TEXTBOOK FOR FOLLOW UP SEMINAR
FOR
ARAB REPUBLIC OF EGYPT AND ETHIOPIA

SEWAGE WORKS ENGINEERING

JANUARY, 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOR
ARAB REPUBLIC OF EGYPT AND ETHIOPIA

SITUATION OF WASTEWATER FACILITIES IN JAPAN

– Future of Sewerage Systems and Current Situation of Advanced Technology –

JANUARY, 1994

by SHUJI TANAKA

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JAPAN INTERNATIONAL COOPERATION AGENCY

Situation of Wastewater Facilities in Japan

- Future of Sewerage Systems and Current Situation of Advanced Technology -

Shuji TANAKA

Head of Wastewater System Division,

Water Quality Control Department,

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1. Prospects of Sewerage Systems

Report of the Central City Planning Council

- Basic function of sewerage systems

    Prevention of flooding

    Improvement of residences and city environment

    Water quality conservation of public water bodies

- Needs of the society

    Advent of aging society

    Development of information-intensive society

    Desire for ease of mind and amenity

    Quest for convenience

    Creating cities where safety prevails

    Conservation of global environment

- Creation of innovative cities supported by sewerage systems

  Creation of environment with regular water circulation

  Cities rich in water scenery and green

  Cities resistant to heavy rain

  Cities withstanding snow

  Creation of cities where "saving water" is a motto

  Cities contributing to conservation of the global environment

  ---- Cities where recycling is actively implemented

  Kitchens free from garbage

  Formation of compound space

  ---- Creation of city environment utilizing the roof of treatment plants

  Advanced information-intensive cities

2. Principal Targets of the 7th Five-year Program for Sewerage Construction

- Promotion of sewerage system construction in middle and small scale cities, where the sewered population is small, and starting new construction of sewerage in cities, where no wastewater system exists

- Promotion of sewerage construction for preventing floods

- Along with promotion of sewerage construction or water quality conservation, implementing actively advanced wastewater treatment

- Promotion of activities for improving the function and quality of the sewerage systems in big cities

- Promotion of multi-purpose utilization of resources, energy and facilities of sewerage

3. Planning for covering the overall prefectural zones with sewerage services

4. Situation of advanced technology related to sewage collection
   - Vacuum sewer systems
   - Pressure sewer systems
   - Full utilization of manhole pumps
   - Popularization of small diameter pipe-jacking methods
   - Advent of various rehabilitation technologies

5. Situation of advanced technology related to treatment facilities

- Prefabricated-type wastewater treatment facilities
- Tunnel-type wastewater treatment facilities
- Temporary treatment facilities --batch type wastewater treatment facilities
- Mobile sludge dewatering vehicle

6. Effective utilization of sludge

- Transforming wastewater sludge into compost
- Transforming sludge into construction material (raw material of bricks, cement)

7. Effective utilization of treated water

- Supply to buildings for use in flush toilet
- Use in environmental facilities
- For melting down snow

8. Utilization of sewerage resources

- Sewerage heat supply project
- Multi-purpose utilization of the space on the roof of treatment plant
- Construction of optical fiber communication networks using sewer piping

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WASTEWATER COLLECTION SYSTEMS IN JAPAN

JANUARY. 1994

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JAPAN INTERNATIONAL COOPERATION AGENCY

1. COMBINED SEWERAGE SYSTEM

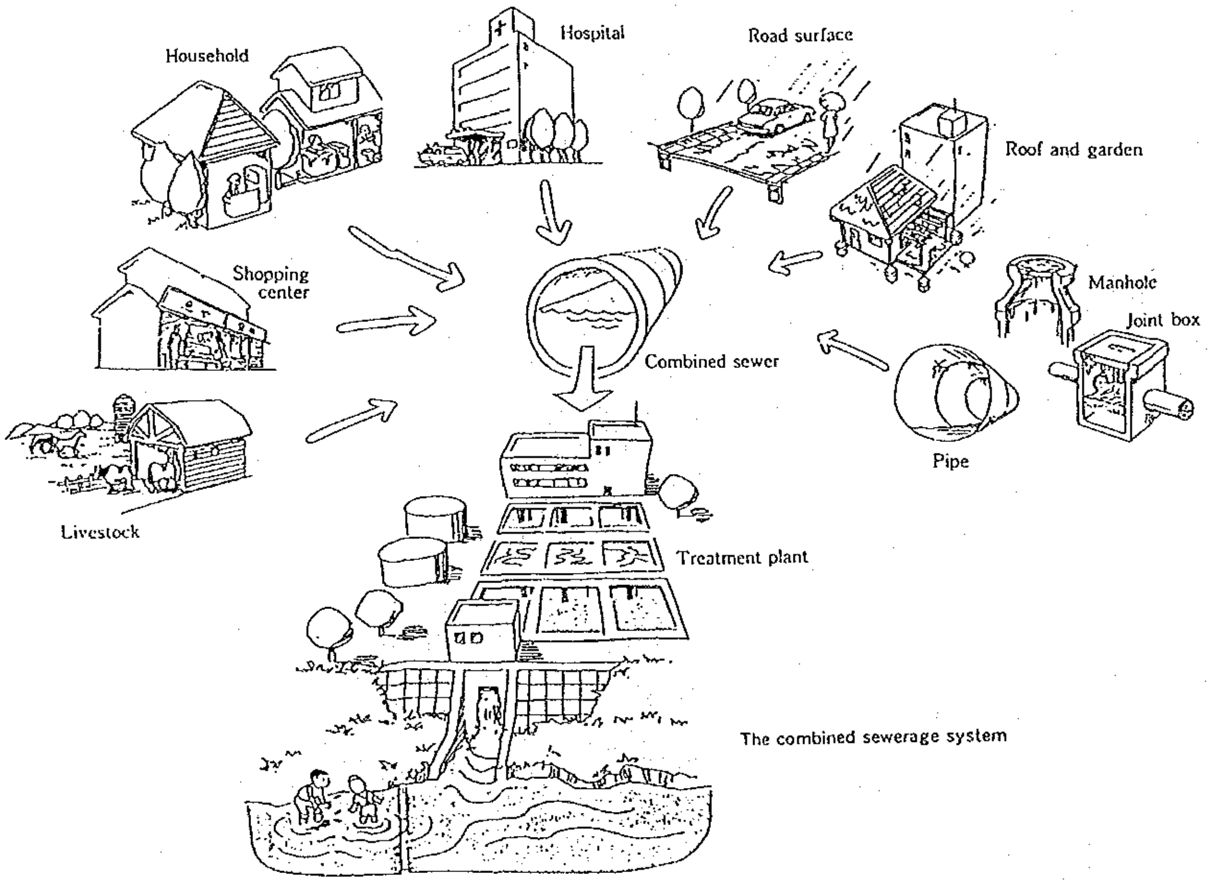
Combined sewerage system and separate sewerage system are two alternatives of the sewage collecting method.

The combined system collects both waste water and storm water with a single pipe called a combined sewer.

In dry weather the system collects all kind of waste water from sources such as household, shopping center, hospitals etc., into the sewer connected to the sewage treat ment plant.

During wet weather the system collects storm water from roof, ground, roadway areas, etc. as well as waste water.

Under conditions of heavy rain, where the storm water far exeeds the waste water, the system discharges some of the waste water mixed with storm water, from storm outlets or pump stations, into rivers, lakes and sea.



The combined sewerage system

2. SEPARATE SEWERAGE SYSTEM

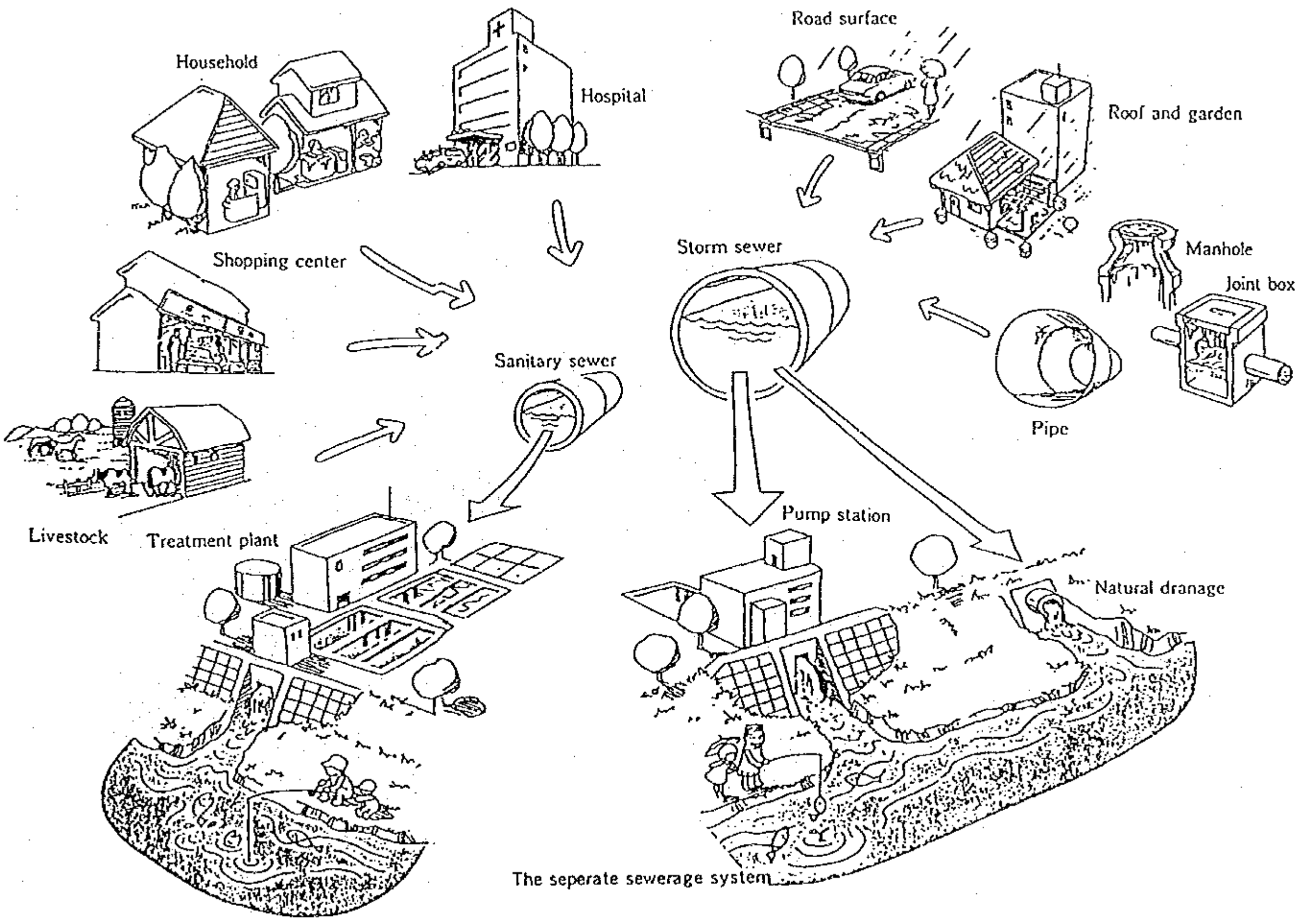
The Separate system collects waste water into a sanitary sewer and storm water into a storm sewer.

In wet weather, therefore, all waste water of the system goes to a sewage treatment plant without being mixed with storm water which goes into rivers, lakes and sea by way of a storm sewer.

A sanitary sewer must avoid infiltration and inflow.

In wet weather a sanitary sewer sometimes becomes flooded because of mis-connections and loose joints which allow infiltration of storm water and underground water.

Routine inspections and maintenance are required in order not to impose quantitative load on the down stream pipes and treatment facilities.



The seperate sewerage system

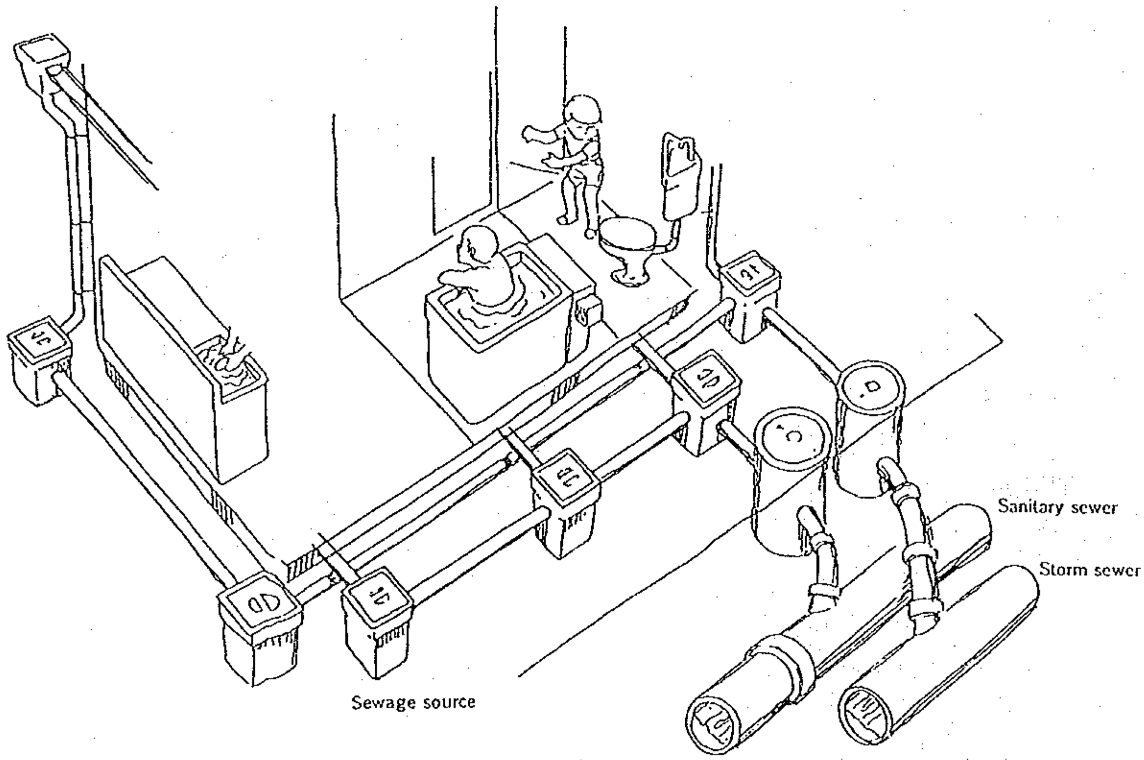
3. PRIVATE SEWERAGE

Private sewerage collects the waste water and/or the storm water which originate in building lots, and then connects the sewage into public sewer. The public sewerage consists of the sewer, constructed under public roads, pump stations and sewage treatment plants.

Thus the waste water is kept out of sight, and returned to natural environment after clarification.

Daily living produces 200~400 liters per day per capita. Such waste water comes from bathing and washing clothes, as well as that from kitchens and flushtoilets.

