3.7 Layout of Facilities

Main structures of the WWTP, such as primary sedimentation tank, aeration tank, final sedimentation tank, sludge thickener, sludge digester, grit chamber and oil separator, chlorination chamber, and effluent pumping station are shown in *Figure AII.3.1* to *AII.3.8*. The structures and the layout of facilities is designed based on the design basis described above and the actual site conditions.

4. Electrical, Instrumentation and Control Facilities

This section describes the purpose, functions and outline of the major electrical equipment, instrumentation and control works. The numbers, shapes, sizes, and brief specifications of the equipment described here are for the preliminary engineering purpose, and may be subject to minor changes at the detailed design stage.

4.1 General

The basic requirements for the electrical, instrumentation and control equipment at the wastewater treatment plant are adequacy, reliability and safety. Adequacy of the major equipment such as circuit breakers, power transformers and the motor control centers are determined largely by the continuous current requirements of the treatment plant loads and the available short-circuit capability of the power supply.

The reliability of the equipment concerns the capacity of the electrical system to deliver power when and where it is required under abnormal, as well as normal, conditions.

Safety involves the protection of plant personnel as well as the safeguarding of equipment under all conditions of operation and maintenance.

The electrical system should be designed with enough flexibility to permit one or more compounds to be taken out of service at any time without interrupting the operation of the plant.

The generation of power from wastewater gas production will be economical if the power is effectively utilized for the plant operation or other purposes.

The design of the wastewater treatment plant electrical system must conform with the applicable local codes and regulations.

4.2 Electric Power Facility

4.2.1 General

The basic power distribution system can best be described as a secondary single selective system. One electric power line shall be received at the main substation. Another separated line should be planned as a stand-by use in the future.

The received power will be stepped down by the two main transformers and connected to the 380 V bus line. Each transformer shall have a capacity for all loads in the treatment plant by the year 2010.

The 380 V will be stepped down to auxiliary power distribution voltage (lighting and receptacles, etc.) by transformers that are installed at required locations.

The protective relay system shall be considered for proper protection of the electrical equipment in adequate/proper manner. Extensive zone protection will be considered for the parallel operation of the generator with utility power.

Specifications of the electric power facility, current-capacity, short-circuit-capacity, etc., shall be designed taking into consideration any future expansion.

4.2.2 Power Requirements of the WWTP

As described in some detail in *Table AII.3.1 "Tulcea WWTP, List of Mechanical Equipment,* the WWTP mechanical equipment require the maximum electric power supply of 685 kW, excluding standby equipment. The electric power requirements by the process are as summarized in the following:

No.	Process	Equipment	Motor outputs (kW)	Remarks
1.	Screens	Mechanical screens/auxiliary equipment	10.8	Standbys excluded
2.	Grit chambers	Blowers	39.8	Ditto
3.	Effluent pumps	Pumps, valves	71.0	Ditto
4.	Primary clarifiers	Scrapers, sludge pumps	7.5	Ditto
5.	Aeration tank blowers	Blower, filters, cranes,	202.0	Ditto
6.	Final clarifiers	Scrapers, sludge pumps,	119.5	Ditto
7.	Chlorine contact tanks	Chemical supply pumps	0.8	Ditto
8.	Sludge thickeners	Scrapers, sludge pumps, valves, screen	17.0	Ditto
9.	Sludge digestion tanks	Mixers, pumps, valves, heaters, fans, blowers	116.2	Ditto
10.	Sludge dewatering	Belt filters, conveyors, pumps, hoists, auxiliaries	100.3	Ditto
	Total power requirements		685.0	kW

4.2.3 Power Generator

An emergency electric power generator of minimum 200 kW capacity should be provided. The generator is driven by a diesel engine and will be used as the minimum plant electric power source when the power supply is suspended. In order to attain the intent of the above design concept, the generator power line should be connected to the 380 V bus line which is charged by the utility supplied power.

4.2.4 D.C. Power Supply

Uninterruptable D.C. power is supplied to breaker control circuit and an emergency lighting facility. Consequently, uniterruptable A.C. power supply for instrumentation and PC system is converted from D.C. by means of an inverted unit.

A sealed lead-acid stationary battery set shall be selected for this purpose due to its excellent quality features. The capacity of the battery set shall be designed by the required current and 30 minutes discharge time.

Each building within the plant will have its own independent uninterruptable power source unit for better and more effective utilization of the filtered/undistorted power source.

4.2.5 Motor Control Facility

Power feeder to the motors and wiring to the controlling equipment is accomplished through motor control center and relay cubicles. The motor control center and the relay cubicles are divided into individual facility center and relay cubicles such as one set for clarifiers and another for scum screen area.

Each motor must be operated manually from the control station to be located adjacent to the equipment. The control panel will be equipped with switches for operation status indication and meters as required.

Major control sequence is to be accomplished through the relay cubicle as required for each mechanical equipment.

The sub-monitoring panel is to be provided in the room for the purpose of detailed monitoring and back-up operation.

Type of cables/wiring to be utilized, conductor sizes, cable routing/layout and arrangement methods, etc. shall be determined appropriately throughout the detailed design stage of this project.

4.3 INSTRUMENTATION

4.3.1 Design Basis

Instrumentation is an important tool of the wastewater treatment plant because it insures an easy and proper operation and maintenance of such facilities.

The equipment should be selected carefully considering its purpose, reliability, locations and costs. They should meet the specific functional needs of the particular equipment with special attention directed toward operation requirements.

4.3.2 Major Monitoring Instrument

Major monitoring equipment to be installed are summarized below. Each equipment has an indication meter, an alarm, etc.

Water level in entrance chamber	Suspended type level meter
Grit chambers	Parshall flume
Primary settling tank, incoming flow	Ultrasonic flow meter
Primary sludge flow	Electromagnetic flow meter
Receiving water level at plant effluent gate box	Suspended type level meter
Effluent pump wells	Suspended type level meter
Dissolved oxygen at aeration tanks	DO meters, air flow meters
Secondary sludge flow	Electromagnetic flow meter
Return and excess sludge flows	Electromagnetic flow meter
Digestion tank temperature	Thermo-coil
Digester outlet gas flow	Orifice flow meter
Heater gas flow	Orifice flow meter
Digested sludge flow	Electromagnetic flow meter
Feed sludge/polymer dosage flow	Electromagnetic
Sludge tank/dosage tank level	Bubble tube level meter
Thickened sludge flow to digesters	Electromagnetic flow meter
Temperature, digester return water basin temperature and hot water basin temperature (outlet water from engine generators)	Thermocoil

4.3.3 Supervisory Control and Data Acquisition System

The system can best be described as a local, independent, process control network with supervisory, central, monitoring station consisting of hard graphic indication (MIMIC) panels and soft monitoring/control station consisting of graphic screens, keyboards, printers, etc. The basic design of the system will be classified as follows:

- Local instrumentation/control station;
- Local process control units (Programmable logic controllers);
- Hard graphic/MIMIC panel;
- Redundant data highway;
- Host computer system and real time data storage;
- Historical data retrieval
- Workstations

4.3.4 Local Instrumentation/Control Station

The local instrumentation/control station will provide a monitoring/control point for each process equipment in the event of computer failure, data highway failure, etc. These will be four local instrumentation/control panels, one for each of the following areas

- Preliminary treatment facility;
- Primary treatment facility;
- Secondary treatment facility;
- Sludge digestion facility;
- Sludge dewatering facility; and
- Power generating facility.

Equipment control, status indication, alarm conditions, indication of measured quantities of process variables, equipment runtime, etc. will be hand wired to the aforementioned local panels as back-up plant operating and monitoring station. Instrumentation/control panels will be located in the electrical room of the respective plant process control building.

The electrical rooms will be environmentally controlled for equipment protection. Local instrumentation/control cabinet will also house the individual instrument loop power supply unit.

4.3.5 Local Process Control Units (Programmable Logic Controllers)

Programmable Logic Controllers, hereinafter named as PLC, will be utilized as the interfacing/control means with field equipment. The PLC technology is adopted for several logical reasons, one of which is the minimum amount of closed loop control required for this plant as well as the rapid development /enhancements made to today's PLC's in comparison to the distributed process controller technology.

Each PLC with its respective I/O's, power supply, etc. will be housed in a separate cabinet independent of any other local control and/or local instrument panel. The design concept derives the installation of one PLC unit or PLC with hot back-up (as applicable) in the following areas:

- Primary treatment facility (single PLC unit);
- Secondary treatment (single PLC unit);
- Sludge digestion facility (single PLC unit);
- Sludge dewatering facility (single PLC unit);
- On-site power generating facility (single PLC unit); and
- Central control room in administration building (PLC unit with hot back-up).

4.3.6 MIMIC Panels (Hard Graphics)

MIMIC panels will be installation (Digital meters) of selected measured process variables (crucial variables) as depicted by the process and/or process design engineers. The foregoing indicating devices/instruments, etc. will be driven by the I/O modules of the PLC installed in the administration building. However, each MIMIC panel will be interfaced with its own utility (one panel).

Adequate speed is necessary to improve and insure proper response time, rapid overall dynamic data update, avoid network crashes, adequate service of host computer to each local processing unit, considerable reduction of CPU halt-time and interrupts of the host computer thereby utilizing execution time of the utility in terms of length of runs (Considerably less restriction associated with length of highway), higher communication speed, lower in cost including cost impact on PLC's and installation cost relative to any other highway.

4.3.7 Historical Data Retrieval

Utilizing historical data retrieval unit will assist plant engineers, laboratory personnel, operating/ maintenance personnel considerably. Row and/or manipulated data will be automatically transferred from the hand disc to the historical data retrieval unit.

Additionally, automatic filing system will be adopted. Actual size of this unit will be determined based on real time capacity required by the system with consideration given to additional space for crunched data, manually entered data, etc.

4.3.8 Work Stations

A single engineering/report generating station will also be installed in the Central Control Room. The operator's workstation will mainly be utilized for plant graphics, equipment control, a point of monitoring live/dynamic/station data, alarms, etc. All events historical data retrieval unit and the hard disc drives.

Equipment will be installed on computer grade furniture. The engineering workstations will mainly be used for reports, trending, manual data entry, engineering computations, etc. The third engineering/report generating workstation will be installed in the plant's superintendent's office.

Emergency lighting will consist of emergency lighting for the required minimum illumination and the guiding lamps. Battery supplied D.C. power is suitable for the power source until the plant gas generator is on.

The motor control center and the relay cubicles are divided into individual facility center and relay cubicles such as one set for clarifiers and another for scum screen area. Each motor must be operated manually from the control station located adjacent to the equipment. The control panel will be equipped with switches for operation.

5. MAJOR PLANT BUILDINGS AND UTILITY SERVICES

5.1 GENERAL LAYOUT

Administrative building will consist of several main areas comprising the control room, laboratory, conference room, administrative personnel area, etc.

The garden with vegetation, which along with the shape of the administrative building, contributes to the control of odors coming from the processes buildings.

All the buildings will be of one story type but some of them have double height ceiling as required for the functional and mechanical needs included in that building.

The workers area should include workshop, storage rooms, restrooms, and a cafeteria for workers. The workshop should be related directly to the service road of the lot to permit easy transport of materials and machinery to be repaired.

The service road will be joined through a gate to the entrance for visitors and parking area that may be open for emergency purposes. Only authorized personnel may visit the plant. For vehicles of inspection or visits to the plant, a parking area with the fiberglass type will be provided.

5.2 Architectural Works

The uncovered preliminary facilities could be a source of odors, and as such, trees should be planted alongside the plant fence to help minimize odors. A landscape design is conceived for the whole lot. There should be trees and grasses wherever they do not disturb wastewater treatment processes.

The workers and administrative buildings are to be separated from other buildings, surrounded by roads and communicated with the outside by an entrance. Shrubs and trees should be planted in front of these buildings to help control odor dispersion.

Administrative Building: The largest areas may be covered with concrete slabs. All the areas may have brick walls, natural light and air conditioning. The floor level of this building is raised more than 30 cm from the ground to protect it from flooding.

Office room may have the capacity of twenty (20) persons with air conditioning system, lighting from 300 to 400 lx. With necessary lockers, desks and chairs.

In addition to the space for laboratory, this area may also include restroom and storage room, with air conditioning, natural and artificial light, and necessary desks and water analysis equipment.

Control and electrical equipment room may have air conditioning and ventilation system. Lighting from 400 to 600 Lx, including electric room which is separated by a partition.

Workers Room: This area consists of restroom for operation and maintenance workers with showers and lockers. This room is also raised 30 cm from the ground level.

Depot/Workshop: This room will be for small and big parts of the plant equipment, roof with metallic structure, brick walls, natural light and fans for ventilation. Lighting is 200 Lx. Rooms separated by partitions for tools storage, welding works, electric works, etc.

Generator Room: Main electrical building shall have a floor level raised 30-cm from the planned ground elevation to avoid possible flooding. The building should face a road to permit the flow of machinery. Noise and vibration prevention measures shall be considered. Mechanical ventilation system shall be provided.

5.3 GENERAL CRITERIA FOR THE STRUCTURAL DESIGN

Foundations: The soil study performed under the feasibility study includes a sub-surface survey of the plant site and surrounding areas. A total of four soil test borings, each 30 m deep, were performed within the site in addition to the neighboring area.

All the collected soil samples were tested in the field and laboratory to determine the characteristics of the soils, classify them, analyze their behavior during construction or under constant.

Such recommendations refer to excavation systems, control of groundwater, foundation levels, inclination of slope, coefficient of lateral pressure, bearing capacity, expected settlements, and all aspects that should be considered in the design and construction of the treatment plant facilities.

The floor levels of the various component buildings of the plant will be installed at a minimum level of 30 cm above the site finished mean grade level of 4.7 m above the mean Black Sea water level (M.W.L).

Structures: The main structures of the plant are cylindrical and rectangular tanks in shape; pipes with large diameters; pumping facilities, and buildings for the administration, operation and maintenance purposes.

The detail design of all the structures shall be performed in light of obtaining security, cost savings, water tightness, durability, and easy to construct.

Cement, aggregates, reinforcement steel bars, and concrete mix designs shall be in accordance with the requirements of relevant Romanian Standards or equivalent international standards.

Loads: The following loads shall be considered for the structural design, if applicable:

- Subpressure of groundwater level.
- Lateral earth pressure.
- Hydrostatic lateral pressure.
- Seismic loads - winds.
- Forces due to temperature.
- Forces due to differential in humidity.
- Curing.
- Differential settlements.
- Dead loads.
- Live loads.
- Movable equipment.
- Stationary equipment.

The area is located in a zone of seismic risk. According to the Regulation P100/1992, the area is located in a D-degree seismic area. Determination of seismic loads shall be in accordance with the Regulations, local codes or other accepted standards. Each type and size of structures shall be individually designed depending on its own conditions assigning the factors of security established by the standards.

The circumstances shall be evaluated and considered in the plant structural design. Any stationary equipment shall be taken as dead load except for the torque, impact and vibrations that might occur when rotary equipment is involved.

Design: The basic material for the construction of the plant structures will be the conventional reinforced concrete structures. Long span beams may be applied to the structures, which may be of post-tensioned with high resistance-cables.

The structure design shall follow the Romanian National Standards STAS 4273/83 or equivalent international standards and publications.

Materials: All materials to be considered for the structural and architectural designs shall be subject to the relevant in the Romanian Standards, or other equivalent international specifications.

5.4 PRINCIPAL PLANT FACILITIES

5.4.1 Storm Drainage System

The planned site elevation is 4.7 m above M.W.L. and the site is not subject to 100-year flooding. The only inundation within the site might be of stagnated stormwater. Hence, an appropriate drainage facility should be provided to handle the stormwater runoffs. Surface drainage may be of open channels or conduits installed along the edge of roads and then discharge the stormwater into nearby drains.

5.4.2 Water Supply System

The public water supply distribution system is available for the treatment plant water system. However, to secure stable clean water supply to be used for the process a supplemental new well may be dug.

5.4.3 Sanitary System

Wastewater resulting from public health water usage will be drained into the sewer located within the plant site.

5.4.4 Site Roads and Parking Areas

Roads and parking areas must be paved with the pavement consisting of granular sub-base and base course materials with an asphalt surface.

5.4.5 Grading and Landscaping

Grading will slope away from structures to the open channels or box culverts. Landscaping includes grass for the area around the roads, structures and buildings. Trees and shrubs will be all along the fence of the site limits.

Shallow rooted small shrubs should be planted at areas where pipe systems exist, to avoid possible damages. This will eliminate clogging and damaging of the pipes.

The use of small trees around roads and buildings help to give a human scale to the project because structures are usually high.

5.4.6 Site Security

The site must be closed with a chain link fence or other appropriate means. The entrances will have a gate with hardware locks to have them closed when necessary.

5.4.7 Safety

Guardrails: For walkways located in hazardous areas of the structures, guardrails must be used. Guardrails shall be painted with safety colors of yellow and black.

Lighting: There shall be exterior lighting all-over the site, along roads, near the structures and along the edge of the surrounding of fence.

