channels.

(b) C-25 and C-37

C-25 and C-37 are viewed as the wrong type of equipment for the channels in terms of discharge length and channel depth. These dredges are designed for more than 1000 m discharge length but the actual discharge length which is more or less 200 m, is far short of this. JICA Study Team measured the water velocity of C-25 at Pak Phanang. It was 7-8 m/sec as described in section 7.1.4 “Actual Observation of Dredging of Navigational Channels”. The velocity is too large and output per hour is remarkably small. It should be controlled to the adequate level of 4.5 –5.5 m/sec.

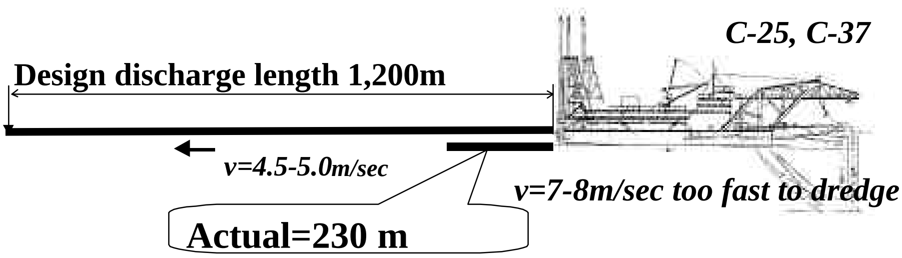


Figure 7.2.2-3 Design and Actual Discharge Length

The design dredging depth of the equipment (10 m) was not meant for shallow work. Hence, the angle of cutter and ladder are not adequate for the 2 to 5 m actual shallow depth dredging. It is difficult, therefore, to take the excavated soil into the suction pipe.

Table 7.2.2-8 Share of Expense & Volume for Maintenance Dredging (1996 - 2000)

Name of Channels	Expenses		Volume	
	(Baht)	(%)	(m^3)	(%)
Pak Phanang	93,944,802	53%	2,073,898	16%
Songkhla	39,359,525	22%	6,856,000	51%
Pattani	9,659,110	6%	796,217	6%
Other channels	4,097,495	19%	3,595,176	27%
Total	175,851,564	100%	13,321,291	100%

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000

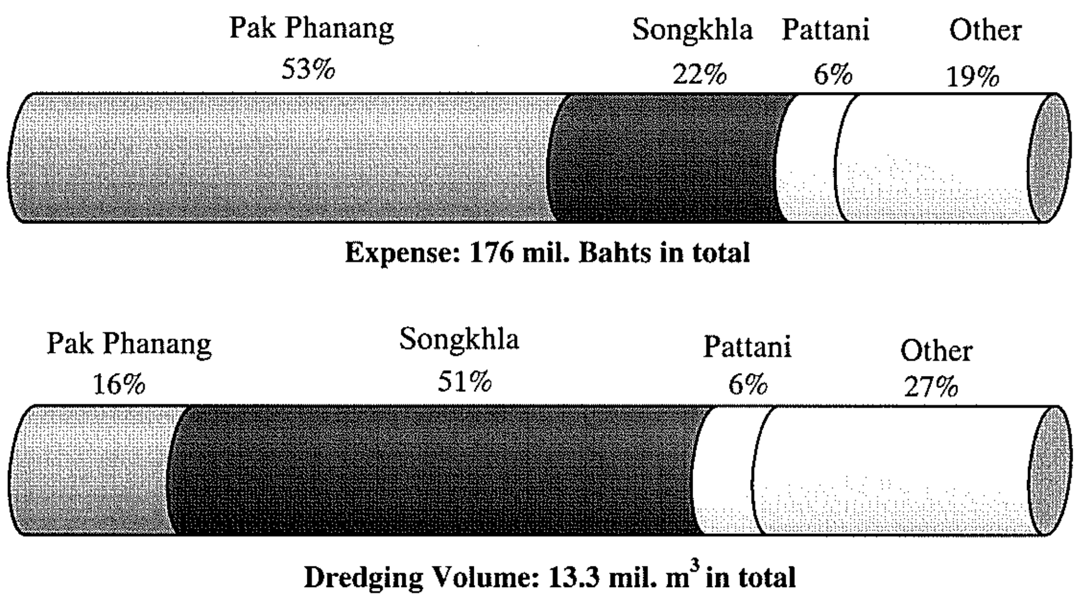


Figure 7.2.2-2 Share of Expenses & Volume for Maintenance

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000

Table 7.2.2.-9 Expense & Volume of Initial and Maintenance Dredging (1996 - 2000)

Channel Type - Name	1996		1997		1998		1999		2000		Total (1996 - 2000)		Maintenance Dredging excluding Initial Dredging (1996-2000)			
	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (%)	Volume (%)
1. Big 6 channels																
Khanom outer channel									899,941	118,020	899,941	118,020	899,941	118,020	1%	1%
- outer channel part 1																
- outer channel part 2																
- outer channel part 3																
Pak Phanang	2,875,968	358,890	898,834	58,380	**90,170,000**	**1,656,628**					93,944,802	2,073,898	93,944,802	2,073,898	53%	16%
Songkhla	6,632,839	981,600	9,908,038	1,398,400	7,718,789	1,019,200	4,991,722	817,200	10,108,136	2,639,600	39,359,525	6,856,000	39,359,525	6,856,000	22%	51%
- deep sea port																
- inner channel																
Pattani (Cutter)	1,497,164	77,657					949,007	114,820	2,482,054	299,040	4,928,225	491,517	4,928,225	491,517	3%	4%
Pattani (Hopper)					899,957	23,300	2,298,168	130,200	1,532,759	151,200	4,730,884	304,700	4,730,884	304,700	3%	2%
Narathiwat			1,428,708	207,060			724,160	91,310	2,054,089	212,400	4,206,957	510,770	-	-	0%	0%
Ko lok **					8,588,932	553,770	8,755,774	433,560			17,344,706	987,330	-	-	0%	0%
2. Midium 18 channels																
Khanom inner channel							1,500,000	63,250			1,500,000	63,250	1,500,000	63,250	1%	0%
Sichon			748,127	60,540			761,311	75,840	209,213	31,185	1,718,651	167,565	1,718,651	167,565	1%	1%
Khlong Tung Ca (Ban Tepa)											-	-	-	-	0%	0%
Tha Mak											-	-	-	-	0%	0%
Pak Duad									232,818	32,052	232,818	32,052	232,818	32,052	0%	0%
Tha Sala			959,347	108,903	2,261,751	214,143	1,302,404	42,970			4,523,502	366,016	-	-	0%	0%
Pak Phaying			**19,999,999**	**338,100**							19,999,999	338,100	-	-	0%	0%
Pak Phun			1,642,826	181,884					2,301,210	381,780	3,944,036	563,664	3,944,036	563,664	2%	4%
Pak Paya											-	-	-	-	0%	0%
Pak Nakhon		391,230			1,994,077	190,155					1,994,077	581,385	1,994,077	581,385	1%	4%
Nathap					539,887	99,540			299,400	31,034	839,287	130,574	839,287	130,574	0%	1%
Nathap					695,320	55,270					695,320	55,270	695,320	55,270	0%	0%
Thepa	912,834	66,801							295,457	44,307	1,208,291	111,108	1,208,291	111,108	1%	1%
Sakhom									694,810	84,590	694,810	84,590	694,810	84,590	0%	1%
Ban Ku Khud-Ban Laem Vang	**6,899,796**	**108,000**			**6,899,500**	**105,000**					13,799,296	213,000	-	-	0%	0%
Sai Buri	631,978	41,280	1,806,571	207,060			258,356	30,240	899,885	71,125	3,596,791	349,705	3,596,791	349,705	2%	3%
Panare	216,280	17,400	586,943	71,190	392,751	49,640	261,880	23,688			1,457,854	161,918	1,457,854	161,918	1%	1%
Tawa (Nong Jig)									632,428	58,300	632,428	58,300	632,428	58,300	0%	0%
Tak Bai																

