Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.1 – GENERAL REQUIREMENTS

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ABBREVIATIONS AND ACRONYMS

AFD	Agence Française de Développement
amsl	Above Mean Sea Level
AWWA	American Water Works Association
CWWDA	Coast Water Works Development Agency
DAF	Dissolved Air Flotation
DI	Ductile Iron
DN	Nominal Diameter
DTM	Digital Terrain Model
ESIA	Environmental and Social Impact Assessment
FS	Feasibility Study
FIDIC	International Federation of Consulting Engineers
GIS	Geographical Information System
GoK	Government of Kenya
GRP	Glass Reinforced Plastic
HDPE	High Density Polyethylene
KPLC	Kenya Power and Lighting Company
MIBP	Mangat I.B. Patel Limited
MOWASSCO	Mombasa Water Supply and Sanitation Company Limited
MWS&I	Ministry of Water, Sanitation and Irrigation
NK	Nippon Koei
NML	North Mainland
NPSH	Net Positive Suction Head
NTU	Nephelometric Turbidity unit
O&M	Operation & Maintenance
RAP	Resettlement Action Plan
RCC	Roller Compacted Concrete
RWPS	Raw Water Pump Station
SML	South Mainland
ST	Steel
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
THM	Trialomethanes
ToR	Terms of Reference
USD	US Dollar

UV	Ultraviolet
WASREB	Water Services Regulatory Board
WB	World Bank
WHO	World Health Organization
WML	West Mainland
WTP	Water Treatment Plant

1. GENERAL

1.1. REFERENCE TO OTHER CHAPTERS

Throughout the Specifications and Prices Schedules, references are occasionally made to other Chapters. All such references are intended solely for the convenience of those using the documents, and the absence of a reference in no manner excludes the application of every other Chapter in the Specifications which may, in the opinion of the Engineer, have any bearing upon the point in question, the intention being that the Contract Documents shall be read and applied as a whole.

1.2. EXISTING FACILITIES WITHIN THE SITE OF WORKS

The proposed sites for the WTP, RWPS and RWPM are within an area which has already been acquired by the Client for the Dam construction and associated components (refer to Section 2.1 – The Site). It is expected that at the time the WTP Contractor mobilises to site, the Dam Contractor shall be active on site.

Power supply – KPLC power supply is available within close proximity of the site. The Contractor shall be responsible for application and payment of any temporary power supply for construction.

Access to site – Temporary / permanent access roads in close proximity to the site have been constructed by the Dam Contractor.

1.3. NON-DISCLOSURE OF INFORMATION

The Contractor shall not without the consent in writing of the Employer disclose particulars of the Contract to any person or furnish or publish or permit to be furnished or published any information with regard to the Employer's business to any person save in so far as may be necessary for the due performance of the Contract and shall preserve strict confidence with regard to any information of a confidential or secret nature received from the Employer or the Engineer.

2. PROJECT SITE

2.1. THE SITE

The Site shall be deemed to include all areas on which temporary and permanent Works are to be constructed, all other areas made available to the Contractor for the execution of the Works and all roads, tracks and footpaths whether private or public between the various parts of the Works. The site is detailed in sections 2.2 – 2.9.

2.2. USE OF LAND AND RIGHT OF WAY

A. The Contractor will, during the execution of the Works, have free and temporary use of working areas and accesses thereto, of the land shown in the Contract. The working areas will include space for the Contractor and the Engineer's offices, camps, stores, yards, constructional plant, temporary roads, parking areas and other temporary works. The Contractor's proposal for temporary works including overall layout plan in conformity with the Tender Documents shall be included in the Contractor proposal.

All use of land is subject to the Engineer's approval.

If the area of the sites is found to be inadequate, the Contractor shall make his own arrangements for all additional working areas in the vicinity of the Works or elsewhere for his site compound, offices, temporary accommodation and living facilities, for offices for the Engineer's Representative.

B. Apart from transport to and from these areas the Contractor shall confine his operations under the Contract to these areas. Before entering any working sites, the Contractor shall give 30 days' notice to the Engineer in writing. Such notices shall be given for each occupation of the working sites.

C. Before entering any additional working sites (if any) the Contractor shall obtain and forward to the Engineer a copy of the written consent of the owner or occupier or Authority having charge of the land stating the purposes for which such land is to be used by the Contractor, and defining the extent and periods of his occupation for which such consent is granted. Notwithstanding the requirements of such consent, additional working sites shall be protected by fences or barriers or other works as required by the Engineer. Wherever practicable a passage shall be maintained for vehicles and pedestrians along public roads and to all adjacent properties.

D. In the event of the Contractor making use of any special temporary way leave or additional accommodation acquired by him pursuant to the Conditions of Contract hereof or any trip for the disposal of surplus materials he shall obtain and forward to the Engineer a copy of the written consent of the owner and occupier or Authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record to be agreed by the Engineer of the condition of the surfaces of the land before entering thereon. The Contractor will not be permitted to occupy space in public roads or thoroughfares along the route of pipelines nor additional accommodation except with the written consent of the Engineer, whose consent will not be given unless the Contractor shall have first obtained the written consent of the Authority concerned and having charge of the road surface.

E. Temporary fences and barriers

Temporary chain-link fences or hoarding shall be provided by the Contractor for the Working Sites.

Where there is no existing fencing or boundary walls the Contractor shall provide, erect before commencing the Works and maintain in good condition to the satisfaction of the Engineer temporary fencing in positions around the Contractor's areas shown on the Drawings or where directed by the Engineer. Except where otherwise specified fencing shall be close-boarded 2400 mm high for WTP Sites or chain link for the remaining area; he shall provide lockable gates at each site entrance.

The Contractor shall remove all temporary fencing on completion of the Works, except for such fencing, or parts thereof as the Engineer may direct to be left in place in good condition for the Employer's use.

F. Temporary buildings etc, Classified as temporary works

Starting from the Commencement date, the Contractor shall have to bear the cost of management of all temporary buildings and/or works.

G. Notice boards / Project sign boards

The Contractor shall manufacture 3 notice boards / project sign boards and erect them as directed by the Engineer. The notice boards shall be fabricated and erected as per the drawing provided as part of the Tender Drawings. The cost of fabrication, installation and any payment demanded by local authorities shall be deemed to be covered under the Contractor financial proposal. Boards shall be minimum 3.00 x 4.00 m and painted galvanized steel plates with support of steel pipes. The Contractor shall be responsible for maintaining this notice boards up to end of the Contract.

H. Advertising and publicity

Advertising will not be allowed on any hoarding whether temporary or permanent, or on any other part of the Works, except such as the Employer may require for this own purposes.

The Contractor shall obtain the permission of the Employer before publishing any article describing the Works. The Engineer's permission shall be obtained before any member of the public is allowed to inspect the Works. All visitors will be required to sign a form of indemnity.

2.3. PROJECT LOCATION

The proposed site is located at Fulugani village, Kasemeni Ward, Kinango Sub-County of Kwale County – Kenya, about 22 km northwest of Mombasa City.

The proposed WTP site lies along a crest situated southeast of the dam reservoir. Approximate location is WGS 84, UTM37M – 558680E, 9559640S with an approx. elevation ranging from 129 masl (metres above mean sea level) to 119 masl.

The site for the Raw Water Pumping Station (RWPS) is located along Mwache river, downstream of the proposed Mwache Dam (approx. 0.5Km). The altitude of the RWPS is estimated as 41m amsl.

The proposed site location of the WTP including the Raw Water Pumping Station (RWPS), relative to the proposed Mwache dam is illustrated in Figure 1.

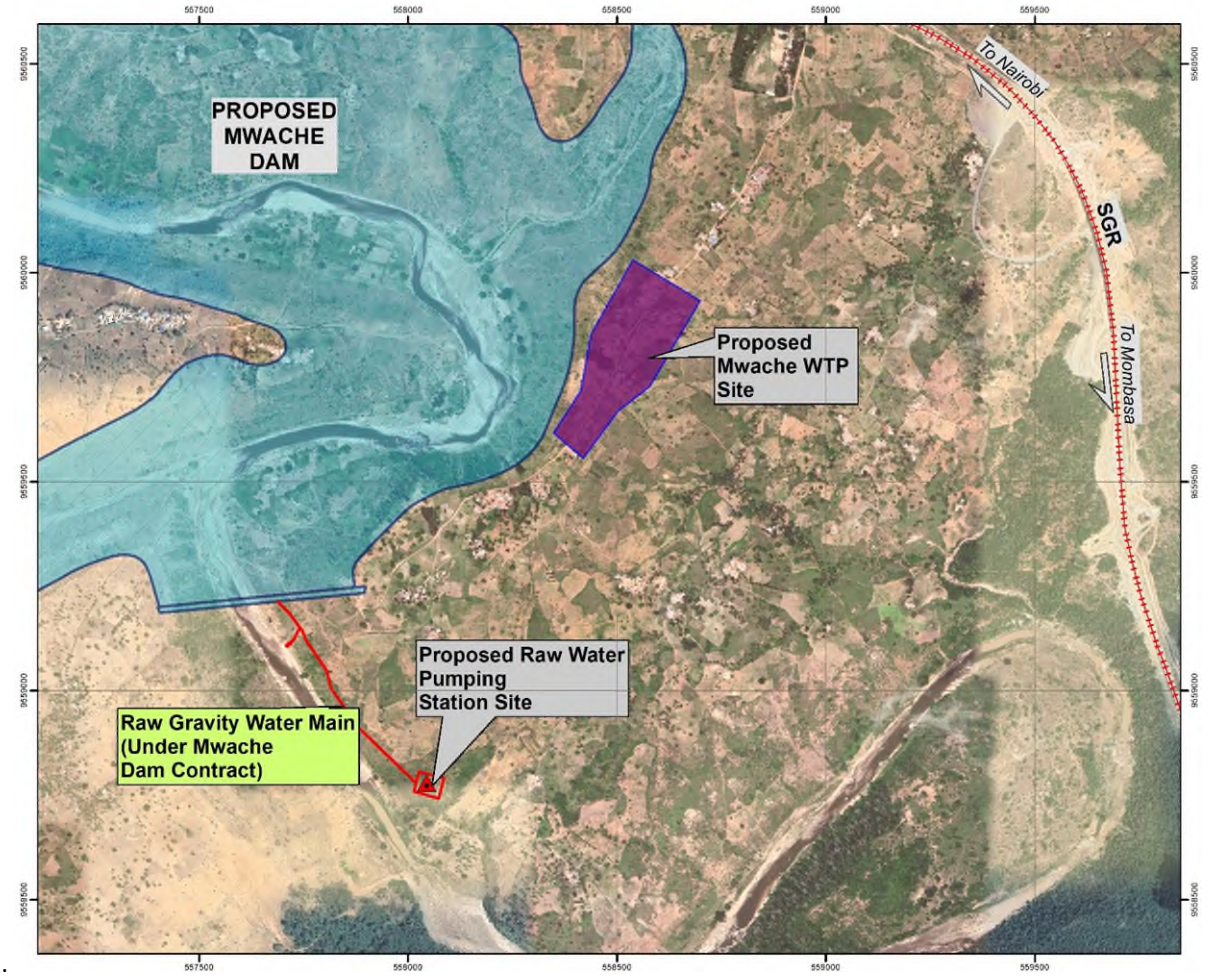

Figure 1: Location of construction site for WTP – Source - Preliminary Design Report (Artelia/MIBP-Nov.2021)

Photos of the proposed WTP and RWPS site are given in Figure 2 and 3 respectively.

Figure 2 : Photos of selected WTP site

Figure 3 : Photos of proposed RWPS site

2.4. SPECIAL CONDITIONS AND HAZARDS

The Contractor shall observe the following conditions when drawing up his proposal for traffic access to the Sites and such proposals shall be submitted to the Engineer for his approval before implementation.

- Access roads for the Dam Contractor
- Location of access gates to suit the agreed traffic plan;
- Restricted headroom due to flyovers and overhead cables;

- Restricted loading to existing services, manholes, etc;
- Existing and new (under Dam Contract) buildings in the locality particularly sensitive (e.g. schools and hospitals), due to their use or condition, to undue noise and vibration;
- Access to private and public properties and buildings.
- High voltage overhead cables

2.5. TRAFFIC ARRANGEMENTS

The proposed sites for the WTP and RWPS are within an area which has already been acquired by the Client for the Dam construction and associated components. It is expected that by the time the WTP Contractor mobilises to site, the Dam Contractor will already be active. The Dam Contractor is responsible for the construction works of the access roads outside the WTP site.

Traffic arrangements within the Dam area but outside the WTP site shall be made in close liaison with the Dam Contractor. Any associated costs of liaison with the Dam Contractor, especially relating to heavy traffic and associated mitigation of damage to the road infrastructure constructed by the Dam Contractor shall be deemed to be covered in the Contractor's proposal.

The Contractor shall seek information on and comply with all requirements and recommendations of the police regarding traffic safety measures. The Contractor shall observe all weight and dimensions restrictions which apply to roads and tracks in Kenya and he shall comply with all reasonable restrictions which may from time to time be imposed by the Engineer, Employer, Police, responsible authority or owner. Where damage to roads and tracks is caused by the Contractor, this shall be repaired at the Contractor's expense. The Engineer's decision on responsibility of damage and reinstatement costs will be final and be binding.

Plans for re-routing traffic along public streets during occupation of the Working Sites will be arranged by the Contractor, and after the approval of the Engineer, with the appropriate Government Authorities which include the Traffic Police.

The Contractor shall provide, erect and maintain during his occupation all barriers and traffic signs as required by the Authorities or instructed by the Engineer. All signs must comply with standard international practice or as otherwise required by the traffic authorities. All written notices on signs shall be in English languages.

The Contractor shall arrange with the owners and occupiers of properties alternative temporary access and shall submit details of such agreed temporary access arrangements where necessary.

The Contractor shall liaise and arrange directly with the Authorities, all required traffic arrangements for transportation of equipment and materials. In all cases, he will comply with the traffic regulation.

2.6. AMENITIES TO BE PRESERVED

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be trimmed or felled except as authorised by the Engineer.

All lights provided by the Contractor shall be so placed or screened as not to interfere with the use of adjacent buildings, road users, traffic or signal lights or other equipment of the Employer or other authority.

The Contractor shall store and place all materials, plant and appliances in such a manner as to prevent them causing injury or damage to persons or property and at a safe distance from roads, tracks and footpaths.

2.7. PROTECTION AND DIVERSION OF EXISTING SERVICES

The Contractor shall be responsible for notifying the service authorities and the Engineer of his intention to expose the services and where so required by the service authority shall not commence operations until the service authority is represented on Site.

The Contractor shall excavate, protect until backfill and backfill in a manner so as not to damage the services.

As soon as a service is encountered in the excavation whether previously located or discovered during the course of excavation for the Permanent Works the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.

The Contractor shall be responsible for maintaining all such services including natural and artificial watercourses encountered by him in the construction of the Works and shall make good any damage caused directly or indirectly by his activities.

2.8. PROTECTION OF ANTIQUITIES AND FOSSILS

As soon as antiquities or fossils are encountered during the course of any excavation, the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.

Vulnerable parts of the discovered antiquities of fossils shall be protected by the Contractor as may be reasonable required by the Engineer.

No requirement of the Specifications regarding the disposal of material arising from site clearance or excavation shall override any provision in the Conditions of Contract as to the discovery of ownership, of fossils, coins, articles of value or antiquity of anything of geological or archaeological interest found on the Site.

2.9. TRANSPORTATION OF MATERIALS AND EQUIPMENT

The Contractor shall take all reasonable precautions to ensure that public streets and thoroughfares used by him either for the construction of the Works or for the transport of plant, labour and materials are not made dirty as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer the Contractor shall take all necessary and immediate steps to clean them.

Vehicles shall be thoroughly cleaned down before leaving the Sites and shall be so loaded that spillage therefore is prevented. Particular care shall be observed when disposing of slurry type material in a highly fluid condition which may additionally be contaminated with bentonite.

Each individual site must be kept clean during the work and must be thoroughly cleaned upon completion.

3. SITE CONDITIONS

3.1. GENERAL

A site investigation has been carried out for the WTP site, a copy of the Geotechnical Investigation Report including the borehole logs and laboratory results, has been included as part of the Tender documents.

The Contractor shall draw his own conclusion from the Geotechnical Report and the Client will not take any responsibility of any conclusion the Contractor may draw thereof.

3.2. SEISMICITY

The evaluation of the ground acceleration to use for the structural calculations will be done in accordance with applicable Kenyan Standards and Eurocodes 8 . In the event of variation, the higher standard shall be adopted.

3.3. CLIMATE

The project area is in the coastal region of Kenya neighbouring the Indian Ocean. The monsoon wind system brings two rainfall seasons. Between January and March, the coast is dominated by the relatively dry north-east monsoon. Between March and September, the monsoon winds blow east to southeast bringing in air from the Indian Ocean. From September, the winds change direction once again and bring more rain. Most of rainfall occurs between March and July and between October and December.

The historical meteorological conditions for the proposed Project site are summarized in the table below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	27.7	28.0	28.4	27.5	26.2	24.9	24.0	24.1	24.7	25.7	26.7	27.5
Relative Humidity (%)	67.5	65.5	67.9	73.3	76.6	75.6	77.3	75.5	73.2	72.9	73.8	71.4
Wind Speed (m/s)	2.75	2.67	2.40	2.75	2.98	3.08	2.99	2.83	2.83	2.68	2.08	2.39
Mean Monthly Rainfall (mm)	33.9	21.4	55.6	84.0	90.3	34.5	27.2	29.3	31.6	60.7	94.7	71.9

Source: *Mwache Multi-Purpose Dam - Phase I; Detailed Design Report – Feb. 2018.*

The above Table gives the mean monthly rainfall. Daily historical rainfall data is available at Kenya Meteorological Department and if required by the Contractor should be obtained at their own cost.

3.4. PROTECTION AND DIVERSION OF EXISTING SERVICES

A. The Contractor shall be responsible for notifying the service authorities and the Engineer of his intention to expose the services and where so required by the service authority shall not commence operations until the service authority is represented on Site.

B. The Contractor shall excavate, protect until backfill and backfill in a manner so as not to damage the services.

C. As soon as a service is encountered in the excavation whether previously located or discovered during the course of excavation for the Permanent Works the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.

D. The Contractor shall be responsible for maintaining all such services including natural and artificial watercourses encountered by him in the construction of the Works and shall make good any damage caused directly or indirectly by his activities.

4. SCOPE OF WORKS

4.1. DESCRIPTION

4.1.1. Parts of the Contract

The Contract includes:

- Firm Part: Design, Build and Operate for Mwache Water Treatment Plant and Mwache raw Water Pumping Station and associated facilities for a treated water production of 93,000 m3/day (Phase 1).

- Conditional Part: Design, Build and Operate for Mwache Water Treatment Plant for an additional treated water production of 93,000 m3/day (Phase 2).

The final capacity of the Plant (Firm and Conditional Part) is therefore 186,000 m3/day.

The Bid Design shall cover the WTP and associated components to the full capacity of 186,000m3/d and shall clearly indicate the components to be implemented in Phase 1 and Phase 2 in compliance with the Employer's Requirements.

Upon award, the Contractor shall prepare detailed designs for the WTP and associated components to their full capacity (186,000m3/d) regardless of the issuance of notification for the Conditional Part. The cost for preparation of detailed designs for the full capacity is to be covered under Schedule 1, item 1.10 (Firm Part).

The table below presents a description of the Works to be implemented for each part:

	Firm Part	Conditional Part
Raw Water Pumping Station	• **Civil Works for final capacity** • **Power supply (High or Medium voltage) for final capacity** • **SCADA system for final capacity** • **Equipment, low voltage electrical works and instrumentation for intermediate capacity (Phase 1)**	• **Equipment, low voltage electrical works and instrumentation for additional capacity (Phase 2)**
Raw water Pumping Mains	• **All necessary works for the implementation of the pumping mains for the final capacity**	• **None**
Water Treatment plant	• **Power supply (High or Medium voltage) for final capacity** • **SCADA room and system for final capacity** • **Civil Works, Equipment, low voltage electrical works and instrumentation for intermediate capacity (Phase 1)**	• **Civil Works, Equipment, low voltage electrical works and instrumentation for additional capacity (Phase 2)**
Treated Water Tank	• **All necessary works for the implementation of the treated water tank for the final capacity**	• **Connection Works of equipment for Phase 2**
Chemicals storage and preparation	• **Civil Works for final capacity** • **Power supply (High or Medium voltage) for final capacity** • **SCADA system for final capacity**	• **Equipment, low voltage electrical works and instrumentation for additional capacity (Phase 2)**

	• **Equipment, low voltage electrical works and instrumentation for intermediate capacity (Phase 1)**	
Workshop	• **For final capacity**	• **None**
Administration building	• **For final capacity**	• **None**
Laboratory	• **For final capacity**	• **None**
Gatehouse	• **For final capacity**	• **None**
Landscaping and roads	• **For final capacity**	• **None**

For more details, refer to the respective price schedules.

4.1.2. Firm Part

The components covered in the firm part of this contract will include the following:

- Raw Water Pumping Station (final capacity 8,900m3/hr) which optimizes energy costs by utilizing the varying water levels in the Dam:
  - **Design and built for the final capacity (8,900 m3/hr): Civil Works, Power supply, Electrical room, SCADA System, fire system, alarm system, drinking water supply, drainage, roads, landscape, security, gatehouse.**
  - **Design and built for the intermediate capacity (4,450 m3/hr): Electromechanical Equipment pipes and fittings, valves, LV boards, instrumentation.**

- Raw Water Pumping Main of approx. length 1.9Km and design capacity of 2.47m^3/s. The TDH varies from 44m to 90m,

- Water Treatment Plant (WTP) with a clear water tank and associated facilities

Water supply facilities (includes an elevated RC tank and pumping system) for the new base camp, clinic, police station (constructed under the Dam Contract) within the vicinity of the Dam with a proposed production capacity of **93,000 m^3/d,** expected to comprise of the following key units:

- Inlet works incorporating raw water flow measurement;
- Pre-treatment if needed
- Coagulation-flocculation;
- Clarifiers or dissolved air flotation for clarification of flocculated water, including sludge removal facilities;
- Sand filters, including filter gallery and filter control room;
- Calco-carbonic balance;
- Disinfection facilities;
- Clear water tank , storage capacity 15,000m3;
- Pump house and air blower room with pumps and air blowers for backwashing of filters;
- Sludge drying beds;
- Backwash water lagoons, and backwash water recirculation pumps;

- Chemical storage building for all reagents. The civil works will be designed and built for the final capacity of the WTP, i.e 186,000 m3/day;
- Disinfection unit. The civil works will be designed and built for the final capacity of the WTP, i.e 186,000 m3/day;
- Administration building, including laboratory;
- Barrack for the staff and families;
- Workshop & store;
- Generator house & switch room;
- Access Roads;
- Gate house.

- Administration building
- Training of the Employer's staff
- Operation and maintenance for 24 months

The services to be provided by the Contractor include, but are not limited to the following:

- Design and additional studies
  - **Execution of any additional studies that may be deemed necessary by either the Engineer, Contractor or any statutory body.**
  - **Additional geotechnical survey (for final capacity)**
  - **Additional topographical survey (for final capacity)**
  - **Preparation of a design report of the installations answering the program fixed by the Employer's Requirements.**
  - **Documents forming the application for building permit (English language), including the architect's drawings and layouts, and in particular the landscaping aspects, so that the Employer has only to file this application to the concerned authorities.**
  - **The preparation of guide drawings, working design drawings for the civil engineering structures, reinforced concrete drawings and calculation notes, drawings and calculation notes for the roads and utilities networks, drawings and diagrams of equipment, erection and dismantling drawings, in compliance with the detailed design accepted by the Employer.**

- Implementation

Works to be carried out by the Contractor include but are not limited to the following:

- **Installation of the site and execution of preparatory works, connection to telecoms, water, electricity and other services.**
- **Adopting mitigating measures provided in the ESIA Reports already agreed with the AFD. In addition, if need be, these documents (ESIA, IEE, EMP, DDR) should be updated and/or preparation of renewal plan. The Client will acquire an ESIA license. However, the Contractor may be required to carry out additional studies as per AFD, World Bank and NEMA guidelines for specific work components / sites including camps. The cost of compliance , including payments demanded by authorities, to additional studies in regard to this shall be deemed to be covered in the Contractor's financial proposal.**
- **Preparation and adopting the management plans as stipulated in the Project ESIA.**
- **Implementation of civil works in accordance with the approved detailed design, as specified in the General Conditions of Contract, including in particular:**
  - preliminary drillings and investigations for the existing facilities and networks, if necessary,
  - earthworks and final backfilling, drainage (including removal and storage of materials and earth),

  - special foundations, if necessary
  - all shell construction (concrete, reinforced concrete, masonry, framework, roofing, sealing, cladding, etc.),
  - all finishing and fitting works for the plant,
  - fences, roads and utilities networks,
  - demolition of existing structures to be removed, if any, including pipes and the reuse or removal and dumping of the corresponding materials in locations authorized by local legislation, and levelling of the land thus freed,
  - connection of the new installations with existing structures (pipes),
  - all pipes, whatever the position, as described on the drawings
- **Implementation of the treatment process in conformity with a detailed design and process flow diagram including:**
  - Pumping station
  - Fine screening (if necessary)
  - Acidification
  - Coagulation – Flocculation – Clarification by flotation
  - Sand filtration
  - UV disinfection
  - Chlorine disinfection
  - Calco-carbonic balance
  - And all other treatment required to achieve performances specifications
- **Implementation of the "electrical, electromechanical and hydromechanical equipment" section in conformity with the performances specifications and technical specifications, including the supply, testing and transportation on site of all necessary materials and equipment and their implementation or erection and adjustment, namely:**
  - electromechanical equipment for the raw water pumping station and associated components.
  - hydraulic, mechanical and electrical treatment equipment, including driving equipment and control, monitoring, measurement, protection and safety devices
  - miscellaneous equipment required for the proper operation and maintenance of the installations, (lighting, heating, telephone, etc.),
  - the remote surveillance system, if any
- **The commissioning of the installation and performance of the tests defined in the Employer's requirements.**
- **The provision of maintenance and operating manuals and as-built drawings of the structures and networks including cadastral measuring/planning drawings in UTM coordinate systems to deliver them to National Agency of Public Registry for registration.**
- **Services for the Employer and the Engineer, as defined below and/or in this tender documents.**
- **Supply of spare parts.**
- **All other necessary works required to complete the construction of the WTP.**
- **Training**

- Operation and Maintenance
  - **The Contractor shall be in charge of the operation of the new raw water pumping station, the pumping mains and the water treatment plant for a treated water capacity of 93,000 m3/day, as specified in Volume 2 for 2 years**

4.1.3. Conditional part

The components covered in the conditional part of this contract will include the following:

- Raw Water Pumping Station : Implementation of the electrical, electromechanical, pipping, instrumentation works for an additional capacity of 4,450 m3/hr

- Water Treatment Plant (WTP) for additional treated water capacity of **93,000 m^3/d,** expected to comprise of the following key units:
  - Inlet works incorporating raw water flow measurement;

  - Pre-treatment if needed

- Coagulation-flocculation;
- Clarifiers or dissolved air flotation for clarification of flocculated water, including sludge removal facilities;
- Sand filters, including filter gallery and filter control room;
- Calco-carbonic balance;
- Disinfection facilities;
- Pump house and air blower room with pumps and air blowers for backwashing of filters;
- Sludge drying beds;
- Backwash water lagoons, and backwash water recirculation pumps;
- Equipment for chemical storage and preparation;
- Equipment for Disinfection;
- Generator house & switch room;

- Operation and maintenance for 24 months

The services to be provided by the Contractor include, but are not limited to the following:

- Design and additional studies
  - **Execution of any additional studies that may be deemed necessary by either the Engineer, Contractor or any statutory body.**
  - **Preparation of a design report of the installations answering the program fixed by the Employer's Requirements.**
  - **Documents forming the application for building permit (English language), including the architect's drawings and layouts, and in particular the landscaping aspects, so that the Employer has only to file this application to the concerned authorities.**
  - **The preparation of guide drawings, working design drawings for the civil engineering structures, reinforced concrete drawings and calculation notes, drawings and calculation notes for the roads and utilities networks, drawings and diagrams of equipment, erection and dismantling drawings, in compliance with the detailed design accepted by the Employer.**

- Implementation

Works to be carried out by the Contractor include but are not limited to the following:

- **Installation of the site and execution of preparatory works, connection to telecoms, water, electricity and other services.**
- **Adopting mitigating measures provided in the ESIA Reports already agreed with the financer. In addition, if need be, these documents (ESIA, IEE, EMP, DDR) should be updated and/or preparation of renewal plan. The Client will acquire an ESIA license. However, the Contractor may be required to carry out additional studies as per the financer guidelines for specific work components / sites including camps. The cost of compliance, including payments demanded by authorities, to additional studies in regard to this shall be deemed to be covered in the Contractor's financial proposal.**
- **Preparation and adopting the management plans as stipulated in the Project ESIA.**
- **Implementation of civil works in accordance with the approved detailed design, as specified in the General Conditions of Contract, including in particular:**
  - preliminary drillings and investigations for the existing facilities and networks, if necessary,
  - earthworks and final backfilling, drainage (including removal and storage of materials and earth),
  - special foundations, if necessary
  - all shell construction (concrete, reinforced concrete, masonry, framework, roofing, sealing, cladding, etc.),

  - all finishing and fitting works for the plant,
  - fences, roads and utilities networks,
  - demolition of existing structures to be removed, if any, including pipes and the reuse or removal and dumping of the corresponding materials in locations authorized by local legislation, and levelling of the land thus freed,
  - connection of the new installations with existing structures (pipes),
  - all pipes, whatever the position, as described on the drawings
- **Implementation of the treatment process in conformity with a detailed design and process flow diagram including:**
  - Pumping station
  - Fine screening (if necessary)
  - Acidification
  - Coagulation – Flocculation – Clarification by flotation
  - Sand filtration
  - UV disinfection
  - Chlorine disinfection
  - Calco-carbonic balance
  - And all other treatment required to achieve performances specifications
- **Implementation of the "electrical, electromechanical and hydromechanical equipment" section in conformity with the performances specifications and technical specifications, including the supply, testing and transportation on site of all necessary materials and equipment and their implementation or erection and adjustment, namely:**
  - electromechanical equipment for the raw water pumping station and associated components.
  - hydraulic, mechanical and electrical treatment equipment, including driving equipment and control, monitoring, measurement, protection and safety devices
  - miscellaneous equipment required for the proper operation and maintenance of the installations, (lighting, heating, telephone, etc.),
  - the remote surveillance system, if any
- **The commissioning of the installation and performance of the tests defined in the Employer's requirements.**
- **The provision of maintenance and operating manuals and as-built drawings of the structures and networks including cadastral measuring/planning drawings in UTM coordinate systems to deliver them to National Agency of Public Registry for registration.**
- **Services for the Employer and the Engineer, as defined below and/or in this tender documents.**
- **Supply of spare parts.**
- **All other necessary works required to complete the construction of the WTP.**
- **Training**

- Operation and Maintenance
  - **The Contractor shall be in charge of the operation of the new raw water pumping station, the pumping mains and the water treatment plant for an additional treated water capacity of 93,000 m3/day, as specified in Volume 2 for 2 years**

4.2. HEALTH AND SAFETY

The Contractor shall submit a Health and Safety Plan and shall formulate and submit site safety regulations/guidelines.

The Contractor shall be responsible for the safety of all workmen and other persons entering the Works and shall, at his own expense (where not otherwise stated) and to the approval of the Engineer, take all measures necessary to ensure their safety. Reference in these respects is made to the Conditions of Contract, but in particular, such measures shall include, but are not limited to, the following:

A. Provision of proper safety and emergency regulation; fire, gas (if any) and electric shock prevention, stretchers and first aid boxes, together with rescue facilities generally, for each place of working.

B. Safe shoring of all excavations.

C. Provision of appropriate Personal Protective Equipment (PPE) for all personnel including the Employer and the Engineer and each of their staff and any authorized visitors to the Site.

D. Safe control of water including provision of ample standby pumping plant.

E. Provision and maintenance of suitable lighting to provide adequate illumination of the Works with appropriate spares and standby equipment.

F. Provision of good and safe access to any part of the Works.

G. Provision of notices written in English languages to be erected at points likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

The Contractor shall submit for the approval of the Engineer the detailed health and safety plan and the site safety regulations/guidelines. When the regulations/guidelines have been approved, and before the work is started, the Contractor shall distribute copies in English languages to all his employees and to the Engineer.

The Contractor shall ensure that all his employees are fully conversant with the safety regulations/guidelines, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

H. Personal protective equipment shall be available and used by operatives when appropriate, including: safety helmet, eye protection, ear protection, hand protection, foot protection.

4.3. TRANSPORTATION OF MATERIALS AND EQUIPMENT

A. The Contractor shall take all reasonable precautions to ensure that public streets and thoroughfares used by him either for the construction of the Works or for the transport of plant, labour and materials are not made dirty as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer the Contractor shall take all necessary and immediate steps to clean them.

B. Vehicles shall be thoroughly cleaned down before leaving the Sites and shall be so loaded that spillage therefore is prevented.

C. Each individual site must be kept clean during the work and must be thoroughly cleaned upon completion.

4.4. SANITATION

A. The Contractor shall maintain the Site in a hygienic condition and shall comply with the requirements of the Engineer. At least all the wastewater produced on the Site, should be reasonably treated and disposed.

B. The Contractor shall comply with the requirements in accordance with local legislation.

4.5. PREVENTION OF NOISE AND DISTURBANCE

A. The Contractor shall in general comply with the recommendations given in the local legislation.

B. The Contractor shall justify the details and arrangements of all plant before installation to ensure that suitable provisions are provided to reduce noise emission in built-up areas.

C. The Contractor shall take noise intensity readings as required by the Engineer and shall submit the results to the Engineer. The Contractor shall comply with measures required by the Engineer to keep noise and disturbance to the reasonable minimum.

4.6. FIRE PREVENTION

A. The Contractor shall make arrangements to the satisfaction of the Engineer for the protection of the Works and any Temporary Works and any adjacent property from fire and shall give the Fire Authority all facilities periodically to inspect the fire prevention arrangements.

B. Particular care must be exercised in connection with the operation of electric-arc welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked lights. Special arrangements will be necessary for the storage of highly flammable liquids on the Site.

C. The Contractor shall remove all rubbish and surplus material of a flammable nature and take such other steps as the Engineer may require but this shall not relieve the Contractor of any of his obligations under the Contract.

4.7. WORK IN THE VICINITY OF OPERATIONAL MECHANICAL AND ELECTRICAL EQUIPMENT

A. Any permanent fencing or other safeguards required to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.

B. Where work has to be carried out in proximity to operational mechanical and electrical equipment other than the Contractor's own plant, the Contractor shall put into operation a « Permit to Work » system to the approval of the Engineer.

4.8. ADJOINING CONTRACTS

This contract is one of several contracts to be implemented separately under the Mwache Dam Water Supply System. Other contracts include:

a) Mwache Multi-purpose Dam

b) Mwache Water Transmission Pipelines and Terminal Reservoirs

All interface issues, and related costs are deemed to be included in the Contractor's rates.

5. OTHER SERVICES TO PROVIDE

5.1. VEHICLES

The Contractor shall procure the following vehicles for the sole use of the Employer / Engineer:

1. Vehicle Description	2. Timeline
i.) **Station Wagons 4x4,3000cc – 3Nr.** ii.) **Double Cabin Pickups 4x4,3000cc – 2Nr.**	• **Within 28 days from Contract Commencement Date**
iii.) **25-Seater Mini-Bus – 1Nr.**	• **28 days before commencement of Operation Service**
iv.) **Single Cab Pick-up, 4x4, 2800cc – 1Nr.** v.) **5 - Ton Truck – 1Nr.**	• **2 months before completion of Operation Service**

The marks, models, colours and other specifications of the vehicles shall be approved by the Senior Resident Engineer prior to ordering. The cost of procurement of the vehicles will be covered under Provisional Sums.

The Contractor shall ensure that all vehicles are licensed, comprehensively insured at all times, serviced and maintained in good condition to the satisfaction of the Chief Resident Engineer. Payments for maintenance shall include for Insurance, provision of fuels, lubricants and tyres, all regular maintenance, minor and major repairs, including those occasioned by accidental damage from whatever cause arising, and everything else necessary to satisfy fully the requirements of this Clause. The cost for operation and maintenance of the procured vehicles will be covered under the Provisional Sums.

In the event of the vehicles being unserviceable for whatsoever reason, the Contractor shall provide alternative vehicles at his own cost of the same model in compliance with the provisions of this clause. The cost for such replacement vehicle to be covered in the Contractor's rates.

The vehicles shall be kept permanently at the disposal of the Engineer. During periods of maintenance or repair the Contractor shall make an equivalent replacement vehicle available.

The vehicles will revert back to the Employer at the end of the Contract. Prior to handing over the vehicles to the Employer, the Contractor shall get the following done:

- Inspection by the Authorized Dealer. The Dealer shall recommend to the Engineer's Authorized Representative what repairs, in addition to the ordinary service, are required to be carried out on the vehicle. The Contractor shall then ensure that the recommended service/repairs are done. A Certificate of Road Worthiness and Satisfactory Mechanical Condition to be obtained from the Dealer.

- Inspection by the Government Inspection Unit, if applicable.

- Inspection and Valuation by the Automobile Association (AA) of Kenya.

- Procure an additional one-year insurance cover for each of the vehicle.

The Contractor shall hand over the respective Inspection / Valuation Reports to the Employer together with the vehicles. The costs for the above inspections, repairs and one-year insurances (from the date of hand-over) are deemed to be covered in the Contractor's Rates.

It is assumed that the total distance covered by the vehicles from the beginning to the Taking over will be less than or equal to 300,000 km.

5.2. TELEPHONE FOR ENGINEER'S REPRESENTATIVE

The Contractor shall pay for the telephone and internet equipment and connection services as instructed by the Engineer. These amounts will be reimbursed to the Contractor under the respective item in the Provisional Sums.

5.3. SITE OFFICES, HOUSING AND EQUIPMENT

The Contractor shall provide dismantlable prefabricated on smooth hardstanding surface (filled) and well insulated fully furnished and equipped offices with all utilities not more than 28 days after the Engineer's Notice to Commence the Works. The offices shall be as follows:

- 4Nr. x 20 m² offices
- 1Nr. Open Plan Office with 10Nr. workstations
- 1 Nr. x meeting room for 20 persons (at least 50 m²)
- 1Nr. x 15m² store
- 1Nr. x 15m² Kitchenette

The offices shall have a hardstanding covered floor 2m wide all around and shall have electricity, internet, water and sanitation facilities. The Contractor shall be responsible for adequate and regular maintenance and repairs of structures, furniture, equipment and appliances therein.

Each office shall be fitted with electric lighting and wall mounted socket outlets, an air-conditioner, one 0.8 m x 1.5 m table with drawers, one fixed 0.9 m x 1.8 m desk with shelves above to take fold drawings, one stool, four chairs, one cupboard fitted with shelves, hat and coat hooks. The kitchenette shall be fully furnished with all the necessary accessories including but not limited to the following; fridge, microwave, cooker, utensils etc.

The offices shall be provided with 1Nr. combined A3 - A4 scanner-colour photocopier-laser printer and a digital camera (minimum specifications 20.9MP DX-Format CMOS, EXPEED 5 Image Processor, 4K UHD, Native ISO 51200, 8 fps - 100 Frames, 180k-Pixel RGB Sensor).

The cost for provision and maintenance of the fully furnished offices including payment for utilities bills any repair works will be included in the Contractor's Rates. Additionally, the Contractor shall provide office consumables (e.g. sugar, refreshments etc.) as instructed by the Engineer and the amounts shall be reimbursed under the respective item in the Provisional Sums.

The Contractor shall rent fully furnished and equipped housing / accommodation for the sole use of the Engineer and the Engineer's Staff. As directed by the Engineer, the housing shall be supplied with all utilities and facilities immediately after the Engineer's Notice to Commence the Works. The costs for provision of accommodation shall be covered under the respective item in the Provisional Sums.

Offices and houses for the Engineer and the Engineer's staff shall be maintained by the Contractor until the issuance of the Commissioning Certificate.

5.4. ENGINEER'S STAFF

The Contractor shall provide for the use of the Engineer the staff listed below. Salaries for Engineer's staff will be included in the Contractor's rates and shall be based on the latest Job Group salary scales for the Government of Kenya Civil Service including basic pay, overtime, hardship allowance, house allowance, per diems and other allowances. The

Contractor shall allow for annual increments in his rates and shall consider Kwale and Mombasa Counties as the primary place of work.

Construction Period

- **One (1) secretary (Group "N")**
- **One (1) office assistant (Group "H")**
- **Five (5) drivers (Group "J")**
- **One (1) surveyor (Group "P")**
- **Two (2) chainmen (Group "G")**
- **One (1) CAD Technician (Group "M")**

Operation Service Period

- **One (1) secretary (Group "N")**
- **One (1) office assistant (Group "H")**
- **Five (5) drivers (Group "J")**

7.

6. GENERAL COORDINATION

The Contractor shall co-ordinate his work with that of his sub-contractors to complete the project in accordance with the program of works, the drawings and specifications and the requirements of the engineer.

6.1. EMPLOYER'S USE OF CONTRACTOR'S TEMPORARY WORKS

The Contractor shall during the progress of the Works allow the Employer, the Engineer and other Contractors employed by the Employer in connection with the Works the use of his roads, scaffolding, constructional plant, other temporary works or services such as described in the present Section. The Contractor shall at every place of working provide proper drainage, lighting and ventilation for other Contractors' erection work and for the Engineer's inspection of the Works. Except for those items entered in the Price Schedules, such assistance shall be included in the rates.

6.2. ASSISTANCE TO THE ENGINEER'S STAFF AND TO OTHER CONTRACTORS

The Contractor shall provide labour for attendance on the Engineer for operations connected with supervision of the Works in particular for topographical survey. The attendance and assistance to the Engineer and his staff shall be included in the rates.

6.3. DISPOSAL OF SURPLUS EXCAVATED MATERIALS

Surplus excavated material and debris arising from the Works shall be:

- dumped on agreed disposal sites at the expenses of the Contractor as agreed with the local authorities. In order to avoid unauthorized disposal the Contractor shall arrange that each cartage Contractor and lorry driver employed for the disposal of such materials is given written instructions as to the approved place where each load is to be tipped. The Contractor shall retain in his office copies of such instructions, together with a list of approved places to be used, for inspection at any time by the Engineer.

The Contractor shall indemnify the Employer against any claims arising from unauthorized disposal of such materials.

- re-used on the site for the landscaping development; in this case, the Contractor Proposal shall justify the characteristics and volume of materials; should the Contractor Proposal not include such arrangements, the re-use shall not be allowed.

7. TENDER DRAWINGS SUPPLIED TO THE CONTRACTOR

The only drawings provided by the Employer to the Contractor are the drawings included in the Tender Documents – Part 2.

8. DOCUMENTS AND DRAWINGS TO BE CARRIED OUT BY THE CONTRACTOR

8.1. DESIGN REPORT

Within 60 days after the Commencement date, the Contractor will submit to the review of the Engineer a Design Report. This report will be based on the Contractor Proposal; it will include the following documents in addition to the documents related to the environmental requirements mentioned in section 4:

- The description of the plant , pumping station and the raw water pumping main
- The detailed design calculations
- The hydraulic profiles (treatment process + pumping main)
- The drawings: Process Flow diagrams, P&IDs, Equipment implementation, pumping station layout and pipe alignment, etc.
- The entering and leaving flows in terms of quantities and pollution loads
- The pre- sizing of the structures
- The sizing of the installed power
- Architectural and landscaping details
- The single line power diagram
- The general organisation of the remote control system
- A weekly general implementation program
- A weekly Contractor's Documents submittal program

8.2. GENERAL PROVISIONS FOR CONSTRUCTION DRAWINGS

As soon as the Engineer notifies comments on the Design Report, the drawings shall be issued by the Contractor for construction. Such drawings shall be deemed to be Construction Drawings, part of the Contractor's Documents.

The drawings issued by the Contractor for construction will include:

- The general layout drawings showing structures, roads, offices, recreational area, etc.
- The foundation drawings, including if any temporary works such as excavation, piling, etc.
- Design and structural calculations and construction drawings for civil and structural works including Bar Bending Schedules.
- The single line power diagram
- The flow chart of the remote control
- Architectural and landscaping drawings.
- Additional shop drawings as required by the Engineer to develop in greater detail the construction required.

All these drawings shall be referred to hereinafter as Construction Drawings.

These drawings will be submitted by the Contractor, in accordance with the Documents' submittal program, to the approval of the Engineer.

Shop reinforcing steel drawings, detail erection drawings, concrete placing (lift) drawings, formwork drawings and other detail drawings shall be prepared by the Contractor on the basis of the Construction Drawings; they will be given for information to the Engineer.

All drawings shall be in the English language, and all dimensions shall be in Metric system. Symbols shall be in accordance with approved Standards. All drawings submitted for approval shall conform to ISO paper sizes A0 to A4. Title block and numbering shall be approved by the Engineer.

The Permanent Works shall be executed in conformity with the Construction Drawings and other drawings approved by the Engineer.

8.3. CIVIL WORKS

8.3.1. General

The Contractor is responsible for the execution of documents (drawings, diagrams, design calculations, erection, etc.) for the different components.

A list of all drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the Works in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions.

8.3.2. Design calculations

The design calculations which may be presented under existing computer forms shall include in particular:

- Title page:
  - **Calculation conditions;**
  - **The values of the maximum stresses under normal and exceptional operating conditions and during handling, transport and erection;**
  - **The main dimensional characteristics:**
  - **The properties of the materials used;**
  - **Bibliographical references used for the calculations.**
  -

- In the text:
  - **The loads to which the supply is subjected and their origin;**
  - **The forces transmitted to supplies and to the foundations;**
  - **Stresses to which the equipment will be subjected under normal and exceptional operating conditions (including handling, transport and erection);**
  - **The permitted safety factors;**
  - **In general, any indications required for a proper understanding of the design of the supply;**
  - **The output, power and characteristics of drive or control motors.**
  - **The Engineer reserves the right, during the design period, to request the Contractor for any additional design calculations which he considers necessary.**

- Drawings
  - **In addition to the documents listed in clause 8.2, the Contractor shall prepare and deliver to the Engineer for information the drawings for:**
    - the Temporary Works,
    - the performance of the Works as necessary for showing the construction methods,
    - the Drawings relevant to the Construction of:
    - Access roads;
    - Contractor's camp and facilities,
    - the detailed drawings of concrete reinforcement and calculation works, as well as bar bending and cutting list,
    - the as-built drawings of all Permanent Works constructed as required in Sub-Clause 6.7 of the Conditions of Particular Application (Part 3) including cadastral measuring/planning drawings in UTM coordinate systems to deliver them to National Agency of Public Registry for registration,
    - the other drawings necessary for the performance of each part of the Works in accordance with the Contract.

The Contractor shall perform also the necessary calculations in connection with the required drawings.

The drawings prepared by the Contractor will be established for cases of maximum load likely to occur during operation of the Permanent Works, and exceptional load situations which may occur during construction in compliance with the method of works.

The Contractor shall be responsible for assuring the adequacy of all parts of the works with respect to loading which might occur during construction and shall supply calculation notes and drawings for any necessary falsework, supports, strengthening as may be required by the Engineer.

The Contractor shall be responsible for the behaviour of the Permanent Works during the various phases of construction. He shall provide all equipment and accessories and all working arrangements necessary to limit stresses on the Works, so that stability of the structures is not threatened and so that stresses and deformation remain within acceptable limits.

In the context of the above-mentioned arrangements, the Contractor may be authorised by the Engineer to reinforce the design of the Permanent Works, provided always that such authorisation shall not entitle the Contractor to any additional payment, either on account of the quantity or quality of the materials used in addition.

8.4. MECHANICAL EQUIPMENT INCLUDED IN THE PRESENT CONTRACT

8.4.1. General

The Contractor is responsible for the execution of documents (drawings, diagrams, design calculations, erection, etc.) for the different supplies.

A list of all drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the Works in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions.

8.4.2. Equipment guide drawings for Civil Works

The Contractor shall supply the following documents for the Engineer's approval:

- Equipment and Civil Works guide drawings showing the layout and overall dimensions of the equipment.
- Drawing of recesses to be made in the concrete with the directions and values of stresses transmitted to the concrete by the equipment.
- Drawings of built-in parts.
- Layout drawings of built-in parts in secondary concrete and embedded parts in primary concrete.
- Overall and detail drawings of the equipment

The Contractor shall supply drawings for information of assemblies, parts of assemblies and large parts of the equipment to the Engineer for information.

These drawings, or where applicable their technical associated documents, shall include, in addition to production dimensions, flatness, straightness, horizontal and vertical tolerances, the values of assembly and operating clearance with the minimum and maximum acceptable deviations, the type and the properties of the materials used in the different parts, the weld categories and the types of non-destructive testing to be carried out on welds, the surface condition valued to be achieved for parts machined in accordance with ISO/R 468 standard.

Drawings, or, where applicable, their technical associated documents shall also include the weights of assemblies, parts of assemblies and detailed parts as well as the surface areas to be painted for large structures.

8.5. SUBMISSION AND APPROVAL

The Contractor shall submit in three (3) hard copies and a digital copy to the Engineer, for review, information or approval, all documents and drawings which he prepares under this Clause (except for "As-Built"). The Engineer will analyse all such designs and drawings, will appraise them as to whether they are reasonable and consistent with the Construction Drawings, will approve if requested and will order changes when deemed necessary.

The Contractor's documents and drawings shall be submitted in a sequence to facilitate the Engineer's study and scrutiny of the same, shall be completed in regard to all computations and data, and shall be traced on size 840 mm x 594 mm (A1-size) or 297 mm x 420 mm (A3-size) paper in color. The title of the drawings, the signature of the Contractor's representative, the date of preparation and the reference to Construction Drawings, if any, shall appear in the bottom right hand corner of the drawing. Within twenty-one (21) days after submission of the drawings, the Engineer will advise the Contractor of his conclusions regarding the drawings.

When approval is requested, the Engineer's conclusions may be one of the following:

- "APPROVED""
- "APPROVED EXCEPT AS NOTED"
- "DISAPPROVED" (with relevant reasons determining rejection duly indicated).

Within fourteen (14) days of the return of documents and drawings marked "APPROVED" or "APPROVED EXCEPT AS NOTED", the Contractor shall present to the Engineer three (3) hard copies and a digital copy of the same. These drawings will have an indices +1 , noted "Approved for Execution by the Engineer on xxx".

No drawing shall be considered valid unless signed by the Engineer. The approval by the Engineer of such drawings shall not relieve the Contractor of his obligations and responsibilities under the Contract.

Those marked "DISAPPROVED" shall be redone and submitted a new to the Engineer.

The Contractor shall not be entitled to a time extension based upon the rejection of designs or detail drawings, because such designs or detail drawings fail to conform to sound engineering principles, or to the Specifications.

All materials ordered or Works performed prior to approval of the relevant designs, shall be at the Contractor's risk.

The Contractor shall bring to the attention of the Engineer any variation to the Contract in the document submitted for approval.

When no approval is requested within twenty-one (21) days after submission of the drawings, the Engineer will notify his comments or requests. All materials ordered, or work performed, prior this notification shall be at the Contractor's risk.

8.6. OWNERSHIP OF DRAWINGS AND DATA

All the drawings, details, bill of materials and any other information or documents furnished by the Contractor shall become the property of the Employer and shall be non-returnable. The Employer will have the right to use this property.

Such information shall be given in hard copy and in digital format.

8.7. DESIGN CRITERIA

Unless otherwise specified, the following figures will be used as design criteria.

- Acceleration due to gravity: for any relevant calculation or evaluation will be: $g = 9.81\ m/s^2$.
- Unit weight:
  - **waste water: 10KN/m³**
  - **Clarified water: 10KN/m³**
  - **Sludge and floating waste: 10,5KN/m³**

9. LAYOUT OF WORKS AND SURVEYS

9.1. REFERENCE POINTS, LINES AND LEVELS

9.1.1. General setting out

At the beginning of the Works, the Contractor and the Engineer shall agree on the definition and general setting out of the structures to be built on the site, based on the general network established for the project.

Three points which shall be used as a reference basis in three dimensions (X, Y, Z) will be made available at site by the Engineer by the date of beginning of the work. These three points shall be handled over to the Contractor, which will accept them as references. The Contractor will provide a detailed table includes the coordinates of all the buildings corners.

Additional bench marks may be provided by the Contractor for triangulation reference.

The Contractor shall be responsible for the conservation of the related benchmarks during the entire duration of the construction and Operation Service Period.

The Engineer shall draw up a report to confirm completion of these operations in the field.

9.1.2. Complementary setting out

During the execution of the Works, the Contractor shall complete the general setting out by as many stakes, seats and gauges as may be necessary.

Lines and levels of reference for erection of equipment

9.1.3. Reference points

At the beginning of erection of equipment, complementary reference points shall be placed by the Contractor. Position of lines and levels shall be defined by mutual agreement of all parties. In case of disagreement the Engineer shall decide.

9.1.4. Approval

The Engineer will draw up a report to confirm completion of these operations in the field.

9.2. RECORD OF SITE BEFORE CONSTRUCTION

The Contractor shall perform topographical survey of the site within 28 days after the Commencement Date, prior to his first entry thereon, and agrees the surface topography and ground conditions of the site and the immediate surrounding areas to the extent considered necessary by either the Engineer or the Contractor. The agreed record shall include the condition of existing services and facilities, buildings, roads, boundary walls, fences and trees and also shall include photographs and spot levels as necessary and written descriptions of the site conditions.

All buildings and structures situated adjacent to the site or close enough to the works which the Engineer considers could be affected by the construction of the works are to be structurally surveyed both internally and externally and agreed with the Engineer prior to construction work commencing. The survey is to include photographs where appropriate.

The survey will be approved by the Engineer.

10. STANDARDS, CODES AND REGULATIONS

10.1. GENERAL

A. General Standard specifications and codes of the following listed authorities wherever cited herein are referred to by use of the abbreviations shown below. All materials and workmanship shall comply with requirements of applicable codes:

		Abbreviation
1	British Standards Institution Linford Wood, Milton Keynes MK14 6LE - UK	BS
2	AWWA 6666 W. Quincy Ave., Denver, CO 80235 – USA	AWWA
3	Deutsches Institute fuer Normung e.v D-1000 BERLIN 30, Burggrafen Str. 6 Germany	DIN
4	Fédération Européenne de la Manutention 80 boulevard A. Reyers B-1030 BRUXELLES – Belgique	FEM
5	Commission Electrotechnique Internationale 1 rue de Varembé Case Postale 56	CEI
6	International Standard Organisation 1, rue de Varembe Case Postale 56 CH1211 GENEVE 20 - Suisse	ISO
7	European Committee for Standardization 36 rue de Strassart 1050 Brussels, Belgium	EN
8	American Society for Testing and Materials 1916 Race Street PHILADELPHIA, PA 19103 – USA	ASTM
9	American Association of Stage Highway and Transportation Officials 444 North Capitol Street, mw WASHINGTON, DC20001 – USA	AASHTO
10	American Concrete Institute Box 19150 - Belford Station DETROIT, MI 48219 - USA	ASI
11	Bundesanstalt fuer Wasserbau D-7500 KARLSRUHE, Kussmaulstr. 17 Germany	BAW
12	Association Française de Normalisation Tour Europe - Cedex 7 92080 PARIS LA DEFENSE – France	AFNOR

13	American National Standards Institute, Inc. 10 East 40th Street NEW YORK, NY 10016 - USA	ANSI
14	American Petroleum Institute	API
15	American Welding Society 205 MW 7th Street MIAMI FLO 33125 - USA	AWS
16	United States Bureau of Reclamation Engineering and Research Center Code 922 Post Office Box 25007 Denver Federal Center DENVER, Colorado 80225 - USA	USBR
17	The Institution of Civil Engineers Publication Thomas Telford Ltd. 1 Heron Quay LONDON E148XF - UK	ICE
18	Eurocode 2, rue Bréderole B-1000 BRUXELLES – Belgique	

B. The Contractor is expected to use any of the above Standards or approved equivalent.

C. Copies of Specifications, codes or standards of the above organizations may be obtained at the addresses shown.

10.2. STANDARDS TO BE ON SITE

The Contractor shall obtain and keep on Site at least one copy of each standard which is referred to in the Specifications. One copy shall be at the disposal of the Engineer's Representative.

10.3. APPLICABLE STANDARDS

A. Unless otherwise specified (or equivalent approved), the Standard to apply will be as detailed in the relevant Technical Specification.

B. Except if otherwise specified, where such standards are mentioned, the latest revision or edition on the Reference Date shall apply.

C. When the Contract Documents contain particular specification or more restrictive specification than required in Standards and Codes listed above, the Contract Documents will always prevail.

D. In case of lack of precise requirements in the Specifications and even if no reference to any standard listed in Sub-Clause hereof, these standards shall be used as a reference.

10.4. STANDARDS OTHER THAN THOSE SPECIFIED

A. Where requirements are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required by Section 14 (Approval of Materials and Equipment), and shall submit written proof that his proposed standard is equivalent in all significant respects to the standard specified. All submissions shall be made in English language.

B. If required, the Contractor shall supply a copy of these standards and regulations in English language.

11. WATER CONTROL

A. Without prejudice to other stipulations in the Contract, all constraints related to the presence of or risks caused by water, all additional work which may prove necessary on this account, all damage caused by water, all pumping in all structures not mentioned in the Contract which the Contractor may find he has to build for water control purposes shall be at the expense of the Contractor.

B. Without prejudice or other stipulations in the Contract, the Contractor shall be responsible for all damage caused to the foundations of the structure or any part of the Works and occasioned by floods, surface water or runoff, or by failure of any part of the diversion or protection works carried out by the Contractor. Any repairs that are necessary will be carried out at his own expense.

C. Before any works are begun, the Contractor shall submit to the Engineer's approval the methods and arrangements he proposes to apply in order to protect the Works, unless these are imposed by the design incorporated in the Contract. Such Engineer's approval shall not relieve the Contractor of his obligations and responsibilities.

12. DEWATERING OF FOUNDATIONS

A. The Contractor shall provide, install, maintain and operate all pumping and other equipment for dewatering for all parts of the Site where this is necessary, and for as long as required for implementation of the works.

B. The dewatering facilities shall be such as to avoid any loss of fine materials, and shall ensure stability of the excavation works and adjacent buildings and facilities.

C. Water removed from the excavations must not be allowed to cause nuisance or damage to traffic or any public or private property or service.

D. All costs relevant to the present section are deemed to have been spread over the rates indicated in the Price Schedules.

13. SURVEYING AND OTHER EQUIPMENTS

A. The Contractor shall provide for the use of the Employer and the Engineer on Site for every-day surveying the following normal accuracy instruments:

- RTK GNSS - 1 base + 2 Rovers and their accessories; antennae (1Nr), external radio (1Nr) and an external battery.
- Automatic Level (Wild or Similar) with legs and metric staff, complete with carrying case – 2Nr
- 3 metre ranging rods (6Nr.)
- Survey umbrellas with stand (2Nr)
- 5 metre retractable pocket Steel Tapes (5Nr)
- 30 metre metal tapes (3Nr)
- 100 metre metal tape (2Nr)
- Builders spirit levels 1000mm long (3Nr)
- Plumb bobs with nylon string (3Nr)
- Wood tripod (2Nr.)
- Aluminium tripod (2Nr.)
- 5 metre staff (2Nr.)
- Hammers 3kg each

B. All equipment supplied to the Engineer under this clause shall revert to the Employer on completion of the work after full servicing and calibration.

C. All survey equipment for the use of the Employer and the Engineer on Site shall be maintained in good order by the Contractor.

D. All costs relevant to the present paragraph are deemed to have been spread over the rate indicated in the Price Schedules.

14. QUALITY OF MATERIALS

14.1. MANUFACTURED MATERIALS

A. All materials, fixtures, fittings, and supplies furnished under the Contract shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first-class and workmanlike manner.

B. The Project site is characterised by highly corrosive environment due to proximity to the Indian Ocean. Resistance to corrosion will be a key consideration in approval of any key material for permanent works proposed by the Contractor.

C. In asking for prices on materials intended for delivery to the site and incorporation in the Works under any portion of these Specifications, the Contractor shall provide the manufacturer or supplier with complete information as may, in any case, be necessary to secure compliance with this Clause and, in every case, he shall quote this Clause in full to each such manufacturer or supplier.

14.2. QUARRIED MATERIALS

The Contractor shall be responsible for investigating and obtaining riprap stones, rockfill, filters and transitions and aggregates for concrete and other purposes. The Contractor shall develop such investigations that he may require to meet the Contract requirements.

14.3. CEMENT

The Contractor shall, within 28 calendar days after the Commencement Date, submit i) all the chemical and physical characteristics of the cement in compliance with the specifications and ii) a forecast on a monthly basis detailing his local cement requirements for the duration of the Contract in a form approved by the Engineer. Throughout the Contract period, the Contractor shall review this forecast at quarterly or more frequent intervals as may seem to him necessary or as may be required by the Engineer. Prior to commencing the Works, the Contractor shall establish a stockpile of cement based on his forecast of cement requirements and sufficient for maintaining his operations.

Throughout the Contract period, the Contractor shall so arrange further deliveries of cement to maintain his stockpile at three months' supply.

15. APPROVAL OF MATERIALS AND EQUIPMENT

15.1. GENERAL

A. All materials and equipment intended to be incorporated in the Works shall be subject to information given by the Contractor to the Engineer. For the materials incorporated in the civil works (including architectural materials), the Engineer shall give approvals, and the Contractor shall wait for this approval prior to order. For the mechanical and electrical equipment, the Engineer shall give only comments or refusals if necessary.

B. Unless otherwise authorized by the Engineer no material or equipment shall be shipped from its point of original manufacture or final shop assembly to the work site before it has been inspected in accordance with Clause 14.3.

15.2. SUBMISSION OF SAMPLES AND DATA

A. The Contractor shall submit for the approval of the Engineer samples, drawings, catalogues, cuts, diagrams and other descriptive data for all mechanical, electrical, architectural and such other materials and equipment as may be designated by the Engineer and which the Contractor proposed to incorporate in the Works. As directed by the Engineer, the Contractor may be required to submit additional technical data in accordance with a detail form furnished by the Engineer.

B. Items submitted shall be properly labelled to indicate the Project Contract number, Contractor, source of supply, manufacturer Contract Item number, and other data required by the Specifications.

C. All items shall be submitted in sufficient time, but not later than 90 calendar days prior to purchase, to permit proper consideration and action thereon without delaying the construction schedule.

D. Items sent for approval shall be shipped prepaid by the Contractor and the Contractor shall give the Engineer advance notice in writing of all items shipped.

E. The results of the tests shall generally indicate:

- Sample identification numbers.
- Sample origin.
- Part of the Works represented by the sample.
- Sampling date.
- Description of tests with reference to the relevant standards.
- Test results (with appropriate units when applicable).
- Date of tests.
- Reference of laboratory undertaking the tests.
- Conclusion (Satisfactory or Unsatisfactory).

15.3. INSPECTION AT THE PLACE OF MANUFACTURE

A. To allow possible inspection of materials and equipment in the course of or on completion of preparation or manufacture, the Contractor shall give the Engineer written notice of the workshops and places where the materials and equipment are manufactured or stored and advise him of the state of progress, so that the inspection may take place at appropriate times and without delaying the dispatch of materials and equipment to the Site. In particular, the Contractor will inform the Engineer of the date of final erection tests or inspection test prior shipping.

B. If the Employer and/or the Engineer decides to attend these tests (or any representatives duly nominated), the cost of the transport, flights tickets and accommodation shall be paid by the Contractor as instructed by the Engineer. These costs shall be covered under the relevant item in the Provisional Sums.

C. In the event during inspections and tests carried out in presence of the Employer and Engineers show inadequacies in the manufacturing process resulting in non-conformance finished products to an unacceptable level, the Employer will deploy his agent or third-party inspector to carry out independent third-party Inspection. In such an event the supply and incorporation of materials from such source shall be stopped immediately until further notice and the Contractor shall instead provide materials from another approved source. The Contractor shall be required to replace at his cost all the rejected materials including the cost of this inspection in the event such third party inspection reveal non-conformance in manufacturing and quality standards. The inspectors shall be provided with full access to carry out third party inspection including the use of the in-house testing processes.

D. The Engineer could make tests on concrete, concrete aggregates, embankment materials, filter materials and other materials as he may from time to time elect, and the Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality. The cost of these tests shall be borne by the Contractor and shall be reimbursed under the relevant item in the provisional sums.

15.4. MANUFACTURER'S CERTIFICATE OF COMPLIANCE

In the case of standard labelled stock products of standard manufacture which have a record of satisfactory performance in similar work over a period of not less than 2 years, the Engineer may accept a statement from the Manufacturer attested by a notary public certifying that the product conforms to the applicable Specifications.

15.5. MILL CERTIFICATES

In the case of materials for which such practice is usual, the Engineer may accept the manufacturer's certified mill and laboratory certificate.

15.6. SERVICE RECORD

If a demonstrable satisfactory service record is available for a material, certain specified tests may be waived by the Engineer.

15.7. TESTING LABORATORY CERTIFICATES

The Engineer may accept at its own decision a certificate from an independent commercial testing laboratory, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

Certificates of test in triplicate shall be provided by the Contractor for all off-Site tests. These shall incorporate all test results, calculations, performance graphs and curves and shall be signed by representatives of the manufacturer, Contractor and Inspector. These certificates shall be provided within two weeks after completing the test. Copies of all test certificates shall be included in the operating and maintenance manual.

15.8. ACCEPTANCE OF MATERIALS

The approval by the Engineer of any material or equipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the Specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective or not conforming to the Specifications.

16. ASSEMBLY MARKING

All parts, or units of shop assemblies, shall be marked, or tagged with piece marks. Marks shall be in accordance with approved erection drawings, shall be clearly legible and so placed as to be readily visible when the part is being erected in the field. Before dismantling for shipment, connecting parts assembled in the shop shall be matchmarked to facilitate erection in the field and marked so as to identify each part with the assembly to which it belongs. The location of the matchmarks shall be clearly indicated on erection drawings. All parts or assembly of parts shall also be so marked as to identify them with this Contract.

17. SHOP CLEANING AND PAINTING

After shop assembly and inspection all parts of the Plant and Erection Equipment shall be cleaned and painted in accordance with the Specifications.

18. NAMEPLATES

A. Each major and auxiliary items of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and address of the manufacturer, rating data, electrical and mechanical characteristics, and other significant information, as applicable. Nameplate of distributing agents only will not be acceptable. As a minimum, all electric motors must have name plates giving the following information:

a) Manufacturer
b) Type, serial number
c) Year of manufacture
d) Rated power (kW)
e) Power factor
f) Efficiency (%)
g) Voltage (V), type of starting
h) No. of Phases
i) Degree of protection
j) Frequency (HZ)
k) Synchronous speed (rpm)
l) Rated current insulation class
m) Rated current
n) Insulation Class

B. Nameplates shall also be provided where required for panel-mounted devices. Dials, gauges, and nameplates shall be marked with the nomenclature and units of measure in the metric system, and a schedule of such makings shall be submitted for review and approval by the Engineer.

C. All nameplates shall be in the English language.

D. Nameplates for Plant Identification and record purposes shall be manufactured from stainless steel with satin finish and engraved with black lettering of a size which is legible from the working level.

E. Warning plate shall be manufactured from stainless steel with satin finish and engraved with red lettering and sited in a position affords maximum personnel safety.

19. TESTS CARRIED OUT BY THE CONTRACTOR

19.1. CONTRACTOR'S TESTING LABORATORY

The Contractor shall establish a laboratory on site fully equipped (including personnel – Lab technologists) to perform the following main tests:

- Soils
  - **Identification.**
  - **Compaction tests.**
  - **Relative density determination.**
  - **Permeability (laboratory).**
  - **Particle size determination.**
  - **Atterberg limits**

- Concrete and concrete materials
  - **Concrete materials suitability tests (refer to civil works specifications -003300 (Concrete)**
  - **Fresh concrete analysis.**
  - **Concrete workability.**
  - **Concrete strength (compression).**
  - **Permeability.**
  - **Temperature**

- Rock and aggregate
  - **Dynamic crushing tests.**
  - **Particle size determination.**

- Laboratory computer equipment
  - **The Contractor's Laboratory shall be equipped with one PC Computer (min. 8GB RAM) from a well-known manufacturer accompanied by printing facilities.**

- Laboratory Alternative

As a minimum requirement, Contractor's site laboratory must have the necessary equipment to carry out all the above listed concrete tests. For other any other tests not listed above but required as per the specifications, the Contractor can propose to the Engineer to use alternative accredited laboratories.

19.2. SPECIAL EQUIPMENT

In addition the Contractor shall provide other Laboratory equipment or/and field testing equipment as specified in the different Sections for the purpose of controlling particular works or/and determining in-site parameters. This equipment shall be available as necessary during the execution of such activities and could be removed from the Site as and when approved by the Engineer.

19.3. METEOROLOGICAL EQUIPMENT

The Contractor shall supply and install at site or where instructed by the Engineer the following supplementary meteorological equipment:

- 2 recorder thermometers;
- 1 rain gauge
- 1 hygrometer;
- 1 anemometer;
- 1 Simplified Piche meteorological shelter

19.4. INSTRUMENTATION CALIBRATION

All instruments used for testing purposes shall have been calibrated by an independent accredited testing authority and shall have a valid calibration certificate from a recognised/ approved test laboratory.

The calibration validity period shall not be longer than 12 months. Instruments used for tests at site shall have been calibrated not more than 3 months before the start of testing.

The Contractor shall provide the Engineer with three copies of calibration certificates and correction graphs etc at the time of testing.

Any test instruments shall be recalibrated if requested by the Engineer.

19.5. RECORD BOOKS OF TESTS RESULTS

A. The sheets recording test results shall be of a type approved by the Engineer. The Records Book of tests and results shall be kept by the Contractor.

B. For any test required by the Contract, the Contractor shall produce a written record, in a form approved by the Engineer, certifying that the test has been completed. The Contractor's representative at the test shall sign the test record. The tests witnessed by the Engineer's Representative shall be certified by the Engineer's Representative on the same test record.

C. A copy of the Records Book shall be supplied once a month (or as requested) for communication, examination, and records to the Engineer's Representative.

20. QUALITY ASSURANCE AND QUALITY CONTROL SYSTEM

Quality Assurance (QA) Quality Control (QC) System covering all aspects of the Contract and the Works must be implemented, documented and maintained by the Contractor during the period of the Contract. The system shall comply with a recognised international Quality Assurance Standard. The System shall as a minimum consist of the following items.

20.1. GENERAL

The Quality Assurance System for the Company shall show the overall QA Organisation and the lines of responsibility, monitoring and action. Furthermore, the overall principles and procedures for establishing Quality Assurance Plans, Control Plans, QA Organisation, etc. for specific projects and contracts, sub-contractors and suppliers shall be provided.

20.2. WORKS INCLUDED IN THE CONTRACT

- Quality Assurance Plan (QAP),
- Control Plan (CP).

As a minimum the Contractor shall, submit the QA System for the Company, Quality Assurance Plan and initial Control Plans for the Works included in this Contract, providing all important and critical activities for controls, inspections and tests to fulfil the specifications.

It is a general requirement that works are only sub-contracted to companies with an effective QA System.

20.3. QUALITY ASSURANCE PLAN (QAP)

The QAP shall as a minimum cover the following issues:

- The Contractor's staff and management organization for the project, management plan, and the quality assurance organization.

The person responsible for the Contractor's QAS shall be authorized and qualified to take decisions on quality assurance issues, and his reference and communication lines to the Company's overall quality assurance organization and its responsible management shall be clearly shown. Persons performing quality control and testing shall be independent of those executing or supervising the Works.

- Management of documents.
- Management of procurement.
- Management of sub-contractors and suppliers, and requirements of their QAS's.
- Control of materials and workmanship, defects and material reconciliation, procedures for corrective actions, etc.
- Handling of deviations, additions or variations to the Contract Documents.

The Contractor's system of management of current documentation for the execution of the Works shall include his sub-contractors and suppliers. It shall show:

- how it is ensured that only valid and approved documents are used for the execution of the Works and
- the method of recording variations and amendments to the documentation.

The Contractor's initial proposed Control Plans describing important and critical verification activities based on the Tender Documents and the Contractor's own considerations in respect of execution of the Works.

20.4. CONTROL PLANS (CP)

20.4.1. General

The Contractor shall present for the Engineer's approval his detailed CP for all quality assurance efforts or measures for the Works or sections thereof. Such CP shall be presented to the Engineer not later than one week before the commencement of the Works or an approved section of the Works.

The CP shall include controls as specified in the Contract as well as any other normal and special controls that the Contractor finds necessary in order to ensure the quality of his work.

The CP shall for each control activity describe type, method, criteria for approval and documentation and who is responsible for performing the activity.

If the Engineer does not approve the CP as submitted, then the CP shall be amended for further approval. Subsequent changes in terms of the quality assurance work will not cause changes in agreed deadlines or contract sums.

20.4.2. Quality control plan

Within 28 calendar days after the Commencement Date, the Contractor shall submit for the Engineer's approval a detailed description of his Quality Control Plan.

The plan shall include the quality control of all aspects of on-site construction, laboratory tests and on-site tests. It will include a quality inspection plan which will cover all items intended for inspection at the Contractor, Sub-contractors and Supplier's works and premises.

The plan shall contain but will not be limited to the following items:

- Organization chart for quality control.
- Curriculum vitae of his staff exclusively appointed for all aspects of quality control during the Contract period.
- List of the Contractor's staff engaged in quality control and material testing.
- Name and address of site materials testing laboratory.
- List of laboratory equipment and description of the laboratory testing capabilities.
- Arrangements for any tests to be performed beyond the capability of the Contractor's laboratory.
- Procedures for comprehensive records.

The Contractor shall be responsible for establishing and maintaining procedures for quality control which will ensure that all aspects of the Works comply with the requirements of the Contract.

The Contractor shall be responsible for routine inspection, sampling and testing of all materials, workmanship, plant and measuring devices.

The Contractor shall establish at Site an efficient, comprehensive records facility and library. Books, drawings, standards, publications and manuals shall be indexed and their distribution controlled.

20.5. THE CONTRACTOR'S CONTROL AND DOCUMENTATION

20.5.1. General

During the Contract period, the Contractor shall, to the satisfaction of the Engineer and State Quality Control body, document that the Works comply with the quality assurance requirements stipulated in the Contract or approved during the Contract period.
Consequently, based on the approved QAP and the CP's, the Contractor shall during the execution of the Works carry out and document the quality control and its compliance with the stipulated requirements.

The Contractor's quality control does not limit his responsibility for the Works according to the Contract.

If the Engineer, during the period of the Contract, can substantiate that the Contractor's control and/or documentation shall be extended, the Contractor shall follow the Engineer's written instructions to this effect at his own cost and within the agreed time for completion.

20.5.2. Method of documentation and filing during execution of the Works

All control activities specified in the Control Plan shall be documented.

The CP's and all other issues related to the QA System shall be kept and maintained by the Contractor in the QA filing system, which shall be kept at the project site throughout the period of the Project.

On the basis of the QAP and CP's the Contractor shall produce the necessary forms for registration, log books, and check lists, etc. before work is commenced.

All documentation shall be provided with identification, the date and signature of the person responsible for the documentation. The identification shall as a minimum comprise:

- name of project,
- activity number as defined in the CP,
- time and place of the control activity.

The Engineer shall have full access to the filing system and he may without notice commission a quality audit.

The Contractor shall keep and maintain at his own costs the "Construction Book" (Log Book) according to Angola regulations and submit it regularly for the approval of the Engineer.

20.5.3. Documents at delivery

At the time of delivery of materials and goods, the Contractor shall submit the following documentation to the Engineer in one original and two certified copies, all certificates, documentation of tests etc. of materials and goods to be used in the Works.

All documents verifying that inspection, control and tests performed are in accordance with the Specifications.

Identification lists with cross-references between documents and materials and goods.

