



CONCEPT DESIGN REPORT

BUSHAR

IRRIGATION WATER STORAGE TANK AND

PUMPING STATION



Contents

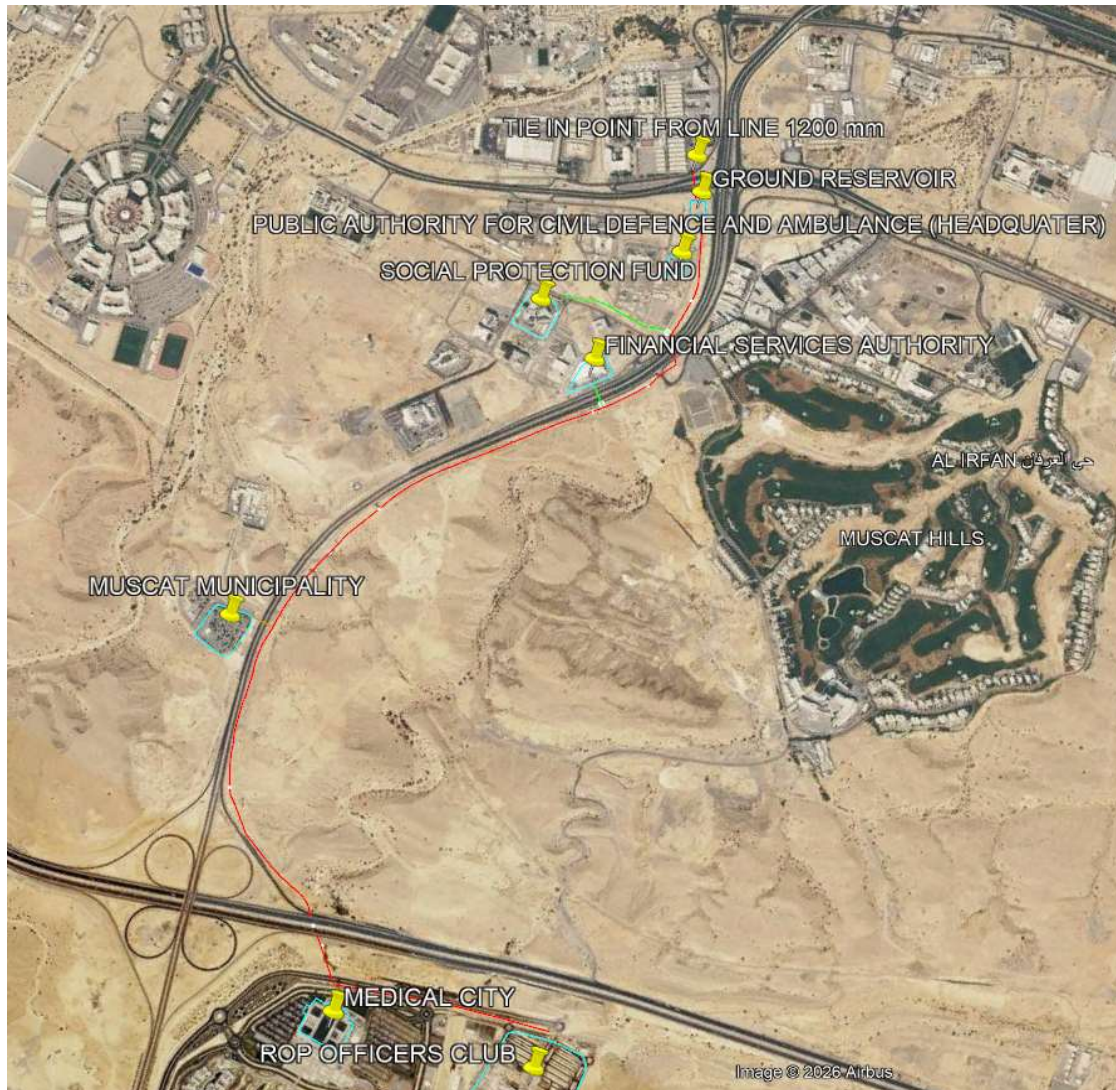
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1. Introduction

The project comprises the design of a Treated Effluent (TE) transmission line from the existing TE network in Bousher Wilayat. A tie-in connection will be provided to the existing TE line to convey the treated effluent to a proposed ground-level irrigation storage tank equipped with the required pumping system.

From the proposed storage tank and pumping station, the TE network will be designed to convey treated effluent to several designated irrigation points associated with the Municipality, as well as to Medical City and the ROP offices, in accordance with the required flow and pressure demands.



2. Scope of Work:

1. **TE Pipeline Design** – Design of the Treated Effluent (TE) pipeline.
2. **Tie-in Point Details** – Preparation of detailed drawings and details for the TE tie-in points.
3. **TE Tank Design** – Design and detailing of the Treated Effluent (TE) tank.

3. Purpose

This report establishes the design concept and engineering basis for a Treated Effluent water storage tank and associated pumping station. The system shall receive Treated Effluent water from the upstream [network](#), provide the required operational storage, and supply the downstream distribution system at the required flow and pressure.

- Treated Effluent water storage tank.
- Duty/standby pumping station.
- Tank level monitoring and control.
- Tank inlet and outlet flowmeters.
- Roof inspection/access openings.
- Protected tank ventilation.
- Tank overflow and drainage systems.
- Standby diesel generator.
- Hydraulic pressure-loss calculations using Darcy–Weisbach and Hazen–Williams methods.
- Pump Total Dynamic Head and NPSH assessment.
- Instrumentation, PLC and SCADA interface.

4. Design Philosophy

The Treated Effluent water tank shall operate as a balancing reservoir between the incoming potable-water supply and the downstream pumping system.

General hydraulic arrangement:

Incoming Network → Inlet Flowmeter → Treated Effluent Water Tank → Pump Suction → Pumps → Outlet Flowmeter → Distribution [Network](#)

The tank shall provide sufficient effective storage while maintaining adequate water depth above the pump suction to prevent vortex formation and cavitation. The pumping station shall normally operate automatically with duty and standby pumps selected according to the required flow and reliability criteria.

5. Design Criteria

Parameter	Symbol	Value	Unit
Required tank effective volume	V	2000	m ³
Maximum inlet flow	Q _{in,max}	125	m ³ /h
Average inlet flow	Q _{in,avg}	-----	m ³ /h
Maximum outlet flow	Q _{out,max}	125	m ³ /h
Unit pump design flow	Q _p	125	m ³ /h
Static pumping head	H _s	-----	m
Pipe length	L	-----	m
Pipe internal diameter	D	200	mm
Pipe roughness	ε	0.04	mm
Hazen-Williams coefficient	C	140	—
Water temperature	T	25	°C
Duty pumps	N	1	#
Standby pumps	N _s	1	#

6. Tank Water Levels

Level	Designation	Value	Main Function
High-High	HH	7.35	Emergency high-level alarm/protection
High	H	7.25	First high level of alarm
Maximum water level	Max	7.15	Normal maximum operating level
Minimum water level	Min	00.65	Normal minimum operating level
Low	L	00.55	First low level of alarm
Low-Low	LL	00.45	Pump protection/emergency alarm

Conceptual order: Roof → Overflow → HH → H → effective storage → L → LL → minimum pump submergence → drain.

HH Level

The High-High (HH) level shall provide an emergency indication of an abnormal increase in tank level. Upon reaching HH, a high-priority alarm shall be generated, transmitted to SCADA and indicated locally. The upstream filling system shall be stopped or controlled where applicable. HH shall not normally be reached during normal operation.

H Level

The High (H) level shall provide an emergency indication of an abnormal increase in tank level. Upon reaching H, a high-priority alarm shall be generated, transmitted to SCADA and indicated locally. The upstream filling system shall be stopped or controlled where applicable. H shall not normally be reached during normal operation.

Max. Level

The Max. level shall represent the normal maximum operating level. At Max, the filling sequence shall stop, reduce, or otherwise control the incoming flow as applicable. The tank shall remain below the overflow level during normal operation.

Min. Level

The Min. level shall represent the normal minimum operating level. At Min., a low-level indication/alarm may be generated and replenishment shall be initiated according to the filling philosophy. Pumps may continue operating provided sufficient submergence is available.

L Level

The Low (LL) level shall protect the pumping equipment. At L, the affected pumps shall automatically stop, a low alarm shall be generated and pump restart shall be inhibited until the safe level is restored. The L elevation shall be established based on minimum pump submergence and suction conditions.

LL Level

The Low-Low (LL) level shall protect the pumping equipment. At LL, the affected pumps shall automatically stop, a low-low alarm shall be generated and pump restart shall be inhibited until the safe level is restored. The LL elevation shall be established based on minimum pump submergence and suction conditions.

