



THE COUNCIL FOR DEVELOPMENT
AND RECONSTRUCTION (CDR)

**ENVIRONMENTAL AND
SOCIAL SAFEGUARD
STUDIES FOR LAKE
QARAOUN POLLUTION
PREVENTION PROJECT**



DESIGN REVIEW OF ZAHLE
WASTEWATER TREATMENT
PLANT



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ELARD LEBANON			
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ELARD Lebanon

Amaret Chalhoub – Zalka Highway
Fallas Building (Playroom) – 3rd Floor
T : +961 1 896 793
T : +961 1 871 361
M: +961 3 910 032



Beirut | Abu Dhabi | Damascus | Tripoli | Baghdad
www.elard-group.com

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LIST OF ACRONYMS

APSP	As per Standard Practises
BOD	Biological Oxygen Demand
CAS	Confirm TO Applicable Standards
CDR	Council for Development and Reconstruction
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EDL	"Electricité du Liban"
ELARD	Earth Link and Advanced Resources Development
HSE	Health, Safety and Environment
MVA	Mega Volts Amperes
O&M	Operation and Maintenance
PLC	Programmable Logic Controller
TCLP	Toxicity Characteristic Leaching Procedure
TP	Total Phosphate
TSS	Total Suspended Solids
WEGL	Within Established Design Guidelines
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

1.1 BACKGROUND

Earth Link and Advanced Resources Development s.a.l. (ELARD) has been appointed by the Council for Development and Reconstruction (CDR) to prepare the environmental and social safeguard studies for the Lake Qaraoun Pollution Prevention Project. This project aims at implementing certain components of the Business Plan to Combat Pollution at the Qaraoun Lake that was prepared by the Ministry of Environment. As a result of this plan, a follow-up Committee led by the Litani River Authority (LRA) was assigned by the government to follow-up implementation of the plan. The government has requested financial assistance from the World Bank, which is supporting the implementation of the following components:

1. Component 1- Improve the Collection of Municipal Sewage
2. Component 2- Increase the adoption of Integrated Pest Management (IPM) practices
3. Component 3- Technical Studies in Solid Waste Management and Capacity Building and Project Management

This capacity assessment study of Zahle Wastewater Treatment Plant is related to Package 1 of Component 1.

1.2 OBJECTIVES

The objective of this assignment is to review the design of Zahle WWTP, its adapted treatment technology and its capacity to cope with effluent quality in addition to evaluation of other aspects of the wastewater treatment such as flexibility and robustness against failures. In order To achieve these objectives, this study will:

- Assess each of the plant components individually, establish its true overall treatment and hydraulic capacity and identify its compliance with applicable standards and accepted design guidelines.
- Assess the overall liquid and solid streams process capacity to cope with effluent qualities and nationally accepted solid management practices;
- Recommend process or operational improvements to increase plant treatment performance and/or simplify plant operation and maintenance;
- Identify and assess the automation of the processes;
- Identify safety practices accommodated in the design and /or used by work contractor; and
- Provide cost estimations for the implementation of the identified recommendations.

1.3 ASSESSMENT MATERIALS

The capacity assessment of Zahle wastewater treatment plant was conducted based on the review of the detailed design documents and drawings listed in APPENDIX A; with the consideration of the national standards and regulation and the Established Design Guidelines for wastewater treatment plant.

2. ZAHLE WWTP OVERVIEW

The Qaraoun Lake (of 220 Mm³ capacity) is considered a major source of water supply for irrigation, hydro power generation as well as for various recreational activities such as swimming, fishing, and boating. The discharges of untreated waste water into the Litani River and the Qaraoun Lake system is negatively impacting these vital and important public issues. Therefore, the treatment of collected wastewater prior to discharge into the system is a necessity from public health and public interest viewpoints. Given the characteristics of the raw wastewater and the requirements of disposal or reuse, the collected wastewater usually requires some type of preparation or treatment before it is rendered fit for disposal or reuse. Generally, in many situations involving domestic wastewater, the treatment consists of removal of suspended solids and 5-day, 20°C BOD, nitrogen and phosphorus which are the most usual parameters of prime interest, even though the degree of treatment required for the discharge into a tributary according to table A of Law 319/76 permit discharging into the Litani River without the need for nutrients reduction. The issues concerning the eutrophic status of the Qaraoun Lake must be considered.

Zahle WWTP is located 4 km south of Zahle Township, on the right bank of the Litani River. The plant is situated on flat area with an approximate elevation of 875 m above sea level. The plant is proposed to serve the city of Zahle and neighboring villages up to the village of Qaa El Rim. The plant is still under construction.

The land used for the WWTP is currently owned by Zahle Municipality. According to the cadastral information, the land was expropriated by the Municipality in 1997 for construction of the WWTP and the sanitary landfill. Total size of the land plot (#508) is 25 hectare. Of which, 90,000 square meter was used for the WWTP and the remaining was used for the landfill. The plot of the land was owned by one land owner. The compensation value was determined by the Expropriation Committee based on the market price at the time of expropriation and all compensation has been paid to the affected person. There are no pending issues or disputes over the ownership on the land used for the WWTP.

The land acquisition didn't involve relocation or loss of shelter, loss of assets or access to assets, and loss of income sources or means of livelihoods.

The complete treatment of wastewater in Zahle WWTP is brought by a sequential combination of various physical unit operation, and chemical and biological unit processes known as EBPR (Enhanced biological phosphorus removal). The performance efficiency of the treatment plant depends not only on proper design and construction but also on good operation and maintenance.

2.1 INFLUENT AND EFFLUENT CHARACTERISTICS

Zahle wastewater treatment plant has been designed to treat wastewater originated from the city of Zahle and its neighboring villages, which is estimated to amount to 37,300 m³/day in the year 2015 and 56,000 m³/day in the year 2030. As per the latest study conducted by Mss. Rafik El khoury & Patrners, the actual sewer networks and the future build one will carry estimated flows of 33,500 m³/d at 2015 and 44,590 m³/d in year 2030 based on connected

population equivalent. This indicates **Zahle WWTP has the capacity to accommodate the entire anticipated flows of sewage**. The design parameters and requirements of the plant are listed in Table 2-1.

Table 2-1 Zahle WWTP design parameters

Parameter	Unit	Inlet	Outlet		
			After primary and secondary treatment	After tertiary treatment	After disinfection
BOD ₅	mg/l	395	< 25	< 15	
COD	mg/l	752	< 125	< 50	
Total SS	mg/l	421	< 35	< 10	
Total Phosphorus	mg/l	64		< 1	
Total Nitrogen	mg/l	15	< 10	< 10	
E. Coli	UFC/100 ml				< 10

2.2 DESCRIPTION OF THE FACILITY

The plant will be installed in two phases. The first phase is designed to serve about 205,000 PE designed to accommodate flows up to the year 2015 with an average flows of 37,300 m³/d. The facilities of the first phase include the following:

- Coarse screens: three (3) units (2 duty + 1 standby);
- Pumping station: four (4) pumps (3 duty + 1 standby);
- Fine screens: three (3) units (2 duty + 1 standby);
- Grit and grease removal: two (2) rectangular channels equipped with two reciprocating independent bridges;
- Distribution chamber: to three (3) lanes Lane A, Lane B and biological treatment bypass;
- Biological treatment: two (2) lanes, Lane A and Lane B, each of them include anaerobic tank and anoxic/aerobic intermittent oxidation ditch;
- Collection and degassing chamber: one (1) chamber for the two lanes;
- Secondary clarifier: two (2) circular tanks with common collection chamber for RAS and SAS acting as pumping station;
- Tertiary filtration: four (4) up flow Filtrazur™ filters, common filter washing wastewater chamber equipped with two (2) pumps (1 duty + standby) for washing wastewater lifting to the inlet pumping station through the internal sewer;
- UV disinfection;

- Other facilities: the coarse and fine screened transport and compacting unit, grit classifier, grease separator and collection.

The second phase is designed to serve about 300,000 PE till the year 2030 with an average flow of 56,000 m³/d. The arrangements for the second phase include the following:

- Coarse screens: place for additional screen;
- Pumping station: place for additional pump;
- Fine screens: place for additional screen;
- Grit and grease removal: place for additional channel;
- Distribution chamber: arrangement for penstocks installation for line C;
- Biological treatment: place for the additional lane, Lane C, which include anaerobic tank and anoxic/aerobic oxidation ditch;
- Secondary clarifier: place for additional circular tank and collection chamber for RAS and SAS pumping station;
- Tertiary filtration: place for additional two (2) up flow Filtrazur™ filters, and arrangement for filter backwashing wastewater connection to the common collection chamber;
- UV disinfection : equipment installation is required;

Sludge treatment line for the two phases includes the following:

- Sludge thickening, GDD screens: three (3) independent equipment;
- Sludge dewatering, super press belt filters: three (3) independent equipment;
- Sludge stabilization, lime treatment;
- Sludge storage area;
- Other facilities for sludge transport and correct disposition in the sludge storage skips.

Figure 2–1 presents the process flow diagram of Zahle WWTP.

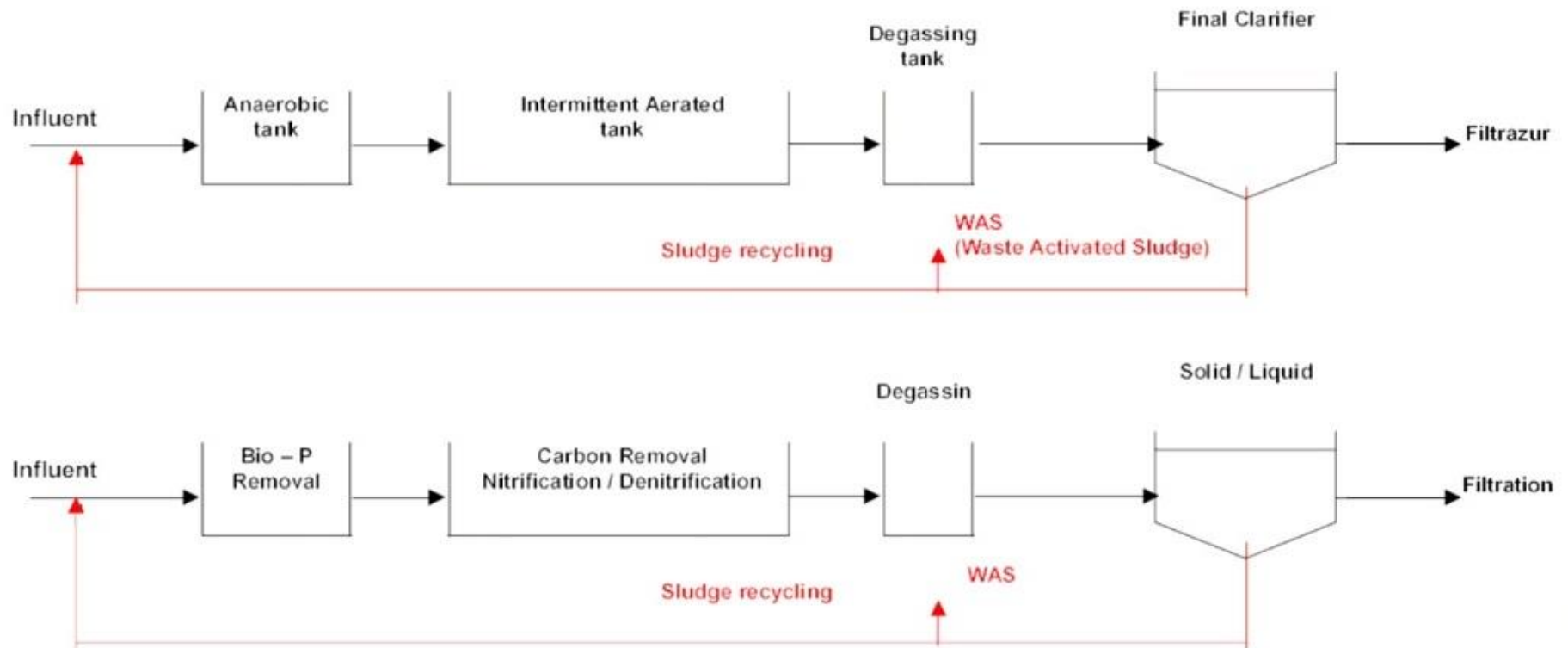


Figure 2-1 Process Flow Diagram of Zahle WWTP

2.3 Major Equipment Installed

In order to evaluate the plant equipment and check the need for any upgrade or replacement, the capacity of the equipment was assessed based on maximum flow requirements. Table 2-2 presents Zahle WWTP equipment verification.

Table 2-2 Zahle WWTP Equipment Verification

Item	Capacity	Capacity/Unit Size	Capacity/ Total Installed	Total Required	Notes
Pumping station	4 (3 duty + 1 standby)	1221 m ³ /h	3,663 m ³ /h	Rain weather peak flow 3,664 m ³ /h	
Grit and grease removal	2 (2 duty)	20 m x 4 m x 4 m	568 m ³	190 m ³ (3 Minutes @ PWWF)	
Air flot	4 (3 duty + 1 standby)	2.2 KW	3.6 kw	ASP	
RAS pumps	3 (2 duty + 1 Standby)	568.26 m ³ /h	1,173 m ³ /h	Sufficient	
Blowers	3 (2 duty + 1 standby)	13,825 Nm ³ /h	27,651 Nm ³ /h	30,300 Nm ³ /h	
SAS pumps	3 (2 duty + 1 standby)	12,043 m ³ /h			
Coarse screens	3 (2 duty + 1 standby)	1,632 m ³ /h	3,264 m ³ /h	Rain weather peak flow 3,664 m ³ /h	No
Skip for coarse screening	2 (1 duty + 1 standby)	1 m ³	2 m ³	Sufficient	
Compacting screw conveyor	1 (1 duty)	9 m / 5.5 KW			
Fine screens	3 (2 duty + 1 standby)	1,832 m ³ /h	3,664 m ³ /h	Rain weather peak flow 3,664 m ³ /h	Yes
Skip for fine screening	2 (1 duty + 1 standby)	10 m ³	20 m ³	Sufficient storage	Used for grit storage too.
Compacting Screw conveyor	1 (1 duty)	10 m / 3 KW			
Flow meter	3 (2 duty + 1 standby)	1,832 m ³ /h	3,664 m ³ /h	Rain weather peak flow 3,664 m ³ /h	Yes
Sand classifier	1 (1 duty)	100 m ³ /h	100 m ³ /h	Sufficient capacity	No standby unit

2.4 Instrumentation

In order to check instrumentation adequacy to proper operation of Zahle WWTP, the automation applications of Zahle WWTP were checked. The minimum required instrumentation to achieve proper biological process operation was installed. The level of automation is sufficient to operate the plant if onsite lab analysis are possible for some critical parameters such as COD, BOD₅, nitrite and total phosphorus. Table 2-3 presents Zahle WWTP automation applications.

