وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية

General Directorate of Water Services -
Ministry Office

Kingdom of Saudi Arabia
Ministry of Water and Electricity

Design Guide for
Wastewater Treatment Plants
In Saudi Arabia

First Edition – Muharram 1428 AH (2007)

This translation is provided for guidance. The governing text is the Arabic text

Contents

Foreword

Saudi Arabia has recently witnessed a huge development in many sectors, including the sewage treatment sector, as many dual treatment plants were established with different systems and were later upgraded to operate with Laws of Tertiary Treatment Plants pursuant to the Royal Decree No. (M/6) dated 23/2/1421.

Due to the variance in the systems, specifications, and design standards of these plants, the idea arose to unify the specifications and standards of designing the plants through issuing a standard design guide to be used in the studies and designs related to the new plants. This unified guide design aim at increasing the efficiency of the established plants, facilitating operation and maintenance works, prolonging the life span of spare parts for all systems in all parts of the plants, according to circumstances of each city. Also, it tries to overcome the difference in treatment systems for all the plants to be established or expanded, in addition to choose the best systems to prevent pollution, in line with the feasibility of each system.

I would like to take this chance to thank all the committee members responsible for preparing this guide for their outstanding efforts, asking Allah to reward everyone well and for the desired benefit to be achieved.

Allah is the Arbiter of Success

Minister of Water and Electricity

Abduallah Abdulrahman Al-Haseen

Duly Signed

Introduction

Saudi Arabia has witnessed a huge urban growth in the past thirty years which led to a huge increase in the urban area and a population growth. Both were so fast for the sewage services programs (public utilities) to keep up with them, especially in urban areas. Therefore, sewage facilities are some of the most underdeveloped facilities in the country due to many reasons: the high cost of establishing these facilities compared to the other ones (infrastructure), the lack of knowledge of the seen and unseen risks of the absence of these facilities, in addition to the nonappearance of any problems from using *Byaras* (Septic Tank) in most of the developed districts until the population density of these districts was reached.

Thus, it became an urgent need for sewerage systems to be fully established in both small and big cities to set an end to the suffering of the citizens due to the continuous overflow of these *Byaras* after waterlogging and the serious damages sewage has caused to health, environment, infrastructure facilities, and public and private buildings in many cities around the country. In addition to that, using water from these *Byaras* has inverse effects such as increasing polluted water levels, which leads to them leaking into water tanks at homes and affecting residential facilities. Also, draining sewage in seas or valleys has environmental damages such as affecting the fish resources and polluting valleys and wells (used for drinking or irrigation). This requires treating the polluted water in accordance with the global and national standards to protect the environment from any pollutions directly affecting citizens' health, and to avoid spreading contagious diseases such as hepatitis, typhoid, bacillary dysentery etc.

Since the start of establishing Wastewater Treatment Plants till the year 1425 AH, the number of the plants established by the water and sewage authorities and Ministry of Municipal and Rural Affairs reached (31) with a total energy of (1,557,361) m^3 per day (according to the count surveys of plants by unifying guide committee of technical specifications of plants in 1425 AH). The implemented plants in all cities around the country follow many treatment systems including bioremediation with the traditional activated sludge as in (North Manfuha Plant in Riyadh, Eskan Plant in Jeddah, Al-Ukayshiyyah Plant in Mecca, the Old Plant in Medina), vital filters treatment such in (South Manfuhah Plant in Riyadh, Al Ukayshiyyah Plant in Mecca), extended Aeration as in Jeddah, Taif and Abha, Natural oxidation lakes in Al Ahsa and Ar-Rass, and mechanical oxidation lakes such as Unayzah and Al-Kharj Plants. Most of these plants were designed to obtain the dual treatment standards (bio-oxygen BOD = 20mg/L, and suspended solids S.S = 10mg/L).

Out of the ministry's desire to unify efforts and overcome the difference in treatment systems by preparing a standard design guide of technical specifications for Wastewater Treatment Plants in Saudi Arabia for the plants to be established or expanded, to choose the best treatment type to eliminate any pollution, and to unify the operation and maintenance systems, equipment's and spare parts in all treatment units, a mandate from the Ministry of Water and Electricity was issued to form a committee for preparing this standard guide, and the committee started preparing it since 15/6/1425 AH. After surveys, discussions and field trips, this standard design guide was introduced, and it contains the following:

Chapter One: Planning
Chapter Two: Initial and Final Designs
Chapter Three: Material Requirements
Chapter Four: Value Engineering
Chapter Five: Implementation
Chapter Six: Timeline
Chapter Seven: Annexes

1- An Example for Determining the Oxygen Amount
2- References
3- Timeline of Studying and Designing a Treatment Plant

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Since the first edition of any guide must have some notices, like any other human work, this guide has a separable page in the end for submitting any notices, suggestions, or additions regarding it to be taken into consideration for preparing the second edition, which the Directorate hopes for it to fulfill this one. The

Directorate also hopes to include the chapters missing from this edition into the second one, including the "Sludge Treatment and its Reuse, and "Supervisory Control and Data Acquisition (SCADA)", "Polymer System". It also hopes to complete the chapter of "Disinfection System", and adding a special chapter for general features of industrial water treatment that has an increasing importance due to the increasing industrial activities in the country, as well as adding a special chapter for design standards of treatment plants with a relatively small capacity.

Our intention is for the sake of Allah

Manager General of General Directorate of Water Services and Electricity

Yaareb Amin Khayat

Duly Signed

1/1/1428 AH

Saudi Arabia

Ministry of Water and Electricity

Chapter One

Planning

Chapter One (Planning)

Chapter One

Planning

Introduction

This chapter discusses planning for choosing the plant site and determining the features of the proper treatment. The chapter includes various sections about the general outline, factors to be considered as they affect the choice of treatment plant sites, explaining how to formulate the goals of establishing Wastewater Treatment Plants and collecting necessary information for the planning process, and determining the peak factor. This chapter includes the available alternatives for sewage treatment and sludge systems, in addition to the discharge of treated water and sludge disposal.

1-1 General Outline of Sewage

There should be a general outline of sanitation for a period ranging between (30-40) years for each city, to be updated every five years, and to be compatible with the structural planning of the city. The general outline should clarify the general plan for sanitation, including network, treatment plants, and the role of plants in the water system in terms of afforestation and reuse, or supporting groundwater inventory, or covering industrial demand and secondary uses of water.

1-1-1 Factors affecting the selection of the plant site

In this Section, the elements affecting selection of the plant location will be discussed to ensure taking into account the activities that affect or be affected by the plant location whether over the short run or long run. These factors are for guidance, where special factors and requirements for certain locations may be added thereto.

The main factors affecting the selection of plant location can be summarized as follows:

1- **Topography:**

Ordinarily, the discharge direction in cities is usually the same as the direction flow of the wastewater discharge systems, where the selection of the plant site in low-lying areas would result in a reduction in the number of lifting plants and construction, operation and maintenance costs, taking into consideration the fact that the site shall not be at risk of being swept away by floods or that the necessary actions are taken to protect the plant from effects of such flash floods.

2- Adequate distance from commercial and residential areas:

The plant location shall be selected as far as possible from commercial and residential areas. The uses of the lands adjacent to the plant shall be specified for purposes which are not residential and commercial, provided that such plant shall be located far away from these places with (1.5 km) to (3 km) radius distance from the boundary wall of the plant and according to the available potentials of the new plants.

3- Reuse requirements or final excess discharge

It is preferable that the plant location is close to the recycling sites and appropriate for pumping to those sites. In addition, it is also advisable that the plant location overlooks a valley or is close to the sea in order to guarantee the competent drainage of the excess treated water. Furthermore, it is necessary to consider the need for partially treated wastewater drainage in case of any fault or breakdown, as well as to specify the drainage requirements (discharge into seas and valleys) and its effect on seawater and groundwater.

4- Land use:

The current and future usages of land at the selected site shall be taken into consideration. It is preferable that the site shall be far from the residential and commercial areas and to fulfill the economic and environmental aspects.

For example, if it is noticed that one area will become of commercial nature in the long run (30 years), another site shall be selected since the plant location will adversely affect the land prices.

The foregoing shall be applied in case of absence of organization chart for a period up to 60 years. However, in case organization chart exists, the agreement between the Ministry of Water and Electricity and the Ministry of Municipal and Rural Affairs within the organization chart shall be followed.

Regarding the areas of population clusters which consist of neighboring villages, the abovementioned considerations shall be taken into consideration to avoid any inconvenience that may occur to the villagers who reside near the treatment plant.

5- Natural and aesthetic significance:

Special natural spaces, entertainment and recreation areas as well as coastal areas, as equipped for public use, shall be avoided.

6- Cultural significance:

The relevant information shall be referred to for determining whether the chosen locations have a historical position or any special characteristic.

7- Land requirements:

The areas required for expanding water treatment works shall be taken into account as a result of the expansion of sewage services. Factors affecting the required areas are as follows:

1. Degree of Treatment.

2. Applied Operations.

3. Degree of Redundancy.

8- Buffer zone:

It is the area required to separate the plant from the owners of the neighboring lands. The quality of the treatment plays a key role in determining this area, while it is preferable that the area shall be green. For the mechanical plants, if the land area is not specified, it shall be appropriate to define it at about 80 meters as it is the case in the state of Arizona, USA. For natural oxidation ponds plants, the land area is preferred to be 300 meters, while additional land area shall be added to this area to ensure preventing damages to the neighboring lands due to the sounds or smells.

9- Sludge handling and reuse facilities:

Sludge disposal requirements shall be considered upon choosing the plant's site. Sludge shall be disposed through manufacturing, reusing or burying it. These techniques contribute to reducing sludge transportation costs as much as possible and avoiding the inconvenience caused by the resulted smells. Sludge burial sites shall be chosen after investigating groundwater, soil type and how far are the site and separation areas from the neighboring lands.

10- Geology and soils:

Soil type plays a major role in estimating cost of implementation. Therefore, soil, including seismic activity and required needs, if necessary, shall be well examined.

11- **Transportation and** access to site:

It is a requirement to study to what extent the access to the site is easy and adequately protected.

12- Utility services

Access to services such as electricity, water and communications shall be examined.

13- Obstacles:

The location of the plant shall be free of obstructions such as power grid lines or other obstructions.

14- **Wind direction:**

Preferably, the prevailing winds in the area shall be taken into account.

1-1-2 Goals of establishing the plant

The objectives and role of the plant in the water system, as well as the water demand sectors to be covered by the plant shall be defined, which may be limited to one or all of the following elements:

1. Restricted agriculture.
2. Unrestricted agriculture.
3. Industry.
4. Groundwater recharge.
5. Drainage in the seas.

1-1-3 Deign life span

The design life span of treatment plants is approximately 20 years old for mechanical equipment; and the concrete life span is about 50 years old.

1-2 Loads and plant products

1-2-1 Data of previous similar plants

The design and operational information for the previous plants on the site shall be provided from start-up until the date of planning for the establishment of a new plant or according to the available information, if any.

1-2-2 Amounts and types of sewage water:

To calculate the design flow, the following shall be explained:

1. The population of the served area.
2. Current organic and inorganic flows and loads.
3. Future organic and inorganic flows and loads.
4. Unusual loads of pollutants.
5. Current water consumption rate and future expectations.

1-2-3 Peak factor

The peak factor shall be determined according to the size of the city or the region served, so that the peak factor for large cities is within (1.6) and for villages and hamlets (2.2), with the exception of cities with special seasons.

1-2-4 Organic and nonorganic loads: The following elements shall be clarified:

1- The organic load of the plant is estimated by extrapolating the previous or similar plants data, based on the current and future water consumption.

2- Unusual pollutant loads, frequency, and effects shall be examined.

1-2-5 Plant products and reuse: The following items shall be clarified:

1- Reuse requirements.

2- The quality of the treated water required.

1-3 Treatment systems

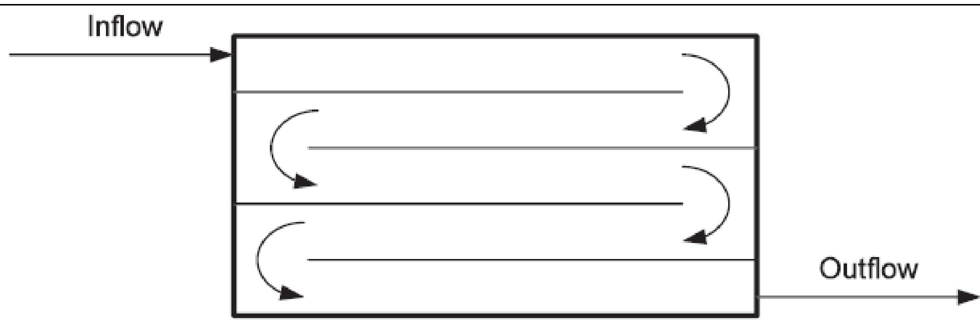
1-3-1 Alternatives for treatment systems

First: Extended aeration system for activated sludge:

It is one of the activated sludge systems. The basins of this system are designed in different shapes (rectangular, square, circular, etc.) and they use a relatively long aeration time, usually between 18-36 hours, and are designed on the basis of a concentration of activated sludge ranging between 3000-6000 mg / liter in the aeration basins. The life of the sludge ranges between (10-30) days and can be used to remove nitrogen. One advantages of this system is the elimination of the need for primary treatment (primary sedimentation basins), which reduces the number of treatment units and the problems of emitting bad odors from the initial stabilization ponds.

This system can withstand sudden change of flow and organic loads, in addition to the digestion of sludge in aeration basins, which eliminates the need for a separate sludge digestion system. Surface aerators or air diffusers can also be used as needed. This system requires large-sized aeration basins ranging between (5-7) times compared to the size of the conventional activated sludge system basins, and also require higher energy consumption.

In the Kingdom, plants with a capacity of (250,000) m³ / day are used due to the ease of operation and the small number of treatment units. The use of the extended aeration system has been recommended for large flows due to the operational and climatic conditions (high temperatures causing odors unpleasant odors emitted from the primary treatment units), constant change in hydraulic and organic loads, and practical experiences of the water directorates. See Figure (1).



(a) Conventional Extended Aeration

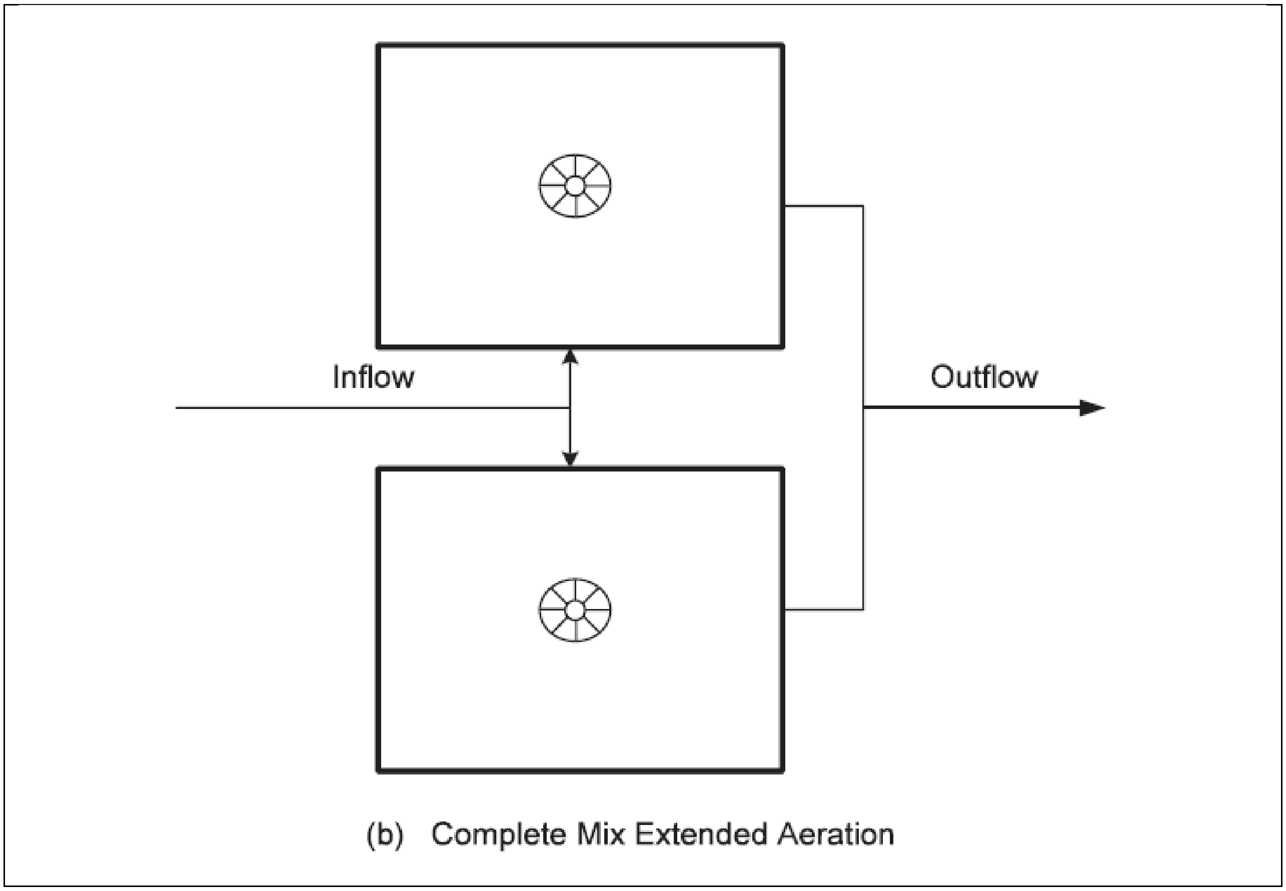


Figure 1: Extended Aeration

Second: Oxidation ditches system:

Circular or oval-shaped channels equipped with mechanical aeration equipment and entered with raw sewage water, which is vented and rotated in the channels at a speed of at least 0.3 m / sec. This system is usually used to remove nitrogen and operates within the extended aeration range, eliminating the need for initial treatment and digestion of sludge in a separate system. This system has the same features as the Extended Aeration System. See Figure (2).

Third: aerated lagoon system:

It consists of Lagoons (basins) with large areas that may be earthy if the land is non-porous or lined with insulation to prevent the leakage of groundwater. The surface aeration system is used to supply and mix the sewage water with oxygen. On this basis, the treatment is carried out using the activated sludge method, except that the activated sludge is not returned to the aeration basins unless designed for that.

The depth of the Lagoons ranges between (2-5) meters and usually 3 meters are used. The aeration time ranges between (5-20) days or more, depending on the type of sewage water and the need for treatment. This system is within the range of extended aeration so that treatment takes place in Lagoons without the need for initial treatment or separate treatment of sludge.

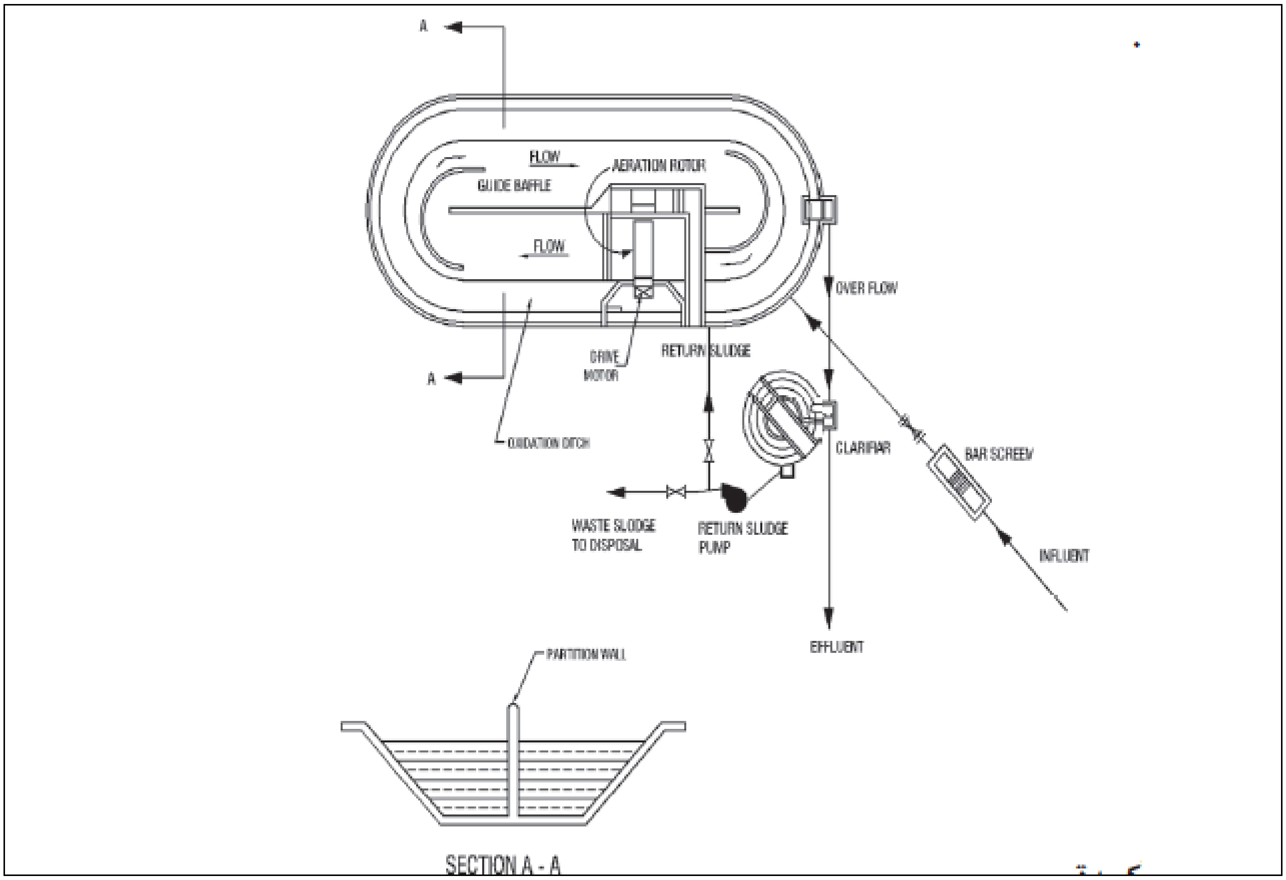


Figure (2) Oxidation Ditches

This system produces water with bilateral treatment specifications, and the concentration of biological oxygen demand (BOD) and suspended substance in the product ranges between (20-60) mg / liter. This system is easy to operate, maintain and perform well in removing the biological oxygen demand (BOD). The concentration of suspended substance may be affected by the growth of algae in the Lagoons and the concentration in the resulting water. See Figure (3).

Fourth: stabilization ponds system:

Natural stabilization ponds System is used in villages far from urban areas. This system is shallow ponds with large surface areas that may be earthy if the ground is nonporous or insulted if the ground is porous to prevent leakage of groundwater. The treatment in this system does not require mechanical equipment for aeration and depends on natural factors such as algae that grow in these ponds and bacteria present in sewage water. This system is easy to design and operate and does not require constant monitoring.

These ponds may be Aerial or Facultative Ponds with depths ranging from (1-1.5) meters, where the aeration is done by wind and contact with atmospheric air, and needs large areas of land and the duration of the water stay in the basin ranges between (10-50) days or sometimes more. Ponds may be anaerobic, so that biological treatment depends on the absence of oxygen, and in this case the ponds are deeper than the previous ones, as their depth ranges between (3-5) meters and the duration of the water stay in them ranges between (2-50) days. These types of ponds usually produce unpleasant odors and are used to treat high organic loads and concentrations.

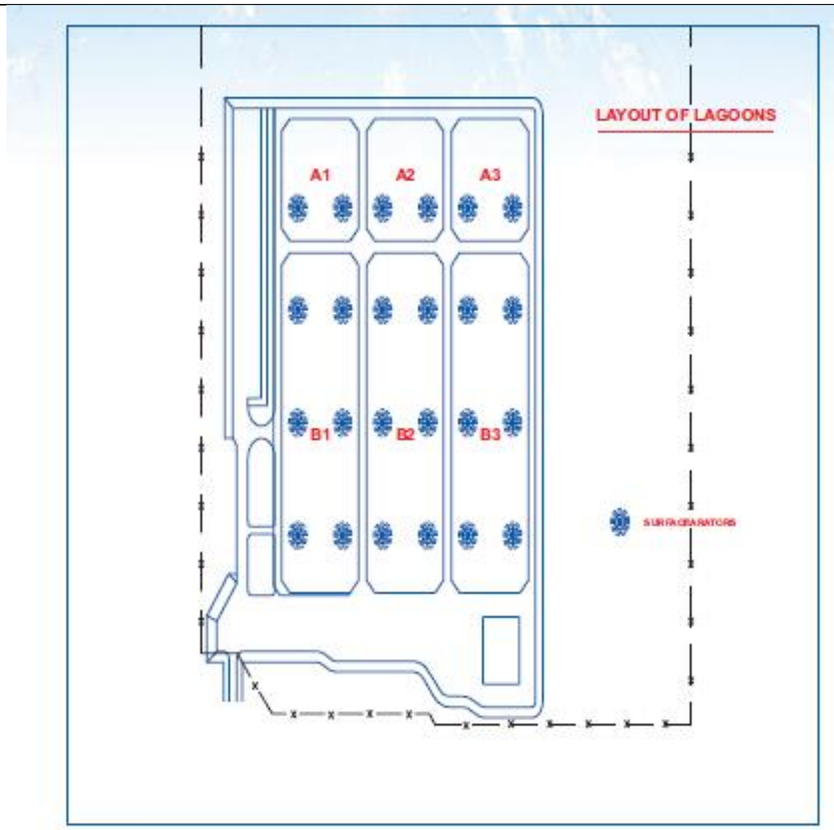


Figure (3) Aerated Lagoons

Fifth: Membrane bioreactors

This system combines an activated sludge system with an ultra- filtration technology whereby filter membranes are immersed within the aeration basins. In this way, treatment is carried out in all its primary, secondary and tertiary stages in one step, in addition to the resulting sludge being fixed, eliminating the need for sludge stabilization units. This system enables to maintain a high concentration of mixed liquor suspended solid (MLSS) in aeration basins, ranging between (10,000_15,000) mg / liter, which leads to an effective treatment and less sludge production. The water is filtered from inside the aeration basins by suctioning it into the filters through holes of a diameter (0.04) microns or less by means of low pressure pumps. This system is characterized by the small area of the plant as the area required for such plants may not exceed 10 times the area of the conventional plants, and the resulting water is of high quality. Thus, a concentration of (5) mg / L or less of the biological oxygen demand (BOD) can be obtained. Also, the membranes do not allow suspended substances to pass through, so there are no suspended materials in the resulting water. This system is one of the modern systems for sewage water treatment that has started to spread widely for use in treating small flows since its development during the past two decades, as there are more than (1500) plants worldwide. Due to its advantages, the system began to be used to treat high flows in a number of major cities in the world, specifically in the United States of America and Canada. See Figure (4).