7. Tank Inlet and Inlet Flowmeter

The inlet pipe shall be sized for the maximum design filling rate. The inlet arrangement shall minimize turbulence, air entrainment, pressure loss and hydraulic short-circuiting.

A dedicated flowmeter shall be installed on the incoming potable-water pipe upstream of the tank. An electromagnetic flowmeter is recommended for potable-water service, subject to project specifications. It shall provide instantaneous flow, totalized volume and a PLC/SCADA signal. The flowmeter shall be installed in an underground concrete chamber, the flowmeter will be equipped with a bypass for maintenance purposes.

8. Tank Outlet and Outlet Flowmeter

The tank outlet shall provide the required flow to the pumping station while maintaining adequate minimum water depth. The arrangement shall minimize vortex formation, air entrainment and cavitation.

A flowmeter shall be installed on the common pump discharge/outlet header to measure total station discharge, instantaneous flow and totalized volume. The flowmeter shall be installed in an underground concrete chamber, the flowmeter will be equipped with a bypass for maintenance purposes.

9. Tank Overflow

A dedicated overflow shall protect the tank against overfilling. It shall be sized for the maximum credible incoming flow and shall discharge safely to an approved drainage/disposal location without pressurizing the tank.

- Overflow shall not be used as the normal level-control mechanism.
- The overflow shall prevent backflow into the tank.
- The termination shall be protected against insects, birds and contaminants.
- Where practicable, the discharge shall be visible to facilitate detection of abnormal overflow.

The conceptual relationship is: $HH = \text{Overflow Level} < \text{Roof}$, with adequate safety margins and freeboard.

10. Tank Drainage

A dedicated drain shall be provided at the lowest practical point of the tank. The tank floor shall be sloped toward a drainage sump or drain outlet. The drain shall permit complete tank emptying for inspection, cleaning, disinfection and maintenance.

- Drain isolation valve.
- Accessible valve location.
- Approved discharge arrangement.
- Backflow/cross-connection protection where connected to another drainage system.

11. Tank Roof Inspection Openings

The roof shall include adequate access and inspection openings. At least one main access manhole shall normally be provided, with additional openings as required by tank size and internal arrangement.

- Watertight and lockable covers.
- Protection against unauthorized access and rainwater ingress.
- Access for inspection of walls, floor, inlet, outlet, level instruments and internal fittings.

12. Tank Ventilation

The tank shall be adequately ventilated to accommodate air displacement during filling and emptying and to prevent excessive positive or negative pressure.

Vent capacity shall be based on the maximum tank filling and emptying rates. Vent openings shall be roof mounted and protected against rain, insects, birds and rodents. Hygienic filtration or equivalent protection shall be provided where required by the applicable potable-water requirements.

Ventilation size shall be calculated based on maximum flow in or out and an air velocity between 0.3 to 1.0 m/s is considered.

13. Pumping Station

The pumping station shall be designed to meet the required downstream flow and pressure. A typical reliability philosophy is N duty + 1 standby, a 2 duty + 1 standby is considered.

- Suction isolation valve.
- Discharge isolation valve.
- Discharge check valve.
- Pressure measurement.
- VFD where required.
- Local control and status indication.
- Automatic duty-pump rotation to equalize running hours.

14. Hydraulic Design and Total Dynamic Head

The pump shall be selected based on the required Total Dynamic Head (TDH):

$$TDH = H_{Static} + H_{Friction} + H_{Minor} + H_{Required}$$

Where H_{Static} is the static elevation difference, $H_{Friction}$ is straight-pipe friction loss, H_{Minor} is local fitting/valve loss, and $H_{Required}$ is the residual pressure/head required at the destination.

15. Darcy– Weisbach Pressure Loss

The Darcy–Weisbach equation shall be used to determine pipe friction loss:

$$h_f = f (L/D) (V^2/2g)$$

where

h_f = friction head loss (m),

f = Darcy friction factor,

L = pipe length (m),

D = internal diameter (m),

V = mean velocity (m/s), and

$g = 9.81 \text{ m/s}^2$.

Velocity is calculated from:

$V = Q/A$, with $A = \pi D^2/4$;

therefore $V = 4Q/(\pi D^2)$,

where Q is in m^3/s .

16. Darcy Friction Factor

For turbulent flow, the friction factor may be determined from the Colebrook–White equation:

$$\frac{1}{\sqrt{f}} = -2 \log_{10} \left[\frac{\varepsilon}{3.7D} + \frac{2.51}{Re\sqrt{f}} \right]$$

where

$Re = \frac{VD}{\nu}$ or $\frac{\rho VD}{\mu}$. For preliminary calculations, an accepted approximation such as Haaland or Swamee–Jain may be used.

17.Minor Losses

Local losses shall be calculated using:

$$h_m = \sum K \left(\frac{V^2}{2g} \right)$$

The calculation shall include entrance and exit losses, elbows, tees, reducers, expanders, isolation valves, check valves, flowmeters, strainers where applicable, and other fittings.

18. Hazen–Williams Calculation

For water pipelines, Hazen–Williams may be used for preliminary design and independent verification:

$$h_f = 10.67 \left(\frac{L}{D^{4.87}} \right) \left(\frac{Q}{C} \right)^{1.852}$$

where

hf is in metres,

L is pipe length in metres,

Q is in m³/s,

D is internal diameter in metres, and

C is the Hazen–William's coefficient.

For new water pipes, a preliminary C value in the approximate range of 130–150 may be considered depending on material, age and project specification. The final adopted value shall be stated in the hydraulic calculation.

19.Darcy–Weisbach versus Hazen–Williams

Item	Darcy–Weisbach	Hazen–Williams
Basis	Fundamental fluid mechanics	Empirical
Fluid applicability	Broad	Primarily water
Pipe roughness	Explicit ϵ	C coefficient
Detailed design	Preferred	Common water-pipe method
Verification	Suitable	Suitable

One method should be designated as the governing calculation method for final design, with the other used as an independent verification where appropriate.

20. NPSH Assessment

NPSH analysis shall verify that the selected pumps operate without unacceptable cavitation. The fundamental requirement is:

$$NPSHA > NPSHR$$

NPSHA is the Net Positive Suction Head Available and NPSHR is the Net Positive Suction Head Required by the pump manufacturer.

21.NPSH Available

For a pump taking suction from an open atmospheric tank:

$$NPSH_A = \frac{P_{atm}}{\rho g} + H_{static,suction} - h_{f,suction} - \frac{P_v}{\rho g}$$

Or, in head terms:

$$NPSH_A = H_{water\ level} + H_{atm} - H_{vapor} - H_{loss,suction}$$

The calculation shall be performed at the minimum operating tank level, normally near LL, and at maximum design flow.

22.Critical NPSH Case

The worst-case NPSH condition normally occurs when the tank is at LL, the pump operates at maximum design flow, water temperature is at the maximum expected value, suction losses are maximum, and atmospheric pressure is at its minimum design value where relevant.

The pump selection shall satisfy $NPSH_A \geq NPSH_R + \text{design margin}$, with the final margin based on the pump manufacturer's recommendation and applicable standards.

23. Standby Diesel Generator

A standby diesel generator shall maintain essential pumping operation during loss of normal electrical power. It shall be sized from a detailed electrical load schedule and shall supply the required duty pump(s), controls, PLC, instrumentation, flowmeters, essential lighting and other identified essential loads.

Generator sizing shall consider running load, motor starting load, pump starting sequence, VFD characteristics, transient performance, future loads and spare capacity.

24. Generator Auxiliary Systems

- Diesel fuel tank.
- Fuel level indication and low-fuel alarm.
- Starting batteries and charger.
- Exhaust system.
- Cooling system.
- Engine ventilation.
- Emergency stop.
- Local generator control panel.
- Run/fault status signals.

Fuel capacity shall provide the required emergency autonomy in accordance with project requirements.

25.Instrumentation and Control

Equipment	Instrumentation
Tank	Continuous level transmitter
Tank	HH level alarm
Tank	H level indication/control
Tank	L level indication/control

Tank	LL level alarm
Tank inlet	Flowmeter
Pump suction	Pressure gauge/transmitter
Pump discharge	Pressure gauge/transmitter
Tank outlet/discharge header	Flowmeter
Pumps	Run/fault/status
Generator	Run/fault/status and fuel level

For critical protection, independent HH and LL level switches may be provided in addition to the continuous level transmitter.