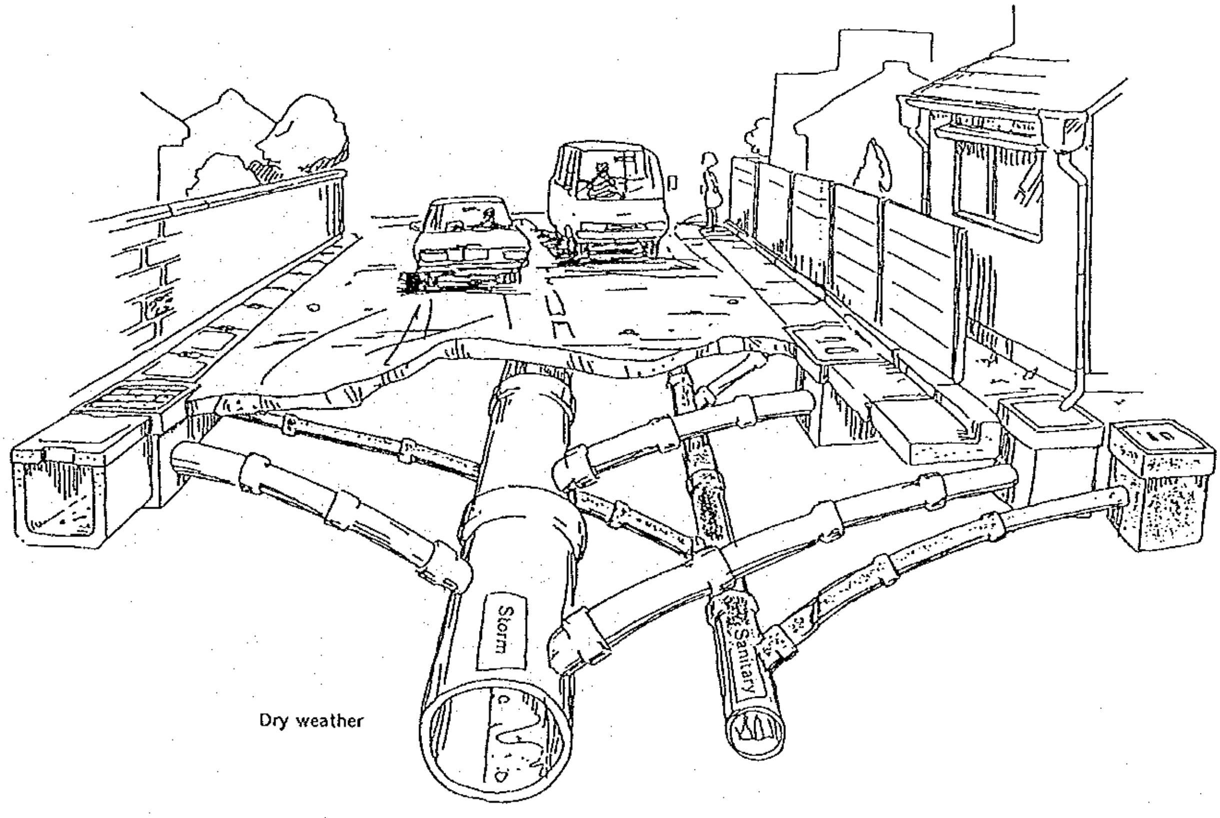
Private sewerage consists of sewer pipes such as vitrified clay pipes and poly vinyl resin ones, as well as joint boxes. It should be constructed and maintained as private property.



4. PUBLIC SEWER [I]
—SANTIARY SEWER—

Waste water flows down from the plumbing to the private sewer in the yard and collects at the connection located in the boundary area between the private land and the public road. From there, the waste water enters the public sewer through the lateral pipe.

Being about 25cm at the upstream end, the diameter of the sanitary sewer becomes wider downstream, in proportion to the area and population which the sewer serves. In some places the diameter is large enough for a grown man to stand up. In the separate system areas, the public sewer as well as the private one should be arranged to handle waste water and storm water separately, the sanitary sewer for waste water and the storm sewer for storm water.



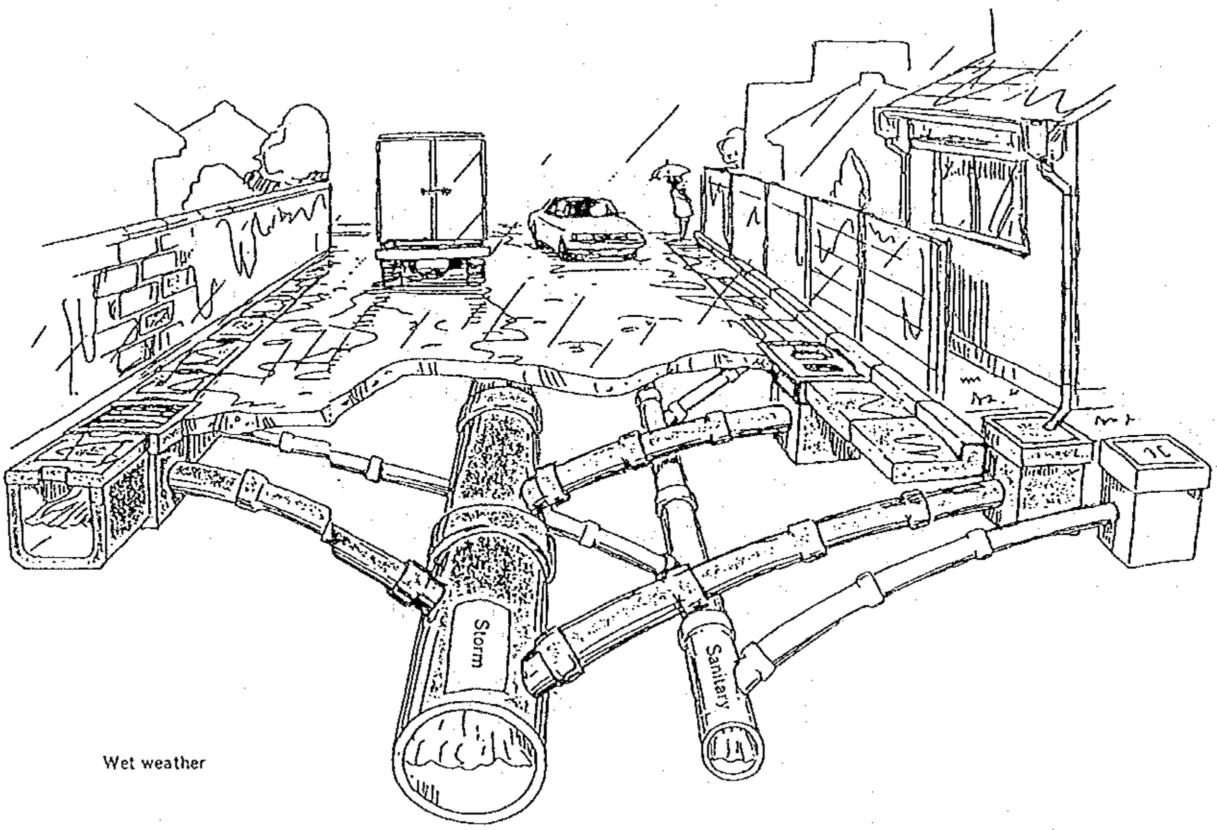
5. PUBLIC SEWER [II]
—STORM SEWER—

The rainfall on private lands flows into the private sewer as storm water, then flows into the public sewer through the connection and lateral pipe.

The rainfall on roads collects in streetinlets connected to the public sewer.

The size of the storm sewer becomes larger in accordance with such factors as the ratio of the roof area and ratio of the paved area to the total drainage area served by the sewer.

In wet weather the amount of storm water is much greater than that of waste water in the same area; therefore, the diameter of the storm outlet or pump station inlet is as wide as 2 ~5m, contrary to its initial diameter of 25cm at the upstream end.



Wet weather

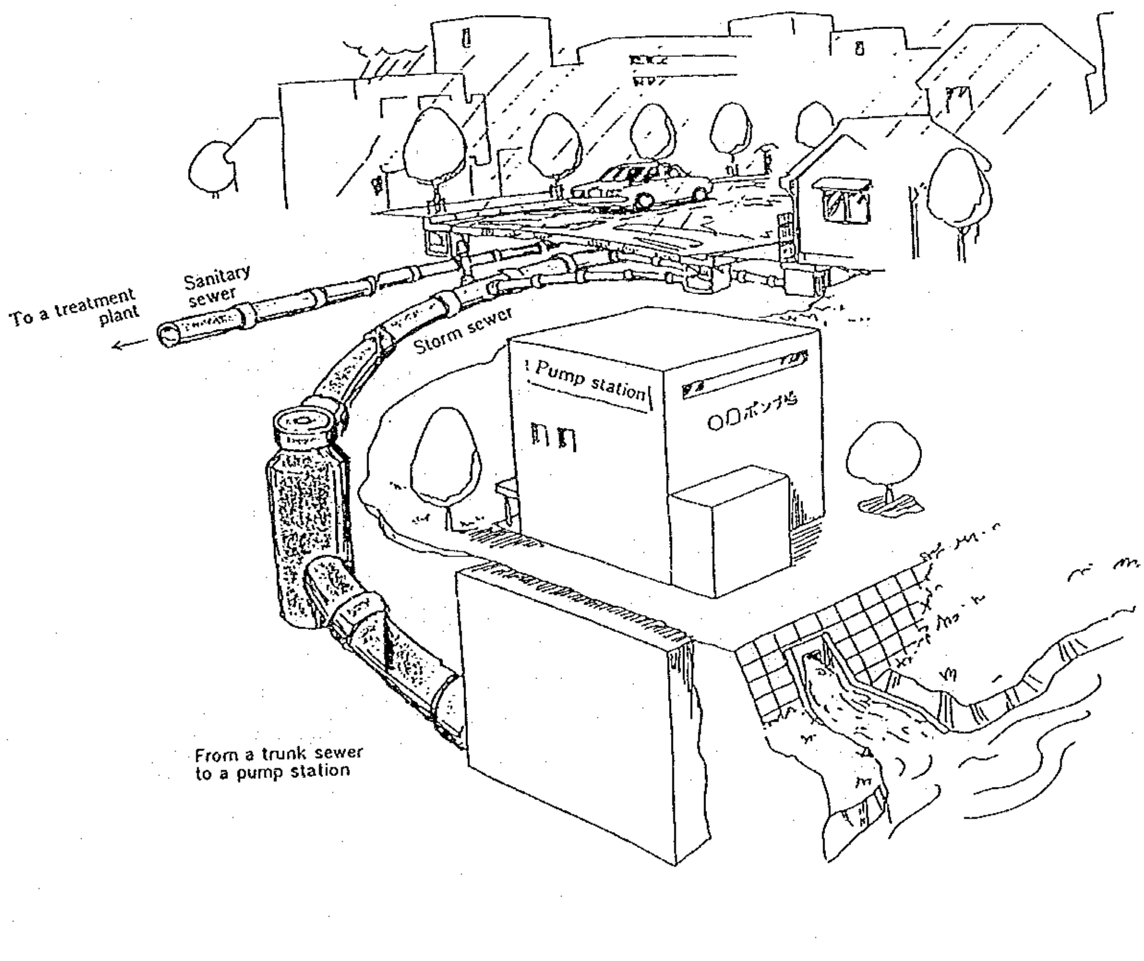
6. PUBLIC SEWER [III]
—TRUNK SEWER—

Both the sanitary and storm sewer should be constructed with such a slope that the flow velocity becomes larger as the water flows downstream in order to prevent solids from settling and piling up in a pipe.

For example, the velocity of 1.0m/sec can be maintained with a slope of ca.0.8% in a concrete pipe measuring 25cm in diameter, or with a slope of 0.03% in a pipe measuring 300cm in diameter. In other words, the slope is less when the diameter is greater.

Trunk sewer is so large in size and so deep underground that it is constructed using various tunneling methods such as shielding, pipejacking, etc..

The downstream end of the sanitary trunk sewer is the inlet of a sewage treatment plant, while that of the storm trunk sewer is the outlet to a river or the inlet of a pump station, as illustrated.



7. FLOW OF WASTE WATER

Waste Water Flow;

(1) By gravity

When the slope of a sewer is nearly parallel with that of the topography of a drainage area, it can be constructed at the same depth throughout, so that pump up is unnecessary even before begining sewage treatment.

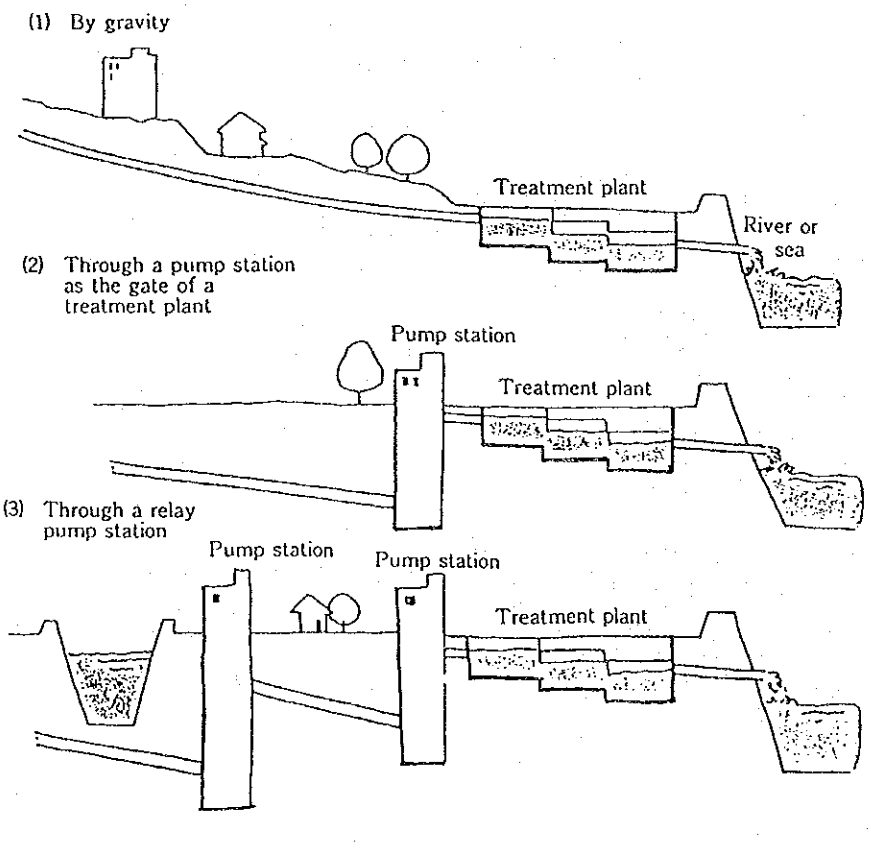
(2) Through a pump station as the gate facility of a treatment plant

When the topography is level, the sewer goes deeper toward the sewage treatment plant, where pump up is required to deliver the water up to the facilities.

(3) Through a relay pumpstation

Longrange sewer under level topography requires a relay pumpstation on the way, because the deeper the sewer becomes, the more difficult it becomes to construct it.

A relay pumpstation is also required when a sewer meets rivers and other utilities.