The use of this system may be appropriate in narrow areas, in the development of existing plants and in places that need high quality of treated water.

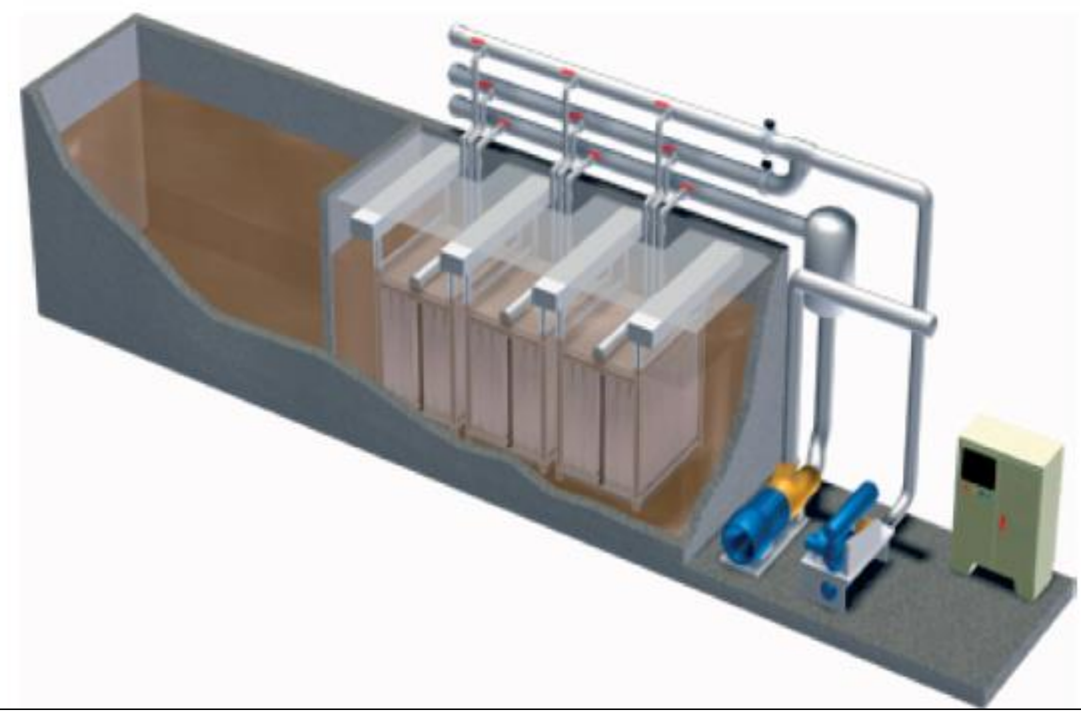


Figure (4) Membrane Bioreactor

1-3-2 Selection of treatment systems

The choice of systems is preferably according to the population census, taking into account that the final decision in choosing the systems is what is weighted by factors evaluating alternatives and economic feasibility:

First: Areas with a population of more than (100.000) a thousand people or more than (25,000 m³ / day):

A system of extended aeration systems with nitrogen removal can be used.

Second: Areas with a population of less than (100.000) a thousand inhabitants or less than (25,000 m³ / day):

1- The system of activated sludge with extended aeration.

2- The system of oxidation channels.

3- Mechanically Aerated lagoon system.

4- Natural stabilization ponds system.

1-3-3 Alternatives evaluation factors

To evaluate alternatives of sewage water and sludge treatment, as well as drainage of water output and disposal of sludge, the following factors shall be taken into consideration as a measure of the evaluation.

1- **Area requirements:**

The land area requirements for treatment operations, the current market value of the land, and the expected value after the end of the life of the plant shall be determined.

2- **Reliability:**

It is also called "reliability," which is how proven experience and reliable sources confirm that the technology applied shall meet the treatment requirements over the design life and local expertise that uses technology can be used in similar circumstances.

3- **Dependability:**

It is the extent of service continuity and the proportion of expected number of stops, number and frequency of lifetime of the technology.

4- **Operating and maintenance:**

A- Complexity:

Difficulty of maintenance, control of technology or equipment, and level of staffing qualification required.

B- Staffing requirements:

The number of Staffing and the level of the qualification for operation and maintenance work. This factor is even more important in areas where a skilled workforce is not available.

C- Power requirements:

Determine the long-term energy cost and the need for a backup power source.

5- Safety:

Needs required to reduce risks to labor and the surrounding environment, as well as the risks of stops, various places, exposure to moving parts and storage work.

6-Constructability:

Determine if implementing the technology is easy or difficult and the requirements for implementation.

7- Residuals aspects

Determine the work of collection and treatment of sludge, as well as disposal, with specifying the quantity and quality.

8-Gases emission:

This factor is concerned with the quantity of gases emitted, especially poisonous ones such as H_2S, and the level of equipment necessary to protect workers and the surrounding environment from these gases.

9- Noise:

Determine the level of noise generated by operation and maintenance, and the impact on the environment.

10- Visual aesthetics:

The plant shall be designed architecturally in accordance with the surrounding environment to become familiar and not reprehensible.

11- Productivity:

The ability of each treatment unit to provide stable performance that produces the final product according to the prescribed drain or use standards.

12- Cost:

Determine the long-term cost of implementation, operation and maintenance. Existing and similar plant costs and market factors may be used.

1-4 sludge

1-4-1 Sludge treatment

The following elements shall be clarified:

1- Quantity and quality of sludge.

2- Sludge treatment alternatives.

3- Details of operations in each alternative.

4- Evaluating alternatives technically and economically, according to what was mentioned previously.

1-4-2 Produced sludge disposal:

The following elements shall be clarified:

1- Sludge disposal alternatives.

2- Evaluating alternatives technically and economically, according to what was mentioned previously.

3- Recommendations.

1-5 Discharge of produced water

The following elements shall be clarified:

1- Alternatives for water Discharge.

2- Conducting mathematical simulations of the environment to which the water will be discharged, such as seas and valleys, and the long-term impact.

3- Follow-up mechanism for the environment that will be discharged into.

4- Evaluating alternatives technically and economically, according to what was mentioned previously.

1-6 Emitted gases and their impact on the environment

The following elements shall be clarified:

1- Estimating the amount and sources of gases.

2- Mathematical simulation of the aerobic environment.

3- Alternatives to control gases.

4- Evaluating alternatives technically and economically, according to what was mentioned previously.

1-7 Studying the environmental implications

1-8 Proper plan

1-8-1 Proper plan selection

The following elements shall be clarified:

1- Summarizing and evaluating alternatives.

2- The sewage water treatment processes selection.

3- The sludge treatment process selection.

4- Sludge disposal methods selection.

5- The final landfill site selection.

1-8-2 Details of the selected plan.

The following elements shall be clarified:

1- The plan and its components.

2- General layout of the sites.

3- Summary of design standards.

4- Hydraulic drawings.

5- Electrical systems.

6- Control systems.

7- Estimated cost of construction.

8- Estimated cost of the operation.

9- Executive program of the plan.

Chapter Two

(Design)

Chapter Two

Table of Contents (Design)

Chapter Two

Design

2-1 Initial design constants

2-1-1 Initial coarse screens

It is designed to remove large materials that may enter the sewage system. See Table No. (1)

2-1-2 Secondary coarse screens

It is located at the outlet of the pumping plant to remove inorganic parts and materials such as plastic cans. See Table No. (1)

Table(1): Design parameters for screen of wastewater treatment plant

No	Parameter	Unit	Initial screen	Coarse screen	Fine Screen
1	Bar depth	mm	10	10	10
2	MaxBar Spacing	mm	50	30	10
3	Maximum approaching velocity	m/s	0.6	0.5	0.5
4	Minimum approaching velocity	m/s	0.4	0.4	0.4

2-1-3 Fine screen

It is designed to remove inorganic matter, particles and floating material. See Table No. (1)

2-1-4 Aerated Grit Champers

It is designed to remove sand and similar materials. The retention time ranges from 6-9 minutes at a water velocity of not less than 0.3 m /s.

2-1-5 Oil and grease removal chambers

They are designed to remove organic and mineral fats and greases and the retention time ranges from 30-40 minutes.

2-1-6 Aeration system

2-1-6-1 Extended aeration tank

1) Sludge age

Sludge age is calculated for de-nitrification and to ensure stabilization of sludge. See Table No. (2)

Table (2): Design sludge retention time of wastewater treatment plant

No.	Minimum two weeks water temperature in Centigrade	Required Sludge Retention time for stabilization of sludge nitrification & de-nitrification (SRT) In days
1	12	29
2	13	27
3	14	25
4	15	23
5	16	22
6	17	20
7	18	19
8	19	18
9	20	16

10	21	15
11	22	14
12	23	13
13	24	12
14	25	12
15	26	11
16	27	10

2) Sludge yield

The value of the measured sludge production factor shall not be less than 0.6 and shall be measured or estimated by the designer using accepted scientific methods.

3) De-nitrification volume

Preferably be more than 10% and less than 30% as determined by the mathematical simulation.

4) Sludge volume index (SVI)

It is an indicator of the sedimentary properties of the sludge and an evidence of the process efficiency, preferably from (100 Up to 125) ml / g.

5) Ratio of food to microorganisms

Preferably to be from 0.05 to 0.12.

6) Oxygen uptake rate Kg O2 / Kg BOD

It is the oxygen required to oxidize carbon and nitrogen. The rate of oxygen consumption shall be determined according to the age of the sludge, to oxidize carbon and nitrogen substances, as well as the application of peak oxygen treatments to be provided. See Table No. 5 and Annex No. 1 to determine the amount of oxygen required for aeration.

7) The correction factor of the effect of mixing and the geometric shape of the aeration tank on Oxygen supply.

(α')oxygen transfer capacity

(α')= (The amount of oxygen available in the wastewater - the amount of oxygen available in the clean water = 0,5)

8) Ethylene propylene dimers Membrane (EPDM)

Whether by diffusers or membranes, it is between (75 - 125) m3 / m2 / hour

Table(3): Peak factor for oxygen uptake rate

No	Peak factor for oxygen uptake rate						
		4 days	6 days	8 days	10 days	15 days	25 days
1	Peak factor for carbon removal	1.3	1.25	1.2	1.2	1.15	1.1
2	Peak factor for nitrification in BOD<1200 kg/d	-	-	-	2.5	2.5	2
3	Peak factor for nitrification in BOD>6000 kg/d	-	-	-	2	1.8	1.5

9) Bacteria selection tank

It is a unit through which the environment is prepared for the reproduction of bacteria, which helps to increase the efficiency of treatment and reduce filamentous bacteria. The site is before the aeration tank, and these units may be aerobic or anoxic or anaerobic. The ratio of food to microorganisms shall preferably be in units of Kg COD / Kg MLSS day according to the number of tanks and the type of reactor as follows:

9-A) Aerobic unit with several basins

The first tank F/M=d. 12Kg COD/ Kg MLSS

The second tank F/M=d. 6Kg COD/ Kg MLSS

The third tank F/M=d. 3Kg COD/ Kg MLSS

9-B) Anoxic unit with one tank, preferably an F / M of (0.1 -2) d. Kg COD/ Kg MLSS

9-C) Anoxic unit with several tanks

The first tank F/M=d. 6Kg COD/ Kg MLSS

The second tank F/M=d. 3Kg COD/ Kg MLSS

The third tank F/M=d. 1.5Kg COD/ Kg MLSS

9-D) Anaerobic unit

The standards of the anoxic units can be applied to these units.

2-1-6-2Aerated ponds

1) Initial ponds of full mixing

For ponds' design, see Table No. (4)

Table No. (4) Initial ponds design standards		
1	shape	Square or rectangular
2	Depth of the pond	2.5m
3	Concentration of solids mixture	1000 – 1500 mlg/L
4	Retention Time	5- 7 days

5	Energy required for mixing	3 - 5 K.W / 1000 m3 of the pond's size
6	Aeration type	Floating mechanical aerators

2) Secondary ponds of particular mixing

Deposition is allowed in the second half of the ponds. For ponds' design, see Table No. (5)

Table No. (4) Secondary ponds design standards		
1	shape	Square or rectangular
2	Depth of the pond	2.5m
3	Retention Time	3- 4 days
4	Mixing Energy	1 - 5 K.W / 1000 m3 of the pond's size

2-1-6-3 Oxidation ponds

First: Anaerobic ponds

The retention rate in anaerobic ponds preferably ranges from (5-7) days, with a depth of 5 meters.

Second: Facuitative ponds

Used at a temperature of more than (10) degrees Celsius, which is at the average minimum temperature for the coldest months in the winter season. The surface loading rate ranges from (45 - 90 kg) BOD / ha / day and the depth of the basin reaches (1.5) m.

Third: Maturation ponds

Of a 1m depth and a retention rate ranging between (4-6) days. The number of ponds operating in series is determined according to the target bacterial numbers in the produced water.

2-1-7 Final clarifier: For the parameters of the final clarifier design, see Table No. (6)

Table No. (6) Design parameters of the final clarifier

No	Parameter	Unit	Value
1	Side water depth	M	4 to 6
2	Diameter	M	4 to 46
3	Inlet well diameter	M	25% of tank diameter
4	Surface loading in maximum flow rate	M3/m2.day	24 to 32
5	Surface loading in minimum flow rate	M3/m2.day	8 to 16
6	Solid loading in maximum flow rate	Kg/m2.hr	6 to 8
7	Solid loading in minimum flow rate	Kg/m2.hr	1 to5
8	Wier loading in maximum flow rate	M3/m.day	260
9	Wier loading in minimum flow rate	M3/m.day	175

2-1-8 Sand filters: For the parameters of the filters design see Table No. 7 & 8

Table No. (7) Design parameters of dual media deep declining rate filters for tertiary wastewater treatment

No	Parameter	Unit	Anthracite	Sand	Filtration velocity
1	Media depth	mm	**400**	**800**	
2	Media size	mm	1.4 – 2.5	0.75 – 1.25	
3	Effective size	mm	1.6	0.8 – 0.9	
4	Uniformity coefficient	mm	1.2 - 1.4	1.3	
5	Density	kg/m3	1.35 – 1.4	> 90%	

				Silica	
6	Maximum filtration velocity when the filter is newly backwashed at average flow rate	m/hr			12
7	Maximum filtration velocity when the filter is just before backwashed at average flow rate	m/hr			6
8	Minimum water backwash rate	m/hr			50 - 70
9	Minimum air backwash rate	m/hr			60

Table No. (8) Design parameters of mono-mdi deep bed declining rate filters for tertiary wastewater treatment				
No	**Parameter**	**Unit**	**Sand**	**Filtration velocity**
1	Media depth	mm	900 - 1200	
2	Effective size	mm	2 – 2.5	
3	Uniformity coefficient		1.2 – 1.4	
4	Density	kg/m3	> 90% Silica	
5	Maximum filtration velocity when the	m/hr		12

	filter is newly backwashed at average flow rate			
6	Maximum filtration velocity when the filter is just before backwashed at average flow rate	m/hr		6
7	Minimum water backwash rate	m/hr		120
8	Minimum air backwash rate	m/hr		110 - 144

2-1-9 Disinfection

Of the three options available for sterilization, what the factors for evaluating alternatives suggest are selected:

1- Chlorine.

2- UV.

3- Natural clarification ponds.

In the event that chlorine gas is used for disinfection, gas scrubbing units shall be used to treat leaks.

2-1-10 Sludge treatment

2-1-10-1 Sludge thickening

A) Gravity thickeners

Table No. (9) Design parameters of Gravity Thickeners

1	Diameter	5 -20 m
2	Side wall depth	3 -4 m
3	Inclination of floors	16 -25%
4	The hydraulic load	4- 6m3/ m2 hr
5	Organic load	20-50 kg/m2 day
6	Hydraulic retention time	12-18hr
7	Solids retention time	shall not be more than 20 hr.
8	Dilution water	shall not be less than 30 m3/ m2 hr
9	The percentage of outward solids shall not be less than	4%

B) Pre-dewatering table

Table No. (9) Design parameters of Pre-dewatering Table		
1	The percentage of outward solids shall not be less than	3- 4%
2	The hydraulic load	(16- 40m3) / hr. per each meter of the walking width
3	The hydraulic load	200kg solids/hr. per each meter of the walking width

2-1-10-2 Sludge dewatering system

A) Compressor gears: The design of the Compressor gears shall be guided by the following parameters:

1- Gear width= 1-3m.

2- Organic load= (45- 180) kg solids/hr. per each meter of the walking width

3- Hydraulic load= (10- 16) m3 / hr. per each meter of the walking width

4- Solids concentration in sludge= (2- 4%)

5- Solids concentration in pressurized sludge= (18-20%)

6- Operation time for compressor gear= (16) hr/ day.

B) Centrifuge system; the design of the system is guided by the following terms:

1- Concentration of inward sludge= 2-4 %

2- Concentration of outward sludge> or = 20 %

C) Sand sludge drying beds

3- This system requires a network of open drainage pipes connected at the bottom of the basin, the distance between each two tubes range from four to eight meters. These pipes shall be covered with a layer of gravel with a height of 30-40 cm. The diameter of the gravel ranges between (1-5) cm, topped with a layer of sand about (25) cm high. Sludge is distributed to these basins through channels the bottom of which is at least 55 cm above the surface of the sand, and they are provided with the necessary gates on their sides. In front of each opening, an anti-sludge splash plat shall be placed over the sand surface, provided that the dimensions of these panels range from (75-90 cm) in length and width. For draining sludge on these basins, the sludge must be spread into these basins at depths of (20-30 cm) and left for a period of (15-8) days to dry, and the loading rate ranges from (5-18) kg / m2 / each time.

2-1-10-3 Thermal drying

It is preferable to use indirect drying, provided that the medium used is oil. The indirect drying technique is based on dispersing the sludge on the tubes containing the hot oil. The solids content using indirect dryers may reach the level between (50-90%), and if the goal is to achieve a solid content of between (65-85%) then dryers with indirect drying technique are the best. For better operation of the dryers, it is preferred that the solids content coming out from the water content reduction units should be more than (18%).

2-2 Conceptual design

It shall contain the following elements:

1- The overall shape of the site, showing the arrangement of treatment units and buildings.
2- Detailed calculations of designs for treatment processes and electrical systems.
3- Number, type and size of treatment units.
4- General diagrams of treatment units.
5- General diagrams for architectural features.
6- General diagrams for electrical systems.
7- General diagrams for control systems.
8- General diagrams for aeration, heating and air conditioning systems.

Ministry of Water and Electricity

Chapter Three

Material Requirements

Chapter Three

Content (Material requirements)

Chapter 1

(Entrance Works)

3.1

3-1-1 Concrete buildings and structures

1. All the ceilings and walls of the channels of the entrance works through which raw sewage flows or will be covered in order to control the odors shall be padded with plastic strips inserted in the concrete by a T-cage while casting the walls and ceiling of the channels, or padded them with fiberglass to protect them from corrosion due to exposure to the sewage gases and the acids formed by them.

2. Separate channels for each mechanical screen shall be designed with a common channel before and after the coarse screens and a chute in the common channel behind the screens to be used to isolate each line.

3. The heights shall allow entry, detection and repair where needed for these areas to be at least at a height of 1.5 m.

4. The distance between the spiral pumps, preferably not less than (90) cm, and in the form of stairs.

5. Small plants are preferred to have a balancer tank to store excess plant power at peak times.

6. The coarse and soft mechanical screens shall be fitted with a dimension hole (60 cm x 60 cm x 40 cm) to drain the water from the gates when carrying out the maintenance and adjust the slope of this location to this hole.

7. The site shall be equipped with a water closet (a toilet) for operator and service technicians if the nearest water closet is more than 100 meters away from the site.

8. The distances behind the electrical panels, whether medium or low voltage shall be sufficient and not less than 1 m to reach the components of the panels from the back for maintenance, dismantling and installation work, and this shall be taken into account when designing the building and where the panels are installed in the building.

9. Basements are best not used as far as possible on such a site.

10. The control room shall be adequate for the size of the operation and follow-up panel, suitable and spacious when maintenance is required, preferably on the second floor of the building and all the front of the room shall be glass with screens for the interior and lower areas, especially if these areas contain water pipes and equipment.

11. Walkers are preferred to be of fiberglass or aluminum fibers to suit the nature of sewage gases.

3-1-23.1.2 Surplus drain side line:

1. Each plant entrance shall be equipped with a side drain line to drain the plant surplus.

2. The surplus drain side line shall be automatic drain by wastage, which adjusts its level to the maximum plant power.

3. The surplus drain side line shall not be preceded by any units or gates that could obstruct its operation when it breaks down, which could cause sinking of the plant entrance.

4. The capacity of the surplus drain side line shall be greater than the capacity of the sewer lines entering the plant entrance to accommodate the discharge of upcoming large quantities, especially in the rainy season.

5. The a drain side line shall be equipped with a flow meter of special specifications as indicated in 3.1.10

6. In the event that it is not possible to equipped some plants with a drain side line because the plant is located in a low area and its surplus cannot be drained by gravity, then consideration shall be given to raising all the components of the plant entrance to prevent flooding and sinking of the plant during rainy seasons. It is also taken into consideration to provide a collection tank at the entrance to the plant equipped with diesel pumps to drain the excess water by pumping to the nearest natural inclination outside the plant surplus line.

7. The weir of the surplus drain side line shall be equipped with a drop-down barrier fixed at the top and a free-moving barrier from the bottom, made of flexible rubber material, for the purpose of preventing the emission of odors from the line.

3-1-3 Lifting pumps

1- Lifting pumps preferably at the entrance of the plant when needed as follows:

a. A plant with a capacity up to (20.000 m3 / day) that uses centrifugal submersible pumps or axial flow submersible pumps to reduce the civil, mechanical and electrical construction costs, and reduce and control odor emissions.

b. A plant with a capacity greater than (100.00) m3 / day that uses screw pumps.

2- The design of screw pumps shall be based on the maximum flow rate, provided that the power of one pump does not exceed the average flow rate, taking into account the existence of a backup pump for maintenance purposes and that the pumps are the same.

3- Centrifugal submersible pumps:

1) These pumps are preferably installed on dry and in a separate pump room from the wet collecting tank.
2) Each pump shall be equipped with an isolation valve with each pump outlet from the inside of the collection tank having concrete protrusions as spacers with a minimum length of (40 cm) with a U-chute for manual isolation to maintain isolation valves.
3) The pumps shall be equipped with a mechanical cutter on the drawing line for fibrous materials and large objects.
4) The fan shall be of the semi-open, non-clogging and self-cleaning type, and the maximum solid objects that these pumps allow to pass through shall be no less than (100) mm.
5) The fan shall be of high-quality materials that are resistant to raw sewage, resistant to abrasive materials (sand - gravel - metal objects).
6) The sealing system shall be of the double mechanical type and made of silicon carbide material, preferably of the combined type.
7) The drive shaft and protection sleeve shall be stainless steel.
8) The engine shall be equipped with the necessary protection sensors (coil temperature, water leakage on the engine, water mixing with oil, top and bottom bearings temperature).
9) The engine shall be protected from running out of foreign objects and water (IP 68).
10) The engine shall be designed to run on dry conditions while ensuring proper cooling.
11) The engine insulation level shall not be less than "F".

12) The engine shall be suitable and configured to work with electronic speed modulators and not in conflict with the performance curves of the pump.

4- Axial flow submersible pumps:

1) These pumps shall be equipped with a fibrous material cutter.
2) The fan shall be of the semi-open, non-clogging and self-cleaning type, and the maximum solid objects that these pumps allow to pass through shall be no less than (100) mm.
3) The fan shall be of high-quality materials that are resistant to raw sewage, resistant to abrasive materials (sand - gravel - metal objects).
4) The sealing system shall be of the double mechanical type and made of silicon carbide material, preferably of the combined type.
5) The drive shaft and protection sleeve shall be stainless steel.
6) The engine shall be equipped with the necessary protection sensors (coil temperature, water leakage on the engine, water mixing with oil, top and bottom bearings temperature).
7) The engine shall be protected from running out of foreign objects and water (IP 68).
8) The engine insulation level shall not be less than "F".
9) The engine shall be suitable and configured to work with electronic speed modulators and not in conflict with the performance curves of the pump.

5- Screw pumps:

1) The inclination of the screw pumps shall be (32-35) degrees and a maximum of 38 degrees.
2) The entrances of the screw pumps shall be equipped with isolation gates for maintenance purposes, so that each pump is equipped with gate with an actuator.
3) The spiral of the screw pump shall be protected by a solid slice on the outer spiral frame to protect against corrosion.
4) The engine shall be equipped with the necessary protection sensors (coil temperature - jars temperature). The engine must be of protection against the penetration of foreign objects. The level

of insulation of the engine shall not be less than "F". The engine shall be suitable and configured to work with electronic speed modulators without the need for any external additives.

