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ASSISTANCE IN DESIGN, CONSTRUCTION AND OPERATION OF THE MUNICIPAL WASTEWATER TREATMENT SYSTEM, BEIJING

US/CPR/84/281

THE PEOPLE'S REPUBLIC OF CHINA

Technical Report*

Mission 16 January - 4 February 1986

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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Vienna

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INTRODUCTION

The job descriptions for assignments under project US/CPR/84/281 - 32.1.I comprised 3 duties that have been accomplished in cooperation with the Beijing Municipal Administration of Municipal Engineering:

1) Detailed account of the problems which currently face the Beijing authorities in planning and executing a programme for the adequate treatment of municipal waste water.

2) Determination of the objectives of the Beijing Municipal Government with regard to the design, construction and operation of waste water facilities capable of treating the city's current and projected combined sewage flows.

3) Approach and methodology for solving the problems identified in 1) above.

Detailed information was requested on means of implementing the following specific activities:

- Instrumentation of the existing waste water monitoring station (to measure flows, BOD, COD, TSS, etc.) and training of personnel in analytical techniques for use with waste water flows.

- Instrumentation of the existing pilot treatment plant and training of pilot plant personnel to improve the plant's ability to yield a range of data for the design of a full scale plant.

- Technical modifications to existing pilot plant to improve its capacity to treat Beijing's waste waters.

- Introduction of new treatment units to the pilot plant to improve its performance.

- Development of a plan for re-use of the final effluent and sludge treatment and disposal.

- Development of a pilot plant programme capable of generating sufficient information for use in the design of a full-scale waste water treatment plant.

1. CURRENT SITUATION

1.1. The Sewerage Scheme (see figure 1.1.)

Beijing metropolis has an area of about 1,400 km^2. The total length of the municipal sewer network, located all over the urban and suburban districts, is 1,600 km, including nearly 1,000 km of combined sewers and 300 km of stormsewers.

The permanant population is 9,000,000 (5,220,000 in the city and

3,780,000 in rural area). Including the floating population, the total number of inhabitants is 10,000,000.

According to statistical calculation, the average sewage flow produced from Beijing area is 1,900,000 m^3/day. About half of the total flow is domestic, the other half being industrial.

There are 6 main sewage drainage systems (catchment basins), and one small one in the south-east of Beijing. There are 16 pumping stations.

Catchment Basin	Estimated Flows	Characteristics
1. Gaobeidian	750,000 m^3/day	60% industrial
2. Zhengwangfen	141,000 m^3/day	domestic
3. Damongmen	192,000 m^3/day	industrial
4. Jiuxianqiao	121,000 m^3/day	industrial
5. Quingme	213,000 m^3/day	domestic - textile
	1,417,000 m^3/day	
6. Xijiao	330,000 m^3/day	steelworks
	1,750,000 m^3/day	

No accurate flow rate measurement has been done due to the lack of flow meters.

On average, the water supply is 1,300,000 m^3/day, mainly from wells in the west suburb of Beijing. Most of the industries have their own wells.

At this time 5,000,000 inhabitants may be connected to the sewerage network.

28 rivers cross the area of Beijing. More than 200 outlets to the rivers are known to exist.

The average rainfall rate in Beijing is 630 mm - 80% of it is centralized within June to September. The rain is of low intensity.

1.2. Gaobeidian Catchment Basin

As the biggest of the six systems, Gaobeidian has a total length of sewer of 500 km (sewage and combined sewers) and collects the wastewater from the greater part of the urban district (downtown) and all of the East suburb.

The average flow water rate is estimated to be 750,000 m^3/day (40% of the overall discharge of the city).

Industrial water (60% estimated) in the catchment basin comes from chemical factories, pharmaceutical factories, paper making mill, winery, printing and dyeing plants plants (about 140 outlets in total), ; 18 of which discharge more than 1,000 kg/day.

The main characteristics of the effluent are:

- pH > 8, with variations upto pH 10
- COD from 360 to 600 mg/litre
- BOD from 150 to 250 mg/litre
- SS about 330 mg/litre

The whole network of the Gaobeidian system works by gravity; there is only one pumping station at Gaobeidian plant.

1.3. Desired Quality of Final Effluent

1.3.1. Standard for pollutants

"Sandard for pollutants in the discharged wastewater of Beijing metropolis" are attached in appendix n°3

The standard is very high, especially for pollutants dicharging into rivers. The standard for discharge of the Gaobeidian plant is;

-BOD < 20 mg/l
-COD < 70 mg/l
-SS < 30 mg/l

This is near equivalent to the highest level of wastewater treatment plant discharges as required by law in France

The two highest levels in France are:

	1st	2d
-BOD	< 15 mg/l	< 30 mg/l
-COD	< 50 mg/l	< 90 mg/l
-SS	< 20 mg/l	< 30 mg/l
-NTK(N)	--	< 40 mg/l
-NTK+NO_2+NO_3(N)	< 10 mg/l	--
-P	< 1 mg/l	--

The very high standard for pollutants of Beijing metropolis is homogeneous with the ambition to recover a good water quality for the rivers.

Nitrigen removal from wastewater must be taken into account for a successful fight against water pollution.

1.3.2. Re-using of Wastewater

Beijing Municipal Administration wants to re-use wastewater in farming etc.

1.4. Wastewater Treatment Plants

There are two plants:

1.4.1. The first is an Imhoff Tank (catchment basin of Jiuxianqiao) which has a capacity of 5,200 m^3/day. Due to lack of time, it could not be visited.

1.4.2. The second is the Gaobeidian plant, of capacity 130,000 m^3/day. Approximately 22% of the total sewage collected from the drainage area is treated.

- 10% goes through a preliminary treatment (several sedimentation tanks without any mechanical removal of sludge), and has been used for irrigation in summer;
- 12% is sent directly to the farmland;
- the remaining 78% is discharged into the Tunghui river.

1.4.3. The other catchment basins have no waste water treatment plants.

1.5. The Beijing Sewage Monitoring Station

On the site of the Linghaojing pumping station, a laboratory has been established to monitor the situation in the six main catchment basins. The duties of this lab are:

- control the pollutants (especially toxicity, heavy metals and harmful matters in wastewater);
- prevent the discharge from industries which exceed the standard;
- protect the sewerage facilities from damage;
- ensure the safety of workers;
- provide analysis for normal operations of wastewater treatment works.

31 persons form the staff of monitoring station, 9 of whom are professional technicians:

- 5 for analytical work
- 3 for sewage flow surveying
- 1 for wastewater treatment.

1.5.1. Sampling

Taking samples for analysis is by nand, there are no automatic sampling units.

1.5.2. Flow metering

There is no accurate flow-measurement.

1.5.3. Analysis

Routine determinations are carried out, mainly by volumetric and colourimetric methods (HMO standards). COD, BOD and SS are performed with adequate accuracy. The technicians of the monitoring station are of the opinion that:

- BOD and COD analyses are too laborious and too long;
- They need to measure greases and oils;
- They need to measure the presence of dangerous and explosive gas in sewers (several accidents have occured in pumping stations or in the network).

The other unresolved issues in monitoring are:

- Analysis of harmful organic matter in sewage and sludge;
- Analysis of heavy metals in sewage and sludge;
- Continuous survey of the sewage flow-rate and surface run-off to sewer;
- pH metering.

The monitoring station does not measure settleable solids, volatile suspended solids and nitrogen compounds (NT_K, NH_4^+, NO_2^-, and $NO_3^=$).

Any analysis is meaningless unless sampling is done with sufficient care to ensure that the analysed wastewater is truly representative of the wastewater being tested.

Without any automtic sampling proportional to the flow of water, the monitoring station cannot give accurate results.

1.6. The Existing Pilot Plant in Gaobeidian

Since 1974, 15 projects have been conducted in pilot scale. Several small units were built and tested:

- Primary clarifier with inclined plates;
- Primary clarifier with multihoppered bottom;
- Pure oxygen diffused aeration tank (UNOX system);
- Conventional aeration tank;
- Rectangular clarifier;
- Thermophilic and mesophilic anaerobic digesters;
- Vacuum filter for sludge dewatering;
- Centrifuge for sludge dewatering;

In general, the volume of each unit (clarifier, tank, digester etc.) does not exceed about 100 m^3. The designs are old and there are no flow meters.

2. SPECIFIC RECOMMENDATIONS

2.1. Network

2.1.1. Plans

Preparation of accurate plans of the severage network is necessary, with longitudinal sections, slopes, diameters, flow directions etc. and details about storm weirs, industrial inlets etc. With accurate plans, sub catchment basins will be defined according to the size, the density of inhabitants or industries. The main sewers will be equipped with flow meters.

2.1.2. Measurement of amount of pollution

The amount of pollution in wastewater is measured on samples correctly taken. The various analyses are of little value unless the sample is truly representative of the conditions and quality actually found in practice.

2.1.2.1. Flows

We recommend the installation(in the first step) in the sewers of Gaobeidian: 10 channels of type"contraflux or/and venturi"from the NEYRTEC ALSTHOM company

Their location is very important.A rough example for flowmeters and"metering rooms" location is given in figure 2.1.2.1.

Their accurate location and size have to be defined with the help of two experts:

-one from NEYRTEC company,

-the other one being a sewer system evaluation expert.

Fellowship for two m/m in France(channels setting and fitting) could be very useful.

The installation of the flowmeters will need civil engineering work to build the "metering rooms",where it will be possible to fit up,movable;

-pH meters with recorders,

-diaphragm,buble,or ultrasonic recording flowmeters,

-automatic sampling units.

2.1.2.2. Sampling (see figure 2122)

Sampling is difficult because the raw waste varies both in composition and flow. The first step is to select a sampling point when there is a good mixture of the matter to be sampled, unaffected by earlier deposits.

We recommend setting up sampling units over flow meter channels in the network. For the detection of heavy metals etc. it is better to take samples on earlier deposits in the factories' outlets.

Samples should be taken with the aim of measuring average quality over a period of 24 hours. It is useful to know how pollution varies during the day, to assess the peak flows and to ascertain the extent of the day-time or night-time pollution (in both dry and wet weather).

Apparatus is available for taking average samples proportional to the flow of water, either by collecting a certain volume of water at regular intervals, with the volume of the sample fixed or varying with flow, or by drawing off uniform quantities according to a time schedule varying with the flow.

The water is circulated through the pipes of the sampling unit at a velocity of at least 60 cm/s to prevent the formation of deposits.

The sample should be stored and transported at a temperature of 4°C.

In the first step we recommend the purchase of 10 automatic sampling units (model Numelec), cooled, equipped with batteries, and taking average samples proportional to the flow of water.

The Beijing municipal administration must know correctly the flows and the amounts of pollution in the sewage

Amount of pollution (in BOD kg/day)	=	V (in m^3/day)	x	C_{BOD} (in kg/m^3)

in order to execute the following tasks:

- design extensions of network
- design wastewater treatment plant
- operate sewers and plants
- impose taxes on pollution amount.

2.2. Main Industrial Sewage

Each main industrial outlet has to be measured correctly. Local staff have to have available lateral contraction channels, where it will be possible to set up portable and recording pH meters, flow meters and automatic sampling units (of the same type as in the network). A reconnaissance of each sewer is needed to precisely locate the number and size of the channels.

In this second step, civil engineering and fitting up of the channels will be carried out by the Beijing technicians.

The recommended first analysis will be: BOD, COD, SS and toxicity by the "Daphnia Test".

The correct operation of the network and the treatment plant depend on a detailed initial survey of the relevant polluting industry.

Most of the factories have to be disconnected from the municipal sewers and equipped with their own plants, because their wastewater is non-biodegradable.

2.3. Monitoring Station

2.3.1. Analyses

First step: BOD, COD, SS, VSS, TSS, DS, pH are indispensable, and may be carried out by the monitoring station. A portable colorimetric comparator can be used to give quick analyses. An oven, (550 °C), has to be bought, to measure volatile suspended solids. A portable ultrasonic flowmeter can be used to measure flows in pipes under pressure as in pumping stations.

Second step: The determination of nitrogen is needed: NH_4^+, NT_K (organic and ammoniacal), NO_2^-, NO_3^{2-}, because (NH_3-NH_4^+) is toxic for aquatic life and drinking water, and consumes a lot of oxygen in rivers.

Toxicity of an effluent can be measured by the short-term inhibition in the effluent of the motility of Daphnia Magna Straus (crustaceans cladocera) commonly known as Daphnia. The results are expressed in equitox units, defined as follows: an effluent contains one equitox/m^3 if it gives rise in 24 hours to the immobilization of 50% of a population of Daphnias under the test conditions.

The best way to appreciate these methods and to define the instruments needed by the monitoring station is to organize a fellowship with a French laboratory:

3 Beijing monitoring station chemical technicians would be sent to France for 3 months.

Third step: Following completion of the necessary work on the building (electricity supply, air conditioning), sophisticated and sensitive apparatus would be installed, in order to measure every micropollutant, heavy metal, etc. (see appendix no. 4).

We propose a sub-contract with a firm to evaluate the building works to Beijing technicians, to sell the instrument and to fit it up.

2.4. Gaobeidian Existing Pilot Plant - Actual Conditions and Improvement

2.4.1. Actual conditions

At the present time a wastewater treatment pilot plant is existing. It has been used for research but it is not suitable for personnel training.

2.4.2. Experts' suggestions

Because the standards required for pollutants in discharged wastewater of Beijing metropolis (see appendix) correspond to a high level for treatment (near to European requirements), the process for wastewater treatment plant must be an activated sludge process. Furthermore, it must be an activated sludges process with very low biological load rate (BLR), near to extended aeration process:

$$BLR = \frac{\text{kg BOD5/day}}{\text{kg MLVSS in aeration tank}} \leqslant 0{,}1$$

The future full-scale treatment plant for Gaobeidian sewage network system must be able to treat 1,000,000 m^3/day with a first step of 500,000 m^3/day. This plant, even in the first step, will be a very large plant with a high efficiency in pollution removal.

We suggest that for training, the authorities build a new modern pilot plant. We think that an appropriate size for training and to meet all the problems that can occur when operating a full-scale plant, will be 2,000 m^3/day (this is the size used by Paris municipality when they want to test a new process).

2.4.3. Beijing municipality request

Because of the cost of such a pilot (US$ 1,000,000), the many problems they have to solve and because of very local and specific conditions, Beijing municipality did not agree to this suggestion and wants to improve the existing pilot facility.

2.4.4. Improvements to the existing pilot

The following paragraphs describe the existing situation and the general improvements suggested. It is proposed that the use of this plant be restricted to that of a training facility with emphasis on enabling local staff to gain experience with activated sludge processes.

2.4.4.1. Existing facilities

Figure 2.4.1. shows the existing plant. It can be re-used and improved with the purpose of developing activated sludge capability.

2.4.4.2. Improvements

a) Pumping station: The waste water delivery from the Gaobeidian pumping station must be replaced by an Archimedes screw pumping device in order to provide a very slow, flexible and regular supply, avoiding overflows and frequent peaks. The maximum pumping rate must not exceed 16 m^3/h (peak value).

Because it is a pilot plant, no standby is required. The standby will be provided by the actual supply.

Figure 2.4.2. shows a general design for the new wastewater supply. The scheme includes: a screw pump; an automatic screening with, in case of clogging, a weir diverting the flow towards a non-automatic screen; a flow-metering device with continuous recording and totalisator; an automatic sampler drive, if possible, by the flow-meter. All polluted water, regardless of source, dewatering, supernatants from sludges storage etc., must be recycled to the head of the plant after the sampler. A by-pass from the wastewater supply to the primary settling tank is necessary, so as not to stop the entire plant if a breakdown occurs in the grit chamber. Please note the location of the devices shown in figure 2.

b) Grit chamber: The grit chamber should be modified as shown in figures 2.4.3.A, 2.4.3.B, 2.4.3.C and 2.4.3.D. This process gives good efficiency, for both grit and greases removal.

The moving bridge and air lift extractor for grit, and skimmer for greases and scums, is a facility which allows good conditions of operation. The bridge should operate at a slow speed (1 m/min) to minimize turbulent conditions and at frequent intervals to avoid excessive grit accumulation in the channel.

c) Primary settling tank: The primary settling tank can operate without major improvements. There are 2 primary sedimentation tanks; only one is necessary for satisfactory operation. The primary clarifier should operate (tank without plates). We suggest improving sludge extraction. Local staff can do this.

d) Aeration basin: The actual aeration basins must be re-used with the gate opened. The settled wastewater will flow through those basins as shown in figure 2.4.4.A.

