CHAPTER- VIII OTHER MEASURES

CHAPTER – VIII

OTHER MEASURES

1. BOTTOM SEDIMENT DREDGING

1.1 OUTLINE

In this section, the dredging and disposal method of the accumulated organic sediment in the Interior Puno Bay is examined for the water quality improvement.

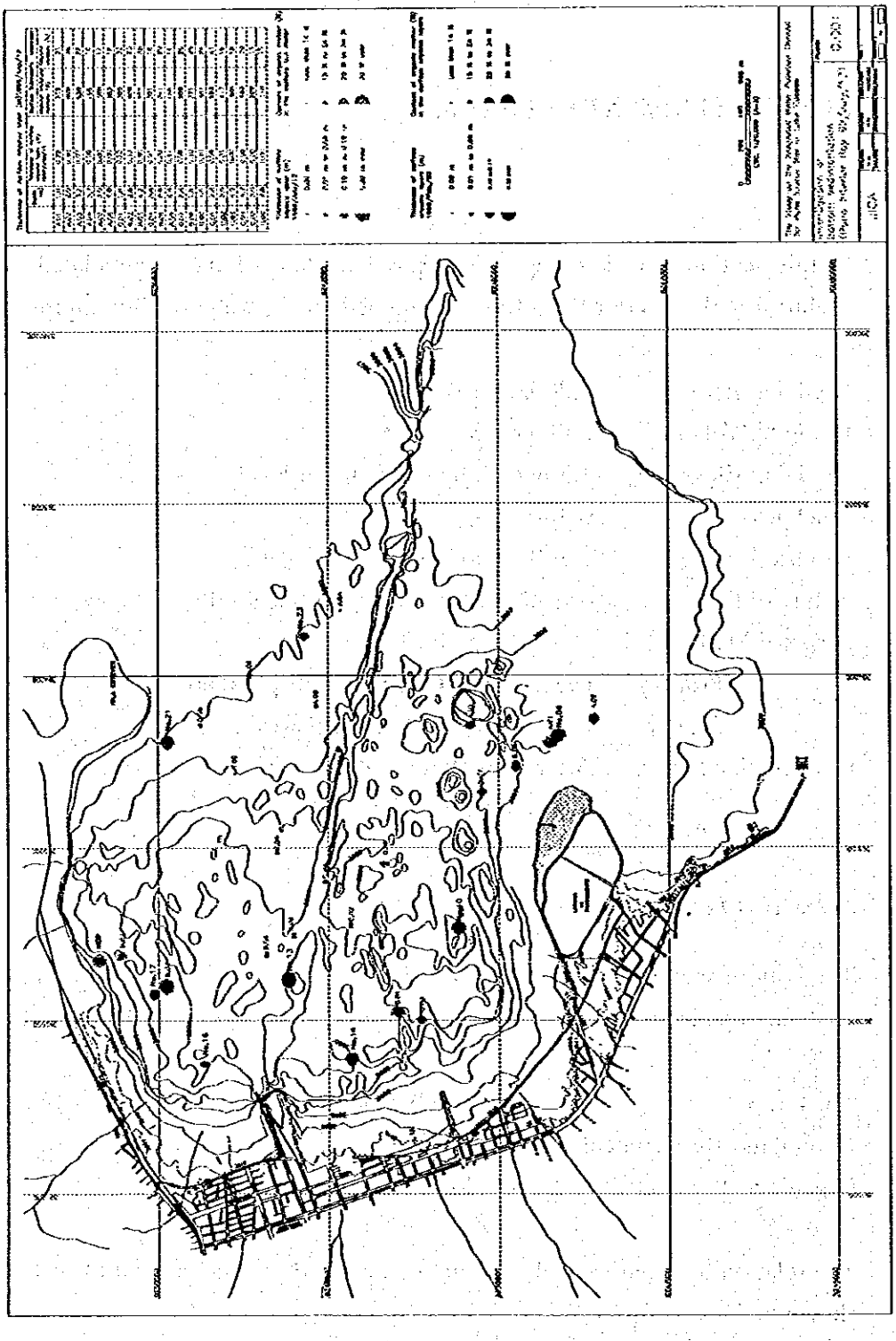
Dredging Area	2,200,000m2
Dredging Volume	660,000m3
Dredging Elevation	1.3 m to 3.5m below water level
Thickness	0.3m
Discharge Length	1,500m maximum
Nature of the soil	organic silt and clay with fine sand
Disposal Method	
Primary	Desiccation at temporary disposal area
Finally	Dumping to final disposal area
Construction Period	After completion of the city sewage treatment system construction (2010 to 2021)

1.2 EXAMINATION OF ACCUMULATED SEDIMENT

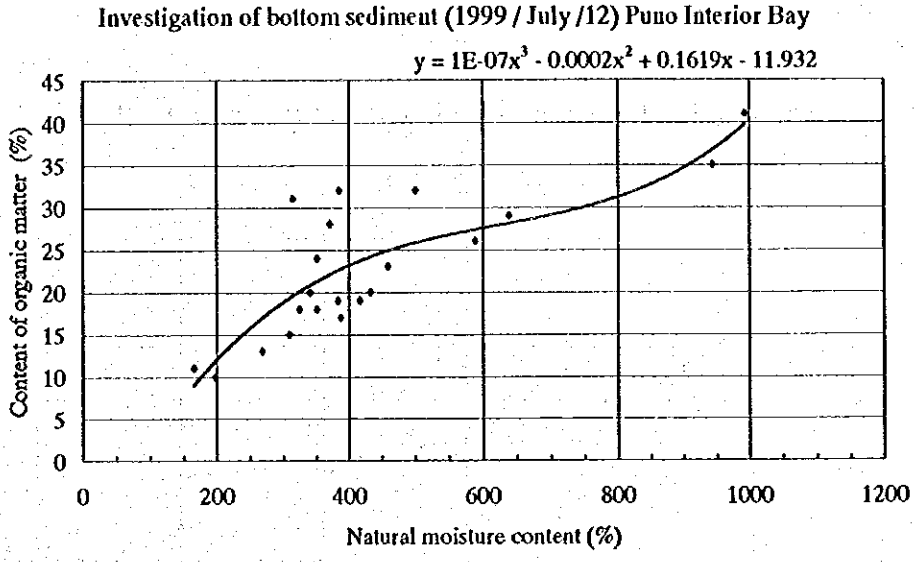
The bottom sediment was corrected in July 1999, the thickness, natural moisture content, organic matter content was measured at a site and the PELT laboratory.

Thickness	0.00m to 0.22 m
Natural moisture content	166% to 993 %
Organic matter content	10% to 41 %

The relation between natural moisture content and organic content of materials is shown in the next figure.



FigureVIII.1.1 Investigation of bottom sediment

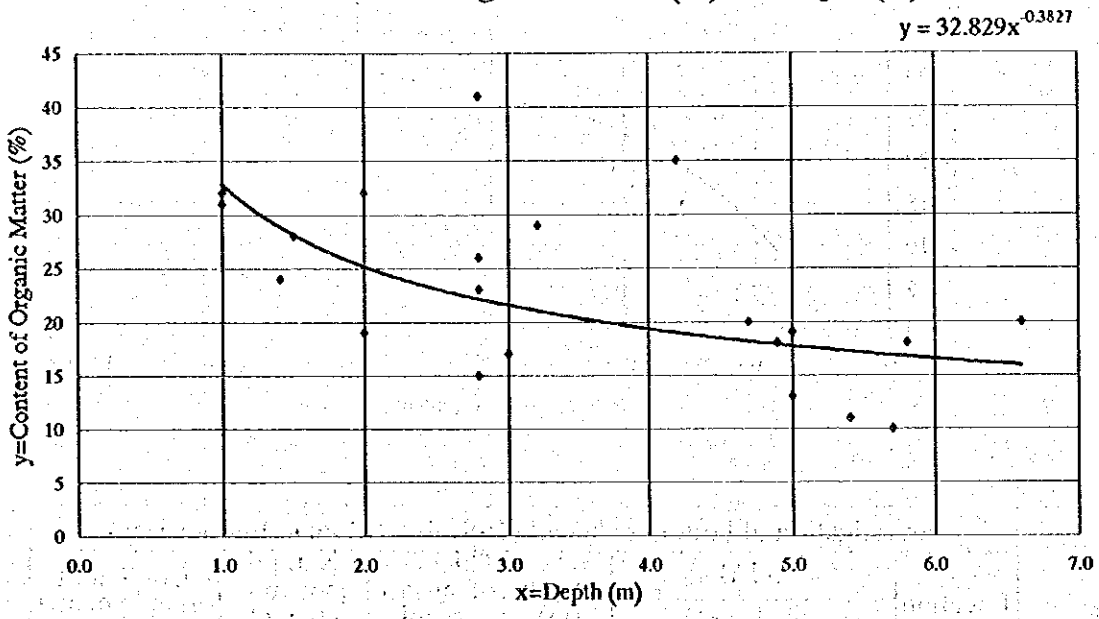


Investigation of bottom sediment (1999/July/12 Puno Interior Bay)						
Location	UTM		Depth (m)	Thickness of surface organic layer (m)	Natural moisture content (%)	Content of organic matter (%)
	X (m)	Y (m)				
A.01	393,620	8,247,691	1.0	0.22	315	31
A.02	393,745	8,347,439	2.0	0.10	500	32
A.03	393,702	8,248,161	3.2	0.07	638	29
A.04	394,377	8,248,927	5.7	0.00	198	10
A.05	393,816	8,249,070	3.0	0.00	388	17
A.06	393,984	8,249,466	2.0	0.00	383	19
B.01	392,354	8,250,354	1.0	0.22	385	32
B.02	392,381	8,250,218	2.8	0.13	459	23
B.03	392,194	8,249,953	4.2	0.20	944	35
B.04	392,379	8,249,365	5.8	0.01	351	18
B.05	392,488	8,249,203	6.6	0.05	341	20
B.06	392,915	8,248,665	5.4	0.11	166	11
B.07	393,311	8,248,097	2.8	0.08	589	26
B.08	393,470	8,247,896	1.5	0.10	371	28
C.00	392,006	8,248,448	1.4	0.10	351	24
C.01	392,031	8,248,591	2.8	0.05	993	41
C.02	392,547	8,248,867	5.0	0.01	417	19
C.03	392,796	8,249,019	4.9	0.00	325	18
C.04	392,964	8,249,301	4.7	0.00	433	20
C.05	393,427	8,249,552	5.0	0.00	269	13
C.06	393,706	8,249,754	2.8	0.00	310	15

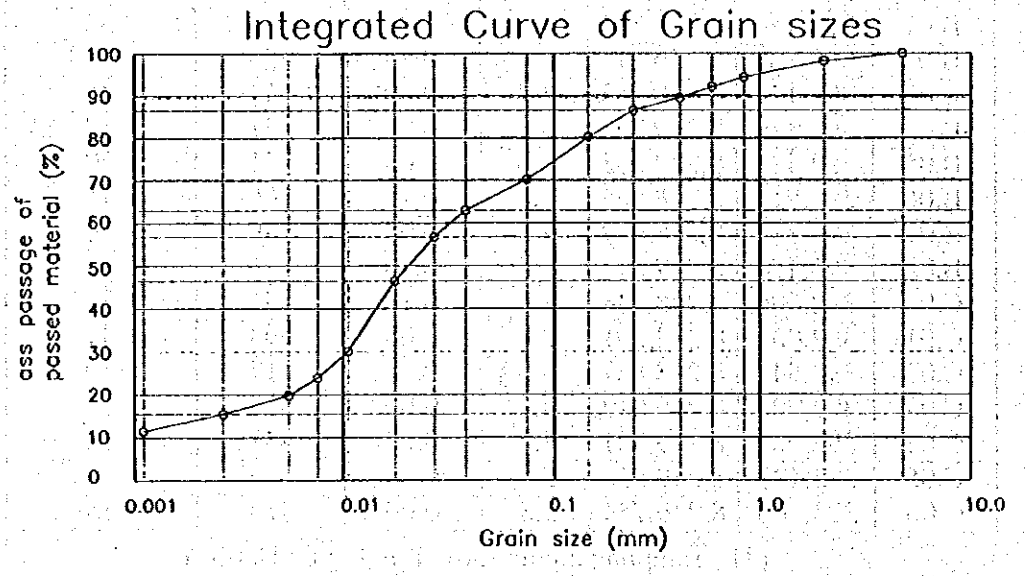
(The sampling points show it in Figure D. 001)

The next figure is expressing the relation between the water depth and organic matter content and there is an increase trend of organic matter content from the depth of 3.5m to shallower.

The relation between organic content (%) and depth (m)



The next figure shows the grain size distribution of organic sediment.



1.3 THE TRANSPARENCY SURVEY OF INTERIOR BAY

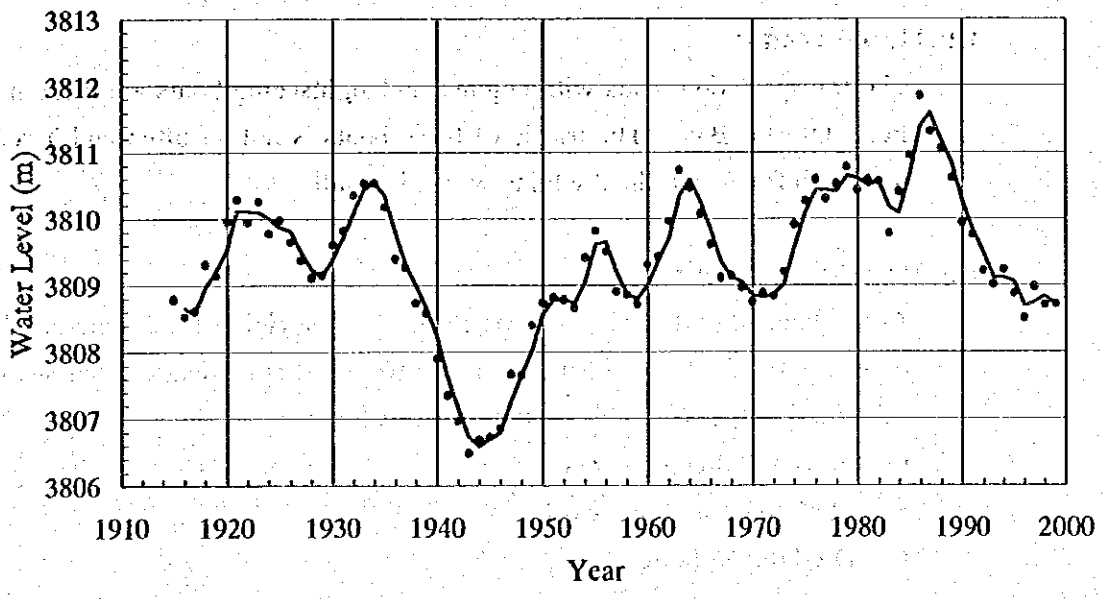
The transparency of the interior bay was investigated on the same day of bottom sediment sampling. The transparency was about 1.0m at the public pier neighborhood and 0.6 m to 0.8 m at the Espinar wastewater treatment plant neighborhood.

1.4 NATURAL CONDITIONS OF THE PUNO INTERIOR BAY

1.4.1 Water Level

The fluctuations of water level of the Lake Titicaca after 1915 are as the next figure. The lowest water level is 3,806.17 m and the highest water level is 3,812.48 m.