5) The wet-well area for each screw pump must be equipped with a hole of dimensions (50 cm x 60 cm x 60 cm) to drain the water leaked from the gates to that area when performing maintenance.
6) To cover the screw pumps, transparent caps shall be placed for monitoring and examination, especially in the lower, middle and upper areas. The caps shall be secured with quick-release hinge locks.
7) The engine room and gear boxes of screw pumps shall be aerated by suction fans and aeration holes with washable screens that prevent dust and contribute actively to reduce the room temperature.
8) The reduction ratio of the screw pump gearbox shall be within (40:1) up to (45:1) to achieve the largest possible capacity.
9) The service factor of the screw pump gearbox shall not be less than (2).
10) The lower bearing of the screw pump must be equipped with a lubrication system (oil) with the sensors and all monitoring and protection devices (pressure and level).
11) The lines of the lower bearing lubrication system are preferably of stainless steel.
12) The upper bearing of the screw pump shall be placed on a ball bearing and shall be designed for a service life (150,000 hours) or more.
13) The drive system shall be equipped with mechanical reverse impedance installed on the gear or the electric motor shaft.
14) In hot areas, the gearbox shall be equipped with an oil cooling system consisting of an oil pressure, a cooler, and a cooling fan, provided that the system equipped a temperature sensor with an instantaneous display and an oil pressure sensor and shall be linked to the control panel and the plant control system. The sensors are still needed in cold areas without the cooling system.
15) The flow-knitting and preventing splashing plate of the pump shall be made of stainless steel type (316 L), provided that it has been chemically treated after the manufacturing process.

6- The mechanical coarse screens shall be placed before the lift pumps at the entrance.

7- A warranty certificate from the system manufacturer stating that this supplied model and all components (bundled components from other companies) are the latest models produced of this type of equipment and that parts are available for a minimum of (15) Year to be submitted by the contractor.

8- Electronic speed modulators shall be installed for equipment requiring controlled operating conditions. The modulators shall be configured for automation according to signals from the operating conditions and constants sensors (such as sensors measuring level, flow .etc.). In addition being used for smooth, soft, gradual start-up and stop purposes to reduce voltage drop on the public electrical system and the effect on equipment in general, as this is a key function. The main operating equipment and equipment whose rated power more than one kilowatt shall be taken into account. The shape and length of the wave and the number of harmonics that are reflected on the power supply network due to the installation of speed change units shall be in accordance with the requirements of the global electrical network. The design shall include means to limit this in accordance with international standard systems. Direct Torque Control System shall be available. See chapter 3.18, concerning this.

3-1-4 The mechanical coarse screens:

1. The capacity of the screens shall be chosen based on the maximum load, provided that the capacity of each screen shall then be chosen based on the average load, taking into account the similarity of the equipment to achieve interoperability and the availability of installed standby equipment.

2. All the components of the coarse screens shall be inside a single solid structure swing and output outside the channel for maintenance and then be put back. The sides are sealed with the channel wall by using rubber strips.

3. Entrances and exits of mechanical coarse screens shall be provided with isolation gates for maintenance purpose.

4. Coarse screens shall be designed for heavy duty and shall have separate management units for each lift and tilt.

5. The equipment shall be completely made of chemically treated stainless steel (SS. 316).

6. The type of coarse strainers shall be:

a. Of an abrasive type, provided that the mechanism for ascending and descending movement is on a gear rail and not by a track. When designing the moving combs, the front of the teeth shall be raked on both sides in an arrow shape to give high flexibility to allow the combs to enter between the holes of the fixed screen bars and thus reduce the problems of deflection and weaving.
b. Of a stepped type, provided that the angle shall not be exceed (15) degrees. The bottom of the screen shall be equipped with a self-cleaning system that prevents the accumulation of sand through it. Driving is done by upper main shaft and connecting arms. The tracks are not used for transmission.
c. Of a continuous movement type through a moving escalator made of reinforced plastic or stainless steel. Taking into account that the design shall be done in such a way that any number of escalators can be removed without affecting the work of the screen.

7. All screens shall be driven by an appropriate electric engine with the necessary protection sensors. The degree of protection of the engine against penetration of foreign objects shall be (IP55) and the degree of isolation shall be no less than class "F".

8. All screens shall be equipped with an electric lifting mechanism to remove them from the channel for maintenance.

9. Screens shall be completely covered to reduce the emission of odors.

10. The screen height above the waste conveyor shall be at least (60) cm as a net distance between the two equipment for convenient maintenance of the conveyor or the possibility to insert a collection container in the event of a transmission system failure. This distance between the refinery and the conveyor shall connected by a stainless-steel collection funnel (Type 304L), which can be removed quickly.

11. Coarse screens shall be equipped for connection to the plant's Supervisory Control and Data Acquisition **(SCADA).**

12. A warranty certificate from the system manufacturer that this supplied model and all its components (bundled components from other companies) are the latest models produced of this type of equipment and that parts are available for a minimum of (15) year, shall be submitted by the contractor.

13. The screens shall be operated with two systems of level difference and a timer in addition to the possibility of operating manually.

3-1-5 System of transferring the waste of mechanical coarse screens

1. The waste of coarse screen shall be transferred and collected by hollow type screw conveyors without shaft.

2. When designing these conveyors, consideration shall be given to the large sizes of waste (tin cans - wood - stones - etc.) that are expected to be seized and removed by mechanical coarse screens.

3. The conveyor duct shall be made of stainless steel, type (316 L).

4. The screw shall be made of special corrosion-resistant iron.

5. Conveyor duct linings shall be of high hardness steel strips or better.

6. The end of the conveyor duct is provided with two openings: the first one is lower for handling the waste compression equipment and the other is horizontal for use in the event of an emergency for handling conveyor belts leading to the containers, provided that the openings are equipped with manual knife gates.

7. The conveyor shall be designed so that the rotation speed is not higher than (20 rpm).

8. The conveyor shall be equipped with a cover in the form of joints not exceeding 1 meter and shall be connected by four screws to limit the odor emissions.

9. All screens shall be driven by an appropriate electric engine with the necessary protection sensors. The degree of protection of the engine against penetration of foreign objects shall be (IP 66) and the degree of isolation shall be no less than class "F".

10. The **conveyor**s shall be prepared to connect to the plant's remote control and monitoring system.

11. A warranty certificate from the system manufacturer that this supplied model and all its components (bundled components from other companies) are the latest models produced of this type of equipment and that parts are available for a minimum of (15) year, shall be submitted by the contractor.

3-1-6 System of washing, compressing and packing the waste of mechanical coarse screens

1. Shall be made of chemically treated stainless steel of type (316).

2. The conveyor shall be equipped with special sewers to drain that water (Flashing system).

3. The conveyor operation and control shall be linked to the automatic system for running the screens.

4. The possibility to operate the system manually and automatically.

3-1-7 Fine mechanical coarse screens:

1. The capacity of the screens shall be chosen based on the maximum load, provided that the capacity of each screen shall then be chosen based on the average load, taking into account the similarity of the equipment to achieve interoperability and the availability of installed standby equipment.

2. All the components of the fine screens shall be inside a single solid structure swing and output outside the channel for maintenance and then be put back. The sides are sealed with the channel wall by using rubber strips.

3. Entrances and exits of mechanical fine screens shall be provided with isolation gates for maintenance purpose.

4. Fine screens shall be designed for heavy duty and shall have separate management units for each lift and tilt.

5. Fine screens shall be completely made of chemically treated stainless steel (SS. 316).

6. The type of the fine screens shall be:

   a. Of an abrasive type, provided that the mechanism for ascending and descending movement is on a gear rail and not by a track. When designing the moving combs, the front of the teeth shall be raked on both sides in an arrow shape to give high flexibility to allow the combs to enter between the holes of the fixed screen bars and thus reduce the problems of deflection and weaving.

b. Of a continuous movement type through a moving escalator made of reinforced plastic or stainless steel. Taking into account that the design shall be done in such a way that any number of escalators can be removed without affecting the work of the screen.

7. All outputs from the fine screens shall be washed, compressed, and clapped with plastic bags.

3-1-8 System of transferring the waste of mechanical fine coarse screens

1. The waste of the fine screen shall be transferred and collected by hollow type screw conveyors without shaft.

2. The conveyor duct shall be made of stainless steel, type (316 L).

3. The screw shall be made of special iron.

4. Conveyor duct linings shall be of high hardness steel strips or better.

5. The end of the conveyor duct is provided with two openings: the first one is lower for handling the waste compression equipment and the other is horizontal for use in the event of an emergency for handling conveyor belts leading to the containers, provided that the openings are equipped with manual knife gates.

6. The conveyor shall be designed so that the rotation speed is not higher than (20 rpm).

7. The conveyor shall be equipped with a cover in the form of joints not exceeding 1 meter and shall be connected by four screws to limit the odor emissions.

8. All screens shall be driven by an appropriate electric engine with the necessary protection sensors. The degree of protection of the engine against penetration of foreign objects shall be (IP 66) and the degree of isolation shall be no less than class "F".

3-1-9 System of washing, compressing and packing the waste of mechanical fine coarse screens

1. Shall be made of chemically treated stainless steel of type (316).

2. The conveyor shall be equipped with special sewers to drain that water (Flashing system).

3. The conveyor operation and control shall be linked to the automatic system for running the screens.

4. Shall be made of chemically treated stainless steel of type (316).

5. The possibility to operate the system manually.

3-1-10 Flow and level meters

1. All the fine screens sensors shall be of the wastewater contactless-type.

2. Temperature and pressure monitoring and control systems shall be installed for screw pump bearings when using oil.

3. A flowmeter for the inlet water of the plant shall be installed and suitable for use in open channels. The appropriate location for measurement is required to ensure that the water does not reverse, which may cause false readings.

3-1-11 Lifting equipment (Cranes)

The level of protection of the special electrical panel shall be high in order not to be affected by the increase emission of gases in this area.

3-1-12 Aeration and air conditioning systems:

1. The engine room and gear boxes of screw pumps shall be aerated by suction fans and aeration holes with washable screens that prevent dust and contribute actively to reduce the room temperature.
2. The selected air conditioning systems must be resistant to the existing sewage and gas environment, and shall be proportionate to the size of the control room and the electrical room to ensure that the temperature does not exceed 25°C.
3. For flexibility of operation and maintenance, the load shall be divided among several air conditioning units.

3-1-13 Safety and firefighting systems

1- Control sites and electrical rooms must be equipped with battery-operated lighting units.

2- Closed areas and equipment rooms shall be equipped with devices to measure the percentage of harmful and dangerous gases and with alarm in the event that the rate is higher than the permitted rates**3-1-14 Supplying the site with drinking water, industrial water and services**

1. The equipment site shall be equipped with air lines for cleaning and maintenance.
2. Coarse and fine screens sites shall be fitted with industrial water lines for cleaning operations.
3. The site shall also be equipped with a drinking water line near the odor treatment unit at the entrance to the plant.

(Oil and grease removal basins)

(3-2)

3-2-1) Concrete structure and buildings:

1. The concrete floor must be protected by using appropriate paintings, oil, grease and chemicals proof and highly scratch resistant.
2. It shall be taken into consideration when designing buildings, to be reasonably vast where it gives a comfortable in between distance (80 cm approximately) in order to maintain each equipment and the other and equipment and wall, it shall also take into consideration to increase the space in the building in the range of (15%) to add some equipment and systems to the building later as a kind of development or renovating to the site.
3. Walkways are preferably to be made of reinforced fiber glass or Aluminum to suit the nature of sewage water gases.
4. Sand removal basins must be designed of no less than 2 basins in any event.
5. When identifying the number of sand removal basins, it shall be taken into consideration to get a complete basin out of service for maintenance purposes, provided, the remaining basins shall bear the utmost design burden of the plant without affecting its performance.
6. 6. Using cupolas is not preferred as far as possible in such a site.
7. Basins concrete must be protected by using corrosion resistant materials to protect it from gases.

3-2-2) Sand filtration system:

1. Gravel and sand gathered from sand removal basins must be washed to remove organic materials to reduce size and weight of filtration outputs as far as possible.
2. Gravel filtration is preferred to be of funnel kind equipped with spiral carrier made from chemically-treated stainless steel.

3-2-4) Sand suction system

1. The capacity of sand extraction pumps must be two times bigger than the design burden.
2. It is preferred to place pumps at the bottom of the basin and equipping the same with a funnel to suck sand, taking into consideration removing pumps easily when necessary.
3. Sand suction lines must be made of chemically-treated stainless steel.

3-2-4) Air blowers:

1. It is preferred to Use the blower with the positive displacement.
2. The rotational speed of the blower of the positive displacement shall not exceed (2000) round per minute.

3. The rotational speed of the blower of the centrifugal shall not exceed (1750) round per minute.
4. Blowers' level must be above ground level to protect the same from damage in case of drowning.
5. The blower must have the necessary accessories including vacuums valve, pressure switch and kill switch.
6. The recommended noise level of Air Blower must not exceed (75 db) one meter away.

3-2-5) Air distributors, valves and pipes:

1. All lines that in contact with sewage water must be made of chemically-treated stainless steel.
2. The possibility to insulate any line by using valves.

3-2-6) Rolling Bridges and their Accessories:

1. The rolling bridges and its accessories must be made of chemically-treated stainless steel.
2. The bridge shall be moved with one engine in the middle.
3. Sensors must be installed at the rolling bridges in the oils and grease removal basins to protect the same from inclination and eccentricity.

3-2-7) Basins discharge system:

1. It is preferred to use discharge system to any basin by gravitation to the plant entrance through pipes as far as possible and to alleviate the need for the usage of mobile pumps to discharge basins as far as possible.
2. Basins that are difficult to be discharged by suction shall be equipped with an external room measuring, approximately (one meter× one meter) and its level is equivalent to the lowest point in the basin to enable mobile pumps to conduct the direct suction.

3-2-8) Flow and leveling measurements:

1. The contractor shall provide a warranty certificate by the systems manufacturer company, reported that the supplied model and all its components (assembled by other companies) is the latest models produced of such type of equipment and shall secure spare parts for a period of no less than five years.
2. Installed measurements shall be connectable by the remote control and monitoring.
3. All micro devices systems that work with microprocessors (valves or equipment) must be installed inside building to protect the same from direct sunlight, sensors also sensors, which applications impose external installation, must be protected from direct sunlight with a canopy to avoid overheating.

3-2-9) Supplying drinking water, industrial water and services to the site:

1. The equipment site must be equipped with air lines to use the same in cleaning and maintenance.

2. Basins sites shall be supplied with industrial water pipelines to be used in cleaning processes.
3. The site shall be supplied with drinking water pipeline near Odor treatment unit.

Chapter 3

(Initial Stabilization Basins)

(3-3)

3-3-1) Concrete structure and buildings:

1. Initial stabilization basins must be designed of no less than (2) basins in any event.
2. It shall be taken into consideration when identifying the number of Initial stabilization basins, to consider a complete basin out of service for maintenance purposes, provided that, the remaining basins shall bear the utmost design burden of the plant without affecting its performance.
3. Floor concrete must be protected by using appropriate paintings, oil, grease and chemicals proof and highly scratch resistant.
4. It shall be taken into consideration when designing buildings, to be reasonably vast where it gives a comfortable in between distance (80 cm approximately) in order to maintain each equipment and the other and equipment and wall, it shall also be taken into consideration to increase the space in the building in the range of (15%) to add some equipment and systems to the building later as a kind of development or renovating to the site.
5. Walkways are preferably to be made of reinforced fiber glass or Aluminum to suit the nature of sewage water gases.
6. Using cupolas is not preferred as far as possible in such a site.
7. The purified water shall be injected through distribution box equipped with adjustable weirs that the burden distribution can be fully hydraulically controlled among basins, provided that, it shall be taken into consideration, at designing the box, that it must be free from undisrupted flow within the same, it also preferred that this box must be installed as a tower in the middle of basins.

3-3-2) Rolling bridges and their accessories:

1. It is preferred that the safety device for the rolling set of the electronic type (Electronic Torque Limiter).
2. The rolling bridges of stabilization basins must be made of stainless steel.
3. It is preferred to connect all components of bridges with stainless steel screws.
4. Walkways installed at bridges must be made of aluminum or fiber glass.

3-3-3) Sludge scraping and collection:

1. Sludge scrapers at the bottom of the final stabilization basins tanks must be suspended at the bridge not loaded on (Nylon wheels) as this hinders the rotational movement of such wheels and its eroding.

3-3-4) Scraping of foam and other floating materials:

1. Scrapers must be installed at the surface of basin to remove the floating materials at the tank surface to foam collecting box.

3-3-5) Weirs

1. Weirs are preferably made from fiber glass with a thickness of no less than (6) mm and its materials are gases and sewage water proof.

3-3-6) Basins discharge system:

1. Basins that are difficult to be discharged by gravitation and required to be discharged by suction shall be equipped with an external room measuring, approximately (one meter× one meter) and its level is equivalent to the lowest point in the basin to enable mobile pumps to conduct the direct suction.
2. It is preferred to use discharge system to any basin by gravitation to the plant entrance through pipes as far as possible and to alleviate the need for the usage of mobile pumps to discharge basins as far as possible.

3-3-7) Lifting equipment (Cranes):

Equipment inside buildings and require cranes that move on two sides, its load must be of no less than (1,5) of the established load.

3-3-8) Measurement and flow devices:

1. It must be confirmed that the complex sludge measurements can work accurately with the existence of gases in the sludge.

3-3-9) Systems of electricity supply and monitoring:

1. .The slip ring related to the electricity supply and signs at the center of the rolling bridge must be designed to bear (2.5) times of the electrical loads installed at the bridge and to record power surge situation when ceasing such equipment in order to assimilate the capacity change of installed engines with the change of its type or the need to operate and maintain the same to install a temporary equipment for this purpose.
2. The slip ring related to the electricity supply and signs at the center of the rolling bridge must be designed as there are a number of unused backup rings equal to half of the used number of loads in order to operate the same when any working ring is out of service.
3. The rolling bridge shall be equipped with (2) electrical sockets with a cover supplied with electrical current source of (15) ampere and (230) volt and frequency 60 monophasic Hertz.
4. Each basin and near the sludge outlet must be supplied with an power supply panel, the first electrical socket with a power of (20 ampere) and voltage (230 volt/60 hertz) monophasic, the second socket with a power of (40 ampere) and a voltage of (400 volt/60 hertz) of a three-phasic. To operate the mobile pumps for the operation and maintenance purposes in respect of the basin and to take into consideration that the panel must be equipped with the necessary basic protectors, power lights, power switch and kill switch.

5. Monitoring and surveillance of Gates and sludge level in basins must be conducted electronically and remotely and it must be connected with SCADA system.
6. Rooms of power panels must be equipped with a ventilation system to filter air from gases by using activated carbon or any other method to prevent gases from entering the power panel and the damage of the internal components because of oxidation.

3-3-10) Safety and firefighting systems:

1. Control sites and electricity rooms must be equipped with battery-operated lighting units that operate when the power is cut off.
2. Closed areas and equipment rooms must be equipped with devices for measuring the percentage of harmful and dangerous gases as well as alarms in case the percentage is higher than the permissible.

3-3-11) Supply the site with drinking water and industrial water:

1. The equipment site must be supplied with air pipes for use in cleaning and maintenance.
2. The sites of these basins need to be supplied with industrial water pipes for cleaning.
3. The site also needs to be supplied with a pipeline for drinking water nearby the special odor treatment unit.

Chapter 4

(Aeration Tanks "Bioremediation")

(3-4)

3-4-1) Concrete and steel structures and buildings:

1. Aeration tanks must be designed in such a way that they are not less than (2) in any way.
2. When determining the number of Aeration tanks, it is taken into consideration that an entire tank may be removed from service for maintenance purposes, provided that the rest of the tanks can bear the entire maximum design load of the plant without affecting its performance.
3. It is preferable to reduce the size of Aeration tanks and increase their number so that the effect of taking one of them out of service for maintenance purposes is as little as possible.
4. In the event that Aeration Tanks are circular in shape, it is preferable that the radius is not more than 12 meters so that the middle of the tanks can be reached for maintenance purposes with affordable crane loads. The tanks must be separated and the crane should be able to stand over at least 70% of the perimeter without obstacles.
5. In the event that Aeration Tanks are rectangular or square in shape and their total width is not more than 16 meters, it is preferable for the tanks to be compact and the outer sides to be equipped with an asphalt road. In the event that the tanks are large, it is preferable not to exceed 16 meters in width, and each 2 paths must be separated by a road of no less than 6 meters in width so that the end of each path can be reached from the outside for maintenance purposes with crane lifting equipment that is characterized by appropriate loads and reasonable cost.
6. It is preferable to control the entry of raw sewage water into the aeration tanks or the exit of activated sludge from the aeration tanks to the secondary stabilization basins by means of adjustable weir gates that enable the hydraulic flow to be controlled on the paths in the event that entry is shared.
7. In concrete bridges that carry aerators of aeration tanks, the expansion and contraction of these bridges must be taken into account. This shall be done without obstacles that may prevent the expansion and contraction of the bridge structure so that excessive stresses are not generated in the bridge structure, which may lead to cracks in the bridges' concrete.
8. Concrete water installations must be insulated with strong materials that resist the influence of sewage water and the gases emitted from it.
9. The aeration tanks must be equipped with an air supply system proportional to the size of tanks. The design must take into account the operational capacity of the system at start-up until reaching the

maximum capacity of the system, which must range between (10-15) years, so that the design is appropriate for the population census and the areas that supply the system with sewage.

10. The building must be equipped with the necessary air filters for the air blowers, which must work automatically by the pressure difference.

3-4-2) Gates and weirs with their operators

1. Aeration tanks should be fitted with weir gates to distribute raw sewage water and define its path.
2. This auto-calibrated measuring weir should include a drive shaft powered by an electric drive device that transmits the vertical longitudinal motion to the rotation axles by means of suitable gear units and transverse drive shafts.
3. Flexible joints shall provide the required insulation between a pivot measuring weir and a fixed concrete aeration tank.
4. The gear box, gears, and dashboards of starters and entire middle cross drive shafts should rest on floor mounted upright bases.
5. The connecting shaft and measuring weir is made of stainless steel while the plugs are made of elastic rubber.
6. The design of the exit weirs' dimensions to allow the passage of maximum drainage and so that the water surface levels within the tank can be controlled.

3-4-3) Ventilation system with air blowers and accessories:

1. Air blowing tubes should be designed in a way that allows their maintenance without the need to empty the tanks.
2. Air compressors shall be provided with a filter to purify the air before it is withdrawn by the compressor, and a muffler must also be provided.
3. An isolation valve and a non-return valve shall be located at the outlet of the air compressor with an air pressure indicator.
4. The system is provided with an air release valve so that this excess air does not affect the aeration of the tanks.
5. The system is installed on a metal base as a complete unit.
6. It is preferred that the speed of rotation and the quality of the compressor be selected so that the sound unit is not more than 75 dB.
7. The system must be equipped with more than one compressor, according to the size of the sewage system and the amount of air required, so that a backup compressor shall be available.

8. The air compressor system control unit is designed so that the backup unit comes into operation during a limited cycle.
9. The air distribution pipelines from the air pressure system to Aeration tanks must be of galvanized iron for small and large sizes installed outside the aeration tanks, and the pipes that come into contact with the wastewater must be of stainless steel (316 L).
10. The compressor must include the following necessary accessories (exhaust valve, pressure switch, emergency stop switch, etc.)
11. The speed of the air compressor should be as follows:
    - In the event that the electric motor power of the air compressor is equal to or greater than 15 kilowatts, the compressor speed is preferably not more than 2000 r / min.
    - If the electric motor capacity of the air compressor is less than 15 kilowatts, the compressor speed is preferably not more than 3500 r / min.
    - The permissible noise level shall be a maximum of 75 dB at a distance of 1 meter from the muffler compressor or soundproof cover.
    - The lifespan of the bearings should not be less than 100,000 working hours.
12. The diffusers shall be of EPDM membrane, not of ceramic.
13. The air pushed to the diffusers must be clean, free of impurities, plankton, or fine solid particles that can clog the microscopic pores of the diffusers.
14. The rate of air flow through the membrane should range between 75 and 125 m^3 / m^2 per hour.

3-4-4) Ventilation system with fixed surface aerators

1. Each ventilator shall consist of vertically mounted fins with a shaft, gears, electric motor and its controller.
2. The fin is installed so that it can be replaced in the event of diving by means of an automatic motor driven baffle in the case of an overflow in the aeration tank, so that it is lowered or raised according to the dissolved oxygen value that is measured from the liquid mixed in the aeration tank.
3. Ventilation systems must be designed for sustainable effective performance under the prevailing operating conditions on the site. These systems must be easy to install.
4. Propeller fin should be of low speed, open and non-clogging.
5. The fin shall be made of mild, heavy steel, able to withstand the stresses caused by fluid movement, and properly anchored and supported by the bridge of the aeration tank. It must include on a flat

plate with 12 pits installed under the plate and made in a way that does not require any welding or assembly on site.