21. SITE FACILITIES TO BE PROVIDED BY THE CONTRACTOR

21.1. ACCESS TO THE SITES

The Contractor shall construct, operate, maintain and remove, if required, access routes to construction sites as defined in chapter 2.1 from existing permanent access and/or site roads, such alternative proposals and additional proposals by the Contractor as may be approved from time to time by the Engineer. Such proposals shall allow all phases of Construction.

Any of these accesses will not be removed except when formally agreed by the Engineer. Removal of these accesses shall be indicated with full details in the General Programme of Works.

21.2. HAUL AND ACCESS ROADS

A. The Contractor shall maintain the existing roads to different site works, as are necessary for the conduct of the work under the contract.

B. These roads will also be used as access roads by the Employer, the Engineer and other Contractors engaged on the construction and completion of the Works.

C. As indicated in paragraph 2.5 the Contractor shall establish reasonable traffic regulations governing traffic on the roads maintained by him, and shall provide signs, pavement markings, traffic signals or other control devices and flagmen as may be required to maintain a safe and unimpeded flow of traffic.

D. Construction and maintenance of such haul and access roads not explicitly paid under separate bills will not be measured for payment as a separate Contract Item.

21.3. ELECTRICITY AND POWER SUPPLIES

A. The Contractor shall make his own arrangements for the supply of electricity for his Temporary Works and other site usage, including tests.

B. The Contractor shall install, operate, maintain and subsequently remove equipment to provide sufficient supplies of electricity for the heating lighting and air conditioning of all offices stores laboratories and other temporary buildings used by the Contractor and by the Engineer in addition to any supplies he may require in connection with the construction of the Works.

C. In addition to his main source of power supply the Contractor shall where necessary provide and maintain standby power supplies adequate to ensure the safety of the Works in the event of failure of the main supply irrespective of the timing or duration of such failure.

D. All site electrical installations shall be carried out in accordance with the current Regulations for the Electrical Equipment of Buildings.

E. The Contractor shall also install on his own expenses all the equipment necessary for the permanent power supply of the plant and raw water pumping station in accordance with the Specifications and approved drawings.

F. The Contractor shall provide at the date of the completion, all approvals and clearance for connection of the permanent works as issued by the Kenya Power and Lighting Company (KPLC).

21.4. LIGHTING

A. The Contractor shall provide sufficient lighting to ensure that, at all times:

- Safe working conditions are provided for all personnel on the work sites;
- The Works can be constructed in complete compliance with the Contract;
- Complete inspections of all work in progress can be made by the Engineer, and security of the Works area and public safety measures are adequate and effective.

B. Unless otherwise directed the minimum intensity of illumination on ground or working surface to be provided for the various operators or work areas shall be as tabulated below:

Illuminance Operation or Area	Design Value (Lux)	Minimum Measured Value (Lux)
Earthworks and excavation	50	20
Concrete placing	100	50
Maintenance shops and mechanical and electrical works	300	200

C. The Contractor shall supply a suitable instrument to the Engineer for measuring the intensity of illumination. The instrument shall comply with BS 667 or equivalent standard as approved by the Engineer.

D. All moving plant used during night operations shall be equipped with sufficient lights and reflectors and fluorescent markings to ensure safe working conditions.

E. The submission to or approval by the Engineer of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

21.5. HOUSING FACILITIES FOR THE CONTRACTOR AND HIS SUB-CONTRACTORS

A. The Contractor shall supply:

- Sufficient and adequate Site offices for his staff.
- Site offices for each of his sub-contractors (one office of 20 m² for each sub-contractor).
- Stores, workshops, compounds.
- Temporary accommodations and living facilities.
- Parking areas.
- All necessary services in relation with these works including water supply, lighting, drainage, heating, air conditioning and refuse disposal.

B. The Contractor shall be responsible for the general cleaning and maintenance of the areas including sanitary installations.

C. Buildings shall be complete ready for use including furniture, household appliances (stove, fridge, fan, air-conditioner, heater, lighting tubes and bulbs). Buildings shall be of the same type as the ones provided for its own staff.

D. The Contractor shall provide medical facilities as required by the Medical Officer for Health.

E. Details and layout of site offices and appurtenant buildings and services shall be to the general approval of the Engineer. The Contractor shall obtain any necessary approval from any local authorities concerned.

21.6. WATER SUPPLY

A. The site for the WTP and raw water pumping station has no existing water supply facilities.

B. The Contractor shall make all provisions for the supply of water required for the execution of the Works as well as adequate quantities of potable water for all personnel.

C. The Contractor shall supply water required for the execution and testing of the Works including any hydrostatic or flooding test for pipes, tanks, lagoons and any installation of the Project.

D. The Contractor shall arrange for the water supply for his staff residences, labour camps, site offices, Works, workshops in addition to the supply of the Operator's Camp. Construction of tubewells, storage tanks, overhead tank, distribution system, and their proper running and maintenance shall be his responsibility. Potable water should be supplied 24 hours a day.

E. Water samples shall be tested every 3 months and certificates submitted to the Engineer indicating that the water is fit for human consumption from an agency approved by the Engineer.

F. The Contractor shall supply water to sub-contractors or other contractors for all their requirements.

G. The construction and maintenance of water supply facilities and the supply of water not explicitly paid under separate bills will not be measured for payment as a separate contract item, and it is assumed that those items are included in the Price Schedules.

21.7. STORAGE AREAS

The Contractor shall make his own arrangements for the installation, operation and removal of this temporary storage and works and during the Contract period. Location and layout of these storage and workyard shall be subject to the prior Engineer's approval.

22. SEWERAGE

The Contractor shall make all provisions, subject to the Engineer's approval to construct, operate and maintain throughout the Construction Period a sewerage system comprising collection, treatment and disposal for all the camps.

23. SOLID WASTES

The Contractor shall make all provisions, subject to the Engineer's approval, for collection and disposal of solid wastes from all camps and workplaces. Wastes shall be collected at least twice a week and disposed by a waste handler licenced by the National Environmental Management Authority (NEMA) and the respective County Government.

A waste management plan shall be prepared by the Contractor, which shall be agreed with NEMA and the respective County Government and the waste shall be managed in accordance with the procedures outlined in the same plan.

24. STORAGE AND USE OF EXPLOSIVES

Except if specifically approved by the Engineer in writing, the Contractor will not use explosives.

25. MEETINGS

A. The Contractor or his nominated Representative shall participate in weekly technical and monthly progress meetings convened by the Engineer and the Employer. Such meetings will generally be held at regular intervals through prior notice, but may also be convened without prior notice, in the event of any unusual occurrence, at the discretion of the Engineer and the Employer.

The Contractor shall immediately notify the Engineer of any unusual occurrence which he considers would justify an exceptional meeting.

B. The agenda shall include approval of the minutes of the previous meetings, progress of the works with respect to the schedule and analysis of the difficulties encountered in the work.

C. The minutes of the meeting shall be prepared by the Engineer and shall be deemed, after approval by the other participants, to be written confirmation of the declarations, instructions and decisions taken during the meeting.

D. The Contractor or his nominated representative shall be able to take decision during the meeting; otherwise he shall be considered that the Contractor didn't attend the meeting.

26. RECORDS

26.1. PROGRESS REPORTS

A. By the fifth (5^{th}) day of the following month of each calendar month, the Contractor shall submit two (2) hard copies and a digital copy of a draft monthly progress report which shall contain at least the following information:

- Percentage progress of the Works compared with the approved programme, together with a description and percentage estimate of the work programmed for the following month.
- List of Contractor's Equipment on Site together with its deployment during the month.
- List of all personnel employed on Site.
- Accident record, if any.
- Summary of all work carried out during the month in question together with a description of any difficulties or problems occurring therein.
- Description of the daily climatic conditions during the month.
- Situation with respect to payments, together with the dates on which the Payment Certificates were submitted by the Contractor.
- Description of any claim made by the Contractor during the month.
- Progress photographs, when available.
- State of progress of customs clearance and local transport operations.

- Inventory of materials stored on Site.
- Tests in progress or already carried out during the month and those planned for the next month.

B. Within two working days of receipt of the draft monthly reports the Engineer will return to the Contractor one copy marked for amendment together with any separate comments for correction or addition to the draft report.

C. Within two working days of receipt of the Engineer's comments the Contractor shall submit four hard copies and a digital copy of the final monthly progress report which will include all of the corrections, additions and amendments requested by the Engineer.

D. Each monthly report shall be in a format approved by the Engineer.

26.2. PHOTOGRAPHS

A. To record the general progress of the work as well as particular details and special phases of erection and commissioning the Contractor shall take photographs at regular intervals, not more than 2 months.

B. Photographs of a given part of the Works shall as far as possible be taken from the same location and at the same angle.

C. Digital photographs will be provided on a flash disk.

27. OPERATION AND MAINTENANCE MANUAL

The Contractor shall provide an O&M Manual as defined in Part 2 – Section 7.4 – O&M Requirements.

28. PROTECTION OF FINISHES

The Contractor shall take every care to prevent damage to the works and shall ensure that adequate protection is given to all works from the activities of following trades and any third party. Vulnerable parts of the works particularly liable to damage shall be protected as may be reasonably required by the Engineer and shall be deemed to be insured against damage in accordance with the conditions of contract.

29. SPARE PARTS

29.1. SPARE PARTS

The Contractor shall provide mandatory sufficient spare parts for the water treatment plant and raw water pumping station as required in the Technical Specifications and as recommended by the manufacturers / suppliers in two lots as follows:

- Spare parts for the **2-year** Contractor's Operation Service – to be provided before issuance of Commissioning Certificate.
- Spare parts for **5-year** Operation Period for the Employer i.e. beyond the Contractor's Operation Service – to be provided 6 months before completion of the Operation Service.

The above requirements for duration of spare-parts takes priority over the Technical Specifications requirements on the same item.

The spare parts shall comply with the Specifications and be new, unused and readily interchangeable with the parts for which they are replacements.

The Contractor shall make use of the spare parts supplied under the Contract for the 2-year Operation Service. In addition, the Contractor shall provide at his own expense such spare parts not supplied before but found to be necessary for proper Operation and Maintenance of the Plant during the Operation Service.

Prior to completion of the Operation Service, the Contractor shall provide a list of the mandatory and recommended spare parts for Employer's 5-year use to the Engineer for approval before procurement. The list shall include all the spare parts recommended by the manufacturers of all key equipment including Pumps, Motors, Switchgear, compressors, VFDs etc., and the additional spare parts deemed necessary during the 2-year operation service.

In addition to the 5-year spare parts, the Contractor shall provide three (3) complete sets of maintenance tools including spanners and any other special tools necessary for the servicing, maintenance and dismantling of the water treatment plant and raw water pumping station. The tools supplied by the Contractor shall be contained in suitably fitted painted steel boxes marked with the contents and fitted with good quality locks and keys.

The cost for the supply of the mandatory and recommended spare parts for the 2-year and 5-year operation periods shall be included in Schedule No. 2 of the Price Schedules. Other specialised tools that the Employer may deem necessary to supplement Contractor's spare part list will be procured under the Contract as instructed by the Engineer and the cost will be covered under the respective item of the Provisional Sums.

29.2. SPARE PART BOOK

The Contractor shall give a spare part logbook. This spare parts book shall contain an assembly drawing of the plant and raw water pumping station which shall show all parts of the plant separately marked, designated and referenced including the material. The list of spare parts shall be cross-indexed with the assembly drawings.

The spare parts logbook shall present information in a simple manner so that non-technical personnel may be able to indent these spare parts. The lists of spare parts proposed by the Contractor shall be made with reference to the spare parts book.

29.3. DUPLICATE

All spare parts shall be exact duplicates and from the same manufacturer of the original parts supplied and interchangeable therewith.

29.4. PACKING AND PACKING LIST

The spare parts shall be suitably identified, treated and packed for a long storage in suitably approved containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each such container, shall be securely fastened in a moisture-proof envelope to the outside of the container. The packing list shall also provide the following information:

- Contractor and Contract number
- Identification, including Contractor's drawing number, reference of each spare part in the container.

29.5. STORAGE ROOM

Electrical and mechanical spares shall be packed and crated separately. Spares for different items of plant shall not be mixed in the same container. All cases, containers or other packages are liable to be opened for such examination as the Engineer may require, and packings shall be designed to facilitate opening and subsequent repacking.

All spare parts shall be stored in a safe place under the responsibility of the Contractor up to the Taking Over Certificate; at this date, he will transfer the Spare Parts in a place indicated by the Engineer.

30. KNOW HOW TRANSFER AND TRAINING OF EMPLOYER'S STAFF

The Contractor shall provide a Know How Transfer and Training to the Employer's staff as defined in Part 2 – section 7.4 – O&M Requirements.

31. DAYWORK

31.1. GENERAL

The Contractor shall complete the Daywork prices in Part 1.

No increase or decrease in price will be made for labour and materials daywork charges.

The daywork prices are not subject to adjustment.

Dayworks shall be paid, if any, through the Provisional Sum amount.

31.2. LABOUR CHARGES

The labour categories qualifying as reimbursable to the Contractor when employed on daywork shall include the gangers and charge-hands working with their gangs but shall exclude supervision for foremen level and above.

The Contractor will be reimbursed for the actual gross remuneration at the current rate for each labourer, tradesman, artisan, etc., which shall be deemed to include the following, but not limited to:

- Basic wage
- Unemployment insurance
- Workmen's compensation
- Service bonus
- Foods and water
- Transportation if any

The rates provided by the Contractor shall cover all the following cost:

- Supervision
- Overheads
- Profit
- Time keeping
- Accommodation
- Insurances
- Holidays with pay
- Travelling
- Subsistence
- Other bonuses
- Allowance for paid sick leave
- Allowance for non-productive time
- Recruitment costs
- Pay packet costs
- Pension
- Allowance for paid public holidays
- Allowance for paid annual leave
- Any statutory charges due
- Any and all other relevant to the employment of such employees including all liabilities, obligations, risks and incidentals for all employees to execute work by dayworks.

In addition,

- Only gangers and charge-hand who are working with their gangs shall be paid for under dayworks. The composition of each working gang on dayworks shall be approved by the Engineer prior to the commencement of such daywork. Any ganger or charge-hand who does not work with the gang shall be deemed to be in a supervisory category.
- Site Agents, Quantity Surveyors, Engineers, Foremen and the like shall be deemed to be covered in the rates and prices in the Daywork Schedules of prices.
- Overtime hours on daywork operations will be worked when expressly required by an instruction in writing from the Engineer. Overtime when required will be paid in the same proportions as actually paid to the employees.

- The daywork hours that labour work will be calculated from the time of arrival of the labour at the site where the work is to be carried out to the time of departure from such site but excluding meal breaks and rest periods, etc., i.e. the net time expended for the work.

The combination of the gross remuneration for daywork will be deemed to constitute the full inclusive charge to the Employer for each respective labourer, artisan, etc. Such combination shall include for all items of equipment and consumable which are normal to the particular labourer, tradesman or artisan in question including portable power tools, manual plant and tools, etc. which have not been listed in the Daywork Equipment Schedule. It shall also include the use of water, lighting, power, the ventilation and sewerage facilities, the use and maintenance of stagings, scaffolding, workshops, stores and the like.

31.3. CONTRACTOR'S EQUIPMENT CHARGES

The Bidder shall complete the Daywork Equipment Schedule in the Schedules of prices in order to provide prices for all items of equipment to be provided on Site which may be required to execute work under daywork.

The schedule must indicate clearly the total hourly operating rate, such as at 28 days prior to the closing date of tender, for each item of equipment. Such rates shall constitute the net charge to the Employer for the equipment, in a state fit to perform its intended function, including operating labour required for the equipment.

The cost of operators shall be included under equipment charges.

Equipment rates for daywork shall take account of the following:

- Small tools are not to be listed separately and the use of such tools will be deemed to be covered in the percentage allowance tendered for daywork labour charges and shall not be the basis of claims for payment under daywork charges.

- No addition shall be allowed on the quoted rate for the transport of the said equipment to and from the areas of work if the equipment is already on Site. If, however, the equipment is brought onto Site especially for the extra work ordered, then the transport shall be charged extra at cost, unless such equipment continues in operation for work of a normal nature under the Contract.

- The operating rates to be quoted are to include for items such as fuel, oils, power, consumable, ground-engaging tools, maintenance, repairs, etc. and other incidentals.

- Full payment of the bid rate will not be made for items not capable of operating properly or unable to perform any of their intended functions.

The daywork operating for equipment will be calculated from the separate times of arrival of each item of equipment at the site where the work is to be carried out to each time of departure from such site but excluding meal breaks and rest periods, etc. as arranged by the Contractor for the respective equipment operators. The time for transport between Working Areas or from a Working Area to other Site areas as relevant will subject to prior agreement with the Engineer, be included for reimbursement at the applicable daywork rates.

The minimum time paid for each item of equipment commencing work on each daywork order will be one hour (operating or standby if applicable) and thereafter the times operating or on standby will be paid to the nearest 0.25 hour (15 minutes).

The combination of the net cost of and the percentage allowance on equipment for daywork will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Daywork Labour and Equipment items in the Price Schedule.

32. COMMISSIONING AND TESTS ON COMPLETION OF DESIGN-BUILD

32.1. COMMISSIONING ACTIVITIES

32.1.1. General

With regard to Clause 11.1 of the Particular Conditions of Contract, the Tests on Completion shall satisfy the following:

- Pre-commissioning tests: inspections prior to flooding to determine whether the installations are in fact ready to be commissioned as defined in Part 2 – Section 7.3-Control of performance levels.
- Permission for flooding given by the Engineer
- Adjustment period lasting at least 60 days, during which the Contractor finalises the installations under operation. Commissioning tests end this period.
- Trial Operation period lasting at least 30 days, for checking that continuous operation complies with the basic design and performance requirements. Performance tests are carried out during this period. The observation period shall not end until correct operation has been observed for a period of 30 consecutive days.
- Commissioning certificate of the plant upon completion of the works, construction, finalisation and adjustments and especially after commissioning of the Performance Tests.

32.1.2. Pre-commissioning tests

The installations should be in working order and all checks and Pre-commissioning tests relating to the civil works and equipment have given satisfaction. The CTM control unit is working properly and the electrical installation has been certified by the authorised agency.

The site installations have been dismantled, the sites cleaned, roads completed and green spaces planted.

The complete operation and maintenance manual, final maintenance plan and test plan for downgraded operation mode have been supplied by the Contractor.

In these conditions, the Contractor shall give the 21-days notice for informing the Engineer of the Date after which the Contractor shall ready to carry out the Pre-commissioning tests.

Within a period of 14 days, the installations shall be inspected with a view to checking that they have been built correctly and in conformity with the Employer's requirements and the design.

On conclusion of this inspection, the Engineer shall notify any observed omissions, imperfections or poor workmanship. The same document shall indicate whether the installation can be flooded (start of the adjustment period) in spite of these imperfections and poor workmanship or whether it is postponed until they have been rectified. In the former case, the Contractor shall have a 15 days "modification period" and a new notification shall be sent to the Contractor to note that these imperfections and poor workmanship have been remedied, at which point the adjustment period begins.

The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period

32.1.3. Adjustment period

The adjustment period begins on the date of flooding's authorisation of the installations notified by the Engineer.

This period allows the Contractor to carry out all the checks and adjustments that he considers necessary and to ensure that there are no construction faults in the civil works and equipment.

This period shall last at least sixty (60) days.

The Engineer shall be informed of all checks and adjustments, all analysis and inspection results in a file kept regularly up to date, in two copies.

During the adjustment period:

- The installation shall be operated under the authority and responsibility of the Contractor: all necessary adjustments, repairs and modifications shall be made by him at his own expense.

- The cost of all electrical energy, fluids and consumables, including reagents required for the correct operation of the plant, shall be borne by the Contractor.

As soon as flooding takes place and during all the duration of the adjustment period, the Contractor shall train the future operating staff of the instructions for operating and maintaining the installation, based this on the operating manual provided prior to flooding. The Contractor shall draw up a staff training schedule in liaison with the Employer and with his approval.

This is updated throughout the adjustment period. In any case, the Contractor shall be responsible for the operation and maintenance of the plant. The trained Employer's staff shall not have any responsibilities in the management of the plant

The length of these periods is to be indicated in the Contractor proposal.

Not later than 50 days after the beginning of the period or as soon as the Contractor considers the installation to be in good working order, he shall inform the Engineer in writing that the observation period can begin.

Provided that the various investigations carried out during the adjustment period indeed confirm that the installation is in good working order, the Engineer will notify that the plant succeed to pass the Commissioning tests .

Then, the Engineer will require the Employer for giving in writing the observation period within ten (10) working days of the date of the Contractor's request.

Should the plant fails to be in good working order, in the opinion of the Engineer, a new 15 days "modification period" shall be given to the Contractor to achieve the works. The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period.

32.1.4. Trial Operation period

The Trial Operation Period runs for a period of at least 30 consecutive days without the installation being stopped.

The aim is to verify that the installation is complying with the Guaranteed Performances and with the Employer's Requirements under continuous working conditions and to assess the operating conditions, particularly with regard to energy and reagent consumption.

During the Trial Operation period, the Contractor shall carry out Performance tests at his own expense.

The Employer shall have full authorisation to have a new series of tests carried out at his own expense prior to acceptance in order to check that the Contractor has fulfilled all his obligations in terms of the quality of treatment, production of residues, electricity and reagent consumption, operation of the installations, miscellaneous types of disturbance, etc.

During the Trial Operation period:

- The installation shall be operated under the authority and responsibility of the Contractor. All necessary adjustments, repairs or modifications are carried out by him and at his expense.

- The energy, fluids and consumables, including reagents, are provided by the Contractor and included in his Price.

In light of the results of all the checks carried out, and in particular those of the Performance tests, the Employer may ask for the observation period to be extended to enable the Contractor to remedy any malfunctions responsible for the observed inadequacies or problems. Penalties for delay may be applied. The cost of additional tests required to ensure that the Contractor has complied shall be borne by him.

The Trial Operation period can be terminated only after a period of 30 consecutive days of proper operation of the installations without the installation being stopped.

32.1.5. Performance tests

Performance tests are carried out during the observation period. Their aim is to determine the capacities of the treatment process, the quality of treatment, the efficiency of the various structures and items of equipment, and energy and reagent consumption in normal operating conditions.

The performance tests are carried out by an organisation that is independent of the Contractor, approved by the Employer and monitored by the Engineer. The associated costs shall be included in the Contractor's financial proposal.

During the test period, the installation is operated by the Contractor with its staff assigned to the operation.

The Contractor shall bear the cost of electrical energy, fluids and consumables (including reagents), which shall be included in his Price.

The organisation in charge of carrying out the tests is responsible for setting up and removing the temporary installations required for the tests.

The costs of carrying out the tests shall be borne by the Contractor.

If the results of the tests are not satisfactory, the Engineer shall notify the Contractor concerned that he must remedy all the observed inadequacies and malfunctions without delay.

When all the results are satisfactory, a test conformity report is drawn up and signed by both parties.

32.1.6. Commissioning certificate

At the end of the trial operation period, provided that it shall be successfully and only if the Performance tests are satisfactory, the Commissioning Certificate will be issued in accordance with Clause 11.5 of the General Conditions of Contract.

33. CONTRACTORS KEY PERSONNEL

33.1. GENERAL

The Contractor shall nominate key personnel for the following positions:

- Project Manager; to be in charge of the overall management of the project during its whole lifetime;
- Process Expert; to be in charge of the process design of the plant and to give advice during the commissioning and the operation and maintenance;
- Electro-mechanical expert; to be responsible over the design and execution of all electromechanical works.
- Structural Engineer ; to be responsible over the design, detailing and erection all the WTP and RWPS structures.
- Electricity and SCADA expert; to manage the electricity and SCADA design and construction / implementation activities;
- Construction Site Manager; to manage the construction activities;
- Construction Site Engineers (civil and structural and others as deemed necessary by the Contractor); to be responsible for engineering aspects during the construction;
- Construction Site Manager; to manage the construction activities;
- Surveyor; to be responsible for all survey works;
- Architect; to be in charge of the architectural and landscaping aspects of the project;
- Health, Safety Environmental and Social (Manager) Expert : to manage ESHS risks and impacts during works and operation
- Environmental and Social Officer;
- Health and Safety officer;

The Contractor shall propose CVs for the key personnel in his proposal.

33.2. MINIMUM QUALIFICATIONS OF KEY PERSONNEL

The key personnel qualifications are evaluated according to section 1.3 "Scoring of the Technical bid" of "Part 1 – Section 3_Evaluation Criteria". The key personnel shall meet the following minimum requirements:

- Project Manager:
  - **At least 15 years' experience in project management**
  - **Experience as project manager from at least 3 WTP construction projects with capacity > 4,500 m^3/h**
  - **Be fluent in English language**
  - **Hold University Engineering Degree in civil engineering or in any other relevant discipline.**
- Process Expert:
  - **At least 15 years' experience in WTP process design**
  - **Experience as process designer from at least 3 WTP construction projects with one project having a capacity > 4,500 m^3/h**
  - **Hold University Engineering Degree in civil / water process engineering or in any other relevant discipline.**
- Construction Site Manager:
  - **At least 15 years' experience in construction site management**

- **Experience as construction site manager from at least 3 WTP construction projects with one project having a capacity > 4,500 m^3/h**
- **Hold University Engineering Degree in civil engineering or in any other relevant discipline.**

- Construction Site Engineers (3Nr):
  - **At least 10 years' experience in construction site works**
  - **Experience as construction site engineer from at least 3 WTP construction projects with one project having a capacity > 4,500 m^3/h**
  - **Hold University Engineering Degree in civil engineering or in any other relevant discipline.**

- Engineering Surveyor:
  - **At least 15 years' experience in engineering surveying**
  - **Experience as a surveyor from at least 3 similar projects**
  - **Hold University Engineering Degree in engineering surveying or in any other relevant discipline.**

- Operation and Maintenance Manager:
  - **At least 10 years' experience in WTP operation and management**
  - **Experience as O&M manager on at least 3 WTP construction projects with one project having a capacity > 4,500 m^3/h and managed for a minimum duration of two years**
  - **Hold University Engineering Degree in civil engineering or in any other relevant discipline.**

- Electromechanical expert:
  - **At least 15 years' experience in WTP and pumping stations design and operation**
  - **Experience as Electromechanical expert from at least 3 WTP construction projects with large pumping stations with at least one project having a pumping station capacity > 4,500 m^3/h**
  - **Hold University Engineering Degree in mechanical / electrical engineering or in any other relevant discipline.**

- Structural engineer:
  - **At least 15 years' experience in structural design of WTPs**
  - **Experience as structural engineer for at least 3 WTP having a capacity > 4,500 m^3/h**
  - **Hold University Engineering Degree in structural / civil engineering or in any other relevant discipline.**

- Electricity and SCADA expert:
  - **At least 15 years' experience in Electrical and SCADA industrial design**
  - **Experience as Electricity and SCADA expert from at least 3 industrial plants with one of which is a WTP construction projects with capacity > 4,500 m3/h**
  - **Hold University Engineering Degree in electrical/electronics engineering , instrumentation and controls engineering or in any other relevant discipline.**

- ESHS manager / expert:
  - **At least 10 years' experience in construction site management and 5 years in similar works experience**
  - **Hold University Engineering Degree in environmental studies or in any other relevant discipline.**

- Environmental and social Officer:
  - **At least 5 years' experience in construction site management and 2 years in similar works experience**
  - **Hold University Engineering Degree in environmental studies or in any other relevant discipline.**

- Health and Safety Officer:

- **At least 5 years' experience in construction site management and 2 years in similar works experience**
- **Hold University Engineering Degree in social/safety studies or in any other relevant discipline.**

- Architect:
  - **At least 5 years' experience in industrial architectural design**
  - **Hold University Engineering Degree in architecture or in any other relevant discipline.**

33.3. REMOVAL AND/OR REPLACEMENT OF KEY PERSONNEL

Except as the Employer may otherwise agree, no changes shall be made in the key personnel. If for any reason beyond the reasonable control of the Contractor, it becomes necessary to replace any of the key personnel, the Contractor shall propose as a replacement a person of equivalent or better qualification than the originally proposed expert.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.2 – DESIGN REQUIREMENTS AND PERFORMANCES SPECIFICATIONS

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1. GENERAL PROVISIONS

1.1. FIELD OF APPLICATION

The present "Design requirements and Performance Specifications" Volume sets out the conditions of particular application for the design and works relating to the Contract for the design, the implementation and operation for **Mwache Water Treatment Plant**.

These design, works and services are to be carried out on behalf of **Coast Water Works Development Agency**, acting as Employer for this project.

The project to be drawn up by the Contractor under the terms of the contract must be designed in such a way as to comply with the following, in order of priority:

- The Employer's Requirements, i.e. by order of priority Design Requirement and Performance Specifications, Technical Specifications and the General Requirements.

- The terms of the "Contractor Proposal" of the successful contractor selected as a result of the competitive tendering procedure and appointed after finalisation of the contract.

The Contractor's project must be designed on the basis of the specifications given in this section 7.2. No waivers will be authorised.

The Contractor is responsible for the dimensional design of the process structures and shall guarantee the performance of the adopted installation.

1.2. LIMITS OF SERVICES

The limits of the works covered by this contract are as follows:

- Upstream limit: connection to the new incoming raw water gravity main from Mwache Dam just outside the RWPS. The diameter of the raw water gravity main has not been finalised. Tentatively, the diameter will be 1600 – 2000mm. The Contractor will be required to liaise with the Dam Contractor to obtain the final pipe diameter and other design parameters which will be essential for design of the RWPS. As a minimum, the WTP Contractor is expected to include **Flow Measurement Equipment** and **Flow Regulation Valves** at the connection to the incoming raw water gravity main within the scope of this Contract.

- Downstream limit: connection to the new treated water gravity main (2 x DN 1000) at the outlet of the treated water reservoir. **Flow measurements** and **Flow Regulation** at the outlet of the treated water tank will be within the scope of this Contract.

- All works for the new raw water pumping station, pumping main and new water treatment plant (including local SCADA), the housing and the conversion and landscaping of the site within the site fencing. The extent of the sites is shown on Tender drawings.

- All access roads within the WTP and RWPS. This will also include the main access road for the WTP which will join Access Road A (being implemented under Mwache Dam Contract) – see Tender Drawings.

- The electric sub-station MV/LV (33kV/3.3Kv/400V) that will supply the plant is part of the Contractor's works.
- The 33kV intake and all further substations required for the plant are within the scope of this Contract.
- Water supply facilities (includes a pumping system and an elevated reinforced concrete tank) for the base camp, clinic, police station (implemented under the Dam Contract).
- Optic fibre from the raw water pumping station to the WTP: connection at the limit of the site to the SCADA system of the plant.

1.3. ORIGIN AND QUALITY OF RAW WATER

1.3.1. Origin

Under this Project, the water sources for Mombasa will be augmented through the implementation of the Mwache Dam Water Supply Project which entails:

- A 84m RCC dam on the Mwache river, crest length 526.1m
- A Raw Water Pumping Station , Raw Water Pumping Main, Water Treatment Plant (WTP) with a clear water tank and associated facilities within the vicinity of the Dam with a drinking water production capacity of 186,000 m^3/d
- Four Terminal Reservoirs; one for each of the target supply areas (NML, WML, SML and Island); namely
  - **Nguu Tatu terminal reservoir, proposed within the existing Nguu Tatu Reservoir Site, serving the North Mainland**
  - **Changamwe Reservoir, proposed at the existing Changamwe Reservoir Site, serving Mombasa Island**
  - **Dongo Kundu Reservoir, proposed to be constructed within Dongo Kundu area in Mtongwe, serving the South Mainland**
  - **West Mainland reservoir, proposed to be located at a100 masl site within the West Mainland, to serve the West Mainland area**
- A system of Treated Water Transmission Pipelines, transmitting treated water from the Mwache WTP to the proposed Reservoirs

A Location Plan of the proposed components of the Mwache Dam Water Supply System is provided in Part 2 – Section 7.7 – Drawings.

A General Layout Plan for the Mwache Dam, proposed WTP site boundary and associated facilities is given in Part 2 – Section 7.7 – Drawings.

Raw water for the new Water Treatment Plant will come from the new Mwache Dam which has a catchment of 3600km^2. The Mwache River (main river being impounded) and its tributaries originate from the coastal ranges on the western end of the coastal plains which is the beginning of the Nyika Plateau. The Mwache River makes several meanders throughout its course and drains into the Indian Ocean through Mwache Creek at Port Reitz south of Mombasa Island. Mwache river and its tributaries are illustrated in the Map presented in Part 2 – Section 7.7 – Drawings.

1.3.2. Treatment capacity

Design capacities of the Water Treatment Plant are as follow:

	Outlet capacity (treated water) (m^3/day)	Inlet capacity (Raw water) (m^3/day)	Treatment Hourly flow (m^3/h)
Firm part	93,000 minimum	97,000 maximum	4,450
Conditional part	93,000 minimum	97,000 maximum	4,450
Total capacity	186,000 minimum	194,000 maximum	8,900

As a safe design, water production will be designed on 22 hours of operation.

1.3.3. Raw water quality

The table below summarizes the raw water quality for the design of the new WTP:

Table 1 – Final proposed water quality design input values

Parameter	Unit	Raw water quality
Colour	True Color Units	10
Taste and odour		-
Suspended matter		15
Oil & Grease	mg/L	7
Physico-chemical limits		
Turbidity	NTU	Minimum: 2 Average: 20 Peak: 100
Conductivity	µS/cm	1500
Total Dissolved Solids (TDS)	mg/l	750
Total Suspended Solids	mg/l	35
Hardness as $CaCO_3$	mg/l	40 – 400
Salinity	mg/l	600
Dissolved oxygen	mg/l	6
Aluminium (Al)	mg/l	< 0,1
Chloride (Cl)	mg/l	250
Copper (Cu)	mg/l	< 0,1
Iron (Fe)	mg/l	1,5
Manganese (Mn)	mg/l	0,05
Sodium (Na)	mg/l	< 200
Sulphate (SO_4)	mg/l	40
Zinc (Zn)	mg/l	< 5
pH		6,3 – 8,4
Magnesium (Mg)	mg/l	50
Chlorine	mg/l	0
Calcium (Ca)	mg/l	90
Ammonia (N)	mg/l	1

Parameter	Unit	Raw water quality
Phosphate (P)	mg/l	0,11
Fluoride (F)	mg/l	< 1,5
Arsenic (As)	mg/l	< 0,01
Cadmium (Cd)	mg/l	< 0,003
Lead (Pb)	mg/l	< 0,01
Mercury (Total Hg)	mg/l	< 0,001
Selenium (Se)	mg/l	< 0,01
Chromium (Cr)	mg/l	< 0,05
Cyanide (CN)	mg/l	< 0,01
Phenolic substances	mg/l	< 0,002
Barium (Ba)	mg/l	< 1
Nitrates (NO_3)	mg/l	2
Limits for organic constituents		
Organic Matter by KMnO4	mg/l	15
Chl-a	mg/l	650
Benzene	µg/l	< 10
Chlorophenols	µg/l	< 10
Polynuclear aromatic hydrocarbons	µg/l	< 0,01
Trihalomethanes Chloroform	µg/l	< 300
Limits for radioactive materials		
Gross alpha activity	Bq/l	< 0,1
Gross beta activity	Bq/l	< 1
Microbiological limits		
Total Viable counts at 37°C	MPN/ml	2000
Coliform	MPN/250 ml	1000
E.Coli	MPN/250 ml	1000
Staphylococcus aureus	MPN/250 ml	
Sulphite reducing anaerobes	MPN/50 ml	
Pseudomonas aeruginosa fluorescence	MPN/250 ml	
Streptococuus faecalis	MPN/250 ml	
Shigella	MPN/250 ml	
Salmonella	MPN/250 ml	

1.4. WATER DISCHARGE

All the wastewater resulting from the water treatment such as: thickeners overflow and water drainage from the drying beds shall be discharged into the dam.

1.5. DESTINATION OF BY-PRODUCTS

The sludge derived from the sludge treatment is to be disposed in dedicated landfill.

2. REQUIRED PERFORMANCE LEVELS

2.1. TREATMENT QUALITY

2.1.1. Drinking water quality

The treated water shall comply with the provisions as follows:

Table 2 – Drinking Water quality standards for Mwache WTP

Parameter	Unit	Raw water quality	Drinking water standards
Colour	True Color Units	10	**15**
Taste and odour		-	**Acceptable to users**
Suspended matter		15	**Nil**
Oil & Grease	mg/L	7	**-**
Physico-chemical limits			
Turbidity	NTU	Minimum: 2 Average: 20 Peak: 100	**0,5**
Conductivity	µS/cm	1500	**1500**
Total Dissolved Solids (TDS)	mg/l	750	**1500**
Total Suspended Solids	mg/l	35	**-**
Hardness as $CaCO_3$	mg/l	40 – 400	**500**
Salinity	mg/l	600	**-**
Dissolved oxygen	mg/l	6	**-**
Aluminium (Al)	mg/l	< 0,1	**0,1**
Chloride (Cl)	mg/l	250	**250**
Copper (Cu)	mg/l	< 0,1	**0,1**
Iron (Fe)	mg/l	1,5	**0,3**
Manganese (Mn)	mg/l	0,05	**0,1**
Sodium (Na)	mg/l	< 200	**200**
Sulphate (SO_4)	mg/l	40	**400**
Zinc (Zn)	mg/l	< 5	**5**
pH		6,5 – 8,4	**6,5 – 8,5**
Magnesium (Mg)	mg/l	50	**100**
Chlorine	mg/l	0	**0,2 – 0,5**
Calcium (Ca)	mg/l	90	**250**
Ammonia (N)	mg/l	1	**0,5**
Phosphate (P)	mg/l	0,11	**-**
Fluoride (F)	mg/l	< 1,5	**1,5**
Arsenic (As)	mg/l	< 0,01	**0,01**
Cadmium (Cd)	mg/l	< 0,003	**0,003**
Lead (Pb)	mg/l	< 0,01	**0,01**
Mercury (Total Hg)	mg/l	< 0,001	**0,001**
Selenium (Se)	mg/l	< 0,01	**0,01**
Chromium (Cr)	mg/l	< 0,05	**0,05**

Parameter	Unit	Raw water quality	Drinking water standards
Cyanide (CN)	mg/l	< 0,01	**0,01**
Phenolic substances	mg/l	< 0,002	**0,002**
Barium (Ba)	mg/l	< 1	**1**
Nitrates (NO_3)	mg/l	2	**10**
Limits for organic constituents			
Organic Matter by KMnO4	mg/l	15	**To be proposed by Contractor**
Chl-a	mg/l	650	**To be proposed by Contractor**
Benzene	µg/l	< 10	**10**
Chlorophenols	µg/l	< 10	**10**
Polynuclear aromatic hydrocarbons	µg/l	< 0,01	**0,01**
Trihalomethanes Chloroform	µg/l	< 300	**300**
Limits for radioactive materials			
Gross alpha activity	Bq/l	< 0,1	**0,1**
Gross beta activity	Bq/l	< 1	**1**
Microbiological limits			
Total Viable counts at 37°C	MPN/ml	2000	**100**
Coliform	MPN/250 ml	1000	**Nil**
E.Coli	MPN/250 ml	1000	**Nil**
Staphylococcus aureus	MPN/250 ml		**Nil**
Sulphite reducing anaerobes	MPN/50 ml		**Nil**
Pseudomonas aeruginosa fluorescence	MPN/250 ml		**Nil**
Streptococuus faecalis	MPN/250 ml		**Nil**
Shigella	MPN/250 ml		**Nil**
Salmonella	MPN/250 ml		**Nil**

2.1.2. Residual of chlorine and pH adjustment

The residual of chlorine rate at the outlet of the treated water reservoir shall be at least 0.5 mg/L.

The Contractor shall install equipment to adjust the pH to ensure calco-carbonic balance of the drinking water.

2.1.3. Sludge dryness

The sludge must be evacuated as a solid and must be able to stay in a heap. In any case, the minimum average dryness of the dried sludge should be 40%.

2.1.4. Noise

The limitations and the treatment of noise are governed by a double objective:

- To limit the noise level for the operating staff of the plant. The plant is an industrial establishment and shall meet the current NEMA regulation concerning noise protection of workers.

- To limit the noise that could be anticipated to disturb the neighbourhood.

At all points bounding the treatment plant site, noise levels must comply with the following specifications:

- Maximum levels:
  - **65 dB(A) by day (7 a.m. to 8 p.m.),**
  - **60 dB(A) during intermediate periods:**
    - Working days: 6 a.m. to 7 p.m. and 8 p.m. to 10 p.m.
    - Sundays and public holidays: 6 a.m. to 10 p.m.
  - **55 dB(A) by night (10 p.m. to 6 a.m.).**

- Maximum emergence conditions (compared to normal conditions):
  - **By day (7 a.m. to 8 p.m.) and during intermediate periods: 5 dBA,**
  - **By night (8 p.m. to 8 a.m.): 3 dBA.**

In the equipment rooms, the sound power emitted by all of the equipment in normal operating conditions must not exceed the following values:

- Total value: 80 dBA

In the administrative/office building, noise levels must be below the following values:

- Total value 45 dBA.

Information about noise should be recorded as per national and international legislation (including WB/IFC and Decree N398)

2.2. TREATMENT CAPACITY

The design capacities are defined in clause 1.3.2. – "Treatment capacity".

The daily water loss shall be reduced to a minimum. In any case, the daily water loss will not exceed 4 % of the design capacity for raw water.

2.3. RAW WATER PUMPING STATION

The required key performance levels for the RWPS shall be as follows:

- Flow Rate (at WTP inlet)
  - **Firm part – min 4,450 m^3/hr**
  - **Conditional part – additional min 4,450 m^3/hr**
  - **Total capacity – min. 8900m^3/hr**

- Efficiency of the motors – **min. 94%**

- Efficiency of the pumps – min. 89**%**

- Noise Level – **max. 70dB (A)**

- Permissible Temperature in pump house – **Ambient temperature + 10°C**

2.4. GUARANTEED PERFORMANCE RANGE

The performances of the water treatment defined in section 2.1 shall be guaranteed for all the raw water quality range and values defined in section 1.3.3. – "Raw water quality".

3. PROJECT DESIGN

3.1. GENERAL

3.1.1. Admissible process

Alternative Tenders are not allowed.

3.1.2. Use of available area

The work area included in the scope of work of the Contractor is limited by the boundary of the site as indicated on the Drawings – Section 7.7. The Contractor shall locate all buildings and structures, including access roads and parking, for this present phase in the area indicated on the Drawings- Section 7.7.

3.1.3. Continuous operation of the plant

The treatment plant must operate normally at the level of required performance throughout the year, in any weather conditions. No interruption of the water treatment is allowed during the operation and maintenance of the plant.

3.1.4. Reliability of the installation

The reliability of the installations, as well as their performance, is major requirements that must be met by the Contractor.

The installation shall, as a minimum, consist of four parallel treatment lines in order to simplify maintenance operations. Provision shall be made for cross-connection of the lines between all facilities.

The installation design must take account of this requirement (reliability analysis, failure risk analysis, etc.), which is more particularly associated with meeting the following reliability targets (non-exhaustive list):

- Installation design must guarantee personal safety,
- Installation design must prevent any risk of flooding or equipment damage,
- Minimised risk of failure leading to damage to the installations.

It must be made clear that the reliability targets must include the down times linked to equipment maintenance and servicing.

The design presented by the successful contractor must include all installations required for the plant to operate perfectly.

All necessary provisions must be made to ensure that the installation shall be reliable and to minimise shutdown and breakdown times. Stand-by units and the main pieces of equipment must be fitted on the spot with a backup system or must be available in the storage place.

Power (electricity) cut: In order to handle this problem, a diesel engine generator which can provide electric energy to meet auxiliary power requirements for the Pumping Station and the Water Treatment Plant and lighting. The generator will be in operation automatically when any power cut from external power source. In addition to that all units are controlled by SCADA system.

In the event of a power failure, the installation must be capable of backing up all data and restarting automatically without incurring damage when the power supply is restored.

Force majeure failure: Force majeure means an exceptional event or circumstance which is beyond the control and can be described as the danger of over loading of the plant due to the high inflow. A general overflow pipe of the plant will be implemented by the Contractor which will divert the whole incoming flow to the Mwache Dam at several point of the plant (minimum: inlet of sand filtration and each type of water tanks).

The Tenderer shall in his proposal include an assessment of the reliability of the plant, including all measures taken to ensure the reliability.

If necessary, the contractual memorandum on reliability, describing the arrangements made, shall be supplemented during the design and implementation phases.

3.1.5. Ease and optimization of operation

The project must be designed in such a way as to ensure easy operation and guarantee maximum safety for personnel.

In order to ease operation, the following design rules will be respected by the Contractor (for the total capacity):

- Number of water treatment lines: Minimum 4
- Number of filtered water tanks: Minimum 2
- Number of backwash water and sludge extraction from clarification tanks: Minimum 2
- Number of disinfection water tanks: Minimum 2
- Number of final ph adjustment water tanks: Minimum 2
- Number of treated water tanks: Minimum 2
- Number of sludge thickening treatment lines: Minimum 2

The clarification treatment will be easily by-passed depending on the turbidity of the raw water (value to be defined by the Contractor). In this case, raw water will pass through aeration and will be diverted to media filtration, by-passing the clarification treatment while respecting the performances requirements presented in chapter *2 - Required performance levels*.

Design of the WTP will allow to by-pass UV disinfection in case of equipment failure at full design capacity.

3.1.6. Maintenance

3.1.6.1. Preventive maintenance

The installation is designed to meet the required performance levels in all situations, even during maintenance operations. The numbers of treatment lines, machines and their capacity, and standby equipment are defined with this in view.

3.1.6.2. Corrective maintenance

The installation is designed to minimise the time required for corrective maintenance. With this in view, it must have the following characteristics:

- easy monitoring and detection of break-downs and abnormal operation,
- accessibility and ease of dismantling/re-assembly (e.g. sufficient space provided for easy operation and maintenance activities),
- easy lifting and handling of the largest items of equipment,
- areas provided for access by maintenance staff.

3.1.7. Hydraulic operation

3.1.7.1. General provision

The design shall be carried out for minimising pumping. As a general rule, the water shall be lifted at the entrance of the plant, and except particular process under pressure, it is assumed that no more water pumping shall be necessary.

The natural slope of the site should be sufficient for operating the plant without pumping at the outlet

3.1.7.2. Hydraulic grade line

The hydraulic grade lines shall be calculated from the raw water pumping station to the overflow of the storage reservoir.

These levels shall be written on the hydraulic profile and on the civil guide drawings.

A minimum freeboard of 50 cm is designed for all the structures above the extreme hydraulic level.

3.1.7.3. Emptying of structures – Low point release devices

All structures containing liquid (water, sludge, reagents, etc.) must be designed so that they can be emptied by gravity flow. In exceptional cases, emptying by pumping can be considered.

All low points of the installation (miscellaneous structures, technical equipment rooms, roads, etc.) must be provided with sumps for removal of liquid by gravity flow or pumping.

3.1.7.4. By-passes

Structures corresponding to the various stages of wastewater treatment must be fitted with by-passes so that they can be isolated in the event of an incident, temporarily preventing their normal operation.

3.1.7.5. Distribution

Equal distribution between various treatment lines or structures must be as strict as possible. This is checked downstream on each of the lines or structures.

The distribution structure should preferably be of the overspill type. This must be adjustable and easily accessible.

3.1.7.6. Outlet water levels

The hydraulic design of the plant should take into account the following water levels:

- Outlet: Lowest water level in the treated water reservoir should be not less than **116 masl**.

3.1.8. Equipment

3.1.8.1. Service life

The service life classes and corresponding service life hours for equipment shall meet the minimum requirements as shown hereafter, in accordance with BS EN 12255-1.

Equipment type	Service life class	Service life	Standard reference
DECANTATION AND CLARIFICATION:			
- Rotating axis mounted on ball bearings, intermediate bearings and gears	4	50 000 h	BS EN 12255-4
- Wheel drives, electrical motors	3	20 000 h	BS EN 12255-4
- Lifting equipment	2	10 000 h	BS EN 12255-4
TANKS AGITATION			
- Electrical motors	3	20 000 h	BS EN 12255-6
- Mixers	4	50 000 h	BS EN 12255-6
SLUDGE TREATMENT			
- Motors	3	20 000 h	BS EN 12255-8
- Gears and bearings of pumps, compressors, scrappers, mixers, dewatering equipment or similar	4	50 000 h	BS EN 12255-8

3.1.8.2. Corrosion protection

The Contractor's attention is drawn to the corrosive character of the atmosphere in the treatment plant.

All equipment must therefore be made of corrosion-proof material. Unless otherwise specified, the following rules shall apply:

- Mechanical equipment in contact with water : Stainless steel 304L
- Mechanical equipment in contact with chemicals : Stainless steel 316L
- Materials for steel structure in treatment places : Aluminium or galvanized steel
- Materials for hand railing and steel works : aluminium or inert materials
- Cable supports : aluminium, inert materials or stainless steel 316L
- Materials for handling equipment : steel with epoxy cover painting
- Materials for ventilation and exhaust ducts, reagents pipes ;… : PVC, HDPE

The defects liability period for the equipment is set out in the Conditions of Contract.

3.1.8.3. Standardisation of equipment

As far as possible, the Contractor shall endeavour to ensure that equipment used in the plant is of the same brand and keep the sizes of mechanical and electrical equipment to a minimum in order to limit the number of spare parts required.

3.1.8.4. Lifting and handling equipment

Equipment shall be provided for lifting, transporting and removing outside the buildings all equipment requiring regular maintenance, notably pumps, motors, fans, etc.

Outside access must be provided for trucks to pick up the equipment.

Lifting equipment (movable if necessary) must be provided for handling stoplogs, trapdoors, inspection hole covers and any items exceeding 15 kg in weight.

Lifting equipment must be provided for loading large items weighing more than 1000 kg on to trucks, in a single operation.

The capacity and type of such equipment shall be adapted to the items to be lifted and to the frequency of use (bracket crane, gantry, bridge crane, monorail, etc.).

Manual controls must not require a force of more than 20 daN for lifting and pulling, and more than 10 daN for operating cranks or drive wheels.

Controls requiring greater forces than these shall be electrically operated from the ground.

3.1.8.5. Submerged equipment

It must be possible to lift all submerged equipment (pumps, mixers, aerators, air diffusers, etc.) from the surface in the above conditions so that they can be maintained without emptying the structures.

3.1.9. Motor efficiency

Motor efficiency will be compliant with Commission Regulation (EU) 2019/1781 of 1 October 2019 laying down ecodesign requirements for electric motors and variable speed drives pursuant to Directive 2009/125/EC of the European Parliament and of the Council, amending Regulation (EC) No 641/2009 with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products and repealing Commission Regulation (EC) No 640/2009.

3.1.10. Limitation of disturbances - Noise

The installations shall be designed at the outset firstly to comply with chapter *2.1.4. - Noise* and secondly to reduce noise disturbance as far as possible.

Special arrangements must be made to prevent the propagation of noise. Noisy machines must be housed in suitably insulated and ventilated rooms.

Special attention must be paid to the handling of doors and windows and the air intakes and outlets (sound traps).

These arrangements are described in detail and accompanied by a calculation note during the working design phase.

3.1.11. Protection and safety of operating staff

It is stipulated that the conditions in which operating staff work to operate the installations built by the Contractor must comply in all respects with the labour legislation in force on the date on which the contract is signed.

The installation is fitted with the necessary monitoring and safety systems for preventing any disorderly operation of the equipment that may present a danger to staff, equipment or the environment.

A push-button type emergency stop must be installed near each rotating machine. If a machine is stopped with this device, it cannot be restarted automatically or manually from the central cabinet.

All rooms shall be provided with emergency exits complying with the regulations in force.

All permanent means of access to machinery (ladders, platforms, stairways, etc.) shall be in accordance with EN ISO 14122.

In addition to the special contract conditions concerning safety, the Contractor shall provide and install the following equipment:

- Lifeline with harnesses for exceptional operations.
- Minimum width of passageways: 1 m except in exceptional circumstances.
- Ladder with safety cage for any height above 2.5 m.
- Removable safety grid for all ground-level manholes on basins or structures over 2.5 m high.
- Assisted handling for all loads over 50 kg.
- Safety lighting in all premises.
- Circuit-breakers and mushroom-head off buttons for all electrical equipment.

The specific safety equipment for the treatment processes is as follows:

- Buoy with mooring ropes and pole at each end of the tank building.
- Descending safety ladder on mobile catwalks.
- Safety eye baths at each reagent unloading cabinet and each location where reagents are used.
- Splash confinement (Plexiglas box) around equipment (pumps, flowmeters, etc.) on reagent networks.
- Maximum confinement of gaseous atmospheres above effluent.
- Ventilation of all process rooms.
- Specific atmosphere treatment by means of odour treatment and air circulation.
- Monorail and lifting tackle cut-offs triggered by blockage detection system.
- Confinement cases for all reagent tanks.
- Frontal and circular scraper bridge cut-offs triggered by blockage detection system, with object removal blade.

3.1.12. Pumping stations

A « pumping station » is defined as a place fitted with more than 1 pump for lifting water, sludge, grit grease, etc. from one structure or equipment (pits, sumps, channels) toward other equipment or structures.

Unless otherwise specified and whatever the number of pumps, 50% stand-by pump shall be enable on the spot and shall start up automatically of another pump breaks down; this pump shall have the same characteristics than the other ones; a circular working could be established among the pump in order to use all of them in a similar manner.

For waste water pumping stations, at least 1 pump shall be "variable speed pump" in order to better follow the inflow.

Non return valves shall be filled in connection with each pump and dismantling valves shall be installed in order to ease the maintenance.

As far as possible the pumps shall be dry-mounted pumps. If the pumps are wet-mounted pumps, provisions shall be made for easy dismantling without emptying the structure and reinstallation shall be secure automatically.

The structures where a general by-pass must be designed for avoiding a general overflow in case of power breakdown are described in the present document.

The pumping station shall be controlled through level switches. It shall systematically be fitted with a high level probe for alarm and low probe for safety (pump stop).

3.1.13. Architectural and urban planning requirements

The Contractor shall acquaint himself with the regulations concerning the area, and take them into account in designing and carrying out the works.

Buildings and structures shall be in harmony with local architecture and be duly landscaped.

The architect's fees are included in the contract amount.

The successful Contractor must prepare drawings in compliance with the local submission requirements for approval purposes. In the event of any modifications required by the local authorities responsible for delivering the building permit, the Contractor shall not be entitled to claim for additional costs.

3.2. PROJECT DESCRIPTION

The project description includes two operating cases:

- Normal operation: means that all the equipment are operative at the specified capacities.
- Exceptional operation: means that some particular equipment are out of order.

Whatever the process selected by the Contractor, the treatment process shall include the following equipment/treatment steps:

- For the water treatment line :
  - **Pre-treatment (if necessary)**
  - **Aeration**
  - **pH adjustment**
  - **Coagulation**
  - **Flocculation**
  - **Clarification by flotation or sedimentation**
  - **Media filtration**
  - **Disinfection**
  - **Final pH adjustment for calco-carbonic balance**
  - **Final disinfection**
- For the sludge line
  - **Sludge thickening**
  - **Sludge drying**
- Treated water reservoir

In addition to the process specified here-above, the plant shall necessarily include:

- Guardhouse
- Offices, storage, workshop, bathroom,….
- Roads, footpaths, green area, parking plot,….
- network for all water required in the treatment process, internal sewage network, all process networks
- Drinking water network,
- MV/ LV electrical switchyard, all the MV and LV networks…

3.3. RAW WATER PUMPING STATION (RWPS)

3.3.1. Extent of the Works

The works under this Contract includes but not limited to the following:

(i) Design, supply, installation and commissioning of mechanical components of the RWPS which includes pump sets complete with all motors and associated pipework. The pipework also includes fittings, valves and other appurtenances.
(ii) Design, supply, installation and commissioning of all electrical installations within the RWPS. This will include electrical panels, switchgear, pump control systems etc.
(iii) Design, supply, installation and commissioning of surge suppression equipment (if necessary) following surge analysis which will be carried out by the Contractor.
(iv) Design of the civil works for the RWPS which will include the pump house, access roads within the RWPS and other buildings within the RWPS.
(v) Design, supply, installation and commissioning of requisite flow measuring instrumentation at the RWPS.

3.3.2. Footprint for the RWPS

The Dam Contractor will implement the following works/components:

(i) Earthworks for the proposed pumping station footprint to a general reduced level of 41m amsl.
(ii) An access road from the WTP to the pumping station (bitumen surfacing, 8m wide) on completion of the Dam. In the interim, a temporary all weather road shall be constructed.
(iii) Raw water gravity main from the Dam draw-off tower to the RWPS (DN1800, PN10).

The Drawings for the Dam's draw-off structure and the raw water gravity main (obtained from the Dam Contract) are provided in Section 7 – Tender Drawings.

3.3.3. DESIGN CRITERIA

3.3.3.1. Preamble

The Contractor will not only have a means obligation but also a results obligation. This will include verification of key design data including the site conditions and ensuring the use of current and correct data for design and selection of the pumps and associated components.

The Contractor will be required to submit to the Engineer the design and shop drawings for approval before ordering of any plant. This will also include submission of data sheets and relevant certificates demonstrating quality control and quality assurance of the manufacturing process.

All workmanship and materials shall be of the highest quality appropriate for each category of work.

The power requirements for the RWPS and WTP will be based on the contractor's final sizing of pumps and equipment required for the project. The Contractor will also be responsible for all liaison with KPLC .

It is proposed that the RWPS be connected to the 33kV line (to be done in the Dam Contract) and feed the WTP at 3.3kV. The Contractor shall make provision for a Kenya Power metering room at the RWPS.

3.3.3.2. Raw Water Abstraction from Mwache Dam

Mwache WTP will be supplied with raw water from the Mwache Dam which is being implemented under a separate Contract. Abstraction of the raw water from the Dam will be through a wet-well type intake tower with four abstraction points/outlets at different elevations: 43.9, 53.0, 68.0 and 83.0 masl. The drawing for the draw-off structure is provided as part of the Tender Drawings.

The scope of works for this Contract commences at the pumping station inlet. The Dam Contractor shall construct the raw water gravity main from the Dam to the boundary of the site of the Raw Water Pumping Station (RWPS) and shall install a blank flange at the pipeline end.

The proposed arrangement for the raw water abstraction, pumping system to Mwache WTP including the limitation of scope for each of the adjoining Contracts is illustrated in the **Figure 1**.

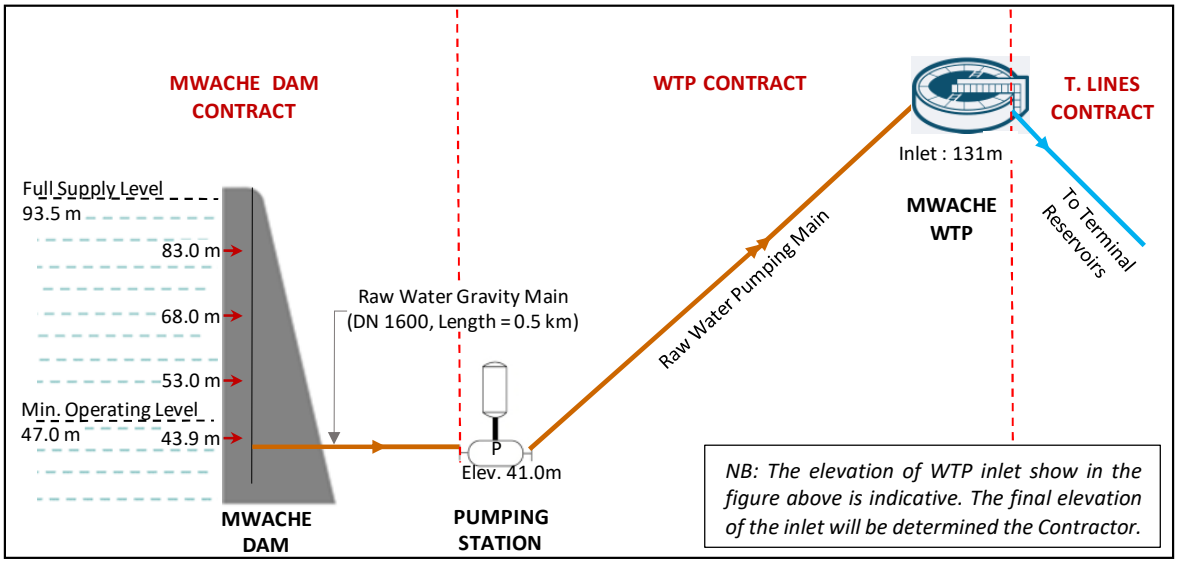

Figure 1: Mwache Dam raw water abstraction and pumping system

3.3.3.3. Design Data

(i) Water Level in the Reservoir

Two key parameters regarding the Mwache Dam reservoir must be considered in the RWPS design:

- Full Supply Level, FSL (which is the elevation of the crest of the spillway) : 93.5 masl
- Minimum Operation Level, MOL : 47.0 masl

A simulation of the Dam reservoir over 54 years is available in the Update of the Dam Design Report (*NK, MIBP, Af, 2017*) and is presented in the **Figure 2**. Further statistical analysis of the water level (on the basis of the simulation results) is given in **Figure 3**.

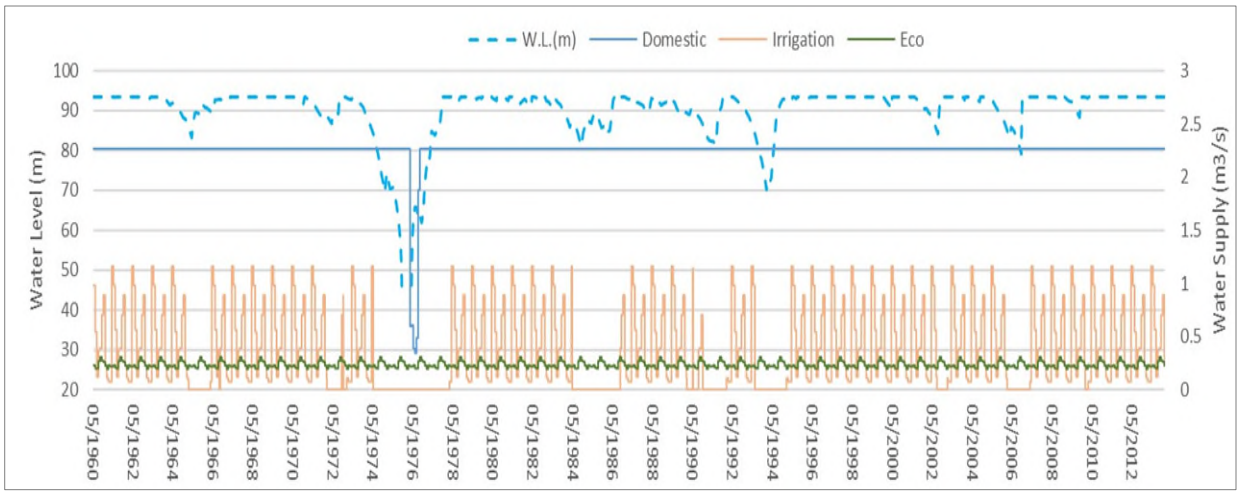

Figure 2: Mwache reservoir simulation results

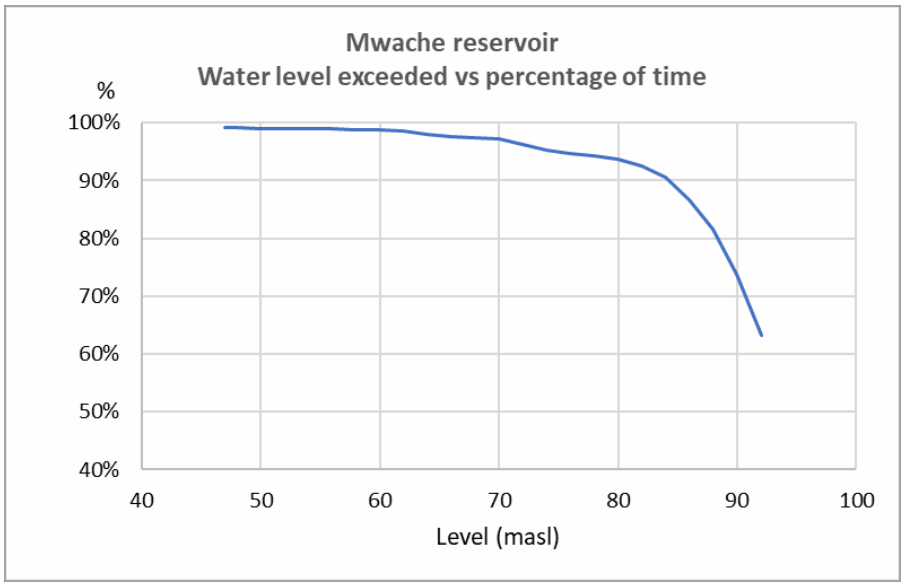

Figure 3: Mwache Dam Reservoir water level analysis

The simulation of the Dam reservoir over 54 years indicates that the water level in the Mwache Dam should be in the upper range most of the time (63% between 92.0 and 93.5 masl, 94% above 80.0 masl). However, in future the situation could possibly be affected by the climate change.

Contractor's design of the RWPS must demonstrate optimization of energy costs through adaptation of the pumping system to the fluctuating reservoir water levels from the minimum supply level to full supply level.

(ii) Hourly flowrate

The WTP will be designed on the basis of 22 hours of operation per day. The final hourly flowrate of treated water will therefore be 8,455 m^3/h and the corresponding maximum final raw water flowrate (to be adopted as the hourly flow rate for the RWPS) will be **8,900 m^3/h**. (Refer to section 1.3.2. - Treatment capacity for respective treatment capacity)

(iii) Variable Production and WTP Inlet Levels

Under Section 3.1.5 (design requirements for WTP), for ease of operation and flexibility, the WTP will be designed to have a minimum of four (4) water treatment lines.

This will ensure the WTP is able to operate at various regimes depending on the treated water demand and also depending on the raw water supply (especially in case of exceptionally low water level in the reservoir). In addition, the production capacity could be affected in case of failure of key equipment.

The outlet lowest water level in the treated water reservoir located at the WTP should be not less than as defined in chapter 3.1.7.6. Based on this and the site topography, the Contractor is to finalise the WTP hydraulic profile to obtain the WTP inlet levels.

Contractor's design of the RWPS must be in tandem with the adopted WTP production flexibility i.e., the number of water treatment lines and the final inlet level of the raw water at the WTP.

(iv) Total Dynamic Head (TDH) / Pumping Head

Preliminary design indicates that the static head will vary as follows:

- From the Minimum Static Head (frequent): 38 m
- To the Maximum Static Head (exceptional): 84 m

The above variation in static head is illustrated in **Figure 4.**

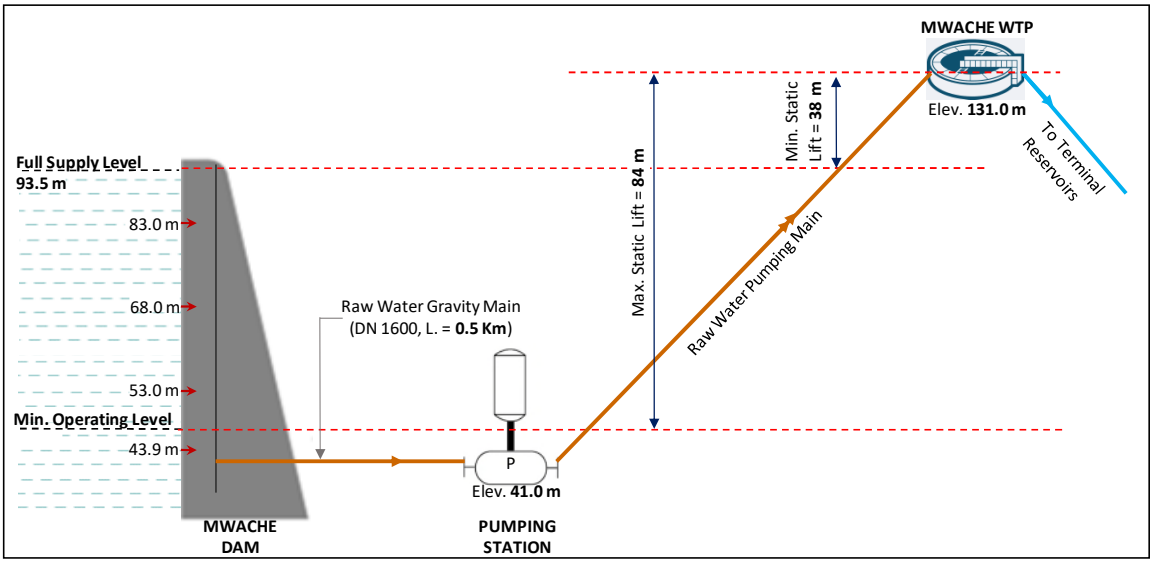

Figure 4 : Schematic Diagram - Varying Static Head

The Contractor must demonstrate that the selected raw water pumps satisfy the requirement of the TDH based on the final calculations for static head and head losses.

(v) Type of Pumps and Standby Requirement

The type of pumps to be provided specifically at the raw water pumping station (duty and stand by) by the Contractor shall be: **Single Stage - Axially Horizontal Split Case - Double Suction Pumps with a Double Volute Casing**.

Standby pumping units to be provided shall be in compliance with the provisions of the local design manual for water supply services (*Ministry of Water and Irrigation Practice for Water Supply Services In Kenya October 2005*).

3.3.3.4. Surge Protection Equipment

The Contractor shall provide evidence (through calculations) that the upstream surge pressure will remain within the limit accepted by the proposed raw water pumping system including the gravity pipeline from the Dam. Otherwise, the Contractor shall design, supply and install the appropriate surge protection equipment.

3.3.3.5. Pipework and Fittings

To comply with Part 2 - Section VII - Volume 5 – Section 14100 – 21 (Pipes and Fittings)

3.3.3.6. Pump Motor Control Philosophy

Each pump set shall have its own 3.3 kV Variable Frequency Drive. The drives shall be installed in a motor control centre room located at one side within the pump house.

The Variable Frequency Drives shall comply with the Standard Specifications provided in Section 5.2 – Medium Voltage VFDs.

The conceptual design indicates the drives are to be selected for 800kW motors. However, final sizing will be based on Contractor's final selection of pumps.

The speed of the pump will be controlled to maintain a steady flow rate taking cognisant of the dam reservoir water levels.

The RWPS shall have a SCADA system that shall collect and record all data from the pumps, power supply, pressure transmitters, and flowmeter etc. All data, communications and controls will be interlinked with the SCADA system for the WTP.

The contractor shall design the pump motor controls based on the following criteria:

- WTP production flexibility i.e., the number of water treatment lines
- The speed of the pumps is to be controlled to run at its duty point, ensuring maximum efficiency, based on the following:
  - Maintain a constant flow rate of 8,900 m^3/hr to the Water Treatment Plant.
  - On the suction head i.e., reservoir water level which will fluctuate during the year.
- Feedback shall be from a pressure transmitter installed in the suction pipeline and from the Electro-Magnetic flowmeters in the discharge lines.
- Feedback from Level Transmitter in Water Treatment Plant receiving tank to maintain a set level in tank
- Each pump will have a pump control valve. The pump shall start against close valve conditions and open once the pump is at speed. The valve should close before stopping the pump.
- The controls shall have the following minimum functions available:
  - Local/Off/Automatic selection
  - Duty cycling between pumps to maintain equal run hours.
  - Local Stop-Start on the panel and remote stop start at the pump.
  - Control Valve open and close.
  - Emergency Stop Push buttons located at pumps and on panels.
  - Local speed adjustment on the drive for maintenance purposes only
  - Network analyser for each pump with Modbus communication
- Standard motor protection Relay shall be provided as a minimum:
  - Overload
  - Underload

  - Earth Fault
  - Over/Under Voltage, phase failure, phase reversal
  - Motor thermal based on calculated capacity
  - No of starts per hour
  - Temperature monitoring relay for all motor windings, DE and NDE motor and pump bearing temperatures (PT100's). Capable of alarm and trip outputs.
  - Suitably rate Power Factor Capacitor complete with fuses.

- Pipeline Backup protection
  - Flow Switch protection in delivery pipelines.
  - Low pressure in the suction line
  - High pressure in delivery lines
- Control system to meet control philosophy requirements.

3.3.3.7. Instrumentation

The following shall be the minimum instrumentation provided in RWPS:

- Pressure Gauge on all suction and delivery manifolds.
- Pressure Transducer on all suction and delivery manifolds, for control purposes.
- Pressure Gauge on each pumps suction and delivery pipes.
- High Pressure Switches on each pumps delivery pipe. Located directly after pump before any valves. For High pressure backup protection i.e. valve closed.
- Low Pressure Switch on suction manifolds. Backup protection due to low suction pressure.
- High Pressure Switch on Delivery manifolds. Backup protection.
- Flow switch on both delivery manifolds as they exit building. Backup protection
- PT 100's in each winding of pump motors
- PT 100's in the Motor DE and NDE bearings
- PT 100's in the Pump DE and NDE bearings
- Electro-magnetic Flowmeters in each delivery pipe external to building.
- Ultrasonic level transducer in Water Treatment Plant Raw water tank with local and remote display complete with 4-20mA and Modbus Communication protocol. The Level shall be transmitted back to the Raw Water Pump house control system. This shall strictly be by fibre optic cable transmission.

3.3.3.8. Conceptual Design

A conceptual design has been developed to guide the Contractor on the expected scope of works. The Contractor is not bound by this conceptual design and can propose an alternative design which is in compliance with the Employer's Requirements. A **Single line network diagram** is included as part of the Tender Drawings (for information only).

The proposed system network includes the following:

- 33kV Supply from Kenya Power
- 33kV 4 Panel Switchboard,
- 3.3kV 12 Panel Switchboard,
- 3.3kV Variable Frequency Drives
- 3.3kV 5 Panel Switchboard at Water Treatment Plant
- 415V Auxiliary Power Switchboard – Raw Water Pumpstation
- 415V Auxiliary Power Switchboard – Water Treatment Plant
- 33/3.3kV Transformers

- 3.3/0.433kV Transformers

3.3.3.9. Additional Requirements for Raw Water Pumping Station

	Particulars	Specifications
1.	Minimum height of building above finished floor levels	
	i.) At pump / motor floor area	As per the pump and EOT crane manufacturer's recommendations. Minimum 8m.
	ii.) Switch rooms	4m
	iii.) Loading / unloading / maintenance bays	7m
	iv.) Kenya Power Metering Room	4m
	v.) Internal pump operation room	4m
	vi.) Internal store	4m
	vii.) External workshop and store	As per the EOT crane manufacturer's recommendations. Minimum 8m.
	viii.) Other areas / facilities	4m
2.	Minimum distances for the pump house:	
	i.) Internal distances between pump plinths	*2m*
	ii.) Distance between pump plinth and walls	*4m*
	<u>Note:</u> Additional 2Nr. Plinths are to be provided as a future provision for the Client.	
3.	Minimum area requirement for other facilities:	
	i.) *Internal pump operation room*	$20m^2$
	ii.) *Internal store*	$50m^2$
	iii.) *External workshop and store*	$200m^2$
4.	Flooring:	
	i.) Pump House	Floor Harner Topping with CC Base
	ii.) Other Facilities within the Pumping Station	

3.4. RAW WATER PUMPING MAIN (RWPM)

3.4.1. PREAMBLE

The RWPM shall be designed and constructed of Ferrous Pipes and Fittings made of either Steel or Ductile Iron, suitable for the working pressure which will be determined by the Contractor. Pipes, valves and fittings shall comply with the relevant International and/or National Specifications as stated in the Technical Specifications.

3.4.2. PIPELINE ALIGNMENT

The Contractor is required to design and construct the Raw Water Pumping Main (RWPM) which will deliver and meet the raw water requirements for the WTP.

Considering the close proximity of the Raw Water Pumping Station to the WTP, the probable alignment of the Raw Water Pumping Main is quite straight forward, traversing in the general Northeast direction from the Raw Water Pumping Station to the WTP Inlet Works.

Two probable routes are suggested as follows:

Option 1: Under this pipeline route option, the Raw Water Pumping Main from the Pumping Station traverses Northwards for approx. 260m then turns Northeast, along the alignment of the proposed Mwache Dam Access Roads A and C corridors for approx. 1.13km before turning Northwest into the proposed WTP Inlet Works. The total length of the proposed Raw Water Pumping Main under Option 1 route is 1.63km.