Fluctuations in the Lake Titicaca water level



1.4.2 Wind velocity and directions

According to the wind statistics data for the period June 1995 to May 1996, there is little strong wind that gives the bad influence to the dredging work.

1.4.3 Current

There is very little flow in the Puno Interior Bay area except dredged channel.

1.4.4 Wave

There is few occurrence of waves that give the bad influence to the dredging work in the Puno Interior Bay that the.

1.4.5 Impact by altitude condition

The atmospheric pressure at Puno is 61.2% of the sea level, which causes the low oxygen density in the air. In the planning of the construction method and estimating of the construction cost, it shall be considered that the influence of the low oxygen density to the efficiency of an engine and an air compressor.

1.5 Other Conditions

1.5.1 Lake Traffic

The transportation boats with engines and sightseeing boats are main at the Puno Interior Bay. The traffic of these boats is not so often and it seems that the influence to the dredging works is small.

1.5.2 Dredging License

At the Puno Bay the "Captania de Puno" has the right of dredging and lake transportation. The main items of the technical specification that shall be submitted to the "Captania de Puno" are as follows:

- Proposed dredging area
- Method of dredging work
- Dredging volume
- Proposed disposal area
- Drawings (Scale=1:5,000 include UTM and geographical coordinate)
- Drawings of dredging area (1:1,000)
- Drawings of disposal area (1:1,000)
- The environmental impact assessment according as DICAPI guideline.

1.5.3 Local materials and equipment

The following material and equipment are available in the Peru.

Puno City or periphery area.
Cement, Fuel, Dumping truck, Trailer truck etc.

Lima city and the periphery area
Large crane, Trailer truck etc.

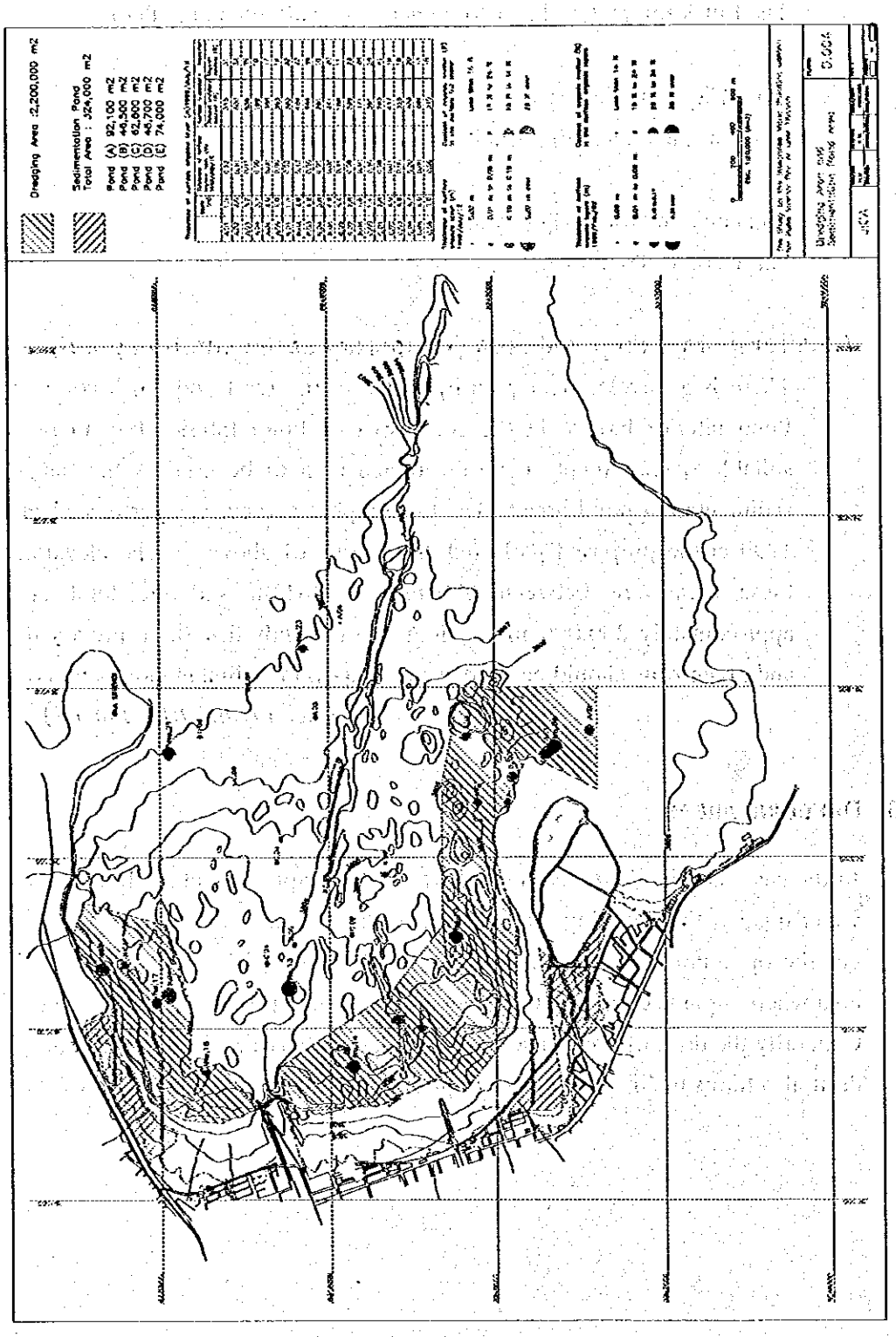
1.5.4 Temporary disposal area (Temporary sedimentation pond)

There is a development plan by PELT in the west and north coast of the Puno interior bay. In the coast area of Puno Interior Bay there is no suitable space except above-mentioned area to be used as the temporary sedimentation pond area. The topographic survey was performed in July 1999 at the proposed park and green zone of above. The elevations of these areas are between 3809m and 3811m and the total area is approximately 200,000 m2. JICA recommends that these proposed park and green zone should be used as the temporary sedimentation pond area.

(See *FigureVIII.1.3 and 4*)

1.6 DREDGING AREAS

In the case that the dredging is employed as the improvement method of the lake water quality, the dredging area and the thickness must be selected attentively to get the optimum cost-effectiveness. In this study JICA selected a dredging area where organic content rate is over 20%. The depth of this area is over 3.5m. Generally the draft of bottom sediment dredger is between 1.2m and 1.5m. This draft also limits the dredging area. *FigureVIII.1.2* shows the dredging area.



FigureVIII.1.2 Dredging area

1.7 CONSTRUCTION PERIOD

In this study, the wastewater treatment plant is planed to construct and the target year is around 2008. JICA considered that the dredging work shall be carried out after the completion of the sewage treatment system.

1.8 DREDGING VOLUME

According to the measuring result carried out in July 1999, the thickness of the organic sediment was less than 0.3 m. The minimum dredging thickness is around 0.3 m even the updated bottom sediment dredging technology. For the cost estimation work, it is employed that the 2,200,000m2 of dredging area and the 660,000m3 of dredging volume.

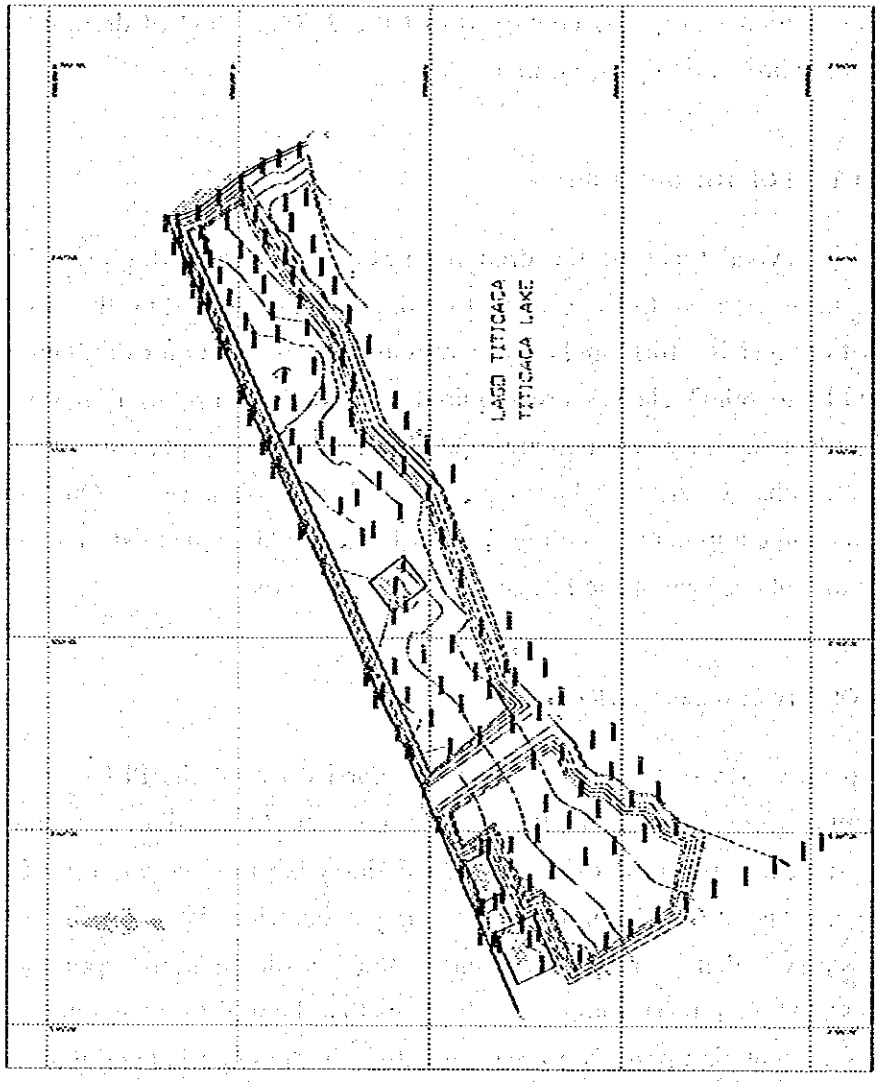
1.9 SELECTION OF THE DREDGER

There is several types of the dredging system in portable high-density bottom sediment dredger. In the case that dredging thickness is thin, the most suitable type of dredger is a turn bucket type system dredger. As for dredging capacity, 100m3/hr to 80m3 classes are required. To the transportation system from dredger to temporary sedimentation pond it is required air pressure energy add to pump discharge energy because of discharge distance. Output of the construction equipment including dredger fleet should be planned as about 85% of rating output because of the low oxygen density atmosphere.

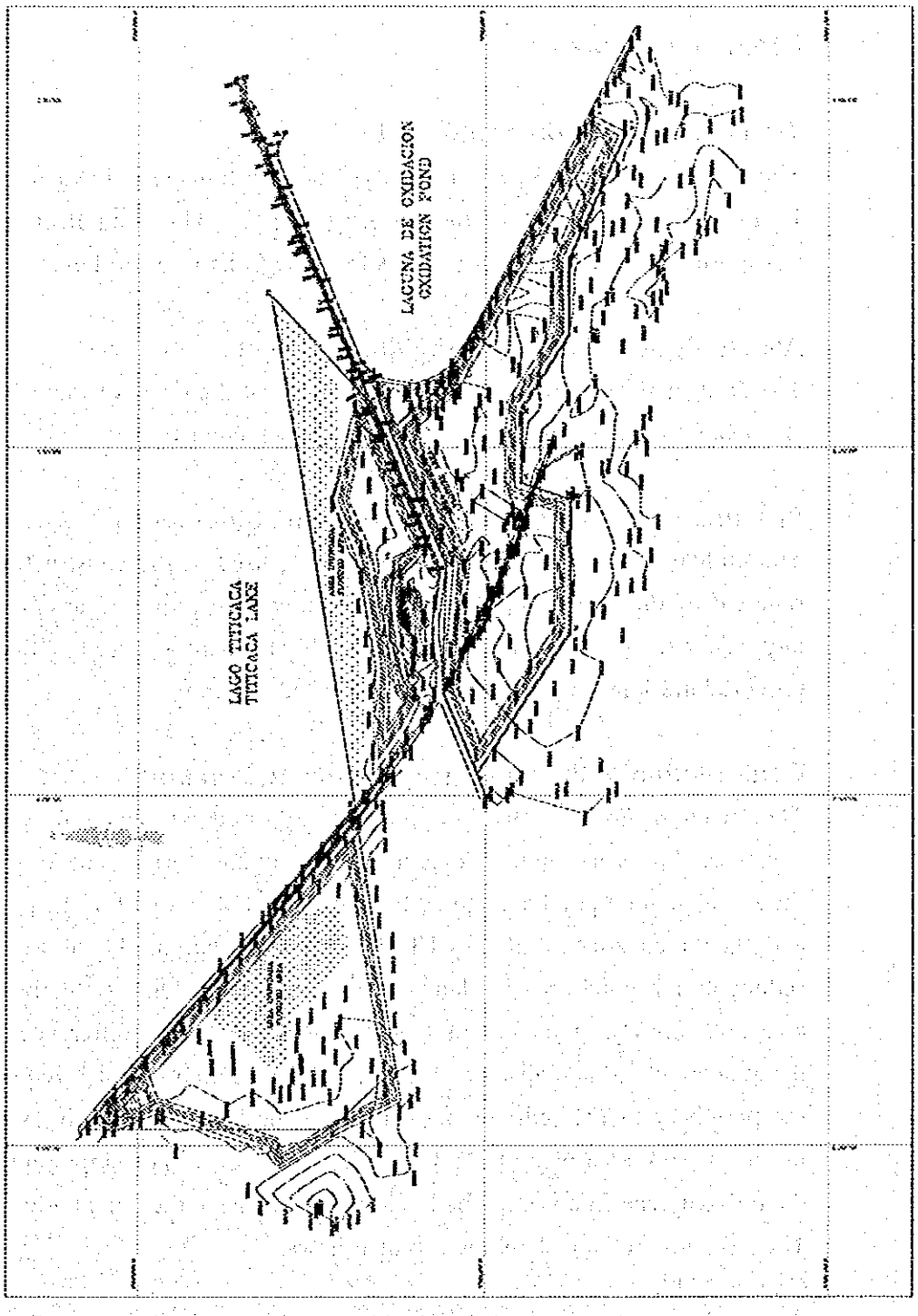
1.10 TEMPORARY SEDIMENTATION POND

The specific gravity test of sediment was carried out at the PBLT laboratory in September 1999. Supposing the moisture content of the sediment at lake floor as 500% and the apparent density of dredged slurry is supposed about 60% with the average. The moisture content of the slurry becomes 864%. The volumes of the slurry that are sent into the sedimentation pond become 660,000m3/0.6=1,100,000m3. It seems that the moisture content of sediment at the sedimentation pond is decreasing within dredging period and it assumes that the value became to around 550 to 600%. The water volume that can return back into the lake through the temporary spillway from the temporary

sedimentation pond during dredging work will be around 320,000m3 to 380,000m3. The volume of sediment that stays behind to temporary sedimentation pond is estimated 720,000 to 780,000m3. The total area of the temporary sedimentation pond is 200,000m2. The average height of the embankment required 4.3m according to the following calculation. 200,000m2*(3.8m+0.5m)=760,000m3. In the cost estimation of final disposal work it is assumed that the moisture content of the sediment become to around 400% after 2 to 3years later from completion of dredging work because of the high evaporation atmosphere of this site.