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000

Note: [shaded box] : Initial Dredging

Bold: Dredging by Contractor

Table 7.2.2.-10 Expense & Volume of Initial and Maintenance Dredging (1996 - 2000) (Cont'd)

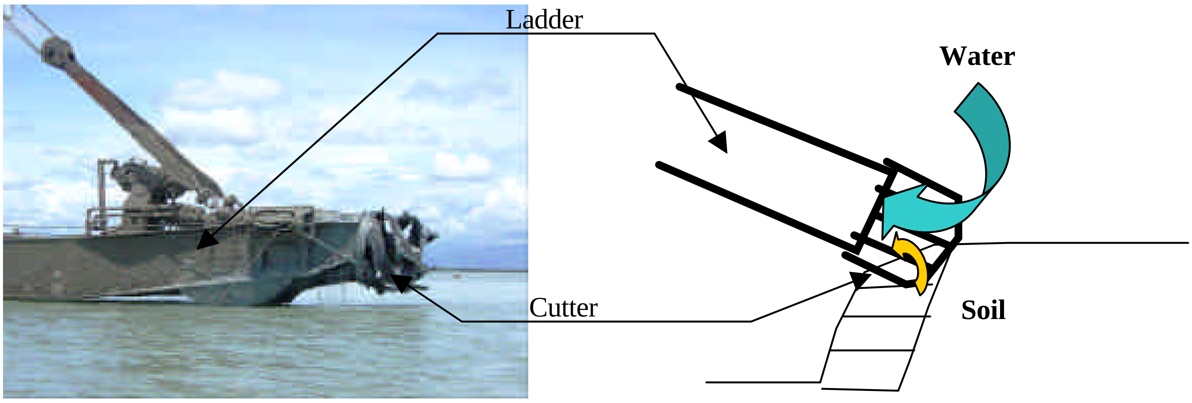
Channel Type - Name	1996		1997		1998		1999		2000		Total (1996 - 2000)		Maintenance Dredging excluding Initial Dredging (1996-2000)			
	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (Baht)	Volume (m^3)	Budget (%)	Volume (%)
3. Small 20 channels																
Lake Songkhla (Thale Noi)			1,241,669	39,612	1,465,950	128,318					2,707,619	167,930	2,707,619	167,930	2%	1%
Chalae **									294,862	32,318	294,862	32,318	294,862	32,318	0%	0%
Khlong Mahakan											-	-	-	-	0%	0%
Khlong Chiang Phong											-	-	-	-	0%	0%
Ban Mai											-	-	-	-	0%	0%
Sala Tham											-	-	-	-	0%	0%
Hua Pa											-	-	-	-	0%	0%
Khlong Sam Rong											-	-	-	-	0%	0%
Bang Lieng ** (Takhria)									149,800	12,312	149,800	12,312	149,800	12,312	0%	0%
Bang Rapa	255,318	14,640									255,318	14,640	255,318	14,640	0%	0%
Ban Sai Samor									227,633	21,732	227,633	21,732	227,633	21,732	0%	0%
Tan Yong Phao	518,965	32,060	**3,279,000**	**62,800**					299,530	40,695	4,097,495	135,555	4,097,495	135,555	2%	1%
Bang Maruad	484,916	34,580			458,028	57,990	856,634	97,662			1,799,578	190,232	1,799,578	190,232	1%	1%
Ta Lo La Veng					299,804	47,410	214,980	26,320	191,613	22,642	706,398	96,372	706,398	96,372	0%	1%
Khlong Gor Tor											-	-	-	-	0%	0%
Laem Ta Chee			669,613	101,940							669,613	101,940	669,613	101,940	0%	1%
Khlong Tu Yong											-	-	-	-	0%	0%
Rusamilae							409,903	62,154			409,903	62,154	409,903	62,154	0%	0%
Kae Kae ** (Lam Pam)							335,607	22,090			335,607	22,090	335,607	22,090	0%	0%
Khlong Kok Kean					**1,820,000**	**260,500**					1,820,000	260,500	1,820,000	260,500	1%	2%
Grand total of CDC II																
4. Channels not including the above channels																
Ban Pra Mor									298,154	38,198	298,154	38,198	-	-	0%	0%
Bang Pumee							30,750	7,776			30,750	7,776	-	-	0%	0%
Fisheries pre consevation Songkhla									360,169	19,686	360,169	19,686	-	-	0%	0%
Khlong Ban Klang										696	-	696	-	-	0%	0%
Khlong Nang Liam									372,501	17,997	372,501	17,997	-	-	0%	0%
Khlong Ra Nod									378,340	22,551	378,340	22,551	-	-	0%	0%
Pak Bang Phum									373,040	44,064	373,040	44,064	-	-	0%	0%
Singhanakhon									950,169	120,570	950,169	120,570	-	-	0%	0%
Songkla Navy Base							9,864	7,448			9,864	7,448	-	-	0%	0%
Grand total implemeted Fiscl Year 1996-2000											238,499,011	16,015,493	175,851,564	13,321,291	100%	100%

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000

Note: [shaded box] : Initial Dredging

Bold: Dredging by Contractor

In addition, dredging starts downward from the top 30-40 cm layer. This also attributes to the small output of the dredging.