Option 2: Under this pipeline route option, the Raw Water Pumping Main from the Pumping Station follows the alignment of the proposed Mwache Dam Access Road corridors for approx. 1.7km before turning Northwest into the proposed WTP inlet works. The total length of the proposed Raw Water Pumping Main under option 2 route is 1.92km.

Under both options, the entire raw water pumping main routes are within the Dam Operation Area whose RAP implementation is in progress, hence no additional RAP will be required. The distance from the RWPS to the WTP is short and there is nothing strategic in the selection of the pipeline alignment. The final alignment will be determined by the Contractor.

3.4.3. PIPELINE CONFIGURATION AND HYDRAULIC SIZING

The RWPM will be designed to meet the raw water requirements for the WTP. In summary, the following design parameters will be followed:

- **Total Discharge - 2.50 m^3/s**
- **Number of Pipelines - two (twin)**
- **Pipe material - Steel or Ductile Iron**
- **Design Equation - Colebrook-White**
- **Roughness coefficient - 0.5 mm**
- **Max. Velocity (for final Plant capacity) 1.5m/s**

The pipe and fittings pressure rating will depend not only on the steady flow conditions but also on the transient conditions (surge pressure) to be analyzed by the Contractor. Consequently, the pipe pressure rating will be determined by the Contractor.

3.4.4. DETERMINATION OF NATIVE SOIL CHARACTERISTICS

At this stage, no data exists along the pipeline route regarding the chemical analysis and electrical resistivity of the native soil. Generally, the soils in the area are moderately to highly corrosive toward steel pipes. Towards Ductile Iron Pipes, they are generally non-corrosive but there are however a few places where their corrosivity may be high.

The following Specification shall be adhered to:

- **Minimum requirement of 3-layer polyethylene coating for Steel Pipes and zinc-aluminium coating for Ductile Iron Pipes**
- **Cathodic Protection system (or equivalent approved by the Employer and the Engineer) of all Steel Pipes all along the pipeline routes**
- **Polyurethane coating for Ductile Iron Pipes at particular locations where soils are highly corrosive (resistivity lower than 500 ohm.cm and/or pH lower than 5)**

The Contractor will be expected to carry out investigation and confirmation of soil corrosion characteristics. The Contractor shall determine the native soil corrosion characteristics in accordance with EN 12501 or DIN 50929 to confirm whether the specified pipe coatings, supplemented by cathodic protection for Steel Pipes, provide adequate protection in keeping with an expected life of 50 years.

Soil characteristics will be determined by carrying out Electrical Resistivity Imaging (ERI inversion routine) or Electrical Resistivity Measurements by the Wenner method and any other tests proposed by the Contractor and approved by the Engineer. Additionally, chemical analysis shall be included to determine potential redox and corrosivity. The Contractor will analyse the results to design the Cathodic Protection System for Steel Pipes or to select the locations, if any, where a Polyurethane Coating is required for Ductile Iron Pipes. The costs for the investigations, design and implementation of an appropriate corrosion protection system are deemed to be covered in the Contractor's financial proposal.

It should be noted that the RWPM alignment will cross the treated water main, from the clear water tank, which will have cathodic protection system. The Contractor's design must therefore put into consideration of existence of cathodic protection for other existing / proposed pipelines.

3.5. WATER TREATMENT LINE

The suggested waterline is presented in the figure and the chapters below.

However the Contractor is free to adapt the suggested waterline due to its experience in water treatment as long as the proposed treatment is compliant with clauses *2 - Required performance levels, 3.1 - General and 3.2 - Project description.*

The selected water treatment stream includes:

Table 3 : Selected water treatment process units

Process unit	***Function***
Pumping station	to raise water from DAM to WTP
Fine screening (optional)	to remove small particles (in particular algae) before clarification
Aeration	To provide oxygen for oxidization of dissolved iron and manganese to their insoluble form, to liberate dissolved gases and removing organic matters, odour etc. and to increase oxygen content thereby imparting a sparkling appearance and "fresh" taste to water

pH adjustment	To adjust pH prior to clarification in order to improve its efficiency
Coagulation	To destabilize colloidal forms by neutralizing the superficial negative charges.
Flocculation with polymer	Coagulant aid: Gather solidly between the particles that can be eliminated by the clarifier
Clarification by Flotation or sedimentation	Eliminate by flotation or sedimentation flocs formed by the flocculation and produce a clarified water whose turbidity is lower to 5 NTU
Media Filtration	It will reduce the residual turbidity below 0.5 NTU.
UV disinfection	Elimination of the pathogen germs and cysts (Giardia and cryptosporidium)
Final chlorination :	The residual chlorine content in the treated water will keep a permanent disinfecting agent in the distribution network.
Final pH adjustment Calco-carbonic balance	Correct the pH of water distributed. Slightly over the saturation pH it provides a protective layer on networks and facilities

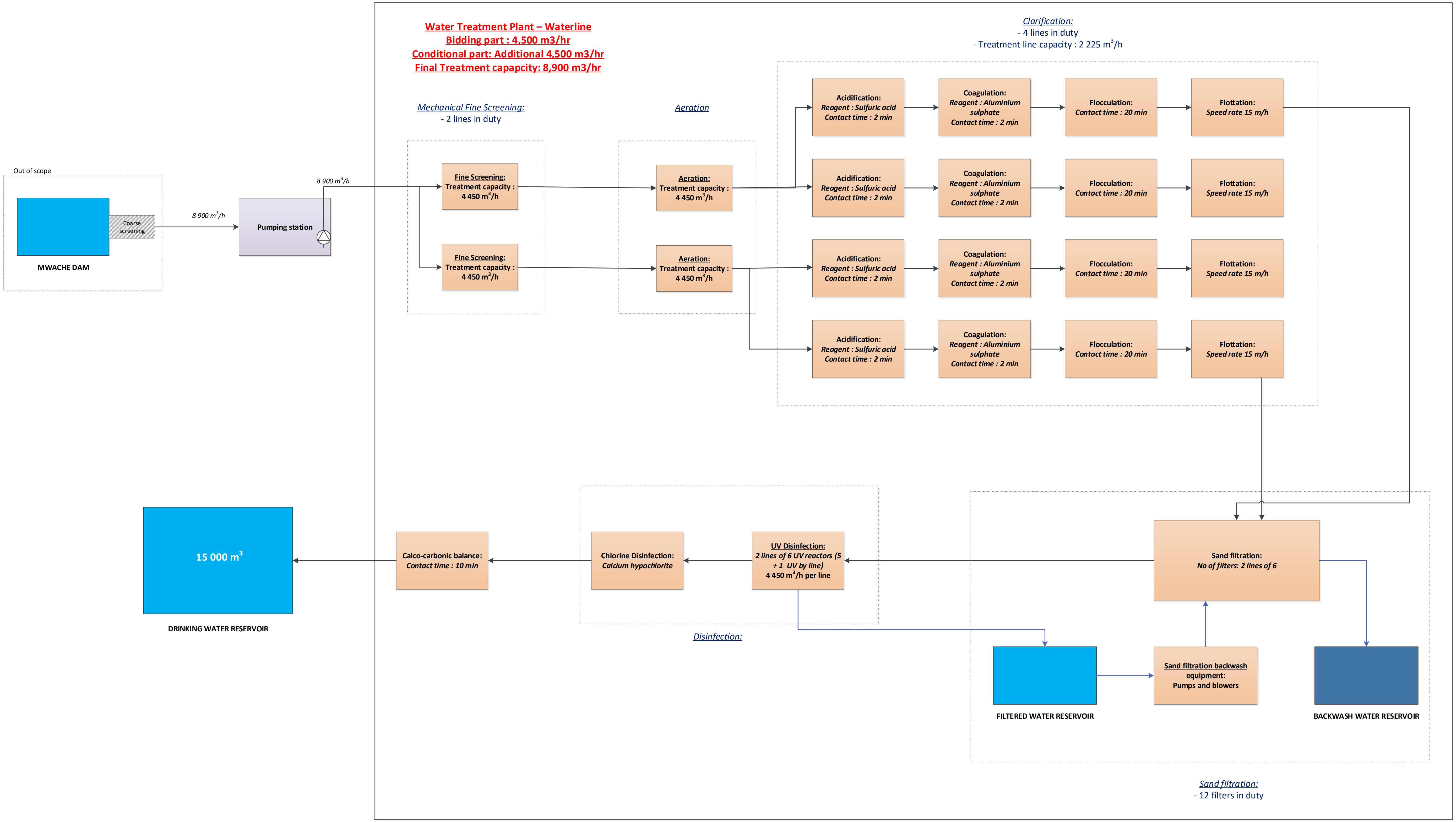

Figure 5: Suggested waterline for Mwache WTP

3.5.1. Inlet chamber

A raw water sampling point shall be provided for quality monitoring.

3.5.2. Aeration

The contractor shall propose the type of aerator of its choice.

3.5.3. Fine screening (optional)

Fine screening is not mandatory in the water treatment line and the decision to implement this stage of treatment shall be made by the Contractor.

Minimum design specifications for this stage are as follows:

- Number of unit:
  - **Firm part: 1**
  - **x part: 1**
  - **Manual by-pass**
- Unit capacity:
  - **4,450 m3/h by line**
  - **Final : 8,900 m3/h**
- Mesh: 1 mm
- Material: stainless steel

3.5.4. Clarification

Clarification includes following treatment stages: pH adjustment, Coagulation, Flocculation and Flotation.

The minimum design requirements for clarification are summarized in the table below.

Table 4 : Clarification minimum design requirements

Clarification		Firm part	Conditional part
Number of lines	u	2	2
1 - Acidification (per line)			
Number of tanks	u	1	1
Retention time	min	2	2
2 - Coagulation (per line)			

Number of tanks	u	1	1
Retention time	min	2	2
3 - Flocculation (per line)			
Number of tanks	u	2	2
Retention time	min	20	20
4 - Flotation (per line)			
Number of tanks	u	2	2
speed rate	m/h	15	15

3.5.4.1. Acidification – Sulphuric Acid injection

Sulfuric acid will be used for pH adjustment prior to coagulation.

During coagulation, pH has to be between 6 and 6.5, in order to avoid aluminium leakage and to improve its efficiency. PH is therefore adjusted, according to pH measurement downstream the coagulation, in the acidification tank, with addition of sulphuric acid.

A simple roof consisting of aluminium roofing sheets will be built over the coagulation and flocculation tanks in order to limit the algae development.

Main equipment per tank:

- Mixer :
  - **Unit per tank : 1**
  - **Agitation : fast**
  - **G value : 500 s^{-1}**
  - **Material : Stainless steel**

3.5.4.2. Coagulation-flocculation

The coagulation-flocculation step is essential to reduce the suspended solids in raw water. Indeed, suspended solids and particles producing turbidity and colour in raw water, must be agglomerated in flocs before the entrance in the flotation tanks or the filters.

In order to allow the floc formation, two different steps are needed:

- Coagulation: carried out under fast agitation in order to assure a good mixing between the raw water and the reagents.

- Flocculation: carried out under slow agitation in order to increase the probability of coagulated particles to come together.

The coagulant reagent shall be Aluminium Sulphate, due to local conditions. However the contractor should considered, when designing the plant that the operator could move later to another type of coagulant, for instance ferric chloride or PAC.

The aluminium sulphate (alum) is injected at the entrance of the coagulation tank. The anionic polymer (polyelectrolyte) is injected just before the flocculation tank. Both tanks shall be equipped with shaft mixers.

A simple roof consisting of aluminium roofing sheets will be built over the coagulation and flocculation tanks in order to limit the algae development.

Main equipment per tank:

- Coagulation :
  - **Mixer :**
    - Unit per tank : 1
    - Agitation : fast
    - G value : 500 s^{-1}
    - Material : Stainless steel

- Flocculation :
  - **Mixer :**
    - Unit per tank : 2
    - Agitation : slow
    - G value : 25 s^{-1}
    - Material : Stainless steel

The design, manufacture, construction, installation, testing and commissioning of a complete polyelectrolyte system and associated equipment shall be provided by the Contractor where required for the proper functioning of the proposed water treatment process, including:

- inductors,
- preparation tanks (minimum 2, 1 duty + 1 stand-by),
- solution transfer pumps (minimum 1 stand-by for all lines),
- stock tanks,
- dosing pumps (minimum 1 stand-by for all lines),
- mixers, and
- ancillary equipment.

3.5.4.3. Flotation

Flotation is normally used in water treatment. In fact, flotation is well-suited to the treatment of floc that is often fragile and that has a relatively low density because it contains hydroxide and/or organic products such as algae.

Flotation is as an effective clarification process, based on the introduction of gas bubbles as the transport medium. Suspended matter is then attach to the bubbles and moves toward the water solution surface—i.e., contrary to

sedimentation. Different bubble generation methods exist, but flotation using dissolved air (DAF – Dissolved Air Flotation) is the most common method used in water treatment.

Solids are floated in the clarifier by chemical coagulation and flocculation, and by adding microbubbles. The microbubbles are created in an unpacked saturator which combines 8 to 15% recycle from the clarified water with compressed air. The pressurized air/water mixture is sent through a row of nozzles or special injector depending on the type of DAF technology.

A pressure drop brings the air out of solution and creates microbubbles, which adhere to the solids and float them to the top of the flotation zone. Clarified water is collected from the laterals at the bottom of the DAF.

Sludge is then either hydraulically removed over a stationary weir by raising the water level on a set interval, or mechanically removed with a scraper

A simple roof consisting of aluminium roofing sheets will be built over the coagulation and flocculation tanks in order to limit the algae development.

Main equipment per tank:

- Air compressor
- Design air pressurization rate : 10 %
- Pressurization pumps (1 installed stand-by for all lines)
- Pressurization nozzles
- Scraper :
  - **Unit per tank : 1**
  - **Material : Stainless steel**
- Stainless steel Process pipes
- Sludge collection system
- Operation bridges

Alternative processes:

The Clarification system shall be a high performance process with compact structure. The allowed processes are:

- lamellar or tube settler
- Centrifloc clarifier or equivalent
- High performance patented processes (Pulsator, Multiflo or equivalent)
- Flotation

Clarifiers using ballasted floc are not allowed.

3.5.5. Filtration

3.5.5.1. Filters characteristics

The filtration is carried out by open gravity filters with a preference for sand filter media. However, the following filter media are also allowed expanded clay or dual media sand-anthracite.

The goal of filtration is to remove the last suspended solids after clarification. It is a finishing step. Indeed, before filtering, the water must be sufficiently clarified, less than 5 NTU.

Filters will not be roof-covered but outlet and backwash valves will be roof-covered.

Minimum performances are the following:

- Filtered water samples shall be tested for 100% compliance with turbidity not exceeding 1.0 NTU,
- The filtration will allow producing water with a turbidity level less than 0.4 NTU, allowing an efficient disinfection. Filtered water samples shall be tested for 95% compliance with the turbidity not exceeding 0.4 NTU,
- Filters shall achieve the filtrate quality specified with a minimum length of filter run of 24 hours,
- Filter media depth will not be less than 0.8 m.

The filter velocity shall not exceed 8 m/h with one filter in backwash and at the maximum flow rate.

The filters shall be fitted with all necessary equipment for fully automatic control under normal conditions. Minimum requirements are level indicator transmitter and head losses indicator and transmitter to the local SCADA.

The filters shall include back washing system with wash water and air scouring. The filter cleaning shall be set manually or automatically by head loss measure into the filter bed.

The wash water supply tank shall be part of the Treated Water Tank and shall have the capacity for at least 2 backwashes.

The filtering media should be in compliance with standards EN 12901 and EN 12902 when applicable.

3.5.5.2. Filters backwash

Filter cleaning can be set manually or automatically by head loss measure into the filter bed or water level. At least, each filter shall be cleaned every 72h.

Water used in washing filters (i.e. wash water and surface flush water) averaged over a 24 hour period shall not exceed 2.5% of the works input averaged over the same 24 hour period.

Main equipment per tank:

- Air blowers (2 duty + 1 stand-by)
- Backwash pumps (2 duty + 1 stand-by)

3.5.5.3. Backwash water supply tank

The tank is sized to hold the volume of water needed for at least half of media filters.

3.5.5.4. Backwash water tank

The tank is sized to hold the volume of water needed for at least half of media filters.

3.5.6. Disinfection

3.5.6.1. UV disinfection

The disinfection is realised by UV process. The water shall comply with the microbiological requirements presented in clause *2.1.1. Drinking water quality* after the UV treatment.

The purpose of the UV disinfection is the destruction of the pathogen germs.

The treatment is composed of two line of half-flow capacity each (4 450 m3/h). During maintenance of one line, the final chlorination dosage will be increased for a complete disinfection.

Each UV reactor is composed of:

- Medium-pressure UV lamps dispensing a dose of 40 mJ/cm2,
- The UV intensity sensor to ensure the specified dose level is maintained,
- The automatic cleaning system for elimination of the fouling on the lamps,
- The SS136L reactor chamber,
- The control power panel and monitoring panel.

3.5.6.2. Chlorine disinfection

Hypochlorite solution injection aims to maintain a residual of chlorine (0.5 to 1 mg/l) at the exit point.

After the UV treatment, addition of hypochlorite solution shall maintain a residual of chlorine, with an objective of 0.5 mg/l, at the exit of the treated water reservoir. The hypochlorite solution shall be produced on the site by electro chlorination or calcium hypochlorite solution. The residual chlorine can also be provided by use of gaseous chlorine. The Contractor shall provide for all three options for residual chlorine.

The sizing of the final disinfection shall be defined by the contractor to comply with objective of 0.5 mg/l as residual of chlorine. However, the minimal capacity of the equipment shall allow the average dosage of 1 mg/l of chlorine. For reliability reason the preparation unit of disinfection solution shall comprise at least two units.

In case the UV reactor is not working, the minimum chlorine dosage should be 2 mg/l.

3.5.7. Final pH adjustment

Addition of lime will be used in order to adjust pH of treated water to neutralise the action of corrosive water in the distribution pipes.

Minimum equipment requirements are presented here below:

- Slurry preparation tank
- Bag loading cages
- Slurry transfer pumps

- Flushing system
- Saturators
- Dosing

Minimum design requirements are presented below.

Table 5 : Final pH adjustment - Calco-carbonic balance

Calco-carbonic balance		
Empty bed contact time	min	10
Number of tank	u	2

3.5.8. Treated water tank

The treated water tank receives the treated water from the disinfection and calco-carbonic tanks. The minimum storage capacity is 15,000 m^3. The tank is divided in two equal capacity tanks, each fitted with baffle walls. One tank can be operational, while the other one is empty for maintenance.

3.6. BACKWASH WATER AND SLUDGE TREATMENT

3.6.1. Process outline description

The backwash water and sludge treatment line shall be composed of:

- Backwash collection tank,
- Sludge thickening,
- Sludge drying beds

In the table below are presented the functions of each stage of the sludge treatment:

PROCESS UNIT	*FUNCTION*
Backwash water tank	Buffer tank, mixing and pumping for sludge thickening
Thickener	Thickening of the clarifier sludge for a better efficiency of the drying beds. The overflow is discharged into the Dam
Drying beds	The thickened sludge is spread on the drying beds for a natural drying up to 40% of Dry Solids.

The contractor is free to propose different solutions, concerning the following points:

- Recycling of backwash water and sedimentation tank sludge
- Thickening of the sludge

In any case the specifications and performance requirements given in §2 have to be respected, in particular the maximum water loss and the minimum dryness of the sludge to be evacuated.

3.6.2. Backwash water recycling

Backwash water recycling is not mandatory. However the backwash water will be treated by sludge thickening before the discharge of the supernatant into the Dam.

The Contractor can adapt the treatment of the backwash water but discharge will be compulsorily into the Dam. And backwash water should be purified of suspended solids before discharging.

3.6.3. Sludge thickening

The process can be a conventional static thickener or a mechanical system. Number of units will be minimum 2.

The overflow dripping or drainage shall necessary be discharged to the Dam.

3.6.4. Sludge recirculation

In the case the contractor has chosen the sedimentation process for clarification, and when the SS entrance rate is low, the operator should have the possibility to recycle a part of the sedimented sludge back to the coagulation tank, in order to improve the efficiency.

In this case, the installation shall include the possibility of recycling of 30% of the volume of the thickened sludge.

3.6.5. Drying beds

The number of beds shall be calculated accordingly to the time needed for 1 bed to be free again, after a complete cycle including filling, drying period, evacuation of the sludge and usual maintenance. The evaluation of the duration of the drying period shall take in account the raining periods as indicated in the General Requirements of the Employer's Requirements.

The drying beds will be reusable type sludge drying beds, with percolation system.

The dried will be easily removed by excavator and conveyed by trucks.

For security reason and in case of heavy maintenance, the calculated number of the beds shall be increased by one additional bed.

The overflow and drainage of the drying beds shall be discharged to the Dam.

3.6.6. By-pass and water discharge

The Contractor shall design and implement the pipes to discharge into the dam following fluids:

- Overflow of the water treatment plant in case of failure during operation
- Overflow of the different tanks and treated water reservoirs in case of failure during operation
- Water from backwash, thickeners and drying beds
- Rainwater after treatment

3.7. REAGENTS STORAGE AND PREPARATION

3.7.1. Chemical reagents selection

Selected reagent are as follow:

- Sulfuric acid
- Aluminium sulfate
- Polyelectrolyte
- Lime
- Calcium hypochlorite

Above listed reagents have been selected regarding their availability in Kenya. The Contractor has to confirm in his proposal their availability in Kenya.

The Contractor is free to modify the selected reagents due to its experience in water treatment but availability in Kenya has to be demonstrated / confirmed.

3.7.2. Chemical reagents injection

All chemical injection devices at each point of application must be duplicated to allow one to be taken out of service for cleaning, without interrupting chemical dosing.

Specific protection equipment or mechanism at the mixing and dosing points, must be implemented by the Contractor to avoid chemical attacks.

3.7.3. Chemical building

One common building, for firm part and conditional part, is intended for the storage, preparation and dosage of the reagents:

- Aluminium sulfate

- Sulfuric acid
- Lime
- Polyelectrolyte for water treatment and sludge treatment
- Calcium hypochlorite

The capacity of the reagent storage shall be at least three months at the final design capacity.

The preparation of all reagents shall be automatic. The minimum number of preparation units per reagent shall be two plus one in stand-by at the final treatment capacity.

If the Contractor selects gaseous chlorine, the chlorination rooms will be separated from the other chemical building and rooms, mentioned above.

3.7.4. Chlorination room (if electrochlorination)

The sodium hypochlorite solution shall be produced by electrolysers from salt and water, at low concentration. In case of maintenance or break of one UV reactor or one electrolyser, or in case of shock chlorination, high content solution of hypochlorite shall be produced with solid Calcium Hypochlorite.

The room, that can be part of the chemical building, shall comprise:

- The salt saturator for brine preparation and pumping,
- The storage of the salt,
- The electrolysers,
- The tank for the hypochlorite solution and pumping.
- The preparation of the calcium hypochlorite solution and pumping
- The storage of the calcium hypochlorite

In case of exceptional situation (for instance if UV disinfection is not in duty), the dosage can be adjusted up to 2 mg/l of chlorine equivalent. In case of normal situation, the dosage shall be 1 mg/l. All equipment for electro-chlorination is designed on the basis of normal (average) situation. For the peak situation, the chlorination dosage shall be adjusted with complementary Calcium Hypochlorite injection.

The storage capacity shall be at least 3 months at the final design capacity.

3.8. NUISANCE TREATMENT - NOISE

Noisy machines, centrifuges and compressors, must be covered, so that the noise level in the technical equipment rooms never exceeds the values given in chapter 2 of the present performance specifications.

The technical equipment rooms themselves must be soundproofed (soundproofing of walls, doors and windows, sound traps on all air intakes).

3.9. FUEL STORAGE AND OTHER CONSUMMABLES

Storage facilities representing at least 30 days' autonomous operation must be provided for all consumables (reagents for treatment excluded) that need to be delivered, calculated on the basis of the maximum consumption of the product concerned. Delivery, unloading and storage points must be provided within the units where these products are consumed and in such a way as to facilitate operation with healthy situation.

3.10. CONTROL / COMMAND AND SUPERVISION SYSTEM (SCADA) FACILITIES

A SCADA system is required for supervising and operating the Raw Water Pumping Station and the Water Treatment Plant. The proposed system is as described hereafter.

3.10.1. Dam measurement and regulation

Even though dam instrumentation is out of our scope of work, we highly recommend that following instrumentation to be installed in the dam or at water intake.

Following symbols are used in this figure.

Symbol	Meaning	Symbol	Meaning
P	Pressure sensor	T°	Temperature sensor
L	Level sensor	UV	Organic matter sensor
NFU	Turbidity sensor	Algae	Algae sensor

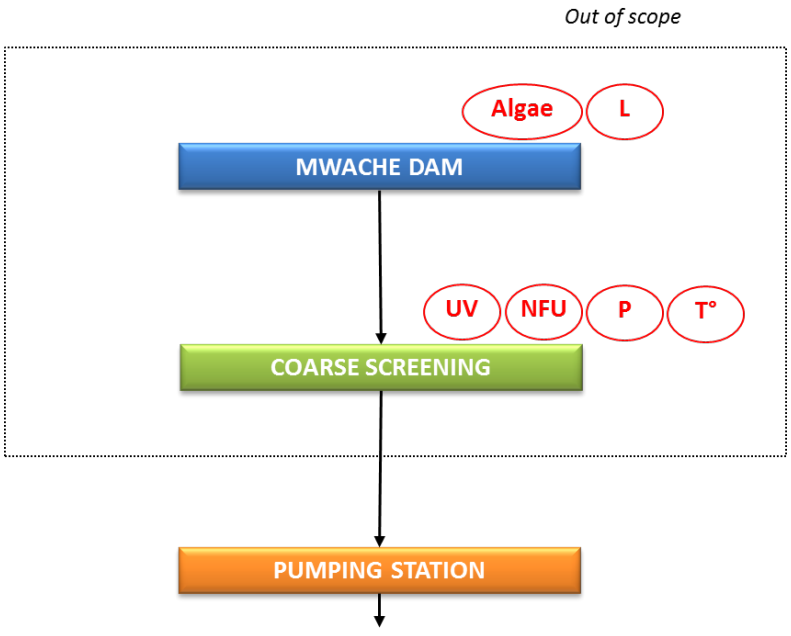

Figure 6 : Dam required instrumentation

The Algal Bloom Sensor is a non-contact instrument that monitors the concentration of chlorophyll-a in real time. Based on the principle of UV fluorescence, this sensor uses chlorophyll-a's innate fluorescence to monitor the growth of overall blue-green algae and sends alerts when a threshold is reached.

3.10.2. Raw Water Pumping Station

3.10.2.1. Measurement, regulation, supervision, remote control and monitoring for the RWPS

The installation shall contain all the measuring devices required to ensure correct operation from the general control room, together with the monitoring, regulation and automation devices ensuring reliable operation and the safety of both staff and installations.

Slaving systems shall be fitted with by-passes (in the event of a break-down or for maintenance) to allow manual or semi-automatic operation (operation during specific periods or on a rate-duration basis, for example).

Instantaneous values and measurements are transferred to and recorded in the control room.

The installation shall include following components:

- Water flowmeters:
  - Raw effluent flow measurement (Electromagnetic Flowmeter or Ultrasonic Flowmeter).

- Pressure sensors:
  - Downstream and upstream of Raw water pumps (The use of ball valves is prohibited in this case).

- Level meters:
  - In all storage and reagent tanks and pump pits.

Each measurement and/or level state can be read locally and shall be transferred to the control room. The use of ultrasonic sensors should be preferred.

- Hydrostatic level: Gasoil tank.

- Mechanical flowmeter: Gasoil to Standby Generator.

- Temperature sensor:
  - Outlet temperature measurement.

- pH-meter:
  - Raw Water.

- Turbidity sensor:
  - Raw Water.

3.10.2.2. Regulation devices – Automatic controllers

The electromechanical equipment of each sub-assembly of the plant is controlled by l

ocal regulation devices and automatic controllers on a hard-wired or programmable logic basis.

These automatic controllers will comply with the following specifications and limiting factors:

- Integrated lightning arrester.

- Autonomous operation (by means of a rectifier-battery-UPS assembly) in the event of a power cut.
- Any automatic controller must be fitted with a by-pass system so that the corresponding unit can be switched to manual or semi-automatic mode.
- Link with the central control room for transmission of all information and for remote control from the central room.

The regulation principles are as follows:

- Pumping: Controlled by water levels in the Dam and in the treated water reservoir.

3.10.2.3. Remote Control and command

The system provides remote control of all essential equipment in the installation to the control room.

The SCADA system provides remote command of all essential equipment in the installation from the control room.

Two redundant PLC will be installed in the control/command panel in the electrical room of the sub-station.

A HMI (Human Machine Interface) should be installed in the front panel of each control/command cabinet.

The data from the dam instrumentation shall be connected to the local SCADA system via an RTU and a fibre optic cable shall be deployed along the pipeline between the dam and the raw water pumping station. (The services concerning the said instrumentation and fibre optic cable are not part of this contract)

The contractor shall nevertheless provide for the integration of this data into the SCADA system.

3.10.2.4. Local Control Room (part of SCADA system)

The local SCADA system will be installed in a local control room.

The local SCADA system will be composed of a minimum of:

- One operator working station with two screens.

Control/command cabinet and local SCADA System should be powered via a dedicated UPS system (Inverter).

3.10.3. Water Treatment Plant

3.10.3.1. Measurement, regulation, supervision, remote control and monitoring for the WTP

The installation shall contain all the measuring devices required to ensure correct operation from the general control room, together with the monitoring, regulation and automation devices ensuring reliable operation and the safety of both staff and installations.

Slaving systems shall be fitted with by-passes (in the event of a break-down or for maintenance) to allow manual or semi-automatic operation (operation during specific periods or on a rate-duration basis, for example).

Instantaneous values and measurements are transferred to and recorded in the control room.

3.10.3.1.1. Waterline

The minimum required instrumentation for the waterline operation is summarized in the figure hereafter.

Following symbols are used in this figure.

Symbol	Meaning	Symbol	Meaning
P	Pressure sensor	pH	pH sensor
Q	Flowmeter	L	Level sensor
NFU	Turbidity sensor	UV	UV dosing sensor
T°	Temperature sensor	Cl2	Free chlorine sensor

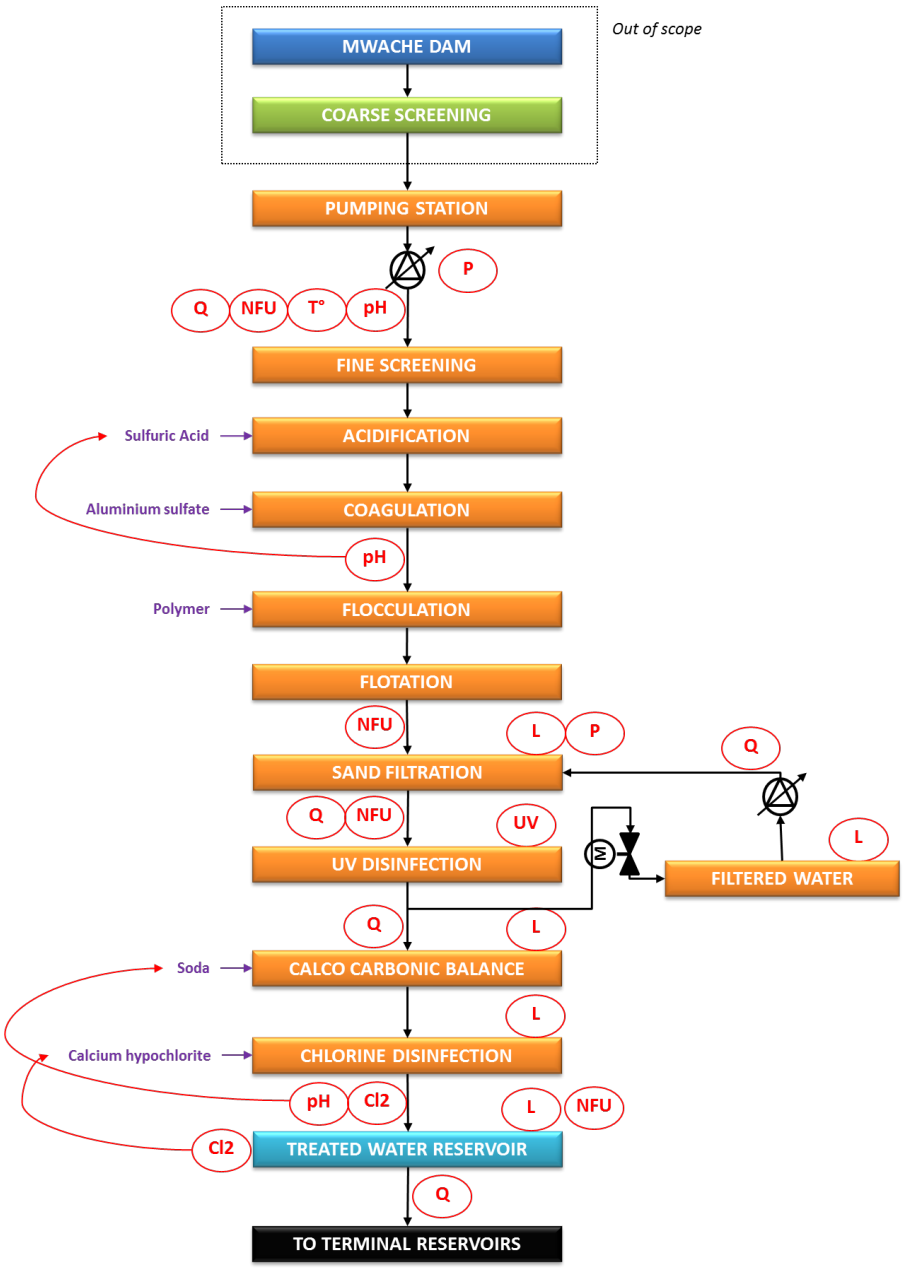

Figure 7 : Waterline required instrumentation

3.10.3.1.2. Sludge line

The minimum required instrumentation for the sludge line operation is summarized in the figure below.

Symbol	Meaning	Symbol	Meaning
P	Pressure sensor	T°	Temperature sensor
Q	Flowmeter	L	Level sensor
NFU	Turbidity sensor	SS	Suspended solids sensor

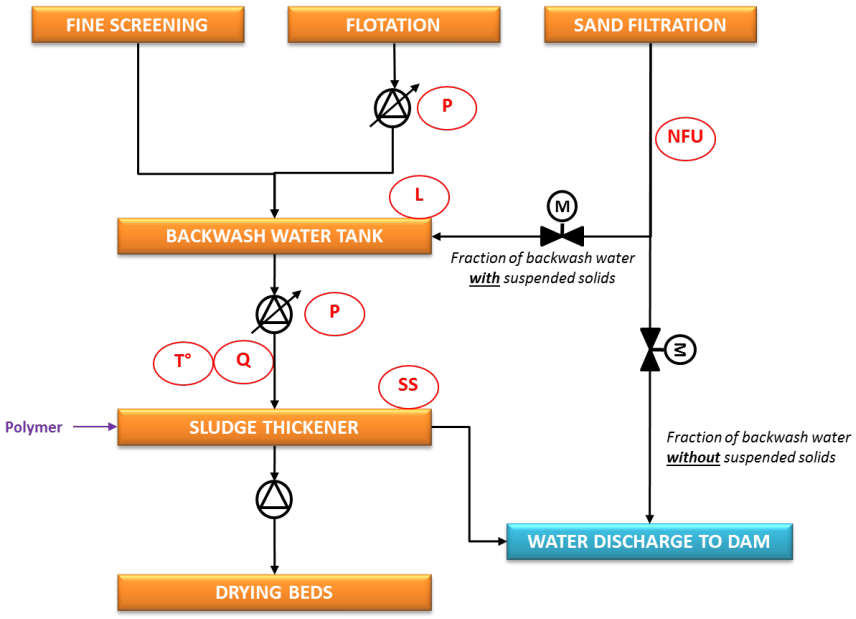

Figure 8 : Sludge line required instrumentation

3.10.3.1.3. Other regulation devices

The installation shall include as well following components:

- Air flowmeters:
  - Air blowers for filter backwash (Sand Filtration).

- Level meters:
  - In all storage and reagent tanks and pump pits.

Each measurement and/or level state can be read locally and shall be transferred to the control room. The use of ultrasonic sensors should be preferred.

- Hydrostatic level: Gasoil tank.

- Mechanical flowmeter: Gasoil to Standby Generator.

- Pressure sensor:
  - Air pressure measurement at the exit of the air blowers.
  - Air pressure measurement at the exit of the pumps.

- Temperature sensor:
  - Inlet of sludge thickener
  - Air temperature measurement at the exit of the air blowers.

3.10.3.2. Regulation devices – Automatic controllers

The electromechanical equipment of each sub-assembly of the plant is controlled by local regulation devices and automatic controllers on a hard-wired or programmable logic basis.

These automatic controllers will comply with the following specifications and limiting factors:

- Integrated lightning arrester.
- Autonomous operation (by means of a rectifier-battery-UPS assembly) in the event of a power cut.
- Any automatic controller must be fitted with a by-pass system so that the corresponding unit can be switched to manual or semi-automatic mode.
- Link with the central control room for transmission of all information and for remote control from the central room.

The regulation principles are as follows:

- Screen cleaning: detection of head loss or controlled by time.
- Sand filter: detection of head loss or controlled by time.
- Sand filter: Controlled by regulation valve.
- Sand filter backwash: Controlled by regulation valve maximum open state.
- Chlorine injection: Controlled by the flow.

The automation architecture principles are as follows:

Table 6 : Automation architecture

Automation Architecture		
Location	Equipment	Function
Sub-station Electrical Room	Redundant PLCs based instrument control/command panel (Two redundant PLCs)	Monitoring, controlling, operation automatically, operation semi automatically.
Pre-treatment building	Deported Input/Output Modules (RIO) based instrument control/command panel	Monitoring, controlling, operation automatically, operation semi automatically.
Blower aeration building	Deported Input/Output Modules (RIO) based instrument control/command panel	Monitoring, controlling, operation automatically, operation semi automatically.
Sludge Building.	Deported Input/Output Modules (RIO) based instrument control/command panel	Monitoring, controlling, operation automatically, operation semi automatically.
Blower sand filters Building.	Deported Input/Output Modules (RIO) based instrument control/command panel	Monitoring, controlling, operation automatically, operation semi automatically.

3.10.3.3. Assistance with operation: Supervision and assistance with maintenance

Information concerning the operation of all the equipment and measurement signals from the measuring devices is transmitted to a central unit situated in the central control room, providing Supervisory Control and Data Acquisition system (SCADA).

In the event of a power cut, this system can work autonomously via a rectifier-battery-UPS assembly (Inverter). It can be interrogated remotely via the telephone network.

The UPS system (Inverter) shall be sized for the total power supply requirements of the complete control/command system with a minimum autonomy of 4 hours.

The SCADA is responsible for at least the following four functions:

- Assistance with operation:
  - Displaying and printing out of alarms (machine faults or measurement/time value thresholds exceeded).
  - Colour mimic display (21" minimum size) possibly broken down into sub-displays showing the various parameters affecting each structure, item of equipment or sensor.
  - Downloading of various types of information: presence of staff, electricity consumption, source of power (grid/generator), energy usage per day and per equipment, etc.
  - Exploitation of measurements: averages, graphs.

- Assistance with maintenance:
  - The system is used to update files on all existing and future structures and equipment and on suppliers and to draw up a programme of preventive maintenance.

- Printing of records:
  - Records of the main data over the period required.

- Filing:
  - Automatic filing on a suitable medium of information forming the journals, after a period to be defined.

3.10.3.4. Remote Control and command

The system provides remote control of all essential equipment in the installation to the local control room located in the WTP and the central control room located in the Administration building.

The SCADA system provides remote command of all essential equipment in the installation from the control room.

Two redundant PLC will be installed in the control/command panel in the electrical room of the sub-station.

Deported Input/output modules will be installed in the control/command panel in the electrical room of the following buildings:

- Blower and backwash pumps building.

- Sludge Building.

- UV building.

The connections between the control room, the PLCs and the deported I/O modules will be realized by an optical fibre ring. All information provided by analogic sensors must be transmitted to the main control room SCADA.

A HMI (Human Machine Interface) should be installed in the front panel of each control/command cabinet.

Each control/command cabinet should be powered via a dedicated UPS system (Inverter).

3.10.4. Remote monitoring

It must be possible to alert any duty staff either manually and automatically by telephone of any malfunctions in the plant.

The Contractor shall describe the system he intends to set up in this respect.

It must also be possible to interrogate the system remotely via an intranet or the Internet.

3.10.5. Control room (SCADA Center)

The control/command system shall include a supervision unit (CTM) and a maintenance unit (CCAM).

Programmable Logic Controllers (PLC) or Remote Terminal Units (RTU) shall be installed locally in the various infrastructures of the site.

All these components shall be connected together by a fibre optic cable ring.

The Programmable Logic Controllers or Remote Terminal Units shall allow the operation in automatic mode of the complete installation by piloting the equipment and by getting all the information for their operation as well as the data transmitted by the instrumentation.

The system of control/command, the Programmable Logic Controllers, the Remote Terminal Units and the instrumentation shall be fed by an uninterruptible power supply (UPS).

The system of control/command, the Programmable Logic Controllers and the Remote Terminal Units shall have full redundancy to ensure the continuity of operation during the dysfunction of one of these components.

The system of control/command shall be able to communicate with the Mwache dam upstream of the station as well as with the reservoirs downstream. The mean of communication will be the fibre optics which will be installed along the pipes by other Contractors.

The Contractor shall include in his offer the equipment and mimics programming necessary for realizing these communications and the data exchange.

The data received from the Mwache Dam are presented in chapter 3.9.1. - Dam measurement and regulation + position of valve.

The data transmitted to the Mwache Dam will be at minimum: the flow of raw water, the flow of treated water.

The data received from the downstream reservoirs will be at minimum: water level in the reservoir, alarms on levels of water.

The fibre optics connecting the sites and the equipment at the Mwache Dam and the reservoirs are not included in this project.

The system of control/command shall be able to be easily connected to the future supervision centre, which should be installed near the reservoirs.

The SCADA system shall be installed in a control room.

The SCADA system shall be composed of a minimum of:

- One Engineer workstation (Administrator).
- Two Operator workstations.
- One Maintenance workstation.
- Two redundant servers.
- Two printers (laserjet).
- One Wall led screen (minimum 55 inch)
- One UPS System.

3.10.6. Storage and backup of data

SCADA will be able to generate daily report and trends of all parameters connected to SCADA every day. Alarms, trends and daily report must be stored in a dedicated server with a storage capacity of 2 years.

Automatic weekly back up of stored data will be planned by the Contractor on a dedicated cloud (minimum storage capacity – 2 years).

3.11. ELECTRICITY SUPPLY

3.11.1. Electricity distribution network connexion

There is no existing power line on site.

The supply of the site will be made by the creation of an electric sub-station MV/LV (33Kv/3.3kV/400V).

The power requirement of the sub-station shall be determined by the Contractor according to the installations and the equipment to be installed by him.

The electric sub-station will be fed by a MV line (33kV) constructed by Kenya Power from the existing network.

The connection line from the HV/MV electric sub-station to the plant is included in this contract as a provisional sum. It will be carried out by a Kenya Power approved contractor and under Kenya Power's supervision, as a part of this contract

3.11.2. MV/LV Electrical sub-station

A private transformer substation must be built.

The total capacity of the new electrical installation must be suited to the requirements defined by the Contractor plus a 25% allowance for further equipment.

The incoming supply will be 33kV from Kenya Power. It is envisaged that the pump motors will operate at 3.3kV. The contractor shall be responsible for the final voltage selection based on motor sizes and starting methods. The starting of the motors shall take into account the fault level and effects of starting the motors on the Kenya Grid.

All auxiliary voltages will be 415/240 VAC 50 Hz. The contractor shall allow for all necessary transformers and switchgear to ensure complete solution.

The indoor-type substation shall comprise the following main items:

- 33 kV Switchboard comprising of
  - Incoming circuit breakers.
  - Bus Section Circuit breakers.
  - Busbar metering Section.
  - Transformer feeder circuit breakers

- 33/3.3 kV Oil Transformers with On load Tap changers.
- 3.3/0.433 kV Oil Transformers with Off load Tap changers.

- 3.3 kV Switchboard comprising of
  - Incoming circuit breakers.
  - Bus Section Circuit breakers.
  - Busbar metering Section.
  - Transformer feeder circuit breakers
  - Motor Feeders to either
    - Variable Speed Drives
    - Auto Transformer Starters.
- 415V Low Voltage Distribution and Motor Control Centres
  - Incoming circuit breakers.
  - Bus Section Circuit breakers.
  - Motor Feeders to either
  - Power Factor compensation panel.
  - Motor control/command cubicles.
    - Variable Speed Drives
    - Soft Starters
    - Star Delta
    - Direct on line
    - Signalling relays and indicator lamps.
    - Select mode switches (Automatic/Manual/Stop).
    - Select mode switches (Run/Stop, Open/Close, etc.)
  - Automatic changeover switches for Generator for LV Auxiliary power only.
  - LV circuits-breakers and tripping systems.
  - LV contactors and relays.
- MV cables and MV cable terminations.
- LV cables and connections.
- Building Services Distribution boards.
- Lightning protection design for all buildings and equipment.
- Earthing including earth mat for substation to meet standards
- Monitoring and safety accessories.

The Contractor shall also be responsible for the following:

- Costs and procedures for obtaining the agreement of the energy distributor. The services shall comply with the rules for constructing and installing subscriber substations issued by "Kenya Power and Lighting Company" (KPLC).

- The extension of the existing medium voltage line in the vicinity to the proposed transformer station.

Back-up power via a Standby Generator shall be provided for back-up power for the WTP and pumping station building services and critical equipment required to monitor the plant. A back-up power for running the raw water pumps is not required therefore the backup system will only be for auxiliary power requirements. The Contractor will design, supply and install an underground fuel storage tank sufficient to ensuring a minimum of 10 days autonomy running of the generators on the basis of 24 hour day operation.

Lightning system shall be installed.

The electrical power distribution shall be made through three distributed divisional electric cupboards installed in the electrical room of the followings buildings:

- Pre-treatment building.
- Blower Aeration building.
- Biological Treatment building.

Each divisional electrical cupboard shall comprise the following main items:

- LV cables and connections.
- Divisional electrical panel.
- LV circuits-breakers and tripping systems.
- LV contactors and relays.
- Variable Frequency Drives.
- Motor Soft Starters.
- Signalling relays and indicator lamps.
- Select mode switches (Automatic/Manual/Stop).
- Select mode switches (Run/Stop, Open/Close, etc.)
- Lightning arrester.
- Earthing.
- Monitoring.
- Control/command panels.

3.12. NETWORKS - UTILITIES

3.12.1. Networks

All networks shall be designed for the nominal capacity, they include :

- Connections between structures
  All hydraulic connections required for the proper operation of the installation are to be provided by the Contractor, along with all inspection holes on pipes.

  Valves / Penstocks shall be provided, as appropriate, to cut off each treatment structure and each section of by-pass pipe individually.

- water network for the treatment process including domestic supply;
  This is fed with treated water taken from the treated water tank and pressurised to service pressure. The necessary discharge shall be determined by the Contractor in accordance with his design.

  The network serves all the sections of the plant with pressurised water. Each place shall fitted with at least one tap. The available head at the taps shall be 4 bar.

  A 50 ND water offtake shall be provided close to each treatment structure.

- Internal sewerage network
  An internal sewerage network shall collect all the internal sewerage water such as draining water from all process, residual chemical water from all process, sanitary sewage, raining water collected on the path of wastes and reagents loaded trucks.

  This network shall be sized according to due justifications plus a 10% allowance; in these calculations, the rainfall with 10-year return period shall be used for inflow on the concerned areas.

  This network shall convey water to a pit fitted with pumps; whatever the number of pumps, **50% standby** shall be available on-the-spot and shall starts up automatically if another pump breaks down; this pump shall have exactly the same characteristics than the other ones. A circular working could be established among the pumps in order to use all of them in a similar manner.

  These pumps shall deliver flow upstream the secondary treatment.

- Fire-fighting network
  This network shall be supplied by the service industrial water network in accordance with the regulations in force.

3.12.2. Lighting

The specified intensity, unless otherwise required as follows:

- Outside ways : 20 luxes.
- Inside ways and stairs: 100 luxes.
- Room inside buildings :300 luxes.
- Offices inside buildings : 500 luxes.

These installations shall be delivered in working order, including the network, inspection holes and protection panels.

3.13. CIVIL WORKS

3.13.1. Scope of section

This clause contains the design requirements for the structural design of treatment units, buildings (including buildings within the RWPS), channels, culverts, etc., to be adopted by the Contractor in his design. Concerning choice of materials, structures shall generally be constructed of reinforced concrete.

3.13.2. General

All structures shall comply with EN Standards and Kenya's construction regulations and laws.

The buildings shall be aesthetically attractive using high quality materials and workmanship.

All buildings within the WTP and the Raw Water Pumping Station shall be **double volume buildings**.

All buildings shall be designed as reinforced concrete frame structures with local hollow brick or natural masonry stones – plastered walls. Structural steel or wood may be used for the support of the roof.

The roof of all buildings shall consist of **pitched concrete roof overlaid by either concrete or clay tiles**. The rainwater collecting systems including gutters shall be made of concrete with uPVC downpipes

Steel structures shall be uncoupled to any vibrating equipment.

The structures shall be designed using internationally recognized building design software. All output shall be neatly presented in English language.

Concrete used for the underground and hydraulic structures shall be watertight. The Contractor shall issue a concrete mix design for the Engineer's approval prior to any concrete works.

All concrete of hydraulic structures shall be made of Sulphate Resistant Cement. On the internal where concrete surface is in contact with water (except for clear water tank), a chemical resistant epoxy shall be applied.

3.13.3. Standards

In case of discrepancies, absence, annulment or justified departure, in particular due to technological advancement, the Contractor shall submit proposals for the Engineer's approval.

A. Reinforced Concrete Buildings

All buildings shall comply with the Kenya Building Regulations and Laws.

Concrete design shall be in accordance with European codes or equivalent.

The buildings shall be designed using internationally recognized building design software. All output shall be neatly presented in the English language.

B. Reinforced Concrete Structures for water and sludge

Underground structures consisting of rectangular and circular concrete tanks, manholes, screen and intake structures, and pumping station chambers shall be designed according to internationally recognized codes for environmental structures, such as ACI 350R "Environmental Engineering Concrete Structures" or equivalent.

It is to be noted that the above or equivalent code shall be used since more stringent concrete design criteria is necessary for water retaining structures, such as listed above, in terms of minimum temperature & distribution reinforcement, concrete cover, and reinforcement bar spacing (maximum) in order to minimize cracking that might lead to leakage.

Concrete used for the underground and hydraulic structures shall be watertight. The Contractor shall issue a concrete mix design for the Engineer's approval prior to any concrete works.

All underground concrete shall be made of Sulphate Resistant Cement. All buried pre-cast concrete units shall be coated with bitumen rubber emulsion. All concrete for hydraulic structures shall have microsilica addition with a ratio of 25 kg of microsilica per 340 kg of cement.

All in-situ concrete structures shall be protected against groundwater by tanking which will terminate at least 30 cm above the finished ground level.

3.13.4. Types of structures

For design purposes reinforced concrete structures shall be classified as follows:

Type 1 – Reinforced concrete structures which are not normally subject to hydrostatic pressure and are not liquid retaining. Examples of type 1 structures include superstructures and electrical supply buildings. Type 1 structures shall be designed in accordance with BS EN 1992-1 or equivalent, which is applied in Kenya.

Type 2 – Reinforced concrete structures which are normally liquid retaining or periodically in contact with liquids. Examples of type 2 structures include station substructures, culverts and tanks. Type 2 structures shall be designed in accordance with BS EN 1992-1 as well as BS EN 1992-3 or equivalent which is applied in Kenya.

3.13.5. Load Conditions

Combination of design loadings shall be applied to find the maximum stresses, subject to practical considerations. All type 2 structures shall be designed for both full and empty conditions with allowance made for any active or at rest soil pressures on walls. No relief shall be given for any passive soil pressure on a wall, on the face remote from a contained liquid.

All liquid retaining structures shall be designed to resist an internal liquid level to the maximum top working level such that the requirements of BS EN 1992-3 are not exceeded. In addition liquid retaining structures shall be designed to resist a liquid level equal to the maximum possible top water level under Ultimate Limit State (ULS).

All pumping stations, tanks and other substructures shall be designed to permit the external excavation to be backfilled prior to construction of the ground level slab and superstructure. In addition to the calculated external earth pressures, walls shall be designed for any surcharge which may be applicable and for the appropriate ground water pressures.

3.13.6. Foundation design

Foundation design shall be based on the geological and geotechnical data derived from field investigations and subsequent laboratory testing for the site. Building foundations and the underground structures shall be checked against allowable bearing capacity and designed against buoyancy and swelling potential of the underlying soil.

The Contractor shall prepare a geological/geotechnical report defining the soil parameters to be used in the design and proposing the method of excavation, ground stabilization, underground drainage, and foundation system. The Contractor may choose to use the geological/geotechnical information given in the tender documents but he is expected to verify the relevance of the given information and shall carry out all additional site investigations necessary, at design or subsequent stages of the works, in order to fully ensure the adequacy of the designs with regard to the actual ground conditions.

The Contractor's foundation and structural design shall take account of the likelihood of settlement and suitable measures such as piling shall be adopted where necessary. Particular problem areas for foundation settlement include different foundation levels and loading within single structures and the interaction of foundation loads between adjacent structures.

A particular attention shall be paid by the Contractor regarding the foundation system to be designed on cut and fill embankments. All necessary justifications shall be provided by the Contractor for the Engineer's approval, and the justifications shall include the following themes: (i) allowable bearing capacity (ii) settlement and consolidation analysis (iii) slope stability (iv) drainage. The Contractor shall perform all in-situ and laboratory tests that are necessary for providing due justifications. The said tests may include, but are not limited to: (i) Standard Penetration Tests (ii) Oedometer Tests (iii) Triaxial Tests (iv) Shear strength tests (v) permeability tests.

The Contractor shall be responsible to provide any type of foundation system for structures or buildings that are deemed to be necessary for their structural and functional integrity.

3.13.7. Structure layouts

Layouts of structures shall incorporate suitable joints, complete with water bars where necessary, to accommodate shrinkage, thermal and foundation movements.

Links between structures such as walkways, channels and pipeline connections shall be suitably jointed to accommodate relative movement, both horizontal and vertical.

3.13.8. Earthquakes

The Contractor shall design structures according to local and European seismic rules and data, submitted to the approval of the Engineer. The Contractor shall carry out all additional investigations necessary, at design or subsequent stages of the works, in order to fully ensure the adequacy of the designs with regard to the area seismicity.

3.13.9. Materials

All materials shall be compliant with Kenyan, British and other specifics standards mentioned in the tender.

All materials shall be chosen considering the aggressiveness of liquids and atmosphere to present a resistance to corrosion in adequacy with the service life of the structures.

3.13.10. Earthwork and excavations

The contractor shall determine the footprint of the excavations and shall proceed to all necessary propping and shoring. He shall, if necessary, provide the dewatering of excavations.

All components and materials arising from excavation works shall become the property of the Contractor except where otherwise provided. The materials shall be removed from the site as work proceeds.

3.13.11. Studs, Bolts and Nuts

All Studs, Bolts and Nuts shall be hot-dipped galvanised and shall consist of a continuous coating to minimum thickness given in Section VII – Corrosion Protection. The zinc coating shall meet the requirements according to ASTM A123, A153, A239 and A385 or equivalent.

Bolts, nuts and studs shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions.

3.14. ROADS, LANDSCAPING, AND FENCING

3.14.1. Access roads and parking facilities

The Dam access roads which will be constructed under the Dam Contract are illustrated in Part 2 – Volume 7.7 – Tender Drawings.

Access road A connects the Nairobi – Mombasa Highway to the left bank of the main dam and will be the main access road during and after construction of the Dam. The road will be of total length of 5.2Km, 6m wide carriageway will be of bitumen surfacing. Towards the WTP, this road terminates at the clinic/police post.

Access road C will be of bituminous surface providing access to the pumping station. The road is about 0.9Km and branches off from road A near the dam. The terrain of this road as it approaches the pumping station is hilly and will involve a lot of earthworks which is intended to be carried out by the Dam Contractor.

Access to the WTP is proposed to be an extension of Road A from the clinic/police post to the south . Considering that there is an existing gravel road, the proposed works will include design and upgrading of the gravel road to paved bitumen standards (similar to Road A).

Tentatively, the longitudinal cross-section is expected to have a 6 metre wide carriageway with 1.5 metre footpaths/shoulders on either side and a drainage reserve of 1.5 metres on either side consisting of an open lined storm-water drain. Access road to the WTP and other access roads within the WTP will be asphalted roads and will be designed in compliance with Section 5.1 – Technical Specifications for roads.

All access roads must be provided with solar street lighting at appropriate spacing to ensure adequate visibility and safety at night.

Parking facilities and offloading areas within the WTP and RWPS will be concrete / cabro paved (heavy duty 80mm) and shall be designed to accommodate ten (10) and ten (10) cars respectively. All the parking spaces for cars shall be covered to provide sun protection .

The Contractor shall submit a functional circulation drawing for heavy vehicles, with a turning area for delivery of reagents and evacuation of sludge.

3.14.2. Landscaping

Grading of the site may be necessary to achieve the most efficient hydraulic profile of the treatment plant. Furthermore, grading shall be used to provide a good surface drainage system.

The completed treatment plant site shall have a good green look and shall be planted with local durable tree and plant species. Evergreen and deciduous trees and plants (including flowers) shall be used to provide a year-around green look.

An irrigation system shall be provided using the treated water produced by the plant.

3.14.3. Fencing

Security fence made of galvanized chain link complete with barbed wire shall be provided around the entire site. Refer to Section 5.1 – Technical Specifications for fencing.

The main access gate shall consist of a 6 m wide, 2.4 m high with a standalone pedestrian gate (1m wide). The gate will consist of galvanised vertical RHS steel sections with adequate horizontal bracing / strengthening to Engineer's approval.

3.15. MISCELLANEOUS

3.15.1. Fire main system

A fire main distribution system shall be provided to afford fire protection to all buildings and structures within the site. The system shall be fed from an elevated tank of capacity to be calculated by the Contractor according to the applicable local building standards. The tank shall be fed with treated water from the treated water tank, using a dedicated booster pumping installation.

The fire main system shall be provided with hydrants, hose reels and foam inlets in accordance with BS 5306 Part 1 or equivalent: foam inlets to handle oil fires shall be for AFFF type foam and shall be confined to areas of oil storage .

The Fire Main System shall be provided in accordance with the following Standards and Codes of Practice:

- BS 5306 or equivalent:Fire extinguishing installations.
- BS 1710 or equivalent:Identification of fire mains.
- BS 5041 or equivalent:Fire hydrant systems.
- BS 5274 or equivalent:Fire hose reels for fixed installations.
- BS 750 or equivalent: Underground hydrants.
- CP 402.201 or equivalent: Fire fighting installations and equipment.
- CP 1013 or equivalent: Earthing of pipes.

Fire hose reels associated with external hydrants shall be located in free standing fibreglass or steel pillars suitably marked.

3.15.2. Potable water system (WTP and raw water pumping station)

A potable water distribution system shall be provided to serve each of the buildings on the site and the housing area.

The water shall be extracted from the treated water tank and pumped (dedicated pump with standby facilities) to an elevated tank. The capacity of this tank shall be at least equal to two days storage of the daily demand for potable water at the WTP.

3.15.3. Potable water system (other facilities within the Dam area)

A base camp, clinic, police post, school etc will be implemented under the Dam Contract. These facilities will be supplied with potable water from the clear water tank within the WTP.

Under this Contract, the Contractor shall design and implement a pumping system from the clear water tank to an elevated 100m^3 reinforced concrete tank. The tank will be located with the Dam operation area of distance not exceeding 3 Km. The height of the elevated reinforced concrete tank is approximately 15m. However, final designs for these works will be finalised by the Dam Contractor in close liaison with the Dam Contractor.

The water shall be extracted from the treated water tank and pumped (dedicated pump with standby facilities) to an elevated tank. The capacity of this tank shall be at least equal to two days storage of the daily demand for potable water at the WTP.

3.15.4. Service water system

A service water distribution system shall be provided to serve the process structures and buildings within the WTP site. The water shall be extracted from the wash water supply tank (UV disinfected water).The system shall be pressure fed from a break pressure tank of capacity equal to one third of the daily demand and a dedicated booster pumping station.

3.15.5. Sewerage and drainage

Every building of the plant shall incorporate washrooms, according to their location and usual presence of staff. A sewer network shall collect all the waste water to a septic tank. Soak pit shall be provided for infiltration of the over flow from the septic tanks.

Underground storm drainage system within the site shall be provided where surface drainage is not possible.

3.15.6. Rain water system

A rain water system will be implemented by the Contractor. The contractor shall propose a smart system in order to drain the maximum portion of the rain water falling on the site in the Dam. The system shall be designed ensuring that oils and other pollutants are not drained to the Dam

The Contractor has to limit to maximum impermeable surfaces and to create infiltration system for water that cannot drained to the Dam.

3.16. BUILDINGS

3.16.1. General

Buildings shall be of reinforced concrete structural frames with local hollow brick or natural masonry stones – plastered walls.

Floors and wall shall be isolated from rising damp with damp proof membranes and courses.

3.16.2. Fire resistance

The covered areas shall meet the minimum fire stability requirements for at least two hours.

3.16.3. Structural steel

Use of structural steel is allowed for the roof support structure.

3.16.4. Protection of structural steel members

All structural steel members shall be hot-dip galvanized and painted. Manufacturing of steel members shall be in accordance with EN ISO 14713. Galvanization shall be in accordance with EN ISO 1461. The Contractor shall provide a certificate stating that the galvanization was done as per the above code.

Before painting the steel members shall be checked for degradation of coating by blistering, peeling, flaking, cracking, lack of adhesion, etc. in the galvanizing. In case such a defect is found, the defected area shall be painted with zinc phosphate.

Finish of the steel members shall be done with polyester based resin with heat hardened powder. Finish color shall be selected by the Architect from the RAL catalogue. Finish paint thickness shall be 60 to 80 μ and the adherence category class 0.

Protection and painting of steel members shall carry a five-year guarantee.

Care must be taken during transportation so as not to damage the steel members.

3.16.5. Miscellaneous metal items

Non-structural metal elements, such as handrails, stairs, ladders, fittings, etc. shall be made of stainless steel, aluminium or glass fibre reinforced polyester (GRP).

3.16.6. Structural woodwork and carpentry

Use of structural woodwork is allowed for the roof structure and visitor gangways.

Treatment of wood shall be in accordance with EN 335-1, Class 4.

All fittings, cables, brackets, etc. used in connection with woodwork shall be made of stainless steel.

3.16.7. Roofing

Building roof system shall consist of pitched concrete roof overlaid with durable clay or concrete, and interior surfacing.

Adequate roof drainage shall be provided by with concrete gutters and piping.

3.16.8. False ceilings

The administrative areas shall have false ceiling. The material used shall meet at least the following minimum requirements:

Dimensions: 60 x 60 cm

Fire resistance: Class M0

Humidity resistance: 100%

Coefficient of absorption W > 0.75

Fixing of panels shall be made with T profiles.

3.16.9. Windows/Ventilation Screens

3.16.9.1. General

Window frames shall be made of aluminium or metal plastic with a minimum coating thickness of 20 microns. The Architect shall select the finish colour from the RAL catalogue.

The windows shall be equipped with secure locking mechanism and handles made of corrosion proof material.

Ventilation grilles shall be made of aluminium and shall be equipped with insect screens. Finish paint shall be thermal lacquer and the colour shall be selected by the Architect from the RAL catalogue.

3.16.9.2. General Glazing

The exterior windows shall meet the following requirements:

Thermal Coefficient $U \leq 1.7$ W/m^2 K

Solar Factor as per EN 410 ≤ 0.63

The interior windows shall meet the following requirements:

Thermal Coefficient $U \leq 1.9$ W/m^2 K

Acoustic factor $R_w \leq 33$ dB

All external doors and windows shall be double glazed.

3.16.10. Doors

Doors into the treatment areas shall be waterproof and made of aluminium. They shall be made as sandwich construction with high quality, soundproof insulation.

Doors within the administration part of the building shall be made of wood.

All doors and door frames shall meet the fireproofing requirements as set forth for the building.

Electronically operated doors shall be provided where appropriate.

Doors into areas accessible by vehicles shall be made as sandwich construction of anticorrosion treated steel. Exterior and interior surfaces shall be coated with polyester lacquer.

Locks and handles shall be made of durable and corrosion proof material.

3.16.11. Security Systems

Security systems shall be provided at points of entry.

3.16.12. Stairs/Ladders/Handrails

Stairs shall be made of reinforced concrete wherever possible with an alternative of stainless steel shade 316L.

Stairs, ladders and handrails shall comply with the Building Safety Regulations in force in Kenya.

Ladders shall be made of anodized aluminium (class 20 minimum). Ladders shall extend 1.1 m above the level they lead.

Handrails shall be made of stainless steel tubular sections, shade 316L or equivalent. They shall be designed to resist the anticipated impact loads. Top of the rail shall be 1.1 m from the finished floor level.

3.16.13. Flooring

All floor areas in the administrative building, except workshops and store rooms, shall be covered with ceramic tiles. Tiling used shall meet the following minimum requirements:

Size of tiles 20x20 or 30x30 cm,

Joint width 8 to 9 mm, Group B1

Surface durability EN 101 ≤ 8

Water absorption EN 99 ≤ 0.1%

Slip resistance ≥ R9

Expansion joints shall be provided at every 30 m^2. The joints shall be made of a combination of rigid and flexible PVC. Joint material shall be oil, acid, detergent, and fire resistant.

Skirting shall be provided for all tiled floors. Skirting height shall be 7 to 10 cm and the length of pieces shall match the width of the floor tiles.

Antiseismic movement joints in foundations and walls shall be composed of suitable aluminum profile coupled with a double strip flexible elastomere. Allowed movement shall be 4 to 6 cm.

Workshop and store room floor shall be covered with epoxy resin coating on top of concrete.

3.16.14. Wall finishes

The external walls of the building shall be covered with 50 percent of local stone. The remaining external wall areas shall be rendered and receive a finish of colored aggregate in a resin base.

Internal finishes shall be as follows:

- Room Wall finish
- Laboratory tiled from floor to ceiling
- Storeroom gloss paint
- Workshop gloss paint
- Kitchen tiling to 2.0 m, gloss paint above
- Dining room gloss paint
- Changing room tiling to 2.0 m, gloss paint above
- Toilets tiling to 2.0 m, gloss paint above
- Corridors gloss paint
- Stairs gloss paint
- Offices emulsion
- Meeting room emulsion

3.16.15. Electrical installations

3.16.15.1. General

Surface mounted galvanized steel conduits and fittings shall be provided in workshops. Elsewhere, wiring shall be installed in rigid PVC concealed conduits with flush fittings.

All electrical installations shall be approved by an approved local technical inspection body.

3.16.15.2. Air-conditioning and ventilation

The building shall have a centralized system for production of hot and chilled water and thermostatically controlled fan coil units in each room.

All offices and other rooms continuously occupied during working hours shall have variable speed ceiling fans at a suitable spacing.

The air-conditioning system of the administration and maintenance buildings shall be designed for the following conditions:

- inside temperature 21-23 °C
- inside relative humidity 40-60 %
- outside maximum temperature 35 °C
- outside minimum temperature 5 °C
- outside relative humidity 65% - 70 %
- ventilation rate min 10 liters per person

The air-conditioning system shall be divided into different split units, using Variable Refrigeration Volume, VRV heat pump systems with compressor motors controlled by an electronic inverter to meet any demand from 10% to 120% for cooling or heating. The outdoor condensing units shall have a copper fins. The system shall have a central exhaust and fresh air ventilation system.

The VRV system shall have individual fan coil unit controls as well as a central network remote controller.

EAC ripple control equipment shall be installed to the air-conditioning system as required by the local regulations.

3.16.15.3. Ventilation and fire detection system for the Raw Water Pumping Station

The contractor shall design and install a mechanical ventilation system where required i.e., switchrooms are to be pressurized to main positive pressure in them.

The heat generated by the Variable Frequency Drives should be extracted through a mechanical extraction system. A common or individual (per drive) based extraction system is to be installed. The Variable Frequency drives will be in an enclosed control room in the pump room. Fresh air is to be provided from outside and not the pump room to pressurise the control room and provide sufficient cooling. This can be natural or forced air system. Air conditioning for the RWPS is not a requirement and should be avoided unless absolute necessary. Mechanical ventilation is preferred.

The contractor shall design and install an addressable fire detection system to protect all rooms within the RWPS. The fire alarm control panel shall be in the control room. A beam detection system shall be utilised in the pump floor room. Smoke and heat detectors shall be installed where applicable. Break glass units shall be installed at all fire exits.

3.16.15.4. Computer network and telephone cabling

Cabling shall be installed for all computers and telephones in the building to be connected to a data exchange network and main switchboard for the telephone system.

3.16.15.5. Cold water system

A tank of sufficient storage capacity for two days' full usage of mains water shall be installed as high as possible in the building. The domestic water supply system shall comply with the British Code of Practice CP 310 or equivalent.

3.16.16. Signs and notices

The Contractor shall provide appropriate project signs as instructed by the Engineer.

Directional signage shall also be provided to the completed building facilities.

3.17. TELECOMMUNICATIONS

The plant shall be connected to the wireless "fixed" line telecom system.

The administration building shall be provided with a switchboard and with telephone lines to all offices. One fax line and one broad-band internet connection shall be provided.

3.18. ANCILLARY BUILDINGS WITH THE WTP

3.18.1. Administration building

The two-story administration building must accommodate:

- lobby reception area minimum floor area 20 m^2, equipped with:
  - **2 floor units with suspended file supports and shelving,**
  - **1 chair on rollers, with arm rests + 2 chairs,**
  - **1 display panel (2 x 1 m),**
  - **1 pedestal desk**
  - **1 side table.**
  - **Armchairs and sofas**

- main administrative office minimum floor area 25 m^2, equipped with:
  - **2 floor units with suspended file supports and shelving,**
  - **1 chair on rollers, with arm rests + 2 chairs,**
  - **1 display panel (2 x 1 m),**
  - **1 pedestal desk**
  - **1 side table.**

- conference room minimum floor area 60 m^2, equipped with:
  - **1 meeting table for 12 people**
  - **12 armchairs on rollers, with arm rests**
  - **1 display panel (minimum 75 inches)**
  - **1 projector and viewport**
  - **Audio or video conferencing equipment**
  - **Cables, cords, A/V equipment, internet connection**

- A control room of about 50 m^2, equipped with:
  - **3 floor units with suspended file supports and shelving,**

- **main control desk with the following equipment: computers, printers, telephone,**
- **one auxiliary control desk with the following equipment: computers, printers, telephone**
- **4 chairs on rollers, with arm rests, side table + 4 chairs,**
- **2 display panels (65 inches each),**
- **2 pedestal desks with additional angle units,**
- **2 side tables.**

- plant manager office minimum floor area 23 m^2, equipped with:
  - **2 floor units with suspended file supports and shelving,**
  - **1 chair on rollers, with arm rests + 2 chairs,**
  - **1 display panel (2 x 1 m),**
  - **1 pedestal desk**
  - **1 side table.**

- chemist's office minimum floor area 18 m^2, equipped with:
  - **2 floor units with suspended file supports and shelving,**
  - **1 chair on rollers, with arm rests + 2 chairs,**
  - **1 display panel (2 x 1 m),**
  - **1 pedestal desk**
  - **1 side table.**

- 2 engineer's offices minimum floor area 18 m^2 each, equipped with:
  - **2 floor units with suspended file supports and shelving,**
  - **1 chair on rollers, with arm rests + 2 chairs,**
  - **1 display panel (2 x 1 m),**
  - **1 pedestal desk**
  - **1 side table.**

- Laboratory including storage and washing space minimum floor area 200 m^2 on the ground floor of which:
  - **record room 40 m^2**
  - **office 40 m^2**
  - **Bacteria testing room 60 m^2**
  - **Other testing room 60 m^2;**

- Workshop and store room for minor maintenance of plant and equipment minimum floor area 200 m2 on ground floor;

- Staff room minimum floor area 85 m^2:
  - **sink and draining-board,**
  - **cupboard,**
  - **2 heating plates,**
  - **1 table for 10 people + chairs**

- Archive rooms

- Toilets, with two WCs and washbasins for managers and visitors;

- A men's cloakroom with:
  - **2 showers,**
  - **2 WCs and washbasins,**
  - **10 lockers;**

- A women's cloakroom with:

- **2 showers,**
- **2 WCs and washbasins,**
- **10 lockers;**

- Office automation equipment:
  - **8 PCs (min. 16GB RAM, 500GB HDD)**
  - **3 black & white laser printer (A4)**
  - **1 black & white laser printer (A4 +A3)**
  - **1 color laser printer (A4+A3)**
  - **1 photocopier (A4+A3),**
  - **1 plotter,**
  - **Networking of the computer equipment (PC, printer, plotter).**

3.18.2. Laboratory

3.18.2.1. Performance requirements

The Contractor shall supply and install laboratory equipment necessary to probe samplings and to perform the following analyses, in accordance with European Standards, as specified in the following table:

Table 7: Required parameters to be analysed

PARAMETERS
Color
Turbidity
Odour
Taste
Temperature
pH
Conductivity
Chlorides
Sulfates
Silicates
Calcium
Magnesium
Sodium
Potassium
Aluminium
Total hardness
Total dissolved solids
Dissolved oxygen
Free carbon dioxide
Nitrates
Nitrites
Iron
Manganese
Suspended matters
Residual chlorine
Total alcalinity
Coliform organisms
Faecal coliforms

The laboratory shall be implemented and equipped by the Contractor with water supply and drainage.