26. Control Philosophy

- Normal: tank level is monitored continuously; pumps operate according to downstream demand; inlet and outlet flows are monitored; duty pumps rotate automatically.
- At Max: filling control stops, reduces or otherwise controls incoming flow according to the approved filling philosophy.
- At H: high-priority alarm and emergency filling protection are initiated.
- At HH: high-priority alarm and emergency filling protection are initiated.
- At Min: level indication is generated and replenishment is initiated as applicable.
- At L: pumps stop, low alarm is generated and pump restart is inhibited until a safe level is restored.
- At LL: pumps stop, low-low alarm is generated and pump restart is inhibited until a safe level is restored

27. Hydraulic Calculation Summary

The detailed hydraulic calculation shall establish:

$$V = 4Q/\pi D^2$$

$$Re = \frac{VD}{\nu}$$

$$h_{f,Darcy} = f \cdot \left(\frac{L}{D}\right) \cdot \left(\frac{V^2}{2g}\right)$$

$$h_{f,HW} = 10.67 \left(\frac{L}{D^{4.87}}\right) \left(\frac{Q}{C}\right)^{1.852}$$

$$h_{minor} = \sum K \left(\frac{V^2}{2g}\right)$$

$$TDH = H_{static} + h_f + h_{minor} + H_{required}$$

The pump shall be selected at the design flow and TDH, with the operating point preferably within the manufacturer's recommended operating range.

28. Hydraulic Profile

A hydraulic profile shall be prepared from the incoming water network through the tank and pumping station to the distribution network. It shall identify ground elevations, tank floor, HH, H, L, LL, overflow, pump centerline, discharge elevation, required terminal pressure, hydraulic grade line and pressure losses.

The hydraulic profile shall also be used to verify the NPSH condition at LL.

29. Design Deliverables

- Design Basis Report.
- Hydraulic calculation.
- Darcy–Weisbach calculation.
- Hazen–Williams verification.
- NPSH calculation.
- Pump selection calculation.
- Tank volume and level calculation.
- Overflow, drain and ventilation calculations.
- Generator sizing calculation.
- Pump station P&ID.
- Tank general arrangement and structural drawings.
- Pump station layout.
- Pipe sizing and valve schedule.
- Flowmeter, pump and generator data sheets.
- Instrumentation list and I/O list.
- Control philosophy.
- Electrical single-line diagram and load schedule.
- SCADA architecture.
- Testing and commissioning procedures.

30. Conceptual System Arrangement

Incoming Treated Effluent water → Isolation valve → Inlet flowmeter → Treated Effluent water tank → Outlet isolation → Suction header → Duty/standby pumps → Discharge header → Outlet flowmeter → Distribution network.

The tank roof shall include protected ventilation and watertight inspection/access openings. A dedicated overflow and drain shall discharge to approved systems. A standby diesel generator with ATS shall supply essential pumping and control loads.

31. Final Design Recommendations

- H shall be the normal maximum tank operating level.
- HH shall provide independent high-level protection/alarm below the overflow.
- L shall be the normal minimum operating level.
- LL shall provide low-level protection and pump shutdown.
- Overflow shall be an emergency protection system and shall not be the normal level-control mechanism.
- Drain shall permit tank emptying for inspection, cleaning and maintenance.
- Ventilation shall be sized for maximum filling/emptying air displacement and protected against contamination.
- Roof openings shall be watertight, secure and suitable for inspection and maintenance.
- Inlet and outlet flowmeters shall provide operational flow and totalized-volume measurement.
- Pumps shall follow an N+1 duty/standby reliability philosophy.
- Darcy–Weisbach shall be used for detailed friction-loss calculations, with Hazen–Williams available as an independent verification.
- NPSH shall be checked at LL and maximum pump flow using the worst expected operating conditions.
- Standby generator shall be sized for all essential loads and motor starting requirements.

32.Information Required for Final Hydraulic Design

The numerical HH, H, L and LL elevations, pipe diameters, pressure losses, pump TDH, NPSH margin, overflow diameter, drain diameter, vent area and generator capacity cannot be finalized without the project-specific design inputs.

Required Input	Purpose
Tank dimensions and floor/roof elevations	Tank volume and level elevations
Maximum and minimum inlet flow	Inlet pipe, flowmeter and overflow sizing
Design/peak outlet flow	Pump and outlet pipe sizing
Pipe lengths, diameters and materials	Darcy/Hazen–Williams losses
Fittings and valves	Minor-loss calculation
Upstream/downstream elevations	Static head and hydraulic profile
Required downstream pressure	Pump TDH
Pump centerline elevation	NPSH available
Maximum water temperature	Vapor pressure for NPSH
Pump curve / NPSHR	Final NPSH verification
Electrical load schedule	Generator sizing

33. Main Power Supply Source:

The proposed pumping station pumps on 0.415 kV level, will be fed by the required power through a proposed distribution substation, of 11/0.415kV transformer (Under the scope of NEDC). This substation shall be fed from the external medium voltage network via OH lines.

34. Power factor:

The electrical power supply system inside the site is designed so that, the overall power factor of the electrical system not less than 0.95 lagging.

35. Design Basis:

The following factors are considering during the design and the selection of the electrical system components:

- Effect of excess power is considered when estimating the motors power based on the international standards recommendations.
- Only, loads of the duty pumping units are considered when estimating the total electrical power demand.
- Effect of motors starting on both the transformers and stand-by electrical generating units is checked and considered.

36. Area Classification and Selection of Electrical Equipment

All areas where flammable and combustible liquids, gases, or dust may be present are classified to determine the minimum criteria for design and installation of electrical equipment to minimise the

possibility of ignition. The criteria for determining the appropriate classification are specified in Article 500 of the American National Electrical Code or as equivalent in BS EN 60079-0:2012.

Electrical equipment in areas classified as hazardous shall be constructed and installed in accordance with the requirements of Article 501 and Article 502 of the National Electrical Code or as equivalent in BS EN 60079-0:2012.

Whenever possible, electrical equipment shall be located in non-hazardous areas.

No electrical equipment shall be located in Class I, Division 1 areas as per National Electrical Code or in Zone 0 areas as per the BS EN 60079-0:2012. Electrical equipment intended for installation in Zone 1 and Zone 2 hazardous areas shall be certified for use in those areas by a recognized testing authority.

All the electrical equipment for hazardous areas shall be certified and approved by independent international testing agency such as BASEEFA, ATEX, and UL.

Motors located in hazardous areas shall be certified in accordance with the Hazardous Area Classification at this section.

37. System Components:

The electrical equipment is:

- Oil-filled, pad-mounted, self-cooled and indoor/outdoor type step-down transformers.
- 0.415 kV Motor Control Centre (MCC), LV switchgear.
- Control and alarm cabinets.
- Wires and cables.
- Lighting and small power systems with the related distribution boards / panel boards.
- Raceways and conduit systems.
- Underground cables and ducts systems.
- System and equipment grounding (Earthing) systems.
- Conduits, wiring, control equipment, junction boxes, and field connections as required for all motors and process units' equipment.
- Telephone network as required.
- A minimum of 20% spare capacity in all cable feeders, terminal cabinets, and exchange circuitry to ensure expansion capabilities.

All bus bars shall be tinned

38. Standby and Emergency Control Philosophies

In the event of a loss of external power supply, an emergency backup generator is also provided. This generator is designed to handle the entire station load, ensuring uninterrupted operation in case of external supply failure. A SLD showing rating and maneuvering between transformers and generators (SLD Attached)

39. Surge Design Criteria and Assumptions

Surge occurs when a steady flow in a system is disturbed by a change of flow over a relatively short time period. This could be due to power failure of a pump station, valve closure or the normal stopping of pumps. Surge control is important in hydraulic systems because it may cause collapse of pipes or pump casings and other operational problems.

Surge analysis is an essential step in the design of a pumping system and is usually done by computer modeling.

Depending on the outcome of the surge analysis, the necessary protection means shall be established such as:

- Hydro-pneumatic surge tanks (one standby surge vessel is required);
- Slow closing and opening control valves;
- Slow closing air release valves;
- Variable speed pumping.

The most commonly used surge protection means is the provision of surge vessels that could be of the bladder type, hybrid type or compressed air compensated type. Then, the surge pressures across the whole transmission lines will be determined and the following design criteria will be considered:

- Selection of pipes and fittings to withstand the surge pressures;
- Identification of proper start-up, operation, and shut down for the system.