Lifesavers: There shall be one lifesaver at each deep and uncovered structure such as clarifiers and anaerobic ponds.

Site Signs: A sign identifying the project and the owner should be put at the entrances of the site. A sign system for orientation within the plant, as well as a color code for elements of the buildings will be provided

5.5 Building Utilities

5.5.1 General Requirements

Systems to be considered for the buildings are:

- Ventilation systems to ensure personnel comfort and control of odors;
- Air-conditioning systems to maintain personnel comfort and the best conditions for the electrical and electronic equipment;
- Sanitary and drainage systems;
- Potable water supply system and hot water;
- Storm drainage systems from roof areas;
- Fire protection systems; and
- Ventilation systems to maintain the best conditions of the mechanical rooms.

5.5.2 Design Basis and Criteria

Indoor Design Parameters:

- Offices, Control and Electrical Room

Temperature	20~25 ℃
Humidity	50~55 %

- Machine Rooms

Maximum temperature	35℃
Ventilation.	

Air Changes:

Machine rooms	4 to 6 changes/hour
Work shops	5 to 10 changes/hour
Store rooms	4 to 6 "
Rest rooms and blower building	3 to 6 "

Outdoor Design Parameters:

- Temperature

Maximum temperature	39	℃
Minimum temperature	-28.6	"
Average temperature	11	"

- Precipitation

  426 mm/year (average)
  48 mm/month for summer time (July)

5.5.3 Specific Building Systems

Office Building: Air conditioning may be provided through a central air handling unit. Wash room area may have exhaust fans. Plumbing systems shall include domestic water supply and sanitary systems.

Roof drainage should be connected to the surface drainage system which discharges flows into the drainage system in the plant site.

Maintenance and Storage Building: This building will have exhaust fans for ventilation. The maximum allowable indoor temperature may be 35℃.

Sanitary drainage system and potable water supply system shall be provided. Roof drainage is also connected to the surface drainage system.

Portable fire extinguishers are provided for fire protection.

Power Substation: Stormwater drainage system for the floor shall be provided.

Generator Building: Roof and sanitary drainage systems should be provided. Forced inlet air and forced air exhaust systems should used for this building.

Sludge Pumping Station: Roof and sanitary drainage systems and potable water supply system shall be provided. Portable hand extinguishers for fire protection are to be provided. Forced exhaust air shall be provided at this building.

Aerated Grit Chamber Blower Room: Roof and sanitary drainage and potable water supply systems shall be provided. Portable hand extinguishers for fire protection will be provided. Natural ventilation shall be used.

Water Supply Pump Room: Roof drainage system shall be provided. Portable hand fire extinguishers may be provided. Forced (fan) air exhaust should be installed at this room.

5.5.4 Natural Conditions

Temperature: Highest, minimum and average temperatures in Tulcea City area are as follows:

Highest monthly average temperature (July)	24.0	℃
Lowest monthly average temperature (January)	3.1	"
Annual average temperature	11.0	"
Lowest recorded temperature	-26.8	"

Humidity: Average humidity in Tulcea in summer is 10 to 20 %, and 45 to 50 % in winter.

Wind: Predominant local wind direction is northeast to the southwest. The wind speeds are in the range between 3 and 4.8 m/sec, generally higher in winter and spring.

Table AII.3.1 Lists of Mechanical Equipment of Tulcea WWTP (1/6)

(1) Screening System Equipment

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output(kW)	Remarks
1	Screen channel influent gates	Cast iron made, manually operated sluice gate	1200W x 1200H	2	—		
2	Coarse screens	Manually screened (removable type)	Clear opening 100 mm, 1.6mW x 3.3mH, 60°	2	—		
3	Fine screens	Mechanically-cleaned, (intermittently operated)	Clear opening 20 mm, 1.6mW x 3.3mH	2	0.75	1.5	
4	Grit chamber effluent gates	Cast iron made, manually operated sluice gate	1.2mW x 1.2mH	2	—		
5	Gate for pump well influent channel	Cast iron made, manually operated sluice gate	0.8mW x 0.8mH Design depth 5.0 m	1	—		
6	Screenings conveyors	Trough belt conveyor	0.5 m W x 6 mL	2	1.5	3	
7	Screenings skip hoist	Wire rope operated	$0.3m^3$ x 20mH	1	2.2	2.2	
8	Screenings hopper	Steel made, motor operated	$5m^3$	1	1.5	1.5	
9	Screening hoist	Motor operated hoist with trolley	1t x 6m H x 23mL	1	2.6	2.6	
	Total motor outputs of (1)					10.8	kW

(2) Grit Chamber, Oil Separator, Flow Measurement Equipment

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output (kW)	Remarks
1	Aeration channel Influent gates	Manually operated, cast iron made sluice gate	800mm W x 800mmH Design hydraulic depth; 2 m	2	—		
2	Blowers	Turbo blower	ϕ80mm x $5m^3$/min.	3 (1)	15	30	Standby excluded
3	Grit collectors	Trolley with a grit lifting pump		2	3.8	7.6	
4	Screw conveyors	Lifting of grit from channel to grit hopper		1	2.2	2.2	
5	Aeration chamber effluent channel gates	Manually operated, cast iron made sluice gate	600mm W x 600mm H Design hydraulic depth; 2 m	2	—		
6	Flow measurement equipm	Parshall flume	7-ft. type	1	—		
	Total motor outputs of (2)					39.8	kW

Table AII.3.1 Tulcea WWTP, List of Mechanical Equipment (2/6)

(3) Pumping Equipment (Effluent Pumping Station)

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	otal out put(kW)	Remarks
1	Pumps	Vertical centrifugal mixed pump	400mmΦ x 15m³/min. x 5.5	4 (1)	—		Effluent pumps
2	Electric motors for pumps	Vertical squirrel cage, water proof type	21kW	4 (1)	21	63	Standby excluded
3	Suction valves	Manually-operated sluice valve	400mmΦ	4	—		
4	Check valves	Slow-closing check valve	400mmΦ	4	—		
5	Discharge valves	Motor-operated butterfly valve	400mmΦ	4 (1)	0.2	0.6	Standby excluded
6	Crane for pumps	Manually-operated crane with chain block	3.2 t x 25mH x 7mW x 19mL	1	–		Trolley rails by
7	Main pumps sealing water supply unit	Unit of water supply pump with pressure tank	40mmΦ x 0.1m³/min. x 35m	1	2.2	2.2	With control
8	Pump room floor drain pumps	Submersible pump	65mmΦ x 0.3m³/min. x 25m	2 (1)	3.7	3.7	Standby excluded
9	Floor drain pumps	Submersible pump	65mmΦ * 0.3m³/min. x 10m	2 (1)	1.5	1.5	Standby excluded
	Total motor outputs of (3)					71.0	kW

Table AII.3.1 Tulcea WWTP, List of Mechanical Equipment (3/6)

(4) Primary Clarifiers (4 units)

No.	Equipment	Type	Specifications	Q'ty	Output kW/uni	Total ouput	Remarks
1	Inlet gates	Sluice gate, manual operation, cast iron, circular	φ1,000. Design hydraulic depth, 3m	4	—		
2	Sludge collectors	Rotating type scraper, center column supported	25mΦ x 2.4mH	4	0.75	3	
4	Sludge draw-off valves	Motor operated eccentric valve	200mmΦ	4	0.2	0.8	
5	Raw sludge pumps	Non-clog centrifugal pumps	100mmΦ x 1m³/min. x 10	2 (1)	3.7	3.7	Standby excluded
6	Bypass gates	Manually operated, cast iron made, circular sluice gate	φ2,000mm. Design hydraulic depth, 1.5m	1	—		
7	Raw sludge flow meter	Electro-magnetic flow meter	100mmΦ	1	—		
8	Raw sludge densitomete	Ultra-sonic type		1	—		In electric works
	Total motor outputs of (4)					7.5	kW

(5) Aeration Tanks (8 tanks)

No.	Equipment	Type	Size and Specifications	Q'ty	Output kW/uni	Total output	Remarks
1	Inflow control weirs	Manually-operated adjustable weirs	400W x 600H Design hydraulic depth 1.1 m	8	—		
2	Movable weirs for control of step inflow	Cast iron made, movable weir weirs	400mmW x 600mmH design depth, 1.1m	24	—		
3	Return sludge inflow control weirs	Cast iron made, movable (separate type)	600mmW x 600mmH design depth 1.1m	8	—		
4	Aeration diffusers	Ceramic made diffuser (fine bubble, 300μ)	0.82m³/min. 8plates/holder header	68	—		Holder headers & butterfly valves
5	Air control valves	Air operated butterfly valve	250mmΦ	32	—		Electro-magnetic box
6	Froth spray nozzles	Cast iron made movable type	15mmΦ x 8 l/min. x 1 kg/cm²	262	—		1.5 m interval 49/1.5=33 units/tank
7	Air flow meters	Oriffice	250mmΦ	8	—		Included in electric works
	Total motor output of (5)					0	kW

Table AII.3.1 Tulcea WWTP, List of Mechanical Equipment (4/6)

(6) Final Clarifiers (4 tanks)

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output	Remarks
1	Inlet gates	Sluice gate, manual operation, cast iron	Circular, 1000mmΦ Design hydraulic depth 1.5m	4	—		
2	Sludge collectors	Rotating scraper, central column support	30mΦ x 3.5 m deep	4	0.75	3	
3	Sludge draw-off valves	Motor-operated eccentric valve	200mmΦ	4	0.2	0.8	
4	Return sludge pumps	Non-clog centrifugal	150mmΦx 2.3m^3/min. x 10m	4	7.5	30	
5	"	"	150mmΦx 3.0m^3/min. x 10m	2	11	22	
6	"	"	250mmΦx 8.0m^3/min. x 10m	2	30	60	
7	Excess sludge pumps	"	100mmΦx 1.0m^3/min. x 10m	2 (1)	3.7	3.7	Standby excluded
8	Return sludge flow meters	Electronic-magnetic flow meter	250mmΦ 200mmΦ	2 2	- -		Included in electric works
9	Excess sludge flow meters	Electronic-magnetic flow meter	100mmΦ	2	-		"
10	Return sludge densitometers	Ultra-sonic type	250mmΦ	2	-		"
	Total motor output of (6)					119.5	kW

(7) Chlorine Contact Tank (1tank)

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output	Remarks
1	Influent gates	Manually operated, cast iron, square type	2,000mmW x 2,000mmH design hydraulic depth, 2 m	1	—		
2	Bypass gates	Manually operated, cast iron, square type	600mmW x 600mmH design hydraulic depth, 1.5m	1	—		
4	Hypochlorite supply pump	Diaphragm pump	Discharge 0.5/min. 20mmΦ	3 (1)	0.4	0.8	Standby excluded
5	Hypochlorite storage and supply tank	FRP made	12.4m^3 φ1.4m x 2.0m H	2	—		
	Total motor output of (7)					0.8	kW

Table AII.3.1 Tulcea WWTP, List of Mechanical Equipment (5/6)

(8) Sludge Thickeners (2 tanks)

No.	Equipment	Type	Size and Specifications	Qt'y	Ouput kW/unit	Total output	Remarks
1	Sludge thickeners	Rotating scraper, with pickets	122mΦ x 4.0mH	2	0.4	0.8	
2	Distribution tank, movable weirs	Manually operated, cast iron weir	300mmW	2	—		
3	Sludge draw-off pump	Non-clog centrifugal pump	100mmΦx 0.4m3/min x 20m	2 (1)	15	15	Standby excluded
4	Sludge draw-off valves	Air operated eccentric valve	100mmΦ	4	0.2	0.8	
5	Sludge screen	Drum screen, self cleaning type	2m3/min.	1	0.4	0.4	
	Total of motor outputs of (8)					17.0	kW

(9) Sludge Digestion Facilities (2 tanks)

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output	Remarks
1	Sludge mixer	Draft tube type	Mixing 2,300 m^3/hr or more	2	22	44	Draft tube 500mmΦ
2	Gas collectors	600mmΦ steel constructed dome, dry and wet seels		2	—		
3	Sludge feed pump valves	Motor operated eccentric valve.	150mmΦ	2	0.2	0.4	
4	Scum draw-off valves	Motor operated eccentric valve.	300mmΦ	2	0.4	0.8	
5	Digested sludge draw off telescope valves	Motor operated	200mmΦ	2	0.4	0.8	
6	Sludge circulation draw off valves	Motor operated eccentric valve.	200mmΦ	2	0.2	0.4	
7	Digested sludge draw off valves	Motor operated eccentric valve.	200mmΦ	2	0.4	0.8	
8	Thickened sludge pipe control valves	Motor operated eccentric valve.	150mmΦ	6	2.2	13.2	
9	Seed sludge pipe control valves	Non-clog sludge pump	100mmΦx 1m^3/min x 15m	2	7.5	15	
10	Sludge circulation pumps	Non-clog sludge pump	100mmΦx 1.4m^3/min x 15m	3	5.5	16.5	
11	Sludge heat exchangers	Spriral type		2 (1)	—		
12	Water circulation pump	Line pump	65mmΦ x 0.6m^3/min x 25 m	2	3.7	7.4	
13	Water heater	Vacuum type		2 (1)	8.3	8.3	Standby excluded
14	Gas booster fans	Turbo fan	150m^3/hr x 500mmq	2 (1)	1.5	1.5	Standby excluded
15	Oil service tank	Steel construction	300 L	1	—		
16	Oil pumps	Gear pump	15mmΦ x 10L/min. x 3kg/c	2 (1)	0.4	0.4	Standby excluded
17	Oil storage tank	Underground cylinder type	15,000 L	1	—		
18	Desulfide Gas scrubbers	Dry type	500m^3/hr.	4	—		
19	Gas holders	Dry seal (membrane), steel construction	2,000m^3	2	—		
20	Waste gas burners	Forced air combustion type	200m^3/hr.	1 1	1.5 2.2	1.5 2.2	Cooling fan blower
21	Floor drain pumps	Submersible pump	65mmΦ x 0.3m^3/min. x 10 m	2	1.5	3	
22	Chain block	Geared trolley	1ton	1	—		
23	Total motor outputs of (9)					116.2	kW

Table AII.3.1 Tulcea WWTP, List of Mechanical Equipment (6/6)

(10) Sludge Dewatering Equipment

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output	Remarks
1	Sludge storage tank mixers	Vertical paddle type	1,500mmΦ	2	7.5	15	
2	Sludge feed pumps	Positive displacement pump	100mmΦ x 20m³/hr. x 20m	5 (1)	5.5	22	Standby excluded
3	Sludge filters	Belt filter press	2 m effective belt width, 130kg/ per hour load in dry solid basis	4	2.2	8.8	
4	No.1Cake conveyor	Trough belt	600mmW x 8,500mmL	4	1.5	6	
5	No.2 Cake conveyors	Horizontal trough belt conveyor	600w * 5500L	2	1.5	3	
6	Cake hoppers	Motor operated	10m³	2	3.7	7.4	
7	Chemical containers	Cylinder type	150 L	2	–		
8	Chemical feeders	Volumetric dry feeder	1 L/min.	2	0.4	0.8	
9	Chemical dosage tank	Cylinder type	15m³ capacity with mixer	2	2.2	4.4	
10	Chemical feed pumps	Positive displacement pump	50mmΦ x 3m³/hr x 20m	5 (1)	1.5	6	Standby excluded
11	Chemical container hoists	Motor operated	1 ton	1 1	1.5 0.4	1.5 0.4	
12	Pumps for belt filter cleaning water	Centrifugal pump	50mmΦ x 0.3 m³/min. x 60 m	5 (1)	5.5	22	Standby excluded
13	Maintenance crane	Suspension type	2 ton	1	–		
14	Chain block	Geared trolley type	2 ton	1	–		
15	Floor drain pumps	Submersible non-clog pump	65mmΦ x 0.3m³/min. x 10 m	2	1.5	3	
	Total motor outputs of (10)					100.3	kW

(11) Aeration Tank Blower System

No.	Equipment	Type	Size and Specifications	Qt'y	Output kW/unit	Total output	Remarks
1	No.1 Blowers	Steel made, multi-stage turbo blower	φ350mm/φ300mm 140m³/min.	3 (1)	–		
2	Electric motors for No.1 blowers	Horizontal squirrel cage, water proof		3 (1)	100	200	Standby excluded
3	No.1 blower valves	Electric-operated valve	φ250mm	3 (1)	0.4	0.8	Standby excluded
4	Dry type air filters	Self cleaning type	150m³/min.	3	0.2	0.6	
5	Wet type air filters	Auto rolling type	150m³/min.	3	0.2	0.6	
6	Maintenance crane	Geared trolley type	3 tons	1	–		
	Total motor outputs of (11)					202	kW
	Grand Total of Motor Outputs					**685**	**kW**

