5.2.2 Duration of Equipment Use

The possible duration of equipment use, which is a basic condition in deciding the required quantities of equipment, is as follows.

(1) Average Daily Working Hours

Judging from the working conditions at the site, it will be appropriate in this Project to use the equipment for one 8-hour work shift as is usual in the Philippines. Within these 8 working hours, 2 hours will be utilized for preparation and clearing away (transportation, adjustment and maintenance of equipment). Therefore, the duration of actual operation per day will be 6 hours, without allowing for operation stoppage due to weather conditions such as rain.

(2) Working Days Per Year

Since the equipment is to be used on esteros and stormwater drains (drainage mains/outfalls and laterals), the number of days the equipment can be operated will be affected by the quantity of rainfall. In this connection, the number of hours of interrupted equipment operation due to the quantity of rainfall was standardized as below from the actual experience in Japan.

Table 5-1. Interruption of Operation Due to Daily Rainfalls

Daily Rainfall	Interruption Per Day (hours)
Less than 1 mm	0
1 mm to 10 mm	3
10 mm to 12 mm	4
12 mm to 15 mm	5
More than 15 mm	6

Note: Net working hours taken as 8 hours per day.

The frequency of daily rainfalls recorded in the project area for the period from 1974 to 1988 is as shown in Table 5-2.

Table 5-2. Frequency of Daily Rainfalls (1974-1988)

Range of Daily Rainfall	Number of Days (Monthly Average from 1974 to 1988)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Below 1 mm	29.0	27.5	30.4	28.2	24.7	14.8	14.6	10.0	12.4	13.2	20.3	25.3	250.4
1 mm to 10 mm	1.5	0.6	0.6	0.8	3.0	7.4	8.5	8.5	9.6	9.4	6.2	3.7	59.8
10 mm to 12 mm	0.1	0.0	0.0	0.1	0.6	0.9	1.6	0.7	1.9	0.5	0.7	0.2	7.3
12 mm to 15 mm	0.1	0.0	0.0	0.2	0.4	1.1	0.9	1.8	0.7	0.9	0.7	0.6	7.4
Over 15 mm	0.3	0.1	0.0	0.7	2.3	5.8	5.4	10.0	5.4	7.0	2.1	1.2	40.3

Note: Observed at Port Area Gauging Station, City of Manila

From the standard interruption of equipment operation due to rainfall (refer to Table 5-1) and the records of daily rainfall in the project area (refer to Table 5-2), the monthly interruption days in the project area are estimated at 8.7 days as the average value during the rainy season and 1.4 days during the dry season. In addition to the interruptions due to rainfall, interruptions due to holidays/equipment repair are taken as 5 days per month. Taking these interruptions into account, the number of possible equipment operation days per month is estimated as below (refer to Table 5-3).

- Rainy Season (June to November) : 17 days
- Dry Season (December to May) : 24 days

Making allowances for the time taken up in preparation work and disassembly/maintenance of equipment, the number of days of equipment operation during the first year is estimated as follows. In this case, allowances are made for an interruption of one month in the dry season for preparation work/trial operation of equipment and for one month in the rainy season for disassembly/maintenance.

(24 days x 5 months + 17 days x 5 months) = 205 days approx.

In subsequent years, the number of days of equipment operation is estimated as follows. Allowance is made for an interruption of one month in the rainy season for disassembly/maintenance.

(24 days x 6 months + 17 days x 5 months) = 230 days approx.

(3) Total Operation Time of Equipment

The service life of the large construction machinery to be used for the Project (dump trucks, wheel cranes, clamshell rollers, etc.), according to past records in Japan, is approximately 7,000 hours. In view of the term of the drainage system retrieval project (planned period: 5 years) and the service life of the equipment, 5 years seem to be the appropriate duration of use of the procured equipment.

Table 5-3(1/2). Monthly Workable Days
(Average: 1974-1988)

Rainy Season (June to November)

Description	Jun	Jul	Aug	Sep	Oct	Nov	Ave
(1) Total Interruption Hours of Operation Due to Rainfall	66.1	68.8	97.3	72.3	76.7	37.5	69.8
(2) Interruption Days of Operation Due to Rainfall	8.3	8.6	12.2	9.0	9.6	4.7	8.7
(3) Interruption Days of Operation Due to Holidays/Equipment Repair	5.0	5.0	5.0	5.0	5.0	5.0	5.0
(4) Total Interruption Days of Operation	13.3	13.6	17.2	14.0	14.6	9.7	13.7
(5) Workable Days During the Rainy Season	16.7	17.4	13.8	16.0	16.4	21.3	16.9

Note: (2) = (1) / (Daily Basic Work Hours: 8 Hours)

Table 5-3(2/2). Monthly Workable Days
(Average: 1974-1988)

Dry Season (December to May)

Description	Dec	Jan	Feb	Mar	Apr	May	Ave
(1) Total Interruption Hours of Operation Due to Rainfall	22.1	7.2	2.4	1.8	8.0	27.2	11.5
(2) Interruption Days of Operation Due to Rainfall	2.8	0.9	0.3	0.2	1.0	3.4	1.4
(3) Interruption Days of Operation Due to Holidays/Equipment Repair	5.0	5.0	5.0	5.0	5.0	5.0	5.0
(4) Total Interruption Days of Operation	7.8	5.9	5.3	5.2	6.0	8.4	6.4
(5) Workable Days During the Dry Season	23.2	25.1	22.9	25.8	25.0	21.6	23.9

Note: (2) = (1) / (Daily Basic Work Hours: 8 Hours)

5.2.3 Work Volume

The following are the work volumes for unclogging the laterals and drainage mains/outfalls and dredging the esteros.

(1) Laterals

Diameter of Drain (inch)	Length (m)	Work Volume (m^3)
12	30,846	1,092
18	44,273	3,522
24	94,226	13,324
30	17,365	3,958
36	6,453	2,156
42	661	303
Total	193,824	24,355

(2) Drainage Mains/Outfalls

Class	Length (m)	Work Volume (m^3)
Box Culvert with Rectangular Concrete Maintenance Hole, 1.5 to 4.4 m in width	15,283	55,345
Box Culvert with Circular Steel Maintenance Hole, 18 inches in diameter	4,340	12,160
Total	19,623	67,505

(3) Esteros

Class	Length (m)	Work Volume (m^3)
Large Esteros (Vitas, Sunog Apog)	2,920	146,450
Small Esteros (Maypajo, Reina, Valencia, Paco, Pandacan, Tripa de Gallina)	10,502	73,215
Total	13,422	219,665

5.3 Equipment Plan

5.3.1 Method of Retrieval

Laterals

There are three alternative methods to remove sediment in the laterals.

(1) Bucket Machine Method

Sediment is removed by introducing a bucket with wire rope into the drains and then withdrawing it using a winch.

(2) Manual Cleaning Method

The principle of this method is similar to the bucket machine method, except that the bucket is withdrawn by hand. This method has been conventionally adopted in Metro Manila, but work efficiency is extremely low and the bucket is impossible to introduce in drains clogged completely with sediment.

(3) Water Jet Cleaning Method

Sediment in the drains is broken into watery mud by pressurized water ejected by a water jet cleaner and then sucked up by a vacuum cleaner. The vacuum cleaner separates the water from the sediment, discharging the water back into the drains and loading the sediment into the dump truck at the site. This method has the highest efficiency among the three methods cited unless a water supply is difficult to obtain.

Laterals in the city of Manila have an extremely high sediment accumulation rate of more than 50% and the first two methods will not be efficient in removing the sediment. As for the water jet cleaning method, permission to use the fire hydrants installed along main streets has been obtained and this will minimize the time to supply water to the water jet cleaner while increasing work efficiency. The water jet cleaning method will also minimize the generation of foul odors during the removal and transportation of sediment, since the vacuum cleaner separates the foul water from the sediment and returns it into the drains without being exposed to the air.

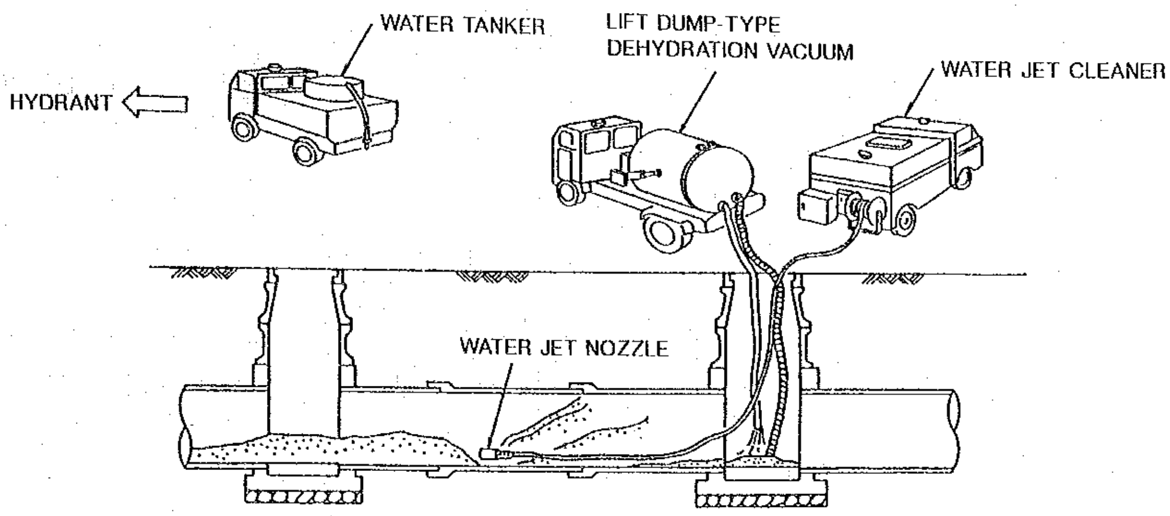
From the above consideration, the water jet cleaning method will be employed for the retrieval of laterals. The general concept of this method is as illustrated in Fig. 5-2.

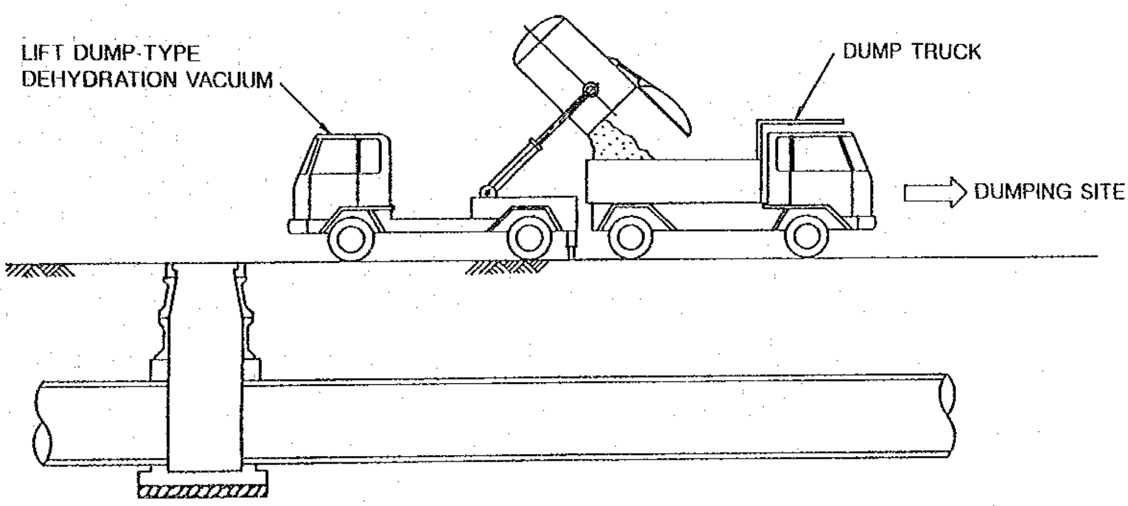
Drainage Mains and Outfalls

There are also three alternative methods to remove sediment from the drainage mains and outfalls.

(1) Pumping Method

This method is performed by using a submersible sand pump or a vacuum pump to suck the sediment from the drains. This is regarded as having the highest efficiency among the three alternatives unless the sediment contains large solid materials. Furthermore, this method does not require the closure of a stream and pumping out of water from the drains, so that retrieval work can be performed throughout the year in both the rainy and dry seasons. It is, however, difficult to employ this method when there is a large accumulation of garbage in the deposits that can easily choke the suction pump. Since the sediment in existing drainage mains/outfalls contains a great volume of solid waste, this method is not applicable.





THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-2 RETRIEVAL PLAN FOR LATERAL
JAPAN INTERNATIONAL COOPERATION AGENCY	

(2) Dragline Method

A crane with attachments collects sediment with a dragline bucket and then removes and dumps the sediment collected around culverts into dump trucks at the site by the use of a clamshell bucket. Although work efficiency is lower than the pumping method, the dragline method is not influenced by the contents of the sediment and it can be employed in both the rainy and dry seasons. It is, however, difficult to employ this method where the maintenance hole is too small to introduce a dragline bucket or a clamshell bucket into the drains.

(3) Manual Cleaning Method

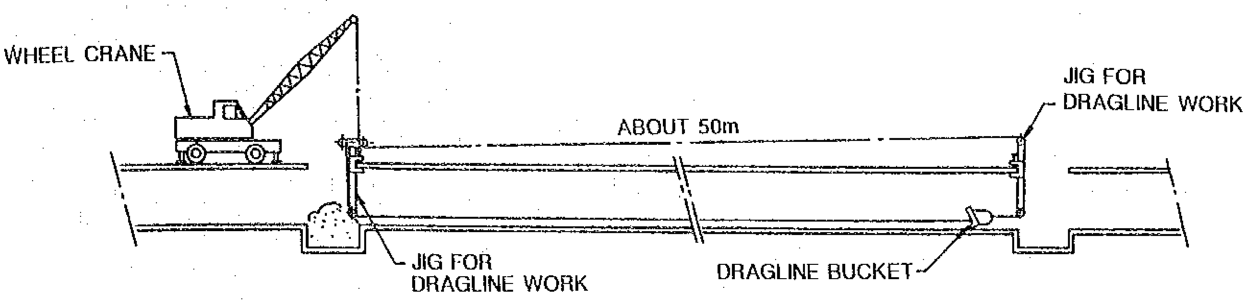
This method is not influenced by the content of the sediment; however, work efficiency is extremely low and this method requires stopping of a stream and pumping out of water from the drains for the safety of working personnel. Therefore, this method can be applied only during the dry season.

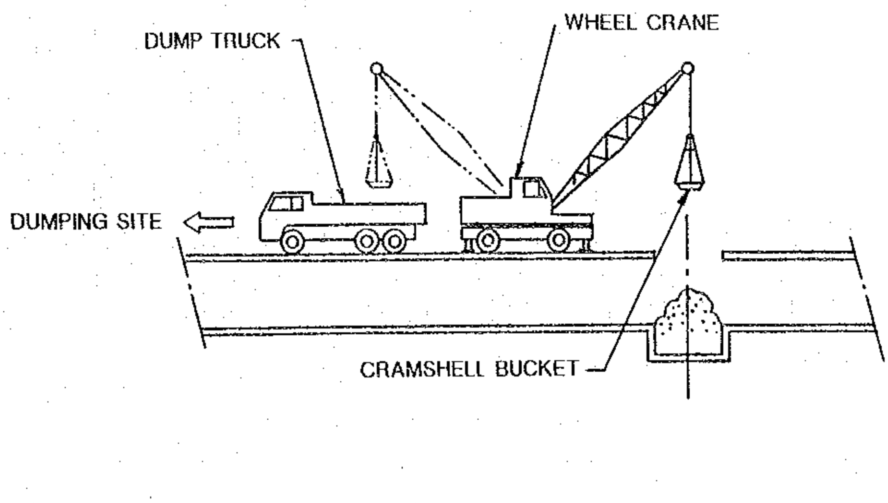
The existing drainage mains/outfalls in the project area are classified into two groups. One group has rectangular concrete maintenance holes 1.5 to 4.4 m in width, and the other has circular steel maintenance holes 18 inches in diameter. For the drainage mains/outfalls with concrete maintenance holes, the dragline method is recommended considering that both the dragline bucket and the clamshell bucket can be introduced into the drains through the maintenance hole and high work efficiency is expected. The general concept of this method is illustrated in Fig. 5-3.

As for the drainage mains/outfalls with steel maintenance holes, it is very difficult to introduce the dragline or the clamshell bucket, and so the manual cleaning method is the only applicable one. The general concept of the manual cleaning method is illustrated in Fig. 5-4.

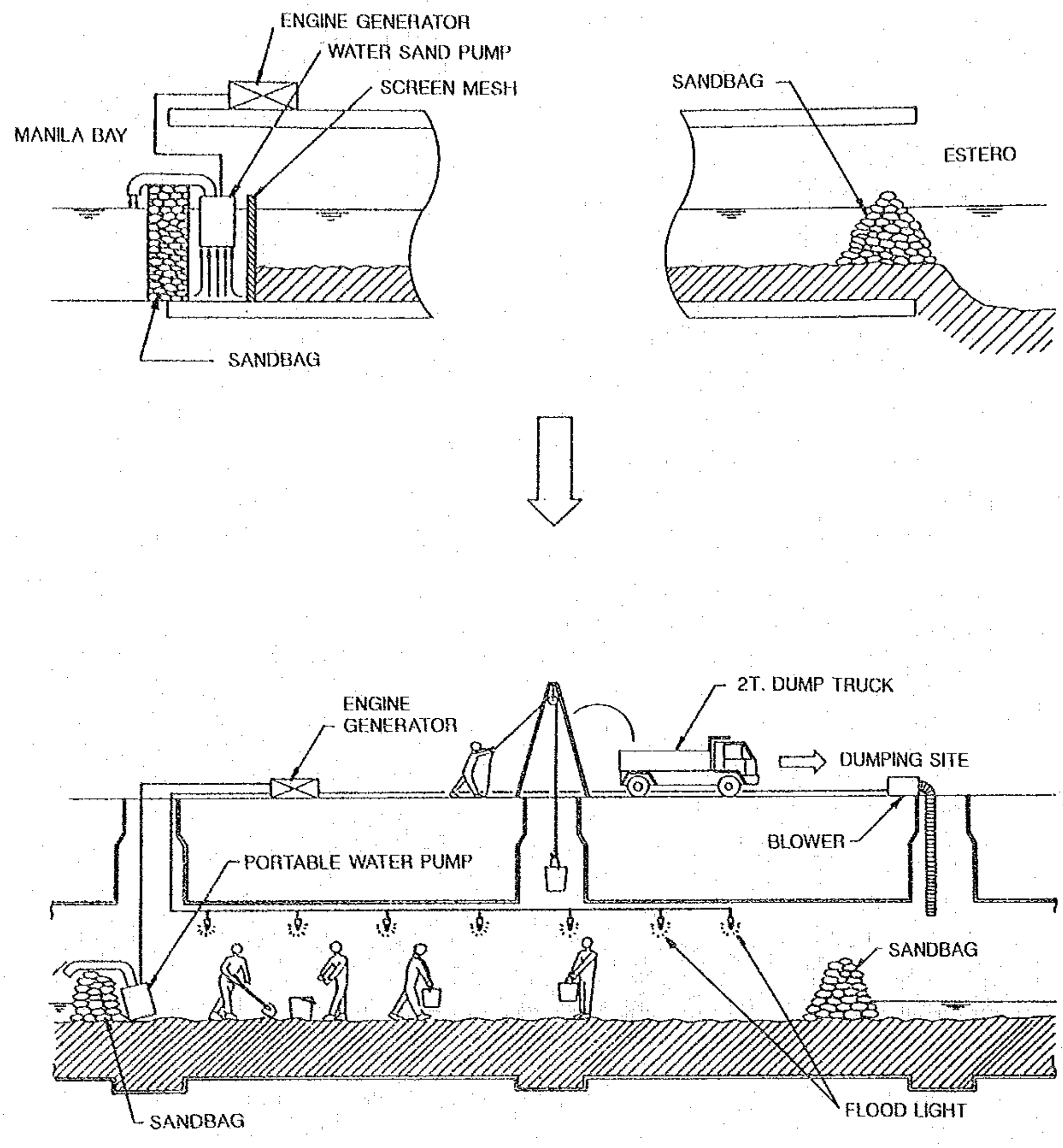
Esteros

There are two alternative methods to dredge esteros as described hereinafter.





THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 5-3 RETRIEVAL PLAN FOR DRAINAGE MAIN AND OUTFALL (IN CASE OF CONCRETE MAINTENANCE HOLE)



THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-4 RETRIEVAL PLAN FOR DRAINAGE MAIN AND OUTFALL (IN CASE OF ø 18" STEEL MAINTENANCE HOLE)
JAPAN INTERNATIONAL COOPERATION AGENCY	

(1) Pump Dredging Method

This method requires the use of a dredging barge equipped with submersible sand pump to suck out the sediment in the esteros. High work efficiency is expected from this method if the sediment to be dredged does not contain large solid materials.

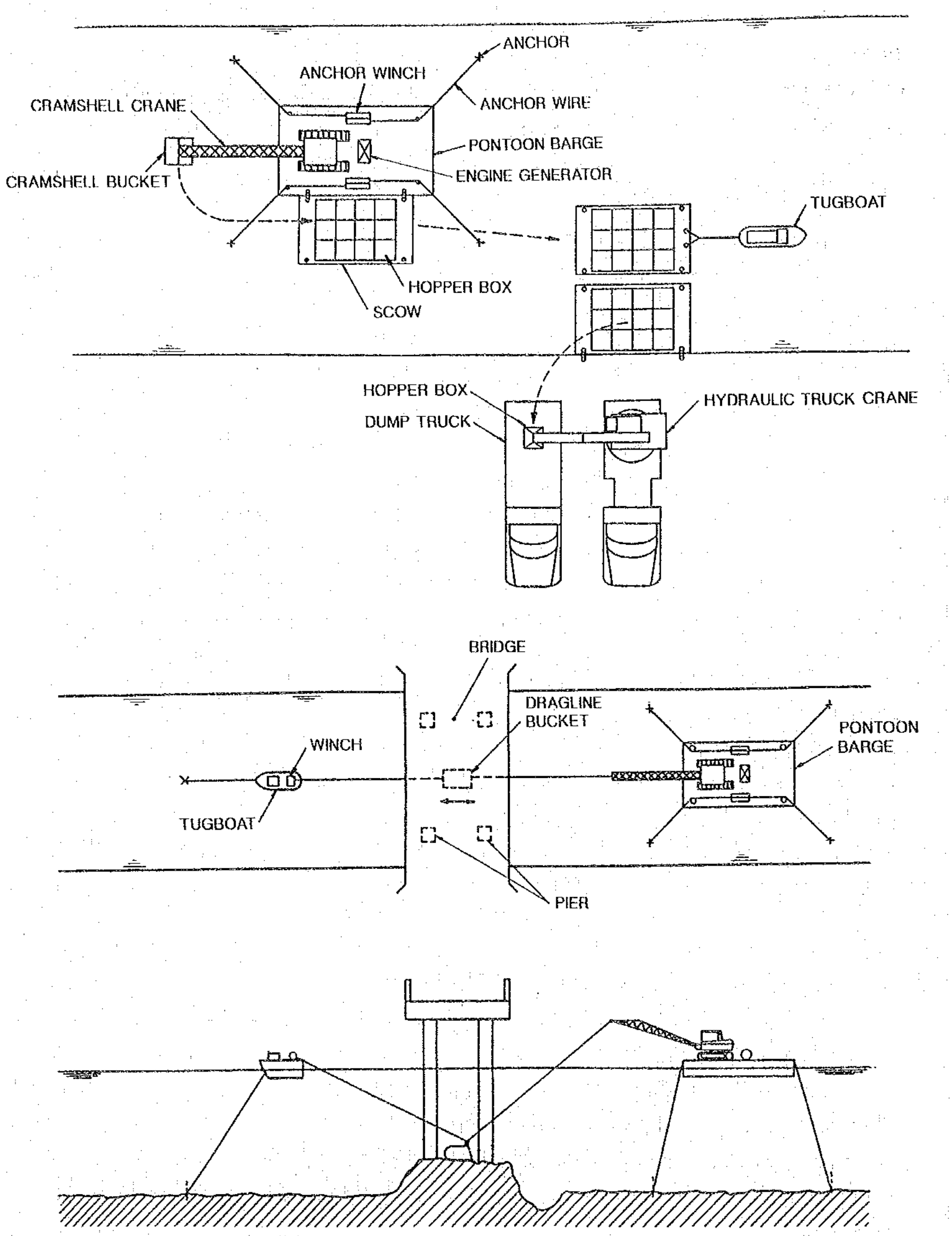
(2) Glove Dredging Method

This method requires the use of a glove attached to either the barge or another vehicle. Although the work efficiency of this method is lower than that of the pump dredging method, it is not influenced by the content of the sediment to be dredged.

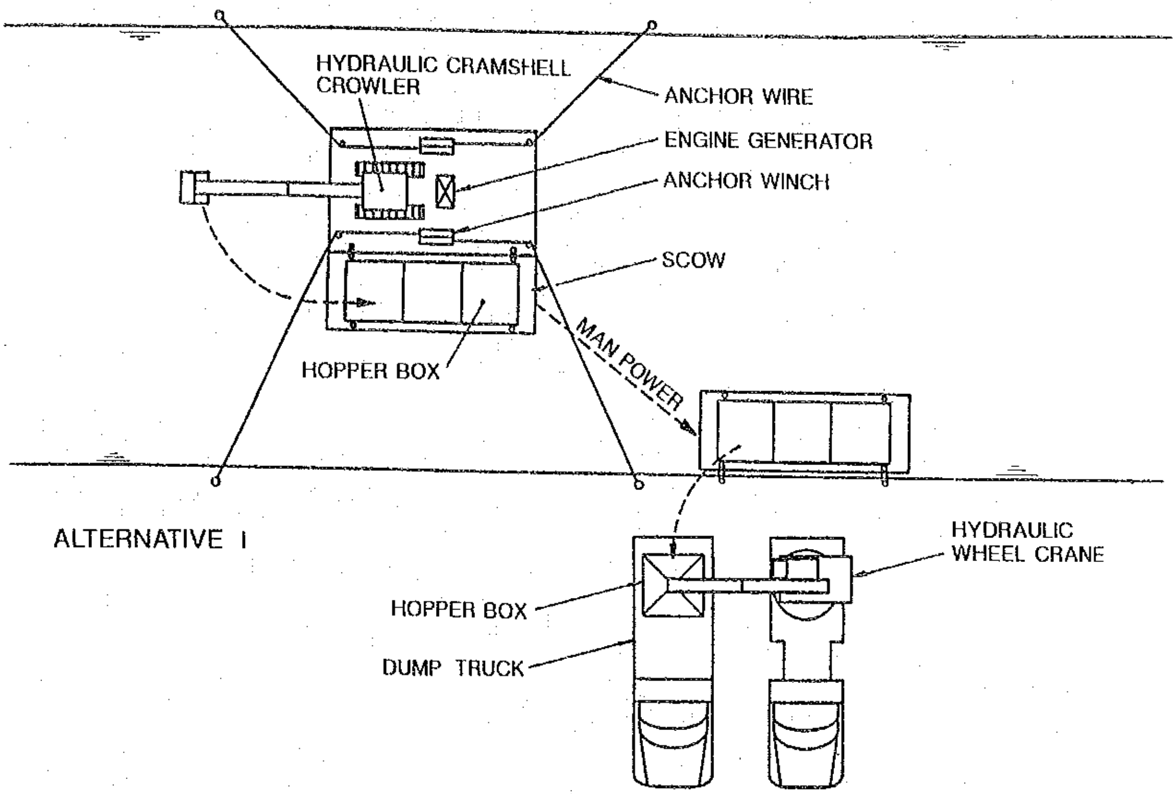
The sediment in the existing esteros contains a great volume of sizeable garbage, and the pump dredging method, if employed, will experience frequent breakdowns of its suction pump. Hence, the glove dredging method is the only applicable method to dredge esteros. Glove dredging will be performed by the use of a pontoon barge floating on the waterways because overland access is difficult. Two types of clamshell will be employed according to the size of esteros.

The Estero de Vitas and the Estero de Sunog Apog have rather wide and deep channels and the clearance of structures crossing them would allow the passage of middle-sized dredgers with a glove capacity of 0.6 m^3. This is in consideration also of the volume to be dredged from the two esteros which account for about 70% of the total dredging volume from esteros. The general concept of the glove dredging method is illustrated in Fig. 5-5.

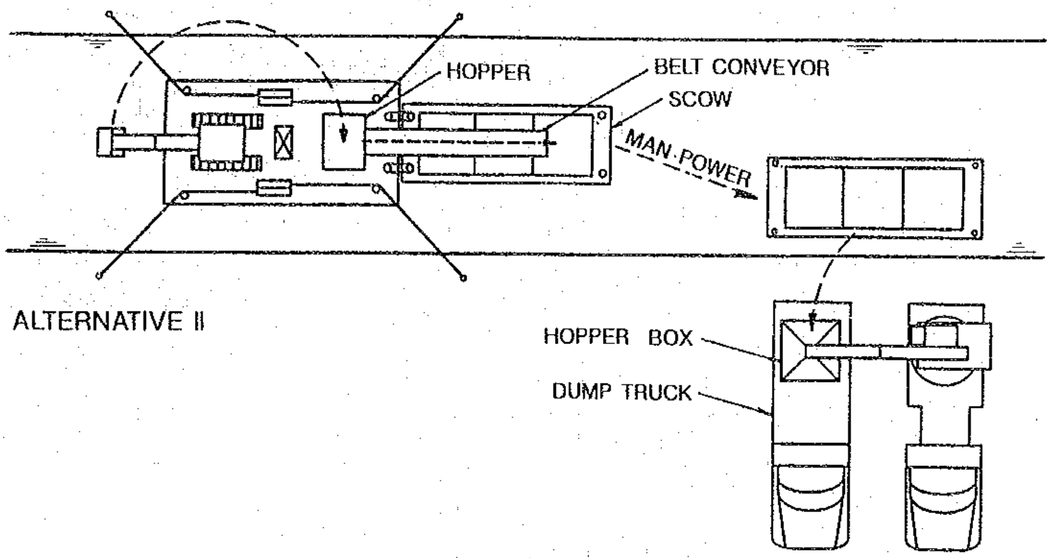
As for the other six esteros of Maypajo, Reina, Valencia, Paco, Pandacan and Tripa de Gallina, the middle-sized glove dredger with 0.6 m^3 capacity cannot pass through their channels due to the small width/depth and the small clearance of crossing structures. Therefore, a smaller size of dredger with a glove capacity of 0.2 m^3 which is also easy to dismantle and reassemble at the jobsite will be employed. The general concept of this dredging method is as illustrated in Figs. 5-6 and 5-7. It is herein assumed that the manual dredging method will be employed in esteros with illegal dwellers where the mechanical dredging method is deemed to be difficult.



THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-5 RETRIEVAL PLAN FOR LARGE ESTERO
JAPAN INTERNATIONAL COOPERATION AGENCY	

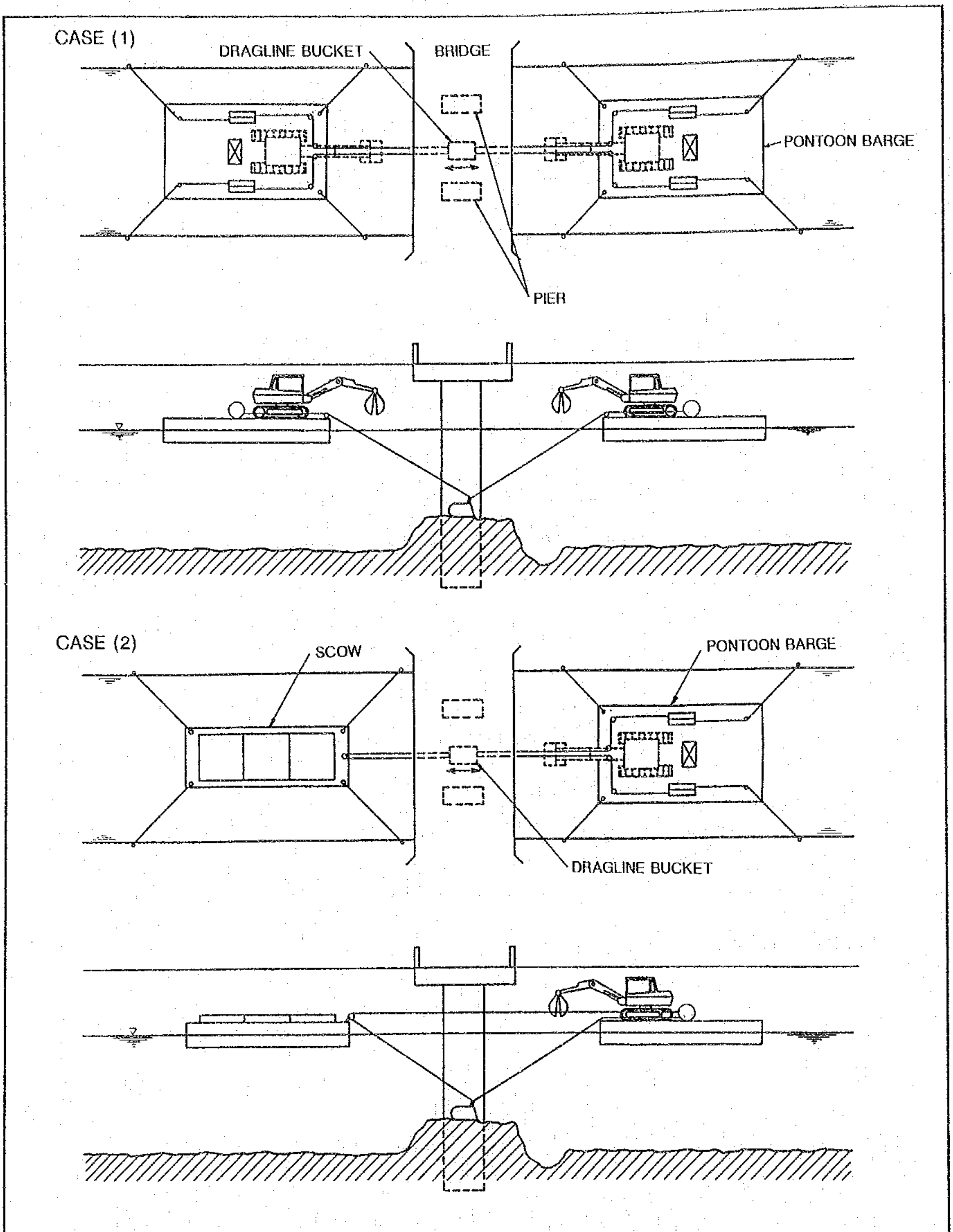


ALTERNATIVE I



ALTERNATIVE II

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-6 RETRIEVAL PLAN FOR SMALL ESTERO
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-7 RETRIEVAL PLAN FOR SMALL ESTERO (BRIDGE PORTION)
JAPAN INTERNATIONAL COOPERATION AGENCY	

5.3.2 Required Functions of the Equipment

Described below are the functions of the equipment for the proposed retrieval work on laterals, drainage mains/outfalls and esteros.

Retrieval Work on Laterals

Removal of sediment from laterals will be done with the use of water jet cleaners of the type commonly used in Japan. The functions of the water jet cleaner and other machinery for the retrieval work on laterals are summarized as follows.

(1) Water Tanker

The water tanker supplies water to the water jet cleaner.

(2) Water Jet Cleaner

The water jet cleaner ejects the pressurized water supplied from the water tanker into the lateral, breaking down the sediment into watery mud.

(3) Lift Type Dehydration Vacuum Cleaner

The vacuum cleaner sucks up the watery mud and separates the water from the sediment in its tank. The water is discharged into the lateral and the sediment is pumped into the dump truck at the removal site.

(4) Dump Truck

The dump truck hauls and dumps the sediment into the dumping site.

Retrieval Work on Drainage Mains/Outfalls
with Concrete Maintenance Holes

This cleaning work is performed by a wheel crane fitted with a dragline bucket to collect the sediment around the maintenance holes. Then the dragline bucket is changed to a clamshell bucket to remove the collected sediment from the culverts and load the sediment into a dump truck which hauls it and dumps it at the dumping site. The functions of the machinery required for the work are as follows.

(1) Wheel Crane

The wheel crane performs the work of a crane to collect and remove sediment from drainage mains/outfalls with the use of dragline and clamshell buckets.

(2) Jig for Dragline Work

The jig fixes the wire rope of the wheel crane to perform the dragline work in the culverts.

(3) Dump Truck

The dump truck hauls the removed sediment and dumps it at the dumping site.

(4) Blower

The blower ventilates the culvert for personnel work.

(5) Engine Generator for Blower

The engine generator supplies electric power to the blower.

(6) Gas Detector (Oxygen, Combustible Gas such as Methane and Hydrogen Sulfide)

The gas detector secures safe working conditions in the culverts.

Retrieval Work on Drainage Mains/Outfalls with Steel Maintenance Holes

Drainage mains and outfalls with steel maintenance holes 18 inches in diameter cannot be cleaned by the large equipment mentioned in Subsection 5.3.1. Therefore, the work is performed mainly by human labor with smaller equipment. The types of equipment and their functions are as follows.

(1) Submersible Sand Pump

The submersible sand pump installed at the outlet of the culvert discharges all existing water after both the inlet and outlet have been closed but before sediment removal work.

(2) Engine Generator for Submersible Sand Pump

The engine generator supplies electric power to the submersible sand pump.

(3) Portable Submersible Pump

The portable submersible pump provided to the work personnel discharges water staying or leaking in the culvert where personnel are working.

(4) Floodlight

The floodlight provides lighting for personnel working in the culvert.

(5) Blower

The blower ventilates and maintains safe working conditions in the culverts.

(6) Engine Generator for Portable Submersible Pump, Floodlight and Blower

The engine generator supplies electric power to the portable submersible pump, floodlight and blower.

(7) Gas Detector (Oxygen, Combustible Gases such as Methane and Hydrogen Sulfide)

The gas detector secures safe working conditions in the culvert.

(8) Dump Truck

The dump truck hauls and dumps the removed sediment to the dumping site.

Retrieval Work on Large Esteros

The dredging volume in Estero de Vitas and Estero de Sunog Apog is 146,450 m^3, approximately 70% of the total volume of all esteros, and the conditions such as width, depth and clearance of bridges crossing these esteros will not be a hindrance to the movement of a middle-sized dredging barge. Therefore, a middle-sized dredging barge with a bucket capacity of 0.6 m^3 will perform the dredging work in the above two esteros. The functions of the machinery to perform the work are as follows.