The velocity of the pressure wave can be determined from the formula:

$$a = \frac{1}{\sqrt{\frac{\gamma}{g} \left(\frac{1}{K} + \frac{(D/t)}{E} \right)}}$$

Where

a = velocity of the pressure wave (m/s);

$\rho = (\gamma/g)$ density of the fluid (kg/m³), for water $\rho = 1000$ kg/m³

K = modulus compression of the fluid (N/m²), for water $K = 2.19 \times 10^9$ N/m²

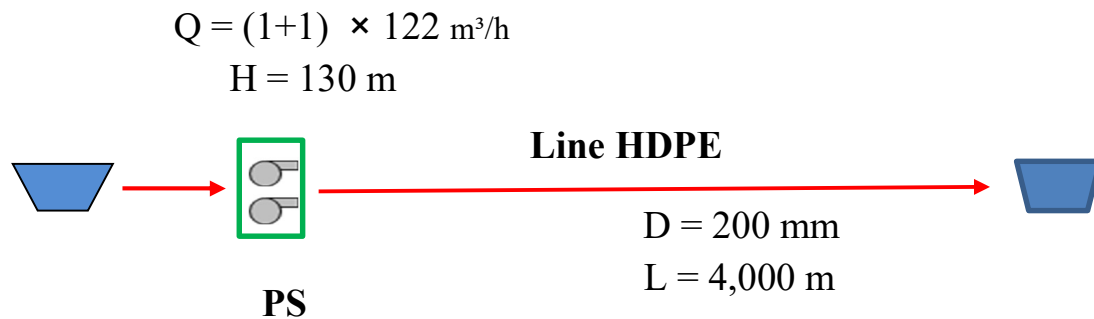
D = inside pipe diameter (m)

t = pipe wall thickness (m)

E = modulus elasticity of pipe wall material (N/m²) = 2.07 x 10¹⁰ for GRP

Water hammer analysis is performed in accordance with the following design criteria:

- Hazen-Williams formula is used for calculation of friction losses through HDPE pipes with C value 140 for HDPE ;C value 130 for DI
- Surge condition is taken as pump shut-down due to power failure.
- Negative surge pressure shall be limited to -0.2 bars, (-2.0 m).
- The design temperature shall be 20°C.



Surge Vessel Data

Label	From – to	Vessel Volume (m3)	Gas Volume (m3)	Connection Pipe diameter (mm)
TE Line	Pipeline from PS to End of Line	1.5	0.5	200 (DI)

40.Structural Works

The design and specification of all work shall comply with BS EN 1992-1-2004 , with applicable local codes when required and with the codes and industry standards.

The design shall consider the followings:

- The type of structure and its occupancy.
- Materials to be used in the construction.
- Loads to be applied on the different structural elements.
- Codes and standards to be used in the design.
- PAW design Guidelines.
- Project Specifications

41.Design Codes and Standards

The cross-sections of the structural members shall be designed based on the stresses created on the members, the strength of concrete and the yield strength of the reinforcing steel.

The following is a summary of specific codes and industry standards and the general design criteria that shall be used in the design and construction of the project.

Specifications for materials shall generally follow the BS standard specifications.

Concrete:

Unless otherwise required structure design shall conform to

- Eurocode: BS EN 1990 to BS EN 1999
- BS EN 206
- BS 8110
- The concrete cubic strength of reinforced concrete shall not be less than 40 N/mm² after 28 days.
- The concrete cubic strength of plain concrete shall not be less than 20 N/mm² after 28 days.

Reinforcing Steel

All the reinforcing steel shall be in accordance with:

- The specification of Carbon Steel Bars for the reinforcement of Concrete (R) BS 4449, 2005.
- Reinforcing steel shall be high tensile deformed bars with minimum yield strength not less than 500 N/mm² for main reinforcement and mild steel for stirrups with minimum yield strength not less than 250 N/mm².
- cover to steel from main reinforcement:

-Footings and all R.C. elements in contact
with soil

=75mm

-Columns above AND WALLS =50mm

-Slabs =30mm

-Beams =30mm

42. Methodology

a. Method of Analysis:

- 3D- Model analysis is prepared for all structural units.
- The analysis is done by using SAP2000 Program taking into considerations
- All acting loads to get the maximum reactions and straining actions at different sections.

b. Results:

- Maximum straining actions for all elements are used for design.

c. Methods of design:

- The ultimate state method is used for design.
- The working stress method is used for crack width calculations.

43.Design Loading

Stresses in the structures shall be calculated considering the following cases of loading.

The following types of loads shall be considered in the design of concrete and steel structures.

The best engineering judgment shall be applied to ensure that the loads and their combinations reflect as near as possible the anticipated loading for each structure according to its intended use.

Dead Loads:

Dead loads shall include the weight of all structural framing. All construction materials permanently incorporated in the building and supported by the framing including built-in-positions and permanent equipment.

The dead weight of the structure proper shall be calculated according to its dimensions and the used material.

Imposed Loads:

Imposed loads include loads due to intended use and occupancy of the area, personnel, movable equipment and partitions and vehicle loading.

Imposed loads shall be in accordance of:

- Dead loads shall be in accordance of BS EN 1991-1-1, "Euro code 1 – Actions on Structures Part 1-1- General Actions – Densities, Self-weight, Imposed Load for Buildings"
- BS EN 1991-1-2, "Euro code 1 – Actions on Structures Part 1-2- General Actions – Actions on structures exposed of fire"
- BS EN 1991-1-4, "Euro code 1 – Actions on Structures Part 1-4- General Actions – Wind Actions"
- BS EN 1991-1-5, "Euro code 1 – Actions on Structures Part 1-5- General Actions – Thermal Actions"
- BS EN 1991-1-6, "Euro code 1 – Actions on Structures Part 1-6- General Actions – Actions during execution"

44.Load Combinations

The structure shall be checked for load combination which will be as follows:

Ultimate Limit State (ULS):

Table A1.2(B) - Design values of actions (STR/GEO) (Set B) , **Persistent and transient**

Eq. (6.10):

$$\begin{aligned}
 W_u &= 1.35 \text{ G} + 1.5 \text{ Q} + 0 \text{ W} + 0 \text{ T} \\
 &1.35 \text{ G} + 1.5 \text{ Q} + 0.9 \text{ W} + 0.9 \text{ T} \\
 &1 \text{ G} + 0 \text{ Q} + 0 \text{ W} + 0 \text{ T} \\
 &1 \text{ G} + 0 \text{ Q} + 0.9 \text{ W} + 0.9 \text{ T}
 \end{aligned}$$

Eq. (6.10a):

$$\begin{aligned}
 W_u &= 1.35 \text{ G} + 1.05 \text{ Q} + 0 \text{ W} + 0 \text{ T} \\
 &1.35 \text{ G} + 1.05 \text{ Q} + 0.9 \text{ W} + 0.9 \text{ T}
 \end{aligned}$$

Eq. (6.10b):

$$\begin{aligned}
 W_u &= 1.15 \text{ G} + 1.5 \text{ Q} + 0 \text{ W} + 0 \text{ T} \\
 &1.15 \text{ G} + 1.5 \text{ Q} + 0.9 \text{ W} + 0.9 \text{ T}
 \end{aligned}$$

Table A1.3 - Design values of actions for use in **accidental and seismic**

Accidental, Eq. (6.11):

$$\begin{aligned}
 W_u &= 1 \text{ G} + 0.7 \text{ Q} + 0 \text{ W} + 0 \text{ T} + 1 \text{ A}_d \\
 &1 \text{ G} + 0.6 \text{ Q} + 0 \text{ W} + 0 \text{ T} + 1 \text{ A}_d
 \end{aligned}$$

Seismic, Eq. (6.12):

$$W_u = 1 \text{ G} + 0.6 \text{ Q} + 0 \text{ W} + 0 \text{ T} + 1 \text{ A}_{Ed}$$

Category of use:		ψ_0	ψ_1	ψ_2
C: Congregation areas		0.7	0.7	0.6
Wind		0.6	0.2	0
Temperature		0.6	0.5	0

G :	Dead load
Q :	Live load
W :	Wind load
T :	Temperature load
A _d :	Accidental load
A _{Ed} :	Seismic load

45.DESIGN LOADS

Self weight

Unit weight of soil (compacted)	19.0 kN/m ³
Construction concrete (reinforced)	25.0 kN/m ³
Construction steel	78.5 kN/m ³
Unit weight of water	10.0 kN/m ³

Live Loads

Live load for equipment's floors (Q)	=5kN/m ²
Live load for inaccessible roof (Q)	=1.50kN/m ²

Floor Cover

Weight of cover for non-accessible roof (G) =3.50kN/m²

46.Other affecting factors

Foundation

Foundation level and allowable bearing capacity shall be according to the approved geotechnical investigation report which shall be prepared during the detail design phase.

1. Metal Works

Access covers, ladders, etc. shall follow PAW standards and the relevant international standards.