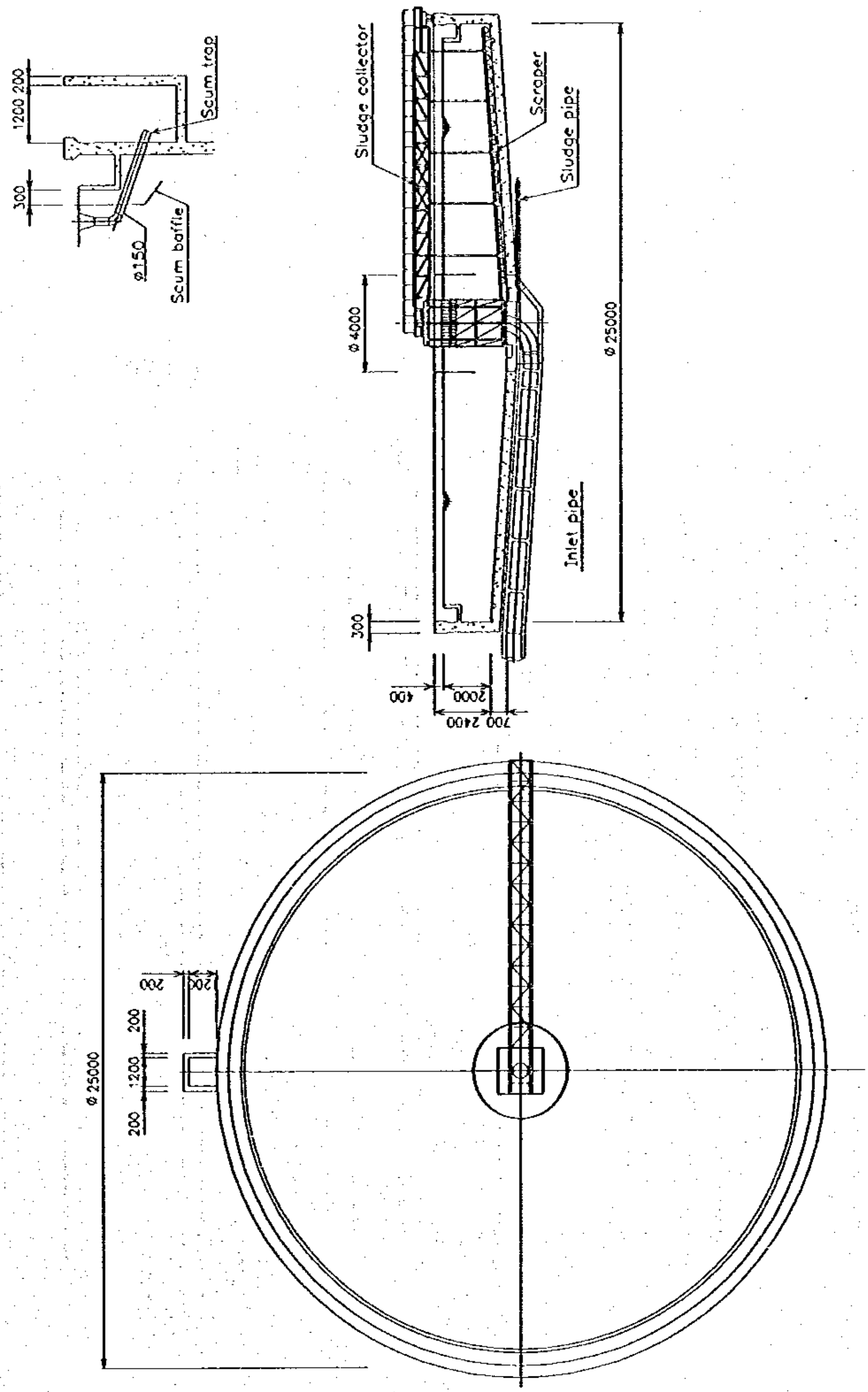


Figure AII.3.1	Primary Sedimentation Tank of Tulcea WWTP

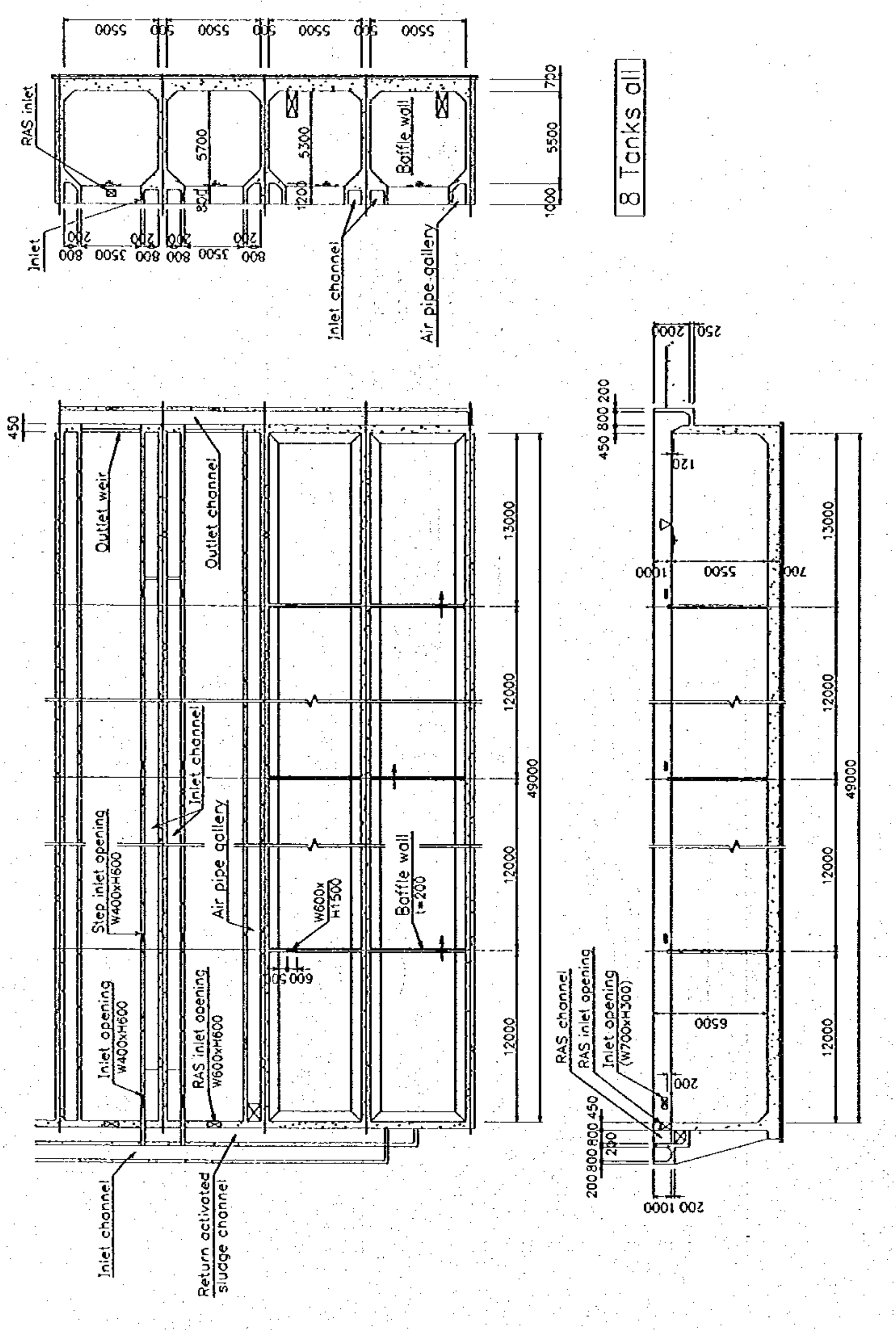


Figure AII.3.2	Aeration Tank of Tulcea WWTP

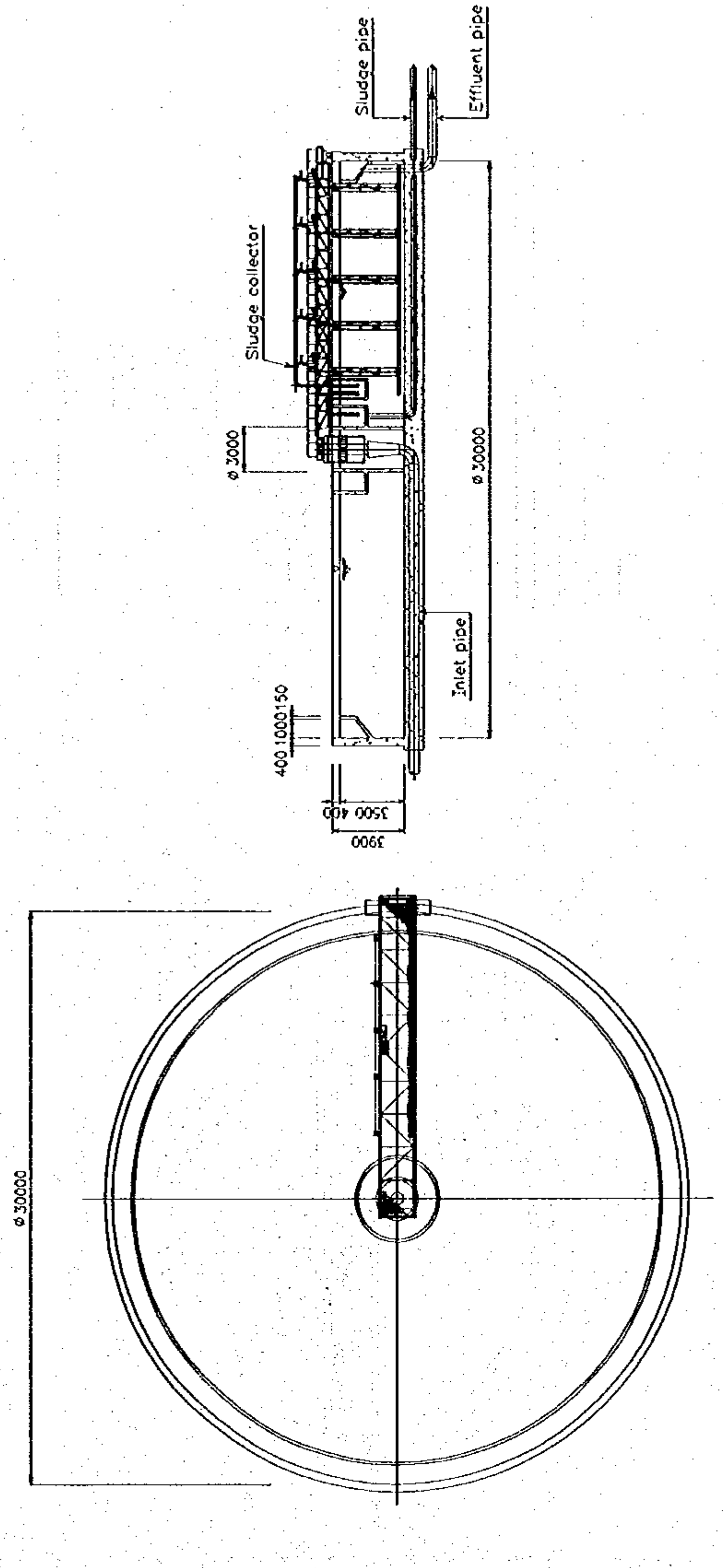


Figure AII.3.3	Final Sedimentation Tank of Tulcea

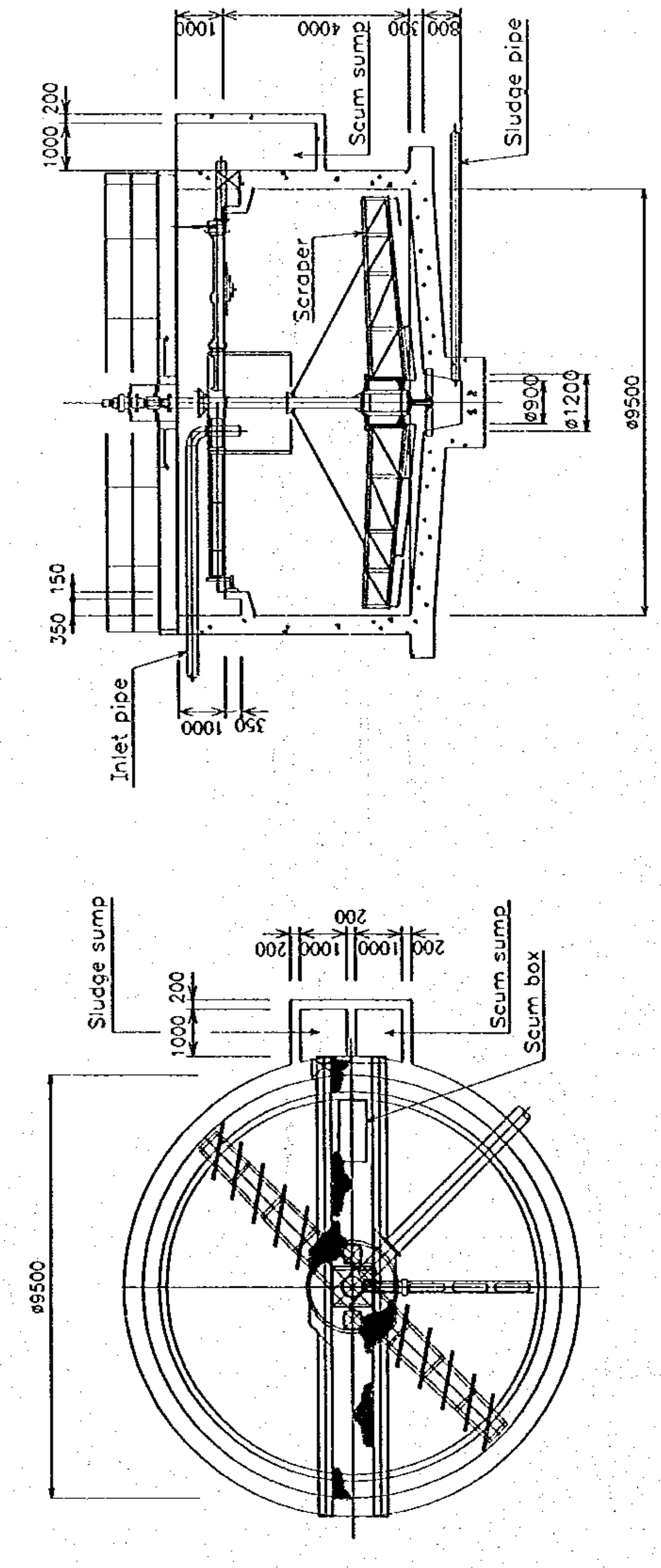


Figure AII.3.4	Sludge Thickener of Tulcea WWTP

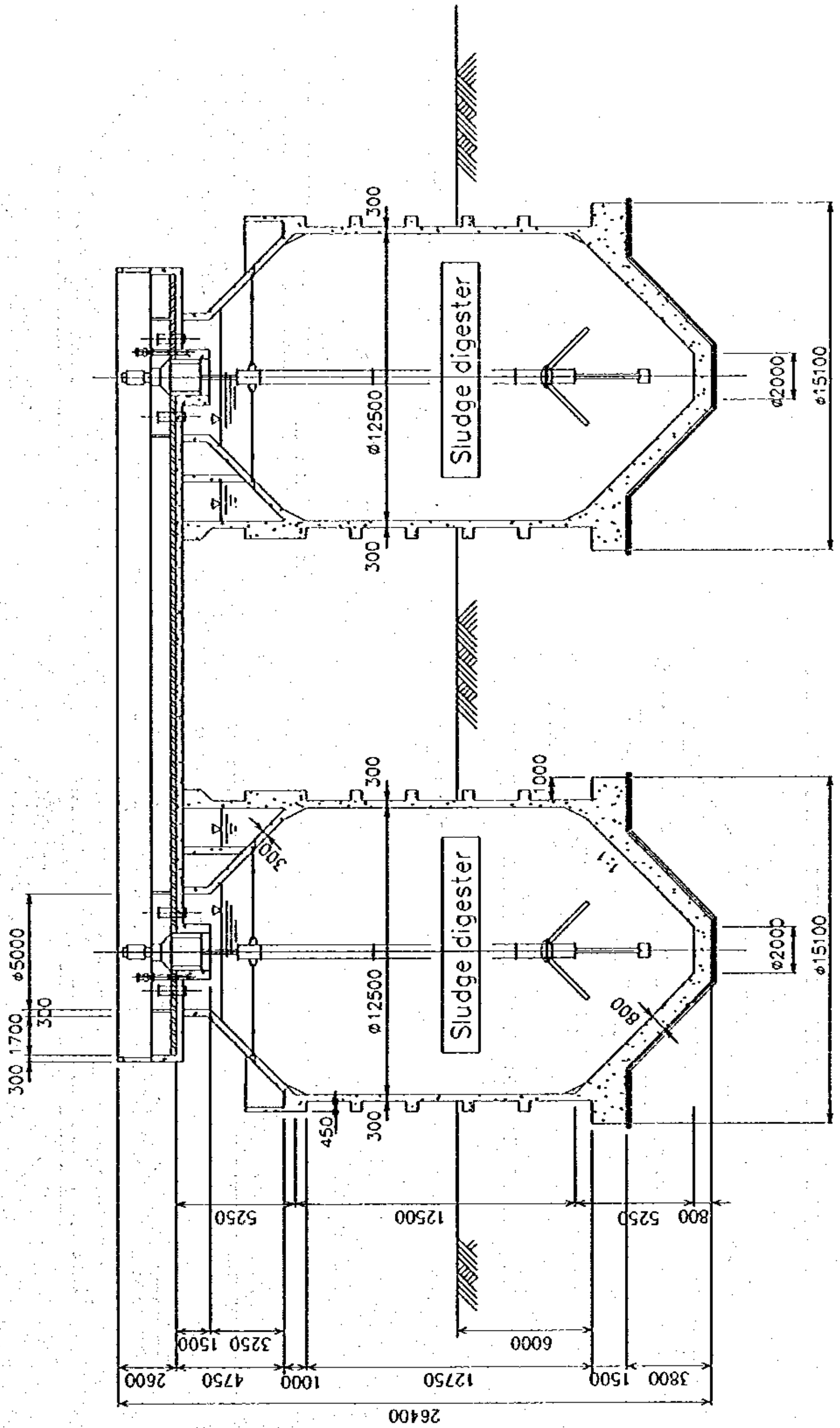


Figure AII.3.5	Sludge Digester of Tulcea

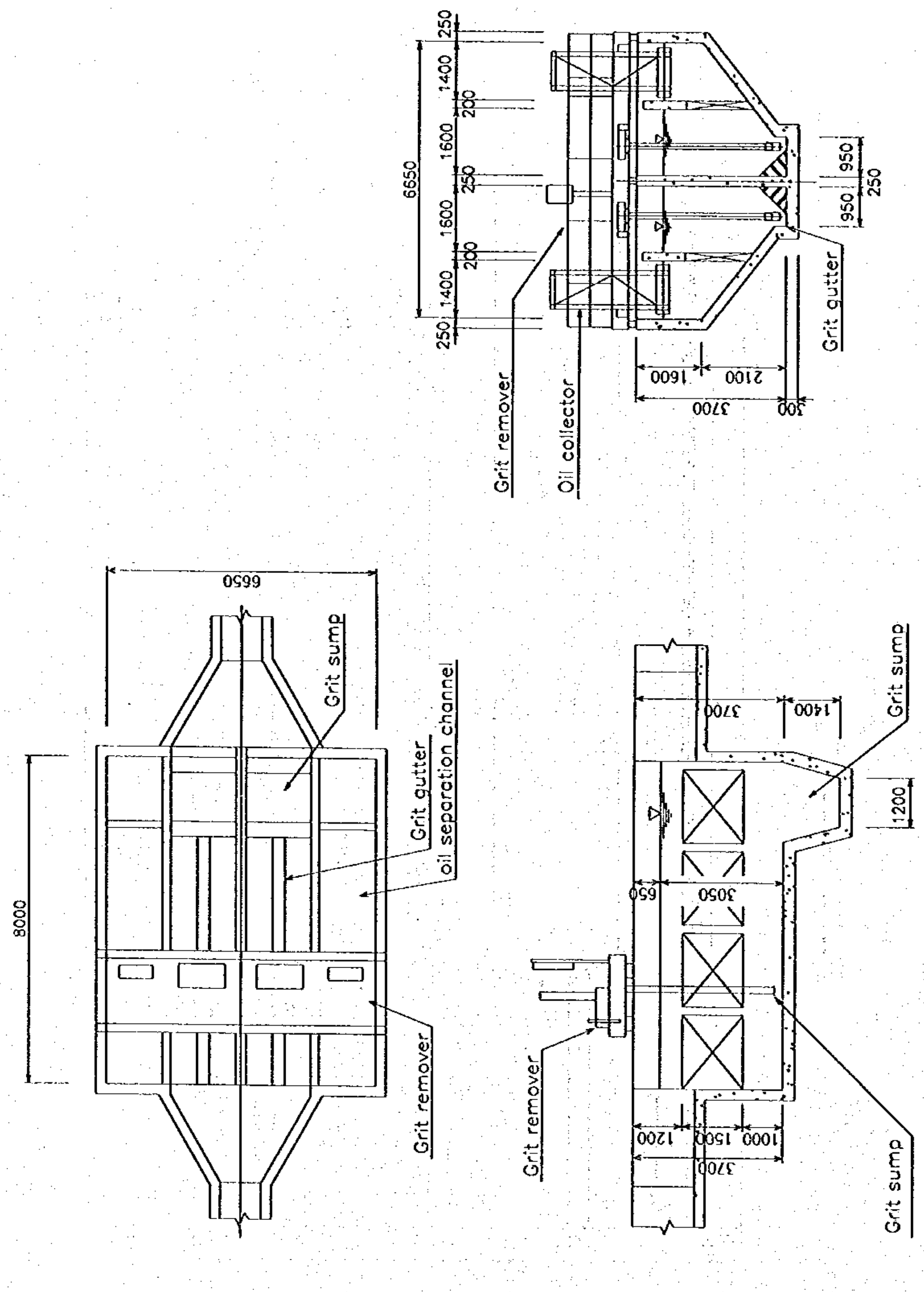


Figure AII.3.6	Grit Chamber and Oil Separator of Tulcea WWTP

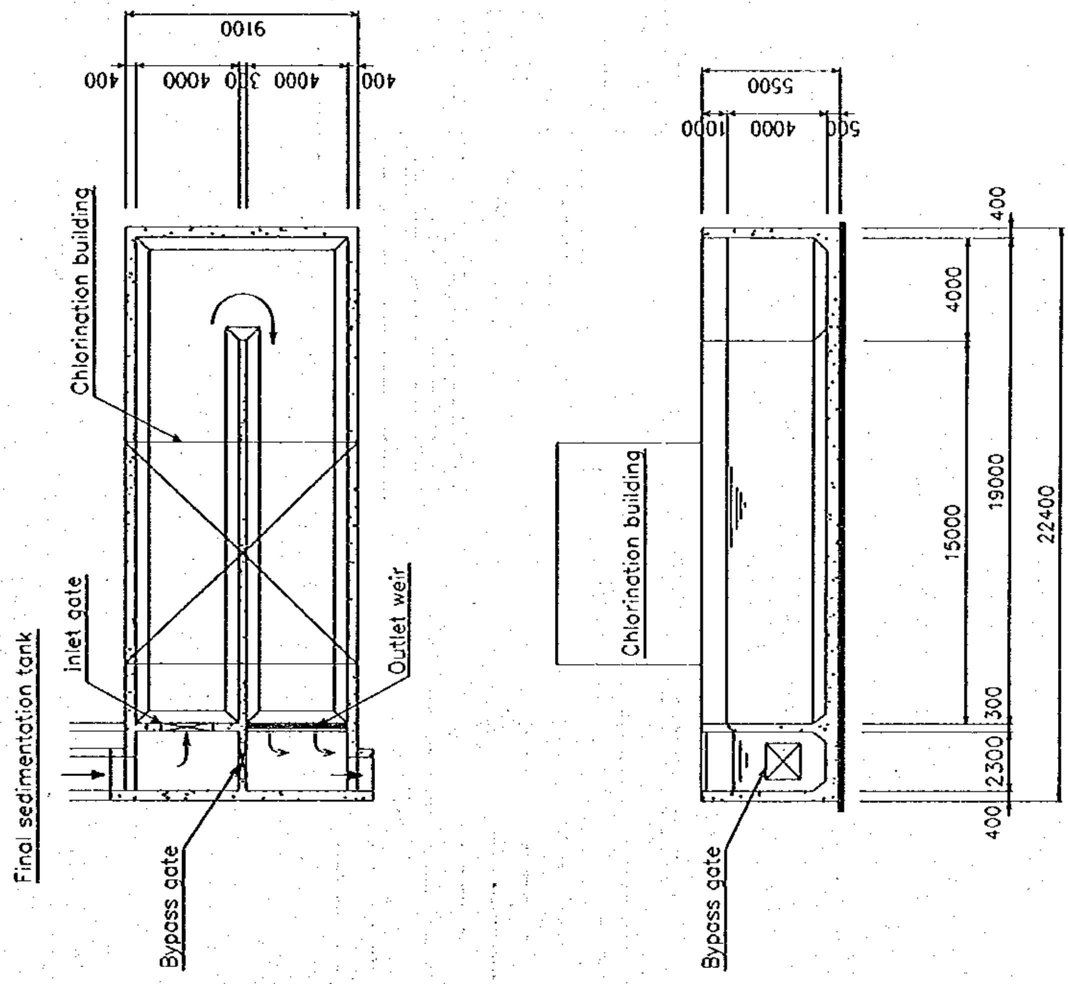


Figure AII.3.7	Chlorination Chamber of Tulcea WWTP

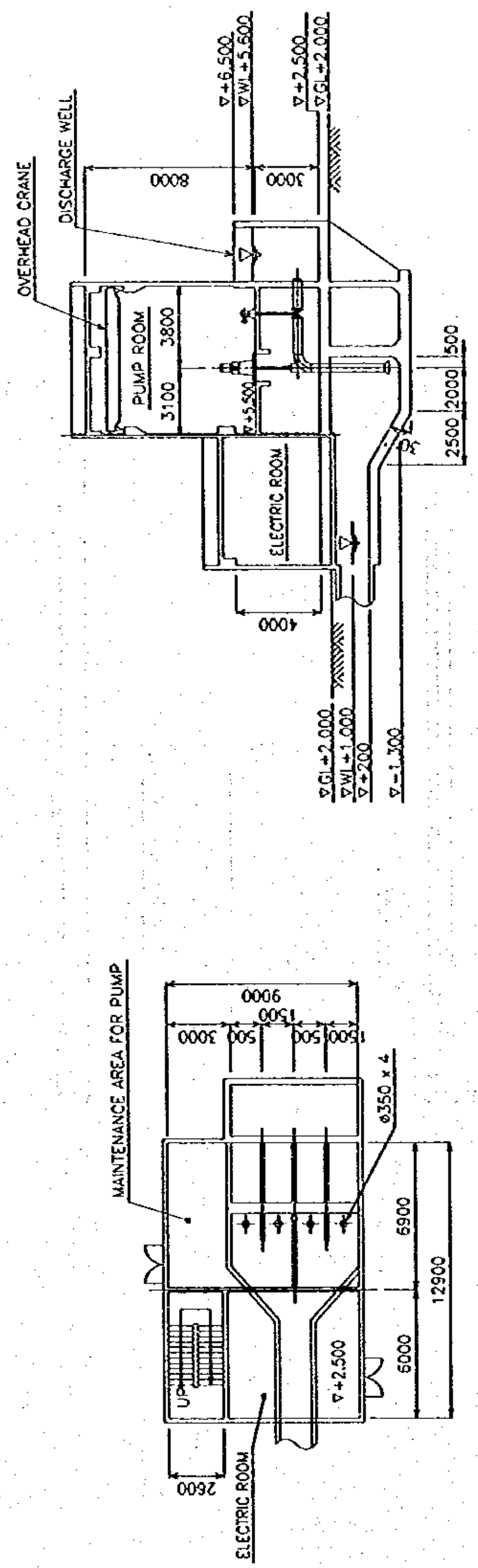


Figure AII.3.8	Effluent Pumping Station of Tulcea WWTP

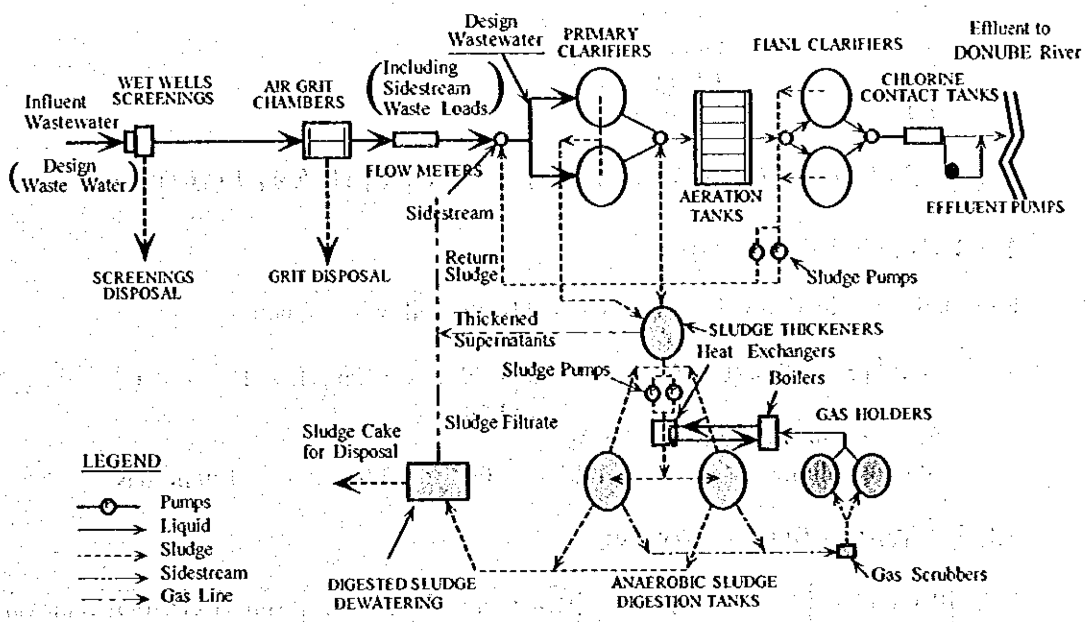
APPENDIX-4 DESIGN CALCULATIONS OF TULCEA WWTP

1. CONVENTIONAL ACTIVATED SLUDGE PROCESS

1.1 DESIGN BASIS

1.1.1 SCHEMATIC OF THE CONVENTIONAL ACTIVATED SLUDGE PROCESS

Schematic of the conventional activated sludge process is shown as follows.



1.1.2 DESIGN WASTEWATER INFLOW RATES

Design wastewater inflow rates are determined as follows.

Average daily flow	Qad	37,000 m³/day	428 L/s
Maximum daily flow	Qmd	43,000 m³/day	498 L/s
Maximum hourly flow	Qmh	53,000 m³/day	613 L/s

1.1.3 DESIGN WASTEWATER QUALITY

Design wastewater quality is determined as follows.

BOD = 130 mg/L
SS = 140 mg/L

1.1.4 DESIGN WASTEWATER QUALITY (INCLUDING SIDESTREAM WASTE LOADS)

Design wastewater quality (including sidestream wastewater loads) is calculated as follows.

BOD = 170 mg/L
SS = 170 mg/L

Parameter	Removal Efficiency (%)			Wastewater Quality (mg/L)		
	Primary treatment	Secondary treatment	Overall removal rate	Raw waste-water	Primary effluent	Secondary effluent
BOD	30	85	89.5	170	119	18
SS	40	80	88.0	170	102	20

1.1.5 POLLUTANT DISCHARGE LIMITS BY NTPA 001