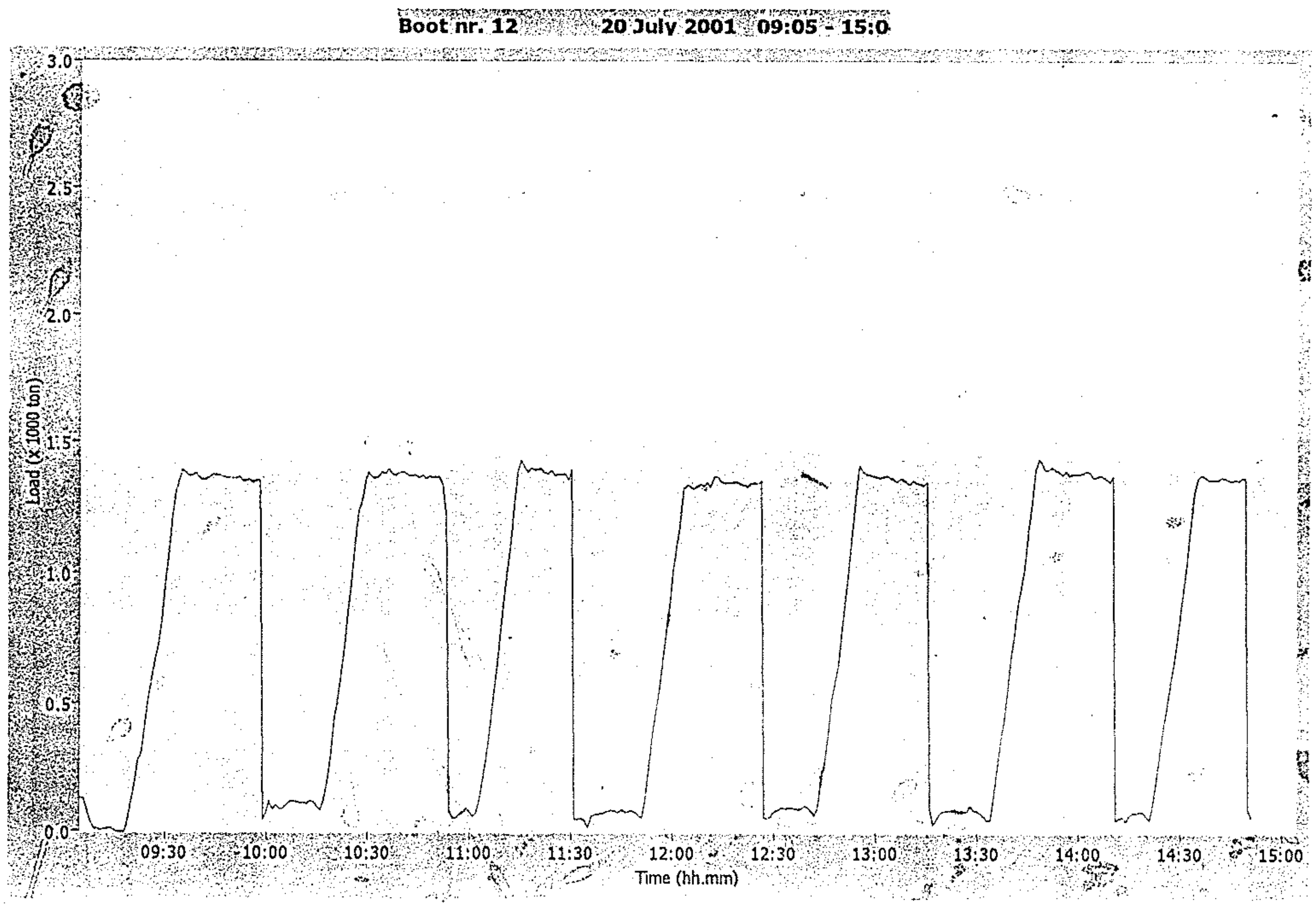
c) Dredged Volume Calculation of Cutter Suction Dredger

Harbour Department currently recorded the dredged volume which is obtained by multiplying a certain hourly production volume by dredging hours. The recorded volume is not obtained by pre and post dredging surveys. For this reason, in view of JICA Study Team, actual production outputs of C-25 and C-37, of which Harbour Department asserts the hourly production volume as 450m^3/hr, may be a half to one-third of recorded volume.

d) Trailing Suction Hopper Dredger

Figure 7.2.2-4 is the record of loading of H12 on July 20, 2001. The recorded line shows the loaded weight with respect to time. The gradually increasing line, top horizontal line, sharp decreasing line and bottom horizontal line indicate the dredging, traveling to disposal area, dumping, traveling back to the dredging area respectively. Because H-12 has a 1,400m^3 hopper capacity and its maximum loading is about 1,400tons, the record shows that the hopper was full of water with a small amount of soils. It also shows that the net dredging hour is about 105 minutes only (15 minutes x 7 cycles) whereas the operation was about 6 hours (360 minutes)

Hence it is recommended to increase excavation time and thus increase output per day.



Source: HD

Figure 7.2.2-4 Loading Record of H-12

e) Evaluation of Present Channel Depth

In spite of dredging work in the past, Songkhla and Pak Phanang still have insufficient depth for vessels. The design depth for Songkhla channel is -9 m but its actual depth is -6.5 m and the depth in front of the wharf is only -5 m. Hence the draft of calling vessels is kept less than 5m. The present depth for Pak Phanang channel is –2m against a design depth of –4m. PTT tankers can only be loaded to less than 50% of their capacity.

Only Songkhla and Pak Phanang are channels the lacking sufficient channel depth for vessels. Other channels have sufficient depth now. Whereas Songkhla, Pak Phanang and Pattani channels need to be dredged every year, other channels need to be dredged only once in several years just to maintain adequate depth for vessels.

f) Heavy Siltation in Pak Phanang Channel

Siltation is very heavy in Pak Phanang channel. From March to December in 1998, a contractor dredged the whole channel, removing 2.68 million m^3 – 1.65 million m^3 to a depth of -4 m plus 1.03 million m^3 of over-dresging. After 1.5 years, siltation of 1.65 million m^3 above the -4m had already take place (see Figure 7.2.2-5). This suggests that about 1.0 million m^3, excluding over-dredging, has to be dredged every year to maintain Pak Phanang channel.