6. The entire fin weight and drive shaft are suspended and supported by a low drive shaft and not supported by external panels. The maximum hydraulic thrust of the aeration device at maximum performance should not exceed the weight of the fin and the total device.
7. The ventilation device is manufactured according to British specifications (EURONORM 25) B3-FH BS-FEB34) or an equivalent. All nails shall be of stainless steel, as is the case for all submerged parts connected to sewage water.
8. The electric motor of the ventilator shall be of the short circuit type and its nominal power shall be 115% of the energy required to drive the ventilator to overcome the resistance of the transmission shift.
9. Surface aerators supplied shall be of variable speeds.
10. The surface aerators supplied shall be of variable depth.
11. The turbine (the entire rotor assembly) must be statically and dynamically balanced to ensure smooth operation and not to wear out the journal bearings of the ventilation unit.
12. The surface ventilator is tested based on how much it dissolves atmospheric oxygen in the water. Each kilowatt hour equals one hour of electricity.
13. The mixing and aeration efficiency of aeration tank components is largely dependent on the relationship between the aerator capacity and the dimensions of the tank. Refer to the ventilator catalog and the manufacturer's recommendations in this regard.
14. The gearbox unit shall be weatherproof and have an oil level sensor and drain plug (oil discharge), a vent tube and a glass level indicator.
15. All gears and bearings must be designed for a lifetime of at least 100,000 hours and must be suitable for continuous operation (24 hours) under tropical conditions. A Service Factor for the gearbox shall be taken at least twice the engine power.
16. Engine power must increase by at least 30% of the maximum absorbent power on the turbine shaft when fully submerged.
17. The control panels for operating the ventilation units shall be of the weatherproof type and equipped with means of protection against overloading and short circuit.
18. Ventilation units shall be fitted with an emergency stop switch of the latch type, and it shall be installed on the tanks.

19. The ventilator turbine shall be made of stainless steel, cast iron, corrosion-resistant alloys, or fiberglass reinforced plastics.
20. All solid parts used in surface ventilation tools must be specially treated and coated with an anti-corrosion material and anti-impact agent of partially septic raw liquid waste.
21. The drive shaft of the turbine shall be made of stainless steel of a grade and quality suitable for handling raw liquids according to their chemical analysis.
22. Gears and gearbox shafts shall be made of case hardened high tensile steel.
23. Weirs exit for sinks should be made of stainless steel with a grade that should be determined according to chemical analyses.
24. All bolts and nuts used should be of stainless steel.

3-4-5) Ventilation system with floating surface aerators

1. The number of surface aerators is determined to supply the air needed to ventilate the surface of the aeration tank and also to mix fluids in it.
2. Floating surface aerators are anchored with rust resistant chains on the walls of the aeration tank.
3. Surface aerators are equipped with a base that helps them to float over the water.
4. The ventilator shall be in accordance with the applicable British standard in this regard, or its equivalent.
5. Surface aerators are equipped with an electric motor with a suitable capacity equivalent to 115% of the energy required to drive the air.
6. Aerators should be made of stainless steel or corrosion-resistant materials.
7. The capacity of the surface aerators must be chosen to give the amount of air needed to complete the biological process without breaking or dispersing the sludge masses formed within the aeration tank.
8. The control panels for operating the ventilation units shall be of the weatherproof type and equipped with means of protection against overload and short circuit.
9. Ventilation units shall be fitted with an emergency stop switch of the latch type, and it shall be installed on the tanks.
10. The ventilator turbine shall be made of stainless steel, corrosion-resistant alloys, or fiberglass reinforced plastics.
11. All solid parts used in surface ventilation tools must be specially treated and coated with an anti-corrosion material and anti-impact agent of partially septic raw liquid waste.
12. The drive shaft of the turbine shall be made of stainless steel of a grade and quality suitable for handling raw liquids according to their chemical analysis.

13. Gears and gearbox shafts shall be made of case hardened high tensile steel.
14. All bolts and nuts used should be of stainless steel.
15. The body of the gearbox must be made of cast iron.
16. Weirs exit for sinks should be made of stainless steel with a grade that should be determined according to chemical analyses.

3-4-6) Submersible jet ventilator system

1. This type of ventilation system is used for small to medium-sized plants with a capacity of 10,000 m3/ day.
2. The number and size of submersible jets are chosen based on the size of the aeration tank, to give the required amount of air needed to mix the liquids in the aeration tank and to properly complete the sludge formation process.
3. The submersible jet aerators are installed at the bottom of the aeration tank on a network of tubes made of reinforced plastic or stainless steel to resist sewage and the spacing is uniform and evenly distributed between them.
4. The air jets shall be of the non-clogging type in each ventilation unit, provided that the shape of the submersible air jet shall be semicircular.
5. Air is supplied to the submersible jet aerators by compressors which are installed inside special rooms near the aeration tanks.

3-4-7) Dissolved oxygen measurement system:

1. This system is used to find and determine the concentration of dissolved oxygen in the aeration tank required for the completion of the biological process.
2. The dissolved oxygen inside the aeration tank is measured by a special device and connected to the ventilator control system or the air supply systems of the aeration tank, so that the dissolved oxygen in the aeration tank does not exceed the permissible and required limits for the treatment process.
3. The preferred type to use is LUMINESCENT DISSOLVED OXYGEN MEASURING SYSTEM and not MEMBRANE TYPE.
4. It is preferred that all other non-sensitive electronic parts be installed inside the buildings or that they be covered well so as not to be affected by high temperatures.
5. The system must be connected to aerators to maintain the required oxygen level.

3-4-8) Basins Discharge System:

1. Basins that are difficult to be discharged by gravitation and need to be discharged by suction shall be equipped with an external room which size is (one meter× one meter) and its level is equivalent to the lowest point in the basin to enable mobile pumps to conduct the direct suction.
2. It is preferred to use discharge system to any basin by gravitation to the plant entrance through pipes as far as possible and to alleviate the need for the usage of mobile pumps to discharge basins as far as possible.
3. Aeration tanks must be equipped with a discharge system that helps to discharge Aeration tank at the time of maintenance.
4. The device consists of submersible pumps that connected with all other remaining basins or with a balancing basin if needed.
5. The treated water must be discharged from the aeration basin after passing it to the third phase of treatment through pipes allocated for such purpose and fixed in the middle of aeration basin in order to transport liquids which are mixed properly with the composed sludge masses.

3-4-9) Supplying drinking and industrial water to site:

1. The drinking water necessary for staff and maintenance must be supplied to the site.
2. The site must be supplied with industrial water (valid for maintenance usages) to wash equipment, floors and tanks.

Chapter 5

(“Stabilization Basins “Secondary Clarifiers")

3-5-1) Concrete or metal structures and buildings:

1. The secondary stabilization basins "stabilizers" must be designed of no less than 2 basins in any event.

2. When identifying the number of sand removal basins, it shall be taken into consideration to get a complete basin out of service for maintenance purposes, provided, the remaining basins shall bear the utmost design burden of the plant without affecting its performance.

3. The clarified water shall be injected through distribution box equipped with adjustable weirs that the burden distribution can be fully hydraulically controlled among basins, provided that, it shall be taken into consideration, at designing the box, that it must be free from undisrupted flow within the same, it also preferred that this box must be installed as a tower in the middle of basins.

4. The clarified water outlets must be designed on the basis of two outlets: the first directs to the triple treatment plant, while the other directs to drainage line of excess water outside the plant in order to separate any unstable basin so that it does not affect clean water coming out of the remaining basins, consequently, affecting the triple treatment plant, it is preferred to use the upper opened channels collected to a circular tower with two collection rings, one of which is upper ring while the other is lower ring in order to reduce the number of pipes coming out from the basins.

3-5-2) Rolling bridges and their accessories:

5. All components of bridges must be of stainless steel.
6. It is preferred to connect all components of bridges with stainless steel screws.
7. Walkways installed at bridges must be made of aluminum or fiber glass.
8. It is preferred that the bridge segments of iron beams or of Truss type.
9. It is preferred that the safety device for the rolling set of the electronic type (Electronic Torque Limiter).
10. It is preferred that the central joint fixed on ball bearing of spherical or cylindrical type.
11. Bearings must be totally water proof and equipped with lubricants tubes to facilitate the lubrication process from the bridge, provided that, the bearings must be designed to be operated without stop in the utmost load range.

3-5-3) Sludge scraping and collection:

2. It is preferred that the sludge scrapers of the dual shaft kind and must be operated by an engine located at the stabilization basin center.
3. It is preferred that the bridge must cover the full tank diameter and it must be of the fixed or rolling type, the bridge floor(walkway) must be made of fiber glass or aluminum with a dual side rails that made of gases proof aluminum.

4. Sludge scrapers at the bottom of the tank must be suspended at the bridge (whenever possible) and not loaded on (Nylon wheels) to avoid wheels eroding and maintenance problems.

3-5-4) Foam scraping and other floating materials.

2. The upper scraper which collects such floating materials shall be made of chemically treated stainless steel.
3. The capacity of suction pump is preferably to be twice design load.
4. A filter or a cutter for suspended materials, such as nylon cases, must be placed at the pump nozzle.
5. The pump engine protection must be (IP68).

3-5-5) Weirs

2. Weirs are preferably made of chemically treated stainless steel or fiber glass.
3. Weirs can be connected with each other with stainless steel screws, so that any part can be replaced when necessary.
4. Scrapers (vacuums) must be placed to clean weirs from suspended materials; these scrapers must be installed on the rolling bridge.

3-5-6) Sedimented sludge withdrawal:

It is preferred to use section tube in the basin, its diameter of no less than (8) inches to ensure no blockage.

3-5-7) Basin discharge system:

1. It is preferred to use discharge system to any basin by gravitation to the plant entrance through pipes as far as possible and to alleviate the need for the usage of mobile pumps to discharge basins as far as possible.
2. Basins that are difficult to be discharged by gravitation and need to be discharged by suction shall be equipped with an external room which size is (one meter× one meter) and its level is equivalent to the lowest point in the basin to enable mobile pumps to conduct the direct suction.

3-5-8) Sludge level measuring:

1. It is preferred to measure sludge level by ultrasonic.
2. The sensor must have a wiper to clean the sensor to avoid sludge sticking; it can be programmed according to the need for cleanness.

3-5-9) Sludge flow level:

1. Installing flow gauge for the incoming water to the plant, it must be suitable in open channels; the appropriate site for measuring must be opted, in order to prevent water from returning in the opposite direction which in turn will give a false reading.

   Measurements shall be connectable by the remote control and monitoring.

2. The contractor shall provide a warranty certificate by the systems manufacturer company, reported that the supplied model and all its components (assembled by other companies) is the latest models produced of such type of equipment and shall secure spare parts for a period of no less than five years.
3. Installed measurements shall be connectable by the remote control and monitoring.
4. All micro devices systems that work with microprocessors (valves or equipment) must be installed inside building to protect the same from direct sunlight, sensors also, which applications impose external installation, must be protected from direct sunlight with a canopy to avoid overheating.

3-5-10) System of electricity supply and monitoring:

7. The slip ring related to the electricity supply and signs at the center of the rolling bridge must be designed to bear (2.5) times of the electrical loads installed at the bridge and to record power surge situation when ceasing such equipment in order to assimilate the capacity change of installed engines with the change of its type or the need to operate and maintain the same to install a temporary equipment for this purpose.
8. The slip ring related to the electricity supply and signs at the center of the rolling bridge must be designed as there are a number of unused backup rings equal to half of the used number of loads in order to operate the same when any working ring is out of service.
9. The rolling bridge shall be equipped with (2) electrical sockets with a cover supplied with electrical current source of (15) ampere and (230) volt and frequency 60 monophasic Hertz.
10. Each basin and near the sludge outlet must be supplied with an power supply panel, the first electrical socket with a power of (20 ampere) and voltage (230 volt/60 hertz) monophasic, the second socket with a power of (40 ampere) and a voltage of (400 volt/60 hertz) of a three-phasic. To operate the mobile pumps for the operation and maintenance purposes in respect of the basin and to take into consideration that the panel must be equipped with the necessary basic protectors, power lights, power switch and kill switch.
11. Monitoring and surveillance of Gates and sludge level in basins must be conducted electronically and remotely and it must be connected with SCADA system.

3-5-11) Supplying drinking and Industrial water to site:

The site must be supplied with industrial water line dedicated for cleaning activities.

Chapter 6

(Medium Lifting Plants)

(3-6)

3-6-1) Concrete structure and buildings:

1. The space between the axial pump of no less than (90) cm, stair-shaped.
2. Each building must be equipped with stairs to reach its roof for maintenance purposes, theses stairs must be vertical in case there is no equipment at the rooftop and if it is broken or axial in case there is equipment on rooftop that need to be maintained continuously to keep staff safety.
3. It shall be taken into consideration when designing buildings, to be reasonably vast where it gives a comfortable in between distance (80 cm approximately) in order to maintain each equipment and

the other and equipment and wall, it shall also take into consideration to increase the space in the building in the range of (15%) to add some equipment and systems to the building later as a kind of development or renovating to the site.

3-6-2) Lifting pumps:

1. It is preferred that the lifting pumps located at the middle lifting plant shall be, when needed, as follows:
   A. A plant of a capacity up to (20,000 m^3/day) using centrifugal submersible pumps or axial flow submersible pumps to reduce construction costs (civil, mechanical and electrical) and to reduce odors and controlling the same.
   B. A plant of a capacity up to (100,000 m^3/day) using axial flow submersible pumps to reduce construction costs (civil, mechanical and electrical) and to reduce odors and controlling the same.
   C. A plant of capacity bigger that (100,000 m^3/day) using screw pumps.
2. Pumps design must be based on the utmost flow rate, provided that, the capacity of the sole pump shall not exceed the average flow rate, taking into consideration a reserve pump for the purpose of maintenance and the pumps must be identical.
3. **The Centrifugal Submersible Pumps**
   1) It is preferred to be dry-installed and in a separate room from the wet collection tank.
   2) Each pump must be equipped with isolation valve, provided that, each pump outlet on the side of collection tank must have concrete joints with at least 40 cm in length and supplied with U like stream to use the same in manual isolation to maintain the isolation valves.
   3) It must be equipped with a mechanical cutter at the pulling line of fibrous materials and large materials.
   4) The propeller is of a semi-opened unblockable and self-cleaning kind and the maximum solids that are permitted to pass through such pumps are no less than (100) mm.
   5) The propeller must be made of high quality raw sewage water proof substance and abrasive resistant (sand- cobblestones- metal objects).
   6) The sealant system must be of double mechanical kind which made of silicon carbide, it is preferred to be of the compact kind.
   7) The prop shaft and protection sleeve must be made from stainless steel.
   8) The engine must be equipped of the necessary protection sensors (coils heat- water leakage on the engine- water- oil mixing- the upper and lower bearings heat).

9) The engine protection against foreign substances and water invasion (IP68).
10) The engine must be designed to a dry work, provided that, it must ensure the appropriate cooling.
11) The engine isolation degree must be of no less than "F".
12) The engine must be appropriate and ready for work with the electronic gear shift consisting with performance curve.

4. Axial Flow Submersible Pumps:

1) The propeller is of a semi-opened unblockable and self-cleaning kind and the maximum solids that are permitted to pass through such pumps are no less than (100) mm.
2) The propeller must be made of high quality raw sewage water proof substance and abrasive resistant (sand- cobblestones- metal objects).
3) The sealant system must be of double mechanical kind which made of silicon carbide, it is preferred to be of the compact kind.
4) The prop shaft and protection sleeve must be made from stainless steel.
5) The engine must be equipped of the necessary protection sensors (coils heat- water leakage on the engine- water- oil mixing- ceasing dry operation-the upper and lower bearings heat).
6) The engine protection against foreign substances and water invasion (IP68).
7) The engine isolation degree must be of no less than "F".
8) The engine must be appropriate and ready for work with the electronic gear shift consisting with performance curve.

5. Screw Pumps:

1) It is preferred that the inclination degree of the screw pumps must be (32-35) and (38) degrees as a maximum.
2) The screw pumps entrances must be supplied with gates to isolate the same for maintenance purposes, so that, each pump shall have a gate powered by electrical operator.
3) It is preferred to protect the pump helix with a solid chip to be installed at the external frame of the helix to protect it from corrosion.
4) The engine must be equipped of the necessary protection sensors (coils heat-ball bearing heat- The engine protection against foreign substances invasion (IP55) - The engine isolation degree must be of no less than "F"- The engine must be appropriate and ready for work with the electronic gear shift with no need to any external additives.
5) The wet well area of every screw pump must be supplied with a hole of (60 cm×60 cm×60 cm) dimensions to drain water leaked from gates when conducting maintenance.

6) In case of covering the screw pump, a transparent cover must be placed in order to monitor and examine the lower, middle and upper area. The covers fixing method must be conducted by quick-disconnect hinged locks.
7) The engine room and screw pumps gear boxes must be ventilated by exhaust shaft and vents equipped with washable filters that prevent dust and effectively contribute to reduce the room temperature.
8) Reduction limits of the screw pump gear box must be a round (4-1 to 45-1) to get the greatest possible capacity.
9) The screw pump service factor must be of no less than (2).
10) The lower bearing of the screw pump must be equipped of lubrication system (oil) with sensors and all surveillance and protection devices (pressure and level).
11) It preferred that the lubrication system of the lower bearing made from stainless steel.
12) The upper bearing of the screw pump must be of sphere bearing and must be designed for an operational life of (150000 hour) or more.
13) The prop system must be equipped with a mechanical reverse rotation barrier installed on electrical shaft.
14) In tropical areas the gear box must be equipped with oil cooling system that consists of oil pump, cooler and cooling fan, so that the system must be equipped with heat sensor with a split-second display and oil pressure sensor to be connected with control panel and surveillance and control system in the plant, there is still a need to sensors in cold regions without cooling system.
15) The flow lamination that prevents water sprinkle from the pump must be made from stainless steel of (316 L) kind and it shall be chemically treated after manufacturing.
16) The contractor shall provide a warranty certificate from the system manufacturer stating that this supplied model and its other components (assembled and produced by other companies) is the latest models produced of this equipment type and to ensure that the spare parts are available for a period of no less than fifteen years.
17) Electrical speed shifts must be installed to equipment that require control of its operational conditions, these shifts must be ready for automatic operation according to signs originated in operation conditions sensing units(level measurement levels- flow…etc.) in addition to use the same in easy start-up and suspension to alleviate voltage drop of the public electricity grid and its effect on equipment in general as it is its fundamental functions, main operational equipment and equipment with capacity exceeds (30 kilowatt) must be taken into consideration. The shape and length of

electrical wave and harmonics number which is reflected on electrical distribution network as a result of speed shift units must be in accordance with the requirements of the global electrical network and the design must consist of methods that reduce this according to the international measurement systems, the direct torque control system must be provided.(see chapter five in relation to the same in section 3-18).

3-6-3) Gates and their operators:

1) It preferred that the entire gates and its accessories must be made from stainless steel of (316 L) type which is chemically treated after manufacturing.
2) Gate shaft must be of ascending type which made of stainless steel of (316L) Type.
3) All gates that require continuous or periodic opening and closing must be equipped with an appropriate electrical operator.
4) Gates operators that its operation requires controlling opening and closing level, must be of the controllable type.
5) Operators manufacture shall recommend choosing operators that are appropriate for each gate in terms of type and loads and according to complete technical calculations for situations and loads that gate can experience to avoid technical problems after a year or two years of operation as a result of poor choice of a suitable type.
6) The gate operators must be ready to be connected through monitor and remote control system at the plant.
7) The contractor shall provide a warranty certificate from the system manufacturer stating that this supplied model and its other components (assembled and produced by other companies) is the latest models produced of this equipment type and to ensure that the spare parts are available for a period of no less than fifteen years.

Chapter 7

(Tertiary Treatment Plant)

(3-7)

3-7-1) System preferable to be applied:

The following types are preferable use:

1- Standard gravity sand filters, single layer type
2- Double sand filters with two layers (sand and activated carbon), either by gravity or by pressure tanks.
3- Thin-film disc filters.
4- Thin-film barrel filters.
    a- It is preferable to use standard gravity sand filters, single layer type (as in Item No. 1 above) in all designs, except in cases where otherwise stipulated.
    b- The triple filtration units shall be according to gravity downstream sand filtration, so that the flow of the filtration units is after the final stabilization basins by gravity through feeding channels controlled by gates and pressure and control channels.
    c- The method of operation of the triple filters must be automatic with the possibility of monitoring them, and it must be complete with the necessary measuring and control devices.

3-7-2) Concrete buildings and structures

1. In the case of standard gravity sand filters, the water inlet to each cell should be by a weir of the entire width of the cell. All weirs in a single cell pathway should be connected to an appropriate distribution channel that helps smooth out the flow turbulence.
2. In the case of standard gravity sand filters, the thickness of the concrete of the ceiling of the filtering area (slabs) must be not less than (10 cm) and it must have a tight fixing mechanism that prevents its disintegration due to pressures during the backwash process.
3. In the case of standard gravity sand filters, the height of the filter area room under the ceiling of the filtering concrete (slabs) must be at least 1 meter in order to be able to enter and clean it in the event of sand leakage into it as a result of breaking the filtering points. The ceiling of the filtering concrete must be provided with an inspection hole measuring 60 cm x 60 cm and have a concrete cover of the same thickness as the ceiling and equipped with two hooks made of a stainless steel rod with a diameter of not less than 16 mm implanted with the iron reinforcing of the cover in order to be able to raise it with the crane. The method of fixing the cover in place must be by means of stainless steel

nails, with the use of silicon or rubber to fill the voids without using concrete mortar materials that are difficult to crack later and that may cause damage to the cover.

4. Take into account when designing the elements for loading slabs to be in the form of columns and not bridges. The distance between them must be at least 1 meter so as not to impede the cleaning process.
5. The water coming from the triple stabilization basins to the sand filter units must have two separate lines. The first line goes to the filter units in normal conditions and goes to the site for use thereof, and the other line goes outside the units in the case of emergency.
6. If sand filter insulation is done, the surplus line can pass the contact sinks by gates.
7. It should be taken into account to separate the filters in the form of paths and make appropriate distances between them in the event that they are more than two rows to facilitate the process of entering the equipment access when the need for maintenance or cleaning is required.
8. Every sand filter must have, upon entry, isolation units used to isolate any sand filter and take it out of service when needed without affecting the operation of the rest of the filters.
9. There must be drainage lines for the channels feeding the filters. These filters go directly to the entrance units or to the water collection tanks resulting from backwashing and are used when cleaning these channels or doing their maintenance.
10. The flow should be in the tertiary treatment (sand filters) by gravity and not by lift pumps, as it was observed that this had an effect on the purity of the final surplus (outside the sand filters).
11. The filtration media should not be placed in the filter basins until the filter floor is hydraulically tested in an acceptable manner and the levels of concrete work lengths are checked for accuracy within the specified tolerances, and to ensure the integrity of the backwash system and acceptance of the filter medium level.
12. Laying the filtration media should include a periodic backwashing procedure while applying the filter media to remove dust and sand from the natural ground.
13. The design should include drainage lines for the channels feeding the sand filters that go directly to the inlet units or to the water collection tanks resulting from backwashing, to be used when cleaning or maintaining these channels
14. . The design must include soft filters of an appropriate size on each line at the entrances to the water collection tanks in order to prevent the entry of dirt that may affect the efficiency of the suction pumps. There should be spare units for these filters.
15. Equipment for discharging sand from the sand filter should be provided in an easy and safe manner.

16. The area of the observation room should be suitable for the size of the operating and monitoring board and be suitable and spacious when maintenance is required. It is preferable that the observation room is on the second floor and overlooks the filters, and all of its facades are made of glass.
17. Each basement must have at least two exits.
18. Walls or floors painting must be appropriate, not affected by dirt, and can be cleaned.
19. Stairs connected to lower basements should be secure and should not be slippy using appropriate safety requirements.
20. A room must be provided for the operators in which lockers are placed in order to save their personal needs. Another room should be provided as a buffet with toilets and sinks.
21. Effective and appropriate ventilation units should be provided in basements and interior rooms, taking into account the creation of many natural ventilation openings.
22. Consideration must be given to making appropriate distances between sand filters to enter equipment when maintenance or cleaning is required.

3-7-3) Valves and their operators:

1- Electric valve actuation is provided; complete remote control units are provided, connected to the control room, provided that the manual system is available in the event of electrical faults.

2- Shafts shall be made of stainless steel.

3- Valve bodies must be made of lined iron or stainless steel to resist water of all kinds.

4- Valves and actuators must be in line with international and Saudi standards for this purpose and with 4683 BS4999/ BTS/ BS specifications or equivalent.

5- Actuators shall include a push motor with an integral reverse starter with automatic cutter, local control facilities, and remote control terminals. The actuating devices shall also generate sufficient torque and energy to induce and continue the movement under mechanical and hydraulic load conditions at any point between the open and close condition of a current whose voltage is less than 10% of the nominal level. In terms of operating speed, the valve and its shut-off are approximately 250 mm per minute.

6- Actuators gears are fully enclosed in an oil process suitable for operation at any angle and have two filling and drainage holes.

7- Electric actuators shall be provided with torque opening and closing switches or status switches as required according to valve type. The reversing device shall be equipped with an automatic cutter and cell controls, and placed inside a suitable enclosure to prevent moisture.

8- The gates must be in all sites and basins that need insulation for maintenance purposes, taking into account that the gates are lightweight and heavy duty and made of treated stainless steel or high-density plastic reinforced with stainless steel. Also, rooms that do not contain isolation gates must be provided with a stainless steel duct to be used to isolate these rooms during maintenance work.