2. ABBREVIATIONS

General

ASTM	American Standard for Testing and Materials
BS	British Standard
ACI	American Concrete Institute

Units

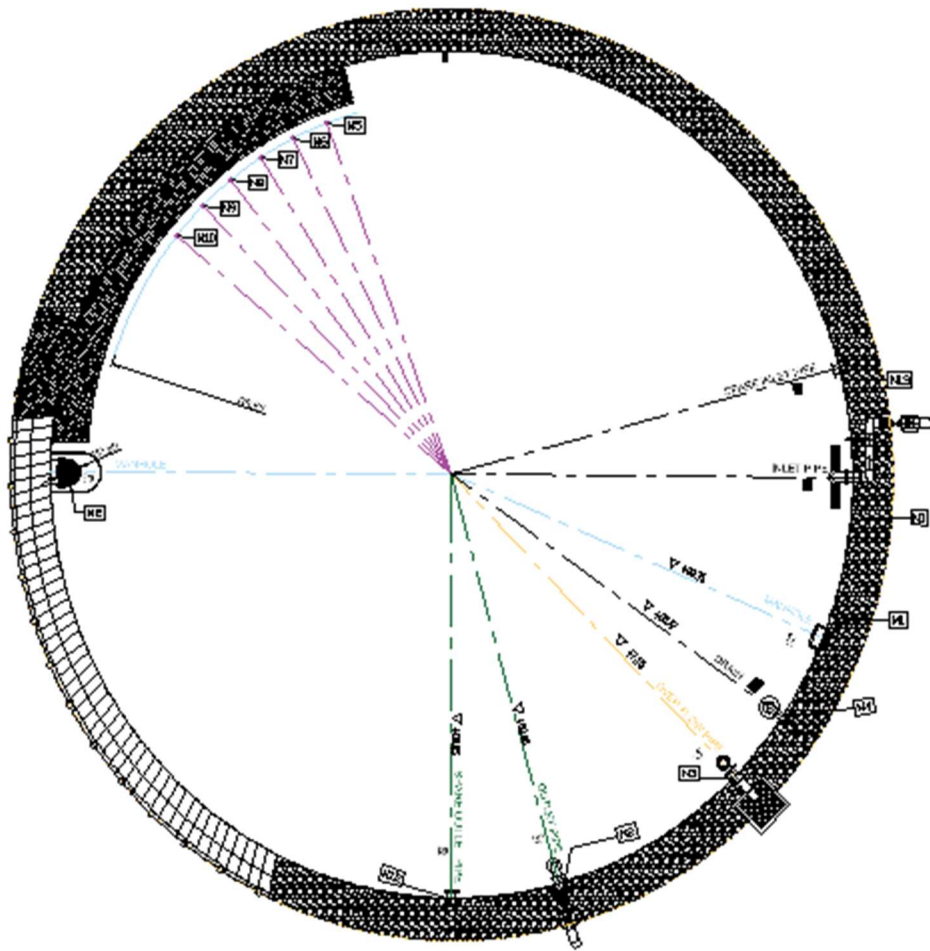
m	SI base unit of length, meter
km/h	SI unit of velocity, kilometre per hour
kN	SI unit of force, kilonewton
kN/m ²	SI unit of pressure, kilonewton per square meter
kg/m ³	SI unit of density, mass in kilogram per cubic meter volume
MPa	SI unit of pressure

3. STRUCTURAL ANALYSIS & STATIC DESIGN CALCULATIONS

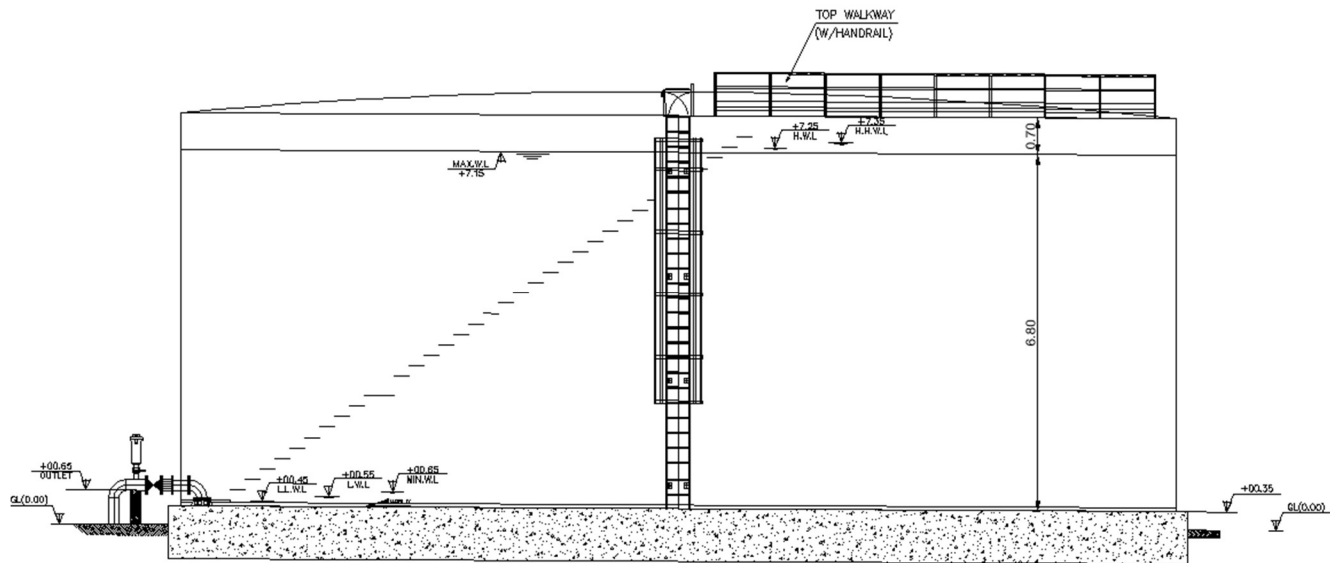
Analysis has been done using the structural analysis program for finite elements **SAP** Version 19.2.1.

The Ground Tank

- The ground tank is GLS tank with capacity 2000 m³ has dimensions 20 m diameter and 7.50 m height with a maximum water head 6.80 m and free board distance 0.70 m.
- The structural system of the tank shells will be GLS and will be designed by the supplier.
- The foundations will be circular raft foundations with estimated depth 1 m and diameter 22 m.



Ground Tank Floor Plan



Ground Tank Elevation

The Pump Station

- Consists of main pumps building attached to electrical control room; the main pumps building has dimensions 6.30 m x 5.40 m x (2.20m below ground level & 4.50m above ground level) in addition to overhead crane for maintenance purpose 2ton capacity.
- The structural system of the pumps building will be reinforced concrete raft foundations and retaining walls for the underground part, while the upper part which consists of two levels, overhead crane level and top slab level will be supported on reinforced concrete columns, beams and corbels.
- The estimated thicknesses of the structural elements will be preliminary as follows,