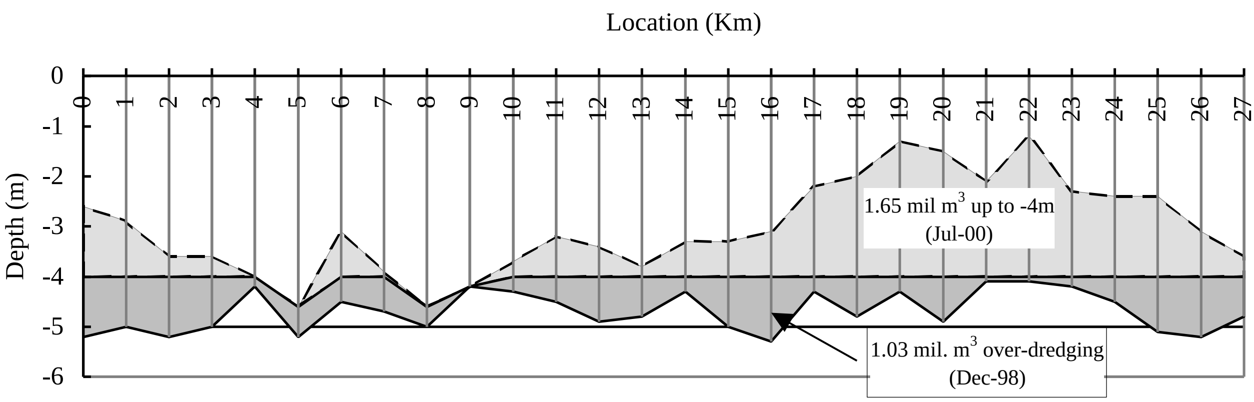


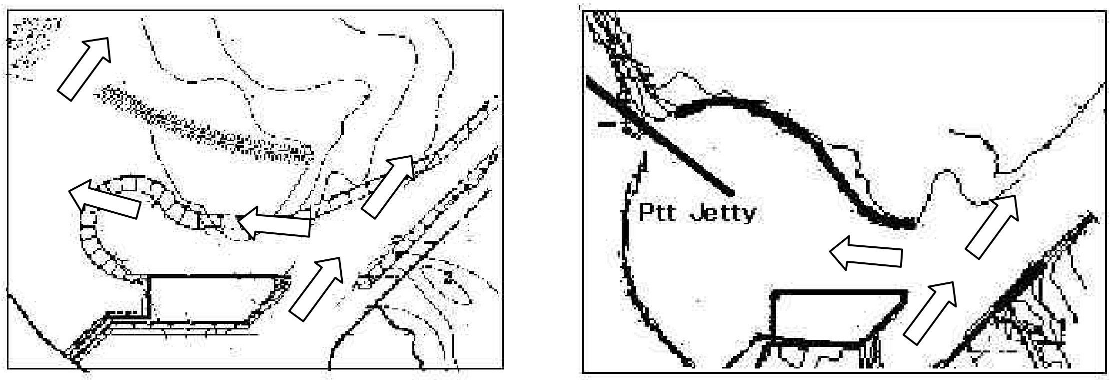
Figure 7.2.2-5 Siltation Volume in Pak Phanang Channel

g) Songkhla Findings

Siltation in the basin

When the breakwater was constructed, one part of the breakwater opened to the sea. When the PTT Jetty was later constructed, this part was closed to protect this jetty from collision with the tankers cased by waves and current. However after closing of the breakwater, heavy siltation started in the harbour basin area in front of wharf.

Seawater causes flocculation of freshwater from Songkhla Lake at the mouth of the basin. The flock moves in two directions: one is out to the sea and the other is into the basin. Before when part of breakwater was open, the flock flowed out to the sea through the breakwater opening, but now the flock cannot flow out. Hence it settles inside the basin area (see Figure 7.2.2-6).



before closing after closing

Figure 7.2.2-6 Flow Direction of Flock in Songkhla

Seabed materials in the channel

Hydorographic survey and Soil sampling were done by JICA Study Team from August 27 to September 4, 2001 to check the channel depth and seabed materials to be dredged. The samples were taken at SKC1 to SKC4 and SKK1 (see Figure 7.2.2-7). The hydrografic survey found the shallowest part of the channel was –6 to –7m. This part had no soil samples and was claimed too hard to dredge.

In October, therefore, the JICA Study Team conducted additional soil sampling at C1 to C3 covering the shallowest part of the channel. The sampling was done in witness of HD official. The results are shown in Table 7.2.2-9. The team and HD official confirmed that the shallowest part was dredgable. Later, in the HD headquarters, captains of the hopper dredgers and officials also confirmed the materials were soft enough to dredge.

Sampling Location are shown in Figure 7.2.2 -7

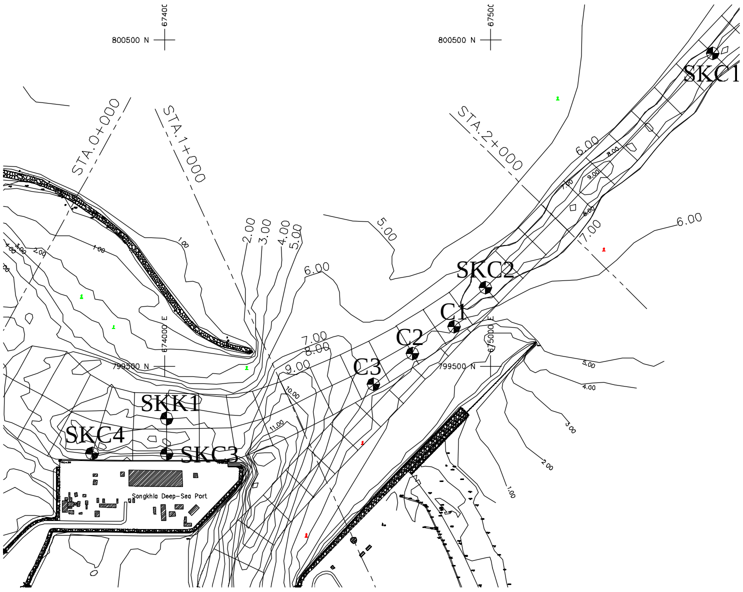


Figure 7.2.2-7 Seabed Sampling Location

Table 7.2.2-11 Type of Soil

Sample No.	SKC1	SKC2	C1	C2	C3	SKC3, SKK1	SKC4
Location	Sta.2 + 700	Sta.2 + 700	Sta.1 + 550	Sta.1 + 400	Sta.1 + 250	Sta.0 + 600	Sta.0 + 400
Soil	Marine Mud	Silty Sand	Silty Sand	Clay	Marine Mud	Marine Mud	Marine Mud
Wet Density	1.4 (t/m^3)	2.0(t/m^3)	2.0 (t/m^3)	1.6 (t/m^3)	1.4 (t/m^3)	1.4 (t/m^3)	1.4 (t/m^3)