8. FLOW OF STORM WATER [I]
—BY GRAVITY OR THROUGH A PUMP—

(1) By gravity

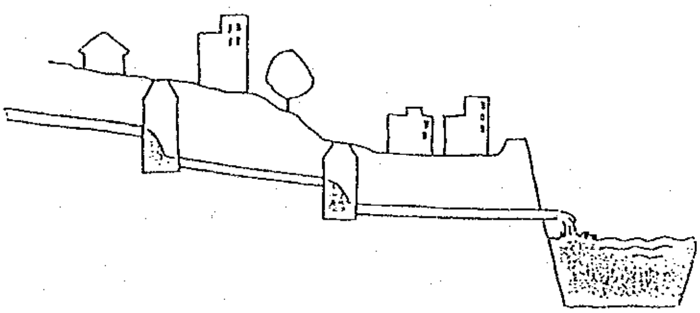
In areas of higher elevation, stormwater is ideally dischargeable into receiving water, such as rivers, lakes or the sea. In this case only a storm sewer is required without any pumps, nor power to drive them.

This kind of area is called a "Natural Drainage Area" or "Drainage Area of Eminence".

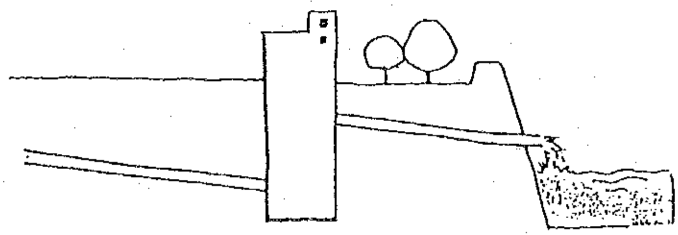
(2) Through a pump

In areas lower than the receiving water level, storm water can not be discharged directly. Thus a storm pump station is necessary to pump the water up to the receiving elevation. This kind of area is called a "Pump Drainage Area" or "Lowland Drainage Area".

(1) By gravity

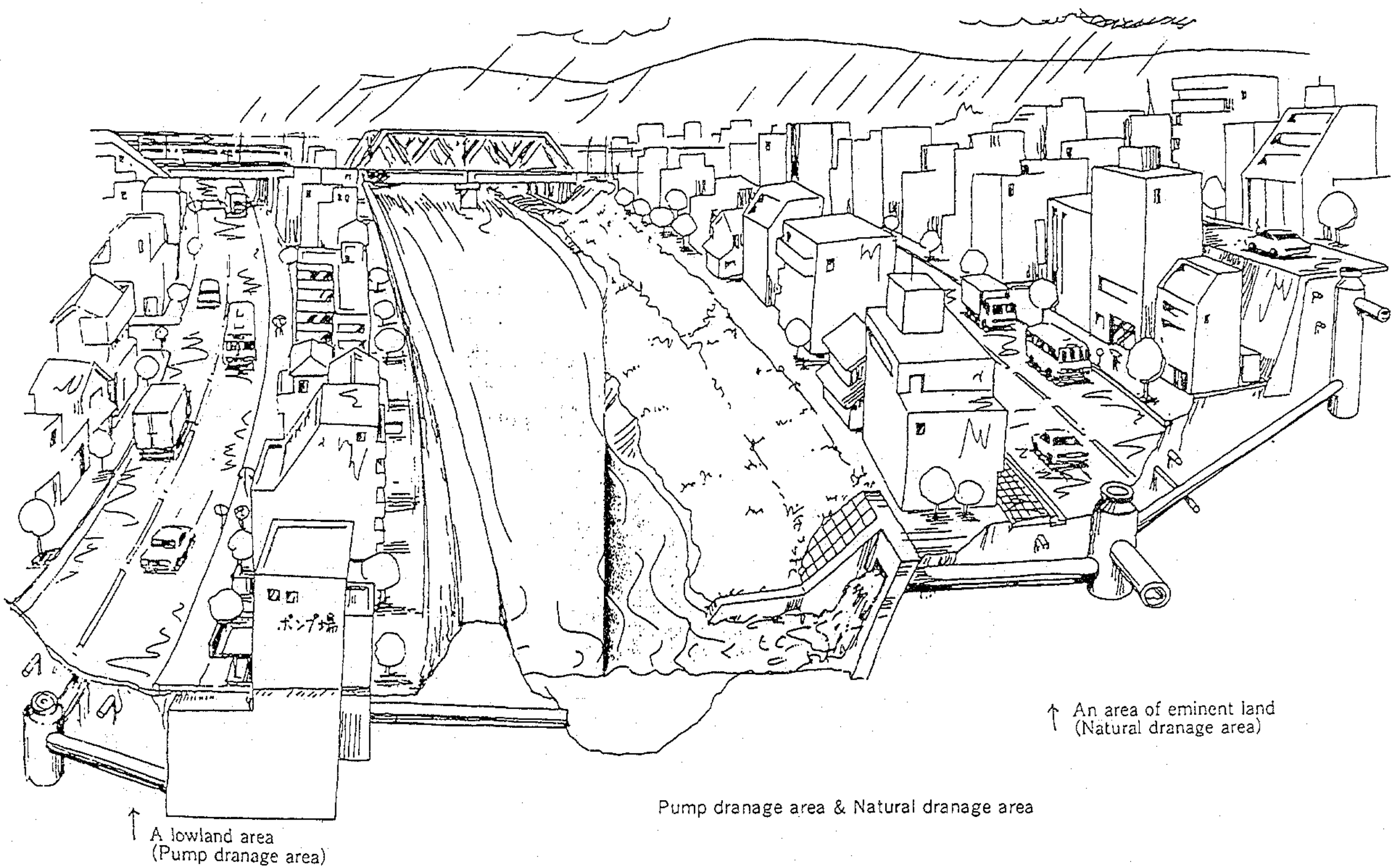


(2) Through a pump



9. FLOW OF STORM WATER [II]

—A TYPICAL IMAGE—

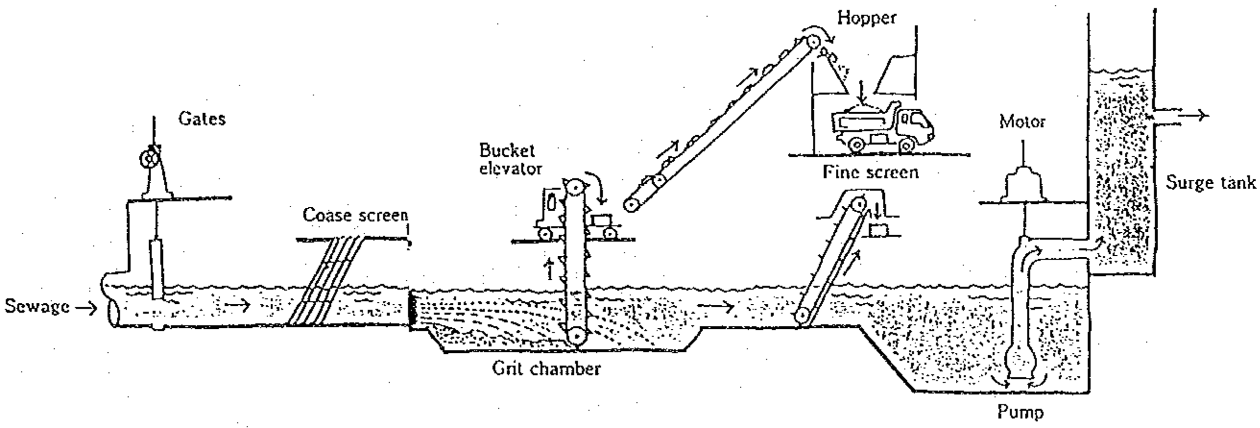


10. PUMP STATION [I]

A pump station elevates waste water and/or storm water coming in through a sewer. The sanitary pump station for waste water and the storm pump station for storm water both remove sand and floating or suspended matters in a grit chamber beforehand.

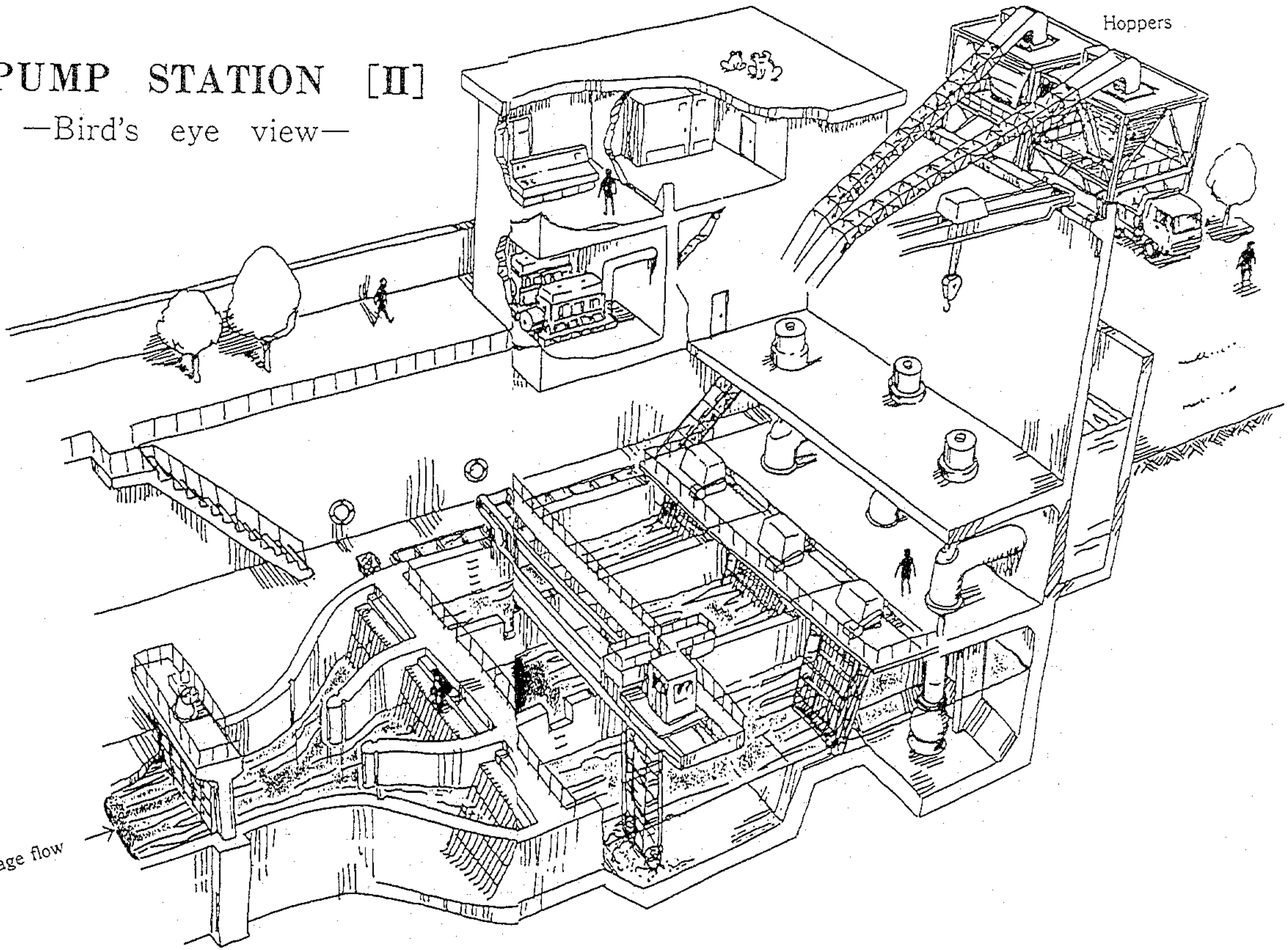
A coarse screen set just at the head of a grit chamber and a fine screen at the end thus avoid clogging of and injuries to mechanical equipment.

The storm water is lifted up to a high enough elevation so that it may be released into a receiving water and the waste water high enough to flow to a treatment facility.



11. PUMP STATION [II]

—Bird's eye view—

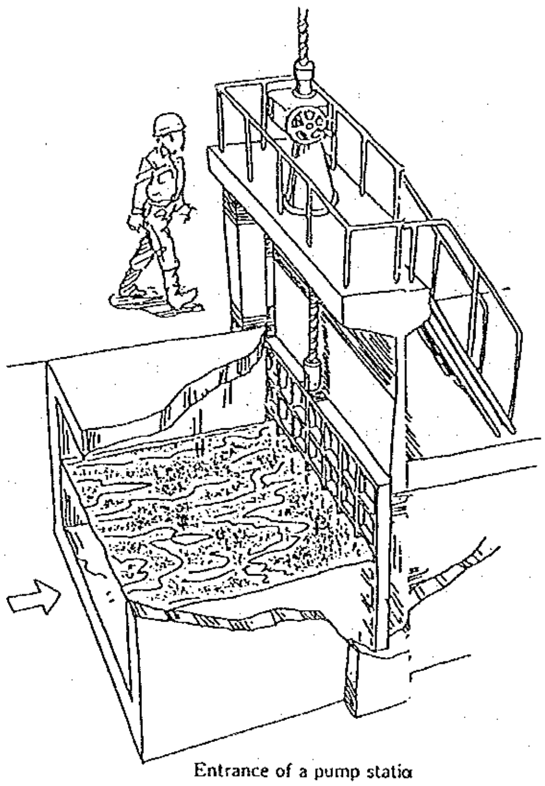


Looking down on
a pump station

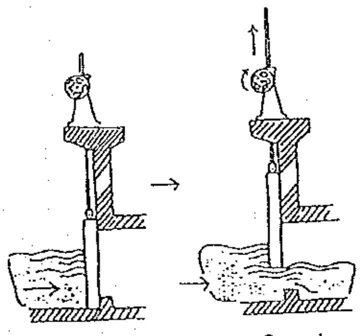
12. GATES

At the entrance of a pump station, gates are installed to control the flow and may be shut to empty the grit chamber and pump pit for inspection and repair, or in the event of an emergency.

Manual gates are the least popular choice compared with motordriven and hydraulic gates because of the longer time needed to operate them.



Entrance of a pump statio

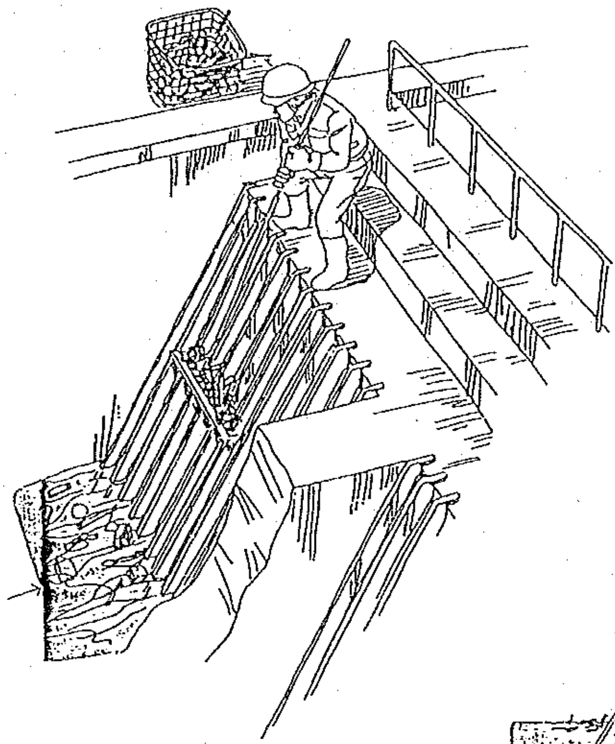


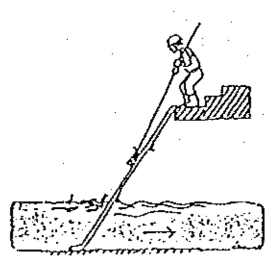
13. COARSE SCREEN

Passing through an entrance gate, sewage (sanitary, storm or combined) flows through metallic bars of a coarse screen with openings measuring between 6～20cm.