We suggest that the first aeration basin should be equipped with (thin bubbles) air diffusers.

Air supply must be as flexible as possible. Dissolved oxygen must remain in the range:

$$0{,}5 \text{ to } 2 \text{ mg/l}$$

by means of manual or automatic devices. (Driving two $75m^3/h$ blowers and one $30m^3/h$ blower).

An anoxia area must be provided to the head of aeration basin in order to allow denitrification.

$$NO_3 + \text{"denitrifants" bacteria} = \text{metabolism bacteria} + N_2 \text{ gas.}$$

In this area a submerged slow mixer is needed to avoid activated sludges settling and to avoid mixed liquor oxygenation (figure 2.4.4.B).

Denitrification is useful for nitrogen removal and to avoid the above reaction in the final clarifier which can lead sludges to float (because of the micro-bubbles of N_2 gas).

Air supply must be sufficient for the peaks and calculated as follows:

Data

- Average Wastewater flow = 10 m^3/h (total flow per day = 240 m^3);
- Wastewater BOD concentration = 250 mg/l;
- Amount of BOD_5 per day = 60 kg/day;
- Primary settling efficiency = 15%
- Amount of BOD_5 per day in aeration tank = 51 kg/day
- Peak flow = 16 m^3/h
- Peak BOD_5 per hour = 4 kg/h
- Amount of MLVSS for BLR = 0,1 = 510 kg.

These flow conditions to the plant are suitable for training purposes. Flow can be set by means of a valve in the existing wastewater supply well.

Air supply needs:

Oxygen:

- Average: $kg/O_2/day = 0,66 \times kg\ BOD/day + 0,07\ kg\ MLVSS$

$$kg/O_2/day = 0,66 \times 51 + 0,07 \times 510 = 70\ kg/day$$

- Peak: $kg/O_2/h = 0,66 \times 4 + \frac{0,07 \times 510}{24} \approx 4,15.\ kg/hour$
- Air:

The air contains 21% of O_2 (the efficiency of diffusers is 3,5% per meter of depth, with thin bubbles). Hence air-supply needs can be calculated. Obviously the minimum air supply must meet peak requirements.

Peak requirements = 19,762 kg air/h ($1\ m^3$ air = 1,293 kg)

Peak requirements = 15,3 m^3 air/h

Efficiency of air-diffuser is 3,5% per meter of depth.

Depth is 3 m -- efficiency will be 10,5%

Air supply needs $\approx 160\ m^3/h$.

If denitrification occurs in the final clarifier (see above 2.4.2.d)the air supply requirements will drop in order to get dissolved oxygen equal to 0,5 mg/l. The sludge recycling rate will then operate at maximum.

e) Final clarifier: Because the overhall plant performance is directly related to the final clarifier efficiency, we suggest building a new final clarifier.

The shape must be circular, with a diameter no less than 5,50 m. The general design is shown in figure 2.4.5. Sludge recycling rate must be at least 200% with ability to reach 300% to 400%.

We recommend the use of an Archimedes screw pump for sludge recycling with a pumping rate of 32 m^3/h. A second pumping device is necessary; it should be a conventional pump with ability to reach 32 m^3/h pumping rate. This pump can be used either to increase sludges recycling rate or to pump out the excess sludges from the activated sludge plant. In an Archimedes screw pump the activated sludges flow is not shredded nor ground up as happens with a conventional pump.

The sludges recycling rate needs to be set correctly. It must be operated with care because plant performance depends upon a proper recycling rate.

The following theory gives the basis for computing sludge recycling rate: For acceptable efficiency with an activated sludge process we need to retain within the aeration basin a sufficient amount of micro-organisms.

Let:

Cs_i = micro-organisms concentration in the aeration basin (g/l or kg/m^3)

V = aeration basin volume (m^3)

amount of micro-organisms = Cs_i x V (kg)

(Cs_i is related to MLVSS)

with a BLR = 0,1; Cs_i = 50% x Cs (MLTSS).

We need to maintain Cs (MLTSS) = 2 x Csi (MLVSS). In the case of this pilot plant we need 510 kg MLVSS, then 1020 kg MLTSS gives for MLTSS concentration, a range of 5 to 6 g/l or kg/m^3, with a BLR = 0,1, the expected SVI should be between a range of 80 to 130.

Setting Recycling Rate (see diagram next page)

For constant Cs, sludge leaving aeration basin = recycled sludges

$$R \times C_R = (R + Q) \times Cs \quad (1)$$

SVI (sludges volume index) is defined as: volume (in cm^3) of 1 gramme of sludge after 1/2 hour settling period. SVI is the inverse from the maximum concentration for a sludge.

Taking into account the units

$$C_R = \frac{1,000}{SVI} \text{ for MLTSS.}$$

Hence equation (1) becomes

$$R \times \frac{1,000}{SVI} = (R + Q) \times Cs \quad (2)$$

$$Cs = \frac{1,000\ R/Q}{SVI\ xR/Q + SVI} \quad (3)$$

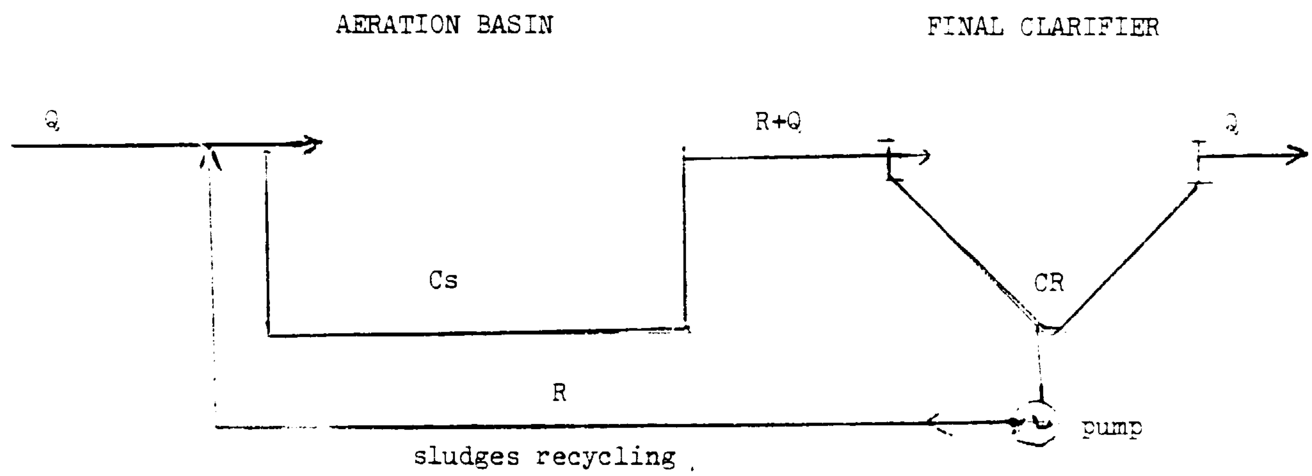
From equation (3) a set of curves must be prepared.

$$Cs_{SVI} = (f)\ R/Q \quad \text{(figure 2.4.6.)}$$

This set of curves is very useful to establish correct sludge recycling rate and shows that an improperly sludge recycling rate leads to significant loss of sludge in a few hours. Several days or weeks are then necessary to recover a normal concentration.

N. b.: SVI is related to BLR such that when BLR increases, SVI increases.

If Cs is too low, SVI will increase. If a correcting action is not performed, a point is reached when, even with the maximum recycling rate, it is impossible to recover normal conditions. Then the only



Let:

Q = influent wastewater flow in M^3/h

R = Recycling rate in m^3/h

Cs = MLTSS concentration needed in aeration basin in g/l or kg/m^3

CR = MLTSS concentration recycled sludges in g/l or kg/m^3

solution is to divert a part of flow to the river in order to drop BLR . Recycling is very important to monitor. We suggest the installation of an ultrasonic flow meter on the recycling pipe.

f) Existing final clarifiers: The existing final clarifiers could be used as a storage and thickening device for excess sludges. The Chinese Engineers are able to perform this improvement by themselves.

g) Treated water, flow measuring and sampling: The same devices as shown in figure 2 must be used for treated water flow measuring and sampling.

h) Sludge dewatering and treatment; For this very small pilot plant sludge production will be very small. The existing equipment is sufficient. Beijing Municipality may wish to use a compost process. This plant is too small to justify building a modern compost plant. Experimentation can be undertaken with very simple tools.

The Beijing Municipality was supplied with information about compost.

i) Electric supply: There are a significant number of electric supply failures (3 to 4 times per month for periods from 2 to 4 hours). An on-site diesel engine alternator is available.

This stand-by supply must be improved or modified as follows:

- Automatic start when normal electric supply fails,
- The stand-by electric supply must be connected only to the strategic devices.

The very first priority is to keep working at least a blower (compressor) to provide a minimum air supply to the thin bubbles air diffusers in order to avoid clogging.

2.4.4.3. New layout for pilot plant

The new layout for an improved pilot plant is shown in figure 2.4.7.

2.4.5. Requirements for improvement of the pilot plant

The improvements described above are only rough designs and schemes. For more details and accurate drawings in order to perform the above improvements and to get practical "know-how", technical assistance is necessary.

The Beijing municipality indicated that much of the suggested equipment should be manufactured in China. We think that this technical help should be performed within 3 periods.

2.4.5.1. Job description

First period

An expert with very good practical knowledge of wastewater treatment plants must be fielded in Beijing as soon as possible. In conjunction with a Chinese engineer, specialized in mechanical design and calculation, the expert will define feasible improvements to the existing plant. For feasible equipments the expert and Chinese engineer will list what can be manufactured in China and what equipment will need to be imported.

Second period (without expert)

Manufacturing period for all experimental equipment to be manufactured in China. Performing period for civil works on the site (concrete, lay-out for pipes, electric supply), (flow-meters and samplers with 2 other experts).

Third period

When all is ready, the expert will come back to Beijing; the job in the third period will consist, in conjunction with Chinese engineers and technicians, of fitting, setting up and checking all new equipments.

2.4.5.2. Duration

- First period: 1 month (all facilities must be provided: Blackboard, paperboard, set for drawing, translater if necessary with good knowledge of technical words).

- Second period: Depends upon Beijing municipality and Chinese factories. Fitting for flowmeters and samplers must correspond with flowmetering and sampling Experts' period and if possible when concrete works will be ready.

- Third period: 1 month if all facilites are available.

2.4.5.3. Remarks

There exists much "know-how" in the designing and building of wastewater treatment plants. The expert must be very careful and will give this "know-how". A lot of details are obvious for an expert, and it is quite difficult for a specialist to bear in mind the necessity to be very accurate in giving such technical details.

2.4.6. Instrumentation for Pilot Plant

2.4.6.1. Mecanical and electrical equipments suggested

- Each machine must be equipped with summing working meters, voltmeters, ammeters;

- Pilot lamps showing whether machinery is running or not;

- Pilot lamps indicating electrical faults - standby electric supply (automatic)

- Valves position indicators

- Times switches, cam programmers, cyclic dosing appa:atus for programming fresh sludge extraction return (recycling) sludges flow according to daily load curve, excess sludge extraction according to daily load curve and experience.

These equipments can be installed separately or grouped together in the existing room display (take care, because most of electric signals for remote data control cannot travel, without special devices, for distances of more than a few meters).

A special logbook is necessary to record daily all mechanical and electrical measurement data, both for maintenance and driving plant needs.

2.4.6.2. Chemistry and biologic equipment

a) First step (as soon as possible)

- Disolved oxygen measuring and recording device,
- Disolved oxygen measuring portable instrument,
- Chemical facilities to determine as often as possible COD, BOD_5, TSS, VSS, MLTSS, MLVSS, (COD, BOD, TSS, VSS for inlet and outlet water), (MLTSS, MLVSS then SVI for activated sludge), glassware, chemicals, miscellaneous furniture, analytical balance - BOD incubator - Drying ovens (105^o and 550^o) - Oxygen tritration equipment.
- Portable automatic colorimetric comparator with pretitrated cuvets who allow a lot of chemical determinations (COD - NO_2 - NO_3 - NH_4 - some heavy metals .....

This will be useful to get quick results in order to be able to set plant operation. For example they need to know the NO_3 concentration in treated water as often as possible to set plant for a good nitrogen removal - if NO_3 outlet is $>$ 40 mg/l, dissolved oxygen in aeration bassin must be dropped to 0.5 mg/l, anoxia area must operate hardly and sludge recycling rate must rise to 400%. If NO_3 outlet concentration keeps in a range of 0 to 15 mg/l, plant is working properly.

- In the same time of MLTSS is determined, SVI must be calculated in order to set accurately sludges recycling rate;
- pH meter with continuous recording and with alarm to the room display in order to divert flow out from the plant if a dangerous value for sludges is reached;
- Secchi disk;
- 2 automatic sampling units;
- 2 flowmeters;
- 1 ultrasonic flowmeter for sludges

A special logbook is necessary to record daily all chemical and biological data.

b) Second step (following satisfactory operation of pilot plant):

- Microscope for activated sludges floc quality analysis:
- Because Gaobeidian sewage system includes a lot of industrial non-bio-degradable discharges with possibility of toxics we suggest:
  - "Daphnia" Test
  - Respirometer (microorganisms oxygen consumption meter).

This sophisitcated equipment (respirometer) requires activated sludges. Wastewater supply will be picked up just before the primary settling tank in order to divert flow out form the plant if a toxic influent is identified.

This equipment (respirometer) will be useful not only to detect toxic influent but also to determine the biodegradability for any kind of discharge. This equipment is able to determine activated sludges adaptability to any kind of discharge. The respirometer will be bought only when building improvements will be completed (electric supply, dust filtration, air conditioned ....).

c) Third step

- A spectrophotometer, in Gaobeidian or in monitoring station;
- Computer.

2.5. A New Pilot Plant at Gaobeidian

A new, modern and efficient sewage treatment pilot facility will ultimately have to be installed of 2,000 m^3/day capacity. Furthermore, aerated composting should be tested for which two approaches are possible (figure 2.5.1 and 2.5.2).

1) A conventional plant with activated sludge;
2) An immersed aerated bed, new technology (now approved for use in France, which lowers the volumes of aeration and eliminates the final clarifier).

Preliminary studies of sludge treatment and their use on farm land can be executed. Chinese technicians can do this by themselves, with the help of their own agronomy expertese. Final designs on this facility must await adequate data of flows and amounts of pollution. Before this new facility is considered, much work (preliminary treatment, disconnection, etc...) has to be carried out at the locations of industrial discharges.

We recommend the assistance of an expert for preliminary studies, preparation of tender documents and specific recommendations about materials and designs.

2.6. Future Full-Scale Plant

A conventional full-scale plant for 500,000 m^3/day at Gaobeidian would need an area of about 36 ha. (see figure 2.6).

Beijing Municipal Administration has to consider this problem now for the six future full-scale plants. It is never too soon to think about sludge treatment (feasibility of compost with sawdust for example), which is the key to a successful wastewater treatment plant.

3. GENERAL RECOMMENDATIONS

3.1. Maintenance Considerations

We understand that only limited maintenance is performed for any equipment. Maintenance must be taken into account in wastewater treatment for all the proposed activities:

- Pilot plant;
- Full-scale plant;
- Laboratory;
- Monitoring station;
- Sewers;
- Pumping stations.

The more modern and sophisticated the equipment is, the more rigorous the maintenance must be. We suggest that Chinese engineers undertake training to learn what planned and scheduled maintenance is and why it is essential to perform such maintenance. Even with a good knowledge of maintenance procedures, they cannot be put into practice without summing working meters and logbooks. for these reasons we suggest acquisition of summing meters and logbooks. Storage and inventory of spare parts must be carefully provided for. Appropriate tools and handling devices must be available.

These considerations are very important and must be integrated into the training programme. Without maintenance, wastewater treatment quality will drop quickly to a low level, leading to a loss of efficiency and waste of money.

3.2. Reliability

A very high level of reliability is required to fight successfully against pollution. A wastewater treatment plant is required to operate properly 24 hours/day and 365 days/year.