Shallow wharf

In front of the container wharf where the shallowest part is -5 m, a hopper dredger cannot operate because of two factors: because its arm may be damaged if it hits the wharf and because vessels are calling frequently. Hence, another type of dredger is needed for this area.

Dredging volumes to –9m

Computation was made on survey data obtained this time. For a design depth of -9 m, the volume is 900,000 m^3 in September 2001 (see Table 7.2.2-12). With an additional amount of over-dredging of 480,000 m^3 (4 km length x 120 m width x 1 m height), the total volume to be dredged is 1.38 million m^3. From February to September 2001, HD achieved the net excavation of 230,000m^3.

Table 7.2.2-12 Volume to be dredged based on the survey in Songkhla Channel

	Survey in Feb. 2000 by HD			Survey in Sep. 2001 by JICA Team		
Station No.	up to -8.0 m (V1)	-8.0 to -9.0 m (V2)	V1+V2	up to -8.0 m (V1)	-8.0 to -9.0 m (V2)	V1+V2
	m^3	m^3	m^3	m^3	m^3	m^3
STA.0+ 000						
STA.0+ 422	13,715	35,870	49,585	5,655	15,230	20,885
STA.0+ 674	9,765	41,265	51,030	7,167	17,387	24,554
STA.0+ 837	16,300	29,136	45,436	17,356	19,220	36,576
STA.1+ 000	15,281	16,300	31,581	14,905	13,857	28,761
Sub-total (Basin Area)	**55,061**	**122,571**	**177,633**	**45,083**	**65,693**	**110,776**
STA.1 000			0			0
STA.1+ 300	22,050	21,300	43,350	33,600	21,000	54,600
STA.1+ 674	52,790	50,116	102,906	76,507	49,742	126,249
STA.2+ 174	62,700	63,000	125,700	71,738	52,215	123,953
STA.2+ 674	66,825	63,000	129,825	42,685	41,175	83,860
STA.3+ 174	61,050	63,000	124,050	38,660	51,960	90,620
STA.3+ 674	48,675	63,000	111,675	29,618	62,988	92,605
STA.4+ 174	25,575	59,750	85,325	8,225	54,010	62,235
STA.4+ 674	0	42,425	42,425	38	35,280	35,318
STA.5+ 000	0	9,242	9,242	0	8,318	8,318
Sub-total (Channel Area)	**394,726**	**557,404**	**952,131**	**346,152**	**442,381**	**788,533**
Ground Total	**449,788**	**679,976**	**1,129,763**	**391,235**	**508,074**	**899,309**

The volume to be dredged up to –9.0m based on the survey in Feb. 2000: 1,129,763 m^3 (a)

The volume to be dredged up to –9.0m based on the survey in Sep. 2001: 899,309 m^3 (b)

The difference between February 2000 and September 2001 is 230,000 m^3 (c)=(a) – (b)

h) Sichon Findings

After the pre-dredging survey on March 16 to 26 , 2001, dredging of Sichon channel by C-37 lasted till April 20, and post-dredging survey was conducted by JICA Study Team on September 15 to 16, 2001. Although, the dredging was intended up to –2m, JICA survey shows shallower part of the channel as hatched in Figure 7.2.2-9.