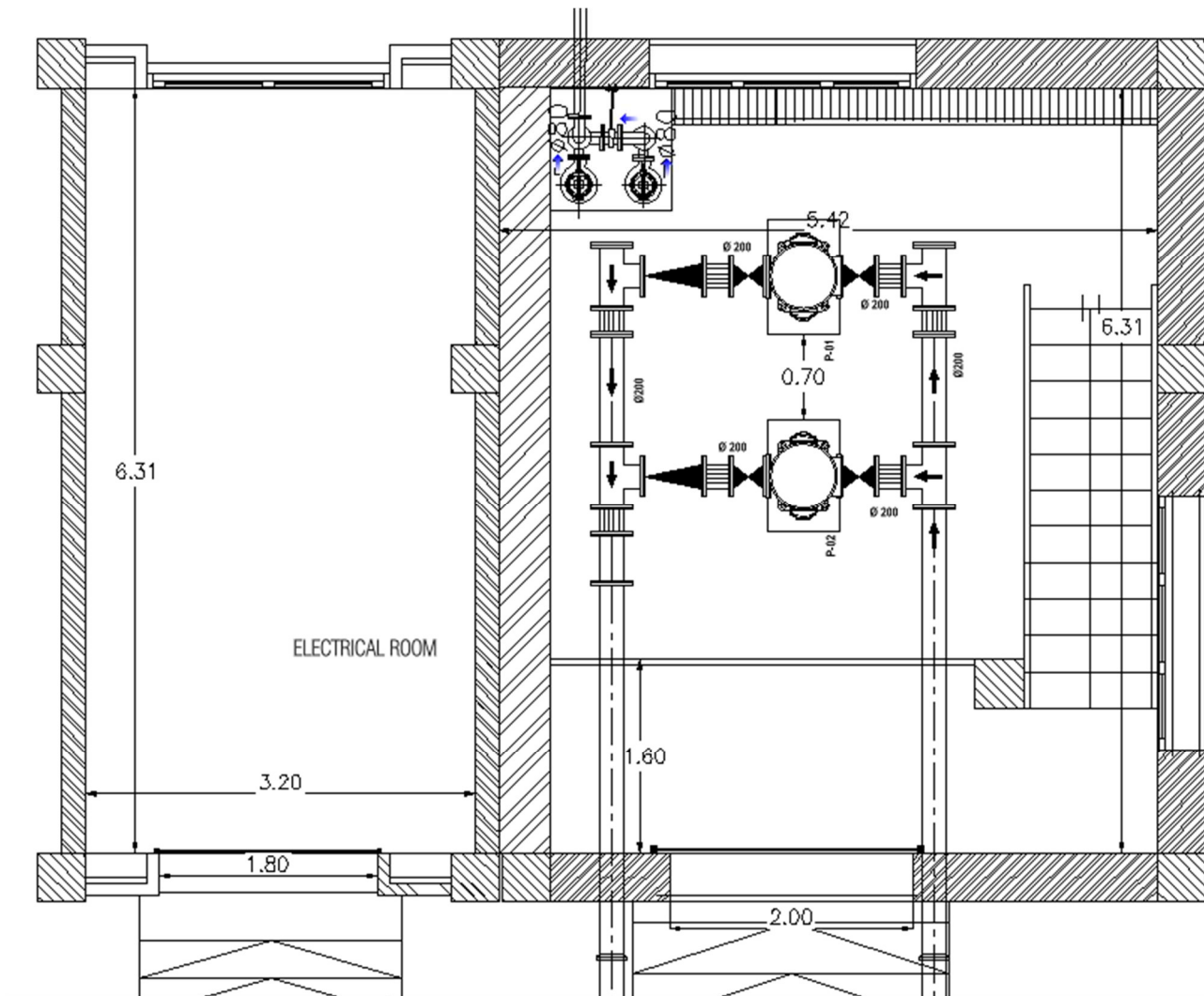
Raft Foundations	500 mm
Retaining Walls	350 mm
Columns	350x600 mm middle & 350x350 mm corner
Beams	200x500 mm & 200x600 mm
Corbels	300 x (300/600) mm
Top slab	150 mm

The Electrical Building

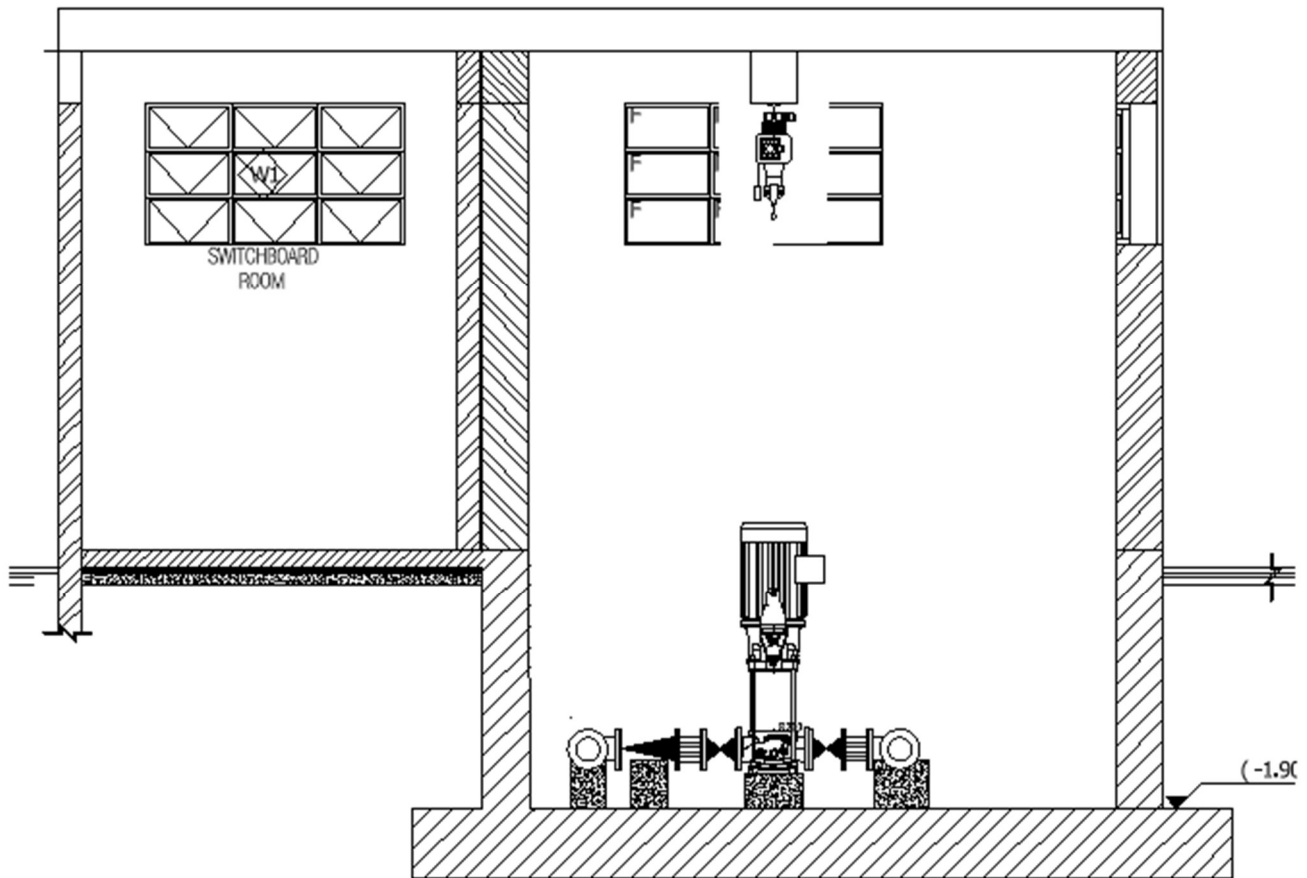
- Consists of main switchboards room with dimensions, 6.30 m x 3.20 m x 4.50 m and totally separated from the pumps building with a joint 20 mm width.
- The structural system of the electrical building will be reinforced concrete solid slab supported on projected beams and columns; the foundations will be isolated strab beam footings in order to solve the structural joint problem.

- The estimated thicknesses of the structural elements will be preliminary as follows,

Isolated Footings	1200x1200x400mm corner & 1500x1500x400mm middle
Strab Beams	350x500 mm
Columns	350x350 mm
Beams	200x500 mm
Top slab	150 mm