FigureVIII.1.3 Temporary Sedimentation Pond (A and B)



FigureVIII.1.4 Temporary Sedimentation Pond (C, D and E)

1.11 DREDGING CONSTRUCTION WORK EXECUTION PLAN

1.11.1 Temporary works

Transportation of dredging fleet

The dredging fleet will be portable type and be transported as cargo from Japan or Europe including the discharge pipes. Dredging fleet will be transported on 13 tons capacity tracks from the Callao port to Puno.

Assembly, dismantling of the dredger fleet

The dredger fleet is assembled and dismantled at the coast of Puno Interior Bay using two numbers of 50 tons capacity track cranes.

Procurement of a general construction equipment

The bulldozer, dumping truck, backhoe etc. , used to the construction and removal of the temporary sedimentation pond, are procured around Puno city. While the crane, backhoe, used assembly dismantling dredger fleet, are procured in Lima periphery and be transported to Puno.

Construction of the temporary sedimentation pond

The temporary sedimentation pond(s) of dredged material will be constructed prior to commencement of the dredging work. The location of the sedimentation pond is planned to be constructed at a part of the park site and the green zone of the PELT development plan in the future. The sedimentation pond area is planed that area of 324,000m2 (effective pond area 200,000m2), embankment length of 6,000m, height difference inside the area about 3,0 m, capacity 760,000m3. The embankment is required at the periphery of the sedimentation pond. The bank material is extracted inside of bank area using 0.7m3 capacity backhoe. For slope protection the polyethylene film is stretched onto the slope inside the bank body.

The structure of the embankment is as follows.

Crown Width	5m
Height	1.5～5.3m
Slope gradient	1:2

Temporary Spill Way

The temporary spillway is constructed to each sedimentation pond to discharge surplus water from pond into the lake. For control of the return water suspended solids concentration (SS) the temporary spillway should have the structure that is able to adjust the height of the accumulated water level. The weir for the water level adjustment is made by wooden material and polyethylene sheet. The drainpipe is constructed using steel pipe or synthetic resins pipes.

Discharge Pipeline

The dredged material from the dredger is conveyed to the sedimentation pond through the discharge pipeline. The constitution of the discharge pipeline is as follows.

Floating Pipeline

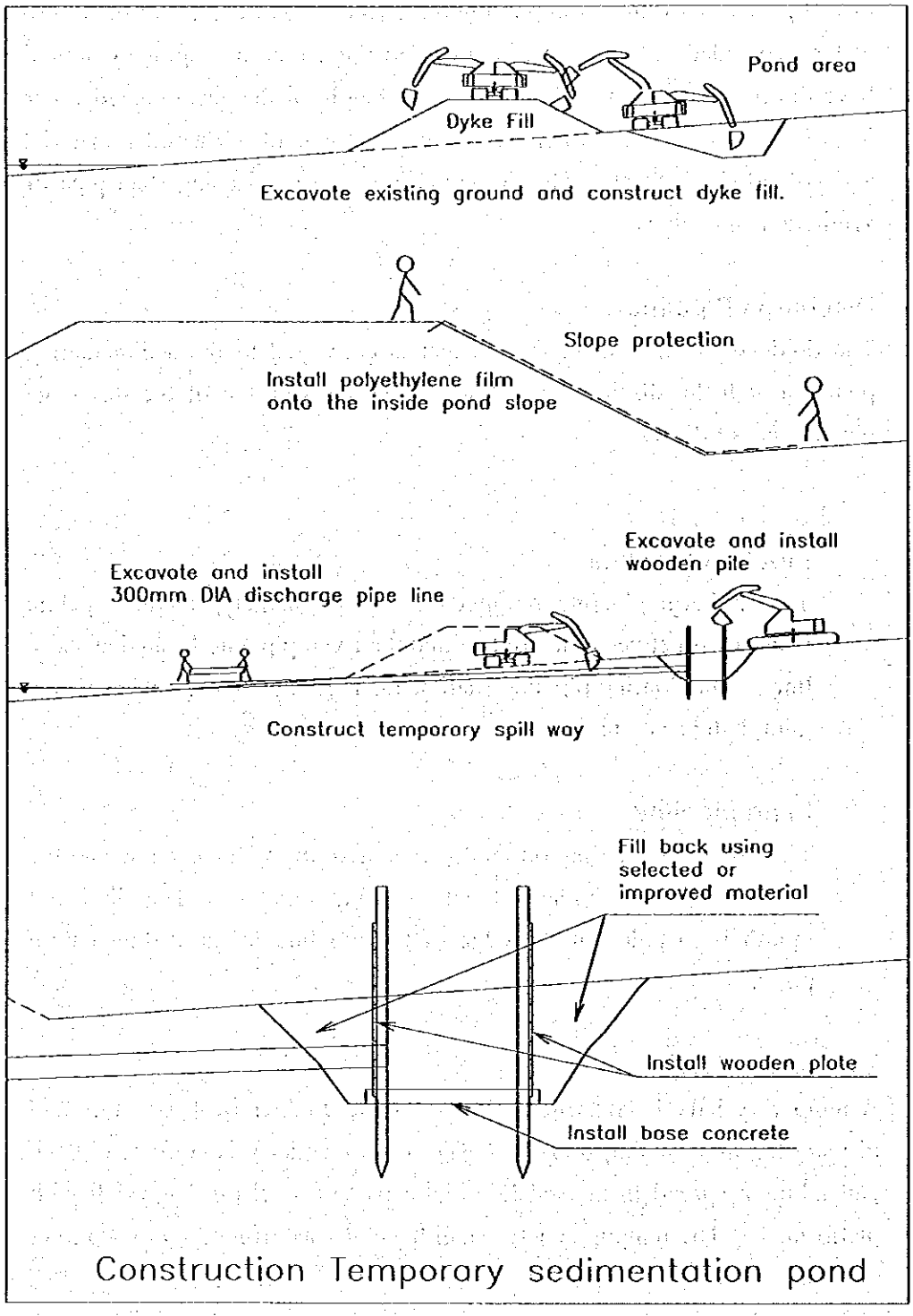
The discharge pipeline mounted on the float, namely, floating pipeline is installed between the dredger and the fixed pipeline located at shore line. The floating pipeline shall be made flexible using rubber sleeve joint, ball joint, etc.

Land pipeline

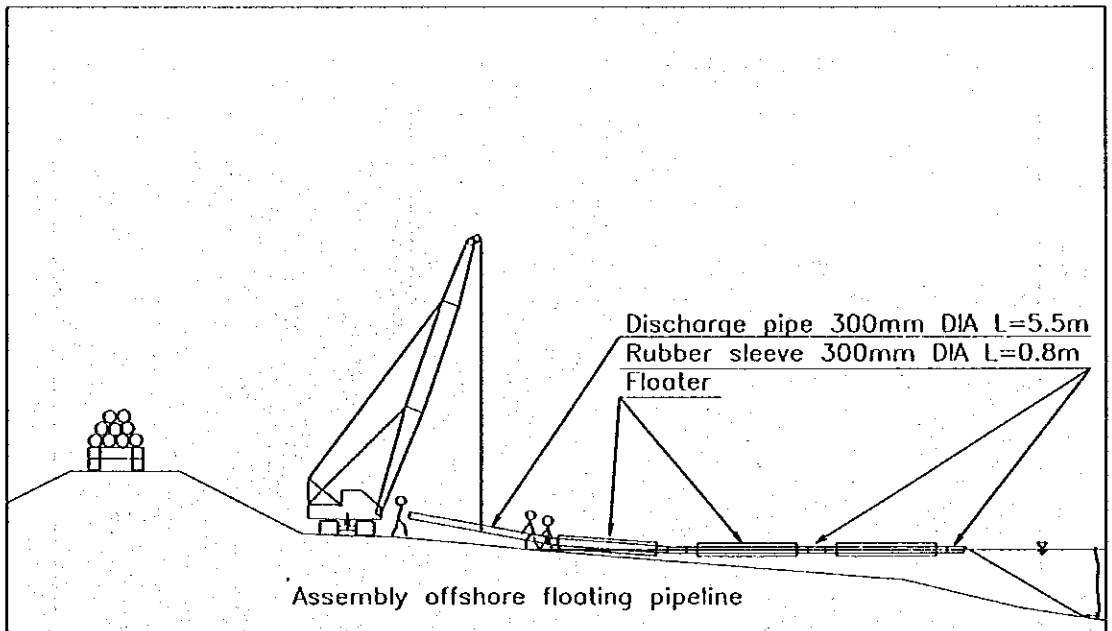
The discharge pipeline on land is mounted on the fixed flame and the lakeside edge is connected with floating pipeline. The discharge mouth is installed at the edge of the pipeline in the sedimentation pond.

Temporary Jetty

A temporary jetty is constructed to use of the dredger fleet assembly and dismantling and loading fuel etc. The temporary jetty is consisted of the embankment spread from landslide and a part of steel pile quaywall with platform. The temporary jetty shall have at least 10m*30m of working space and the depth of minimum 2m in front of the working space.

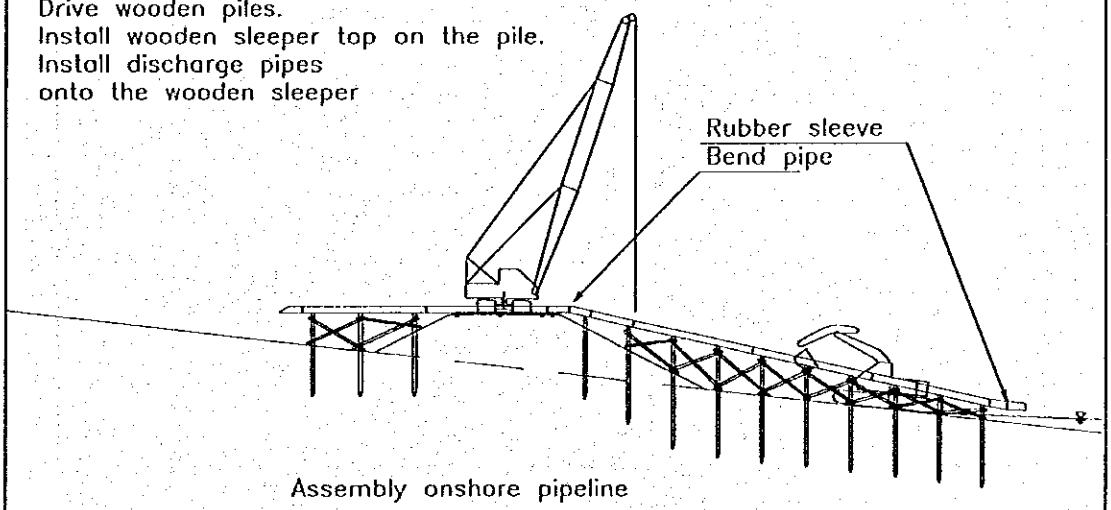


Construction Temporary sedimentation pond



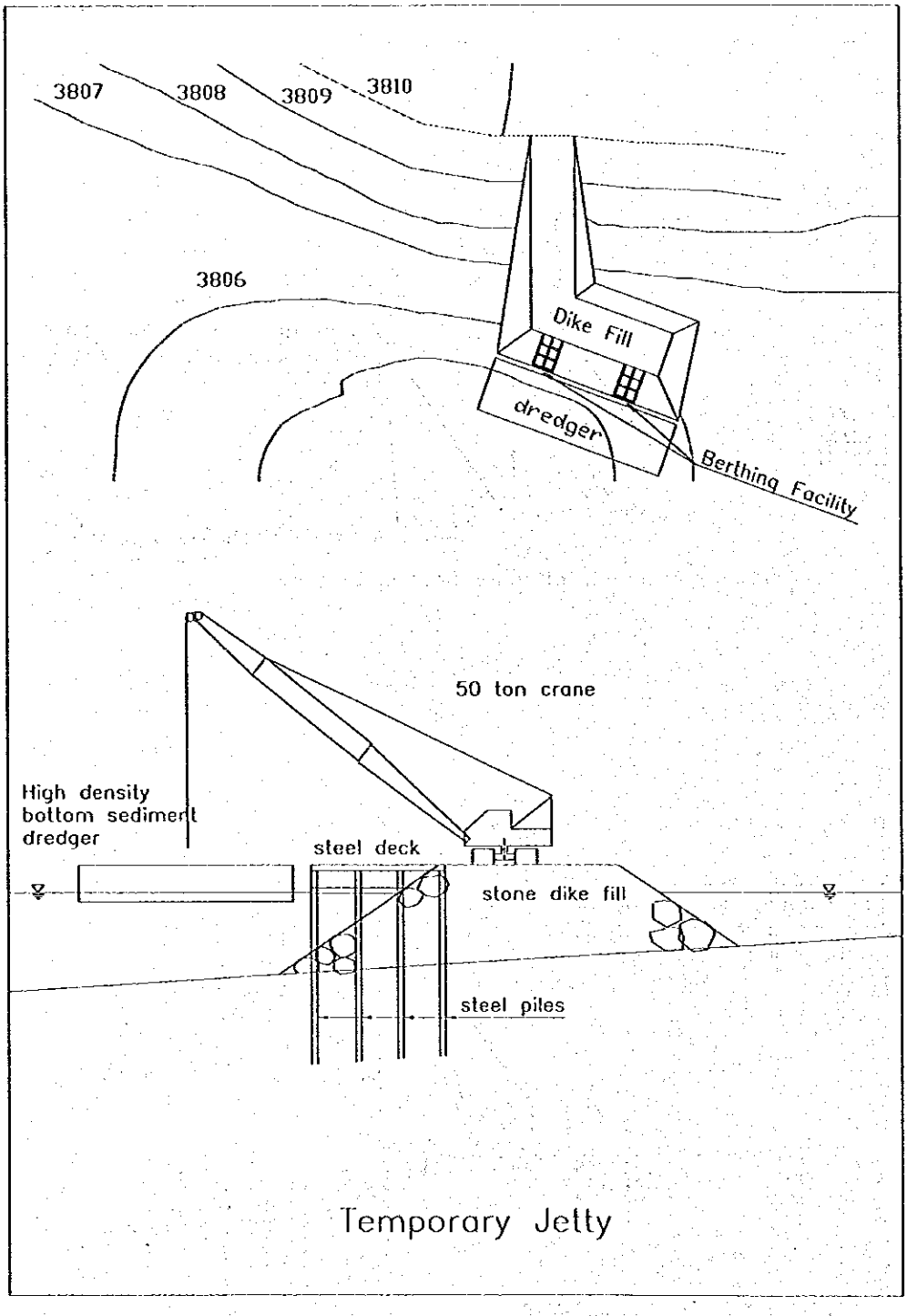
Assembly offshore floating pipeline

Drive wooden piles.
Install wooden sleeper top on the pile.
Install discharge pipes
onto the wooden sleeper



Assembly onshore pipeline

Assembly discharge pipeline


3807
3808
3809
3810
3806
Dike Fill
dredger
Berthing Facility
50 ton crane
High density
bottom sediment
dredger
steel deck
stone dike fill
steel piles
Temporary Jetty

1.11.2 Main work

Dredging

The dredger will be employed the turn bucket type high density bottom sediment dredger. Operation hour is 18 hours/day and the dredger crew works in two shifts of nine hours.