Table 2-3 Zahle WWTP Automation Applications

Process/Unit	Application	Availability
Preliminary treatment	Automatic screen cleaning based on head loss, total flow treated and/or timers	Yes
Biological treatment	On-line respirometry	No
	On-line measurement of BOD load	No
	Automated sludge age (SRT) control	No
	Automated biological sludge wasting control	No
	Automated ORP control in the control of biological nutrient removal process	Yes
	On-line measurement of MLSS concentration	No
	On-line dissolved oxygen monitoring and control	Yes
Secondary clarifier	On-line measurement of NH ₂ -N, NO ₃ -N and PO ₄ -P concentrations	No
	On-line effluent TSS or turbidity analysis	No
Tertiary filters	On-line monitoring of turbidity and/or phosphorus concentration	No
	On-line monitoring of head loss	Yes
Aeration system	Automated blower control based on-line dissolved oxygen sensors	YES
	On-off aeration control	Yes
	Variable speed control of mechanical aerators	Yes
Disinfection/UV irradiation	UV intensity monitoring and control	Yes
	Flow pacing of UV lamps	Yes
	Initiation of automatic self-cleaning	Yes
Sludge thickening	Automatic flow pacing of chemical addition	No

2.5 Process Description

The plant was designed to remove carbonaceous pollution and nutrient from the wastewater through a Biological Nutrient Removal (BNR) activated sludge process. This treatment process removes total nitrogen (TN) and total phosphorus (TP) from wastewater through the use of microorganisms under different environmental conditions (Metcalf and Eddy, 2003).

Nitrogen Removal: Total effluent nitrogen comprises ammonia, nitrate, particulate organic nitrogen, and soluble organic nitrogen. The biological processes that primarily remove nitrogen are nitrification and denitrification (Jeyanayagam, 2005). Nitrification occurs in the presence of oxygen under aerobic conditions, and denitrification occurs in the absence of oxygen under anoxic conditions.

During nitrification ammonia is oxidized to nitrite by one group of autotrophic bacteria, most commonly *Nitrosomonas* (Metcalf and Eddy, 2003). Nitrite is then oxidized to nitrate by another autotrophic bacteria group, the most common being *Nitrobacter*.

Denitrification involves the biological reduction of nitrate to nitric oxide, nitrous oxide, and nitrogen gas (Metcalf and Eddy, 2003). Both heterotrophic and autotrophic bacteria are capable of denitrification.

Phosphorus Removal: Biological phosphorus removal relies on phosphorus uptake by aerobic heterotrophs capable of storing orthophosphate in excess of their biological growth requirements. The treatment process designed to promote the growth of these organisms, known as phosphate-accumulating organisms (PAOs) in mixed liquor (WEF and ASCE/EWRI, 2006). Under anaerobic conditions, PAOs convert readily available organic matter [e.g., volatile fatty acids (VFAs)] to carbon compounds called poly-hydroxyalkanoates (PHAs). PAOs use energy generated through the breakdown of polyphosphate molecules to create PHAs. This breakdown results in the release of phosphorus (WEF and ASCE/EWRI, 2006).

Under subsequent aerobic conditions in the treatment process, PAOs use the stored PHAs as energy to take up the phosphorus that was released in the anaerobic zone, as well as any additional phosphate present in the wastewater. In addition to reducing the phosphate concentration, the process renews the polyphosphate pool in the return sludge so that the process can be repeated (Jeyanayagam, 2005).

Phosphorus can also be removed from wastewater through chemical precipitation. Chemical precipitation primarily uses aluminum and iron coagulants or lime to form chemical flocs with phosphorus. These flocs are then settled out to remove phosphorus from the wastewater (Viessman and Hammer, 1998). However, compared to biological removal of phosphorus, chemical processes have higher operating costs, produce more sludge, and result in added chemicals in sludge (Metcalf and Eddy, 2003). When TP levels close to 0.1 mg/L are needed, a combination of biological and chemical processes may be less costly than either process by itself.

Zahle wastewater treatment plant was designed using this technology to achieve biological phosphorus removal, where the main advantage of this process is the significant reduction of reagent consumption.

As the biological phosphorus removal efficiency depends directly on surplus biomass production, primary sedimentation is not provided upstream of the anaerobic tanks. Without primary sedimentation, activated sludge has to treat higher pollution loads. Consequently, biological sludge production is increased. By this means, a bigger quantity of phosphorus is naturally extracted from the mainstream. Furthermore, the full amount of readily biodegradable (soluble) substrate provided by raw water is available at the inlet of anaerobic zone, which also could significantly, improves Bio-DeP efficiency.

2.6 ZAHLE WWTP RELIABILITY INDEX

In order to assess the reliability of the designed plant, EPA classification of reliability was utilized as guidance. Zahle Wastewater treatment plant has almost all the requirements of

class 1 but we are obliged to classify it as class II according to EPA reliability index classification since it miss the holding basin as presented in Table 2-4.

Table 2-4 Reliability Classification (U.S. EPA, 1974)

Component	Class I		Class II		Class III		Zahle WWTP	
	Treatment System	Power Source	Treatment System	Power Source	Treatment System	Power Source	Treatment System	Power Source
Holding Basin	Adequate capacity for all flows		Not applicable		Not applicable		No	
Degritting		Optional		No		No		Yes
Primary sedimentation	Multiple units ^a	Yes	Same as class I		Two minimum ^a	Yes	NA	NA
Aeration basins	Two minimum w/equal volume	Yes	Same as class I	Optional	Single unit permissible	No	Two w/equal volume	Yes
Blower or mechanical aerators	Multiple units ^c	Yes	Same as class I	Optional	Two minimum ^c	No	Multiple units ^a	Yes
Diffusers	Multiple sections ^d		Same as class I		Same as class I		Multiple Sections	
Final sedimentation	Multiple units ^b	Yes	Multiple units ^a	Optional	Two minimum ^a	No	Multiple units ^a	Yes
Chemical flash mixer	Two minimum or back up ^e	Optional	No backup	Optional	Same as class II	No	Two mixers	Yes
Chemical sedimentation	Multiple units ^b	Optional	No backup	Optional	Same as class II	No	Multiple Units	Yes
Flocculation	Two minimum	Optional	No backup	Optional	Same as class II	No	No	No
Disinfection basins	Multiple units ^b	Yes	Multiple units ^a	Yes	Same as class II		Multiple units ^b	Yes

^a Remaining capacity with largest unit out of service must be for at least 50 % of the design maximum flow.

- ^b Remaining capacity with largest unit out of service must be for at least 75 % of the design maximum flow.
- ^c Remaining capacity with largest unit out of service must be able to achieve design maximum oxygen transfer; backup unit need not be installed. for at least 75 % of the design maximum flow.
- ^d Maximum oxygen transfer capability must not be measurably impaired with largest section out of service.
- ^e If only one basin, backup system must be provided with at least two mixing devices (one may be installed).

2.7 PRODUCED SLUDGE CLASSIFICATION

Wastewater Activated Sludge is classified in two types according to pathogen densities as presented in Table 2-5. Zahle WWTP produced sludge can be classified as class B Bio-solids according to the selected sludge treatment, lime stabilization by addition of sufficient lime to the sludge to raise the pH to 12 for 2 hours, which is considered one of the processes that significantly reduce pathogens.

Table 2-5 Sludge Classification (U.S. EPA, 1992)

Classification	Description
Class A	Salmonella bacteria be less than 3 most probable number of organisms per four grams of total solids. Enteric viruses be less than 1 per four grams of total solids. Viable Helminth ova be less than 1 per four grams of total solids
Class B	Sludge have less than 2 million fecal coli-forms per gram of sludge or that it be treated in process to significantly reduce pathogens (PSRP)

The sludge resulting from the plant will be relayed to the municipal solid waste landfill located at close to the plant. The demonstration of nonhazardous and toxic contents using TCLP must be performed regularly in addition to paint filter test. These testing are part of regular operation and will be the contractor's responsibility while they operate the plant for the first two years (one year of DNP – Default Notification Period and one year of operation) under a DBO contract. In addition, testing sludge is required by the landfill authority before disposal and no landfill will accept the sludge without those tests.

3. PLANT ASSESSMENT

3.1 MAJOR PLANT UNIT OPERATION ASSESSMENT

The pre-treatment building is divided into two logical zones:

- Wastewater inlet, screening and lifting; and
- Wastewater degritting and degreasing.

The wastewater is flowing by gravity to the concrete structure inlet well. The inlet structure have been designed for the final maximum hydraulic flow of 4,667 m³/h but only electromechanical equipment, necessary for the first phase of 3,264 m³/h hydraulic flows, were provided. The inlet structure has been equipped with a concrete bypass pipe in order to drain off the final peak flow (horizon 2030) in case of emergency or failure.

The screening is achieved in two steps using mechanically racked coarse screens followed by mechanically operated fine screens.

3.1.1 COARSE SCREENING

The objective of coarse screening is to retain a maximum quantity of voluminous materials that may disturb the inlet pumping station operation. Wastewater is flowing from the Inlet well to the concrete coarse screen channels. Four screening channels were provided three of them designed to accommodate the first phase flows and the fourth is foreseen for the final phase flow rates. Three vertical screens of the of 40 mm spacing size (two duty and one standby) are provided. Each screen is able to screen 1,632 m³/h and can be isolated by manually operated individual sluice gate.

The screening waste is transferred and compacted by a 9 m screw conveyor to storage skips. Two screened storage skip of 1 m³ volume (one duty and one standby) were provided.

The coarse screening design verification is presented in Table 3-1.

Table 3-1 Coarse Screening Design Verification (WEF, 1998)

Parameter	Design requirement	Zahle plant	Verification
Clear spacing between bars	15 – 75 mm	40	CAS
Inclination from Vertical	0 – 30 degrees	0 degree	CAS
Approach velocity	0.6 – 1.2 m/s	0.775 m/s	CAS
Allowable head loss	0.15 to 0.6 m	0.20 m	CAS
Screening Quantity	6 L/10 ³ m ³	2 x 1 m ³ storage skip	Sufficient Storage

3.1.2 FINE SCREENING

There are four screening channels, three channels are designed for the first phase and the last channel is foreseen for the final maximum hydraulic flow rate. Three automatic screens of 10 mm spacing (two duty and one standby) are provided. The capacity of each screen is

1,832 m³/h and their start and stop are controlled by time set-point or, in case of over fouling, according to the signal from one differential level transmitter. Over flow is foreseen in case of failure of the fine screens that discharges into the pumping station.

The fine screens are provided with a transport and compacting screw conveyor of 10 m length and two skips of 10 m³ storage volume each (one duty and one standby).

The fine screening design verification is presented in Table 3-2.

Table 3-2 Fine Screening Design Verification (Crites and Tchobanoglous, 1998)

Parameter	Design requirement	Zahle plant	Verification
Clear spacing between bars	0.2 – 12.7 mm	10	CAS
Bar inclination from Vertical	0 – 30 degrees	0 degree	CAS
Approach velocity	0.6 – 1.2 m/s	0.85 m/s	CAS
Allowable head loss	0.15 to 0.6 m	0.20 m	CAS
Screening Quantity	56 L/10 ³ m ³ (US EPA 1979,1987)	2 x 10 m ³ storage skip	Sufficient Storage

3.1.3 GRIT AND GREASE REMOVAL

Grit and grease removal phase include stimulated flotation processes combined with grit removal in two rectangular concrete tanks of 4 m width, a liquid depth of about 4 m and a length of about 20 m, which is able to treat the peak wet weather flows. The average retention time in the grit/grease separator unit is about 10 to 15 minutes at average flow, with a minimum of 5 minutes at peak flow. The grit/grease removal system contains:

- One go and back bridge (for each line);
- Four Aeroflots stirrers as mechanical aeration system for grease (for each line);
- An airlift system, for grit removing (one for each line);
- A grit classifier for sand washing (one unit for two lines).

Go and back bridge and the four aeroflots are foreseen for a continuously running. The settled grit on the floor of the tank is extracted continuously by the air-lift system, installed on the bridge, and then discharged in a common channel for the two units. Grit is separated from the water by a screw conveyor, functioning as grit classifier, and collected into a container. Sand and grit is defined as all particles whose diameter exceeds 0.20 mm and specific gravity exceeds 2.65 Kg/l. Grit is usually relatively inoffensive, and many of the particles are inert, it is usually disposed of by burial.

Floated grease is removed using mechanical surface scrapers, and then collected by a hopper into two containers.

The grit removal design verification is presented in Table 3-3.

Table 3-3 Grit Removal Design Verification (U.S. EPA 1987)

Parameter	Design requirement		Zahle plant	Verification
	Range	Typical		
Detention time	10 – 15 minutes at average flows	5 minutes at PWWF	8 minutes at PWWF	Acceptable
Horizontal velocity	0.24 to 0.4 m/sec	0.3 m/sec	0.03 m/sec	Acceptable
Surface loading rates	1000 to 3000 m ³ /m ² .day	1200 m ³ /m ² .day	1100 m ³ /m ² .day	Acceptable
Settling velocity				
50 mesh	2.8 – 3.1 m/min	2.9 m/min		
100 mesh	0.6 – 0.9 m/min	0.8 m/min	0.86 m/min	Acceptable
Grit removal	0.004 – 0.21 m ³ /10 ³ m ³	0.2 L/m ³	With the fine screen skip	Sufficient capacity
Air rates	0.3 to 0.7 m ³ /m.min		No data Available	

All calculated theoretical design parameters were within established design guidelines.

3.2 MAJOR PLANT UNIT PROCESS ASSESSMENTS

The theoretical capacity of each major component will be determined and later verified. A brief description comparing parameters is provided in Table 3-4.

Table 3-4 Typical Unit Process Design Parameters and Established Design Guidelines

Unit Process	Design Parameter	Evaluation Criteria
Biological reactor (Including Aeration)	HRT / SRT	Aerobic: 5 to 25 days (SRT) Anaerobic 0,5 to 1.5 h (HRT) Anoxic 0.5 to 1 h (HRT)
	MLSS (Mixed Liquor Suspended Solids.	3000 to 4000 mg/l
	Organic loading rate	0.25 Kg BOD5 / m3.d
	F/M ratio	0.05 to 0.1 Kg BOD5 / (Kg MLVSS.d) Glumrb, 2003
	Recycle Ratio	WAS 25 TO 100 % Qi IR 100 to 400 % of Qi
Effluent Filter	Hydraulic and solids loading rates	3.4 L / m ² .s @ Peak hourly flow rate
Disinfection (Chlorination/UV)	Retention time	
	Effluent solids	
	UV dosage/transmissivity	
Sludge Thickening and Dewatering	Hydraulics and solid loading rates	0.5 to 1.5 Kg / h.m ² of Thickener Area

Unit Process	Design Parameter	Evaluation Criteria
	Chemical dosage (If applicable)	210 to 430 g Ca(OH) ₂ / Kg Dry solids
	CBFP Solids loading rate	150 Kg/m.h coagulant sludge
Sludge Digestion	Hydraulic retention Time	15 to 60 days
	Volatile Solids loading	1.6 to 4.8 Kd/m ³ .d Volatile Solids

3.2.1 Biological reactor

In order to achieve the required effluent standards, the biological treatment must ensure:

- Carbon removal by biological oxidation;
- Nitrogen removal by nitrification/denitrification biological process; and
- Enhanced biological phosphorus removal.