(1) Clamshell Crawler

The clamshell crawler installed on a pontoon barge performs the dredging work with its 0.6 m^3 clamshell bucket. Dredging under bridges is performed by the clamshell crawler with its 0.6 m^3 dragline bucket.

(2) Pontoon Barge

The pontoon barge supports the clamshell crawler for the dredging work in the esteros.

(3) Scow

The scow consisting of 12 hoppers with a capacity of 2 m^3 each loads and transports the dredged sediment from the dredging pontoon barge to the unloading point.

(4) Tugboat

The tugboat tows the pontoon barge and the scows, and also assists in anchoring of the pontoon barge and dredging under the bridges.

(5) Hydraulic Truck Crane

The hydraulic truck crane unloads the dredged sediment from the scows to the dump trucks.

(6) Dump Truck

The dump truck hauls the dredged sediment and dumps it in the dumping site.

Retrieval Work on Small Esteros

The dredging conditions in esteros other than the Estero de Vitas and Estero de Sunog Apog are not suitable to maneuver middle-sized barges. Also, the wheel crane with a clamshell bucket cannot dredge the esteros directly from the maintenance roads where illegal residents have built their houses. Therefore, these esteros will be dredged by the use of an easy setup type dredging barge equipped with a 0.2 m^3 clamshell crawler. The functions of the machinery for the dredging work on such esteros are as follows.

(1) Hydraulic Clamshell Crawler

The hydraulic clamshell crawler installed on the pontoon barge dredges the esteros.

(2) Pontoon Barge (Easy Setup Type)

The pontoon barge supports the clamshell crawler and dredging under bridges is done by a dragline bucket, anchor winch and wire rope.

(3) Scow (Easy Setup Type)

The scow consisting of three hoppers with a capacity of 2 m^3 each loads and transports the dredged sediment.

(4) Hydraulic Wheel Crane

The hydraulic wheel crane sets up the pontoon barges and the scows at the jobsite and unloads and loads the dredged sediment from the scows to the dump trucks. The hydraulic wheel crane with a clamshell bucket will also dredge from the maintenance roads of the esteros.

(5) Dump Truck

The dump truck hauls the dredged sediment and dumps it at the dumping site. It also hauls the disassembled pontoon barges and scows to the jobsite.

(6) Gas Detector (Hydrogen Sulfide)

The gas detector secures safe working conditions by checking for any hydrogen sulfide accumulations in the sediment.

(7) Truck Tractor and Semi-Trailer

The truck tractor with a semi-trailer hauls the clamshell crawlers to the jobsite.

(8) Small Scow for Manual Dredging (Easy Setup Type)

The scow, equipped with two hoppers with the capacity of 2 m^3 each, loads sediment dredged by manual labor.

5.3.3 List of Equipment

In accordance with the study on functions of equipment required for the proposed methods of retrieval work made in Subsection 5.3.2, the following types and quantities of equipment were selected. Equipment specifications are presented in Subsection 5.3.4 and the details of calculation for the quantity of equipment are in Appendix 3.

Retrieval Work on Laterals

Item No.	Kind of Equipment	No. of Units Per Group	No. of Groups	Total No. of Units
1	Water Jet Cleaner, 4-ton, Truck-Mounted, 200-250 Bar, 150-200 l/min	1	3	3
2	Lift Dump Type Dehydration Vacuum Cleaner, 4-ton, Truck-Mounted, 740 mm Hg, 1.5 m^3	1	3	3
3	Water Tanker, 4-ton, Truck-Mounted 3.5 m^3	1	3	3
4	Dump Truck, 4-ton, 2.6 m^3	2	3	6

Retrieval Work on Drainage Mains/Outfalls with Concrete Maintenance Holes

Item No.	Kind of Equipment	No. of Units Per Group	No. of Groups	Total No. of Units
1	Wheel Crane, with 0.6 m^3 and 0.3 m^3 Dragline Bucket, Clamshell and 25-ton by 3 m Crane, Special Jig for Dragline	1	4	4
2	Dump Truck, 4-ton, 2.6 m^3	2	4	8
3	Blower, ϕ300 mm, 240V, 0.3-0.6KW	1	4	4
4	Diesel Engine Generator, 20KVA, 240V, 3-Phase, 60Hz	1	4	4
5	Gas Detector (O_2, CH_4, H_2S)	1-1/4	4	5

Retrieval Work on Drainage Mains/Outfalls with 18" Diameter Steel Maintenance Holes

Item No.	Kind of Equipment	No. of Units Per Group	No. of Groups	Total No. of Units
1	Submersible Sand Pump, ϕ100 mm, 1 m^3/min, H15 m	1/2	4	2
2	Diesel Engine Generator, 45KVA, 240V, 3-Phase, 60Hz	1/4	4	1
3	Portable Submersible Volute Pump, ϕ50 mm, 0.12 m^3/min, H10 m	2	4	8
4	Floodlight, Mercury, 300-400W, 240V, 6Hz	7	4	28
5	Blower, ϕ300 mm, 240V, 0.3-0.6KW			
6	Diesel Engine Generator, 20KVA, 240V, 3-Phase, 60Hz	1	4	4
7	Dump Truck, 2-ton, 1.4 m^3	3	4	12
8	Gas Detector (O_2, CH_4, H_2S)	1-1/4	4	5

Retrieval Work for Large Esteros

Item No.	Kind of Equipment	No. of Units Per Group	No. of Groups	Total No. of Units
1	Clamshell Crawler, 0.6 m^3	1	2	2
2	Pontoon Barge, 20m x 9m x 1.8m	1	2	2
3	Scow, 15m x 6m x 1.8m; Hopper, 2 m^3 x 12	2	2	4
4	Tugboat, 60PS, 9m x 3m x 1.5m	1	2	2
5	Hydraulic Truck Crane, 25-ton x 3m; Boom, 24-25m	1	2	2
6	Dump Truck, 11-ton, 6.5 m^3	3	2	6

Retrieval Work on Small Esteros

Item No.	Kind of Equipment	No. of Units Per Group	No. of Groups	Total No. of Units
1	Hydraulic Clamshell Crawler, 0.2 m^3	1	3	3
2	Pontoon Barge, Easy Setup Type, 12m x 5m x 1.8m	1	3	3
3	Scow (Easy Setup Type, 8.5m x 3.2m 1.5m, 2 m^3 Hopper x 3	2	3	6
4	Hydraulic Wheel Crane, 20-ton x 3m, Boom 19-20m	1	3	3
5	Dump Truck, 4-ton, 2.6 m^3	3	3	9
6	Gas Detector (H_2S)	1-1/3	3	4
7	Truck Tractor with Semi-Trailer, 11-ton	1/3	3	1
8	Scow for Manual Dredging, Easy Setup Type, 6m x 3m x 1.5m, 2 m^3 Hopper x 2	2/3	3	2

5.3.4 Specifications of Equipment

Retrieval Work on Laterals

(1) Water Jet Cleaner

- Vehicle	4-ton Diesel Truck-Mounted, Left-Hand Drive
- Displacement Pressure	200-250 bar
- Displacement Volume	150-100 liters/minute
- Water Tank Capacity	min. 1.5 m^3
-Water Jet Nozzle	Five different types of nozzle for cleaning of lateral sizes φ12" to φ42", in addition to one handgun type
- High Pressure Hose	min. 80 m

(Note: Displacement pressure shall be adjustable to that of a handgun nozzle for personal use.)

(2) Lift Dump Type Dehydration Vacuum Cleaner

- Vehicle	4-ton Diesel Truck-Mounted, Left-Hand Drive
- Vacuum Pressure	max. 740 mm Hg
- Air Flow	15-20 m^3/min
- Discharge Pressure	0.5 to 1 kg/cm^3
- Vacumn Collection Tank Capacity	min. 1.5 m^3
- Suction Hose	φ6" x 20 m
- Discharge Hose	φ6" x 5 m

- Mute Lowest Height min. 2.2 m

- Tank Lift Stroke min. 1.2 to 1.5 m

(Note: Dehydrated sediment in the tank shall be dumped into dump truck at the jobsite.)

(3) Water Tanker

- Vehicle 4-ton Diesel Truck-Mounted, Left-Hand Drive

- Tank Capacity min. 3.5 m^3

(Note: The water tanker shall be equipped with a pump to transfuse water to the water jet cleaner.)

(4) Diesel Dump Truck

- Loading Capacity min. 4 tons

- Bed Capacity min. 2.6 m^3

- Steering Location Left-Hand Drive

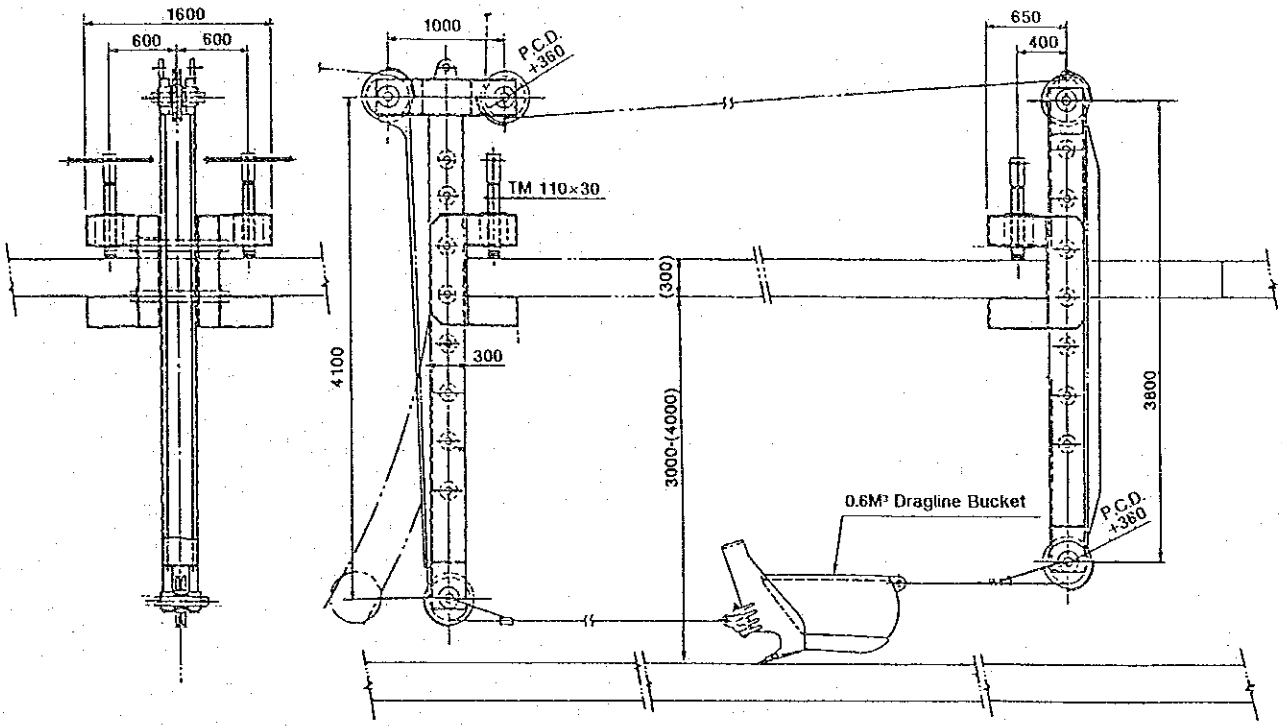
(Note: The structure of the bed shall not leak water from the dredged sediment loaded on it. Sheet cover shall be equipped on the bed.

Retrieval Work on Drainage Mains/Outfalls with Concrete Maintenance Holes

(1) Wheel Crane

- Dragline
  °Bucket Capacity 0.6 m^3 and 0.3 m^3

  °Jig for Dragline Work See Fig. 5-8



THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-8 STANDARD TYPE OF JIG FOR DRAGLINE WORK
JAPAN INTERNATIONAL COOPERATION AGENCY	

- Clamshell (Outrigger Fully Extended, 360° Swing)

°Bucket Type	Plate
°Bucket Capacity	0.6 m^3 and 0.3 m^3
°Work Radius	min. 7 m with 0.6 m^3 bucket
°Dumping Height	min. 2.5 m for 0.6 m^3 bucket

- Crane (Outrigger Fully Extended, 360° Swing)

°Load x Work Radius	min. 25 ton x 3 m min. 10 ton x 8 m

- Boom Length	8.0 to 9.5 m
- Rope Speed	max. 80 m/min, more or less min. 40 m/min, more or less

- Traveling Performance

°Turning Radius	min. 8 m, more or less

(Note: All accessories including buckets, jig, tools and others to perform the dragline, clamshell and crane shall be equipped on the wheel crane.)

(2) Diesel Dump Truck

(Same as for Work on Laterals.)

(3) Blower

- Type	Outdoor, Portable with max. ϕ300 mm x 10 m flexible duct

- Power Source

°Voltage	240V
°Phase	1 or 3
°Capacity	0.3 to 0.6KW
°Frequency	50/60Hz

- Fan Size	max. ϕ300 mm

(4) Diesel Engine Generator

(Same as for Item (6), Work on Drainage Mains/Outfalls with Steel Maintenance Hole.)

(5) Gas Detector

- Type	Portable, Simple Waterproof with Alarm Buzzer
- Measuring Gas	Oxygen, Combustible Gas such as Methane, Hydrogen Sulfide
- Temperature Range	0 to +40° C
- Sensor Cable Length	Approx. 5 m
- Power Source	Dry Battery

(Note: One spare sensor shall be included.)

Retrieval Work on Drainage Mains/Outfalls with Steel Maintenance Holes

(1) Pump

- Fluid	
°Component	Sewage and garbage
°Temperature	0 to 40°C
- Pump	
°Type	Submersible Sand
°Bore	φ100 mm
°Discharge	min. 1 m^3/min
°Head	min. 15 m
- Motor	
°Capacity	10-15KW

- Power Source

°Phase	3
°Voltage	240V
°Frequency	60Hz
- Cable	Cabtyre, 2PNCT x 20 m
- Discharge Hose	PVC, Flexible, ϕ100 mm x 20 m

(2) Diesel Engine Generator for (1)

- Type	Weatherproof Bonnet
- Alternator	
°Capacity	45KVA
°Voltage	240V
°Phase	3 (4-wire)
°Frequency	60Hz
°Speed	1800 rpm
°Power Factor	80%
°Cooling System	Self-Ventilation
- Diesel Engine	
°Type	Water-cooling
°Starting System	Cell Motor
°Fuel	ASTM No. 2 Diesel Oil

(Note: Control Panel shall be equipped with necessary meters to control generator and engine.)

(3) Pump

- Fluid	
°Component	Sewage
°Temperature	0 to 40°C

- Pump	
°Type	Portable, Submersible Volute
°Bore	φ50 mm
°Discharge	min. 0.12 m^3/min
°Head	min. 10 m
- Motor	
°Capacity	0.5 - 0.75KW
- Power Source	
°Phase	1 or 3
°Voltage	240V
°Frequency	60Hz
- Cable	Cabtyre, VCT x 15 m
- Discharge Hose	PVC, Flexible, φ50 mm x 50 m

(4) Floodlight

- Type	Mercury Lamp with Stabilizer, Waterproof Glove and Guard
- Capacity	300-400W
- Power Source	
°Voltage	240V
°Frequency	60Hz
- Cable	Cabtyre, 3/c x 5 m with Waterproof Plug
- Holding Stand	Adjustable Height Approx. 1-2 m
- Power Cable	Cabtyre, 3/c x 100 m with Waterproof Socket for distribution. Seven sockets shall be installed every 10 m in 70 m of cable.

(5) Blower

(Same as Item (3), Work on
Drainage Mains/Outfalls with
Concrete Maintenance Hole.)

(6) Diesel Engine Generator for Items (3), (4) and (5)

- Type	Weatherproof Bonnet
- Alternator	
°Capacity	20KVA
°Voltage	240V
°Phase	3 (4-wire)
°Frequency	60Hz
°Speed	1800 rpm
°Power Factor	80%
°Cooling System	Self-Ventilation
- Diesel Engine	
°Type	Water-cooling Diesel Engine
°Starting System	Cell Motor
°Fuel	ASTM No. 2 Diesel Oil

(Note: Control Panel shall be equipped with necessary meters to control generator and engine.)

(7) Diesel Dump Truck

- Loading Capacity	min. 2 tons
- Bed Capacity	min. 1.4 m^3
- Steering Location	Left-Hand Drive

(Note: The structure of the bed shall not leak water from the dredged sediment loaded on it. Sheet cover shall be equipped on the bed.)

(8) Gas Detector

(Same as Item (5), Work on Drainage Mains/Outfalls with Concrete Maintenance Holes.)

Retrieval Work on Large Esteros

(1) Clamshell Crawler (refer to Fig. 5-9)

- Clamshell Capacity

°Bucket Capacity	min. 0.6 m^3
°Ground Pressure	min. 0.55 kgf/cm^2
°Working Radius (Swing 360°)	min. 12 m
°Digging Depth	min. 10 m
°Dumping Height	min. 3 m

- Dragline Capacity

°Bucket Capacity	min. 0.6 m^3
°Ground Pressure	min. 0.55 kgf/m^3
°Cutting Radius	min. 10 m
°Digging Depth	min. 5 m
°Dumping Height	min. 4 m
°Radius at Max. Dumping Height	min. 8 m

- Crane Capacity

°Lifting Load x Operating Radius	min. 30 tons x 3 m

- Operating Weight	max. 35 tons
- Primary Resolved Weight	max. 25 tons
- Boom Length	18-20 m

(Note: All attachments to perform dragline, clamshell and crane shall be equipped.)