3.18.2.2. Specification for the Laboratory

3.18.2.2.1. Equipment to supply

The laboratory equipment needed for the analyses mentioned in 1.1 shall include but not be limited to the equipment listed below. The equipment listed below is described for guidance and the characteristics indicated are minimum requirements:

- Precision balance:
  - **capacity 200 g, sensitive to 0.1 mg,**
  - **quantity 1.**

- Rough single pan balance:
  - **capacity 2 kg, sensitive to 0.1 g,**
  - **quantity 1.**

- Refrigerator:
  - **300 litres capacity with top freezing chamber of 28 litres capacity, the compartment with four shelves and semi-automatic defrosting,**
  - **quantity 1.**

- Water deionizer:
  - **This water should be of an adequate quality to be used for bacteriological analysis without further treatment. This deionizer shall be electrically insulated and connected with an earthing system,**
  - **quantity 1.**

- Digital laboratory pH meter:
  - **covering the range 0-14 pH and with accuracy better than ±0.02 pH unit. The meter shall be supplied with all spare parts and accessories with ten spare electrodes,**
  - **quantity 1.**

- Portable pH meter:
  - **battery operated, range 0-14 pH with an accuracy of ± 0.1 pH including spare parts and accessories,**
  - **quantity 2.**

- Conductivity meter (laboratory):
  - **7 scales: 0 to 500 milli siemens or millimho.cm with automatic temperature compensation. Complete,**
  - **quantity 1.**

- Turbidity meter (laboratory):
  - **5 scales 0 to 1000 nephelimetric: turbidimetric unit. Complete,**
  - **quantity 1.**

- Oxymeter (portable):
  - **dissolved oxygen between 0.03 and 500 mg. Saturation index between 0.35 and 100% automatic temperature compensation between 0 and 75°C. Compensation for salinity,**
  - **quantity 2.**

- Spectrophotometer:
  - **single beam, wave length range 325-925 nm, with readings ion optical densities, transmission and concentrations,**
  - **quantity 1.**

- 10 litre carboys:
  - **quantity 5.**

- Plastic pails:
  - **5 litres and 10 litres capacities,**
  - **quantity 6.**

- Stop watches:
  - **with triple action for start, stop and reset,**
  - **quantity 2.**

- Interval timer:
  - **provided with alarm bell,**
  - **quantity 2.**

- Portable water pump:
  - **capacity minimum 300 l/h - Total head 5 m,**
  - **quantity 1.**

- pH test papers:
  - **range 1-11 pH,**
  - **quantity 100.**

- pH standard solutions:
  - **quantity 2 sets.**

- Infrared spectrophotometer:
  - **wave length range 4000-650 nm,**
  - **computer interface for data recording and evaluation,**
  - **quantity 2.**

- Microscope:
  - **occular lens 10x, objective lenses 4x, 10x, 40x et 100x,**
  - **quantity 1.**

- Ovens:
  - **for 20°C, 40°C, 105°C and 180°C,**
  - **volume 50 l each,**
  - **quantity 1 for each temperature range, 4 in total.**

- Bacterial analysis material:
  - **material enough for five analyses daily during 2 years.**

- Glass ware:
  - **enough for listed analyses with spares for 2 years operation.**

- Chemicals:
  - **all necessary chemicals for listed analyses during 2 years.**

- Electronic bacteria culture counter:
  - **for Petri jar ø90 mm,**
  - **with magnification lens 2x,**
  - **quantity 2.**

- Automatic titrimeter:
  - **central microprocessor unit,**
  - **adapted software,**
  - **automatic burette,**
  - **pH and temperature sensors,**
  - **support and agitation system,**
  - **quantity 1.**

- Distillator to distill potable water:
  - **25 litres/hour 380 V, 60 Hz,**
  - **quantity 1.**

- Portable refrigerator for transporting samples:
  - **operation on car battery 12 V DC,**
  - **quantity 1.**

- Auto clave for laboratory use:
  - **quantity 1.**

- Variable temperature incubator:
  - **10 degrees to 70 degrees Celsius 220 V AC, 60 Hz,**
  - **quantity 1.**

- Vacuum/Pressure pump:
  - **quantity 1.**

- Six place stainless steel manifolds:
  - **quantity 1.**

- UV sterilizers:
  - **quantity 1.**

- Hydrosol stainless steel filter holder:
  - **quantity 1.**

Supplied fittings should be associated with their all accessories, supplements, choices and their necessary parts to make the analysis mentioned in the performance requirements.

3.18.2.2.2. Sample receiving and preparation room

Small One room where the samples shall be received, registered, prepared (mixed, composited and where needed preserved) and stored. Sample bottles shall be cleansed and stored in this room.

This room shall have its own water supply and drainage and shall have two independent washbasins. It shall have two entrances one of which should be independent from the main laboratory in order to serve as a reception and another which should communicate with the main laboratory. This room shall be adjacent to the laboratory used by the Contractor.

The room shall be equipped with two secured and aerated refrigerators (minimum unit capacity 130L), a freezer, and a sonic homogenizer and shall have bench and cabinet area for storing required sample bottles, and chemicals for sample preservation.

An emergency shower and eye bath shall be installed.

3.18.2.2.3. Records

The Contractor shall supply laboratory operating instructions and a sampling and analysis program for the conditioning plant operation control.

The Contractor shall provide a computer and a data base software for the record of analysis results.

3.18.2.2.4. Independent laboratory used by the plant operator

This laboratory shall be accredited and shall be selected by the Contractor and validated by the Employer.

3.18.3. Workshop - Store

The workshop-store covers an area of about 200 m². It is equipped with the minimum following:

- a 2000 kg monorail with electrical lifting tackle,
- heavy-duty shelving (permissible unit loads of 100 kg), with storage compartments and trays (total length of shelving: 20 m),
- a fixed heavy-duty workbench with fixed parallel-jaw vice, 2.50 m,
- a wall panel for storing small tools, dimensions about 4 x 1 m,
- a set of tools: socket, flat and right-angled wrenches, screwdrivers, pliers, etc.,
- a compressed air pipe winder,
- and all other basic equipment and tools to be used for maintenance of pumps, water meters and other accessories

3.18.4. Gatehouse

Situated at the main entrance to the plant site, the gatehouse shall cover at least about 10m². It is equipped with the following:

- a toilet and washroom,
- an office,
- two chairs
- a worktop
- a set of shelves.

3.18.5. Functions of technical equipment and staff rooms

In his design, the Contractor shall indicate the arrangements he intends to make with respect to the following:

- Visual comfort: natural lighting in all work rooms, protection against sunlight for all exposed facades, good electric lighting provided by low-luminance quality fixtures.
- Acoustic comfort: soundproofing of all partition, exterior and interior walls and floors. Noise absorption of ceilings and walls to prevent noise reverberation.
- Thermal comfort: air-conditioning and heating in order to maintain a temperature of 20-25°C.
- Ease of maintenance: stoneware or similar flooring, washable walls, good-quality joinery both indoors and outdoors.
- It must be possible to modify interior distribution systems in each sector with the minimum amount of work.

The arrangement of the various elements of the building must be functional: special care must be paid to connections between corridors, ramps and stairways.

All furniture supplies shall meet the following requirements:

- Modern functional design adapted to the architecture and indoor arrangements.
- Ergonomic design for operating rooms.
- Standard quality for staff and other rooms.
- Harmonisation with supervision and control equipment in the control room.

The supplies shall be sufficient to enable the plant to commence operation immediately. They shall be adapted to the architecture and use of the rooms in question. They shall comply with the following principles, which shall be adapted in accordance with the architecture proposed by the Contractor.

3.19. ANCILLARY BUILDINGS WITH THE RWPS

In addition to the raw water pump house, the Contractor shall design and provide the following building structures:

- Kenya Power Metering Room
- Transformers yard
- Internal pump operation room (minimum floor area 20 m^2)
- Internal store (minimum floor area 50 m^2)
- Switchrooms
- External workshop and Store (minimum floor area 200 m^2) which will have at least the following provisions:
    - At least 5000 kg (and must be able to lift the heaviest component within the pump house) monorail with electrical lifting tackle,
    - heavy-duty shelving, with storage compartments and trays (total length of shelving: 20 m),
    - a fixed heavy-duty workbench with fixed parallel-jaw vice, 2.50 m,

- a wall panel for storing small tools, dimensions about 4 x 1 m,
- a set of tools: socket, flat and right-angled wrenches, screwdrivers, pliers, etc.,
- a compressed air pipe winder,
- and all other basic equipment and tools to be used for maintenance of pumps, water meters and other accessories

Other facilities to be provided with the RWPS will include:

a) **lobby reception area minimum floor area 20 m^2, equipped with**:

- 2 floor units with suspended file supports and shelving
- 1 chair on rollers, with arm rests + 4 chairs
- 1 display panel (2 x 1 m)
- 1 pedestal desk
- 1 side table

b) Plant manager office minimum floor area 25 m^2, equipped with:

- 2 floor units with suspended file supports and shelving,
- 1 chair on rollers, with arm rests + 2 chairs,
- 1 display panel (2 x 1 m),
- 1 pedestal desk
- 1 side table.

c) Operator's office, minimum floor area 25 m^2, equipped with:

- 2 floor units with suspended file supports and shelving,
- 1 chair on rollers, with arm rests + 2 chairs,
- 1 display panel (2 x 1 m),
- 1 pedestal desk
- 1 side table.

d) gatehouse shall cover at least about 15m^2.

- a toilet and washroom,
- an office,
- two chairs
- a worktop
- a set of shelves

e) A store, minimum floor area 15 m^2, equipped with suspended file supports and shelving,

f) Washrooms including Bathrooms and changing rooms at least four (4) for each gender.

An indicative / conceptual **General Layout Plan** illustrating the Employers minimum requirement is provided as part of the Tender Drawings.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.3 – CONTROL OF PERFORMANCES LEVELS

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1. TESTS ON COMPLETION

1.1. GENERAL

With regard to Clauses 9, 10 and 11 of the General and Particular Conditions of Contract, the Tests on Completion shall satisfy the following:

- **Pre-commissioning tests**: inspections prior to flooding to determine whether the installations are in fact ready to be commissioned.
- **Permission for flooding** given by the Engineer
- **Adjustment period** lasting at least 20 days, during which the Contractor finalises the installations under operation. **Commissioning tests** are carried out during this period.
- **Trial Operation** lasting at least 30 days, for checking that continuous operation complies with the basic design and performance requirements. **Performance tests** are carried out during this period. The Trial Operation Period shall not end until correct operation has been observed for a period of 30 consecutive days.
- **Commissioning Certificate** of the plant upon completion of the works, construction, finalisation and adjustments and especially after commissioning of the Performance Tests.
- **Retention Period** for the performance of the installations and correct operation of all the equipment and structures installed (longer guarantees may apply to specific points is otherwise specified).

1.2. PRE-COMMISSIONING TESTS

The installations should be in working order and all checks and Pre-commissioning tests relating to the civil works and equipment have given satisfaction. The CTM control unit is working properly and the electrical installation has been certified by the authorised agency.

The site installations have been dismantled, the sites cleaned, roads completed and green spaces planted.

As per GCC 5.6, The Contractor is now allowed to submit Operation & Maintenance Manuals by instalments, the draft before commencement of commissioning tests, and the balance prior to the Commissioning Certificate (when commissioning tests have passed and been approved). The draft O&M Manuals will be submitted to the Engineer review before the commencement of commissioning tests.

The Final Operation and Maintenance Manual and the Final Maintenance Plan will be supplied by the Contractor.

In these conditions, the Contractor shall give the 21 days' notice for informing the Engineer of the Date after which the Contractor shall be ready to carry out the Pre-commissioning tests.

Within a period of 14 days from after the submission of the 21 days' notice, the installations shall be inspected with a view to checking that they have been built correctly and in conformity with the Employer's requirements and the design.

On conclusion of this inspection, the Engineer will notify any observed omissions, imperfections or poor workmanship. The same document will indicate whether the installation can be flooded (start of the adjustment period) in spite of these imperfections and poor workmanship or whether it is postponed until they have been rectified. In the former case, the Contractor will have a 15 days "modification period" and a new notification will be sent to the Engineer to

note that these imperfections and poor workmanship have been remedied, at which point the adjustment period begins.

The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period.

1.3. ADJUSTMENT PERIOD AND COMMISSIONING TESTS

The adjustment period begins on the date of flooding's authorisation of the installations notified by the Engineer.

This period allows the Contractor to carry out all the checks and adjustments that he considers necessary and to ensure that there are no construction faults in the civil works and equipment.

During this period are carried out all the specific operational tests necessary for the demonstration that the works can operated safely and as specified, under all available operating conditions.

This period shall last at least twenty (20) days.

The Engineer shall be informed of all checks and adjustments, all analysis and inspection results in a file kept regularly up to date, in two copies.

During the adjustment period:

- The installation shall be operated under the authority and responsibility of the Contractor: all necessary adjustments, repairs and modifications shall be made by him at his own expense.

- The cost of all electrical energy, fluids and consumables, including reagents required for the correct operation of the plant, shall be borne by the Contractor.

As soon as flooding takes place and during all the duration of the adjustment period, the Contractor shall train the future operating staff of the instructions for operating and maintaining the installation, based this on the operating manual provided prior to flooding. The Contractor shall draw up a staff training schedule in liaison with the Employer and with his approval.

This is updated throughout the adjustment period. In any case, the Contractor shall be responsible for the operation and maintenance of the plant. The trained Employer's staff will not have any responsibilities in the management of the plant

After the minimum period of 20 days and as soon as the Contractor considers the installation to be in good working order, he shall inform the Engineer in writing that the Trial Operation Period can begin.

Provided that the various investigations carried out during the adjustment period indeed confirm that the installation is in good working order, the Engineer will notify that the plant succeed to pass the Commissioning tests .

Then, the Engineer will require the Employer for giving in writing the Trial Operation Period within ten (10) working days after the date of the Contractor's request.

Should the plant fail to be in good working order, in the opinion of the Engineer, a new 15 days "modification period" shall be given to the Contractor to achieve the works. The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period.

1.4. TRIAL OPERATION PERIOD

The Trial Operation period runs for a duration of 30 consecutive days without the installation being stopped.

The aim is to verify that the installation is complying with the Guaranteed Performances and with the Employer's Requirements under continuous working conditions and to assess the operating conditions, particularly with regard to energy and reagent consumption.

During the Trial Operation period, the Contractor shall carry out Performance tests at his own expense.

The Employer shall have full authorisation to have additional tests carried out at his own expense prior to acceptance in order to check that the Contractor has fulfilled all his obligations in terms of the quality of treatment, production of residues, electricity and reagent consumption, operation of the installations, miscellaneous types of disturbance, etc.

During the Trial Operation period:

- The installation shall be operated under the authority and responsibility of the Contractor. All necessary adjustments, repairs or modifications are carried out by him and at his expense.

- The energy, fluids and consumables, including reagents, are provided by the Contractor and included in his Price.

In light of the results of all the checks carried out and in particular those of the Performance tests, the Employer may ask for the Trial Operation Period to be extended to enable the Contractor to remedy any malfunctions responsible for the observed inadequacies or problems. Penalties for delay may be applied. The cost of additional tests required to ensure that the Contractor has complied shall be borne by him.

The Trial Operation period can be terminated only after a period of 30 consecutive days of proper operation of the installations.

After completion of the trial operation period, the Contractor will replenish all chemical for 2 months of operation at full capacity and refuel the diesel generator tanks at their maximum capacity.

1.5. PERFORMANCE TESTS

Performance tests are carried out during the Trial Operation period. Their aim is to determine the capacities of the treatment process, the quality of treatment, the efficiency of the various structures and items of equipment, and energy and reagent consumption in normal operating conditions.

The performance tests are carried out by an organisation that is independent of the Contractor, approved by the Employer and monitored by the Engineer.

The tests are determined on the basis of the protocol given in Annex to the Employer's Requirements, adapted by the Contractor and submitted to the Engineer for approval.

During the test period, the installation is operated by the Contractor with its staff assigned to the operation.

The Contractor shall bear the cost of electrical energy, fluids and consumables (including reagents), which shall be included in his Price.

The organisation in charge of carrying out the tests is responsible for setting up and removing the temporary installations required for the tests.

The costs of carrying out the tests shall be borne by the Contractor.

If the results of the tests are not satisfactory, the Engineer shall notify the Contractor concerns that he must remedy all the observed inadequacies and malfunctions without delay. The Contractor will not be entitled to any additional costs for the remedy works.

When all the results are satisfactory, a test conformity report is drawn up and signed by both parties.

1.6. COMMISSIONING CERTIFICATE

At the end of the Trial Operation Period, provided that it shall be successfully and only if the Performance tests are satisfactory, the Commissioning Certificate will be issued in accordance with Clause 11.7 of the General and Particular Conditions of Contract.

2. TEST PROTOCOL

The test protocol shall be proposed by the Contractor and approved by the Engineer. Minimum requirements are listed here below.

2.1. WATER TREATMENT

2.1.1. General procedures

Refer to chapter *1 - Tests on completion*.

2.1.2. Instrumentation

All measurement instruments shall be checked and rated and a rating certificate provided.

2.1.3. Quality of treatment

Refer to chapter *1.5 - Performance tests*.

2.1.4. Checking the operation of certain structures

Various measurements and checks are performed to assess the operation of individual structures.

The test protocol shall be proposed by the Contractor and approved by the Engineer. The Contractor shall provide intermediate inspection parameters for assessing the proper operation of the structures, for example localised inflow/outflow samples, water characteristics, etc.

The test protocol shall include the following points in particular:

- Water quality:
  - **Raw water**
  - **After clarification**
  - **After filtration**
  - **Final treated water**
  - **At the discharge point in the Dam**

- Reagent consumption (if any)
  - **The consumption level must be measured daily on any treatment process involving the addition of reagents.**

- Efficiency of backwash:
  - **Air flow**
  - **Water flow**
  - **Head losses recovery after backwash**
  - **Filter media losses**

- G value for mixers

2.2. SLUDGE TREATMENT

The quantities of sludge must be noted.

The quantities of reagents consumed must be noted (where applicable).

The final dryness will be measured by an independent laboratory.

2.3. CHECKING OF GENERAL OPERATION

2.3.1. Energy consumption

Active and reactive energy consumption shall be measured each day for the plant as a whole and for each of the main components. Voltage, Intensity and Cosφ shall be carried out in order to check the power of each equipment and for the whole installation.

2.3.2. Other points to be noted

- Consumption of all reagents.

- Working time of the main items of equipment

- Measurements of power consumption by equipment: pumps, blowers, mixers, compressors, UV reactors, etc.

2.4. NOISE

2.4.1. At the edge of the property

During the tests, an overall measurement of the noise emitted by the installation shall be carried out at the edge of the properties. The measurement shall be made by an organisation approved by the Engineer and in accordance with the conditions set out in international and national legislations (including WB/IFC and Degree N398).

The measurement point shall be chosen in agreement with the Engineer.

The measurement shall be carried out for a period of 24 hours, during which the installation shall be in normal operation, in conditions that are as close as possible to nominal working conditions.

2.4.2. Within the premises (at the plant)

The appropriate measurements shall be performed to ensure that the arrangements made by the Contractor comply with regulations concerning the safety of staff and with the guarantees provided by the Contractor.

3. INTERPRETATION OF RESULTS

3.1. QUALITY OF WATER TREATMENT

With regard to the parameters mentioned in Part 2 – Section 7.2 "Design requirements and performances specifications" – chapter 2.1.1, the results obtained for each daily mean sample must comply with the requirements of the Performance specifications.

In any event, if the target has still not been attained at the end of the guarantee period, the Contractor shall modify the installation at his own expense, and a new guarantee period of one year shall commence at the end of the corresponding work. The performance tests shall then be carried out at the Contractor's expense.

3.2. QUALITY OF SLUDGE TREATMENT

3.2.1. Quality

The dryness of dried sludge shall at least comply with the requirements set out in the Performance specifications, without any addition of reagent higher than that stipulated in the contract in the corresponding operating conditions.

3.2.2. Sludge production

The mean sludge production ratio shall be calculated over the test period. In calculating this mean ratio, no account shall be taken of days with a higher intake than the reference loads. The mean ratio shall be no higher than that specified in the Schedule of Guaranteed Performances.

3.3. ENERGY AND REAGENT CONSUMPTION

The results of energy and reagent consumption measurements must comply with the Schedule of Guaranteed Performances.

However, without affecting the validity of the tests, the following tolerances will be allowed for excess consumption:

- Electrical energy 5%,
- Reagents: 10%.

Consumption shall be assessed over the entire test period.

3.4. NOISE

The results of general noise level measurements at the edge of the property and in the premises must comply strictly with the Performance specifications.

4. PRICE REDUCTIONS FOR FAILURE

In accordance with the results of the Performance Tests or other tests performed during the Trial Operation Period, the Employer may apply the following price reductions for failure for over-consumption beyond certain tolerances, the amount of these price reductions for failure being defined in the Particular Conditions – Special Provisions.

4.1. ELECTRICITY

For loads measured at the time of the tests, a tolerance of 5% is allowed with the respect to the Schedule of Guaranteed Performances.

A price reduction for failure may be applied for over-consumption between 5% and 10%, as defined in the Particular Conditions – Special Provisions.

Any over-consumption of more than 10% will lead to the installation being rejected.

4.2. CHEMICALS (WHERE APPLICABLE)

For consumption measured at the time of the tests a tolerance of 10% is allowed with respect to the Schedule of Guaranteed Performances without any penalty.

A price reduction for failure may apply for over-consumption between 10% and 20%, as defined in the Particular Conditions – Special Provisions.

Any over-consumption of more than 20% will lead to the installation being rejected.

5. REJECTION OF THE INSTALLATION

Should the Contractor fail to satisfy the requirements under which the works can be accepted, the Employer may reject the faulty installations and apply the coercion measures provided for in the General Conditions of the Contract.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.4 – OPERATION & MAINTENANCE REQUIREMENTS

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1. SCOPE OF THE OPERATION SERVICE PERIOD

The Contractor shall be responsible for Operation Service Period of two (2) years after the issuance of Commissioning Certificate, for the firm part only or for both firm and conditional part (whether the conditional part is notified or not). During the Operation Service Period, the Contractor shall operate the Plant in such a way that the attainable design / manufacturers performance criteria are achieved and maintained at all times.

During the Operation Service Period, the Contractor shall provide on-site training of the nominated staff in managing, operating and maintaining the Plant. Requirements for off-site training shall be agreed with the Employer.

The method statement and programme submitted with the Contractor's Tender shall form the basis of the Contractor's procedures for Operation Service Period and shall be used to establish a set of standard operational procedures for the Plant. Prior to the end of the Construction Contract, the following documents shall be prepared by the Contractor and approved by the Employer's Representative, being produced in a user-friendly style and in a format suitable for use in training the Employer's staff in the Operation and Maintenance of the Plant:

- **Resource Allocation Statement**: Description of staff, materials, plant and equipment required for operating and maintaining the Plant.
- **Resource Allocation Program**: Bar chart schedule for the periods of use of staff, materials, plant and equipment.
- **System Development and Implementation Plan**: Management of administration, operation, maintenance and technical services.
- **Operations Plan**: Operation of the Plant under normal operation conditions and in cases of partial or complete shutdown.
- **Maintenance Plan**: Maintenance procedures to ensure the continuous operation of the Plant under normal operation and in cases of partial or complete shutdown.
- **Comprehensive Safety Policy**: Definition of the Contractor's responsibilities regarding safety and health of all authorized people being situated at the Site.
- **Standard Procedures Document**: Step-by-step implementation procedures for the effective management and operation of the Plant.

The Staff training programme shall be submitted for the approval of the Employer's Representative at least six (6) months before the actual start of the Operation Service Period.

The Contractor's responsibilities during the Operation Service Period shall include, but not be limited to the following:

- **management of the Plant operations,**
- **provision of manpower (key skilled personnel, semi-skilled, unskilled and security personnel),**
- **provision and payment of electricity,**
- **provision of all chemicals,**
- **provision of other consumables including fuel, lubricants, etc.,**
- **payment of levies and other statutory deductions to comply with all appropriate local regulations,**
- **operation of the Plant,**
- **adjustment of process whenever necessary,**
- **preventive and routine maintenance,**
- **repair and replacement work,**
- **repainting work,**
- **monitoring of performance,**

- **reporting,**
- **data filing and processing,**
- **trouble shooting / diagnostic analysis,**
- **training of staff,**

The performance of the treatment plant shall be monitored as described in chapter 5.2 of this section and shall consider the alterations approved by the Employer's Representative during the Performance Tests Periods and the Operation Service Period.

At the end of the Operation Service Period, the Contractor shall hand over the Plant to the Employer in fully functional conditions with all necessary maintenance, repainting, repair and replacement works having been done to the satisfaction of the Employer's Representative.

All cost in relation to Operation Service Period shall be borne by the Contractor. He shall be liable for any damages including any injuries to persons that may arise during operation, maintenance and staff training.

2. ADMINISTRATION

2.1. FACILITIES AND EQUIPMENT

Unless otherwise specified, the Contractor shall provide the facilities and equipment required for a proper functioning of the Operation Service Period, before starting with the Operation Service Period.

During the Operation Service Period, the Contractor shall make use of the following existing facilities and equipment provided during the construction period:

- The pumping station,
- The pumping mains
- the water treatment plant,
- the treated water tank,
- discharge pipe to the dam
- administration building including offices, equipment and facilities,
- workshop including equipment and stores,
- laboratory including equipment and facilities,
- mobile equipment,
- spare parts.

The Contractor shall hand over the facilities and equipment complete and in good condition at the end of the Operation Service Period.

2.2. STAFF

2.2.1. Organisation

The work programme, organisation chart, number of manpower and job descriptions of all staff necessary for O&M Period as submitted by the Contractor with his Tender will form the basis for the organisation of the services. It may, however be amended by the Contractor to meet the requirements of these services to the approval of the Employer's Representative. Additionally, CV's shall be submitted of the proposed professional staff.

To this regard, before the end of the Design-Build Period, the Contractor shall submit to the Employer's Representative, for approval, a fully detailed work programme for Operation Service Period of the Plant. This shall include an organisation chart with number and job descriptions for each grade of staff up to and including the Plant Manager.

In order to accomplish the approved work programme, the Contractor shall provide all expertise, staffing and labour being necessary for a continuous efficient performance of O&M Period. The operation activities shall be programmed

and operated accordingly in close co-operation with the Employer's Representative and, if present, with other Contractors.

Staff and labour shall include, but not be limited to the following categories:

- project manager,
- section managers,
- qualified engineers and experts, with minimum:
  - **Treatment Process Expert**
  - **Electro-mechanical Expert**
  - **SCADA Expert**
- qualified technicians,
- administration and clerical staff,
- semi-skilled labour,
- unskilled labour,
- security personnel.

The selected staff shall be physically and mentally competent to perform the work required of them and shall possess the necessary ability for specific assigned tasks. Any staff not having the requisite qualifications and abilities shall be substituted, at the cost of the Contractor, within one month after requested by the Employer's Representative.

The senior personnel shall be able to read, write and converse in English.

The Contractor shall provide proper round the clock attendance and especially day-and-night availability of the key personnel. All absence of key personnel on leave shall be compensated by temporary replacement with adequate staff members.

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for his labour and staff.

2.2.2. Knowledge and operation transfer to Coast Water staff

The operation service period will be used as a training period for the selected personnel who are expected to run the operation of the treatment plant and raw water pumping station after the departure of the DBO Contractor.

The staff to be trained will be recruited jointly by the Contractor and the Employer. They will be employed by the Contractor for a 2-year employment contract with a provision to be absorbed by the Employer upon successful completion of the training. Salaries for these staff, including any allowances payable, will be at the Employer's salary scales and will be covered as a Provisional Sum in the Price Schedules.

The cost of on-site training of the selected personnel, including key personnel for training, training materials, provision of requisite Personal Protective Equipment's (PPE) amongst others, for the whole duration of the operation service will be covered in the Contractor's rate for the operation service. The cost for off-site training, which may include but not limited to site visits to similar installation (bench marking) will be covered as a Provisional Sum.

Tentatively, the staff to be trained will be as follows:

i.) Plant Manager – 1Nr.

ii.) **Process Engineers / Operators – 5Nr.**
iii.) **Mechanical Engineers – 3Nr.**
iv.) **Electrical Engineers – 3Nr.**
v.) **System Developers / SCADA Experts – 3Nr.**
vi.) **Chemists -3Nr.**
vii.) **Technicians – 6Nr.**

The Contractor will provide the suggested qualifications for each of the above positions to the joint recruitment panel for review and agreement.

The staff to be trained will fully be integrated into the Contractor's plant operations and will be under the whole responsibility of the Contractor during the operation service. Performances and OPEX of the WTP remain the responsibility of the Contractor during the operation service.

2.2.3. Personnel Relations

Cultural differences and behavioural patterns often cause difficulties in the personnel relations between members of the operation and maintenance staff. In order to select personnel with compatible cultural and behavioural backgrounds, an applicant test programme shall be prepared. The relevant tests shall be utilised during personnel recruitment and hiring.

Difficulties in the personnel relationship between the staff members shall be detected on the basis of personnel records, and shall be solved by meetings with the concerned employees.

The benefits and everyday needs of the employees shall be considered by maintaining optimum labour relations, public relations and supply of medical, social and clerical services.

2.3. LEGAL AND FINANCIAL ASPECTS

2.3.1. General

The Contractor shall verify and consider all legal aspects concerning staff engagement, land and property acquisition and disposal, disputes and claims with regard to the national and local conditions of law.

During Operation Service Period, all capital investment, costs, payrolls and taxes shall be accounted, recorded and paid by the Contractor.

The tasks of the Contractor will also include the general budgeting of Operation Service Period, the utilisation of proper audit functions and the administration and payment of assurances.

The Contractor shall be responsible for the payment of all electricity, water and other services utility costs in connection with the Operation and Maintenance of the Plant as well as any charges for the disposal of sludge and other residuals.

2.3.2. Damage

The Contractor shall be responsible for any damage to the Plant caused by his operation and maintenance services. The Contractor shall eliminate the damage without undue delay and without additional cost to the Employer.

The Contractor shall be responsible for any damage to public properties caused by his operation and maintenance services. The damage shall be searched, identified and repaired on the expense of the Contractor, even if the Employer will receive a relevant invoice from the concerned parties.

2.4. SAFETY AND SECURITY

The Contractor shall submit a Health and Safety Plan as required by Kenyan Legislation.

2.4.1. Safety

The Contractor shall provide a safety specialist being responsible for the preparation, implementation and maintenance of a comprehensive safety program, which shall be periodically evaluated during Operation Service Period and be approved by the Employer's Representative. The specialist shall develop the safety and health policies, standards and procedures.

The responsibility of the safety specialist includes performing safety training and conducting safety inspections, sessions and practice. He will also be responsible for the investigation of accidents.

A safety committee shall be formed and regular safety meetings shall be organised.

All safety equipment and tools shall be provided and maintained by the Contractor.

2.4.2. Fire protection

The safety specialist shall prepare, implement and maintain a comprehensive fire protection and prevention programme, which shall be approved by the Employer's Representative.

The safety specialist will also be responsible for the inspection and maintenance of the fixed and portable fire protection equipment and for the investigation of fire incidents.

During Operation Service Period, the safety specialist shall develop and implement a project emergency action plan and fire hazard inspection procedure.

2.4.3. Security

In order to protect property, materials and facilities against unauthorised entry and trespass, pilferage and theft, destruction, damage, sabotage, embezzlement, fraud and other dishonest, illegal or criminal acts during the Operation Service Period, a security programme shall be prepared, implemented and maintained. The Employer's Representative shall approve the security programme.

2.5. ENVIRONMENT

The Contractor shall provide an environmental specialist being responsible for the preparation, implementation and monitoring of a comprehensive environmental management plan, which shall be periodically evaluated during Operation Service Period and be approved by the Employer's Representative.

The specialist shall develop the environmental monitoring procedures. These procedures have to be agreed with Coast Water environmental department before implementation.

2.6. REPORTING

The Contractor shall submit monthly, semi-annual and annual reports including any important details concerning performance, staffing, training and Operation and Maintenance of the Plant. After approval by the Employer's Representative, the reports shall be used as a guide for regulation, adjustment and modification of the plant facilities. The reports shall continuously record and demonstrate the performance of staffing, training and Operation and Maintenance. The number of copies of each report shall be five (5) hard copies plus five (5) soft copies. The layout of the reports and other general requirements shall be discussed with the Employer's Representative and arranged to his satisfaction.

The shift leaders in charge of operation during the 24 hour day shall prepare a daily machine journal. The journal shall be a record of all the readings of flow rates, counter readings, pressure values, temperatures, odours, etc. for all facilities and equipment of the treatment plant. A file shall be maintained on site for storage of hardcopies from supervisory control panel printouts showing the listed parameters. In addition, all characteristic operation data of any major item of the treatment plant and all remarks and comments of the shift leaders concerning abnormal readings, overloads, stoppage, outages and other operation events shall be recorded.

Monthly laboratory reports shall be prepared presenting the results of the records of laboratory tests and continuous quality control measurements.

The monthly reports shall be prepared including, but not being limited to:

- monthly raw water flow rate curves and tables showing daily maximum, average and minimum inflow values,
- quantities of sludge and other residuals and record of delivery to disposal site,
- laboratory average daily, weekly and monthly results tabulated with maximum and minimum values,
- diagrams showing the performance of the Plant,
- calculation of monthly penalties for non-compliance with the attainable criteria for the set parameters,
- daily consumption figures of electricity and chemicals,
- service hours of main machinery and equipment,
- times, duration, reason and remedying of emergency operation and outages,
- other data requested or events of significant importance,
- statistics of staff members and labour utilization,
- information on major equipment repair, overhaul and other maintenance works,
- spare parts used and mobile equipment,
- Monthly expenditures.

Semi-annual and annual reports shall be prepared including, but not be limited to:

- Monthly, semi-annual and annual average raw water flow rates with maximum and minimum values over the operation period,
- Monthly, semi-annual and annual quantities of sludge and other residuals and record of delivery to disposal site,

- Monthly, semi-annual and annual average quality of raw water, treated water, water discharged in the Dam and sludge with maximum and minimum values as well as other data as temperatures, etc.,
- Summary of monthly penalties for non-compliance with the required performances stated in "V2-S2 Performances specifications volume - Clause 2 – Required performance levels" of current tender dossier,
- Monthly, semi-annual and annual electricity and chemical consumption figures,
- service hours of main machinery and equipment,
- Monthly, semi-annual and annual staff and labour utilization,
- times, duration, reason and remedying of emergency operation and outages,
- information on major equipment repair, overhaul and other maintenance works,
- spare parts used and a list of remaining spare parts,
- Monthly, semi-annual and annual expenditures,
- Semi-annual and annual results of environmental monitoring and performances indicators
- Staff: organization, training
- Legal and financial aspects
- Safety and security reports

2.7. ACCESS TO FACILITIES

The Employer shall have the right to bring visitors to the treatment plant. The visitors shall be received by the Employer and the Contractor shall not be in charge of such visits. Visitors shall only have access to the meeting room facilities and the special visitor circuit provided inside the plant.

The Employer shall give notice at least 48 hours in advance for visits.

The Contractor shall provide 2 permanent offices to the Employer.

3. OPERATION

3.1. PLANNING AND MANAGEMENT

The Contractor shall entrust adequately experienced key staff with the responsibility of operating the water treatment plant.

The key staff shall plan, establish and administer the organisation of the operation of the plant.

3.2. PROVISION OF ELECTRICITY, CHEMICALS, VEHICLES & SPARE PARTS

3.2.1. Provision of Electricity, Chemicals, Lubricants, fuel, gas and Consumables

During the entire Operation Service Period, the Contractor shall provide the necessary supplies of electricity, chemicals, lubricants, fuel, gas and consumables sufficient to continuously operate the Plant.

Lubricants shall be supplied in accordance with the recommendations of the various equipment and Plant manufacturers.

The Contractor shall limit the various types of lubricants by consolidating these, with the manufacturer's approval, into the least number.

The Contractor shall provide the Employer's Representative with three (3) copies of a list showing the proper lubricants (after consolidation) for each item of equipment and Plant with a schedule giving the estimated frequency and quantity of lubrication required. This will not relieve the Contractor from supplying this information within the Operation and Maintenance Manuals as well.

At the end of the Operation Service Period, the Contractor shall provide to the Employer adequate supplies of chemicals, lubricants, fuel and consumables sufficient to continuously operate the Plant. Such supplies shall cover one (1) month supply of locally available materials and six (6) months' supply of materials not locally available.

3.2.2. Provision of Tools and Appliances

The Contractor shall make use the tools and appliances supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide two complete sets of such tools and appliances not supplied before, but found to be necessary for proper Operation and Maintenance of the Plant.

At the end of the Operation Service Period, the Contractor shall hand over to the Employer two complete sets of all tools and appliances. The Contractor shall replace tools and appliances which are not in a serviceable condition or which have been lost.

3.2.3. Provision of Spare Parts

The Contractor shall make use of the spare parts supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide at his own expense such spare parts not supplied before, but found to be necessary for proper Operation and Maintenance of the Plant.

At the end of the Operation Service Period, the Contractor shall hand over to the Employer adequate supplies of spare parts sufficient to operate and maintain the Plant for a further period being equal to the difference between six (6)

years and the actual Operation Service Period carried out by the Contractor. The requirement for such spare parts will be based on a comparison of spare parts used during the actual Operation Service Period carried out by the Contractor and on the manufacturers' written confirmation of recommended spare parts, and will have to be agreed with and approved by the Employer's Representative.

3.2.4. Disposal of Sludge and Residuals

The Contractor shall arrange for the disposal of the dried sludge or any residual removed from the water or generated at the treatment plant to a landfill located not more than 100 km away from the WTP site.

All cost in connection with the disposal of residuals and transportation of sludge shall be borne by the Contractor.

3.3. PENALTIES FOR NON-COMPLIANCE

Following the completion of the Performance Tests Periods, the attainable criteria with regard to treated water standard will have been determined, which will be assumed to be either the guaranteed performances or the average of the results obtained from the two Performance Tests Periods whichever is applicable (i.e. if the performance test were failed and damages have been paid, the results actually obtained will apply).

The Contractor shall be responsible for taking whatever steps are necessary to maintain these attainable criteria during the Operation of the Plant.

The Contractor shall carry out the composite and continuous sampling and testing as described in Sub-Clause 5.2 below, and any other tests as necessary to fully control and monitor the performance of the water treatment plant.

Penalties for non-compliance with regard to effluent standards will apply if more than 2 consecutive samples exceed the attainable criteria by up to 10% or if any sample exceeds the attainable criteria by more than 10%. The amount of these penalties is defined in the Particular Conditions – Special Provisions.

3.4. EMERGENCY CONDITIONS

The Contractor shall establish requirements for dealing with potential hazardous conditions. All possible situations of emergency shall be scheduled within an emergency plan. Herein, the required services, additional required structures, equipment, staff and other resources shall be planned and recorded for the possible situations of emergency. The emergency action plan shall be submitted for approval to the Employer's Representative.

Every effort shall be made to ensure that any emergency situation at the treatment shall be limited to the shortest possible period to minimise any negative effects on the environment.

Any necessary shutdown of the plant for operational adjustments shall be restricted to the possibly shortest period with minimum flow at the inlet works and shall be approved by the Employer's Representative.

4. MAINTENANCE

4.1. GENERAL

Administrative maintenance policies shall be prepared and implemented by the Contractor, based on the developed maintenance programme. The policies shall be approved by the Employer's Representative and shall include, but not be limited to:

- preventive maintenance,
- overhauls and half-overhauls plan,
- Outages and unexpected repair works plan.

A basic maintenance management system shall be implemented after approval by the Employer's Representative. It shall include, but not be limited to:

- planning and scheduling,
- maintenance personnel,
- maintenance instructions,
- inventory control of items,
- equipment records,
- forms for costs and budgets.

The Contractor shall periodically carry out maintenance. It shall include, but not be limited to the provision of all required spare parts, material and personnel.

All items of equipment shall be inspected and maintained in accordance with the manufacturer's specifications and to the local conditions. Replacements, repairs and painting shall be carried out immediately and when necessary. Maintenance records showing all maintenance work carried out on each item of equipment shall be updated daily and shall be made available at any time for examination by the Employer's Representative. The installed equipment shall be checked and serviced daily.

The operating conditions of any instrument shall be maintained by function checks and services. Calibration shall be checked and corrected whenever necessary. After submission of the calibration data for approval, the instruments shall be calibrated as required and directed by the Employer's Representative.

Water retaining structures shall be cleaned regularly and freed from all clinging matter, which should be disposed at approved sites. Maintenance services shall include, but not be limited to the repair of surfaces and cracks, correction and/or repair of irregularities and defects at construction and expansion joints, corrective measures ensuring the water tightness and painting. Such maintenance has to be approved by the Employer prior to implementation.

The buildings, HVAC, electrical and sanitary installations shall be kept clean and continuously maintained in a proper and orderly manner. All interior and exterior structures, structural elements, equipment, installations, infrastructural elements and others shall be maintained, repaired, painted and replaced if necessary and/or as directed by the Employer's Representative.

The maintenance of site works shall include, but not be limited to the repair, painting and the replacement of defective items for traffic areas, pipes and fittings (including protection), cables, channels, roads, lighting poles and fences and shall also include the maintenance of lawn areas, plants, shrubs, bushes and trees.

4.2. MANAGEMENT

The management of maintenance shall include, but not be limited to:

- implementation and operation of a separate maintenance budget system comparing the budget with the general budget of Operation and Maintenance,
- planning and controlling the work of subcontractors.
- establishing of requirements for equipment manuals, for each item of equipment,
- setting out procedures for installation and commissioning, instructions for Operation and Maintenance and listings of component parts.

4.3. PLANNING AND SCHEDULING

The performance of maintenance shall be administered using a maintenance work package system in which the job priorities, the work assignment and the available personnel are listed. The required daily work shall be scheduled in charts by the hour or more detailed.

The maintenance work package system shall consider the manufacturers' maintenance manuals and also conditions like topography, climate and operation of the water treatment plant.

The maintenance work package system shall include a chart for periodic maintenance of any equipment and Plant on Site. The chart of every equipment and Plant shall indicate any necessary step of preventive maintenance.

The maintenance work package system shall be submitted to the Employer's Representative for approval.

4.4. MAINTENANCE PERSONNEL

Only highly skilled and trained personnel shall be assigned to perform inspections, repairs and preventive maintenance tasks. Specific skills are required for the maintenance of mechanical, electrical and instrumentation machinery and equipment.

4.5. MAINTENANCE INSTRUCTIONS

At an agreed central location, all manufacturers' maintenance manuals and other information shall be filed for each item of equipment.

The recorded data shall be well organised and documented together with the relevant general arrangement drawings in order to enable ready availability.

A manual describing the preventive maintenance of the equipment and Plant shall be prepared and approved by the Employer's Representative.

All the information mentioned above shall be available to the maintenance staff.

4.6. INVENTORY CONTROL OF ITEMS

A central storeroom for spare parts, equipment and supplies shall be maintained. All parts shall be assigned with item identification codes, each of them possibly being an extension of the design and construction documents.

A computerised system shall be implemented using the item identification code to record all necessary information of any item, to place the items in the storeroom and to re-order the items in case of requirement. This system shall keep a record of the quantity of each item remaining in stock, shall allow a direct comparison with the recommended stock level, as well as indicating the replacement lead-time.

4.7. EQUIPMENT RECORDS

The performance and the future requirements of maintenance shall be recorded daily and updated in the equipment records. All maintenance of equipment, identification of occurred problems and action taken to avoid failure shall be recorded. The records shall be made available at any time for examination by the Employer's Representative.

4.8. WORK CONTROL AND OUTAGE PLANNING

Work control shall be established by preparing and implementing procedures of corrective and protective maintenance, of tool control and of spare parts issues.

Outages of maintenance shall be bridged or repaired as soon as possible so as to minimise negative effects on the environment. Therefore, the Contractor shall use a standard procedure like the critical plan method (CPM) to sufficiently schedule for maintenance outages.

Resource planning shall be carried out in order to find out the requirements for special materials, special tools and/or special equipment for bridging or repairing any outage as soon as possible.

5. TECHNICAL SERVICES

5.1. PLANT CHEMISTRY

The Contractor shall develop and maintain a chemical treatment programme to minimise corrosion, extend system life and maintain efficiency of the water treatment plant.

The project systems shall be reviewed and recommended in relation to the chemical treatment programme. Required improvements of the systems shall be carried out, after approval by the Employer's Representative.

The Contractor shall provide the staff necessary for implementation of the chemical treatment programme.

5.2. MONITORING

The measured values and results shall be recorded daily and shall be presented in the monthly and semi-annual reports being submitted to the Employer's Representative.

5.2.1. Water treatment

5.2.1.1. Flowrate measurements

All measurement instruments shall be checked and rated once a year and a rating certificate provided.

Continuous flow measurements, with graphic recordings, shall be performed at the following points:

- At the outlet of the pumping station;
- At the entrance of the WTP;
- At the outlet of the WTP;
- At the outlet of the treated water tank;
- At the discharge point in the Dam;
- By-pass if any;

5.2.1.2. Quality of treatment

A laboratory will be created at the plant. The scope of the laboratory is to undertake the necessary chemical, physical and microbiological tests required for the performance monitoring of the WTP.

The performance monitoring tests, as shown hereafter, will be conducted in laboratory by the Employer.

The Contractor will be responsible to carry out all the tests necessary for the daily operation of the plant. The Contractor will use this laboratory to perform any tests he may deem necessary for the daily operation of the plant.

5.2.1.2.1. Water parameters to be monitored

The monitoring of the water treatment quality will be carried out by the Contractor. Analyses will be carried out by an independent laboratory two times per year in order to validate the results and methods used. The costs of these independent tests will be borne by the Contractor.

Each sample shall be analysed for the following parameters:

- pH
- Conductivity
- Turbidity
- Iron
- Manganese
- Organic matter
- Chlorophyll-a
- Calco-carbonic balance
- Temperature
- Residual of chlorine
- Total hardness
- Total Viable counts at 37°C
- Coliform
- E.Coli

5.2.1.3. Checking the operation of certain structures

Various measurements and checks are performed to assess the operation of individual structures.

The test protocol shall be proposed by the Contractor and approved by the Employer's Representative. The Contractor shall provide intermediate inspection parameters for assessing the proper operation of the structures, for example localised inflow/outflow samples, sludge characteristics, etc.

The test protocol shall include the following points in particular:

- Water treatment:
  - **Raw water**
  - **After clarification**
  - **After filtration**
  - **Final treated water**
  - **At the discharge point in the dam**
- Reagent consumption (if any)
  - **The consumption level must be measured daily on any treatment process involving the addition of reagents.**

- Efficiency of backwash:
  - **Air flow**
  - **Water flow**
  - **Head losses recovery after backwash**

- Grease and oil traps : Every three months, two localised samples are taken upstream and downstream of the structure, and the quantity of hexane-extractable material (HEM) analysed.

5.2.2. Sludge treatment

The quantities of sludge must be noted.

The quantities of reagents consumed must be noted (where applicable).

The final dryness will be measured by an independent laboratory.

5.2.3. Checking of general operation

5.2.3.1. Energy consumption

Active and reactive energy consumption shall be measured each day for the plant as a whole and for each of the main components. Voltage, Intensity and Cosφ shall be carried out in order to check the power of each equipment and for the whole installation.

5.2.3.2. Other points to be noted

- Consumption of all reagents.

- Working time of the main items of equipment

- Measurements of power consumption by equipment: pumps, blowers, mixers, compressors, UV reactors, etc.

5.2.4. Noise

Noise levels shall be measured two times per year. Noise measurements shall be carried out shall during a period when all the installations, in particular those involved in sludge treatment, are in operation.

- At the edge of the property

During the tests, an overall measurement of the noise emitted by the installation shall be carried out at the edge of the property. The measurement shall be made by an organisation approved by the Employer and in accordance with the conditions set out in standard NF S 31.010.

The measurement point shall be chosen in agreement with the Employer.

The measurement shall be carried out for a period of 24 hours, during which the installation shall be in normal operation, in conditions that are as close as possible to nominal working conditions.

- Within the premises (at the plant)

The appropriate measurements shall be performed to ensure that the arrangements made by the Contractor comply with regulations concerning the safety of staff and with the guarantees provided by the Contractor.

5.3. DATA FILING AND PROCESSING

Sufficient hardware and software shall be supplied, installed and operated in order to enable the following data filing and processing operations. Sufficient trained staff shall be provided to ensure that this system runs efficiently.

- all kind of process control measures,
- inventory control concerning supply and removal items,
- all kind of management,
- preparation of reports in English languages,
- record keeping and operation,
- maintenance of equipment and laboratory data,
- additional programs as directed by the Employer's Representative.

The hardware and software configuration shall comply with the actual required minimum standards for running the latest version MS Windows. At the end of the Operation Service Period, the hardware and software shall be handed over to the Employer.

In order to achieve a proper functioning control of process performance, an interdisciplinary reporting and data filing system shall be provided and operated, combining the fields of Operation and Maintenance like expenditure, personnel, operations performance, maintenance performance and laboratory activities.

Changes in the computer systems shall be documented. Proposed computer system modifications shall be developed or reviewed. The realisation of modifications and repairs shall be co-ordinated by the Contractor.

5.4. QUALITY CONTROL

The Contractor shall develop a quality assurance programme resulting in a quality control manual, which shall conform to Standard EN ISO 9001.

A quality control management system shall be developed and maintained, based on the prepared quality control manual. All employed staff shall be trained in the application of the quality control management system.

All programmes and systems prepared for Operation and Maintenance as well as for Staff Training shall be integrated in the quality control management system.

The quality control management system shall be approved and finally certified by a commonly accepted certification agency.

6. TRAINING

6.1. GENERAL

On-Site training of the staff to manage, operate and maintain the water treatment plant and raw water pumping station after the 2-year operation service shall be included in the tender.

The objective of the training is to provide the selected personnel with the necessary knowledge of technology, operation and maintenance of all equipment, installations and work included in the project, which will ensure a sound and stable operation and maintenance of the project components implemented under the Contract.

During the operation service period, the Contractor shall provide on-site training of the selected personnel in managing, operating and maintaining the plant and raw water pumping station on the basis of a structured programme submitted at least six (6) months before the start of the training period for the approval of the Employer's Representative.

As described in chapter 2.2.2, the salaries and any allowances of selected staff to be trained will be paid by the Contractor at the Employer's salary scales for the 2-year operation service period and will remain under the Contractor's responsibility.

The Contractor will be required to provide practical instructions to the selected staff during this period to ensure that by the end of this period the staff will be considered capable of managing, operating and maintaining the Plant to the highest internationally accepted standards without additional supervision.

Training shall be based on all the procedures detailed in the Operation, Maintenance and Safety Manuals including, but not limited to managing, operating, controlling and performance monitoring of the treatment process, data filing and processing, reporting, assembly, dismantling and maintenance of equipment and Plant as well as fault finding, without affecting the normal Operation and Maintenance. Particular emphasis shall be laid on safety precautions during Operation and Maintenance.

The training shall in general consist of familiarisation with the operational aspects of the systems as a whole, followed by familiarisation with specific items of equipment.

The training shall be based on the actual plant and the implementation of operation and maintenance schedules outlined in operation and maintenance manuals provided by the Contractor.

The training shall also be directed towards the specific requirements of the trainee, as the instruction and familiarisation of the various personnel involved will vary with respect to their operational capacity, as the personnel will require different aspects to be emphasised.

All training shall be successfully completed and demonstrated before termination of Operation Service Period can take place. If in respect of progress of works and the daily operation of the plant and systems, it is required that any systems or equipment has to be put into use by the Employer before Taking Over, it is the Contractor's responsibility that all necessary instructions and training have been given to the selected staff, for full understanding of the technology and operation, prior to commencement of the Employers' utilization of such systems or equipment.

The total allowance to cover the Contractor's expenses in connection with training shall be included in the tender.

6.2. TRAINING PROGRAMME

The training programme shall include, but need not be limited to the following:

- Organisational structure of the personnel required for management, Operation and Maintenance of each component of the Plant and Pumping Station

- Manpower requirements, by skills and trades, necessary for the management, Operation and Maintenance of each component of the Plant and Pumping Station.
- Detailed description of each element of the training programme, which will show how the necessary skills shall be imparted to the personnel, assigned by the Employer.
- Identification of the minimum educational levels or standards of technical skill which must have been obtained for each position by the assigned personnel, which levels and standards should be readily available in Kenya.
- CVs of the proposed Instructors, including qualification and education.

6.3. EXECUTION OF TRAINING

To ensure that adequate training is given, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the selected personnel to carry out these activities even if they are not required during the actual operation of the Plant.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. The necessary rooms/buildings for training shall be provided as part of the Permanent Works. All training equipment shall become the property of the Employer at the end of the Training Period.

Training shall be carried out in the English language. However, the Contractor shall provide a sufficient number of English interpreters to overcome any difficulties arising due the assigned personnel not being completely fluent in the required language.

The Contractor shall submit quarterly training reports to the Employer detailing the performance evaluation of the staff under training. The format and other contents to be covered in the quarterly training reports shall be agreed with the Employer.

6.4. TECHNICAL CONTENT

6.4.1. Training for Operation of the WTP and Raw water Pumping Station

All the selected staff to be trained shall be included in the training on the treatment plant and raw water pumping station operation. This training shall consist of a minimum 4 weeks of theoretical training followed by practical on-site training. At the initial 2-3 months, the staff will be enrolled in job shadowing to the Contractor's key personnel who will be running the treatment plant and pumping station. Thereafter, the staff who will pass the training tests will be fully integrated into the Contractor's operations team and assigned duties under the supervision of the Contractor.

6.4.2. Training on the SCADA system

SCADA Training must be provided in advance of commissioning to:

- Enable the staff under training to participate in the full process commissioning of the system.

- Enhance optimal operation of the Plant,
- Ensure safe operation and maintenance of the plant and SCADA system.

SCADA training will include but not limited to the following:

- Loading and starting up the Operating System.
- System Operators interface.
- Operator control of program/task execution.
- Operator control of disc files.
- File transfer tasks – archiving, retrieval.
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.
- SCADA system interrogation facilities – alarm lists, log printouts select mimic and trend display etc..
- Alarm acknowledges accept/delete.
- Control actions, e.g. start pump, close valve.
- All functions associated with each access level of the SCADA system.

The contractor must additionally provide a specific five-day course for a minimum number of three (3) participants.

The Plant Manager and selected System Developers / SCADA Experts will additionally be trained on the following:

- **Basic systems design overview.**
- **The use of computers to perform diagnostics and to tune other parts of the system.**
- **Changing passwords and access control.**
- **Sequence verification.**
- **Preventive maintenance.**
- **The system database structure.**
- **System database building/configuration.**
- **Mimic building.**
- **Applications program interface to the system database.**
- **Management information system interface.**
- **Downtime loading of control programs/sequences to PLCs.**
- **Advanced operating features.**

6.4.2.1. System Operators

The Contractor must provide for a minimum number of six (6) operators participating in each course.

This purpose-designed course is to be held at the Centralised Technical Management on site. Training must be provided in advance of commissioning to:

- Enable the Recipient's user staff to participate in the full process commissioning of the system.
- Optimal operation of the Plant, including both sewage and sludge lines.

- Safely operate the plant and maintain the SCADA system.

6.4.2.2. Course Contents

This course shall be designed to familiarise the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

- Loading and starting up the Operating System.
- System Operators interface.
- Operator control of program/task execution.
- Operator control of disc files.
- File transfer tasks – archiving, retrieval.
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.
- SCADA system interrogation facilities – alarm lists, log printouts select mimic and trend display etc..
- Alarm acknowledge accept/delete.
- Control actions, e.g. start pump, close valve.
- All functions associated with each access level of the SCADA system.

6.4.2.3. System Supervisors Personnel

The contractor must additionally provide a specific five-day course for a minimum number of three (3) participants.

To be held at the Plant Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

- Basic systems design overview.
- The use of computers to perform diagnostics and to tune other parts of the system.
- Changing passwords and access control.
- Sequence verification.
- Preventive maintenance.

6.4.2.4. System Developers/Programmers/Engineers

The contractor must additionally provide a specific five-day course for a minimum number of three (3) participants.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- The system database structure.
- System database building/configuration.

- Mimic building.
- Applications program interface to the system database.
- Management information system interface.
- Downtime loading of control programs/sequences to PLCs.
- Advanced operating features.

6.5. CONTRACTOR'S PERSONNEL

Considering that training of the selected staff will be carried out during the 2 – year operation service, the Contractor will provide both instructors / trainers and key personnel who will be running the plant and pumping station operations. This will allow theoretical training to proceed concurrently with plant operations for the initial 4 weeks. Thereafter, the instructors / trainers and Contractor's plant operations team will jointly train the staff through "hands-on" job shadowing for 2-3 months. It is envisaged that when the staff under training are integrated into Contractor's plant operations team the instructors / trainers will not be needed.

The job-shadowing period may be extended at Contractor's cost and discretion in order to ensure the selected staff have attained the required training and expertise to operate the water treatment plant and raw water pumping station.

The Contractor shall provide training personnel for each of the positions required for management, operation and maintenance as identified in the training programme. All Instructors shall be qualified personnel with at least 10 years of experience in their training field; their CVs will be submitted to the agreement of the Employer in the Training Programme.

The cost of instructors / trainers including any materials required for the training is deemed to be covered within the Contractor's rates.

6.6. TRAINING TEST PERIOD

The 4th month from the commencement of training shall be considered as the Training Test Period. During this period, the Plant and Pumping Station are to be entirely managed, operated and maintained by the trained personnel under the supervision of the Contractor. The Contractor shall remain, nevertheless, fully responsible for the successful Operation and Maintenance of the Plant and Pumping Station.

If, during the Training Test Period, any section of the Plant fails to achieve the required performance standards or any fault cannot be located or rectified, Contractor's key personnel are required to assume "hands-on" operational activities.

If the Employer's Representative considers that the Plant are not being properly managed, operated or maintained, the Contractor shall immediately provide additional training as necessary. Once this additional training has been successfully completed, the Contractor shall seek the Employer's Representative's approval for a repeat of the Training Test Period of 30 days for that section of the Plant. Training Test Periods shall be repeated until the Employer's Representative is satisfied that the assigned personnel is successfully managing, operating and maintaining the Plant.

No additional payment will be made to the Contractor for the repetition of a Training Test Period as described above, nor will the Contractor have the right to claim any payment in connection with Operation and Maintenance for the repetition of any Training Test Period.

7. FINAL TESTS

Prior to the end of the Operation Service Period, the Plant will be finally tested for their performance and the condition of the Plant will be checked.

Provided the Plant achieve the performance as guaranteed under the Contract (or the attainable performance if damages have been paid for shortfall of performance), and maintenance with all necessary repairs, replacements etc. as well as staff training has been carried out to the satisfaction of the Employer's Representative, and the spare parts, chemicals, lubricants and consumables as described further above have been provided by the Contractor, and the Contractor has completed all his other obligations under the Contract with regard to O&M Period, the Completion Certificate for Operation Service Period will be issued by the Employer's Representative, and the Employer will continue to operate and maintain the Plant. Otherwise the Operation Period will be extended until the Completion Certificate for Operation Service Period can be issued at the expense of the Contractor.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.5.1 – TECHNICAL SPECIFICATIONS CIVIL WORKS

CONTENTS

SECTION	*TITLE*
01001	Design criteria for Civil Engineering
01010	Corrosion protection
01020	Basic mechanical requirements
02100	Site preparation
02210	Open air excavations
02220	Embankment, fill and backfill
02232	Roads
02240	Geotextile
02250	Geomembrane
02346	Bolting
03100	Formworks
03200	Reinforcement
03250	Concrete structure joints
03300	Concrete
04000	Masonry works
05100	Steel works
07000	Wateproofing, isolation and roofing
08100	Aluminium doors, windows and glazing
08200	Painting
08300	Suspended ceilings
08400	Miscellaneous tiling
08500	Wood works
08900	Sanitary installation
09500	Fencing and gabions

SECTION 01001
DESIGN CRITERIA FOR CIVIL ENGINEERING

1.1. STANDARDS

The structure is designed according to the most recent European Standards or similar acceptable Standards. Some of the key European Standards are as follows:

- EN 1990 – Eurocode 0 – Basis of structural design : All parts of Eurocode 0
- EN 1991 – Eurocode 1 – Actions on structures : All parts of Eurocode 1
- EN 1992 – Eurocode 2 – Design of concrete structures : All parts of Eurocode 2
- EN 1993 – Eurocode 3 – Design of steel structures : All parts of Eurocode 3
- EN 1994 – Eurocode 4 – Design of composite steel and concrete structures : All parts of Eurocode 4
- EN 1995 – Eurocode 5 – Design of timber structures : All parts of Eurocode 5
- EN 1996 – Eurocode 6 – Design of masonry structures : All parts of Eurocode 6
- EN 1997 – Eurocode 7 – Geotechnical design : All parts of Eurocode 7
- EN 1998 – Eurocode 8 – Design of structures for earthquake resistance : All parts of Eurocode 8
- EN 1999 – Eurocode 9 – Design of aluminium structures : All parts of Eurocode 9

1.2. GENERAL

In accordance to the European Standards, the following Design Criteria / Parameters shall be as follow:

1) Class of consequences of structure : CC2
2) Service life of the structures : .....50 years
3) Class of watertightness of liquid retaining structures : .....Class 2
4) Class of exposure :
   a) XA2, for concrete surfaces exposed to soil, underground water, wastewater and sludge
   b) XF1 for concrete surfaces exposed to weather and not included in the above category
   c) XC4 for other concrete surfaces
5) Thermal effects:

a) The thermal difference between internal and external faces of the reservoir wall is taken to 15°C for thermal moment's calculation

6) Crack opening criteria:

a) For the concrete elements retaining liquid, crack opening depends on the class of watertighness. For a Class of watertightness 2, crack opening w_{k1} is limited to is 0,15 mm. Moreover, we limit the maximal tensile stress in the homogenized concrete section to f_{ctm}.

b) For concrete elements not retaining liquid, the maximum crack widths is fixed according to class of exposure, with a maximum of 0,25 mm.

c) Finally, in all cases, the maximum stress in steel at Serviceability Limit State cannot be above 200 MPa.

7) All dispositions shall be taken into account concerning the stability and the watertightness of pipes embedded into concrete elements.

8) Levels indicated on drawings are considered after settlement.

a) Maximal absolute settlement : .....10 mm

b) Maximal relative settlement : ..... 1 mm / meter

1.3. MATERIALS

A. Concrete

The concrete of all the water retaining structures shall be classed as graded C30/37, according to EN 1992-1, thus:

- f_{ck} = 35 MPa
- f_{ctm} = 2,9 MPa
- E_{cm} = 33 GPa
- For calculation at Service Limit State, creep shall be taken into account with creep coefficient (φ), and $E = E_{cm}/(1+ \varphi)$

Other characteristics are :

- Unit weight : 25 kN/m³ when unfavourable
  24 kN/m³ when favourable
- Creep coefficient φ = 2
- thermal expansion coefficient 10^{-5} °K^{-1}
- Average shrinkage strain $\varepsilon_{cs} = 2.10^{-4}$

Reinforced concrete structures not retaining water, such as buildings, shall have as a minimum class C20/25 concrete.

B. Rebars

- Ductility class B, according to EN 1992-1 Appendix C
- f_{yk} = 500 MPa

- ε_{uk} ≥ 5 %
- Es = 200 GPa
- Cover : According to EN 1992-1, with a minimum of 50 mm

C. Steel used for steel constructions

- Grade S355 according to EN 1993

1.4. ACTIONS

A. Wind

According to EN 1991, with data taken from section 01000 – General specifications

B. Earth

Unit weight of soils and active pressure coefficients shall be taken from geotechnical investigations report included with Tender documents.

C. Hydrostatic pressure

Unit weight of raw water and drinking water is 10 kN/m³

Unit weight of wastewater and sludge is 11 kN/m³

Design shall consider every possibility of liquid levels in structures. Particularly, some intermediate walls can be in the case with full level liquid on one side and no liquid on the other.

D. Snow

Not Applicable.

E. Seismic

According to EN 1998.

F. Loads during works

Load on earth fill is either 10 kN /m² or the load generated by a specific construction plant depending on Contractor methods. The most unfavourable case shall be considered for calculation.

G. Live loads

According to EN 1991, with the following precisions :

- Raft, industrial slab and slab receiving public : 5 kN/m²
- Inaccessible terrace (except for maintenance) : 1,5 kN/m²
- Accessible terrace : 2,5 kN/m²
- Heavy load roads : 30 tonnes truck or 5 kN/m²
- Live loads around structures: 10 kN/m²

H. Fire

- Minimum : ½ h firewall
- Normal risk rooms : 1 h firewall
- High risk rooms : 2 h firewall

Transformer rooms, electric rooms and chemical rooms are considered high risk

I. Freezing

Not applicable

1.5. CALCULATION

Calculation shall be made according to Eurocode or equivalent methods, considering both STR and GEO ultimate limit states. For GEO, the approach 2 defined in EN 1997-1 shall be used.

Both Ultimate Limit Sate and Serviceability Limit Sate shall be calculated, respecting all criteria given in this section

A. Geotechnical assumptions

Geotechnical assumptions used shall come from the geotechnical report given with Tender documents.

If he judges it necessary, the Contractor shall realise, at his own costs, complementary geotechnical investigations to ascertain himself about design of all structures and earthworks under the scope of works.

B. Stability against uplift pressure

Stability of structures against uplift pressure shall be verified with UPL Ultimate limit state.

Unless otherwise specified, calculation of structures and buried pipes against uplift pressure shall be done considering the highest water table level mentioned in the geotechnical report.

C. Stability of excavations against buoyancy

Stability against buoyancy shall be verified with HYD Ultimate limit state.

D. Combinations of action to verify

The combinations of action to verify, both for Serviceability Limit State, and for Ultimate limit states STR, GEO, UPL and HYD, are given in EN 1990 and EN 1997.

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SECTION 01010
CORROSION PROTECTION

1. GENERAL

1.1. WORK INCLUDED

This section of specifications covers the corrosion protection of all equipment to be supplied, unless different requirements are specified in the subsequent sections.

1.2. RELATED WORK

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. SYSTEM DESCRIPTION AND CHARACTERISTICS

1.3.1. GENERAL

Paint characteristics shall be determined taking into account the function, location of each item of equipment and type of protection required.

With the exception of surfaces to be embedded in concrete, all equipment shall be given marine protection for overseas shipment. Corrosion protection systems shall be selected considering the shipment, site storage and final use conditions.

Equipment shall be protected from the corrosive action of water when such equipment is submerged or partially submerged, and from the corrosive action of the atmosphere.

The protection of all equipment will be designed for all possible types of corrosion, namely: chemical, electrochemical and biological.

Each coat of paint shall be of a different colour.

All safety components and accessories which, in contact with water, might be subject to serious corrosion or scaling, liable to cause operating faults, shall be protected from corrosion and, wherever possible, from scaling by the use of materials whose mechanical and physical qualities must meet the conditions of use imposed on the components.

1.3.2. EQUIPMENT SUBMERGED, PARTIALLY SUBMERGED OR SUBMITTED TO HUMID ENVIRONMENT

Equipment located in parts of the structure where humidity or condensation is high shall be protected with the same system as that used for the submerged or partly submerged parts.

On the parts of equipment inaccessible after erection, the entire protective system shall be applied before shipment to the site.

The paints system shall be an epoxy-tar based system. The system selected shall be such that it can accept a final coat at site. The minimum guaranteed thickness of the protective coating shall be 450 micrometers.

1.3.3. EQUIPMENT EXPOSED TO THE OPEN AIR

The protection system shall be applied without the final coat.

The minimum thickness of the total intermediate coat shall be specified and guaranteed by the Contractor.

1.3.4. PARTS EMBEDDED IN CONCRETE

The protective system for submerged parts or parts exposed to air, as applicable, shall be applied over a length of 10 cm measured from the line of penetration in the concrete

1.3.5. MACHINED SURFACES

A protective varnish shall be applied to the dried and cleaned surfaces either with the aid of a brush or with a spray gun. This varnish must be capable of being easily removed by the application of petrol or trichlorethylene. The Contractor supplying trichlorethylene shall warn personnel of the health hazard resulting from the use of this ingredient.

1.3.6. INTERNAL SURFACES OF METALLIC TANKS

Unless otherwise specified, the internal surfaces of metallic tanks designed to contain oil shall be blast cleaned and immediately protected with two coats of oil-proof enamel paint.

1.3.7. INSIDES OF BOX GIRDERS

The insides of box girders not accessible for painting after erection shall be subjected to a watertightness test using compressed air, unless specified to the contrary for each particular case at the written request of the Contractor. The compressed air pressure will be 1.5 bar for the test.

On completion of this test, a desiccating powder shall be blown into the box girders in order to dry the air. The aperture shall then be carefully sealed by means of a welded plate.

1.3.8. ACCESS WAYS, PLATFORMS, HANDRAILS, LADDERS, COVERS, LAMPPOSTS, STEEL STAIRS, FOOTBRIDGES, GRATING

All these items shall meet the following:

- items located on open air: protected by hot dip process galvanization;
- items located in rooms or inside a closed structure: made with aluminium, stainless steel (at least 314L) or inert materials.

1.3.9. SURFACES INACCESSIBLE AFTER ASSEMBLY AND ERECTION

Surfaces inaccessible after assembly and/or erection of the equipment shall be prepared and protected using the complete system selected for the whole of the equipment before such erection and assembly are carried out.

In the event of assembly without a sufficient gap being available, a flexible seal will be installed between the various parts, after assembly.

1.3.10. COLOURS

The colours proposed shall be submitted to the Engineer for approval.

The colours of pipework for services shall be according to Employer's standards.

1.4. QUALITY ASSURANCE

1.4.1. REFERENCES

The Contractor shall furnish references of the paint manufacturers and of the paint application subcontractors.

1.4.2. STANDARDS AND REGULATIONS

Supplies and works shall comply with the following standards or equivalent:

- Standards of the US Steel Structure Painting Council (SSPC) for corrosion and metal protection.
- European scale of rusting degree for anti-rust paint. Published by the European Committee of the association of paint printing inks and art colours (42 avenue Marceau, PARIS 8e).
- Din 55928 or Swedish standard S.I.S. 05590 or equivalent on the cleanness degree of metallic surfaces.

1.5. DOCUMENTS TO BE SUBMITTED

For each type of protection system, the Contractor shall submit the following documents to the Engineer for information and comment:

1.5.1. TECHNICAL INFORMATION SHEETS

Technical information sheets concerning the paint used, giving the following:

1. Origin, definition, destination, composition;
2. Properties, including: recommended thickness of dry coat, graphs showing drying times, maximum and minimum coating times and pot life as a function of temperature, highest and lowest duty temperatures, flash point;
3. Conditions of application, including air temperature and humidity and temperature of the substrate;
4. Compatibility and method of protection;
5. Efficiency;
6. Packing and storage;
7. Reference to DIN standard.

1.5.2. PAINTING PROCEDURE

8. Preparation of surfaces (substrate, underlying layers, damaged area),
9. Products applied and thickness of each coat,
10. Place of application;
11. Description of the paint application facilities;
12. Temperature and humidity limits.

1.5.3. APPLICATION REPORT

13. Daily report of the maximum and minimum ambient temperature and list of parts to be painted;
14. Daily report of the maximum and minimum humidity level in the paint application room;
15. Other pertinent information;
16. A table indicating the various items of equipment to be protected (on X-axis for example) and the various types of protection (on Y-axis for example): quality, thickness, colour per coat and areas to be painted.

1.5.4. SCALE OF RUSTING

Stereotype No. 7 of the European scale of rusting for anti-rust paint.

1.6. STORAGE

The storage conditions of painting products shall comply with the recommendations indicated on the supplier's technical data sheets. Non-respect of these conditions may give rise to rejection of the product. In particular, the Contractor is deemed to be fully acquainted with the climatic conditions prevailing on site and shall be required to take such conditions into account.

The stores used for the storage of paints and associated thinners shall be closed and covered, thereby enabling the temperature and degree of humidity to be maintained at a level consistent with the specifications indicated on the product instructions for use.

1.7. ENVIRONMENTAL LIMITATIONS

Sand blasting and painting work shall be carried is out only when the ambient air temperature and degree of humidity within the requirements of the product instructions for use.

Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.

The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during paint application.

1.8. PROGRAMME

The contractor shall clearly indicate in his manufacturing programme and in his erection programme, the global periods scheduled for the application of corrosion protection coatings.

1.9. GUARANTEE

17. All the protection systems adopted shall have a design life of 8 years, to be certified by the Office National D'Homologation des Garanties de Peinture Industrielle (or approved equivalent).

18. The performance of the protective paintwork during the Maintenance Period will be inspected by the Engineer in presence of both the Contractor and the Employer. No rust point or blister shall be accepted at the end of the maintenance period. Any necessary repair work shall be determined on the basis of the results of these inspections.

2. PRODUCTS

2.1. GENERAL

1. Each coat of paint shall be of a different colour.

2. Equipment exposed to ultra-violet radiation shall be given special protection. Areas to be protected in this manner shall be determined in relation to the normal operating conditions of each item of equipment.

2.2. COLOURS

The colours proposed shall be submitted to the Engineer for approval. For guidance purposes, the Contractor could make the choices indicated hereafter:

1. Aluminium: for equipment exposed to sunlight, the thermal effects of which could be detrimental to protection performance.

2. Moving parts in the immediate vicinity of personnel access ways shall feature black stripes 6 cm wide and inclined at 30° to the vertical.

3. The colours of pipework for services shall be according to RAL standards.

2.3. SCHEDULES OF PAINTING

2.3.1. FERROUS METAL SUBJECT TO CONTINUOUS OR INTERMITTENT IMMERSION IN WATER

1. Abrasive blast cleaning SA 2.5.

2. Two or three coal tar epoxy coats.

3. Minimum dry film thickness of the system not less than 450 mm.

Or:

1. Abrasive blast cleaning SA 2.5.

2. One coat of zinc rich primer minimum thickness 40 μm.

3. Two or three coats of vinyl coal tar.

Minimum dry film thickness of the system not less than 450 μm.

2.3.2. FERROUS METAL SUBJECT TO SPLASH, UNFAVOURABLE ATMOSPHERIC EXPOSURE OR HUMID ENVIRONMENT

Same as for ferrous metal subject to continuous or intermittent immersion in water.

2.3.3. PAINTING SCHEDULES FOR TYPICAL OUTDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5

2. One coat epoxy polyamide metallic zinc rich primer.

3. One coat epoxy polyamide.
4. One chlorinated rubber tie coat.
5. One coat high build chlorinated rubber.

Dry film thickness of the system not less than 220 μm.

Or:

1. Abrasive blast cleaning SA 2.5
2. One coat zinc rich epoxy paint.
3. One intermediate coat epoxy paint.
4. One top coat acrylic polyurethane paint.

Dry film thickness of the system not less than 180 μm.

2.3.4. PAINTING SCHEDULES FOR TYPICAL INDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5.
2. One coat weldable holding primer for protection during manufacture and erection.
3. One coat of epoxy zinc rich primer.
4. One intermediate coat of epoxy paint.
5. One coat of epoxy paint.

Dry film thickness of the system not less than 150 μm.

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of epoxy zinc rich primer.
3. One intermediate coat of modified epoxy paint.
4. One coat of modified epoxy paint.

Dry film thickness of the system not less than 150 μm.

2.4. GALVANISING

Galvanising shall be applied by the hot-dip process and shall consist of a continuous coating to minimum thickness as follows:

	Average of Specimens tested μm (g/m²)	Any Individual Specimen μm (g/m²)

Rolled steel exposed to the atmosphere only		
t < 6 mm t > 6 mm	87 (609) 100 (700)	79 (553) 87 (609)
Rolled steel under ground surface or in water	210 (1470)	165 (1155)
Cast iron and malleable iron	87 (609)	79 (553)
Bolts, nuts and washers	55 (385)	44 (308)

The zinc coating shall meet the requirements according to ASTM A123, A153, A239 and A385 or equivalent.

3. EXECUTION

3.1. PREPARATION

3.1.1. GENERAL

The Contractor shall take all reasonable precautions to ensure that the protective coatings are not damaged during handling in the factory, during transport or during erection. In particular, he shall ensure that no damage is caused through the use of inappropriate packing systems.

In the event of damage, the Contractor shall make good the existing protective coating, using the same products and under the same conditions of application.

For all the equipment included in the supply, a single make of paint approved by the Engineer and identical products for identical operating conditions shall be chosen.

Regardless of where the corrosion protection coating is applied, the cost of all the necessary installations shall be borne by the Contractor.

3.1.2. SURFACE PREPARATION

3.1.2.1. BARE METAL SUBSTRATES AND DAMAGED AREAS

1. Before any treatment, the surfaces will be cleaned using an appropriate method.

2. Blast cleaning (using non-siliceous sand, corundum, treated slag or shot). The surface quality grade will be DS 2.5, minimum. The surface roughness value to be obtained after cleaning shall be defined by the paint supplier. Wet sand-blasting is prohibited.

3. Careful removal of dust.

3.1.2.2. PRE-PAINTED SUBSTRATES AND SURFACE PREPARATION BETWEEN EACH COAT

1. Before carrying out any treatment, the surfaces will be cleaned using an appropriate method.

2. The surface preparation will be defined in relation to the primer applied in the workshop and to the requirements for the correct adhesion of the other coats, which will be defined by the paint supplier (surface roughness, possible removal of zinc salts, etc.).

3. Careful removal of dust.

3.1.3. PAINT COATINGS

The choice of place(s) for the application of the final coats shall be made in relation to the following:

1. Type of product,

2. Programme and procedure of manufacture and erection,

3. Climatic conditions,

4. Mode of application of the paint,

5. Equipment, materials and personnel available,

Other factors may be taken into account.

3.2. APPLICATION IN WORKSHOP

3.2.1. GENERAL

The Contractor shall not proceed with painting of any of the equipment subject to workshop inspections and tests without the prior written approval of the Engineer.

For galvanisation, all steel work shall be fully fabricated before galvanising, no machine or shop work, boring, punching etc. will be allowed after galvanising. Minor damage to the galvanising resulting from transportation and erection shall be repaired at site in an approved manner, e.g. by painting with an approved zinc-rich paint, containing at least 92 weight per cent zinc powder.