3-7-4) Gates with their operators and pipework:

1- Gate actuators specifications are subject to the same specifications applicable to valve actuators mentioned in paragraph (3-7-3) of this design guide.
2- Piping systems must be constructed of materials suitable for the fluids to be transported and the environmental medium through which they pass.
3- All systems must have sufficient room for cleaning and drainage during testing, preparation and operation.
4- All units must have the possibility of complete drainage without dismantling the pipework or the plant.
5- Drainage and cleaning holes should be easily accessible.
6- All supports must be constructed to adequately withstand the static and moving loads resulting from temperature occurring during testing, normal operating conditions and those resulting from temperature.
7- When installing, take into account not to overload the equipment with additional loads (such as the weights of the draft and ejection lines).
8- There must be sufficient flanges in places where pipes pass through the concrete.
9- Air duct work shall be of composite steel welded with fused liners and a minimum of flanges.
10- All piping works are subject to the Saudi or international standard specifications applicable to them in this regard.
11- The valves of sand filters for the operation process must be of electrical types, and in the case of their height above ground level, which makes it difficult for the operator to perform his work safely and correctly, it is preferable to place suitable stairs or ladders.
12- The equipment operation system should be flexible so that it can be operated from the main control panel or from the local board for each equipment.
13- There must be flexibility in operating the main gates, so that they can be operated from the main control panel or from the local board for each equipment.
14- Each pump room should have a water collection point with submersible pumps available.
15- It is preferred to have points for washing water at each site.

16- Warning units should be made in the basements when the water level rises, either because of broken lines or because of leaks.

3-7-5) Specification of pipes within filter basins:

1. Pipes must be installed in a way that permits conducting dismantling, assembly and maintenance easily.
2. Pipes must be made from stainless steel or UPVC to void its chemically corrosion. Stainless steel is preferable due to its ability to endure external stress.

3-7-6) Compressed air system:

When designing ducts, the following considerations must be taken into consideration:

- Air outlets must be made at the upper part of ducts and near the end-use sites.
- There is no low pressure between the compressor and the usage site with more than 10% of the original pressure.

3-7-7) Air blowers:

1. Air must be blown coinciding with reverse wash process with water to the sand filters in order to get the best results and to ensure removal of suspended impurities inside the filter in order to maintain the water quality resulted after the sand filtration process.
2. Air compressors can be identified according to the number of sand filters and the capacity of sewage water treatment units, as it must give air quantity necessary for cleaning filters, at least two air compressors must be provided (one compressor in service+ the other is a reserve) each of them must have a capacity of (100%) of the design load, Machineries must be placed in air compressor room of the triple filtration units.
3. Changeover switch must be provided to air compressor connection in order to give a warning sign at the control panel that there is no pressure.
4. The air withdrawn from the air compressors room must give natural ventilation.
5. The air compressor's speed must be as follows:-
    - In case that the electrical engine capacity of air compressor is equal to or more than (15 kwatt) so, the compressor's speed must be preferably no more than (2000 round/minute).
    - In case that the electrical engine capacity of air compressor is less than (15 kwatt) so, the compressor's speed must be preferably no more than (3500 round/minute).
    - The permitted noise level must be (75dB) as a maximum at a distance of (1 meter) from the muffler compressor or a muffler cover.
    - The bearings life expectancy must be of no less than (100,000 hour) of operation.

- The air compressor must have the necessary accessories (relief valve, pressure switch and emergency switch, .etc.)
- Pressing air compressors in ducts must be sufficient to deliver air to air diffusers at the basin bottom under pressure of (0, 50 kg\cm^2) - while air speed in ducts is ranging from (12-16 m/s).
- Air blown to the air diffusers must be pure and free from impurities, suspended particles or solid fine particles that may block the micropores of air diffusers.
- The air diffusers ducts must be designed in a way that permits conducting maintenance to ducts without the need to discharge basins.

3-7-8) Reverse washing pumps:

1. The reverse washing for the filter basins must be conducted by the concurrent injection for air and water within basins through air chamber.
2. The reverse washing process for basins must be commenced automatically by an adjustable and programmable cascade control; usually it must lead to cleaning of every filtration basin in a pre-arranged succession, and during the reduction of sewage water flow to the treatment plants.
3. A space must be provided, for the ultrasonic level gauge placed in the filter basin room entrance to, as the time clock of water control device at the entrance room exceeds the pre-prepared level. When water reaches the minimum level, the reverse wash cycle for basin continues until finishing, hence, the program is automatically varies to the main adjustment situations.
4. A space must be provided to cease the program at any time, whether to wash the basin once more or to clean the basin outside the cascade by the manual control at the units control panel.
5. Two pumps for reverse washing must be provided (ne is working+ the other is a reserve), each of them with a capacity of 100% of the designation requirements, the pump must be placed at the pumping units of the reverse washing which usually placed at the bottom of chlorine feeding tank.
6. The reverse washing water must be released through chlorine feeding tank.
7. A pressure distribution switch must be installed at the pump connection to get a warning sign at the control panel in case of losing pressure.
8. The reverse washing pumps must be of the mixed screw flow type, it must be installed at a vertical wet well, the flow average depends on the final design, pumping pressure shall not exceed (20 bar), each pump must be equipped with withdrawal and discharge pressure gauge and bearings heat indicator together with an alert, working hours, direct electrical current reading and writing diagrams for a period of (30) days.

9. Rotation axe must be made from stainless steel, and the blower body must make from wrought iron painted with a material to protect it from rust.
10. Samples suction pumps of the contiguity basins outside the building, the suction point must be of the final production.
11. The base height of all pumps installed in vaults must be (30-40 cm) of the ground level installed on it to ensure that its engines do not drown when water flooding inside the vault as a result of some broken down valves and to give a chance to take action before reaching this level.
12. The capacity of pumps that produced washing water (wastewater) must be consistent with the tank capacity, in order to install and filter in the reverse washing at any time.

3-7-9) Washing water pumps:

1. Soft filters must be installed at the entrances of water collection tanks to prevent garbage which can affect the suction pumps efficiency.
2. Waste washing water (waste water) pump capacity must be consistent with tank capacity, so that, the timeline to wait washing the second set of filters must not exceed five minutes, taking into consideration that some pumps are out of service.
3. Pumps must be used to suck sand filters waste water and returning it to the main lifting units at the plant entrance, this must be done in case this water is not flowing through gravitation.
4. Two pumps to drain washing water must be provided (one is working+ the other is a reserve), each of them with a capacity of 100% of the designation requirements, the pump must be placed at the collection washing water tank.
5. Waste washing water pumps must be of the totally submerged kind with all attached devices including no- return and isolation cock, pressure and discharge gauge, chain to lift pumps, water level gauge and to protect pump engine from working in case of dryness.
6. Rotation axe must be made from stainless steel, and the pump body must be made from cast iron painted with a material to protect it from rust.
7. Each pump room must have water collection point and providing a submersible pump.
8. Cranes and winches must be provided to lift equipment for the maintenance purposes.

3-7-10) Air diffusers and cellular filtration:

1. When constructing a floor for the filtration basin which will bear the filtration process, it must be taken into consideration to leave spaces that diffusers (nozzles) cam emerge and extend through a chain of air chambers.

2. Nozzles bearings must be placed at the filter floor in asymmetrical pattern at distances of (200mm) of the right angles to the central axe of the filter and at a distance of (150 mm) in parallel with the central axe to provide nozzels intensity of (50 nozzels/ square meter).
3. Nozzels must be made of multi-part structure which made from poly propylene and provided with vertical adjustment for at least fifty mm.
4. The nozzle design and its bearing must permit conducting pressure test after completing the floor and before installing nozzle shafts.
5. The nozzle ceiling must be full of harmonized rents and cracks to prevent filtration media (sand) from leakage within the same, provided that, the nozzles vents must not exceed 1mm.
6. When designing the nozzle, it must be taken into consideration the necessary precautions to the ability to change nozzles which may expose to any dysfunction during operation, during the periodic maintenance period.

3-7-11) Basins discharging sand system in sand filtrations:

1. Equipment to discharge sand from sand filter easily and safely must be provided.
2. The flow coming to the sand filters must be discharged through feeding channels that can be controlled through gates and controlling and adjustment ducts.
3. The water filtered from filtration basins must be discharged to chlorine feeding basins by the tube head.
4. At designing filtration basins, it must take into consideration the ability to discharge basins from sand from sand filtrations.

3-7-12) Flow and level measurements:

1. Water flow to each filter can be controlled by control channel operated with an engine that leads to feeding channel of each basin.
2. The flow rate of each basin must be balanced by a butterfly valve working through float valve at the exit to the pure filtered water channel which must be adjusted to suit water level in filtration basin.
3. The high level can be identified by level detector of the ultrasonic kind and placed at the general entrance room of the sand filtrations.
4. A space must be provided to install the level gauge of the ultrasonic kind, as the time clock of cascade control device exceeds the commencement of the reverse washing of basins which is pre-identified at the entrance room.

3-7-13) Lifting equipment (cranes):

1 The minimum assessed power for cranes at the air compressors and pumps room must be (1.5) of the existed loads.

2 The properties of the monorails cranes at the filter ducts path, must be of manual wire rope kind, one layer cylinder, disk brakes and hook's joint must be tested with 150% of the total load with safe pick up installed at the manual chain fixed on vertical tugger.

3-7-14) Power supply and control:

1. All parts of the triple treatment units must be remotely controlled through units operation from the main control room, the main control room must be supplied with all gauge, pressure control, flow rate and levels, warning devices and temperature indicators and otherwise.
2. All power supply extensions including cables, cable trays and power distribution panels must be designed in compliance with the international standards requirements.
3. In case of high ceiling rooms, lighting must be installed at side walls and at heights that can be reached easily by maintenance staff.
4. The main and sub- power panels must be installed at the center of power room to facilitate access to all parts of the panel.
5. All power electrical panels must be made from elements resistant to gases, humidity and its protection grade must be of no less than IP55.
6. All electrical conductive rods must be painted with tin or any other equivalent substance that prevents to be affected with gases and oxidation.
7. An electrical source shall be provided at every site.

3-7-15) Ventilation system and air conditioning:

1. Equipment rooms must be equipped with a suitable ventilation system as per the standardized specifications **ASHRAE62.**
2. Equipment rooms that consist of air compressors must be equipped with a system that enables the passage of filtered air through it.
3. In must be taken into consideration at designing the equipment rooms, to isolate walls in a method that comply with the international standards to prevent noise and heat transmission.
4. All measurement and control rooms must be equipped with air conditioners of split kind or of any other central air conditioning type as per the control room size and requirements.

3-7-16) Supplying drinking and Industrial water to site:

1. Site must be supplied with drinking water necessary for operators and maintenance staff.

2. Site mist be supplied with industrial water (valid for maintenance usages) to wash equipment, floors and tanks.
3. Every supply system consists of a concrete ground tank or above ground fiber glass tank(as per the necessity) with two distribution pumps (one is at service+ the other is a reserve) and what the supplying system needs, including non-return and isolation valves, pipes, pumping pressure gauges and supplying system measuring and control devices.
4. Stainless steel pipes are used to distribute water to all usage points.
5. Every system consists of devices necessary to filter water and impurities and sanitizing the same to ensure the used water quality, water coolers are placed in measuring and control rooms.

Chapter 8

(Sludge Reuse System)

(3-8) Sludge reuse system

To be added in the next issue- God willing.

Chapter 9

(Sludge Disposal System)

(3-9) Sludge Disposal System

To be added in the next issue- God willing.

Chapter 10

(Sludge Thickening System)

(3-10) **Sludge Thickening System**

To be added in the next issue- God willing.

Chapter 11

(Sludge Digestion System)

3-11) Sludge digestion system

To be added in the next issue- God willing.

Chapter 12

(Sludge Natural Drying System)

(3-12) **Sludge Natural Drying System**

To be added in the next issue- God willing.

Chapter 13

Sludge Mechanical Drying system

3-13) Mechanical system to reduce water content in sludge

3-13-1) Concrete buildings and structures

1- It is necessary to paint the floors with special paints that prevent slipping in the presence of polymer material on them from the system equipment.
2- It is preferred not to use basements on this site.
3- All drainage channels inside this building must be covered.
4- The building is determined according to the number of mechanical dewatering units to be constructed according to the capacity of the plant.
5- Consideration must be given to establishing units to remove odors inside the building.

6- It must be taken into account that the benefit for the compartment of the aforementioned units is provided with some openings that can be covered with types of transparent plastic or glass for lighting purposes.
7- It is taken into account when constructing that there are completely separate rooms for control panels, operation and electricity.
8- The construction takes into account the supply lines and drinking and industrial water networks.
9- Gates are created to allow entry of heavy equipment for maintenance work.
10- The unit must be provided with all usage facilities such as bathrooms, toilets, and a special room to store chemicals in it as a subsidiary store, as well as another room to store maintenance materials and tools.
11- In the construction of buildings, it is taken into account that the concrete works shall be provided with insulating materials against corrosion, oxidation and gases rust.
12- It should be taken into account that floors are well constructed in concrete to avoid water leaks and vibration.

3-13-2) Flow and level meters:

The dewatering equipment should contain a sludge flow meter, and the sensor should only be near the equipment and before the thickening tank, while the plate on which the readings appear should be far from the equipment site and preferably in the observation room.

3-13-3) Lifting Equipment (Cranes)

The electrical panel of this lifting equipment needs to have a high degree of protection from gases.

3-13-4) Mechanical Dryers (Compression Belts):

1- Each drying equipment should have a thickening unit to increase the power and efficiency of the dewatering equipment.
2- It is preferable to use belts instead of gears when transmitting power from the driver to the dewatering equipment.
3- Fixed ladders should be placed on each dewatering unit.
4- Resistant iron (316 degree stainless steel) should be used for sinks, tanks and pipes in these dryers.
5- The belt should be of split type and be attached to suede along the belt
6- It is preferable to control the tension and weight of the belts by means of a hydraulic system.
7- Dewatering rollers shall be greased or lined with insulation to prevent corrosion.

3-13-5) Sludge feed pumps:

1. The sludge feed pump shall be designed to deliver the rated capacity at a speed not exceeding (200 rpm).
2. Cartridge mechanical seals should be used instead of filling for sludge feed pumps.
3. It is preferable to place a filter before the pumps to prevent impurities from entering the pump.
4. The amount of sludge entering the dryer must be controlled by a gearshift attached to the pump.

3-13-6) Polymer pumps:

1. The location of the polymer pumps should be completely isolated from the mixing sites, drinking water lines, industrial water lines or sludge lines to avoid the drowning of these pumps.
2. The submersible pump, which is used to raise washing water in the polymer mixing area, must be characterized by high energy and a large capacity to drain, and it must also suit the quality of the water coming to it and mixed with the polymer material of high viscosity or raising the bad polymer mixture due to a defect in the system and may need to be vacuumed.
3. Polymer pumps must be controlled electrically by electronic gearshifts attached to the dewatering units' flow meters.

3-13-7) Supplying the site with industrial water:

The site must be supplied with industrial water at the appropriate pressure and quantities for washing operations and belt cleaning.

1. **3-13-8) Control and power supply Systems**The electrical panels in the building must be of a high degree of protection.
2. Also, all the sensors inside this building must have a high degree of protection from gases.

3-13-9) Aeration and air conditioning systems:

The aeration and air conditioning systems or the gas treatment unit must change the air continuously at least ten times an hour to ventilate the building and reduce the gas percentage so that the gas concentration in this area does not exceed the permissible limits (in no case exceeding 5 parts per million.

Chapter 14

Sludge Thermal Drying System

3-14) Sludge thermal drying system

It will be added in the next issue - God willing.

Chapter 15

Sludge thermal combustion system

3-15) Sludge thermal combustion system

It will be added in the next issue - God willing.

Chapter 16

Dried Sludge Transportation and Storage System

3-16) Dried sludge transportation and storage system

3-16-1) Hollow shaftless screw conveyors:

1. The bushings for these conveyors must be not less than 20 mm thick in the horizontal and oblique conveyors, as for the vertical ones, they can be 15 mm.
2. All engines must be with gearshifts for these conveyors if they are vertical or oblique and are at the end of the conveyor from the top.
3. Conveyor speeds should not exceed 25 rpm maximum.
4. The length of the conveyor should not exceed 25 meters in any case.
5. The caps for these conveyors should be of the easy-open type.
6. Water sprinklers must be fitted to the conveyor to protect linings in the event of dry operation and areas where sludge does not reach.
7. The screw conveyor shall be made of stainless steel 316L.
8. It is always preferred to use this type if possible.
9. The design must take into account the ease of accessibility of these conveyors for maintenance work.
10. The degree of protection against penetration of foreign objects and water should be IP68 for the electric motors located at the bottom that are exposed to frequent washing due to the splashing of sludge. As for the motors on the top, the degree of protection against object penetration should be IP55.
11. Spiral conveyors must be protected so that when one stops, all the conductors stop. The packing group should be independent of the drainage group, providing all conveyors with the necessary protections (torque, temperature, aspects relay...)
12. The conveyors must be electrically connected to each other. When the conveyor fails, the conveyors supplying it will stop.
13. In the case of a conveyor for distribution to two tanks or two silos, the conveyor must be two parts with two separate motors within a single conduit connected to the middle by a flange instead of being one piece, and the rotation of the distribution must be against the rotation.

3-16-2) Shafted screw spiral conveyors

1. The bushings for these conveyors must be not less than 20 mm thick in the horizontal and oblique conveyors, as for the vertical ones, they can be 15 mm.
2. All engines must be with gearshifts for these conveyors if they are vertical or oblique and are at the end of the conveyor from the top.
3. Conveyor speeds should not exceed 25 rpm maximum.
4. The length of the conveyor should not exceed 25 meters in any case.
5. The caps for these conveyors should be of the easy-open type.
6. Water sprinklers must be fitted to the conveyor to protect linings in the event of dry operation and areas where sludge does not reach.
7. The screw conveyor shall be made of stainless steel 316L.
8. The bushings for these conveyors must be not less than 20 mm thick in the horizontal and oblique conveyors, as for the vertical ones, they can be 15 mm.
9. The degree of protection against penetration of foreign objects and water should be IP68 for the electric motors located at the bottom that are exposed to frequent washing due to the splashing of sludge. As for the motors on the top, the degree of protection against object penetration should be IP55.
10. Spiral conveyors must be protected so that when one stops, all the conductors stop. The packing group should be independent of the drainage group, providing all conveyors with the necessary protections (torque, temperature,)
11. In the case of a conveyor for distribution to two tanks or two silos, the conveyor must be two parts with two separate motors within a single conduit connected to the middle by a flange instead of being one piece, and the rotation of the distribution must be against the rotation.
12. The conveyors must be electrically connected to each other. When the conveyor fails, the conveyors supplying it will stop.

3-16-3) Sludge storage silos:

1. The tank must be completely made of materials resistant to high gases concentrated in these tanks, and it must be painted with special materials and guaranteed for a period of not less than 10 years.
2. The tank must be in the form of pieces attached to each other by screws so that any part can be replaced when needed, and it must be possible to remove the upper layer when needed.
3. Silos drainage gates must be equipped with a manual (shutdown / open) control system in the event of faults.

4. It is preferable that the conveyor linings located under the silos should be made of Hardex (high hardness iron) chips.
5. Each silo shall be provided with at least 2 knife gates, and be fitted with a suitable actuator with dimensions of 50 x 50 cm and evenly distributed on the sides, for the purpose of draining the silos in the event of failure of the lower conveyor.
6. There shall be an internal drain line for the sludge conveyor to be used in the event of silo maintenance or top conveyor failure.
7. These silos must be equipped with external and internal ladders for maintenance and inspection of silos.
8. Silos must be constructed according to the operating capacity of the plant in which the resulting sludge is calculated for a period of more than 24 hours.
9. It is preferable to construct a reserve silo for emergency conditions.
10. Levels must be made to control the filling and drainage, and they must be connected automatically to the feeding or drainage gates so that the feeding stops at this silo in the event of a high level and the transfer goes to another silo, and if the silos are full, the conveyors should stop.
11. It is necessary to place ventilation holes for the tank and it is preferable to connect it with odor control systems.

3-16-4) Safety and firefighting systems

The silos should be provided with security and safety equipment starting from protection on stairs and others.

Chapter 17

(Methane Collection, Compressing, and Combustion System)

3.17 Methane Collection, Compressing, and Combustion System

It will be added in the next issue, God willing.

Chapter 18

(Control and Power Supply Systems 'General')

3-18 Control and power supply Systems 'General'

3-18-1 Concrete buildings and structures:

1. The distances behind the electrical panels, whether medium or low voltage shall be sufficient and not less than 1 m to reach the components of the panels from the back for maintenance, dismantling and installation work, and this shall be taken into account when designing the building and where the panels are installed in the building.
2. The area of the electrical panel room shall be sufficient to perform maintenance work and to add new panels in the future if needed within 30% of the existing panel load.
3. Electrical panels and engine control centers shall generally be expandable when future electrical equipment is needed.
4. Be careful not to place any electrical panels or microcontrollers inside wet sites.

3-18-2 Basic layouts of electrical systems:

All layouts shall be certified (AS BUILT) and be in both hard and soft copy (on CD).

3-18-3 Transformation Centers:

- Supplies to each plant shall be made by two transformers, each transformer bearing the plant's entire load
- The main supply system shall be via an oil-insulated main transformer (13.8 kV – 338/220 V), (3) phase, (4) wires, and (60) Hertz.

3-18-4 Electrical Networks:

1. The power factor of the electrical network shall be optimized to be at least (0.93).
2. Electricity supply to the treatment units shall be by the ring system.
3. The electrical transformers for entrance works shall be of adequate capacity and contain spare units.
4. The load supply sources (transformers and distribution panels) shall be close to the loads location.

5. The electrical loads of the treatment equipment shall be distributed in a balanced manner, to give flexibility in Operation and maintenance of this equipment.
6. It is preferred to supply service buildings with low voltage (110-220 volts).

3-18-5 Electrical panels (General):

1. All electrical panels shall be of a totally type tested.
2. The electrical panel assembly rods shall be painted with a tin or a suitable special coating, preferably in accordance with applicable international standards to protect them from sewage gases. Also, suitable stands shall be provided to withstand the short circuit current for a period of (3) seconds without causing any damage. The rods shall also be isolated to prevent any accidental contact, and be painted according to standard systems.
3. All electrical panels and engine control centers shall be divided into two or more parts in such a way that each part can be isolated for the maintenance of a part. The other parts shall work (under voltage).
4. Electrical panels and engine control centers shall generally be expandable when electrical equipment are required in the future.
5. The ends of electrical wires or voltage conductors shall be coated with tin or another coating to prevent the accumulation of carbon, preferably in accordance with the applicable international regulations.
6. The electrical supply of electrical outlets and small loads shall be via dry transformer (220-380 volts), and preferably with (127 V).
7. The power outlets of the type (outlets of 110 V) shall be complied with the regulations of National Electrical Manufacturer Association NEMA 5.20R and (outlets of 110 V) shall be complied with the regulations of National Electrical Manufacturer Association NEMA 6.30R.
8. The outlets in wet areas and rooms shall be fitted with the feature of ground-fault circuit interrupter (GFCI).
9. All electrical panels shall comply with the regulations of National Electrical Manufacturer Association (NEMA 12).

10. Circuits of outlets and small loads are in wires of size (2x4 mm2+ 1x4 mm2) grounded, inside a plastic pipe sized 3/4 inch.
11. The motherboard circuit breakers shall be a molded case circuit breaker (MCCB) and each circuit breaker of capacity (70 amps) or more shall be equipped with a ground disconnector (Growl Fault Relay).
12. All engines shall be supplied in the motor control center (MCC), which shall contain all starting and control devices for each engine separately using a Programmable Logic Controller (PLC) or Supervisory Control and Data Acquisition (SCADA) systems.
13. All electrical and mechanical devices shall be connected to the site's grounding system.
14. All electrical and control panel rooms shall be air-conditioned.
15. The distances behind the electrical panels, whether medium or low voltage shall be sufficient and to reach the components of the panels from the back for maintenance, dismantling and installation work, and this shall be taken into account when designing the building and where the panels are installed in the building.
16. The area of the electrical panel room shall be sufficient to perform maintenance work and to add new panels in the future if needed.
17. All electrical panels shall be fitted with a clean air aeration system of gases using activated carbon or any other method to prevent gases from entering the electrical panel, which may damage the internal elements.
18. The design constants of the medium voltage main distribution panel shall be in accordance with the standard principles approved by the manufacturer and shall be specified and not be limited to what the manufacturer adopts. It is recommended that the buildings installed are air-conditioned to improve the performance and operation of the protection and control units as they consist of electronic elements and are very sensitive to temperature as well as breakers.
19. The electrical panel assembly rods shall be painted with a tin or a suitable special coating, preferably in accordance with applicable international standards to protect them from sewage gases. Also, suitable stands shall be provided to withstand the short circuit current for a period of (3) seconds without causing any damage.

20. The level of protection of the panels shall be at least (IP55).
21. All signal transmitters and control units shall be inside the building at a temperature not exceeding (25 ° C).
22. Starting the electric engines shall be according to the electrical capacity as follows:
    a. Capacity is less than (10 kW) of the direct on line (DOL) type.
    b. Capacity is greater from (10 kW) to (17 kW) of star and delta type.
    c. Capacity is greater from (30 kW) by the soft starter.
23. The lowest service factor for electric engines shall be (1.15).
24. Electrical circuit breakers with a capacity of 630 amps and larger shall be retractable.

3-18-6 Engine operation control centers

1. It shall be retractable type for flexibility in operation and partial maintenance of the equipment with other equipment and the equipment shall be from the same source.
2. The level of protection against penetration of foreign objects shall not be less than (IP55).
3. All actuators, valves, electrical panels, and control panels shall be equipped with outlets to connect to the Supervisory Control and Data Acquisition (SCADA) system.
4. The Supervisory Control and Data Acquisition (SCADA) system and all associated devices shall be in accordance with "Field Bus Foundation" international standards. “The electronic measuring and control devices shall be linked to the "Profile Plus" global system to give a high speed of data transfer. Thus, all devices shall have a card to simulate a SCADA system with a "Profi Bus" output.
5. The SCADA system shall be equipped with a printer to print all the events and variables in the system and operate a log book and shall be of the digital type.
6. Use paperless recorders with at least six channels.
7. All current meters preferably shall be of analog type and not digital.
8. The temperature signal transmitter in the heat switches shall be of the digital type and use the RTD's Resist Tepm. Detector system and have analogue outputs (4-20 mA) and at least have an open point and another closed backup point.