(2) Pontoon Barge (refer to Fig. 5-9)

- Dimension

°Length	approx. 20.0 m
°Breadth	max. 9.0 m
°Depth	max. 1.8 m
°Load Draft	max. 1.0 m
- Anchor	500 kg x 4
- Anchor Wire	ϕ24 mm x 200 m x 4
- Anchor Winch	300 kg x 15 m/min x 2
- Engine Generator	100/125KVA, 50/60Hz
- Submersible Pump	ϕ50 mm x H10 m

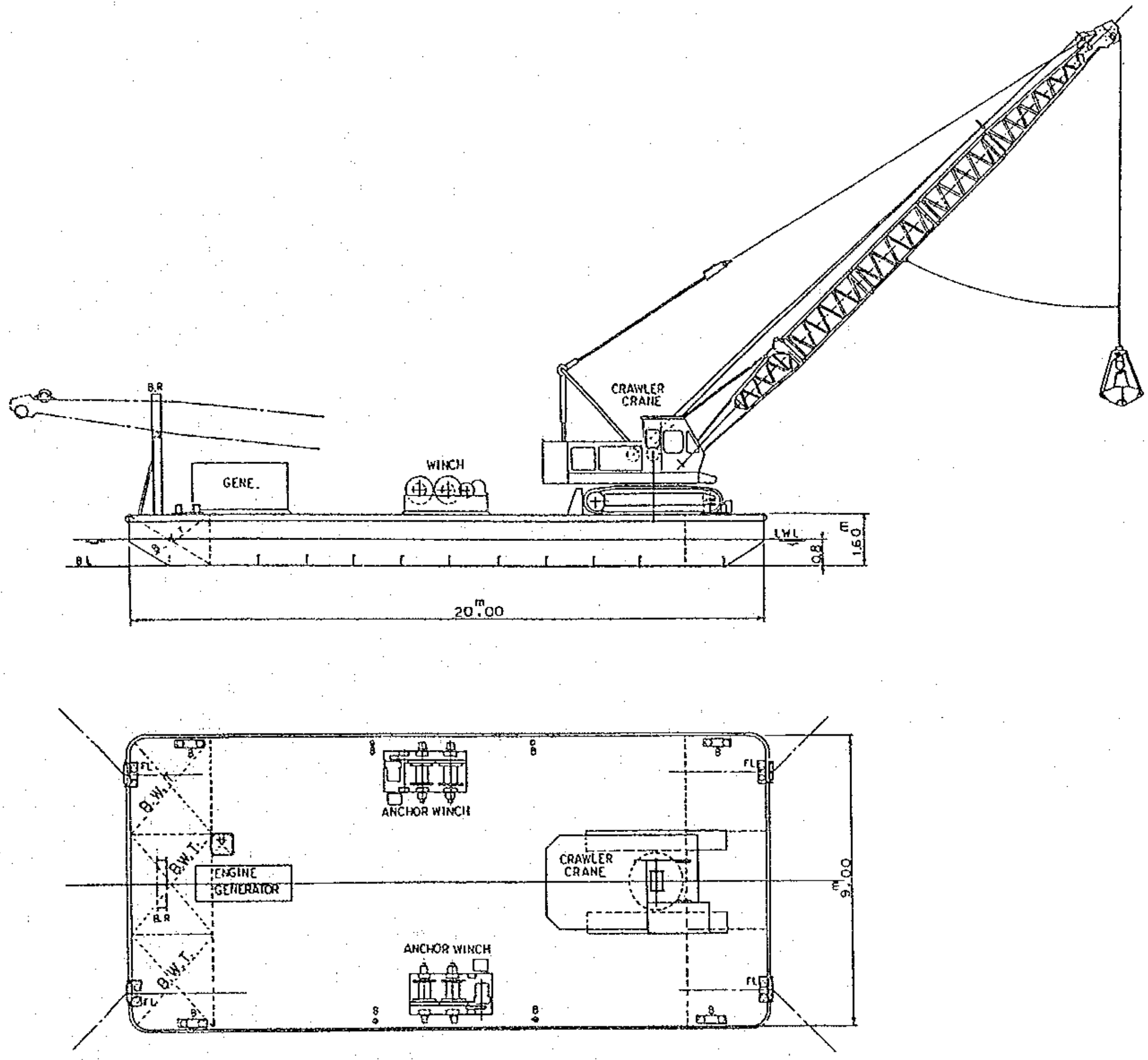
(Note: All accessories such as towing and mooring ropes and other necessary items to perform the work shall be equipped on the barge.)

(3) Scow (refer to Fig. 5-10)

- Dimension

°Length	approx. 15.0 m
°Breadth	max. 6.0 m
°Depth	max. 1.8 m
°Load Draft	max. 1.0 m
°Hopper Box	2 m^3 x 12

(Note: Twelve (12) hoppers, each with capacity of 2 m^3, towing and mooring ropes, and other necessary items shall be equipped on the scow.)

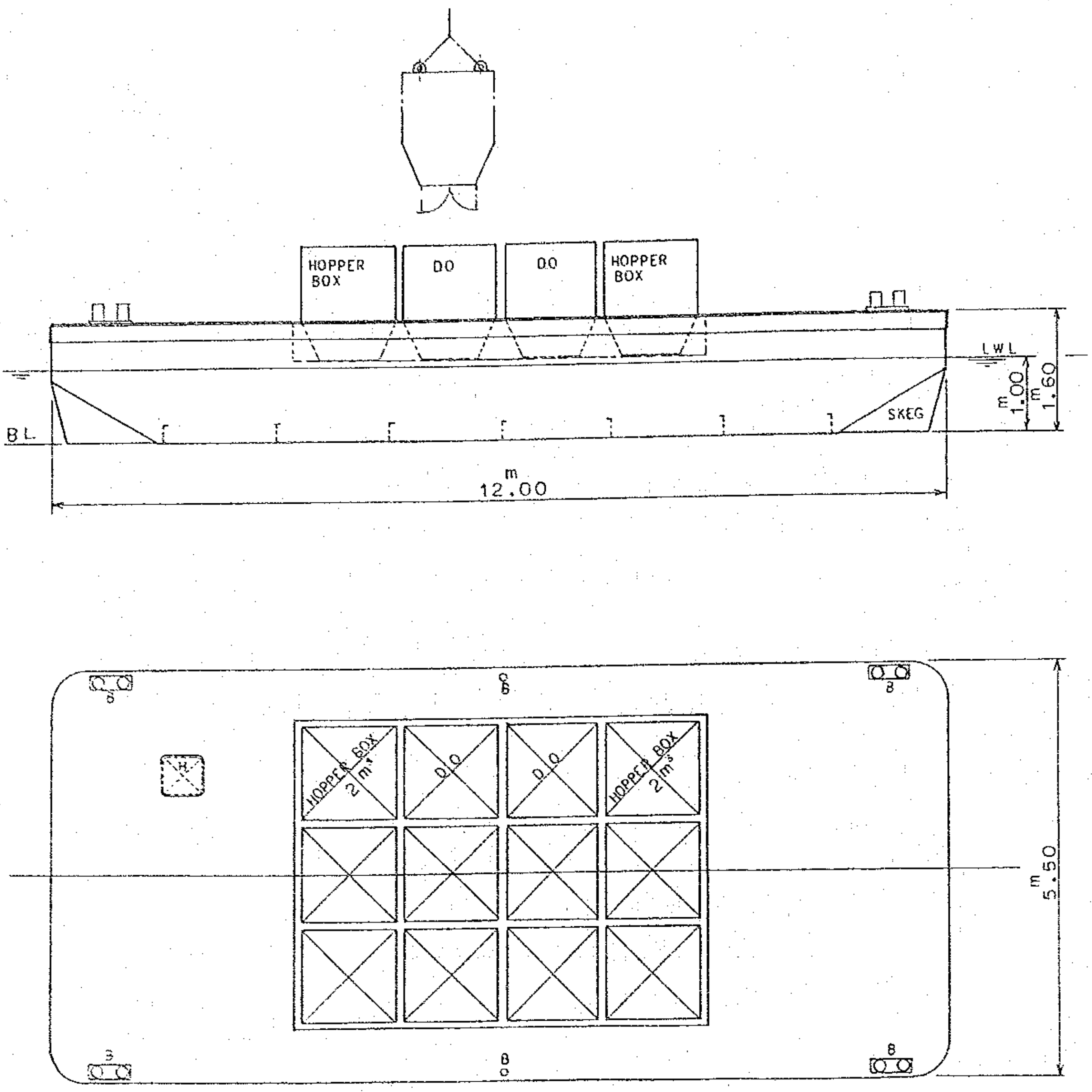


DIMENSIONS		
LENGTH		20.00m
BREADTH		9.00m
DEPTH		1.60m
LOAD.DRAFT	abt	0.80m

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 5-9 STANDARD TYPE OF DREDGER FOR LARGE ESTERO



DIMENSIONS		
LENGTH		12.00m
BREADTH		5.50m
DEPTH		1.60m
LOAD.DRAFT	abt	1.00m
HOPPER BOX(2m³)		12 PC

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA

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Fig. 5-10 STANDARD TYPE OF SCOW FOR LARGE ESTERO

(4) Tugboat (refer to Fig. 5-11)

- Dimension

°Length	approx. 9.0 m
°Breadth	approx. 3.0 m
°Depth	max. 1.5 m
°Main Engine	60 ps
°Anchor System	1
°Navigation Light	2

(Note: Other necessary items to perform the work shall be equipped on the boat.)

(5) Hydraulic Truck Crane

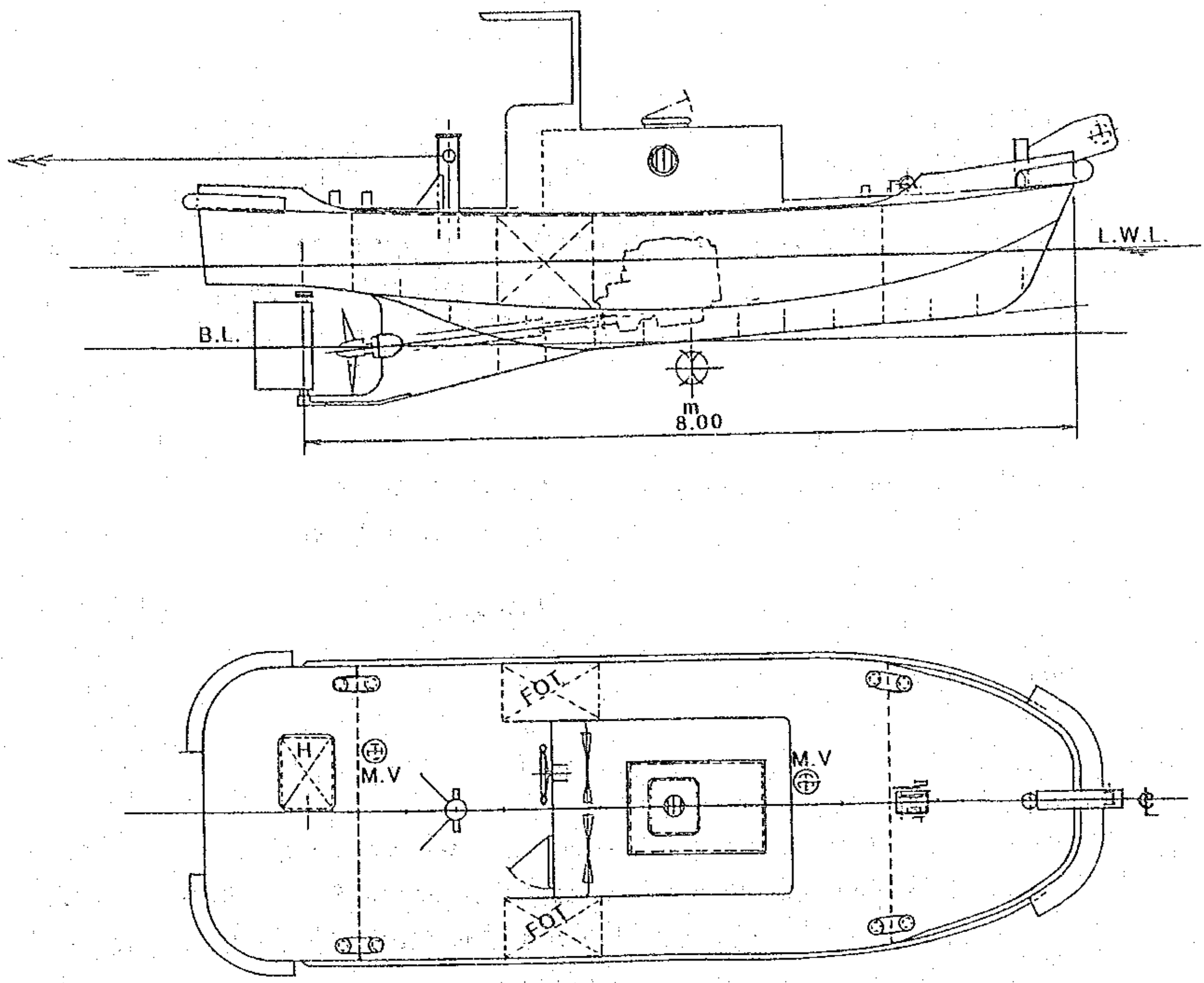
- Crane Capacity (Outrigger Fully Extended, 360° Swing)	min. 25 ton x 3 m min. 45 ton x 12 m
- Boom Type	Telescopic
- Boom Length	
°Basic	10-11 m
°Maximum	24-25 m

(Note: The hydraulic truck crane shall open the bottom of the hopper at unload and load the dredged sediment from the scow to the dump truck. All other necessary items to perform the work shall be equipped on the crane.)

(6) Diesel Dump Truck

- Loading Capacity	min. 11 Tons
- Bed Capacity	min. 6.5 m^3
- Steering Location	Left-Hand Drive

(Note: The structure of the bed shall not leak water from the dredged sediment loaded on it. Sheet cover shall be equipped on the bed.)



DIMENSIONS	
LENGTH	9.00m
〃 (P.P)	8.00m
BREADTH	2.80m
DEPTH	1.20m
LOAD.DRAFT	0.80m
MAIN ENGINE	60 PS

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 5-11 STANDARD TYPE OF TUGBOAT

Retrieval Work on Small Esteros

(1) Hydraulic Clamshell Crawler (refer to Fig. 5-12)

- Clamshell Capacity

°Bucket Capacity	min. 0.2 m^3
°Cutting Radius	min. 5.0 m
°Dumping Height	min. 2.5 m
°Radius at Max. Dumping Height	min. 3.0 m
°Max. Digging Depth	min. 4.0 m
°Ground Pressure	min. 0.3 kgf/m^2

- Range of Swing — 360°

- Operating Weight — max. 7 tons

- Dimension at Transportation

°Overall Length	max. 6.5 m
°Overall Width	max. 2.5 m

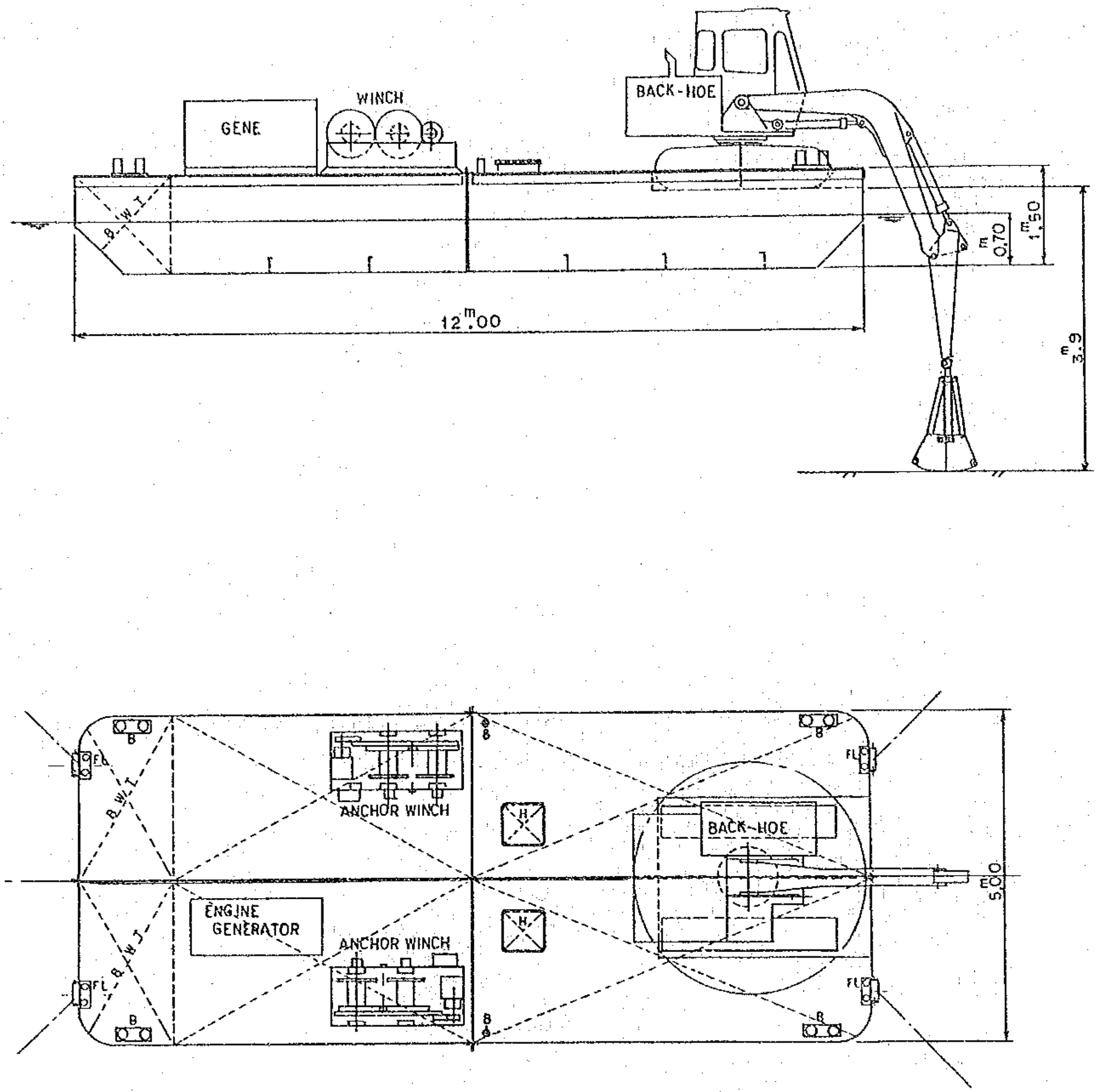
(Note: All necessary items to perform the dredging work shall be equipped on the hydraulic clamshell crawler.)

(2) Pontoon Barge (Easy Setup Type, refer to Fig. 5-12)

- Dimension

°Length	approx. 12.0 m
°Breadth	max. 5.0 m
°Depth	max. 1.8 m
°Draft	max. 1.0 m

-Anchor	300 kg x 4
- Anchor Wire	ϕ18mm x 100 m x 4
- Anchor Winch	1300 kg x 15 m/min x 2
- Engine Generator	70/85KVA, 50/60HZ x 1
- Belt Conveyor with Hopper	1
- Submersible Pump	ϕ50mm x 1



DIMENSIONS	
LENGTH	12.00m
BREADTH	5.00m
DEPTH	1.50m
LOAD.DRAFT abt	0.70m

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-12 STANDARD TYPE OF DREDGER FOR SMALL ESTERO
JAPAN INTERNATIONAL COOPERATION AGENCY	

- Dragline Bucket 0.3 m^3 x 2 or 3

(Note: The pontoon barge shall be easy setup type to assemble and disassemble at the jobsite. The disassembled parts shall be loaded on the 4-T dump truck. The anchor winch shall perform the dragline work under bridges with 0.3 m^3 bucket. All necessary items to perform the dredging work shall be equipped on the barge.)