After galvanising all members shall be dipped in a dichromate solution bath to avoid formation of white rust during storage and transportation.

3.2.2. APPLICATION REPORT

The Contractor shall submit the application report defined as follows:

- Daily report of the maximum and minimum ambient temperature and list of parts to be painted,
- Daily report of the maximum and minimum humidity level in the paint application room,
- Other pertinent information.

3.2.3. QUALITY CONTROL IN WORKSHOPS

Inspection before shipment:

1. The Engineer reserves the right to inspect the paint application facilities in the Contractor's and/or his subcontractor's workshops and to ensure that they comply with the prescribed standards and painting procedure.

2. The number of coats of paint and the total thickness of the coating will be checked and the Engineer reserves the right to have the thickness of individual coats checked in his presence. On a protected surface, a test area and a number of test points shall be defined by the Engineer. The minimum measured thickness shall not be below 90% of the guaranteed thickness and the average of all measurements shall no be below the guarantee. The Contractor shall supply the measuring apparatus, which shall be of the electronic detection type (Brandl Positector or similar), giving readings accurate to within 1 micrometer. One measurement shall be taken every 0.5 m² or every 0.5 linear metres.

3. Adhesion tests shall be performed on submerged and partially submerged equipment, in accordance with DIN standard. The instruments required, in accordance with the same standard, shall be supplied by the Contractor.

3.3. APPLICATION ON SITE

3.3.1. GENERAL

The protective coating on surfaces damaged during handling, transportation and erection shall be repaired using the same surface preparation and products, depending on the protection system approved.

3.3.2. INSPECTION BEFORE APPLICATION

Protection inspections shall be carried out jointly by the Engineer and the Contractor after:

1. Erection of completed equipment;

2. Dust removal, washing with fresh water (except where otherwise instructed by the Engineer) and drying if deemed necessary by the Engineer.

Surfaces to touch up will then be defined by mutual agreement.

3.3.3. INSTALLATIONS FOR THE APPLICATION OF PROTECTIVE COATINGS ON SITE

The Contractor shall install all necessary equipment for:

1. Rinsing of structural surfaces that have been in contact with a salty atmosphere during transport, with the exception of surfaces to be sand blasted at site.

2. Drying of surfaces to be sand blasted;

3. Checking of air temperature and degree of humidity at the place of work execution, together with the necessary shelters and special arrangements required for carrying out these measurements;

4. Distributing compressed air for sand blasting and paint work;

5. Removal of sand blasting dust and thinner evaporation gases;

6. The protection of ancillary equipment and structures against the projection of products, their vapours, sand and dust.

3.3.4. SURFACE PROTECTION BY PAINTING

3.3.4.1. SUBMERGED OR PARTIALLY SUBMERGED EQUIPMENT

Reapplication of the protective coating on surfaces damaged during handling and transport, using the same products, depending on the protection system selected.

3.3.4.2. EQUIPMENT IN THE OPEN AIR

1. Reapplication of the primer protection on surfaces damaged during handling or transport, using the same products, and depending on the protection system used in the workshop;

2. Application of top coat;

3. The minimum thickness of the top coat shall be defined and guaranteed by the Contractor.

3.3.4.3. SURFACE OF PARTS EMBEDDED IN CONCRETE

All traces of grease and scaling shall be removed prior to concreting.

3.3.5. QUALITY CONTROL ON SITE

1. Checking of application conditions, compliance with paintwork standards and procedures.

2. Checking of surface preparation.

3. Checking of the number of coats and of the total coating thickness using testing apparatus to provided by the Contractor.

4. If necessary, when in doubt: additional adhesion tests as per Standard NFT 30-038 standard or DIN equivalent. Testing apparatus to provided by the Contractor.

5. Acceptance of the protection system shall be combined with the overall acceptance procedures for the equipment covered.

Section 01020
BASIC MECHANICAL REQUIREMENTS

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the general requirements applicable to all mechanical equipment to be supplied, unless different requirements are specified in the subsequent sections.

In case of conflict between the requirements of this general specification and those of the specific equipment specifications, the latter shall have precedence.

1.2. QUALITY ASSURANCE

1.2.1. GENERAL

The equipment shall be manufactured in accordance with established practice. All the components shall be finished as required by their importance, position and destination. The manufacture shall be sound, without any faults likely to impair their ability to fulfil their purpose:

1. All equipment shall be designed in compliance with up-to-date practice;

2. Equipment design shall take into account control and maintenance operations as well as operating incidents;

3. The general aesthetic appearance shall be studied and shall blend in with the overall architecture of the structures.

1.2.2. MATERIALS

1.2.2.1. GENERAL

Materials shall be new.

Rolled and cast steel shall be of good quality and free from blow or shrinkage holes, porosity, cracks or other defects.

Cast iron is not acceptable for any tap, valve bodies or components subject to internal pressure.

The Contractor shall indicate in the calculation notes the quality of the materials with reference to International (ISO) or American (ASTM,..) or European (DIN or BS or NF,..) or Japanese (JIS) or equivalent standards, and their mechanical and chemical properties. Such information shall be given for all materials used in the construction of the main items of equipment before procurement commences.

Materials shall comply with the list below or be similar according to other acceptable standards:

1.2.2.2. MAIN TYPES OF MATERIALS

European standards or equivalent as below:

- Structural steel:.....NF EN 10025
  .....NF EN 1013
- Non alloy high strength steel:.....NF EN 10083
- Low alloy high strength steel:.....NF EN 10083
- Corrosion resisting steel:.....NF EN 10088
- Iron casting:.....NF EN 1561
- Alloy steel casting:..... NF A 32054
- Steel bolts and nuts: ..... NF EN ISO 3506
  NF EN 20898.
- Corrosion resisting steel bolts and nuts: ..... NF EN ISO 3506
  NF EN 20898
  NF EN 10088.
- Steel pipes and fittings: ..... NF EN ISO 559
  NF EN ISO 2604
  NF EN ISO 4200
  NF EN ISO 5252.
- Bronze: ..... NF E 44158
  NF EN ISO 5755

Alternative materials shall be submitted to the Engineer's approval.

1.2.2.3. TESTING OF MATERIALS

All materials shall be tested in compliance with the relevant European or ASTM or similar acceptable standards. In particular:

- CCH 70-2 for the castings.
- CS GFF 3-72 or equivalent for the forgings.
- ASTM for steel plates pipes and laminated products.

1.2.2.4. CAST STEELS AND CASTINGS

Before any part is cast, drawings of the major items showing the proposed locations of the samples which are to be sent for mechanical and chemical tests, shall be submitted for the Engineer's approval.

Blow holes and all other such defects which become apparent after cleaning or machining must be ground to sound metal before any rectification is undertaken.

Castings shall not be twisted nor show any other form of distortion, nor increase in their dimensions (above that already taken into account) which could cause interference with other parts. The metal structure of the castings shall be homogeneous and free of all non-metallic impurities.

If, at any point of a critical section, the casting exhibits any unacceptably high concentration of impurities or alloying elements, the part will be rejected.

Major castings shall be submitted to ultrasonic inspection or radiographic examination where the results of ultrasonic testing is doubtful or not practical. These tests shall be complemented by magnetic particle inspection or dye penetration test.

The Manufacturer shall establish a quality sheet for each major casting.

Castings exhibiting defects of severity levels 4 or 5 in category A through E in accordance with ASTM-E 186 will be rejected.

Casting defects shall only be corrected by welders of the highest quality using the best welding techniques. All castings requiring rectification during any stage of the manufacturing process after they have been initially annealed, shall, unless otherwise indicated, be re-annealed.

Casting defects which require correction by welding shall be reported to the Engineer and shown on a drawing or by means of photographs. Approval shall be obtained from the Engineer before the corrective work is carried out.

1.2.3. WELDINGS

1.2.3.1. QUALIFICATION

For pressure tanks and hydraulic cylinders, the qualification of welding procedures and welders shall be in accordance with the requirements of ASME, Boiler and Pressure Vessel Code, Section IX.

For other components the qualification of welding procedures and welders shall conform either to ASME, Section VIII, Division 1, Section IX or the Standard Qualification Procedure of the American Welding Society at the Contractor's option.

Other welding standards and procedures translated in English will be accepted only to the extent that they conform to the above accepted codes and specifications. Exceptions to these standards and procedures will be made only where approved in writing by the Engineer.

1.2.3.2. WELDING

Welding shall be performed by the electric-arc method. Electroslag welding will also be permitted.

All welds shall be made continuous. Welds on gate or other submerged equipment shall be watertight. Butt welds shall be full penetration welds welded from both sides.

Contractor will provide sufficient temporary bracing to control distortion during welding.

1.2.3.3. WELDED STRUCTURES - STRESS RELIEVING

Components, mainly those made up of large cross-section members, welded to the middle of the section or having large weld beads, shall be given stress-relieving heat treatment. This treatment shall apply in particular to:

a. Components which will have to be precision machined;
b. Structures exposed to buckling forces;
c. High carbon steel components;
d. Equipment submitted to internal or external pressure.

This list is given for guidance purposes and shall not relieve the Contractor of his responsibility.

1.2.3.4. WELD FINISH

Welds shall display good appearance and shall be suitable for painting. Structural welds shall be ground.

Final machining of welded parts shall be performed after welding and if applicable after stress relieving.

1.2.3.5. WELD TESTING

Non-destructive tests shall be in accordance with NF EN 10246.

For each item of equipment the Contractor shall propose for the Engineer's approval the type and extent of non-destructive weld testing.

A. The Contractor will proceed with examination of at least 20% of the weld lengths completed by each welder.

Butt welds will be given radiographic test. The Contractor shall propose the best suited type of test for welds other than butt welds.

B. Welds on pressure tanks and servomotors shall be fully tested.

C. In addition to the requirements A, all main welds shall be fully tested by ultrasonic and magnetic particle or dye penetrant tests complemented by radiographic examination where interpretation by other methods is unclear.

D. Minor welds shall be spot tested.

Examination of welds and acceptance or rejection will comply NF EN 10246.

1.2.3.6. WELD REPAIRS

Defective welds shall be repaired by removing the weld material from the defective zone until sound metal is reached. The weld shall then be remade. Repaired areas shall be subjected to a new radiographic examination.

If a radiograph reveals an unacceptable zone, an extra radiograph will be taken on each side of the said zone.

If the new radiographs do not indicate any defect that would require rejection of the weld, only the zone covered by the first radiograph will be repaired. If further unacceptable defects are indicated, a complete radiographic examination shall be carried out.

Any given weld area cannot be repaired more than twice.

1.2.3.7. ELECTRODES

Electrodes must be stored under the conditions specified by the supplier and used within a maximum time of six months as from their date of manufacture. If this duration is to be exceeded, the Engineer will have the right to require the execution of new electrode quality tests.

For electrodes particularly sensitive to humidity (especially basic electrodes), if they have not been stored in a dry condition in perfectly watertight wrappings, they shall be baked before use, according to the supplier's instructions.

1.2.4. GENERAL PROVISIONS FOR EQUIPMENT DESIGN

1.2.4.1. WEAR

The Contractor shall be considered to be fully aware of the properties of the water used and the atmospheric conditions and, accordingly, under normal operating conditions, the equipment supplied shall not be subject to any abnormal wear.

All parts of equipment subject to water-induced wear shall be provided with interchangeable parts that can be easily refilled by welding or replaced. These interchangeable parts shall be made from a material selected in relation to the intended use and the probable wear of the part. The Contractor shall indicate the composition and properties of the materials used on the basis of analyses carried out by the suppliers. He shall specify the type of electrode suitable for refilling by welding if this process is used. The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

All electrical equipment parts liable to normal or accidental wear shall be designed to resist the action of atmospheric agents and climatic conditions.

1.2.4.2. NOISE

The project is designed to limit noise as much as possible.

- At the edge of the site: the noise level must not exceed the following values:
  - 65 dB(A) during the day (07:00 to 20:00).
  - 60 dB(A) during intermediate periods:
    - work days: 06:00 to 07:00 and 20:00 to 22:00.
    - Sundays and holidays: 06:00 to 22:00.
  - 55 dB(A) during the night (22:00 to 06:00).
- Maximum emergence:
  - Daytime and intermediate periods: 5 dB(A),
  - Night-time: 3 dB(A).
- In technical equipment rooms:

The sound power radiated by all the equipment during maximum operation must not exceed the following values (per octave band):

Frequency in Hz							
Log in dBA							

Overall value: 80 dBA.

- Generally speaking, levels must comply with the most stringent requirements of the Local regulations in force at the time of the contract.

1.2.4.3. VIBRATIONS

During normal operation, the vibration r.m.s velocity, measured on the unit bearing supports, shall not exceed 4.5 mm/s. The vibration r.m.s speed is defined in standard VDI 2056.

The various manoeuvres of the gate and valve equipment shall be carried out under all possible loads without any harmful vibration or excessive noise occurring.

The knife edge of each gate shall be streamlined and designed to prevent vibrations regardless of their degree of opening.

1.2.4.4. ACCESS AND PROTECTION EQUIPMENT

Provision shall be made for access to and protection of the equipment so as to ensure safety during operation, maintenance and inspection. All rotating parts such as wheels, shafts, transmission belts and all live electrical equipment shall be suitably protected by metal housings. Such provision is to be made at the locations and in the positions approved by the Engineer.

The Contractor shall supply all catwalks, platforms, ladders, railings, trap-doors, manholes, and access hatches tied up to the equipment and necessary for proper operation, maintenance and personal safety.

The Contractor shall submit to the Engineer for approval his proposals for the passage of gutters and for the locations of trap-doors, platforms, access doors and ladders, together will all dimensions of spaces to be allowed for the passage of equipment.

1.2.4.5. ARRANGEMENT OF OPERATING EQUIPMENT

No manual controls for lifting or pulling manoeuvres shall require a force of more than 200 Newton, and no manual controls involving the operation of a wheel crank shall require a force of more than 100 Newton.

Wheel cranks shall be located approximately 1 m above floors or platforms. The controls and measuring instruments shall be readily accessible, without any need for special equipment, and clearly marked with identification numbers.

1.2.4.6. HANDLING AND DISMANTLING

All equipment shall be installed by using the normal operational ways. No acceptance will be done by the Engineer for installations using exceptional means.

Equipment shall be designed for easy dismantling and maintenance operations. Dismantling and maintenance of electrical equipment shall be possible without stopping or disturbing other equipment in its vicinity.

All equipment or parts of equipment designed to be dismantled and handled shall be provided with:

a. Lifting rings, lugs, hoisting collars;

b. Slings, chassis and special handling apparatus such as: grappling beams, monorails, trolleys, jacks, pulley and ratchet systems, etc.;

c. Special jack screws appropriately located and in sufficient numbers for the dismantling of the relevant parts.

For heavy components, the Contractor shall provide special facilities for lifting each component. The Contractor shall also provide the necessary lifting gear for this equipment such as manually or electrically operated monorail hoists, hydraulic jacks, etc.

The above equipment shall be included in the Contractor's supply and shall be retained by the Employer.

1.2.4.7. INTERCHANGEABILITY

All machined parts included in winches, pumps, gears, etc. and all moving parts in general, shall be interchangeable and capable of being easily erected on a similar type of apparatus, except for standardised equipment.

For all the contract equipment, all electrical or hydraulic apparatus, equipment, instruments and accessories (for air, water or oil circuits) of the same rating and designed to perform the same functions or operate under comparable conditions within a given operating range, shall be identical and interchangeable.

If certain modifications are made to the equipment during manufacture or erection, these modifications must be submitted for the Engineer's prior approval and shall be made to all the equipment of the same type.

At his own expense, the Contractor shall keep for a minimum period of ten years all the manufacturing drawings and all design data likely to be of use in making repairs or possible replacement of components of the equipment.

1.2.4.8. TEMPERATURE RISE

The maximum temperature of metal parts of bearings and thrust bearings and that of lubricating oil shall be:

- Metal parts:.....80°C.
- Lubricating oil: .....60°C.

These temperatures when reached shall trigger an alarm in the control room.

The temperatures hereunder shall trigger emergency shut down of the unit:

- Metal parts:.....85°C.
- Lubricating oil: .....65°C.

The temperature rise of metal parts of bearings, thrust bearings, reduction gears and other mechanical systems shall not exceed 40°C above the ambient temperature or, in the case of outdoor equipment, 40°C above the outdoor temperature in the shade.

The rise in temperature of lubricating oil, measured around the metal parts quoted above shall not be more than 30°C above the ambient temperature or, in the case of outdoor equipment, 30°C above the outdoor temperature in the shade.

1.2.4.9. LUBRICATION

Lubrication devices and systems are included in the supply. Lubricating bearing materials shall be submitted to the Engineer's approval.

Self-lubricating systems will be provided wherever possible and are mandatory for submerged or temporarily submerged equipment unless the loads applied prevent their use.

Self-lubricating systems for submerged or partially submerged parts shall be provided with protective seals.

The systems proposed shall be of proved and referenced design. References shall be supplied by the Contractor.

1.2.4.10. OPERATING SPEEDS AND LOADS

The operating speeds defined in the technical specifications shall be guaranteed under normal operating conditions and under all loads within a 5% tolerance band.

The maximum operating loads specified by the Contractor shall be considered as guaranteed.

1.2.4.11. NAMEPLATES

All equipment shall have a permanent engraved metal nameplate secured by screws clearly showing all pertinent information regarding the equipment, in the English language, including at least the following:

a. Manufacturer's name and address,

b. Name, type, serial number and other equipment identification data,

c. Rating and other design data,

d. Date of manufacture.

1.2.5. DESIGN OF MISCELLANEOUS DETAIL EQUIPMENT

1.2.5.1. AUXILIARY PIPEWORK AND PRESSURE TANKS

Pipework shall be supplied with the corresponding flanges, nuts and bolts, threaded unions, isolating valves (cast iron excluded), supports and anchoring.

Pipework design shall comply with the following values:

a. Slope greater than 1% for the drainage lines.

b. Water and oil flow velocities not to exceed 4 m/s.

Pipework embedded in concrete shall be systematically tested under pressure before concreting. All pipe end seals or blank flanges necessary for these tests shall be provided by the Contractor. No pipework made of malleable materials, such as lead, copper, etc. shall be embedded in concrete.

Pipe internal and external protection shall be by hot galvanizing. Subsequently, after each welding operation, the galvanization is to be repaired by wire brushing and application of a compatible enriched zinc paint.

Galvanization is not required for oil piping. The external surface of the oil pipes shall be protected by painting as per Section 01010 - Corrosion protection.

All flanges and couplings shall be suitably placed to facilitate dismantling of corresponding equipment and appliances, with a sufficient number of isolation valves to avoid loss of fluid when partial dismantling work is carried out.

All pipes shall be installed in order to be easily dismantled for maintenance.

Flanges and couplings shall be suitably placed to facilitate dismantling. These flanges and couplings shall be indicated on drawings, with the dimensions.

Tests:

c. Pressure tanks and pipework shall be tested at a pressure at least 50% greater than the maximum operating pressure.

d. Free-surface tanks and basins shall be tested for watertightness before painting. They shall be filled with water for 24 hours. The watertightness of the welds shall be tested with compressed air and a soapy solution, or by any other method approved by the Engineer.

1.2.5.2. TIGHTNESS OF WATER AND OIL CIRCUITS

All bearings, oil, water and air pipes, pumps and other associated apparatus shall be perfectly tight. No water, air, oil or grease leak shall take place. Any condensation and possible leakage shall be collected and drained off. The design shall be such that no oil splashes or vapour will reach electrical equipment.

1.2.5.3. COUPLINGS

Couplings between electric drive motors and the various types of driven equipment shall be of the semi-elastic type and shall have a service factor of 1.5.

1.2.5.4. BOLTS, NUTS, SCREWS

All bolts, nuts and screws in contact with water or in a damp atmosphere shall be made of corrosion-resisting materials. A pre plating treatment of 10-12 microns shall be applied to High Resistance Bolts subject to continuous or intermittent immersion in water. Particular care shall be taken to avoid contact corrosion. Threads under vibration shall be especially treated with special resins.

All shims to be used shall be protected from corrosion by cadmium plating, sherardisation or by any other process approved by the Engineer.

1.2.5.5. ANCHORING

For all anchoring, use of "fish-tail" systems is strictly prohibited.

1.2.5.6. SEALS FOR GATES AND VALVES

The Contractor shall pay particular attention to seal joints, especially in corners, so that a continuous line of contact is maintained. The seal corner joints shall be cast in one piece and vulcanised or glued to the lateral and frontal seals.

The seal backing plate holding bolts shall be of stainless steel. The bolt holes in the gate skin plate, the seals themselves and the backing plate shall be drilled in the workshop. If the gates are to be shipped dismantled, the seals shall be removed and packed separately.

All gate and valve seals shall be free of any defect. The seals must be made of synthetic rubber, non-reactive to contact with grease or hydrocarbons. The seals shall be designed to make field adjustment and maintenance easy.

The seals of the gates shall comply with the requirements given hereunder without any special devices having to be used. Local leaks and average leaks per linear metre of seal shall not exceed the following values:

a. Local leaks: 0.25 litres per second;

b. Average leaks: 0.10 litres per second per metre.

Valves seals shall be completely watertight.

1.2.5.7. HOLES FOR CONCRETING AND GROUTING

Holes of at least 200 mm in diameter shall be provided in the horizontal part or bottom of linings between stiffeners and welded seams, in order to concrete a surface area of approximately one square-metre. Hole-covers shall also be provided.

All holes in the hydraulic conduits for concreting and grouting purposes shall be fitted with screwed plugs and then seal welded in place, rendering the part watertight, and shall be carefully ground flush.

1.2.6. EMBEDDED PARTS AND LININGS

1.2.6.1. GENERAL

All embedded parts and linings shall be designed to withstand both the hydrostatic pressure at the point of installation as well as the grouting pressure**.**

The stiffeners of the vertical embedded parts shall be designed so as not to hinder the concreting carried out on site.

Sufficient quantities of tie bars and adjusting rods shall be provided. The latter shall be attached to the steel plates embedded in the primary concrete. The steel plates will be designed solely for adjusting the position of the corresponding embedded parts and shall under no circumstances be subjected to high loads nor shall they replace the anchorings embedded in the primary or secondary concrete. If, according to the design of the embedded parts, the Contractor supplies and installs steel sections to be embedded in the secondary concrete for adjustment of the embedded parts, then such sections shall not be less than 40 mm from the concrete surface facing.

All surfaces having contact with the seals as well as the sliding surfaces shall be made of corrosion resisting materials.

All corrosion resisting parts, whether intended for the sill, the side walls, etc. installed in the sluiceway shall be perfectly flush with the sluice profile. Any unevenness or level differences will be rejected.

For normal stiffening of vertical or horizontal embedded parts (except in the case of self-resisting embedded parts), the end of the stiffeners shall not, insofar as possible, cut the concrete in the form of "L" or "T" sections.

1.2.6.2. FIXED PARTS FOR GATES

In order to facilitate the introduction of gates into their slots, the top of the embedded parts making up the gate slot shall have a lead-in section which diverges 30° from the vertical. The frontal embedded parts shall comprise an upper section to ensure good contact with the transverse seals when the gate arrives in the closed position.

1.2.6.3. LININGS

The welds joining the steel plates together and joining the steel plates to the corrosion resisting steel sliding surfaces located in the sluices shall be very carefully ground flush and refilled if necessary, so that there are no cracks, protrusions nor misalignments.

All welds shall be continuous, solid and watertight. They shall all be subjected to crack detection tests:

a. Crack detection tests along 100% of the joints between liners;

b. Crack detection tests for 20% of all other welds.

No indentations or protrusions over 1.5 mm in depth or height, or with a slope greater than 3° shall be permitted on any part of the sluices surface.

1.2.7. DESIGN CRITERIA

In his design calculations, the Contractor shall consider the most adverse conditions that will have to be withstood by the equipment, whether in operation or during manufacture, transport and erection.

1.2.7.1. LOADING CONDITIONS

1.2.7.1.1. ***Water loads***

Water loads shall be considered as follows:

- 10 kN/m³ for clean water
- 11 kN/m³ for sewage water

1.2.7.1.2. ***Allowance shall be made for the following loads:***

a. Weights, buoyancy, hydrodynamic loads and loads generated by gates, valves and penstocks movements (such as friction forces);

b. Loads generated by the guiding systems;

c. Loads generated by the obstruction of trash racks.

1.2.7.1.3. ***Earthquakes:***

The Contractor shall design structures according to local seismic rules and data, submitted to the approval of the Engineer.

1.2.7.1.4. ***Hydraulic transient***

The pressure surges generated by the closure of valves and gates shall be taken into account. The maximum amplitude of the pressure surge to be taken into account is specified in the corresponding section.

1.2.7.1.5. ***Load combination***

Each of the following conditions shall be considered for normal loading of gates.

a. Gate or valve closed:

The effect of the following loads shall be combined:

- Hydrostatic load corresponding to the water level acting on the gate or valve, no water on the opposite side;
- Dead weight of the gate and hoist connecting rods bearing on the gate, reaction forces acting on the supports;

b. Gate or valve being closed or opened at any point of travel:

The effects of the following loads shall be taken into account:

- Weight of the gate (included weight of any other gate-mounted equipment, ballast,..);
- Weight of hoist connecting rods bearing on the gate;
- Hydrostatic load corresponding to the piezometric level acting on both sides of the gate or valve;
- Hydrodynamic loads corresponding to flow conditions;
- Rated hoist pull, rated thrust (if any) or required control load acting on the gate;
- All load components caused by seal friction, guide loading, friction of pistons and pins of cylinders after a long inactive period and other effects;
- Additional friction and/or blocking forces in the guiding devices and against the seals.

1.2.7.2. ALLOWABLE STRESSES

Gate: unless otherwise specifically indicated for a type of structure or equipment, allowance shall be made for the following values: - DIN standard 19704. Chapter 7 or equivalent.

1.2.7.3. BUCKLING OF CYLINDRICAL PARTS, CONDUITS, PENSTOCKS

The factor of safety against buckling for cylindrical parts shall be as specified in the CECT design code.

1.2.7.4. LOADS ON SUPPORTS, ANCHORS AND CONCRETE

The Contractor shall furnish the values of the loads applied by the equipment on the supports and anchors.

The allowable compression stress applied on the concrete shall meet DIN 19704/4114 standards or equivalent.

1.2.7.5. PERMISSIBLE TOLERANCES ON GATES AND FITTINGS

(Any tolerances specified in the subsequent sections have priority over these tolerances).

Tolerances shall be as follows:

1. For all stainless sealing strips: sills, lateral risers and frontal cross pieces: In the longitudinal and transverse directions:

   a) local flatness: 0.5 mm over 100 mm
   b) general flatness: 1 mm
   c) general straightness: 1 mm

2. On the standard lining panels:

   Along the height and width of the sluice:

   a) local flatness: 1.5 mm over 500 mm
   b) general flatness: 2 mm
   c) general straightness: 2 mm

   Along the length of the lining panels:

   a) general straightness: 2 mm

The general flatness condition shall apply to the lining panels after on-site welding, i.e. along the whole length of a given side wall.

Between the lateral stainless steel sealing strips:

1. Parallelism (between sealing strips): 2 mm.

2. Perpendicularity (of each sealing strip to the sill): 1 mm.

All tolerances shall allow a good operation of the equipment. All tolerances not in agreement with above specified values shall be submitted to the Engineer's approval.

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SECTION 02100
SITE PREPARATION

1. GENERAL

1.1. WORK INCLUDED

1.3.1. SCOPE OF SUPPLY

This section covers all operations in connection with clearing, grubbing and stripping of various parts of the Works sites and other locations related to the Works.

1.3.1. LIMITS OF SUPPLY

It is the intent of these specifications that the site preparation in connection with demolition, excavation and backfill shall be within the limit lines and grades shown on the drawings and defined herein, but the right is reserved to modify such limits and grades during the progress of the work, as may be judged necessary by the Engineer.

1.2. RELATED WORK

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. SUBMITTALS

Twenty eight days before the beginning of the work, the Contractor shall submit to the approval of the Engineer:

A. A programme of work, he intends to carry out, area by area, to enable the Engineer to assess the consequences of the clearing and stripping works, as regards to the relevant Authority.

B. The arrangements the Contractor intends to adopt to carry out the work.

1.4. SEQUENCING – SCHEDULING

The clearing of the site shall be performed at the earliest practicable time in order to facilitate further survey works.

2. PRODUCTS

Not applicable

3. EXECUTION

3.1. CLEARING

1. Clearing shall consist in removing all trees and bush, including removing of tree stump, with manual and mechanical means. Chemical means are not permitted.

2. The Contractor shall remove and eliminate all wastes at his own costs in a landfill approved by the Engineer.

3.2. STRIPPING

1. Stripping shall consist of removing all top soil: rubbish, vegetal matters, debris and humus.

2. Stripping shall be required for all earth foundations of various types of fill and where the foundation has not been constructed by excavating.

3. No separate stripping will be required in areas to be excavated and when the excavated materials will not be used in Permanent Works.

4. The minimum depth of stripping shall be 25 cm or where this requirement is inapplicable as directed by the Engineer.

5. The Contractor shall not dispose of surplus topsoil without the written permission of the Engineer.

3.3. DEMOLITION

Demolition works are included in stripping; they concern all structures, pipes, roads … to be demolished on the works area...

3.4. PROTECTION OF OTHER AREAS

1. The Contractor shall ensure that trees and other vegetation outside the areas of the permanent works and the minimal areas required for temporary works including access are protected and preserved from damage.

2. Any additional clearing required by the Contractor for construction of temporary works, and for any other purpose shall be at the Contractor's expense and shall not be carried out without the approval of the Engineer.

3. The Engineer reserves the right to reinstate any damage to vegetation and the surface of the ground beyond the areas of the Works (including temporary works) at the expense of the Contractor.

3.5. DISPOSAL OF MATERIALS

A. Stumps, roots, logs and other objectionable matter removed in the site preparation operation shall be removed from the limits of the work and disposed of.

B. Disposal areas shall be approved by the Engineer.

C. Other materials from clearing and stripping operations shall become the property of the Contractor and shall be at the Contractor's option burnt or removed from the site well in advance of the programmed date for the start of impoundment or disposed of as approved.

D. Burning will be permitted only at times when conditions are considered favourable for burning and at locations approved by the Engineer. Materials to be burnt shall be piled neatly and when in a suitable condition shall be burnt completely.

E. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk. Burning shall be thorough so that burned materials are reduced to ashes. No logs, branches or charred pieces shall be permitted to remain.

F. The Contractor shall at all times take special precautions to prevent fire from spreading to areas beyond the limits of the cleared areas and shall have available at all times suitable equipment and supplies for use in preventing and suppressing fires.

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SECTION 02210
OPEN AIR EXCAVATIONS

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with such excavation methods and to such dimension and depths that allows for proper execution of the Works.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

Excavation as specified under this section shall include when necessary all ripping, drilling, blasting, scaling down, supporting, loading, transporting, dumping and stockpiling of excavated materials in approved disposal areas and preparation of surfaces for foundations.

1.4. DEFINITION

1. According to the dimensions, line levels and grade as shown on the drawings or directed by the Engineer:

   - The « elevation » line or neat-line shown on the drawings is the line within which no material shall be permitted to remain.
   - All excavations out of « elevation » line shall be considered as overbreak.
   - "Geological overbreaks" shall be those due only to the geology of excavated material. This will not concern overbreaks due to other reasons such as the method of excavation. Classification as geological overbreak shall be decided by the Engineer.

2. Classifications of excavation types

   a) Rock excavations

   Rock is defined as sound and solid masses, of such hardness and texture, that it cannot be effectively loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper, equipped with one digging point of standard Manufacturer's design adequately sized for use with and propelled by a crawler-type tractor rated minimum 250 kW (335 HP) flywheel operating in low gear. Engineer's assessment on the above shall be deemed as final.

All boulders or detached pieces of solid rock, more than 2.7 tons will be classified as rock excavation.

b) Common excavations

Common excavation includes all materials other than rock excavation and are also termed soil excavations. All boulders or detached pieces of solid rock less than 1 cubic metre in volume will be classed as common excavation.

3. In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

1.5. CODES AND STANDARDS

BS 410 Test sieves. Technical requirements and testing.

BS 812 Testing aggregates.

BS 1377 Methods of test for soils for civil engineering purposes

BS 5930 Code of practice for Site investigations

BS 6031 Code of practice for earthworks

BS 6187 Code of practice for demolition

ISO EN 965, 964-1, 12956, 10319 : Test of geotextile

USBR: Earth Manual of "Bureau of reclamation" US Department of the Interior.

LCPC: Laboratoire Central des Ponts et Chaussées.

1.6. SUBMITTALS

1. Mass haul diagram.
   a) Before Works execution, the Contractor shall arrange and provide to the Engineer's agreement a Mass haul diagram.
   b) This diagram will be submitted to the Engineer at least one month before Works beginning.
   c) To establish this project, the Contractor shall take into account either geotechnical surveys that will have been carried out previously (if any), or his own soil investigations.
   d) No work shall start before the Engineer has notified his complete and unreserved agreement to the Contractor who may not claim any compensation in this respect.

2. Method of work
   a) Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the method, sequences and equipment proposed for carrying out the work. This will include all patterns and supporting where appropriate.
   b) Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the planning of exploitation for quarries and borrow areas and method statements.

c) Within two weeks of receipt of any proposed plan, the Engineer will give in writing to the Contractor, approval or rejection of that plan in whole or in part. If approval is withheld the Contractor shall submit a new plan. No rock excavation shall be started in areas for which the overall plan has not been approved by the Engineer.

d) The Contractor will submit to the Engineer, at least one month before Works beginning, all calculation notes, documents and drawings that he will have produced about slopes stability. Works shall not begin before the Engineer's agreement concerning the technical solution chosen by the Contractor to ensure slopes stability and safety. If supports and protections are found to be useless, justifications shall be submitted.

3. Topographical survey before any works

At least 30 days before start of any excavation work, a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer.

4. Topographical survey on completion of the excavation work

On completion of each type of excavation and not later than 3 days after a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer.

5. Excavation records

The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work of all excavations works. When applicable the following data shall be recorded for each working face together with such other data as the Engineer may request:

- volume excavated in soil,
- volume excavated in rock,
- location and drilling pattern for rock excavation,
- number and classification of men and plant engaged,
- unusual occurrences, rockfall, unstable or soft ground and inflows of water.

1.7. TOLERANCES

1. Excavations shall be made to the full dimensions required and shall be finished to the prescribed lines, slopes and grades.

2. Any excavation beyond the lines, slopes and grades shown on the drawings or directed by the Engineer which is performed by the Contractor for any purpose (such as for working space) shall be kept within the limits approved by the Engineer. If such excavation should in the opinion of the Engineer, require to be backfilled, such backfilling shall be done to the satisfaction of the Engineer with material approved by the Engineer.

3. Beneath load bearing structures, foundations and other reinforced concrete work, the filling of any over-excavation shall be of the same quality concrete as that required for the associated concrete structure unless the Engineer permits leaner concrete.

4. For the excavations to be covered by concrete, or core material and adjacent filters or transition the tolerances shall be as follows:
   - for the levels:
     +0
     -100 mm
   - for the horizontal dimensions:
     +100 mm

-0

5. For other excavations the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
   - for the levels:
     +0
     -150 mm
   - for the horizontal dimensions:
     +150 mm
     -0 mm.

2. PRODUCTS

Not applicable.

3. EXECUTION

3.1. INSPECTION

1. Topographical survey before works

   Before the commencement of any earthworks the sites shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels and these agreed ground levels shall form when required the basis for the calculation of quantities of any subsequent excavation and filling.

2. Topographical survey on completion of excavation works

   On completion of each type of work (common excavation, rock excavation...) the areas shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish the different volumes excavated.

3.2. GENERAL

1. The Contractor shall arrange excavation activities with due regard for the safety of the Works and the personnel on site.

2. Excavated surfaces which will remain permanently exposed shall be finished off in a neat and workmanlike manner and shall be graded to provide adequate drainage.

3. All necessary precautions shall be taken to preserve the material below and beyond the prescribed lines for excavation in the soundest possible conditions.

4. Excavations needed by the Contractor's installations shall be submitted to the approval of the Engineer.

3.3. INVESTIGATIONS

Before drawing up his earth movement balance, the Contractor shall carry out on the following basis all ground investigations necessary for Works execution.

1. Investigations required under this Contract: not applicable.

2. Investigations carried out by the Contactor at his own expenses and risks, and included in the time for completion: scope of works to be approved by the Engineer.

3.4. SUPPORT AND PROTECTION

1. All temporary slopes shall be made safe and protected if necessary. These protections shall include temporary supports including shoring, sheeting and bracing where necessary, the diversion of water and the provision and maintenance of such protections.

2. Berms shall be maintained free of fallen material.

3.5. COMMON EXCAVATION

1. Common material shall be excavated to bedrock or to the lines and grades shown on the drawings or as required by the Engineer. Excavation for any structure or area shall include excavation necessary to ensure the stability of slopes associated with such structure or area.

2. Where the excavation is provided to accommodate structures, such excavation shall allow the proper placing and bracing of forms.

3. If at any point in excavation the natural foundation material is disturbed or loosened during the excavation process or otherwise, it shall be compacted in place or where directed it shall be removed and replaced with approved suitable material and compacted as preparation of foundation structure or embankment as the case required at the expense of the Contractor.

3.6. ROCK EXCAVATIONS

1. Rock excavations shall be performed with heavy percussion tools complete with rock bits, hydraulic wedges, blasting or other specific method for rock excavation.

2. If blasting is used, it must be carried out in accordance with Explosives Laws of Kenya. The Contractor shall provide proper buildings or magazines in suitable positions for the storage of explosives in manner and quantities to be approved. He shall also be responsible for the prevention of any unauthorised issue of improper use of any explosives brought on the works and shall employ only licensed and responsible persons to handle explosives for the purpose of the works. Excavation shall be carried out utilizing a controlled perimeter blasting technique as approved by the Engineer, in order to produce smooth faces, conforming to the prescribed neat-lines and to prevent or minimize the occurrence of blast, induced fractures in the rock outside the excavation lines:

    a) Presplitting on smooth blasting shall be used where shown on the drawings or directed by the Engineer for vertical or near vertical faces excavated which will be permanently exposed or which will be covered with concrete or shotcrete.

b) Unless otherwise agreed, trim blasting techniques shall be used in all horizontal or sloping surfaces at the bottom of the excavations for all foundation of concrete structure or where required by the Engineer.

3. When necessary, the Contractor shall provide heavy duty blasting mats adequately held down to prevent damage from flying rocks.

4. Immediately following blasting and at any time during the Contract, all loose materials which appear unsafe or to endanger workmen or structure or equipment shall be scaled and removed. All materials loosened by scaling shall be removed from the excavation.

5. Blasting shall be restricted to such periods and such parts of the works as the Engineer may prescribe. If, in the opinion of the Engineer, blasting would be dangerous to persons or property or to any finished work or is being carried out in a reckless manner, he may prohibit it, and order the rock to be excavated by other means.

6. When required by the Engineer, concrete structure foundation shall be finished using hand tools for the last 25 cm.

3.7. EXCAVATION IN BORROW AREAS

1. At least one month before any borrow area is opened the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit the area until the Engineer has given his approval.

2. All material from borrow areas shall be tested by the Contractor and approved by the Engineer.

3. At any time during the exploitation of a borrow area, the Engineer may withdraw his approval for the continued utilization of that borrow area.

3.8. EXCAVATION IN QUARRY

1. At least one month before a quarry is opened, the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit it until the Engineer has given his approval.

2. All material from quarry shall be tested by the Contractor as described in these specifications and approved by the Engineer.

3.9. TRENCH EXCAVATIONS

A. The trench must be sufficiently wide at all points to lay pipes and carry out backfilling operations around the pipes. Subject to different stipulations notified by the Engineer, the bottom width shall not be less than:

1. For one pipe:

$$1.2\ D + 0.70 \text{ (in m)}$$

in which:

D = outer diameter of the pipe in metres.

2. For n pipes in the same trench:

$$n (D + 0.50) + 0.70 \text{ in m}$$

3. For one or more ducts:

$$3 \times n \times D \text{ with } n = \text{number of ducts and } D = \text{widest diameter}$$

B. Trenches for welded steel pipes shall include recesses for joints. These recesses shall be 1 m wide on either side of the trench edge.

C. The bottom of the trenches is levelled at least 0.10 m below the level planned for the outer invert of the pipe. If there should be any rocks projecting above this level, they shall be completely excavated and the corresponding cavities filled in if necessary.

D. The normal depth of the trenches shall be such that the thickness of fill above the outer soffit of the pipe shall not be less than 1.0 m.

E. The Contractor shall take all necessary measures to avoid cave-ins and ensure safety for staff, if necessary by sloping, shoring, planking or reinforcing the sides of the excavation using all means suited to the nature of the soil and as approved by the Engineer.

F. Excavated material shall not be deposited less than 3 m from the edge of the trench.

3.10. DISPOSAL OF EXCAVATED MATERIALS

1. Excavated material shall be disposed of in disposal areas indicated on the drawings or agreed by the Engineer at any distance.
2. Disposal areas shall be well drained and left in tidy, safe and stable conditions.
3. In so far as they may be suitable and comply with the Specifications, materials arising from excavations shall be used in the Works.
4. All surplus or unsuitable excavated materials shall be disposed to spoil banks at locations shown on the drawings or accepted by the Engineer.
5. All necessary measures shall be taken not to obstruct natural drainage courses with the spoil banks.
6. Suitable slopes shall be given to the surface to ensure drainage.
7. Maximum heights will be determined by the Engineer.

3.11. PREPARATION OF EXCAVATED SURFACES

1. Common excavations for foundations
   c) The surface shall be cleaned of all loose material.
   d) The foundation shall be compacted if necessary to a depth of 0.20 m to a minimum dry density of 95% of the optimum density according to the standard proctor test (NF P 94 093).
   e) For foundation on gravel materials, the in situ foundation material to depth 0.20 m shall be compacted in such a manner as to achieve a uniform density throughout of 80% of the relative density.
   f) The surface shall be free from standing or running water.

g) Where the ground surface under any compacted embankment or structure is not suitable, as determined by the Engineer, after the required excavation or removal of top soil, the Contractor shall further remove the unsuitable material to such depth and in such area as may be directed.

h) The foundation just after compaction shall receive a layer of blinding concrete.

2. Rock excavations for foundations

After completion of the excavations and other required works such as rock bolting, etc., the following operations shall be carried out where relevant:

i) Any degraded or weathered material located beyond the theoretical excavation lines shall be removed. This includes materials in cracks, seams, faults and cavities, which will be removed by using hand tools or compressed air water jet to a depth where sound materials is encountered or until the depth cleaned out is at least four times the width of the surface opening.

j) Rock surfaces shall be thoroughly cleaned by the use of high pressure water air jet. Brushing shall be employed if appropriate and required by the Engineer.

k) After having been cleaned out, cracks, seams, faults cavities, trenches or pits shall be filled with concrete, shotcrete or cement slurry as required or agreed by the Engineer.

l) A first cleaning shall be carried out to allow a geological examination of the foundation surface and to define possible treatment if required.

m) After geological acceptance by the Engineer, the final cleaning of the rock shall be made not more than 24 hours before concreting and the rock shall be kept wet and protected from the sun.

3.12. POSSIBLE DEMOLITION OF BURIED STRUCTURES.

If masonry or concrete structures are encountered during excavation works, the Contractor must first inform the Engineer then proceed with the demolition, removal, transport and disposal of this material. Such material shall be treated as sound rock. These works shall not give the right to any additional payments.

3.13. RESTORATION OF BORROW AREAS AND QUARRY

1. At the end of works, all borrow areas and quarry shall be left in safe conditions as approved by the Engineer.

2. The surface of borrow areas shall be left in a reasonably smooth and even condition as approved by the Engineer.

3. Borrow areas shall be drained by the means of open ditches where necessary to prevent the accumulation of standing water.

3.14. SPECIAL INSTRUCTIONS FOR CERTAIN KINDS OF EXCAVATIONS

1. Bottom of excavation

Any hollows or lenticles that are more compressible than the bottom of the excavation in general must be drained and replaced by material with similar compressibility to that of the sound earth at the same depth.

In particular, before the blinding concrete is put in place, the bottom of excavations must be carefully inspected in order to check the quality of the foundation sand and gravel (substitution of pockets of clay-loam by carefully compacted clean sandy-gravely soil, over a minimum depth of 0.5m under the base slab).

2. Excavations at the foot of slopes

Care must be taken when excavating at the foot of slopes so as to avoid any movement of the slope.

3. Acceptance of excavations for structures

A band of at least 0.80m in width will be provided outside the formworks everywhere around the structures to be built.

The Contractor shall supply the Engineer with:

- Earthworks in conformity with the approved design drawings with an altitude tolerance in compliance with § 1.7 Tolerances,
- bearing capacity checked by plate bearing tests (1 test for 250m² of excavation), EV1 and EV2 being the deformation moduli according to the procedure of LCPC-CT2: EV2/EV1 < 2 with EV2 > 50 MPa, Westergaard's modulus: K > 50 MPa/m.

3.15. KEEPING EXCAVATIONS DRY DURING WORKS

1. General

Except for any special dispensations which might be granted by the Engineer, the Contractor must protect the excavations from water, at his own expense, so that the works can be performed in dry conditions.

The method used to drain water from the excavation is the responsibility of the Contractor and must be submitted for the Engineer's opinion, and possibly the opinion of a geotechnical consultancy where the stability of the ground may be involved.

2. Runoff outside the site

The crest of the excavation shall be surrounded by drain slots to collect runoff outside the excavation and evacuate it at a suitable distance from the excavations.

3. Water from the walls and bottom of excavations

Characterised sources or even single threads of water must be intercepted or diverted at their outlets. The measures used for this purpose must not cause soil erosion or subsidence.

During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.

4. Water collection and pump sump

If, because of the site layout, particularly in the case of buried structures, water in the excavations cannot be evacuated by gravity, the water must be collected in a sump from which it can be pumped. The Contractor must take all the necessary precautions to prevent wash out of fines.

5. Dewatering or water table drawdown

The Contractor's attention is drawn to the precautions to be taken to avoid effects of water table drawdown on existing structures (stability, wash out of fines, etc.).

Before any operation, the contractor must submit to the Engineer the calculation notes related to dewatering established by a geotechnical consultancy, as well as the precautionary measures taken for the existing structures.

oOo

SECTION 02220
EMBANKMENT, FILL AND BACKFILL

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with:

1. Backfill around all structures.
2. All embankments
3. Roads embankments.
4. Backfill of trenches.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents

1.3. DESCRIPTION

1. Fill and backfill work as specified under this Section shall include filling or backfilling with random or selected materials approved by the Engineer and built up in horizontal layers, the thickness of which shall be determined according to trials carried out by the Contractor before the beginning of any filling work.

1.4. REFERENCES

1. BS 1377:1990 Methods of test for soils for civil engineering purposes
2. ASTM: American Society for Testing and Materials.
3. USBR: Earth Manual of "Bureau of Reclamation"
   US Department of the Interior.

1.5. SUBMITTALS

1. A mass haul diagram shall be submitted to the Engineer in the form and following the description given in Section 02210 "Open air excavations".

   This mass haul diagram shall be drafted and submitted together with the general mass haul diagram of Section 02210.

2. At least one month before starting the filling operations, the Contractor shall submit a complete programme showing the proposed filling program including quantities and origin of materials.

3. At least one month before starting the filling operations, the Contractor shall submit to the Engineer a detailed method statement covering the filling operations and material placement.

4. On a weekly basis, the Contractor shall submit to the Engineer summary sheets giving the results of all controls performed during the week on a format to be agreed with the Engineer.

5. The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work for all fill work including:
   a) quantities of materials placed with their type, core, filters,...,
   b) location of the material placed,
   c) number and classification of men and plants engaged,
   d) weather during the day,
   e) inflows of water or any other unusual occurrence.

1.6. TOLERANCES

1. All fill and backfill shall be constructed to the lines and dimensions shown on the Drawings or as required by the Engineer.

2. For compacted fill and backfill, the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
   - level (vertical) =..... +0, -5 cm,
   - dimension (horizontal) = ...+15, -0 cm (on the dimension of fill).

1.7. CONTROLS

1. All the controls required in the present Specification shall be performed in the Contractor's laboratory or in a laboratory he will have chosen with the agreement of the Engineer.

2. PRODUCT

2.1. GENERAL

1. Fill and backfill materials shall be derived as much as possible, from required excavations for permanent works to be constructed under the Contract, or from designated on-site borrow areas and quarries, subject to their compliance with the relevant Specifications and approval of the Engineer. Where quantities are insufficient or available materials do not comply with the Specifications materials shall be obtained by the Contractor from external sources approved by the Engineer.

2. All fill and backfill materials shall be well graded in accordance with the USC classification system.

3. All materials as specified hereinafter shall be subject to the prior approval of the Engineer

2.2. SELECTED COMPACTED FILL

The material shall comply with the following requirements:

- D maxi = 100 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm sieve (square openings) between 5 and 15%.
- Plasticity index IP ≤ 15.

2.3. SELECTED COMPACTED ROCKFILL

The material shall comply with the following requirements:

- D maxi = 200 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm sieve (square openings) between 0 and 5%.

2.4. RANDOM COMPACTED FILL

The material shall comply with the following requirements:

- D maxi = 800 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm sieve (square openings) between 0 and 5%.
- Maximum particle size of the top layer of embankment shall be 250mm.

2.5. SMALL FILL

The material shall comply with the following requirements:

- D maxi = 20 mm.
- Gypsum content < 2%.
- CBR test (at 95% of modified Proctor test): > 80.
- Sand equivalent: 40<SE<60.

2.6. SAND LAYER

The material shall comply with the following requirements:

- D maxi = 4 mm.
- Fraction passing 0.074 mm sieve (square openings): 5%.
- Plasticity index: < 6.

3. EXECUTION

3.1. INSPECTION

1. Before the commencement of any fill works the site shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels and these agreed ground levels shall form when required basis for the calculation of quantities of any subsequent filling.

2. No fill shall be placed in any section of the Works until the foundation has been inspected and approved by the Engineer.

3. Placing of a layer shall not be done until the preceding layer has been inspected and accepted by the Engineer.

3.2. GENERAL

1. All backfill operations shall be performed in the dry.

2. Prior to the commencement of placing backfill materials adjacent to structures, the backfill areas shall be cleared of all remaining concrete forms, other temporary works and unsuitable materials, and shall be subject to the approval of the Engineer.

3. The backfill materials shall be placed in such manner as to ensure that they can be satisfactorily compacted without damage to the structure.

4. The sequence of filling behind or around a structure and the maximum difference in height at any time between fill levels shall be approved by the Engineer.

5. Filling around structure is permitted only if the structure is completely achieved, or if the unachieved part is not necessary to handle earth pressure. In all case, approbation of the Engineer is required before filling around any structure.

6. Filling around liquid retaining structure shall begin only after validation of watertightness tests.

7. Sheeting and timbering supporting the excavations shall be removed, step by step, to prevent any settlement.

8. Where instructed by the Engineer, timbering and sheeting shall be left in place.

9. Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within 100 cm vertically of the surface of the concrete.

10. Where instructed, selected granular fill material approved by the Engineer shall be placed around the structure.

11. A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

3.3. SELECTED COMPACTED FILL

1. Placing and compaction

Selected compacted fill shall be placed in layers not exceeding 250 mm and at least 1.5 time $D_{maximum}$.

Each layer shall be compacted by means of a vibrating smooth drum roller or vibrating plate so as to achieve a dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{max}}} \geq 95\%$$

with:

γ_d = field dry density;

γ_{dmax} = standard Proctor maximum dry density.

2. Placement moisture content of the material shall be so that:

$$-2 < w - w_{opt} < +2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt}: optimum moisture content of the standard Proctor compaction test.

3. Test Pad

Prior to the commencement of Contract Earthworks on site, the Contractor shall propose a methodology for the Compaction of soils in accordance with the requirements of this Specification, for approval by the Engineer.

The Contractor shall demonstrate their methodology consistently achieves the requirements of the Specification by constructing a number of test pads (minimum 20m dimension) and recording the layer thickness, any required drying or moisture conditioning, applicable construction plant (eg 10t vibrating sheeps foot roller) and required number of passes.

The Contractor shall undertake in situ field density tests (and permeability tests as appropriate) in accordance with the testing requirements of this Specification, sufficient to satisfy the Engineer that the required material parameters are achieved.

4. Control

Two controls shall be made on the first layer placed in order to determine the suitability of the equipment used and the number of passes.
If changes occur in the nature or the origin of the fill material used during the works or at the request of the Engineer, new tests shall be performed.
A minimum of one control every 250m^3 of material placed shall be performed.
Final acceptance of materials shall only be made after they have been dumped, spread and compacted.

3.4. BACKFILLING OF TRENCHES

1. General

Every section of the pipeline shall be covered as soon as possible after being lowered into the trench, but no section of the line shall be covered without pipe surveying and express approval of the Engineer.

Each section shall be backfilled after the pipe has been placed in its final position in the trench and after all welded joints and bends have been coated and all defects in the pipe coating repaired.

Backfilling shall be done carefully to prevent displacement of the pipes or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench sides, without leaving any voids.

Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified herein.

On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

2. Sand layer

In every cases and for all types of pipe, a sand layer of at least 10cm in thickness and composed of sand such as described in paragraph 2.6 shall be laid under the pipe.

3. “Small fill”

The backfill around and up to 40cm above the pipes shall be in accordance with materials described in paragraph 2.5 “Small fill”, placed, compacted and controlled as described in paragraph 3.3.

4. “Normal fill”

Above the “small fill” and except otherwise shown on drawings or directed by the Engineer, trenches shall be backfilled using materials described in paragraph 2.2 "Selected compacted fill" placed, compacted and controlled as described in paragraph 3.3.

SECTION 02232
ROADS

1. GENERAL

1.1. WORK INCLUDED

1. Roads and related works inside the project boundaries.

2. The Contractor shall be responsible of the design, the construction, the maintenance and reinstatement of the various access roads to the Site Works.

3. The Contractor shall in consequence take all necessary arrangements to build the access roads in accordance with local Standards and Regulations.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. STANDARDS AND REGULATIONS

AASHTO	Standard Specifications for Highway Bridges
BS 434 Part 1	Bitumen road emulsions
BS 594	Hot rolled asphalt for roads and other paved areas
BS 598	Sampling and examination of bituminous mixtures for roads and other paved areas
BS 812	Testing aggregates
BS 1377	Methods of test for soils for civil engineering purposes.
BS 4987	Coated macadam for roads and other paved areas
NF P 18561	Aggregates – Measurement of the flakiness index

ASTM Standards as referenced throughout this Section

1.4. SUBMITTALS

All documents concerning the quality of materials and all the results of routine tests prescribed in the present Section shall be submitted to the Engineer, at the frequency and on the form agreed at the start of the Works.

1.5. TOLERANCES

The surface at each stage during the construction of the roads shall comply with the requirements set out below.

« Specified level » shall be the level shown on the Drawings, or deduced by reference to the finished road level and minimum layer thicknesses.

« Smoothness » shall be measured as the maximum gap beneath a 3.0 m long straight-edge used longitudinally or beneath a template, to suit the specified camber shape of the road, used traversely.

Surface	Tolerance from specified level (mm)	Smoothness (mm)
Sub-grade (formation)	+0 to -25	-
Granular sub-base	+0 to -25	-
Granular road base	+5 to -15	15
Base course	+5 to -10	10
Wearing course	+5 to -5	5

In addition, the wearing course shall have no backfall from any drainage point.

Immediately before the construction of any layer, the surface on which it is to be laid shall be tested for accuracy of formation and smoothness, and if any areas are found to be outside the specified tolerances such areas shall be scarified, reshaped, recompacted, broken out and replaced, or otherwise treated until the specified smoothness and accuracy are obtained.

Notwithstanding the above requirements, no layer of road construction shall have a thickness less than the thickness shown on Drawings.

2. PRODUCTS

2.1. GENERAL

Fill and backfill shall come, as much as possible, from excavations of nearby structures.

All the hereafter materials shall have the prior agreement of the Engineer.

2.2. GENERAL FILL

The material shall comply with the following requirements:

- Maximum diameter: 200 mm
- Fraction passing 0.074 mm sieve (square opening) ≤ 15%
- Plasticity index ≤ 15
- Organic matter content < 0.1%

2.3. SUB-BASE COURSE

It shall be approved material reasonably well graded complying with the following requirements:

- Maximum diameter: 50 mm.
- Plasticity: ≤ 15.
- Californian Bearing Ratio ≥ 25% at 95% of Proctor optimum density.
- Organic matter content ≤ 0.1%.

2.4. BASE COURSE

Base course material may be either naturally occurring sound hard gravels or crushed rock obtained from quarries.

The material shall comply with the following grading requirements:

Material size (in millimetres) (square openings)	Per cent finer by weight
40	100
30	90 - 100
20	70 - 100
10	50 - 80
5	30 - 60
2	20 - 40
0.2	5 - 20
0.075	2 - 15

In addition, the material shall meet the following test requirements:

- Dry density: ..... ≥ 17.5 kN/m³.
- Plasticity: ..... 6 ≤ IP ≤ 15.
- California Bearing Ratio: ..... ≥ 80% at 95% of Proctor optimum density.
- Los Angeles: ..... ≤ 30.
- Organic matter content:: ..... < 0.1%.

Where graded crushed stones are used, the following requirements shall be added:

- Flattening coefficient (NF P 18-561) ≤ 30.

2.5. STONE AGGREGATES FOR BITUMEN SEAL

Stone aggregates shall consist of clean, washed, dry, hard, angular, sound-crushed stones or crushed gravel of uniform quality, free from dust, clay, flat or laminated particles and from other detritus materials.

The grading requirements of the material shall be as follows:

Material size (in millimetres) (square openings)	Per cent finer by weight	
	Type A	Type B
20	100	85 - 100
10	85 - 100	0 - 7
2.4	0 - 2	0 - 2

In addition, the material shall meet the following requirements:

- Flattening coefficient (NF P 18-561) ≤ 30.

2.6. AGGREGATES FOR READY MIX ASPHALT-CONCRETE

The aggregate shall be of crushed gravel conforming to the following gradation:

Sieve size	Per cent passing
25.0 mm	100
20.0 mm	85 - 100
5.0 mm	45 - 65
2.5 mm	30 - 50
315 microns	12 - 23
80 microns	4 - 8

The portion of the total aggregate passing the 400 micron sieve shall have a plasticity index of not more than 6.

2.7. SEALING

The operations of final trimming of the formation, compaction of the sub-grade and placing and compaction of the granular sub-base and rod base shall be carried pit without intermediate delays.

2.8. CONTROLS

The frequency of the tests shall be as required by the Engineer according to the results of previous tests and material variations.

3. EXECUTION

3.1. INSPECTION

No excavation and fill shall start without prior agreement of the Engineer.

3.2. GENERAL

All fill operations shall be performed in the dry.

The fill materials shall be placed in such a manner as to ensure that they can be satisfactorily compacted without damage to adjacent structures.

Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within 50 cm vertically of the surface of the concrete.

A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

Moisture content of materials may have to be adapted by drying or moistening operations, in order to fulfil the requirements of the present Specification.

3.3. INVESTIGATIONS

The Contractor shall carry out, if necessary, all surveys and investigations required for a proper and safe execution of the Works

3.4. GENERAL FILL

Prior to any fill, area of the embankment shall be cleared and stripped as required in Section 02100 "Site preparation" or otherwise directed by the Engineer.

Placing and compaction shall be adapted to the material used according to its grading and plasticity in order to achieve a CBR value in situ more than or equal to 25%.

Placing and compaction for earthfill materials

1. Selected compacted fill shall be placed in layers not exceeding 300 mm and at least 1.5 time $D_{maximum}$.

2. Each layer shall be compacted by means of a vibrating smooth drum roller so as to achieve a dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{max}}} \geq 95\%$$

with:

γ_d: field dry density

γ_{dmax}: standard Proctor maximum dry density

3. Placement moisture content of the material shall be so that:

$$-2 \leq W - W_{opt} \leq +2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt}: optimum moisture content of the standard Proctor compaction test.

4. Placing and compaction of rockfill materials
   a) The maximum lift thickness shall be 300 mm and at least 1.5 time $D_{maximum}$.
   b) Each layer shall be compacted by means of a vibrating smooth drum roller, so as to achieve a relative density in the range of 60 to 70%.
   c) The relative density shall be determined by the USBR Method Designation E12.
   d) If necessary to achieve the compaction requirements the material shall be wetted.

3.5. SUB-GRADE PREPARATION

Prior to receiving the base course or sub-base course, the sub-grade shall be graded to the line and levels shown in the Contractor's approved drawings and the surface shaped to the same profile as the finished surface of the road.

Once the required level is obtained, the sub-grade material shall be compacted to a depth of 300 mm minimum.

Compaction shall be achieved by means of a smooth drum vibrating roller with the following minimum characteristics:

- Minimum static weight 8t
- Drum diameter ..... not less than 1500 mm
- Minimum static weight per metre of drum 3.5t

The number of passes shall be adapted to the material.

- All soft areas shall be cut out and filled with approved material brought to the correct level after compaction.
- The Contractor shall perform some tests in order to prove that compaction depth can be reached as required.

3.6. SUB-BASE COURSE

In-situ CBR tests shall be made as required in paragraph 3.11 "Controls" or as directed by the Engineer to determine the necessity for a sub-base layer either on natural ground or embankments.

If CBR $\geq$ 25%: no sub-base required.

If 25 > CBR $\geq$ 10%: sub-base 200 mm minimum thickness.

If CBR < 10%: sub-base 300 mm minimum thickness.

The sub-base course material shall be spread longitudinally in uniform layers not exceeding 150 mm loose thickness.

Each layer shall be compacted to the following standards:

a. Dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{max}}} \geq 95\%$$

with:

γ_d = field dry density

γ_{dmax} = standard Proctor maximum dry density

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt}: optimum moisture content of the standard Proctor compaction test.

CBR ≥ 25% shall be achieved for the sub-base course to be approved.

3.7. BASE COURSE

Base course shall generally be the wearing course.

The Contractor may propose to add cement to the base course material as described in Part II "Products", in order to:

- reduce moisture content of the material;
- improve the characteristics of the base course and thus diminish the quantities used and/or diminish the maintenance.

The base course material shall be spread longitudinally in uniform layers not exceeding 200 mm loose thickness.

Each layer shall be compacted to the following standards:

a. Dry density:

with:

γ_d = field dry density

γ_{dmax} = standard Proctor maximum dry density

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt}: optimum moisture content of the standard Proctor compaction test.

CBR ≥ 80% shall be achieved for the base course to be approved.

3.8. BITUMEN SURFACING (DOUBLE LAYER LINING)

3.3.1. GENERAL

Where required on drawings, the surface of roads and platform shall be covered with a bitumen seal as specified herein.

This work shall consist of a prime coat and two seal coats covered with stone aggregate. The bitumen shall be applied using a mechanical bitumen sprayer, capable of providing a uniform bitumen film at the rates specified.

The bitumen shall be sprayed at the temperatures approved by the Engineer. The Contractor shall take all necessary safety precautions when handling bitumen.

Bitumen surfacing may also be termed seal coat.

3.3.1. APPLICATION

1. The rates of application of prime and seal coats are as specified below, subject to approval or modification by the Engineer based on the results of trial sections to be prepared by the Contractor prior to the commencement of surfacing works. Such rates and order application shall be:
    a) The bituminous prime coat shall be a medium curing bitumen cutback, MC 30, applied at a rate of 1.0 litre per square metre to the surface of the base course for the road carriageway width.
    b) The first seal coat, a binder coat, shall be straight run bitumen 80/100 applied at a rate of 1.0 litre per square metre and covered with 20 mm stone aggregate (type B) at a rate of 16 litres per square metre.
    c) The second seal coat shall be straight run bitumen 80/100 applied at a rate of 0.9 litre per square metre and covered with 10 mm stone aggregate (type A) at a rate of 10 litres per square metre.

2. Immediately before the application of the prime coat, the surface of the base course material shall be swept clean of all loose material to the satisfaction of the Engineer using soft-haired brushes and the material brought to a damp condition by a light sprinkling of water as necessary.

3. The prepared base course shall be primed and the first seal coat shall not be applied until the prime coat has been left to for a period sufficient to allow it to dry thoroughly but in any event not less than 24 hours after the application of the prime coat.

4. Traffic shall not be permitted to use the primed surface unless the surface is adequately protected to the approval of the Engineer. Notwithstanding such protection, traffic shall not run over a primed base during its period of curing.

5. Before the application of the first seal coat the primed surfaced shall be thoroughly examined and any weak or damaged areas shall be made good by cutting out the unsatisfactory material and replacing it and re-priming the affected area to the approval of the Engineer.

6. Repaired areas shall be at least equal in standard to and integral with the rest of the primed surface.

7. Immediately before application of the first seal coat, the primed surface shall be brushed and thoroughly cleaned to the approval of the Engineer. The rate of application of bitumen shall be as directed by the Engineer and shall be within ± 10% of the specified rate as measured by the Road Tray Test.

8. The Contractor shall ensure that the coverage of the bitumen is even and complete, that the joints between spraying strips are straight and that not bitumen is sprayed on adjacent complete surfacing. There shall be no areas of the binder coat with an excess or deficiency of bitumen. Any sections with a deficiency shall be resprayed, and in sections with an excess of binder the material shall be removed by burning off and the section resprayed all to the approval of the Engineer.

9. Prior to the commencement of spraying of surface, a strip of paper 2 m wide or similar protection shall be laid over the previous section and the bitumen sprayer shall commence spraying from over this strip. Protection shall also be laid on the shoulders to ensure that the surface dressing terminates at the edge of the carriageway and forms a neat line.

10. Rolling shall commence at the edge of the carriageway and proceed in a longitudinal direction. Immediately following the application of the binder coat of bitumen the surface shall be covered with approved stone aggregate. The rate and method of spreading the stone aggregate shall be such that a finished appearance of a closely-knit mosaic of stone particles firmly adhering to the bitumen shall be achieved, with individual aggregate grains in contact with their adjacent grains.

11. The surface shall be rolled with an approved pneumatic typed roller immediately after the application of the stone aggregate. Overlap on successive passes shall be at least half the width of the roller.

12. The completed bitumen surfacing layer shall be evenly textured and graded, show no lean or fat areas and shall not have any areas which will allow the accumulation of water.

13. Bitumen surfacing shall not be carried out when the road temperature is below 20°C.

14. All stone aggregate shall be dry and free from deleterious matter. Where stone aggregate has become dusty in transit or in the stockpile, they shall be cleaned to the Engineer's satisfaction.

3.9. ASPHALTED ROADS

Where ordered by the Engineer, the roads and platforms shall be built according to the drawings and the following specifications:

1. A cutback (liquid asphalt of medium curing MC 70) shall be sprayed over the base at a rate of 0.7 to 1 kg per square metre.

2. A 5 cm wearing course shall be made of a ready mix asphalt-concrete spread with a grader or finisher and then compacted; the wearing course shall have the following characteristics:
   a) Aggregates as specified in section 2.
   b) Content of asphalt penetration grade 60/70 (ASTM D946) shall be between 4 and 6 percent.
   c) Marshall stability test (ASTM D1559) shall not be less than 3250 newtons and the flow value less than 16 hundredths of an inch (4 mm).
   d) Degree of compaction not less than 97 percent of the standard specimen specific gravity (ASTM D1074).

3. A 4 cm finishing course shall be made of a ready mix asphalt concrete of finer grading spread with finisher and then compacted as specified for the wearing course.

3.10. RELATED WORKS

3.3.1. KERB KAYING

Edges shall be of type T4 according to EN 1340 and NFP 98 340/CN, with mass concrete and standard grey facing. They shall be made of prefabricated concrete sections 1.00 m and exceptionally 0.33 m long.

Precast concrete kerbs shall be laid true to line and level and any kerb found to be more than 5 mm out of line or level at either end shall be lifted and relaid.

Kerbs shall be bedded on a layer of concrete Type B, 20 cm thick , laid on a concrete foundation and shall be backed with concrete shaped up to the required cross-section, all as detailed on the Drawings.

Specially cast radiused kerbs shall be used on curves of 12 m radius or less.

Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with performed joint filler 13 mm thick. Expansion joints shall be carried trough the concrete backing and foundation.

Kerbs shall be made with concrete class B according to Section 03300.

3.3.1. FOOTHPATHS

The formation and sub-grade footpaths shall be prepared as specified for roads, except that proof-rolling will not be required.

Edging to footpaths shall be of precast concrete. It shall be bedded in a shaped up concrete foundation.

No sub-base will be required for footpaths. The base shall be as specified for road base, laid and compacted to a minimum thickness of 75 mm using a roller of not less than 2.5 tons mass or other approved equipment giving equivalent compaction.

Where a flexible final surface is specified that base course shall be sealed with a coat of cut-back bitumen, 100 sec grade sprayed on at the rate of 1.4 l/m² and shall be covered by a wearing course of 6 mm nominal size medium textured wearing course macadam not less than 25 mm thick made and laid in accordance with BS 4987.

Where concrete flags are specified as the final surface, they shall be bedded on a layer of sand approximately 50 mm thick, laid on the base course. Joints shall be made with 3:1 sand/cement mortar. Paths surfaced with concrete flags will not normally have precast concrete edging.

3.3.1. ROAD MARKINGS

Where shown on the Drawings or directed by the Engineer, the Contractor shall paint markings on the completed road surfaces.

Before paint is applied, the road surface shall be thoroughly cleaned and dried to remove all dust and other deleterious matter.

Except where otherwise specified all lines shall be 100 mm wide. All lines shall be premarked with dots at approximately 3 m centres on straight lines and 1 m centres on curves. Lines on curves shall not be formed by a series of straight sections around the curve. The alignment shall not deviate more than 20 mm in 25 m. The width of the lines shall not be varied more than plus or minus 6 mm from the specified width.

The paint shall be applied with due regard to the Manufacturer’s instructions. Lines and other road marking shall be applied uniformly and shall have sharply defined edges without runs or spatters.

3.11. CONTROLS

The following controls shall be made on materials either placed or in situ:

Test	Sub-grade	Sub-base	Base
Californian bearing ratio (in situ)	1 per 100 m³	1 per 100 m³	1 per 100 m³
Density of soil in place	-	1 per 200 m³	1 per 200 m³

Nuclear method may be used for testing density of soil in place.

The frequency and nature of the tests may be amended as required by the Engineer depending on the results of previous tests, material variations or climatic conditions.

3.12. MAINTENANCE WORKS

The Contractor shall properly maintain all roads, both permanent and temporary at the Engineer's satisfaction.

Such maintenance shall include all things necessary to maintain the roads in an operational and safe condition for the vehicle and weather condition for which the particular road is designed, and shall include, but not limited to, repairs to foundation and road surface, clearing of drains, repairing or supplementing signs, and clearing and stabilizing batter and fill slips.

Upon completion of the Contract and before the issue of Taking Over Certificate, all roads constructed, upgraded and/or used by the Contractor shall be left in good condition to the satisfaction of the Engineer.

The asphalt works for the required permanent roads shall be done at the end of works, when the circulation of heavy trucks is not likely to occur. If the Sub-base or Base courses are damage during construction works, the Contractor shall repair it according to the specifications and at the satisfaction of the Engineer before asphalt works. For temporary roads, the Contractor can propose a design different from the specifications, provided he demolishes it at the end of works to build the permanent roads according to the specifications. In all cases, the price items for roads in the Bill of Quantities include all temporary, maintenance and permanent road works.

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SECTION 02240
GEOTEXTILE

1. GENERAL

1.1. SCOPE

This specification is applicable to all required geotextile

1.2. RELATED WORKS

These works must be carried out in compliance with all the other specifications included in the contract.

1.3. REFERENCED DOCUMENTS

ASTM Standards :

1.	D 123	Standard Terminology Relating to Textiles
2.	D 276	Test Methods for Identification of Fibers in Textiles
3.	D 3786	Test Method for Hydraulic Burst Strength of Knitted Goods and Nonwoven Fabrics, Diaphragm Bursting Strength Tester Method
4.	D 4354	Practice for Sampling of Geosynthetics for Testing
5.	D 4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon Arc Type Apparatus)
6.	D 4439	Terminology for Geosynthetics
7.	D 4491	Test Methods for Water Permeability of Geotextiles by Permittivity
8.	D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
9.	D 4751	Test Method for Determining Apparent Opening Size of a Geotextile
10.	D 4759	Practice for Determining the Specification Conformance of Geosynthetics
11.	D 4833	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
12.	D 4873	Guide for Identification, Storage, and Handling of Geotextiles
13.	D 5141	Test Method to Determine Filtering Efficiency and Flow Rate for Silt Fence Applications Using Site Specific Soil

1.4. SCHEDULE

In addition to the general schedule, the Contractor shall hand the Engineer a precise schedule for laying the various geotextiles with the corresponding layout drawing.

2. PRODUCTS

2.1. PHYSICAL AND CHEMICAL REQUIREMENTS

A. Fibers used in the manufacture of geotextiles and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers, composed of at least 95% by weight polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

B. Geotextile Requirements. The geotextile shall meet the requirements of following List. Woven geotextiles will not be allowed. All numeric values in the following table, except AOS, represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values). Values for AOS represent maximum average roll values.

The filtration geotextile should comply with the following characteristics:

- Non-Woven geotextile
- Mass per unit area : at least 400 g/m²
- Thickness (standard NF EN 964-1): 3mm
- AOS (Apparent Opening Size) as per ASTM D 4751 : 0.42 mm (±10%)
- POA (Percent Open Area) : at least 10%
- Permeability > 0.09 m/s
- Grab tensile strength : 1500 N
- Trapezoidal tear strength : 750 N
- Puncture strength : 750 N
- Gradient Ratio test (ASTM D5101). Ratio should be <2.5.

2.2. CERTIFICATION

A. The Contractor shall provide to the Engineer a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns and other pertinent information to fully describe the geotextile.

B. The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request.

C. The Manufacturer's certificate shall state that the furnished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program. The certificate shall be attested to be a person having legal authority to bind the Manufacturer.

D. Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products.

2.3. SAMPLING, TESTING AND ACCEPTANCE

A. Geotextiles shall be subject to sampling and testing to verify conformance with this specification. Sampling for testing shall be in accordance with ASTM D 4354. Acceptance shall be based on testing of either conformance samples obtained using Procedure A of ASTM D 4354, or based on manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D 4354. A lot size for conformance or quality assurance sampling shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

B. Testing shall be performed in accordance with the methods referenced in this specification for the indicated application. The number of specimens to test per sample is specified by each test method. Geotextile product acceptance shall be based on ASTM D 4759. Product acceptance is determined by comparing the average test results of all specimens within a given sample to the specification MARV. Refer to ASTM D 4759 for more details regarding geotextile acceptance procedures.

2.4. SHIPMENT AND STORAGE

A. Geotextile labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style number, and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

B. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

C. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71EC (160EF), and any other environmental condition that may damage the physical property values of the geotextile.

3. EXECUTION

3.1. GENERAL

Atmospheric exposure of geotextiles to the elements following lay down shall be a maximum of 14 days to minimize damage potential.

3.2. JOINTING

Jointing of geotextiles shall be by overlap or by sewing. Unless otherwise specified the minimum overlap shall be 500mm. Where the geotextile is used for drainage blankets the encapsulated overlap shall be one metre unless otherwise specified.

As an alternative to overlapping, sewing of the joints is permitted. Sewing of the joints shall comply with:

- Seam type: J - seam or Double -J- seam
- Stitch type: Lock stitch. One or two lines of lock stitching to suit the application and site conditions.
- Thread type: Polyester thread 300 tex (minimum).

Depending on the ground conditions and the intended function of the Geotextile, the Contractor can propose other method of jointing for Engineer' review and approval.

3.3. PREPARATION OF FORMATION LEVEL

Before installing the geotextile, the following points must be checked:

- The area must be cleaned and compacted so that it is free of any vegetation, irregularity, depression or sudden change in elevation.
- The surface must be cleared of all roots, rocks more than 50 mm in diameter and other debris.
- No surface must have suffered excessive erosion due to water or wind.
- The water content must not be excessive at any point on the surface.
- The surface must not display any shrinkage cracks beyond the project specifications.