Pump Station Plan

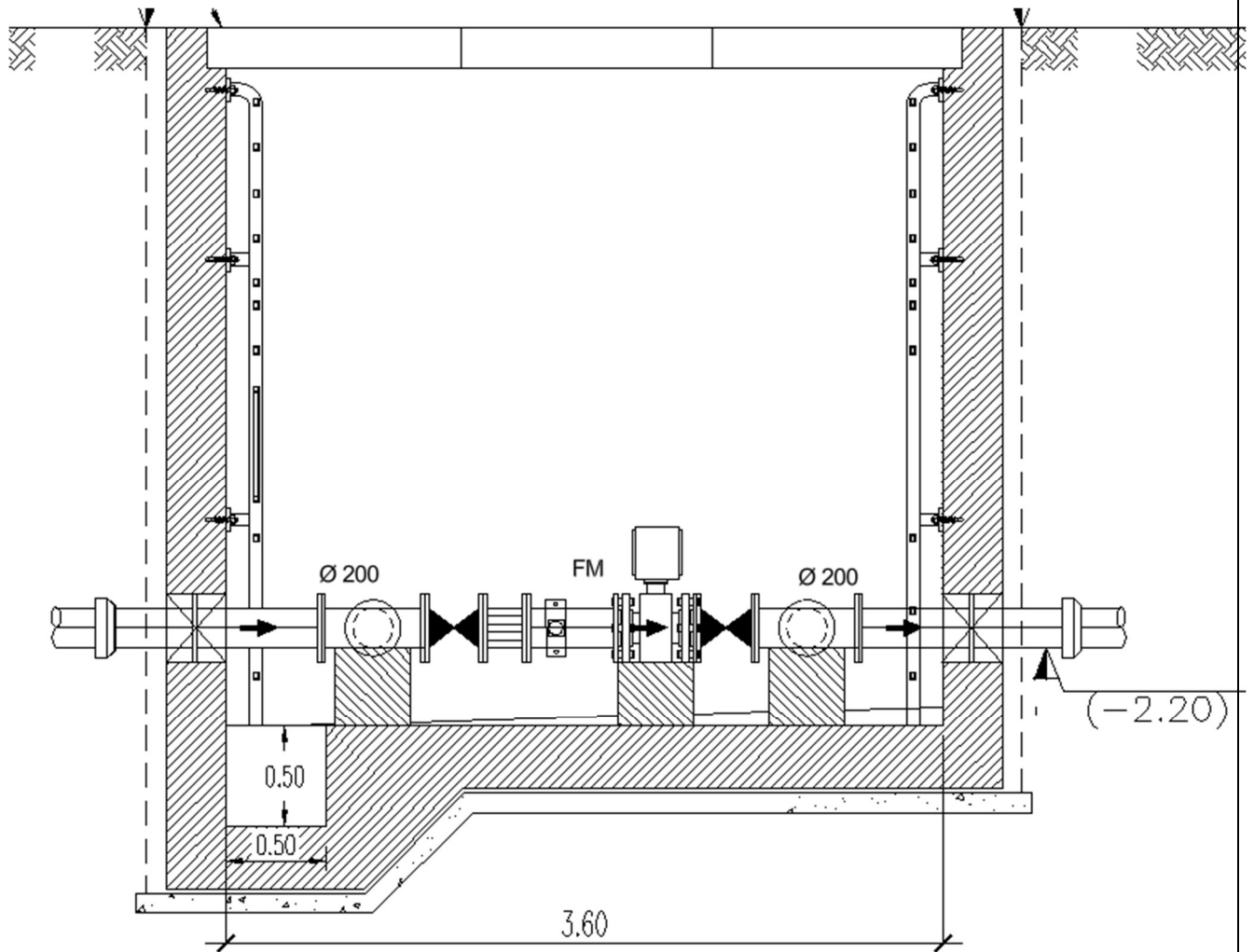


Pump Station Sectional Elevation

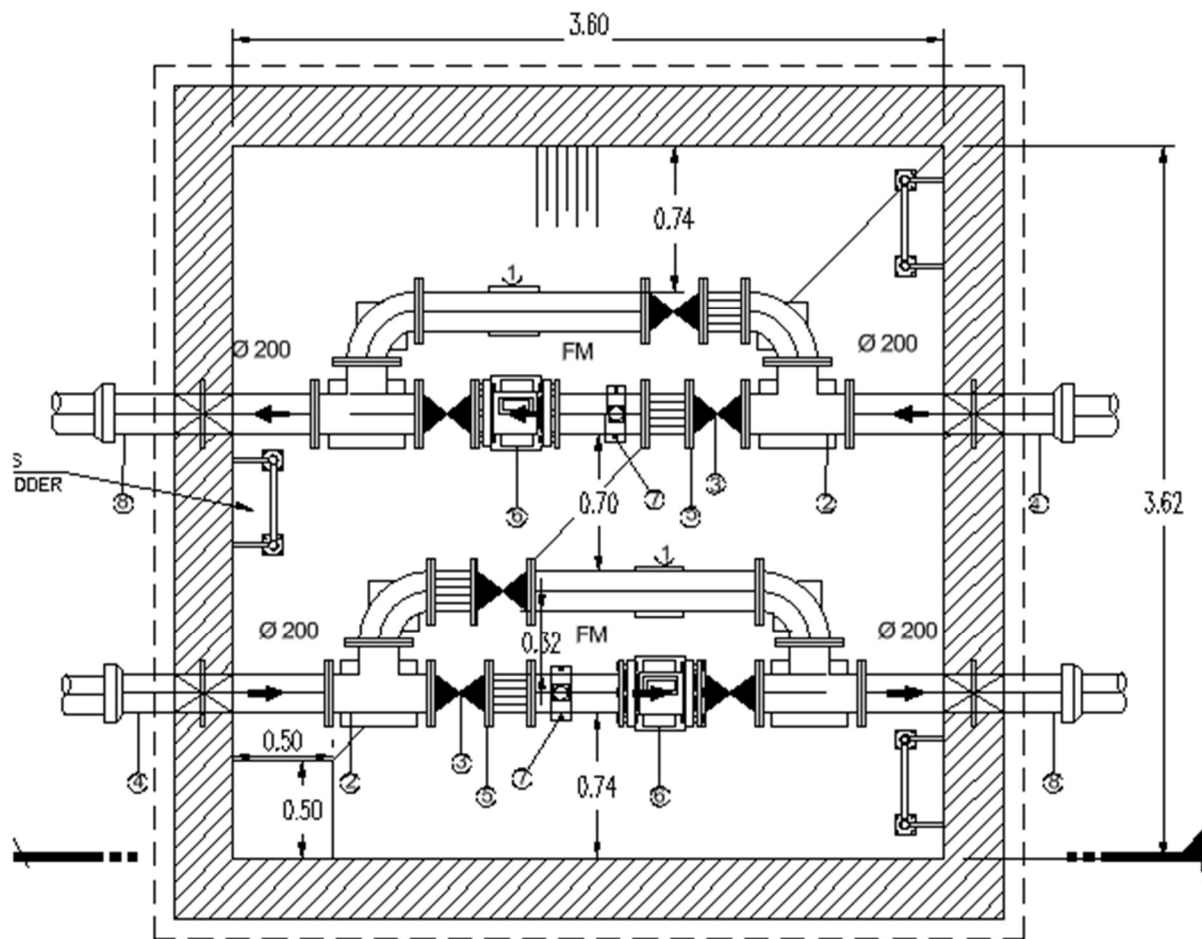
The Control and Flow Meter Chamber

- The chamber has dimensions 3600x3600x3500 mm, it is totally underground.
- The structural system of the chamber will be reinforced concrete raft foundations and retaining walls in addition of top precast cover slabs.
- The estimated thicknesses of the structural elements will be preliminary as follows,

Raft Foundation	400mm
Retaining walls	300mm
Precast Slabs	200mm



Flow Meter Chamber Sectional Elevation

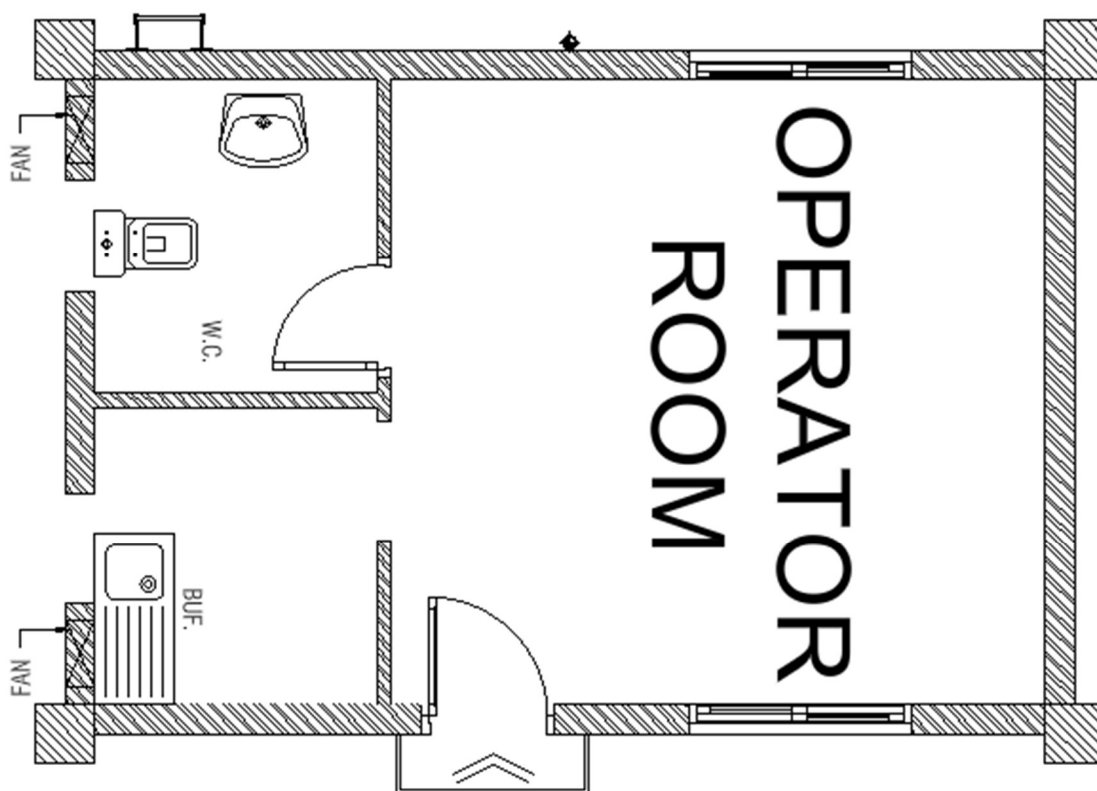


Flow Meter Chamber Plans

Operator Room

- Consists of separate concrete building with internal dimensions 4.60mx3.00m x3.00 m
- The structural system will be solid slab system supported on projected beams and 4 corner columns tied with plinth beams at the level of the slab on grade.
- The foundations will be isolated footings
- The estimated thicknesses of the structural elements will be preliminary as follows,