Following the installation of a full scale plant (1,000,000 m^3/day), the improvement of river quality will reach a higher level. If a major breakdown occurs, all results achieved within a period of several months or years can be lost in few hours. Beijing municipality should not undertake very sophisticated Probabilistic Reliability Analysis (PRA), since this technique has yet to be perfected. Since reliability is not only a science, but also an attitude of mind, we suggest applying a set of very simple rules frequently applied in France. A few days training in an appropriate institution will be sufficient to acquire a good knowledge of reliability principles.

3.3. Control of Industrial Discharges

Industrial discharges are very significant in the Gaobeidian sewerage system, so controls of these discharges must be efficient. We recommend installation of flow-metering and sampling to the main discharges. Control, even if accurate, is only a control and will never be a means to fight pollution. Since the factory's engineers are not specialists in wastewater treatment, we suggest Beijing municipality provides assistance to industry to help them solve their specific wastewater treatment problems.

To finance this activity discharge taxes could be established.

Industrial wastewater must be treated on site with appropriate processes. This is very important for factories whose discharge is not bio-degradable. After treatment on the site, these discharges should be eliminated from the sewereage network, treated on-site and discharged directly to the river.

There are 4 main reasons for the above recommendation:

a) Industrial wastes are not always bio-degradable and will flow through the municipal wastewater treatment plant without any kind of treatment.

b) They include large volumes of clean water, so energy is wasted in pumping them through the treatment plant.

c) If the treatment on the site breaks down, there is a risk that toxics reach the municipal wastewater treatment plant and kill activated sludge bacteria. If this scenario happens, neither the industrial discharge nor the domestic wastewater will be treated for at least 3 weeks (period to recover a normal amount of activated sludge).

For bio-degradables and non-toxic discharges pre-treatment will be sufficient. They can be treated by the municipal wastewater treatment plant.

d) Heavy metals and harmful matters are concentrated by activated sludge. This could be dangerous if sludges are used in farmland.

3.4. Operator Training

Since wastewater treatment is a speciality requiring specific knowledge of several technologies, we suggest a special course in a Chinese university or institute be considered.

In France several such institutes teach wastewater treatment technologies. Course duration is generally 3 years for a technician and 5 years for an engineer. Courses include Chemistry, Biology, Mechanics, Electricity, Hydraulics, Instrumentation, Measuring Technologies, Management, Sewers and Treatment Plant Operations, Maintenance, Sampling, etc.

Two persons for 6 months each should be sent to such an institute in a developed country.

- 5 months spent in the institute,
- 1 month spent in a large wastewater treatment plant.

For example "La Fondation de l'Eau" in Limoges (France) is able to provide a training programme tailored to the needs.

3.5. Plant Operation

A wastewater treatment plant requires maintenance and also accurate and constant adjustment. In the USA operators require a special licence. There are several kinds of licences according to the size of the plant.

We suggest preparation of a manual covering operation of a plant addressing the following issues:

- Type of sampling and analysis needed, where, how often, when?
- Operating variables, where, how often, when?
- How to perform maintenance?
- What records should be kept?

This means checklists must be completed for normal operations and emergency conditions.

The following logbooks are required:

- Mechanical logbook (mechanic/electricity equipment)
- Plant operating logbook (chemical analysis/biological data).

The results of the main analytical determinations must be available as quickly as possible.

DCO - TSS - VSS - MLTSS - MLVSS - Disolved oxygen (continuous recording) - Flow (continuous recording) - NO_3.

The automatic portable colorimetric comparator will be very useful for this purpose. Drying ovens are needed for (TSS - VSS - MLTSS - MLVSS) determination.

Amount of pollution entering the plant:

Amount = Concentration x Flow

The daily expected amount of pollution must be available to operators. A specific set of curves ,similar to the recycling rate according to the inlet flow and SVI ,are very useful.

4. CONCLUSION

We recommend to the Beijing Municipal Administration to proceed to fight pollution step by step.

Before building any full-scale plant, they have to know exactly the sewerage network and the pollution loads of both domestic and industrial sewerage. This can be followed by controlling each industrial discharge and collecting, by extension of the network, all the sewage in the catchment basin.

List of Figures

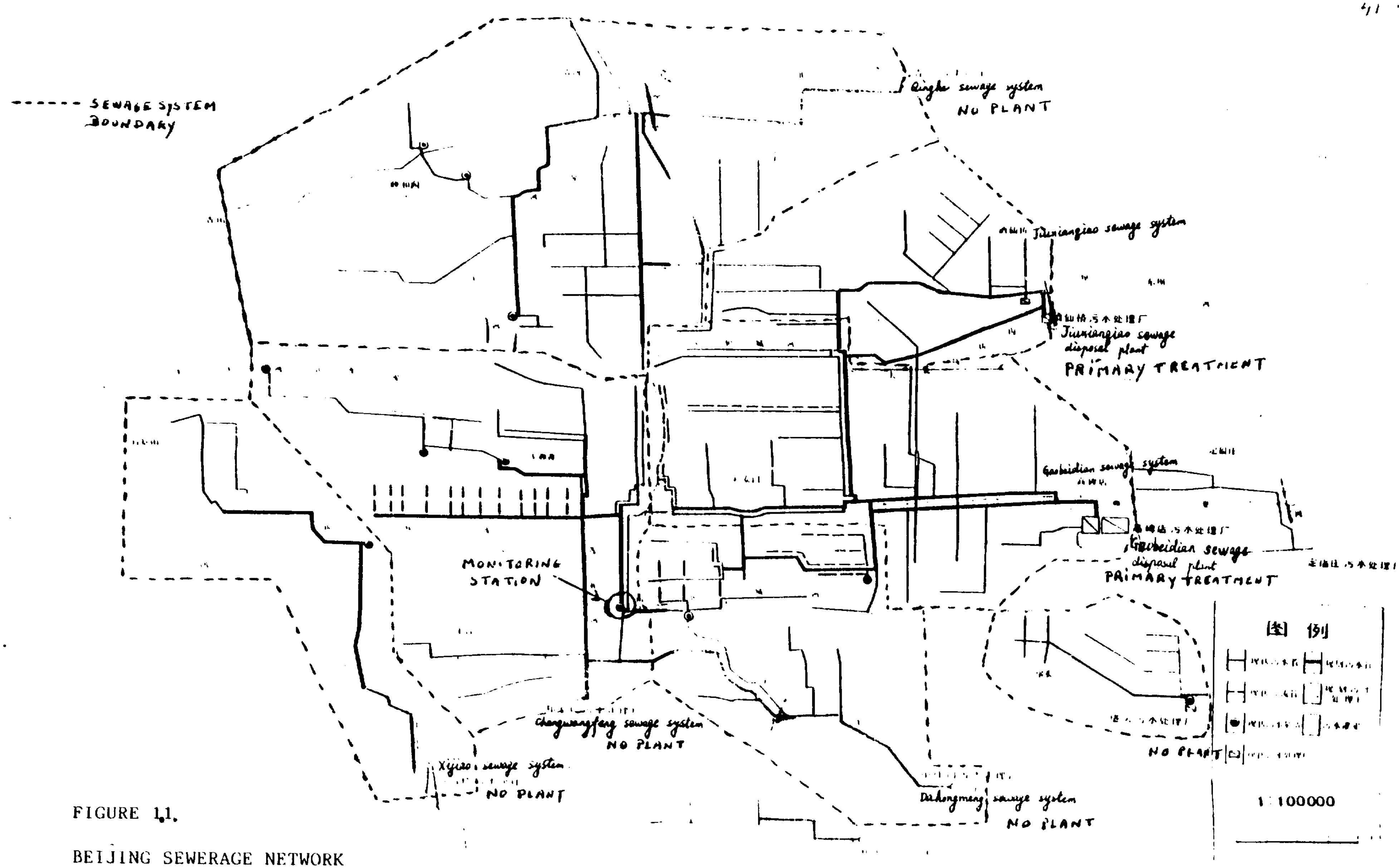


FIGURE 11.

BEIJING SEWERAGE NETWORK

Figure no. 2.1.2.1

EQIPMENT REQUIRED FOR NETWORK

First Step

a) Flow meters
   - Civil engineering (channels)
   - Recording meters (diaphragm or ultrasonic)
     - with pH meters and 0^o meters
     - without pH meters and 0^o meters

b) Automatic sampling units
   Portable, cooled, with batteries, capable of taking average samples proportional to the flow of water

c) Portable explosion detector

d) Portable pH meter

Second Step

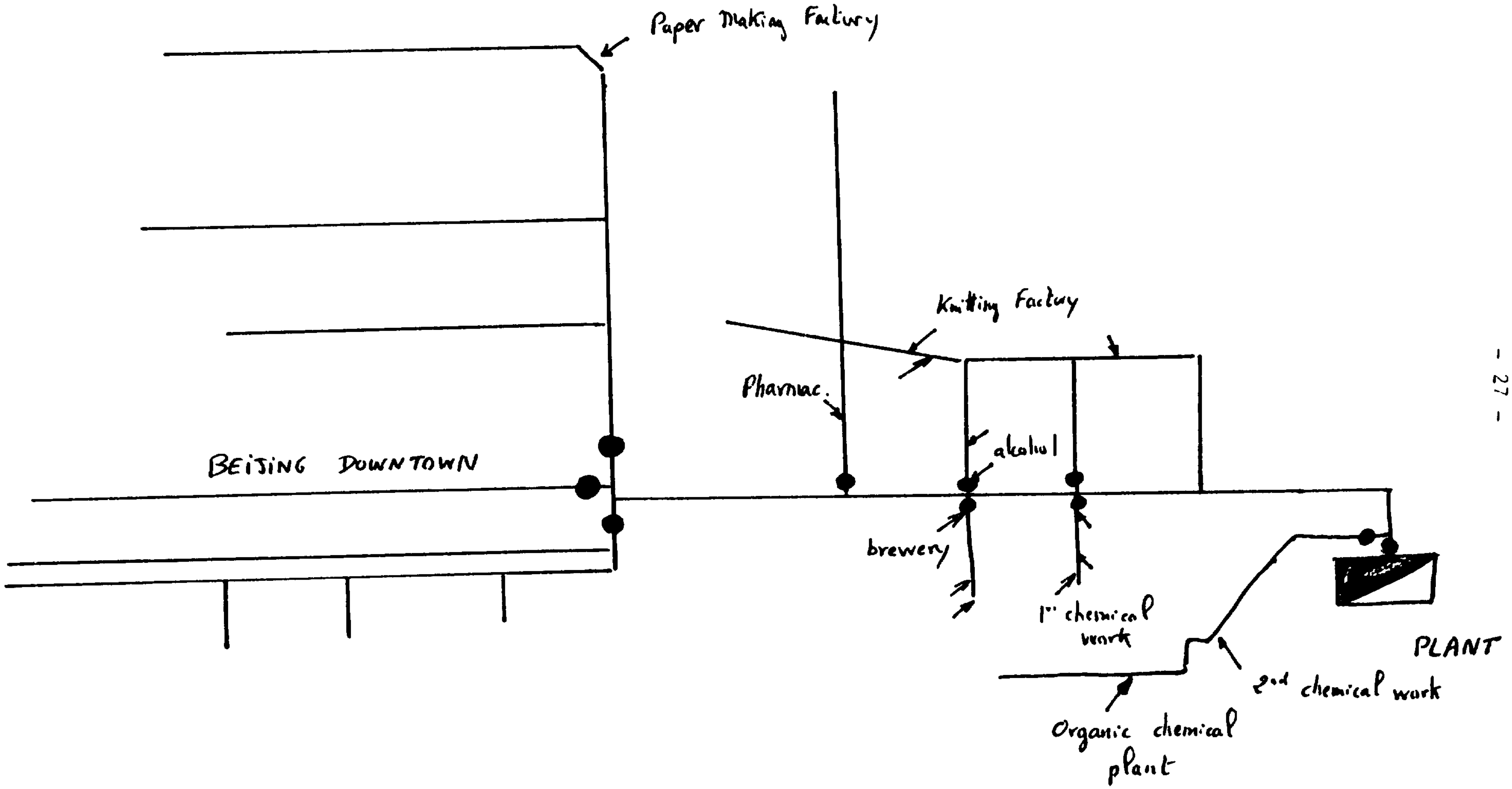
Supplementary flow meters, automatic sampling units, and safety equipment (to be defined after one year)

For details and prices please see Appendix No. 6

Figure no. 2.1.2.2.

GAOBEIDIAN CATCHMENT BASIN

PROPOSITION FOR THE LOCATION OF FLOW METERS



● FLOW METERS TO BE INSTALLED

Figure n° 2.3

EQUIPMENTS REQUIRED FOR MONITORING STATION

FIRST STEP

a) BOD and COD analysis facilities, allowing :
100 COD analysis per day and 30 BOD analysis per day

b) Facilities to measure TSS and VSS, allowing :
50 to 100 analysis per day

c) Portable colorimetric comparator

d) Portable ultrasonic flowmeter

e) Miscellaneous

SECOND STEP

a) NTK, NH_4, NO_2, NO_3 analysis facilities, allowing
100 analyses per day

b) Heavy metals analysis facilities

c) Spectrophotometer for routine analysis

d) Toxicity Test (Daphnia)

e) Miscellaneous

THIRD STEP

a) Miniral oils, Hydrocarbon analysis

b) Organic Matters

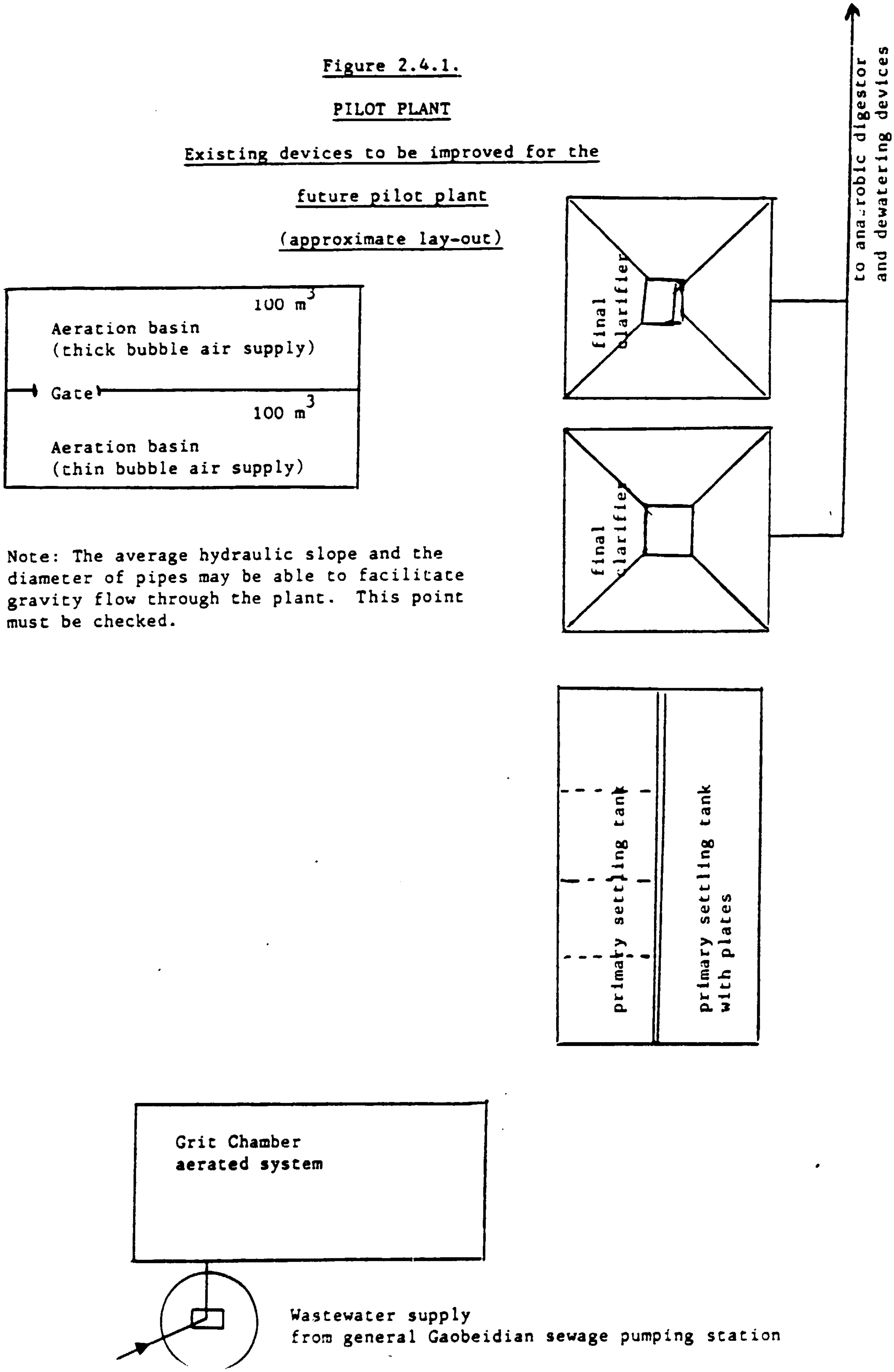
c) Miscellaneous

For details please see appendix n° 4

Figure 2.4.1.