9. All equipment, devices and parts shall be of the most recent production of this model, preferably not exceeding a year before installation.
10. A complete manufacturer's catalog for each sensor shall be prepared showing the method of preventive maintenance and problem solving.
11. Main electrical panels shall be placed in isolated and air-conditioned rooms.

3-18-7 Electronic Speed Modulators

1. Electronic speed modulators shall be installed in locations where the nature of their operation requires speed controlling to provide operational flexibility for the plant to make it the best possible position. These sites include, but not limited to (lift pumps at the plant's entrance, sludge recycling pumps, polymer pumps, air blowers, surface aerators, spiral sludge conveyors, mechanical equipment for sludge squeezing, etc.).
2. Standard systems: The unit shall comply with the following measurements: Canadian Standards Association (CSA), National Electrical Manufacturers Association (NEMA), International Electrotechnical Commission (IEC), Deutsches Institut für Normung (DIN), British Standards (BS) (BS), and Saudi standards.
3. Power source: rated voltage: the rated voltage (according to the motor voltage to which it will be installed) shall be (+/- 10%) three phase, and the insulation voltage (according to the motor specification) and the control voltage shall be 220/240 volts, single-face, 60 Hr).
4. Rated capacity: The rated unit capacity (depending on the engine power to be installed at 5 kW at a temperature of at least (50°C) for the surrounding medium.
5. Assembly and components: The unit shall be installed standing on a wall of small units and on the floor for large units. The unit shall be factory tested with level of protection (IP 20). The bus- bars shall also be made of copper covered in insulated tin and the break connectors shall be made of heat-shrink materials. The panel shall be coated with suitable paint, and the unit door shall open on the right side. The electronic components of the speed modulators shall be of the heavy duty type. The voltage and nominal current control components shall be adjustable and equipped with a time timer to increase and decrease speed. The engine shall also have the proper adjustable protection from (high and low current, unbalanced current/ground fault current), a protection from (high and low

voltage/phase sequence and repeated start-up) and protection for thyristors, programmable controls, indicators and switches, etc.

6. Units required: shall be fully assembled and manufactured from panels with dimensions and thicknesses in accordance with the manufacturer standards.
7. Installed interference prevention signals shall be included in the display of electronic speed modulators that ensure the safe and orderly operation of equipment and engines and be linked to the control system in use.
8. The electronic speed modulators can be operated remotely from the control room in which the operator is located, and on site, directly from the unit.
9. The contractor shall state the details of the heat load calculation that shows the degree of protection from penetration of foreign objects to the composite panel within the unit and all other components of the system, so that it shall not be less than (IP 20).
10. The control units' output wave shall be sinusoidal or as close to that as possible so that the unit-driven gearboxes are not affected and the width shall be comprehensive for any additional units needed to achieve this, and the output shall be in accordance with the international standard systems that determine it.
11. The shape and length of a wave and the number of harmonics reflected on the grid due to the installation of the electronic speed modulators shall be in accordance with the requirements of the global electro-grid or international standard systems, and the system shall include the means to limit this in accordance with international standard systems.
12. The installed system shall be connected to the on-site operator panel so that the system can be isolated and overrun in the event that failure or malfunction of the electronic speed modulators so as not to affect the operation of the site and in order to operate safely in accordance with standard systems, i.e. to provide all necessary means to prevent interference between breakers In a safety way.
13. An operating panel shall be available to operate, allow access, continue, program and adjust all settings (constants) and unit functions without using a PC, and confirm in detail.
14. It shall be ensured that the installed units are compatible with the grounding system used on the site.

15. The units shall be selected based on the shape of the curve representing the relationship between speed and flow, speed and torque, speed and electrical power of the equipment to be installed on and shall be described in detail.
16. The system installed on filters to prevent radio frequency interference shall be included to reduce interference and interference with communications in the area where the modules are to be installed, in accordance with international standard systems and specifications.
17. The direct torque control feature shall be available in the installed units.
18. The module shall have the means to allow or provide communication and conversation with programmable logical units as well as with the Supervisory Control and Data Acquisition (SCADA) System and shall be displayed and be able to communicate with any global communications system.
19. A warranty certificate from the system manufacturer stating that this supplied model and cancellation of all components (bundled by other companies) is the latest model produced of this type of equipment and that parts are available for a minimum of (15) year, shall be submitted by the contractor.

3-18-8 Protection system:

Level of protection against the penetration of foreign objects: All equipment and components shall be of the proper level of protection against contact with any part carrying electricity, protection against the penetration of foreign objects commensurate with their operational location, and shall be explosive-resistant in areas containing gases, flammable or explosive substances, including external and internal light units.

3-18-9 Aeration and air conditioning systems:

All electrical panels shall be fitted with a clean air aeration system of gases using activated carbon or any other method to prevent gases from entering the electrical panel, which may damage the internal elements.

Chapter 19

(Supervisory Control and Data Acquisition 'SCADA System')

3.19 Supervisory Control and Data Acquisition, SCADA System

It will be added in the next issue, God willing.

Chapter 20

(Industrial Water Feeding System "'General")

3-20 Industrial water feeding system (general)

3-20-1The System

1. Pressure tanks shall be installed in tertiary treatment units to protect the pressurized industrial water grid from the effects of a water hammer.
2. Install a self-cleaning auto filter shall be installed on the industrial water line.

Chapter 21

(Drinking Water Feeding System "General")

3-21) Drinking Water Feeding System (General)

It shall be added in the next issue - God willing.

Chapter 22

(Disinfection System)

3-22) Disinfection system

3. 22 .1) UV Sterilization Unit:

1. The main body shall be made of stainless material, preferably of Stain Steel, and fixed on both ends of the channel whose content the rays are to be shed.
2. The lamp holder is made of quartz and an appropriate (O - rang) shall be used to ensure the bulbs are tightened when replacing them.
3. The cooling system shall be carefully selected due to the importance of controlling the temperature of the lamps. The fluids used shall be carefully selected and it is preferable to use the available ones inside the KSA.
4. Hygiene system: It shall operate automatically at intervals without the need to stop sterilization.
5. Control Panel: All parameters required for operation and control shall be shown in a well-considered way.

Chapter 23

(Backup Generator Plant)

3-23) Backup Generator Plant

It shall be added in the next issue - God willing.

Chapter 24

(Polymer System)

3-24) Polymer System

It shall be added in the next issue - God willing.

Chapter 25

(Odor Control and Gas Treatment System)

3-25) Odor Control and Gas Treatment System

3-25-1) Preferred Systems:

Odors are eliminated and controlled in the following ways:

1. By chemical methods, using caustic soda and activated carbon, it is used in high concentrations. (Expensive system) (The system is difficult to be maintained and needs a high technical level).
2. Using active carbon alone, this system is used in lower concentrations.
3. By biological methods (sensitive system and affected by temperature change) (economical) (easy to operate and maintain) (high initial cost).

3-25-2) Important Specifications for the System and Gas Concentrations:

The concentration of hydrogen sulfide released into the atmosphere shall not exceed (1) parts per million.

3-25-3) Flow and Level Meters:

The PH sensor needs to be wet continuously to keep it from being damaged and this is taken into account in the way the line is designed.

3-25-4) Exhaust Fans:

- The fan shall be made of stainless steel, and reinforced plastic is not preferred.
- The odor control system shall have sufficient capacity to overcome the obstructions resulting from the passage of the drawn gases through the paths, fittings and valves, so that there is a negative pressure that achieves the withdrawal of gases without leakage to the atmosphere without treatment.
- The flow shall be greater than the designed capacity of the system and controlled by valve.

3-25-5) Pipes and Fittings:

- The appropriate material for manufacturing the valves that deal with caustic soda solution shall be CPVC and not UPVC, where the caustic soda temperature reaches 80 degrees Celsius, and the manufacturers recommend not to use UPVC for temperatures that exceed (60) degrees Celsius.
- The system shall be equipped with a drain line to expel air to the outside in case maintenance is required.
- It is preferred that all lines be of chemically treated stainless steel.

3-25-6) Tanks for Chemical Materials (Caustic Soda) and Treatment of Wet Gases

1. The manufacturing material shall be reinforced fiberglass, with a thickness of not less than (6 millimeters) for all internal supports.
2. The tank shall be equipped with a ladder made of aluminum or iron with an epoxy coating.
3. The base of the carbon shall be reinforced to prevent collapse of the coal layer inside the tank.
4. All internal contents of the tank shall be of materials that are not affected by high gas concentrations and humidity.
5. The tank shall be provided with two holes, each opening diameter is (600 mm). The first hole is at the top of the tank surface with a hinged door cover and the second hole is side and closed with a flange attached with screws for easy carbon filling and the entry of workers for maintenance work.
6. All raw materials for manufacturing materials shall be of good quality and have an analysis and quality certificate indicating the composition ratios for the tank, and there shall be an approved certificate that the products used are of the best quality.

3-25-7) Carbon Tanks:

1. The manufacturing material shall be reinforced fiberglass with a thickness of not less than (6 mm) for all internal supports.
2. The tank shall be fitted with a ladder made of aluminum or epoxy coated iron.
3. The base of the carbon shall be reinforced to prevent collapse of the coal layer inside the tank
4. All internal contents of the tank shall be of materials that are not affected by high gas concentrations and humidity.
5. The tank shall be provided with inspection holes made of translucent Lexan.

6. The sprayers installed on the scrubbing system shall have ceramic materials and plastic shall not be used, in order to avoid being damaged by heat in the event of a fire (God forbid) inside the tank, and therefore the washing system shall not work to extinguish the fire and reduce the heat.
7. The scrubbing (activation) mechanism of the activated carbon in the dry gas treatment units shall be fully automatic (automatic) with the possibility of manual operation.
8. The tank shall be provided with two holes, each opening diameter is (600 mm). The first hole is at the top of the tank surface with a hinged door cover and the second hole is side and closed with a flange attached with screws for easy carbon filling and the entry of workers for maintenance work.

3-25-8) Recycling and Injection Pumps:

- Seal wash system shall be added with electrical control valve to avoid continuous wear of seals.
- The sealants shall be of the type that works at high caustic soda concentrations so that the concentration is not less than (50%), and a guarantee from the contractor is required.
- The pump shall be made of stainless steel for its resistance to caustic soda, corrosion and great flexibility in operation.

3-25-9) Active Carbon:

1. Activate charcoal shall be virgin spherical type and be derived from bitumen coal.
2. Activation shall not start if there is no flow and this shall be done by a water flow switch. The same shall be suitable for wastewater treatment unit, especially hydrogen sulfide.
3. The maximum possible humidity shall not exceed (10%).
4. Activated charcoal shall be activated using just sodium hydroxide or water.

3-25-10) Supplying the Site with Drinking Water and Industrial Water:

The site needs drinking water lines for the system.

3-25-11) Technical Specifications Required in Site Coverage to Treat Odors:

1. Consideration shall be given to the drainage of rainwater that collects at the top of the caps in the dips between the pieces of the caps.

2. Through our experience with the caps, each curved piece loses its shape when dismantled, so each piece shall be provided with transverse supports for easy re-assembly of the parts if it is required to be dismantled for operation and maintenance purposes.
3. Fixation shall be in concrete using Quick Connection for ease of disassembly and installation.
4. It is necessary for detection holes to be available with hinges and quick connectors, so that these covers can be opened when needed.

3-26) Tanks Discharge Plant

This plant shall not contain many devices and equipment whose specifications are required to be worked out. It is simply a channel of a certain size to receive the incoming wastewater by tanks, but the importance of this plant and the need to implement the same is due to the presence of many parts in the regions and governorates that were not served by the sewage network. In addition to its reliance on cesspits to treat and store wastewater produced therefrom. Because of the importance of the same, this plant shall be implemented in a technical and tight manner to deal with this type of wastewater that contains high quantities of suspended materials and other organic materials that need appropriate treatment so as not to affect the units of the main purification plant, which is expected to be treated inside it.

Discharge Plant Parts:

1. Main channel: its design depends on the percentage of parts served in that area and the stages of completing the sewage networks to serve the same, as well as on the size of the main purification plant ... So it is recommended that it consist of the following:
   a) A square, rectangular, or circular cross-section channel of salt-resistant concrete, which shall be lined with plastic foil interleaved in the concrete by means of a cap (T).
   b) It is desirable for the channel to be circular from one of the pipes with high resistance to wastewater, preferably from fiberglass or plastic with a high thickness. Openings can be made at the top of the pipes with a flexible connection and a size that matches the openings of the mechanisms of the tanks tightly that can empty the contents of the tanks and ensure that no smell emanating therefrom. Therefore, the installation of a deodorizing unit can be dispensed with in these plants ... The channel shall be protected by covering it with reinforced concrete and placing other protection around these pipes by means of berths that prevent the wheels of tanks from reaching them.
2. Spaces for tanker movement:

   It is desirable to allow easy movement of tanks so that the tanker load can be unloaded in an easy way. So the plant shall be designed to accommodate the expected number of tanks according to the quantities of flow expected to be discharged into the plant, and this only comes by using large areas that give the tanks freedom of movement without affecting the main downstream and friction with concrete and sidewalks established for downstream protection.

3. An entrance suitable for entering the trucks, as it is equipped with the necessary devices and equipment for the movement of tanks.
4. A convenient exit does not also interfere with the entrance or with the outside traffic in the city.

Chapter 27

(Electrical Wiring and Lighting System" General")

3-27) Electrical wiring and lighting system (general)

3-27-1) General

1. Lighting poles shall be of galvanized iron.
2. The outdoor lighting fixtures shall be high-pressure sodium (250 watts), (220 volts) and controlled by a photoelectric cell.
3. Indoor lighting shall be fluorescent with electronic transformer (Bullast) and economical fluorescent bulbs.
4. Lighting extensions shall be separate from power extensions.
5. The lighting circuit wire shall not be less than (2 x 4 cm^2 + 2 x 4 cm^2 ground) inside the (3/4) inch plastic pipe.
6. Lighting switches are preferably to be (20) amps, (120) volts.
7. The lighting is fed by a dry transformer (380 - 220) volts, preferably with (127) volts.
8. All lighting circuits shall contain earth wire of no less than (four mm^2).
9. Lighting panels' specifications shall not be less than NEMA 12 specifications.

Chapter 28

(Aeration and Air Conditioning Systems "General")

3-28) Aeration and Air Conditioning System (General)

3-28-1) Concrete buildings and structures:

The doors and windows of the equipment building shall be designed to keep the rooms completely isolated from the outside atmosphere, and the equipment building and other components shall be fully ventilated and include suction fans for the equipment as well as push fans, while the electric and operating control rooms shall be equipped with proper air-conditioning equipment.

1. Equipment rooms shall be equipped with a suitable ventilation system according to the ASHRAE 62 standards.
2. Equipment rooms with air compressor shall be equipped with a system allowing filtered airway.
3. When designing equipment rooms, it shall be taken into account that the walls shall be insulated in line with the International Noise Suppression Regulations.
4. The room shall be supplied with air on one side and drawn from the opposite side.
5. All the measuring and control rooms shall be air-conditioned and use split or central air conditioning depending on the size and requirements of the control room.

Chapter 29

(Laboratory)

3-29) Laboratory

3-29-1) Concrete buildings and structures:

1. The laboratory shall be of a well-insulated concrete building to maintain the temperature.
2. The lab shall consist of a lobby for normal tests and rooms for special analysis that require some kind of precision.
3. It is preferable to divide the laboratory into different sections according to the type of analysis required.
4. The floors and walls shall be of types that are not affected by chemicals, and they shall be easy to clean and be made of ceramic or resistant paint.
5. The spacing between analysis tables shall be suitable to allow freedom of movement during work.

3.29.2 Laboratory equipment:

1. Analysis tables:

The table shall be suitable, contain drawers, and have an acid- and base-resistant surface, and have a barrier that traps spills and prevents them from spreading on the floor.

2. Fume cupboards:

They shall be fully equipped in terms of electrical, water, and compressed air supply to perform analyses that are of a kind of risk.

3. Air compressor

A compressed air source shall be available as it is used in many operations such as drying and ventilation to activate bacteria, to calibrate dissolved oxygen devices, and so on.

4. Cooling chamber

It is preferred for storing some solutions and chemicals that have little stability.

3-29-3) Devices, standards, tools and chemicals:

3-29-3-1) Necessary equipment

Sewage laboratories depend on some equipment necessary to perform the necessary analyses, and other devices are preferred. Some of the necessary equipment that the sewage laboratory shall have are:

1. PH scale.
2. Turbidity meter.
3. DO scale.
4. TDS scale.
5. Distillation device (distillation unit).
6. Automatic calibration device.
7. Amm, PO4, NO3, NO2 Estimators.
8. A filter device with a suction pump for determination of suspended substances.
9. Drying ovens.
10. Kilns.
11. Special incubators for BOD samples.
12. Bacterial cultures.
13. Free chlorine and total chlorine measuring devices.
14. Total Kjeldahl Nitrogen (TKN) device for measuring and estimating the total concentration of organic nitrogen.
15. Total Organic Carbon (TOC) device for measuring and estimating the total concentration of organic Carbon.
16. Digestion System to estimate Chemical Oxygen on Demand (COD).
17. Optical electro-microscope.
18. Pressure and Heat Sterilizer, Autoclave.
19. A cooler to store standard solutions, bacterial dishes, and samples.
20. A high-speed centrifuge of at least (5,000) rpm.
21. Heater and magnetic stirrer device.

22. A water-bath.
23. Sample homogenizing device.
24. Electric stirrer.
25. Filter pump for bacterial analysis.

3-29-3-2) Preferred equipment:

Among the devices that are preferred to be available are the following:

1. Heavy metals assessment device.
2. Oil estimator.
3. Spectral analyzer.

3-29-3-3) Tools that shall be provided:

As for the tools, the following shall be provided:

1- Glassware, including the following:

1. A cup with a capacity of 1000, 1500, 1000, 200, 100 and 50 ml.
2. Graduated Tester with a capacity of1000, 1500, 1000, 200, 100, 50 and 10 ml.
3. A pipette of 25,10,5 and 1ml.
4. Standard Flask of 1000, 1500, 1000, 200, 100, 50 and 25 ml.
5. Conical flask of 1000, 1500, 1000, 200, 100 and 50 ml.
6. Flasks of different sizes.
7. Special flasks of different sizes and opaque color.
8. Test pipes of different sizes.
9. A glass-stem.
10. Bacteria culture dishes.
11. Burettes of different sizes.
12. Washing flask.

2- Holders and claspers as follows:

1. Test tube holder.

2. Burette holder.
3. Flasks holder.
4. Electric stirrer holder.
5. Tube clasper.
6. Magnetic clasper.

3- filter papers

1. Filter papers with a porosity (1.2) micron and a diameter of 7 cm.
2. Filter papers of different porosity and sizes.
3. Filter papers for bacterial analysis.

4- Crucibles

1. Drying beakers of 100 ml.
2. Incineration crucibles of 80 ml.

3-29-4) Analysis:

3-29-4-1) Chemical analysis:

This section includes two types of analyses as follows:

A- Basic chemical analyses as follows:

1. Bio-oxygen Demand (BOD) test.
2. Chemical Oxygen on Demand (COD) test.
3. Suspended substances assessment.
4. Total Kjeldahl Nitrogen (TKN) assessment.
5. Total Organic Carbon (TOC) assessment.
6. PH test.
7. Dissolved oxygen test (DO test).
8. Amm, PO4, NO3, NO2 test.
9. Turbidity test.
10. Volatile acids test.

11. Alkaline.
12. Chlorides.
13. Sludge analysis.
14. Free and total chlorine test.

1. **Secondary chemical analyses including:**

   Oil assessment.
2. Total dissolved salts test.
3. Sulfate test.
4. Total solids test.

3-29-4-2) Microbial analysis:

A- Includes the following basic tests:

1. Total coliform bacteria detection.
2. Fecal bacteria detection.

B- Secondary microbial tests as follows:

1. Helminth eggs test.
2. Activated sludge Examination.

3-29-5) Lighting and electrical installations system

Electricity supply sources of different voltage shall be available, i.e. a line of (220, 380) volt. In the case of a 110 volt line, it is preferable to have a control room.

3-29-6) Supplying the site with drinking water, industrial water and services

The site shall be provided with drinking water, industrial water and compressed air lines.

3-29-7) Aeration and air conditioning systems

Some of the necessities that shall be available are the Aeration and air conditioning systems, as there shall be a good aeration system for all parts of the laboratory and the attachments, which shall be an overhead system that includes a cooling and heating system as well as an Intake system and intake system for gases (fume cupboards).

3-29-8) Safety and firefighting systems

1. Emergency sprinklers and eye wash taps shall be provided.

2. A pharmacy for chemical laboratories is required.
3. Appropriate coats, gloves, goggles and masks shall be provided to protect workers.
4. The laboratory shall have emergency exits.
5. Laboratories' firefighting and extinguishing systems shall be available.

Chapter 30

(Safety and Firefighting Systems)

3-30) Safety and firefighting systems

3-30-1) Concrete buildings and structures:

1. The stairs connected to the lower basements shall be safe, non-slip and comply with the appropriate safety requirements.
2. Room floors shall meet safety requirements to be non-slip.
3. Each closed or semi-closed building shall be equipped with devices to measure the percentage of harmful and dangerous gases and with alarm in the event that the rate is higher than the globally permitted rates.

3-30-2) Required equipment

1. All types of extinguishers needed for electrical - gas use of different sizes, conforming to the standard specifications, shall be provided.
2. Fixed and movable extinguishers shall be available in designated areas.
3. An automatic fire alarm system that works on smoke and fire detectors and gives an audible and visual alarm that shall be available.
4. Water cocks for a complete firefighting water network next to each unit shall be available. A fire extinguishing box containing water hoses of appropriate lengths shall be available next to each valve.
5. Full oxygen cylinders equipped with masks and compressors for refilling with air shall be provided.
6. Safety shoes shall be available to protect against electricity, heat and sewage.
7. A helmet shall be available in sufficient quantities.
8. Electrical insulation equipment shall be available for use during fire.
9. Indicative panels indicating the security and safety methods to be followed shall be available in locations.

Chapter 31

(Pipes and Fittings "General")

3-31) Pipes and Fittings

3-31-1) General:

1. Ductile or stainless steel pipes shall be used, and plastic pipes shall not be used inside basements because plastic pipes are weak and easy to break, which may lead to the basement sinking.
2. Every pipe that passes through a wall or floor shall be through a sleeve, unless there is a technical or construction reason to be cast on it for ease of maintenance and changing the line when needed.
3. If two large tubular are parallel to each other, they shall be separated by a sufficient distance of protection in the event of a breakage, if possible, according to the recommended international specification.
4. A drain point shall be placed to facilitate line emptying.
5. Flushing points consist of a quick-fitting connection and valve that shall be installed to allow complete washing of the pipes, pumps and valves. These points shall be installed on the suction and discharge lines, at the elbows and divisions, and their number and locations shall be subjected to the approval of the supervising engineer. Also, sources of treated water with sufficient pressure (not less than 10 bar) shall be provided at these points.
6. Automatic valves shall be installed to remove condensate in locations where airborne steam is likely to condense.
7. Exposed pipes shall be distinguished from each other by painting or drawing in visible color, and the colors shall be in accordance with international regulations. The color code shall be chosen in a manner consistent with the existing plants, and arrows indicating the direction of flow and supply shall be placed.
8. With regard to underground piping extensions, the pipes shall be parallel to the walls and there shall be no intersections between the pipes as far as possible. Pipes shall also be located, deep, and fully described in the plans.

9. Pipes and channels shall be equipped with relief valves when the levels or diameters are changed.
10. The concrete blocks needed in the pipelines shall fixed in the branches and elbows areas, both in the horizontal and vertical axes of the pipeline routes, and the necessary chairs for the valves and flow meters shall be made and their design calculations shall be provided.

Chapter 32

(Valves and Accessories "General")

3-32) Valves and Accessories

3-32-1) General:

1. Valve locations, ease and safety of access shall be reviewed by operators.
2. A small check valve shall be placed after each large valve.
3. The out-of-reach overhead valves shall be equipped with grooved rollers that are driven by chains.

Chapter 33

3-33) General

3-33-1) Concrete Buildings and Structures:

1. All pumps installed in the basements shall have a base height of not less than (30-40 cm) from the floor level on which they are installed in order to ensure that their engines do not sink when water floods into the basement due to not working of some faulty valves and gives an opportunity to act before reaching this level.
2. The exterior paints of the basement shall be beige (earthy) to withstand dirt or dust, and be not rough so that dust does not penetrate into them and thus difficult to clean. As for the basins, they remain in the color of fair face.
3. The Interior paints for walls and buildings ceilings shall be of a bright, non-absorbable type of dirt, oil, grease and sludge stakes and washable.
4. Floor concrete shall be protected with suitable paints that are resistant to oils, greases and chemicals, as well as highly resistant to scratching.
5. Each building shall be provided with stairs to reach its roof for the purpose of its maintenance, provided that these stairs shall be vertical in the absence of equipment on the roof of the building and it shall be cracked or spiral in the case of equipment that requires continuous maintenance in order to preserve the safety of workers.
6. It shall be taken into account the proper leveling each room or ceiling so that the washing or rain water is directed immediately to the point of discharge.
7. When designing buildings, it shall be taken into account, so that it gives comfortable interstitial distances (up to 80 cm) for the purpose of maintenance between each equipment and the other, and between the equipment and the wall, it is also taken into account to increase the building space up to (15%) in order to add some equipment and systems in the building later as a kind of development or modernization of the site.