Biological reactor was divided in two trains for a maximum flexibility of the installation. Each train constituted of the following tanks:

- One anaerobic tank to achieve enhanced biological phosphorus removal;
- One intermittent anoxic/aeration ditch which provide carbon and nitrogen removal; and
- One collection, degassing distribution chamber for solid/liquid separation and distribution to final clarifiers.

The proposed process is a conventional activated sludge, which provides high operation flexibility for carbon, nitrogen and enhanced biological phosphorus removal.

The total volume of biological reactors is 45,800 m³. Inclusive of an anaerobic zone of 68,000 m³ and an intermittent aeration zone of the volume 39,000 m³.

This volume is divided in two concrete tanks, designed as an oxidation ditch, equipped with submersible mixers for water mixing during anoxic phases, and a diffused aeration system to dissolve oxygen for the biological pollutant oxidation. The distribution between aeration and mixing phases per day is 8 hours for mixing and 16 hours for aeration. This leads to an aeration volume of 26,000 m³ and anoxic volume of 13,000 m³. Intermittent aeration process allows separation of aeration and mixing functions in the activated sludge tank while achieving carbon and nitrogen removal in the same basin.

Theoretical retention time, organic loading, MLSS, recycle ratio and other design parameters listed in Table 3-4 were calculated and found to be within established design guidelines.

3.2.2 Secondary clarifiers

The final clarifiers are of radial suction type. They achieve the settlement and separation of suspended solids of the mixed liquor flow from the aeration tanks and sludge recycling to the activated sludge tanks. The extraction of sludge is continuous and can ensure the minimum retention time of the biologically active sludge within the tanks. Distribution of mixed liquor to the tanks and removal of sludge from the floors is achieved without disturbing the settling

sludge solids within the tanks. The secondary clarifier design verification is presented in Table 3-5.

Table 3-5 Secondary Clarifier Design Verification

Parameter	Design Requirement	Zahle WWTP	Verification
Surface overflow rate	<33 m ³ /m ² .d (Glumrb, 2003)	23.52 m ³ /m ² .d	WEGL
Detention Time	4 hrs (Glumrb 2003) 1.5 – 2 hrs (Willis, 2005)	3,7 hours	WEGL
Weir Loading Rates	<250 m ³ /d/m (Glumrb, 2003)	200 m ³ /d/mH	WEGL
Peak Solids loading rate	< 171 Kg/m ² .d (Glumrb, 2003)	170 Kg/m ² .d	WEGL

The theoretical calculation of the surface overflow rate, the weir loading rate and the peak solid loading rate fall within the established guidelines.

3.2.3 TERTIARY TREATMENT – FILTRAZUR™

The Filtrazur™ is a rectangular concrete tank featuring false floor located above the filtering media. The floor is fitted with specific nozzle that can be removed from the top and relies on concrete beams. Nozzles function is to permit collecting treated water during the filtration phase and ensure equal distribution of clear water during the filtration phase. (Refer to Figure 3-1)

Water to be filtered is evenly split to filters by a feed channel, a tranquilization chamber and a weir to a feed shaft. The weir is responsible for the distribution.

The Filtrazur™ is a constant flow, head accumulation type filter. The level in the feed shaft rises as the filter clogs. The filter is washed on time or when a given head loss has been reached.

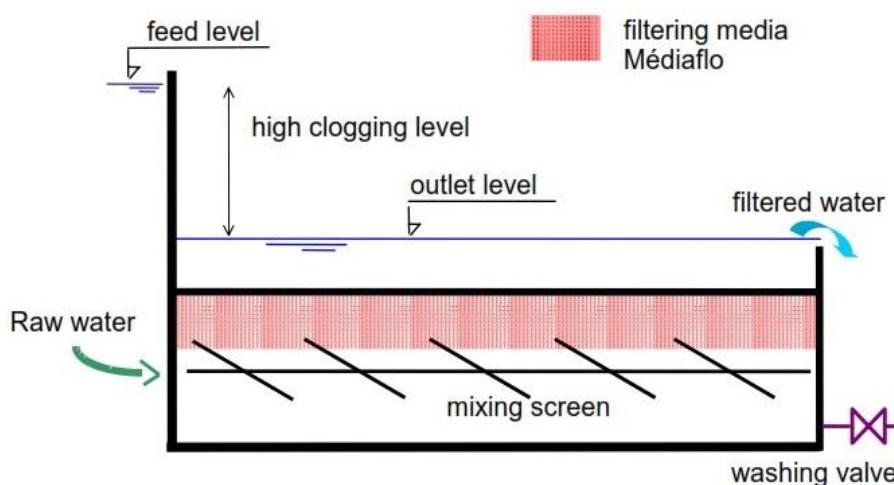


Figure 3-1 Filtrazur™(Courtesy of Degremont)

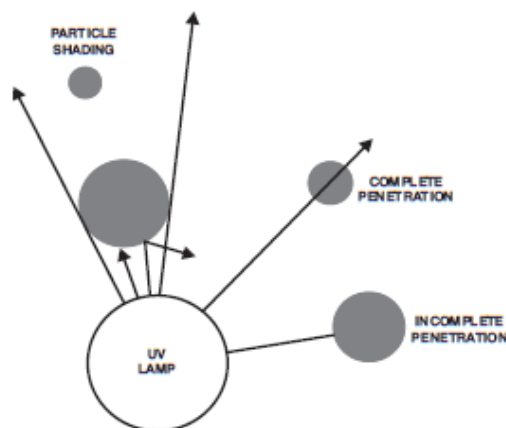
3.2.4 FINAL DISINFECTION BY ULTRAVIOLET SYSTEM

The very effective ability of UV for disinfection purposes is its photochemical reaction with the cell's DNA which is the main target of UVC, as its maximum absorption at 254 nm. Throughout several configuration changes, micro-organisms lose their ability to reproduce (indirect cell death) or their ability to synthesize essential protein products (direct cell death).

The amount of UV energy required to inactivate microorganisms is dependent on the UV transmittance of the liquid and suspended solids concentration. Many of the constituents found in wastewater absorb UV light, which results in a lower UV intensity.

Particles can scatter UV light or shade microorganisms from the radiation. Bacteria and Viruses in wastewater, are often bonded together as a floc, or associated with particulate matter. It has been estimated that about 1% of all microorganisms in wastewater are associated with particles (Parker and Darby, 1995). These organisms are more difficult to disinfect than their free-floating counterparts.

Figure#: 3-2



(Impact of particules on UV disinfection)

The UV dose delivered within a reactor is defined as the product of the average UV intensity within the reactor multiplied by the contact time of the liquid passing through the reactor. There are no instruments that directly measure the average UV light intensity within a reactor (Qualls et al., 1989). UV radiometers are probes that are used to detect UV light intensity at a given wavelength (usually 253.7 nm). However, this value is specific to the point in the reactor at which the measurement was taken and the to the water quality in the reactor at that point in time. Degremont provided online UV radiometers at the surface of the quartz sleeve. This online probe measures the decrease in lamp intensity as a percentage of the initial intensity. This factor is incorporated into mathematical methods to calculate the average intensity and than a more accurate calculation of dose.

Most of the necessary parameters for the supplied system disinfection capacity verification were not available to us. We must note that a typo mistake exist in the process design reports where the UV C-dosage capacity was noted as 50.8 m J/m² instead of m J/ cm² which is the adequate minimum dosage capacity required for 4 log inactivation.

3.3 SLUDGE TREATMENT PROCESS

The excess sludge treatment is constituted of two elements: GDD screens for pre-thickening of biological sludge and belt filter press for dewatering. Sludge stabilization is achieved by lime treatment downstream from the dewatering unit.

Sludge Thickening on a GDD screen is a two-step process includes:

- Flocculation by adding polymer in a dynamic flocculation reactor upstream of the GDD screen to produce a homogenous mixture; and
- Thickening step where the sludge previously flocculated is sped across the fine screen's horizontal rack and is continuously scraped by rubber blades.

The filtrate is collected in the bottom part of the apparatus and returned to the plant head.

Thickened sludge flows into a belt in the drainage zone; the sludge is then trapped between the lower and upper belts. The two, continuously driven belts pass over a series of return rollers with decreasing diameters, for gradual sludge pressurization. At outlet, the two belts separate and the cake are dislodged for evacuation by screw conveyor to the lime treatment.

3.3.1 POLYMER PREPARATION UNIT

Polyelectrolyte is mixed with biological sludge upstream of GDD screens, and then the additional polyelectrolyte is filed between the dynamic thickener and the belt press dewatering. Flocculation is only achieved with emulsion polymer. The polymer preparation unit, which is fully automatic is set for a dosing rate of 10 liters of polymer per one ton of DrySolid . The polyelectrolyte active dose is 5 kg/l and the maximum foresaw dilution is 2 g/l. The dosing pump station consists of three pumps (two duty and one standby) of 1,505 l/h capacity and 20 m head in addition to a preparation tank of 5 m³ volume.

3.3.2 LIME TREATMENT

Lime treatment aims at stabilizing dewatered sludge before its final disposal. Dewatered sludge from belt filters is mixed with the quick lime CaO by two eccentric shaft pumps (one duty and one stand by) of 10 m³/h capacity. The storage volume is 40 m³ which is adequate for 8 days storage at least.

The lime silo is equipped with a flow assister to pour lime required for sludge stabilization. Finally, sludge is stored in four skips of 25 m³ volume (6.8 days storage) before being disposed.

3.3.3 FINAL SLUDGE DRYNESS

The final effective sludge dryness depends on many parameters including volatile matter content, quality of sludge extracted in front of the dewatering operation, polyelectrolyte dose and lime dose. The expected final sludge dryness before disposal is 20%.

3.3.4 *Sludge Disposal and Management*

In the design phase of the project, a feasibility study screened sludge disposal alternatives with the consideration of the local situation which is characterized by the following:

- Impossibility to discharge into the receiving water bodies due to the limited flow rate available;
- Proximity of agricultural terrains;
- Proximity of Zahle landfill;
- Relative proximity of low value terrain on which deposits can be built;
- Difficulties in expropriating terrains;
- Favorable climatic conditions during summer period (April - October), characterized by high temperature and insolation; and
- Absence of burning plant.

The proximity of Zahle landfill was the most important factor at feasibility and design phase for its selection as the best scheme for disposing the wwt sludge and waste material. Another advantage was that the Co-disposal of domestic waste and sewage sludge increases the stabilization of the waste, the reduction of degradable organic compounds leached is then more rapid and eventually and the treatability quality of the leaches is improved.

3.4 ODOUR CONTROL MEASUREMENT

Odour control in Zahle wastewater treatment plant is achieved by chemical adsorption. Odour removal by chemical adsorption includes neutralisation, oxidation and reduction reactions. This is achieved by putting the air to be treated in contact with one or more reagent solutions through successive scrubbing in which the components causing the odours react and is dissolved, creating odourless, chemically stable forms. The successive scrubbing are disposed in the following order: acid scrubbing then alkaline and oxidant scrubbing.

The adopted odour treatment in Zahle WWTP eliminates ammonia and amines, hydrogen sulphide, organic sulphides, mercaptans and carboxylic acids.

Odour control measurement in the inlet building and the sludge dewatering building has been foresaw. The deodorized zones are indicated in Figure 3-2.

The number of changes for each hour was selected depending on the type of treatment in each room. The calculated total deodorization flow rate was 32,800 Nm³/hr.

Odour removal prevents polluting of the surrounding environment and ensures the safety of the staff in the wastewater treatment plant.

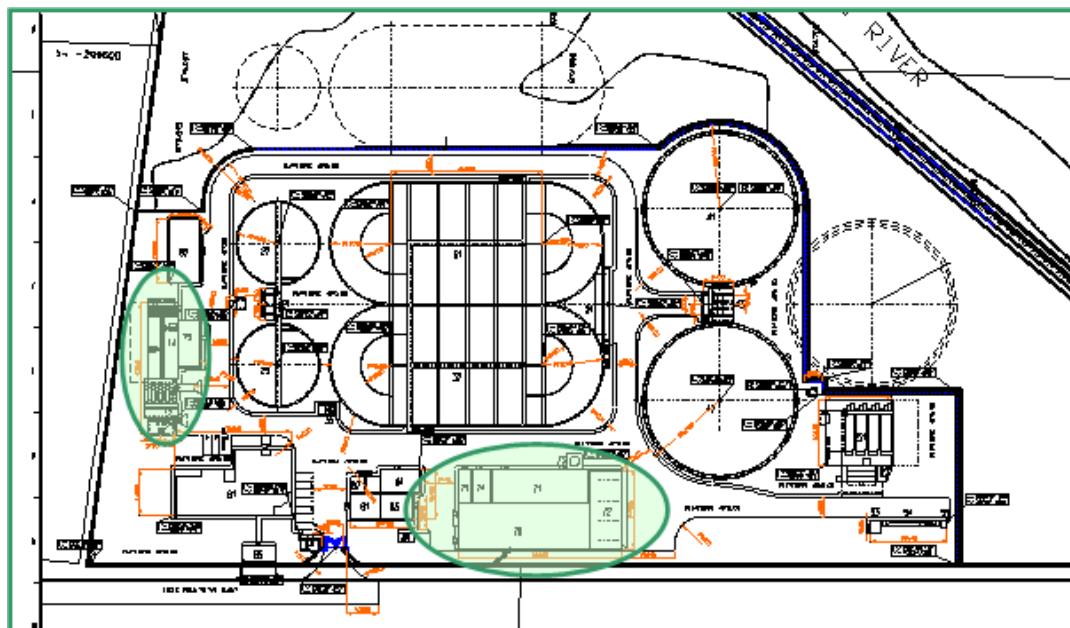


Figure 3-2 Zones with Odour Control in Zahle WWTP

3.5 EMERGENCY STANDBY POWER

Standby power generators of 1.25 MVA were provided as noted on the electrical plans. No additional information about the generator type, manufacturer data and diesel consumption were provided. It was not possible to assess the diesel storage tank capacity with consideration of the standby power generators specifications.

It might be necessary to isolate the non-critical loads, as these loads will have significant effects on the generator sizing. Such isolation will require load-shedding provisions to the electrical distribution system for the non-critical loads; this must be considered at the time of designing of Motor Control Centres, the starters, and PLC programming.

A second important consideration is the sequence of loading to the diesel generator. In case the full load is applied to the generator in a single step, the system may encounter problems due to the limits on maximum allowable voltage and frequency dips and the subsequent recovery time related to load applying on diesel generators.

However, if the process allows applying load in multiple steps, then the generator size can be significantly reduced. The multiple-step process will require an in-depth understanding of the process flow to figure out the steps for starting, in addition to close coordination between the electrical and process components. It is to be noted that the emergency load may be required to start in the first step, while the rest of the loads can be started with sequenced time delay.