PILOT PLANT

Existing devices to be improved for the future pilot plant (approximate lay-out)



Note: The average hydraulic slope and the diameter of pipes may be able to facilitate gravity flow through the plant. This point must be checked.

Figure 2.4.2. - New wastewater supply

- Dirty waters must be recycled from wherever they are produced (dewatering supernatant from sludges storage etc...) (Recycling after sampler and not before).

- Supply from general pumping station is regulated by the valve in the actual well. It could be usefull to rise and drop the flow with the valve to test the new supply efficiency.

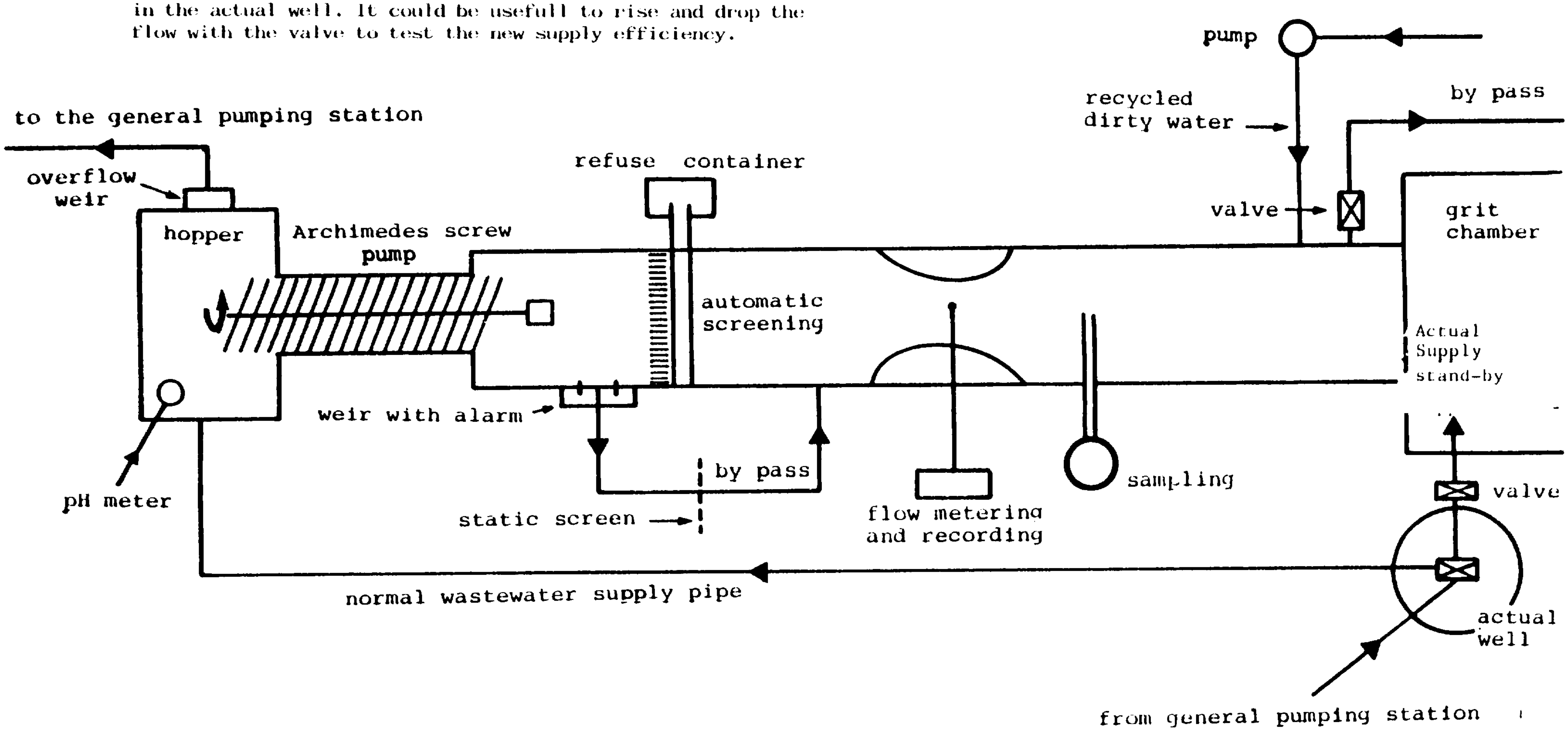


Figure 2.4.3. - New Grit Chamber

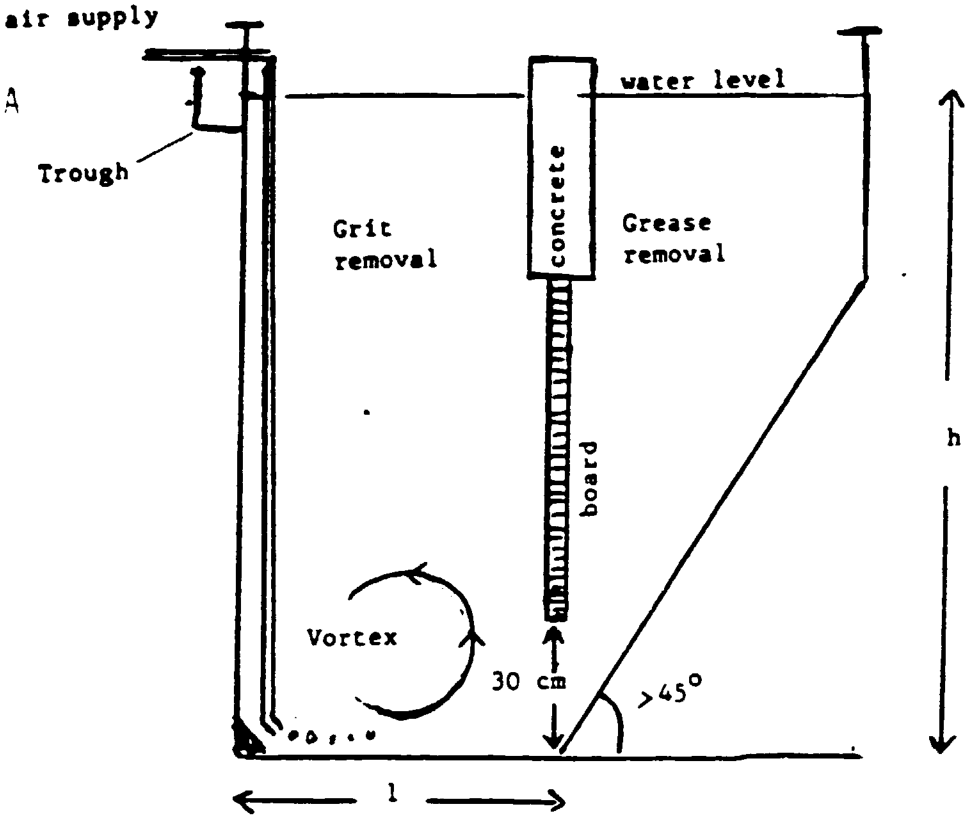


Fig. 2.4.3.A

$\frac{h}{l}$ = 1,5 to 2,5

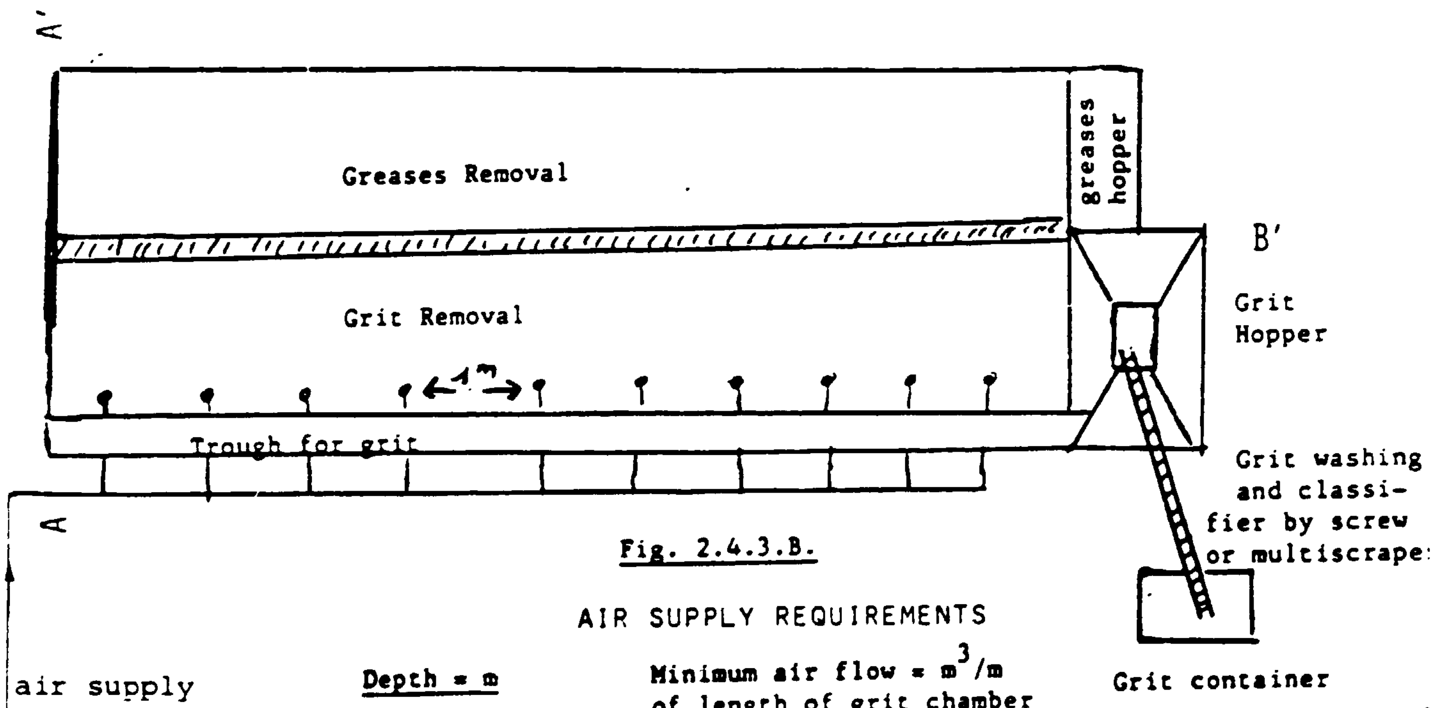


Fig. 2.4.3.B.

AIR SUPPLY REQUIREMENTS

Depth = m	Minimum air flow = m^3/m of length of grit chamber
1,5	12 to 15
2,0	11 to 14
2,5	10 to 14
3,0	10 to 14
4,0	10 to 13,5

Figure 2.4.3. (cont)