Pollutant discharge limits by NTPA 001 is regulated as follows.

BOD < 20 mg/L
SS < 60 mg/L
T-N < 10 mg/L
T-P < 1.0 mg/L

1.2 CALCULATIONS OF SIDESTREAM POLLUTANT LOADS

1.2.1 RAW SLUDGE VOLUME

Raw sludge production volume is calculated by the following equation.

Solid production (t/day) = $43{,}000 m^3/day \times 140 mg/L \times 10^{-6} \times 0.4$
= 2.408 t/day
Sludge concentration 2.0 %
Sludge volume 2.408 × 100 ÷ 2.0% = 120 m^3/day

1.2.2 WASTE SLUDGE VOLUME

Parameter	Influent quality (mg/L)	Reaction tank influent quality (mg/L)	Primary clarifiers removal Efficiency (%)
BOD	130	91	30
SS	140	84	40

Assuming that the reactor influent S-BOD is 66.7% of the total BOD; then Scs is 60.7 mg/L
Waste sludge production volume is calculated by the following equation:

$$Qw \times Xw = (a \times Scs + b \times Sss - c \times \theta \times XA)Q$$

where,

Qw	Volume of waste sludge (m^3/day)	
Xw	Average SS concentration of waste sludge (mg/L)	
Q	Influent volume to reactors (m^3/day)	43,000
XA	MLSS concentration in reactors (mg/L)	1,660
Scs	Influent soluble-BOD concentration to reactors (mg/L)	60.7
Sss	Influent SS concentration to reactors (mg/L)	84
a	Sludge yield coefficient of S-BOD(mg MLSS/mgSS) 0.4~0.6	0.5
b	Sludge yield coefficient of SS(mg MLSS/mgSS) 0.9~1.00.	0.95
c	Coefficient of SS reduction due to indigenous respiration of activated sludge micro-organisms (L/day) 0.03~0.05	0.04
θ	HRT in reactor basins (day) 6.5 / 24	= 0.27

therefore,

$$Qw \times Xw = (0.5 \times 60.7 + 0.95 \times 84 - 0.04 \times 0.27 \times 1660) \times Q \times 10^{-6}$$
$$= 92.17 \times Q \times 10^{-6} = 3.96 \text{ t/day}$$

Solid production = 3.95 t/day
Sludge concentration = 0.5 %
Sludge production = 3.96 × 100 ÷ 0.5 = 793 m^3/day

1.2.3 THICKENED SLUDGE

Thickened sludge production volume is calculated by the following equation.