3.6 SAFETY

Many safety measures and practices are recommended to ensure proper operation of wastewater treatment plants. These measures should be considered and included in the

design phase where some accessories can be provided in a later stage. The assessment of the safety measures in Zahle WWTP presents the following:

- The plant was surrounded with a fence and the access to the plant is secured through one main gate located in front of the administrative building. The gate is electrically operated, but it is not provided with an intruder security alarm;
- The plant was not provided with surveillance cameras;
- The plant was not equipped with intruder alarms to notify security guards of any intrusion.
- All ladders and catwalks were provided with safety handrails;
- No data were provided about the fuel storage tank capacity, installed control and safety devices (i.e. flame aerestor, level control, overflow alarms... etc.) or leak and spill containment instruments and equipment;
- Fire alarms in generator room, transformer and electrical rooms were not provided;
- Chemical reactor pumping station is provided with openings for low natural ventilation;
- Chemical reactor pumping station is provided with a shower including eye bath;
- Generator room walls were not sound proofed, sound attenuator was only provided on air inlet while nothing provided for the outlet one;
- Generator and transformer room is provided with forced ventilation but without sound attenuator; and
- Blower's room is provided with ventilation grids at low level and ventilation fan on the upper opposite levels as per standard practices.

We propose the following as safety improvement measures:

- Provide the main gate and external fences with an intruder alarm linked to the administrative building and guard house.
- The plant should be provided with surveillance cameras linked to the administrative building;
- The plant should be equipped with a fire alarm system and Fire frightening tools;
- Generator room walls should be totally sound proofed as per standard practices; and
- The generator room shall be provided with overhead monorail crane to facilitate maintenance works.

3.7 HEALTH, SAFETY AND ENVIRONMENT MANAGEMENT

The Project contractor, Degremont / BUTEC is requested to apply a QHSE plan as part of the signed contract that highlights the main impacts of the project construction phase and proposes control measures to address and mitigate these impacts. CDR HSE regulations ensure Project compliance with national legislation and regulations. Degremont also applies its internal QHSE policy where more stringent measures are required. The Supervising Engineer who represents the contracting authority (CDR) must supervise the works and ensure that the CDR HSE requirements are implemented and shall report against any violation of these requirements to CDR. CDR Safety, Health and Environment regulations are presented in Appendix A.

During the operation period, the contractor will be responsible for monitoring aspects based on a DBO contract. In addition, a supervising engineer will be hired by the implementing agency (CDR) to supervise the proper operation of the plant.

4. FINDINGS AND RECOMMENDATIONS

The evaluation of Zahle WWTP unit operations and the unit processes treatment capacity aimed to determine whether there is any design concerns, deficiencies, missed or undersized equipment. This was achieved through the calculation of the theoretical treatment capacity of each major component in comparison with the applicable standards and established design guidelines. As a result, **no noncompliance issues were identified** in the design and it was confirmed that Zahle WWTP has the capacity to treat all the wastewater including the sewage collected through the project.

Although the current design of Zahle WWTP is compliant, some recommendations were made to further reduce the plant operation complexity, reduce refused solids production or ameliorate its dewatering quality. The evaluation findings and the proposed improvement measures include the following:

- A. To avoid the detrimental impact of returning high nutrient concentrated streams via the dewatering filtrate return, the provision of a holding tank capable of storing these flows during peak flow periods and then returning these concentrated streams during low flow periods shall be investigated. The estimated peak return flow of 400 m³/h can be reduced to about 235 m³/hr by shifting the operation of filter washing and sand classifier operation to low flow periods and provision of a holding tank to store the dewatering filtrates during peak flow periods.
- B. The WAS (wasted activated sludge) is pumped from the two (2) final settlement tank bottoms directly to the Gravity Drainage Decks (GDD) without passing through a WAS Receiving Tank (WRT). Such tank will provide a break between wasting and thickening, reducing the control complexity by allowing sludge thickening equipment to be fed independently. Thickening process handling WAS that can significantly and quickly vary in strength which requires frequent adjustment of chemical dosages.

Sludge thickening and dewatering processes are very sensitive to flow and mass loadings. Providing of an equalization facility (WAS Receiving tank) upstream of thickening and dewatering processes will minimize the variations in feed strength and flow will improve the performance and simplify plant operation control. We advise to build such equalizing tank to hold at least 250 to 500 m³ of activated sludge, equivalent to quarter to half of the daily plant sludge production.

Based on the design estimated wastewater flows and characteristics about 28,000 m³ of sludge (as 20% dry solids) would be produced in the year 2015 if the sewerage network is completely built and all houses in the plant catchment area were connected. The plant and the sewerage networks construction is still in progress. The estimated completion time for the plant construction is by October 2015. The sewerage network construction will expand at least till the end of 2017 taking into consideration the actual progress of works and estimated contracting time for the Sewerage expansion.

By reviewing the actual sewerage network coverage in Zahle and the network expansion work progress, and based on previous experience, it is estimated that only

about 30-40% of the anticipated design flows will reach the plant during the first two years of operation. The usage of the sludge as waste-covering material in the municipal landfill is to be considered at earlier stage. The produced sludge will reach a maximum of 11,000 m³ (as 20% dry solids) yearly. In the initial phase, first two years, the sludges must be discharged directly into the landfill, since the observation of the noxious-substance contents limits cannot be obtained. In the next phase, when the sludge quality data are established, its use in agriculture must be investigated.

Because of the great quantity of fresh produced sludge by the WWTP as estimated according to plant design ultimate flows and due to the limited capacity of Zahle sanitary landfill, this suggestion on waste disposal must not become final and the project administration shall consequently search for an economically valid and sustainable final waste disposal system. Sludge disposal is a common problem for most of the wastewater treatment plants in Lebanon and the Lebanese government will develop viable sludge disposal/recovery options by the completion of the sewerage expansion works.

Beside sludge, other waste materials are produced by the plant:

- Material produced during screening;
- Sand decanted in the sand separator; and
- Oil and grease separated upon entering the plant.

Screened material is collected in tanks beside the screening section and subsequently carried to the landfill. Washed sand can be used in building. Otherwise must be dumped in a landfill as coverage material. In the absence of a burning facility, oil and grease must be stocked in oiltight containers until future solutions are found.

The subject of the final sludge management plan and its final destination was not fully covered in this assessment report as this subject is out of the scope of this study.

C. the plant designer did not incorporate any sludge digester justifying this decision as the adopted BNR process made anaerobic stabilization less feasible because:

- The relatively long sludge age typically employed reduce the waste activated sludge (WAS) degradability such that self-sustaining biogas generation is more challenging;
- Raw sewage is fed to the activated sludge system to drive the BNR process, depriving the digester of readily biodegradable feed; and
- The digester return stream is nutrient rich, exacerbating the difficulties of achieving high levels of nitrogen and phosphorus removal.

BNR Waste activated sludge (WAS) only anaerobic digestion has been previously regarded as being high risk due to the low inherent degradability and lack of references. However, degradability testing (Coombabah WWTP, Australia) indicated this was a potential option, and two BNR WAS only mesophilic digesters were commissioned in early 2013. The digesters are fed waste activated sludge from an oxidation ditch facility operating at a nominal 15 d SRT, thickened to 5% solids using

gravity drainage decks. Since commissioning the digesters have achieved an average volatile solids destruction of about 30% consistently achieving Grade B quality biosolids. Gas production significantly exceeds the heating requirements generating an energy self-sufficient operation, including in winter.

Mesophilic anaerobic sludge digestion is well established at sewage treatment facilities worldwide. The technology offers significant reduction and stabilization of volatile solids, improved dewaterability and the generation of biogas (methane) with lower energy inputs than competing processes. Mesophilic digestion operates at elevated temperatures (typ. 35 - 40°C), with some of the generated methane used for heating the sludge, creating a self-sustaining process. Excess methane is potentially available for electrical power generation.

Accordingly, recommendations to further enhance plant performance are provided in Table 4-1. Where possible, costs were provided.

Table 4-1 Review Findings and Recommendations to further enhance plant performance

Areas of improvement	Recommended Solution	Anticipated Improvement	Cost
<p>Peak return flow is estimated to be about 400 m³/h resulting from dewatering supernatants in addition to back wash and sand classifier flows.</p>	<ul style="list-style-type: none"> - Provision of a holding tank capable for storing these flows during peak flow periods and deliver them during low flow periods. - Consider operating of the filter washing and sand classifier during low flow periods. 	<p>Reduce peak flows and eliminate the detrimental impact of returning nutrients with the dewatering supernatants recycled flows.</p>	<p>230,000 USD</p>
<p>The wasted activated sludge (WAS) is pumped from the final settling tanks directly to the gravity drainage decks (GDD) without passing through a WAS receival tank (WRT).</p> <p>Sludge thickening and dewatering processes are very sensitive to flow and mass loadings.</p>	<p>Provision of at least 250 m³ WAS receival and equalization tank, as a break between wasting and thickening phases. The tank of 250 m³ volume is adequate to handle quarter of the WAS volume produced in the plant per day.</p>	<p>The WAS receival tank (WRT) will:</p> <ul style="list-style-type: none"> - Provide a break between wasting and thickening phases, this reduces the control complexity as the sludge thickening equipment will be fed independently. - Reduce frequent sludge conditioner chemical dosages adjustment based on WAS flows strength. - Improve process performance as a result of minimizing variations in feed strength and flow when WRT is provided 	<p>200,000 USD</p>

Areas of improvement	Recommended Solution	Anticipated Improvement	Cost
<p>About 11,000 m³/year of sludge (as 20 % dry solids) would be produced at the initial stage (first two years of operation). Sludge is planned to be disposed in Zahle landfill for this stage till the full build of the sewerage networks, When the plant operates with complete network the sludge production can reach 28 000 m³ . This is considered to reduce approximately landfill capacity by half. Another sludge disposal schem shall be provided.</p> <p>Screening materials are also relayed to the landfill. Approximately 4 m³/day screened material are expected to be produced.</p>	<p>In the initial phase, first two years, the sludges must be discharged directly into the landfill, since the observation of the noxious-substance contents limits cannot be obtained.</p> <p>In the next phase, when the sludge quality data are established, its use in agriculture must be investigated.</p>	<p>upstream of thickening and dewatering phases</p> <p>These suggestions on waste disposal are initial solutions; the project administration shall consequently search for an economically valid and sustainable final waste disposal system with the consideration of the national government viable sludge disposal/recovery plan.</p>	<p>1.</p>
<p>About 7.5 m³/year of sand would be produced at the initial stage (Horizon 2015)</p>	<p>It is recommended to use washed Sand in building, otherwise it can be dumbered in a landfill as coverage material.</p>		
<p>There is no burning facility suggested to handle the resulted oil and grease.</p>	<p>Oil and grease must be stocked in oiltight containers until finding a proper solution for</p>	<p>National policy for oil and Grease disposal and management shall be established</p>	

Areas of improvement	Recommended Solution	Anticipated Improvement	Cost
	disposal.		
The plant is provided with standby power generators of 1.25 MVA.	It is recommended to isolate the non-critical loads. The isolation requires load-shedding provisions to the electrical distribution system for the non-critical loads; this must be considered at the time of designing of Motor Control Centres, the starters, and PLC programming.	The isolation of the critical loads will have significant effects on the generator sizing.	
Applying the full load to the generator in a single step, may lead to problems in the system due to the limits on maximum allowable voltage and frequency dips and the subsequent recovery time related to load applying on diesel generators.	It is recommended to understand the process flow to figure out the steps for starting, in addition to close coordination between the electrical and process components. The emergency load may be required to start in the first step, while the rest of the loads can be started with sequenced time delay.	Applying the load in multiple steps will address expected system problems and reduce the generator size.	
The assessment of the safety measures in Zahle WWTP indicated to deficiencies that may hinder proper operation of the plant.	<p>It is recommended to apply the following safety measures:</p> <ul style="list-style-type: none"> - Provide the main gate and external fences with an intruder alarm linked to the administrative building and guard house. - The plant should be provided with surveillance cameras linked to the administrative building; 	Applying these safety measures ensures proper operation of Zahle wastewater treatment plant.	

Areas of improvement	Recommended Solution	Anticipated Improvement	Cost
	<ul style="list-style-type: none"> - The plant should be equipped with a fire alarm system and Fire frightening tools; - Generator room walls should be totally sound proofed as per standard practices; and - The generator room shall be provided with overhead monorail crane to facilitate maintenance works. 		
<p>Sludge digestion was not incorporated in plant design. This was justified as the adopted BNR process made anaerobic stabilization less feasible because:</p> <ul style="list-style-type: none"> - The relatively long sludge age typically reduce the waste activated sludge(WAS) degradability such that self-sustaining biogas generation is more challenging; - Raw sewage is fed to the activated sludge system to drive the BNR process, which deprive the digester of readily 	<p>Provision of mesophilic digester for anaerobic digestion of WAS resulting from the plant. Mesophilic anaerobic sludge digestion is well established at wastewater treatment plants worldwide. This technology offers significant reduction and stabilization of volatile solids, improved dewatering ability and requires lower energy inputs. It is a self-sustaining process where it operates at elevated temperatures (typ. 35 - 40°C) using some of the generated methane for heating and the rest can be used for electrical power generation.</p>	<p>BNR waste activated sludge (WAS) anaerobic digestion has been previously seen to be not beneficial due to low inherent degradability and lack of references. However, degradability testing (Coombabah WWTP, Australie) indicated that mesophilic was a potential option. Two BNR WAS mesophilic digesters were commissioned in early 2013. The digesters are fed with WAS resulted of oxidation ditch facility operating at a nominal 15 d SRT, thickened to 5% solids using gravity drainage decks. Since commissioning, the digesters have achieved an average volatile solids destruction of</p>	<p>2,500,000 USD</p>

Areas of improvement	Recommended Solution	Anticipated Improvement	Cost
biodegradable feed; and - The digester return stream is nutrient rich, this exacerbate the difficulties of achieving high levels of nitrogen and phosphorus removal.		about 30% consistently resulting digested sludge classified as Grade B according to biosolids quality. Gas production significantly exceeded the heating requirements. This solution can be considered self-sufficient operation even in winter.	

5. REFERENCES

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GLUMRB, (2003) Recommended Standards for Water Works, Great Lakes–Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, Health Education Services, Albany, NY.

Metcalf & Eddy, Inc., (2003) Wastewater Engineering: Treatment and Reuse, 4th ed., McGraw-Hill, Boston.