Figure 2.4.3.C

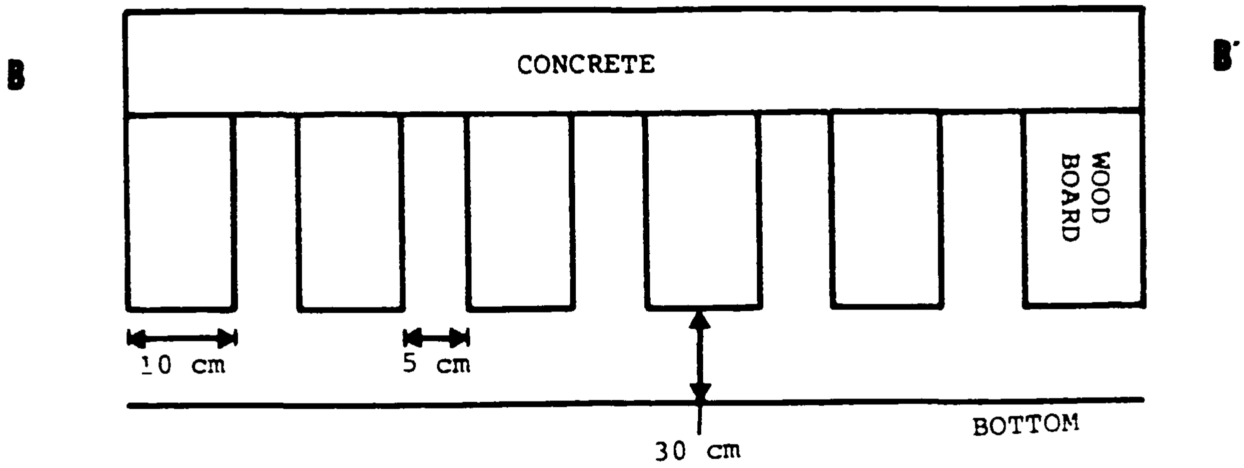


Figure 2.4.3.D

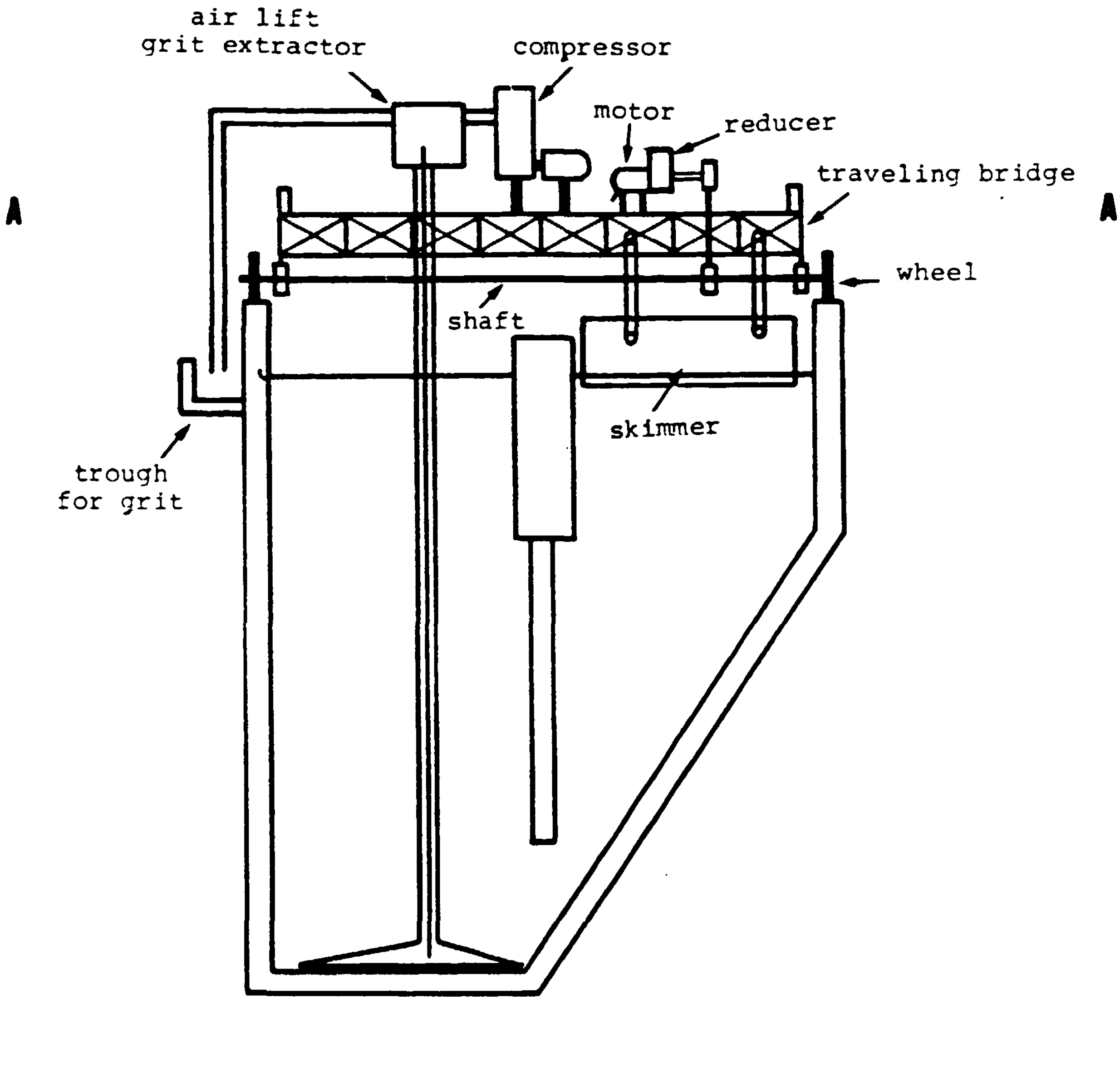


Figure 2.4.4. New Aeration Basin

Fig. 2.4.4.A

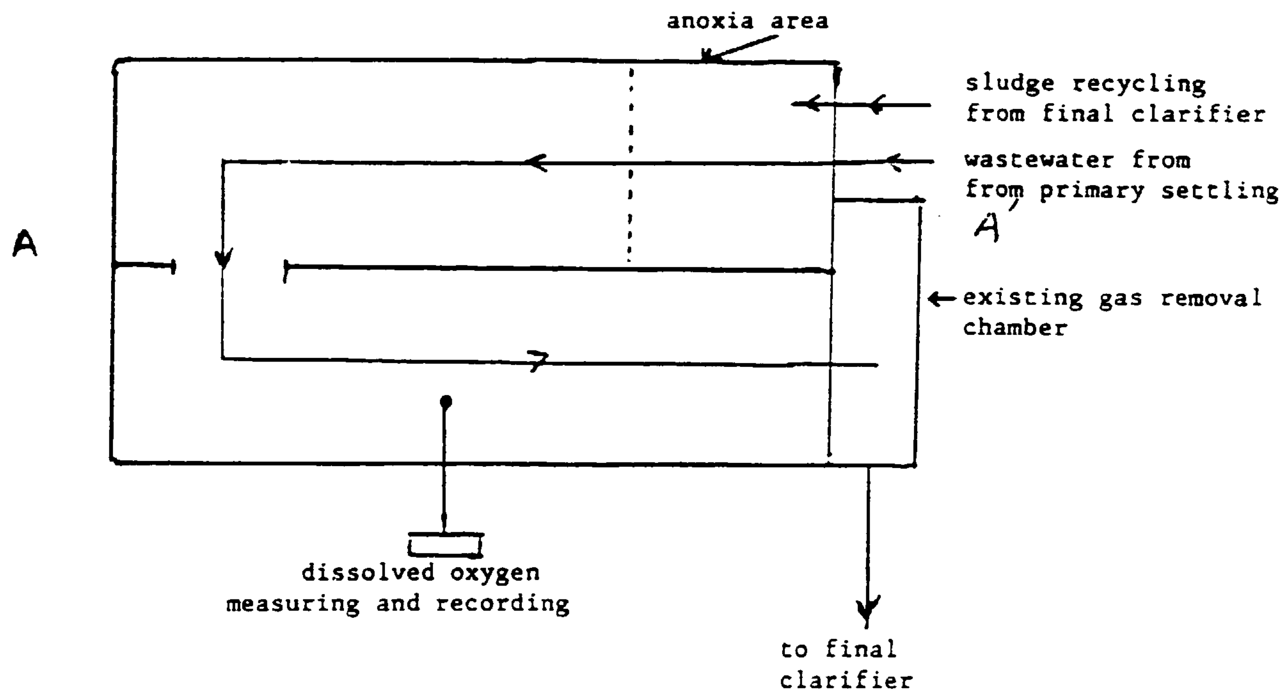


Fig. 2.4.4.B

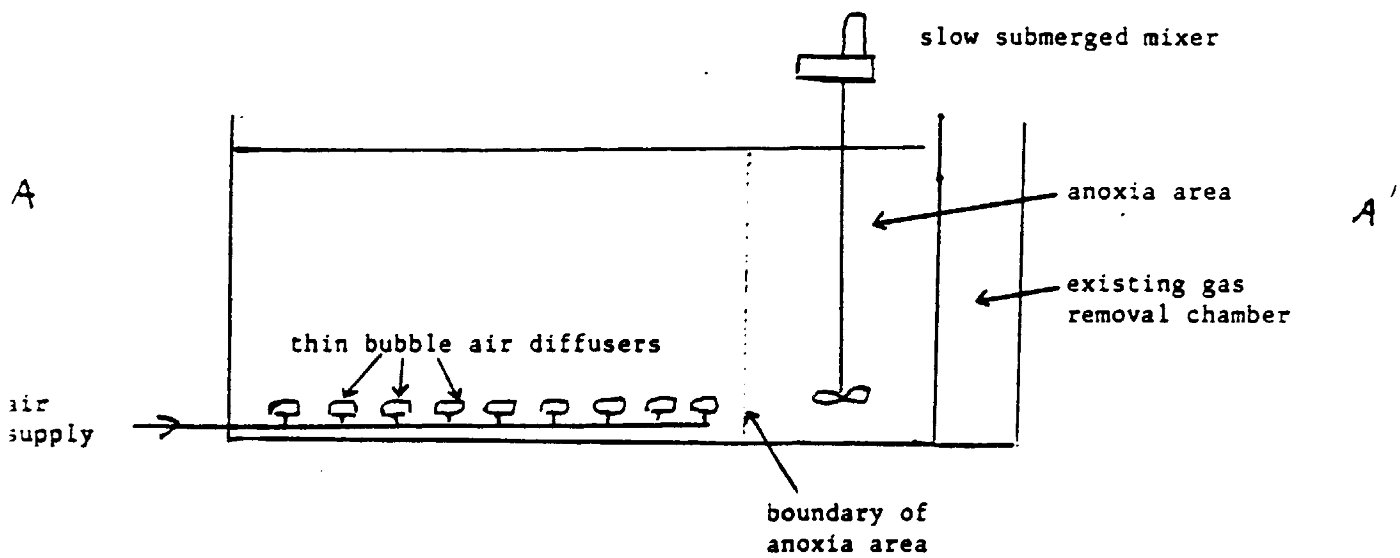


Figure 2.4.5.

New final clarifier and sludge recycling

(Rough scheme)

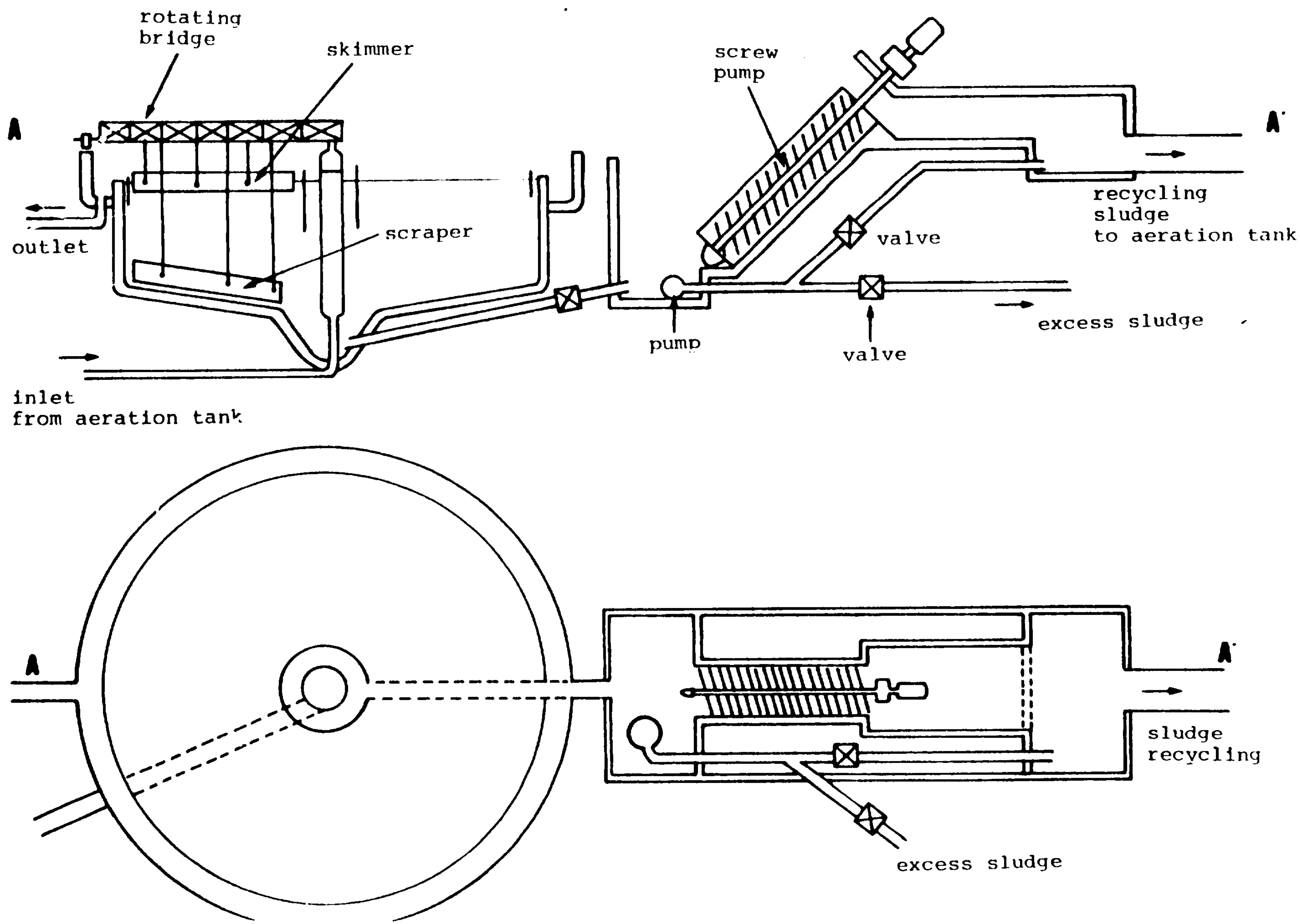


Figure 2.4.6.

Curves for setting re-cycling rate

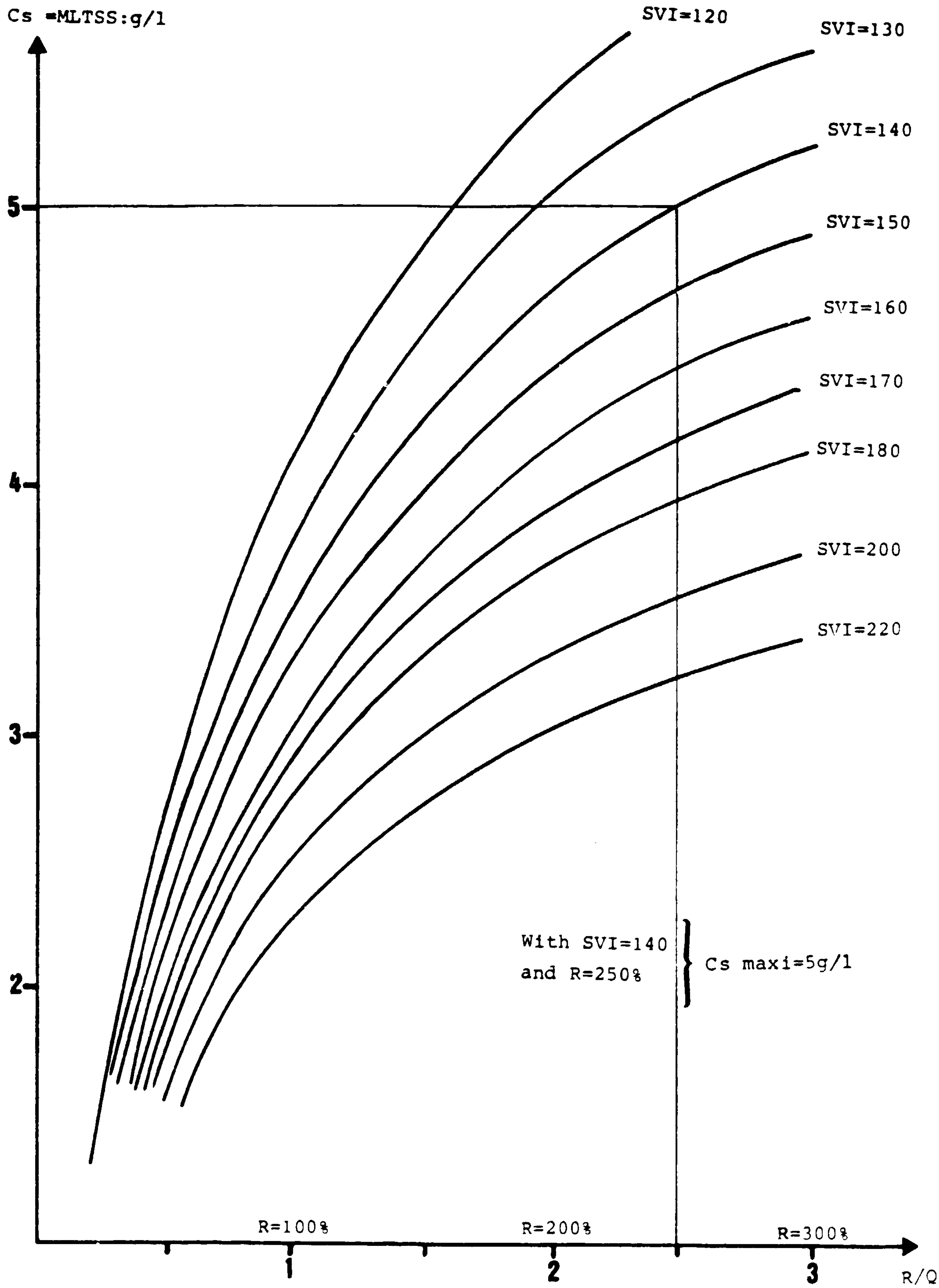


FIGURE 2 7.