This protects pumps, conduits and valves from large objects such as pieces of timber and dead animals.

The screen is placed on a slope of 45° to 60° from the horizontal, so that the operators can pull up the screenings using a hand rake.





14. RECTANGULAR GRIT CHAMBER

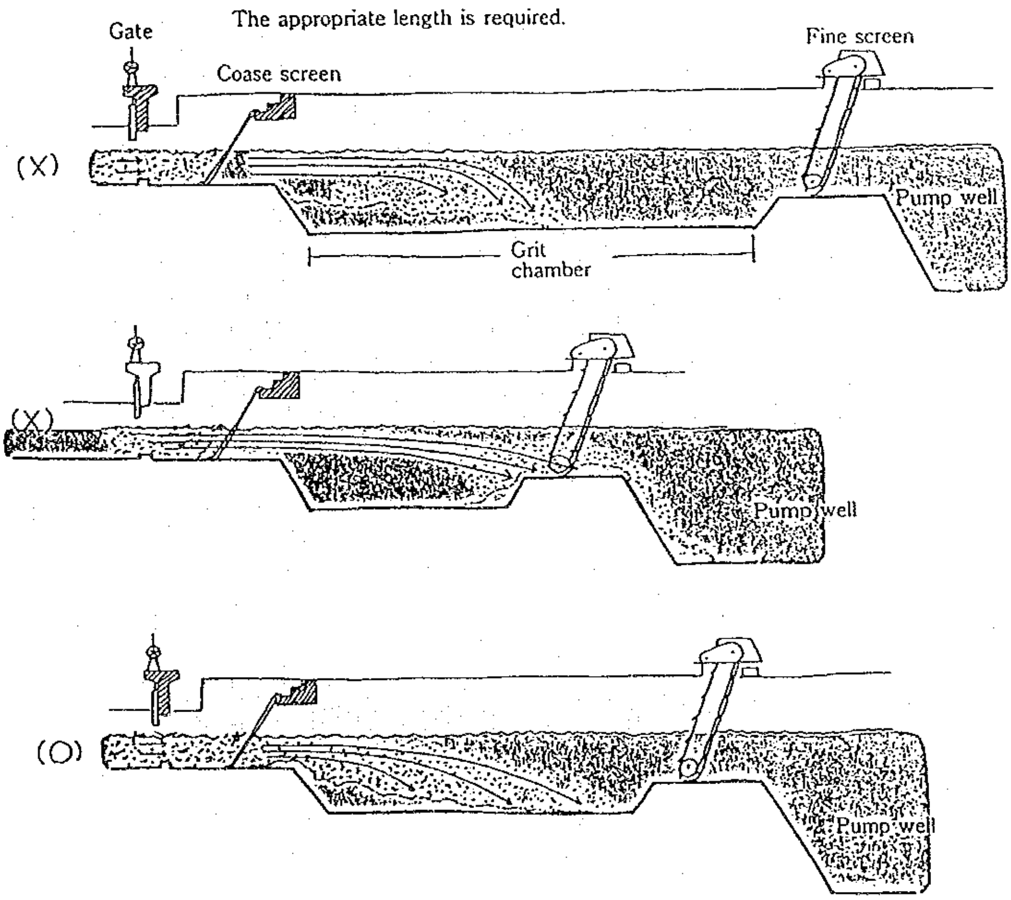
The removal of grit and sand is necessary to prevent the clogging of conduits, to protect pumps, and to protect equipment in sewage treatment process which the material of intended size follows.

To cause only sandy material to settle, a suitable size of and flow velocity through the basin should be secured :

(1) Too large in size and low in velocity, the material settles in the upstream portion of the basin.

(2) Too small in size and high in velocity, the material passes through the basin.

The length, width and velocity designed preferably, the material of intended size or larger could settle in the basin while lighter organic solids could be carried forward in suspension.

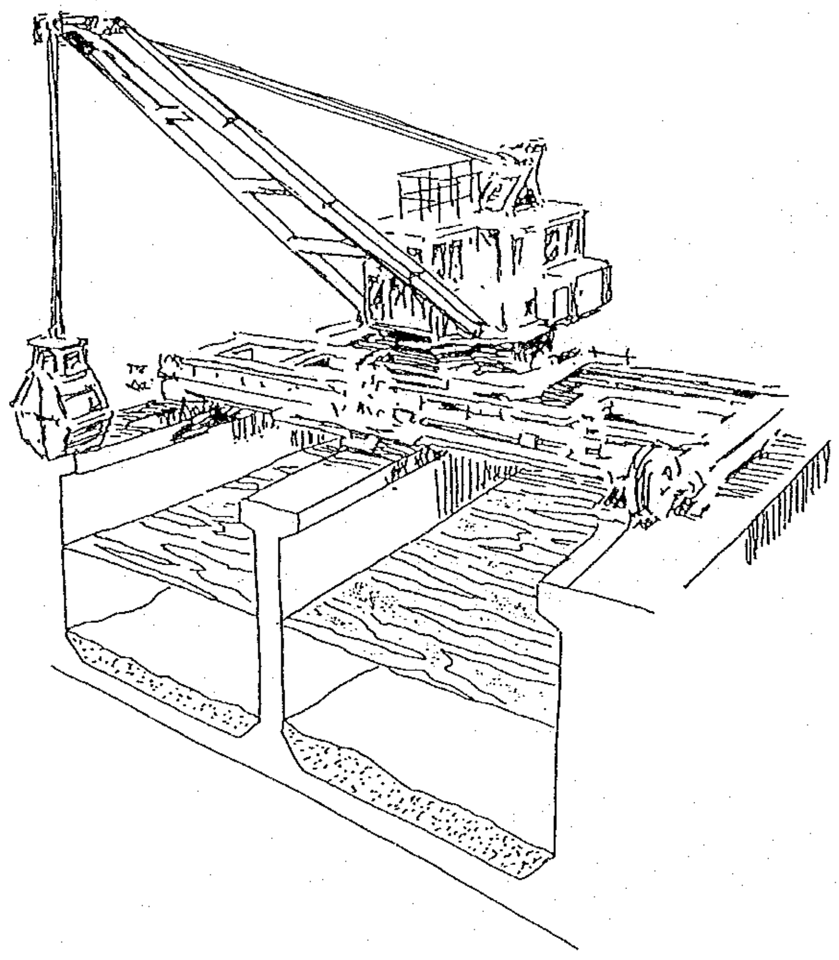


15. CLEANING GRIT CHAMBERS [I] —BY A CLAMSHELL BUCKET—

Grit chambers are cleaned manually and mechanically. Recently mechanical cleanig devices have become quite popular, such as a clamshell bucket and a bucket conveyor.

A clamshell bucket is hung down from a portal crane or rotary crane such as that shown on the next page.

Catching the sand which has settled in the bottom of the chamber, the clamshell is hung up and swung toward a conveyor which receives, conveys and washes the sand on its way to a hopper (a car loader).

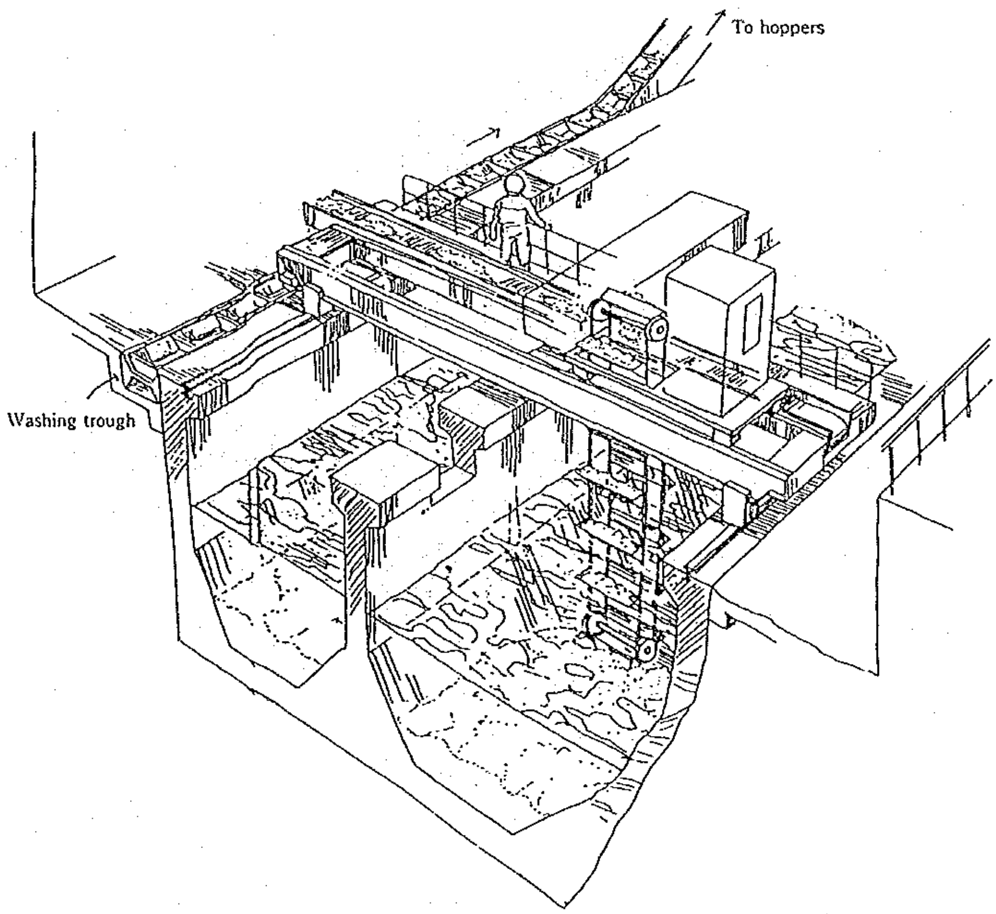


16. CLEANING GRIT CHAMBERS [II]
—USING A BUCKET ELEVATOR—

A bucket elevator is a vertically moving bucket flight set on a cart which travels horizontally on rails of the bridge, which runs along and over the basin channels.

Only one unit of this machine is necessary for cleaning every channel, because of the moving system.

The settled matter scooped up continuously by the buckets goes to the hopper through the conveyors. On the way, organic matter is washed down to the basin.

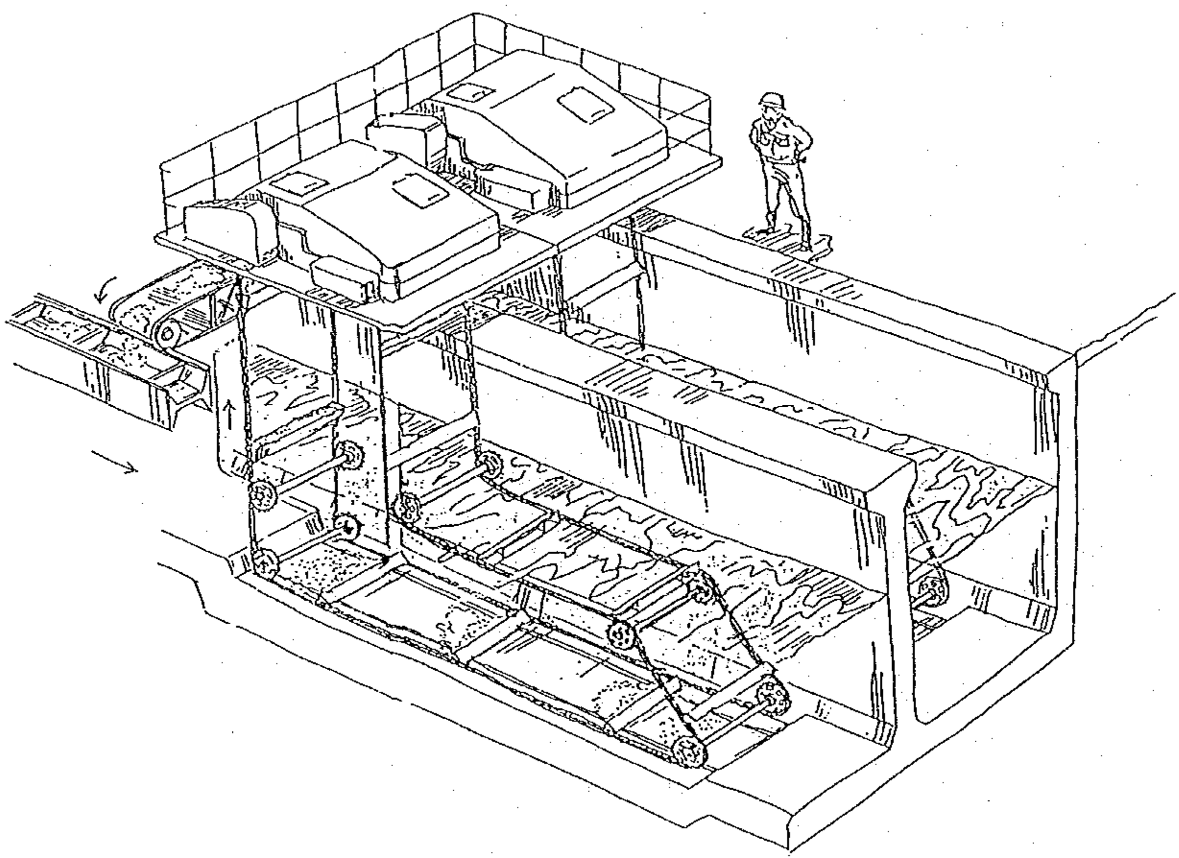


17. CLEANING GRIT CHAMBERS [III]
—BY A BUCKET CONVEYOR—

A bucket conveyor is a bucket flight set in each channel of the basin. As illustrated, the settled matter is scooped from the entire length of the channel bottom.

Each bucket moves at a speed of 0.5 ~3m per minute.

Thus scooped up, the settled matter is handled using the same process as that explained in the preceding page.