Anchor points in the waste must not have been leveled and must be situated in waste that has not been reworked in situ.

At each stage, the Geotextile Installer must confirm in writing that the state of the formation level on which the geotextile are placed is acceptable. The acceptance certificate must be sent to the Engineer before any geotextile is deployed on the surface in question.

The acceptance certificate report concerning the foundation levels must include at least the following information:

- - Date and time,
- - Description of the accepted area(s),
- - Sketch indicating the accepted area(s),
- - Partial or complete acceptance,
- - Comments,
- - Name and signature of the Geotextile Installer's representative.

3.4. TRENCH

Trench excavation shall be done in accordance with details of the project drawings. In all instances excavation shall be done in such a way so as to prevent large voids from occurring in the sides and bottom of the trench. The graded surface shall be smooth and free of debris.

3.5. GEOTEXTILE PLACEMENT

A. In placement of the geotextile for filtration applications, the geotextile shall be placed loosely with no wrinkles or folds, and with not void spaces between the geotextile and the ground surface. Successive sheets of geotextiles shall be overlapped a minimum of 300 mm, with the upstream sheet overlapping the downstream sheet.

1. When required in trenches equal to or greater than 300 mm in width, after placing the drainage aggregate the geotextile shall be folded over the top of the backfill material in a manner to produce a minimum overlap of 300 mm. In trenches less than 300 mm but greater than 100 mm wide, the overlap shall be equal to the width of the trench. Where required in trench less than 100 mm the geotextile overlap shall be sewn or otherwise bonded. All seams shall be subject to the approval of the Engineer.

2. Should the geotextile be damaged during installation, or drainage aggregate placement, a geotextile patch shall be placed over the damaged area extending beyond the damaged area a distance of 300 mm, or the specified seam overlap, whichever is greater.

B. At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacturer, transportation or storage.

C. Filtration geotextile shall not be placed during strong winds (4 m/s).

D. The geotextile shall be free of tensile stresses folds, and wrinkles.

E. The geotextile is ballasted after positioning. The Contractor chooses the most appropriate ballasting method for site conditions and the expected winds. He may use bags of soil or tires. The Contractor shall be responsible for the supply, placement and removal of the ballasting.

F. The deployed geotextile should not be exposed over the maximum allowable exposure time specified by the Manufacturer. If the allowable exposure time has been exceeded, a joint inspection shall determine if the geotextile has been damaged. If needed, additional CQA tests will be requested to verify the physical properties of the textile have not diminished due to exposure.

3.6. DRAINAGE AGGREGATE

When applicable (as shown on drawings), placement of drainage aggregate should proceed immediately following placement of the geotextile. The geotextile should be covered with a minimum of 300 mm of loosely placed aggregate prior to compaction. If a perforated collector pipe is to be installed in the trench, a bedding layer of drainage aggregate should be placed below the pipe, with the remainder of the aggregate placed to the minimum required construction depth.

3.7. SITE VERIFICATION

A. The installation of the filtration geotextile will be inspected by the Contractor's representative in presence of the Engineer: visual inspection of the placement and aspect, measurement of the overlap, ballasting.

B. If the installation does not comply with the specification and rules of the art, the Contractor will be responsible to make necessary correction including replacement at no cost for the Employer.

SECTION 02250
GEOMEMBRANE

1. GENERAL

1.1. SCOPE

This section is applicable to all the required geomembrane.

1.2. DEFINITIONS

A. "Regrind" and "Trim": Finished geo-membrane sheet material that was cut from the edges or ends of rolls during the manufacturing process, or is off-specification material due strictly to thickness or surgical blemishes.

B. "Reclaimed" or "Recycled": Materials which have been shipped from the manufacturing facility, rejected, and returned for reuse, or material which has actually seen some type of field service and has been returned to be remanufactured into new geo-membrane.

C. "Crazing": Hairline cracks that may form when HDPE geo-membranes are folded creased or pinched.

1.3. STANDARDS

The design and construction shall comply with ASTM or Equivalent DIN/ISO/EN.

1. ASTM D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
2. ASTM D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting
3. ASTM D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
4. ASTMD 1505 Test Method for Density of Plastics by the Density-Gradient Technique
5. ASTM D 1603 Test Method for Carbon Black in Olefin Plastics
6. ASTM D 3895 Test Method for Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
7. ASTM D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
8. ASTM D 4833 Test Method for Index Puncture Resistance of Geo-textiles, Geo-membranes, and Related Products

9. ASTM D 5199 Test Method for Measuring Nominal Thickness of Geo-textiles and Geo-membranes

10. ASTM D 5397 Evaluation of Stress Crack Resistance of Polyolefin Geo-membranes Using Notched Constant Tensile Load Test

11. ASTM D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geo-synthetics

12. ASTM D 5721 Practice for Air-Oven Aging of Polyolefin Geo-membranes

13. ASTM D 5885 Test Method for Oxidative Induction Time of Polyolefin Geo-synthetics by High-Pressure Differential Scanning Calorimetry

14. ASTM D 5994 Test Method for Measuring Core Thickness of Textured Geo-membrane

15. ASTM D 6693 Test Method for Determining Tensile Properties of Nonreinforced PE and Nonreinforced flexible PP geomembranes

16. GRI Test Method GM-10 Specification for the Stress Crack Resistance of Geomembrane sheet

17. GRI Test Method GM-11 Accelerated weathering of geomembranes using a fluorescent UVA-condensation exposure device

18. GRI Test Method GM-12 Asperity Measurement of Textured Geo-membranes Using a Depth Gauge

    (GRI: Geosynthetic Research Institute)

2. PRODUCTS

2.1. CHARACTERISTICS OF THE GEOMEMBRANE

A. The supplied geomembrane shall comply with the following characteristics:

1. Nature :HDPE smooth membrane,

2. Nominal density : high density 0.940 to 0.959 g/ccm, as per ASTM D1505 / ASTM D 792 (Method B)

3. Nominal thickness: 1.5mm minimum thick sheet per ASTM D5199 for smooth geomembrane. Tolerance are as specified in table (2) for textured geomembrane and table (3) for smooth geomembrane.

4. Raw materials: virgin PE resin (97 to 98%) and Carbon Black (2 to 3% per ASTM D 1603)

5. Carbon Black Dispersion : Categories 1, 2 and 3 per ASTM D 5596

6. Tensile properties : see table (ASTM D 6693)

7. Uniform in color (black)

8. UV treated, weather resistant, durable,

9. Watertight, and free from pinholes, blisters and contaminants.

10. -Compatible with the disposal of waste and mechanically acceptable considering the geotechnical data

11. HDPE sheets as wide as possible to minimize field seams (not less than 5 m wide).

12. The geomembrane sheets that are to be installed on the bottom of the Class II cells and in the leachate evaporation ponds shall be smooth.

13. The sheets shall be free of and resistant to fungal or bacterial attack and free of cuts, abrasions, holes, blisters, contaminants and other imperfections.

14. Geo-membrane sheets and seams shall conform to the requirements listed in Tables 1, 2 and 3 for Manufacturing Quality Control (MQC) and Construction Quality Control (CQC) or equal specification standard references mentioned.

B. HDPE sheets should be manufactured by one of the following method:

a. flat die calendaring extrusion method from virgin PE resin ,or

b. blown film process.

C. The surface structure shall be formed during one production run and shall be different each surface side to support the chosen layer combination by increasing of the internal shear interaction from top side to bottom side.

D. The contractor shall specify the nature and characteristics of the geomembrane in his technical proposal and shall justify his choice considering the particular constraints of the project.

E. The following remarks are a must in manufacturing:

a. Each roll produced shall have its own test certificate

b. The rolls being manufactured are to be labeled in printing with 'RC RAZ landfill' project name, thickness, roll dimensions, day of manufacturing, roll no. and manufacturer name and mark.

c. Bill of lading

2.2. QUALITY CONTROL PRIOR TO SHIPMENT OR INSTALLATION OF THE GEOMEMBRANE

2.2.1. MANUFACTURING, SAMPLING AND TESTING

A. Raw materials shall be tested in accordance with the approved MQC manual. Any raw material which fails to meet the geo-membrane manufacturer's specified physical properties shall not be used in manufacturing the sheet. Seaming rods and pellets shall be manufactured of materials which are essentially identical to that used in the geo-membrane sheet. Seaming rods and pellets shall be tested for density, melt index and carbon black content in accordance with the approved MQC manual. Seaming rods and

pellets which fail to meet the corresponding property values required for the sheet material, shall not be used for seaming.

B. Geo-membrane sheets shall be tested in accordance with the approved MQC manual. As a minimum, MQC testing shall be conducted at the frequencies shown in Table (1) and Table (2).Sheets not meeting the minimum requirements specified in Table (1) and Table (2) shall not be sent to the site.

2.2.2. INTERFACE FRICTION TESTING

A. Laboratory interface friction tests shall be conducted on the following interfaces (The interfaces may be tested together in lieu of using two separate tests):

- Textured HDPE Geo - membrane (1.5 mm thick) / Protection geotextile.

- Textured HDPE Geo - membrane (1.5 mm thick) / Leak control geogrid

B. The test should be performed by an authorized laboratory.

C. Tests shall be conducted in accordance with DIN 18 137. Normal stresses of 10, 30 and 60 kN shall be considered Soil components shall be the same as used for full scale construction and shall be compacted to the same moisture-density requirements specified for full-scale field placement. Soil components shall be saturated prior to shear. Geo-synthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field. A minimum residual interface friction angle of 10 degrees is required for all interfaces.

2.2.3. SUBMITTALS BY THE CONTRACTOR

A. The following information shall be submitted by the Contractor to the Engineer before the deployment of any geomembrane to ensure that the materials and subgrade preparation meet the requirements of this specification:

1. Product data for geomembrane and seaming adhesive, solvent and extrusion

2. Standards of materials and Manufacturer

3. Manufacturing and field installation quality control and quality assurance plans at least fourteen (14) days prior to geomembrane shipment

4. Shop drawings showing fabrication and installation details for geomembrane liner: lay-out, seams, penetrations, anchorage, methods of sealing to other construction… The drawings shall clearly differentiate the factory and field seams and joints.

5. Type of product delivery (width and length of rolls…)

6. Samples : not less than one 30 cm long seam of factory-bonded seam

7. Installer certificates signed by the manufacturer certifying that the Installer complies with requirements.

8. Manufacturer's certified raw material test reports and a copy of the MQC certificates, a minimum of fourteen (14) days prior to shipment of geo-membrane to the site.

9. Manufacturer's certified sheet material test reports and a copy of the MQC certificates, a minimum of fourteen (14) days prior to shipment of geo-membrane to the site showing the compliance of the shipped products with all specifications as stated in Table 1, provided by a third party independent inspection agency.

10. Statement of qualifications for firms and persons to demonstrate their capabilities and experience, including a list of completed projects with project names, areas, type of materials, names and addresses of clients…

B. All materials delivered to the site shall be tested at an approved laboratory at the Contractor's cost. If a sample fails, a second and third samples are tested. If the second or third sample fails, the roll from which the sample is taken is to be rejected.

Tabl. 1 - TECHNICAL SPECIFICATIONS OF HIGH DENSITY POLYETHYLENE (HDPE) TEXTURED GEO MEMBRANE (1.5 MM)

Properties	Test Method ASTM	Test Value (2.0mm)	Testing frequency
Thickness mils (min . ave.) * lowest individual for 8 out of 10 values . * lowest individual for any of the 10 values .	D 5994	nominal (- 5%) -10% - 15%	Per roll
Asperity height mile (min .ave.)(1)	GM12	0.25mm	Every 2nd roll (2)
Density (min . ave)	D1505 /D792	0.94 g/cc	90.000kg
Tensile properties (min ave) (3) * yield strength . * break strength * yield elongation * break elongation	D6693 Type IV	 22 KN / m 16 KN /m 12% 100%	9.000 kg
Tear Resistance (min .ave)	D 1004	187N	20.000Kg
Puncture Resistance (min .ave.) .	D4833	400N	20.000Kg
Stress crack resistance (4)	D 5397(APP)	300hr	Per GRI GM10
Carbon black content (range)	D 1603 (5)	2.0-3.0%	9.000 kg
Carbon black dispersion	D 5596	Note (6)	20.000 kg
Oxidative introduction time (OIT) (min .ave) . (7) (a) standard (OIT) (b) high pressure (OIT) (Min. ave) - retained after 90days	 D 389 D5885	 100 min 400 min	90.000 kg
Oven Aging at 85ºc (7), (8) . a- standard (OIT) (min .ave.) - % retained after 90 days . b- high pressure(OIT) (min .ave.) - % retained after 90 days.	D5721 D3895 D5885	55% 80%	Per each Formulation
UV Resistance (9) (a) Standard (OIT)(min.ave.) - or – (b) High Pressure (OIT)(min.ave.)-% retained after 1600 hrs (11)	GM11 D3895 D5885	 N.R (10) 50%	Per each Formulation

(1). of 10 reading ; 8 out of 10 must be > 0.18 mm , and lowest individual reading must be > 0.13 mm.

(2). Alternate the measurement side for double sided textured sheet .

(3). Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 33mm. Break elongation is calculated using a gage length of 50mm.

(4). The SP-NCTL test is not appropriate for testing geomembrane with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP- NCTL test should be the manufactures mean value via MQC testing .

(5). Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established .

(6). Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in categories 1or 2 and 1 in category 3.

(7). The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane .

(8). It is also recommended to evaluate sample at 30 and 60 days to compare with the 90 day response.

(9). The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hours condensation at 60°C .

(10). Not recommended since the high temperature of the Std –OTI test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11). UV resistance is based on percent retained value regardless of the original HP-OIT value.

Tabl. 2 - TECHNICAL SPECIFICATIONS OF HIGH DENSITYPOLYETHYLENE (HDPE) SMOOTH GEOMEMBRANE (1.5 MM)

Properties	Test Method ASTM	Test Value (2.0mm)	Testing frequency
Thickness mils (min . ave.) * lowest indivual of 10 values .	D 5199	nom (mil) -10%	Per roll
Density (min)	D1505 /D792	0.94 g/cc	90.000kg
Tensile properties (min ave) (1) * yield strength . * break strength * yield elongation * break elongation	D6693 Type IV	 22 KN / m 40 KN /m 12% 700%	9.000 kg
Tear Resistance (min .ave)	D 1004	187N	20.000Kg
Puncture resistance (min .ave)	D4833	480N	20.000Kg
Stress crack resistance (2)	D 5397(APP)	300hr	Per GRI GM10
Carbon black content %	D 1603 (3)	2.0-3.0%	9.000 kg
Carbon black dispersion	D 5596	Note (4)	20.000 kg
Oxidative introduction time (OIT) (min .ave) . (5) (a) standard (OIT) (b) high pressure (OIT) (Min. ave) - retained after 90days	 D 3895 D5885	 100 min 400 min	90.000 kg
Oven Aging at 85ºc (5), (6) . a- standard (OIT) (min .ave.) - % retained after 90 days . b- high pressure(OIT) (min .ave.) - % retained after 90 days.	D5721 D3895 D5885	 55% 80%	Per each Formulation
UV Resistance (7) (a) Standard (OIT) (min.ave.) - or – (b) High Pressure (OIT)(min.ave.)-% retained after 1600 hrs (9)	GM11 D3895 D5885	 N.R (8) 50%	Per each Formulation

(1). Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction .

Yield elongation is calculated using a gage length of 33mm.

Break elongation is calculated using a gage length of 50mm

(2). The yield stress used to calculate the applied load for the SP- NCTL test should be the manufactures mean value via MQC testing .

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.

(4). Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in categories 1or 2 and 1 in category 3.

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6). It is also recommended to evaluate sample at 30 and 60 days to compare with the 90 day response.

(7). The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hours condensation at 60°C.

(8). Not recommended since the high temperature of the Std –OTI test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9). UV resistance is based on percent retained value regardless of the original HP-OIT value.

Tabl. 3 - TESTS TO BE PERFORMED IN THE COURSE OF INTERNAL TESTING AND EXTERNAL SUPERVISION; MINIMUM FREQUENCY

Property	Test according to (or equivalent to)	Frequency of internal testing	Frequency of external testing
Marking	as specified	each roll	once a year
general properties	ISO 1133	twice per shift	once a year
straightness, flatness	ISO 1133	once a week	once a year
Nominal thickness	Max. deviation of individual values from the mean, max. 10% lowest individual value= nominal thickness	each roll	once a year
material identification	ONORM S 2073	as specified	once a year
melt mass flow rate	ISO 1133/18	twice a week	once a year
carbon black content	ISO 6964) 1)	twice a week	once a year
resistance to tear strength	DIN 53 563	once a week	once a year
Puncture resistance	DIN 16 726		once a year
Resistance to punctual, quasistatical, individual loads	ONORM S 2073 perforation force DB 1≥ 6000N		once a year
low temperature brittleness	DIN 16 726, no cracks at -20°		once a year
uniaxial tensile strain	DIN EN ISO 527	once a work day	once a year
multi-axial tensile strain	ONORM S 2073		once a year
change in dimension after heat reversion test	ONORM S 2073	twice a week	once a year
behaviour after aging at high temperatures	ONORM S 2073		once a year

3. EXECUTION

3.1. PREPARATION

A. Geomembrane is to be installed over a protection geotextile. Each day during placement of geo-membrane, the Project Manager and the Contractor (Installer) shall inspect the surface on which geo-membrane is to be placed and certify in writing that the surface is acceptable. In case of need, repairs to the subgrade shall be performed at no additional cost.

B. Anchor Trenches: where an anchor trench is required, it shall be placed at least 60cm far from the edge of slope as shown on the Drawings. The anchor trench shall be constructed of the depth and width shown on the Drawings. Only the amount of anchor trench required for placement of geomembrane in a single day shall be excavated. Ponded water shall be removed from the anchor trench while the trench is open. Trench corners shall be slightly rounded to avoid sharp bends in the geo-membrane. Loose soil, rocks larger than twelve and a half (12.5) mm in diameter, and any other material which could damage the geo-membrane shall be removed from the surfaces of the trench. The geo-membrane shall extend down the front wall and across the bottom of the anchor trench. Backfilling and compaction of the anchor trench shall be in accordance with Specification.

3.2. INSTALLATION CONDITIONS

A. The Contractor shall proceed with installation only when existing and forecasted weather conditions permit placement and seaming of geomembrane to be performed according to the specifications, the manufacturers' written instructions and the warranty requirements.

B. Geo-membrane should not be placed or seamed during conditions of rainfall, excessive atmospheric moisture, blowing dust, strong wind (>4m/s), or at temperatures outside any of recommended ranges (5°C to 35°C, 25°C for seams).

3.3. GEOMEMBRANE DEPLOYMENT

A. Geosynthetic materials are positioned:

1. When all earthworks and civil works in the cell have been finished,
2. After joint acceptance and reception of the support structure (in accordance with the requirements recommended by the supplier and the specifications),
3. When rigid structures to which the geosynthetic materials are connected have been prepared for this purpose,
4. When anchor trenches have been excavated,
5. When the necessary ballasting materials are present on the site.

B. Unwinding the rolls must be done in such a way that subsequent anchorage and assembly operations can be done correctly. The assembly must be made quickly after unwinding the rolls, not more than 12 hours after unwinding.

C. A number is assigned to each laid strip, in accordance with the design placement drawing. This number is marked on the as-built drawing.

D. The Contractor shall:

1. Respect overlap widths between strips so that he can make seams or assemblies without additional repositioning,

2. Position the assembly line on the embankment along the line of greatest slope,

3. Avoid horizontal assemblies on embankments and berms,

4. Avoid all «drum skins» at the bottom of embankment,

5. Wherever possible, avoid triple points at the bottom of embankment.

E. The geomembrane shall be placed to minimize mechanical tensile and compression forces in the placement plane, particularly after waste has been put into landfill.

F. Precautions shall be taken to prevent damage to the protection geotextile by restricting the use of heavy equipment over the liner system. The installation can be done by using a lightweight, rubber-tired equipment such as a 4-wheel drive vehicle, directly on the geotextile, under the condition that this vehicles does not make any sudden stops, starts or turns.

G. Where a textured geomembrane is placed over geotextile, a smooth slip sheet shall be placed over the geotextile in order to allow the geomembrane to slide into its proper position. Once the overlying geomembrane is properly positioned, the slip-sheet shall be carefully remove, paying close attention to avoid any movement of the geomembrane.

H. The procedures and equipment used shall not elongate, wrinkle, scratch, or otherwise damage the geo-membrane or underlying subgrade. Geo-membrane damaged during installation shall be replaced or repaired, at the Engineer's discretion. Only geo-membrane panels that can be anchored and seamed together the same day shall be deployed. Adequate ballast (i.e., sand bags) shall be placed on the geo-membrane, without damaging the geo-membrane, to prevent uplift by wind. No equipment shall be operated on the top surface of the geo-membrane without permission from the Engineer. When a vehicle is permitted to operate on the geomembrane, a protective layer of fine materials of at least 60cm shall be placed before by the Contractor where the equipment has to operate.

I. Seams shall be oriented parallel to the line of maximum slope. Where seams can only be oriented across the slope, the upper panel shall be lapped over the lower panel.

J. The methods used to deploy and backfill over the geo-membrane shall minimize wrinkles and tensile stresses in the geo-membrane. The geo-membrane shall have adequate slack to prevent the creation of tensile stress. The wrinkle height to width ratio for installed geo-membrane shall not exceed zero point five (0.5). In addition, geo-membrane wrinkles shall not exceed one hundred fifty (150) mm in height. Wrinkles that do not meet the above criteria shall be cut out and repaired in accordance with the installer's approved CQC manual.

K. A minimum of five (5) thickness measurements shall be taken along the edge of each panel width and at least two thickness measurements shall be taken along each panel length. The thickness shall be measured in accordance with ASTM D 5994. If thickness readings fall below the values specified in Table 1 and 2, the entire panel shall be rejected and replaced.

L. Ballasting shall be applied on geomembranes after they have been positioned. The Contractor shall choose the most appropriate ballasting method for site conditions and the expected winds. He may use bags of soil or tires. The Contractor shall be responsible for the supply, placement and removal of the ballasting.

3.4. FIELD SEAMING

A. Trial Seams:

Trial seams shall be made under field conditions on strips of excess geo-membrane. Trial seams shall be made each day prior to production seaming, whenever there is a change in seaming personnel or seaming equipment and at least once every four hours, by each seamer and each piece of seaming equipment used that day. One sample shall be obtained from each trial seam. This sample shall be at least one (1) m long by five hundred (500) mm wide with the seam centered lengthwise. Ten random specimens twenty five (25) mm wide shall be cut from the sample. Five seam specimens shall be field tested for shear strength and five (5) seam specimens shall be field tested for peel adhesion using an approved quantitative tensiometer. Jaw separation speed shall be in accordance with the installer's approved CQC manual.

B. Field Seams:

1. Panels shall be seamed in accordance with the geomembrane manufacturer's recommendations. In corners and odd-shaped geometric locations, the number of field seams shall be minimized. Seaming shall extend to the outside edge of panels. Wet surfaces shall be thoroughly dried and soft subgrades compacted and approved prior to seaming. The seam area shall be free of moisture, dust, dirt, and foreign material at the time of seaming. Fish mouths in seams shall be repaired.

2. The geomembrane shall be seamed by hot wedge welding methods The hot wedge welder leaves a small gap between the two sealed liner sides. This gap enables the CQC team to use an air test to test the seam quality. The air test is a field test in which a needle and gauge are placed at one end of the seam and then pressurized. The seam, which can be up to 150m long, has to remain under pressure for 5 minutes. After the 5 minutes has passed and the seam passed the test, the needle is then removed and an extrusion weld is placed over the needle hole.

3. Extrusion welding shall only be used for patching and seaming in locations where hot wedge welding methods are not feasible. Seam overlaps that are to be attached using extrusion welds shall be ground prior to welding. Grinding marks shall be oriented perpendicular to the seam direction and no marks shall extend beyond the extrudate after placement. Extrusion welding shall begin within ten (10) minutes after grinding. Where extrusion welds are temporarily terminated long enough to cool, they shall be ground prior to applying new extrudate over the existing seam. The total depth of the grinding marks shall be no greater than ten (10) percent of the sheet thickness. The extrusion welds shall be tested by the vacuum box test. This test consists in placing a soapy solution all over the extrusion weld, then a box with a plexiglass top is then put on the weld. The weld then receives a 5 psi vacuum from the box and a visual inspection of the weld is performed. If the seam fails there will be noticable air bubbles forming from the soap.

3.5. PENETRATIONS

For geomembrane penetration, factory fabricated boots as recommended by the Manufacturer of the Geomembrane shall be used wherever possible.

The Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Field seams for penetrations shall be non-destructively tested in accordance with the installer's approved CQC manual. Seams that fail non-destructive testing shall be repaired in accordance with the installer's approved CQC manual and non-destructively tested prior to acceptance.

3.6. CONNECTION TO STRUCTURES

The connection of the geomembrane to structural components of the Works shall be by bolts and washers, or such other methods, as recommended by the Manufacturer of the Geomembrane. The Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

The method of installation and tensioning of bolts to the structural components shall be to the approval to the Engineer.

3.7. PROTECTION AND BACKFILLING

A. The deployed and seamed geo-membrane shall be covered with the sand layer or protection geo-textile and leachate collection drainage material within five (5) calendar days of acceptance.

B. Wrinkles in the geo-membrane shall be prevented from folding over during placement of drainage materials. Drainage material shall not be dropped onto the geo-membrane or overlying sand or geo-synthetics from a height greater than one (1) m.

C. Equipment with ground pressure less than forty (40) kPa shall be used to place the sand protection layer and the drainage system over the geomembrane. A minimum of six hundred (600) mm of soil shall be maintained between full-scale construction equipment tires/tracks and the geo-membrane or overlaying geo-synthetics during the covering process. Equipment placing drainage material shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 8 km/h.

3.8. DEFECTS AND REPAIRS

3.8.1. DESTRUCTIVE SEAM TEST REPAIRS

Seams that fail destructive seam testing may be overlaid with a strip of new material and seamed (cap stripped). Alternatively, the seaming path shall be retraced to an intermediate location a minimum of three (3) m on each side of the failed seam location. At each location a three hundred (300) by five hundred (500) mm minimum size seam sample shall be taken for two (2) additional shear strength and two (2) additional peel adhesion tests using an approved quantitative field tensiometer. If these tests pass, then the remaining seam sample portion shall be sent to the QC laboratory for five (5) shear strength and five (5) peel adhesion tests in accordance with the QC laboratory's approved procedures. To be acceptable, four (4) out of

five (5) replicate test specimens must meet specified seam strength requirements. If these laboratory tests pass, then the seam shall be cap stripped between that location and the original failed location. If field or laboratory tests fail, the process shall be repeated. After cap stripping, the entire cap stripped seam shall be non-destructively tested in accordance with paragraph 6.6.2 B, Non-Destructive Field Seam Continuity Testing.

3.8.2. PATCHES

Tears, holes, blisters and other defects shall be repaired with patches. Patches shall have rounded corners, be made of the same geo-membrane, and extend a minimum of one hundred and fifty (150) mm beyond the edge of defects. Minor localized flaws shall be repaired by spot welding or seaming as determined by the Engineer. Repairs shall be non-destructively tested. The Engineer may also elect to perform destructive seam tests on suspect areas.

3.9. VISUAL INSPECTION AND EVALUATION

A. Immediately prior to covering, the geo-membrane, seams, and non-seam areas shall be visually inspected by the Engineer for defects, holes, or damage due to weather conditions or construction activities. At the Engineer's discretion, the surface of the geo-membrane shall be brushed, blown, or washed by the installer if the amount of dust, mud, or foreign material inhibits inspection or functioning of the overlying material.

B. Each suspect location shall be non-destructively tested in accordance with paragraph '3.7.3 – 3) Non-Destructive Field Seam Continuity Testing'. Each location that fails non-destructive testing shall be repaired in accordance with Section '3.8.2-Patches', and non-destructively re-tested.

3.10. CONSTRUCTION QUALITY CONTROL

3.10.1. CONSTRUCTION QUALITY CONTROL (CQC) SAMPLES

One CQC sample, five hundred (500) mm in length, for the entire width of a roll, shall be obtained for every ten thousand (10,000) square meters of material delivered to the site. Samples shall not be obtained from the first one (1) m of the roll. The samples shall be identified by manufacturer's name, product identification, lot and roll/panel number. The date, a unique sample number, and the machine direction shall also be noted. In addition, a three hundred (300) mm by three hundred (300) mm sample shall be collected, labeled, and submitted to the CQC Inspector each time CQC samples are collected.

3.10.2. CONSTRUCTION QUALITY CONTROL (CQC) TESTS

A. The Contractor shall provide all CQC samples to the CQA team to determine density, specific gravity, thickness, tensile strength at break, elongation at break, and tear resistance in accordance with the methods specified in Table 1 and Table 2. Samples not meeting the specified requirements shall result in the rejection of applicable rolls/panels. As a minimum, rolls/panels produced immediately prior to and immediately after the failed roll/panel shall be tested for the same failed parameter. Testing shall continue until a minimum of three successive rolls/panels on both sides of the original failing roll/panel pass the failed parameter.

B. Non-Destructive Field Seam Continuity Testing

C. Field seams shall be non-destructively tested for continuity over their full length in accordance with the installer's approved CQC manual. Seam testing shall be performed as the seaming work progresses, not at the completion of field seaming. Any seams which fail shall be documented and repaired in accordance with the installer's approved CQC manual.

D. Destructive Field Seam Testing

E. A minimum of one destructive test sample per two hundred and fifty (250) m of field seam shall be obtained at locations approved by the Project Manager. Sample locations shall not be identified prior to seaming.

F. Samples shall be a minimum of three hundred (300) mm wide by one (1) m long with the seam centered lengthwise. Each sample shall be cut into three (3) equal pieces, with one piece retained by the installer, one piece given to the CQA Team, and the remaining piece given to the Project Manager for testing and/or permanent record.

Each sample shall be numbered and cross referenced to a field log which identifies:

- panel number;
- seam number;
- date and time cut;
- ambient temperature within one hundred fifty (150) mm above the geo-membrane;
- seaming unit designation;
- name of seamer;
- seaming apparatus temperature and pressures (where applicable).

G. Ten twenty five (25) mm wide replicate specimens shall be cut from the installer's sample. Five (5) specimens shall be tested for shear strength and five (5) for peel adhesion using an approved field quantitative tensiometer. Jaw separation speed shall be in accordance with the approved CQC manual. To be acceptable, four (4) out of five (5) replicate test specimens shall meet the specified seam strength requirements in Table (5).If the field tests pass, five (5) specimens shall be tested at the QC laboratory for shear strength and five (5) for peel adhesion in accordance with the QC laboratory's approved procedures. To be acceptable, four (4) out of five (5) replicate test specimens shall meet the specified seam strength requirements in Table (5). If the field or laboratory tests fail, the seam shall be repaired in accordance with paragraph 6.7, Destructive Seam Test Repairs. Holes for destructive seam samples shall be repaired the same day they are cut.

3.10.3. SUBMITTALS BY THE CONTRACTOR

During and after installation of the geomembrane, the contractor shall submit:

1. Surface Preparation: Certification from the CQC Inspector and installer of the acceptability of the surface on which the geo-membrane is to be placed, immediately prior to geo-membrane placement.

2. Thickness Measurement: Test results of panel thickness measurement, certified by CQA Inspector.

3. Non-Destructive Field Seam Continuity Testing: CQA Inspector's certified test results on all field seams.

4. Destructive Field Seam Testing: Installer and certified CQA laboratory test results on all destructively tested field seams.

5. Destructive Seam Test Repairs: CQA Inspector's certified test results on all repaired seams.

6. Interface Friction Testing: Certified laboratory interface friction test results including description of equipment and test method, a minimum of fourteen (14) days prior to geo-membrane shipment.

7. Samples: Geo-membrane QA and CQA samples not less than one 30 cm long seam of field-bonded seam

8. Warranties

SECTION 02346
BOLTING

1. GENERAL

1.1 WORK INCLUDED

The section covers the requirements for:

1. the supply bolts and dowels,
2. the installation of bolts and dowels,
3. the testing of bolts and dowels,
4. the supply and placement of wire mesh fabric for temporary protection.

The specifications for the bolts cover resin grouted and cement grouted bolts.

The works will be carried out with the Engineer' approval for particular case only.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DEFINITIONS AND DESCRIPTIONS

1. A bolt is a high yield deformed bar of specified diameter and length which is end anchored with resin grout, fully column bounded with either resin or cement grout, equipped with a faceplate, hemispherical washer and nut and tensioned to a specific load. The use of resin or cement grout for the column grout shall be at the contractor's discretion.

2. Alternative materials with equivalent service characteristics may be proposed to the agreement of the Engineer.

3. A **dowel** is a high yield deformed bar of specified diameter and length for which the protruding portion may be either straight or bent, which is fully grouted with either resin or cement grout. Dowels will not be fitted with accessories nor will they be tensioned. The use of resin or cement grout shall be at the Contractor's discretion.

Bolts and dowels shall be installed in portions of the work where anchorage of concrete or steel structures are required or where the stability of soil faces exposed by the excavations will not be maintained naturally.

It is intended that in general treated soils reinforcement will be provided mainly by dowels.

1.4 CODES AND STANDARDS

1.3.1. GENERAL

The work including in this Section shall comply with the requirements of the following standards and codes, except where this Specification differs from these standards and codes, in which case the requirements of the Specification shall take precedence.

International Society of Rock Mechanics (ISRM).

ISRM Suggested method for Rock Anchorage Testing (ref. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstrcts, v. 22, n2, p 714-83, 1985).

1.4.2 AMERICAN CONCRETE INSTITUTE

ACI 318-77 Building code requirements for pre stressed concrete.

1.3.1. AMERICAN SOCIETY FOR TETINGAND MATERIALS (ASTM)

ASTM A 185 Steel welded Wire Fabric, for Concrete Reinforcement

ASTM C150 Porland Cement

ASTM D4435 Standard method for rockbolt anchor pull test

ASTM F432 Standard specification for roof and rock bolts and accessories

1.4. QUALITY ASSURANCE

1.3.1. TESTS AND CONTROLS

1. The Contractor shall make trial tests of bolts and dowels before any installation proceeds.

2. The trial programme shall include sufficient pull-out tests to failure, or to such lesser load as the Engineer may approve, and dowels anchored in suitable rock to determine the adequacy of the anchorage used and the correct torque or tension where appropriate to apply to the bolts. The trial assembles shall show that the bolt, the anchorage system and the tensioning system proposed by the Contractor will be suitable for the work.

3. the affectiveness of the installation procedure shall be checked by testing to yield load a minimum of 1 bolt in 100 installed.

1.5.2 TOLERANCES

4. Position.....± 150 mm

5. Alignment.....± 5°

1.5. SUBMITTALS AND APPROVALS

1. Not later than 45 das prior to commencement of excavation, the Contractor shall submit to the agreement of the Engineer.

The different types and characteristics of dowels, bolts and accessories he intends to use.

For exposed bolts and accessories, the protective coating compound the Contractor intends to have applied at the factory with possibility of recoating at site if required.

Grouting equipment and method.

2. Schedule for grouting bolts and dowels

Prior to grouting the Contractor shall submit a schedule for grouting for the Engineer's approval.

All granted bolts shall be grouted in place immediately prior to backfilling or concreting or in the case of permanently exposed faces, upon completion of the work in any area, unless otherwise required by the Engineer.

2. MATERIALS

2.1. TENSIONED BOLTS

1. Bolts shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa complying with ASTM F432, in various lengths and diameters as specified.

2. The bar length specified shall be the required length of bar to be bonded to the soil and due extra allowance in the cutting length shall be made for any length including the threaded portion protruding from the rock as required for installation. One end shall be threaded for at least 150 mm with coarse cut thread which shall not reduce the overall specified bar diameter by more than 3 mm. The other end shall be chamfered to facilitate installation.

3. Bolts shall be provided with face plate, hard steel flat and hemispherical washers and nuts.

4. The face plate shall be domed load indicating type and fitted with hemispherical washer to permit seating of the plate at inclinations up to 30° from normal to the bolt, with the following minimum dimension characteristics:
   - for 20 mm dia rockbolt, diameter 120 mm and 8 mm thick plate,
   - for 25 mm ida rockbolt, diameter 150 mm and 8 mm thick plate.

5. Couplings for connecting adjacent sections of a bolt shank and bolt extensions shall have a center stop so that each section is connected by an equal length of thread. Such threads shall be capable of transferring the yield load of the bolt from one section to the other without, in any way, overstressing the coupling or the threads of the bolt shank or extension. Couplings for hollow core bolts shall be such as not to interfere in any way with the flow of grout through the core of the bolt.

6. Cement grouted bolts shall be supplied with suitable tubes for injecting grout and permitting release of air from the hole. Bearing plates for bolts to be grouted shall be supplied with holes to accommodate the grouting and venting tubes. Alternatively, groutable bolts having a hollow core may be used, in which case the bearing plates shall have one hole for the grouting or air venting tube.

7. For all bolts which be permanently exposed, all portions of the bolts, the bearing plates and accessories which will be permanently exposed shall be coated after installation with an approved protective coating compound. The engineer may nevertheless require grouting to be used for protection of the shank.

8. All bolted connections on site, with the exception of small frames shall be made with turned barrel bolts or high strength friction grip bolts. Black bolts may be used for minor frames and structures. All structural bolts shall be fitted with 6 mm thick machine faced washers. Bolt holes shall be drilled and shall not be formed by burning or punching, and shall be free of burrs and sharp edges. All cut edges shall be dressed free from burrs and jags to a neat finish. Drift pins shall not be used to enlarge holes.

2.2 DOWELS

Dowels shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa, in various lengths and diameters as specified.

Dowels shall be either straight bars or shall have the protruding end bent to facilitate the specified connection between the rock and surrounding concrete or shotcrete when so detailed on the drawings.

Dowels for installation with resin or cement cartridge shall be threaded at one end sufficiently for attachment of the installation equipment. The other end shall be chamfered to facilitate installation.

2.2. WIRE MESH

1. Wire mesh shall be of a standard approved by the Engineer.

2. Welded wire mesh shall comply with ASTM A 185.

2.3. GROUT

1. Resin grout shall be a commercially produced epoxy product in capsule form with both fast and slow setting times as applicable especially formulated for use with rockbolts or dowels, and transported, stored and utilised in accordance with the manufacturer’s recommendations.

2. Cement grout shall be a commercially prepared product in capsule form especially produced for use with rockbolts or dowels. The product shall not contain any material which could corrode the bolts or dowels.

3. Unless otherwise specified, all non-shrinking grout specified on the drawings or where proposed to be used by the Contractor, shall have a compressive strength of not less than 60 N/mm2 at 28 days. Mixing proportions and instruction for use shall be followed in strict compliance with the manufacturer's direction. Grouting materials in contact with water shall be of non-metallic and non-toxic type. The Contractor shall submit his technical specifications of grouting materials to the Engineer for approval.

2.5 RESERVE SUPPLY

4. To be able to perform the excavation work without delay, the Contractor shall always have a reserve inventory of bolts and dowels of various types and length, wire mesh and other accessories. Such inventory shall be adequate to meet the requirement for the following month as well as provision for unforeseen conditions. The inventory status shall be reported to the Engineer on a monthly basis.

5. As the work progresses the Contractor shall supply additional bolts to site as instructed by the Engineer.

2.4. TORQUE WRENCH

The Contractor shall a standard torque wrench for calibrating impact and torque wrenches used in the work. This controlled torque impact wrench shall have a control device that can be set to cut off over the required range of torques. This wrench shall not be used for any other purpose. All impact and torque wrenches shall be calibrated at least once every month.

2.5. PULLOUT TEST EQUIPMENT

The Contractor shall provide two sets of approved pullout test equipment for use in making tests, to comprise of a suitable hydraulic jack, having a center bore in the ram for installation of the jack concentrically over the longitudinal axis at the bolt, hydraulic pump, and all other required accessories.

3. EXECUTION

3.1. GENERAL

1. Bolting shall be carried out in the pattern and sequences as indicated on the drawings or as directed or as proposed by the Contractor and agreed by the Engineer.

2. Before grouting, the Contractor shall check the tension of all tensioned bolts and retorque where necessary.

3. Where opencut excavation is carried out in successive lifts or benches, support of each newly exposed soil face shall be completed prior to blasting of the next bench unless otherwise authorized by the Engineer.

4. Bolts required to support the underground excavation shall be set and tensioned at agreed locations, as soon as practicable after each round is excavated and before the face is further advanced. Any bolt, which is damaged by blasting or other operations to the extent that it can no longer be effectively retensioned, shall be replaced as required by the Engineer.

3.2 DRILLING

5. Standard percussion drilling equipment may be used for drilling bolts or dowels.

6. Holes for bolts shall be drilled to the depths and at locations and orientation shown on the drawings, directed or as agreed by the Engineer.

7. Unless otherwise proven acceptable by site trials, the bolts shall be installed in holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the bolt, and will be such that, for the anchorage used, the load capacity of the bolt at the yield point of the steel can be developed. In cases where it is necessary to couple lengths of grouted bolts to achieve the total length of bolt required, the diameter of the hole around and above the coupling shall be sufficient to allow the free passage of grout.

8. The holes shall not be more than 100 mm longer than the grouted length of the bolt unless otherwise proven acceptable by site trial.

9. Immediately prior to installation of any bolt, the hole shall be flushed with water and cleaned of all drill cuttings and debris to the satisfaction of the Engineer.

3.3 INSTALLATION AND TENSIONNING OF BOLTS

3.3.1 INSTALLATION AND TENSIONING OF BOLTS

10. Installation

The method of installation and tensioning of bolts shall be to the approval to the Engineer, Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Bolts shall be inserted in the hole and the anchorage firmly seated and tightened. No damage shall be caused to the thread of the protecting end of the bolt.

Prior to installing the bolts, the soil surface shall be prepared to provide uniform bearing at right angles to the longitudinal axis of the bolts.

For resin grouted rockbolts a sufficient number of cartridges shall be used to ensure the annulus around the bolt is completely filled over the full length of the hole.

End cartridges for the anchorage zone shall be of fast setting resin whilst the column shall be filled with slow setting resin or cement cartridges. Tensioning shall be carefully controlled to ensure that it takes place after setting of the end cartridges but prior to commencement of setting of the column grout.

11. Tensioning

The hexagonal nut of the tensining end of the bolt shall be free running on the thread of the bolt and shall be tightened to a torque required to cause a load in the bolt equal to 50 kN for the 20 mm dia rockbolt and 100 kN for the 25 mm dia rockbolt. The requisite torque for the bolts shall be determined by in place testing of the bolts in accordance with the bolt Manufacturer's directions. Bolts which are damaged or overstressed by over torquing shall be replaced by the Contractor.

All necessary preparation of a bolt for grouting shall be made during the initial installation of the bolts. After the bolt has been tensioned, the tension shall not be relaxed for grouting or any other purpose.

If it is found that any bolt will not take the required torque without anchorage slip, another bolt shall be installed in a new hole drilled in the immediate vicinity of the unsatisfactory bolt.

If, at any time, the Engineer or Contractor finds that any bolts have become loose or have lost their tension, the Contractor shall retension all such bolts by reapplying the specified torque.

Expanding or resin anchor bolts for fixing equipment or structures to concrete shall have pull-out strength not less than the tensile strength of the bolt.

3.3.2 INSTALLATION OF DOWELS

The method of installation of dowels shall be to the approval of the Engineer. Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the dowel shall be drilled and cleaned to the approval of the Engineer. The gauged amount of cement grout or cartridges of resin or cement grout shall then be inserted and the bar driven firmly into the hole (by spinning in the case of resin cartridges). If cement grout is used, the grout shall be inserted using a tremie pipe pushed down to the bottom of the hole and withdrawn slowly as the grout is placed. After installation the bar shall be vibrated for a short period to ensure the complete distribution of the grout around the full length of the bar. Additional grout shall be added to make up any shortfall.

3.4 TESTING OF ROCK BOLTS AND DOWELS

3.4.1 GENERAL

Prior to the installation of bolts in the Works the Contractor shall carry out a series of tests as agreed with the Engineer to prove the capacity of the system and the Contractor's capability to correctly install and tension the bolts.

12. for the purpose of these tests, anchorage slip shall be deemed significant if an outward movement of the bolt anchorage occurs and continues without increase in the hydraulic jack loading, or with a decrease in the hydraulic jack loading.

13. If a bolt fails to meet the pullout test requirement, another bolt shall be installed in a new hole drilled as close as practicable to the unsatisfactory bolt.

14. The tests shall demonstrate:

    The number of resin cartridges required to provide the end anchorage with an applied load equal to the bars characteristic yield strength and taking into account the overlength variatin of holes.

    The number of resin or cement cartridges to fill the annulus around the rockbolt over the length of the hole between the anchorage and collar of the hole.

    The strength of the resin grout to fully anchor the bars up to the characteristic strength of the bolts.

    The composition of the cement grout.

    The capacity of the equipment to install the longest fully grouted bolts.

    The equipment for tensioning the bolts to the specified loads.

    The capability of each crew to correctly install and tension the bolts.

The Contractor shall undertake the tests with the equipment to be used on the Works and shall install the test bolts in a suitable rock face in a steeply upward direction.

The Contractor shall provide a suitably calibrated direct tensioning jack and/or load cell of capacities in excess of the characteristic strength of the rockbolts. Loads and deformations shall be recorded during the tests.

3.4.2 TENSIONED BOLTS

15. A final torque test of bolts shall be made in the presence of the Engineer during the final inspection of the work, and immediately prior to any grouting of bolts. The number of bolts to be tested will be determined by the Engineer, with consideration given to the total number of bolts installed and the results of such tests.

16. The Contractor shall make a pullout test of each bolt that does not retain the applied torque, as determined by the Engineer. All pullout tests shall be made in the presence of the Engineer. A pullout test result which indicates that the anchorage will take a tension equal to 90 percent of the yield strength of the bolt shank as determined by trial tests, without significant anchorage slip; will beacceptable.

17. All bolts which are installed and tensioned within 15 metres of subsequent blasting work shall be tested after each blast within such longer period as many be approved by the Engineer.

3.4.3 DOWELS

As locations designated by the Engineer, the Contractor shall conduct pullout tests in the presence of the Engineer. A pullout test which indicates that the dowel will take a tension equal to 90 per cent of its yield strength without significant slip will be acceptable.

3.5 CEMENT GROUTING OF BOLTS

18. The grouting shall be performed in accordance with a method approved by the Engineer.

19. The Contractor shall supply all plant and materials required to grout the bolts in place after installation.

20. Where a tube system is proposed by the Contractor, such system shall be subject to the Engineer’s approval, and the Contractor shall demonstrate to satisfaction of the Engineer that the proposed system will provide complete filling of the annular space around the bolt.

21. The water/cement ratio by weight shall be between 0.30 to 0.44. Special agreed admixture shall be added to the grout to prevent shrinkage. This non shrink admixture shall be added strictly as recommended by the Manufacturer. Calcium chloride will not be permitted. Grout shall be forced into the drill hole at the appropriate point to completely fill the space all around the rock bolts. All air shall be vented from the drill hole adequately. If during the grouting of any bolt, grout is found to flow from points in the rock surfaces adjacent to the bolts, such leak shall be plugged or caulked. Grout which has not been injected into a hole within 1 hour of mixing shall not be used.

22. The Contractor shall ensure that grouted bolts are neither loosened nor disturbed in any way until at least 7 days after completion of grouting.

3.6 WIRE MESH

23. Where wire mesh will be placed for temporary protection for safety of person and equipment, it shall be securely fastened to the bearing plates or bolts. The Contractor shall clearly demarcate his working area with appropriate boundary fencing to facilitate him taking responsibility for his works. He shall however provide access to the Engineer and the Employer’s representative to all working areas to allow inspections of workmanship, and compliance with is methods of working in accordance with approved Method Statements as

stipulated in section. The Contractor shall provide sufficient watchmen, notices, warning sirens, fencing and/or such other measures as are necessary for the protection of all persons and property. Sites shall be fenced all around during Implementation as well as for security for the Operation and Maintenance phase of the plant(s). The protection and security of sites during construction shall be the responsibility of the Contractor. Where specified, the Contractor shall install chain link fencing around sites. The fence shall be provided with 2.2 m high X 40 mm angle iron posts at a distance of maximum 2 m apart with a double winged gate at the main access, as well as a personnel gate as specified. The fence shall be installed on 20 cm (wide) by 20 cm (high) kerbing set in concrete. Outward overhang posts 50 cm long shall be installed with three strands of barbed wire for security purposes. Chain link fence shall be coated with extruded Vinyl. Fence posts, shall be hot-dip galvanised, after all appurtenances have been welded to them.

24. Overlaps in the wire mesh shall not be less than 300 mm and shall be secured with wire clips.

25. Additional wire mesh anchors shall be used to secure wire mesh to the soil surface between bolts and to secure the edges of wire mesh and provide anchorage at overlaps and where sagging may occur. There wire mesh anchors patterns shall be approved by the Engineer.

SECTION 03100
FORMWORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply, installation and execution of formwork for concrete structures.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

Formwork shall be designed supplied and installed in order to produce concrete parts meeting specified shape, dimensional and position requirements, without defects or irregularities and within the prescribed tolerance limits.

1.4. DEFINITIONS

A. Abrupt irregularities

Any local irregularity resulting from incorrect alignment or relative displacement of the formwork, unsatisfactory condition of formwork or any other cause.

Abrupt irregularities will be measured directly or using a rule or a template of 20 cm long.

B. Gradual irregularities

Refer to any other difference between the theoretical and actual lines of the concrete faces. They shall be measured with a straight rule for plane surfaces and with an appropriate template for curved surfaces of 1.50 m long.

C. Honey combs, grout losses and surface plucking shall not be considered as irregularities but as defects.

1.5. STANDARDS AND REGULATIONS

The following Standards shall be used, in this order of priority:

1. British Standards
2. European Standards.

1.6. STANDARDS OF FINISH

A. Class 1

This is a very high quality finish where formwork shall ensure a particularly accurate line of finish: surfaces in contact with hydraulic flow and surfaces exposed to view:

1. The surfaces delineated by panel joints shall be regular.

2. Unless otherwise indicated, panel joints shall be vertical or horizontal, perpendicular or in alignment with the water flow.

3. Construction joints shall match architectural design details where necessary and shall be submitted for the Engineer's approval.

4. Formwork linking systems shall not be permitted unless otherwise approved by the Engineer.

5. All abrupt irregularities shall be ground to obtain chamfers of 1-over-50.

   For surfaces that will be subjected to flowing water at a rate of more than 10 m/s, no smoothing will be tolerated and any irregularity outside specified limits which cannot be repaired by bush hammering or grinding shall be repaired with epoxy resins or any other product approved by the Engineer. Such resins or products shall be applied by approved specialists.

B. Class 2

Formwork for structure surfaces and joints and, in general, all structures not requiring a special finish, i.e. surfaces not exposed to the view:

1. The surfaces delineated by joints between formwork panels shall be regular.

2. Unless otherwise indicated, joints shall be vertical or horizontal or parallel to the overall lines of the structure.

3. Construction joints positions shall be submitted for the Engineer's approval.

4. If accepted, formwork linking systems shall be placed uniformly with aligned joints as to achieve a symmetrical pattern in the finish concrete surface.

C. Class 3

1. Surfaces designed for construction joints between different construction stages with, where applicable, steel bars passing through them.

2. Surfaces designed to be coated at a later stage.

D. Class 4

Surfaces contained by formwork but which will be permanently concealed in the completed work.

E. Surface state tolerances in millimetres

Formwork class	Abrupt irregularities	Gradual irregularities
Class 1 Class 2 Class 3 Class 4	2 4 8 nil	6 8 15 40

N.B.: The clauses of this article are also applicable to concrete surfaces not effectively shuttered.

1.7. DESIGN

A. Formwork and falsework shall support without appreciable deformation the weight of the fresh concrete, reinforcement and embedded parts as well as the forces induced by falling concrete, with vibration, impacts of handling equipment, personnel, temperature variations and climatic agents.

B. Joints between panels shall be grout-tight and shall provide satisfactory continuity of concrete surfaces.

1.8. CURVED FORMWORK

A. Curved surfaces of radius less than or equal to 2 m shall conform strictly to the theoretical curve.

B. Curved surfaces shall be given by curved formworks, even for 2D curved ones:

a. Either by plywood built on site,

b. Either by industrial curvable iron formworks.

1.9. SUBMITTALS

A. Working drawings of formwork with props, stays, spacers and fastening systems shall be submitted to the Engineer for information.

B. The specifications and manufacturer's instructions for the following items and products shall be submitted for the Engineer's approval:

1. Sheathings or liners.
2. Spacers and falsework.
3. Special supports embedded in the concrete if agreed on principle.
4. Dressing material for stripping.
5. Slip forms where applicable.

1.10. LAYOUT TOLERANCES

A. Layout deviations of concrete facings shall be compatible with the functions of the structure considered and with related structural functions, especially with regard to mechanical supplies.

For electromechanical works, tolerances shall be indicated on the drawings.

B. Unless otherwise indicated, the positive and negative tolerances are as follows:

1. On any linear dimension L (in m), measured between opposing facings, edges or intersecting edges:

$$T\ (cm) = \frac{1}{4}\sqrt[3]{L}$$

with a minimum of 0.5 cm and a maximum of:

a) 1 cm for class 1 formwork

b) 3 cm for other classes of formwork

2. On vertical dimensions:

$$T(cm) = 0.0005 \times H$$

where:

H = height of the item in cm

Upper limits: 0.05 x E or 3 cm

E = thickness of the item in cm

3. On alignments or gradients:

$$T(cm) = 0.0005 \times L$$

where:

L = length in cm

For the curved parts, the tolerances are fixed by analogy

4. On the layout with respect to the reference marks indicated to the Contractor: planimetry and altimetry:

$$T\ (cm) = \frac{1}{2}\sqrt[3]{D}$$

where:

D = distance in metre between the control point and the reference mark with an upper tolerance limit of 3 cm and a lower limit of 0.5 cm.

2. PRODUCTS

2.1. FORMWORK MATERIALS

A. Generally speaking, forms shall be made of wood or metal. Unless specified to the contrary, they shall be made of plywood for wood for exposed surfaces where the visual impact is particularly important.

All panels other than metal panels shall be new when they are first used on site.

B. Panels may be reused on site on condition that they are carefully cleaned, reconditioned or surfaced from time to time and if they will be capable of producing concrete surfaces conforming to the specifications. After repeated use, the Engineer may require the Contractor to scrub the form or to provide new ones.

C. Spacers and fasteners shall be designed in such a manner that, after stripping, no metal part will be closer to the surface of the facing than the minimum concrete cover agreed for the reinforcement.

D. For water retaining concrete structure, a plate of 50 mm minimum diameter shall be welded in the middle of spacers and fasteners to avoid leakages.

2.2. DRESSING MATERIALS FOR STRIPPING

A. Surfaces exposed to concrete must be coated with form oil or other approved dressing material.

B. Dressing material shall facilitate wetting of the form surface, reduce bubble formation, leave no notable trace on concrete surfaces and protect the form surface from any damage such as corrosion.

C. They shall be compatible with the treatment that may be applied to the concrete surfaces (painting, coating, etc.).

2.3. EXCAVATED SURFACES USED AS FORMS

A. At the Contractor's request, and after the Engineer has given his approval, the lateral forms of buried parts of concrete structures may be omitted with the concrete being placed directly against the excavated surfaces. Such placement of Concrete shall negatively impact the structural integrity of the element.

B. In cases where the omission of formwork is accepted, the dimensions of the concrete parts shall be increased by 3 cm on each face in contact with the excavated surfaces.

C. At the Engineer's instruction, a layer of blinding concrete shall be spread or projected over the excavated surface before placing the concrete.

3. EXECUTION

3.1. INSPECTION

Reference levels and alignments, levels and positions of previous concrete lifts and the position of previously placed reinforcement bars shall be checked before installing the formwork.

3.2. PREPARATION

A. After cleaning, the forms shall be coated with a dressing material in accordance with the manufacturer's instructions.

B. The forms shall be protected from dust and dirt, after the above treatment.

3.3. INSTALLATION

A. The forms shall be installed and securely braced in such a manner that the concrete surfaces produced come within the tolerance limits defined in Part I herein.

B. If necessary, forms shall be installed with a counter-deflection.

C. Unless otherwise indicated, exposed corners shall be provided with 25 x 25 mm chamfers by mean of moulding strip placed in the formwork.

D. Construction joints levels shall be provided with battens defining the limits between two concrete lifts, where directed by the Engineer.

E. Formwork for successive vertical lifts must make good contact with the concrete in the preceding lift, such that there will be no excrescences, bulges, tears or other outward signs of a faulty junction such as grout leakage.

F. Blockouts, inserts and embedded items should be properly identified, positioned and secured.

3.4. STRIPPING OF FORMS

A. Formwork shall not be removed without the approval of the Engineer. Notwithstanding this approval, the forms shall not be moved or removed until the concrete has acquired sufficient strength to support its weight and the construction or design loads that it may be required to bear.

B. Stripping shall take place without impact or vibration to the concrete and care shall be taken not to damage the concrete surfaces.

C. Stripping operations may be decided in relation to the results of compression tests on specimens kept under conditions similar to those of the structure considered. These test specimens shall be taken in addition to the test pieces specified in section on concrete.

D. Concrete compressive strength tests may be replaced by sclerometer measurements.

E. Generally speaking, the forms and supports of suspended structures shall not be removed until the ratio of the compressive strength of test specimens kept under similar conditions to those of the structure considered to the specified strength is greater than the ratio of the deadweight plus construction loads to the design load, with a minimum value of 0.50.

F. In general, formwork shall be left in place for the following period after the concrete is cast:

1. minimum of 36 hours: vertical surfaces of piers and columns,
2. minimum of 36 hours: vertical surfaces of footings, walls and dams,
3. minimum of 20 days: suspended beams and slabs,
4. minimum of 12 hours: tunnel linings,
5. minimum of 7 days: arch roof of underground chambers.

The times above specified shall have elapsed from the end of concreting. According to the results of the laboratory tests and site trials, the aforesaid minimum times may be reconsidered by the Engineer. In all cases, the Contractor shall demonstrate that removal of formwork will not in any way adversely affect the concrete of permanent work.

3.5. REPAIR OF SURFACE DEFECTS

A. If the concrete surfaces after stripping have certain local defects (such as honey combs or surface defects) or irregularities, the Contractor shall advise the Engineer before undertaking any repairs so that the said defects and irregularities can be inspected and notified in a jointly-signed report.

B. If in the Engineer's opinion that the defects will not have any significant impact on the quality of the structure, the Contractor shall propose the necessary repair work prior to any repairs.

C. In case of serious defects, the Engineer may order the whole lift concerned to be removed and replaced.

D. Repairs of local defects and holes left by form fasteners and spacers shall be carried out using cement mortar containing an adhesive and an additive mixture to prevent shrinkage.

E. Holes left by form fasteners and spacers may, for certain concrete facings not in contact with water, be left as they are, with the Engineer's approval.

F. Spalling, burrs and irregularities not compatible with specified type of finish shall be repaired by smoothing as specified for defects, or ground.

G. Within 24 Hours after form removal all fins and loose materials shall be removed and surface defects including the holes shall be remedied unless otherwise required by the Engineer.

SECTION 03200
REINFORCEMENT

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply and installation of steel bars or steel fabrics used for reinforcement in concrete works, either for permanent or for temporary structures.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

The following Standards shall be used, in this order of priority:

1. British Standards.
2. European Standards.

1.3.1. TESTS AND INSPECTION

A. If the Contractor does not have the Supplier's Certificate or mill certificates, or if the reinforcement appears to be in a deteriorated condition in the Engineer's opinion, the Contractor shall bear the cost of arranging for tests to be carried out in an approved laboratory.

B. The tests will cover the following characteristics:

1. Diameter (determined by weighing)
2. Tensile strength
3. Bending tests

C. Six samples per diameter shall be taken for determining each of the above-mentioned characteristics.

D. If two tests of a given characteristic give unsatisfactory results, the reinforcement bars concerned shall be considered defective.

E. If one test of a given characteristic gives an unsatisfactory result, a new sampling of six samples from the same batch shall be taken for a new series of tests on the

characteristic in question. If the results of the new tests are all satisfactory, the reinforcement bars will be accepted. If this is not the case, the bars shall be considered defective.

1.4. SUBMITTALS

A. Supply of steel bars

Manufacturer's test certificates or mill certificates including details of physical and chemical properties.

Six (6) samples of each diameter of the proposed steel bars for testing at a laboratory approved by the Engineer. The associated costs for testing for approval and random testing in the course of works execution will be deemed to be included in the Contractor's Financial Proposal.

B. Welding of reinforcement bars will not be allowed

Nevertheless in particular cases, the Engineer could agree with bars welding; in such cases the following documents will be submitted to the approval of the Engineer.

1. A welding programme.
2. Certificates of steel reinforcement weldability.

C. Spacers shall be submitted to the approval of the Engineer.

1.5. TOLERANCES

A. Tolerance on the distance (d) between reinforcement bars in walls, slabs or beams:

1. 0.5 cm for d less than 15 cm
2. 1.0 cm for d between 15 and 80 cm
3. 2.0 cm for d greater than 80 cm

B. Tolerance on length of bars: + 4 cm except when these bars are in a discontinuity zone (support surface, etc.) where the tolerance will be + 1.5 cm.

C. Tolerance on concrete covering thickness:

1. Minus 15% with a maximum of 10 mm
2. Plus 30%

2. PRODUCTS

2.1. STEEL GRADES

The following types of steel shall be used for reinforcement:

1. Plain round mild steel or High yield steel bars conforming to BS 4449.
2. Cold worked steel bars conforming to BS 4461.
3. Fabric reinforcements made of cold drawn high tensile bars conforming to BS 4483.

Reinforcement shall be High yield steel bars conforming to BS 4449 as well as BS EN 1992-1 and BS EN 1992-3, with a minimum yield strength (noted f_{yk} in BS EN 1992-1) of 460 MPa and a minimum characteristic strain (ε_{uk})of 5%, which corresponds to a class B of ductility in BS EN 1992-1.

2.2. REINFORCEMENT SPACERS

A. Spacers may be made of metal, concrete, cement mortar or plastic.

B. Metal spacers or metal chairs shall not come into contact with the formwork.

C. Concrete or cement mortar spacers shall be of sufficient size to remain stable and shall be of equivalent quality to that of the concrete.

D. Unless their actual shape makes them perfectly stable, all spacers shall be provided with systems for attaching them to the reinforcement.

2.3. DELIVERY OF STEEL REINFORCEMENT

A. When the steel bars for concrete reinforcement are delivered on site, they must be straight, without bends or windings, without stains or other damage. Bars accidentally bent will be rejected; however, after removal of the bent parts, the remaining straight sections could be accepted if the available length is sufficient.

B. When the steel reinforcement is delivered already shaped and assembled, it will be transported to the place of use with great care to ensure that no parts will not be permanently deformed.

2.4. STORAGE OF STEEL REINFORCEMENT

A. The steel reinforcement bars shall be stored in such a manner that different diameters cannot be mixed.

B. Storage yards shall be clean and designed in such a manner that none of the steel reinforcement is in contact with the ground or subject to damp conditions.

2.5. WELDING OF BARS

A. The Engineer may authorise end-to-end welding of steel bars and spot welds on bars as a replacement for binding, depending on the steel bar weldability certificates.

B. The Engineer will prescribe tensile and bending tests on welded parts in order to check the quality of welds and prove that the procedure will produce adequate strength and other necessary properties in the splice.

C. Where agreed, welding of bars shall be carried out in strict accordance with the steel Manufacturer's instructions.

2.6. BENDING OF REINFORCEMENTS

1. Steel reinforcement for reinforced concrete shall be fixed in accordance with the detailed Drawings to be prepared by the Contractor and approved by the Engineer. The Contractor shall provide bending schedules and shall be responsible for checking them and ensuring their accuracy before ordering and bending the reinforcement.
2. The bars shall be bent cold in a manner that will not injure the metal and in accordance with BS 4466. No bar exempt links and stirrups shall be bent to a smaller radius than twice its diameter. All bars which are lapped to secure continuity shall, unless otherwise stated to the contrary, overlap not less than the values given in BS 8110. Reinforcement projecting from partly finished work shall not be bent unless permitted by the Engineer and shall be protected from damage.

3. EXECUTION

3.1. PREPARATION

Firm rust on steel reinforcement will be permitted but rust which is loose or flaky shall be wiped off firmly with burlap or wire-brushed. Any dirt, oil and other contaminants shall be removed before the reinforcement is placed in the Works.

3.2. PLACING OF REINFORCEMENT

1. Before being fixed in position all reinforcing bars shall be cleaned of all mill scale, rust, dried grout, paint, oil, grease, earth or any other substance which may impair the bond between the reinforcement and the concrete.
2. The reinforcement shall be placed and securely fixed in the exact position required and the Engineer` s approval obtained before concreting is commended. On walls the horizontal and vertical bars shall be securely bound together with 16 s.w.g annealed soft iron wire at intervals not exceeding 400 mm and at all intersection.
3. The ends of links and bindings shall be bent around the bars for at least 225 degrees so as to fit tightly.
4. Fabric reinforcement when laid adjacent to other sections of reinforcement or when lapped shall have a minimum lap of 300 mm for the main wires and 150 mm for transverse wires.
5. Anchorage length and overlap length shall not be inferior to 60 times bar diameter, unless stated otherwise.
6. Reinforcement in angles shall be placed taking into account the unwanted thrust effect from curved rebars in tension.

3.3. COVERING OF REINFORCEMENT BARS

Unless otherwise indicated, the minimum thickness of concrete covering the steel reinforcement shall be as follows:

1. For concrete cast directly against earth: 7,5 cm
2. Concrete in contact with water and atmospheric or aggressive agents: 5 cm (protection such as coating or painting shall be neglected, unless if approved by the Engineer)
3. Concrete in dry rooms: 3 cm
4. The covering over all reinforcement is to be at least equal to:
   a) its diameter (Φ) if it is a single bar,
   b) $\Phi \times n^{0,5}$ if it is a group of n bars, with a maximum of 55 mm
5. The concrete cover of the horizontal bars of a vertical layer of reinforcement shall exceed 4/3 of the maximum nominal aggregate diameter.

3.4. MINIMUM REINFORCEMENT FOR RESERVOIRS

In addition to BS EN 1992-1 and BS EN 1992-3, the following criteria apply for reservoirs:

For reservoir walls, the steel section of reinforcement (in m²) shall not be inferior to 0,125 % of wall width (in m) on each face and both vertically and horizontally.

For reservoir raft, the steel section of reinforcement (in m²) shall not be inferior to 0,25 % of raft thickness (in m) in each direction. This section shall be spread on the top and bottom layer of reinforcement.

3.5. PROTECTION

As the concrete sets, after it has lost its plasticity, the steel reinforcement shall not be subjected to shocks or any external force (bending or use of bars for moving personnel) for a period of 48 hours.

SECTION 03250
CONCRETE STRUCTURE JOINTS AND NEOPRENE BEARING PAD

1. GENERAL

1.1. WORKS INCLUDED

This section covers the supply, installation or execution of different types of joints in all concrete structures and neoprene bearing pads.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DEFINITION AND DESCRIPTION

A. Contraction joint

1. It is a contact between 2 elements generally without continuity of reinforcement, or half continuity of reinforcement.

2. Such joints will enable concrete cracks to be localized and construction phases to be localized.

3. They shall have no filler material (concrete cast against concrete).

B. Expansion joint

1. An expansion joint is formed by creating complete discontinuity with clear gap between 2 elements.

2. The purpose of expansion joints is to prevent structural disruptions as a result of temperature variations or differential movements, including earthquake effects in seismic regions.

3. The joints shall be filled with preformed joint filler.

C. Construction joint

1. The continuity of both concrete by special preparation and of reinforcement shall be assured.

2. These joints localize construction phases.

D. Sealing strip (or waterstop)

1. Watertight sealing is achieved by a natural rubber or PVC strip held in the two parts of structures in contact.

2. Strips are fitted to contraction and expansion joints.

E. Joint sealing compound

Joints may be sealed with an elastomer joint-sealing compound.

F. Neoprene bearing pads:

These elements shall provide vertical support and allow small horizontal displacements. They can be used for example between roof slabs and supporting water retaining walls under temperature shrinkage or during earthquake.

G. Preformed gap filler:

For the remaining part of gap in expansion joint and around neoprene bearing pad.

1.4. QUALITY ASSURANCE

All the products used in joint work shall be of proven quality and shall be obtained from reputable manufacturers and approved by the Engineer.

1.5. STANDARDS AND CODES

The following Standards shall be used, in this order of priority:

1. ASTM D1751

2. British Standards.

3. European Standards.

1.6. SUBMITTALS

A. Technical data sheets giving the physical, chemical and mechanical characteristics of:

1. Sealing strips and special connection parts

2. Preformed joint fillers

3. Joint sealing compound

4. Neoprene bearing pads

B. A sample of all the products to be used in joint construction.

C. Results of quality control tests carried out in the factory on sealing strips and joint sealing compound.

D. Manufacturer's instructions for the storage and use of products.

1.7. TOLERANCES

A. Sealing strips

1. With respect to the formwork before pouring of concrete: 5 mm in all directions.

2. With respect to the final faces of the structure after pouring of concrete: 20 mm in all directions.

B. Joint sealing

After making the joint, the surface of the facing shall be continuous and smooth and shall not have any local irregularity greater than 5 mm.

C. Bridge joints

1. The level difference between the top carriage way surface of the bridge joint and the finished surface of the bridge deck shall be less than 5 mm.

2. The level difference between the 2 sectional irons forming the built-in part of the joint shall be less than 2 mm.

D. Neoprene bearings

1 mm in flatness and horizontality for lower surface (head of water retaining wall) and upper surface (roof slab).

2. PRODUCTS

2.1. SEALING STRIPS AND CONNECTION PARTS

A. Material

Sealing strips shall be of rubber sections for type 1 and polyvinyl chloride (PVC) for type 2 waterstop.

Type 1 will be used for expansion joints or contraction joints in structures bearing a water pressure more than 5 mwc.

Type 2 will be used for contraction joints.

B. Rubber Material Characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than Elongation on rupture greater than Percentage of cinders less than Shore hardness	20 MPa 450% 4% 60 to 70	15 MPa 350% 4%

C. PVC material characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than Elongation on rupture greater than Maximum water absorption after 48 h immersion at 50°C Shore hardness	12 MPa 250 % 3 % 50 to 60	15 MPa 350 %

D. Range of dimensions (in mm)

Type	Width	Centre bulb	Outer flanges
1	300-350	45-55	23-27
2	200-230	No	18-22

E. Protection

Water stop and sealing strip materials shall be stored carefully on site to avoid damage and contamination with oil, grease, or other pollutants. The storage area shall be cool, well ventilated and away from direct sunlight.

2.2. PREFORMED JOINT FILLER

The preformed expansion joint fillers shall consist of a compressible, rot-proof and elastic material of the Flexcell or equivalent type conforming to ASTM D1751.

2.3. JOINT SEALING COMPOUND

A. The joint sealing compound will be an elastic, adhesive, waterproof elastomer capable of stopping the intrusion of foreign materials in the joint.

B. The product shall not have any chemical action on the materials with which it will come into contact (concrete, preformed joint filler).

C. Characteristics

1. Density:..... 1700 kg/m³ minimum
2. Shore hardness: 25-30
3. Consistency after polymerization: ..... Rubbery

4. Proportion of solvent: .....Nil

5. Shrinkage: .....Nil

6. Vertical creep:.....Nil

7. Minimum deformation: .....25 %

8. Minimum deformation in compression and traction without bond breaking, creep or cracking in the temperature range of 0-70°C.

2.4. BRIDGE JOINTS

A. Bridge joints shall be formed by steel and neoprene rubber.

B. Bridge joints shall be of the medium-heavy type capable of accommodating movements of 20-30 mm.

2.5. NEOPRENE BEARING PADS

Same quality as for bridge joints but without reinforcement of steel plates. Sticking with approved glue on its sub-surface.

3. EXECUTION

3.1. INSPECTION

All the products making up the joints (sealing strips, special parts, preformed joint filler, joint sealing compound, bridge joints) will be inspected and checked by the Engineer before installation.

3.2. SEALING STRIPS AND SPECIAL PARTS

A. Sealing strips as well as special intersection or connection parts, shall be fastened to the formwork or the reinforcement so as to keep them in the correct position as defined on the drawings during concreting operation.

B. Under no circumstances shall sealing strips fastening devices compromise watertightness (nailing for example).

C. Sealing strips as well as special intersection or connection parts shall be interconnected in order to guarantee total continuous sealing. The method of connection shall be of an approved type such as hot-vulcanized connection using an electric vulcanizer, or cold connection using a preformed rubber sleeve, and special solvent, as specified by the manufacturer of the strips.

D. The Contractor shall take particular care when concreting around the sealing strips. The consistency, particle size distribution, placing and internal vibration of the concrete shall be such that encasing is obtained. Large aggregates shall in all cases be removed from the strip encasing zone.

E. Restarting parts of sealing strips or special parts shall be protected from the risk of mechanical accidents and, if necessary, from the effects of solar radiation if the exposure time were to exceed one month.

F. All sealing strips or special parts incorrectly installed or connected, punctured or damaged, will be rejected and replaced.

3.3. PREFORMED JOINT FILLER

A. The preformed joint fillers shall be installed in the positions defined on the drawings against the first concreted face of the joint.

B. The method of fixing the preformed joint filler (copper or bronze nailing or bonding with an adhesive compatible with the filler material) shall ensure proper stability of the joint filler before and during concreting.

C. Joints between preformed joint filler panels shall be made watertight in order to prevent the penetration of underlying cement grout.

3.4. JOINT SEALING

A. The edges of joints shall not show any signs of spalling or beading. Any repairs that may be required on the joint lips shall be carried out using epoxy resins approved by the Engineer.

B. Before filling with the joint sealing compound, the joint faces shall be cleaned of any loose laitance by sand-blasting or grinding or brushing. The faces shall be clean and dry when the mastic compound is applied.

C. The joint sealing compound shall be applied in strict accordance with the manufacturer's recommendations.

3.5. BRIDGE JOINT

A. Anchor bars of bridge joint shall be welded to the reinforcement bars.

B. The two parts of the bridge joint shall form an integral part during concreting of the second part of the joint and shall be separated as soon as concrete setting is done.

3.6. NEOPRENE BEARINGS

A. The reinforced neoprene pads shall be settled on perfectly flat and horizontal surfaces.

B. The performances (ashlar) of the bearing surfaces shall be slightly larger than the neoprene pad. The ashlars shall be refilled on pointed surface with a mortar dosed at 500 kg of cement per cubic metre of sand. The neoprene bearings shall be placed on green mortar. For case in-situ structures the Contractor shall design a formwork system allowing for an easy stripping around the bearing.

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SECTION 03300
CONCRETE

1. GENERAL

1.1. WORK INCLUDED

This section covers the execution of concrete works for all structures.