NEW LAYOUT FOR IMPROVED PILOT PLANT

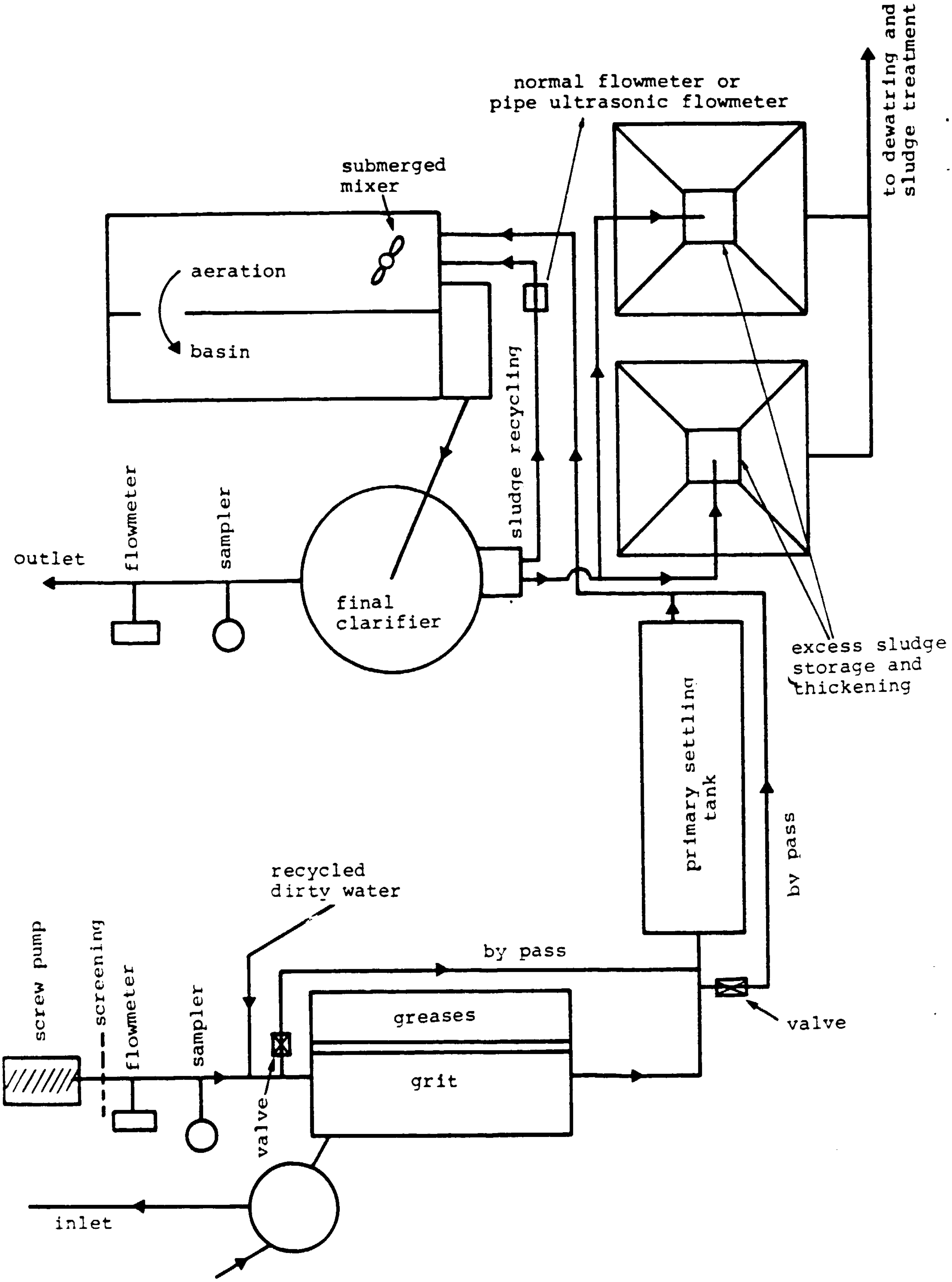


Figure n° 2.4.8

LIST OF EQUIPMENT REQUIRED FOR IMPROVEMENT OF THE EXISTING PILOT PLANT

1) MECHANICAL AND ELETRICAL EQUIPMENT

a) Ammeters

b) Pilot Lamps

c) Time Switches

d) Cyclic dosing Apparatus

e) Summing Working Meters

f) Log-book

2) CHEMICAL AND BIOLOGICAL EQUIPMENT

FIRST PHASE :

a) D.O. measuring and recording device

b) D.O. measuring (portable)

c) BOD, COD, SS, TSS, VSS ....., measuring

d) Portable colorimetric comparator

e) pH meter with continuous recording

f) Log-book

SECOND PHASE :

a) Microscope

b) Toxicity (Daphnia) Test

c) Respirometer

For details please see appendix n° 5

Figure no. 2.5.1.

New Pilot Plant (2,000 m^3/day)

Main Specifications

	Influent	Effluent
BOD	200	20
COD	484	70
BS	339	30
VSS	*	*
NT_K	*	*
NH_4^+	*	*

*) to be defined later.

Activated sludge treatment (extended aeration) will be required to reach the desired standards.

Phase 1: Water Treatment		Approved Cost US$
a) Grit and grease removal		50,000
b) Primary settling tank		100,000
c) Aeration tank		300,000
d) Final clarifier		200,000
	Subtotal	650,000
Phase 2: Sludge Treatment		
a) Thickener (settling tank)		50,000
b) Dewatering unit		150,000
c) Compost unit		150,000
		350,000
		US$ 1,000,000

Note: The cost includes 60% Civil Engineering and 40% Equipment.

Figure no. 2.5.2.

NEW PILOT PLANT
2000 M^3/Day
ROUGH SCHEME

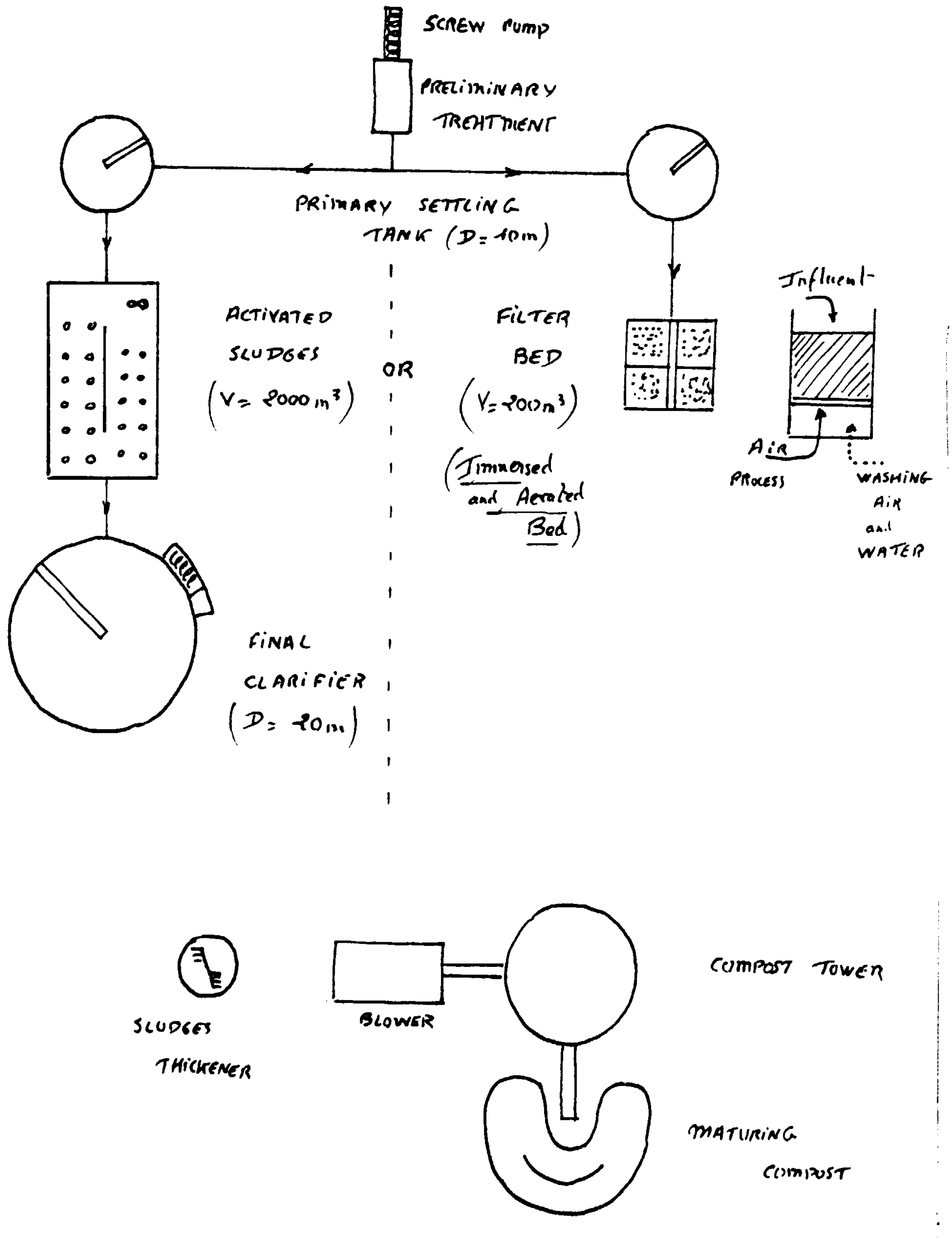
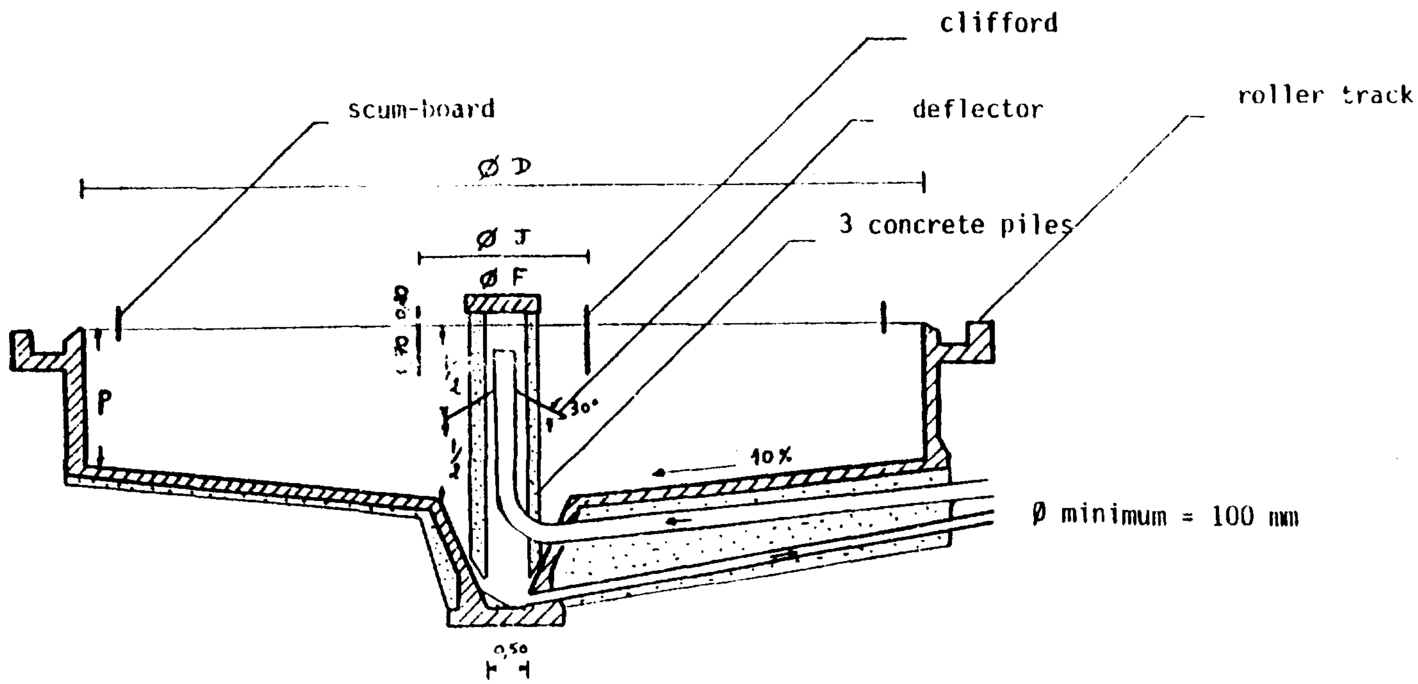


Figure no. 2.5.3. CIRCULAR SEDIMENTATION TANK

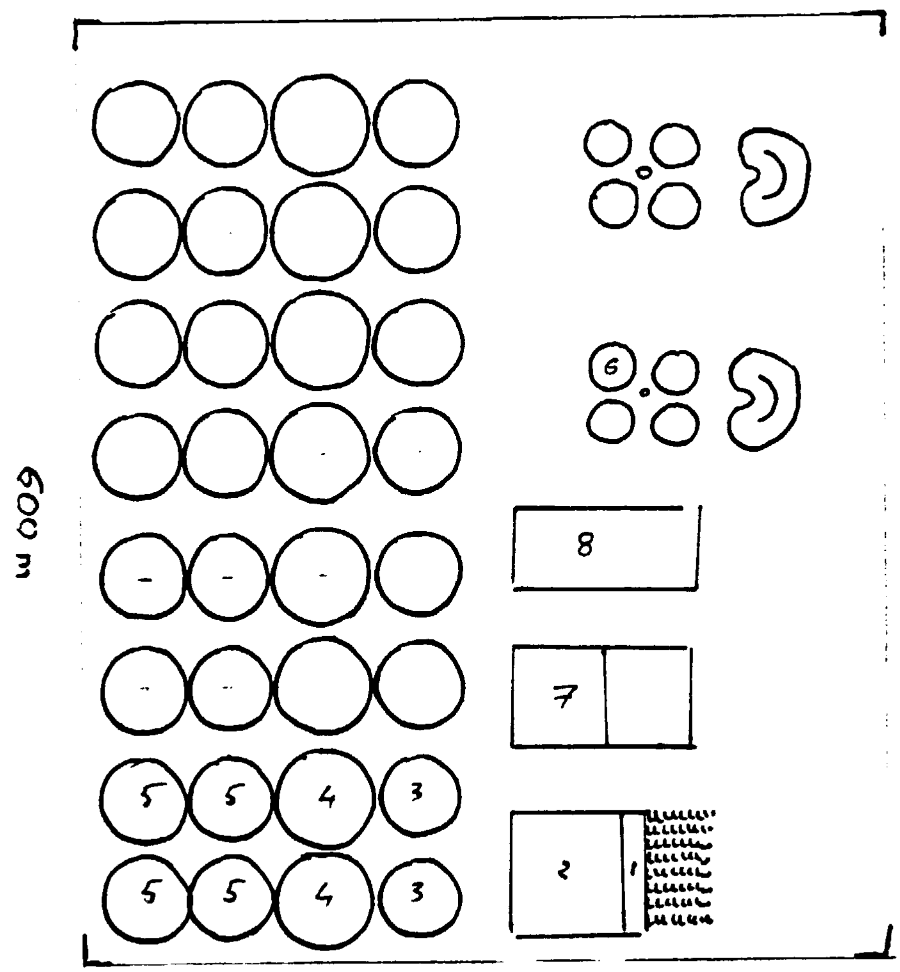


- $S_j - S_f = 1m^2$ for $25\ m^3 / h$
- p = 2,00 m for Ø D = 15 m; 2,20m for Ø D = 20 m ; 2,25 for Ø D = 25m ....
- Scraper blade : in suspension, once blade of height = 25 to 30 cm
- Scraper bridge = 1 lap minimum in 30 minutes
- $\frac{\text{peak flow}}{Sd-Sj} < 0{,}8 m/h$
- continuous sludge return

AFBSN/CL/09

Figure no. 2.6.

GAOBEIDIAN FULL SCALE
WASTE WATER TREATMENT PLANT
500.000 M^3/DAY
ROUGH SCHEME



1. PUMPING STATION (8 SCREW PUMPS)
2. PRELIMINARY TREATMENT
3. PRIMARY SETTLING TANK (D= 45m)
4. AERATION TANK (V= 25000 m^3)
5. FINAL CLARIFIER (D= 45 m)
6. COMPOST TOWER
7. AIR SUPPLY BUILDING
8. SLUDGES THICKENING and DEWATERING

Figure no. 4.1.