Transportation of dredged material

The dredged material will be transported through the 300mm-diameter steel made discharge pipeline by the discharge pump and compressed air.

Maintenance of the temporary sedimentation pond

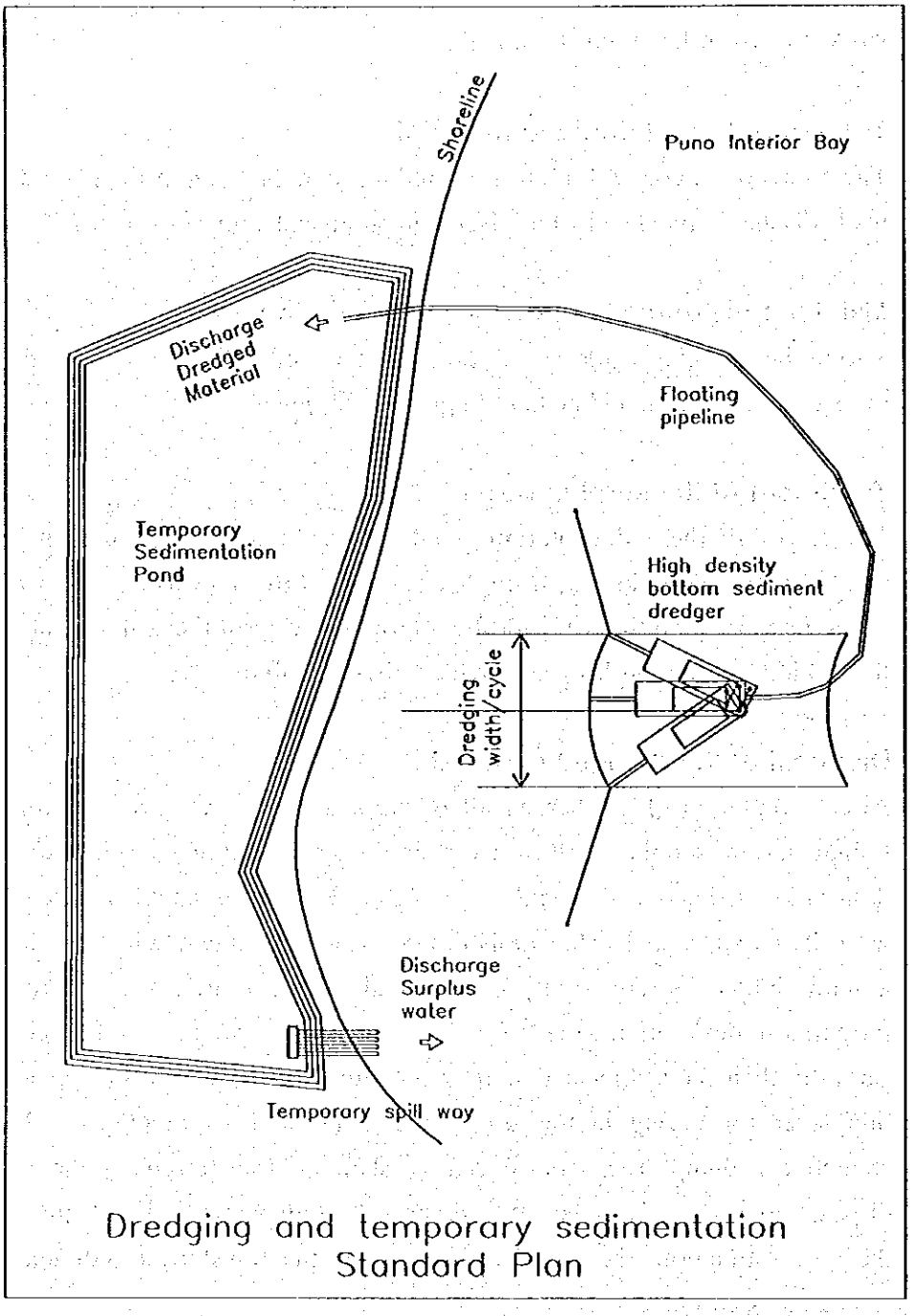
Within the dredging work period the temporary sedimentation pond and the discharge pipeline should be kept in good condition.

Treatment of the surplus water

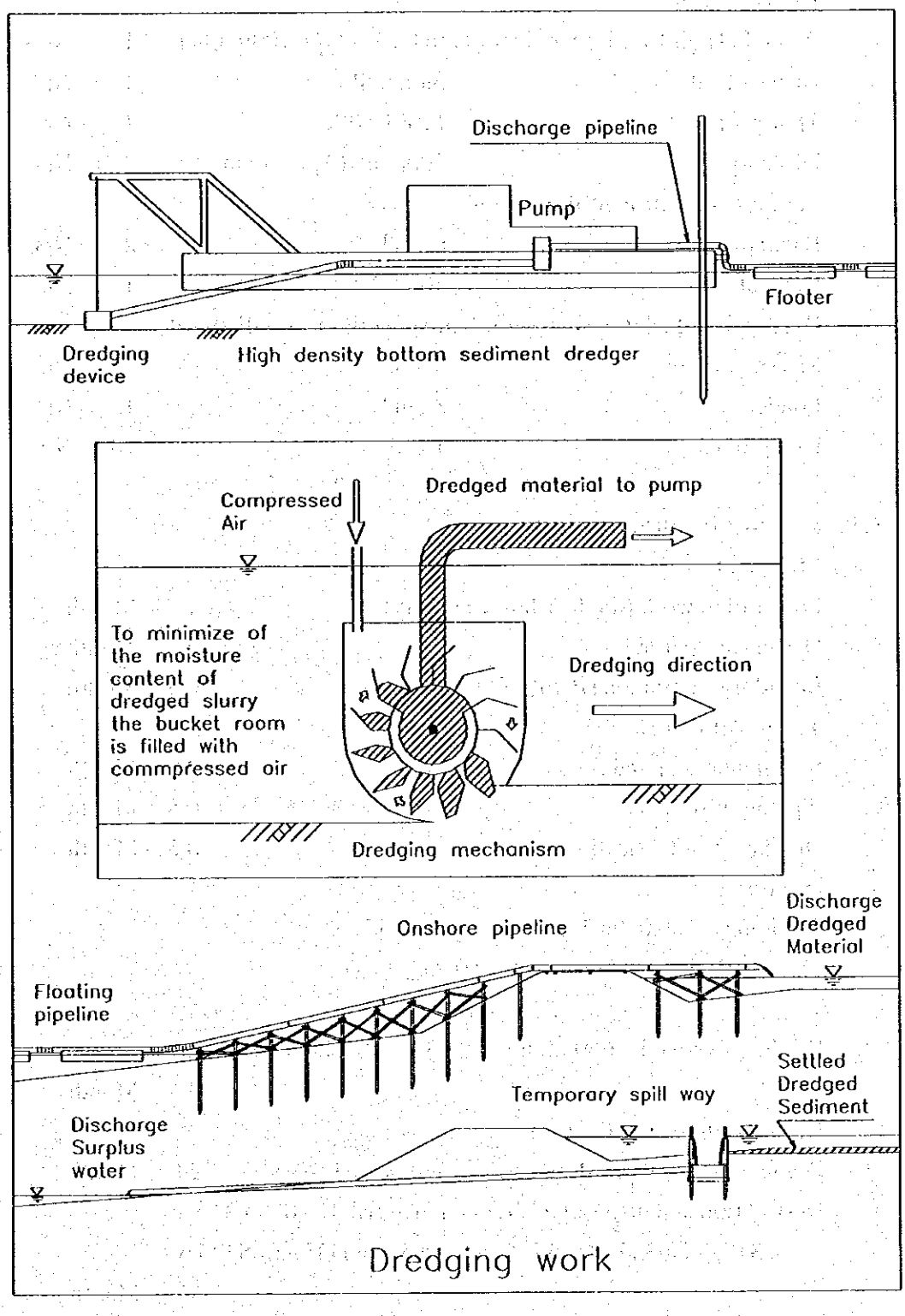
The slurry in the sedimentation pond is separated to the sediment and surplus water while flowing from discharge point to spill way. The weir of the temporary spillway should be adjusted to control the water level and the turbidity of the surplus water, which discharge to the lake.

Disposal of the dredged material

After completion of discharges all of surplus water, the surface layer of sedimentation should be turn over and excavate drainage channel for desiccation using marsh backhoe. After 2 years of above desiccation work it is expected that the moisture content of sediment will became to around 400%. For transport to final disposal area it is required furthermore desiccation work. Some parts of the dyke fill will be opened carefully then the sediment that flew out from the pond shall be spread in thin layer for drying in the sun. The desiccated sediment after dried enough for dump truck transportation shall be transferred to the final disposal area where is supposed to be near the sedimentation pond site. In the cost estimation, the moisture content of the transferred sediment is estimated as around 200%.



Dredging and temporary sedimentation
Standard Plan



Dredging work

1.11.3 Construction equipment

Dredger fleet

Portable High Density Dredger (Turn bucket type 100m3/hr)		1	Nr
Anchor boat	3ton 60PS	1	Nr.
Transport boat	FRP D50PS	1	Nr.
Discharge pipe	300mmDIA, L=5.5m	300	Nrs.

Temporary sedimentation pond

Backhoe	0.7m3	2	Nrs.
Generator	50KVA	1	Nr.

Dredged material desiccation, transportation and disposal

Marsh backhoe	0.4m3	1	Nr.
Loader	3.3m3	1	Nr.
Dump track	10m3	10	Nrs.

1.11.4 Construction period

Mobilization

Preparation work (dredger home country)	1	Month
Ocean transportation	2	Month
Inland transportation (Peru)	0.5	Month

Temporary work

Sedimentation pond	21	Month
Pipeline installation	0.5	Month
Dredger fleet fabrication	0.5	Month

Dredging

Dredging 660,000m3/650m3/day=1,015days

1,015days/20days/month=50.75

51 Month

Dredger overhaul 660,000m3/50m3/hr/3,000hrs=4.4=4 times

3 Month

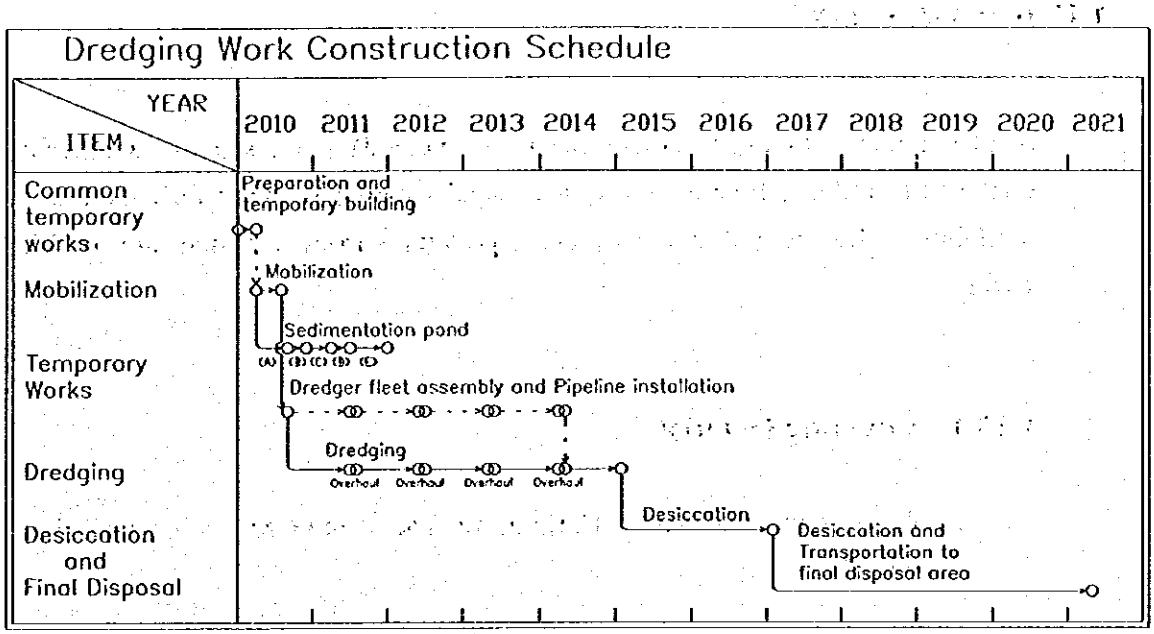
Dredged material disposal

Dredged material pre-desiccation 540,000m3 24 Month

Desiccation and disposal of dredged material 310,000m3

310,000m3/(10 tracks*6 times/day* 6m3/time)=847days

56 Month



1.12 COST ESTIMATION

1.12.1 Condition of the estimation

Construction period	2010 to 2016
Dredging volume	660,000m3
Discharge distance	Maximum 1,500m
Dredging depth	1.3m to 3.5m
Dredging thickness	0.3m
Shape of the dredging area	normal
Scattering of the dredging area	normal
Lake weather condition	normal
Obstruction	normal
Restrictions to the construction	non
Soil condition	Organic Silt Cray

1.12.2 Construction Cost

The construction cost of dredging work is as follows.

Total in S/.	120,436,000	S/.

1.13 ALTERNATE PLAN

Sand capping onto the sediment (covering method) is chosen as an alternate method of dredging because the cost of sand capping is lower than the one of dredging. This method aims to prevent pollutants from releasing into the lake water.

1.13.1 Covering Material

As the covering material the Cotimbo river sand and Charcas beach sand are examined.

- The sand of the Cutimbo River is accumulating to the Cutimbo bridge periphery that locates 21 km (0.5 hrs drive) from Puno to the south . There is the place where the fine sand suitable as covering material is accumulating. But the quantity is being limited therefore it is required to use the sieved sand from gravel mixture material.
- Charcas beach sand is fine sand and not necessary to sieve. It is suitable to extract by sand pump from the lake and the transport by the hopper barge.
- Other than the above two points, it is available silty sand in the Puno Interior Bay.

1.13.2 Construction Method and construction equipment

a) Cutimbo River sand

In the case that the Cutimbo River sand is used, following method combination is appropriate.

- Extraction — Tire shovel and 1/2 inch sieve
- Onshore transportation — Dump track
- Offshore transportation — Floating pipeline and sand pump
- Sprinkling — Floating pipeline and sand pump

The maximum total length of offshore transportation by floating pipeline is

restricted due to total loss water head by frictional resistance in the pipeline, and in this case the 500m of total discharge length is the economical limits.

The proposed construction equipment is as follows;

Excavating, sieving, loading

•	Loader	3.3m3	2Nos.
•	Sorting machine	1/2inch mesh screen	1No.

Onshore transportation

•	Dump track	15m3	10Nos.

Offshore transporting

•	Hopper	100m3	1No.
•	Generator	300KVA	1No.
•	Sand pump	180KW	1No.
•	Water pump	22KW	1No.
•	Stirrer machine	22KW	1No.
•	Discharge pipe	200mmDIA steel pipe	200Nos.
•	Flexible pipes	200mmDIA Rubber Sleeve	200Nos.
•	Float	FRP made Floater	100Nos.
•	Anchor	100KG	10Nos.