(3) Scow (Easy Setup Type, refer to Fig. 5-13)

- Dimension
  - °Length approx. 8.5 m
  - °Breadth max. 3.2 m
  - °Depth max. 1.5 m

- Hopper Box 2 m^3 x 3

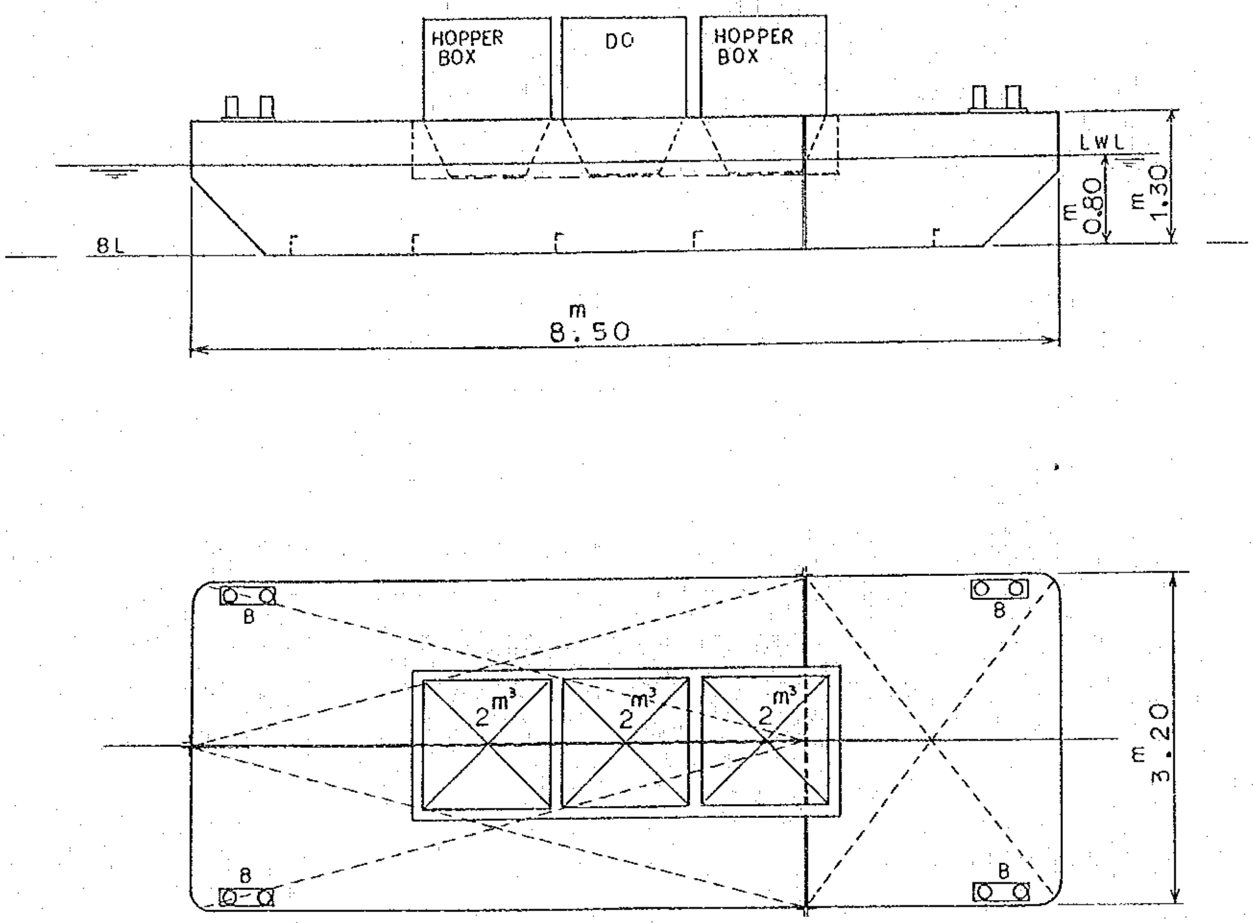
(Note: Three hoppers, each with 2 m^3 capacity, towing and mooring ropes, jig for dragline work and other necessary items to perform the work shall be equipped on the scow. The scow shall be easy setup type to assemble and disassemble at the jobsite. The diassembled parts shall be loaded on the 4-T dump truck.)

(4) Hydraulic Wheel Crane

- Crane Capacity

  (Outrigger Fully Extended, 360° Swing)

  °Lifting Load x Operating Radius
  - min. 20 ton x 3 m
  - min. 7 ton x 7 m
  - min. 5 ton x 9 m
  - min. 3 ton x 12 m



DIMENSIONS		
LENGTH		8.50m
BREADTH		3.20m
DEPTH		1.30m
LOAD DRAFT	abt	0.80m
HOPPER BOX(2m³)		3 PC

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-13 STANDARD TYPE OF SCOW FOR MECHANICAL DREDGING AT SMALL ESTERO
JAPAN INTERNATIONAL COOPERATION AGENCY	

(Without Outriggers, Stationary, 360° Swing)

°Lifting Load x Operating Radius	min. 7 ton x 3 m
	min. 5 ton x 6 m
	min. 3 ton x 5 m

(Without Outriggers, Creep, 360° Swing)

°Lifting Load x Operating Radius	min. 5 ton x 5 m
	min. 3 ton x 5 m

- Boom Type	Telescopic
- Boom Length	
°Basic	7-8.5 m
°Maximum	19-20 m
- Traveling Performance	
°Traveling Radius	min. 5 m, more or less
- Number of Seat	1
- Clamshell Bucket	
°Type	Hydraulic
°Capacity	min. 0.3 m^3

(Note: The hydraulic wheel crane shall open the bottom of the hopper and load the dredged sediment into the dump truck. The hydraulic crane with clamshell bucket shall dredge esteros from maintenance road. All other necessary items for the work shall be equipped on the crane.)

(5) Diesel Dump Truck

(Same as Item (4), Work on Laterals.)

(6) Gas Detector

- Type	Portable, Semi-Waterproof, with Alarm Buzzer
- Measured Gas	Hydrogen Sulfide
- Temperature Range	0 to +40°C
- Power Source	Dry Battery

(Note: One spare sensor shall be included.)

(7) Diesel Truck Tractor and Semi-Trailer

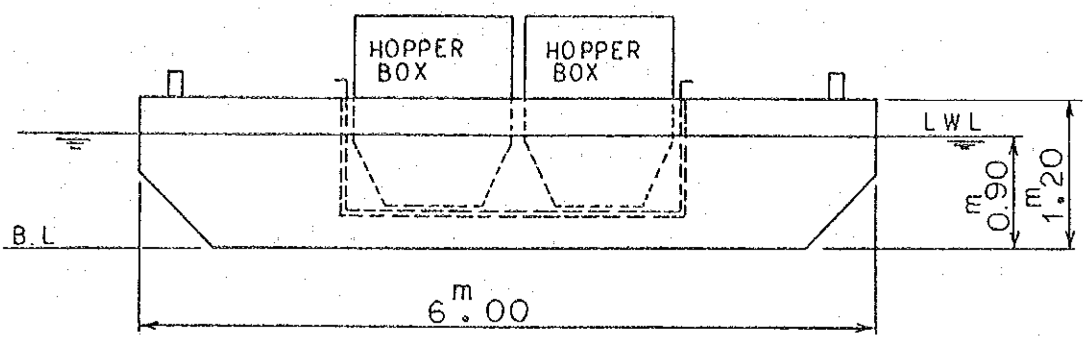
- Loading Weight	min. 11 tons
- Steering Location	Left-Hand Drive

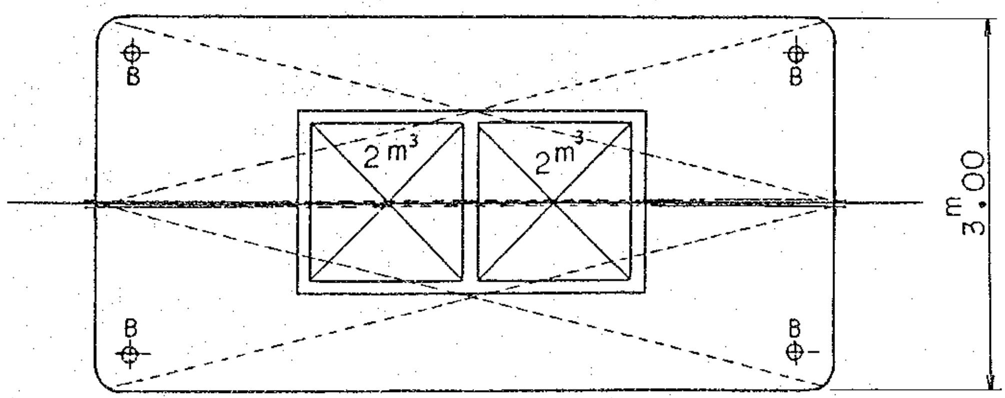
(Note: The semi-trailer shall load the hydraulic clamshell crawler on its bed.)

(8) Scow for Manual Dredging (Easy Setup Type, refer to Fig. 5-14)

- Dimensions	
°Length	approx. 6.0 m
°Breadth	max. 3.0 m
°Depth	max. 1.5 m
°Draft	max. 1.0 m
- Hopper Box	2 m^3 x 2

(Note: Two hoppers, each with 2 m^3 capacity, towing and mooring ropes and other necessary items to perform the work shall be installed on the scow. The scow shall be an easy setup type to assemble and disassemble at the jobsite. The disassembled parts shall be loaded on the 4-ton dump truck.)





DIMENSIONS	
LENGTH	6.00m
BREADTH	3.00m
DEPTH	1.20m
LOAD.DRAFT abt	0.90m
HOPPER BOX(2m³)	2 PC

THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 5-14 STANDARD TYPE OF SCOW FOR MANUAL DREDGING AT SMALL ESTEROS

5.3.5 Model Implementation of Retrieval Work

Aim of Model Implementation

The proposed retrieval work for the existing drainage channels and drains will require a rather big organization for simultaneous operation of the various types of equipment which include more than 80 units of construction machinery. Sophisticated technical skills will also be required in the operation of the equipment such as the adjustment of water pressure ejected from the water jet cleaner, disassembly/reassembly of easy-setup type dredgers, etc. The mechanized retrieval work is regarded as a sort of pilot project in the Philippines, since the Government of the Philippines has inadequate knowledge regarding the operation and maintenance of the equipment to be procured under the Project. Hence, in order to maximize the work efficiency of equipment and avoid accidents that might occur during operation, it has been decided to carry out actual retrieval work in a model area, as a part of the Project, with the aim of transferring knowledge concerning operation and maintenance as agreed upon in the discussions with the Philippine government officials concerned.

The model area has been selected as the area most urgently requiring retrieval of the existing drainage channels and drains and which will contribute to the immediate reduction of flood damage. Flood damage reduction is also aimed at by the Model Implementation, together with the transfer of technical knowledge.

Preconditions of Model Operation

All the equipment, with the exception of equipment to be used in the manual dredging work in areas of illegal residence along the minor esteros, will be used in the Model Implementation area. Retrieval work will be executed by Japanese contractors and supervised by Japanese consultants who have sufficient experience in carrying out the same type of work as that to be implemented under the Project.

Technical knowledge will be transferred to the selected personnel listed below from organizations under the National Capital Region (NCR), Department of Public Works and Highways (DPWH), who will be responsible for the operation and maintenance of the equipment to be procured.

- Flood Control and Water Supply Section, Maintenance Division, NCR	:	145 engineers
- NCR North Manila Engineering District	:	24 engineers
- NCR South Manila Engineering District	:	44 engineers
- NCR Regional Equipment Service	:	125 engineers

Term of Model Implementation

Working conditions for the retrieval of drainage channels and drains vary greatly between the rainy season and the dry season. During the rainy season, which usually continues from June to November, increased water in drainage channels and drains will hamper the work and cause long work interruptions. This is especially true in drainage mains/outfalls with steel maintenance holes that require manual cleaning which is very difficult to carry out in the rainy season. During the dry season, on the other hand, working conditions are better and the work efficiency of equipment is expected to increase. To minimize the decrease of work efficiency in the rainy season and to maximize the efficiency in the dry season, the Model Implementation with its aim of transferring technical knowledge regarding the operation and maintenance of equipment will need to be carried out both in the rainy and dry seasons with varied working conditions.

The first shipment of equipment is expected to arrive in Manila by the middle of the dry season (around February), assuming that equipment procurement will take two months. The equipment is, however, intended for manual unclogging work on drainage mains/outfalls with steel maintenance holes and does not include large construction machinery. The first stage of Model Implementation will take place immediately after the delivery of equipment, but it can be executed only in the dry season. Therefore, the term of the first Model Implementation is assumed to be about four months from the time of equipment delivery up to the end of the dry season.

The second shipment of equipment consisting mainly of large construction machinery is expected to arrive in Manila at the beginning of the rainy season (around June), assuming that equipment procurement will take six months. Considering that the term of Model Implementation should cover both the rainy and dry seasons, the second stage of Model

Implementation is assumed to continue for about seven months starting immediately after the delivery of equipment up to the first month of the dry season. The term of the second stage of Model Implementation will need to include about one month for preparation work and initial test operation of the construction machinery. Accordingly, the actual retrieval work of the Model Implementation will be executed in the remaining six months.

Standard Work Volume of Model Implementation

The standard work volume per day is calculated as shown in Table 5-4 on the basis of the total number of work days for 5 years (see Subsection 5.2.2) and its corresponding total work volume (see Subsection 5.2.3).

Table 5-4. Standard Work Volume Per Day

Work Item	Total Work Days	Total Work Volume (m^3)	Standard Work Volume (m^3 per day)
Retrieval of Laterals	1,125	24,355	21.6
Retrieval of Drainage Mains/Outfalls with Concrete Maintenance Holes	1,125	55,345	49.2
Retrieval of Drainage Mains/Outfalls with Steel Maintenance Holes	720*	12,160	16.9
Retrieval of Large Esteros	1,125	146,450	130.2
Retrieval of Small Esteros	1,125	73,215	65.1

Note *: Work can be done in the dry season only.

The standard work volume of the Model Implementation is then calculated as shown in Table 5-5 on the basis of the term of the Model Implementation and the above standard work volume per day.

Table 5-5. Standard Work Volume of Model Implementation

Work Item	Term of Model Implementation (month) Dry Season	Rainy Season	Total Work Days	Standard Work Volume (m^3 per day)
Retrieval of Laterals	1	5	109	2,354
Retrieval of Drainage Mains/Outfalls with Concrete Maintenance Holes	1	5	109	5,363
Retrieval of Drainage Mains/Outfalls with Steel Maintenance Holes	-	4	96	1,622
Retrieval of Large Esteros	1	5	109	14,192
Retrieval of Small Esteros	1	5	109	7,095

Sites and Work Volume of Model Implementation

The sites for Model Implementation were arranged to be in (1) areas regularly visited by floods (see Subsection 4.3.3), (2) areas with dense populations and a high level of socioeconomic activity, and (3) areas without administrative problems such as difficulty in the necessary removal of illegal dwellers. In addition, the sites were selected on the premise that the actual work volume of Model Implementation is almost equal to the standard model work volume mentioned above. From these considerations, the following were decided on as the sites of the Model Implementation.

- Retrieval of Laterals : 13 laterals in Paco and Sta. Ana drainage areas with total length of 16,140 m (refer to Table 5-6)

- Retrieval of Drainage Mains/Outfalls with Concrete Maintenance Holes : Estrada with length of 592 m, and Remedios with length of 1,355 m

- Retrieval of Drainage Mains/Outfalls with Steel Maintenance Holes : Vito Cruz with length of 400 m

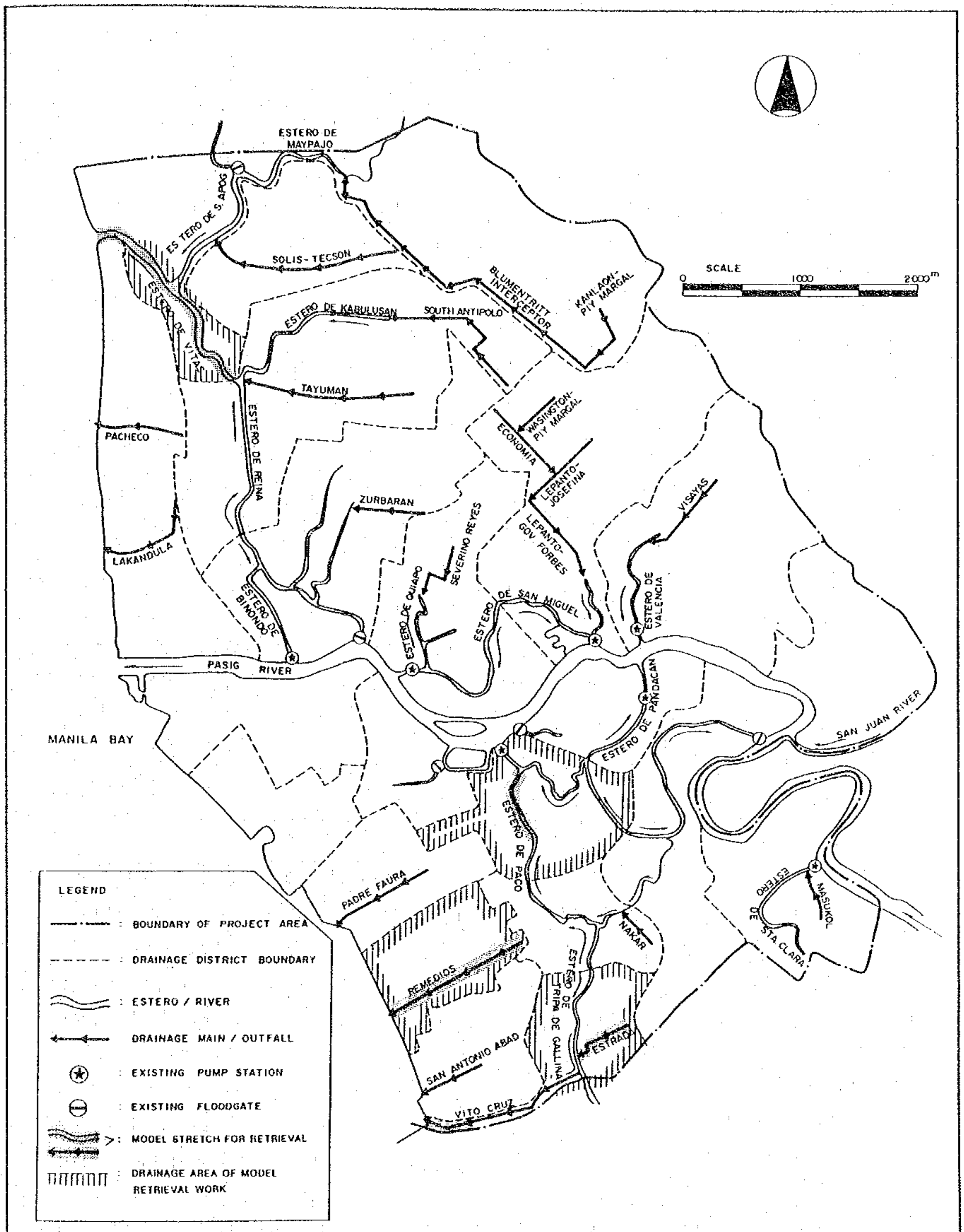
- Dredging of Large Esteros : Vitas with length of 1,800 m from river mouth

- Retrieval of Small Esteros : Paco with length of 758 m from Paco Pumping Station

Table 5-6. Laterals for Model Implementation

Item	Name of Street	Length (m) by Diameter (inch) 12	18	24	30	36	42	Total
1	Pedro Gil, Paco			1650				1650
2	Mendiola Extension, Paco			300				300
3	Estrada, Malate		450	500				950
4	Vito Cruz, Sta. Ana			2150				2150
5	South Avenue, Sta. Ana		540					540
6	South Superhighway, Sta. Ana			1500				1500
7	Dart, Paco			800				800
8	M. Guanzon, Paco			1300				1300
9	G. del Pilar, Paco		900					900
10	Taft Avenue, Ermita		450	1500	450			2400
11	Dr. J. Quintos, Sr., Paco			250				250
12	Remedios, Malate		150			150		300
13	Roxas Boulevard			3100				3100
	Total	0	2490	13050	450	150	0	16140
	Work Volume (m^3)	0	204	1903	103	49	0	2260

The sites of the Model Implementation and their drainage areas are as shown in Fig. 5-15. By using all equipment to be supplied on these stretches during the term of the Model Implementation, the actual work volume to be achieved by the Model Implementation will amount to approximately 10% of the total work volume, as shown in Table 5-7.