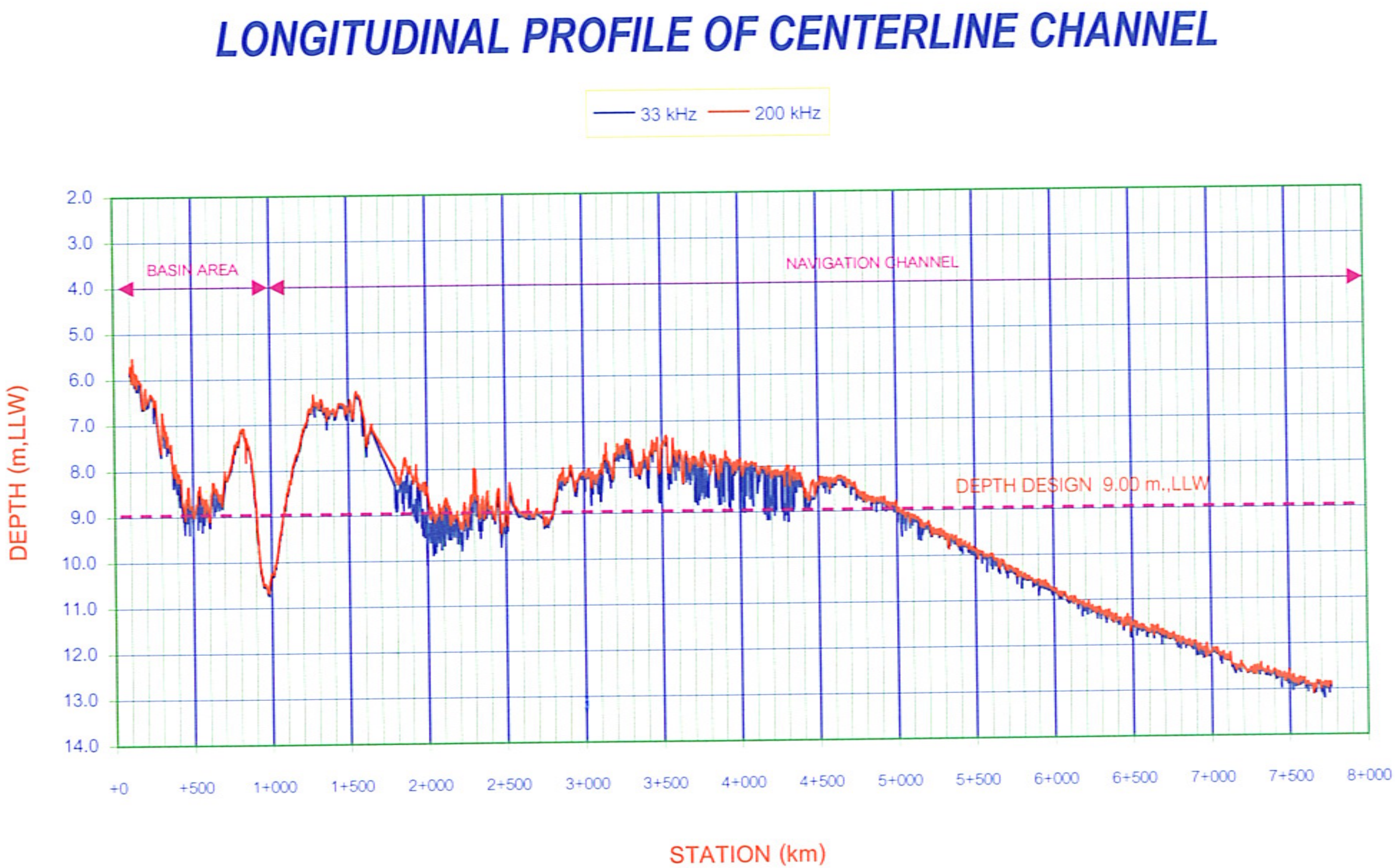


Figure 7.2.2-8 Longitudinal Profile of Centerline Channel

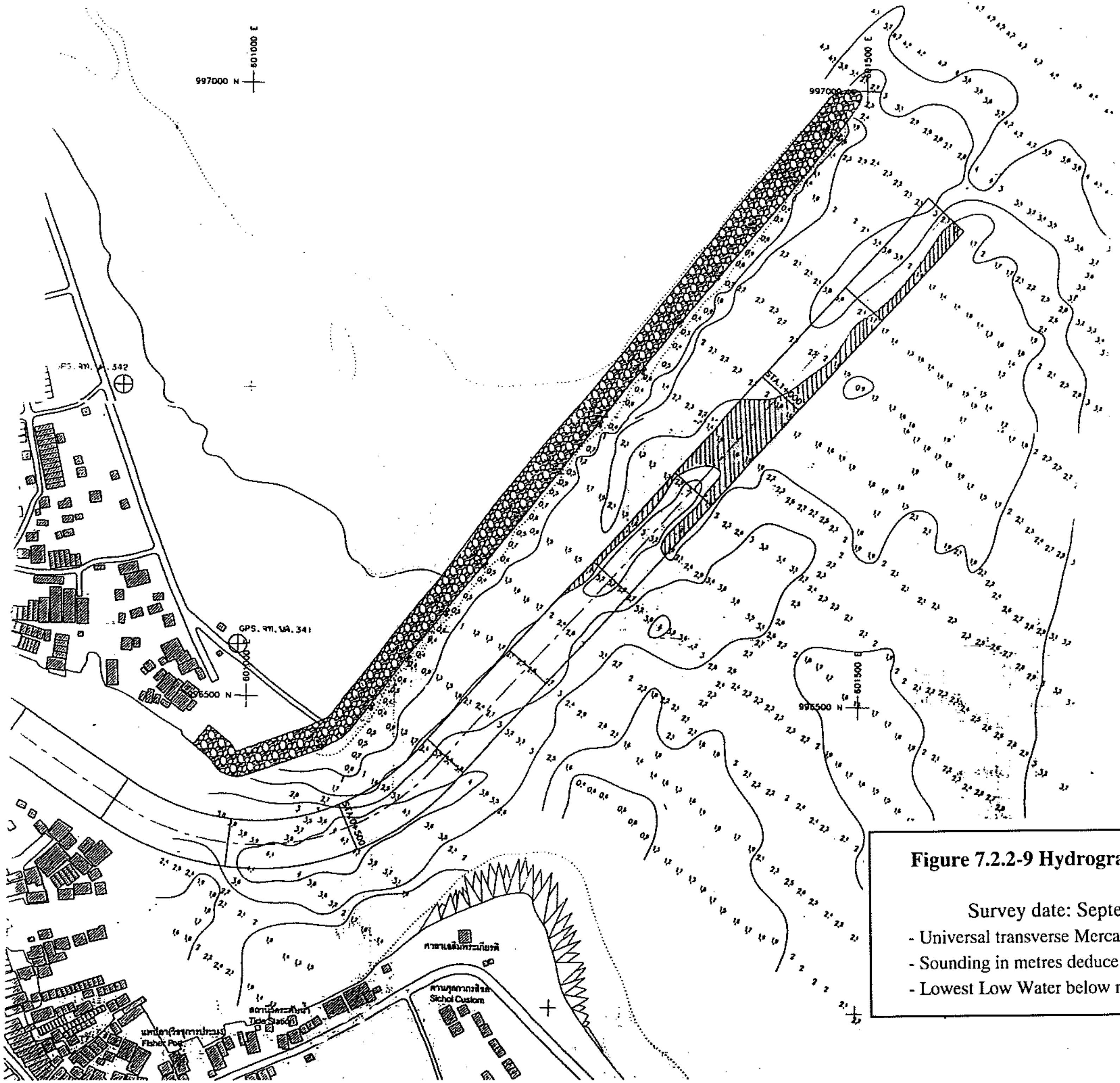


Figure 7.2.2-9 Hydrography of Sichon Channel

Survey date: September 15-16, 2001

- Universal transverse Mercator production grid Indian Datum
- Sounding in metres deduce to lowest low water
- Lowest Low Water below mean sea level = 1.00m

3) Recommendations for improving operation output

(a) Diffuser at the end of discharge pipe

The vacuum of suction pipe should be set 150-160 mmHg for water only before starting excavation, in order to dredge a high concentration material and achieve high dredging output. The design discharge pipe length of C-25 and C-37 is more than 1,000m, but actual discharge takes place at 200m. It is therefore impossible to control the velocity to get an adquate vacuum. For operation of these dredgers, a diffuser should be put at the end of the pipe to reduce its diameter to 50%-70% or to about 14". When dredging pump engine starts, the rpm should be increased gradually so the vacuum gauge can be maintained at 150-160 mmHg. In case the engine cannot be stabilized, the size of the diffuser nozzle needs to be reduced. This process needs to be repeated until the engine becomes stable and a vacuum can be maintained 150-160 mmHg. Thereafter dredging work should continue at this rpm level. When the dredging pump starts with only water, the vacuum should be kept 150-160 mmHg, which in terms of water velocity will be 5.5 m/sec (see Figure 7.2.2 -10).