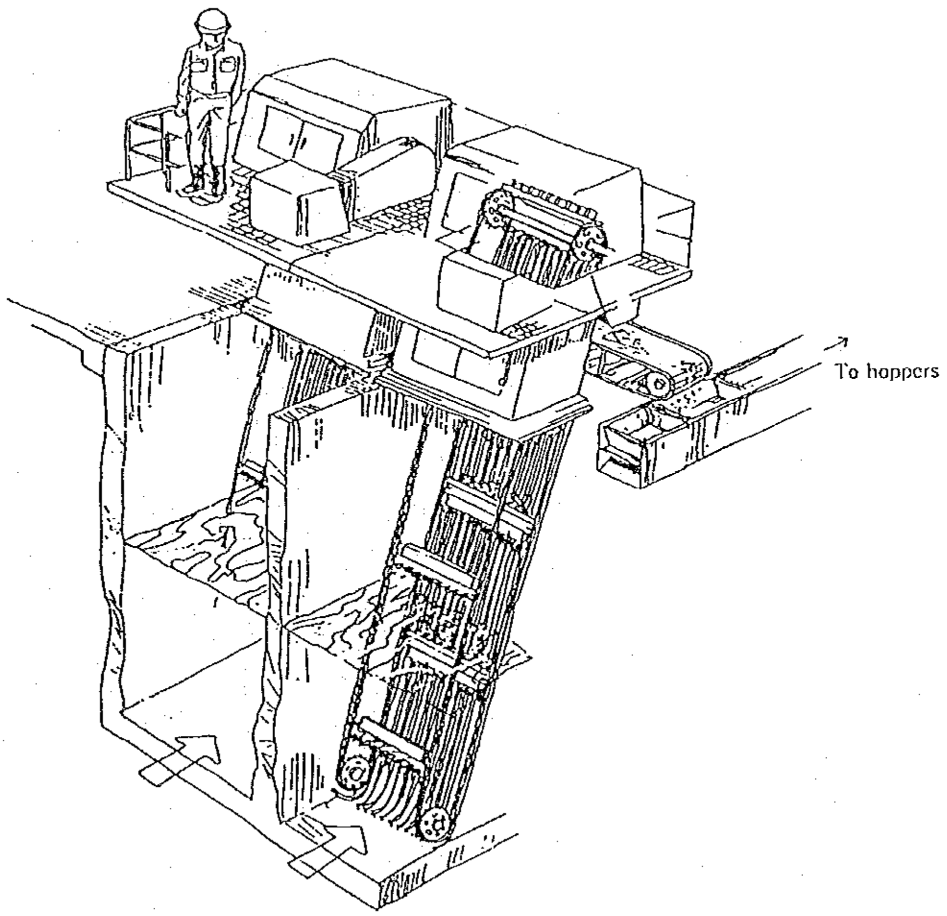


18. FINE SCREEN

A fine screen is a facility to remove the solid matter which has passed through the coarse screen.

The matter is raked from the screen mechanically or manually.

The bars, with the pitch of 1.5~5cm, are set at an angle of 70° in case of mechanical rakes and 45°~60° in case of manual ones.



19. PUMPS [I]
—CHARACTERISTICS—

Axial flow, mixed flow and centrifugal pumps are used in a pump station. Each type has either a vertical or horizontal axis.

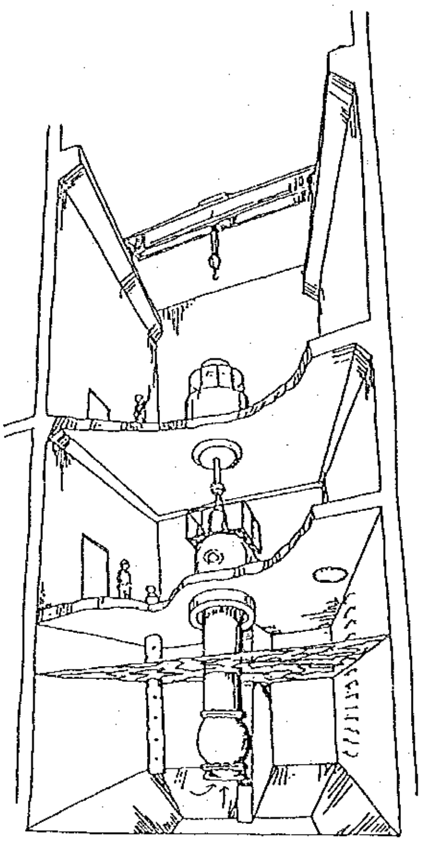
The capacity and available head are roughly shown in the table as pump characteristics.

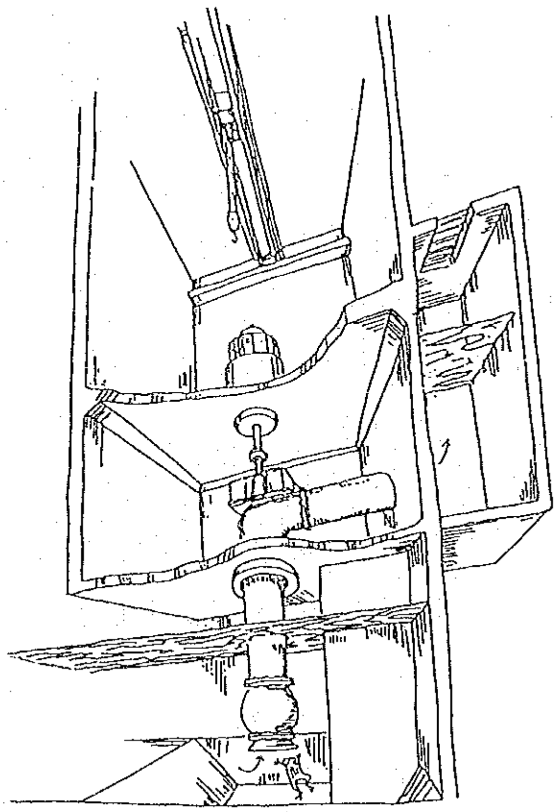
A typical axial flow pump with a vertical axis is illusrated on the facing page.

The driving device, such as an electric motor, is set on the upstair of the pump floor, so that it is well protected against floods.

Pump Characteristics

Pump type	Capacity	Head
axial flow	large	low
mixed flow	medium	medium
centrifugal	small	medium



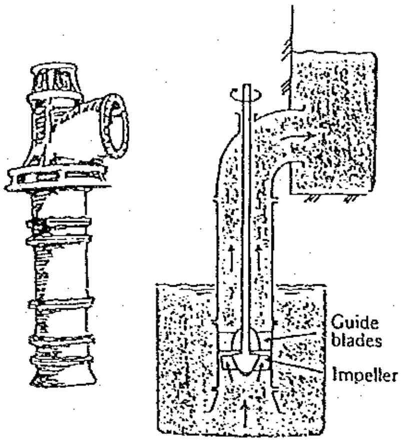


20. PUMPS [II]
−MECHANISM−

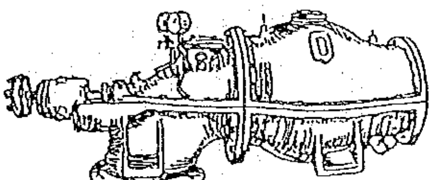
An axial flow pump has an impeller and guide blades which lift the water along the pump axis.

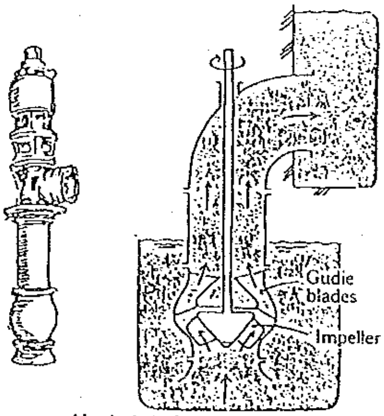
A mixed flow pump also has an impeller and guide blades which lift the water along the pump axis and make the flow slant to the axis at the impeller.

The centrifugal pump has an impeller which revolves to give the water centrifugal force as flow energy.

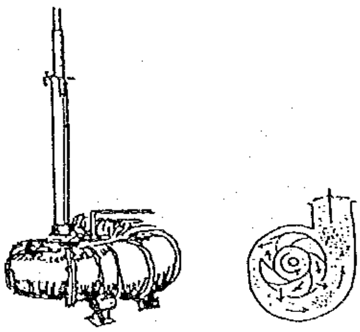


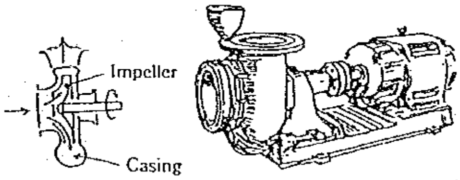
Vertical shaft
axial flow


Horizontal shaft
mixed flow



Vertical shaft
mixed flow


Vertical shaft cetrifugal



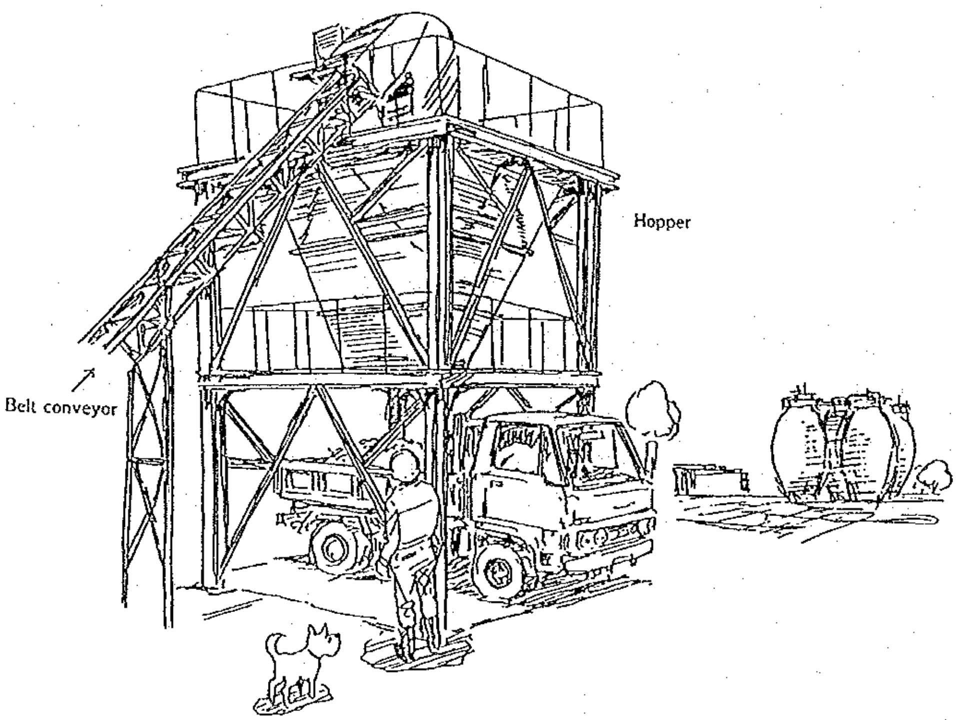
Centrifugal ; One-side suction
type

21. HOPPER

Sand and screenings conveyed upward from the grit chamber are stocked in a hopper.

After a substantial amount has collected, it is loaded on a dump truck and usually taken to landfill sites.

The hopper surroundings tend to develop unpleasant odors because of leakage from the hopper. Intensive cleaning is the key to maintenance.



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Training Division,
Japan Sewage Works Agency

PREFACE

This book provides a information about wastewater treatment facilities in Japan. In this book about 50 photos are shown. Most of them may be useful to develop high systems for both countries.

Jun-ichi Yumikura

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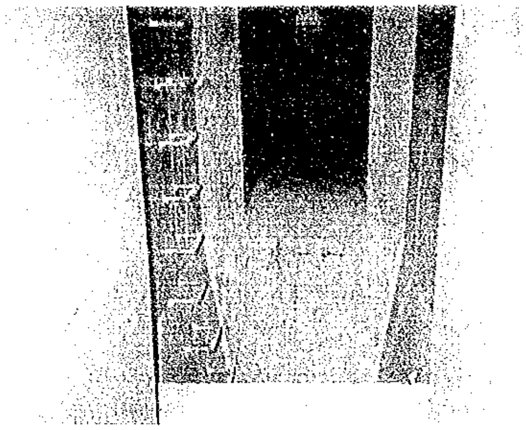
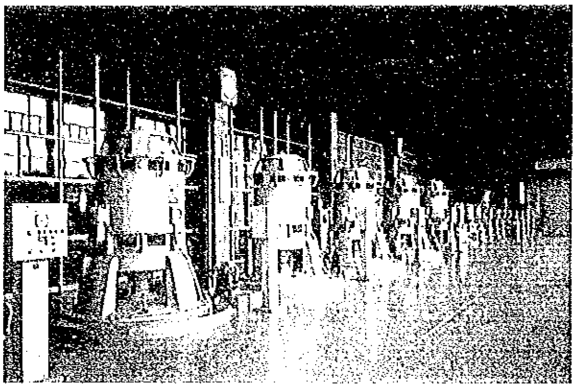
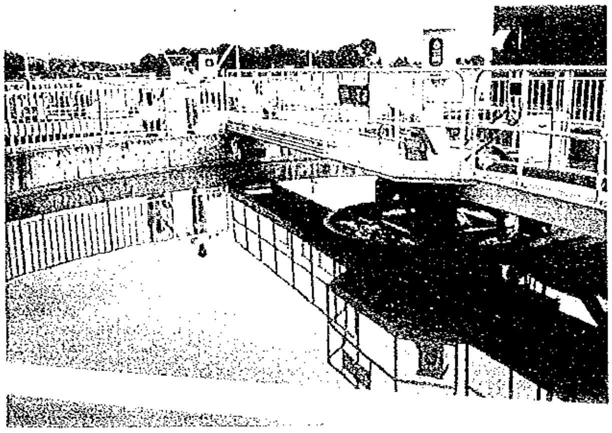
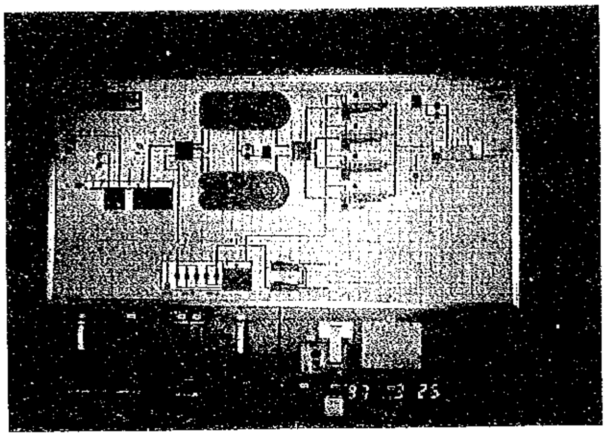
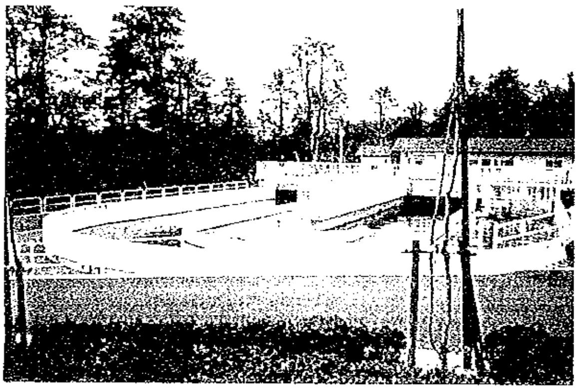
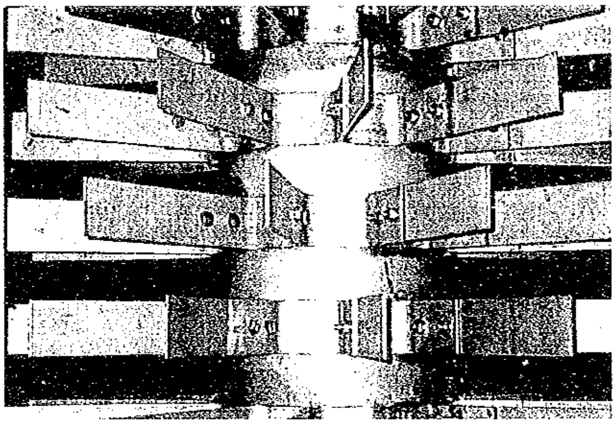