THE PROJECT FOR THE RETRIEVAL OF FLOOD PRONE AREAS OF METRO MANILA	Fig. 5-15 STRETCH FOR MODEL IMPLEMENTATION OF RETRIEVAL WORK
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table 5-7. Work Volume Achieved by Model Implementation

Work Item	(1) Work Volume Achieved by Model Implementation (m^3)	(2) Total Work Volume (m^3)	(1)/(2) (%)
Retrieval of Laterals	2,260	24,355	9.3
Retrieval of Drainage Mains/Outfalls with Concrete Maintenance Holes			
- Estrada	563		
- Remedios	1,355		
Subtotal	5,001	55,345	9.0
Retrieval of Drainage Mains/Outfalls with Steel Maintenance Hole	1,600	12,160	13.2
Dredging of Large Esteros	14,000	146,450	9.6
Dredging of Small Esteros	7,000	73,215	9.6
Total	29,861	311,525	9.6

5.4 Implementation Plan

5.4.1 Implementation Policy and Points of Note

Items to be implemented under the Project can be divided into procurement of the equipment and the on-site Model Implementation. Equipment to be procured includes large construction machinery and customized vehicles requiring special orders. A period of 4 to 6 months will be necessary from the time the order is made to the time of delivery in Manila. The time required for procurement will vary according to the type of equipment, and since the Model Implementation using the equipment procured will be greatly affected by the weather conditions in the rainy season, delay in the arrival of the equipment in Manila may precipitate alterations to the schedule of the Model Implementation. In this connection, a rational plan for project implementation has to be established by carrying out an adequate adjustment between the term for procurement and that of the Model Implementation.

Various types of work using large construction machinery will be integrated with each other in the Model Implementation, requiring careful schedule control and adequate safety measures. There is also the possibility that problems such as generation of foul odors and noise will occur during the deposit removal work and transportation of the deposits removed to dumping sites. The on-site supervisors will be required to take appropriate actions concerning these environmental problems.

The aim of the Model Implementation is not merely to achieve the targets that have been set but also to effect transfer to the Philippine governmental agencies of technology associated with the management and operation, as well as maintenance, of the equipment. There is then a need to maintain close contact with the Philippine governmental agencies to achieve this end.

5.4.2 Construction Supervision Plan

In accordance with the contract, the consultant will invite bids on behalf of the Department of Public Works and Highways. During the term of on-site Model Implementation, the consultant will also send to the site a permanent supervisor, who is well acquainted with the details of the Project and has adequate technical expertise to give directions and carry out adjustments of the work and who will work for the transfer of technology involved in the operation.

5.4.3 Equipment Procurement Plan

Equipment required under the Project is not manufactured in the Philippines and will have to be imported from abroad. Equipment to be procured consists of customized vehicles (water jet cleaners, vacuum cleaners, etc.), dredging vessels and dump trucks, and the number of these types of equipment will add up to over 80. The Model Implementation using all these types of equipment needs to be quickly implemented after the equipment's arrival in Manila and delays in arrival may greatly affect the schedule of the Model Implementation as a whole. It will not be appropriate to transport the equipment in several shipments and it is, therefore, inappropriate to divide the locations of procurement between Japan and a third country.

Construction machinery in use in the Philippines at present includes, besides Japanese products, those produced in the United States of America and Europe. There is little difference in the prices of these machines, however, and Japanese products being the most commonly used, it will be most advantageous to use Japanese products for the Project when considerations are made for future repairs and maintenance. There has been no specific request from the Government of the Philippines for procurement of equipment from a third country.

In view of the above, all equipment will be produced and tested in Japan, exported to the Philippines by sea and, after landing in the Philippines, be delivered to the equipment storehouse of the DPWH at Libertad in the city of Manila.

5.4.4 Implementation Schedule

A provisional schedule for the entire project implemention is given in Fig. 5-16. As shown in the figure, the detailed design will be carried out by the Japanese consulting firm for 1.5 months after the Exchange of Notes. Thereafter, the first shipment of equipment is scheduled by the middle of the dry season, assuming that equipment procurement will take about two months. The first equipment is, however, intended for manual unclogging work on drainage mains/outfalls with steel maintenance holes and does not include large construction machinery. The first stage of Model Implementation will take place immediately after the delivery of equipment and continue for about four months (refer to Subsection 5.3.5).

The second shipment of equipment consisting mainly of large construction machinery is expected to arrive in Manila around the beginning of the rainy season (around June 1990), assuming that equipment procurement will take six months. The second stage of Model Implementation will continue for about seven months starting immediately after the delivery of the equipment. The Model Implementation will cover all kinds of the proposed retrieval work with the exception of the aforesaid manual unclogging work for drainage mains/outfalls with steel maintenance holes.

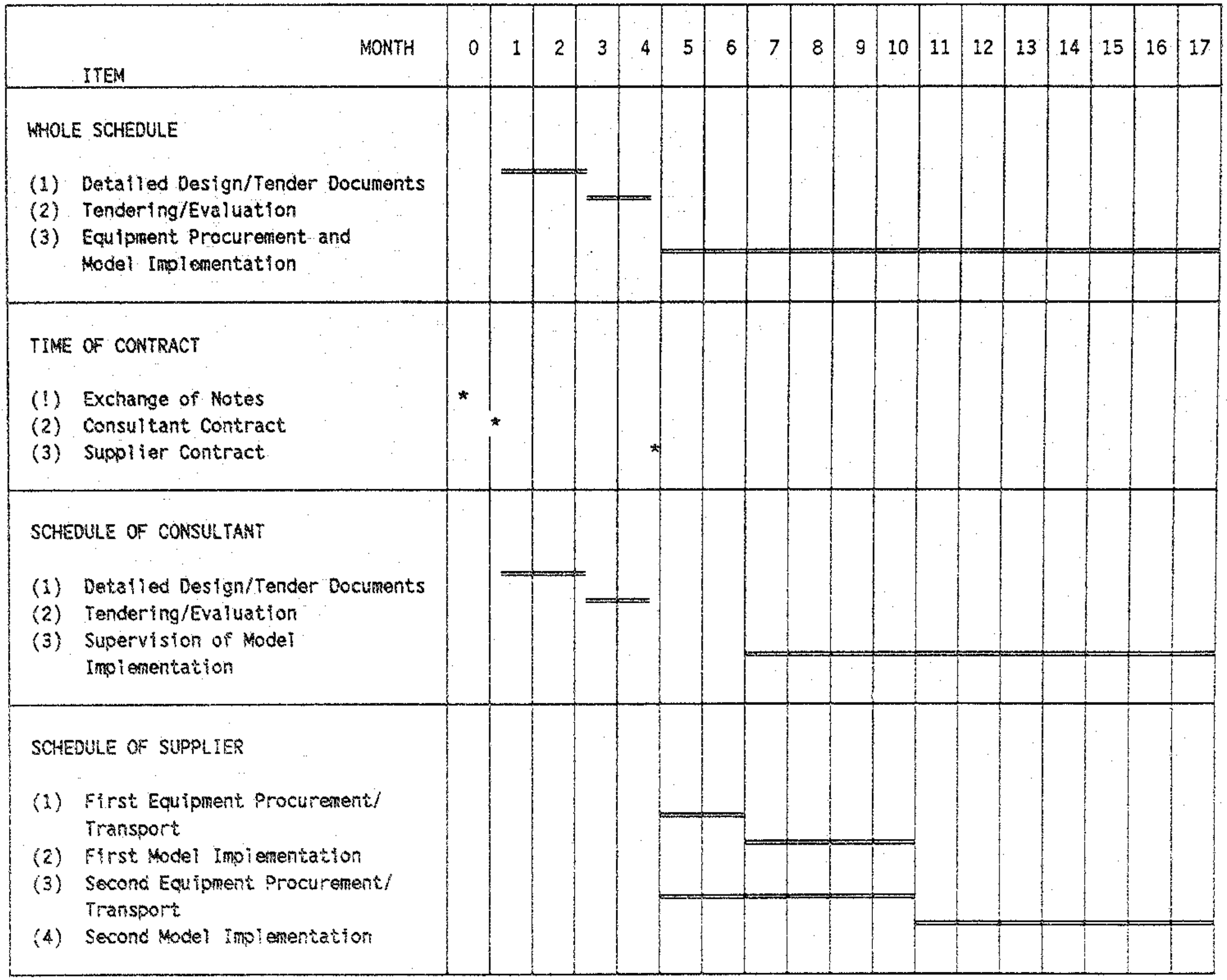


Fig. 5-16 IMPLEMENTATION SCHEDULE

5.4.5 Scope of Work

The work to be undertaken by both governments are summarized as follows.

Work by the Government of Japan

(1) Supply of Equipment

(a) Equipment for Dredging Esteros

- Clamshell Crawler with Pontoon Barge	5
- Scow	10
- Tugboat	2
- Hydraulic Truck Crane	2
- Hydraulic Wheel Crane	3
- Dump Truck	15
- Truck Tractor with Semi-Trailer	1
- Appurtenances	lot

(b) Equipment for Unclogging Drainage Mains/Outfalls

- Wheel Crane with Dragline Bucket, Clamshell and Crane	4
- Submersible Sand Pump Set with Diesel Engine Generator	2
- Dump Truck	20
- Appurtenances	lot

(3) Equipment for Unclogging Laterals

- Water Jet Cleaner	3
- Lift-Dump Type Dehydration Vacuum	3
- Water Tanker	3
- Dump Truck	6
- Appurtenances	lot

(2) Model Implementation

(a) Retrieval of Laterals	:	13 laterals in Paco and Sta. Ana drainage areas with total length of 16,140 m
(b) Retrieval of Drainage Mains/Outfalls with Concrete Maintenance Holes	:	Estrada with length of 592 m, and Remedios with length of 1,355 m
(c) Retrieval of Drainage Mains/Outfalls with Steel Maintenance Holes	:	Vito Cruz with length of 400 m
(d) Dredging of Large Esteros	:	Vitas with length of 1,800 m from river mouth
(e) Retrieval of Small Esteros	:	Paco with length of 758 m from Paco Pumping Station

<u>Work by the Government of the Philippines</u>

(1) To prepare the project dumping sites.

(2) To prepare the storehouses for project equipment.

(3) To provide facilities for electricity, water supply and other incidentals.

(4) To bear the commissions of the Japanese foreign exchange bank for banking services.

(5) To arrange tax exemption and customs clearance of equipment at the port of disembarkation.

(6) To accord Japanese nationals whose services may be required in connection with the supply of the equipment and the services under the verified contract such facilities as may be necessary for their entry into the Philippines and stay therein for the performance of their work.

(7) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the Philippines with respect to the supply of the equipment and services under the verified contracts.

(8) To maintain and use properly and effectively the facilities constructed and equipment procured under the grant aid.

(9) To bear all the expenses, other than those to be covered by the grant aid, necessary for the construction of facilities as well as for the transportation and installation of the equipment.

CHAPTER 6. PROJECT EVALUATION AND CONCLUSION

6.1 Impact of Project

The following are the effects expected when the Project is completed and the proposed retrieval of existing drainage channels and drains is accomplished.

(1) Economic Impact

The Study on Flood Control and Drainage Project in Metro Manila being conducted at present by JICA has confirmed that the existing drainage system in the city of Manila and its vicinity can convey stormwater of a 10-year return period. This capacity, however, has deteriorated due to the deposits and garbage blocking the drains causing inundation by stormwater in wide areas over a long period of time.

The floods have caused extensive damage to houses and public buildings, interruption of the operations at workplaces, and disruption of communication and transportation networks. In accordance with the aforesaid study, probable flood damage was estimated as shown in Table 6-1.

Table 6-1. Probable Flood Damage

Flood Return Period (year)	Inundation Area (km^2)	Damage Value (million pesos)
2	8.7	495
3	10.7	634
5	13.4	797
10	17.1	1,061
Annual Average Damage		282

Upon completion of the retrieval work, the existing drainage system in the city of Manila and its vicinity will be restored to handle stormwater of up to a 10-year return period. This will result in the reduction of inundation damage to an area of approximately 17 km^2, which corresponds to about 30% of the total area of the city of Manila and its vicinity, and savings at an annual average of approximately 280 million pesos which can be used in other worthy projects.

(2) Social Impact

Great beneficial effects on society are expected from the completion of the Project.

- Inundations due to stormwater lasting over long periods of time have aggravated sanitary problems such as occurrences of infectious diseases. Reduction of stormwater inundations through implementation of the Project will lead to a sanitary environment which will in turn contribute to the improvement of living standards and stabilization of people's livelihood.

- Every year during the rainy season, stormwater inundations occur over periods of one week to, in some cases, one month in the city of Manila and its vicinity, resulting in disruptions of the transportation network. Implementation of the Project will solve this problem and contribute to the stabilization of economic activities.

- Deposits in the existing drainage system contain a large amount of garbage which serves as the source of foul odors and is a breeding ground for insects causing infectious diseases. Besides the reduction of inundation damage, the removal of deposits in the existing drainage system will lead to the improvement of living conditions.

6.2 Conclusion

As explained above, the Project is expected not only to be very effective in reducing damage due to floods in the city of Manila and its vicinity but also to contribute widely towards the improvement of living conditions. Furthermore, the Department of Public Works and Highways (DPWH) of the Government of the Philippines has secured the funds required for operation and maintenance of the equipment to be supplied under the Project, as well as the personnel required from the staff of its regional office, the National Capital Region (NCR). Therefore, it is appropriate that the Project be implemented through grant aid from the Government of Japan since there are no problems with respect to funding and personnel requirements in the recipient country.

Since the Project's objective is to retrieve the existing drainage systems in Metro Manila and its vicinity, more effective results could be obtained should the Government of the Philippines intensity its efforts to cope with the illegally dumped garbage with more effective measures that could be realized through coordination and cooperation among the NCR, the Metropolitan Manila Commission (MMC) and the city/municipal government offices.

Urban drainage systems are being improved in Metro Manila and in other regions of the Philippines. To maintain their functions, completed drainage systems will required adequate maintenance in the future. Hence, it is expected that through this Project, which is regarded at a sort of pilot project for the retrieval of existing drainage systems, the Government of the Philippines will develop the appropriate methodology for facility retrieval and widely implement it throughout the country.

APPENDIX 1

LIST OF SURVEY TEAM MEMBERS

ITINERARY OF FIELD SURVEY

LIST OF INTERVIEWEES IN THE PHILIPPINES

LIST OF SURVEY TEAM MEMBERS

Name	Assignment	Official Designation
Yoichi Takeuchi	Leader	Deputy Director, Planning Department, Chubu Regional Construction Bureau, Ministry of Construction
Susumu Hatada	Drainage Planner	Director, Nerima Branch Office, Seibu Management Office, Sewerage Bureau, Tokyo Metropolitan Government
Satoshi Kinugawa	Grant Aid Planner	Officer, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs
Susumu Heishi	Flood Control Planner	Staff, CTI Engineering Co., Ltd.
Makihiko Otogawa	Implementation Planner	Staff, CTI Engineering Co., Ltd.
Keikoo Sasaki	Equipment Planner	Staff, CTI Engineering Co., Ltd.
Katsuhiro Ikari	Cost Estimator	Staff, CTI Engineering Co., Ltd.

ITINERARY OF FIELD SURVEY

Date	Activities
March 28 (Tue)	Arrival of Study Team in Manila
March 29 (Wed)	Courtesy call to Embassy of Japan, DPWH and JICA Philippine Office
March 30 (Thu)	General site reconnaissance
March 31 (Fri)	General site reconnaissance
April 1 (Sat)	Compilation of survey results
April 2 (Sun)	Holiday
April 3 (Mon)	Meeting with DPWH and preparation of minutes
April 4 (Tue)	Meeting with DPWH and signing of agreed minutes
April 5 (Wed)	Report to Embassy of Japan and JICA Philippine Office
April 6 (Thu)	Site reconnaissance of North Manila
April 7 (Fri)	Site reconnaissance of North Manila
April 8 (Sat)	Compilation of survey results
April 9 (Sun)	Holiday
April 10 (Mon)	Site reconnaissance of South Manila
April 11 (Tue)	Site reconnaissance of South Manila
April 12 (Wed)	Study on necessary project works
April 13 (Thu)	Joint meeting with MWSS, MMC and DPWH
April 14 (Fri)	Reconnaissance of the dumping sites
April 15 (Sat)	Study on necessary project works
April 16 (Sun)	Holiday
April 17 (Mon)	Review of results of related studies
April 18 (Tue)	Collection of necessary data
April 19 (Wed)	Collection of necessary data
April 20 (Thu)	Preparation of field survey results
April 21 (Fri)	Final meeting with DPWH; Report to Embassy of Japan and JICA Philippine Office
April 22 (Sat)	Departure for Japan

LIST OF INTERVIEWEES IN THE PHILIPPINES

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

Teodoro T. Encarnacion	Undersecretary
Manuel Bonoan	Assistant Secretary
Eugenio D. Manalo	Regional Director, NCR
Antonio A. Alpasan	Project Manager IV, PMO-MFCP
Jose C. Guanzon	Chief Civil Engineer, Planning Service
Nonito F. Fano	Chief Civil Engineer, PDD-NCR
Jose T. Agustin	Chief Civil Engineer, MD-NCR
Tesoro P. Sison	Regional Equipment Engineer, NCR
Toshiki Kawakami	JICA Expert

METROPOLITAN MANILA COMMISSION

Leonardo Espinoza, Jr.	Acting Executive Director

PRESIDENTIAL MANAGEMENT OFFICE

Emmy Reyes	Chief Presidential Staff Officer

ENVIRONMENTAL MANAGEMENT BUREAU

Esterlito M. Pinlac	Pollution Control Specialist

MANILA CITY COUNCIL

Jaime dela Rosa	Councilor

EMBASSY OF JAPAN

Koji Kaminaga	First Secretary

JICA MANILA OFFICE

Moriya Miyamoto	Resident Representative
Katsuhiko Oshima	Deputy Resident Representative
Katsuhiko Ozawa	Assistant Resident Representative

APPENDIX 2

MINUTES OF DISCUSSIONS

MINUTES OF DISCUSSIONS
ON
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR RETRIEVAL OF FLOOD PRONE AREAS
IN METRO MANILA
IN
THE REPUBLIC OF THE PHILIPPINES

In response to the request made by the Government of the Republic of the Philippines, the Government of Japan decided to conduct the Basic Design Study on the Project for Retrieval of Flood Prone Areas in Metro Manila (hereinafter referred to as "the Project") and the Japan International Cooperation Agency (JICA) has sent the Basic Design Team headed by MR. YOICHI TAKEUCHI, Deputy Director, Planning Department, Chubu Regional Construction Bureau, Ministry of Construction, from March 28 to April 22, 1989.

The Team had a series of discussions with the authorities concerned of the Government of the Republic of the Philippines and conducted a field survey.

As a result of the study, both parties have agreed to recommend to their respective governments that the major points of understanding reached between them as attached herewith should be examined towards the realization of the Project.

Manila, Philippines; April 4, 1989.

YOICHI TAKEUCHI Team Leader Basic Design Study Team JICA	TEODORO T. ENCARNACION Undersecretary Department of Public Works and Highways, Government of the Philippines

ATTACHMENT

1. The objectives of the Project are:

   (a) To supply suitable equipment for the retrieval of the existing drainage system; and

   (b) To effect technology transfer which will be made through the actual implementation of the retrieval works in a pilot area.

2. The Department of Public Works and Highways, Government of the Republic of the Philippines, is to be responsible for administering and executing the Project.