Sprinkling

•	Barge	Unifloat UF-1A	7Nos.
•	Barge	Unifloat UF-1AS	2Nos.
•	Spad	350mmDIA* 1 0 m	2Nos.
•	Winch	15KW＊1.8Ton	2Nos.
•	Anchor	500KG	2Nos.
•	Generator	50KVA	1No.
•	Energy dissipater, Bend pipe etc.		LS.
•	Anchor boat	1T 50PS	1No.
•	Consumption		LS

Temporary work

•	Temporary jetty	LS

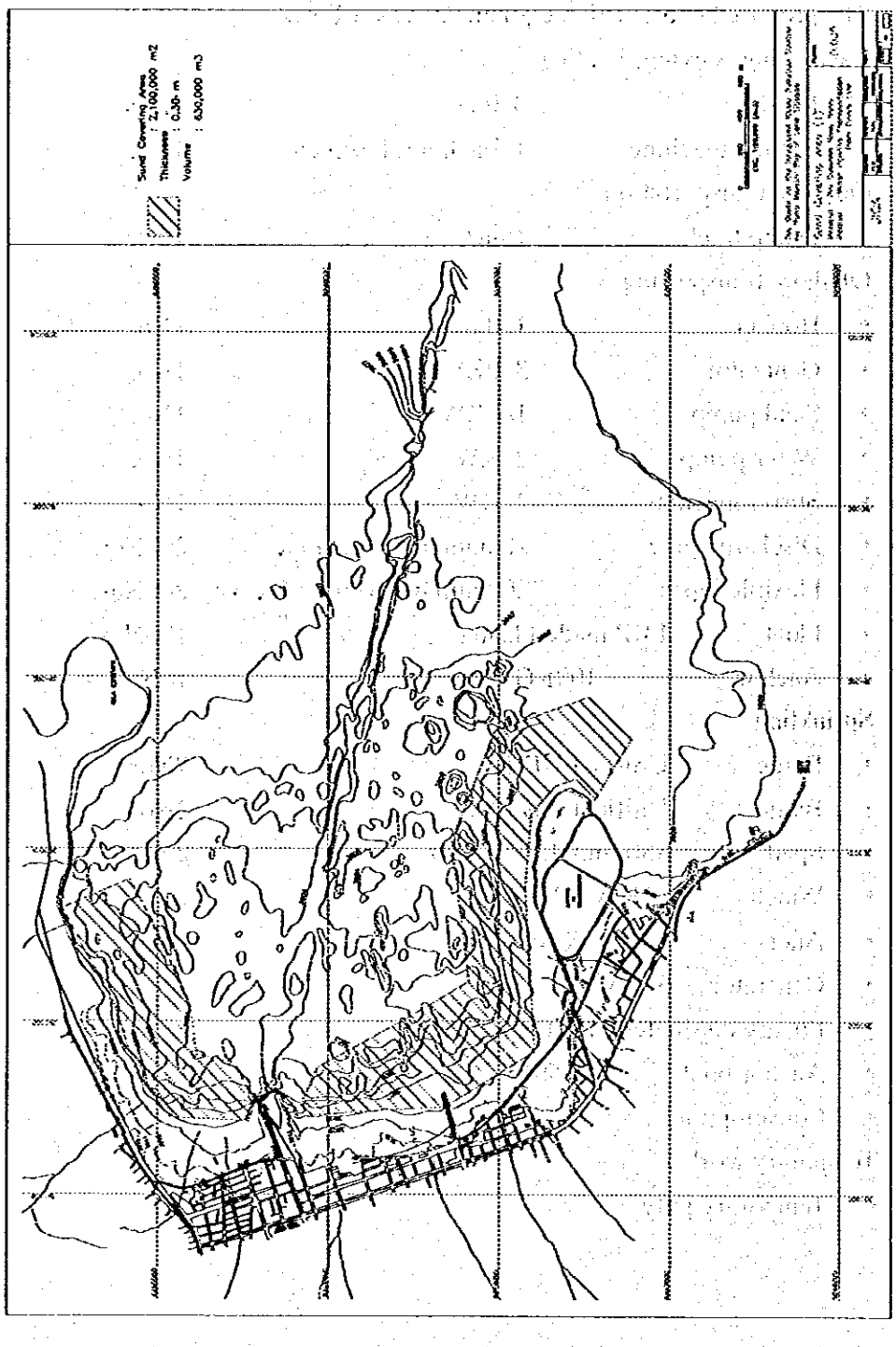
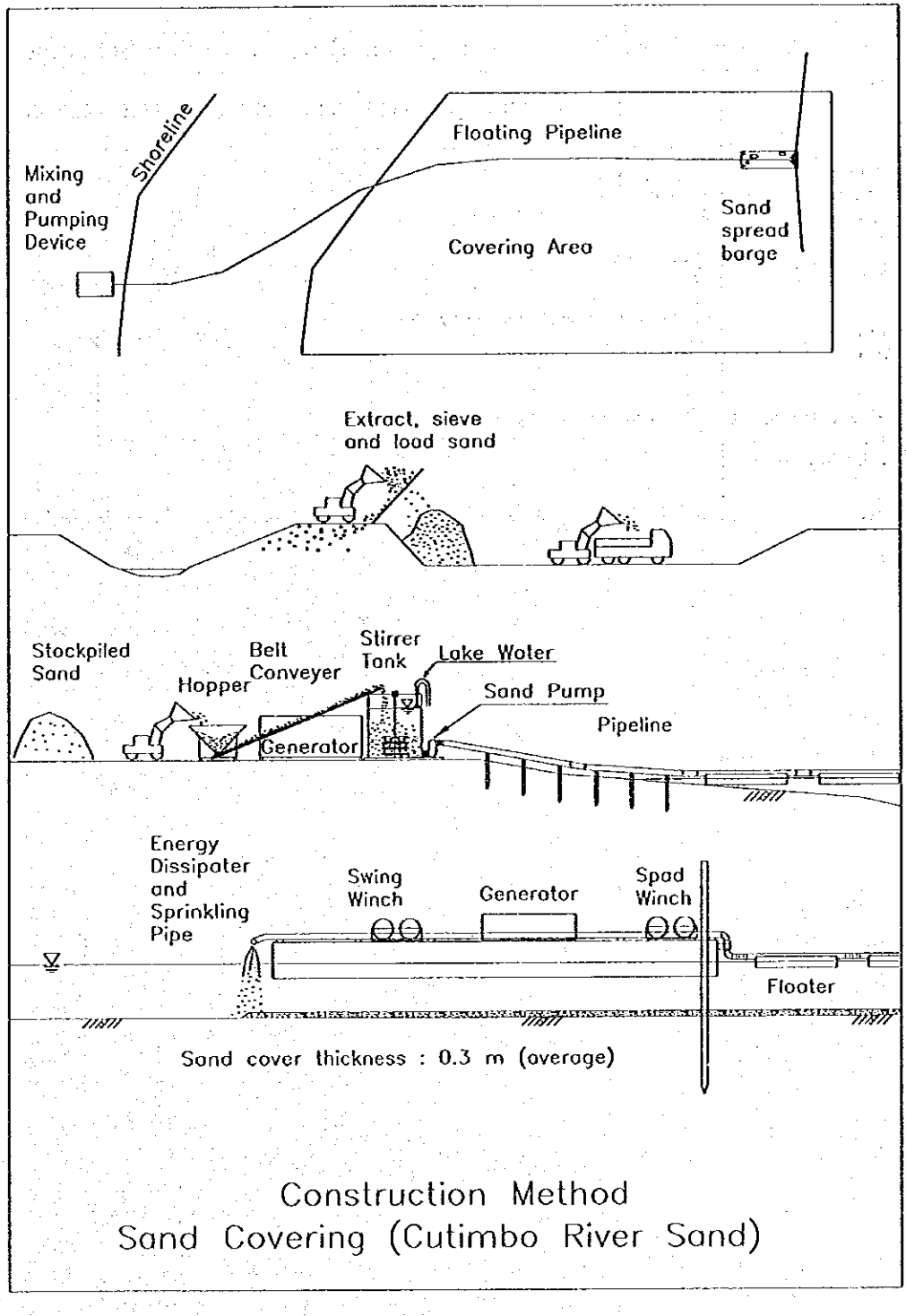
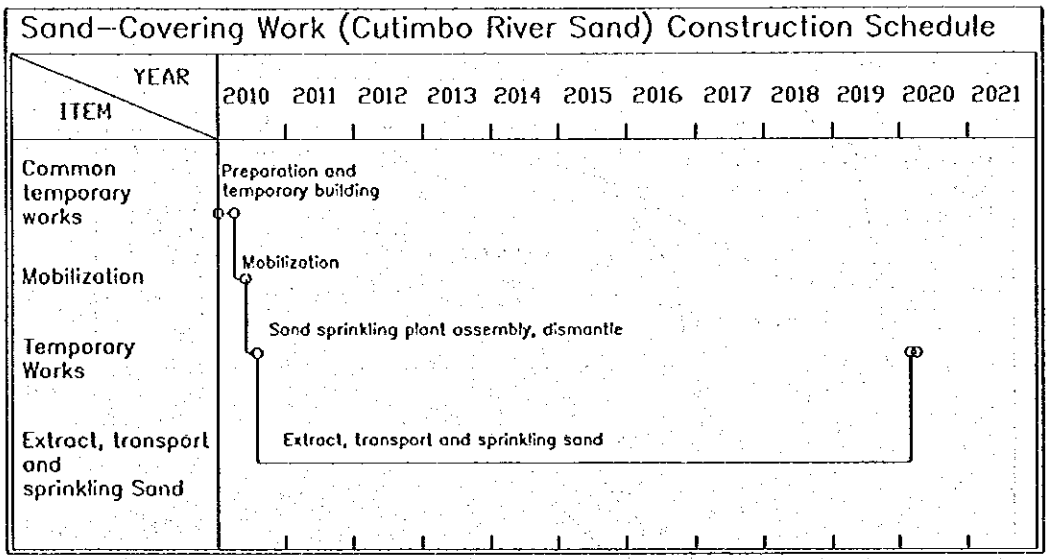


Figure VIII.1.5 Sand Covering Area (Cutimbo River Sand)



Construction Method
Sand Covering (Cutimbo River Sand)


Sand-Covering Work (Cutimbo River Sand) Construction Schedule
YEAR
ITEM
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Common temporary works
Preparation and temporary building
Mobilization
Mobilization
Temporary Works
Sand sprinkling plant assembly, dismantle
Extract, transport and sprinkling Sand
Extract, transport and sprinkling sand

b) Charcas Beach sand

In the case that the Charcas Beach sand is used, following method combination is appropriate.

- Extraction — Sand Pump Barge
- Offshore transportation — Hopper barge and tug boat
- Sprinkling — Sand Pump Barge

The proposed construction equipment is as follows;

Extract and loading

- Barge Unifloat UF-1A 7Nos.
- Barge Unifloat UF-1AS 2 Nos.
- Spad 350mmDIA* 1 0 m 2 Nos.
- Winch 15KW*1.8Ton 3 Nos.
- Anchor 500KG 2 Nos.
- Generator 150KVA 1 Nos.
- Sand pump 75KW 1 Nos.
- Plumbing material 1 Nos.
- Anchor boat 1T 50PS 1 Nos.
- Consumption 1 Nos.

Transport

- Barge Unifloat UF-1A 36 Nos.
- Steel material 20ton
- Tug boat 200PS 1 Nos.

Sprinkling

- Barge Unifloat UF-1A 7 Nos.
- Barge Unifloat UF-1AS 2Nos.
- Spad 350mmDIA* 1 0 m 2 Nos.
- Winch 15KW*1.8Ton 3 Nos.
- Anchor 500KG 2 Nos.
- Generator 150KVA 1 Nos.
- Sand pump 22KW 1 Nos.
- Water pump 22KW 1 Nos.
- Energy dissipater, Bend pipe etc. LS

• Anchor boat	1T 50PS	1No.
• Consumption		LS.

Temporary work

• Temporary jetty		LS.

c) Puno Interior Bay sand

In the case that the Puno Interior Bay sand is used, following method combination is appropriate.

• Extraction	Portable pump dredger
• Offshore transportation	Floating discharge pipeline
• Sprinkling	Floating discharge pipeline

It is conceivable that there are two types of construction method, the first one is to employ portable pump dredger and the second one is to use combination of existing bucket dredger at Puno Bay, hopper barge, tug boat and sand pump. In this report, the cost estimate is done by the first method of pump dredger.

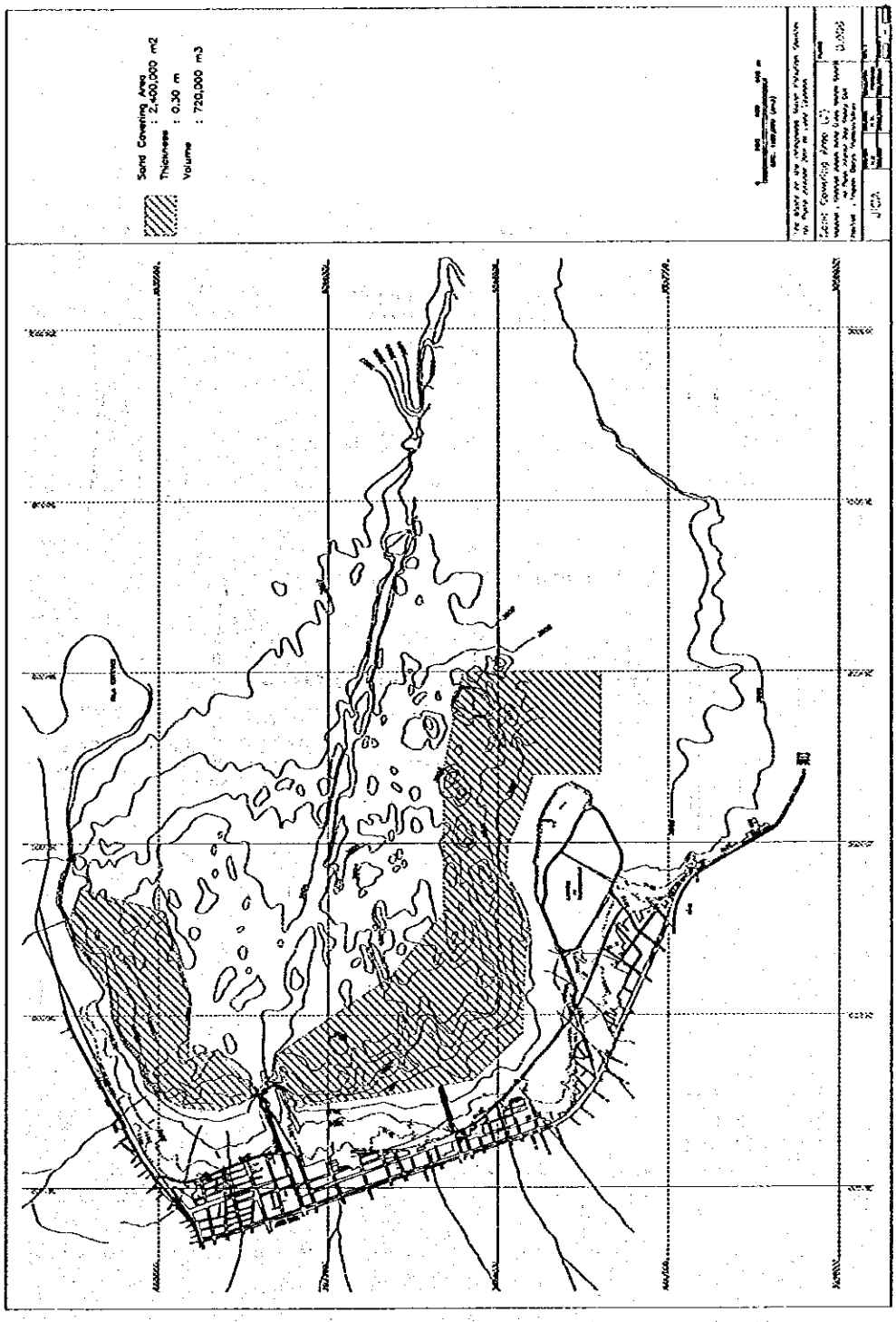
The proposed construction equipment is as follows;