Isolated Footings	1500x1500x400mm
Plinth beams	200x500 mm
Columns	350x350 mm
Beams	200x500 mm
Top slab	150 mm

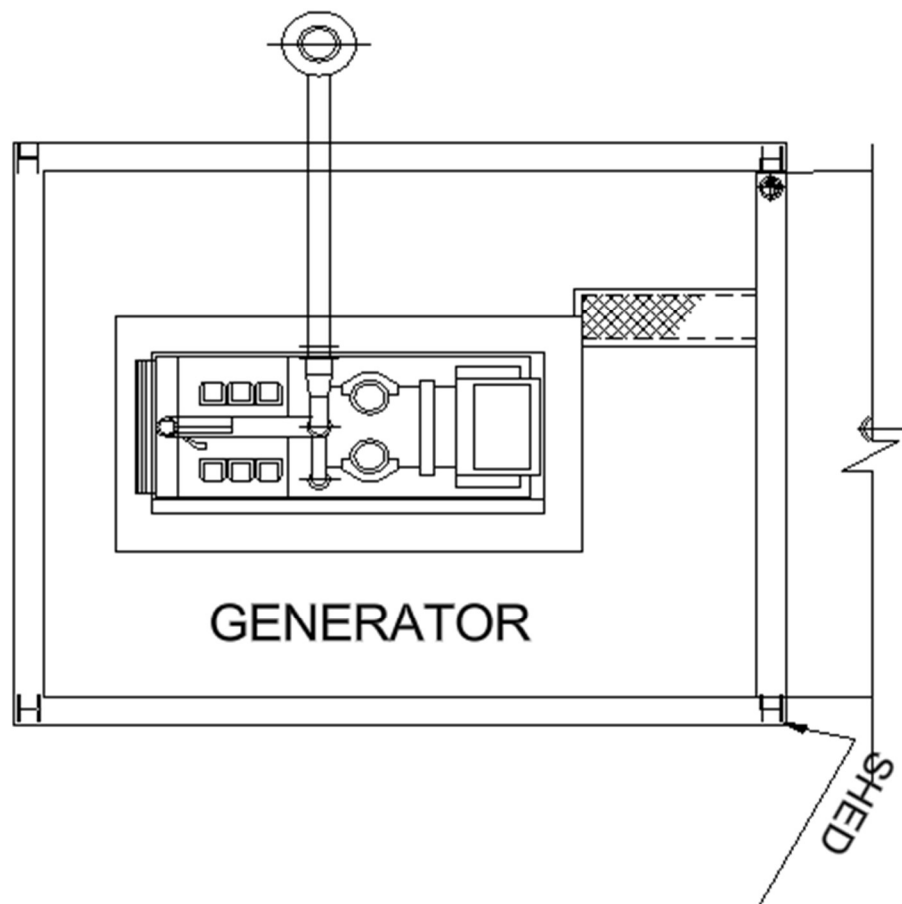


Operator Room Plan

1. Generator Steel Shed

- Consists of covered steel shed with dimensions 5.30m x 4.00m, the cover is sandwich panel insulated corrugated sheets supported on roof Z purlins that supported on the framing beams, the main 4 supporting columns are IPE supported on isolated footings with concrete pedestals. The whole structure will be braced with roof horizontal bracing plus side vertical bracing.
- The estimated thicknesses of the structural elements will be preliminary as follows,

Roof cover	Insulated sandwich panel corrugated sheets
Roof purlins	Z200
Framing beams	IPE 260
4 Supporting columns	IPE 300
Horizontal and Vertical Bracing	ANGLES 100X100
4 Concrete pedestals	400mmX400mm
4 Concrete footings	1300mm x 1300mm x 350mm



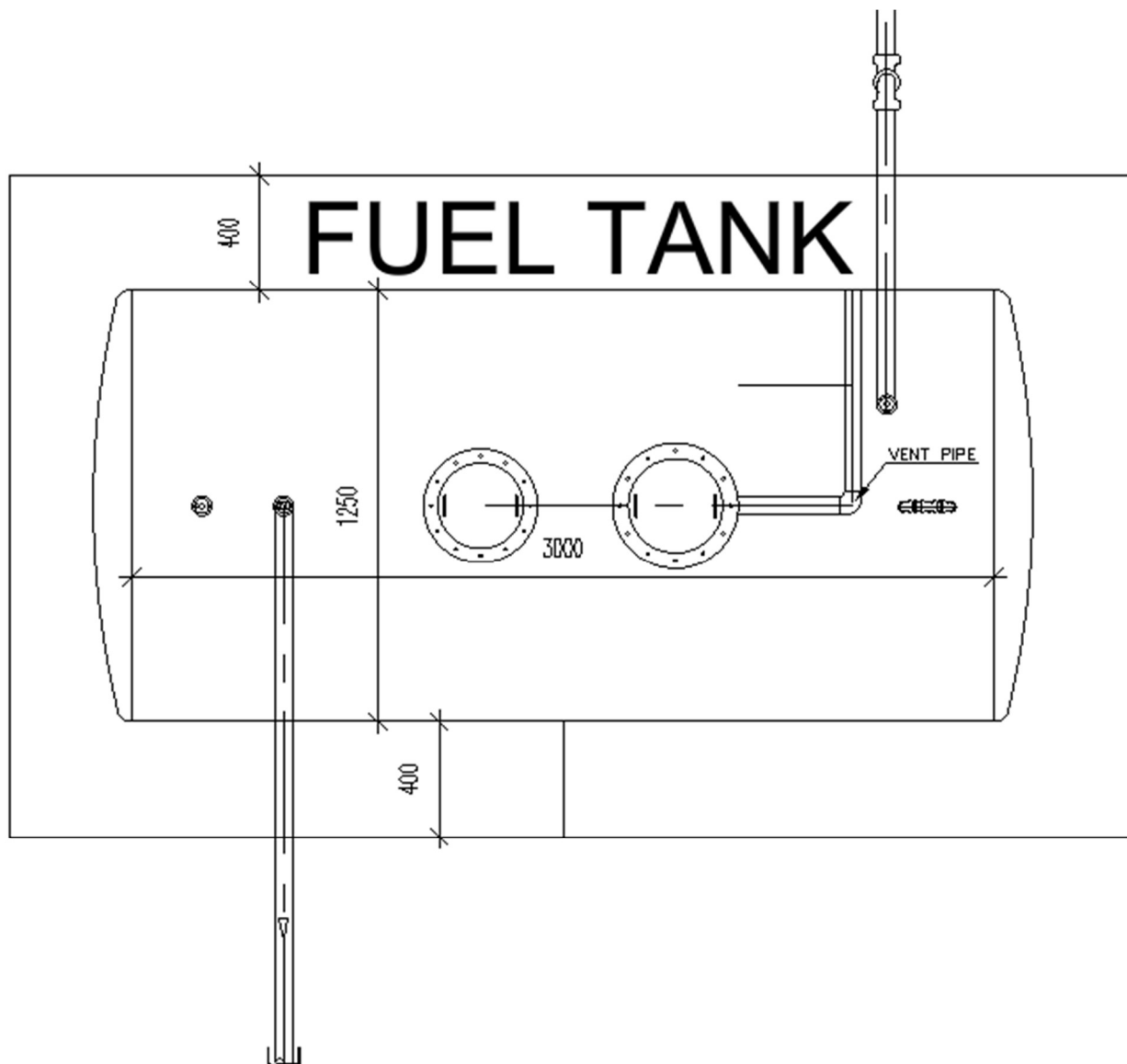
Generator Steel Shed Plan

2. Fuel Tank Base

The fuel tank base will be raft foundation surrounded by 4 short retaining walls with height according to the mechanical design.

- The estimated thicknesses of the structural elements will be preliminary as follows,

Raft foundations	300 mm
Retaining walls	250 mm



3. Water Hammer Vessel Base

- The base is raft foundations supporting 3 concrete pedestals on them the steel vessel will be supported.
- The estimated thicknesses of the structural elements will be preliminary as follows,

Raft foundations	2300mm x 2300mm x 350 mm
3 Rc Pedestals	400mm x 400mm