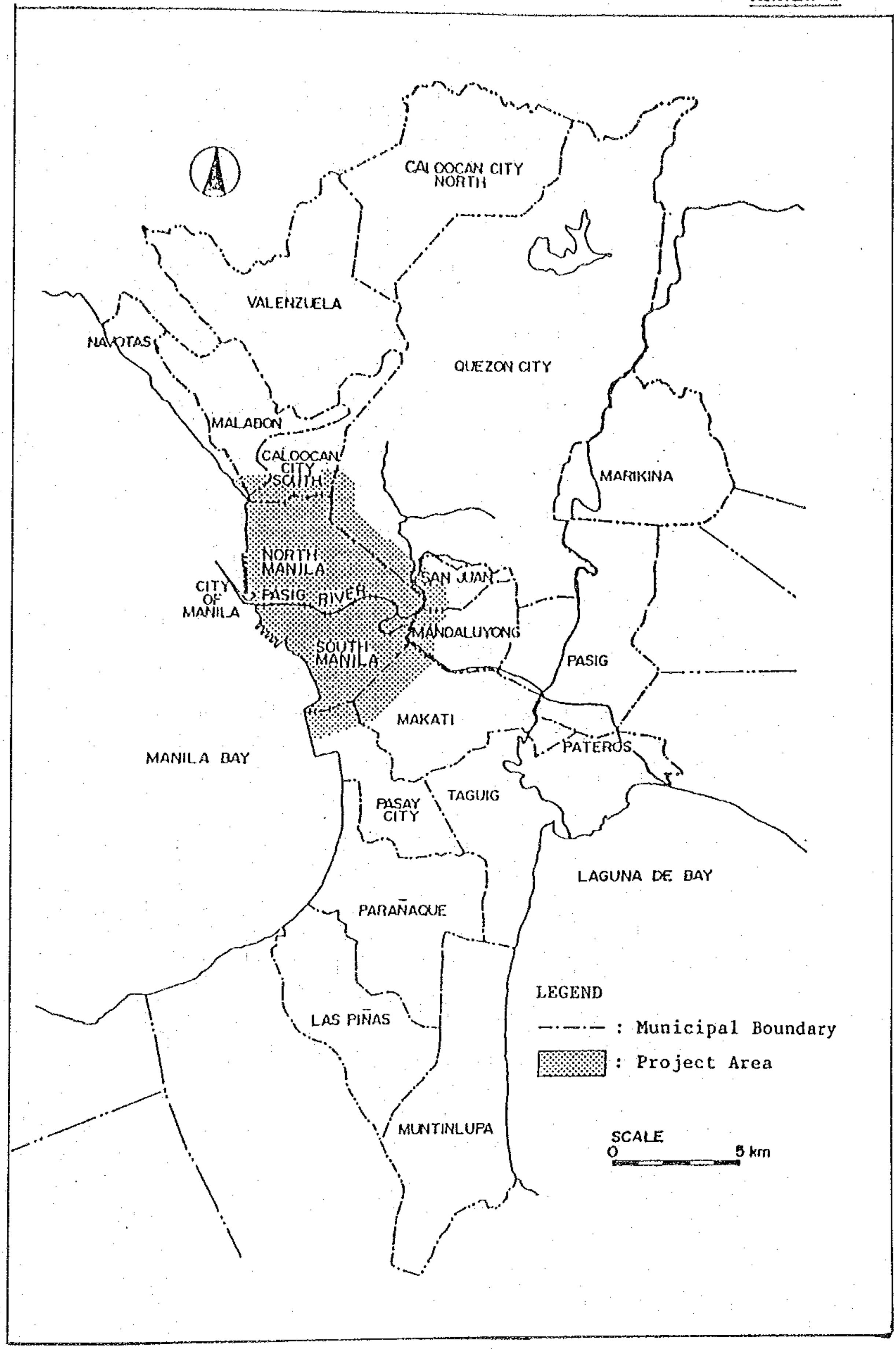
3. The Project Area will be the City of Manila and its vicinity. The retrieval portion of the existing drainage system will be selected within the limits of the Project Area (refer to Annex I).

4. The Project Dumping Site for spoils removed from the drainage system will be Navotas and Paranaque .

5. The Basic Design Study will convey to the Government of Japan, the desire of the Government of the Republic of the Philippines that the former shall take the necessary measures of cooperation by providing the necessary equipment and other items listed in Annex II within the scope of the economic cooperation program in the form of a Grant.

6. The Philippine side understood the Japanese Grant Aid system explained by the Team, including in principle the use of a Japanese consulting firm and a Japanese general contractor.

7. The Government of the Republic of the Philippines will take necessary measures as listed in Annex III on condition that the Grant Aid by the Government of Japan would be extended to the Project.


CALOOCAN CITY NORTH
VALENZUELA
NAVOTAS
QUEZON CITY
MALABON
CALOOCAN CITY SOUTH
MARIKINA
NORTH MANILA
SAN JUAN
CITY OF MANILA
PASIG RIVER
MANDALUYONG
SOUTH MANILA
PASIG
MAKATI
PATEROS
MANILA BAY
PASAY CITY
TAGUIG
LAGUNA DE BAY
PARAÑAQUE
LEGEND
: Municipal Boundary
: Project Area
LAS PIÑAS
MUNTINLUPA
SCALE
0
5 km

ANNEX II

EQUIPMENT AND WORK ITEMS TO BE PROVIDED BY THE GOVERNMENT OF JAPAN (TENTATIVE)

1. EQUIPMENT

The equipment will be provided to remove the spoils at the existing drainage mains/outfalls, laterals, and esteros. The major items of equipment to be provided are provisionally listed below. It is herein noted that the items of equipment may be altered according to the peculiar condition of the existing drainage system. Details of the condition will be clarified by the Basic Study Team during the field survey from March 28 to April 22, 1989.

(a) Equipment to Declog Drainage Mains/Outfalls and Laterals

(1) Water Jet Cleaner;
(2) Vacumn Cleaner;
(3) Water Tanker; and
(4) Dump Truck.

(b) Equipment to Dredge Esteros

(1) Water-Sand Pump Set;
(2) Engine Generator;
(3) Vacumn Cleaner;
(4) Backhoe, Crawler Type; and
(5) Dump Truck.

2. MODEL IMPLEMENTATION OF RETRIEVAL WORK IN A PILOT AREA

Actual retrieval work will be executed in a pilot area so as to effect the transfer of knowledge to enable the Government of the Republic of the Philippines to continue the appropriate operation and maintenance of the supplied equipment.

ANNEX III

ITEMS TO BE UNDERTAKEN BY THE GOVERNMENT OF THE REPUBLIC OF THE PHILIPPINES

1. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in the Philippines and prompt internal transportation of equipment provided under the Grant.

2. To bear the commissions to the Japanese foreign exchange bank for the banking services based upon the banking arrangement.

3. To exempt Japanese nationals involved in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in the Philippines with respect to the supply of the products and the services under the verified contract(s).

4. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract(s) such as facilities as may be necessary for their entry into the Philippines and stay therein for the performance of their work.

5. To bear all the expenses, other than those to be borne by the Grant, necessary for the execution of the Project.

6. To ensure the necessary budget and personnel for the proper and effective operation and maintenance of the equipment provided under the Grant.

APPENDIX 3

CALCULATION OF REQUIRED NUMBER OF EQUIPMENT

CALCULATION OF REQUIRED NUMBER OF EQUIPMENT

1. Standard

This calculation for the required number of the equipments is referred to the following standards under the consideration of the present condition of the flood prone areas in Metro Manila.

"Kensetsu-Sho Doboku Koji Sekisan Kijun"
("Cost Estimation Standard for Civil Work")
Supervised by Technical Study Section, Minister's Secretariat, Ministry of Construction, Government of Japan.
Edited by Doboku Koji Sekisan Kenkyo Kai.

"Kowan-Kuko Ukeoi Koji Sekisan Kijun"
("Cost Estimation Standard for Construction of Harbors and Airports")
Edited by Ports and Harbors Bureau, Civil Aviation Bureau, Ministry of Transport, Government of Japan, Published by Japan Port and Harbor Association.

"Gesuido Shisetsu Ijikanri Sekisan Yoryo (An) -Kanro Hen-"
("Cost Estimation Standard for the Maintenance of Sewage Facility (Proposed) -Conduit facility-")
Supervised by Sewerage and Sewage Purification Department, City Bureau, Ministrty of Construction, Government of Japan.
Published by Japan Sewage Works Association.

2. Workable Hours and Days

This calculation is based on the following workable hours, days and terms.

Workable Hours per Day (T_1)	8 hr/day
Equipment Operation Hours (T_2)	6 hr/day
Workable Days per Year	
First year (D_1)	205 days/year
Least 4 years (D_2)	230 days/year
Project Term (Y_1)	5 years

3. Laterals

3.1 Dimension and Sediment Volume

Size (inch)	Length (m)	Sediment Volume (m^3)
ø12"	30846	1092
ø18"	44273	3522
ø24"	94226	13324
ø30"	17365	3958
ø36"	6453	2156
ø42"	661	303

Total Length (La_1) 193824 m

Total Sediment Volume (Va_1) 24355 m^3

Average sedimentation of each laterial is approximately 50%.

3.2 Productivity

Productivity of one water jet cleaner for each size of lateral sedimented is approximately 50% is listed as follows;

Size (inch)	Productivity (m/day)
ø12"	160
ø18"	90
ø24"	65
ø30"	38
ø36"	26
ø42"	19

No available numerical data is existing for the productivities of the cleaning by the water jet cleaner for laterials sized ø30", 36 and 42". Therefore the above-listed data for these sized laterials is calculated from that of the lateral sized ø27.5" which datum is available.

3.3 Required Number of Equipment

(1) Water Jet Cleaner

The days required to complete the cleaning of each size of lateral by using one water jet cleaner is calculated according to the following:

$da_1 = la_1 / ea_1$

da_1	:	Required days	day
la_1	:	Length of lateral	m
ea_1	:	Productivity	m/day

- Required Days for the Cleaning Work of Each Size of Lateral

Size (inch)	Required Days (days/Unit)
ø12	193
ø18	492
ø24	1450
ø30	457
ø36	249
ø42	35

- Total Required Days (D_3) 2876 days

- Required Number of Water Jet Cleaner (Na_1)

$$Na_1 = D_3/(D_1 + D_2 \times 4)$$
$$= 2876 / (205 + 230 \times 4)$$
$$= 2.6$$
$$= 3$$

(2) Lift Dump Type Dehydration Vacuum Cleaner

The vacuum cleaner dehydrates the removed sediment and dump it to the dump truck in the job site. Therefore the required number of the vacuum cleaner is one for one water jet cleaner.

. Required Number of Vacuum Cleaner (Na_2)

$$Na_2 = 1 \times Na_2$$
$$= 1 \times 3$$
$$= 3$$

(3) Water Tanker

The number of required water tanker is one for one water jet cleaner, because water is utilized from a fire hydrant installed along the streets.

. Required Number of Water Tankers

$$Na_3 = 1 \times Na_1$$
$$= 1 \times 3$$
$$= 3$$

(4) Dump Truck

Sediment removed forom laterals is loaded from the vacuum cleaner to the 4t dump truck. The required number of the dump truck is calculated as follows:

. Productivity per Hour of 4t Dump Truck (qoa_1)

$qoa_1 = (60 \times qa_1 \times fa_1 \times Ea_1) / Cma_1$

qoa_1 : Production per cycle m^3/cycle
4t dump truck, sediment specific grairty
1.8, 2.2 m^3/cycle

fa_1 : Soil factor
Loose, excavated, high water containing clay, 1.25

Ea_1 : Job efficiency 0.9

Cma_1 : Cycle time min/cycle
$Cma_1 : ta_1 + ta_2 \times 2 + ta_3$
ta_1 : Loading time min/cycle
Loading time of the removed sediment to dump truck is regulated by the productivity of the vacuum cleaner.

In the case of the productivity of the vacuum cleaner is 4 m^3/hr and Work loss factor 0.25

ta_1 = qo_1 x (1 + 0.25) x 60 / 4
= 2.2 x (1 + 0.25) x 60 / 4
= 42 min/cycle

ta_2 : Hauling time from the job site to the Dumping Site min/cycle
Time Surveyed 45 min/cycle

ta_3 : Hauling time from the job site to the Dumping Site min/cycle
45 min/cycle

Cma1 = 42 + 45 x 2 + 10
= 142 min/cycle

qoa_1 = (60 x 2.2 x 1.25 x0.2) / 142
= 1.0 m^3/hr

- Productivity of dump truck per day (qoa_2)

qoa_2 = qoa_1 x T_2
= 1 x 6
= 6 m^3/day

- Required Number of 4t Dump Truck per One Water Jet Cleaner (na_1)

The required number of 4t dump truck is calculated to be based on the maximum removable volume of sediment, 9.109m^3/day from lateral sized ø24", 50% of average sedimentation as follows:

na_1 = 9.189 / qoa_2
= 9.189 / 6
= 1.5
= 2/unit

- Required Number of 4t Dump Truck (Na_4)

N_4 = na_1 x Na_1
= 2 x 3
= 6

4. Drainage Mains and Outfalls

4.1 Dimension and Sediment Volume

Width (m)	Length (m)	Sediment Volume (m^3)
Concrete Rectangular Maintenance Hole		
1.57 - 4.40	15283	55345
ø18" Steel Maintenance Hole		
1.10 - 3.50	4340	12160
Total Length (Lb_1)		19623 m
Total Sediment Volume (Vb_1)		67505 m^3

4.2 Required Number of Equipment

4.2.1 Concrete Rectangular Maintenance Hole

The width of rectangular shaped concrete maintenance hole is sufficient to use a dragline bucket which capacity is $0.6m^3$ or $0.3m^3$. Therefore the calculation is based on the productivity of a $0.6m^3$ dragline bucket to complete the whole cleaning of the drainage mains and outfalls which leads are made of concrete within 5 years.

. Required Volume to be Removed per Day (Vb_2)

$Vb_2 = Vb_3 / (D_1 + D_2 \times 4)$

Vb_3 : Sediment volume m^3

55345 m^3

$Vb_2 = 55345 / (205 + 230 \times 4)$

$= 49.2 \ m^3/day$

(1) Wheel Crane

One wheel crane performs as a crane to open a maintenance cover, a dragline to collect sediment and a cramshell to load the removed sediment to a dump truck with exchange of its attachment.

• Productivity of $0.6m^3$ Dragline Bucket per Hour (qob_1)

$qob_1 = (3600 \times qb_1 \times fb_1 \times Eb_1) / Cmb_1$

qb1 : Production per cycle m^3/cycle

$0.6m^3$ bucket 0.53 m^3/cycle

fb_1 : Soil factor = 1.25

Eb_1 : Job efficiency = 0.20

Cmb_1 : Cycle time sec/cycle

$Cmb_1 = 1b_1 \times 2 / Vb_1 \times 60 + tb_1$

b_1 : Dragline speed 45 m/min

$1b_1$: Distance between maintenance hole 50 m

tb_1 : Work loss time 20 sed/cycle

$Cmb_1 = (50 \times 2) / 45 \times 60 + 20$

= 154 sec/cycle

$qob_a = (3600 \times 0.53 \times 1.25 \times 0.2) / 154$

= 3 m^3/hr

• Productivity of $0.6m^3$ Cramshell Bracket per Hour (qob_2)

$qob_2 = (3600 \times qb_2 \times fb_2 \times Eb_2) / Cmb_2$

qb2 : Production per cycle m^3/cycle

$0.6m^3$ bucket 0.44 m^3/cycle

fb_1 : Soil factor = 1.25

Eb_2 : Job efficiency = 0.25

Cmb_2 : Cycle time

90° 36 sec/cycle

$qob_2 = (3600 \times 0.44 \times 1.25 \times 0.25) / 36$

= 13.7 m^3/hr

. Work Time Ratio of Dragline Bucket and Cramshell Bucket

The collection of the sediment to a maintenance hole and the dumping of the sediment is performed by the same sheel crane with exchange of its attachment. The worktime ratio of a dragline bucket and a cramshell bucket is as follows:

$3 \times tb_2 = 13.7 \times (6 - tb_2)$
tb_2 : work time by a dragline bucket hr/day
$tb_2 = 4.9$ hr/day

Therefore the ratio of work time is as follows:

Dragline bucket	4.9 hr/day
Cramshell bucket	1.1 hr/day

. Productivity of Wheel Crane with Dragline Bucket per Day (Vb_4)

The productivity of a wheel crane with a dragline bucket is as follows:

$$Vb_4 = qob_1 \times tb_2$$
$$= 3 \times 4.9$$
$$= 14.7 \text{ m}^3\text{/day}$$

. Required Number of Hydraulic Wheel Crane (Nb_1)

$$Nb_1 = Vb_2 / Vb_3$$
$$= 49.2 / 14.7$$
$$= 3.3$$
$$= 4$$

(2) Dump Truck

The required number ofr the 4t dump druck to haul the sediment removed and loaded by a clamshell bucket from a drainage main and an outfall is calculated as follows:

. Productivity of 4t Dump Truck per Hour (qob_3)

$qob_3 = (60 \times qb_3 \times fb_3 \times Eb_3) / Cmb_3$

qb3 : Production per cycle m^3/cycle

4t dump truck, soil specific gravity 1.8,

2.2 m^3/cycle

fb_3 : Soil factor = 1.25

Eb_3 : Job efficiency = 0.9

Cmb_3 : $tb_3 + tb_4 \times 2 + tb_5$

tb_3 : Loading time min/cycle

The loading time of the sediment from a drainage main or an outfall to a dump truck is calculated as follows:

$tb_3 = (qb_3 \times 60) / qob_2$

$= (2.2 \times 60) / 13.7$

$= 10$ min/cycle

tb_4 : Houling time from job site to dumping site min/cycle

Surved time 45 min/cycle

tb_5 : Dumping time min/cycle

10 min/cycle

$Cmb_3 = 10 + 45 \times 2 + 10$

$= 110$ min/cycle

$qob_3 = (60 \times 2.2 \times 1.25 \times 0.9) / 110$

1.3 m^3/hr

. Productivity of 4t Dump Truck per Day (qob_4)

$qob_4 = qob_3 \times T_2$

$= 1.3 \times 6$

$= 7.8$ m^3/day

. Required Number of 4t Dump Truck per Hydraulic Wheel Crane (nb_1)

$nb_1 = Vb_3 / qo_b4$

$= 14.7 / 7.8$

$= 1.9$

$= 2$/unit

. Required Number of 4t Dump Truck

$$Nb_2 = nb_1 \times Nb_1$$
$$= 2 \times 4$$
$$= 8$$

(3) Portable Blower

The hydraulic wheel crane is wired personnel in a drainage main or an outfall for dragline work. Therefore to keep the safe condition, a portable blower is required to ventilate.

. Required Number of Portable Blower (Nb_3)

$$Nb_3 = 1 \times Nb_1$$
$$= 1 \times 4$$
$$= 4$$

(4) Diesel Engine Generation for (3)

One diesel engine generation is required for a portable blower.

. Required Number of Diesel Engine Generation (Nb_4)

$$Nb_4 = 1 \times Nb_1$$
$$= 1 \times 4$$
$$= 4$$

(5) Gas Detector (Oxygen, Combustible Gas, Hydrogen Sulfide)

The gas detector is necessary to protect personnel working in a drainage main or an outfall from hazardous gas. One gas detector is required for one hydraulic wheel crane and one spare for all hydraulic wheel cranes.

. Required Number of Gas Detector (Nb_5)

$$Nb_5 = 1 \times Nb_1 + 1$$
$$= 1 \times 4 + 1$$
$$= 5$$

4.2.2 D18" Steel Maintenance Hole

D18" steel maintenance holes installed on a drainage main and an outfall cannot be cleaned by the mechanical procedure here above-mentioned because of their narrow diameters. Also, it is impossible to perform the cleaning work by using a vacuum pump because of much garbage such as plastic bags, cans and bottles including sediment and fluid.