Sludge solids = 2.408 + 3.96 = 6.37 t/day
Primary sludge   Excess sludge
Sludge volume = 120 + 793 = 913 m^3/day
(2.0%)   (0.5%)
Solids = 6.37 × 0.85 = 5.42 t/day
Assuming sludge concentration is 3.5 %
Sludge volume = 5.42 × 100 ÷ 3.5 = 155 m^3/day

1.2.4 SLUDGE SUPERNATANT OF THICKENERS

Sludge supernatant of thickeners is calculated by the following equation.

Liquor volume = 913 − 155 = 758 m^3/day
Solids weight = 6.37 × 0.15 = 0.96 t/day
BOD = 758 × 2000 × 10^{-6} = 1.52 t/day
BOD is assumed to be of 2,000 mg/L

1.2.5 DIGESTED SLUDGE

Digested sludge production volume is calculated by the following equation.

Digested sludge solids = 5.42 × (1 − 0.7 × 0.5) = 3.52 t/day
Digested sludge volume 3.0 %
= 3.52 × 100 / 3.0 = 117 m^3/day

1.2.6 DEWATERED SLUDGE(SLUDGE CAKE)

Dewatered sludge production volume is calculated by the following equation.

Solids = 3.52 × 100 / 0.9 = 3.17 t/day
(Assuming 20.0 % solids concentration)
Cake volume = 3.17 × 100 / 20.0 = 16 m^3/day

1.2.7 DIGESTED SLUDGE FILTRATE

Digested sludge filtrated weight is calculated by the following equation.

Filtrate volume = 155 − 16 = 139 m^3/day
Dry solids weight = 3.52 × 0.10 = 0.35 t/day
BOD = 139 × 1,500 × 10^{-6} = 0.21 t/day
(Assumed BOD concentration = 1,500 mg/L)

1.2.8 SIDESTREAM VOLUME AND WASTE LOAD

Sidestream volume and waste load is calculated by the following equation.

Thickener supernatants   Sludge filtrate
Liquor volume = 758 + 139 = 897 m^3/day

Dry solids	=	0.96	+	0.35	=	1.31 t/day
BOD	=	1.52	+	0.21	=	1.72 t/day

1.2.9 WASTEWATER QUALITY (INCLUDING ALL SIDESTREAMS)

Wastewater quality (including all sidestreams) is calculated by the following equation.

Overall wastewater flow = Influent + Sidestreams

Maximum daily flow = 43,000 + 897 = 43,897 m^3/day

Then, the design wastewater flow characteristics are;

BOD = $(43,000 \times 130 \times 10^{-6} + 1.72) / 43,897$

$= 0.0001666 \times 10^{-6} = 167 \rightarrow 170$ mg/L

SS = $(43,000 \times 140 \times 10^{-6} + 1.31) / 43,897$

$= 0.0001669 \times 10^{-6} = 167 \rightarrow 170$ mg/L

1.3 SLUDGE PRODUCTIONS

1.3.1 RAW SLUDGE

Raw sludge production volume is calculated by the following equation.

Solid production (t/day) = 43,000 × 170 × 10-6 × 0.4

= 2.924 t/day

Sludge concentration 2.0 %

Sludge volume 2.924 × 100 ÷ 2.0 = 146 m^3/day

1.3.2 WASTE SLUDGE VOLUME

Parameter	Influent quality (mg/L)	Reaction tank influent quality (mg/L)	Primary clarifiers removal Efficiency(%)
BOD	170	119	30
SS	170	102	40

Assuming that influent S-BOD to reactor basins is 66.7% of the raw wastewater BOD,S-BOD concentration is estimated to be; 79.4 mg/L

Waste sludge production volume is calculated by the following equation.

$$Qw \times Xw = (a \times Scs + b \times Sss - c \times 0 \times XA) Q$$

where,

Qw	Volume of excess sludge (m^3/day)		
Xw	Average SS concentration of waste sludge (mg/L)		
Q	Influent volume to reactors (m^3/day)		43,000
XA	MLSS concentration in reactors (mg/L)		1,667
Scs	Influent soluble-BOD concentration to reactors (mg/L)		79.4
Sss	Influent SS concentration to reactors (mg/L)		102
a	Sludge yield coefficient of S-BOD (mg MLSS/mgSS)	0.4~0.6	0.5
b	Sludge yield coefficient of SS (mg MLSS/mgSS)	0.9~1.00.	0.95
c	Coefficient of SS reduction due to indigenous respiration of activated sludge micro-organisms (L/day)	0.03~0.05	0.04
0	HRT in reactor basins (day)	6.3 / 24 =	0.26

therefore,

$$Qw \times Xw = (0.5 \times 79.4 + 0.95 \times 102 - 0.04 \times 0.26 \times 1667) \times Q \times 10^{-6}$$

= 118.95 × Q × 10^{-6} = 5.11 t/day
Solid production = 5.11 t/day
Sludge concentration = 0.5 %
Sludge production = 5.11 × 100 ÷ 0.5 = 1,023 m^3/day= 0.7 m^3/min.

1.3.3 RETURN SLUDGE

Return sludge volume is calculated by the following equation.

Sludge return ratio 50 %
Return sludge volume = 43,000 × 0.5 = 21,500 m^3/day = 14.9 m^3/min.

1.3.4 GRAVITY SLUDGE THICKENERS

Gravity thickened sludge production volume is calculated by the following equation.

Solids inflow = 2.924 + 5.11 = 8.04 t/day
Primary sludge Excess sludge
Sludge inflow = 146 + 1,023 = 1,169 m^3/day
Thickened sludge solids = 8.04 × 0.8 = 6.43 t/day
Assume solids content to be 3.5 %
Thickened sludge volume = 6.43 × 100 / 3.5 = 184 m^3/day

1.3.5 ANAEROBIC SLUDGE DIGESTERS

Anaerobic digested sludge production volume is calculated by the following equation.

Input solids = 6.43 t/day
Input sludge volume = 184 m^3/day
Volatile solids content of sludge 70 %
Solids destruction rate 50 %
Digested sludge solids = 6.43 × (1 – 0.7 × 0.5) = 4.18 t/day
Assume solids concentration is 3.0 %
Digested sludge volume = 4.18 × 100 / 3.0 = 139 m^3/day

1.3.6 SLUDGE DEWATERING

Dewatered sludge production volume is calculated by the following equation.

Input solids = 4.18 t/day
Recovered solids (90%) = 4.18 × 0.9 = 3.76 t/day
Assuming solids concentration as 20.0 %
Sludge cake volume = 3.76 × 100 / 20.0 = 19 m^3/day

1.4 COMPONENT OF FACILITIES

1.4.1 PRIMARY CLARIFIERS

Primary clarifiers specifications are calculated by the following equation.

Average daily flow, Qad = 37,000 m^3/day
Maximum daily flow, Qmd = 43,000 m^3/day
Maximum hourly flow, Qmh = 53,000 m^3/day
Hydraulic surface load rate = 35 m^3/m^2·day
Totally 2 clusters, each consisting of 2 tanks, total number of basins is 4 units

Hydraulic load on each basin is 43,000 ÷ 4 = 10,750 m^3/day/basin
Required surface area of each basin = 10,750 ÷ 35 = 307 m^2

(1) Tank Geometry (In accordance with the Romanian Standards),

Internal diameter 25 m
Effective depth 2.0 m
Number of basins 4 basins
Surface area of a basin 423 × 4 = 1,692 m^2
Hydraulic capacity of a basin 1,692 × 2 = 3,384 m^3
Check for hydraulic conditions of basins under the different flow rates.
Retention time
3,384 × 24 / 43,000 = 1.89 hours > 1.5
Surface load rate
43,000 / 1,692 = 25.4 $m^3/m^2 \cdot$day < 35

(2) Raw Sludge Pumping Equipment

The pumps will handle the mixture of primary and excess sludge having solids concentration of 2%.

Sludge solids8.04 t/day, Solids concentration 2 %
Sludge volume 402 m^3/day = 0.28 m^3/min.
Pump type: Centrifugal screw pump
Pump bore size: 100 mm
Delivering capacity: 1 m^3/min.
Total dynamic head: 10 m
Number of pumps: 3 Units (including 1 standby)

1.4.2 REACTOR TANKS

Reactor tanks specifications are calculated by the following equation

Design flow, Qmd = 43,000 m^3/day
BOD−SS load 0.30 kgBOD/kg SS day
MLSS 1,667 mg/L
Return sludge solids concentration 5,000 mg/L
Sludge return ratio = 1,667 ÷ (5,000 − 1,667) = 0.50
Inflow BOD to reactors 43,000 × 170 × 10^{-3} kg BOD/day × (1 − 0.3)
= 5,117 kg BOD/day
Reactor tanks SS = V × 1,667 × 10^{-3} kgMLSS
Required tank capacity = 5,117 ÷ 1.667 ÷ 0.30 = 11,371 m^3
Aeration time = 11,371 × 24 ÷ 43,000 = 6.3 hours
At Qmd, aeration time of 6 hours or more is secured.
Required tank capacity = 6 × 43,000 ÷ 24.00 = 10,750 m^3
Tank geometry
Width = 5.5 m
Effective depth = 5.5 m
Cross sectional area = 5.5 × 5.5 − $1/2 \times 1.0^2 \times 2$ − $1/2 \times 0.6^2 \times 2$
= 29 m^2
Number of tanks = 4 tanks 2 clusters 8 tanks
Capacity of one tank = 11,371 ÷ 8 = 1,421 m^3
Tank length = 1,421 ÷ 29 = 49.01 use 49 m

Tank geometry			
W	5.5 m	×	8 Tanks
L	49 m		
H	5.5 m		

Check of aeration time
Tank capacity = 29 × 49 × 8 = 11,368 m^3
Aeration time = 111,368 × 24 / 43,000 = 6.3 hours

Check for additional tank requirement to upgrade the process

Additional tank capacity required for the advanced treatment process will be provided by adding tanks to the conventional activated sludge aeration tanks. The wastewater inflow will be distributed both to the existing and additional tanks. The wastewater will be distributed in proportion to the treatment capacity of both trains.
The total detention time will be 12.3 hours.
As the detention time in the conventional treatment process is 6.3 hours, the required retention time for additional tanks is

12.3 − 6.3 = 6.0 hours

Check capacity and wastewater distribution ratio
Existing tanks 6.3 / 12.3 = 0.516
Additional tanks 6.0 / 12.3 = 0.484
Wastewater flow distribution rates
Existing tanks 43,000 × 0.516 = 22,181 m^3/day
Additional tanks 43,000 × 0.484 = 20,819 m^3/day

Additional Reactor Tanks
Required tank capacity = 43,000 × 6.0 ÷ 24 = 10,670 m^3
Number of tanks = 4 tanks 2 clusters 8 tanks
Tank capacity = 10,670 ÷ 8 = 1,334 m^3
Tank length = 1,334 ÷ 29.00 = 46.0 use 46 m

Tank geometry			
W	5.5 m	×	8 Tanks
L	46 m		
H	5.5 m		

Check retention time
Tank capacity = 29 × 46 × 8 = 10,672 m^3
Retention time = 10,072 × 24 / 43,000 = 6.0 hours

1.4.3 FINAL CLARIFIERS

Final clarifieres specifications are calculated by the following equation.

Design flow QD = 43,000 m^3/day
Surface load rate = 25 $m^3/m^2\cdot$day
2 clusters each consisting of 2 tanks, total tank number is : 4 tanks
Influent to each tank = 43,000 ÷ 4 = 10,750 m^3/day/tank
Required surface area of each tank = 10,750 ÷ 25 = 430 m^2

(1) Check by the Romanian Standards

Internal diameter 30 m

Effective depth 3.5 m
Tank numbers 4 basins
Surface area 616 × 4 = 2,464 m^2
Capacity 2,464 × 3.5 = 8,624 m^3
Surface load rate 17 $m^3/m^2 \cdot day$
Retention time
At Qmd 8,624 × 24 / 43,000 = 4.81 hours
Qv=Qmh + Qrmax = 53,000 + 21,500 = 74,500 m^3/day
8,624 × 24 / 74,500 = 2.78 > 2.0
Surface load rate
At Qmd 43,000 / 2,464 = 17 $m^3/m^2 \cdot day$ < 25
At Qv 74,500 / 2,464 = 30.2 $m^3/m^2 \cdot day$ < 52.8
Weir loading
Weir length L = π × 23.5 × 4 = 295 m
At Qmd 43,000 / 295 = 146 $m^3/m \cdot day$
At Qv 74,500 / 295 = 252 $m^3/m \cdot day$
As compared with the Japanese Standards, the weir loading appears to be high side. The weir length may be increased in detailed design.

(2) Check for Advanced Treatment

The advanced treatment will be performed through two trains, existing and advanced treatment process trains.
The wastewater will be distributed to each train in proportion to the reactor tanks hydraulic retention time.

Wastewater distribution
Existing train 22,181 m^3/day
Additional train 20,819 m^3/day
Check for additional tanks
Surface load rate 15 $m^3/m^2 \cdot$ day or lower
Cluster 2 with 2 tanks, then total tank number is 4 units
Flow rate to each tank 20,819 ÷ 4 = 5,205 m^3/day.tank
Required surface area of each tank = 5,205 ÷ 15 = 347 m^2
D = 30 − 2.3 = 27.7 m
According to Romanian Standards A = 0.785 × $(D^2 - 3^2)$ = 595 m^2
Diameter 30 m
Effective depth 3.5 m
Number of tanks 4 units
Water surface area 616 × 4 = 2,454 m^2
Capacity 2,464 × 3.5 = 8,624 m^3
Overflow rate 8.4 m^3/m^2/day
Check the existing tank overflow rate
20.819 / 2,464 = 8.4 m^3/m^2/day < 15

(3) Return Sludge Pumps

Return sludge pumps are specified as follows.

Average 50 % sludge return rate is considered, but pump capacity 100 % return rate is provided to prevent and restore sludge bulking.
Return sludge volume = 21,500 m^3/day = 15 m^3/min.
60 % and 40 % of sludge will be transported by 4 and 2 pumps respectively, through double pipelines.
Pump capacity 7.5 × 0.25 = 1.87 use 1.9 m^3/minute/unit

" 7.5 × 0.50 = 3.73 use 3.8 m^3/minute/unit

By operating above pumps, the return sludge rates can be adjusted at the order of 5% to 15 %.

Pump type	No.1 Screw centrifugal	No.2 Screw centrifugal
Diameter	150 mm	200 mm
Capacity	1.9 m^3/min.	3.8 m^3/min.
TDH	10 m	10 m
Number of pumps	4 units	2 units
Motor output	7.5 kW	11 kW

(4) Excess Sludge Pumps

Excess sludge pumps are specified as follows.

Excess sludge volume = 1,023 m^3/day = 0.7 m^3/min

Two lines will be provided, then the capacity of a pump = 1.02 m^3/min

Type of pump	centrifugal sludge pump
Diameter	100 mm
Capacity	1.0 m^3/min
TDH	10 m
Number of pumps	2 units (1-standby)
Motor output	3.7 kW

(5) Chlorine Contact Tanks

Chlorine contact tanks specifications are calculated by the following equation.

Design flow rate = 43,000 m^3/day

Chlorine contact time = 15 minutes

Required tank capacity: 43,000 ÷ 1,440 × 15 = 448 m^3

Channel width: 4.0 m

Effective depth: 3.0 m

Tank length: 447.9 ÷ 4.0 ÷ 3.0 = 37.3 m → 38 m

Number of tanks 1 unit

Chlorine contact tank geometry
W 4 m × H 4 m × 1 Tank
L 38 m

1.5 ANAEROBIC SLUDGE DIGESTERS

1.5.1 Sludge Thickeners

(1) Hydraulic Capacity of Tanks

Hydraulic capacity of tanks are specified as follows.

Solids input	= 8.04 t/day
Input sludge volume	= 1,169 m^3/day
Output sludge volume	= 184 m^3/day
Floor loading	= 60 kg/m^2/day
Required surface area	= 134 m^2
Tank geometry	Circular radial flow type
Internal diameter	= 9.5 m

Effective depth	=	4 m
Number of tanks	=	2 units
Water surface area	$3.14 / 4 \times 9.5^2 \times 2 =$	142 m^2

(2) Sludge Withdrawal Pumps

Sludge withdrawal pumps are specified as follows.

The pumps will have capacities that can send thickened sludge in around 8 hours.

Pump capacity	$Q = 184 \times 1/8 \times 1/60 = 0.38 m^3/min.$
Pump	Sludge pump with suction screw
Diameter	100 mm
Discharge capacity	1.20 m^3/min.
TDH	20 m
Motor output	15 kW
Number of pumps	2 units(including one standby)

(3) Sludge Screens

Sludge screens are specified as follows.