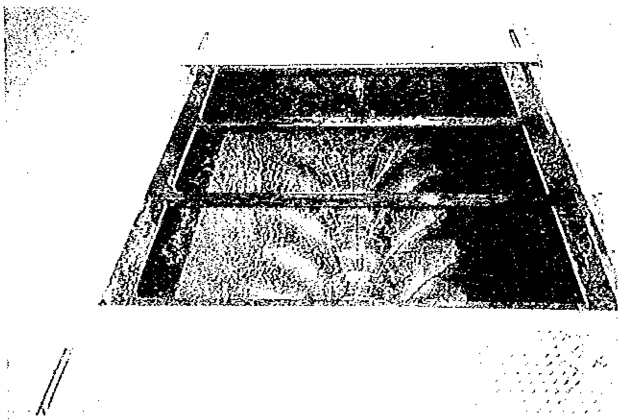
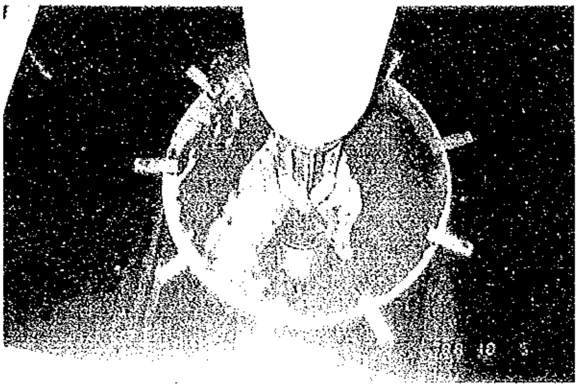
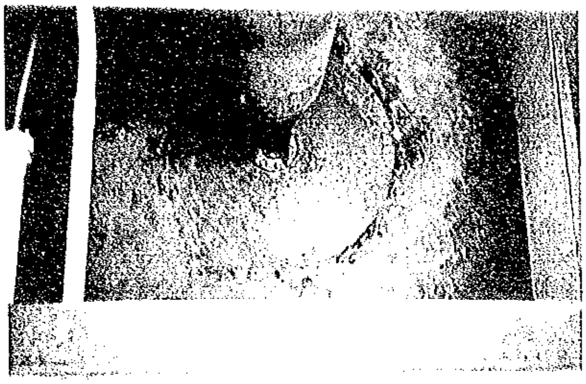
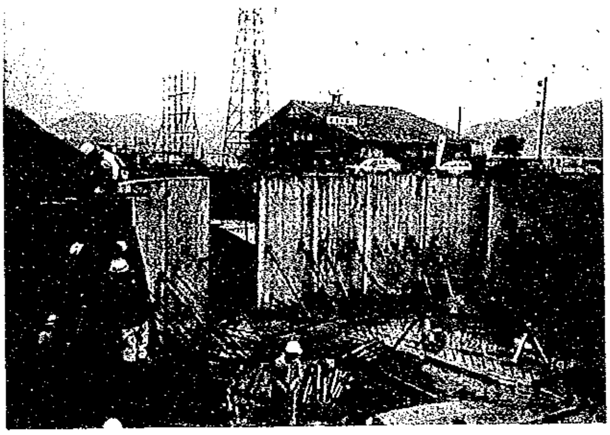
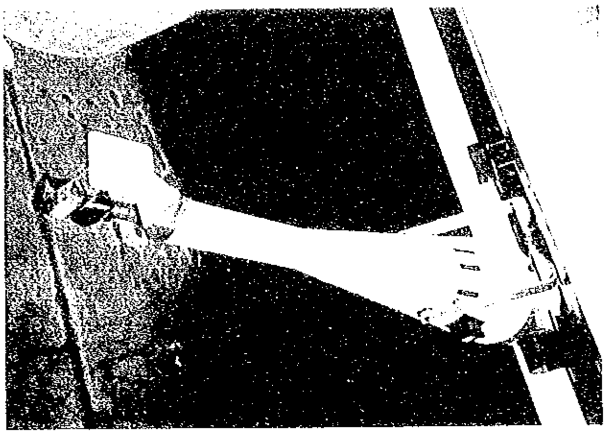


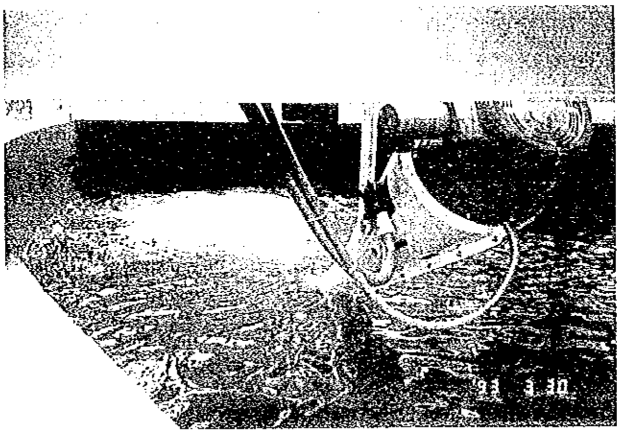
Photo 1-1 Grit Chamber and Screen	Photo 1-2 Pumping Station
Photo 2-1 Primary Sedimentation Tank	Photo 3-1 Oxidation Ditch (OD), Control Panel
Photo 3-2 OD, General View	Photo 3-3 OD, Horizontal Aerator
Photo 3-4 OD, Horizontal Aerator, in Operation	

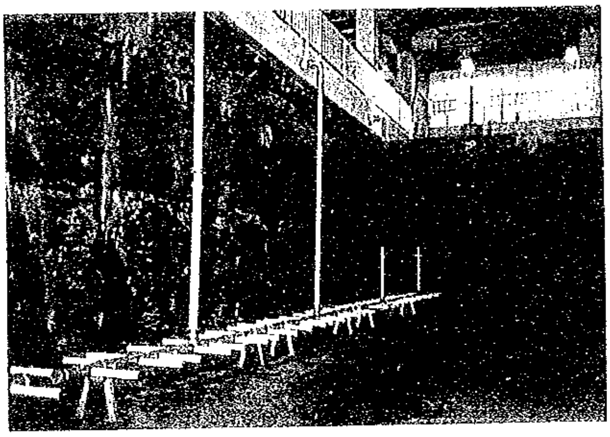












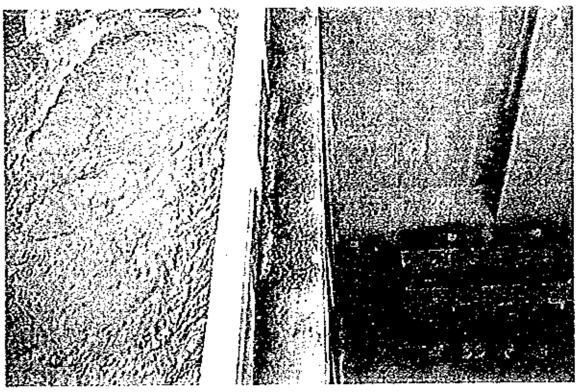
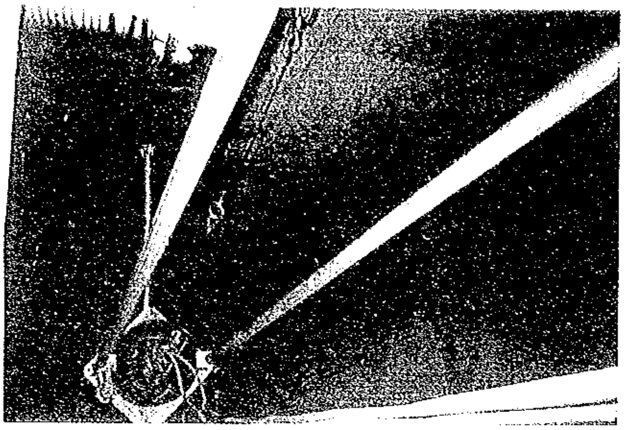
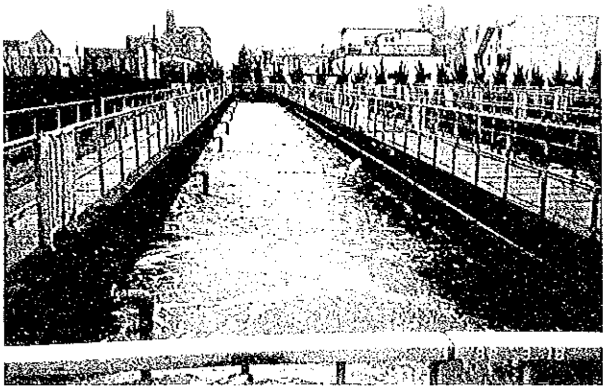
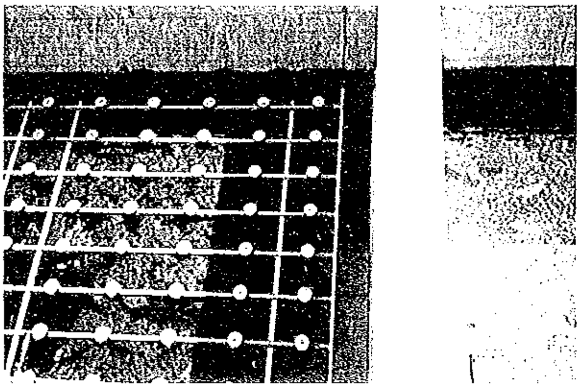
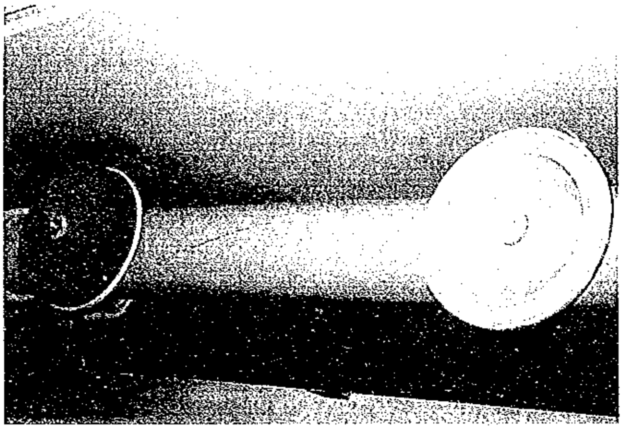


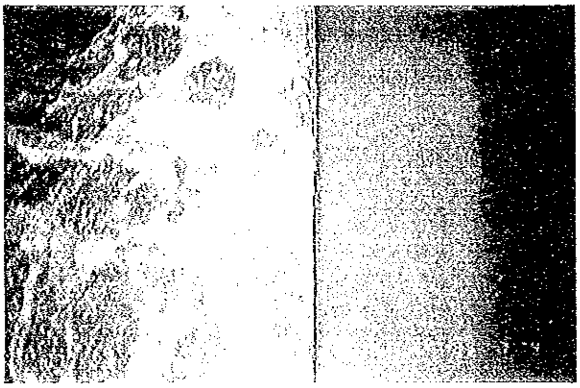
Photo 3-5 OD, Vertical Aerator	Photo 3-6 OD, Vertical Aerator, in Operation
Photo 3-7 Prefabricated Oxidation Ditch (POD)	Photo 3-8 POD, Screw Type Aerator/Mixer
Photo 3-9 POD, Screw Type Aerator, in Operation	Photo 3-10 Conventional Activated Sludge Process, Empty
Photo 3-11 Conventional Activated Sludge Process, Expanding.	

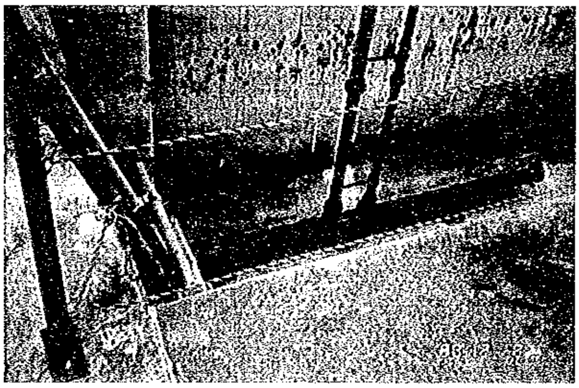












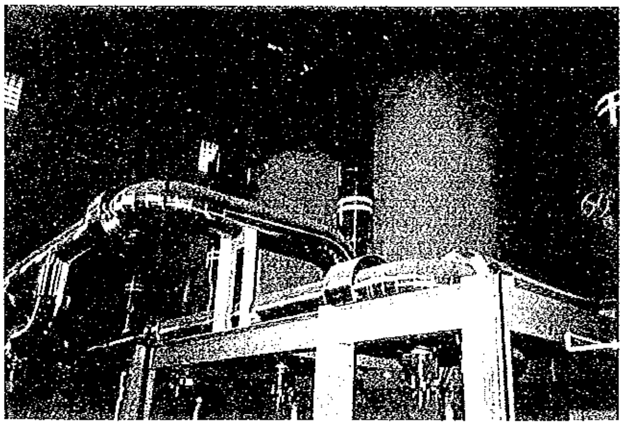
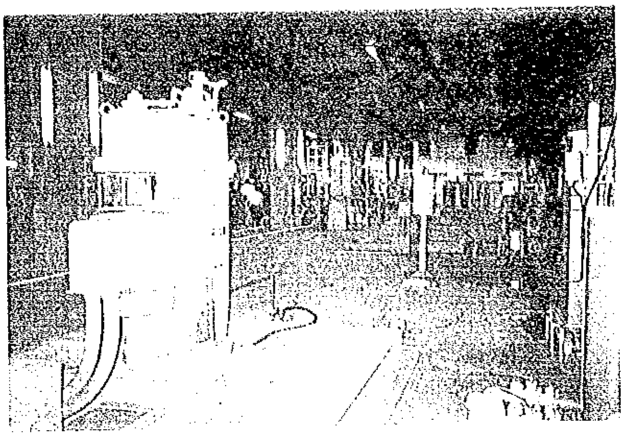
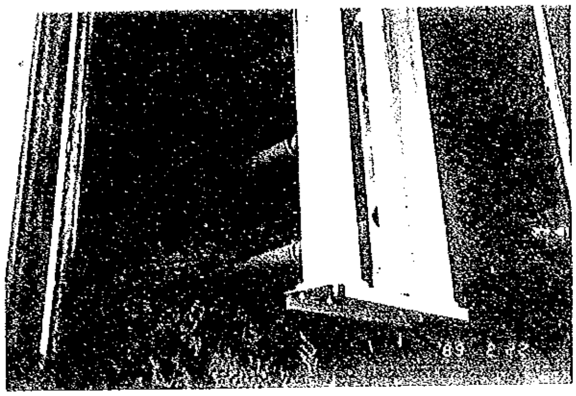
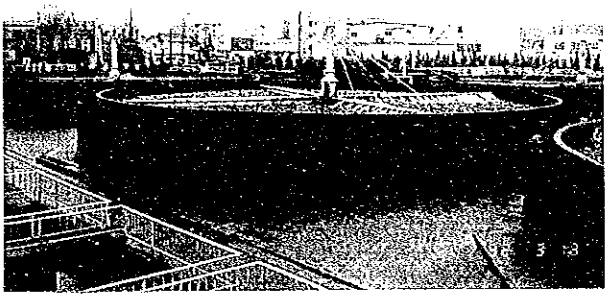
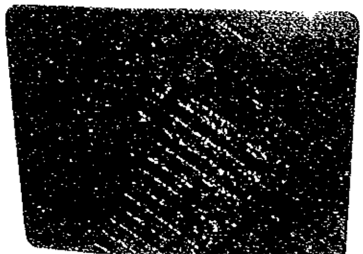