1.2. RELATED SECTIONS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. STANDARDS AND REGULATIONS

A. Local Standards

All applicable local standards

B. British Standard

BS EN 1992-1	Eurocode 2 - design of concrete structures - part 1-1: general rules and rules for buildings
BS EN 1992-3	Eurocode 2 - Design of concrete structures - Part 3: Liquid retaining and containment structures
BS EN 1998-1	Design of structures for earthquake resistance – General rules, seismic actions and rules for buildings
BS EN 1998-4	Design of structures for earthquake resistance – Silo, tanks and pipelines
BS EN 1998-5	Design of structures for earthquake resistance – Foundations, retaining walls and geotechnical aspects
BS EN 206-1	Concrete - part 1: specification, performance, production and conformity
BS EN 197-1	Cement - Part 1: composition, specifications and conformity criteria for common cements
BS l2	Specification for ordinary and rapid hardening Portland cement

BS l46: Part 2	Specification for Portland blast furnace cement (Metric units)
BS 340	Specification for precast concrete kerbs, channels, edgings and quadrants
BS 368	Precast concrete flags
BS 812	Grading of aggregates
BS 1200	Building sands from natural sources
BS 1881	Testing Concrete
BS 3148	Methods of tests for water for making concrete
BS 4027	Specification for sulfate-resisting Portland cement
BS 4246	Low heat Portland blast furnace cement
BS 5328	Methods for specify concrete
BS 5896	Specification for high tensile steel wire strand for the prestressing of concrete
BS 6073	Specification for precast concrete masonry units
BS EN 933-3	Tests for geomtrical properties of aggregates
BSI 6089	Guide to assessment of concrete strength in existing structures

C. American Concrete Institute (ACI)

ACI 121R	Quality Assurance Systems for Concrete Construction
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 305	Hot Weather Concreting

D. American Society for Testing and Materials (ASTM)

ASTM A 416	Specification for Uncoated Seven-Wire Stress-Relieved Steel Strand for Prestressed Concrete
ASTM A 421	Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 31	Test Method of Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Specification for Concrete Aggregates
ASTM C 39	Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C 40	Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C 42	Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 70	Test Method for Surface Moisture in Fine Aggregate
ASTM C 88	Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 114	Methods for Chemical Analysis of Hydraulic Cement
ASTM C 177	Test Method for Material Finer than 0.075 mm Sieve in Mineral Aggregates by Washing
ASTM C 125	Definition of Terms Relating to Concrete and Concrete Aggregates
ASTM C 127	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	Test Method for Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	Test Method for Clay Lumps and Friable Particles in Aggregate
ASTM C 143	Test Method for Slump of Portland Cement Concrete
ASTM C 150	Specification for Air-Entraining Admixtures for Concrete
ASTM C 151	Test Method for Autoclave Expansion of Portland Cement
ASTM C 172	Method of Sampling Freshly Mixed Concrete
ASTM C 191	Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C 192	Method of Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 204	Test Method for Fineness of Portland Cement by Air Permeability Apparatus
ASTM C 231	Test Method for Air Content of Freshly Mixed Concrete by the pressure Method
ASTM C 309	Specification for Liquid Membrane - Forcing Compounds for Lining Concrete
ASTM C 348	Test Method for Flexural Strength of Hydraulic Cement Mortars
ASTM C 349	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using Portions of Prisms Broken in Flexure)

ASTM C 360	Test Method for Ball Penetration in Fresh Portland Cement Concrete
ASTM C 403	Test Method for time of setting of concrete mixtures by Penetrations Resistance
ASTM C 451	Test Method for Early Stiffening of Portland Cement (Paste Method)
ASTM C 469	Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C 494	Specification for Chemical admixture for concrete
ASTM C 496	Test for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	Test Method for Total Moisture Content of Aggregate by Drying
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 596	Test Method for Drying Shrinkage of Mortar Containing Portland Cement
ASTM C 618	Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM D 75	Practices for Sampling Aggregates
ASTM D 2419	Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2487	Classification of Soils for Engineering Purpose.

E. Association Française de Normalisation (AFNOR)

NF P 15-436	Binders - Measuring of hydration heat of cement by means of semi-adiabatic calorimetry (Langavant method)
NF P 18-561	Aggregates - Measurement of the Flattening coefficient
NF P 15-317	Hydraulic binders – sea-water resisting cements
NF P 15-319	Hydraulic binders – sulphate resisting cements

F. Deutsches Institut Fur Normung

DIN 1048	Testing Method for concrete; fresh concrete.

1.4. SUBMITTALS

A. The Contractor shall advise the Engineer not later than 2 months after the commencement date and at least 6 weeks before commencement of any permanent Concrete Works, by means of a detailed memorandum, of the arrangements he proposes to adopt regarding the production of sand and aggregates and the manufacture of concrete, as well as for casting of the concrete.

B. Documents on concrete manufacturing

C. The Contractor shall submit to the Engineer's approval detailed drawings of the phases of concreting, specifying the locations of the various construction joints, any particular arrangements which may be required, and the order of implementation of the different phases.

D. Test results

The results of the tests shall generally indicate:

1. Identification number of sample.
2. Origin of sample.
3. Part of structures represented by the sample.
4. Drawing date of the sample.
5. Description of test with reference to a given standard.
6. Test result.
7. Date of test.

E. Cement

1. Test report for approval of cement before use.
2. Chemical and physical analyses for each make.
3. Copy of the cement storage record-book submitted at the end of each week.

F. Aggregates

Test report for approval of aggregate before any use.

G. Water

Detailed memorandum for approval.

H. Additives

Test results.

I. Concrete

1. Results of tests on mix design studies including the calibration certificates of all batching and testing equipment used during the mix design.
2. Results of concrete suitability tests.
3. Results of control tests.
4. Complete records shall be kept by the Contractor of all concreting. The records shall include the time of mixing and casting, weather conditions, quantity, mixture proportions, amount of additives, slump and water content of each cast, as well as the results of any tests made on the concrete.

1.5. DESCRIPTION

A. The major part of the concrete may be considered as reinforced concrete except in volume with some embedded items. In consideration of the behaviour of massive concrete blocks (setting temperature, shrinkage) and for reasons of construction (concreting or/and equipment erection schedules, etc,) concrete shall be placed in a number of planned pours or lifts (a lift being defined as a volume of concrete poured without any interruption).

B. Except as otherwise specified or shown on the drawings or directed by the Engineer the extent of any horizontal length of a pour shall not exceed 15 m. The height shall in general not exceed 2.5 m, in some exceptional cases (with at least one small horizontal dimension) higher.

C. In the building parts such as service rooms, staircases, etc.. reinforced concrete works with a medium to high percentage of reinforcement shall be involved. In principle, the above mentioned provision concerning the massive concreting sections remains valid.

D. Finally, concreting sections will be provided such as second phase concrete for pockets or around embedded items. In these cases, relatively small quantities of concrete will be placed under confined conditions.

E. All concreting of continous lifts are separated by construction or expansion joints. In general, the reinforcement will be continued over the construction joints.

F. Pouring of lifts of limited dimensions does not exclude other means to avoid cracking such as the use of low heat of hydration cement, low cement ratio and refrigeration of concrete constituents.

G. All concrete shall be "hydraulic type concrete", watertight by its own media.

2. PRODUCTS

2.1. CEMENT QUALITY

A. Unless otherwise specified, the cement shall be Portland Cement type CEM I or CEM III according to EN 197-1

1) The cement shall meet the following specifications:

Characteristics	Value	Test Method
Minimum compressive strength at 28 days	30 MPa	ASTM C 349
Initial setting time (Vicat needle) more than	90 mm	ASTM C 191
Initial setting time less than	180 mm	
Le Chatelier stability - cold and hot expansion less than	3 mm	NFP 15-432
Shrinkage at 28 days of mortar less than	0.08 %	ASTM C 596
+ chemical characteristics S03 less than	5 %	ASTM C 114
Hydration heat at 5 days (Langavant bottle) less than	260 J/g	NFP 15-436
+ equivalent sodium oxide (Na20+0.658 K20) less than	0.6 %	ASTM C 114

Potential alkali reactivity of cement - aggregate Combination - expansion at:		
6 months less than	0.075 %	ASTM C 227
12 months less than	0.1 %	ASTM C 227

\+ for cement only.

B. The mixing of cements or cement and mineral admixtures, such as milled slag, fly ash, pozzolan or fillers shall be authorised provided the effect of such blends made before mixing in the batching plant or during mixing be tested in accordance with the Engineer's instructions and the result submitted to the Engineer.

2.2. APPROVAL OF CEMENT BEFORE ANY USE

A. Each make of cement shall be constituted by cement from a homogeneous source (same factory, same fabrication process and same basic material).

B. The delivery of any make of cement to the primary silos at site shall not take place until written approval has been given by the Engineer, after examination of the test report. This test report shall be the result of tests carried out in the cement works or in a laboratory approved by the Engineer.

C. The tests shall include:

1. Flexural and compressive strength at 2,7, 28 and 90 days.
2. Initial and final setting time on pure paste.
3. Cold and hot expansion.
4. Shrinkage of cement mortar.
5. Chemical analysis.
6. Hydration heat (measured at 12 hours 1, 2, 3, 5 and 7 days) by the insulated.
   Langavant bottle method. (NF P 15-436) which is a semi-adiabatic measurement.
7. Potential alkali reactivity of cement - aggregate combination (test duration: at least 2 years: the 6 months test will be extended for at least six additional months).
8. Blaine's specific surface (ASTM C 204).

D. Each characteristic shall be taken as equal to the average of three measurements made under each test (except for the compressive strength which shall be the average of 6 measurements).

2.3. VERIFICATION OF CEMENT DELIVERED

A. Control sampling shall be effected on each supply before the cement is delivered to the primary silos at site and when required by the Engineer.

B. Every 1000 t or not less than once a month, the following control tests shall be carried out:

1. Hot and cold expansion
2. Flexural and compression strength at 2 and 28 days
3. Initial and final setting time on pure paste
4. Blaine's specific surface

C. Every 5000 t or not less than once a month, the following control tests shall be carried out:

1. Heat of hydration (measured at 12 hours, 1, 2, 3, 5 and 7 days).
2. Chemical analysis.

D. Every 1000 t, and not less than once a month, a sample shall be taken at the silo of the batching plant and shall be kept in the laboratory for a minimum duration of 6 months (conservation samples). These samples (5 kg) are designed to allow the performance of tests a posteriori, in case of dispute or for information.

E. No cement shall be used before the flexural and compression strength at 2 days, the initial and final setting times, and the Blaine specific surface are known.

2.4. CEMENT DELIVERY

A. The cement shall be delivered in bulk or in bags, with the exception of cement for grouting, repair or finishing works or any other particular works, which will be delivered exclusively in bags.

B. Transport from the factory to the site shall be effected in watertight containers specially designed for this purpose.

C. The installations for transport from the container to the silo and from the silo to the mixer shall be watertight.

D. Once the supply in bags has been approved, the cement shall be delivered in bags of standard dimensions. The identification of the cement, the name of the manufacturer and the weight of the bags shall be clearly marked on each bag. Cement from damaged bags shall be neither used nor replaced in the bag without the prior approval of the Engineer.

2.5. CEMENT STORAGE

A. The cement supplied in bulk shall be stored in watertight silos designed to ensure that there is no loss in storage. The silos shall be emptied and cleaned every 6 months and whenever there is a change in the type or origin of the cement.

B. The cement supplied in bags shall be stored in a dry place, fully enclosed and covered, isolating them from the soil and from atmospheric agents. The store shall be of sufficient

dimensions to allow easy access for identification, removal of samples, counting and moving the bags. The bags shall not be stored in piles exceeding 2.5 m in height.

C. The cement shall be used in chronological order of its arrival. The temperature of the cement at the time of its use shall not exceed 70°C.

D. The total storage capacity of the primary silos at site shall be sufficient to guarantee normal progress of works on site for a duration of 20 calendar days.

E. The use of any cement that has remained in storage on site for more than 4 months shall be subject to a complete series of physical tests to ensure that the specifications are complied with.

F. Any cement which has been exposed to the elements or which has set, even partially, or which has been rejected in compliance with the specifications shall not be used for the permanent Works and shall be removed from the silos or stores.

2.6. CEMENT STORAGE RECORD-BOOK

The Contractor shall keep for every silo a cement storage record-book in which the following will be noted:

1. The quantity of cement in store at the end of the week.
2. The quantities, origin and location of storage of the various batches delivered during the week.
3. The quantities used daily and the structures in which the cement is used.

2.7. OVERALL QUALITY OF AGGREGATES

A. The aggregates shall be crushed material originating from rock that is neither sensitive to the environment nor likely to have any harmful effect with regard to the other concrete ingredients. Fine aggregates for concrete may consist of natural sand. Provenance of aggregates after washing, screening and possibly crushing is subject to prior Engineer's approval with evidence of their suitability as regards to the requirements of the present specification.

B. The aggregates shall meet the requirements of ASTM C 33.

C. The density of the aggregates shall be greater than 2.55 t/m³.

2.8. GRADING OF FINE AGGREGATES

A. The fine aggregate shall be made up of two separate categories, which shall be:

1. Fine sand 0 - 0.630 mm
2. Coarse sand 0.630 mm - 5.0 mm

B. The grain size characteristics of the fine aggregate after mixing the two categories shall be within the following range:

Sieve Designation	Per cent passing by weight
4.8 mm (N°4)	95 to 100
2.4 mm (N°8)	85 to 95
1.2 mm (N°16)	60 to 85
0.595 mm (N°30)	30 to 65
0.297 mm (N°50)	15 to 40
0.149 mm (N°100)	5 to 20
0.074 mm (N°200)	0 to 5

C.

1. The fineness modulus shall be within the range of 2.2 to 3.1.

2. Continuity, that is the percentage in mass retained between two successive sievings, shall not be greater than 40%.

2.9. GRADING OF COARSE AGGREGATES

A. The coarse aggregates shall be divided into 3 categories:

1. 5/12.5

2. 12.5/25

3. 25/50

B. Coarse aggregates will be divided into classes defined by d/D, and shall meet the following conditions:

US Standard Sieve Designation	Per cent passing by weight		
	5 /12.5 mm	12.5 /25 mm	25 /50 mm
76.2 mm (3 inches)	-	-	100
50.8 mm (2 inches)	-	-	90-100
38.1 mm (1 1/2 inch)	-	100	35-65
25.4 mm (1 inch)	-	90-100	3-10
19.1 mm (3/4 inch)	100	35-65	0-3
12.7 mm (1/2 inch)	90-100	3-10	-
9.5 mm (3/8 inch)	35-65	0-3	-
4.8 mm (No. 4)	3-10	-	-
2.4 mm (No. 8)	0-3	-	-

2.10. NOT USED.

2.11. PROPERTIES OF AGGREGATES

A. General

Characteristic	Value	Test Method	Field of application
Water absorption, Ab	< 5	ASTM C 127 ASTM C 128	Coarse aggregate Fine aggregate
Los Angeles, LA	< 40	ASTM C 131 ASTM C 535	Aggregates > 2.5 mm Coarse aggregates
Flattening coefficient	< 30	NF P 18-561	Aggregates > 4 mm
Sand equivalent ESV	> 75	ASTM C 2419	Fine aggregate mixtures of sands

B. Sand equivalent

Fine aggregates having an equivalent sand value (ESV) which is less than the specified value may be accepted if the blue value (BV) measured according to standard NFP 18-595 is less than 1 g per 100 g of fines passing through the 80 micron sieve.

2.12. TRANSPORT AND STORAGE OF AGGREGATES

A. The transport and storage methods shall be such as to guarantee a stable and uniform water content and to avoid any segregation.

B. The different classes of aggregates shall be stored separately in silos or on a concrete platform or by any other means guaranteeing an equivalent level of cleanliness. The storage area must be designed to ensure effective drainage of the aggregates.

C. The capacity of the storage specified in para. B for each class of aggregates shall be sufficient to ensure progress of work on the site for a duration of 14 days.

2.13. VERIFICATION OF AGGREGATES

A. Normal frequency N

1. Every week or every 500 m³ of concrete if the volume of concrete manufactured is less than 500 m³ per week.

2. For every new delivery of a material of different origin or obtained by a different process.

B. Frequency xN

1. Every x tests carried out at the normal frequency.

2. For every new delivery.

C. Tests to be performed on the aggregates:

Characteristics	Method ASTM	Field of application	Frequency
Grain size analysis	C 136	All aggregates	N
Water content	C 566	Fine aggregates	N
Water content	C 566	Coarse aggregates	N
Fineness modulus diagram	C 136	All aggregates	10 N
Water absorption	C 127	Coarse aggregates	5 N
Water absorption	C 128	Fine aggregates	5 N
Los Angeles	C 131-C535	Aggregates > 2.5 mm	15 N
Organic matter	C 40	Fine aggregates	10 N
Sand equivalent	D 2419	Fine aggregates	N

Soundness Flattening Coefficient	C 88 NF P 18-561	All aggregates Aggregates > 4 mm	15 N 5 N

D. The tests shall be performed on samples taken in accordance with the Engineer's instructions.

E. Diagram of fineness modulus

At the specified frequency, a series of 10 sieve analyses will be made at intervals of about 1 hour. The following will be noted on a diagram: the 10 results, the average of the 10 results, the straight lines situated at 0.10 and 0.20 unit above and below the mean value. The results of the fineness modulus determined by the normal sieve analyses shall also be shown on this diagram.

F. Blue value

Measurement of the blue value shall be made where the equivalent sand value (ESV) is less than the specified value.

2.14. WATER

A. The mixing and curing water shall be free of any impurities which might significantly affect the duration of setting, the strength or durability of the concrete or which might affect the appearance of the concrete by discolouration, coloration or efflorescence.

B. The mixing and curing water shall meet the following specifications:

Impurity	Maximum content (part per million - ppm)
Suspended matter Carbonates and bicarbonates Sulphate (SO3) Dissolved salts	2000 1000 1000 2000

C. Where the dissolved salt concentration exceeds the specified value, or where the water quality is doubtful in the Engineer's opinion, comparative tests of compressive strength and setting time will be performed on two cement pastes with the same cement, one with the water in question and the other the reference paste, with distilled water in the same proportions. The water will be acceptable if the test results comply with the following values:

Test	Limit	Standard
Compressive strength at 7 days minimum result compared to reference paste	90 %	ASTM C 349
Start of setting: maximum difference from time of reference paste	1 h	ASTM C 191

D. Control tests shall be carried out:

1. For approval of the water.
2. For any change in the source of supply.
3. In any event, once every three months.

2.15. ADDITIVES

A. Additives shall comply with ASTM C 494.

B. The use of additives containing calcium chloride is forbidden.

C. All additives shall be in liquid form.

D. Provision shall obligatorily be made for the automatic addition of any additive.

E. The concrete shall be made with addition of a water-reducing plasticizer, with the exception of blinding concrete.

F. The Contractor shall submit, for approval of any proposed additive, a memorandum demonstrating, on the basis of test results, the compatibility of the additive with the other concrete ingredients, its influence on the proportion of water for equal consistency, its effect on consistency for equal proportions of water, the times of beginning and end of setting of the neat cement paste, and the mechanical strengths of the concrete obtained. These tests are performed for the optimum proportion proposed and for half and double of this optimum proportion.

G. Where specified, the following additives shall be used:

1. Air entrainer.
2. Shrinkage reducer for certain sealing grout or mortars; this additive shall be free of iron.
3. Setting accelerator for shotcrete.

2.16. CLASSES OF CONCRETE

A. The concrete classes are defined by their characteristic compressive strength at 28 days of 150mm diameter by 300mm cylinders followed by the characteristic compressive strength at 28 days of 150mm cubes in MPa. The coarser aggregate dimensions in mm is specified (See Classification Table below).

B. The characteristic strength f_{ck} is the compressive strength at 28 days on 150 mm dia cylinder for all concrete classes A, B, C, D, below which less than 5% of the tested samples should be found.

C. Classification table:

Class	Class according to BS EN 206-1	Definition	f_{ck} (MPa)	Coarser aggregate dimension (mm)	Cement content kg/m³		Max water/ Cement ratio max W/C
					min	max	
A	C30/37	Reinforced concrete Precast concrete	30	25	350		0.45
B	C20/25	Unreinforced and lightly reinforced concrete	20	40	250	320	0.55
C		Shotcrete	25	-	350	400	-
D		Blinding concrete	15	25	180	250	-
E		Porous concrete	10	40	200	250	-

2.17. CONCRETE COMPOSITION

For each class of concrete, a memorandum shall be submitted to the Engineer demonstrating that for the design consistency, the proposed composition and the installations on site will produce concrete satisfying the specifications.

If the proposed concrete has not been made previously from materials of the same type and origin and with equivalent site installations, a concrete design study shall be made for testing, with the exception of blinding concrete.

2.18. CONCRETE DESIGN STUDY (CONCRETE CLASSES A, B, C)

A. Purpose

1. Check that the nominal composition of the concrete proposed by the Contractor enables the specification to be met.

2. Check that the concrete specifications are still respected if the quality of the ingredients reaches the specified limits or the probable limits of the ingredients used.

3. Check that the concrete specifications are still respected if the proportions of the ingredients reach the specified limits or the probable limits resulting from the site installation (the design limits may also be chosen so as to study several nominal compositions simultaneously).

B. The design test will involve the following operations:

1. Three batches meeting the nominal formula.

2. Eight batches varying from the nominal formula as follows:
   a) Two batches by modifying the proportions of aggregates (for example variation of the ratio of the mass of coarse aggregates to that of finer aggregates by 10% in either direction).
   b) Two batches by altering the quantity of mixing water (10 l/m³ more and less).
   c) Two batches by altering the quantity of cement (25 kg/m³ more and less).
   d) If an additive or additives are used, two batches by altering the quantity or quantities of additives (half and double the optimum quantities).

C. Measurements made for concrete classes A, B and C:

1. Each batch shall be the subject of the following measurements:

2. consistency;

3. density and air content within the fresh concrete;

4. density of concrete at 28 days;

5. compressive strength at 7 days on three samples;

6. compressive strength at 28 days on three samples and static modulus of elasticity and Poisson's ratio (in addition to ASTM C 469 strains shall be measured for stresses of 3, 5, 7, 9, 11 MPa).

7. The components shall be subject to the control measurements specified elsewhere.

8. Also to be noted are the following factors:
   - Temperature of the components and of the concrete during the tests.
   - Aspect of the fresh concrete during performance of the consistency test and of the preparation of the specimens.
   - Aspect of breakage during the mechanical tests.

D. Not used.

E. Interpretation of the design test:

1. The design test shall be considered valid and the composition of the concrete accepted if all the following conditions are met:

   e) All consistency results are within the specified ranges.

   f) The arithmetic mean (fcE) of the 9 measurements (3 tests on each of 3 batches) of compressive strength in MPa measured at 28 days is greater than:

   $$fc + (C_E - C_{min})$$

   and greater than 1.1 fc,

   formula in which C_E is the compressive strength at 28 days of the cement used for the design test and C_{min} is the minimum guaranteed value of the cement's compressive strength at 28 days.

   g) The arithmetic mean of the 3 compressive strength tests on each of the complementary batches is within the range of fcE ± 0.15 fcE.

2. If the above conditions are not totally satisfied but the concrete is close to the required values or well in excess of these values, the Engineer will, if the Contractor submits a proposal to this effect, fix the nominal composition of the concrete without any further design test.

F. Not used.

2.19. CONCRETE SUITABILITY TESTS (CONCRETE CLASSES A AND B)

A. The suitability test, to be performed on the site at least 40 days before making any concrete for the permanent Works, shall be aimed at verifying the following:

1. that the concrete made by applying the nominal composition, using the materials and constructional plant delivered to the site, satisfies the specifications,

2. that the concrete composition, considering the installations it is envisaged to use, will enable the structures to be built in a satisfactory manner,

3. that the characteristics of the plant are in conformity with those submitted to the Engineer's approval.

B. The suitability test, performed under conditions representative of the site (transport, installations and plant used, temperature, etc) implies the making of three batches to the nominal composition and will involve:

1. Casting of a reference concrete sample in representative formwork, where required by the Engineer.

2. Casting of a volume of 1 m^3 of concrete.

3. Performance of the same sampling and tests as for the design test.

4. Verification of the characteristics of the site installations or the materials supplied.

C. The test shall be interpreted on the same basis as the design test.

2.20. NOT USED

2.21. CONCRETE CONSISTENCY (CONCRETE CLASSES A AND B)

A. The consistency of the concrete shall be such that it can be placed using the site facilities and compacted so as to enclose completely the reinforcement bars and embedded parts and completely fill the formwork, with neither voids nor segregation.

B. Consistency shall be checked by measuring the slumps test (ASTM C 143).

C. For concrete with aggregate larger than 40 mm, the test shall be performed on the fraction of concrete passing 40 mm sieve (the larger aggregate being removed in accordance with ASTM C 172).

D. The consistency classes are as follows:

Consistency Class	Nominal slump (in cm)	Nominal Tolerance
Very stiff	1	0 - 2
Stiff	3	2 - 4
Semi-plastic	5	3 - 7
Plastic	8	6 - 10
Fluid	15	12 - 20

E. The consistency classes shall be applied in the following manner:

1. 3 cm for mass concrete without embedded parts.

2. 5 cm for slabs and lightly reinforced parts of the structures, for the main structures and the upper sections of walls and columns.

3. 8 cm for narrow walls (< 40cm), columns, beams and heavily reinforced parts of the structures, and for lining concrete in underground excavations.

4. Fluid conditions (slump of 15 cm or higher) shall be exceptionally applied when required by Engineer (around steel lining penstock for instance).

F. The Engineer reserves the right to specify different consistencies where required by the nature of the works.

G. The concrete consistency shall be measured at the time it is used at the Engineer's discretion. If the measurement made falls outside the specified limits, two control measurements shall be made immediately, and the result shall be taken as the average of the three measurements, rounded off to the nearest centimetre.

H. In case of sampling for testing the strength of the concrete, 3 measurements shall always be made.

2.22. PARTICULAR SPECIFICATIONS FOR SHOTCRETE

The composition of shotcrete shall be defined by the Contractor in accordance to Internationally recognised Standards approved by the Engineer.

The Contractor shall propose to the Engineer the composition of the shotcrete in terms of sieving of the aggregates alone and of the aggregate-cement mix. The particle size curves shall fall within the reference ranges recommended by AFTES. The Contractor shall also communicate to the Engineer the results of the tests carried out in laboratory in accordance with the same recommendations, depending on which concrete projection technique is adopted.

A. Suitability test

Forty days before commencing any shotcrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement-mixers, of the control devices and the sprayed installations, under normal site operating conditions.

2. The quality of the shotcrete:

   - simple compressive strength at 8 h, 24 h, 7 days and 28 days,
   - adherence of the shotcrete to the terrain (minimum adherence on the most critical fissures or joints: 50% of the maximum adherence obtained on sound surfaces),
   - continuity of the shotcrete (no voids between the terrain and the shotcrete nor within the shotcrete itself),
   - apparent density of the shotcrete,
   - effective composition of the concrete,
   - consistency measurement (without additives).

   These tests shall be carried out on not less than three tests panels for each mix for testing. Sets of test panels shall comprise one shot downwards on to a horizontal surface, one shot on to a vertical surface and one shot on to a overhead horizontal surface.

2.23. SPECIAL SPECIFICATIONS FOR POROUS CONCRETE

A. Porous concrete is one containing no sand, used for drainage purposes under structures.

The Engineer shall be responsible for defining whether or not it is to be used.

B. Composition

No sand shall be used.

2.24. PARTICULAR SPECIFICATION FOR BLINDING CONCRETE

A. The blinding concrete is designed to be placed in the structure foundations on common soil; the layer of blinding concrete must be impermeable.

B. The concrete shall be obtained from a mix of sand, aggregates in the 5-12.5 and 12.5-25 size categories and cement at 275 kg minimum per m³ of concrete. The exact composition shall be proposed by the Contractor.

2.25. PARTICULAR SPECIFICATIONS FOR FLUIDIFIED CONCRETE

A. Fluidified concrete will be used only when required by the Engineer.

B. The concrete composition shall be the composition of a pumpable concrete and the amount of material finer than 0.250 mm (fine sand and cement) shall be at least 450 kg per cubic metre of concrete.

This concrete shall have a consistency measured by the slump test of 6 cm with the tolerance specified above, before addition of the fluidizer.

C. The fluidizer shall be added to the concrete mixture already transported to the concreting site in a liquid form by means of an automatic control system. The fluidizer addition shall be followed by an additional mixing of the concrete-fluidizer mixture in a special concrete mixer (minimum mixing time: 3 mn) or in the truck mixer itself (minimum mixing time: 5 mn).

D. The amount of fluidizer added shall be such that the slump of the mixture after the additional mixing is 15 cm. However this amount shall not be less than 0.5 % of the cement in weight.

E. The setting retarder effect of the fluidizer may be compensated by use of an approved combined setting accelerator if required.

F. Suitability test

Forty days before commencing any concrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement mixers, of the control devices for fluidizer addition, of the additional mixing and of the final transport of fluidified concrete to the site (pipes, channels...).

2. The quality of the fluidified concrete:

   a) Consistency measurement (before and after the fluidizer addition).

   b) Simple compressive strength at 1, 3, 7 and 28 days.

   The strength shall be at least 90 % of the corresponding strength of the same concrete without addition of the fluidizer.

c) Measurement of air content of fresh concrete after the additional mixing.

d) The compatibility of the fluidizer with any other additive possibly used, as requested above for any additive proposed.

e) Suitability of the concrete mix as regards to segregation.

f) Suitability of the concrete mix as regards to pumpability.

g) Effect of the variations in the quantity of fluidizer added, as described above for the submittal of any additive to the approval of the Engineer.

2.26. CONCRETE MIXING

A. The aggregates, water, cement and additives shall be mixed in an automatic concrete-mixer with batching by weight, equipped with:

1. a wattmeter (slumpmeter or any other approved concrete workability meter),

2. a printed register for recording the date and time of batching, the weight of cement and aggregates and the water-cement ratio.

3. A continuous moisture measuring device for sand.

B. The output of the plant shall be adapted to the programme of work and shall be at least 25 m³/hour.

C. After the concrete has been mixed, no subsequent addition of water in the course of concreting will be tolerated.

D. The mixing operation shall be under the control of a suitably experienced supervisor.

E. The sequence of filling a mixer with the concrete ingredients shall be studied during the suitability tests and subject to the approval of the Engineer and unless otherwise authorized, the same sequence of filling shall be followed throughout the work.

F. The quantity of mixed materials per batch shall not exceed the manufacturer's rated capacity of the mixer, and shall be further reduced for fluid concrete.

G. An automatic timing device shall be used to set the duration of mixing.

H. Mixing time shall be adjusted according to mix compositions and the mixers used and shall be at least 45 s after all components have been added. In the case of concrete containing admixtures, a minimum mixing time of 60 s shall be observed.

I. At intervals decided by the Engineer, but which normally be once per day for coarse aggregates and at some other interval depending on the operation of the continuous moisture measuring device for sand, the Contractor shall carry out tests by an approved method to determine the free moisture content of the aggregates. Based on these tests, adjustments shall be made to the quantity of water added to the mix to maintain the specified water cement ratio.

J. On commencing work with a clean mixer, the first batch shall contain only half of the normal quantity of the coarsest aggregate category and 10 % extra cement so as to compensate for the fine material and cement which is left sticking to the drum. This batch shall be mixed for at least one minute longer than normal.

K. The mixer shall be completely emptied before being charged with the materials for the succeeding batch.

L. Weight tolerances:

1. Cement and water: ……..± 2%

2. Aggregates:
   - Sand..... ± 3%
   - Coarse aggregate ..... ± 5%
   - Total of the aggregate..... ± 3%

3. Admixture: ± 5%

M. Checking of weighing scales

The precision of the weighing scales of the batching plant shall be checked at the beginning of each month.

If the precision falls outside the specified tolerances, the batching plant shall not be used again until the scales have been adjusted or repaired as necessary.

N. Mixer performance

Mixer performance shall be determined in accordance with ASTM C 94 to determine the uniformity of the mixture.

3. EXECUTION

3.2. INSPECTION

A. No concreting shall start until issue by the Engineer of a 'concrete permit'.

B. The Contractor shall request this permit at least 24 hours before the presumed start of concreting and after checking that the parts designed to be embedded in the concrete (reinforcement bars, waterstop joints, tie-rods, etc) and the formwork are correctly placed and fixed and that all surfaces designed to be in contact with the concrete have been prepared. The checking before concreting will also include for the dam, water circulation through the watertight coiled pipes, as well as the resistance of these pipes to pressure in excess of the maximum service pressure.

3.3. PREPARATION

A. Before casting any concrete layer, the surface of the previously cast concrete shall have been subjected to treatment consisting of the following operations:

1. Grout shall be removed from the surface, so as to reveal the mosaic of the concrete, without dislodging the coarser aggregates, nor the reinforcement bars or other embedded parts. Where possible, treatment shall be effected after the concrete has set but before

hardening, using either a water jet under pressure or a mixture of air and water under pressure, alternatively by brushing the surface with a wire brush. Where this treatment is precluded by the hardening of the concrete, the surface shall be treated either by high-pressure water jet or by sand blasting, or by scabbling the surface. In case of scabbling, the fissured or loosened pieces shall be removed

2. Cleaning with water and air under pressure.

3. Moistening for a minimum duration of 24 hours before concreting.

4. Elimination of excess water and final cleaning.

B. Before placing concrete on the rock or common soil, the foundation surfaces shall be prepared as indicated under Section 02210.

3.4. CONCRETE PLACING

A. Concrete shall be transported from the mixer to its final position in such a manner that the concrete as placed shall not have lost excessive moisture or grout, nor become segregated.

B. The concrete shall be placed and compacted in a such a manner as to avoid any movement of formwork, reinforcement bars, embedded parts or parts to be embedded.

C. If required by the Engineer, the first layer of fresh concrete placed on hardened concrete shall consist of a mix which is the same as that of the new lift but without the larger nominal category of coarse aggregates. This layer shall be between 4 and 10 cm thick as directed and shall be covered before it has started setting.

D. On rocky surfaces, immediately before concreting, a 5 cm thick layer of concrete class A shall be placed over the entire surface and in any fracture joints, so as to ensure an effective rock-concrete bond. The necessary arrangements shall be adopted to cover this mortar with concrete before it has started setting.

E. The necessary arrangements shall be taken to ensure that all waterstop and other embedded items are effectively well covered by concrete and that they are not subject to any movement compared to their theoretical position.

F. Qualified personnel shall be included in the concreting team to apply the appropriate remedial action in case of any incident such as movement of forms, steel bars, joints, drains, ducts, grouting valves, grouting groove protection, etc.

G. The Contractor shall provide a means of direct communication between the concrete batching plant and the location of concreting (telephone or radio-telephone).

H. In case of simultaneous placing of different classes of concrete, the Contractor shall provide a system of identification which will follow each concrete until it is placed.

I. The concrete shall be poured as close as possible to its final position. The concrete shall be moved within the formwork by shovel and not simply by flow induced by vibration which is forbidden. Any accumulation of gravel shall be dispersed within the mass of the concrete. Any water shall be removed as and when it appears.

J. Within each lift, concreting shall be effected in successive layers not exceeding 50 cm in thickness, unless otherwise stipulated by the Engineer.

K. For massive concrete structures, the lifts shall not exceed 2.50 m in height. The time interval between completion of one lift and starting the next shall be at least 72 hours.The height of these lifts and the time elapsed between successive lifts may be modified depending on temperature changes recorded in the concrete already cast, as compared to the specified temperatures.

L. Before it is covered by a new layer, each layer shall be fully compacted but shall not have begun to set.

M. All concrete shall be compacted by internal high frequency vibrators except the fluidified concrete. The number, size, frequency and power rating of the vibrators shall at all times be adequate to obtain appropriate and rapid compaction of the entire volume of concrete to be placed. A third of the required number shall be kept available for use no more than 15 min from the location of compaction.

N. The vibrators shall be introduced vertically at regular intervals within the concrete to be compacted. If the layer being placed covers a freshly compacted layer, the vibrators shall be introduced to a depth of about 10 cm in the preceding layer. The vibrators shall be withdrawn slowly, so as not to allow the formation of any void.

O. Vibration shall continue until the rise of air bubbles has practically stopped, and shall be stopped as soon as laitance or excess water appears.

P. The vibrators shall not be inserted into the concrete hazardly or irregularly, nor used to move the concrete from one point to another within the formwork. The vibrators shall not enter into contact with the reinforcement bars nor with the formwork.

Q. Where use of external vibrators is agreed, they shall be securely clamped to the shutters to ensure maximum efficiency.

R. Where the presence of air bubbles is prejudicial to the structure, the thickness of the layers shall be reduced, and additional compaction shall be effected along the formwork, after the regular compaction of the overall concreted area.

S. If in the course of placing concrete, it may become necessary by reason of an unavoidable breakdown of plant or for other reasons accepted by the Engineer, to interrupt concreting and if the concrete has taken its initial set, the surface of the concrete shall be treated as a construction joint.

3.5. CONCRETING IN HOT WEATHER

A. When the daily maximum temperature exceeds 35°C, concreting shall take place at night-time, unless special arrangements are adopted for mixing, transport and placing of the concrete.

B. These particular arrangements could include:

1. Spraying of gravel and pebbles.
2. Cooling of water.
3. Spraying of formwork.
4. Protection of the concrete during transport and placing against solar radiation.

5. Use of ice in mixing water.

6. Painting water tanks with reflecting paint.

C. In all cases, the temperature of the concrete when it is placed shall be less than:

1. 28°C for massive structures, i.e. structures with a thickness more than 0.60 m.

2. 32°C for other structures of which the thickness is less than 0.60 m.

3.6. CONCRETING IN COLD WEATHER

1. In cold weather concreting may take place only if the following precautions and provisions are rigorously observed.

2. Suitable means shall be provided to warm the aggregate and/or mixing water, or otherwise to ensure that the temperature of the concrete leaving the mixer shall not be lower than 100C. Aggregates, cement and mixing water bearing or containing ice shall not be used and no ice shall be present in any mixer, hopper, skip, vibration or other apparatus in contact with the concrete. Mixing water shall not be heated above 60oC. Salt or chemicals including proprietary accelerators or hardeners shall not be mixed with the concrete for the purpose of preventing freezing or accelerating hardening unless permitted by the Engineer.

3. Concrete when deposited shall have a temperature of not less than 5oC. Suitable precautions shall be taken to ensure that the temperature of the concrete after placing does not fall below this temperature until it has thoroughly hardened.

4. In putting forward his proposals for concreting in cold weather, the Contractor shall have regard to the recommendation contained in “Winter Concreting” as published by the Cement and Concrete Association, 52 Grosvenor Gardens, London SW1, UK.

5. If the Engineer is not fully satisfied with the Contractor’s arrangements, no concreting shall take place when the shade temperature is below 20C or if there is any prospect of frost within 24 hours (i.e. if the shade temperature is below 30C and falling).

6. The Contractor shall provide and keep available for the Engineer’s use a thermometer suitable for measuring the temperature of aggregate and a maximum and minimum thermometer which shall be hung in a position approved by the Engineer.

3.7. CONCRETING IN WET WEATHER

During wet weather, all necessary tarpaulins, baffles, diversion channels, etc., shall be laid to protect areas prepared for concreting and/or newly placed concrete from heavy rain and run-off. Surfaces on or against which concrete is to be placed shall be protected from becoming excessively wet prior to concreting.

3.8. CURING OF CONCRETE

A. Exposed concrete surfaces shall be kept damp by one of the following methods:

1. Covering horizontal surfaces with a layer of sand, hessian or other absorbent material maintained in a damp condition.

2. Continuous watering, maintaining a flow of water over the concrete.

3. After watering, covering of the surface with an impermeable membrane.

4. Application of a curing compound.

B. The use of a curing compound will not be permitted for surfaces which will receive a further concrete lift without any further preparation and for surfaces whose aspect may be affected by the curing compound.

C. Curing shall commence as soon as possible after placing of the concrete for unshuttered parts and immediately after removal of formwork in other cases.

D. Curing shall be continued for a period of 14 days unless otherwise agreed by the Engineer.

E. Underground concrete shall not require curing when the relative humidity of the air is higher than 75%.

3.9. SECOND STAGE CONCRETE FOR SEALING EMBEDDED PARTS OF EQUIPMENT

A. Placing of second stage concrete shall not proceed until embedded parts have been completely assembled, aligned and secured.

B. Constant caution shall be exercised in placing concrete to avoid distortion and displacement of parts being embedded.

C. The workability shall be sufficient to achieve satisfactory pouring in the interstices of the first stage concrete.

D. A controlled expansive admixture from an approved manufacturer shall be added. The admixture shall be mixed in accordance with the manufacturer's instructions. Prior tests shall be conducted before final approval can be given by the Engineer to adjust the amount of admixture to obtain. Cast iron powder admixture shall not be used in contact with high-tensile steel nor in direct contact with water.

E. For small holes (section less than 1 dm^2), mortar shall be used. The mix shall be 450 kg of cement per cubic metre of sand with the addition of an approved controlled expansive admixture.

F. Interface between the first and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.

G. Interface between the equipment and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.

H. Formwork shall be perfectly connected with the first stage concrete; irregularities shall be made good by means of grinding.

3.10. PRECAST CONCRETE

A. The working drawings may provide for certain parts of structures to be made from precast elements but, for ease of execution, the Contractor may ask to precast other parts of structures not initially indicated as such.

B. The Contractor shall submit clear details of the casting and placing procedures that he intends using as well as his planned arrangements for the precasting yard. Precasting work can start as soon as the Engineer has given his approval of the foregoing details and arrangements.

C. Precasting shall be organised in such a manner that:

1. Precast parts are always kept away from sunlight.
2. Precast parts are not handled for a period of 8 days after casting, unless concrete strength tests indicate the possibility of handling the parts within a shorter time.
3. All parts from the same mould are stored together.
4. No stored part shall be subjected to any load other than its deadweight.
5. Precast parts are installed in their final positions no earlier than 21 days after casting, unless concrete strength tests indicate the possibility of reducing this time.

D. The casting date and part references (or mould number) shall be written on each part in the fresh concrete.

E. Faces in contact with covering concrete after placing shall, if necessary, be treated as concrete construction joints; this clause shall be especially applicable in cases where intermediate slabs are used, the restarting surface of which must be treated accordingly.

3.11. CONCRETE SHUTTERING UNDERGROUND

A. Such concrete shall be placed mechanically unless otherwise approved by the Engineer.

B. Inflowing water shall be collected and piped to a dewatering system before executing any lining concrete.

C. Arch keying shall be carried out as accurately as possible and, in any case, shall meet the minimum lining thickness requirements. Unless otherwise specified on drawings or approved by the Engineer, the minimum thickness requirements is the thickness of the concrete between the 'A' line and the exposed surface of the concrete. Keying shall be checked by exploratory drillings made at the Engineer's request.

D. With the exception of fluidified concrete (refer to the particular specification), the concrete shall be compacted using external vibrators and completed using internal vibrators inserted inside the formwork through windows. The number and size of these windows shall be sufficient to vibrate the concrete under optimum conditions.

E. Closure of these windows shall be made watertight.

F. Unless explicitly authorised by the Engineer, no timber supports shall be incorporated in the final lining.

3.12. BLINDING CONCRETE

A. Blinding concrete shall be used when the structural concrete is in contact with a non-rock foundation.

B. The final mean thickness shall be 10 cm and never less than 5 cm.

C. Blinding concrete shall cover the entire area to be concreted.

D. The Contractor shall arrange for the recovery and elimination of all infiltrating water so that there is no risk of the concrete being washed out.

3.13. SHOTCRETE

A. Shotcrete shall be used for permanent work structures only as directed by the Engineer.

B. In so far as is possible and after scaling and cleaning, walls shall be wetted before placing shotcrete. The same precautions shall be taken in the case of shotcrete placed in several layers.

C. There shall be no significant inclusion of rebound in the finish work, no hollow areas, good adherence to the rock and reasonably smooth surface finish.

D. The final thickness of shotcrete shall never be less than 5 cm.

E. The Contractor shall provide for all inflowing water to be collected and diverted through drilled drains or surface pipes in order to prevent the shotcrete from being washed out and uplift pressures from forming on the treated surfaces.

F. Mesh reinforcement must be fixed to the rock or to a preliminary layer of shotcrete at several points. The concrete covering on the reinforcement shall be of 20 mm minimum thickness.

G. After placing the shotcrete, any movement of the steel reinforcement shall be prohibited.

H. The profile after shotcreting shall be considered in the same manner as an excavation profile and shall not therefore have any part projecting inside the line as defined by the Engineer.

3.14. WEAR-RESISTANT CONCRETE

A. The Contractor shall propose special micro-concrete of the Lafarge "Alag" type or similar with high adherence, abrasion-resistance and shock-resistance characteristics at places where this is necessary as defined on the drawings.

B. A complete file containing the characteristics of the products and details of the procedure to be used shall be submitted to the Engineer for approval.

C. In all cases, the following minimum procedure shall be followed:

1. Floor reinforcements shall be placed at a minimum of 10 cm from the finished surface with a tolerance of +2 cm and -0 cm.

2. Pouring of primary concrete shall take into account the thickness of the wear-resistant concrete, i.e. 8-10 cm from the finished level (rebars must be embedded by at least 2 cm).

3. The top surface must be cleaned with air and water under pressure before it has completely set, or by high-pressure cleaning after it has set.

4. The support must be completely saturated (24-48 hours).

5. Wear-resistant concrete is poured and thoroughly vibrated in chequerboard 2 m x 2 m slabs during stage 1 (class 1 surface quality).

6. The concrete is kept moist after it has begun to set (by spraying or by using a curing agent).

7. The stage 2 slabs are cast after a minimum period of 24 hours.

3.15. CONCRETE FOR DIAPHRAGM WALL COATING

Not used

3.16. DEPOSITION OF CONCRETE ON FOUNDATIONS

A. The Contractor should keep free of running water and pools the surface of rock upon or against which concrete is to be deposited. Fissures or seams in the rock shall be cleaned out to a depth satisfactory to the Engineer and if necessary stemmed with cement mortar of an approved mix. The rock surface will be inspected by the Engineer before concreting starts.

B. For deposition of concrete on earth foundations the surface of foundation shall be levelled out before concreting, a layer of blinding concrete shall be disposed on all the surface in contact with the concrete structure and the concreting may start after approval by the Engineer.

C. The blinding concrete layer shall not be less than 5 cm thick. Blinding concrete specified on the drawings shall be measured and paid at the rate tendered.

D. For hydraulic structures the concrete foundations shall be placed over and/or aside an adequate filter sufficiently drained, as shown in the drawings or as specified by the Engineer.

3.17. CONCRETING CONSTRUCTION JOINTS

A. The location of concrete construction joints, other than joints shown of the Drawings or specified, shall be approved by the Engineer; concrete shall be placed continuously between joints.

B. Duration between the two stages of concrete for a construction joint shall be approved by the Engineer.

C. All construction joints shall terminate against firm shuttering. All necessary steps shall be taken by means of timber edgings, etc. to ensure an exact finish to edges of joints which are exposed to view.

D. Before placing concrete against concrete which has already set at a construction joint, the surface of the previous concrete shall be prepared by the following methods. If the preparation is carried out before the previously placed concrete has hardened, the surface shall be cleaned with water and air at 5 kg/cm² pressure to expose the coarse aggregate. If the concrete has hardened the surface shall be scabbled at least 2 cm deep and cleaned in such manner that no loose particles of aggregate or damaged concrete remain on the surface. In all cases the surface shall be thoroughly cleaned with an air and water jet at 5 kg/cm² pressure to remove all laitance, scum and foreign matter. The surface shall be wetted before placing new concrete against it.

E. Construction joints shall be so located and the amount of concrete placed at any one time shall be so limited in size and shape as to minimise shrinkage and temperature effects.

3.18. CONCRETING MOVEMENT JOINTS

A. Joints between concrete surface are not intended to bond together (contraction joints) shall have the first formed surface painted with two coats of bituminous paint, the second applied after the first has thoroughly dried or according to the instructions of the Engineer.

B. Waterstops shall be fixed with at least 5 cm clearance from any reinforcement bar, accurately positioned as shown on the Drawings and tightly fixed in the shutters before concreting starts. Connections shall be made to ensure watertightness and all precautions taken for careful concreting around the waterstop.

C. No nail shall be driven through any part of a waterstop for fixing. Any waterstop punctured or torn to any extent shall be replaced before concreting.

D. Shuttering of the first concreted surface of the joint shall be placed carefully perpendicular to the surface of the structure. Waterstops shall be placed carefully on a straight line and perpendicular to the surface of the joints, and/or according to the shape shown on the Drawings or instructions of the Engineer.

E. Particular care shall be taken with the protection of the outer part of waterstops half embedded in the structure and awaiting completion.

F. In the event of excavation in the vicinity of the waterstop or when more than one month elapses before completion of the structure, a protection device such as a wooden box shall be provided by the Contractor. Rubber waterstops shall be stored in as cool a place as practicable and in no case shall they be exposed to the direct rays of the sun.

G. All joint implements such as waterstops, joint fillers, sealing compounds, etc. shall be handled and settled in accordance with the instructions given by the Manufacturer. All related notices and instructions shall be furnished to the Engineer prior to any approval being given.

H. Compressive filler (flexcell) when placed against concrete faces shall be fastened with adhesive before concreting of the next element.

I. When required, the joints shall be sealed with concrete mortar containing 400 kg of cement per cubic metre of mortar containing admixture if requested by the Engineer. The edges of the grooves shall be previously carefully watered and cleaned with a brush to remove any foreign bodies. Then the grooves shall be filled with mortar, compacted and surfaced and dressed by handwork. Immediately after completion, the joint shall be protected against the sun and regularly sprinkled with water as requested by the Engineer.

3.19. FINISHING OF NON-SHUTTERED CONCRETE SURFACES

A. The Contractor shall be responsible for finishing non-shuttered concrete surfaces as soon as concrete placing has been completed and before hardening.

B. Surfaces shall be finished using a simple screed, a vibrating screed, a float, etc. or by any other means enabling the required quality to be obtained. Screed guiding devices and supports shall be submitted for the Engineer's prior approval.

C. Surfaces shall be provided with a slope to allow water to drain off, as provided for on the drawings or as instructed by the Engineer.

3.20. FLUIDIFIED CONCRETE

A. The fluidified concrete shall not be poured from more than 1 metre in height and where required channels or pipes for the concrete transport shall be used.

B. The fluidified concrete shall be poured within the time for which the fluidizer has a real effect. No addition of fluidizer or water or any other additive in order to prolong this effect will be tolerated after the initial addition of the fluidizer.

C. Shuttering and forms shall be designed to withstand the full load exerted by the liquid concrete. In addition they shall be fully watertight in order to prevent any loss of the mix.

D. Where required by the Engineer, the fluidified concrete will be slightly compacted by use of low frequency vibrators.

3.21. INSPECTION TEST AND ACCEPTANCE OF CONCRETES CLASSES (A, B AND C)

A. Definitions

1. Lot: a lot of concrete is a structure or part thereof or set of structures or parts of similar structures cast in a single lift using concrete of the same class.

2. Sampling: a given sampling is effected on a single batch and one batch can give rise to only one sampling.

3. Result: a result is the average of the measurements made on all the samples taken for a given sampling (generally three).

B. Sampling frequency

1. The number of samplings made shall be as follows:

    h) Mass concrete (Class B)

    1. one for a lot of less than 500 m^3
    2. two for a lot of more than 500 m^3

    i) Other concrete (Class A)

    1. one for a lot of less than 50 m^3
    2. two for a lot of 50 to 250 m^3
    3. three for a lot of more than 250 m^3

2. The sampling frequency shall be greater at the beginning of the works in order to make sure of quality levels as quickly as possible, and during periods when, in the Engineer's opinion, quality is considered doubtful.

C. Tests to be carried out

1. The following tests shall be carried out for each sampling:

    j) Three samples for determination of compressive strength (cylinders or cubes) after 28 days (ASTM C 39).

    k) One measurement of air content (ASTM C 231).

    l) One consistency measurement (ASTM C 143).

    m) One temperature measurement.

    Additional tests may be required by the Engineer, especially when the concrete consistency varies to a significant extent.

2. On average every three samplings and in accordance with instructions given by the Engineer:

    n) Three samples for determination of the compressive strength after 7 days.

    o) Three samples for determination of the tensile strength after 28 days (ASTM C 496).

3. On average every 30 samplings and in accordance with instructions given by the Engineer, 12 samples for determination of modulus of elasticity, compressive and tensile strength after 90 and 365 days (six after 90 days and six after 365 days).

4. All samples shall be taken at the time and on the site of concrete placing.

D. Concrete acceptance criteria

1. A lot shall be deemed to conform to specifications when the following conditions are satisfied:

    p) Consistency: the test result(s) come within the specified tolerances.

    q) Compressive strength after 28 days:

    1. Each result is higher than 0.85 fc
    2. In the event of three or more samplings from a lot, the average of the results is greater than fc.

2. A concrete of a given class shall be deemed to conform to the specification when the average of any 3 consecutive results (not necessarily from the same lot) is higher than fc.

E. Use of 7-day and 28-day test results

For each class of concrete, the results of all the tests shall be used to establish a "least-square" line of best fit to define the relationship between test results and the age of the concrete. The relationships shall be continuously updated during the period of the Contract, and shall be used for the initial assessment of 90-day strength from 7-day and 28-day strengths, or the initial assessment of 28-day strength from 7-day strength.

F. Ready-mix lorries

The concrete in each ready-mix lorry shall be checked for uniformity within the context of the concrete suitability tests and then every quarter according to ASTM C 94. If concrete uniformity is not satisfactory, one of the following measures will be taken until the specifications are met:

1. Increase in mixing time.
2. Reduction in quantity of concrete transported.
3. Modification of ready-mix lorry.

3.22. TESTING FOR WATERTIGHTNESS OF REINFORCED CONCRETE RESERVOIRS

On completion of the works, the reservoirs (i.e. all concrete structures which can accommodate more than 1000 cubic meter of liquid) shall be tested for watertighness when filled with water, before backfilling around the reservoirs and before applying coating or facing on external face of walls.

Each reservoir shall be filled slowly with a rate of 1.50 m (rise of water level in 24 hours, up to top water level). Before testing a period of 10 days will be necessary for the initial soakage and every day water will be added to raise the water level to its initial level. It will have to make clear that the level drop decreases each day.

Water for tests shall be provided by the Contractor. The Contractor shall provide all necessary equipment to transfer the water used for tests from one reservoir to another to be tested.

When the soakage period has been completed, the test shall be started by refilling the reservoir to top water level and accurately recording the level each day over a period of seven days. The evaporation shall be checked by fixed in the reservoir a steel tank filled with water. Any drop in level in the steel tank will then be considered as evaporation loss. The structure will be deemed to be watertight if the total loss of water does not exceed 0.5 l per day and per square meter of wet concrete face.

The reservoir shall not be finally accepted as satisfactory until all leakages exceeding this value have been eliminated by treatment with appropriate products and with pressure grouting techniques. In this eventually, the treatment shall be approved by the Engineer and the Contractor shall repair at his own expense any leak involved.

From the time a reservoir is accepted, the Contractor shall keep the interior in wet conditions until commissioning of reservoir. This can be assessed by keeping a minimum water level inside each accepted reservoir, or any other mean approved by the Engineer.

Just before commissioning, each reservoir shall be emptied and disinfected according to a methodology proposed by the Contractor and approved by the Engineer.

3.23. ACTION IN THE EVENT OF NON CONFORMANCE (FOR CONCRETE CLASSES A, B AND C)

A. If the consistency of the concrete is outside the nominal tolerance by inside the maximum tolerance, the composition of the fresh concrete shall be checked immediately, in particular the water content of the aggregates and quantity of water in the concrete. The Contractor shall make all necessary adjustments to recover the right consistency.

B. If the consistency of the concrete is outside the maximum tolerance, the concrete shall be rejected.

C. If the 28-day test results assessed from 7-day test results is abnormally low the Contractor shall stop concreting, establish the reasons for the strength decrease and take the necessary remedial action.

D. If the 28-day test confirm the assessment from 7-day test that the characteristics of concrete do not conform to the Specifications the volume of concrete represented by the samples shall at the discretion of the Engineer be subject to one or more of the following provisions:

1. Cores from the suspected portions of the structure shall be drilled and tested in accordance with BS 6089 to determine whether the equivalent cylinder strength of the in situ concrete satisfies the specified strength requirements.

2. If the results of test on the cores taken in terms of (1) indicate that the concrete does not satisfy the specified requirements, the Engineer will decide whether or not full scale load tests or an ultrasonic pulse velocity investigation may be carried out.

3. If in the opinion of the Engineer, the load tests are impracticable, or if a tested portion of the structure fails to pass the tests the Contractor shall, on the instructions and directions of the Engineer, and if possible, strengthen by approved means each section that failed or which contains concrete that failed, as relevant and also any other section, irrespective of strength requirements, the functional purpose of which is affected.

4. The works shall be demolished and reconstructed at the Contractor's expense, if the reinforcement or strengthening of the structure is not possible.

E. If it is found during concreting that the coefficient of variation of 28-day test results for a particular class of concrete is less or more than 14 percent, the Contractor and the Engineer shall meet to decide on the necessary reduction or increase respectively in cement content required to maintain the nominal strength of the concrete with the specified rate of failure. The reduction or increase in cement content shall be to the Contractor's account if this is attributable to him.

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SECTION 04000
MASONRY WORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers masonry works as required for:

- Internal positions.
- Other small structures according to Drawings or specified by the Engineer.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. QUALITY ASSURANCE

Finished rendered work shall be true, plumb, or level and straight to a maximum tolerance of 3 mm in a 1 m.

Finished surface shall be free of waves or distortions, square with adjoining work, flush with casings, and free of any defect detrimental to appearance or performance.

All masonry works will be rendered (see 2.5) on both internal and external walls.

1.4. CODES AND STANDARDS

A. British standards

BS EN 1745	Masonry and masonry products - Methods for determining design thermal values
BS EN 772	Methods of test for masonry units
BS EN 845-2	Specification for ancillary components for masonry - Part 2: lintels
BS EN 1015	Methods of test for mortar for masonry.
BS EN 13139	Aggregates for mortar
BS EN 998-2	Specification for mortar for masonry - Part 2: masonry mortar
BS 5628-1	Structural use of unreinforced masonry

BS 5628-3 Materials and components, design and workmanship

B. French standards

NF P 13-301 Hollow terra cota bricks.

NF P 13-304 Facing clay bricks.

XP P 13-305 Clay masonry units. Common solid or perforated clay bricks and perforated clay blocks. Requirements and test methods.

2. PRODUCT

2.1. NATURAL BUILDING STONE

All natural building stone shall be capable of withstanding when wet a crushing stress of 5.5N/sq.mm. The source of stone shall be approved by the Engineer and the stone supplied therefrom shall be free from Magadi, overburden, mudstone, cracks, sandholes, veins, laminations or other imperfections. The stone shall either be chisel or machine dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces. Stones shorter than 375mm will rejectedNatural building stone shall be 20cm thick for outside walls and 15cm thick for partitions.

Natural building stones shall be well soaked before use and the tops of walls shall be kept wet as the work proceeds. The stones shall be properly bonded so that no vertical joint in a course is within 115mm of a joint in the previous course. Alternate courses of walling at angles and intersections shall be carried through the full thickness of the adjoining walls. All perpends, reveals and other angles of the walling shall be built strictly true and square.

The stones shall be bedded, jointed and pointed in 1:3 cement: sand mortar with beds and joints of 9mm thick flushed up and grouted solid as the work proceeds. All walls to be reinforced with heavy duty gauge hoop iron at every alternate course.

All masonry work shall be cured in accordance with the relevant Standards and /or as directed by the Engineer.

2.2. CONCRETE BLOCKS

The blocks shall be 20 cm thick for outside walls and 10 cm for partitions.

No overall dimension (width, height or length) shall differ by more than 3 mm from the specified dimensions.

The minimum compressive strength shall be:

a. for individual unit: 15 MPa,

b. for the average of 3 units taken as a sample: 17 MPa.

The maximum water absorption shall be 250 kg/m³, when soaked for one hour in water.

All units shall be sound and free of cracks or other defects, and shall have uniform colour, texture and appearance.

2.3. CONCRETE LINTELS

Lintels for doors, windows and other openings left in the concrete block walls and partitions shall be reinforced concrete designed according to the span of the opening, but never less than 10 x 15 cm. Each lintel shall be reinforced with a minimum of four 10 mm dia. bars.

2.4. MORTAR FOR PLACING BLOCKS

General requirement for sand used in concrete (Section 03301) applies except that the sand for mortar shall contain no particle greater than 2 mm.

The mix shall be 400 kg cement per m^3 of sand.

The mortar is to be mixed dry in a mechanically operated drum type mixer and water shall be added after the constituents have been thoroughly mixed.

Mortar which has begun to set or which has been mixed for more than 30 minutes shall not be used or remixed.

The mixer shall be operated at the speed recommended by the manufacturer and the total quantity of materials mixed in each batch shall not exceed the rated capacity of the mixer.

The entire content of the drum shall be discharged before a new cycle of batching is started and at all times the inside of the drum shall be kept free from a build-up of materials. The mixer drum shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

2.5. METAL WALL TIES

Cavity walls and wall facing shall be provided with galvanised steel ties with a minimum section of 10 mm^2.

Not less than 4 ties shall be fixed per square metre.

2.6. MIXES FOR RENDERING (CEMENT OR CEMENT-LIME PLASTERING)

The mixes for rendering shall be:

Treatment	Mix proportions (parts by volume)		
	Cement	Lime	Sand
Exterior	1	1	5
Interior	1	1	6
Rough cast finish	1	2	9
Smooth finish	1	4	8

The method of measuring materials for the render shall be such that the specified proportions of the materials can be controlled and accurately maintained during the progress of the work.

The quantity of water shall be such as to obtain a satisfactory workability for the specific use of each render.

Render which is set or become dry or unworkable shall not be used nor retempered with water.

Any render that is not used within 30 minutes after the first water has been added shall be rejected and removed from the Site.

The equipment and tools used for transporting and for placing batched render shall ensure that contamination and loss of ingredients do not take place.

2.7. BRICK WORK

2.3.1. BRICKS

Bricks will be used for partitions only.

Bricks shall be of the best available quality.

Bricks shall be sound, hard, uniform in colour, regular in size and shape with straight parallel surfaces and sharp arises and free of cracks, stones and lumps, especially of lime.

Bricks intended for fair-faced walls with tooled joints shall be particularly suitable with regard to durability and weather-resistance and of uniform colour.

Bricks shall be well burnt. Their compression strength shall be at least 5.5 N/mm² on an average of any twelve (12) bricks, but at least 3.5 N/mm² for any individual brick.

The Contractor shall submit brick samples along with test certificates to the Engineer for approval.

2.3.1. DAMP-PROOF COURSE

Damp-proof course shall be provided for all block-work at approximately 200 mm above ground level using.

- bituminous roofing felt not less than 3 mm thick or
- polyethylene sheeting not less than 0.5 mm thick
- or any other approved material,

laid on an even bed of cement-sand mortar (1:1) and lapped 150 mm at all joints. The damp-proof membrane shall cover the full width of the blocks.

2.3.1. MORTAR

Mortar to be placed between the bricks shall be cement-lime-sand mortar in the ratio of 1:1:6.

Below the damp-proof course, the blocks shall be laid in cement-sand mortar in the ratio of 1:4.

2.8. INTERNAL PLASTER

Internal plaster shall be applied to walls and partitions in offices, toilets and entrance hall.

Internal plaster to walls and ceilings shall be applied to the bonding coat. The undercoat shall be 1 part gypsum browning plaster to 3 parts sand by volume, applied firmly in one continuous operation between angles and joints to a thickness of not less than 10 mm, cross scratched to provide a key for the next coat.

The finishing coat shall be gypseum finishing plaster applied to a thickness of 5 mm and trowelled or floated to produce a tight, matt, smooth surface with no hollows, abrupt changes of level or trowel mark. This coat shall be applied to the undercoat as soon as it has set and has developed reasonable suction. Internal plastering shall generally be carried out in accordance with BS5492.

Alternatively internal plaster to walls shall be applied to the bonding coat in two coats. The undercoat shall be a mix of 150 kg cement, 0.30 m³ lime and 1 m³ sand applied to a thickness of 15 mm. The finishing coat shall be to the same mix, but the sad shall be very fine, applied to a thickness of 5 mm.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

2.9. EXTERNAL SMOOTH RENDER

Smooth render shall be applied to plinths, columns, overflows and gargoyles, copings, and elsewhere as required.

The undercoat shall consist of one part sulphate resisting cement to two parts lime to six parts sand by volume. It shall be applied firmly in a thickness of 15 mm cross scratched to provide a key for the next coat.

The finishing coat shall be composed of one part white Portland cement, one part lime, one part limestone powder and four parts white gypsym by volume with oxide colouring agent added to suit applied in a thickness of 8 mm. The coat shall be trowelled to create a flat, smooth, hard surface.

Coats shall be applied in a continuous operation wherever possible. Joints where unvavoidable shall be formed with a neat V-joint through the full thickness of the finishing coat.

2.10. EXTERNAL TEXTURED TYROLEAN RENDER

Textured render shall be applied to mid-wall panels and roof fascias and elsewhere as required.

The undercoat shall be one part sulphate resisting Portland cement to two parts lime to four parts sand by volume applied in a thickness of 15 mm.

The textured coat shall consist of one part white Portland cement to five parts lime to three parts of sand by volume with oxide colouring agent added to suit and shall be spattered onto the wall by a hand operated machine to five an even but rough texture to the surface. All adjoining surfaces that are not to receive the finish shall be adequately masked. The thickness of coating shall be sufficient to cover the undercoat. External rendering shall be carried out in accordance with BS 5262.

3. EXECUTION

3.1. PREPARATION

All surfaces designated to receive concrete blocks shall be clean and level to the lines and grades shown in the Drawings or as directed.

Laying of blocks shall not proceed until the Engineer has inspected and approved the prepared surfaces.

3.2. BLOCKWORK (CONCRETE BLOCKS REFERRED ALL AS BLOCKS)

Blockwork shall be built without recesses or projections unless otherwise shown on the Drawings.

Blocks shall be soaked in water before use. The tops of walls left off shall be wetted before work is recommended.

Blocks shall be well buttered with mortar before being laid and all joints shall be thoroughly flushed up, raked or pointed as the work proceeds. Except or otherwise specified vertical and horizontal joints are not to exceed 1 cm in thickness.

Blockwork shall be carried out in a uniform manner such that no portion shall be more than 1 m above another. Blockwork shall be kept true and square and the whole properly bonded together. Particular attention shall be paid to ensure strict verticality of blockwork.

Half block walls and inner and outer skins of double-skin walls and casings shall be built in stretcher bond.

All blockwork shall be cleaned down on completion to remove mortar dropping, runs or stains and again before rendering to remove any efflorescence.

Expansion joints shall be provided in external blockwork at approximately 12 m centres. The joint shall be formed with "Flexcell" or other approved expansion strip and sealed with "Seaastic" or other approved joint sealer. Care shall be taken to ensure that the wall is properly bonded or tied at each side of the expansion joint to prevent any loss of stability.

When required, galvanised steel ties, meshes or cramps shall be carefully embedded in the mortar.

3.3. BONDING OF BLOCKS TO CONCRETE WORKS

Where blockwork abuts concrete columns, walls or beams, there shall be adequate bonding between the two materials by means of wire ties or approved wire mesh which shall be recessed 40 mm from the face of the brickwork or blockwork at such intervals as approved by the Engineer.

3.4. CONNECTION WITH DOORS AND WINDOWS

The spaces around the door frames and built-in items shall be solidly fixed with mortar.

Spaces around the door and window hold fasts shall be filled with concrete Class A.

3.5. BRICKS OR BLOCKS TO BE RENDERED

Blocks which are to receive rendering or plastering shall have a surface which will ensure good adhesion of the applied finish.

3.6. RENDERING

Projecting burs of grout shall be removed and the surface shall be wire brushed and cleaned with scrubbers. If the surface is smooth it shall be prepared by roughening with a pointed tool to form pocks, not less than 3 mm deep, spaced not more than 5 cm apart.

Outside rendering shall be of uniform thickness applied in one coat of 15 mm minimum.

Inside plastering shall be 20 mm thick made of two layers: 15 mm under coat and 5 mm finished coat.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

3.7. LAYING OF BRICKS

The Engineer will take samples of bricks at random from deliveries to the site for comparison with the approved specimen. Supplies which are not in conformity with the requirements shall be removed from the site.

All brick work shall be set out and built to the thickness and heights required, be built strictly vertical and all quoins etc. shall properly be bonded together, laid perfectly plumb, true to line, level and in accurately spaced courses.

Before laying the bricks they shall be soaked in water for at least one (1) hour.

Mortar shall be mixed dry and water added until the correct consistency is obtained. All mortar shall be used within forty-five (45) minutes after the addition of water.

Walls shall be bricked up in a uniform manner so that no portion is raised more than 0.75m at any time.

Mortar joints shall be full and approximately 10 mm thick. They shall be raked out at least 10 mm deep as the work proceeds.

At concrete columns, surfaces shall be chipped and steel binders shall provide rigid connection between column and blockwork, wherever no expansion joints are provided.

3.8. FINISHING

Following completion of rendering all surfaces shall be thoroughly cleaned.

Any unsatisfactory work shall be removed and the rendering shall be re-applied.

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SECTION 05100
STRUCTURAL STEEL CONSTRUCTION AND STEELWORKS

1. GENERAL

1.1. WORK INCLUDED

The Work included under this Section consists of shop design, supply and installations of miscellaneous metalwork (steel, stainless steel, aluminium,…) when required, including but not limited to the following items (if any):

1. Structural steel construction
2. Railings.
3. Ladders.
4. Steel stairs and rungs.
5. Hatches.
6. Hand rails.
7. Footbridges.
8. Chain-link fences.
9. Cast iron frames, covers and gratings.
10. Steel frames for precast concrete covers, miscellaneous metal covers and gratings.
11. Placing of anchor or embedded items.
12. Various steel supplies.

The work shall include all fittings, cutting, drilling and blocking required to install the Work, and to make all the required connections with adjoining work. All anchors, sockets, pipe sleeves and expansion bolts required for fixing the metalwork to the construction shall be furnished by the Contractor, except anchors for erection of equipment supplied under other contracts which will be supplied by other Contractors.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. QUALITY ASSURANCE

a. General

Manufacturing of metalwork shall be executed by qualified personnel.

b. Qualification of Welders

Welders shall be certified welders in accordance with AWS 01.1. or approved equivalent.

Uncertified welders shall pass at site qualification tests in accordance with procedures recommended by AWS 01.1 or approved equivant

c. All the aluminium installation should be manufactured by a single manufacturer with a uniform finish and based on a prototype approved by the Engineer.

1.4. STANDARDS AND CODES

1. Eurocodes

2. American Society for Testing and Materials

   a) ASTM A 36 ..... Specification for Structural Steel

   b) ASTM A 48 .....Specification for Gray Iron Castings

   c) ASTM A 53 ..... Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

   d) ASTM A 307 .....Specification for Carbon Steel Bolt and Studs, 60 000 psi Tensile

   e) ASTM A 575 .....Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

   f) ASTM A 788 .....Specification for Steel Forging, General, Requirement.

   g) ASTM B 221 ..... Specification for aluminium Alloy Extended bars, Rods, Wires Shapes and Tubes

3. American Welding Society

   AWS D1.1 Structural Welding Code

1.5. SHOP DRAWINGS

The Contractor shall prepare all shop drawings and possible erection drawings on the basis of the data contained on the Construction Drawings, the design criteria supplied by the Engineer and the actual dimensions of the structures and items already built.

Shop drawings of all metalwork shall show detail of assembly, method of assembly, detail of anchorage or connection with the main structures.

1.6. SUBMITTALS

The Contractor shall submit the following documents:

- Copies of certified manufacturer's tests.
- Shop drawings and erection drawings shall be submitted to the Engineer's approval at least one month before beginning the manufacture of the various items.

1.7. TOLERANCES

A. Manufacture Tolerances

1. Dimensions without direct influence on the assembly of the element: 0.2%.
2. Main dimensions: 0.1%.
3. Local (area 200 x 200 mm): 0.5/400 cm².
4. Flatness: 1 mm.
5. Main parallelism, main squaring: 1 mm/m.
6. Straightness, alignment: 2 mm.

B. Erection Tolerance

7. Dimension without influence on the operation of the element: 0.2%.
8. Main dimensions: 0.1%.
9. Local (area 200 x 200 mm): 0.5/400 cm².
10. Flatness: 1 mm.
11. Straightness, alignment: 2 mm.
12. Verticality: 2 mm.
13. Horizontality: 2 mm.

C. All tolerances shall allow proper operation of the equipment.

2. PRODUCTS

2.1. MATERIALS

Except where otherwise specified, in accordance with EN 1993, EN 10025, EN 10210 and 10219.

2.2. FABRICATION

Each part shall be clearly marked in such a manner that part can be easily identified on shop erection drawings.

All metalwork shall be carefully and accurately assembled by welding or by screws, bolts and rivets, concealed as far as possible.

The joints shall be filled, milled or machined as may be necessary to secure close and perfect connections. All frames shall be provided with suitable bracing connections. All frames shall be provided with suitable bracing to maintain alignment during transport.

Members shall not be overstressed during the construction and hammering will not be permitted.

Any metalwork damaged during transport or erection shall be removed by the Contractor and replaced by new materials to the satisfaction of the Engineer at no extra cost to the Employer.

Built-up work shall be assembled completely at the shop, accurately finished and the section match-marked for field erection.

Concerning ladders, the fabrication shall include back protection whenever the ladder height is more than 2 m.

3. EXECUTION

3.1. INSPECTION

The Engineer will inspect all metalwork before erection on Site, such inspection covering:

1. assembly quality,
2. geometric characteristics,
3. corrosion protection,
4. embedded supports,
5. quality of surface finish.

3.2. ERECTION

No metalwork shall be incorporated into the Permanent Works until it has been inspected and approved.

All embedded metalwork shall accurately set in place before the concrete is poured or, subject to the approval of the Engineer, recesses may be left in the concrete and the metalwork placed, anchored and blocked in place after the concrete of the structures has set.

Where, in the Engineer's opinion, it is impracticable during construction to place anchors or fasteners required for the installation of ladders, or other miscellaneous metalwork, holes shall be drilled in the structures and expansion bolts installed.

Grout, where required, shall consist of epoxy cement or of aggregate, sand, cement and water in the proportions proposed by the Contractor and approved by the Engineer. Forms for grouting shall be installed where necessary. Grout shall fill all space of recesses, with no voids. After grout has hardened, any visible wedges shall be removed, and exposed joints neatly finished to a smooth dense surface.

3.3. WELDING

Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter along the edges prepared for welding. The cut surfaces shall be free of all injurious defects.

Weddings shall be made in accordance with the Code for Arc and Gas Welding in Building Construction, as formulated by AWS. All welding shall be continuous along the entire line of contact, except where tack welding is permitted. All exposed welds shall be ground smooth.

No welding of galvanised steel shall be permitted.

Inspection of welds in all steel may begin immediately after the welds are completed. In addition to inspection as required by AWS D1.1, all welds shall be visually examined. Procedure, technique and standards of acceptance shall be in accordance with AWS D1.1.

The Engineer reserves the right to direct radiographs of the welds. Location and findings of all radiographic inspections, together with descriptions of any repairs made, shall be recorded on proper testing sheets.

3.4. CORROSION PROTECTION

Corrosion protection, galvanization and/or painting shall be carried out in accordance with Section 01010 - Corrosion protection.

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SECTION 07000
WATERPROOFING, INSULATION AND ROOFING

1. GENERAL

1.1. WORK INCLUDED

The works covered by this Section relate to the following items:

- Roofing;
- Framework;
- Covering;
- Weather-proofing;
- Heat insulation;
- Sound insulation
- Odour-proofing.

of all the closed and covered enclosures in order to guarantee closure and cover, and to prevent nuisance caused by noise and smells.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

The works in the present Section will cover all necessary works for the completion of the building, including framing, insulation, claddings, cladding accessories like bottom flap, acroterion cover, corner pieces, opening surround, cover strips, plugging,...

All the holes in the cladding will be such as to avoid any deformation (oblong holes), in any direction due to the deformation of the framing.

All the supply for the present Section shall be manufactured by a single manufacturer to insure a uniform finish.

When required, special washers shall be introduced to avoid direct contact between framing and aluminium cladding.

It also includes supply and installation of:

- Stormwater downpipes;
- Zenith lighting;
- Smoke outlets and associated remote control devices;

- Connections for roof outlets for smoke pipes or ventilation ducts;
- Connection and interface works between the different structures;
- All the accessories needed for perfect finishing work;
- Protective barriers to prevent falling of personnel and objects during the works period in accordance with regulations in force on the date of signature of the contract.

1.4. CODES AND STANDARDS

Works are to be carried out in accordance with standard professional practice, and in compliance with all current rules and standards.

- For example, French Standards AFNOR may be used together with DTU Specifications (Series 43 - Waterproofing, 43.1, 43.2, 43.3 and 43.5 - Ribbed steel sheet roofing.)
- Specific trade regulations where relevant (claddings, double-sided roofing, etc.).
- Fire prevention regulations (APSAIRD rules).
- Industrial safety regulations.

The Contractor shall propose a product and the corresponding standards guaranteed by the supplier and/or the manufacturer.