Type	Rotary drum screen
Screen opening	4 mm
Capacity	2 m^3/min.
Motor output	0.4 kW
Number of screens	1 unit

Screen capacity is so determined that the sludge quantity being sent concomitantly from 2 raw sludge pumps (each q = 1.0 m^3/min.) can be screened.

1.5.2 Anaerobic Sludge Digestion Tanks

(1) Hydraulic Capacity of Tanks

Hydraulic capacity of tanks are specified as follows.

Sludge solids input	=	6.43 t/day
Input sludge	=	184 m^3/day
Detention time		20 days
Tank temperature		35 °c
Required tank capacity		$184 \times 20 = 3,675 m^3$

(2) Tank Geometry

Tank geometry is specified as follows.

Type	Single stage digestion
Internal diameter	12.5 m
Effective tank depth	21 m
Number of tanks	1 clusters × 2 tanks
Capacity	2,015 m^3/tank , 4,030 m^3 total tank capacity

1.5.3 Gas Storage Tanks

(1) Capacity of Tanks

Capacity of tanks are calculated by the following equation.

Total solids input to digesters = 6.43 t/day

Assuming that 70 % of the input sludge solids are volatile, and 1 kg of which produce 0.425 m^3 gas, the total gas production can be estimated as follows:

Total gas production = 6.43 × 0.7 × 10^3 × 0.425 = 1,913 m^3/day

Storage time 8 hours

Tank storage capacity = 1,913 × 8 / 24 = 638 m^3/day

(2) Tank Geometry

Tank geometry is specified as follows.

Type	Dry-seal type steel tanks
Number of tanks	2 units
Diameter	11.6 m
Effective height	9.2 m
Storage capacity	1,000 m^3

1.5.4 MECHANICAL SLUDGE DEWATERING

(1) Filter Capacity

Filter capacity is calculated by the following equation.

Solids input = 4.18 t/day , Input sludge volume 139 m^3/day

Belt press filter

Yields per unit length	130 kg/m/hr
Filter width	2 m
Daily operation time	6 hr
Working days/week	5 day

Solids loads per hour = 4.18 × 7 / 5 × 10^3 / 6 = 975 kg/hr

Required number of belt press = 975 / 130 / 2 = 4 use → 4 units

Type	:	Belt filter press
Filter loading rate	:	130 kg/m/hr
Filter width	:	2 m
Number of filters	:	4 unit

1.6 CHLORINE REQUIREMENTS

Required quantity of hypochlorite solution is calculated by multiplying the dosing rate by the wastewater flow rate as shown in the following equation:

$$VR = Q \times R \times (100 / C) \times (1 / d) \times 10^{-3}$$

where

VR	Required hypochlorite solution (L / hr.)
Q	Wastewater flow rate (m^3 / hr)
R	Chlorine dosing rate(mg / L)
C	Effective chlorine concentration in chemical (%)
d	Specific gravity of hypochlorite solution (at the effective concentration ofC %)

At the maximum daily flow rate, the required hypochlorite solution is:

Q	=	$43{,}000\ m^3/day$	=	$1{,}792\ m^3/hr$								
R	=	3 mg/L										
C	=	10 %										
d	=	1.2										
VR	=	Q	×	3	×	(100 / 10)	×	(1 / 1.2)	$\times 10^{-3}$			
	=	0.036	×	Q	=	65 L/hr.	=	1 L/minute				

(1) Hypochlorite Solution Storage Tanks

Hypochlorite solution storage tanks are specified as follows.

8 days storage capacity for the maximum daily flow rate. Then, the capacity is:

$V = 0.065\ m^3/h \times 24 \times 8 = 12.4\ m^3$

Tank specifications

Type	FRP made cylinder type
Internal diameter	1.8 m
Height	2.9 m
Capacity	$6\ m^3$
Number of tanks	2 units

(2) Dosing Pumps

Type	Diaphragm
Diameter	20 mm
Discharge	0.5 L/min..
Motor output	0.4 kw
No. of unit	3 units (including 1 standby)

1.7 DIGESTER HEATING SYSTEM

1.7.1 TEMPERATURE

Lowest daily average temperature	0 °c
Soil temperature	15 °c
Input sludge temperature	10 °c
Digester tank temperature	35 °c

1.7.2 REQUIRED CALORIES FOR SLUDGE HEATING SPECIFIC HEAT 1.0 KCAL/KG·°C

Required calories for sludge heating specific is calculated by the following equation.

$Q = 184 \times (35 - 10) \times 103 \times 1.0 = 4{,}593{,}711$ Kcal/d

1.1.6 1.7.3 HEAT LOSSES TANK INTERNAL DIAMETER 12.5 M

(1) Surface Area of the Digestion Tank

	Internal diameter	12.5	m
	r	R	h
Top slab (gas portion)	1.00	3.00	2.0
A1		38.7	m^2
Top slab(liquid portion)	3.00	6.25	5.75
A2		133.5	m^2
Side wall(above ground)	6.25	6.25	9.50
(down to 1m below ground) A3		372.9	m^2
Side wall(underground)	6.25	6.25	2.50
(up to 1m from surface) A4		98.1	m^2
Bottom slab	1.00	6.25	7.75
A5		172.2	m^2

A1 = 35.5(side) + 3.14(top, r) = 38.67
A2 = 133.5 , A3 = 372.9 , A4 = 98.1 , A5 =169.0 + 3.14 = 172.2

(2) Overall Thermal Conductivity Coefficient (kcal/m², °c /hr)

	RC thicknes s (m)	Water proof motor	Insulation (polyurethane foam)	Concrete block	Spray concrete	Gas portion	Internal α 1(thermal conductivity)	External α 2(thermal conductivity)	K
	(λ=1.4)	(λ=1.2)	(λ=0.22)	(λ=1.0)	(λ=1.4)	(λ=0.48)			
Roof slab(gas portion)	0.3	0.03	0.04				20	20	0.464k1
Roof slab(liquid portion)	0.3	0.03	0.04				300	20	0.474k2
Upper side walls (1m underground or higher)	0.3		0.04	0.15		0.26	300	20	0.360k3
Lower sidewalls (1m underground or lower)	0.3						300	5	2.395k4
Bottom slab	0.8				0.1		300	5	1.182k5

The overall thermal conductivity coefficient can be calculated by the following equation:

$$1/K = 1/\alpha_1 \times \delta_1/\lambda_1 + \delta_2/\lambda_2 + 1/\alpha_2$$

where

K Overall thermal conductivity coefficient (kcal/m² °c·hr.)

α_1 Thermal conductivity coefficient of gas or sludge (kcal/m² °c·hr.)
1 / k1 = 2.16 k1 = 0.464

α_2 Thermal conductivity coefficient of air or ground (kcall/m² °c·hr.)
1 / k2 = 2.11 k2 = 0.474

λ_1, λ_2 Thermal conductivity coefficient of insulation material (kcall/m²·°c·hr.)
1 / k3 = 2.78 k3 = 0.360

δ_1, δ_2 Thickness of insulators (m) 1 / k4 = 0.42 k4 = 2.395
1 / k5 = 0.85 k5 = 1.182

(3) Overall Heat Losses

Portion of tank	Heat transfer area	Thermal conductivity coefficient	Number of tanks	Difference of temperature	Total heat losses
	(m²)	(Kcal/m²/°c/hr)	(unit)	(°c)	
Roof slab(gas portion)	38.67	0.464	4	35	2,509
Roof slab(liquid portion)	133.5	0.474	4	35	8,854
Upper sidewalls(1m under ground above)	372.9	0.360	4	35	18,795
Lower sidewalls (up to 1m below ground surface)	98.1	2,395	4	35	32,895
Bottom slab	172.2	1.182	4	35	28,484
				Total	91,537

Overall heat losses = 91,537 Kcal / hr

1.7.4 HEATING SYSTEM

24 hours continuous heating. A total of 20 % heat losses from pipes are considered.

4,593,711 / 24 + 91,537 × 1.2 = 301,249 Kcal / hour

Efficiency of water heater 0.9

301,249 / 0.9 = 334,721 Kcal / hour

Water heater

450,000 Kcal / hr × 2 units (including 1 standby)

1.8 ANAEROBIC SLUDGE DIGESTION SYSTEM

1.8.1 DIGESTION TANK

Hydraulic capacity of tanks are specified as follows.

Solids input = 184 m³/day
Detention time 20 days
Temperature 35 °c
Required tank capacity 184 × 20 = 3,675 m³

1.8.2 TANK GEOMETRY

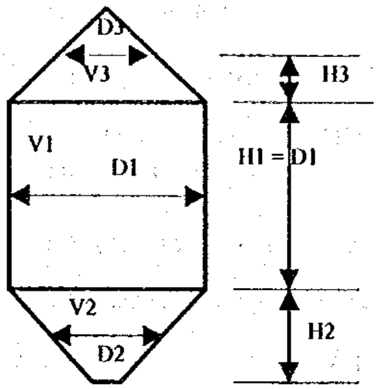
Tank geometry is specified as follows.

Type single stage tank
Internal diameter 12.5 m
Effective tank depth 21 m
Number of tanks 2 clusters 4 tanks
2,015 m³/tank D1 = 12.5 m
(1,837 m³/ tank or larger) D2 = 2 m
D3 = 6 m

1.8.3 TANK CAPACITY

Tank capacity is calculated by the following equation.

Effective depth		12.5 m	Portion V1
"		5.25 m	Portion V2
"		3.25 m	Portion V3
Total		21m	
V1	=	$\pi / 4 \times D^2 \times D$	
	=	$\pi / 4 \times D^3$ =	1,533 m^3
V2	=	$\pi / 4 \times D^2 \times (D/2) / 3$	
		$- \pi / 4 \times D2^2 \times (D2/2) / 3$	
	=	$\pi / 4 / 6\ (D^3 - D2^3)$	
	=	254 m^3	
V3	=	$\pi / 4 / 6\ (D^3 - D3^3)$	
	=	227 m^3	
		V total	2,015 m^3



1.9 REQUIRED OXYGEN

Required oxygen is calculated by the following equation.

Required O_2 : OD = OD_1 + OD_2 + OD_3
where
OD_1 : Oxygen required for BOD oxygenation (cell synthesis)
OD_2 : Oxygen required for endogenous respiration
OD_3 : Oxygen to be utilized for maintaining required dissolved oxygen level

1.9.1 REQUIRED OXYGEN FOR BOD OXIDATION(CELL SYNTHESIS) : OD1(KGO_2/DAY)

OD1 = A(kgO_2/kgBOD) × BOD removed (kg BOD/day)
where
A : kg oxygen required to remove kg BOD (kgO_2/kgBOD), 0.5~0.7 → 0.6
Q = 43,000 m^3/day
OD_1 = 0.6 × Q × 101.2 × 10^{-3} = 0.0607 Q kgO_2/day
Influent BOD = 119 − 18 = 101.2 mg/l

1.9.2 OXYGEN REQUIRED FOR ENDOGENOUS RESPIRATIONOD_2(KGO_2/DAY)

OD_2 = B(kgO_2/kgMLVSS·day) × VA(m^3) × MLVSS(kgMLVSS/m^3)
where
B : Oxygen consumption due to endogenous respiration per unit MLVSS 0.05~0.15
(kgO_2/kgMLVSS·day) 0.05
VA: Capacity of aerobic portion of reactor(m^3) Q × 6 ÷ 24 = 0.25 Q
MLVSS/MLSS = 0.8
OD_2 = 0.05 × 0.25 × Q × 1,500 × 10^{-3} × 0.8
= 0.0150 Q kgO_2 / day

1.9.3 REQUIRE OXYGEN TO MAINTAIN DISSOLVED OXYGEN LEVEL: OD3(kgO_2/DAY)

OD_3 = COA × Q × 10^{-3}

where COA : Aeration tank dissolved oxygen 1.5 mg/l concentration

Return sludge ratio R = 0.5

OD_3 = 1.5 × (1 + 0.5) Q × 10^{-3}

= 0.00225 Q kg O_2/day

1.9.4 TOTAL OXYGEN REQUIREMENTS

OD = OD_1 + OD_2 + OD_3

= 0.0607 Q + 0.015 Q + 0.00225 Q = 0.0779 Q (kgO_2/day)

1.9.5 AERATION EQUIPMENT (DIFFUSERS, FINE BUBBLES, SPIRAL FLOW)

Aeration equipment is calculated by the following equation.

EA = 7.5, ρ = 1.293, Qw = 0.233

Air volume (N m^3/day)

= (Required oxygen(KgO_2)) / (EA(%) × 10^{-2} ×ρ(air/Nm^3) × Qw(kgO_2/kg air))

= (0.0779 Q) / (7.5 × 0.01 × 1.293 × 0.233)

= 3.45 Q = 148,325 (Nm^3/day) = 103 (Nm^3/min.)

Install one blower for each train

Required blower capacity 103 ÷ 2 = 52 m^3/tank·unit

Blower spec.	Cast-iron made multi-stage turbo blower
Inlet/outlet diameters	ϕ200 / ϕ200
Capacity	50 m^3/min.
Motor output	37.5 kW
Number of units	3 units (including 1 standby)

1.10 SCREENS AND PUMPING STATION

1.10.1 FLOW RATE

Flow rate is determined as follows.

Qad	37,000 m^3/day	428 L/s
Qmd	43,000 m^3/day	498 L/s
Qmh	53,000 m^3/day	613 L/s

1.10.2 INCOMING SEWER

Incoming sewer is specified as follows.

Friction formula	Manning (n= 0.013)
Size of incoming sewer	ϕ 1,000 mm
Sewer slope	1.2 ‰
Incoming sewer invert elevation	4.316 m above M.W.L.
Full flow rate of incoming sewer	0.613 m^3/sec
Full flow velocity in incoming sewer	0.781 m/sec

Item	Wastewater flow rates (m³/s)	Flow velocity (m/sec)	Water depth (m)	Water surface elevation at entrance (m)	Head loss ahead of chamber	Gate chamber water elevation (m)
Average daily	0.428 0.699	0.845 1.082	0.616 0.616	4.932	0.036	4.896
Maximum daily	0.498 0.812	0.870 1.114	0.684 0.684	5.000	0.039	4.961
Maximum hourly	0.613 1.001	0.781 1.000	1.000 1.000	5.316	0.031	5.285

Note: Ratio of flow to full flow   Ratio to full velocity   Ratio to full sewer depth   From tables

1.10.3 Influent Gate

Influent gate is specified as follows.

Elevation of gate bottom 4.300 M.W.L.
Gate type and size square 1.2 m

Items		Average daily flow	Max. daily flow	Max. hourly flow	Wet weather flow	Remarks
Wastewater Inflow rates (Q)	m³/s	0.428	0.498	0.613		
No. of gates operated (n)	Unit	2	2	3		
Wastewater inflow to each gate	m³/s/gate	0.214	0.249	0.204		Q/n
Wastewater elevation ahead of gate	M.W.L.	4.896	4.961	5.285		
Wastewater depth at gate (H)	m	0.596	0.661	0.985		
Wastewater flow area at gate (A)	m²	0.715	0.794	1.182		1.2×H
Flow velocity through gate(V)	m/s	0.300	0.314	0.173		Q/nA
Head losses at gate(Δh)	m	0.007	0.008	0.002		
Water elevation after gate	M	4.889	4.954	5.283		

Total head losses at gate(Δh) $1.5 \times v^2/2g = 0.0765 \times v^2$

1.10.4 Coarse Screen

Coarse screen is specified as follows.

Channel invert elevation 4.30 m M.W.L.
Channel width 1.6 m
Screen clear opening 100 mm
No. of screens 2
Slope of screens 60 degrees from horizontal

Items		Average daily flow	Maximum daily flow	Maximum hourly flow	Wet weather flow	Remarks
Wastewater inflow rates (Q)	m^3/s	0.428	0.498	0.613		
No. of channels used		2	2	3		
Wastewater inflow to each channel	m^3/s	0.214	0.249	0.204		Q/n
Wastewater elevation ahead of screen	m M.W.L.	4.889	4.954	5.283		
Wastewater depth ahead of screen	m	0.589	0.654	0.983		
Flow area in channel(A)	m	0.942	1.046	1.238		1.6 × H
Approaching flow velocity to screen	m/s	0.227	0.238	0.165		Q/n A
Flow velocity in screen(V2)	m/s	0.241	0.252	0.175		
Head loss in screen(Δh1)	m	0.000	0.000	0.000		
Actual head loss in screen(Δh2)	m	0.000	0.000	0.000		3 × Δh 1
Allowable head loss at screens (Δh3)	m	0.100	0.100	0.100		Δh3>h2
Wastewater elevation after screen	m M.W.L	4.789	4.854	5.183		Δh3

$\delta h = \beta \times (s/d)^{4/3} \times \sin\alpha = 0.0492268$

$\beta = 2.42$, $d = 150$ mm, $s = 9$ mm, $\alpha = 60°$, $\sin 60 = 0.866$

Loss by screen $= \delta h \times v^2/2g = 0.04923 \times v^2/2g$ (hw)

Flow velocity through screen $V1 \times (s+d)/d = 1.06\ V1$

1.10.5 Fine Screen

Fine screen is specified as follows.