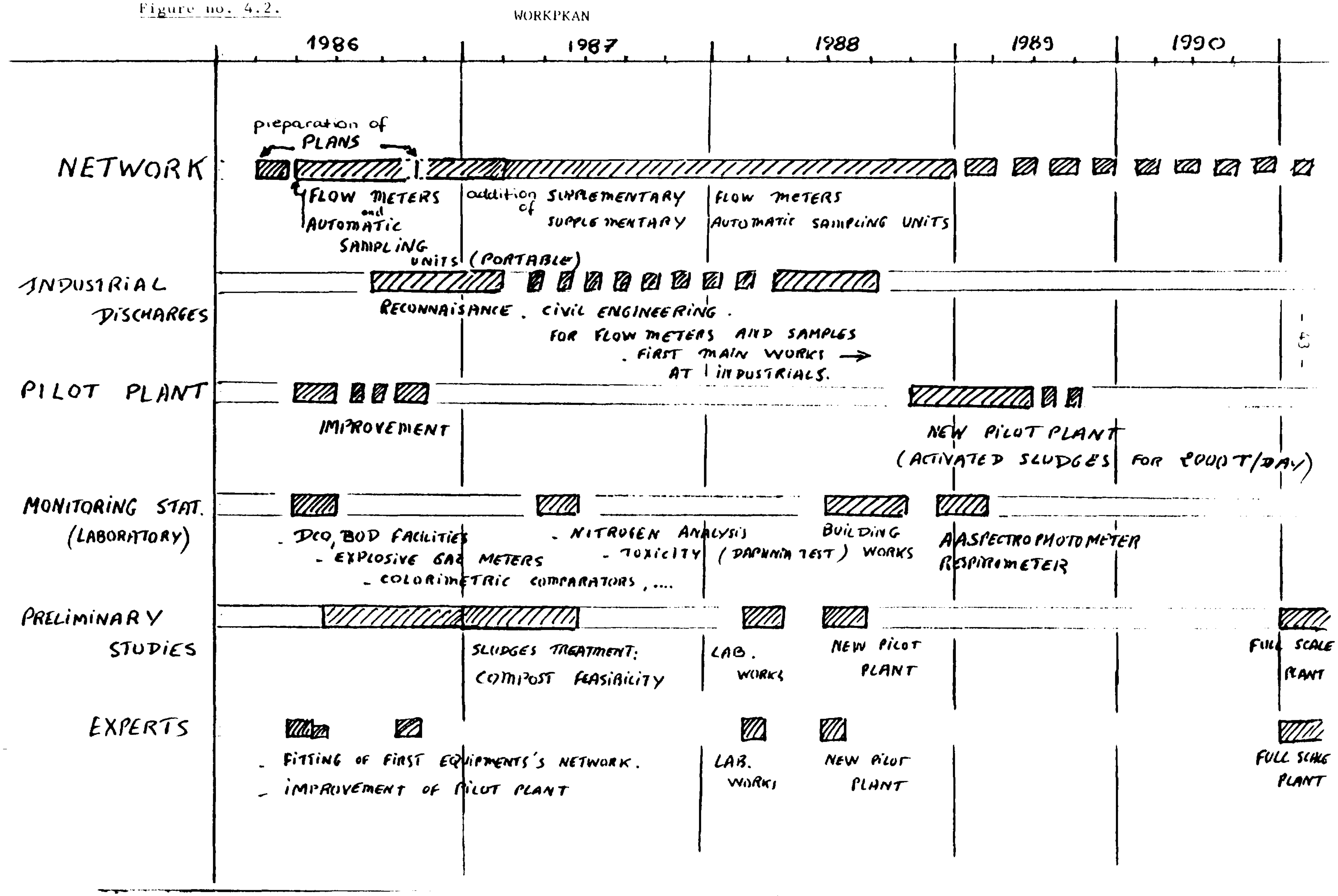
Proposed Training Programme

I) Study Tours

- 5 men x 1 month in France and in the Netherlands. In France:
  - ACHERES plant (2.100.000 m^3/d)
  - VALENTON under construction plant (600.000 m^3/d)
  - SOISSONS plant (Immersed Bed and Compost)
  - LE HAVRE respirometer
  - Laboratory of the Paris Municipality

II)	Fellowships	m/m
	1) Flow metering (in Neyrtec factory)	
	2 men x 1 month	2
	2) Wastewater treatment operation (in "Fondation de l'Eau", Limoges)	
	4 men x 3 months	12
	3) Analyses (in French laboratory, to be defined)	
	3 men x 3 months	9
	4) Reliability rules (in Agence de l'Eau, Artois-Picardi)	
	4 men x 0,25 month	1
	TOTAL	24 m/m

Figure no. 4.2.


WORKPKAN
1986
1987
1988
1989
1990
NETWORK
preparation of PLANS
FLOW METERS and AUTOMATIC SAMPLING UNITS (PORTABLE)
addition of SUPPLEMENTARY SUPPLEMENTARY
FLOW METERS AUTOMATIC SAMPLING UNITS
INDUSTRIAL DISCHARGES
RECONNAISANCE . CIVIL ENGINEERING .
FOR FLOW METERS AND SAMPLES
. FIRST MAIN WORKS AT INDUSTRIALS.
PILOT PLANT
IMPROVEMENT
NEW PILOT PLANT
(ACTIVATED SLUDGES FOR 2000 T/DAY)
MONITORING STAT. (LABORATORY)
- DCO, BOD FACILITIES
- EXPLOSIVE GAS METERS
- COLORIMETRIC COMPARATORS, ...
- NITROGEN ANALYSIS
- TOXICITY (DAPHNIA TEST)
BUILDING WORKS
A SPECTROPHOTOMETER
RESPIROMETER
PRELIMINARY STUDIES
SLUDGES TREATMENT: COMPOST FEASIBILITY
LAB. WORKS
NEW PILOT PLANT
FULL SCALE PLANT
EXPERTS
- FITTING OF FIRST EQUIPMENTS'S NETWORK.
- IMPROVEMENT OF PILOT PLANT
LAB. WORKS
NEW PILOT PLANT
FULL SCALE PLANT

LIST OF APPENDICES

APPENDIX

1) List of documents given to Beijing Municipality
2) Slide show presented in Gaobeidian, January 23, 1986
3) Standard for polluants in discharged wastewater of Beijireg Metropolis
4) Details and prices of equipment required for monitoring station
5) Details and prices of equipments required for pilot plant
6) Details and prices of equipments required for network
7) Persons met for discussions
8) Acknowledgements

Appendix no. 1

List of Documents Given to Beijing Municipality

- Textes d'interet général. Pollution des eaux. Décrets et arretés du 28 octobre 1975.
- Catalogue de mesures hydrauliques, NEYRTEC. ALSTHOM ATLANTIQUE.
- Memento statistique (AFBSN)
- La Station D'Epuration D'Achères, Plaquette SIAAP
- Cartes Générales = Assainissement du SIAAP.
- Carte Générale de l'Assainissement de la Région Ile de France
- Compostage des Boues Résidaires Urbaines (AFBSN - AFBLB)
- Cahier Technique No. 9 (AFBSN). Apuration des eaux résiduaires
- Cahier Technique No. 8 (AFBSN) - Epantage des eaux résiduaires en terrain agricole.
- Cahier Technique: Branchements au reseau d'assainissement.
- Nitrification et Dénitrification en chenal ouvert
- Document stereau sur le procédé BIOTERRA
- Aspects Economiques de l'eau en Ile de France
- Section vue of a good final clarifier
- Water Collection Label France
- Sciences et Techniques Munipales - Fiabilité des stations d'opération
- Manuel d'Analyse des Eaux - Photometre du Dr. Lange
- Documentation Technique sur les Procédés. OTU, Degremont, Passavant, EPAP
- Documentation Technique sur les Mesures de Debits et les Echantilloneurs Aquasampler - ISCO
- Biocarbone Process
- By Y. Raak: How to Fight Against Pollution
- Preliminary Results in PRA Analysis (Douai Plant)
- Introduction à l'Epuration Biologique, M. G. Mastancuono

- Circulaire du 4/11/1980 (Ministère de l'Environnement) - Lutte contre la pollution des eaux: conditions de détermination de la qualité minimale d'un rejet d'effluent urbain.

- Comment Calculer une Récirculation - Problèmes de Surdébit

Appendix no. 2

Slides Show Presented in Gaobeidian (23/1/1986)

The set of slides you are going to see show general designs and some details about the different process working in a modern municipal wastewater treatment plant.

With very few exceptions the heart of such a treatment plant consists of a biological process. This means the pollution removal is mainly performed by microorganisms (bacteria and protozoa). The challenge is to maintain a large quantity of microorganisms and to provide good conditions for growth. Such conditions for microorganisms are a good oxygen supply, sufficient space and food without too much toxics and poisons. Obviously the "food" is the "pollution" which is to be removed.

There are several ways to design a biological wastewater treatment plant. For example, wastewater can be mixed in a special tank with the microorganisms. Another way consists of a bed of coarse material, where microorganisms are growing making a slime coating on the media. The wastewater has to trickle through the "biological" filter.

Special facilities are needed in addition to the biological process. Slides 1,2 and 3 show a rough scheme for a municipal wastewater treatment plant. We can see on the left of the scheme the wastewater entering the plant. Before entering the plant, sewage has been elevated in order to allow it to flow by gravity into the treatment facilities. The sewage is elevated by pumps or an Archimedes screw.

The first device we see is a screen. The main purpose of screening is to remove large solids and trash, such as rags, sticks, lumber and other debris that could clog pumps and piping, and interfere with the proper operation of the treatment facilities.

Next comes the grit removal system. Grit removal facilities are designed to allow the settling of sand, gravels, small stones and other large sized materials. This system also removes floating materials like greases and scums.

Next water is treated in a primary settling tank where suspended solids settle to the bottom. For good settling operation the water needs minimum disturbance. The design of the inlet must be carefully performed. This tank must be very accurately levelled; this is very important. Perfect "horizontality" is absolutely required.

The bottom is slightly sloped from outside to inside. A special scraper brings the settled suspended solids towards the centre as it rotates. In the centre a well is provided for storage and pumping away the settled materials. The scraper is moved by means of a rotating bridge. A skimmer is fitted to this bridge in order to remove the remaining floating materials.

Settled water is collected in the periphery of the tank by means of a syphoned weir. The settled water can then flow through the biological plant. In this scheme water is mixed with microorganisms in an aeration tank (mixed liquor). This process is called the activated sludge process. The detention time in the aeration tank depends upon the biological loading rate. It may be few hours, for a high loading rate, or 24 hours and more, for a low loading rate. The lower the biological loading rate, the higher the efficiency in BOD removal will be.

Next the mixed liquor flows to a final settling tank (final clarifier), where the activated sludge is seperated from clean water.

Because almost one month is needed to reach the required amount of microorganisms for good efficiency, and because the detention time even in low loading is quite short (6 hours to 24 hours), the sludges must be recycled form the final clarifier to the aeration tank.

Following are a set of slides (approximately 30) showing technological details about the different devices in such a plant with appropriate explanations.

APPENDIX NO. 3

****
*STANDARD FOR POLLUTANTS *
* IN DISCHARGED WASTEWATER *
* OF BEIJING METROPOLIS *
* (ON PROBATION) *
****

26. Jan. 1986

STANDARD FOR POLLUTANTS IN DISCHARGED WASTEWATER OF BEIJING METROPOLIS
(on probation)

A. On the basis of "Law for Prevention of Water from Pollution in People's Republic of China" and "Rule of Implementing the 'Law for Prevention of Water from Pollution in People's Republic of China' in Beijing Metropolis", this document of standard was formulated for controling the discharge of pollutantsin wastewater, in order to protect the water from pollution, stand guarantee for reasonable utilization of water resource, promote the economical development and protect the health of people.

B. This standard will be applicated to every unit in Beijing which discharges the pollutants wastewater.

C. According to classification of surface water by the "Rule of Implementing the 'Law for Prevention of water from Pollution in People's republic of China' in Beijing Metropolis", in this document, the pollutants discharged with wastewater into surface water and its collection area were divided into three grades as a standard for discharging.

1. Surface waterbody of different classes and its collection area.

In class-1 mainly included: the upper reaches of Chao-bai river beyond Xiangyang Gate, the upper reaches of Yong-ding river beyond Sanjiadian Gate, the Jing-Mi diversion canal, Nan-han river, the Yong-ding diversion canal and Ju-ma river.

In class-2 mainly included: the lower reaches of Chao-bai river below Xiang-yang Gate, the lower reaches of Yong-ding river below Sanjiadian Gate, Chang river, Wen-yu river, Qing river, Ba river, the city moat, Ju river, Cuo river, the upper reaches of Dashi river beyond the Ma-ge-zhuang bridge, waterbodies in city proper used for sight-seeing and recreational purpose.

In class-3 mainly included: the lower reaches of Lian-hua river below the Dahongmen Gate, Feng-gang distributary, Gang-gou river, North Grand Canal, the lower reaches of Dashi river below the Ma-ge-zhuang bridge, Xiao-qing river, Tian-tang river and Long river.

2. The standard for wastewater pollutants discharged into surface waterbody of different classes and its collection area.

In waterbodies of class-1 and its collection area, for discharging the wastewater pollutants to the waterbody located in the protected zone of class-1 and class-2 which have been confirmed by the "The temporary provision of administration on protection of the water resource in Miyun reservior, Huairou reservior and Jing-Mi diversio canal Beijing Metropolis" and "Administrational regulation of protection ofwater resource of Guanting reservior", the standard grade-1 must be complied with, but for that discharged into the other waterbody and its collection area of class-1 outside the protection zones of class-1 & 2, the standard of grad-2 would be adopted.

The standard of grade-2 is also applicated to pollutants discharged into the waterbodies of class-2 and its collection area and into Tong-hui, Lian-hu[illegible] Liang-shui rivers.

Pollutants discharged into the waterbodies of class-3 and its collection area should meet the requirements of the standar of class-3.

3. Values of standard.

Table 1 Standard for Water Pollutants Discharging into Surface Waterbodies and its collection area

NO.	Pollutants or Determinants	The maximum allowable discharging concentration(mg/l) (p^H, color, temperature are except.)				
		St. of class-1	Standard of clss-2 G		Standard of class-3	
			Origin. unit	New unit	Orig. unit	New unit
1	Hg and its inorg. compound	0.001	0.005	0.002	0.01	0.002
2	Cd "	0.01	0.03	0.02	0.05	0.02
3	Cr^6 "	0.05	0.3	0.2	0.5	0.2
4	Cr^3 "	0.5	1.5	1.0	2.0	1.0
5	As "	0.04	0.2	0.1	0.2	0.1
6	Pb "	0.10	0.2	0.1	0.5	0.1
7	Cu "	0.1	0.5	0.5	1.0	1.0
8	Ni "	0.5	0.5	0.5	1.0	0.5
9	Zn "	1.0	3.0	3.0	5.0	3.0
10	pH value	6.5-8.5	6.0-8.5	6.0-8.5	6.0-8.5	6.0-8.5
11	S.S.	30	70	50	100* 150** 300	80* 100** 200
12	Colour	10	50	50	80	80
13	Temp.(C)	30	35	35	35	35
14	BOD_5	5	40	20	60	60
15	COD	15	80	60	100* 200	100* 160
16	Sulphide	0.01	0.30	0.20	1	0.5
17	Vol. phenol	0.01	0.5	0.2	1	0.5
18	Cyanide	0.05	0.4	0.2	0.5	0.5
19	T. phosphorus (for Rogor)	0.1 0.8	0.5	0.3	0.5	0.3

(Continued)

20	Mineral oil	0.3	5	4	10	8
21	Formalin	0.5	1	0.5	2	1.5
22	Nitrobenzol	0.5	1	0.5	3	1
23	Aniline	0.1	0.5	0.4	1.5	1
24	Chlorobenzol	0.02	0.1	0.05	0.2	0.1
25	Benzol series	2.5	3	2.5	3	2.5
26	Fluoride	1	3	2	8	4
27	Developer (TSS, CD-2 CD-3)	0.2***	2***	1.5***	4***	2***
28	Total soluable solids	500	900	800	1200	1000

* Standards for wastewater discharged from pulp mill, paper board, tannery, fiber board hot pressing.

** Standards for water discharging of ash scouring and mineral tail water.

*** Discharging concentration of developer in condition of a 5 ton of water to be consumed in average for developing and printing per 1000m. and 35mm. of cinefilm.

D. Standard for pollutants discharged into municipal sewers(which are managed by the municipal administration department).

1. This standard was divided as standard A and standard B.

(a) Wastewater discharged finally from sewer and can not be received by municipal wastewater treatment works should meet the requirement of standard A.

(b). Wastewater discharged from sewer into wastewater treatment works (which is operated by municipal organ) must meet the requirement of standard B.

2. Values of standard.

Table 1

Standard for Discharging Water Pollutants from Municipal Sewers

NO	Pollutants or Determinants	Max. Allowable discharging concentration(mg/l) (pH, colour, temperat. excep.)	
		Standard-A	Standard-B
1	Hg and its inorganic compounds	0.05	0.05
2	Cd " " "	0.1	0.1
3	Cr^{6} " " "	0.5	0.5
4	Cr^{3} " " "	2.0	2.0
5	As " " "	0.5	0.5
6	Pb " " "	1.0	1.0
7	Cu " " "	1.0	1.0
8	Ni " " "	1.0	1.0
9	Zn " " "	5.0	5.0
10	pH value(no less than 5)	6—9	6—9
11	S.S.	160 200*	500
12	Colour	80*(***)	100*
13	Temperature(C)	35	35
14	BOD_5	100 200*	500
15	COD	150 300*	500
16	Sulphide	1	10
17	Volatile phenol	1	5
18	Cyanide	0.5 10**	2
19	Organic phosphate pesticide	0.5	1
20	Mineral oil	10	10
21	Formalin	2	
22	Nitrobenzol	2	5
23	Aniline	1	3
24	Chlorobenzol	o.2	
25	Benzol series	2.5	10
26	Fluoride	5	10
27	Developer (ss,CD-2 CD-3)	3**	
28	Total soluable solid	1500	2000
29	Positive ionic synthetic detergent	10	15

(Continued)

30	Settling solid(mg/l/15min)	10	10
31	Grease	50	100

*Standards for wastewater discharged from pulp mill, paper board, tannery, fiber board hot pressing.