Water Environment Federation (WEF) and the American Society of Civil Engineers, (1998). Urban Runoff Quality Management

APPENDIX A: LIST OF DOCUMENTS AND DRAWINGS

Item	Type
Process flow diagram	Document
Mass balance	Document
Hydraulic profile calculation note	Document
Material submittal/ sewerage pipes	Document
Process description	Document
Process description/ odor control	Document
Pretreatment/ report control philosophy	Document
Biological phosphorus removal treatment/ report control philosophy	Document
Aeration tanks - chemical reactors/ report control philosophy	Document
Clarification tanks and sludge pumping station/ report control philosophy	Document
Tertiary treatment and utilities/ report control philosophy	Document
Sludge treatment/ report control philosophy	Document
P&ID / identification system for P&ID drawings	Document
Chemical reactor data sheet/ aluminum sulphate dosing pumps	Document
Chemical reactor data sheet/ aluminum sulphate storage tank	Document
Main gate and fence details	Drawing
Main gate and fence implantation	Drawing
Fence and gate elevation sheet	Drawing
Handrails and ladders details	Drawing
Guard room plan sections and elevations	Drawing
Guard house/ plan section and elevation	Drawing

Item	Type
Schedule of steel doors and windows	Drawing
Schedule of wooden doors and windows	Drawing
Schedule of aluminum doors and windows	Drawing
Chemical reactor pumping station/ slab plan/ roof plan/ sections/ elevations and details	Drawing
Filtrazur/ architecture drawings/ plan view	Drawing
Filtrazur/ architecture drawings/ roof view	Drawing
Filtrazur/ architecture drawings/ sections	Drawing
Filtrazur/ architecture drawings/ elevation and details	Drawing
Flow metring/ plan/ roof plan/ sections/ elevations and details	Drawing
Blowers room/ electrical room/ plan view	Drawing
Blowers room/ electrical room/ roof	Drawing
Blowers room/ electrical room/ sections	Drawing
Blowers room/ electrical room/ elevations	Drawing
Dewatering building/ slab plan level	Drawing
Dewatering building/ sections	Drawing
Dewatering building/ elevations and roof plan	Drawing
Workshop and storage building/ elevations and sections	Drawing
Workshop and storage building/ plan view and roof	Drawing
Wastewater network/ river crossing typical section collectors	Drawing
P & I sim bology	Drawing
Hydraulic profile	Drawing
Off plant pumping station/ plan view/ elevations/ sections and details	Drawing

Item	Type
Pretreatment/ plan view	Drawing
Pretreatment/ elevations	Drawing
Pretreatment/ sections	Drawing
Reception cabin/ plan view and cross sections	Drawing
Administration building details	Drawing
Administration building/ schedule of openings	Drawing
Administration building/ elevations	Drawing
Administration building/ plan view	Drawing
Administration building/ roof plan	Drawing
Administration building/ sections	Drawing
General layout/ main sewer network	Drawing
General layout/ main sewer network and storm water network/ composite drawing	Drawing
Pretreatment/ P & ID/ coarse screening - pumping station/ fine screening	Drawing
Pretreatment/ P & ID/ grit and grease removal unit	Drawing
Distribution/ anaerobic tanks/ P & ID	Drawing
Aeration tank/ P & ID	Drawing
Clarification tanks/ sludge pumping station/ P & ID	Drawing
Tertiary treatment utilities/ P & ID/ filtration	Drawing
Tertiary treatment utilities/ P & ID/ disinfection UV/ metering utilities	Drawing
Sludge treatment/ P & ID	Drawing
Air treatment aspiration network/ P & ID	Drawing
Air treatment for odors control/ P& ID	Drawing
General single line diagram	Drawing

Item	Type
Automation system/ general architecture/ PLC and SCADA	Drawing
General/ electrical/ load list	Drawing
Coarse screening/ plan view and cross sections/ assembly drawings	Drawing
Pretreatment pumping station/ plan view and cross sections/ assembly drawings	Drawing
Fine screening/ plan view and cross sections/ assembly drawings	Drawing
Grease and grit removal tank/ plan view/ assembly drawings	Drawing
Grease and grit removal tank/ sections/ assembly drawings	Drawing
Anaerobic tanks/ plan view/ assembly drawings	Drawing
Anaerobic tanks/ cross sections/ assembly drawings	Drawing
Aeration and degassing tanks/ plan view/ assembly drawings	Drawing
Aeration and degassing tanks/ section and details/ assembly drawings	Drawing
Chemical reactor dosing pump station/ plan view and cross sections/ assembly drawings	Drawing
Clarification tanks/ plan view/ assembly drawings	Drawing
Clarification tanks/ section and details/ assembly drawings	Drawing
Sludge pumping station/ plan view and cross sections/ assembly drawings	Drawing
Feltzazur/ plan view/ assembly drawings	Drawing
Feltzazur/ sections and details/ assembly drawings	Drawing
UV disinfection/ plan view and sections/ assembly drawings	Drawing
Flow metering/ plan view and cross sections/ assembly drawings	Drawing
Blowers room/ electrical room/ plan view and section/ assembly drawings	Drawing
Blowers room/ electrical room/ sections/ assembly drawings	Drawing
Dewatering building/ plan view and cross sections/ assembly drawings	Drawing

Item	Type
Dewatering building/ polymer room/ assembly drawings	Drawing
Chemical reactor pumping station/ plan and section view/ civil guide drawings	Drawing

APPENDIX B: CDR HEALTH, SAFETY AND ENVIRONMENT REGULATIONS

CDR Safety, Health and Environment Regulations

Safety, Health and Environmental Regulations

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Preamble

The Safety, Health and Environmental Regulations are in two parts:

PART I - General Safety, Health and Environmental Regulations;

PART II - Supplementary Safety, Health and Environmental Regulations.

PART II shall have priority over PART I.

Whenever the term "Engineer" is used in these Safety, Health and Environmental Regulations, it shall be construed as defined in the Conditions of Contract.



Part I. General Safety, Health and Environmental Regulations

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Part I General Safety, Health and Environmental Regulations

1 Introduction

- 1.1 The prevention of injury and/or illness to site personnel and the public, damage to the Works and to public and private property, protection of the environment, and compliance with applicable laws, are primary objectives of CDR (the Employer). Because of the importance CDR places on meeting these objectives, selected minimum requirements are outlined in these Safety, Health and Environmental Regulations with which Contractors shall comply while working on CDR contracts. Given that these Regulations cannot cover every eventuality, the Contractor shall be expected to exercise good judgement in all such matters, even though not mentioned in these Regulations, and shall take any and all additional measures, as required or necessary, to meet his responsibility for safety, health and environmental matters during the period of the Contract.

CDR and its representatives shall not be held liable for any actions taken by the Contractor that are attributed to following the minimum requirements stated hereinafter.

- 1.2 The Contractor shall, throughout the execution and completion of the Works and the remedying of any defects therein:
- (a) have full regard for the safety of all persons on the Site and keep the Site and the Works in an orderly state appropriate to the avoidance of danger to any person;
 - (b) know and understand all laws governing his activities along with any site requirements and work site hazards. Such information shall be communicated by the Contractor to his personnel and subcontractors;
 - (c) take all necessary measures to protect his personnel, the Employer's personnel, other persons, the general public and the environment;
 - (d) avoid damage or nuisance to persons or to property of the public or others resulting from pollution, noise or other causes arising as a consequence of carrying out the Works.

2 Compliance with Regulations

- 2.1 The Contractor shall comply with the requirements of these Safety, Health and Environmental Regulations and all other applicable regulations or requirements under Lebanese laws, laid down by relevant authorities or issued by the Employer or the Engineer concerning safety, health and the environment, in force or introduced or issued from time to time during the period of the Contract.

In so far as these Regulations are applicable, they shall apply to sites and personnel outside the Site associated with the performance of the Contract.

- 2.2 The Regulations equally apply to subcontractors and all other parties engaged by the Contractor and their personnel. The Contractor shall ensure all such parties are fully aware of and comply with the Regulations.
- 2.3 The Contractor shall comply with all notifications and written or verbal instruction regarding safety issued pursuant to these Regulations by the Employer, Engineer or relevant authorities within the time specified in the notification or instruction.

Whenever the Contractor is required to obtain the approval, agreement, permission, etc of the Engineer, such approval, agreement, permission, etc shall not relieve the Contractor of his responsibilities and obligations under these Regulations or the Contract.

- 2.4 The Contractor shall adopt a positive approach, awareness and responsibility towards safety, health and the environment, and take appropriate action, by:
- (a) ensuring the Regulations are enforced and followed by the Contractor's personnel. Any failure by the Contractor's personnel to follow the Regulations, shall be regarded as a failure by the Contractor.
- (b) paying attention to possible injury to unauthorised persons entering the site, particularly children.

- 2.5 Whenever in these Regulations the Contractor is required to provide test certificates for equipment and personnel or to comply the relevant authorities' requirements and no independent test facilities are available or no relevant authorities exist in Lebanon, the Contractor shall provide:

- (a) in lieu of independent test certificates:
- for equipment - details of the tests and the date of the tests that have been carried out by the Contractor and a written statement that the Contractor has satisfied himself that the item of equipment is fit and safe for use;
 - for personnel - details of the training and experience and a written statement that the Contractor has satisfied himself that the person has the required level of competency;
- (b) in lieu of relevant authorities' requirements - details of the Contractor's own rules, regulations, requirements and procedures regarding safety, health and the environment.

If the Engineer is dissatisfied with the details provided by the Contractor, the Contractor shall provide further details or carry out further tests or provide further written statements as may be reasonably required by the Engineer.

When the Engineer has satisfied himself regarding the Contractor's own rules, regulations, requirements and procedures provided in accordance with (b) above, such rules, etc., shall be deemed to form part of these Regulations and to which Clause 3 shall equally apply.

3 Failure to Comply with Regulations

3.1 General

3.1.1 Should the Contractor fail to comply with any of the Regulations or requirements:

- (a) the Engineer may suspend the Works or part of the Works until the Contractor has taken necessary steps, to the satisfaction of the Engineer, to comply with the regulations or requirements.
- (b) the Employer may, following written notice to the Contractor, carry out themselves or arrange for another contractor to carry out such measures as they consider appropriate on behalf of the Contractor. Any such actions by the Employer shall not affect or diminish the Contractor's obligations or responsibilities under the Contract.
- (c) the Engineer may, following written notice to the Contractor specifying the breach or breaches of these Regulations by the Contractor, impose the fines stipulated in Sub-Clause 3.2. All deductions for fines by the Engineer will be subject to the approval of the Employer.
- (d) the Engineer may, by written notice of suspension to the Contractor, suspend all payments to the Contractor under the Contract if the Contractor fails to rectify any breach of the Regulations within the period specified by the Engineer, provided that such notice of suspension:
 - (i) shall specify the nature of the failure or failures; and
 - (ii) shall request the contractor to remedy each such failure within a specified period after receipt by the Contractors of such notice of suspension.

Such suspension of payment will remain in force until such time as the Contractor has rectified the breach or breaches to the satisfaction of the Engineer. No interest shall be paid on the suspended payments.

3.1.2 Failure to comply with the Regulations or requirements shall be considered a breach of contract by the Contractor and may result in termination of the Contract by the Employer.

3.1.3 In the event of the Employer or Engineer taking action based on Sub-Clause 3.1.1(a) or (b) or 3.1.2, the Contractor shall not be entitled to any additional costs or extension to the Contract Completion Date.

3.1.4 All costs incurred by the Employer pursuant to Sub-Clause 3.1.1(b) and the fines imposed on the Contractor by the Engineer under Sub-Clause 3.1.1(c) shall be deducted from amounts otherwise due to the Contractor.

3.2 Fines

3.2.1 Failures by the Contractor to comply with the Regulations or requirements are classified as follows:

F1 - breaches of Sub-Clause 5.6 (personal protective equipment);

F2 - breaches of Clause 7 (work in Public Areas);

F3 - breaches other than F1 and F2.

3.2.2 The basic fine for each classification in Sub-Clause 3.2.1, is as follows:

for F1 - \$100;

for F2 - \$500;

for F3 - \$200.

3.2.3 Fines will be applied as follows:

(a) for the first breach of each regulation or requirement - the basic fine. If the same or similar breaches occur in different situations or locations at the same time, the Engineer may apply fines for each situation or location; this will not apply to breaches related to personal protective equipment.

(b) for a second or subsequent breach of the same Regulation or requirement or failure to rectify a previous failure within the time specified by the Engineer - twice the basic fine.

4 General Requirements

4.1 Preamble

4.1.1 All references to safety shall be deemed to include health and the environment.

4.2 Safety Officer

4.2.1 The Contractor shall appoint a competent Safety Officer who shall be responsible for safety, health and the environment. The Safety Officer shall be given sufficient time by the Contractor to carry out his duties; minimum requirements shall be as follows:

Workforce on Site of over 250	-	full time Safety Officer;
Workforce on Site of 100-250	-	50% of Safety Officer's time;
Workforce on Site below 100	-	as required for the Works but a minimum of 5 hours per week of Safety Officer's time where more than 20 workers.

4.2.2 The Contractor shall provide the Safety Officer with appropriate identification, including a white hard hat with red cross symbol and a identification badge. The appointment of the Safety Officer shall be in writing and copied to the Engineer. The appointment shall include specific instructions to enforce these Regulations and delegated authority to take any action, measure or to issue instructions regarding their enforcement. All persons on Site shall be made aware of the name and authority of the Safety Officer and instructed to comply with any instruction or direction on safety matters, verbal or in writing, issued by the Safety Officer.

4.2.3 The Safety Officer shall be provided with a mobile phone or other similar means of communication. The Safety Officer shall be accessible and available at all times including outside normal working hours.

4.3 Safety Training

- 4.3.1 The Contractor shall provide safety induction training for all site personnel upon starting on site.
- 4.3.2 The Contractor shall provide safety refresher/reinforcement training at regular intervals for his staff.

4.4 Safety Meetings

- 4.4.1 The Contractor shall hold regular safety meetings to provide safety instructions and receive feedback from site personnel on safety, health and environmental matters. A weekly Safety Meeting shall be chaired by the Safety Officer and minutes shall be taken of the meeting. The meeting/minutes shall cover all relevant issues including actions to be taken. A copy of the minutes shall be given to the Engineer. The Safety Officer should attend the Contractor's weekly site meetings and "Safety" should be an item on the agenda.

4.5 Safety Inspections

- 4.5.1 The Safety Officer shall make regular safety inspections of the work site. The Safety Officer shall prepare a report of each inspection. This report shall include details of all breaches of these Regulations and any other matters or situations relating to safety found during the inspection, instructions issued by the Safety Officer and actions taken by the Contractor. A copy of the Safety Officer's inspection reports shall be given to the Engineer.

4.6 Control of Substances Hazardous to Health

- 4.6.1 Hazardous materials shall be stored in approved safety containers and handled in a manner specified by the manufactures and/or prescribed by relevant Authorities (see Sub-Clause 2.5).
- 4.6.2 Only properly trained and equipped personnel shall handle hazardous materials.

4.7 Potential Hazards

- 4.7.1 The Contractor shall inform employees of potential hazards, take appropriate steps to reduce hazards and be prepared for emergency situations.
- 4.7.2 The Contractor shall make an assessment of every operation involving hazardous substances. The assessment shall be recorded on a Hazardous and Flammable Substances Assessment Method Statement which shall be submitted to the Engineer prior to the delivery and use of the substance on Site.