Channel invert elevation	3.900 M.W.L.
Channel width	1.6 m
Bar screen clear opening	20 mm
Thickness of screen bars	8 mm
No. of units	2 units
Slope of screen	75 degrees to horizontal

Items		Average daily flow	Maximum daily flow	Maximum hourly flow	Wet weather flow	Remarks
Wastewater Inflow rate (Q)	m^3/s	0.428	0.498	0.613		
No. of channels in use (n)		2	2	3		
Flow rate in each channel	m^3/s	0.214	0.249	0.204		Q/n
Water elevation ahead of screen	M.W.L.	4.789	4.854	5.183		
Water depth ahead of screen (H)	m	0.889	0.954	1.283		
Sectional area of flow in channel	m^2	1.422	1.526	1.616		$1.6 \times H$
Approaching velocity to screen (V1)	m/s	0.151	0.163	0.127		Q/nA
Flow velocity through screen(V2)	m/s	0.211	0.228	0.177		
Head loss through screen($\Delta h1$)	m	0.002	0.002	0.001		
Actual head loss in screen($\Delta h2$)	m	0.005	0.005	0.003		$3 \times \Delta h1$
Allowable maximum loss ($\Delta h3$)	m	0.100	0.100	0.100		$\Delta h3 < h2$
Water surface elevation after screen	M.W.L.	4.689	4.754	5.083		$\Delta h2$

$\delta h = \beta \times (s/d)^{4/3} \times \sin\alpha = 0.688907$

$\beta = 2.42$, $d = 20$ mm, $s = 8$ mm, $\alpha = 75°$, $\sin 75 = 0.9659$

Loss by screen $= \delta h \times v^2 / 2g = 0.68891 \times v^2 / 2g$ (hw)

Flow velocity through screen $V1 \times (s+d) / d = 1.400\ V1$

1.11 GRIT, OIL/GREASE REMOVAL EQUIPMENT

1.11.1 Design Wastewater Flow Rates

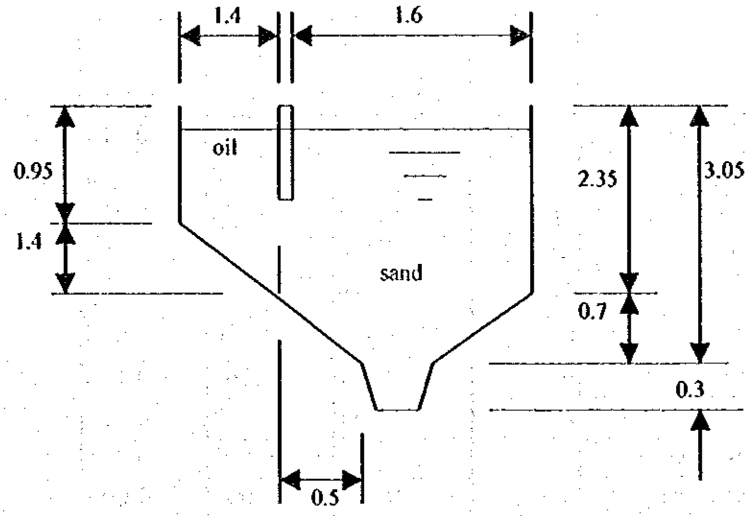
Design wastewater flow rates are determined as follows.

Qad	37,000	m^3/day	428	L/s
Qmd	43,000	m^3/day	498	L/s
Qmh	53,000	m^3/day	613	L/s

1.11.2 Grit, Oil/Grease Separation

Grit, oil/grease separation is specified as follows.

2 trains 1 channels each, then totally 2 channels
Qww 53,000 m^3/day = 613 L/sec
Flow to each channel 26,500 m^3/day = 307 L/sec
Retention time 3 minutes
Capacity $53,000 \times 3 \div 1,440 = 110.4\ m^3$
Section area 6.8 m^2
Length 8.1 m
Capacity $6.8 \times 8 \times 2 = 110.4\ m^3$
(check for flows)
At maximum daily flow Qmd 43,000 m^3/day
Retention Time $(110.4 \times 1,440) / 43,000 = 3.7$ min.



Chamber cross sectional area

1.4	×	0.95	=	1.33
1/2	×	1.4^2	=	0.98
1.6	×	3.05	=	4.88
−1/2	×	0.5^2	=	−0.13
−1/2	×	0.7^2	=	−0.25
Total				6.82 m² use → 6.8 m²

Air supply volume

Romanian Standards Q = 0.3 m³ air / m³ water
= 0.3 × 2,208 = 663 m³/hour
= 11 m³/min

Japanese Standards Q = 0.01 m³/sec·m × channel length/m (0.005~0.013)
= 0.01 × 8 × 2
= 0.162 m³/sec = 10 m³/min

Then, the total air is 11 m³/min
Blower equipment 2 unit
1 unit each for 1 train
then, 1 blower capacity = 11 ÷ 2 = 5.5 use → 6 m³/min
Air blower specifications
Roots blower 3 units (including 1 standby)
ϕ 80mm × 6 m³/min
Grit volume from combined sewage: 0.001~0.02m³ grit/1,000m³ sewage
Then, grit volume = 0.02 / 1000 × 53,000 = 1.06 m³/day

1.11.3 Grit Pumps

Grit pumps are calculated as follows.

Pump capacity is to remove the grit in 20 minutes. As allowances the capacity is two times of the grit
quantity. Then, the pump capacity is:
(1.06 m³/day × 2) / (4 units × 2 minutes) = 0.0265 m³/min
Assuming the grit content in the withdrawn wastewater at 10 %, the required pump

capacity is:

0.0265 × 100 / 10 = 0.265 m^3/min.

Assume the pump velocity to be 2.5 m/sec, the pump diameter will be:

146 × $(1.4/2.5)^{0.5}$ = 48 mm use 75 mm

1.11.4 FLOW MEASUREMENT

Use two units of Parshall flume

				Flow per each unit(Q / 2)
Qad	37,000 m^3/day	=	1,542 m^3/hour	771 m^3/hour
Qmh	43,000 m^3/day	=	1,792 m^3/hour	896 m^3/hour
Qww	53,00 m^3/day	=	2,208 m^3/hour	1,104 m^3/hour

Select 7 ft flume, range of flow 306 ~ 12,380 m^3/hour

1.12 SLUDGE DIGESTER EQUIPMENT

1.12.1 MIXERS

(1) Specifications

Type Up/down flow screw mixers (with a draft tube, from manufacturer's catalog)

Capacity	1,200 m^3/hour
Draft tube diameter	400 mm
Motor output	11 kW
Quantity	4 units

(2) Sludge Mixing Capacity

Sludge turn over rate (mixing the whole sludge volume 8~12 times/day)

Q = (8~12) × 2,015 (Tank volume = 2,015m^3) / 24

= 672 ~ 1,007 m^3/hour use → 1,200 m^3/hour

1.12.2 TANK APPARATUS(ON ROOF TOP)

Tank apparatus are specified as follows.

Gas collectors(steel made)	ϕ600 mm × 1 unit
Gas relief valve (wet type)	ϕ200 mm × 1 unit
Gas relief valve (dry type)	ϕ200 mm × 1 unit (including valve and flame arrester)
Quantity Total	4 units

1.12.3 WATER HEATERS

(1) Specifications

Type	Vacuum type water heater	
Heater capacity	450,000 Kcal/hr.	
Heater transfer area	9.9 m^2	
Fuel	Sludge gas and oil	
Electric motors	Burner motor	1.5 kW
	Oil pump	0.4 kW
	Oil heater	1.0 kW
	Fan	1.5 kW
Quantity	3 units (1standby)	

(2) Nominal Heat Output

Total required heat = 301,249 Kcal/hr
Nominal heater capacity Q = (301,24 9) / (2 × 0.9)
= 167,360 Kcal / hr. → 450,000 Kcal / hr
(Heater efficiency 0.9) (No. of units:2)

1.12.4 OIL SERVICE TANKS

(1) Specifications

Type	Steel made rectangular tank
Tank capacity	150 L
Quantity	1 unit

(2) Tank Capacity

Store oil of more than one hour consumption

q = (450,000 × 2) / (10,200 × 0.85) = 104 L / hr. use → 150 L

β : Heating value of A-diesel oil 10,200 kcal/kg
γ : Specific gravity of A-diesel oil 0.85 kg/L

1.12.5 OIL PUMPS

(1) Specifications

Type	Gear pump
Size	ϕ 15 mm
Discharge	5 L/min.
Discharge pressure	3 kg/cm^2
Electric motor	0.4 kW
Quantity	2 units (including 1 standby)

(2) Pump Discharge

Capable of supplying a 300-liter capacity tank within 30 minutes

Q = 150 / 30 = 5 L/minute

1.12.6 OIL STORAGE TANK

(1) Specifications

Type	Underground cylinder type
Storage capacity	7,500 L
Quantity	1 unit

(2) Tank Capacity

Store more than 3-day oil consumption.

V = 104 × 24 × 3 = 7,474 L use → 7,500 L

1.12.7 GAS BOOSTER FANS

(1) Specifications

Type	Turbo fan
Capacity	81.8 $m^3/hr.$
Pressure (static pressure in water column)	500 mm Aq

Electric motor 1.5 kW
Quantity 2 units (including 1 standby)

(2) Capacity

Sludge gas consumption

q = 450,000 / 5,500 = 81.8 m^3/hr.

(Sludge gas heat value 5,500 Kcal/m^3)

Check for gas consumption

Required energy	Kcal/day	7,229,968
Heater operation time	Hour	8.0
Gas production	m^3/day	1,913
Gas consumption	m^3/day	657

Required heat energy 301,249 Kcal/hr.
Heater output 450,000 Kcal/hr.
No. of units 2 units

1.12.8 HEAT EXCHANGE

(1) Specifications

Type Spiral type heat exchanger
Heat transfer area 15 m^2
Water temperature Inlet 35°c, Outlet 40°c
" 70°c, " 60°c
Quantity Total Nos. 4 units

(2) Energy Transfer

Provide an exchanger to each digester

Required energy per unit, M = 7,229,968 × 1 / 4 = 1,807,492 Kcal/day
= 75,312 Kcal/hr.

(3) Required Heat Transfer Area

A = (M × 1.2) / (K × Δtm) = (75,312 × 1.2) / (600 ×27.4)
= 5.5 m^2 use 15 m^2

M = Heat transfer 75,312 Kcal/hr.
K = Overall heat transfer coefficient 600 Kcal/m^2 hr. °c
Δtm Logarithmic average of temperature difference
= (Δt1–Δt2) / (ln Δt1 / Δt 2)
= (30 – 25) / (ln (30/ 25) = 27.4 °c
Δ1 = 70 – 40 = 30 °c
Δ2 = 60 – 35 = 25 °c

(4) Sludge Recirculation

Q 1 = M / (C × Δt× γ × 60) = 75,312 / (1 × 5 × 1,000 × 60) = 0.25 m^3/min.

C Sludge specific heat 1 Kcal/kg·°c
Δt Temperature difference between inlet and outlet sludge
40 – 35 = 5 °c
γ Unit weight of sludge 1,000 kg/m^3

(5) Water Recirculation

Q 2 = 75,312 / (1 × 5 × 1,000 × 60) = 0.13 m^3/min.

Δt Difference of temperature between inlet and outlet

70 – 60 = 10 °c

1.12.9 SLUDGE CIRCULATION PUMPS

(1) Specifications

Type	Sludge pump with suction screw
Size	100 mm
Discharge	0.7 m^3/min.
TDH	15 m
Motor output	5.5 kW
No. of units	4 units

(2) Capacity

Sludge circulation rate Q = 0.25 m^3/min. use → 0.7 m^3/min.

(3) Head

Total head = Actual head + pipe losses + losses in heat exchanger (10m)
= use 15 m

(4) Motor Output

P_m = 0.163 × 0.7 × 15 × (1 + 0.2) / 0.4 = 5.13 kW use → 5.5 kW

1.12.10 HOT WATER CIRCULATION PUMPS

(1) Specifications

Type	Line pump
Size	65 mm
Capacity	0.34 m^3/min.
TDH	25 m
Motor output	3.7 kW
Quantity	4 units

(2) Capacity

Return from exchanger, Q = 0.13 m^3/min.

(3) Head

Total heads = Actual head + pipe losses + losses in heat exchanger (20m)
= use 25 m

(4) Motor output

Pm = (0.163 × 0.4 × 25 × (1 + 0.2) / 0.6
= 3.26 kW use → 3.7 kW

1.12.11 GAS HOLDER

(1) Specifications

Type	Steel made Dry seal type
Capacity	1,100 m^3
Size	12.6m ϕ × 13.3mH
No. of tanks	2 units

(2) Capacity

Gas generation	1,913 m^3/day			
Retention time	8 hr.			
Storage capacity	1,913 × 8 / 24 / 2	= 319 m^3	use →	1,100 m^3

1.12.12 GAS SCRUBBERS

(1) Specifications

Type	Dry type (intermittent) scrubbers	
Capacity	150 m^3/hr.	
Size	1,800 mm × 4,200 m H × 2 units	
No. of units	2 × 1,800 mm × 4,200 m H × 2 units	2 units

(2) Capacity

Treat all the gas produced

$Q = 1{,}913 \times 1 / 24 / 2 = 40$ m^3/hr. use → 150 m^3/hr.

(3) Diameter of Towers

Velocity of gas flow 1 m/min.

$D = (4 \times 150 / 60 / 3.14 / 1)^{0.5} = 1.785$ mϕ, use → 1800 mmϕ

(4) Chemical Consumption

Inflow and outflow gas H2S concentrations are 100 ppm and 10 ppm, respectively.

$V1 = 0.235 \times 10^{-3} \times Q \times \mu$

$= 0.235 \times 10^{-3} \times 150 \times 24 \times 0.9 = 0.761$ L/day

(μ Removal efficiency = 90%)

$V0 = V1 / (C0 \times 0.8) = 0.761 / (100 / 1{,}000) \times 0.8$

$= 9.5$ L/day

C0 : Chemical requirements to absorb 100 kg hydrogen sulifide= 1000 kg

γ : Nominal specific gravity of chemical 0.8

(5) Life of Chemical

$T = (V \times 10^3) / V0 = (5 \times 10^3) / 9.5 = 525$ days

$V =$ Volume 5 m^3

1.12.13 WASTE GAS BURNERS

(1) Specifications

Type	In furnace
Capacity	300 m^3/hr.
Size	1,500 mm D × 10,200 mm H

Motor	Cooling fan
"	Gas blower
No. of units	2 units

(2) Treatment Capacity

Capacity: all produced gas

Q = 1,913 × 1/24 × 2.0 × 1/2

= 80 m^3/hr. use → 300 m^3/hr.

1.12.14 SEED SLUDGE PUMPS(SLUDGE WITHDRAW)

(1) Specifications

Type	Sludge pumps with suction screw
Size	100 mm
Capacity	1 m^3/min.
T.H.L	15 m
Motor output	7.5kW
No. of units	2 units

(2) Capacity

Q = 1 m^3/min.