**Discharging concentration of developer in condition of a 5 ton of water to be consumed in average for developing and printing per 1000m. and 35mm. of cinefilm.

***Standards for printing and dyeing discharging.

E. For discharging the wastewater containing radioactive matter the "State Provision on Prevention from Radioactive Matter" should be complied with. Wastewater produced from hospital, sanatorium and other medical and health units should be conformed to "State Standard for Hospital Sewage Discharging"(on probation).

F. All constructed facilities for wastewater treatment must be kept in normal operation and give full play to its benefit. When the wastewater was turned over to municipal wastewater treatment works for centralized treatment, stop operation or demolition of the original facilities should be subject to approval of environmet protection authority.

G. Monitoring measures.

1. Monitoring and analytical procedure servicing this standard should follow the "BJG Unified Method for Industrial Wastewater Monitoring".

2. In this standard, from No 1to 8 as shown as in list of water pollutants discharging should be monitored at the outlet from working shop or treating construction attached to it. AS for the others, it should be monitored in unit or the treating

facilities of it.

H. This standard should be observed and controled by environmental protection department of various level.

I. All problems concerning with the substantial application of this standard should be explained responsiblly by BJG Environmental Protection Bureau.

J. This standard becomes effective since 1. November 1985.

BOD	20
COD	70
SS	30

APPENDIX 4

EQUIPMENT REQUIRED FOR MONITORING STATION

DETAILS AND PRICES

The prices are without VAT in US $:

1 dollar = 7,16 france as on 1 April 1986

Three alternatives are given for each piece of equipment:

1 basic equipment

2 more efficient equipment

3 very sophisticated and automatic equipment

NOTE: Transportation is not included in the price of the equipment.

French notation of numbers is used in the price lists.
One million in French notation is: 1.000.000
20 decimal 40 in French notation is: 20,40

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
FIRST STEP				
a) BOD - COD				
- BOD_5				
Existing Equipment				
- O_2 measurement: - 10 BOD/day	$ 2.095	2.095		
- thermostatic dryer with electronic regulation of temperature - volume 260 litres	$ 2.095	2.095		
- O_2 measurement: 20 BOD/day	$ 2.095	2.095		
OR				
Existing equipment				
- O_2 measurement - 10 BOD/day	$ 2.095		2.095	
- complementary equipment for BODs by manometric method - 20 BOD/day				
10 analysers BOD, 10 sets	$ 11.175		11.175	
5 thermostatic dryers 20°C	$ 3.495		3.495	
accessories (plugs, flasks, chemicals, mercury solution)	$ 2.375		2.375	
OR				
Complete equipment for BODs measurement by manometric method - 30 BOD/day				
15 analysers BOD, 10 sets	$ 16.760			16.760
8 thermostatic dryers 20°C	$ 5.860			5.860
accessories	$ 3.215			3.215
Sub-total BOD		$ 6.285	$ 19.140	$ 25.835

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
_ COD				
5 x 12 sets COD Manual titration				
100 COD/day usable for NTK analyses :	$ 16.760	16.760		
OR				
5 x 12 sets COD 100 COD/day usable for NTK Automatic titration	$ 16.760		16.760	16.760
unity control and spectrophometry (FIA) Note: Care in selection of accurate equipment - can serve for other analyses :	$ 16.760 25.140		16.760	25.140
Sub-total COD		$ 16.760	$ 33.520	$ 41.900
b) TSS and VSS				
Filtration 3 sets :	$ 390	390	-	-
Accessories for vacuum filtration (emptying pump, pipes, supports) :	$ 1.050	1.050	-	-
existing drying room 105°				
Supplementary drying oven 105° :	$ 490	490	-	-
Oven 550°C + dryer :	$ 1.325	1.325	-	-
Centrifuge :	$ 1.245	1.245	-	-
Precision scales :	$ 2.375	2.375	-	-
Consumables: fibreglass filters (3 months supply) :	$ 1.260	1.260	-	-
Sub-total TSS and VSS		$ 8.135	$ 8.135	$ 8.135

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
c) Portable colorimetric comparator				
- Pocket - Photometer including, manual, power supply charger and Ni/Cd Accus :	$ 780	780	-	-
- Thermostate apparatus for 100° C and 148° C for 6 cuvette-tests :	$ 280	280		
- Programfilters for NH_4, PO_4, COD, Cyanide, chromium, nitrite, iron, copper, zinc, nitrate, cadmium, silver, chloride, sulfate, nickel, chlordioxid, ozone, formaldehyde :	$ 1.560	1.560		
- Variable pipettes 0,2 - 1,0 ml 1,0 - 5,0 ml :	$ 230	230	-	-
- Cuvette test with pre-pipetted reagent 25 cuvettes :	$ 30	30	-	-
Facilities for 3 months	$ 1.600	1.600		
Sub Total : portable colorimeter		$ 4.480	$ 4.480	$ 4.480
d) Portable ultrasonic flowmeter	$ 2.100	$ 2.100	$ 2.100	$ 2.100
Sub Total	$	$ 2.100	2.100	$ 2.100

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
e) Miscellaneous				
Balance :	$ 2.795	2.795	-	-
pH meter x 2 :	$ 1.955	1.955	-	-
Distilled water, demineralised (deliver 4 :	$ 1.830	1.830	-	-
litres/hour) + 2 containers of 20 litres :	$ 210	210	-	-
Sub-total Miscellaneous		$ 6.790	$ 6.790	$ 6.790
TOTAL FIRST STEP :		$ 44.550	$ 74.165	$ 89.240
<u>SECOND STEP</u>				
a) <u>NTK, NH_4, NO_2, NO_3</u>				
NTK				
- Mineralisation: the COD sets can be used with the following accessories:				
Mineral belljar 24				
Emptying spouts 2 :	$ 120	120	120	120
Distillation :	$ 70	70	70	70
Titration: manual: spectrometer UV, Visible (see C) :	$ 1.875	1.875		
OR				
- Automatic distillation	$ 3.160		$ 3.160	
OR				
- Distillation, automatic titration	$ 15.715			15.715
Sub-total NTK		$ 2.065	$ 2.065	$ 15.905

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
NH_4, NO_2, NO_3 - Manual titration; spectro UV, visible (see C) - Automatic titration in continual flux (FIA) with sample holder (as for COD) with extra accessory	$ 1.395		1.395	1.395
Sub-total NH_4, NO_2, NO_3		$ 0	$ 1.395	$ 1.395
b) Heavy metals Atomic absorption flame spectrometer accuracy 0,1 mg/l:	$ 18.995	18.995		
OR Atomic absorption flame spectrometer + Atomic absorption spectrometer oven + Hydrid method for Hg, As, Se sensitivity 0,001 mg/1 :	$ 70.000 77.000		70.000	77.000
Sub-total heavy metals		$ 18.995	$ 70.000	$ 77.000
c) Spectrophotometer for routine analysis, UV - visible (180 to 1000 nm) manual :	$ 15.530	15.530	18.475	
OR + automatic, enregistrar, integrator :	$ 18.475		18.475	
OR + automatic and data processing (computer) :	$ 28.720			28.720
Sub-total spectrophotometer		$ 15.530	$ 18.475	$ 28.720

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
d) Toxicity test (Daphnia) small glassware :	$ 560	560	-	-
Sub-total d		560	560	560
e) Miscellaneous				
Ionometer and electrodes :	$ 1.260	1.260	1.260	1.260
microscope :	$ 1.120	1.120	1.120	1.120
thermometers :	$ 100	100	100	100
security cupboard to stock the gas bottles necessary for atomic absorption :	$ 3.075		3.075	3.075
Sub-total e		$ 2.480	$ 5.555	$ 5.555
Total second step		$ 39.630	$ 99.335	$ 129.135
THIRD STEP				
a) Mineral oils (hydrocarbons)				
- spectrophotometer IR: (global dosage) :	$ 13.950	13.950	13.950	13.950
- charged phase chromotography :	$ 22.350			22.350
- integrator: (identification) :	$ 5.600			5.600
Sub-total		$ 13.950	$ 13.950	$ 41.900
b) Organic matters				
- liquid chromotography (HPLC) :	$ 34.900	0	34.900	34.900
- ionic chromotography (can be used for other analyses) :	$ 98.000	0	0	98.000

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
- preparation equipment for the chromatography	$ 8.400	0	8.400	8.400
Sub-total b		$ 0	$ 43.300	$ 141.300
c) Miscellaneous				
accessories for analyses in continual flux (FIA) fluid circuits: compressed air, vide, stabilised electric current, demineralised water, ultra-pure water, various gases	$ 5.590			5.590
furniture and accessories	$ 13.000			13.000
refrigerators, dishwasher, misc. equip	$ 27.900 $ 13.950	13.950	13.950 13.950	27.900 13.950
Sub-total c		$ 13.950	$ 27.900	$ 60.440
Total Third Step		$ 27.900	$ 85.150	$ 243.640
<u>TOTAL GENERAL 3 STEPS</u>		$ 112.080	$ 258.650	$ 462.015
- <u>COMPLEMENT</u>				
Supplementary analyser in constant flux (FIA) + accessories for - 3 - or FIA for - 2 -	$ 25.140 $ 5.590		25.140	25.140 5.590
FINAL TOTAL		$ 112.080	$ 283.790	$ 492.745

REMARKS AND GENERAL RECOMMENDATIONS

1) The equipment described above is able to cope with a substantial amount of analytical work. This amount has been evaluated after a 10 day mission. The list may be adjusted as additional information becomes available.

2) The equipment described above does not include the improvement to the building such as:

- power supply
- air conditioning (necessary for sophisticated equipment)
- dust filter
- humidity

3) The equipment providing very sensitive and accurate analysis must be installed in separate rooms to avoid interferences.

For instance:

When analysis of heavy metals is performed with A.A., spectrometer, interference will occur if sulphate mercury is used in the same room.

APPENDIX NO 5

EQUIPMENT REQUIRED FOR PILOT PLANT

DETAILS AND PRICES

The prices are without VAT in US $:

1 dollar = 7,16 france as on 1 April 1986

Three alternatives are given for each piece of equipment:

1 basic equipment

2 more efficient equipment

3 very sophisticated and automatic equipment

NOTE: Transportation is not included in the price of the equipment.

French notation of numbers is used in the price lists.
One million in French notation is: 1.000.000
20 decimal 40 in French notation is: 20,40

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
1) Mechanical and electrical equipment				
- A set of ammeters, pilot lamps, time switches, cyclic dosing apparatus, summing working meters, connection with flow-meters, and D.O. measuring :	$ 6.285	6.285	6.285	6.285
Sub total 1 :	$ 6.285	$ 6.285	$ 6.285	$ 6.285
2) Chemical and biological equipment - FIRST PHASE				
a) D.O. measuring and recording :	$ 3.500	$ 0	$ 3.500	$ 3.500
b) D.O. measuring (portable) :	$ 1.650	$ 1.650	$ 1.650	$ 1.650
c) BOD, COD, SS, TSS, VSS				
- BOD				
Existing equipment :	$ 0	0		
OR				
2 analysers BOD 10 sets :	$ 2.235	2.235	2.235	2.235
1 thermostat oven 20 °C :	$ 700	700	700	700
accessories :	$ 35	35	35	35
1 lab oxymeter :	$ 2.095	2.095	2.095	2.095
COD				
Existing equipment :	$ 0	0		
OR				
1 set for 6 COD analyses :	$ 1.485	1.485	1.485	1.485
manual titration :	$ 0	0		
photometric titration :	$ 1.550		1.550	

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
OR				
Titration: spectrophotometry	$ 4.670			4.670
- SS, TSS, VSS				
Centrifuge				
Filtration under vacuum :	$ 1.245	1.245	1.245	1.245
Dryer 105° and oven 550° :	$ 710	710	710	710
Precision balance :	$ 1.135	1.135	1.135	1.135
Consummables: fibreglass filters (3 months	2.375	2.375	2.375	2.375
supply) :	$ 135	135	135	135
Sub-total c :	$	$ 12.150	$ 13.700	$ 16.820
d) Portable colorimetric comparator see details in appendix 4 (c) - first step :	$ 4.480	$ 4.480	$ 4.480	$ 4.480
e) Ph meter with continuous recording	$ 3.500	$	$ 3.500	3.500
f) log-book				
SUB-TOTAL FIRST PHASE		$ 18.280	$ 26.830	$ 29.950

	PRICE DETAIL	- 1 - BASIC EQUIPMENT	- 2 - MORE EFFICIENT EQUIPMENT	- 3 - VERY SOPHISTICATED AND AUTOMATIC EQUIPMENT
Chemical and biological equipment - SECOND PHASE				
a) Microscope :	$ 1.120	1.120	1.120	1.120
b) Toxicity Test (Daphnia) Small glassware :	$ 560	560	560	560
c) Respirometer including apparatus with 2 reactors, software, pipes, ready to operate This very sophisticated equipment can be used for the full scale Plant :	$ 55.870			55.870
Total SECOND PHASE		$ 1.680	$ 1.680	$ 57.550
TOTAL 1) (chemical and biological)		$ 19.960	$ 28.510	$ 87.500
TOTAL GENERAL 1) + 2)		$ 26.245	$ 34.795	$ 93.785

APPENDIX N° 6

EQUIPMENT REQUIRED FOR NETWORK

DETAILS AND PRICES

The prices are free of VAT in US $ on the basis of:

1 dollar = 7.40 francs as on 7 April 1986

NOTES

1. Transportation is not included in the price of the equipment.

2. Two alternatives are presented,
   Page 71: installing 10 samplers
   Page 72: installing 5 samplers

EQUIPEMENT REQUIRED
FOR NETWORK (10 samplers)

		NO.of UNIT	UNIT PRICE	TOTAL PRICE	TOTAL PRICE in U.S.$
FLOW-METERS					
CHANNEL	NEYRTEC CONTRAFLUX and VENTURI	10	10000 F	100000 F	13500 $
RECORDING METERS	PONSELLE CAISSON.SERIE CE	10	20000 F	200000 F	27000 $
pH-O°RECORDING METERS	PONSELLE CAISSON.SERIE CE	5	20000 F	100000 F	13500 $
AUTOMATIC SAMPLING UNIT	NUMELEC APAE 2420	10	50000 F	500000 F	67600 $
PORTABLE EXPLOSION DETECTOR	TRITOX SC 30	1	15000 F	15000 F	2000 $
PORTABLE pH METER	PONSELLE APPAREIL POCHE.SERIE M	1	5000 F	5000 F	700 $
	TOTAL			920000 F	124300 $

EQUIPEMENT REQUIRED
FOR NETWORK (5 samplers)

		NO.of UNIT	UNIT PRICE	TOTAL PRICE	TOTAL PRICE in U.S.$
FLOW-METERS					
CHANNEL	NEYRTEC CONTRAFLUX and VENTURI	10	10000 F	100000 F	13500 $
RECORDING METERS	PONSELLE CAISSON.SERIE CE	10	20000 F	200000 F	27000 $
pH-O°RECORDING METERS	PONSELLE CAISSON.SERIE CE	5	20000 F	100000 F	13500 $
AUTOMATIC SAMPLING UNIT	NUMELEC APAE 2420	5	50000 F	250000 F	33800 $
PORTABLE EXPLOSION DETECTOR	TRITOX SC 30	1	15000 F	15000 F	2000 $
PORTABLE pH METER	PONSELLE APPAREIL POCHE.SERIE M	1	5000 F	5000 F	700 $
	TOTAL			670000 F	90500 $

Appendix No. 7

List of Main Persons We Met for Discussions

Ms. Tang Naihui	Engineer and Deputy Director Direction of Public Utility
Ms. Tao Li Fen	Deputy Chief Engineer Beijing Municipal Administration Municipal Engineering
Mr. Zhang Bao Zhen	Deputy Director, Engineer Gaobeidian East Suburb
Mr. An Xiong	Chief Engineer, Senior Engineer Gaobeidian East Suburb
Ms. Xiang Ying Ling	Translator Beijing Foreign Economic Relations

Appendix No. 8

ACKNOWLEDGEMENTS

We would particularly like to thank our Chinese friends for the extremely warm welcome which they extended to us, for all the kind attention which they gave us, for the care that they showed always to see that we had everything we needed and for their overall good-naturedness.

We are equally very touched by all the presents we received and the memories with which we are left.