4.8 Accident Reporting

- 4.8.1 The Contractor shall report all accidents and dangerous occurrences to the Engineer. The Contractor shall prepare a report on each accident or dangerous occurrence and a copy of the report, together with witness statements and any other relevant information, shall be submitted to the Engineer. A reportable accident or dangerous occurrence shall include any accident to any person on Site requiring medical attention or resulting in the loss of working hours or any incident that resulted, or could have resulted, in injury, damage or a danger to the Works, persons, property or the environment.
- 4.8.2 In the event of an accident or dangerous occurrence, the Contractor shall be responsible for completing all statutory notifications and reports. Copies of all statutory notifications and reports shall be passed to the Engineer.
- 4.8.3 All accidents and dangerous occurrences shall be recorded in a Site Accident Book. The Site Accident Book shall be available at all times for inspection by the Engineer.
- 4.8.4 The Contractor shall immediately rectify any situation or condition that could result in injury, damage or a danger to the Works, person, property or the environment. If the situation or condition cannot be corrected immediately, the Contractor shall provide temporary barriers and appropriate warning signs and devices and/or take other appropriate action necessary for the protection of persons, property and the environment.

4.9 Notices, Signs, etc.

- 4.9.1 All safety, health, environmental and other notices and signs shall be clearly displayed and written in both Arabic and either English or French. All requirements, instructions, procedures, etc., issued by the Contractor concerning these Regulations shall be printed in both Arabic and English and displayed and readily available to Contractor's personnel.

4.10 First Aid and Medical Attention

- 4.10.1 The Contractor shall have comprehensive First Aid Kit(s) on Site at all times. First Aid Kits shall be conveniently located and clearly identifiable.
- 4.10.2 The Contractor shall have one employee on site trained in first aid for every 25 employees. Such persons shall be provided with appropriate identification, including a red hard hat with a white "red cross" symbol and a identification badge.
- 4.10.3 The Contractor shall make contingency arrangements for calling a Doctor and transporting injured persons to hospital. The telephone numbers of the emergency services and the name, address and telephone number of the Doctor and nearest hospital shall be prominently displayed in the Contractor's site office.

4.11 Employee Qualifications and Conduct

- 4.11.1 The Contractor shall employ only persons who are fit, qualified and skilled in the work to be performed. All persons shall be above the minimum working age.

4.11.2 Contractor's personnel shall use the toilet facilities provided by the Contractor.

4.11.3 The Contractor shall ensure:

- (a) that no firearms, weapons, controlled or illegal substances or alcoholic beverages are brought onto the Site and that no personnel under the influence of alcohol or drugs are permitted on Site.
- (b) that all personnel obey warning signs, product or process labels and posted instructions.
- (c) that drivers or operators of vehicles, machinery, plant and equipment follow the rules for safe operations. Drivers shall wear seat belts and obey all signs and posted speed limits.

5 Safety Requirements

5.1 Personal Protective Equipment

- 5.1.1 The Contractor shall provide personal protective equipment, including hard hats, safety glasses, respirators, gloves, safety shoes, and such other equipment as required, and shall take all measures or actions for the protection and safety of Contractor's personnel.
- 5.1.2 Non-metallic hard hats shall be worn at all times by all personnel at the worksite with the exception of those areas where the Engineer has indicated it is not necessary to do so.
- 5.1.3 Safety glasses shall meet international standards and be available for use and worn in specified worksite areas. As a minimum, safety glasses shall be worn for the following types of work: hammering, chipping, welding, grinding, use of electrically powered or pneumatic equipment, insulation handling, spray painting, working with solvents, and other jobs where the potential of an eye injury exists. Face shields and/or monogoggles shall be worn where possible exposure to hazardous chemicals, cryogenic fluids, acids, caustics, or dust exists and where safety glasses may not provide adequate protection.
- 5.1.4 When handling acids, caustics, and chemicals with corrosive or toxic properties, suitable protection, such as acid suits or chemical resistant aprons and gloves, shall be worn to prevent accidental contact with the substance.
- 5.1.5 Personnel shall not be permitted to work whilst wearing personal clothing or footwear likely to be hazardous to themselves or others.
- 5.1.6 The wearing of safety shoes with steel reinforced toes is recommended for all Contractor's personnel on site. In all cases, Contractor's personnel shall wear substantial work shoes that are commensurate with the hazards of the work and the worksite area.

5.1.7 Hearing protection, including muffs, plugs or a combination thereof, shall be provided for all personnel operating in areas where the noise level exceeds 90 decibels. Such protection shall also be provided for operators working with equipment exceeding such a level. This may include equipment such as excavators, shovels, jackhammers, saws, drills, grinders, and the like are being used.

5.1.8 The Contractor shall encourage employees to wear substantial work gloves whenever practical and safe to do so.

5.2 Fire Protection and Prevention

5.2.1 The Contractor shall comply with fire protection instructions given by the Authorities having jurisdiction in regard to fire protection regulations.

5.2.2 The Contractor shall, upon moving on site, provide to the Engineer and the Authorities a fire prevention and evacuation plan. This shall include drawing(s) showing the fire assembly points. The fire prevention and evacuation plan and drawing(s) shall be updated from time to time as the Works progress. The Contractor shall ensure all personnel are fully informed on escape routes and assembly points and any changes thereto.

5.2.3 Fuel storage will not be permitted in construction work areas. Contractors may establish fuel storage tanks in special areas set aside for the purpose and approved by the Engineer. Storage tanks shall be adequately banded to control spillage. Fire extinguishers shall be provided and installed in a suitable nearby location.

5.2.4 Highly combustible or volatile materials shall be stored separately from other materials and as prescribed by relevant authorities and under no circumstances within buildings or structures forming part of the permanent Works. All such materials shall be protected and not exposed to open flame or other situations which could result in a fire risk.

5.2.5 No combustible site accommodation shall be located inside or within 10 metres of a building or structure forming part of the permanent Works, Where units have to be used in these circumstances, they shall be constructed of non-combustible materials and have a half-hour fire rating inside to outside and outside to inside. Non-combustible furniture shall be used where practical.

5.2.6 All temporary accommodation and stores shall be provided with smoke detectors and fire alarms.

5.2.7 Smoking shall be banned in high risk areas.

5.2.8 Expanded polystyrene with or without flame retarding additive, polythene, cardboard and hardboard shall not be used as protection materials.

5.2.9 Plywood and chipboard shall only be used as protection on floors. Vertical protection shall be non-combustible. Debris netting and weather protection sheeting shall be fire retardant.

- 5.2.10 When using cutting or welding torches or other equipment with an open flame, the Contractor shall provide a fire extinguisher close by at all times. All flammable material shall be cleared from areas of hot works, or work locations prior to welding or oxy/gas burning operations. All hot works shall cease half an hour before the end of a work shift to allow for thorough checking for fires or smouldering materials. Where appropriate, areas of hot works are to be doused in water before the shift ends.
- 5.2.11 An adequate number of fire extinguishers of types suited to the fire risk and the materials exposed shall be provided. These shall be placed in accessible, well-marked locations throughout the job site. Contractor's personnel shall be trained in their use. Extinguishers shall be checked monthly for service condition and replaced or recharged, as appropriate after use.
- 5.2.12 Only approved containers shall be used for the storage, transport and dispensing of flammable substances. Portable containers used for transporting or transferring gasoline or other flammable liquids shall be approved safety cans.
- 5.2.13 Fuel burning engines shall be shut off while being refuelled.
- 5.2.14 Adequate ventilation to prevent an accumulation of flammable vapours shall be provided where solvents or volatile cleaning agents are used.
- 5.2.15 Flammables shall not be stored under overhead pipelines, cable trays, electrical wires, or stairways used for emergency egress.
- 5.2.16 Paints shall be stored and mixed in a room assigned for the purpose. This room shall be kept under lock and key.
- 5.2.17 Oily waste, rags and any other such combustible materials shall be stored in proper metal containers with self-closing lids and removed every night to a safe area or off site. Every precaution shall be taken to prevent spontaneous combustion.

5.3 Electrical Safety

- 5.3.1 All temporary electrical installations, tools and equipment shall comply with current regulations dealing with on-site electrical installations.
- 5.3.2 The Contractor shall establish a permit-to-work system for work on or in proximity to energized circuits of any voltage. Contractor's personnel shall not commence work on such circuits unless a permit to work has been issued and adequate safety measures have been taken and the work operation has been reviewed and approved by the Engineer.
- 5.3.3 Only authorised personnel shall be allowed to work or repair electrical installations and equipment.
- 5.3.4 Portable tools and equipment shall be 110 volt, unless otherwise agreed by the Engineer.

- 5.3.5 When portable or semi-mobile equipment operates at voltages in excess of 110 volts, the supply shall be protected by a Residual Current Device (RCD) regardless of any such device fitted to the equipment. The RCD must have a tripping characteristic of 30 milliamps at 30 milliseconds maximum.
 - 5.3.6 All static electrically powered equipment, including motors, transformers, generators, welders, and other machinery, shall be properly earthed, insulated, and/or protected by a ground fault interruption device. In addition, the skin of metal buildings and trailers with electric service shall be earthed. Metal steps, when used, shall be securely fixed to the trailer.
 - 5.3.7 Lamp holders on festoon lighting shall be moulded to flexible cable and be of the screw in type. Clip on guards shall be fitted to each lamp unit.
 - 5.3.8 All tungsten-halogen lamps shall be fitted with a glass guard to the element. These lamps must be permanently fixed at high level.
 - 5.3.9 Electrical equipment shall be periodically inspected and repaired as necessary by competent persons.
 - 5.3.10 Any work on electrical equipment and systems shall be made safe through locking, tagging, and/or isolation of the equipment before work commences. Prior to the start of the work, the equipment or systems shall be tested to insure that they have been properly de-energized and isolated.
 - 5.3.11 Electrical repair work on energized systems shall be avoided whenever possible.
 - 5.3.12 Electrical trouble shooting shall be conducted only after getting written approval of the Engineer.
 - 5.3.13 Unauthorized personnel shall not enter enclosures or areas containing high voltage equipment such as switch gear, transformers, or substations.
- 5.4 Oxygen/Acetylene/Fuel Gases/Cartridge Tools**
- 5.4.1 Compressed oxygen shall never be used in the place of compressed air.
 - 5.4.2 Flash-back (Spark) arrestors shall be fitted to all gas equipment.
 - 5.4.3 Liquid Petroleum Gas (LPG) cylinders shall not be stored or left in areas below ground level overnight. Cylinders must be stored upright.
 - 5.4.4 The quantity of oxygen, acetylene and LPG cylinders at the point of work shall be restricted to a maximum of one day's supply. Cylinders shall be kept in upright vertical rack containers or be safely secured to a vertical support.
 - 5.4.5 Cartridge tools shall be of the low velocity type. Operators must have received adequate training in the safe use and operation of the tool to be used.

5.5 Scaffolding/Temporary Works

- 5.5.1 No aluminium tube shall be used, except for proprietary mobile towers, unless otherwise agreed with the Engineer.
- 5.5.2 Drawings and calculations shall be submitted to the Engineer, prior to commencement of work on site, for all Temporary Works, including excavations, falsework, tower cranes, hoists, services and scaffolding. Design shall conform to international standards.
- 5.5.3 The Engineer will not approve Temporary Work designs but the Contractor shall take account of any comments on such designs made by the Engineer.
- 5.5.4 The Contractor shall inspect and approve all Temporary Works after erection and before access, loading or use is allowed. Completed and approved Temporary Works shall be tagged with a scaff-tag or similar safety system and the Safe Structure insert displayed. For scaffolding, one tag shall be displayed every 32 m² of face area. A central record system shall be kept on all Temporary Work. Temporary Works shall be inspected weekly and similarly recorded.
- 5.5.5 All mobile scaffold towers shall be erected in accordance with the manufacturer's instructions and a copy of these shall be submitted to the Engineer prior to any use on site. Additionally, all towers shall be erected complete with access ladder, safety rails and kick boards whatever the height.
- 5.5.6 The Contractor shall repair or replace, immediately, any scaffold including accessories, damaged or weakened from any cause.
- 5.5.7 The Contractor shall ensure that any slippery conditions on scaffolds are eliminated as soon as possible after they occur.
- 5.5.8 All scaffolds used for storing materials, for brick or block laying, for access to formwork or for any other purpose where materials may accidentally fall, shall be provided with wire mesh guards or guards of a substantial material, in addition to kick boards.

5.6 Use of Ladders

- 5.6.1 Manufactured ladders shall meet the applicable safety codes for wood or metal ladders. Metal ladders shall not be used where there is any likelihood of contact with electric cables and equipment. All metal ladders shall be clearly marked: "Caution - Do not use around electrical equipment".
- 5.6.2 Job made ladders shall not be permitted.
- 5.6.3 Extension or straight ladders shall be equipped with non-skid safety feet, and shall be no more than 12 m in height. The maximum height of a step ladder shall be 2 m. Ladders shall not be used as platforms or scaffold planks.
- 5.6.4 Ladders rungs and steps shall be kept clean and free of grease and oil.

5.6.5 Extension and straight ladders shall be tied off at the top and/or bottom when in use. Only one person shall be allowed on a ladder at a time.

5.6.6 Defective ladders shall be taken out of service and not used. Ladders shall not be painted and shall be inspected for defects prior to use.

5.7 Elevated Work

5.7.1 The Contractor shall provide all personnel, while working at an elevated position, with adequate protection from falls. Details of such protection shall be submitted to and approved by the Engineer.

5.7.2 The Contractor shall carry out daily inspections of all elevated work platforms. Defects shall be corrected prior to use.

5.7.3 Roofing & Sheet Material Laying

(a) A Method Statement detailing the procedures to be adopted shall be submitted to and agreed with the Engineer prior to commencement of work on site.

(b) Mobile elevating work platforms or the equivalent shall be used to install roofing and sheet materials wherever practicable and a suitable base is available.

5.7.4 Erection of Structures

(a) A Method Statement detailing the procedures to be adopted shall be submitted and agreed with the Engineer prior to commencement of work on site.

(b) Safety harnesses and lines shall be provided by the Contractor for use by the erection personnel and worn at all times.

(c) Mobile elevating work platforms or the equivalent shall be used to erect structures wherever practicable and a suitable base is available.

5.7.5 Mobile Elevating Work Platforms

Operators shall be trained in the safe use of such platforms and hold a current Certificate of Competence (see Sub-Clause 2.5).

5.7.6 Hoists

(a) A copy of the current Test Certificate (see Sub-Clause 2.5) shall be submitted to the Engineer before any hoist (personnel or material) is brought into operation on the site. Where the range of travel is increased or reduced a copy of the revised Test Certificate shall be submitted.

(b) Each landing gate shall be fitted with a mechanical or electrical interlock to prevent movement of the hoist when any such gate is in the open position.

(c) Safety harnesses must be worn and used by personnel erecting, altering and dismantling hoists.

5.7.7 Suspended Cradles

- (a) Suspended cradles shall be installed, moved and dismantled by a specialist contractor.
- (b) Suspended cradles shall comply with local regulations.
- (c) All powered suspended cradles shall incorporate independent safety lines to overspeed braking devices and independent suspension lines for personal safety harness attachment.