3-33-2) General Technical Specifications and Requirements:

1. Conformity specifications and metrology: The supplied materials, equipment and systems shall conform to the requirements of the Saudi standard specifications or international specifications for similar and similar works in the applicable cases, and the contractor must comply with the general conditions issued by the Ministry of Public Works and Housing for building work in all contract works

2. Units of Measurements: The system of international units of measurement "SI" "metric system" shall be obliged to in all work in design and implementation, including all meters, flow measurement, speed, dimensions and measurements of pipes, cables, and others.

3. Equipment capacity shall be selected using a safety factor of no less than (1.25) for the equipment to cross the action points on its operating curve. There must also be spare equipment for use during maintenance and repair work for the basic equipment important for operation, unless otherwise indicated.

4. All equipment shall be suitable for environmental conditions such as ambient temperature from (0) to (55) degrees Celsius, relative humidity from (10 to 98) and height above sea level, and it shall work efficiently and at its maximum capacity in the weather conditions prevailing in the Kingdom of Saudi Arabia.

5. The identical equipment shall be of one type in order to facilitate dealing with it and to secure spare parts and maintenance.

6. The equipment shall be of modern design and production and this must be proven by the manufacturer

7. All equipment shall be produced by an internationally known company

8. Each equipment shall be provided with "a name plate" containing all the basic information indicating the equipment name, model, capacity, name of the manufacturer and design data according to international systems, as well as tanks shall be provided with plates showing the name of the tank, its number, capacity, dimensions.... and others

9. All equipment shall be provided with the necessary protections to ensure that it will not be damaged or broken as a result of overloading and human errors.

10. The mechanical and electrical equipment shall be installed so that there is sufficient space for maintenance and repair work in its place, as well as preparing suspension equipment to lift and remove it, and any height for installing the equipment must be appropriate, leaving a space between it and the heads of workers.

11. The information according to which the equipment was requested and secured shall be provided by the manufacturers to be used as a reference when any problem occurs or the need for any change, modification or spare parts request in the future.

12. All security instructions, recommendations and warnings shall be provided, and it includes any materials, tools, or special tools for working with any specific equipment or workstation, whether electrical or mechanical equipment.

13. Any equipment or special tools needed to dismantle or install specific equipment shall be provided.
14. List of equipment, technical specifications, identification information, manufacturers and their addresses shall be provided.
15. The contractor shall provide the schedule that shows preventive maintenance work according to the work conditions at the site.
16. All equipment, pumps and pipes shall be suitable for the medium passing through in terms of its quality and density.
17. Valves shall be placed in all places that require complete isolation so that maintenance procedures are done safely
18. The amount of vibration shall be measured in all plan equipment and must be within the internationally permissible limits.
19. All rotating parts must be in static and motion states (static and dynamic in all operating conditions
20. The materials shall be chosen so that they are not affected by the materials to which they are exposed and the surrounding climatic conditions
21. Measurement and Control Devices: The flow measurement, level and control devices shall be equipped with digital readers of the appropriate range
22. All major equipment shall be equipped with digital working hour counters
23. Appropriate pressure gauges shall be placed at the inlets and outlets of the pumps, and the pressure gauge shall be suitable for the work pressure, and each gauge shall be provided with an isolation valve, the pressure gauges on the sludge and foam lines shall be of the type with

" Diaphragm Pressure Gauge"

24. All plant units and equipment must be provided with a card showing the performance and product and a full definition of the technical specifications.

3-33-3) Flow and Level meters and Measuring Devices:

1. Using non-paper recorders with memory to keep data for a period of three to six months. The data can be dumped and loaded onto computers for safekeeping.
2. The contractor shall provide a warranty certificate from the system manufacturer stating that this supplied model and all its components, which shall be from the same company, are the most recent models that have

been produced of this type of equipment and that they provide guaranteed spare parts for a period of not less than five years.

3. The installed gauges shall be linkable to the plan's remote control and monitoring system

4. All microprocessor systems (valves or equipment) shall be installed inside buildings to protect them from direct sunlight. Sensors whose applications are imposed externally shall be protected. An umbrella shall be provided to protect them from the sun's rays to ensure that they do not overheat.

5. In gas gauges it is necessary to ensure that the presented gauge can measure wet methane gas and ensure this

6. For RTD thermometers, (a FOUR WIRE METHOD) shall be required to obtain accurate readings.

7. It is preferred in all gauges that the display screen is away from the same scale to protect it.

8. The quality of the level sensors shall be of the type that is not in contact with sewage.

3-33-4) Drawings, Operating and Maintenance Manuals, and Spare Parts for All Equipment:

1. The contractor shall prepare all the plans, data and accounts on the computer, and after the completion of the implementation he must provide the magnetic disks and three certified copies on paper

2. Drawings according to implementation: comprehensive for all modifications and completely identical to the last implementation, the drawings shall be comprehensive for all parts of the buildings, equipment, and project services, and the plans must contain all projections, sections and interfaces necessary to show the drawings.

3. The name and address of the manufacturer and all contact information needed to be mentioned in all operation and maintenance manuals

4. It is necessary to mention information about the installed equipment and its model, and all technical information about it, such as its power, voltage and special curves.

5. It is necessary to mention the safety instructions and include all the necessary recommendations to maintain the safety of workers when operating and maintaining the equipment.

6. It is necessary to mention the safety instructions for preventive maintenance, malfunctions, methods of dismantling and installing parts of the equipment, detailing the components of the internal equipment, indicating the parts numbers, schedules of the necessary spare parts.

7. The contractor shall provide the operation and maintenance manuals in sufficient time prior to receipt and are complete and comprehensive of all lifting equipment specifications and their maintenance, he shall

indicate the number of technicians required to operate and maintain the equipment and their specializations and technical levels

8. The contractor shall provide recommendations of the manufacturers of spare parts for each equipment in the project as follows:

A- Sufficient spare parts required for a period of two years for each equipment, provided that they are provided based on the recommendations of the manufacturer in the catalogs of operation and maintenance, and that it shall be studied on the basis of the use of equipment in the sewage plant and approved and on the responsibility of the manufacturer.

B. General and consumable spare parts (such as: bearings, oil seals and circuit breakers, contactors, fuses, relays … etc.), maintenance materials and the tools recommended by the manufacturer for effective and continuous operation for a period of two years after the date of the final receipt of the project, and all special equipment necessary to dismantle, install and maintain the equipment as recommended by the manufacturer.

C. Precision devices required for two years, in addition to spare parts for all precision devices.

3-33-5) Training:

The contractor shall, during the first operation period, train the people who will work on operating and maintaining the plant after receiving it in the best way to operate, and on ways to correct the defect in case it occurs, and a training schedule should be made to be presented to the supervising engineer at least two weeks before the start of training.

3-33-6) Gates and their Operators:

1. It is preferred that the gates and all their operators be made of stainless steel type (316L) that has been chemically treated after the manufacturing processes.

2. The gate lift shaft shall be of the ascending type and made of stainless steel type (316L).

3. All gates whose locations require continuous or periodic programmed opening and closing shall be provided with an appropriate electrical operator

4. Gate operators whose operation requires control of the opening and closing level shall be of the adjustable type

5. The recommendation shall be made in choosing the appropriate operators for each gate in terms of type and loads by the operator's manufacturer and based on complete technical calculations of the conditions and

loads that the gate will be exposed to, in order to avoid the emergence of technical problems in the gates after one or two years of operation due to the poor selection of the type.

6. Gate operators shall be equipped to connect to the plant's remote control and monitoring system.

7. The contractor shall submit a warranty certificate from the system manufacturer stating that this supplied model and all its components (assembled from the production of other companies) are the most recent models that have been produced of this type of equipment, and that they guarantee the availability of spare parts for a period of not less than five years.

8. The safety factor shall not less than (2)

All gates that work through an electric motor shall operate in the circulatory system

All gates shall be equipped with a graduated scale between the closing and opening ratios and that these ratios be transmitted electrically through a signal system or operate according to the level of the level automatically.

3-33-7 Hoists and cranes:

1. The load of the equipment inside the buildings and the need for the overhead cranes moving in two directions shall be a minimum (1.5) of the load intended to be loaded.

2. It shall be supply with a simple cable and not by a contact channel as it is affected by the gases produced by the sewage water.

3. The design should take into account easy access to these hoists and the electrical panel when maintenance is required

4. It shall be powered by electric motors

5. The contractor shall submit a warranty certificate from the manufacturer, stating that this hoist is one of the most recent models that have been produced, and that a guarantee of no less than (10) years is provided for the availability of spare parts.

6. Manual, overhead, single and double winches and slip bridges shall be tested according to international regulations such as **FEM/DIN/PMAA/BS** and others.

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Ministry of Water and Electricity

Chapter Four

Value Engineering

Chapter Four

(Value Engineering)

Value Engineering

Applying Value Engineering in Sewage Water Projects

Introduction:

Value engineering studies can theoretically be carried out and applied at any phase of project development, starting with the planning phase until the operation and maintenance phase, but value engineering is an analysis of functions to identify and classify them and then achieve those required functions by other creative methods that achieve the required balance between cost, function, performance, appearance and quality by proposing different alternatives, which means making radical changes to the design or coming up with a completely new design that achieves the required functions to the fullest extent and with the lowest possible costs.

Value engineering is not a substitution of an element with another or substance with another, nor is it a process of patching here or modification there for formal improvement with the essence remaining the same. Therefore, it is preferable to apply value engineering studies in early phases and before the approval of systems, services and project design, the earlier the phase in which the study is conducted, the higher the return, because this avoids the cost of re-doing some work, delay or completely redesigning. Value engineering study may be impractical after the end of the design work and may be impossible upon completion of the implementation, unless the project has a repetitive attribute in the application, such as schools and hospitals, for example, or its application is in the field of operation and maintenance.

Value engineering studies may be conducted in more than one phase, such as conducting value studies during programming the project requirements, and then another study after completing the concept phase or subsequent phase of design.

Conducting value engineering studies aims to achieve the maximum savings and development with a minimum time and physical effort, and this is not usually achieved unless the study was conducted in the early phases of study, so that if we look at the elements affecting the project costs shown in the two figures below, we will find that the design of the project is the most element that affects the costs and quality of the project by up to (50%) among the effect of other elements, while the design cost does not exceed (3%) of the total value of the project.

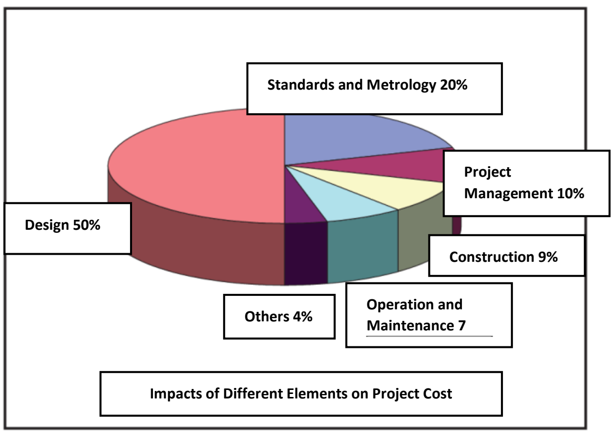
So, applying value engineering studies in the early phases achieves this for the following reasons:

1- Maximum savings are achieved when studying projects in the planning phases, because the effort costs and time spent in this phase are minimal.

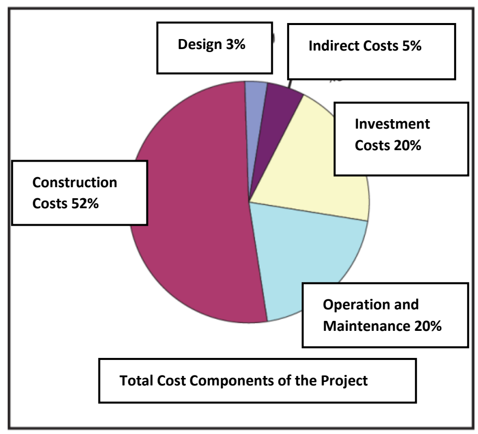
2- Ease of implementing value engineering proposals at this phase, including re-design if necessary.

3- The opportunity of the owner or higher management agreeing to implement the study proposals is greater at this phase than in the later phases.

4- The impact of the study at this phase is minimal and imperceptible on the overall project timeline.



Impacts of Different Elements on Project Cost



Total Cost Components of the Project

(4-1) Regulations:

The consultant designing the project applies the value engineering studies within the concept studies and final designs for the required treatment plant project, and he shall conduct a comprehensive procedure for all proposed treatment systems and the structural, mechanical and electrical systems to present an integrated value study of the project technically and economically, and to that end, he shall do the following:

1. Collect technical data, information about the site, principles and design criteria for the proposed plant project, and determine the principles and standards proposed for the designs of the plant units, including the plant's capacity, implementation phases, technical information for the quality of sewage entering the plant, the required standards for the plant surplus, the level of treatment, and proposals for the optimal reuse of the surplus.

2. Present and study the proposed systems for treatment in proportion to the required design principles and standards, evaluate these systems and submit proposals and visualizations for the most appropriate

systems to achieve technical efficiency for economic treatment of implementing them with the required quality.

3. The consultant shall apply the value engineering approach to the concept studies. It includes three main elements, namely identifying the functions and the proposed systems alternatives to achieve these functions and the economic costs of implementing them with the required quality.

4. The consultant shall form a team of value studies from the various specializations related to the project, with the participation of one of the Ministry's specialists, and he shall provide and prepare all the requirements of the work team and its management.

5. The consultant shall prepare a comprehensive report for the Ministry to study the value engineering of the project in the concept study phase, and proposals for systems alternatives, their evaluation and recommendations thereon.

6. After receiving the Ministry the value engineering report for the concept studies, an appointment is set with the consultant and the work team to discuss the results of the studies, proposals and recommendations to take the necessary decision in its regard and approve the completion of the final designs of the project.

7. The consultant shall prepare the value engineering study for the final designs of the treatment system approved by the ministry, and he shall apply the value engineering approach to all systems and equipment for project designs to propose appropriate alternatives to achieve the highest technical efficiency and economic feasibility of the project.

8. During the value engineering study for final designs, the consultant shall take into consideration the life cycle cost of the project (LCC), including the operating and maintenance costs.

9. The consultant shall submit a complete report of the value engineering study for the final designs of all systems, equipment and units of the project and the proposals and recommendations necessary for discussion with the Ministry's specialists and take the appropriate decision regarding it to complete the final designs of the project.

(4-2) Value Engineering work Plan:

Any value study of any project usually takes several sequential and regular steps carried out by a team of many specializations related to the project in order to reach the optimal utilization of available resources and proposing alternatives and ideas that would improve performance and reduce the total cost, where the approach and steps of value engineering universally adopted are applied Internationally in value engineering studies.

4-2-1) Pre-study phase:

The success of the work team in conducting the required value study depends on the availability and completeness of information and good coordination with all parties, A and receiving all documents related to the study before starting the workshop, then the team leader selects and forms the appropriate work team to study the project and gives a brief explanation to the team members about the project and the objectives of its study and what are their roles and responsibilities during the study. Usually, the preparation plan and getting ready in the pre-study period includes the following activities:

1- Define / specify the objectives and scope of the value study.

2- Review all project design documents.

3- Prepare the required models and making a cost analysis.

4- Complete the final arrangements to start the workshop.

The team leader shall begin by creating the appropriate atmosphere and climate for the study and giving each team member the opportunity to read and review the master plans, contract documents, general and private standards, with the aim of a full and complete familiarity with the nature of the project and build a good idea of the project.

4-2-2) Value study phases:

A- Information:

The value study phase or the so-called value workshop shall begin with giving an overview of the project by the members, each in his specialty, in order to exchange information and collectively discuss it, and review the models and data prepared for various information for discussion, determine the study priorities, and for further interaction and integration among members of the same team.

B- Function analysis:

The work team, after understanding the project in its previously given form, shall perform function analysis that includes the definition of functions, their classification and linking them to actual and due costs, and the use of (F.A.S.T) technology to identify the main and secondary functions needed for the project and then draw the final diagram for the jobs sequence logically, and define the objectives and field of study through function linking.

C- Brainstorming:

It is the most important phase in the value study, and to prepare the work team for this phase, the method of Force Field Analysis is usually applied. The work team shall propose all ideas without reservation to give the team members full freedom to brainstorm, as much as they can, to achieve the functions required for the project at the lowest costs while maintaining improvement of the functional performance and required quality. There is a specific method for brainstorming, often through the concept of value engineering technique.

D- Evolution:

At this phase of the study, the team leader shall clarify the bases and standards for evaluating the ideas presented in the previous phase, and what are the important axes that shall be focused on when evaluating ideas. The team often develops the ideas and studies their advantages and disadvantages to reach the best ideas and the highest evaluation. Some techniques such as Weighted Evaluation are also used to compare the proposed alternatives and choose the best ones in a scientific and accurate way.

E- Development:

The ideas are then divided on the work team to develop them and then presented to the team leader and team members to finalize any amendments or additions, and thus choose proposals that give new value to the project and lead to improved performance, and achieve financial savings as possible for the project.

F- Consideration of life cycle cost of the project (LCC):

The main proposals shall be compared with the total cost of the proposal, taking into account operation, maintenance and life cycle cost of the project. The proposal is then chosen by priority from this standpoint.

4-2-3) Post-study phase:

In the post-study phase, a value engineering report is presented. At the same time, an oral presentation is made briefly about the value study that has been completed and the conclusions and recommendations it has reached, in the presence of the decision-makers in the project. After completing the recommendations, implement them and take them into account in future projects in order to make clear the benefits of using value engineering.

The proposals and the final results of the study can be discussed and followed up their application to the project. The results shall be evaluated after completing the recommendations, implement them and take them into account in upcoming projects, so that the benefits from the use of value engineering can be seen.

(4-3) Ideas to be Implemented in Treatment Plants to Lower Reduce Costs

1. Reducing distances among plant parts.
2. Utilizing the ground level and rearranging the treatment parts.
3. Reducing the height of the aeration tanks.
4. Using a wall of iron fence.
5. Re-planning of the chlorination building in proportion to the size of the plant.
6. Integration of polymer and dewatering system into one building.
7. Re-planning the administration building.
8. Using iron tanks.
9. Using iron structures and concrete walls.
10. Using scraper of equal length with the tank radius.
11. Using floating ventilation.
12. Reducing distribution rooms.
13. Eliminate sand classifiers.
14. Adjustment of the air compressor building site.
15. Reconsider the pipe sizes.
16. Reducing the number of backup pumps and generators.
17. Using reinforced plastic pipes (HDPE, UPVC).
18. Modifying the design of the final filtering system.
19. Modify the resulting sludge treatment system.
20. Reconsidering the plant capacity.
21. Redesigning the treatment units.
22. Reconsidering the maximum flow factor.
23. Adjusting the capacity of chlorine tanks.
24. Replacing the drying system by adding chemical desiccants.

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Chapter Five

Implementation

Chapter Five (Implementation)

Topic

Chapter five

Implementation

Introduction:

There is no doubt that the implementation stage of any project is considered the most important partial of the stages that the project goes through until the project has been operated and then benefited from because implementation of the plans and design basically leads to success of this stage. The implementation of the plans and design should be adopted on the ground in a thoughtful technical way, taking into consideration the priority in implementing the parts of the project and achieving what guarantees the ease of starting towards the completion of the project with ease, as well as making maximum use of any part that can be clearly implemented.

(5-1) Implementation plan:

1- The parts of the project must be analyzed and distributed into units or phases, provided that each phase or several phases are executed without relying on other parts or phases. For example, the units of the purification plant can be classified into units that depend on the hydraulic path, starting from the entrance of the plant and ending to the external outfall, in the sequence of these units where it can only be started after execution of the hydraulic path. As for other units such as sludge treatment units, and if they have a less important link with the hydraulic path, they can be implemented after taking the necessary precautions and knowing their real locations in a manner that does not conflict with the hydraulic path that shall be carried out. As for other units, such as support buildings, fuel tanks, power generators, and units that do not depend on the hydraulic path, it is possible to start any other work in a manner that does not conflict with the prior planning of the implementation of the works and does not lead to obstruction of other units.

2- Classification of works and their distribution to:

- Mechanical works.

-Civil works.

-Electrical Works.

-Electronic and control business.

- The contractor is required to review of the design by three main suppliers for mechanical and electrical works and discussion of the aforementioned suppliers to reach the best submission after reviewing the hydraulic and biological calculations and the treatment system to obtain the best solutions and the best equipment. According to this, the mechanical and electrical works have been credentialed by the sub-contractor.

Submit the following major plans for credential:

A-The general plan of location includes the best distribution of facilities.

B - General scheme of piping distribution.

C - Hydraulic diagram.

This is done by determining the proportions of these works, compared to the total cost of the project. The mechanical and electrical works are supplied, according to the schedule, prepared for the implementation of the project, so that they have been supplied to the location at intervals commensurate with the installation periods for each unit after testing it at the factory and in the location after installation and before it if necessary.

3- Ensure that the site is free from any obstacles, hindering the implementation of the works, and in the case that this happens, the works that can be started to be implemented and their sizes shall be determined, compared to the whole business that represents the project and work to remove these obstacles in a thoughtful manner that does not affect the current services and works.

4- Study the timetable, submitted by the contractor and ensure its logic, ability to adhere to it and its suitability for the period of the contract, agreed upon for implementation, and it is preferable that it is designed, according to the computer programs that are credentialed and common in many projects.

5- Providing the location with the equipment and the technical and professional manpower, necessary for the workflow, in accordance with the timetable, provided by the contractor, and ensuring that some workers are qualified to carry out the works and install the equipment and devices, in accordance with the recognized technical specifications, contained in the contract, concluded with the executor.

6- Making a *check* on the credentialed design and studying the plans by which it is required to implement the project, in accordance with those designs and by the way which guarantees the achievement, in accordance with the contract concluded with the contractor. Therefore, the planned content and the actions, contained in it shall be determined so that they can be studied and approved later.

7- Ensure that the location offices are equipped in a manner, consistent with the presence of technicians and labors and provide them with all necessary for use, in order to meet the needs of the workers, required to complete the work assigned to them.

8 - Study the terms of the contract and ensure the importance of their application without any difficulties.

9 - Preparing schedules to monitor the progress of work and ensure that they contain all the elements of the project, which are required examination and monitoring of their implementation without accumulation.

10- Preparing the minutes of the periodic meetings at the location and the like, which are necessary to advance work and monitor achievement.

11- Ensuring the quantities of accomplishment, in accordance with the disbursement plan and in a manner that does not conflict with the proposed financial program during the contract periods.

12- Monitoring the readiness of the equipment and the available types of labor at the location. This must be persistently, so that their shortage does not affect the workflow.

(5-2) Submitting works for authorization:

After setting implementation priorities, plant submissions are arranged and defined, according to the credentialed priorities in which the following works can be started:

1- Civil and mechanical plans.

2- Electrical diagrams.

3- Other schemes.

This can be applied to all units of the plant. Because of the importance of electrical and mechanical works, adequate care is given for the study and application of all the rules and regulations in force in all relevant authorities so that it can be ensured that this equipment is properly supplied and can be used properly. It is very important to make sure that there is a distributor or agent for all this equipment at the Kingdom so that it can be easily accessed to ensure the possibility of maintaining and repairing all equipment in the fastest time.

(5-3) Routine tests during implementation:

It is important to ensure the performance and efficiency of all the facilities and equipment of the project before starting their operation, entering them into service or receiving them in a preliminary receipt. Therefore, when needed, it is necessary to conduct some experiments that are required by the working and operating conditions, even if not provided in the contract, concluded with the executor.

Primary Receipt:

As provided in the contracts, it starts from receiving the contractor's letter that states that all work has been completed and ready to enter actual operation. After the formation of the required committees, the following actions are done:

1- Classification of works and their distribution to committees, according to the type of works and the specialization of the required committees.

2- Each committee conducts the required tests and compares them with the credentialed and internationally recognized standards and specifications.

3- Checking the identity papers of all equipment and devices.

4- Counting all observations and making sure that they do not affect the benefit from the project.

5- Making the necessary minutes after the contractor submits the necessary schedule to cover the notes.

(5-4) Operation guarantee:

This period starts from the issuance of the initial receipt to the issuance of the final receipt, and the contractor shall do the following in a manner that does not conflict with the contract, concluded with him or the operation and maintenance contractor, in charge of the following:

1- Operating the plant, according to the standards, designed on it.

2- Loading all equipment and devices, according to conditions and ensuring that they respond to the loads, are not affected and fall outside the level, required for operation.

3- Ensuring that results are obtained, according to what has been contracted with the executor.

4- Ensuring the general level of the plant's performance, as well as ensuring the efficiency of each unit and ensuring that the required results are obtained.

(5-5) Final receipt:

The minutes with the final receipt shall have been made after the success of the operation during the year of the guarantee, ensuring that the required results are obtained and making sure that the devices and equipment bear the flows and loads, agreed upon. So the following shall be done:

1- Conducting specific tests on some electrical and mechanical devices.

2- Compare the plant results with the credentialed design manuals.

3- Ensure the level of residual smells in the plant.

4- Check the noise level.

5- Ensure the level of fuel, consumed and consumption of equipment and devices.

6- Ensure that the workers are trained according to the contract and that they can be relied upon to operate the plant without any problems.

Kingdom of Saudi Arabia

Ministry of Water and Electricity

Chapter six

Timeline

Chapter 6

(Timeline)

Chapter six

Timeline

6-1Preparation of Timeline

6-1-1Business scheduling planning

With the expansion of production units and the increase in administrative burdens, the need for assistive methods of taking sound decisions has become necessary to achieve the main goal of business management, which is to raise the level of productive efficiency.