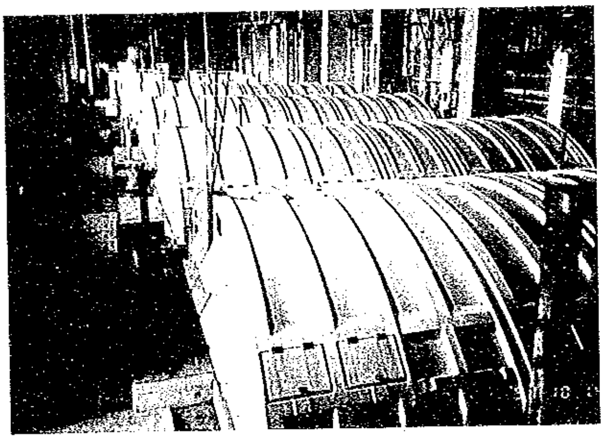
Photo 3-12 Deep Aeration Tank: 10 meters deep	Photo 3-13 Step Aeration: 4 inlets
Photo 3-14 Anaerobic Oxic Process: to prevent sludge balking and get high phosphorus removal	Photo 3-15 Diffuser
Photo 3-16 Anaerobic Oxic Process, in Operation	Photo 3-17 Jet Type Aerator
Photo 3-18 Pure Oxygen Generator	

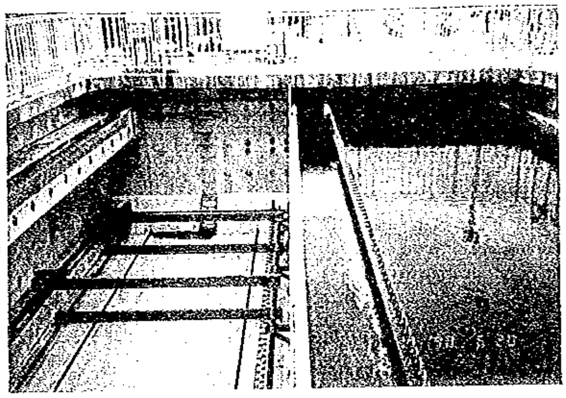












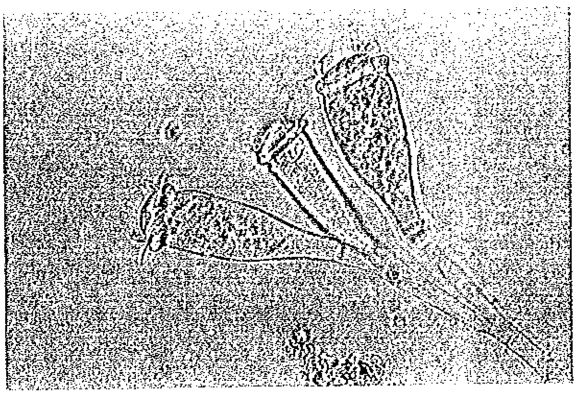
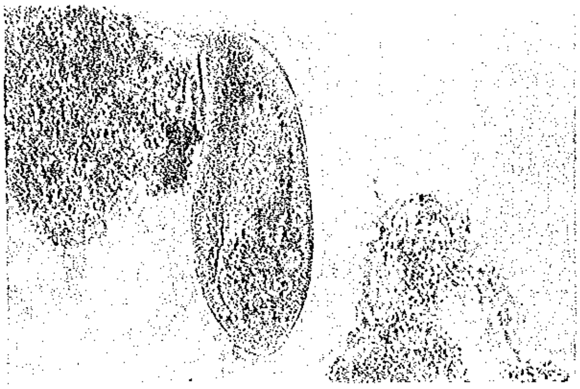
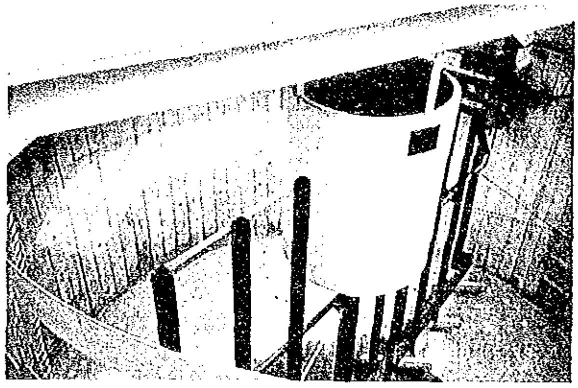
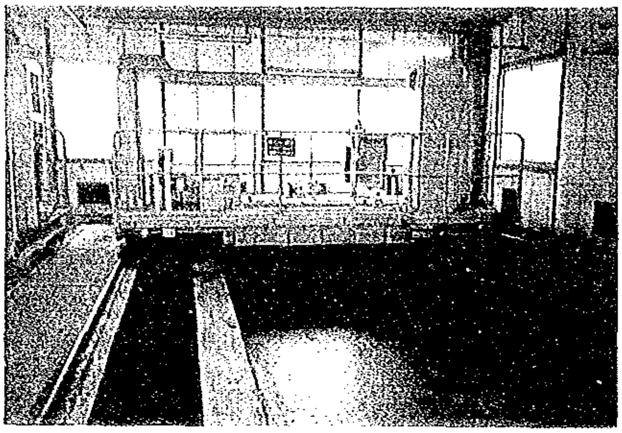
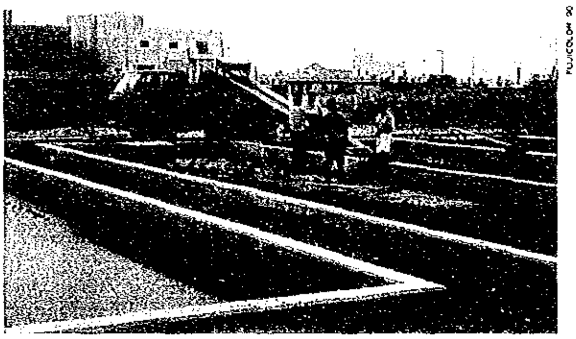


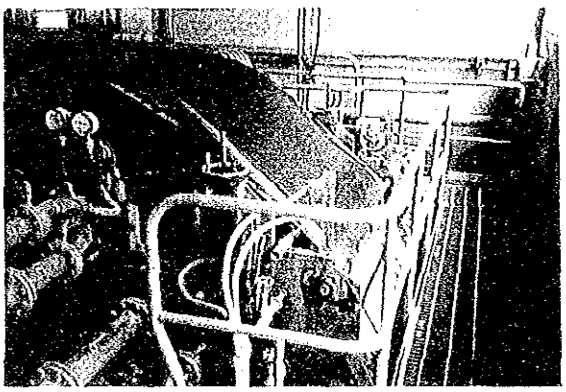
Photo 3-19 Pure Oxygen Process	Photo 3-20 Batch Reactor
Photo 3-21 Trickling Filter	Photo 3-22 Rotating Biological Contactor (RBC)
Photo 3-23 RBC, General View	Photo 3-24 Secondary Settling Tank: left; expanding
Photo 3-25 Microscopic Test, *Epistylis* sp.	

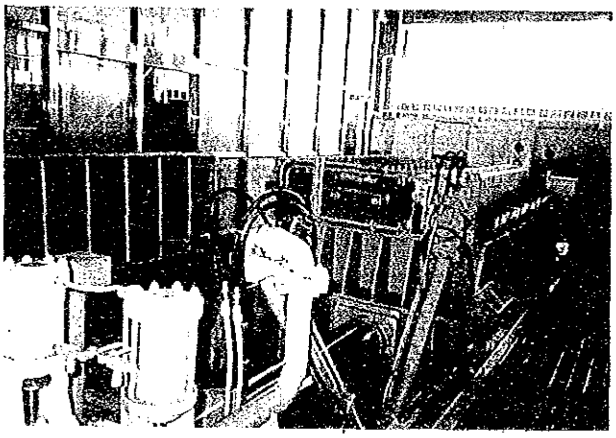












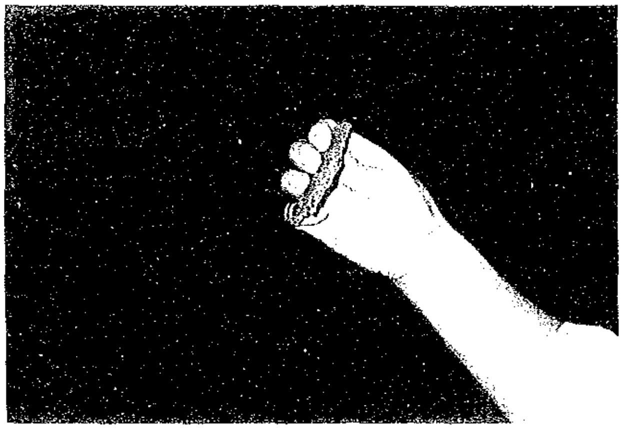
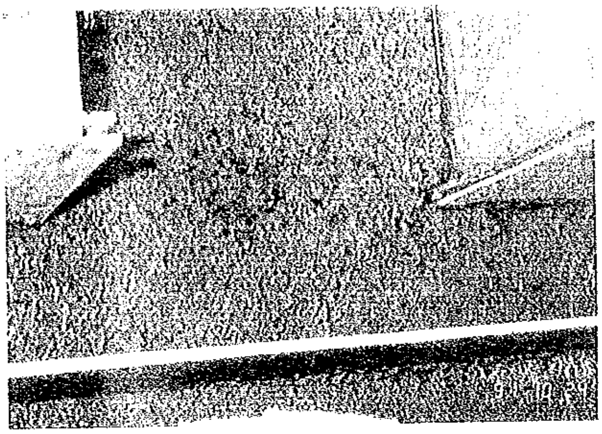
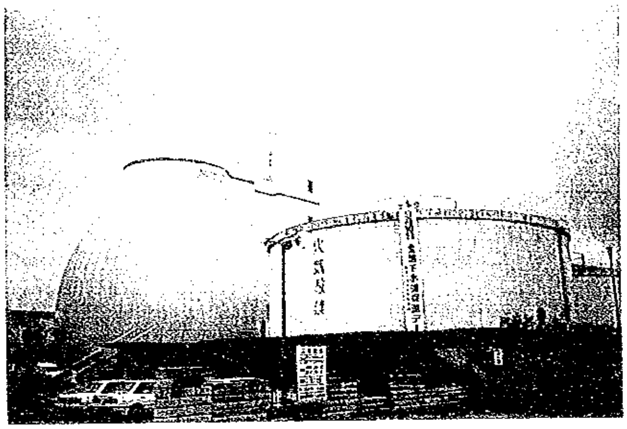
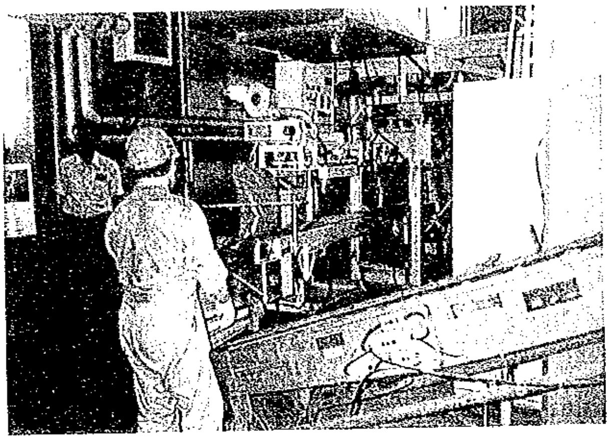
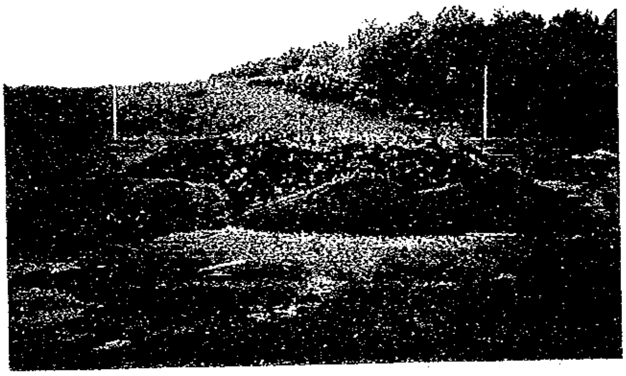


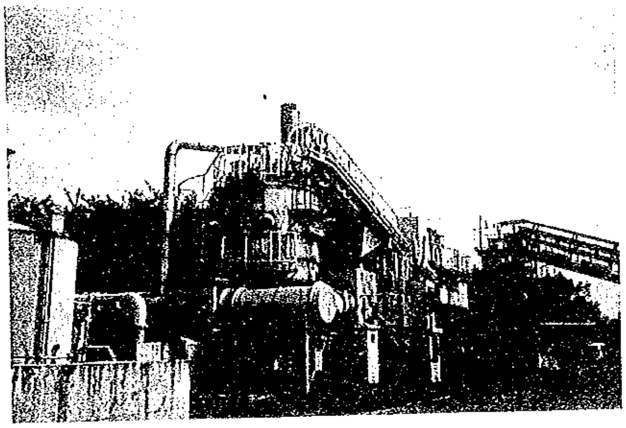
Photo 3-26 ibid, *Paramecium* sp.	Photo 4-1 Sludge Thickener
Photo 4-2 Flotation Thickener	Photo 4-3 Sand Drying Bed
Photo 4-4 Vacuum Filter	Photo 4-5 Filter Press
Photo 4-6 Sludge Cake: from filter press	