5.8 Use of Temporary Equipment

- 5.8.1 The safe design capacity of any piece of equipment shall not be exceeded, nor shall the equipment be modified in any manner that alters the original factor of safety or capacity.
- 5.8.2 Mobile equipment shall be fitted with suitable alarm and motion sensing devices, including backup alarm, when required.
- 5.8.3 The Contractor shall ensure that the installation and use of equipment are in accordance with the safety rules and recommendations laid down by the manufacturer, taking into account the other installations already in place or to be installed in the future.
- 5.8.4 The Contractor shall inspect Equipment prior to its use on the Works and periodically thereafter to ensure that it is in safe working order. Special attention shall be given to such items as cables, hoses, guards, booms, blocks, hooks and safety devices. Equipment found to be defective shall not be used and immediately removed from service, and a warning tag attached.
- 5.8.5 Natural and synthetic fiber rope made of material such as manila, nylon, polyester, or polypropylene shall not be used as slings if approved by the Engineer.
- 5.8.6 Only trained, qualified and authorized personnel shall operate equipment. All drivers and operators shall hold a current Certificate of Training Achievement for the equipment being used (see Sub-Clause 2.5).
- 5.8.7 A safety observer shall be assigned to watch movements of heavy mobile equipment where hazards may exist to other personnel from the movement of such equipment, or where equipment could hit overhead lines or structures. The observer shall also ensure that people are kept clear of mobile equipment and suspended loads.
- 5.8.8 When mobile or heavy equipment is traveling onto a public thoroughfare or roadway, a flagman shall insure that traffic has been stopped prior to such equipment proceeding. While the mobile or heavy equipment is traveling on a public roadway, a trailing escort vehicle with a sign warning of a slow-moving vehicle that is dangerous to pass shall be provided.

5.8.9 Cranes:

- (a) The Contractor shall give a minimum of 48 hours notice to the Engineer prior to bringing a mobile crane on site.
- (b) No cranes shall be erected on the site without the prior approval of the Engineer. The Engineer may direct the Contractor as to locations where cranes may not be located. The Contractor shall take such directions into account when submitting his proposals for crane location points, base footings, pick up points and swing radius. Compliance with any such direction shall not entitle the Contractor to any extension of the Period of Completion or to any increase in the Contract Price.
- (c) Safety harnesses shall be worn and used at all times by personnel engaged on the erection, alterations and dismantling of tower cranes.
- (d) The Contractor shall provide a copy of the current Test Certificate (see Sub-Clause 2.5) to the Engineer before any crane (tower or mobile) is brought into operation on the Site.
- (e) All lifting tackle must hold a current Test Certificate (see Sub-Clause 2.5). All lifting tackle must be thoroughly examined every 6 months and an inspection report raised.
- (f) All fibrous/webb slings shall be destroyed and replaced 6 months after first use.
- (g) All crane drivers/operators shall hold a Certificate of Training Achievement for the class of crane operated (see Sub-Clause 2.5).
- (h) All banksman/slingers shall hold a Training Certificate from a recognized training agency (see Sub-Clause 2.5).
- (i) Only certified slingers/banksmans shall sling loads or guide crane/load movement.
- (j) The maximum weekly working hours of a crane driver or banksman shall be restricted to 60 hours.
- (k) Under no circumstances, shall a crane or load come within 4 m of any energized overhead power line or other critical structure.

5.9 Locking-out, Isolating, and Tagging of Equipment

- 5.9.1 Equipment that could present a hazard to personnel if accidentally activated during the performance of installation, repair, alteration, cleaning, or inspection work shall be made inoperable and free of stored energy and/or material prior to the start of work. Such equipment shall include circuit breakers, compressors, conveyors, elevators, machine tools, pipelines, pumps, valves, and similar equipment.
- 5.9.2 Where equipment is subject to unexpected external physical movement such as rotating, turning, dropping, falling, rolling, sliding, etc., mechanical and/or structural constraints shall be applied to prevent such movement.

5.9.3 Equipment which has been locked-out, immobilized, or taken out of service for repair or because of a potentially hazardous condition shall be appropriately tagged indicating the reason it has been isolated and/or taken out of service.

5.9.4 Where safety locks are used for locking out or isolating equipment, the lock shall be specially identified and easily recognized as a safety lock.

5.10 Installation of Temporary or Permanent Equipment

5.10.1 During installation and testing the Contractor's specialist engineer shall be in attendance.

5.10.2 All control mechanism panel and wiring diagrams shall be available and printed in both Arabic and either English or French.

5.11 Laser Survey Instruments

5.11.1 Details of the types and use of laser instruments shall be submitted and agreed with the Engineer.

5.12 Working in Confined Spaces

5.12.1 Confined spaces, including tanks, vessels, containers, pits, bins, vaults, tunnels, shafts, trenches, ventilation ducts, or other enclosures where known or potential hazards may exist, shall not be entered without prior inspection by and authorisation from the Site Safety Officer and the issuance of a Hazardous Work Permit.

5.12.2 Prior to entering the confined space, the area shall be completely isolated to prevent the entry of any hazardous substances or materials which could cause an oxygen deficient atmosphere. All equipment that could become energized or mobilized shall be physically restrained and tagged. All lines going into the confined space shall be isolated and/or blanked.

5.12.3 Personnel working in a confined space where emergency escape or rescue could be difficult, shall wear a safety harness attached to a lifeline.

5.12.4 A qualified attendant(s), trained and knowledgeable in job-related emergency procedures, shall be present at all times while persons are working within the confined space. The attendant shall be capable of effecting a rescue, have necessary rescue equipment immediately available, and be equipped with at least the same protective equipment as the person making entry.

5.12.5 All equipment to be used in a confined space shall be inspected to determine its acceptability for use. Where a hazard from electricity may exist, equipment utilized shall be of low voltage type.

5.12.6 The atmosphere within the confined space shall be tested to determine it is safe to enter. Acceptable limits are:

- oxygen: 19.5% lower, 22% higher;
- flammable gas: not to exceed 10% of lower explosion limit;

- toxic contaminants: not to exceed the permissible exposure limit.

Subsequent testing shall be done after each interruption and before re-entering the confined space, as well as at intervals not exceeding 4 hours. Continuous monitoring is preferable and may be necessary in certain situations.

5.12.7 Adequate ventilation shall be provided to ensure the atmosphere is maintained within acceptable limits.

5.13 Demolition

5.13.1 A detailed Method Statement detailing the demolition procedures/techniques to be used shall be submitted to and approved by the Engineer prior to commencement of work on site.

The Method Statement must include full details of measures to be taken to ensure that there are no persons remaining in the building/structure and to distance members of the public and Contractor's personnel from the building/structure prior to demolition.

5.14 Use of Explosives

5.14.1 The Contractor shall not use explosives without the written permission from the Engineer and relevant authorities (see Sub-Clause 2.5).

5.14.2 The Contractor shall observe all regulations regarding proper purchasing, transportation, storage, handling and use of explosives.

5.14.3 The Contractor shall ensure that explosives and detonators are stored in separate special buildings. These secured buildings shall be constructed, located and clearly marked in Arabic and English:

"DANGER - EXPLOSIVES"

all as approved by the Engineer and relevant authorities (see Sub-Clause 2.5).

5.14.4 The Contractor shall ensure that all possible precautions are taken against accidental fire or explosion, and ensure that explosives and detonators are kept in a proper and safe condition.

5.14.5 The Contractor shall ensure that explosives and detonators are always transported in separate vehicles and kept apart until the last possible moment and that metallic tools are not used to open boxes of explosives or detonators.

5.14.6 Blasting Procedure: the Contractor shall carry out blasting operations in a manner that will not endanger the safety of persons and property. The Contractor shall, along with other necessary precautions:

- (a) clear all persons from buildings and the area affected by the blasting. All such persons shall be given adequate notice of the actual time and date of blasting,

- (b) ensure that police and other local authorities are kept fully informed, in advance, of the blasting programme so that they may be present when blasting takes place if they so require,
- (c) erect warning notices around the area affected that blasting operations are in progress,
- (d) carry out a thorough search of buildings and the area affected prior to blasting,
- (e) ensure that blasting is only carried out by experienced shot firers. Priming, charging, stemming and shot firing shall be carried out with greatest regard for safety and in strict accordance with the rules and regulations of the relevant authorities (see Sub-Clause 2.5).
- (f) ensure that explosive charges are not excessive, charged boreholes are properly protected and proper precautions are taken for the safety of persons and property.

5.14.7 The Contractor shall maintain an up-to-date inventory of all explosives and explosive devices and shall submit a monthly report to the Engineer, detailing the use of all explosives by date and location.

5.15 Excavation and Trenching

5.15.1 An excavation permit signed by the Engineer must be issued before excavation proceeds in any work location. The Contractor shall investigate and identify the location of existing services by study of the drawings, a visual/physical study of the site, sweeping by appropriate detection equipment and where necessary hand excavation of trial holes.

Following this investigation, the Contractor shall submit a written request for an excavation permit to the Engineer.

The Engineer will return the permit signed and dated to indicate:

- services which are to be maintained.
- services which are to be isolated.
- any special precautions to be taken.

A sample Excavation Permit is given in Appendix 1.

5.15.2 The issue of an Excavation Permit by the Engineer shall not relieve the Contractor of his responsibilities under the Contract.

5.15.3 The side of all excavations and trenches exceeding 1.3 meters in depth which might expose personnel or facilities to danger resulting from shifting earth shall be protected by adequate temporary supports or sloped to the appropriate angle of repose.

5.15.4 All excavations, slopes and temporary supports shall be inspected daily and after each rain, before allowing personnel to enter the excavation.

- 5.15.5 Excavations 1.3 metres or more in depth and occupied by personnel shall be provided with ladders as a means for entrance and egress. Ladders shall extend not less than 1 metre above the top of the excavation.
- 5.15.6 The Contractor shall provide adequate barrier protection to all excavations. Barriers shall be readily visible by day or night.
- 5.15.7 Excavated or other materials shall not be stored at least 0.65 metres from the side of excavations.

5.16 Concrete Reinforcement Starter Bars

- 5.16.1 The Contractor shall ensure concrete reinforcement starter bars are not a danger to personnel. Where permitted by the Engineer, starter bars shall be bent down. Alternatively, the starter bars shall be protected using either hooked starters, plastic caps, plywood covers or other methods agreed with the Engineer.

6 Environmental and Health Requirements

6.1 Protection of the Environment

- 6.1.1 The Contractor shall be knowledgeable of and comply with all environmental laws, rules and regulations for materials, including hazardous substances or wastes under his control. The Contractor shall not dump, release or otherwise discharge or dispose of any such material without the authorisation of the Engineer.
- 6.1.2 Any release of a hazardous substance to the environment, whether air, water or ground, must be reported to the Engineer immediately. When releases resulting from Contractor action occur, the Contractor shall take proper precautionary measures to counter any known environmental or health hazards associated with such release. These would include remedial procedures such as spill control and containment and notification of the proper authorities.

6.2 Air Pollution

- 6.2.1 The Contractor, depending on the type and quantity of materials being used, may be required to have an emergency episode plan for any releases to the atmosphere. The Contractor shall also be aware of local ordinances affecting air pollution.
- 6.2.2 The Contractor shall take all necessary measures to limit pollution from dust and any windblown materials during the Works, including damping down with water on a regular basis during dry climatic conditions.
- 6.2.3 The Contractor shall ensure that all trucks leaving the Site are properly covered to prevent discharge of dust, rocks, sand, etc.

6.3 Water Pollution

6.3.1 The Contractor shall not dispose of waste solvents, petroleum products, toxic chemicals or solutions in the city drainage system or watercourse, and shall not dump or bury garbage on the Site. These types of waste shall be taken to an approved disposal facility regularly, and in accordance with requirements of relevant Authorities. The Contractor shall also be responsible to control all run-offs, erosion, etc.

6.4 Solid Waste

6.4.1 General Housekeeping

- (a) The Contractor shall maintain the site and any ancillary areas used and occupied for performance of the Works in a clean, tidy and rubbish-free condition at all times.
- (b) Upon the issue of any Taking-Over Certificate, the Contractor shall clear away and remove from the Works and the Site to which the Taking-Over Certificate relates, all Contractor's Equipment, surplus material, rubbish and Temporary Works of every kind, and leave the said Works and Site in a clean condition to the satisfaction of the Engineer. Provided that the Contractor shall be entitled to retain on Site, until the end of the Defects Liability Period, such materials, Contractor's Equipment and Temporary Works as are required by him for the purpose of fulfilling his obligations during the Defects Liability Period.

6.4.2 Rubbish Removal and Disposal

- (a) The Contractor shall comply with statutory and municipal regulations and requirements for the disposal of rubbish and waste.
- (b) The Contractor shall provide suitable metal containers for the temporary storage of waste.
- (c) The Contractor shall remove rubbish containers from site as soon as they are full. Rubbish containers shall not be allowed to overflow.
- (d) The Contractor shall provide hardstandings for and clear vehicle access to rubbish containers.
- (e) The Contractor shall provide enclosed chutes of wood or metal where materials are dropped more than 7 metres. The area onto which the material is dropped shall be provided with suitable enclosed protection barriers and warning signs of the hazard of falling materials. Waste materials shall not be removed from the lower area until handling of materials above has ceased.
- (f) Domestic and biodegradable waste from offices, canteens and welfare facilities shall be removed daily from the site.
- (g) Toxic and hazardous waste shall be collected separately and be disposed of in accordance with current regulations.

(h) No waste shall be burnt on Site unless approved by the Engineer.

6.4.3 Asbestos Handling and Removal

The Contractor shall comply with all local regulations regarding the handling of asbestos materials. In the absence of local regulations, relevant International Standards shall apply.

6.4.4 Pest Control

The Contractor shall be responsible for rodent and pest control on the Site. If requested, the Contractor shall submit to the Engineer, for approval, a detailed programme of the measures to be taken for the control and eradication of rodents and pests.

6.5 Noise Control

6.5.1 The Contractor shall ensure that the work is conducted in a manner so as to comply with all restrictions of the Authorities having jurisdiction, as they relate to noise.

6.5.2 The Contractor shall, in all cases, adopt the best practicable means of minimizing noise. For any particular job, the quietest available plant/and or machinery shall be used. All equipment shall be maintained in good mechanical order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable. Stationary noise sources shall be sited as far away as possible from noise-sensitive areas, and where necessary acoustic barriers shall be used to shield them. Such barriers may be proprietary types, or may consist of site materials such as bricks or earth mounds as appropriate.

6.5.3 Compressors, percussion tools and vehicles shall be fitted with effective silencers of a type recommended by the manufacturers of the equipment. Pneumatic drills and other noisy appliances shall not be used during days of rest or after normal working hours without the consent of the Engineer.