Due to the limited capabilities of the human mind, it cannot be aware of all the factors affecting the workflow and the economics of the project. This has led to the development of scientific methods or methods for preparing implementation programs, the most important of which are:

1. Program Evaluation Review Technique (P.E.R.T)
2. Critical Path Method (C.P.M)

    1. The PERT Technique is useful for evaluating and reviewing project programs in order to know the best ways to achieve the highest efficiency possible.
    2. The Critical Path Method is useful in examining the relationship between time and cost in implementing projects and programs and the potential for substitution and exchange for implementation at the least possible time.
    3. The P.E.R.T Technique helps the management to make decisions regarding the possibilities of implementation, alternatives to utilizing the available resources and capabilities for the purpose of using them adequately and effectively.
    4. The Critical Path Method is one of the modern methods of dealing with proper planning of work and accuracy of this planning in implementing projects.

    The above-mentioned methods are now scientifically one thing and these methods are being applied in three steps.

6-1-2Schedule preparation steps:

The first step

In this step, a phased network is drawn between all the steps that express the parts of the work and the sequence of process in terms of progress and delay.

The second step:

In this step, specific information is provided as needed for each process to estimate the timeline for project implementation.

The third step:

In this step, the costs are balanced against the time estimates and the trade-off is studied on the basis of time costs. Taking into account that the usefulness of any program depends on the elements of accuracy, logical sequence, and familiarity with all the influencing elements in the workflow, and that the capabilities on which the program were developed are to make full use of its energy as possible and the operating rates are representative of what can be obtained from Various production units. It shall also be taken into consideration all possible malfunctions due to technical reasons or due to weather factors, as well as official weekends, holidays, events, sick, occasional and regular leave and other influencing considerations, bearing in mind that the executive program that is being prepared now is merely filling of quotas to be submitted as part of the tender.

6-1-3 Elements of P.E.R.T Technique

PERT Technique is based on two main elements:

A. **Analysis** B. **Drawing or network**

A. **Analysis:** Based on the results of this analytical process, the main points in the program are as follows:

1. The beginning of the program and the end of its intermediate phases, which are the fixed elements of the program.
2. The processes or activities to be achieved and implemented, which are the dynamic elements of the program, i.e. the evolving elements that consume money, time and effort.

B. Drawing or network:

1. The drawing or network is the main pillar of PERT Technique, as it solves a logical series of process that must be fully implemented to reach a specific and clear goal, that is, it is a diagram of how works are connected in this drawing or network.
2. The drawing represents the sequence of process and phases, so the related items are different such as priorities, deadlines, and associations, and the following rules can be considered key in drawing a network in the correct way:
   - Each arrow represents only one process.
   - Each phase has a special number or code.
   - It is not possible to return back to phase that has been implemented.
   - It is not possible to start any of the processes before the completion of the process or the previous processes leading to.
   - There is a complete correlation between the processes from a given phase and those that have ended. The single-phase processes may start at different times and the time allotted to the execution of the launch phase represents the time limit that its direct launches can carry out the process immediately following them.
   - Phases and processes constitute a time series, during which the work progresses on a regular basis from one phase to another process to the next to the next process, etc.

It shall be noted here that the phase explains the full relationship that exists between incoming and outgoing process, which may take time in turn, but this time does not necessarily mean time or work such as the drying time of cement. The relationships between the processes and the phases can be of two types:

A. Serial relationships among the reasons for their origin are the inevitable dependency, the scarcity of means and capabilities, etc.
B. Parallel relationships, which means ability to implement.

- Other cases are also presented for another type of process, which we call compound process, which means that we can start implementing several processes after we have achieved a certain percentage in the implementation of a process, for example. It is also possible that two or more processes start and end at the same phases in a project, and then the final process is considered linked to the implementation of the other processes. For more clarifications and the rest of showing the logical limitations related to the connection of process with each other, we usually resort to finding fake phases and processes that do not take much time or effort.

3- Network position: The position of the network requires in the first place the determination of the target or what we call it (phase - target).

Establishing such a matrix requires taking the table of processes as a basis and examining the horizontal line contained in the matrix. For example, if we take phase (b), we find that process (3) starts from it and reaches its final phase (c). Thus, we record (3) in column (c) containing phase (b) horizontally. If the project includes a large number of processes, it becomes necessary to develop a diagram of the project or an affiliation tree for it. The network also requires defining responsibilities and tasks in a detailed and documentary way.

4- An example of applying PERT technique to a construction project:

Let us now take an example from the field of buildings and consider that the goal or phase is the goal, which is to establish equipment in a building. The phases that are included in the entire project are:

A. Starting of studies.
B. Studies Completion.
C. Direct construction.
D. Equipment request.
E. Construction Completion
F. Receipt of equipment.

Note: These phases are not written in their actual order, in order to clarify the error and treat it afterwards.

1. Project study.
2. Prepare the direct construction process.
3. Prepare the equipment request transaction.
4. Construction implementation.

5. Executing and bringing the equipment and supplies.
6. Install equipment or supplies and finish construction.

Phases	Subsequent processes
A	1
B	2,3
C	4
D	5

As for the two phases (E), (F) we have encountered a difficulty, which is that each of these two phases has a subsequent process, which is the installation of equipment or supplies, but this process cannot be started before reaching the two mentioned phases and this requires completing the analysis process by creating a new phase called The name (G) means starting with setting up the equipment, and this means that there is a constraint between the two phases (E), (F), which is called a fake operation or a conditional link.

Completing this analysis allows us to complete the table of inter-phase relationships and processes as follows:

Phases	Subsequent processes
E	Fake processes E & N
F	Fake processes F & G
G	6
H	Non

The next step is to examine the processes in the coordination of the reached phase for each process, and this appears in the following table:

Previous operations	Phases
1	B
2	C
3	D
4	E
1-5	F
Fake processes E & G	G
Fake processes F & G	G
6	H

Completing all the aforementioned tables allow us to set the following matrix:

	A	B	C	D	E	F	G	H
A	_	1	_	_	_	_	_	_
B	_	_	2	3	_	_	_	_
C	_	_	_	_	4	_	_	_
D	_	_	_	_	_	5	_	_
E	_	_	_	_	_	_	Fake processes E & G	_
F	_	_	_	_	_	_	Fake processes F	_

							& G	
G	_	_	_	_	_	_		6
H	_	_	_	_	_	_	_	_

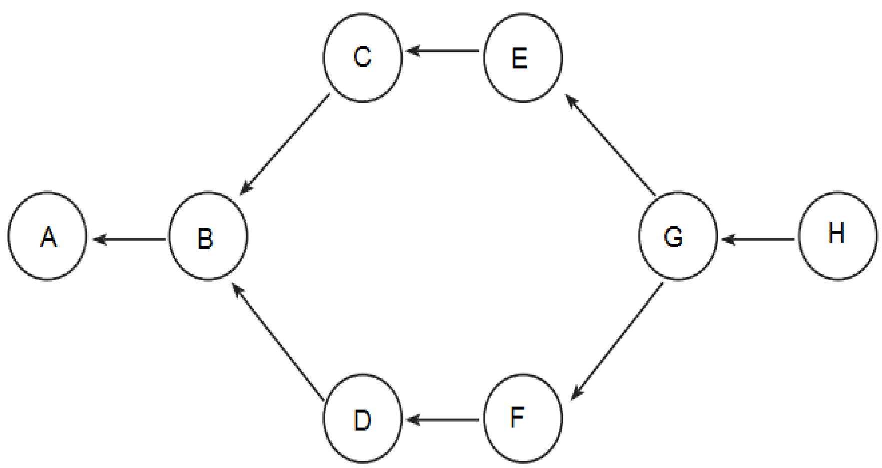
Network drawing method:

This can be achieved by classifying the phases into groups of generators:

1- First generator: The phases reached after only one operation is performed from the start of the program. The following is a table of generators for the above-mentioned network as an example:

The beginning	First generator	Second	Third	Fourth	Fifth
A	B	C	E	G	H
		D	F		

Thus, the next grid is explained to the previous table:



When drawing this or any other grid, the following issues **shall be taken into consideration:**

1. All phases and processes must appear in the grid without exception.
2. The signs, numbers, and symbols of the processes and the phases shall be clearly displayed.

6-1-4 Practical results of the PERT technique:

1. Helping to fully understand the problem, to identify places of ambiguity and to distribute responsibilities.
2. Helping to clarify and define responsibilities at the administrative level.
3. Providing a clear and accurate idea of the activity for each person responsible for this activity.
4. Helping in making decisions and knowing the reason for starting some operations and activities.
5. Explaining the difficulties in reaching some goals in a quick and clear manner.
6. Clarify the implementation limits for a project.
7. Helping to avoid unhelpful actions.
8. Providing a complete communication tool between the groups of organs responsible for implementing the project.
9. Including all the time details for each real operation in the project.
10. Be close to reality as possible.
11. It is expressed in one time unit in all project work (such as day, week, month, or year).

6-5-1 Elements that must be met for the success of preparing the implementation program:

First: quantify and describe items of work, operation method, maintenance account, raw materials, tasks and equipment.

Second: general location of the project.

Third: Taking into account the minimum time required for a given action.

Fourth: Taking into account the equipment and workers that shall be present in the operating space.

Fifthly: Taking into account the nature and division of sections for operating rates.

Sixth: The work continues and the start of a business or parts thereof is suspended on the completion of other works or parts thereof.

Seventh: Other elements that may not come to mind.

Eighth: costs and their relationship to working conditions, position and time.

(6-2) Phases and requirements for the Study of Treatment plants (Barchart System)

First: the phase of collecting and analyzing information and plans:

1. Compilation of plans (organizational, topographic, regional connection, horizontal projection of the sewage network - general information chart (drinking water - electricity).
2. Information about the facilities (sewage, drinking water, other facilities).
3. Information on facilities, industrial businesses and residents.
4. Climate (rain, winds, heat, humidity, evaporation).
5. Zone hydrology.

Second: Field survey

1. Field survey (topographic position - terrain and general tendencies - locations and levels of reference levels.
2. Possible locations for a treatment plant (at least two).
3. Organizational situation (urbanization and expansion - irregularities - regional connectivity and its problems - the state of public utilities. Sewer drainage problems).
4. Landfill site, specifications and effects.
5. Outfall sites for neighboring communities.
6. Hydrological situation (the effect of floods, torrents and groundwater on the site of the plant).

Third: Topographic works:

1. Connect the coordinates with the reference points (B.M).
2. Scan plant site and link it with the network contour lines.
3. Scan industrial sites and business routes.

Fourth: Water analyses:

1. Raw sewage analyses: conditions for taking samples (age - time - temperature - exposure to air - other water contents - passage to private facilities).
2. The main analyses: (bio-oxygen demand - dissolved oxygen - suspended substances - acidity and alkalinity).

3. Special analyses: (ammonium nitrate - nitrates and nitrites - chlorides - hydrogen sulfur - toxic substances).
4. Water measurements and determination of irregular factor.

Fifth: After-treatment water uses:

1. Determine the degree of treatment required.
2. Determine the specifications of the water required after treatment.
3. Descriptive note.
4. Pre-study plans.

(6-3) Preliminary Studies:

First: General studies:

1. Population study.
2. Climatic study.
3. Hydrological study.
4. Geological study of the site (number and levels of boards).
5. Specifications of samples and their physical, mechanical and chemical properties.
6. Site study, technical and economic comparisons, and final site determination.

Second: Technology Studies:

This item studies the following:

1. Screens types.
2. Flow and drain meters.
3. Water entrance.
4. Oxidation ponds.
5. Liquidators.
6. Sterilization and filtration.
7. Sludge disposal.
8. Disposal of liquid materials.

All these studies are based on technical, health and economic comparisons to determine the preferred methods.

(6-4) Detailed studies:

First: Design and Calculations:

1. Hydraulic - mechanical - electrical - structural, etc.
2. The arithmetic note.
3. Shop drawing.
4. Operations and maintenance staff studies.
5. Laboratory studies and periodic analyses.
6. Industrial safety requirements.

Second: Preparing the executive file (s):

1. Descriptive and arithmetic notes.
2. Plans of preliminary studies.
3. Shop drawing.
4. Technical condition books (mechanical, electricity, structural, architectural, health, etc).
5. The implementation plan and phases, the program and instructions for operating the human staff, and the program and instructions for operating and investing the plant.
6. Tables of quantities and price analysis.
7. Contract and inclusions.

Third: the works required by the contractor:

1. Study the structural, architectural, mechanical, electrical, sanitary and other plans and ensure that there is no conflict among them.
2. Time schedule.
3. Conducting the topographic lifting and creating a coordinate grid for the sites of the buildings.
4. Checking hydraulic plans and ensuring correct levels of entry and exit of water from water installations.

5. Submission of shop drawing for drilling works according to the approved levels of hydraulic plans.
6. Start drilling according to the sequence of work in the time program.
7. Providing implementation plans for mechanical and electrical work of equipment.
8. Providing implementation plans for regular concrete and reinforced concrete works.
9. Providing wooden formwork and concrete mix design.
10. Starting regular and reinforced concrete works for water installations and other ancillary facilities according to the sequence of works in the schedule.
11. Water leakage and filtration testing works for water installations.
12. Concrete insulation works.
13. Mechanical and electrical works (equipment installation, automation and control system).
14. General site works (leveling (excavation + backfilling) + basement installation + general site lighting works).
15. Installation of interconnecting pipes between water facilities.
16. Works of rain water drainage network.
17. Irrigation and fire extinguishing system.
18. Road works and paving them after completing all buried works.
19. Afforestation and cultivation of green spaces.
20. Preliminary delivery of the project.
21. Operation and maintenance works carried out by the contractor for a period of at least one year.

Note: The feasibility of the performance of the work phases is due to the way in which individual contractor's equipment, labor and material capabilities are employed.


Chlorine Contact Chamber
Pump Station
Secondary Clarifiers
Primary Settling Basins
Fermenter
DAF Thickener
Grit & Screen Facility
Control Room
Utility Building
Heating Building
Digesters
Bioreactor

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية

Kingdom of Saudi Arabia

Ministry of Water and Electricity

Chapter seven

Annexes

Chapter Seven Content (Annexes)

Chapter Seven

Annexes

Annex No. 1

1- **An example to illustrate how to determine the amount of oxygen demand required in the aeration tank.**

BOD to be oxidized = 72500 kg/day

Nitrogen to be nitrified = 13250 kg/day

Nitrogen to be denitrified = 13250 kg/d

Oxygen uptake rate for BOD5 (OUc)= 0.56 + ((0.15 *fT * SRT)/(1+ 0.17 *fT *SRT))

fT = 1.072^T-15 >

fT = 1.072^32-15 = 3.26

OUc (T=32C) = 0.56 + ((0.15*3.26 * 10)/(1+ 0.17 * 3.26 *10)) =1.31 kgO2/kg BOD

Oxygen for BOD removal = 72500 * 1.31 = 94975 kg O2/d

Oxygen for nitrification = 13250*4.75 = 60553 kg O2/d

Oxygen recovered from Denitrification = 13250*2.86 = 37895 kg/d

As there is no measurement available for oxygen uptake rate for carbon and nitrogen removal , peak factors should be applied (fe =1.2 ,fN= 1.8)

Total oxygen requirement (AOR)= (94975* 1.2) + (60554*1.8) - (37895) = 185072 kgO2/day

Annex No. 2

(Design Manual References)

1- Metcalf & Eddy Inc (1990). Wastewater Engineering, Treatment, disposal and re-use, Third edition, U.S.A.

2- Water Environmental Federation (1990), Operation of Municipal Wastewater Treatment Plants, Manual of Practice No 11, Second edition, U.S.A.

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4- German Association for Water Environment (2001), Dimensioning of Single -Phase Activated Sludge Plants, German ATV-DVWK Standards, Germany.

5- Metcalf &Eddy Inc (2003), Wastewater Engineering, Treatment and re- use, Fourth edition, U.S.A.

6- AL-Qadi M.M.AL-Khider (2003), Design of Stabilization Ponds In Arid Regions of Saudi Arabia, PhD Dissertation, Alexandria University, Alexandria, Egypt.

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Inc., 2nd Ed., 1999, 1-56676-688-5

Annex No. (3) Timetable for the period of studies and designs for a wastewater treatment plant

Items		First Month				Second Month				Third Month				Fourth Moth				F i
		Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1
First: Phase of collect and analyze information and plants																		
1	Compilation of plans (organizational - topographic - regional connection - sewage network horizontal plan - general information chart (drinking water - electricity).	■	■	■														
2	Information about the facilities (sewage - drinking water - other utilities)		■															
3	Information on industrial establishments, businesses and residents			■														
4	Climate (rain - winds - heat - humidity - evaporation).			■														
5	Zone hydrology.				■													
Second: field survey																		
1	Field survey (topographic position - terrain and general tendencies - locations and levels of reference levels.	■																
2	Possible locations for a treatment plant (at least two).	■																
3	Organizational situation (urbanization and expansion - irregularities - regional connectivity and its problems - the state of public utilities. Sewer	■																
4	Landfill site, specifications and effects.		■															
5	Outfall sites for neighboring communities.		■															
6	Hydrological situation (the effect of floods, torrents and groundwater on the		■															
Third: Topographic works:																		
1	Connect the coordinates with the reference points (B.M).			■														
2	Scan station site and link it with the network contour lines.				■	■												
3	Scan industrial sites and business routes.						■											
Fourth: Water analyses:																		
1	Raw sewage analyzes: conditions for taking samples (age - time - temperature							■										
2	The main analyzes: (bio-oxygen demand - dissolved oxygen - suspended							■										
3	Special analyzes: (ammonium nitrate - nitrates and nitrites - chlorides -								■									
4	Water measurements and determination of irregular factor.								■									
Fifth: After-treatment water uses:																		
1	Determine the degree of treatment required.									■								
2	Determine the specifications of the water required after treatment.									■								
3	Descriptive note.										■							
4	Pre-study plans.										■							

																											Week 2		
																											Week 3		
																											Week 4		
																											Week 1	Sixth Month	
																											Week 2		
																											Week 3		
																											Week 4		
																											Week 1	Seventh Month	
																											Week 2		
																											Week 3		
																											Week 4		
																											Week 1	Eighth Month	
																											Week 2		
																											Week 3		
																											Week 4		
																											Week 1	Ninth Month	
																											Week 2		
																											Week 3		
																											Week 4		

Continued Annex No. (3) Timetable for the period of studies and designs for a wastewater treatment plant

Preliminary Studies:

	Items	First Month				Second				Third Month				Fourth Moth				F
		Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1
	First: General studies:																	
1	Population study.																	
2	Climatic study																	
3	Hydrological study																	
4	Geological study of the site (number and levels of boards).																	
5	Specifications of samples and their physical, mechanical and chemical properties.																	
6	Site study, technical and economic comparisons, and final site determination.																	
	Second: Technology Studies:																	
	This item studies the following:																	
1	Screens types.																	
2	Flow and drain meters.																	
3	Water entrance.																	
4	Oxidation ponds.																	
5	Liquidators.																	
6	Sterilization and filtration.																	
7	Sludge disposal.																	
8	Disposal of liquid materials.																	
	All these studies are based on technical, health and economic comparisons to determine the preferred methods.																	
	Detailed studies:																	
	First: Design and Calculations:																	
1	Hydraulic - mechanical - electrical - structural etc.																	
2	The arithmetic note																	
3	Shop drawing.																	
4	Operations and maintenance staff studies.																	
5	Laboratory studies and periodic analyzes.																	
6	Industrial safety requirements																	
	Second: Preparing the executive file (s):																	
1	Descriptive and arithmetic notes.																	
2	Plans of preliminary studies.																	
3	Shop drawing.																	
4	Technical condition books (mechanical, electricity, structural, architectural, health, etc).																	
5	The implementation plan and stages, the program and instructions for operating the human staff, and																	
6	Tables of quantities and price analysis.																	
7	Contract and inclusions.																	

																																		Week 2			
																																		Week 3			
																																		Week 4			
																																		Week 1	Sixth Month		
																																		Week 2			
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																																		Week 3			
																																		Week 4			
																																		Week 1	Ninth Month		
																																		Week 2			
																																		Week 3			
																																		Week 4			

Appendix No. (4) Schedule for the execution of works by the contractor

Contractor Required Work

First Year

	Items	Month No (1)	Month No (2)	Month No (3)	Month No (4)	Month No (5)	Month No (6)	Month No (7)	Month No (8)	Month No (9)	Month No (10)	Month No (11)	Month No (12)
1	Study the structural, architectural, mechanical, electrical, sanitary and other plans and ensure that there is no conflict among them.	■	■										
2	Time schedule.			■									
3	Conducting the topographic lifting and creating a coordinate grid for the sites of the buildings.	■											
4	Checking hydraulic plans and ensuring correct levels of entry and exit of water from water installations.	■											
5	Submission of shop drawing for drilling works according to the approved levels of hydraulic plans.			■									
6	Start drilling according to the sequence of work in the time program.				■	■	■	■					
7	Providing implementation plans for mechanical and electrical work of equipment.		■	■	■								
8	Providing implementation plans for regular concrete and reinforced concrete works.		■	■	■	■	■	■					
9	Providing wooden formwork and concrete mix design.			■	■								
10	Starting regular and reinforced concrete works for water installations and other ancillary facilities according to the sequence of works in the schedule.				■	■	■	■	■	■	■	■	■
11	Water leakage and filtration testing works for water installations.							■	■	■	■	■	■
12	Concrete insulation works.								■	■	■	■	■
13	Mechanical and electrical works (equipment installation, automation and control system).									■	■	■	■
14	General site works (leveling (excavation + backfilling) + basement installation + general site lighting works).												
15	Installation of interconnecting pipes between water facilities.						■	■	■	■	■	■	■
16	Works of rain water drainage network.												
17	Irrigation and fire extinguishing system.												
18	Road works and paving them after completing all buried works.												
19	Afforestation and cultivation of green spaces.												
20	Preliminary delivery of the project.												
21	Operation and maintenance works carried out by the contractor for a period of at least one year.												

Second Year

	Items	Month No (13)	Month No (14)	Month No (15)	Month No (16)	Month No (17)	Month No (18)	Month No (19)	Month No (20)	Month No (21)	Month No (22)	Month No (23)	Month No (24)
1	Study the structural, architectural, mechanical, electrical, sanitary and other plans and ensure that there is no conflict among them.												
2	Time schedule.												
3	Conducting the topographic lifting and creating a coordinate grid for the sites of the buildings.												
4	Checking hydraulic plans and ensuring correct levels of entry and exit of water from water installations.												
5	Submission of shop drawing for drilling works according to the approved levels of hydraulic plans.												
6	Start drilling according to the sequence of work in the time program.												
7	Providing implementation plans for mechanical and electrical work of equipment.												
8	Providing implementation plans for regular concrete and reinforced concrete works.												
9	Providing wooden formwork and concrete mix design.												
10	Starting regular and reinforced concrete works for water installations and other ancillary facilities according to the sequence of works in the schedule.	■	■	■	■	■	■	■	■	■	■	■	■
11	Water leakage and filtration testing works for water installations.	■	■	■	■	■	■	■	■	■	■	■	■
12	Concrete insulation works.	■	■	■	■	■	■	■	■	■	■	■	■
13	Mechanical and electrical works (equipment installation, automation and control system).	■	■	■	■	■	■	■	■	■	■	■	■
14	General site works (leveling (excavation + backfilling) + basement installation + general site lighting works).												
15	Installation of interconnecting pipes between water facilities.	■	■	■	■	■	■	■	■	■	■	■	■
16	Works of rain water drainage network.												
17	Irrigation and fire extinguishing system.												
18	Road works and paving them after completing all buried works.												
19	Afforestation and cultivation of green spaces.												
20	Preliminary delivery of the project.												
21	Operation and maintenance works carried out by the contractor for a period of at least one year.												

Third Year

	Items	Month No (25)	Month No (26)	Month No (27)	Month No (28)	Month No (29)	Month No (30)	Month No (31)	Month No (32)	Month No (33)	Month No (34)	Month No (35)
1	Study the structural, architectural, mechanical, electrical, sanitary and other plans and ensure that there is no conflict among them.											
2	Time schedule.											
3	Conducting the topographic lifting and creating a coordinate grid for the sites of the buildings.											
4	Checking hydraulic plans and ensuring correct levels of entry and exit of water from water installations.											
5	Submission of shop drawing for drilling works according to the approved levels of hydraulic plans.											
6	Start drilling according to the sequence of work in the time program.											
7	Providing implementation plans for mechanical and electrical work of equipment.											
8	Providing implementation plans for regular concrete and reinforced concrete works.											
9	Providing wooden formwork and concrete mix design.											
10	Starting regular and reinforced concrete works for water installations and other ancillary facilities according to the sequence of works in the schedule.	■	■	■	■	■	■	■	■	■		
11	Water leakage and filtration testing works for water installations.	■	■	■	■	■	■	■	■	■	■	
12	Concrete insulation works.	■	■	■	■	■	■	■	■	■	■	■
13	Mechanical and electrical works (equipment installation, automation and control system).	■	■	■	■	■	■	■	■	■	■	■
14	General site works (leveling (excavation + backfilling) + basement installation + general site lighting works).	■	■	■	■	■	■	■	■	■	■	■
15	Installation of interconnecting pipes between water facilities.	■	■	■	■	■	■	■	■	■		
16	Works of rain water drainage network.	■	■	■								
17	Irrigation and fire extinguishing system.				■	■						
18	Road works and paving them after completing all buried works.											■
19	Afforestation and cultivation of green spaces.											■
20	Preliminary delivery of the project.											
21	Operation and maintenance works carried out by the contractor for a period of at least one year.											

Note: The feasibility of the performance of the work phases is due to the way in which individual contractor's equipment, labor and material capabilities are employed.

																							Month No (36)		
																							Month No (37)	Fourth year	
																							Month No (38)		
																							Month No (39)		
																							Month No (40)		
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