Figure 7.2.2-10 Diffuser at the End of Discharge Pipe

(b) Cutter position against the ground to be dredged

For the Cutters, the ladder should be placed at such a position that the excavation face be two times of the cutter diameter. If the section to be dredged is thin, the top of cutter may be welded and closed somewhat to narrow the entrance of the suction pipe. This may achieve greater efficiency.

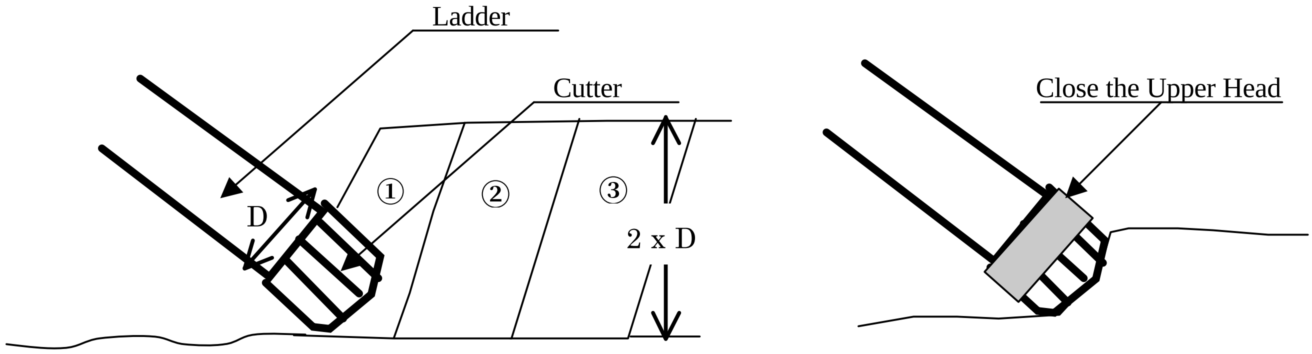


Figure 7.2.2-11 Cutter Position against the Ground to be Dredged

(c) Increase the advance distance for one Spud in Pak Phanang Channel

Work needs to focus on the location 15-24 km from estuary which is very silted. Care needs to be taken not to overdredge since it is a waste of time. The fact that overdredging has occurred in the past suggests that the pattern of dredging should be changed to rooster-cone sweeps using two spuds rather than parallel sweeps using one spud (see Figure 7.2.2-12). Using the rooster-cone sweeps, 14 km (or at least more than 10km) can be accomplished [where 70 m advance x 2 boats x 20 days x 5 months = 14 km].

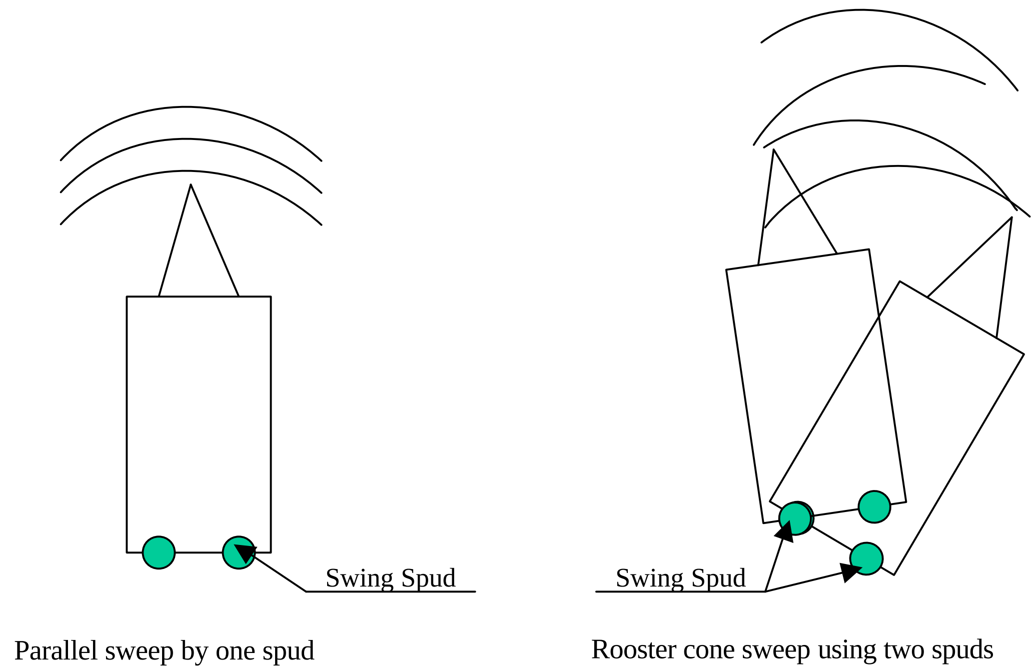
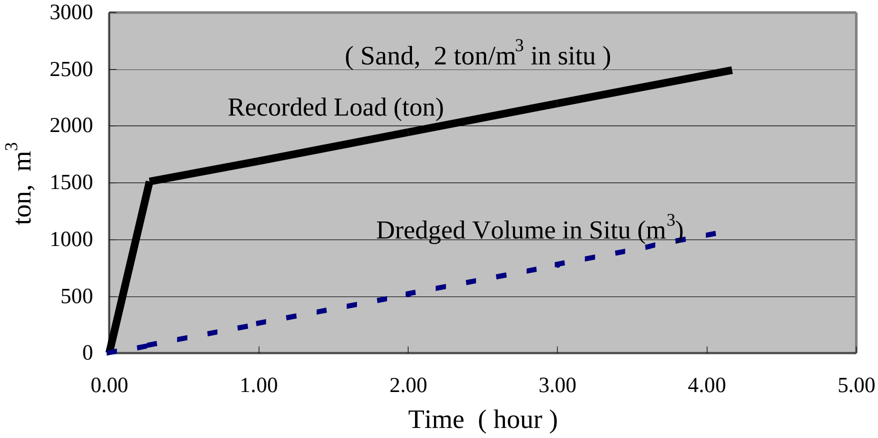


Figure 7.2.2-12 Parallel Sweep and Rooster Cone Sweep

(d) Increase loading time of Hopper Dredger

In order to increase the dredging volume and thus maximize the daily output, dredging needs to be done continuously for about 5 hours before going to disposal area. The loading record will appear as shown in Figure 7.2.2-4.