6.5.4 Areas where noise levels exceed 90 decibels, even on a temporary basis, shall be posted as high noise level areas.

7 Additional Requirements for Work in Public Areas

7.1 General

7.1.1 These additional requirements shall apply to all works carried out in Public Areas.

7.1.2 Public Areas are defined as areas still used by or accessible to the public. These include public roads and pavements, occupied buildings and areas outside the Contractor's boundary fencing.

7.1.3 All work in Public Areas shall be carried out to minimise disturbance and avoid dangers to the public.

- 7.1.4 Before commencing work, the Contractor shall ensure that all necessary resources, including labour, plant and materials, will be available when required and that the works will proceed without delays and be completed in the shortest possible time. Periods of inactivity and slow progress or delays in meeting the agreed programme for the works, resulting from the Contractor's failure to provide necessary resources or other causes within the control of the Contractor, will not be accepted. In the event of such inactivity, slow progress or delays, the Contractor shall take immediate action to rectify the situation, including all possible acceleration measures to complete the works within the agreed programme.

Details of the actions and acceleration measures shall be submitted to the Engineer. If the Engineer is dissatisfied with the Contractor's proposals, the Contractor shall take such further actions or measures as required by the Engineer. All costs incurred shall be the responsibility of the Contractor.

7.2 Method Statement

- 7.2.1 The Contractor shall submit to the Engineer a method statement for each separate area of work in Public Areas. The Method Statement shall include:
- (a) a general description of the Works and methodology of how it will be carried out.
 - (b) details of the measures and temporary works to minimise disturbance and safeguard the public. These shall include temporary diversions, safety barriers, screens, signs, lighting, watchmen and arrangements for control of traffic and pedestrians and advance warning to be given to the public.
 - (c) details of temporary reinstatement and maintenance of same prior to final reinstatement.
 - (d) for works involving long lengths of trenches or works to be completed in sections, the lengths or sections of each activity (eg up to temporary reinstatement, temporary reinstatement, final reinstatement) to be carried out at any one time.
 - (e) details of the availability of necessary resources (labour, plant, materials, etc) to complete the work.
 - (f) a programme showing start and completion dates and periods for all activities of each length or section, including temporary works, and the works overall.
 - (g) such further information as necessary or required by the Engineer.
- 7.2.2 The Contractor shall not commence work, including temporary works, until approval of the Contractor's Method Statement by the Engineer.
- 7.2.3 Method Statements shall be updated based on actual progress or as and when required by the Engineer.

7.3 Closure of Roads, etc.

7.3.1 The closure or partial closure of roads, pavements and other public areas will only be permitted if approved by the Engineer and Relevant Authorities. The Contractor shall detail for each closure the extent of area to be closed, the reasons and duration of the closure and, where appropriate, proposed diversions.

A sample Street Closure Permit is given in Annex 2.

7.4 Trench and Other Excavations

7.4.1 The requirements covering trench and other excavations will depend on the location and type of the excavation and the potential risks to the public.

7.4.2 The following guidelines apply particularly to trenches but shall also apply to other types of excavations:

(a) before commencing work the Contractor shall:

- notify the Engineer on the location and duration of the work. An excavation permit signed by the Engineer must be issued in accordance with Sub-Clause 5.15.1 before excavation proceeds in any work location;
- obtain permission from relevant authorities including the police when required;
- erect all temporary works such as barriers, warning signs, lighting, etc;
- have available adequate materials for temporary supports to sides of excavations and necessary labour, plant and materials to complete the work within the shortest possible time;

(b) in carrying out the works the Contractor shall, unless otherwise permitted or required by the Engineer:

- not open more than one excavation within a radius of 250 metres;
- limit the length of trench excavation open at one time to 150 metres;
- maintain and alter or adapt all temporary works including supports to sides of excavations;
- remove all surplus excavated material the same day it is excavated;
- complete the works, including final reinstatement within ten days;
- where final reinstatement is not achieved within the required time, to carry out temporary reinstatement;
- ensure that any temporary reinstatement is maintained at the correct level until final reinstatement is achieved.

7.4.3 The above guidelines shall not relieve the Contractor of his obligations and responsibilities.

7.5 Safety Barriers

- 7.5.1 Safety barriers shall be provided to the perimeter of work areas and to trench and other types of excavations and to existing openings such as manholes, drawpits and the like. When exposed to the public, safety barriers shall be provided to both sides of trenches and around all sides of openings.
- 7.5.2 The Contractor shall provide details of the type or types of safety barriers for each excavation for the approval of the Engineer prior to commencing work. No work shall commence until the safety barriers are in place.
- 7.5.3 The type of safety barrier used shall be appropriate to the particular location and the potential risks to the public. Examples of different types of safety barriers are given below:
- Type 1 - excavated material;
 - Type 2 - non-rigid barrier of rope or florescent tape strung between metal rods driven into the ground;
 - Type 3 - rigid barrier of timber, steel or concrete. Such barriers could be in the form of horizontal rail(s) or sheet material secured to posts driven or concreted into the ground.
- 7.5.4 The following are guidelines on the type of safety barriers that could be used in differing situations. They apply particularly to trenches but also apply to other types of excavations, existing openings and to the perimeter of work areas:
- areas not subject to vehicular traffic - Types 1 or 2;
 - roadways (low traffic speed) - Types 1 or 2;
 - roadways (high traffic speed) - Types 1 or 3.
- 7.5.5 The above examples of the types of barriers and the guidelines on situations in which they could be used shall not relieve the Contractor of his obligations and responsibilities.

8 Contractor's Site Check List

- 8.1 A sample Contractor's Site Check List is included in Annex 3. This is included to assist contractors should they wish to introduce such a system as part of their site management procedures. The list is not exhaustive and further items will need to be added by the Contractor.
- 8.2 The list is issued for guidance only, and does not, in any way, revise or limit the requirements covered elsewhere in these Regulations.

Contractor's Site Check List

Annex 1

Sample Excavation Permit

To: (Engineer)

From: (Contractor) Date:

CDR Contract No:

Request for Excavation Permit No:

Please give approval for excavation to proceed in the following area:

Work to start on:

Existing services have been checked and identified by:

Drawings	#	Physical Survey	#
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Catscan	#	Trial Holes Excavation	#
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Signed (Contractor):

Approval of Engineer

The above excavation may proceed, subject to the following:

Services to be maintained:

Services to be isolated before work proceeds:

Other matters:

Signed (Engineer):

Date:

Contractor's Site Check List

Annex 2

Sample Street Closure Permit

To: (Engineer)

From: (Contractor) Date:

CDR Contract No:

Request for Street Closure Permit No:

Please give approval for the closure of the following street(s) from to
(dates)

Street(s):

Reasons:

Proposed diversions:

Signed (Contractor):

Approval of the Engineer

The above street(s) may be closed for the periods stated subject to the following conditions:

Approval has been given by relevant authorities and the police;

Other:

Signed (Engineer):

Date:

Contractor's Site Check List

Annex 3

Sample Contractor's Site Check List

Safe Access:

- arrangements for visitors and new workers to the site
- safe access to working locations
- walkways free from obstructions
- edge protection to walkways over 2m above ground
- holes fenced or protected with fixed covers
- tidy site and safe storage of materials
- waste collection and disposal
- chutes for waste disposal, where applicable
- removal or hammering down of nails in timber
- safe lighting for dark or poor light conditions
- props or shores in place to secure structures, where applicable

Ladders:

- to be used only if appropriate
- good condition and properly positioned
- located on firm, level ground
- secure near top. If not possible, to be secured near the bottom, weighted or footed to prevent slipping
- top of ladder minimum 1 metre above landing place

Scaffolding:

- design calculations submitted
- proper access to scaffold platform
- properly founded uprights with base plates
- secured to the building with strong ties to prevent collapse
- braced for stability
- loadbearing fittings, where required
- uprights, ledgers, braces and struts not to be removed during use
- fully boarded working platforms, free from defects and arranged to avoid tipping or tripping

- securely fixed boards against strong winds
- adequate guard rails and toe boards where scaffold 2m above ground
- designed for loading with materials, where appropriate
- evenly distributed materials
- barriers or warning notices for incomplete scaffold (ie not fully boarded)
- weekly inspections and after bad weather by competent person
- record of inspections

Excavation:

- underground services to be located and marked and precautions taken to avoid them
- adequate and suitable timber, trench sheets, props and other supporting materials available on site before excavation starts
- safe method for erecting/removal of timber supports
- sloped or battered sides to prevent collapse
- daily inspections after use of explosives or after unexpected falls of materials
- safe access to excavations (eg sufficiently long ladder)
- barriers to restrict personnel/plant
- stability of neighbouring buildings
- risk of flooding
- materials stacked, spoil and vehicles away from top of excavations to avoid collapse
- secured stop blocks for vehicles tipping into excavations

Roof Work:

- crawling ladders or boards on roofs more than 10 degrees
- if applicable, roof battens to provide a safe handhold and foothold
- barriers or other edge protection
- crawling boards for working on fragile roof materials such as asbestos cement sheets or glass. Guard rails and notices to same
- rooflights properly covered or provided with barriers
- during sheeting operations, precautions to stop people falling from edge of sheet
- precautions to stop debris falling onto others working under the roof work

Transport and Mobile Plant:

- in good repair (e.g. steering, handbrake, footbrake)
- trained drivers and operators and safe use of plant
- secured loads on vehicles

- passengers prohibited from riding in dangerous positions
- propping raised bodies of tipping lorries prior to inspections
- control of on-site movements to avoid danger to pedestrians, etc.
- control of reversing vehicles by properly trained banksmen, following safe system of work

Machinery and Equipment:

- adequate and secured guards in good repair to dangerous parts, e.g. exposed gears, chain drives, projecting engine shafts

Cranes and Lifting Appliances:

- weekly recorded inspections
- regular inspections by a competent persons
- test certificates
- competent and trained drivers over 18 years of age
- clearly marked controls
- checks by driver and banksman on weight of load before lifting
- efficient automatic safe load indicator, inspected weekly, for jib cranes with a capacity of more than one tonne
- firm level base for cranes
- sufficient space for safe operation
- trained banksman/slinger to give signals and to attach loads correctly, with knowledge of lifting limitations of crane
- for cranes with varying operating radius, clearly marked safe working loads and corresponding radii
- regularly maintenance
- lifting gear in good condition and regularly examined

Electricity:

- measures to protect portable electric tools and equipment from mechanical damage and wet conditions
- checks for damage to or interference with equipment, wires and cables
- use of the correct plugs to connect to power points
- proper connections to plugs; firm cable grips to prevent earth wire from pulling out
- "permit-to-work" procedures, to ensure safety
- disconnection of supplies to overhead lines or other precautions where cranes, tipper lorries, scaffolding, etc. might touch lines or cause arcing

Cartridge Operated Tools:

- maker's instruction being followed
- properly trained operators, awareness of dangers and ability to deal with misfires
- safety goggles
- regular cleaning of gun
- secure place for gun and cartridges when not in use

Falsework/Formwork:

- design calculations submitted
- method statement dealing with preventing falls of workers
- appointment of falsework coordinator
- checks on design and the supports for shuttering and formwork
- safe erection from steps or proper platforms
- adequate bases and ground conditions for loads
- plump props, on level bases and properly set out
- correct pins used in the props
- timberwork in good condition
- inspection by competent person, against agreed design before pouring concrete

Risks to the Public:

- identify all risks to members of the public on and off site, e.g. materials falling from scaffold etc., site plant and transport (access/egress) and implement precautions, e.g. scaffold fans/nets, banksmen, warning notices etc.
- barriers to protect/isolate persons and vehicles
- adequate site perimeter fencing to keep out the public and particularly children. Secure the site during non-working periods
- make safe specific dangers on site during non-working periods, e.g. excavations and openings covered or fenced, materials safely stacked, plant immobilised, ladders removed or boarded

Fire - General:

- sufficient number and types of fire extinguishers
- adequate escape routes, kept clear
- worker awareness of what to do in an emergency

Fire - Flammable Liquids:

- proper storage area

- amount of flammable liquid on site kept to a minimum for the day's work
- smoking prohibited; other ignition sources kept away from flammable liquids
- proper safety containers

Fire - Compressed Gases, e.g. Oxygen, LPG, Acetylene:

- properly stored cylinders
- valves fully closed on cylinders when not in use
- adopt "hot work" procedures
- site cylinders in use outside huts

Fire - Other Combustible Materials:

- minimum amount kept on site
- proper waste bins
- regular removal of waste material

Noise:

- assessment of noise risks
- noisy plant and machinery fitted with silencers/muffs
- ear protection for workers if they work in very noisy surroundings

Health:

- identify hazardous substances, eg asbestos, lead, solvents etc and assess the risks
- use of safer substances where possible
- control exposure by means other than by using protective equipment
- safety information sheets available from the supplier
- safety equipment and instructions for use
- keep other workers who are not protected out of danger areas
- testing of atmosphere in confined spaces; provision of fresh air supply if necessary. Emergency procedures for rescue from confined spaces

Manual Handling:

- avoid where risk of injury
- if unavoidable, assess and reduce risks

Protective Clothing:

- suitable equipment to protect the head, eyes, hands and feet where appropriate
- enforce wearing of protective equipment

Welfare:

- suitable toilets
- clean wash basin, hot/warm water, soap and towel
- room or area where clothes can be dried
- wet weather gear for those working in wet conditions
- heated site hut where workers can take shelter and have meals with the facility for boiling water
- suitable first aid facilities

Work in Public Areas

- all risks to the public identified
- method statement approved
- road closures approved
- temporary diversions in place
- safety barriers erected/maintained
- safety signs and lighting installed/maintained
- labour, materials, plant and other resources sufficient to meet programme
- temporary reinstatement completed and properly maintained
- permanent reinstatement completed at earliest possible date

Part II Supplemental Safety, Health and Environmental Regulations

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Sub-Clause 6.6:
Contamination of Water
Supplies

Add the following Sub-Clause 6.6:

- (i) No person shall be employed on the Contract who is suffering from an enteric infection or who is a carrier of typhoid or other waterborne disease.
- (ii) Any staff engaged in work prescribed by the Contract as involving a risk to potable water supplies shall be tested to ensure that he is not a carrier of typhoid or other waterborne disease.

A register shall be kept on Site showing the name, address and date of test of each man so tested.

- (iii) Should any person on the Works be attacked by an illness associated with looseness of the bowels, this shall be promptly reported to the Employer's Representative. The Employer's Representative may then instruct that the person affected be suspended temporarily or permanently from the Contract, or be employed only on certain parts of the Works.
- (iv) The Employer's medical officer may at any time examine any or all of the Contractor's personnel to confirm that they are not suffering from, or carriers of, enteric infections, typhoid or other waterborne disease.
- (v) Adequate sanitary accommodation and washing facilities shall be provided for any part of the Works where men are working.

Sub-Clause 7.1: General

Add the following to Sub-Clause 7.1:

When carrying out work in public roads the Contractor shall comply with Legislative Decree No. 68: Enactment Governing Excavation Works to layout lines of Public Utility in Streets and their Servitudes dated 9 September 1983 issued by the President of the Council of Ministers.”