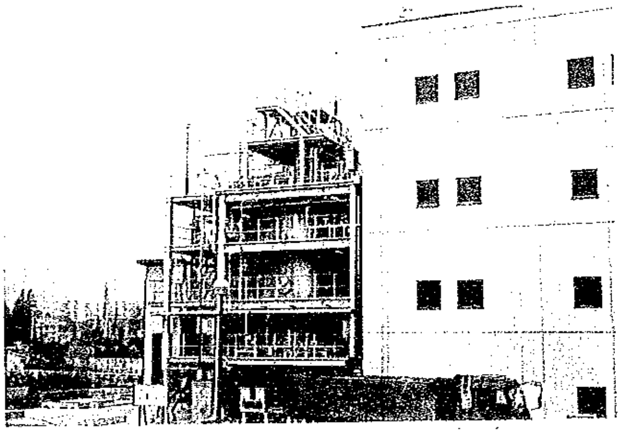
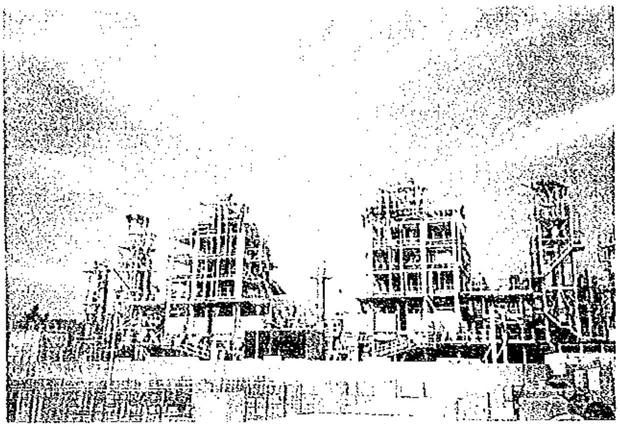
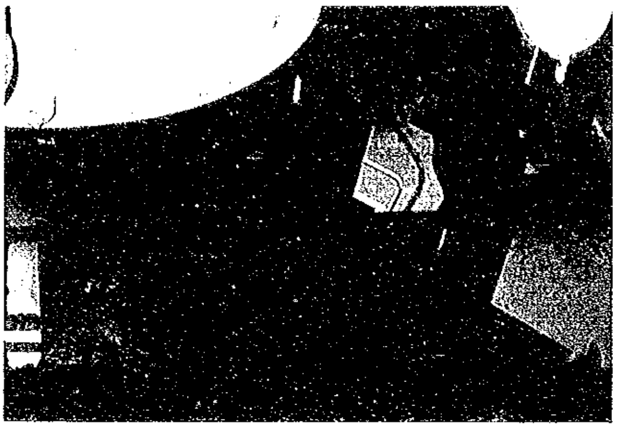
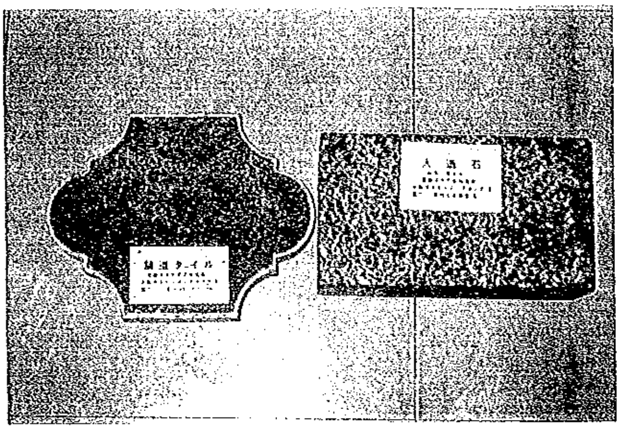
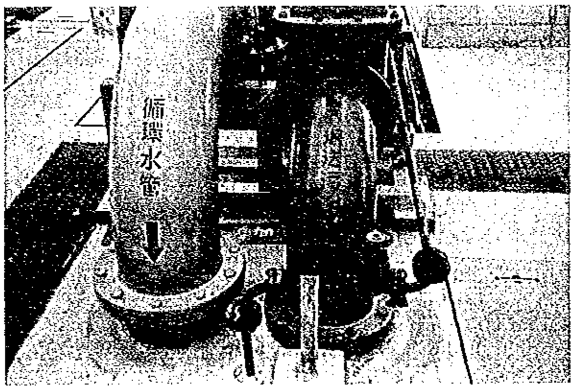


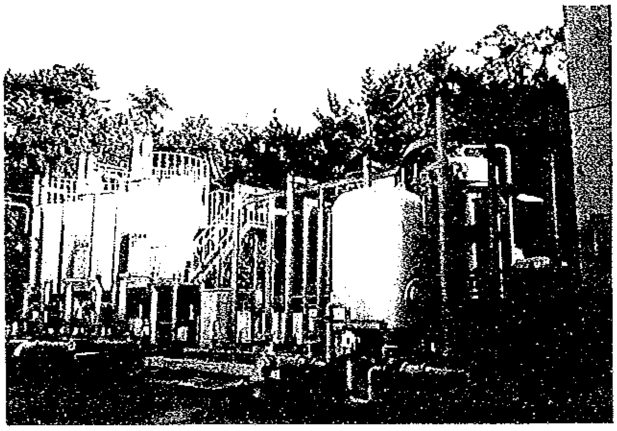
Photo 4-7 Centrifuge	Photo 4-8 Belt press: gravity thickening part
Photo 4-9 Digestion Tank: left; new type (egg shape)	Photo 4-10 Composting
Photo 4-11 Anaerobic Composting: retention time; 2 years	Photo 4-12 Multiple-hearth furnace
Photo 4-13 Fluidized Bed Incinerator	











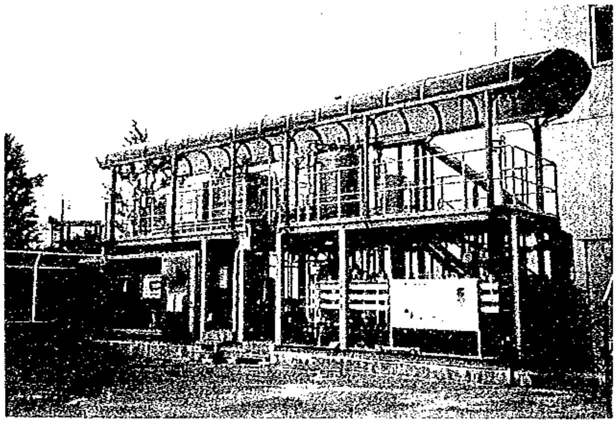
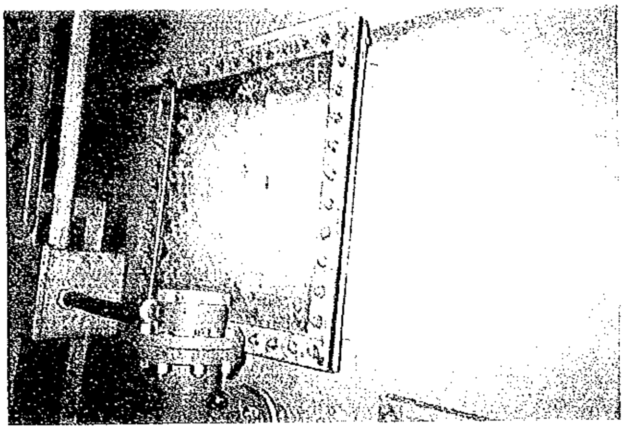
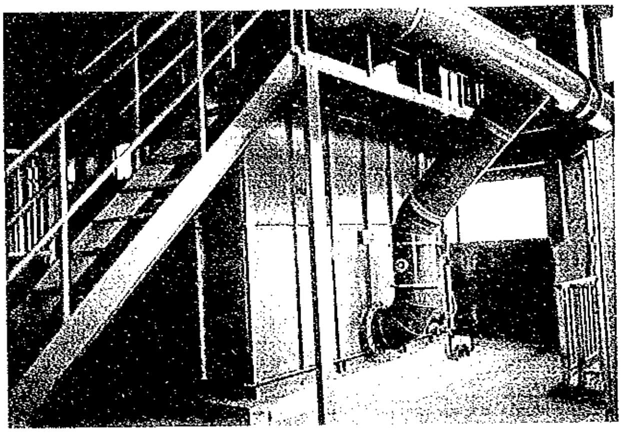
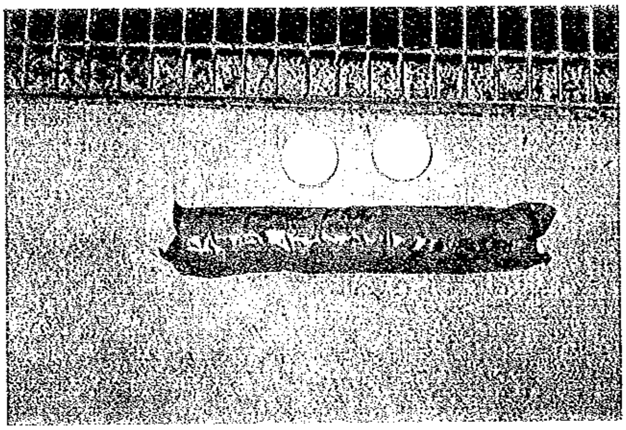


Photo 4-14 Sludge Melting Incinerator	Photo 4-15 ibid, Cooling
Photo 4-16 ibid, Reuse	Photo 5-1 Nitrification & Denitrification: left; recircuration pipe, right; return sludge pipe
Photo 5-2 Sand Filtration	Photo 5-3 Ozone Injection
Photo 5-4 Reverse Osmosis: 50 cu. meters/day	







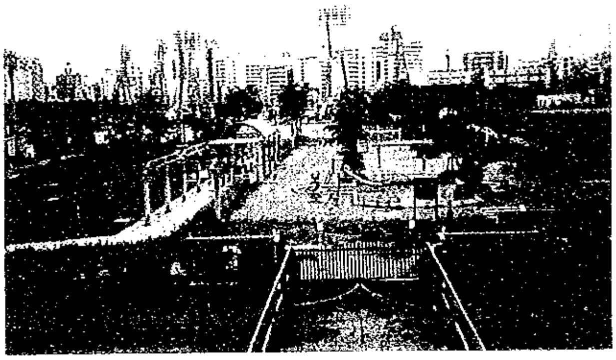
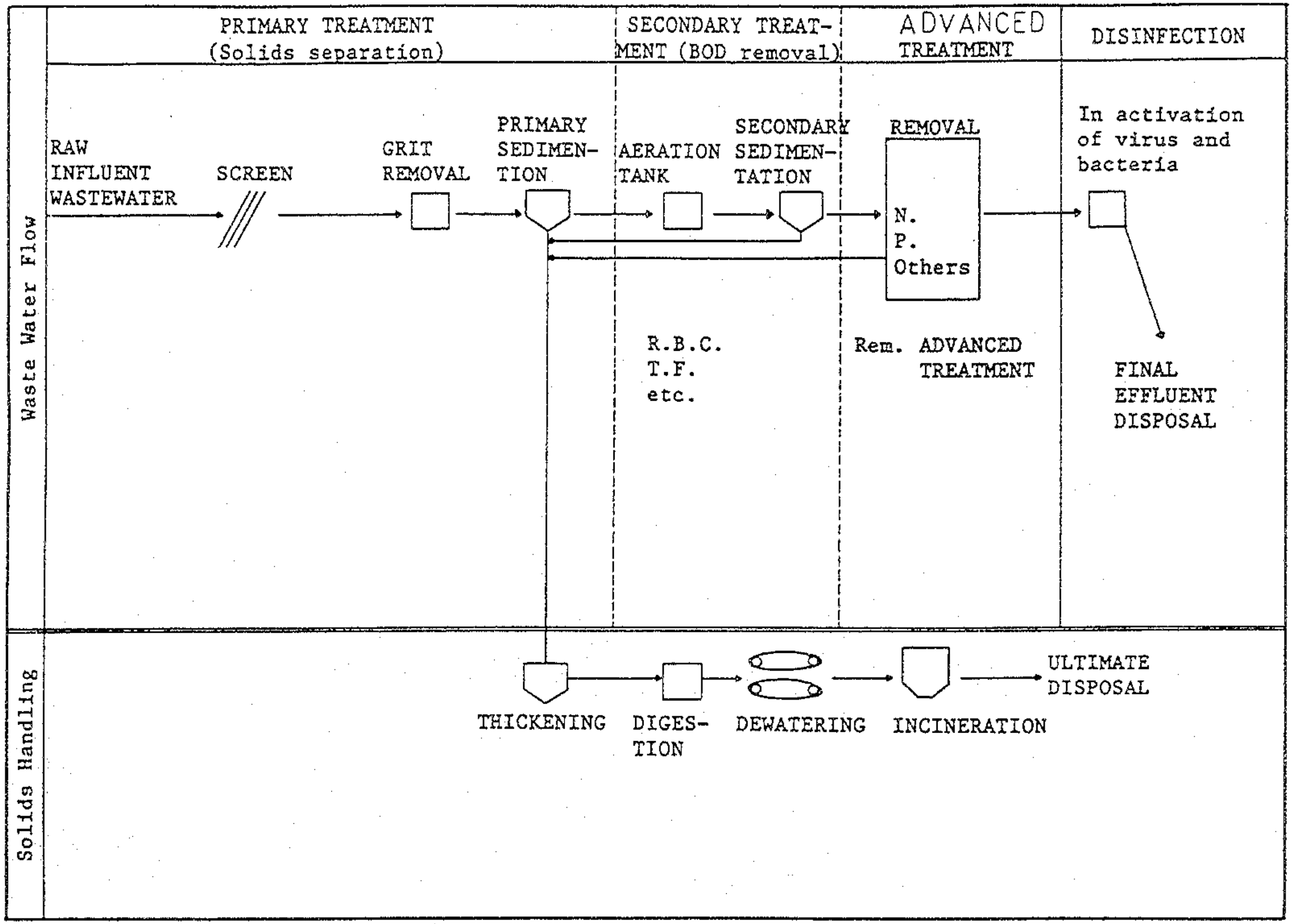


Photo 6-1 Soil Deorderizing	Photo 6-2 Chemicai Deorderizing
Photo 6-3 Active Carbon Deorderizing	Photo 6-4 Chroline Tablet
Photo 6-5 Roof Park	Photo 6-6 Discharge
Photo 6-7 Mt. Fuji	

APPENDIX

Typical Schematic Flow and Process Diagram
Number of Wastewater Treatment Plants Classified by Treatment Method
Comparison of Characteristics of Each Treatment Process
BOD and Protozoa

Typical Schematic Flow and Process Diagram



Number of Wastewater Treatment Plants Classified by Treatment Method

Total	500 or more	100 to 500	50 to 100	10 to 50	5 to 10	<5	Designated total amount of Wastewater treated in a day during dry weather (in 1,000 cu.m/day) / Treatment method		
4				4			Plain sedimentation		Simple
7				4	2	1	High rate trickling filter		Middle grade
12		1	2	8		1	High-rate biological oxidation settling		
595	12	124	102	245	57	55	Conventional	Activ-ated sludge proces s	High grade
54	9	10	14	15	3	3	Step-aeration		
17				3	3	11	Extended aeration		
							Contact stabilization		
7		3		3	1		Oxygen		
5		1	3		1		Nitrification-denitrification		
12					2	10	Sequencing batch reactor		
89		1		4	19	65	Oxidation ditch		
24			1	6	6	11	Rotating biological contactor		
6				2		4	Aerobic filter		
3		1				2	Anaerobic/aerobic filter		
1						1	Others		
(46)	(2)	(9)	(8)	(5)	(7)	(15)	Advanced treatment		
836	21	141	122	294	94	164	Total		

COMPARISON OF CHARACTERISTICS OF EACH TREATMENT PROCESS

	Primary settling	Aeration time(hr)
Conventional activated sludge process	yes	6-8
Step aeration process	yes	4-6
Oxygen activated sludge process	yes	1-3
Oxidation ditch process	no	24-48
Sequencing batch reactor reactor	no	*with settling 16-24
Trickling filter process	yes	*15-25 cu.m/sq.m/day
Rotating biological contactor process	yes	*about 5 g/sq.m/day

BOD and Protozoa

Class	Protozoa	BOD of effluent	Condition
I	Uronema, Colpidium, Glaucama, Oicomonas, Bodo, Dexiotrichides, Paramecium.	> 30	bad
II	Litonotus, Loxophyllum, Chilodonella, Oxytricha, Trachelophyllum	ranged widely	unstable
III	Aspidisca, Vorticella, Epistylis, Carchesium, Opercularia, Zoothamnium, Philodina,* Rotaria.*	< 20	good

*: Rotifers

JICA