Therefore, the cleaning work for the drainage main and outfall shall be performed by personnel and shall be completed in a dry season under the consideration of personnel safety.

The required number of equipment for the personnel work is estimated according to that for the work to complete Vito Cruz Manila Outfall whose sediment volume is the most of them.

- Dimension and Sediment volume of Vito Cruz Manila Outfall

Depth (hc_1)	2.05 m
Width (wc_1)	1.96 m
Length (Lc_1)	1325 m
Sedimentation Ratio (Pc_1)	97%
Sediment Volume	5166 m^3

- Workable Months and Days

Workable months per year (M_1)	6 months/day
Workable days per month (D_4)	24 days/month

- Required Number of Labour Parties (nc_1)

One party of labours consists of 4 personnel who perform excavation and transportation in the outfall, excluding the labours who transport and dump the sediment removed from the outfall to a dump truck.

$Nc_1 = Vc_1 / (D_4 - dc_1) \times Vc_2$

dc_1 : Work days for closing down and water discharge

Closing down 5 days

Water discharge (including temporary installation) 4 days

$dc_1 = 5 + 4 = 9$ days

Vc_2 : Productivity per day by a party consisting of 4 labourers

Personnel excavation, 10 m^3/day per 4.2 labours.

Therefore 9.5 m^3/day is produced by 4 labours.

$Nc_1 = 5166 / (144 - 9) \times 9.5$

$= 4.0$ parties

(1) Submersible Sand Pump

The pump shall be installed temporarily at the outlet of Vito Cruz Manila along Manila Bay after close down of the inlet. Then all water in the outfall shall be discharge before the retrieval work.

. Discharge Volume (Vc_3)

$$Vc_3 = (Lc_1 \times hc_1 \times Wc_1) \times (100 - Pc_1) / 100$$
$$= (1325 \times 2.05 \times 1.96) \times (100 - 97) / 100$$
$$= 159.7 \text{ m}^3$$

. Required Pump Capacity (Vc_4)

Water discharge shall be completed within a day after the close down of the outlet and the temporary installation of pumps but before the retrieval work.

$Vc_4 = (Vc_3 \times fc_1) / (T_2 \times 60)$

fc_1 : Safety factor 2

$Vc_1 = (159.7 \times 2) / (6 \times 60)$

$= 0.89$

$= 1$ m^3/min

- Required Number of Submersible Sand Pump (Nc_1)

The required number of the submersible sand pump is two including one spare.

$Nc_1 = 1 + nc_2$
Nc_2 : Spare pump 1
$Nc_1 = 1 + 1$
$= 2$

(2) Diesel Engine Generator for (1)

One diesel engine generator is required for the above-mentioned submersible sand pump operation.

- Required Number of Diesel Engine Generator for (1)

$Nc_2 = 1$

(3) 2t Dump Truck

The sediment removed by labours is haulted to the dumping site by 2t dump trucks.

- Productivity of 2t Dump Truck per Hour (qoc_1)

$qoc_1 = (60 \times qc_1 \times fc_1 \times Ec_1) / Cmc_1$
qc1 : Production per cycle m^3/cycle
2t dump truck, soil specific gravity 1.8,
1.1 m^3/cycle
fc_1 : Soil factor = 1.25
Ec_1 : Job efficiency = 0.9
Cmc_1 : Cycle time min/cycle
$Cmc_1 = tc_1 + tc_1 \times 2 + tc_3$
tc_1 : Loading time min/cycle
$tc_1 = (qc_1/tc_4) / (qc_2 \times 60)$
qc_2 : production of labour per cycle m^3/cycle
0.02 m^3/cycle

tc_4 : Cycle time of labour sec/cycle
30 sec/cycle

$tc_1 = 1,1/0.02 \times 30/60$
$= 27.5$ sec/cycle

tc_2 : Hauling time min/cycle
time surveyed 45 min/cycle

tc_3 : Dumping time min/cycle
5 min/cycle

$Cmc_1 = 27.5 + 45 \times 2 + 5$
$= 122.5$ min/cycle

$qoc_1 = (60 \times 1.1 \times 1.25 \times 0.9) / 122.5$
$= 0.6\ m^3/hr$

. Productivity of a 2t Dump Truck per Day (qoc_2)

$qoc_2 = qOc_1 \times T_2$
$= 0.6 \times 6$
$= 3.6\ m^3/day$

. Required Number of Dump Truck per Party (nc_2)

$nc_2 = Vc_2 / qoc_2$
$= 9.5 / 3.6$
$= 2.6$
$= 3$/party

. Required Number of Dump Truck (Nc_3)

$Nc_3 = nc_2 \times nc_1$
$= 3 \times 4$
$= 12$

(4) Portable Submersible Pump

Water leaked or stayed in the outfall during the retrieval work shall be discharged by using portable submersible pumps installed in the job site which capacity is 0.12 m^3/min.

Two portable submersible pumps includikng one spare are required for the work of one party in the outfall.

. Required Number of Portable Submersible Pump (Nc_4)

$$
\begin{aligned}
Nc_4 &= 2 \times nc_1 \\
&= 2 \times 4 \\
&= 8
\end{aligned}
$$

(5) Portable Blower

One portable blower is required for one party to ventilate in the outfall.

. Required Number of Portable Blower (Nc_5)

$$
\begin{aligned}
Nc_5 &= 1 \times nc_1 \\
&= 1 \times 4 \\
&= 4
\end{aligned}
$$

(6) Flood Light

Luighting system is necessary for the personnel work in the outfall. Flood light 300 w shall be installed every 10 m in work distance 70 m for one party.

. Required Number of Flood Light (Nc_6)

$$
\begin{aligned}
Nc_6 &= 70/10 \times Nc_1 \\
&= 7 \times 4 \\
&= 28
\end{aligned}
$$

(7) Diesel Engine Generator for (3), (4) and (5)

One diesel engine generator per party is required for the personnel retrieval work in the carvert.

. Required Number of Diesel Engine Generator (Nc_7)

$$
\begin{aligned}
Nc_7 &= 1 \div nc_1 \\
&= 1 \times 4 \\
&= 4
\end{aligned}
$$

(8) Gas Detector (Oxygen, Combustible Gas and Hydrogen Sulfide)

The gas detector is necessary for the work in the carvert to protect personnel from hazardous gas.

The required number of the gas detector is one for a party and one spare for whole four parties.

. Required Number of Gas Detector (Nc_8)

$$
\begin{aligned}
Nc_8 &= 1 \times nc_1 + 1 \\
&= 1 \times 4 + 1 \\
&= 5
\end{aligned}
$$

5. Esteros

5.1 Dimension and Dredging Volume

	Average Width (m)	Length (m)	Dredgomg Volume (m^3)
Vitas	31.9	1800	103300
Sunnog-Apog	21.2	1120	431500
Mayopajo	13.6	1800	9750
Della Reina	19.5	2855	32760
Valencia	7.5	1124	3955
Paco	20.8	1859	13760
Pandacan	9.7	1134	4800
Tripa de gallina	7.7	1730	8190

Total Length (Ld_1) 13422 m

Total Dredging Volume 219665 m^3

5.2 Required Number of Equipment

The dredging barge type is classified to a middle size and a small size assemble/disassemble barges according to the condition of esteros.

The middle size barge performs the dredging in Estero de vitas and Estero de Sunog Apog whose width and size of bridges are sufficient to pass through them. And their dredging volume is approx. 70% of it.

The small size barge performs the dredging in the other esteros which is not sufficient for the dredging of the middle size barge.

5.2.1 Large Esteros

The required volume to be dredged in Estero de Vitas and Estero de Sunog Apog within 5 years is calculated as follows:

- Required Dredging Volume (Vd_2) 14645 m^3

- Required Dredging Volume per Day (Vd_3)

$$Vd_3 = Vd_2 / (D_1 + D_2 \times 4)$$
$$146450 / (205 + 230 \times 4)$$
$$= 130.1 \ m^3/day$$

- Required Dredging Volume per Hour (Vd_4)

$$Vd_4 = Vd_3 / T_2$$
$$120.1 / 6$$
$$= 21.7 \ m^3/hr$$

(1) Middle Size Dredging Barge

. Productivity per Hour of 0.6 m^3 Cramshell Glove Crowler (qod_1)

qod_1 = [(qd_1 x fd_1 x kd_1 x 60^2)/Cmd_1] x (Ed_1 x d_1)

qod_1 : Glove capacity 0.6 m^3

fd_1 : Soil factor
Soft clay 0.95

kd_1 : Glove excavation factor
Soft clay 0.95

Cmd_1 : Glove cycle time sec/min
Dredging depth is shallow 60 sec/cycle

Ed_1 : Job efficiency
Weather condition, normal,
Soil thickness - plane shape - position -
Cross section shape, very variable 0.7

d_1 : Work time efficiency
Under the condition of Ed_1 0.7

qod_1 = [(0.6 x 0.95 x 0.95 x 60^2) / 60] x 0.7 x 0.7
= 15.9 m^3/hr

. Required Number of Middle Size Dredging Barge (Nd_1)

Nd_1 = Vd_4 / qod_1
= 21.7 / 15.9
= 1.4
= 2

(2) Scow

The dredging work on the esteros is not influenced by the tidal current and rough weather, therefore one tug boat maneuvers one dredging barge and two scows. The tug boat tows the scows for 3 hours and maneuvers the dredging barge for 3 hours in a day.

- Loading Capacity of Scow2 (B_1)

Bd_1 = $(1/5 + dd_1/vd_1 \times 2) + (qod_1 \times T_2) / (td_1 \times fd_1)$

dd_1 : Average towing distance of a return trip km
The distance to be dredged in Estero de Vitas is 1.8 km and in Estero de Sunog Apog 1.2 km. Therefore, the distance is assumed at 1.8 km.

vd_1 : Average towing speed km/hr
6.5 km/hr

td_1 : Towing time per day hr/day
3 hr/day

$$Bd = (1/5 + 1.8/6.5 \times 2) + (1.59 \times 6) / (3 \times 0.95)$$
$$= 25.2\ m^3$$

The scow consists of 12 hoppers, 2 m^3 capacity each.

- Required Number of Scow (Nd_2)

$$Nd_2 = 2 \times Nd_1$$
$$= 2 \times 2$$
$$= 4$$

(3) Tug Boat

- Required Number of Tug Boat (Nd_3)

One tug boat is required for one dredging barge and two scows.

$$Nd_3 = 2 \times Nd_1$$
$$= 1 \times 2$$
$$= 2$$

(4) 11t Dump Truck

The road and traffic condition surrounding Estero de Vitas and Estero de Sunog Apag is suitable to haul the removed sediment by a 11t dump truck.

- Productivity per Hour of 11t Dump Truck (qod_2)

qod_2 = (60 x qd_2 x fd_2 x Ed_2) / Cmd_2

qd2 : Production per cycle m^3/cycle

11t Dump truck, soil specific gravity 1.8

6.1 m^3/cycle

fd_2 : Soil factor

Loose, excavated, high water containing clay 1.25

Ed_2 : Job efficiency 0.9

Cmd_2 : Cycle time min/cycle

$Cmd_2 = td_2 + td_3 \times 2 + td_4$

td_2 : Loading time min/cycle

The crane hooks up 2 m^3 hoppers from a scow, and loads the removed sediment to a 11t dump truck.

$td_2 = (qb_2 \times td_5) / (2 \times 60)$

td_5 : Cycle time of crane

90° 30 sec/cycle in addition of the hopper and wire operation, and loss time.

60 sec/cycle

$td_2 = (6.1 \times 60) / (2 \times 60)$

= 3 min/cycle

td3 : Hauling time min/cycle

Surveyed time 45 min/cycle

td_4 : Dumping time min/cycle

10 min/cycle

$Cmd_2 = 3 + 45 \times 2 + 10$

= 102 min/cycle

$qod_2 = (60 \times 6.1 \times 1.25 \times 0.9) / 102$

= 4.0 m^3/hr

- Productivity per day of a 11t Dump Truck (qd_3)

$qd_3 = qod_2 \times T_2$

= 4 x 6

= 24 m^3/day

- Required Number of 11t Dump Truck per Dredging Barge (nd_1)

$$nd_1 = Vd_3 / (Nd_1 \times qd_3)$$
$$= 130.1 / (2 \times 24)$$
$$= 2.7$$
$$= 1/\text{unit}$$

- Required Number of 11t Dump Truck

$$Nd_4 = nd_1 \times Nd_1$$
$$= 3 \times 2$$
$$= 6$$

(5) Hydraulic Truck Crane

- Loading time of 11t Dump Truck per Dredging Barge per Day (qtd_6)

$$qd_6 = Vd_3 / (Nd_1 \times 2)$$
$$= 130.1 / (2 \times 2)$$
$$= 32 \text{ min/(day, unit)}$$

- Required Number of Hydraulic Truck Crane per Dredging Barge (nd_2)

$$nd_2 = td_6 / (T_2 \times 60)$$
$$= 32 / (6 \times 60)$$
$$= 0.09 / \text{unit}$$

- Required Number of Hydraulic Truck Crane (Nd_5 or $N'd_5$)

$$Nd_5 = nd_2 \times Nd_1$$
$$= 0.09 \times 2$$
$$= 0.18$$
$$= 1$$

One hydraulic truck crane is required when the unloading/loading stations installed at one point along the esteros for two dredging barges.

But the whole dredging work will be stopped when the crane will be troubled or broken.

And where it is difficult to collect six dump trucks at one station for the unloading/loading, another station is necessary to dredge the esteros continuously. Therefore one hydraulic truck crane is required for one dredging barge.

. Required Number of Hydraulic Truck Crane ($N'd_5$)

$$N'd_5 = Nd_5 \times Nd_1$$
$$= 1 \times 2$$
$$= 2$$

5.2.2 Small Esteros

It is impossible to dredge the small size esteros by the middle size dredging barge because their width is narrow and many squatters live along the both sides of them. Therefore the esteros are dredged by using the small size barges (Easy Set-up Type).

. Required Dredging Volume (Ve_1) 73215 m^3

. Required Dredging Volume per Day (Ve_2)

$$Ve_2 = Ve_1 / (D_1 + D_2 \times 4)$$
$$73215 / (205 + 230 \times 4)$$
$$= 60.1 \ m^3/day$$

. Required Dredging Volume per Hour (Ve_3)

$$Ve_3 = Ve_2 / T_2$$
$$60.1 / 6$$
$$= 10.1 \ m^3/hr$$

(1) Small Size Dredging Barge (Easy Set-up Type)

Required number of the dredging barge with a 0.2 m^3 hydraulic cramshell crawler is calculated as follows:

- Productivity of Hydraulic Cramshell Crawler per hour (qoe_1)

$qoe_1 = [(qe_1 \times fe_1 \times ke_1 \times 60^2)/Cme_1] \times (Ee_1 \times e_1)$

qe_1 : Bucket capacity m^3
0.2 m^3

fe_1 : Soil factor
Soft clay 0.95

ke_1 : Glove excavation factor
Soft clay 0.95

Cme_1 : Glove cycle time sec/min
Cramshell 180 42 sec/cycle

Ed_1 : Job efficiency
Clamshell, excavating and loading ground of clay 0.4

e_1 : Work time factor
Under the condition of Ee_1 0.7

$qoe_1 = [(0.2 \times 0.95 \times 0.95 \times 60^2) / 42] \times 0.4 \times 0.7$
$= 4.3\ m^3/hr$

- Required Number of Small Size Dredging Barge (Ne_1)

$Ne_1 = Ve_4 / qoe_1$
$= 10.0 / 4.3$
$= 2.3$
$= 3$

(2) Scow (Easy Set-up Type)

Two scows are required for one dredging barge under the consideration of the work conditions of the esteros.

The scows are maneuvered by personnel towing with rope from the shore of the esteros.

. Capacity of Scow (Be_1)

Be_1 = (1/5 + de_1/ve_1 x 2) + (qoe_1 x T_2) / (te_1 x fe_1)

dd_1 : Average towing distance of km
The unloading/loading point is installed at the place where the squatter does not exist. The distance is assumed 0.2 km.

ve_1 : Average towing speed km/hr
Personnel towing with rope 1.5 km/hr

te_1 : Towing time per day hr/day
Personnel towing with rope 3 hr/day

Be_1 = (1/5 + (0.2 x 2)/1.5) x (4.3 x 6) / (3 x 0.95)
= 4.2 m^3

The scow equips three hoppers which capacity is 2 m^3 each, to minimize the unloading and loading time from the scow to the dump truck. Therefore the capacity of the scow is 6 m^3.

. Required Number of Scow (Ne_2)

Ne_2 = 2 x Ne_1
= 2 x 3
= 6

(3) 4t Dump Truck

The 4t dump truck to hauls the dredged sediment to the dumping site.

. Productivity of Dump Truck per Day (qoe_2)

Same as that of 4.2.1 (2)

qoe_2 = 7.8 m^3/day

- Required Number of Dump Truck for One Dredging Barge (ne_1)

$$ne_1 = Ve_2 / (Ne_1 \times qe_2)$$
$$= 60.1 / (3 \times 7.8)$$
$$= 2.6$$
$$= 3/\text{unit}$$

- Required Number of 4t Dump Truck (Ne_3)

$$Ne_3 = ne_1 \times Ne_1$$
$$= 3 \times 3$$
$$= 9$$

(4) Hydraulic Wheel Crane

The road and traffic condition surrounding the small esteros and the unloading/loading spaces for the dredged sediment from the scow to the dump truck are very complicated because the small esteros are in the densed population area.

Therefore one hydraulic wheel crane is required for one dredging barge to minimize the working loss time.

- Required Number of Hydraulic Wheel Crane (Ne_4)

$$Ne_4 = 1 \times Ne_1$$
$$= 1 \times 3$$
$$= 3$$

(5) Gas Detector (Hydrogen Sulfide)

It is possible to blow out hydrogen sulfide from the sediment during the dredging work in the small esteros, because much garbage is spoiled and sedimented in them. Therefore, the gas detector is required to secure the personnel working on the barge.

. Required Number of Gas Detector (Ne_5)

One gas detector is required for one dredging barge and one spare for all barges.

$$\begin{aligned} Ne_5 &= 1 \times Ne_1 + 1 \\ &= 1 \times 3 + 1 \\ &= 4 \end{aligned}$$

(6) Truck Trailer

One 11t truck trailer is required to transport 0.2 m^3 hydraulic cramshell crowler, winch and engine generator for the disassembled barge. And also the truck trailer transports the equipments mentioned in 4.2.2.

. Required Number of Truck Trailer (Ne_6)

$$\begin{aligned} Ne_6 &= 1/3 \times Ne_1 \\ &= 1/3 \times 3 \\ &= 1 \end{aligned}$$

(7) Small Scow for Personnel Dredging (Easy Set-up Type)

It is impossible to maneuver the dredging barge in the small esteros where the squatters built the houses along the both sides of them.

Therefore, the dredging work is performed by personnel with the small sized assemble/disassemble scows in such the small esteros.

The scpw towed by personnel in the small esteros is 4 m^3 consisting of 2 hoppers which capacity is 2 m^3 each.

- Required Number of Scow for Personnel Dredging (Ne_7)

The scows are used temporarily when the dredging barges cannot maneuver in the small esteros.

Therefore the required number of the scow is two.

$Ne_7 = 2$