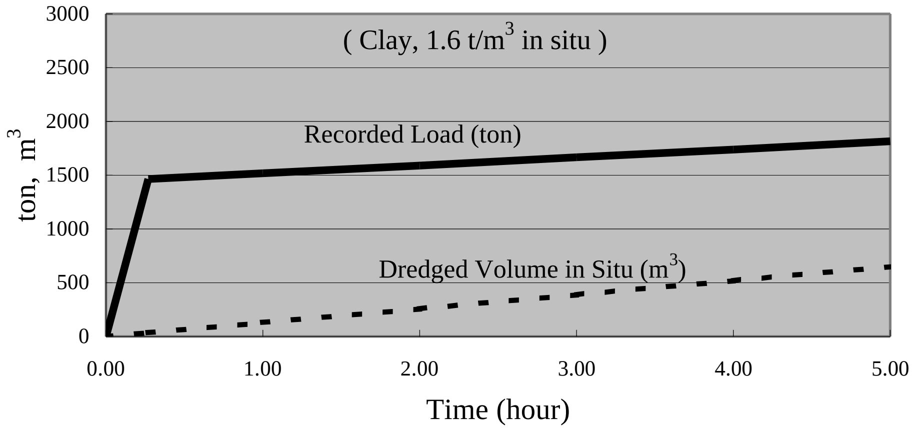


Figure 7.2.2-4 Loading Records of Continuous Operation for Sand and Clay Soil Dredging

5) Management control should be improved. Currently, the procedure is to make a pre-survey and then check results once after the work is finished which means only once in 1.5-2.0 years. Instead it is recommended to survey the whole area, determine the shallowest places and set dredging priorities. Work surveys should be made every 1-2 weeks and daily records should be made of time worked and tonnage carried. The goal of daily monitoring and recording system is to try to optimize the volume of soil/water through control of several variables: pump engine rpm, speed of dredger, strength of suction mouth and weight of suction pipe.

(e) Global Positioning System (GPS)

It is recommended that Global Positioning System (GPS) be used to monitor the Cutter Suction Dredges C-25 and C-37 in Pak Phanang to confirm their work positions (see Figure 7.2.2 -14). A control reading should be taken to establish GPS accuracy. Software should be used for recording daily positions. GPS is also recommended for the Hopper Dredger in Songkhla to increase the accuracy of the path of the dredger (see Figure 7.2.2 -15).

Figure 7.2.2-14 GPS for Cutter Suction Dredger

Figure 7.2.2-15 GPS for Trailing Suction Hopper Dredger

(4) Dredging Program of Navigational Channels

1) Dredging at Pak Phanang channel takes such a long time due to the length of the channel that there is insufficient time to maintain the design depth if a single dredging pass is made. This is due to the volume of 1.0 million m^3/yr that must be dredged. Therefore, it is recommended to use C-25 and C-37 simultaneously in parallel on this channel.

2) For Songkhla, there are three recommendations.
   (1) The initial dredging objective should be to achieve a depth of -8 m channel depth and -9 m depth in front of the wharf. This will allow for unloading at the wharf even during low tide, and 10,000 DWT vessels can enter the channel during high tide.
   (2) At a second stage, the channel depth should be increased to –9 m so that even during low tide, vessels can enter the channel.
   (3) The method of dredging in front of the wharf should be studied. Trailing Suction Hopper Dredge cannot be used since it can hit the wharf. Also the Grab is not possible below –8 m because of hitting. Hence the Backhoe should be used to a depth of –8 m. Then the work should be switched to Cutter since it can perform accurate depth control. It is even possible to consider using only Cutter Suction Dredge for the entire work should the wharf be free from vessel berthing for a certain period of time.

3) Recommended Maintenance Dredging Program (see Table 7.2.2-13)
   (1) Channels should be categorized by the type of dredgers:
   Trailing Suction Hopper Dredger (C-1) or 20" Cutter Suction Dredger (C-25, C-37) or 12"Cutter Suction Dredger & Back Hoe and Mini Cutter Suction Dredger C-39

   (2) Hopper dredger should be used in Songkhla and Pattani channels

   (3) C-25, C-37 should be used at the deeper depth channel in Pattani (-5m), Khanom outer channel (-5m), and Pak Phanang (-4m). They can be used at the shallow depth channels (-2m) in Pak Nakhon, Pak Paya, Pak Phun and Pak Phaying.

   (4) 14" Cutter Suction Dredger should be used where the channel has a shallow depth –2m and protected with jetties.

   (5) Back Hoe should be used on channels with no jetty. And back Hoe & C-39 should be used in Songkhla Lake

   (6) The volume to be dredged should be estimated from the past dredging record, the forecasting of siltation, and the present depth of channels.

Table 7.2.2-13 Recommended Maintenance Dredging Equipment Plan

Channel Type - Name	Dredging Equipment
1. Trailing Suction Hopper Dredger	
Songkhla	H-10, H-12
Pattani, Laem Ta Chi	H-2, H-4, H-8
2. Cutter Suction Pump Dredger **(a) 20" type C25, C37**	
Pak Phanang	C-25, C-37
Pattani (Cutter) Pak Nakhon, Pak Paya, Pak Phun, Pak Phaying, Khanom outer channel, Narathiwat	C-25, C-37, (C-1)
(b) 14" type C1	
Khanom inner channel, Sichon, Tha Sala, Nathap, Sakhom, Thepha, Bang Ra Pha, Ko Lok, Panare, Bang Maruad , Sai Buri, Tan Yong Phao, Tawa (Nong Jig), Tak Bai	C-1
3. Back Hoe, C39	
Khlong Tung Ca (Ban Tepa), Tha Mak, Pak Duad, Ban Sai Samor, Rusamilae, Khlong Tu Yong, Khlong Gor Tor, Ta Lo La Veng, Khlong Kok Kean, Chalae (Pak Rawa)	BH
(Lake)	
Thale Noi, Hua Pa, Takhria, Sala Tham, Ban Mai, Khlong Chiang Phong, Khlong Mahakan, Ban Ku Khud, Lam Pam, Khlong Sam Rong	BH, C-39