Dredging, transportation, sprinkling consistency work

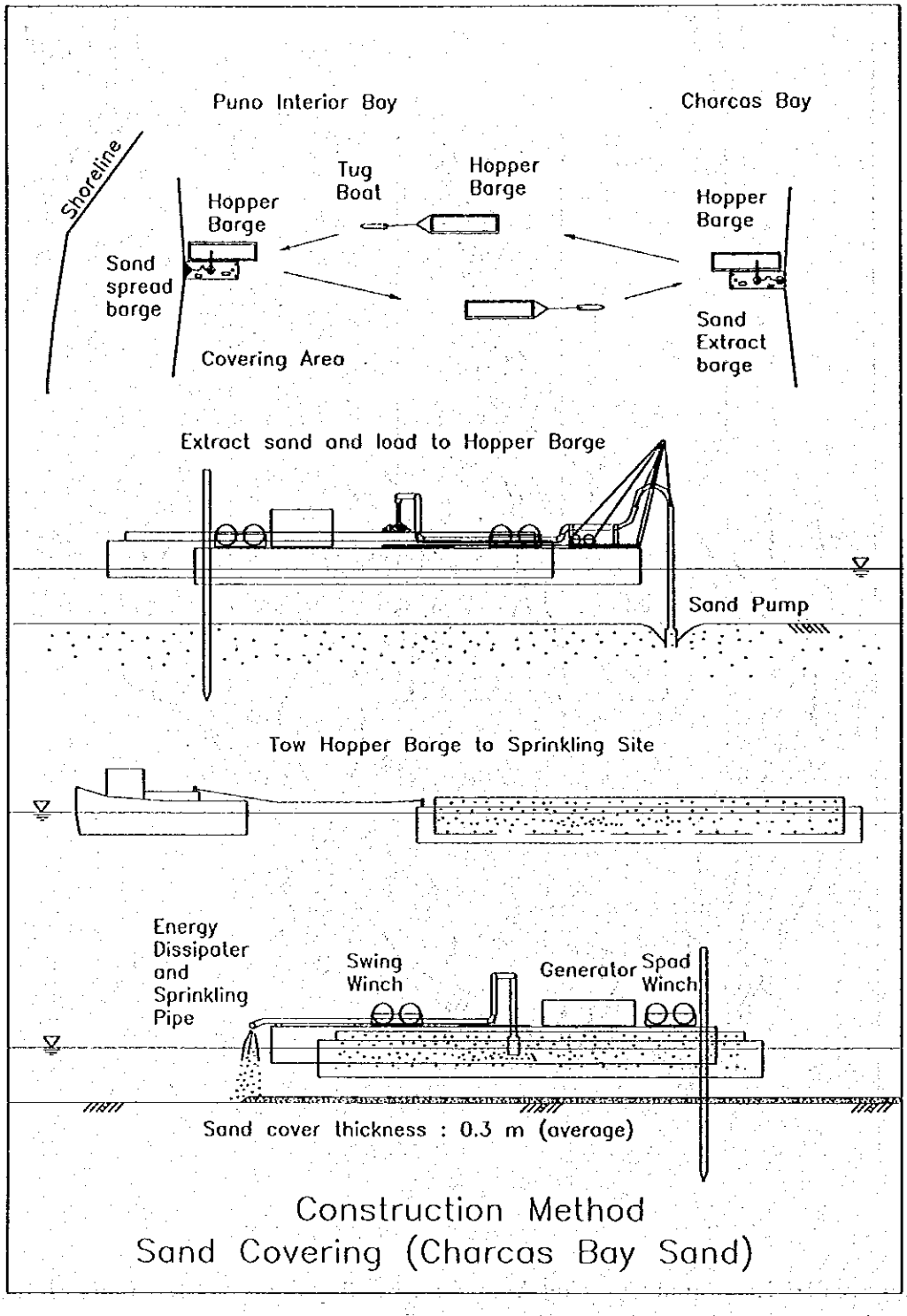
• Portable pump dredger	D-600PS	1 No.
• Anchor boat	1T 50PS	1 No.
• Discharge pipe	Steel made 300mmDIA	200 Nos.
• Flexible Pipe	300mmDIA Robber sleeve	200 Nos.
• Float	FRP made Floater	200Nos.
• Anchor	100KG	10Nos.
• Barge	Unifloat UF-1A	4 Nos.
• Generator	50KVA	1 No.
• Energy dissipater, Bend pipe etc.		LS.
• Winch	15KW＊1.8Ton	2Nos.
• Anchor	100KG	4Nos.
• Consumption		LS
• Silt Fence		LS

Temporary work

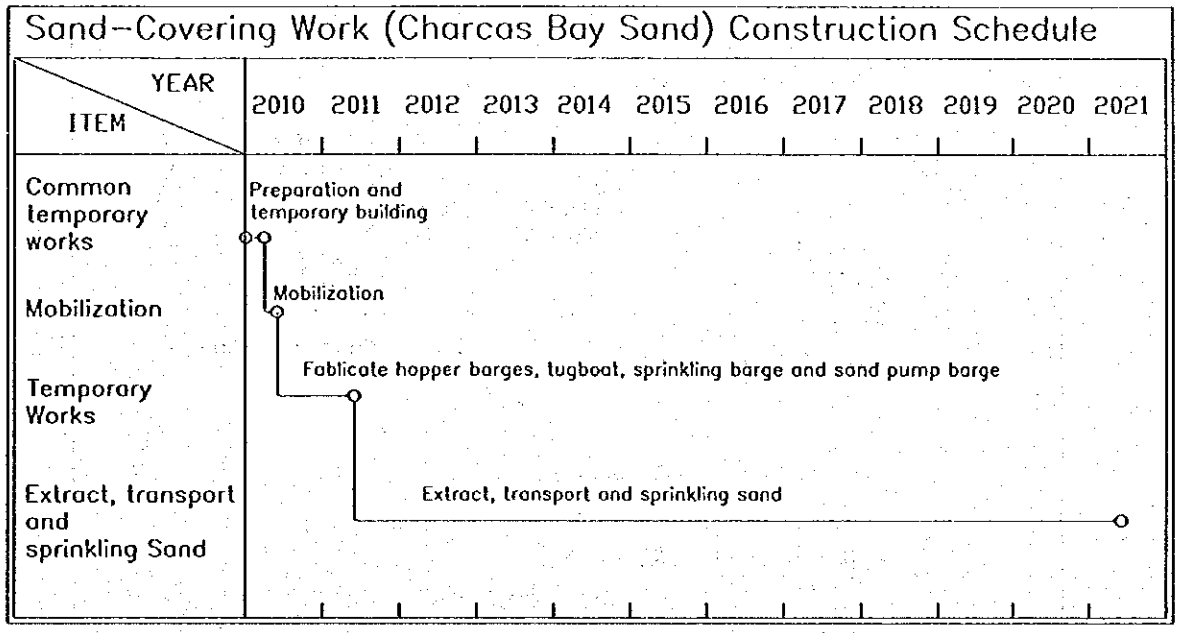
• Temporary jetty		LS

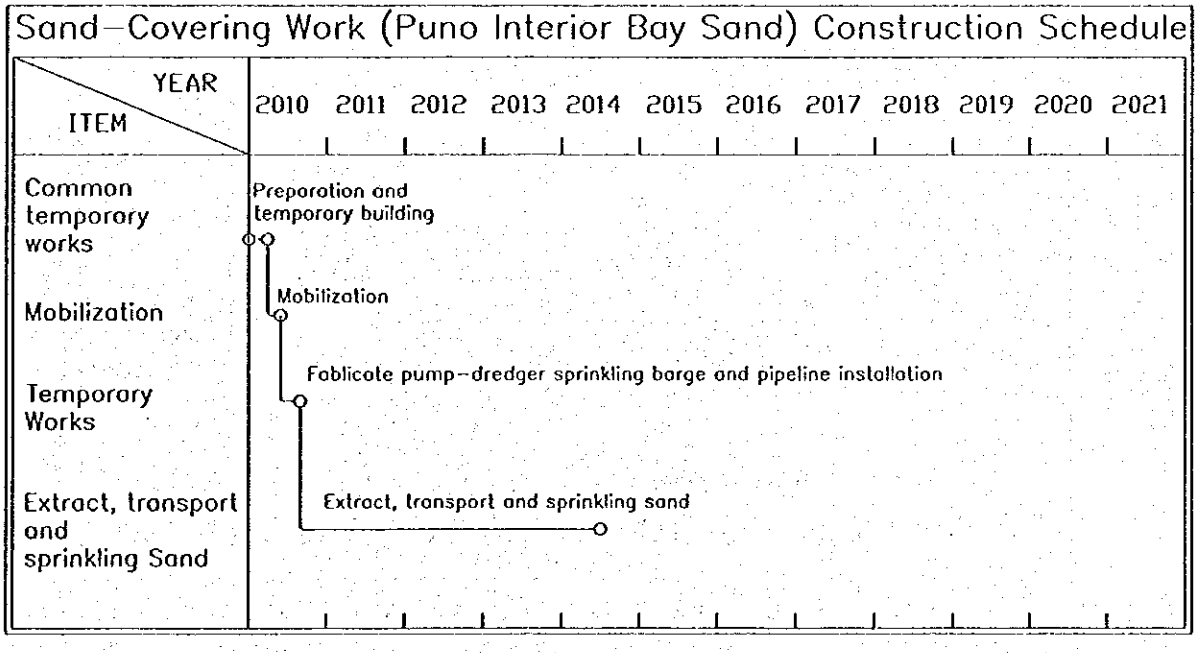


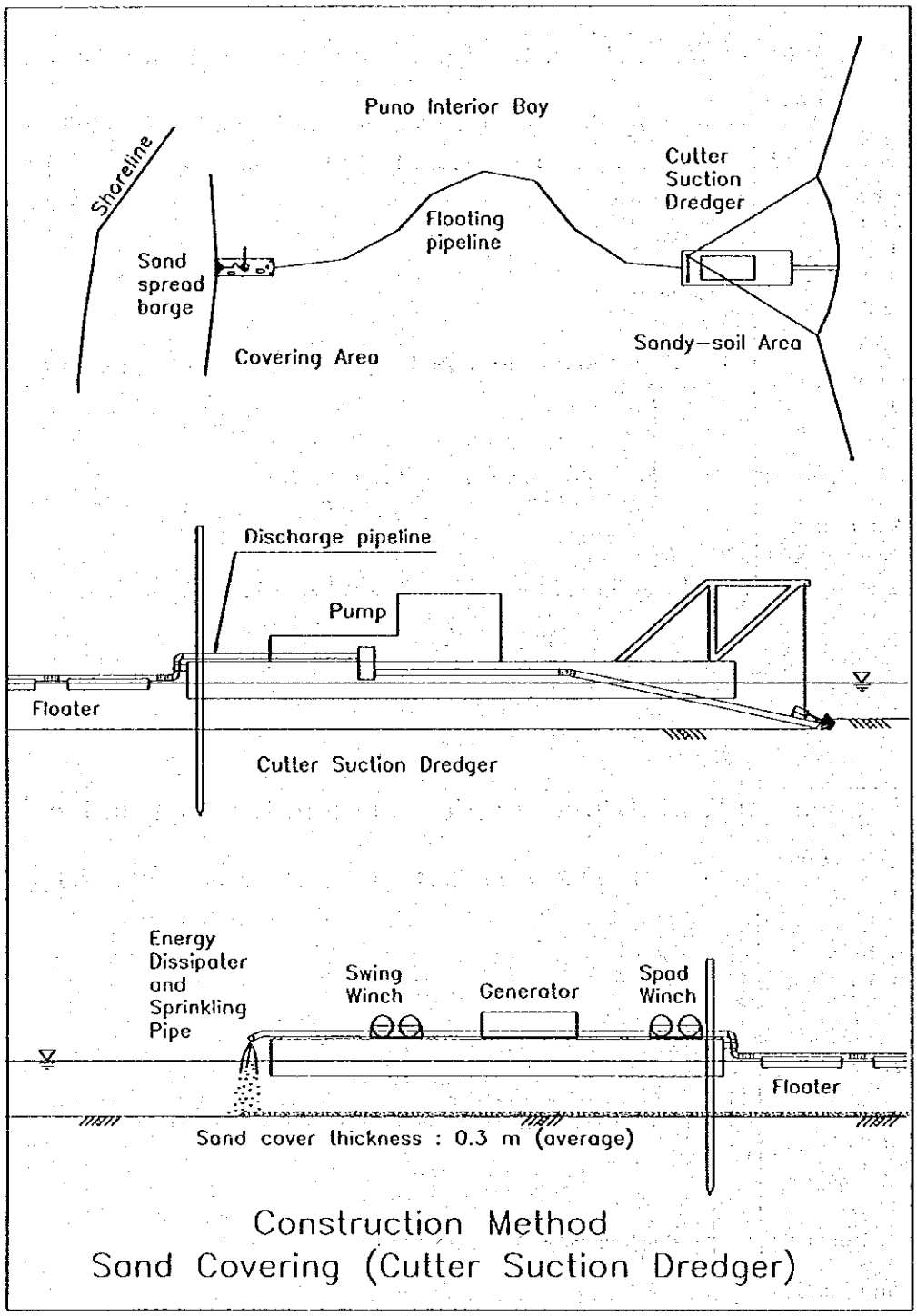
FigureVIII.1.6 Sand Covering Area (Charcas Bay Sand and Dredging Method)



Construction Method
Sand Covering (Charcas Bay Sand)


Sand-Covering Work (Charcas Bay Sand) Construction Schedule
YEAR
ITEM
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Common temporary works
Preparation and temporary building
Mobilization
Mobilization
Temporary Works
Fablicate hopper barges, tugboat, sprinkling barge and sand pump barge
Extract, transport and sprinkling Sand
Extract, transport and sprinkling sand


Sand-Covering Work (Puno Interior Bay Sand) Construction Schedule
YEAR
ITEM
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Common temporary works
Preparation and temporary building
Mobilization
Mobilization
Temporary Works
Fablicate pump-dredger sprinkling barge and pipeline installation
Extract, transport and sprinkling Sand
Extract, transport and sprinkling sand



Construction Method
Sand Covering (Cutter Suction Dredger)

1.13.3 Construction cost

The construction cost of each method is as follows.

a) Cutimbo river sand

- Total in S/. 23,800,000 S/.

b) Charcas Beach sand

- Total in S/. 29,338,000 S/.

c) Puno Interior Bay SandySoil

- Total in S/. 19,670,000 S/.

1.14 RECOMMENDATION

JICA considered the dredging and disposal method is not recommendable plan because of its high construction cost.