(3) Total Dynamic Head

H = 15 m

(4) Motor Output

Pm = 0.163 × 1 × 15 × (1 + 0.2) / 0.4

= 7.34 kW use → 7.5 kW

1.13 APPARATUS FOR SLUDGE DEWATERING EQUIPMENT

1.13.1 SLUDGE STORAGE TANK MIXER

(1) Specifications

Type	Vertical paddle type
Shape	Approximately 4,000mm ×6,400mm × 2,500mmH
Capacity	64 m^3
Blade size	1,500 mmϕ
Motor output	7.5 kW
No. of units	2 units

(2) Tank Capacity

Store average one-day sludge production

V = 139 × 1 / 2 = 70 m^3

1.13.2 SLUDGE SUPPLY POMP

(1) Specifications

Type	Single-axis screw pump

Size	φ 100 mm
Capacity	20 m^3/hour
TDH	20 m
Motor output	5.5 kW
No. of units	5 units

(2) Discharge Capacity

One pump to each dewater equipment
(one-standby pump for all dewatering equipment)

$$Q1 = 130 \times 2 \times 10^{-3} \times 100 / (0.2 \times 1.5)$$
$$= 1.95 \text{ m}^3\text{/hour} \quad \text{use} \rightarrow 20 \text{ m}^3\text{/hour} \quad 0.33 \text{ m}^3\text{/minute}$$

Filter velocity	130 kg/m·hr.
Filter width	2 m
Sludge solid concentration	0.2 %
Allowance	1.5

(3) Electric Motor Output

$$Pm = 0.163 \times 20 \times 0.33 \times (1+0.3) / 0.3$$
$$= 4.71 \text{ kW} \quad \text{use} \rightarrow 5.5 \text{ kW}$$

1.13.3 Chemical Feed Pump

(1) Specifications

Type	Single-axis screw pump
Size	φ 50 mm
Capacity	3 m^3/hour
TDH	20 m
Motor output	1.5 kW
No. of units	5 units (including one standby)

(2) Discharge Capacity

A pump to each dewater equipment
(one standby pump for all dewatering equipment)

$$Q1 = (30 \times 2 \times 10^{-3} \times 0.01 \times 100) / (0.2 \times 1.5)$$
$$= 2.925 \text{ m}^3\text{/hour} \rightarrow 3 \text{ m}^3\text{/hour} \quad 0.05 \text{ m}^3\text{/min.}$$

Filter velocity	130 kg/m·hr.
Filter width	2 m
Solid concentration of sludge	0.2 %
Allowance	1.5

(3) Electric Motor Output

$$Pm = 0.163 \times 20 \times 0.05 \times (1+0.3) / 0.25$$
$$= 0.85 \text{ kW} \quad \text{use} \rightarrow 1.5 \text{ kW}$$

1.13.4 Chemical Solution Tanks

(1) Specifications

Tank type	Steel made cylinder type
Tank capacity	15 m^3
Approx. size	1,700 mmφ × 2,300mmH

Electric motor output 2.2 kW (for mixer)
No. of tanks 2 units

(2) Sludge Storage Tank Capacity

Dosing rate $4.18 \times 10^3 \times 0.008 \times 7/5 = 46.82$ kg/day
Dewatered solids 4.18 t/day
Chemical dosing rate (Polymer) 0.8 %/kg·ds
(5 days/week operation)
Storage capacity. 2 hours of design sludge volume
2 tanks (alternately used)

$V = (47 \times 100) / (0.2 \times 2/6/3)$
$= 3{,}902$ L use → 4,000 L

Chemical solution concentration 0.2 %
Operation time a day 6 hours
Retention time 2 hours

1.13.5 Chemical Feeders

(1) Specifications

Type	Chemical pump
Supply rate	1.0 L/min.
Electric motor output	0.4 kW
Quantity	2 units

(2) Supply Rate

One feeder is attached to each solution tank, supplying chemical in 15 to 20 minutes.

$Q = (4{,}000 \times 10^3 \times 0.2) / 100 \times (1/(15 \sim 20)) \times 1/0.5$
$= 1.1 \sim 0.8$ → 1.0 L/min.

Apparent specific gravity of polymer 0.5

1.13.6 Chemical Containers

(1) Specifications

Type	Stainless steel made, cylinder container
Effective capacity	150 L
Quantity	2 units

(2) Capacity

Provide 2 tanks (alternately used), with capacity of 7-day chemical consumption.

$V = 46.82 \times 7/5 \times 0.5 \times 7 \times 1/2$
$= 115$ L use → 150 L

1.13.7 Filter Cloth Washing Pumps

(1) Specifications

Type	Multi-stage centrifugal pump
Size	ϕ 50 mm
Discharge	0.2 m^3/min.
Total head	60 m
Electric motor output	5.5 kW
Quantity	5 units (including 1 standby)

(2) Discharge Pumps

One pump to each dewatering machine, and one standby pump for all equipment.

Q = 100 × 2 = 200 L/min. use → 0.2 m^3/min.

Then, the pump discharge per 1 m cloth is 100 L/min.

Total dynamic head 60 m

Electric motor output

Pm = 0.163 × 60 × 0.30 × (1+0.2) / 0.5

= 4.69 kW → 5.5 kW

1.14 EFFLUENT PUMPING STATION

1.14.1 Flow Rate

Flow rate is determined as follows.

Qad	37,000 m^3/day	428 L/s
Qmd	43,000 m^3/day	498 L/s
Qmh	53,000 m^3/day	613 L/s

1.14.2 Pumping Equipment

(1) Design Flow Rates

Qad	37,000 m^3/day	26 m^3/minute
Qmd	43,000 m^3/day	30 m^3/minute
Qmh	53,000 m^3/day	37 m^3/minute

(2) Wastewater Pumps

4 units (including 1 standby), mixed flow centrifugal type driven by electric motor.

Wastewater inflows	Wastewater inflow rates (m^3/minute)	Pump discharges: Wastewater pumps 15 / 4(1)		(m³/min/unit) / No. of units	Total pump discharge (m^3/minute)
Qad	26	30		2	30
Qmd	30	30		2	30
Qmh	37	45		3	45

(3) Pump Size:

Pumps Q = 15 m^3/minute

D = $146(Q/V)^{0.5}$ V = 2.5 m/sec

= 358 mm use → 400 mm

(4) Wastewater Surface Elevations:

Suction water levels at inflow of

Qad	1.000	M.W.L.
Qmd	1.000	M.W.L.
Qmh	1.000	M.W.L.

Suction water levels at inflow of

Qad	5.600	M.W.L.
Qmd	5.600	M.W.L.
Qmh	5.600	M.W.L.

(5) Actual Head:

Qad	5.600	–	(1.000)	=	4.600 m
Qmd	5.600	–	(1.000)	=	4.600 m
Qmh	5.600	–	(1.000)	=	4.600 m

Total head losses at pump equipment:

Pump size	ϕ 400	
Pump bore(m)	0.4	
Pump discharge(m^3/min)	15	
Pump discharge(m^3/sec)	0.250	
Delivery bore sectional area (m^2)	0.126	
Pump velocity(m/s)	1.990	
Loss coefficients		
Inlet	0.15	
Sluice valve	0	
Check valve	1.0	
Outlet	1.0	
Bend	0.25	
Friction loss	f' × L/D	1.195
Total	3.595	

(6) Head Losses

ϕ 400 = 0.727 m $F \times V^2/2g$

Pipe length L = 15 m

Friction loss by Darcy-Wiseback Formula

$hf = f \times L/D \times V^2 / 2g$

f = 0,02 + 1/(2000 × D) (New cast iron pipe)

For old cast-iron pipes multiply the 'f' by 1.5

	ϕ 400	
D(m)	0.4	
F	0.021	
f' = 1.5×f	0.032	

(7) Total Head Required

Qad	4.600	+	0.727	=	5.327 m
Qmd	4.600	+	0.727	=	5.327 m
Qmh	4.600	+	0.727	=	5.327 m

The required total pump head is then 5.5 m

(8) Shaft Power of Mixed Flow Centrifugal Pumps

$L = k \times \gamma \times Q \times H / \mu$

where

L Shaft power of pump

k 0.163 kW or 0.222 PS

Q Pump discharge (m^3 / min)
H Pump total dynamic head (m)
γ Specific gravity of water (γ=1)
μ Pump efficiency

Calculations for shaft power requirements

Items		ϕ400	
Pump discharge(Q)	m^3/min	15	
TDH (H)	m	5.5	
Pump efficiency(μ)		0.72	
Shaft power	kW	19	

(9) Outputs of Pump Drives

$P = L(1+\alpha) / \mu \times G$

where

P Pump power (kW)
L Pump shaft power (kW)
α Allowance for motor 0.15
   Allowance for engine 0.2
μG Transmission efficiency (1.0 for direct connection)

	ϕ400	
Shaft power (L)	19	
Allowance (α)	1.15	
Efficiency of transmission (μG	1.00	
Pump drive output (P) kW	21	

(10) Pump Specifications

		Vertical mixed flow centrifugal pumps	
Pump bore	mm	400	
Pump discharge	m^3/min.	15	
Total dynamic head	m	5.5	
Motor/engine outputs	kW	21	
Pump drive		Motor	

2. RECIRCURATION PROCESS

2.1 DESIGN BASIS

2.1.1 DESIGN WASTEWATER INFLOW RATES

Design wastewater inflow rates are determined as follows.

Average daily flow Qad 37,000 m^3/day 428 L/s

Maximum daily flow	Qmd	43,000 m^3/day	498 L/s
Maximum hourly flow	Qmh	53,000 m^3/day	613 L/s

2.1.2 Design Wastewater Quality

Design wastewater quality is determined as follows.

BOD = 130 mg/L
SS = 140 mg/L
T-N = 20 mg/L
T-P = 3.5 mg/L

2.1.3 Design Wastewater Quality (including sidestream waste loads)

Design wastewater quality (including sidestream waste loads) is calculated as follows.

BOD = 145 mg/L
SS = 160 mg/L
T-N = 24 mg/L
T-P = 4.6 mg/L

Parameter	Removal Efficiency(%)			Wastewater Quality (mg/L)		
	Primary treatment	Secondary treatment	Overall removal rate	Raw waste-water	Primary effluent	Secondary effluent
BOD	30	91	93.7	145	101.5	9.1
SS	40	93	95.8	160	96.0	6.7
T-N	10	60	64.0	24	21.6	8.6
T-P	10	78	80.2	4.6	4.14	0.9

2.1.4 Pollutant Discharge Limits by NTPA 001

Pollutant discharge limits by NTPA 001 is regulated as follows.

BOD < 20 mg/L
SS < 60 mg/L
T-N < 10 mg/L
T-P < 1.0 mg/L

2.2 CALCULATIONS OF SIDESTREAM POLLUTANT LOADS

2.2.1 Raw Sludge Volume

Raw sludge production volume is calculated by the following equation.

Solid production (t/day) = 43,000 × 140 × 10^{-6} × 0.4
= 2.41 t/day

Sludge concentration 2.0 %

Sludge volume 2.41 × 100 ÷ 2.0 = 120.4 m^3/day

2.2.2 WASTE SLUDGE VOLUME

Parameter	Influent quality (mg/L)	Reaction tank influent quality (mg/L)	Primary clarifiers removal Efficiency(%)
BOD	130	91	30
SS	140	84	40

Assuming that the reactor influent S-BOD is 66.7% of the total BOD; then Scs is 60.7 mg/L
Waste sludge production volume is calculated by the following equation:

$$Qw \times Xw = (a \times Scs + b \times Sss - c \times \theta \times XA)Q$$

where,

Qw	Volume of waste sludge (m^3/day)		
Xw	Average SS concentration of waste sludge (mg/L)		
Q	Influent volume to reactors (m^3/day)		43,000
XA	MLSS concentration in reactors (mg/L)		3,000
Scs	Influent soluble-BOD concentration to reactors (mg/L)		60.7
Sss	Influent SS concentration to reactors (mg/L)		84
a	Sludge yield coefficient of S-BOD(mg MLSS/mgSS)	0.4~0.6	0.5
b	Sludge yield coefficient of SS(mg MLSS/mgSS)	0.9~1.00.	0.95
c	Coefficient of SS reduction due to indigeneous respiration of activated sludge micro-organisms (L/day)	0.03~0.05	0.04
θ	HRT in reactor basins (day)	12.3 / 24	= 0.51

therefore,

$$Qw \times Xw = (0.5 \times 60.7 + 0.95 \times 84 - 0.04 \times 0.51 \times 3{,}000) \times Q \times 10^{-6}$$
$$= 48.64 \times Q \times 10^{-6} = 2.09 \text{ t/day}$$

Solid production = 2.09 t/day
Sludge concentration = 0.9 %
Sludge production = 2.09 × 100 ÷ 0.9 = 232 m^3/day

2.2.3 THICKENED SLUDGE

Thickened sludge production volume is calculated by the following equation.

Sludge solids = 2.41 + 2.09 = 4.50 t/day
(Primary sludge) (Excess sludge)
Sludge volume = 120.4 + 232 = 353 m^3/day
(2.0%) (0.9%)
Solids = 4.50 × 0.85 = 3.82 t/day
Assuming sludge concentration is 3.5 %
Sludge volume = 3.82 × 100 ÷ 3.5 = 109 m^3/day

2.2.4 SLUDGE SUPERNATANT OF THICKENERS

Sludge supernatant of thickened weight is calculated by the following equation.

Liquor volume = 353 − 109 = 244 m^3/day
Solids weight = 4.50 × 0.15 = 0.67 t/day
BOD = 244 × 2000 × 10^{-6} = 0.49 t/day
BOD is assumed to be of 2,000 mg/L
T-N = 244 × 700 × 10^{-6} = 0.17 t/day
T-N is assumed to be of 700 mg/L

T-P = 244 × 180 × 10^{-6} = 0.04 t/day
T-P is assumed to be of 180 mg/L

2.2.5 DIGESTED SLUDGE

Digested sludge production volume is calculated by the following equation.

Digested sludge solids = 3.82 × (1 – 0.7 × 0.5) = 2.49 t/day
Digested sludge volume 3.0 %
Sludge volume = 2.49 × 100 / 3.0 = 83 m^3/day

2.2.6 DEWATERED SLUDGE(SLUDGE CAKE)

Dewatered sludge production volume is calculated by the following equation.

Solids = 2.49 × 0.9 = 2.24 t/day
(Assuming 20.0 % solids concentration)
Cake volume = 2.24 × 100 / 20.0 = 11 m^3/day

2.2.7 DIGESTED SLUDGE FILTRATE

Digested sludge filtrated weight is calculated by the following equation.

Filtrate volume = 83 – 11 = 72 m^3/day
Dry solids weight = 2.49 × 0.10 = 0.25 t/day
BOD = 72 × 1,500 × 10^{-6} = 0.11 t/day
(Assumed BOD concentration = 1,500 mg/L)
T-N = 72 × 150 × 10^{-6} = 0.01 t/day
(Assumed BOD concentration = 150 mg/L)
T-P = 72 × 80 × 10^{-6} = 0.01 t/day
(Assumed BOD concentration = 80 mg/L)

2.2.8 SIDESTREAM VOLUME AND WASTE LOAD

Sidestream volume and waste load is calculated by the following equation.

		Thickener supernatants		Sludge filtrate		
Liquor volume	=	244	+	72	=	315 m^3/day
Dry solids	=	0.67	+	0.25	=	0.92 t/day
BOD	=	0.49	+	0.11	=	0.59 t/day
T-N	=	0.17	+	0.01	=	0.18 t/day
T-P	=	0.04	+	0.01	=	0.05 t/day

2.2.9 WASTEWATER QUALITY (INCLUDING ALL SIDESTREAMS)

Wastewater quality (including all sidestreams) is calculated by the following equation.

Overall wastewater flow = Influent + Sidestreams
Maximum daily flow = 43,000 + 315 = 43,315 m^3/day
Then, the design wastewater flow characteristics are;
BOD = (43,000 × 130 × 10^{-6} + 0.59) / 43,315
= 0.00014278 × 10^6 = 143 → 145 mg/L
SS = (43,000 × 140 × 10^{-6} + 0.92) / 43,315

	=	0.000160302	×	10^6	=	160	→	160 mg/L		
T-N	=	(43,000	×	20	×	10^{-6}	+	0.18) / 43,315		
	=	0.000024038	×	10^6	=	24.0	→	24 mg/L		
SS	=	(43,000	×	3	×	10^{-6}	+	0.05) / 43,315		
	=	0.000004619	×	10^6	=	4.6	→	4.6 mg/L		

2.3 SLUDGE PRODUCTIONS

2.3.1 RAW SLUDGE

Raw sludge production volume is calculated by the following equation.

Solid production (t/day) = 43,000 × 160 × 10^{-6} × 0.4
= 2.75 t/day

Sludge concentration 2.0 %

Sludge volume 2.75 × 100 ÷ 2.0 = 137.6 m^3/day

2.3.2 WASTE SLUDGE VOLUME

Parameter	Influent quality (mg/L)	Reaction tank influent quality (mg/L)	Primary clarifiers removal Efficiency(%)
BOD	145	101.5	30
SS	160	96	40

Assuming that influent S-BOD to reactor basins is 66.7 % of the raw wastewater BOD,S-BOD concentration is estimated to be; 67.70 mg/L

Waste sludge production volume is calculated by the following equation:

$$Qw \times Xw = (a \times Scs + b \times Sss - c \times \theta \times XA)Q$$

where,

Qw	Volume of waste sludge (m^3/day)		
Xw	Average SS concentration of waste sludge (mg/L)		
Q	Influent volume to reactors(m^3/day)		43,000
XA	MLSS concentration in reactors (mg/L)		3,000
Scs	Influent soluble-BOD concentration to reactors (mg/L)		67.7
Sss	Influent SS concentration to reactors (mg/l)		96
a	Sludge yield coefficient of S-BOD(mg MLSS/mgSS)	0.4~0.6	0.5
b	Sludge yield coefficient of SS(mg MLSS/mgSS)	0.9~1.00.	0.95
c	Coefficient of SS reduction due to indigeneous respiration of activated sludge micro-organisms (1/day)	0.03~0.05	0.04
θ	HRT in reactor basins (day)	12.3 / 24	= 0.51

therefore,

$Qw \times Xw = (0.5 \times 67.70 + 0.95 \times 96 - 0.04 \times 0.51 \times 3{,}000) \times Q \times 10^{-6}$

$= 63.54 \times Q \times 10^{-6} = 2.73$ t/day

Solid production = 2.73 t/day

Sludge concentration = 0.9 %

Sludge production = 2.73 × 100 ÷ 0.9 = 304 m^3/day
= 0.21 m^3/min.