In the three of alternate sand capping methods, the Puno Interior Bay Sandy Soil Method gives the lowest construction cost and the Cutimbo river sand method gives 33% higher cost. The dredger using in the cost estimation of sand covering method is expected from a foreign country because in this stage it is difficult to make sure of the operation schedule of the portable dredger belongs to the Peru government.

JICA recommends the sand covering method using Puno Interior Bay Sandy Soil as the Puno Interior-Bay water quality improvement method.

However the 19,670,000 S/. of construction cost is still a high amount.

After completion of the sewage treatment system, the bottom sediment should be observed periodically. In the rainy season the muddy water is flowing in to the Puno interior bay and if it is observed the settlement of non-organic sediment on the existing organic matter this plan should be re-examined.

2. MONITORING PROGRAMME

2.1 PHYSICAL AND CHEMICAL CONDITIONS

The monitoring program obtains a basic data for the water environmental condition, and the final goal is improvement and preservation of water environmental condition in Lake Titicaca.

Practice of Monitoring

Practice of monitoring is summarized as below.

- PELT conducted the monitoring in the lake by the simplified analysis methods from 1993 to 1997.
- The PELT's new laboratory has been established in cooperation with JICA Study Team for monitoring of water environment since 1998.
- DIGESA is planning to classify the water quality by water quality standards in Lake Titicaca.
- The responsible organization for environmental condition in Lake Titicaca, namely, PELT, DIGESA and DASA, held a conference regarding cooperation system toward with improvement and preservation of water environmental condition in the Lake Titicaca on September 1999.

Strategy of Monitoring Program

The following strategies should be considered for establishment of monitoring program

- A monitoring program consists of two parts, one is monitoring for wastewater from workshops, industries and wastewater treatment plant, the other is for water bodies of the lake and drainages.
- Water parameters of monitoring should follow the law regarding water quality standards.
- to avoid redundant monitoring by assigning roles to the relevant departtment or project.
- The PELT's laboratory should take initiative in sampling and water analysis in Puno. Some parameters that can not be analyzed by PELT's

capacity should be analyzed in DIGESA's laboratory in Lima. (refer to *Table VIII.2.1*)

- The method of analysis should be standardized by DIGESA.
- The results of monitoring is managed in common by the responsible organization for environmental condition.
- Based on the above-mentioned conditions, the monitoring program for Lake Titicaca is considered below.

(1) WATER POLLUTION SOURCES

Generally, wastewater from workshops and industries may occur hazardous contamination and organic pollution in water environment. For example, plating, chemical and tanning industries may cause hazardous contamination and food, papermaking, slaughterhouse and some kind of industries may cause organic pollution are listed.

According to the field survey in the Study area, no factories discharging hazardous contamination are found. However, slaughter house, alcohol products and food products (processing, bakery, sweetshop, etc) as organic pollution sources are found. However, these factories are small scale facilities except slaughterhouse. Consequently, the monitoring program for water pollution sources in the Study area is focused on organic pollution sources.

Contents of Monitoring Program

In principle, the water environmental control of the Puno Interior Bay is the subject of this program. Consequently, minimum contents of monitoring which are enough to evaluate organic pollution or eutrophication. Outline of monitoring program is described as follows.

Monitoring target:	Food and processing industries (5 facilities)
	Wastewater treatment plant (WWTP)
Frequency of Monitoring:	Workshop / Industry: 2 times a year
	WWTP: 12 times a year (refer to *Table VIII.2.2*)
Monitoring parameter:	Flow measurement,
	Temperature, pH, DO, SS, BOD, COD, NH_4-N, NO_2+NO_3-N, T-N, PO_4-P, T-P, Total coliform

(refer to *Table VIII.2.3*)

(2) WATER ENVIRONMENT

The previous monitoring program was conducted by PELT from 1993 to 1994. After 1995, this program became intermittently, and stopped in 1997. Consequently, no series of data on water quality in Puno Interior Bay was recorded. (refer to *Table VIII.3.4*)

The new monitoring program is planned referring to the previous monitoring program.

Contents of Monitoring Program

Monitoring targets are proposed as follows.

- Lake water and its bottom sediment
- Drainage channels

Monitoring point

〔Lake water〕

Monitoring points are the same points of the lake water quality survey in this Study. The monitoring points are classified into two categories. One is a main point which is selected to grasp the longitudinal water quality condition from the Interior Bay to the Exterior Bay. The other is a supplementary point which is selected to grasp a local distribution of water quality. (refer to *Figure VIII.2.1*)

〔Drainage channel〕

Monitoring targets are the same drainage channels surveyed in this Study. Five drainage channels are selected based on the amount of discharged pollution load. It is necessary that the monitoring points should be reconsidered according to the improvement of water quality of the drainage channels. Based on the existing condition, the selected drainage channels are shown in *Figure VIII.2.2.*

Monitoring frequency

Basically, monitoring frequency is set up once a month, and these are summarized in *Table VIII.2.2.*

Observed item and analysis parameter by PELT

Water quality parameters which were are observed and analyzed by PELT, have been selected to grasp the water quality condition as minimum requirement. And further, it is necessary that meteorology data and water level in the lake be collected. These items and parameters are shown in *Table VIII.2.3.*

Moreover, the additional study for the mechanism of water pollution in the lake is proposed as below. According to the capacity and the ability of the laboratory, the Study should be conducted.

Biological research

Concentration of Chlorophyll-a in the lake

Release of nutrients from sediment

formation of sediment

Organization

It is expected that two organizations are responsible for the monitoring program. The selected two organizations and its reason are described as follows.

PELT (Special Bi-national Project for Lake Titicaca)

- The previous monitoring program from 1993 to 1997 was carried out by PELT.
- PELT and JICA have established the laboratory in Puno.
- PELT and JICA have conducted the water quality survey and biological research for this study.

DIGESA (The Ministry of Health)

- DIGESA is responsible for establishment and superintendence of The Environmental Quality Standards.

However, the environmental quality standard for the interior Puno Bay is not established yet. Accordingly, it is desired that the monitoring program be conducted by the cooperation of PELT and DIGESA. In the future, on the occasion of the establishment of the environmental quality standard in the interior Puno Bay, it is desirable that a new organization to be reestablished by PELT and DIGESA.

Personnel organization

The personnel organization is planned as follows.

Role	Required No. of personnel	remarks
Chief	1 person	
Analyst	3 persons	Chemist 2 persons, Biologist 1 person
Analysis Assistant	4 persons	
Labor	1 person	

Cost Estimation

Additional capital investment and maintenance costs are calculated as below. The details are shown in *Table VIII.3.5.*

- Additional capital investment : 246 thousand soles
- Operation and maintenance cost : 184 thousand soles/year

2.2 BIOLOGICAL ASPECTS

These proposals are for an Environmental Monitoring Plan (EMP) to describe and assess biological changes occurring in Puno Interior Bay. The proposals cover submerged macrophytes, benthos and zooplankton.

Submerged Macrophytes

At the moment, submerged macrophytes are mainly restricted to the shallow waters of the eastern side of the Interior Bay. Up to perhaps 40 years ago they occurred over most or all of the bay. The monitoring programme should assess both the distribution and abundance of submerged macrophytes and the species present.

Thus, annually, all submerged macrophytes of Puno Interior Bay should be accurately mapped and species composition of each locality recorded. Abundance should be noted qualitatively as dense, moderate or sparse. Accurate mapping can only be done quickly and accurately with GPS. As ecosystem conditions improve, increases in the distribution, abundance and species diversity will occur. If conditions become worse, all of these characteristics will decrease.

Improvements in submerged macrophyte communities will be a key indicator for improving ecological conditions in Puno Interior Bay.

Benthos

Apart from the eastern side of Puno Interior Bay, benthos has virtually disappeared from the locality. Its reappearance will be a good indication of greatly improved ecosystem conditions. The monitoring programme should consist of the following:

Monitoring Sites

- 4 locations close (about 50 m) to the western shore, two to the north and two to the south of the main jetty;

- 2 locations close (about 100 m) to Esteves Island;

- 2 locations close (about 100 m) to Espinar Island;

- 4 locations in the centre of Puno Interior Bay;

- 4 locations in the eastern part of the bay, two to the north and 2 to the south of the main navigation channel.

Monitoring Frequency

- 2 times in the wet season;
- 2 times in the dry season.

Sampling Method

- at each locality at each occasion, 3 Ekman samples with the sediment filtered through a 1 mm mesh sieve;

- samples examined separately to produce averages for each sampling occasion.

Sample Analysis

- all species identified as far as possible;

- all species counted and numbers per square meter calculated, for each of the 16 sites on each of the 4 sampling days per year.

Improved ecosystem conditions will be demonstrated by the occurrence of benthos from localities where it is now absent, by increasing densities and by more species being found.

Zooplankton

Zooplankton occurs over all the Puno Interior Bay, but is extremely patchy - being found in very high numbers in some areas and very low numbers in others. This is at least partly due to the greatly varying water conditions over the bay. The great dominance of cladocerans over copepods is a characteristic of highly

eutrophic waters. Monitoring programmes should look for a more even distribution of zooplankton over the Interior Bay (as water conditions improve) and a reducing dominance of cladocerans.

The monitoring programme should therefore consist of the following:

Monitoring Sites

- two locations close (about 50 m) to the western shore, one to the north and one to the south of the main jetty;

- one location close (about 100 m) to Esteves Island

- one location close (about 100 m) to Espinar Island

- two locations in the centre of Puno Interior Bay;

- two locations in the eastern part of the bay, one to the north and one of the south of the main navigation channel.

Monitoring Frequency

- one time in the wet season;
- one time in the dry season.

Sampling Method

- at each locality on each occasion, one sample obtained by hauling the plankton net (40 μ mesh) from the bottom (depth recorded) to the surface.

Sampling Analysis

- each sample stored in preservative and concentrated to 100 ml;

- 5 x 1 ml subsamples taken and numbers of copepods and cladocerans counted in each to produce average numbers for each sample on each date;

- numbers per litre estimated.

Improved ecosystem conditions will be shown by increasing numbers of zooplankton occurring in areas of previously poor water quality and an increasing proportion of copepods relative to cladocerans.

Phytoplankton

Phytoplankton occurs in very large numbers over all the Interior Bay, and is particularly abundant in the summer months. These high numbers are due principally to the high levels of nitrate and phosphate nutrients. As water quality improves, phytoplankton biomass and volume will decrease. The monitoring programme has been designed to show this.

The monitoring programme should therefore consist of the following:

- Monitoring Sites: The same as for zooplankton

- Monitoring Frequency: Every two months

- Sampling Method:

  At each locality on each occasion, phytoplankton samples should be taken by hauling a 40μ mesh plankton net just below the surface for a measured distance (say 100m or 200m). This will enable calculation of the volume of water filtered. The net should be hauled slowly. If insufficient phytoplankton is collected, the towing distance should be increased (by a known amount so that the volume of water filtered can always be calculated). The sample should be filtered, dried (at 105°C) and scraped into a measuring cylinder of small volume. To this is added an exactly known volume of water. The resulting additional volume as recorded on the measuring cylinder is the volume of the phytoplankton sample. This can be converted into volume of phytoplankton per unit volume of water eg /m^3 or /100m^3 of lake water.

The method gives an approximate measure of phytoplankton volume. More detailed methods are available (eg measuring chlorophyll *a* by spectrophotometry or fluoresence) but are costly to implement. If the method described above is not accurate enough (particularly as water quality improves and phytoplankton volumes decrease) the more detailed methods will need to used if the monitoring programme is to continue.

Table VIII.2.1 Assignment of Water Quality Analysis

Parameter		PELT	DIGESA
General and Organic Parameter	Temperature	O	
	Transparency	O	
	pH	O	
	DO	O	
	SS	O	
	BOD_5(COD)	O	
	NH_4-N, NO_2-N, NO_3-N, T-N	O	
	PO_4-P, T-P	O	
	ORP	O	
	Moisture content	O	
	Ignition Loss	O	
	Total Coliform	O	
	Total Coliform	O	
	Flow Rate Measurement	O	
Hazardous Parameter	Selenium (Se)		O
	Mercury (Hg)		O
	PCB		O
	Esters Escalates		O
	Cadmium (Cd)		O
	Chromium (Cr)		O
	Nickel (Ni)		O
	Copper (Cu)		O
	Lead (Pb)		O
	Zinc (Zn)		O
	Cyanide (CN-)		O
	(Fe)		O
	Sulfurous		O
	Arsenic (As)		O
	Nitrogen (T-N)		O
	M.E.H.		O
	S.A.A.M.		O
	C.A.E.		O
	C.C.E.		O
Biological Parameter	Biological Conditions (Benthos)	O	
	Biological Conditions (Phyto/Zoo Plankton, Macrophytes)	O	

1) Extractive material in Hexane (mainly Grease)
2) Active substances in Methylene Blue (mainly Detergent)
3) Extract of column of active carbon by alcohol (according to the Slow Flow Method)
4) Extract of column of active carbon by chloroform (according to the Slow Flow Method)

Table VIII.2.2 Frequency of Monitoring and Sampling for Monitoring Program

Item	Water Pollution Sources		Water Environment			Biological Conditions	
	Workshop / Slaughter House	Wastewater Treatment Plant	Lake Water	Lake Sediment	Drainage Channel	Lake Water / Sediment	
Number of Monitoring Points (point)	5	1	7 (main), 5 (supplem.)	12	5	16 (benthos), 8 (zoo/phyto plankton), (macrophytes)	1
Frequency of Monitoring (time/year)	2	12	12 (main), 6 (supplem.)	2	12	4 (benthos), 2 (zooplankton), (phytoplankton), 1 (macrophytes)	6
Number of Sampling Times (time/survey)	1	1	1 (upper and lower layer)	1	3	1	
Total Number of Samples (sample/year)	10	12	228	24	180	64 (benthos), 16 (zooplankton), (phytoplankton)	48

Table VIII.2.3 Parameters for Monitoring Program

Parameter	Workshop / Slaughter House	Wastewater Treatment Plant	Lake Water	Lake Sediment	Drainage Channel
Temperature	o	o	o		o
Transparency			o		
pH	o	o	o		o
ORP				o	
DO	o	o	o		o
SS	o	o	o		o
BOD_5	o	o	o		o
COD_{Mn}	o	o	o		o
Moisture content				o	
Ignition Loss				o	
T - N (Kj-N)	o	o	o	o	o
NH_4 - N	o	o	o		o
NO_2+NO_3 - N	o	o	o		o
PO_4 - P	o	o	o		o
T-P	o	o	o	o	o
Total Coliform	o	o	o		o
Flow Rate Measurement	o	o			o
Biological Conditions (Benthos)				o	
Biological Conditions (Phyto/Zoo Plankton, Macrophytes)			o		

Table VIII.2.4 The Execution of the Previous Monitoring in Puno Interior Bay

Point Name	1993												1994												1995												1996												1997											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
IMU													o	o	o	o	o	o	o	o	o	o	o	o				o	o	o	o	o	o							o	o	o	o																		
Uelle Puno													o	o	o	o	o	o	o	o	o	o	o	o																																						
La Estives					o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o				o	o	o	o	o	o							o	o	o	o																		
La Espinar																												o	o	o	o	o	o																												
Boya del canal													o	o		o												o	o	o	o	o	o							o	o	o	o																		
Icio canal																												x	x	x	x	x	x																												
Ntro canal																												x	x	x	x	x	x																												
Lida canal																												x	x	x	x	x	x																												
Ykakota																												o	o	o	o	o	o																												
Rco hundido																												o	o	o	o	o	o							o	o	o	o																		
Uelle huaje																												o	o	o	o	o	o																												
La del diablo																												x	x	x	x	x	x							o	o	o	o																		
Uinta bova																												o	o	o	o	o	o							o	o	o	o																		
Bova del uelle																																								o	o	o	o																
Cardo palma																																								o	o	o	o																
Uaje																																								o	o	o	o																
Ro viejo																																								o	o	o	o																
Uelle espinar																																								o	o	o	o																
Bova del canal																																								o	o	o	o																
Ntro bahia																																								o	o	o	o																
Ro chimu																																																														
Ya chimu																																																												
Ente isla esteves																																																												
Uelle isla estives																																																												
Teves-san jose																																																												
Ya san jose																																																												
Ya muelle																																																												
Boya del muelle																																																												
Uelle laykakota																																																												
Pinar norte																																																												
Escargo espinar																																								o	o	o	o																

Note : o Parameter : Temperature, Conductivity, TDS, pH, Transparency, Turbidity
NO_2-N, NO_3-N, NH_4-N, PO_4-P, Total-P

x Parameter : Temperature, Conductivity, TDS, pH, Transparency, Turbidity

Table VIII.2.5 Cost Estimation for Monitoring Program

Items		unit	Unit Cost (Foreign currency)	Unit Cost Local currency	Foreign C. (soles)	Local C. (soles)	Total (soles)
Capital investment	High pressure steam sterilizer	1 set	15,000 soles/set	0 soles/set	15,000	0	15,000
	Total	-			15,000	0	15,000

$= 3.15 soles
$= 116.7 yen

Items			unit	Foreign currency	Local currency	Foreign C. (soles/year)	Local C. (soles/year)	Total (soles/year)
Maintenance Costs	Personnel expenses	Chief	12 man-month.	- soles/man-month.	2,400 soles/man-month.	0	28,800	28,800
		Analyst	36 man-month.	- soles/man-month.	1,600 soles/man-month.	0	57,600	57,600
		Analysis Assistant	48 man-month.	- soles/man-month.	1,200 soles/man-month.	0	57,600	57,600
		labor	12 man-month.	- soles/man-month.	800 soles/man-month.	0	9,600	9,600
		Sub-total	108 persons	-	-	0	153,600	153,600
	Rental fee	Boat	14 day/year	- soles/day	100 soles/day	0	1,400	1,400
		Car	52 day/year	- soles/day	150 soles/day	0	7,800	7,800
		Sub-total				0	9,200	9,200
	Expendables	Chemicals	1 set	9,450 soles/year	- soles/mon.	9,450	0	9,450
		Sub-total				9,450	0	9,450
	Repair	2%	1 set	2,700 soles/year	- soles/mon.	2,700	0	2,700
		Sub-total				2,700	0	2,700
	Others*	5%	1 set	- soles/mon.	7,680 soles/mon.	0	7,680	7,680
		Sub-total				0	7,680	7,680
	Administration (1% for Personnel expenses)		1 set	- soles/year	- soles/mon.	0	1,536	1,536
						0	0	0
		Sub-total				0	1,536	1,536
	Total							184,766

note : * It is equal to 5% of the personnel expenses.

< Car >		
Lake sampling	12	day/year
Sediment sampling	2	day/year
Treat. plant sampling	12	day/year
drainage c. sampling	12	day/year
preparatory	12	day/year
pollution source	2	day/year
Total	52	day/year

<Boat>		
Lake sampling	12	day/year
Sediment sampling	2	day/year
Total	14	day/year

	Instrument	Machinery
Property (soles)	27,000	135,000
Life (year)	7	15
Remain	0%	10%

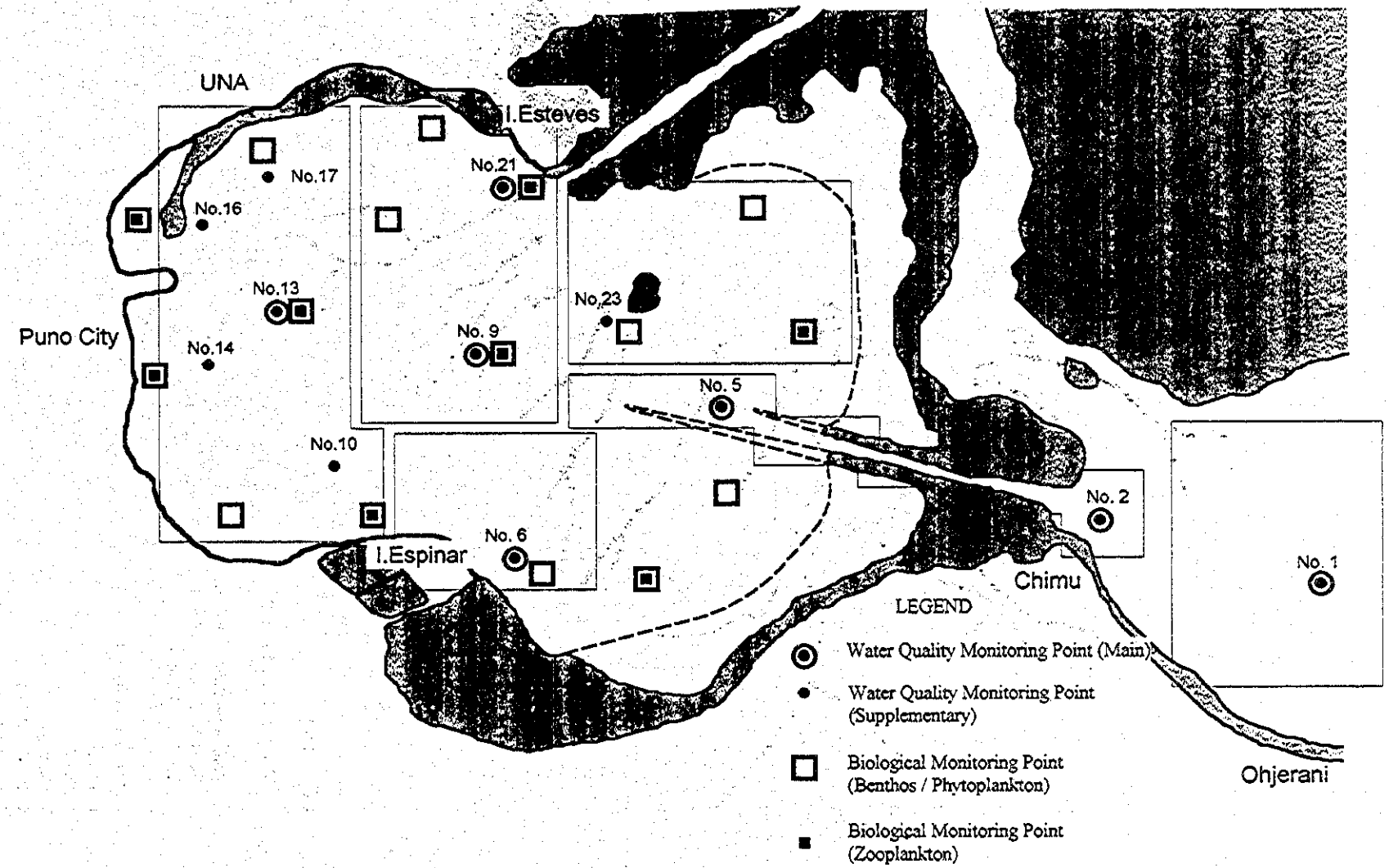


Figure VIII.2.1 Monitoring Points of Puno Interior Bay

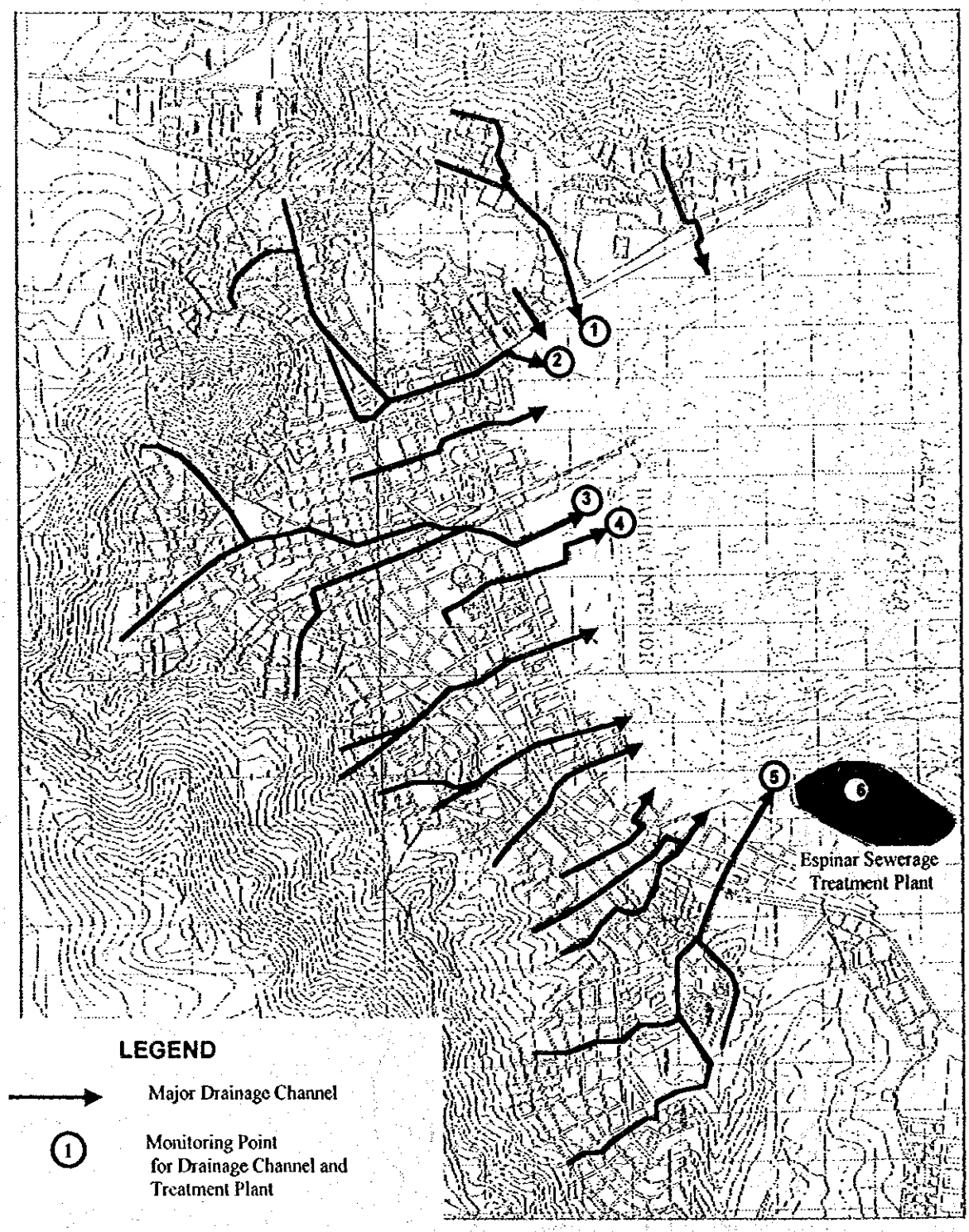


Figure VIII.2.2 Monitoring Points of Drainage Channels and Espinar Wastewater Treatment Plant

CHAPTER- IX NON-STRUCTURAL MEASURES

CHAPTER – IX

NON-STRUCTURAL MEASURES

1. TARGET AND STRATEGY

The non-structural measures described in this chapter are proposed as supplement to the structural measures (the sewerage development and the solid waste management) mentioned in the previous chapters of this Study, for the integrated pollution control of the Lake Titicaca.

These non-structural measures have the targets aiming at: (1) the development and sustainment of the organizational functions of the entities involving in the conservation of the Puno Bay's environment; (2) the motivation of public participation into the activities developed for the conservation of the Puno Bay's environment.

The following strategies are suggested to achieve these targets:

(1) Development of an **institutional consolidation plan** for strengthening the Puno Province Municipality's institutional capacity, the Multisectorial Committee, and the coordination between these entities involving in the conservation of Puno Bay's environment;

(2) Development of a **public educational program** to promote and motivate the public participation into the tasks for the conservation of the Puno Bay's environment.

2. POSSIBLE MEASURES

In other chapters of this report, several specified measures had been discussed for strengthening the managerial capacity of the Puno Municipal Enterprise for Potable Water and Sewerage (EMSAPUNO) and the Division of Public Cleaning of the Puno Province Municipality. To supplement to these measures, the following four non-structural measures are proposed:

(1) The **institutional consolidation plan;**

(2) The **public education program;**

(3) The **installation of *the Clean Day*;**

(4) The **enforcement of environmental regulations.**

2.1 INSTITUTIONAL CONSOLIDATION PLAN

The **institutional consolidation plan** proposed here aims at the strengthening of the Puno Province Municipality's institutional capacity, and the Multisectorial Committee, as well as the strengthening of the coordination between the entities involving in the conservation of the Puno Bay's environment, by identifying the roles of the most important entities.

(1) Identification of roles of the main relevant entities

There are many entities involving in the conservation of Puno Bay's environment as shown in *Figure VIII.2.1*. This figure also presents the inter-relationships between these entities, as observed by the Study Team. Each of these entities has a specified characteristic, and has some channels to access to some groups of the Puno City's resident.

At this present time, it is observed that the following three entities are taking the most important role in the conservation of the Puno Bay's environment: **(1) the Puno Province Municipality, (2) the Multisectorial Committee of Ecology and Environment** (Multisectorial de Ecología y Medio Ambiente, or "the Multisectorial Committee" in short), and **(3) the PELT** (Binational Special Project of Lake Titicaca).

The institutional capacity of each entity should be strengthened to effectively carry out the tasks aiming at the conservation of the Puno Bay's environment. Besides, the role of each entity in the framework of conservation of the Puno Bay's environment should also be identified, and the coordinational relationship between these three entities should be improved.

The roles that these three main entities should take can be identified as following:

(1) **The Puno Province Municipality** is responsible for the administrative management of all activities for the socio-economic development and the conservation of natural environment of the Puno Province. Taking this responsibility, the Municipality should develop the projects for improving the services of water, urban sanitation, urban sewerage, etc. oriented to the Puno City's residents, organize the programs or campaigns for motivating the residents into the conservation of the environment, formulate and execute the regulations and the plans necessary for the sanitary services, environmental management, etc.

(2) **The Multisectorial Committee** takes the role as a coordinator between the PELT, the Municipality, the mass media, and other relevant entities. Through these entities, the Multisectorial Committee shall access to as many residents as possible, to promote the educational programs, and to motivate the residents into the events, campaigns, and other activities which are performed for the conservation of the Puno Bay's environment.

(3) **The PELT** takes the role as a technical adviser, responsible for monitoring the changes in environment, advising the relevant entities on the environmental conservation technology, conducting the projects to utilize the new technology for the conservation of the Puno Bay's environment, etc. The projects conducted by the PELT should not be duplicated with the ones conducted by the Puno Province Municipality.

The three above-mentioned entities should concentrate its efforts in performing its function respectively, in order to avoid duplicate efforts, and to effectively push forward the programs and campaigns aiming at the common purposes.