1.5. SUBMITTALS

- Calculation notes for framework, roofing, insulation, etc.
- Working design drawings with associated justification and detailed technical specifications;
- Report of terrace water priming test;
- Technical solutions, processes and schedule for work on structures to be rehabilitated.
- Colour shall be approved by the Employer and for this purpose, samples shall be submitted to the Engineer together with documentation required.

2. PRODUCTS

2.1. GENERAL

The materials used must comply with standards and regulations in force at the time of signature of the contract and must take into account the aggressive coastal climate for the Project

2.2. TRANSLUCENT PANELS

If PRV colourless translucent ribbed panels are used for external cladding, they shall comply with Standard NF P 38301.

The supply shall include any additional connecting and supporting accessories.

2.3. HEAT INSULATION

2.3.1. VAPOUR BARRIER

Self-adhesive strips or added screens shall be laid as per DTU.

2.3.1. INSULATING SHEETS OR PANELS

Non-loadbearing insulating panels shall be installed and will contribute to heat resistance. It shall be laid as recommended per DTU.

Work shall comprise all laying and connection constraints, in particular for ventilation between roof sheets and insulation.

If panels are used, they shall be cut and raised level with ridge ventilation openings, to ensure free ventilation of buildings.

2.4. CLADDINGS

A. Cladding shall be constructed of prelacquered steel sheets with minima thickness of 0.50 mm.

B. All accessories shall be prelacquered aluminium, as for outside cladding, with the same colour, or another colour as approved by the Engineer.

All types of additional profiles and joint needed (like compriband expandable joints or gun laid joints), particularly at connecting points with other structures (for instance masonry, window and door frames) shall ensure absolute air and watertightness and perfect finish.

C. Bottom flap shall be provided to form a dripboard at connection with walls and openings, closing up the bottom of the roof panels.

D. Acroterion cover shall be provided and crowns the top, at the connection with gutters, flashings or counterwallings.

E. Corner pieces shall be provided and especially shaped for re-entrant and projecting angles.

2.5. ROOFING MATERIALS

2.3.1. LIGHT WEIGHT ROOFING SCREEDS

Roof screeds will consist of cement, sand and pumice (1:3:7) finished with 6mm layer of cement and sand (1:4) topping. Screeds shall not be laid in areas exceeding 10 square meters during any period of 24 hours. As bays are formed, batten strips must be used to retain the exposed edge of the screed. Screed shall be finished to fall and currents to receive roofing.

2.3.1. ASPHALT ROOFING

Roofing asphalt shall be to B.S 988/1966 Table 3 Column III,tropical Mastic Asphalt laid in two coats to a thickness of 20mm on and including black sheathing felt and finished with two coats aluminium paint to horizontal and vertical surfaces.

2.3.1. CONCRETE TILE ROOFING

Concrete single lap tiles and fittings shall be to B.S 473 and 550 Part2, Group B of the colour, finish, type, size and manufacturer approved by the Engineer. A full range of fittings must be available to match the tiles. Tiles shall be 380 x 230 mm nominal unless otherwise specified. Tiles and fittings must be true to shape and of uniform structure and colour. Surface coating shall be firmly bonded. Fixing shall include nailing to battens at every third course, at eaves, verges and at the top course under the ridge.

Ridges and hips shall be bedded in cement mortar matching the colour of the tiles and roofs shall be left watertight.

2.3.1. CLAY ROOFING TILES

Clay roofing tiles shall be “best” or selected quality single lap “Mangalore” tiles as manufactured by M/s Clayworks Limited, or approved equivalent. Socketed hips, and third or half round ridge tiles shall be provided as required.

All tiles shall be uniform in size and shape and free from twists or other defects and shall be laid in strict accordance with the manufacturer’s printed instructions.

On gable ends to roofs, the tiles should be laid with straight joints with the special left-hand verge tiles provided by the manufacturer.

All tiles to be laid shall be equal in every respect to samples deposited with and approved by the Engineer. No broken, chipped, cracked or otherwise defective tiles shall be used in the work.

All tiles to verges, top and caves courses shall be securely nailed to battens with strong galvanised steel nails.

Extreme care should be taken to avoid any staining or marking of the roof tiles with mortar and any tiles so marked must be replaced immediately.

3. EXECUTION

3.1. GENERAL

All waterproofing, insulation and roofing works shall be carried out in conformity with relevant European Standards or approved equivalent.

3.2. COVERING AND WATERPROOFING

The terraced roofs shall be waterproofed by means of watertight layers and treated as specified hereinafter.

A. HEAT INSULATION

Before rendering the roof waterproof, a thermal insulation shall be laid consisting of 5 cm polystyrene foam, laid on a vapour barrier of 2/10 mm thick PVC sheet. Slabs of polystyrene foam shall be carefully placed without any gap. Broken slabs will not be allowed.

B. WATERPROOFING

The waterproofing shall be laid on a 100 g/m² glass fibre material for separating from heat insulation.

The waterproofing shall be constituted of two 110/35 thermoplastic bituminous elastomer flexible watertight coatings placed on a 250 g/m² unwoven polyester base. The first coating shall be unrolled dry and the second shall be propane gas heat-welded to the first.

The Contractor may propose non-conventional covering or sealing processes providing the same guarantees as standard solutions or elastomeric double layer lining.

All the necessary precautions shall be taken to limit noise (urban-type soundproofed equipment), dust and accident risks.

C. RAISING

On the inside faces of the parapet walls and all around the projections of the flatroofs (stacks of smoke pipes, ventilation, air coolers, etc.), the first coating shall be bond by a cold impregnation sealant and a hot sealant application layer. The second flexible watertight coating shall be self-protected by aluminium sheeting and shall cover the inside face and the top of the parapet.

Expansion joints on the roof shall be covered with a continuous aluminium sheet, as shown on drawings. Special care shall be taken at crossing of two expansion joints.

D. COVERING

All roofs shall receive over the waterproofing:

- a layer of 10/30 gravel 8 cm thick, or
- precast tiles 30 x 30, 3 cm thick made with mortar with 350 kg of cement per cubic metre of sand; tiles will be placed with thin joint filled with bitumen and over a layer of sand 3 cm thick.

E. RAIN-WATER DOWN PIPES

Drainage or rain-water will be either through outside down pipes, or down pipes embedded in a concrete column or prefabricated water spout.

Down pipes shall be made of PVC, and 125 mm in diameter. A strainer shall be provided to prevent solid substances going through. At right angles with the emptying of rain-water a lead plate 40 cm x 40 cm welded to a pipe 30 cm long connecting the down pipe shall be provided. This plate shall be situated between two coats of bitumen felt, or butyl film.

When the rain-water down pipes are outside the building a lead plate shall be provided in order to pipe the waters down to a zinc box situated outside and fixed on the front of the buildings. From this box the rain-water down pipe shall be laid and fixed on the wall by removable pipe collars of galvanised steel.

Rain-water down pipes shall be connected to the general rain-water drainage system by means of a pit closed with a cast iron cover.

The Contractor shall submit the detailed layout of the drainage system to the approval of the Engineer.

All constructional measures shall be taken to weather-proof the facades of the structures.

SECTION 08100
ALUMINIUM DOORS AND WINDOWS - GLAZING

1. GENERAL

1.1. WORK INCLUDED

This section covers the manufacturing and fixing of natural anodized aluminium external air-tight doors and windows with single or double glazing as required for the various buildings.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. CODES AND STANDARDS

ASTM A-788	Specification for Steel Forging, General, Requirements.
ASTM B-221	Specification for Aluminium Alloy Extruded Bars, Rods, Wires Shapes and Tubes.
ASTM C-158	Method for Testing Flexural Testing of Glass.

1.4. QUALITY ASSURANCE

All the aluminium installation should be manufactured by a single manufacturer with a uniform finish.

2. PRODUCT

2.1. ALUMINIUM

Sections should be extruded from 6063-T5 aluminium alloy conforming to ASTM B-221.

2.2. FASTENING DEVICES

All the fastening devices shall be of aluminium, stainless steel or other corrosion resistant material with sufficient strength, and if visible should blend with the frame finishes.

2.3. HARDWARE - GENERAL

All the hardware fixed shall be of best quality available in the market. The finish of hardware must closely match the finish of doors and windows.

2.4. SCREEN AND MOSQUITO NET

All windows and ventilation openings shall be provided with insect corrosion resistant external screen and/or mosquito net.

2.5. HANDLE

Handle shall be brass or aluminium alloy, 100 mm long fixed with screws of the same material.

2.6. LOCK

At least all external doors shall be capable to be locked.

Locked doors shall be delivered with 3 keys.

Lock shall be automatic dead locking mortise lock with 2 bevelled latches and handles.

2.7. STOPPER

When required, doors shall be fitted with foot-operated friction door stoppers.

2.8. HYDRAULIC DOOR CLOSER

When required, doors shall be fitted with single-action type, face fixing hydraulic door closer.

2.9. HINGE

Hinge shall be brass built hinge of size 100 x 50 mm or extra heavy steel-butt-hinge of size 130 x 80 mm depending of the size of the door.

When shown on the Drawings or directed, doors shall be fitted with double-action oxidised brass, sprint-butt-hinge of size 100 x 50 mm.

2.10. GLASS

All the glass shall comply with the appropriate section of ASTM C-158.

Sheet glass shall be colourless free from bubbles, distortion and flaws of other significant nature. The glass shall be properly cut to fit the rebates so as to have a uniform space to accommodate rubber insertion all round the panel between edge of the glass and the rebate.

Plain glass is the type to be used for windows, doors, etc. unless otherwise directed. Its minimum thickness shall be 5 mm. The breaking strength under flexural load shall be not less than 30 MPa. It shall withstand 24 hours exposure to hydrochloric acid vapour and subsequent return to open air without impairment of either its transparency clearness or lustre.

Where phonic insulation is required, glasses shall have an acoustic absorption factor of 32 dB over the range 100 to 3200 Hz.

Unless otherwise agreed, glass blades for louvres shall be 150 mm wide with 25 mm overlaps and shall have polished edges.

Where the total length of a louvre exceeds 1100 mm, mullions shall be incorporated in the frame so that no louvre blade is larger than 1100 mm.

The blades shall be set into interlocking metal clips fixed to the frames. The clips and the frames shall be of aluminium.

Head and cell sections of the louvre frames shall match and be fitted with dual softness PVC or neoprene insert weatherstrips.

2.11. GLAZING BEADS

Metal glazing beads shall be supplied with the metal frame and shall be tightened with sunken screws.

All aluminium doors and windows shall have locking glazing beads and extruded vinyl gaskets.

2.12. DOORS AND WINDOWS

All windows and outside doors shall be designed to support a pressure of 1.5 kPa.

Buckling of openings: three angles of an opening being maintained fixed, a force of 100 N applied upright on the fourth free angle shall not introduce a displacement of this free angle greater than 5 mm.

The openings support a vertical force of 1 kN at the top edge of the door or windows opposed to the hinges without any permanent deformation.

Standard sized doors shall operate under a force of less than 5 daN and opening windows under a force of less than 3 daN.

Lock system shall be quick and efficient with the handle at 4 cm free distance from any fixed element.

Metallic joinery shall be built from standard sections allowing a dust proof joinery with double elastomer joints.

Number of hinges shall be 2, 3 and 4 for openings height of 1.00, 1.80 and 2.50 m respectively. Hinges shall be fitted with bronze ring and the male part shall be adjustable.

2.13. ENTRANCE ROLLING DOORS

Aluminium sheeting on steel framed door electrically controlled, suspended and rolling on an upper rail supported by the steel structure.

Insulation equivalent to insulation of aluminium insulated sheet walling (refer to section).

Ventilation openings with screen 600 x 600 mm.

Opening for glazing 600 x 800 mm (glass equivalent to the glass used for internal windows - refer to Section 2.10.D above).

Finishing equivalent to the sheet walling.

Shop drawings to be proposed to the Engineer's approval together with shop drawings for the whole buidings structural steelworks and sheet walling.

2.14. GLASS BLOCKS

Glass block walls shall be constructed from hollow glass blocks 240 x 240 x 80 mm or equivalent dimensions set in mortar in a perimeter framing to connecting walls and ceilings of aluminium channel sections.

The wall shall be set against the floor on 2 layers of bituminous felt. Channel sections shall be fixed to walls and ceilings with the concave face against the glass blocks and lined with 10 mm thick foamed polystyrene and 1 layer of bituminous felt before mortar is placed.

The glass blocks shall be set with flush joints to true horizontal and vertical lines in a 250 mm module. All channel sections shall be completely filled with mortar, and the joints between channels and mortar filled with an approved elastic joint filler.

Glass block walls shall be reinforced with 8 mm hot dip galvanized plain reinforcement bars around the perimeter and in every horizontal and vertical joint.

3. EXECUTION

3.1. FRAME

Where practicable, frames shall be placed prior to construction of enclosing walls and ceilings.

Frames shall be securely braced into position until permanent anchors are set.

3.2. GLAZING

Glazing channels, stops and rabbits shall be cleaned before receiving the glazing materials.

Glass shall be set in a manner which produces the best possible degree of uniformity in appliance.

Glass shall be protected from breakage after installation by installing streamers or ribbons attached to the framing and held free from glass.

3.3. PAINTING OF METAL WORK

All metal works shall be shop painted.

3.4. CLEANING

Glass shall be cleaned with methylated spirit on completion.

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SECTION 08200
PAINTING

1. GENERAL

1.1. WORK INCLUDED

1. All surfaces to be painted
2. Surfaces as directed by the Engineer.

1.2. RELATED SECTIONS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. STANDARDS

Society for Protective Coatings (SSPC) Specifications, or equivalent

1.4. QUALITY ASSURANCE

Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this Section shall be used.

1.5. SUBMITTALS

The Contractor shall submit 4 months before the scheduled date of painting 3 colour schedules of painting together with a description of colour codes, composition and manufacturer's recommendations concerning preparation of the surface and method of application of the paint of each type of paint and each type of exposure condition, as directed by the Engineer.

1.6. SAMPLE AREAS

Sample areas of not less than 1.50 m x 1.50 m shall be prepared and painted, one for each colour and/or type of surface finish as required or as directed by the Engineer.

If approved by the Engineer the sample areas will serve as minimum reference standards for painting.

1.7. DESCRIPTION OF WORK

The rooms will include the following interior works:

- Dust-resistant, non-slip and washable paint on floors with 10 cm run-up on interior walls in all rooms except rooms with acid-resistant paint.
- Acid-resistant paint on floors with 10 cm run-up on interior walls in all electrical equipment, deodorisation and reagent storage rooms.
- Two coats of paint on all interior walls in technical equipment rooms, except pump pits, UV and tank building rooms.
- Two coats of glyptal paint on ceilings in electrical equipment rooms.

1.8. DELIVERY, STORAGE AND HANDLING

Paint materials shall be delivered in sealed original labelled containers, bearing manufacturer's name, type of paint, brand name, colour designation and instructions for mixing and/or thinning down.

.All paints and associated materials shall be stored in dry covered storage which is adequately ventilated and protected from temperature extremes. Any paint which is, in the opinion of the Engineer, not in good original conditions according to manufacturer's specifications, shall be replaced by the Contractor at his own expense.

Precautionary measures shall be taken to prevent fire hazards and spontaneous combustions.

1.9. ENVIRONMENTAL REQUIREMENTS

Blast cleaning and painting work shall be carried out only when the ambient air and degree of humidity are within the requirements of the instructions for use of the product.

Paints shall be applied only to surface that are thoroughly dry and under such conditions of humidity and temperature as will cause evaporation rather than condensation. The surface temperature shall always be at least 3°C higher than the dew point.

Generally all work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C.

Adequate continuous ventilation shall be maintained before, during and after application of paint up the time of the paint if thoroughly dry.

Paint when applied shall be at approximately the same temperature as the surface on which it is applied.

2. PRODUCT

2.1. GENERAL

The type and quality of paint to be incorporated in the Works will be nominated by the Engineer, and only those products approved by the Engineer shall be accepted.

The proposed paint must have ability to withstand the corrosive coastal climate at the Project Site.

All materials shall be proven, first grade products and shall meet or exceed the average standards of reputable local manufacturers.

3. EXECUTION

3.1. INSPECTION

The Contractor shall thoroughly examine surface scheduled to be painted prior to commencement of work.

Defects and deficiencies in surface which may adversely affect work shall be corrected.

3.2. PROTECTION

The Contractor shall adequately protect other surface from paint and damage and shall repair damage to other surface as a result of inadequate or unsuitable protection. This shall include furnishing sufficient shields and protective equipment to prevent spray or dropping from fouling surfaces not being painted and particularly surfaces within storage and preparation areas.

Cotton waste, cloths and materials which may constitute a fire hazard shall be placed in closed metal containers and removed daily from Site.

Fittings and fastenings shall be carefully removed prior to painting operations. These items are to be carefully stored, cleaned and replaced on completion of work in each area.

3.3. PREPARATION

3.3.1. GENERAL

1. Surfaces to be painted shall be clean before applying paint or surface treatments. All oil, grease, dirt, rust, loose materials and other foreign substances shall be removed.

2. No coating work shall begin before the prepared surfaces, or the manner of preparation, have been approved by the Engineer.

3. Cleaning and painting shall be so programmed that dust or spray from the cleaning process will not fall on wet, newly painted surfaces.

4. Where required, imperfections and holes in surfaces shall be filled or obliterated in an approved manner.

5. Hardware, electrical fixtures and similar accessories shall be removed during preparation and painting operations and shall be replaced upon completion of painting operations.

3.3.1. CONCRETE AND MASONRY SURFACE

1. New concrete surface receiving paint shall be cured for a minimum of 28 days before being painted.

2. The Contractor shall remove contamination and shall acid etch and rinse new concrete floors with clear water, ensuring acid alkali balance is achieved.

3. The Contractor shall remove dirt, loose mortar, scale, powder, and other foreign matter from concrete and concrete block surfaces which are to be painted or to receive a clear seal.

4. Oil and grease shall be removed with a solution of tri-sodium phosphate, which shall then be thoroughly washed and drained from the surface.

5. Hairline cracks, small holes and imperfections on plaster surfaces shall be filled with patching plaster and the surface shall be smoothed to match adjacent surfaces.

3.3.1. WOOD SURFACE

1. Wood surface shall be planned or sanded to remove all tool marks.

2. All holes, cracks and depressions shall be cleaned out and overfilled with non-shrinking wood filler which, when completely set, shall be sanded back to match the adjacent surfaces.

3.3.1. PLASTER

1. Plaster shall be at least 2 months old and shall be thoroughly dry, clean, and free from grit, loose plaster, and surface irregularities before paint is applied.

2. Cracks and holes shall be repaired with patching plaster.

3. All plaster surfaces shall be tested for the presence of alkali which, if present, shall be removed with a solution of zinc sulphate mixed in the proportion of 1 kg to 2 litres of water. After drying, the precipitate shall be removed by brushing.

3.3.1. APPLICATIONS

No paint or other products may be applied until the surface has been prepared to the satisfaction of the Engineer and until the surface is completely dry.

Each coat of paint is to be slightly darker than the preceding coat unless otherwise approved by the Engineer.

Each intermediate coat is to be lightly sanded back before the application of the subsequent coat.

The paint shall always be thoroughly mixed according to the manufacturer's instructions prior to application and only approved thinners may be used.

The time between coats shall not be less than that recommended by the manufacturer.

Any painting considered to be unsatisfactory by the Engineer shall be sanded back and repainted at the Contractor's expense.

3.4. CLEANING

During painting the work area shall be kept clean and free of dust or other harmful substances.

On completion of painting the whole area shall be thoroughly cleaned or any splashes, spills or runs.

3.5. DRY FILM THICKNESS

The protective paint systems shall be applied in continuous films to give, at the minimum, the total dry thickness indicated in the coating schedule, as measured by approved methods.

One steel material wet thickness gauges shall be used continuously by the applicator during application to ensure that the dry thickness requirements will be met.

3.6. COATING SCHEDULE

The following coating schedule shall be adopted:

a. Wooden frames, doors

- Surface preparation: as specified.
- Prime coat: plasticised nitrocellulose sealer (2:) (such as NC Wood Sealer).
- Finish coat: plasticised nitrocellulose topcoat (3:) (such as NC Glossy Wood Finish).

b. Concrete and plaster

- Surface preparation: as specified.

- 1.Vinyl Emulsion Paint
- Prime coat: alkali resisting masonry sealer (1:12) (such as Dulux Primeon).
- Finish coat: vinyl acetate emulsion paint (3:60) (such as Paintex Vinyl Emulsion).
- 2.Plastic Emulsion Paint
- Finish coat: (3:60)
- 3.Hard Gloss Enamel Paint
- Long oil alkyd resin paint (3:60) (such as Dulux Synthetic Enamel).
- 4.Oil Repellent Paint and Concrete exposed to chemical action or heavy duty
- In cracks and holes: epoxy sand mortar
- Prime and finish coat: epoxy paint (4:120) (such as Epoxy Concrete Finish).
- 5.White colour Paint.
- No painting shall be applied to aluminium, stainless steel, copper bronze, chromium, nickel, brass or galvanized surfaces, unless directed by the Engineer.

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SECTION 08300
SUSPENDED CEILINGS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading and erection of the miscellaneous suspended ceilings.

Works include but are not limited to the followings:

- supply and installation of metal framework and attachments for mounting to the load-bearing structure,
- supply and installation of tiles, strips, ceiling panels or other components of the ceiling itself including hooking, mounting and connection systems (anchors, clips, slides, slide rails, etc.),
- finishing (laquered metal profiles for edge covering, etc.) and all related works,
- protection of metal structures in the conditions defined in the present document,

1.2. RELATED WORK

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

Suspended ceilings shall be installed in halls, offices, washrooms and in all pedagogical and living facilities. They won't be allowed neither in process areas nor in all exploitation and technical rooms in contact with water or condensation.

The false ceilings proposed may be of concealed framework, aluminium ceiling panels, coated gypsum board or laminated wood.

The acoustic ceilings proposed may be of mineral fiber, fiberglass, metal, wood, foam or polyester.

The selected materials must be suitable for the type of premises in which they are to be installed (humidity, excess pressure, etc.).

1.4. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

Application of ceiling units shall be done in strict accordance with the manufacturer's specifications unless otherwise approved.

1.3.1. DESIGN CRITERIA

The false ceiling primary framework (where applicable) must be able to support the weight of lighting fixtures.

The secondary framework must be able to support the other technical equipment whether flush-mounted or suspended (fire detection system, sound installation, etc.).

All necessary measures must be taken to prevent problems due to condensation.

In damp premises, the false ceiling framework must be connected to the building earthing system.

1.3.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3. Workshop inspections and tests:
    A. The seals and the embedded parts shall be presented separately and unpainted for checking.
    B. The surface appearance of embedded parts shall be examined and their dimensions checked.
    C. All dimensions shall be checked.
    D. Welds: Refer to Section 01020.

1.5. SUBMITTALS

The Contractor shall carry out studies, calculations, diagrams, construction and detail drawings of structures. These drawings shall show clearly the sizes, methods of fixing, jointing and anchorages to be used in the process.

1.6. DIMENSION TOLERANCES

1. Ceiling panels and metal strips: 1/500 of the span between supports, with upper limit at 5 mm.

2. Fibreboard panels: 1/300 of the span in the case of visible framework.

3. Unevenness tolerances: 3/10 mm for chamfered components.

4. Gap between visible framework and panels: 1 mm maximum.

5. General flatness of suspended ceilings made of panels, of fibreboard and aluminium: deflection or camber less than 3 mm under 1.20 m rule for ceilings smaller than 4 m² and under 2.00 m rule for ceilings larger than 4 m².

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURING

The Contractor shall chose framework and materials in relation to regulatory requirements, in particular those concerning fire and panic risks, and contractual requirements in terms of resistance, absence of uplift, suitability in relation to humidity conditions of premises and soundproofing, and corrosive environment

Timber framework shall be treated with insecticide using products with the CTB.F label that do not stain the ceilings,

2.2. SPARE PARTS AND SPECIAL TOOLS

The contractor shall specify and supply the special tools required for equipment maintenance.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. GENERAL

Space to receive ceiling units shall be satisfactorily closed and protected against the weather two months before beginning and during work.

Temperature shall be maintained at 10°C or above while system is being installed.

Space to receive ceiling units shall be dry and with no more dampening materials to be installed.

All cuts and recesses for incorporating components supplied by the different trades (electricity, heating, ventilation, etc.) are under Contractor's responsibility. This work must be carried out on the basis of instructions supplied by the different companies during the preparation of slab layout drawings, to be submitted, prior to any production, for the approval of the Owner or his representative,

The Contractor shall create grooves, notches and holes in the walls and load-bearing framework for securing, anchoring or putting in place of suspended ceiling components. He shall also fill in any such grooves, notches and holes that remain visible after installation work,

The Contractor is responsible for installation and removal of any scaffolding needed for performance of the works, irrespective of the height of the structures,

Tarpaulins and protection of structures of other trades, that might be damaged during the performance of the works described in the present chapter, shall be set.

Perfect coordination shall be assured:

- for the fitting of ducts, piping and wiring and installation of apparatus (light fittings, outlets, fire detectors, sound installation etc.),
- for connection of the structures (stability, etc.),
- for painting and covering works.

3.3. CEILING SUSPENSION SYSTEM

The false ceilings will be either suspended to the underside of the floors, of poured reinforced concrete on standard formwork or COFRASTRA type metal formwork (or similar), or on prestressed permanent shuttering concrete slab, under the framework comprised of beams and prestressed purlins.

In these last three cases, drilling and power-activated fastening is prohibited.

False ceiling framework must be installed using clamps around the purlins.

The provision of any special parts for securing the components is included in the supply.

3.4. FIELD QUALITY CONTROL

1. Erection tolerances:

   Refer to Section 01020 and paragraph 1.6.

2. Examination of paintwork.

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SECTION 08400
MISCELLANEOUS TILING

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply and execution of floor tiling in the office buildings, laboratories, guard post and all living areas.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. QUALITY ASSURANCE

All tiles shall be worked, installed and fixed according to the instructions of the Manufacturer.

2. PRODUCTS

2.1. CERAMIC TILES

All ceramic tiles shall be high quality local products produced by firing at high temperature with bright ceramic glaze.

Tiles shall have uniform size, uniform colour and uniform shape with rounded edges on the finished face.

Minimum tile thickness shall be 6 mm.

Tiles shall be manufactured at a minimum pressure of 60 bars.

2.2. MARBLE TILES

Marble shall be compact, dense, metamorphic rock of limestone origin. It shall have a minimum density of 2.7.

It must be evenly grained with sugar like appearance when broken.

Generally marble tile shall be of 150 x 150 mm size and 12 mm thick, or as shown on the Drawings.

The colour of the marble shall be as indicated in the Drawing or as directed.

The edge of the marble tiles shall be dressed true and square by rubbing them with carborundum stone or any other approved means and the same will be fixed in position.

2.3. MORTAR

The joint filler shall be white cement grout which bond to dry tile, non-shrinking, strain, resistant and permanent in colour. Grout shall be water resistant and shall not wash out under water and certified by the manufacturer for the intended use.

The ratio of cement sand mortar for laying and embedding marble tile work shall be (1:2) to (1:3) as determined by preliminary test.

Hand mixing, when permitted by the Engineer, shall be done on clean hard platform of only such quantity as required for immediate use with just sufficient water to produce mortar or stiffest consistency and sufficient workability.

If directed, the mixing shall be done by mechanical mixers.

The dry materials shall be dry mixed for approximately two minutes and for three minutes after addition of water making total minimum time of five minutes in a mortar mixer.

When hand mixing is permitted, the materials shall be mixed dry before adding water, until uniform colour of mixed materials indicates thorough distribution of cementitious materials. After dry mixing is completed, water shall be added until well mixed mortar of the required plasticity is obtained.

2.4. ANTI-ACID RESISTANT TILING

Unless otherwise specified, the Contractor shall supply and install in electrical rooms anti-acid resistant tiling and band these tiles with anti-acid cement grout.

2.5. TOPPING SCREEDS

Topping screeds that are less than 50 mm thick and are laid on to damp proof membrane as a base for floor finishes shall be in the proportion of one part sulphate to four parts sand by volume.

Topping screeds that are over 50 mm thick either laid direct on to base concrete or damp proof membrane shall be in the proportion 1 part sulphate resisting cement to 1 ½ parts fine aggregate to 3 parts coarse aggregate by weight.

Base concrete shall be prepared as described in the Specification. All screeds shall be finished with a wood float to give an even, slightly coarse texture with no ridges or steps.

Topping screeds shall be laid in bays of not more than 10 m² and the Engineers approval to the positions of joints between bays shall be obtained before starting work.

2.6. VINYL FLOOR TILING

2.3.1. VINYL TILES

Vinyl floor tiles shall be mat finished, heavy duty, 5 mm thick, 300 x 300 mm tiles with colour and texture approved by the Engineer.

2.3.1. ADHESIVE

Adhesive shall be Enbond-128 Extra or equivalent according to the recommendation of the manufacturer of the tiles.

2.3.1. VINYL TILE FOR ELECTRICAL ROOMS

In addition for all electrical rooms, the tiles shall be special tiles designed for electrical room.

3. EXECUTION

3.1. PREPARATION OF BACKGROUND SURFACE

Surface over which the tiles are required to be fixed shall be clean of all dirt and dust and should be properly hacked so that the mortar sticks well to the surface.

3.2. GENERAL

Straight edges shall be accurately set to the lines established and reset at suitable intervals to keep the joints parallel over the entire area.

The joints and connections shall be made with great care to guarantee maximum watertightness.

Joints shall not exceed 3 mm.

Spaces between ceramic tiles shall be filled with cement paste having the same colour as the tile or as approved.

As much as possible tile cutting shall be avoided. However, if it is necessary, the smallest size shall be one half of the normal size. Cutting shall be done carefully using a suitable tile cutter to produce straight and neat edges.

All pipes and channels which will subsequently be covered by tiles shall be placed in accordance with the Drawings, and the Engineer's approval shall be necessary before any such installations may be covered by tile work.

All cable ducts and plumbing shall be completed to the satisfaction of the Engineer before tiling is started.

3.3. INSTALLATION OF VINYL TILES

3.3.1. PREPARATION OF BASE

1. Floors to receive vinyl tiles shall be brought to proper grade, and shall be smooth and levelled as indicated in the section of cement concrete flooring.

2. Vinyl tiles shall be laid when the concrete floor is thoroughly dry.

3.3.1. INSTALLATION OF TILES

1. The cutting of tiles joint between tiles shall be of uniform width. Fractional changes in dimension without varying the uniformity of joint widths shall be permitted. Tile shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut-tiles shall be laid to the straight edges. Straight edges shall be set accurately to the lines established and reset at suitable intervals to keep the joints parallel over the entire area.

2. Excessive adhesive shall be removed before it dries.

3. No traffic shall be permitted over recently placed tiles until adhesive has set up sufficiently.

4. Finish cleaning shall be in accordance with the tile manufacturer's recommendations using minimum amount of water.

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SECTION 08500
WOOD WORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers rough and fine timber for structural elements, frames and finishing where required in the buildings.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. STANDARDS AND CODES

ASTM A-307	Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile
ASTM D-3110	Specification for Adhesives Used in Non-structural Glued Lumber Products
ASTM D-3499	Test Methods for Toughness of Plywood
ASTM E-283	Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors
EN 1995	Eurocode 5 : design of timber structures

1.4. GUARANTEE

If any shrinkage or warping occurs or any other defect appears in the joiner's work, before the end of the Defects Liability Period, such defective work shall be taken down and replaced and any other work disturbed shall be made good at the Contractor's expense.

1.5. HARDWARE, LOCKS AND GLAZING

Locks and Glazing shall be in accordance with Related Section 08100.

1.6. DESCRIPTION

Doors and door frames located in halls and offices shall be made of wood.

Wooden timbers will not be accepted for the purpose of this project.

2. PRODUCTS

2.1. TIMBER

2.3.1. GENERAL REQUIREMENTS

1. Materials shall comply with the European standards applicable to the type of wood: EN 14081, EN 14080, EN 14374, EN 14279, EN 636, EN 300, EN 312 and EN 622 or approved equivalent.

2. The Contractor shall produce designs and offer standard locally-manufactured items and details for approval.

   Where standard items cannot be used, the Contractor shall produce at his expense further drawings and sketches as are necessary to define joinery details. These shall be agreed with the Engineer before work starts on the items concerned.

   At an appropriate early stage in the Contract, the Contractor shall submit for approval samples of timber, related materials and, where appropriate, finished work for items such as doors, door frames and window frames. The name, origin and grading of each proposed timber shall be stated, together with details proposals for preservative treatment. Once samples have been approved they will be retained by the Engineer as a standard and any work failing to meet the standard of the relevant sample will be liable to rejection.

3. Timber shall be first class from the heart of a sound tree, in which the sap wood is entirely removed, and the wood is uniform in substance, straight in fibre, free from large or dead knots, flaws, shakes or blemished or any kind.

4. For first class teak wood, the size of the knot shall not be more than 13 mm and there should not be more than one knot in every 0.25 m^3 of timber.

5. For first class deodar wood, the size of the knot shall not be more than 25 mm and there shall not be more than one knot in every 0.12 m^3 of timber.

2.3.1. SEASONING OF TIMBER

Moisture contents for timber less than 2.5 cm thick shall be not more than 12% and shall be less than 15% for timber more than 2.5 cm thick.

2.3.1. STORAGE

Timber shall be stored in a dry ventilated covered storage.

Care shall be taken to prevent damage to the timber.

Joinery shall be protected from the weather during transit and shall be stored under cases, clear of the ground in clear, dry, ventilated structures after priming.

2.2. FORMICA

Formica shall have 1.5 mm thickness with 0.5 mm lamination and matte finish.

2.3. GLUE AND ADHESIVE

Adhesive shall comply with ASTM D-3110.

Laminated woods shall be glued using water resistant adhesive having minimum shear resistance of 1.4 MPa at 35°C, and of 0.1 MPa at 116°C.

For teak wood sheet and other mill works "Herferinu" adhesive or approved equal shall be used.

2.4. NAILS, SCREWS AND BOLTS

Nails, screws and bolts shall be galvanised.

All nails and screws used with reactive timber (becoming stained and disfigured by reaction with ferrous metals) shall be non-ferrous metals.

The diameter of the nail or screw shall be suited to the woods being fixed and to which a fixing is being made, and the length shall be such as to give a sufficiently strong and secure fixing.

2.5. WOODEN SKIRTING

Wooden skirting shall be made of deodar.

3. CONSTRUCTION

3.1. SHOP ASSEMBLY

All woodwork, as far as practicable, shall be assembled in workshop, finished and prime coated before delivery for fixing.

3.2. JOINTS

All joints shall be mortise and tenon joints, unless otherwise specified or shown on the Drawings. The joints shall fit truly and fully without filling.

All joints shall be fixed with tight driven hard dried wooden or bamboo plugs. Joints shall be secured with approved glue before the framing is done.

Glue shall not be used in joints which are exposed.

3.3. NAILS AND SCREW

The holes of correct size shall be drilled before inserting screws. Hammer shall not be used for driving in or starting in the screw. All screws shall be dipped in oil before they are inserted in the woods.

The heads of the nails or screws shall be sunk and puttied.

3.4. DOOR FRAMES

Frame thickness shall be shown on the Contractor's Drawings for Engineer's review and approval.

Doors shall have 1.7 mm (± 0.5 mm) clearance from their frame at each side.

The leaf of each door shall be fixed to the frame with 3 hinges.

3.5. DOOR LEAVES

Flush doors shall conform to the applicable requirement of ASTM-E 283.

Door leaves shall be of well seasoned hardwood, cross gained and face veneered with 5 ply 6 mm plywood on each side as shown on the Drawings.

Doors shall operate under a force of less than 5 daN.

3.6. TOLERANCE

All doors shall conform to the requirement of EN 24.

3.7. FINISHING

Any exposed surface of timber works shall be smooth, even, and neat.

In addition to sanding machine, all woodwork shall be smoothed by hand using "OO" sand paper to achieve the required smooth surface, free from machine and tool marks, abrasions, raised grains and other undesirable defects.

Oil borne or water borne preservatives shall be applied to timber surfaces to be painted or to be connected to any painted surface. Coal tar creosote or any creosote solution shall not be used.

Unexposed Timber works shall be painted before installation.

3.8. PRECAUTIONS

3.3.1. PROTECTION

All precautions should be taken by the Contractor to preserve and protect the timber or wooden items erected at site against weather, insects, injuries, etc., during the whole construction period.

3.3.1. PRESERVATION

Preservation material shall be applied in strict accordance with recommendations of the preservative manufacturer and shall be given to all woodwork which comes in contact with or built into any wall, floor, ceiling or any other structure. All the rough woodwork which is not finished and exposed woodwork whether abutting any structure or not shall be given preservative treatment.

3.9. COVERING THE TIMBER

The Contractor shall give at least 7 days notice to the Engineer in writing where any timber is to be covered in the ground or in walls or otherwise. Failing this, the Engineer may order it to be uncovered at the Contractor's expense.

No paint or varnish shall be applied unless the finishing is approved or otherwise the work shall be liable to be rejected in whole or part.

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SECTION 08900
SANITARY INSTALLATION

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply and installation of all sanitary works including water closet, wash hand basins, urinals, sinks, low down and high level cisterns, automatic flushing tanks, showers, taps, valves, and any special fixtures, including connection to the mains.

All the supply will be connected to the sumps.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

Sanitary installations shall be supplied for each independent facility. At least each facility shall have:

- One (1) European type water closet connected to the main.
- One (1) wash hand basin.
- Tiles on walls up to 1m in height, in accordance with Section 08400 – Miscellaneous tiling.

Moreover the main building shall be equipped with a drinking water fountain, a shower and a 50L water heater.

2. PRODUCT

2.1. EUROPEAN TYPE WATER CLOSET

European type water closet shall be of vitreous enamelled china single coupled with (S) or (P) shaped syphon of dimensions 69 x 38 x 39.5 cm (h), with 13 litres coupled cistern and standard PVC seat and cover fixed with nuts, washers and rubber buffers.

A chromium plated toilet paper holder close to each closet shall be installed.

2.2. CISTERN

The flushing cistern shall be made of non-corrodible material or to be protected against corrosion. It shall be provided with a corrosion resistant alloy or plastic ball valve with float of diameter not smaller than 100 mm with an additional 13 mm cock and an overflow pipe at least one size larger than the supply pipe, with a minimum internal diameter of 18 mm, and it shall be fixed on mild steel or cast iron cantilever brackets, if required.

2.3. FLUSH PIPE

The flush pipe shall be chromium plated steel pipe, the holes for inlet and overflow in the cistern shall be made watertight by inserting rubber washers or other means of providing a watertight joint.

2.4. KITCHEN SINK

Sink shall be of enamelled iron or 18-SWG stainless steel bowl with self-contained drain board of a size as shown on the Drawings. The sink shall be fitted with chromium plated 38 mm coupling and rubber plug and chain, 38 mm dia chromium plated bottle or strap with waste pipe with all necessary accessories.

2.5. LAVATORY BASINS

Wash hand basin shall be vitreous china having hard enamelled coating. The size of the basin shall be 52 x 64 cm x 19 cm with pedestal 18 x 70 x 21 cm (base) or fixed to the wall with mounted on mild steel brackets enamel painted. Fifteen 15 mm pillar cock chromium plated shall be connected to water supply, lines. Waste coupling 31 mm and chain plug connected to PUC waste pipe. Any back skirting shall be true to receive the splash back or the wall.

2.6. DRINKING WATER FOUNTAINS

Self-contained, refrigeration unit with electric supply of 230 V, single phase, 50 Hz current.

2.7. TAPS

All taps shall be of heavy duty type, chromium plated or brass or approved equivalent and must be able to withstand the corrosive environment at the Project site.

2.8. WATER HEATER

Glass lined, insulated electric water heater and storage tank, 9 kW heater, 400-V, 3-phase, 50 Hz, shall be complete with immersion type thermostats and heating elements, inlet and outlet connections, safety relief valve and drain valve.

2.9. THERMOSTATIC CONTROL WATER MIXER UNIT

Thermostatic control water mixer unit shall be installed on hot and cold water pipes, near outlet of water heater to control the temperature of supply at source. The mixer unit shall be of import quality and made of stainless steel.

The mixer unit shall operate satisfactorily for the following ranges of temperature:

- Output temperature: ..... 41-45°C
- Input temperature:
  - hot water: ..... 55-60°C
  - cold water:..... 10-20°C.

2.10. DOMESTIC WASTE WATER DRAINAGE AND SEPTIC TANK

The waste water drainage concerns drainage for the guard house and the associated works for septic tanks.

Wastewater drainage pipework shall be a captive ring seal type to BS 4514 manufactured in grey uPVC. Whilst the tender drawings indicate the position, length and diameter of the drainage pipework, the detailed design is to be undertaken by the Contractor on site following approval of the different sanitary fittings. Such design shall be undertaken in accordance with the requirements of BS 5572.

The installation of the drainage pipework shall be in accordance with the requirements and typical details given in BS 8000:Part 13 and BS 5572. All pipework shall be required to the pass the following air test.

1. Temporarily seal open ends of pipework with plugs.

2. Connect a 'U' tube water gauge and air pump to the pipework via a plug or through the trap of an appliance.

3. Pump air into pipework until gauge registers 38 mm.

4. Allow a period for temperature stabilisation, after which the pressure of 38 mm is to be maintained without loss for not less than 3 minutes.

Septic tanks will be provided in order to ensure a treatment system for sanitary waste Contractor can propose concrete septic tanks or plastic septic tank. When used for septic systems the septic tank shall meet British standards for the implementation of septic tank system.

Concrete will be ready mixed with cement conforming to, TYPE I. It will have a minimum compressive strength of 5,000psi (28) days. Reinforcement will be top, side and bottom reinforcing #3 and #4 rebar (grade 60) with structural reinforcing fiber. A controlled expansion hydrophilic waterstop, 3/4"x1", will be placed between the top and bottom half of the septic tank

in the joint line of the tank. The primary inlet and the outlet will have a rubber seal that meets or exceeds the vacuum & hydrostatic pressure requirements of A.S.T.M. specification C-923.

3. EXECUTION

Sanitary applications shall be installed according to Manufacturer's specifications and according to good workmanship.

The system of sceptic tank for the Guard House will be designed by the Contractor in accordance with the Manufacturer's specifications and according to good workmanship.

The drawings and calculations note for the design of the septic tanks shall be approved by the Engineer before works commences.

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SECTION 09500
FENCING AND GABIONS

1. GENERAL

1.1. WORK INCLUDED

This section covers miscellaneous works which are necessary for the completion of the Works or which may be required by the Engineer.

1.2. RELATED WORKS

Works shall be executed in accordance with all other sections of Tender Documents.

1.3. DESCRIPTION

Are described in this Section the followings:

- Fencing
- Unwoven fabric filter
- Gabions

2. PRODUCTS

2.1. FENCING

Unless otherwise specified the fencing shall be of the following types:

A. Wire mesh type

The fence generally consists of:

- Precast reinforced concrete poles (115 x 115mm) – C30/37 with a mass concrete pad footing.
- Chain link to gauge 12 galvanised steel wire
- Straining wires to gauge 12 galvanised steel plain wires
- Wires on the crank to be gauge 12 galvanised steel barbed wire
- All exposed concrete edges of posts to have 25 x 25mm chamfers

- Average spacing between posts shall be 3m with every 10th post and all corner posts strained
- The top of all posts to be kept in uniform line.

Fence total height shall be at least 3 m, and aspect shall be validated by the Engineer after presentation of at least 3 samples.

B. Concrete type

The fence generally consists of a continuous reinforced concrete fencing consisting of grooved posts founded on concrete blocks with continuous chaining in the lower part. The spaces between the posts will be filled either with precast concrete panels anchored in mortar or with masonry blocks covered with a 2 cm thick finishing mortar, or with "CMI Bricks". Access gates shall be provided according to the Drawings. The boundary wall height shall be minimum 2.5m and aspect shall be validated by the Engineer after presentation of at least 3 samples.

The concrete of the posts and prefabricated panels will be class B as per section 03300 of this Tender Document. The top part of the fencing will have 4 rows of galvanized iron barbed wire, increasing the effective height of the fencing to 3 metres.

2.2. UNWOVEN FABRIC FILTER

The unwoven fabric filter shall be a felt made from continuous filaments of pure polyester.

The minimum characteristics shall be as follows:

Weight	(g/m²)	300
Breaking point	(kg/cm)	29
Elongation	(%)	35
Modulus of deformation	(kg/cm)	70
Bursting strength	(kg/cm²)	25
Breaking strength NFG 07.001	(kg/cm²)	9
Breaking stretch NFG 07.001	(%)	60
Tearing strength (transverse)	(kg)	17

2.3. GABIONS

The materials comprise:

- Box gabions
- Mattresses gabions

A. Gabions Boxes and Mattresses

The gabions shall be flexible zinc coated gabions of the sizes as stated in the drawings fabricated of wire mesh of the type and size and selvedge as specified below.

Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 millimetres, or otherwise as stated in the Drawings and so that downslope distance between vertical partitions never exceeds 110 mm.

Gabion dimensions will be as followed:

- Gabion boxes : 2x1x1 m and 3 x1x1 m
- Gabion mattresses: 6 x 2 x 0.3 m and 3 x 2 x 0.3 m

B. Wire Fabric for Gabions

Gabions shall be manufactured with all components mechanically connected at the production facility with the exception of the gabion lid, which is produced separately from the base. The front, base, back, sides and diaphragms of the gabions must be folded into a single unit.

The fabric shall be triple-twisted hexagonal woven steel wire mesh complying with EN 10218. All tests on the wire mesh must be performed prior to manufacturing the mesh.

The wire shall be galvanized before weaving and test samples shall meet the requirements of EN 10218, EN 10223, EN 10244. All wire used in the fabrication of gabions and in the wiring operations during construction shall, after galvanizing, have extruded *onto* it a coating of polyvinyl chloride compound (PVC) in accordance with EN 10245-2 : 2001. The polymer coating shall be capable of resisting the deleterious effects of natural weather exposure, immersion in salt water and not show any material differences in the initial characteristics of the polymer coating prior to such exposure.

Wire diameter and mesh size shall be:

- For Box gabions: 3.0 mm and 100 x 120 mm respectively.
- For Gabion Mattresses : 2.2 mm, with 60 x 60 mm meshes.

The woven mesh used to made the lid of the gabions will have a larger diameter to prevent accelerated degradation of the mesh due to the movement of stone within the mattress. It will respect the following specifications:

- For Box gabions: 3.2 mm.
- For Gabion Mattresses : 2.7 mm.

The wire mesh shall have sufficient stretchability equivalent to a minimum of 10% of the length of a section of mesh under test without reducing the diameter or tensile strength of the individual wires.

The selvedging must be such that the mesh will not unravel and the strength of the connection between the selvedge wire and the mesh shall be equal to or greater than the breaking strength of the mesh.

C. Binding and Connecting Wire

Sufficient binding and connecting wire must be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work. The diameter of the

selvedge wire shall be 3.90 mm or greater for both box gabions and mattresses. The diameter of lacing wire shall be 2 40 mm.

Binding and connecting wire shall be manufactured by the manufacturer of the gabions unless otherwise approved by the Engineer.

D. Tolerances for Gabions and Gabion Wire

Gabion and gabion materials shall be manufactured to the following tolerances:

Gabion Dimensions

A tolerance of + 5% on the width and height of the gabion and a tolerance of ± 3% on the length shall be permitted.

Mesh Dimensions

A tolerance of i 15% on the nominal size of the mesh shall be permitted.

Wire Thicknesses

A tolerance on the diameter of all wire in the above Clauses of ± 2.5% shall be permitted in accordance with BS 1052. The weight of gabions is therefore subject to a tolerance of ± 5%.

Gabions incorporated in the permanent works shall be such that on average their dimensions shall conform to those given in the Drawings.

E. Stones for Gabions and Gabion Bedding

The rock for Reno mattress shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of the structure.

Mattress rocks shall range between 0.06 m and 0.15 m. The range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on the mattress exposed surface. The size shall be such that a minimum of two layers of rock must be achieved when filling the mattress.

Material for gabion fill shall be obtained from the processed excavated materials from borrow areas, provided the following requirements are satisfied:

M (fill material for Mattresses)

Material size in millimetres (square opening)	Percent finer than in weight
180	100
150	85-100
120	60-85
75	0-25
60	0-5

3. EXECUTION

3.1. FENCING

Fencing shall be installed as per Manufacturer requirements and other relevant sections of this Tender Document, especially section 03300 - Concrete.

3.2. GABIONS

A. Method of Construction of Gabions

The Contractor's attention is drawn to the fact that the highest standard will be demanded for constructing gabions.

Gabions shall be assembled using manufacturer's assembly instructions or failing that, following assembly instructions published by Maccaferri except that double turns shall be used in all lacing instead of alternate single and double turns, and by ASTM A975.

The Contractor shall prepare the formation for pitching and gabions by trimming the excavation accurately to the specified dimensions. Where over-excavation occurs it shall be backfilled with compacted fill or, if a gravel backing is used, with the gravel backing material, all to the approval of the Engineer and at the expense of the Contractor. Gabion mattresses placed on the spillway section of embankments shall be aligned with their long dimension downslope such that the maximum compartment dimension measured downslope is 1.0 m. Where two layers exist, the upper layer shall be laid directly upon the lower layer and all adjacent selvedge wires shall be laced.

The gabions shall be unpacked, unfolded on a hard flat surface, stretched out and stamped out of any unnecessary creases. The sides and internal diaphragms shall be raised to the vertical and checked to see that heights are the same and correct. The diaphragms shall be pulled upright to the same height as sides and wired to the sides using the same helical wire connecting each diaphragm to the bottom of the gabion.

Every contact between boxes or between diaphragms and boxes or between lids and boxes- shall be laced.

Individual lacing wire shall be minimum 2000 mm long arid lacing wires shall be joined. All lacing shall be done as a continuous lacing operation and the wire shall pass through every mesh with double turns. Lacing wire shall be laced around selvedges or wire mesh. All connections between lacing wires shall be 5 (five) close turns by pliers.

The wired-up gabions shall be carried to the final position, if not assembled at the final position, and wired securely to the adjoining gabions to give a continuous joint along the adjacent edges. They shall be placed and wired together empty.

Where appropriate units should be placed on headers and stretchers in alternate courses, and vertical joints should not be continuous but staggered.

Before filling, the gabions shall be accurately positioned in their required location, straightened to remove all kinks in the wire mesh and tensioned to avoid bulges occurring during filling. The method adopted for tensioning the gabions shall be to the approval of the Engineer.

Completed gabions shall be inspected and approved by the Engineer before filling commences.

Gabions may be filled by hand. The stones must be tightly packed to minimize the formation of voids. The size of a void shall not be greater than the minimum particle size specified and the

voids ratio shall be less than 30%. The filling shall start at the bottom if the gabions are laid on a slope. Particular care must be taken to avoid the use of flat stones as these do not compact properly and cause the gabions to bulge.

In box gabions with exposed faces, bracing wires shall be fixed laterally and vertically in accordance with manufacturer's assembly instructions or as ordered by the Engineer. Care should be taken to ensure that the bracing wires are evenly tensioned to avoid bulges occurring in the gabion face.

Gabions shall be overfilled by 25 to 50 mm to allow for settlement. Gabion lids shall be stretched tightly over the fill material and securely wired down. If voids are formed between the fill and the gabion lid, then these may be filled with small stones provided that no small stones occur on an exposed face.

Where shown on the Drawings or otherwise directed by the Engineer, the gabion mesh shall be cut, folded and wired together to form mitre joints, angles, curves or slopes which are not possible to obtain in the structures with the standard rectangular gabions. The mesh must be cleanly cut, and the surplus mesh cut completely out, or folded back or on to, and neatly wired to an adjacent gabion face. The cut edges of the mesh shall be securely laced together with binding wire. Wherever possible, gabions shall be cut, folded and wired in a region where relatively low flow velocity occurs.

Sizes of gabions shall be as shown on the Drawings or as ordered by the Engineer.

B. Tolerances for Completed Gabion Structures

When completed, gabion boxes and mattresses should be straight and vertical and free from bulges or kinks in the wire mesh.

If bulges or sags do occur in a box gabion, then the maximum allowable departure from vertical, as measured with a plumb bob from the top or bottom selvedge wire shall be 50 mm.

If bulges or sags do occur in a mattress gabion, then the maximum allowable departure from vertical, as measured with a plumb bob from the top or bottom selvedge wire shall be 10 mm.

C. Workmanship for Gabion Structures

Before the gabion works are allowed to proceed fully, the Contractor will construct and fully complete a minimum length of upstream facing of 30 m to the satisfaction of the Engineer. During the construction of this sample length, the Contractor will ensure that his site staff become fully familiar with the construction techniques required to achieve an acceptable level of workmanship.

During the construction of the remaining works, the sample length will be used as a reference to ensure that the same level of workmanship is maintained throughout the Contract.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.5.2 – TECHNICAL SPECIFICATIONS EQUIPMENT

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SECTION 11100
CENTRIFUGAL PUMPS

1. GENERAL

1.1. WORK INCLUDED

The works to be included in this section consist of the design, manufacture, delivery, off-loading, erection, testing and commissioning of the mechanical equipment for the centrifugal pumps to be designed by the Contractor.

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. DESCRIPTION

1.3.1. MAIN CHARACTERISTICS

a. All pumps shall be driven by electric motors in accordance with the requirements of the electrical specifications. All pumps shall comply with the requirements of ISO 9905, Technical Specification for Centrifugal Pumps - Class I.

b. The direction of rotation of all the pumps shall be clockwise when viewed from the motor end of the pump set assembly.

c. All pumps of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.

d. The pumps shall be sufficiently robust to withstand all forces under the most arduous conditions associated with normal and abnormal operations. These shall include:

- Normal starting and stopping against an open delivery valve.
- Starting against closed valve without overheating.
- Reverse rotation due to backflow in case of flap valve failure.
- Transients due to power failure and emergency shutdown.

e. The pump rotating assembly design shall be such that the first critical speed of the pump with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the pump.

f. Each component casting of the water pump body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive coastal environment.

g. The design and construction of the rotating assembly shall take into account the possibility of uplift forces caused by the pressure transients during pump start-up or shut-down. The Contractor shall show how this force is counteracted.

h. Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

i. The design of the suction manifold shall avoid risk of ingesting entrapped air or other condition likely to result in cavitation. The Net Positive Suction Head (NPSH) of the installation has to be calculated by the Contractor. It must suit the required NPSH given by the pump manufacturer.

j. Velocities in the suction and delivery branches shall be sufficiently low to prevent hydraulic turbulence and cavitation within the pump and the pipework and sufficiently high to prevent settlement of any suspended solids.

k. The pump and its drive motor shall be suitably rated and the characteristic curve selected as appropriate to allow for any increased head, due to sliming, etc., of the rising main, without unacceptable loss of delivery during the lifetime of the pump.

l. All wastewater pumps shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces dues to grit.

m. The type of pumps to be provided specifically at the raw water pumping station by the Contractor shall be: Single Stage - Axially Horizontal Split Case - Double Suction Pumps with a Double Volute Casing.

1.3.2. OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

1.3.2.1. PUMP DUTIES

Each of the pumps shall be capable of operating continuously without damaging effects due to cavitation (if any); If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.2.2. PUMP SUCTION ABILITY (NPSHR)

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.2.3. PUMP RATED SPEED (NR)

The maximum rated speed of the pumps shall be as recommended the manufacturer with the maximum speed for the selected /adopted pumps being in compliance with the guidelines

provided by the Ministry of Water and Irrigation Design Manual 2005, or an equivalent International Standards.

1.3.3. HEAD-FLOW CHARACTERISTICS

The pump "Head-Flow" characteristics in the specified operating range shall be stable so that a tangent drawn at any point on the curve will be downwardly directed in the direction of increasing flow.

1.3.3.1. PUMP SHAFT POWER AND PUMP EFFICIENCY

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed.

1.3.3.2. REVERSE ROTATION CAPABILITY

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.4. QUALITY ASSURANCE

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routing tests.
3. Workshop inspections and tests:

   a) At the end of manufacture, the pumps shall be presented, unpainted, completely erected for dimensional checking.
   b) One pump of each type with its driving motor shall be tested at the manufacturer's plant to demonstrate complete compliance with the Specifications. In case the tests are not satisfactory, necessary modifications shall be done by the manufacturer and all pumping sets will be tested.

The Contractor shall submit the results of workshop tests.

1.5. SUBMITTALS

The Contractor shall provide the pump performance curves for each pumping unit.
Moreover, the Contractor shall determine in his bid the:

- Rotating speeds (tr/mn),
- Power of the associated motors (kW),
- Weights of the units and of each essential component,

2. PRODUCTS – COMPONENTS AND SUB-ASSEMBLIES

2.1.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).
The submersible pumps shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the

discharge connection. There shall be no need for the personnel to enter the wet-well. Sealing of the pumping unit to the discharge shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with O-ring, gasket or diaphragm which has to be replaced will not be acceptable. No portion of the pump shall need any support directly on the sump floor.

Pump shafts shall run in antifriction ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust lads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Oil level shall be maintained by a constant level oilier with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm. Impellers must be of the enclosed type. All submersible pumps shall be of the centrifugal type easily removable for inspection or service and requiring no bolts nuts or any other fastenings.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed such that, on any point along the full speed operating curve of the pump, no components are over loaded. Pumping units shall be designed to operate without cavitations or damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.1.2. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable.

The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.1.3. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing.

The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. For motors below 75 kW shall have a thermistor embedded into the windings. For motors of75kW and larger shall have PT100 temperature sensors shall be embedded in the stator load coils to monitor the temperature of each phase winding. The PT100's shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o - ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable.

All motors 75 kW and above shall have heaters installed in the motor windings. The connections should be brought out to the terminal box for connection.

The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus of minus 10% the motor shall be designed for operation up to 40^{o}C ambient temp. and with a temp. rise not to exceed 85^{o}C. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes 1.0 mm Triad cables shall be used for the monitoring of PT100's and optional protecting sensors.

The pump will have a minimum efficiency of 94% with an IE3 Motor Class.

2.1.4. BEARING

All bearings shall be liberally rated to ensure cool running and meet the load factors specified. For all motors of 75kW and larger shall have for both motor DE and NDE bearings, PT100's temperature sensors installed. These shallbe connected to the motor control centre for temperature monitoring.

2.1.5. LABELS

A label made of non-deteriorating material shall be attached to each pump and motor in a place where it can be easily read and shall show the following information:
Manufacturers, serial numbers and types of both pump and motor
Nominal flow in m^3/h (Q_{opt})
Manometric head in m (H_{man} opt)
Efficiency eta opt in %
Net positive suction head ($NPSH_{req}$ opt) in m
Power consumption, voltage, start-up mode in kW, V
Speed of rotation 1/min
Pumps shall withstand continuous operation at full load (8000 hours/year).

2.1.6. IMPELLERS

Impellers and guide vanes (if any) shall be of stainless steel, accurately machined and smoothly finished to minimise hydraulic losses. The rotating elements shall be balanced to achieve minimum vibration and shall be statically and dynamically balanced before final assembly.

The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework. The impeller shall be provided with means of preventing abrasive matter getting to the glands. Clearance at the eye rings and wear plates shall be kept to a minimum and where it is found necessary to cut back the impeller, this is to be done on the vanes only.

Where specified the impeller shall have renewable wear rings.. Eye rings and wear rings shall be bronze or other compatible materials and shall be replaceable without machining.

Impellers, as far as practicable, shall be hydraulically balanced to reduce end thrust on the bearings to the minimum possible. Machining of holes in the impeller shall not be used to balance hydraulic forces.

The suction arrangements shall be such as to avoid pre-rotation in the suction pipework and present a good flow pattern at the entrance to the impeller.

2.1.7. PUMP SHAFTS

The pump shaft shall be of high tensile stainless steel adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft.

The shaft coupling between pump and motor shall be of the flexible type and shall be provided with guards.

2.1.8. VOLUTE

Pump volute shall be single-piece stainless steel non-concentric design with smooth passages large enough to pass any solids that may enter the impeller. Minimum inlet and discharge size as specified. The volute shall have a mating flange machine, and provided with a blind-flange, correct positioned for a flushing valve.

2.1.9. WEAR RINGS

A wear ring system shall be used to provide efficient sealing between the volute and the suction inlet of the impeller. The wear ring shall be stationary and made of brass or rubber- cladded steel frame, which is driven, fitted to the volute inlet. These pumps shall also have a stainless steel impeller wear ring heat – shrink fitted to the suction inlet of the impeller to mate the stationary wear ring.

2.1.10. SURGE VESSEL

The materials to be used for the execution of the hydro pneumatic vessel (if necessary) will be as follows:

Body and bottoms: stainless steel;

The bottom is small or large radius, chosen based on operating pressures and the same materials as the body;

Pipes and fittings such as flanges, reductions, tees, etc. will be carbon steel with welding process be compatible with the body and the bottoms;

All parts in contact with water will be treated with corrosion allowance of 1.5 mm;

The pressure safety valve will be in bronze;

The level measuring tube is stainless steel and is to have indication of magnetic type and shall have four no magnetic switches for level indication and compressor control;

The bolts or screws or immersed in humid atmosphere are respectively made of stainless steel or cadmium-plated. They will mount normally greased. When necessary, they will be locked by an appropriate system;

Joints shall be consistent with the water quality.

All controls shall be automatic

The maximum operating pressure will be equal to the maximum operating pressure under transient with a further upward buffer of 4 bar.
The body of the vessel will be tested at the factory according to the tests prescribed by the applicable standards for pressure devices.

2.1.11. COMPRESSORS

At least two (2) compressors must be provided, one as reserve. It will back up the other in case of default. In manual mode, the 2 compressors can be operated simultaneously.
Each compressor will be equipped with a compressed air tank and all needed connecting pipes.
The voltage of the compressors' motor will be 415 V / 50 Hz. The protection degree of the motor will be IP 55, with an insulation Class F and a temperature rise Class B.
Each compressor will have its own electric panel with circuit breaker, contactor, thermal protection relay and the relays for automatic operation according to the level sensors.
It shall be operated either automatically according to the water level in the vessel or manually.
The front panel will have the following equipment:

a) Ammeter;
b) Voltmeter;
c) Control switches and push-buttons;
d) A 3 pos selector switch:
e) External isolator switch;
f) Emergency push button

2.2. FABRICATION

a. Casing

The casing shall be gray cast iron EN JL 1040 or equivalent, with smooth waterway and fitted with wearing rings. Wearing rings shall be provided for pumps running more than 1000 hours a year. The wearing rings shall be of bronze casting CuSn 12 or equivalent.

b. Impeller

The impeller shall be enclosed, accurately machined, and statically and dynamically balanced. The impeller shall be made of the following materials:

- Bronze casting CuSn12 or equivalent.
- gray cast iron EN JL 1040
- Stainless steel, AISI 304 or equivalent

c. Shaft

The pump shaft shall be of high tensile stainless steel precision-ground, and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water. The shaft shall be rigidly supported by at least two (2) sets of heavy-duty antifriction ball bearings. Lubrication of bearings shall be done with grease.

d. Shaft coupling

The shaft coupling between pump and motor shall be of the flexible type and shall be provided with guards.

2.3. SPARE PARTS AND TOOLS

To comply with provisions of the 7.1 - General Requirements, Section 29 – Spare Parts.

The Contractor is to supply all the recommended spare parts by the manufacturer. As a minimum, the following spare parts are to be provided:

Pump shaft – 1Nr.

Shaft protection sleeve – 2Nr.

Spacer sleeve – 2Nr.

Plain bearing - 2Nr.

Set of impeller – 2Nr.

Set of O-rings – 1 Nr.

Set of stuffing box packing, 15 meter – 1Nr.

Packing extractor – 2Nr.

Complete coupling – 1Nr.

Set of rubber inserts for coupling – 5Nr.

Set of pump bearings – 1Nr.

Set of pump bearings – 1Nr.

Set of motor bearings – 1Nr.

Temperature sensor PT100 pump bearing – 2Nr.

Balancing piston – 1Nr.

Temperature sensor PT100 motor bearing – 1Nr.

Pressure sustaining valves – 1Nr.

Suction butterfly valves – 1Nr.

Delivery butterfly valve – 1Nr.

Suction pressure gauge – 2Nr.

Delivery pressure gauge – 2Nr.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

- Holes position
- Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- Examination of paintwork.

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

a. The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

b. The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. INSTALLATION INSPECTION

a. When the Contractor is satisfied that the pump sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.

b. The pump sets will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3.3. PRE-COMMISSIONING TESTS

a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.

b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.

c. Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.3.4. COMMISSIONING TESTS

a. Tests shall be carried out on each pump set and shall include but not necessarily be limited to the following:

- performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
- vibration monitoring to demonstrate compliance with specified vibration severity limits;
- reverse rotation of the pump set due to backflow;
- simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.

b. Performance proving tests shall be carried out on one pump set at a time by pumping clean water. The Contractor shall submit to the Engineer a method statement on the way he intends to carry out these tests, particularly concerning water supply and output. Performance data shall include H-Q curves, power inputs, pump set efficiency curves and rotation speeds. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.

c. Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.

d. The purpose of the performance proving tests is to confirm the factory tested results and verify the performance of the pump sets under site conditions over the full operating range. In the event the proving test results are not satisfactory compared to the factory tested results, the Contractor shall immediately rectify the discrepancy.

e. The Contractor shall demonstrate the total plant losses are within the values calculated by the Contractor. In the event that the measured head losses are higher than the calculated values, the Contractor shall rectify the discrepancy immediately.

f. The pump sets, associated ancillary equipment and any component of the piping system will be liable for rejection if they fail to achieve satisfactory performances as required by the Contract.

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SECTION 11110
PROGRESSIVE CAVITY PUMPS

1. GENERAL

1.1. STANDARDS

Requirements for the design, design verification and validation, manufacturing and data control, performance ratings, functional evaluation, repair, handling and storage of progressing cavity pumps will be compliant with ISO 15136-1:2009.

1.2. WORK INCLUDED

The works to be included in this section consist of the design, manufacture, delivery, off-loading, erection, testing and commissioning of the mechanical equipment for the progressive cavity pumps to be designed by the Contractor.

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.3. RELATED WORKS

Supplies and works included under this section shall comply and co-ordinated with all others parts and section of the contract.

1.4. DESCRIPTION

1.4.1. MAIN CHARACTERISTICS

a. All pumps shall be driven by electric motors in accordance with the requirements of the electrical specifications.

b. The direction of rotation of all the pumps shall be clockwise when viewed from the motor end of the pump set assembly.

c. All pumps of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.

d. The pump rotating assembly design shall be such that the first critical speed of the pump with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the pump.

e. Each component casting of the pump body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive and abrasive action of the raw water

f. The pumps shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces dues to grit.

1.4.2. OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

1.4.2.1. PUMP DUTIES

Each of the pumps shall be capable of operating continuously without damaging effects. If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.4.2.2. PUMP SUCTION ABILITY (NPSHR)

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.4.2.3. PUMP RATED SPEED (NR)

The maximum rated speed of the pumps shall be designed by the Contractor.

1.4.2.4. PUMP SHAFT POWER AND PUMP EFFICIENCY

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed.

1.4.2.5. REVERSE ROTATION CAPABILITY

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.5. QUALITY ASSURANCE

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routing tests.
3. Workshop inspections and tests:

   a) At the end of manufacture, the pumps shall be presented, unpainted, completely erected for dimensional checking.

b) One pump of each type with its driving motor shall be tested at the manufacturer's plant to demonstrate complete compliance with the Specifications. In case the tests are not satisfactory, necessary modifications shall be done by the manufacturer and all pumping sets will be tested.

The Contractor shall submit the results of workshop tests.

1.6. SUBMITTALS

The Contractor shall provide the following curves for each pumping unit:

- Efficiency (%) (Minimum efficiency required: 60%)
- Horsepower (kW)

Moreover, the Contractor shall determine in his bid the:

- Rotating speeds (tr/mn),
- Power of the associated motors (kW),
- Weights of the units and of each essential component,

2. PRODUCTS – COMPONENTS AND SUB-ASSEMBLIES

2.1.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust lads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oilier with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed to operate without damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.1.2. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.1.3. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class H insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus of minus 10% the motor shall be designed for operation up to 40oC ambient temp. and with a temp. rise

not to exceed 85oC. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

2.1.4. BEARING

The pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. Bearing life for all pump and motor bearings shall be 100,000 hours minimum

2.1.5. MECHANICAL SEAL

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies, gland packing is optional. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.1.6. ROTOR AND STATOR

The pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

2.2. SPARE PARTS AND TOOLS

The Mandatory Spare Parts are for each size of pump furnished (for 3 years trouble free operation) :

- One stator,
- One rotor,
- One connecting rod,
- One set connecting rod joint assembly,
- One bearing assembly,
- One set of V-belts
- Two sets of drive pins, washers, and screws,
- Two sets of gaskets and o-rings,
- One mechanical seal.
- And any other spare deemed necessary for 3 years trouble free operation

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

a. Holes position

b. Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

1. Examination of paintwork.
2. Machine must run without water and without any noticeable problem (noise, axial position…) for a duration as requested in the test standards (refer to §1.1).

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

a. The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

b. The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. INSTALLATION INSPECTION

a. When the Contractor is satisfied that the pump sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.

b. The pump sets will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3.3. PRE-COMMISSIONING TESTS

a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.

b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.

c. Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.3.4. COMMISSIONING TESTS

a. Tests shall be carried out on each pump set and shall include but not necessarily be limited to the following:

- performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
- vibration monitoring to demonstrate compliance with specified vibration severity limits;
- reverse rotation of the pump set due to backflow;
- simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.

b. Performance proving tests shall be carried out on one pump set at a time by pumping clean water. The Contractor shall submit to the Engineer the way he intends to carry out these tests, particularly concerning water supply and output. Performance data shall include power inputs, pump set efficiency curves and rotation speeds. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.

c. Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.

d. The purpose of the performance proving tests is to confirm the factory tested results and verify the performance of the pump sets under site conditions over the full operating range. In the event the proving test results are not satisfactory compared to the factory tested results, the Contractor shall immediately rectify the discrepancy.

e. The Contractor shall demonstrate the total plant losses are within the values calculated by the Contractor. In the event that the measured head losses are higher than the calculated values, the Contractor shall rectify the discrepancy immediately.

f. The pump sets, associated ancillary equipment and any component of the piping system will be liable for rejection if they fail to achieve satisfactory performances as required by the Contract.

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SECTION 11120
DOSING PUMPS

1. GENERAL

1.1. WORK INCLUDED

The works to be included in this section consist of the design, manufacture, delivery, off-loading, erection, testing and commissioning of the mechanical equipment for dosing pumps.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- Section 01010 - Corrosion protection
- Section 01020 – Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- Civil Engineering works and Building works;
- Section 15100 – Pipes and fittings;
- Section 15150 – Valves, gates and appurtenances;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

Pumps shall be diaphragm-type volumetric dosing pumps for dosing the various corrosive, abrasive, loaded or viscous reagents.
The pumps shall be completely sealed.
Dosing pumps shall be provided with required equipments such as (non exhaustive list):

- Foot valve, when the pump is installed in suction;
- Filter, when the pump is installed with a flooded suction;
- Injection nozzle;
- Back pressure valve;
- Safety valve;
- Pulsation dampener;

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §4.4 “Standards, codes and regulations” of P2_S5_Volume1: General requirements

1.4.2. DESIGN CRITERIA

Accuracy of dosing

- Flow rate< ± 1 %
- Linearity < ± 2 %

The repeatability of calibration shall be < ±1%, in the range 25% - 100% of variation in stroke length and in the range 20% - 100% of variation in velocity.

1.4.3. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical and electrical tests and chemical analysis.

B. All moulded and cast parts shall be submitted for inspection.

C. Workshop inspections and tests:

a. At the end of manufacture, the pumps shall be presented, unpainted, completely erected for dimensional checking.

b. One pump of each type with its driving motor shall be tested at the manufacturer's plant to demonstrate complete compliance with the Specifications. In case the tests are not satisfactory, necessary modifications shall be done by the manufacturer and all pumping sets will be tested.

The Contractor shall submit the results of workshop tests.

1.5. SUBMITTALS

The Contractor's proposal shall include:

- guaranteed performance levels (compliant with API 675),
- outline drawings for the proposed equipment,
- the characteristics of the equipment, and in particular the stage-discharge curves, efficiency, power consumption and requisite NPSH of the proposed pumps,
- the type of materials proposed,
- technical data sheets or manuals for the paints used,
- the painting procedure,
- the test procedure.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

The materials used must take into account the characteristics of the fluids to be pumped. The Contractor shall propose materials suited to the fluid being pumped for each component of the dosing pump.

The dosing diaphragm shall be coated with a layer of Teflon to ensure optimum resistance at all times to the liquid (sulphuric acid, permanganate, aluminium sulphate, polymer, lime, etc.).

Other parts in contact with the liquid shall be made of non-corrodible materials such as inert materials (polypropylene, PVC, etc.) or stainless steel.

2.2. SPECIAL TOOLS AND SPARE PARTS

The Contractor shall specify, and supply one set of special tools required for dismantling and maintenance of the dosing pumps and ancillaries.

The Contractor shall supply all the necessary spare parts recommended by the manufacturers for 3 years of operation and maintenance. The list of spare parts shall be submitted to the Engineers' approval.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. SETTING

Dosing pumps shall be installed according to normal codes of practice and the manufacturer's instructions.

3.3. FIELD QUALITY CONTROL

3.3.1. COMMISSIONING TESTS

3.3.1.1. GENERAL

a. The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;

4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

b. The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.3.1.2. INSTALLATION INSPECTION

a. When the Contractor is satisfied that the pump sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.

b. The pump sets will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.3.1.3. PRE-COMMISSIONING TESTS

a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.

b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.

c. Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.3.1.4. COMMISSIONING TESTS

a. Tests shall be carried out on each pump set and shall include but not necessarily be limited to the following:

- performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
- vibration monitoring to demonstrate compliance with specified vibration severity limits;
- simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.

b. Performance proving tests shall be carried out on one pump set at a time by dosing clean water. The Contractor shall submit to the Engineer the way he intends to carry out these tests, particularly concerning water supply and output.

c. The accuracy, linearity and repeatability of dosing shall be tested in a range of 20%-100% of the maximum flow rate.

d. Dosing rates shall be measured using suitable flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.

e. Pressure measurements shall be taken at a number of locations as directed by the Engineer. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated.

f. The purpose of the performance proving tests is to confirm the factory tested results and verify the performance of the pump sets under site conditions over the full operating range. In the event the proving test results are not satisfactory compared to the factory tested results, the Contractor shall immediately rectify the discrepancy.

g. The pump sets, associated ancillary equipment and any component of the piping system will be liable for rejection if they fail to achieve satisfactory performances as required by the Contract.

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SECTION 11220: VERTICAL SHAFT MIXERS

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of vertical shaft mixers equipment, including but not limited to:

a. Blade paddles,

b. Driving units,

c. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

1. Embedded parts

   Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.
   The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.
   Concreting of the embedded parts shall be covered by Civil Works Section.

2. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;
B. Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil Works Specifications;
B. Electrical works covered by the Electrical Equipment Specifications;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. OPERATING CONDITIONS

We distinguish in between mixers used for the preparation of the reagents, mixers used for mixing water with reagents and slow agitation mixers which are used in flocculation basins.

The Contractor shall provide characteristics of the proposed equipment:

- Circulation speed of the fluids,
- Rotation speed,
- Absorbed power,
- Helix diameter and speed,
- Weight of the assembly and each equipment

1.3.2. CONTROL AND MONITORING

The operation mode of the mixers should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the mixing chambers area. It will be IP 55 protected.

The box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator
2. Lighted button “ON”
3. Lighted button “OFF”
4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the mixers, namely:

1. The way water level in mixing chambers will be maintained constant regardless to the influent flow rate.

Moreover the following detectors shall be installed and connected to the PLC:

1. High and low levels detection soundings in chambers.
2. Malfunctions and alarms.

1.3.3. MATERIALS

1. Helix, blades – paddles, vertical shaft axis, mountling steel frame: in stainless steel 316L or inert materials
2. Motor casing: in stainless steel 316L or cast iron with epoxy.
3. Secondary gear: galvanized alloy steel or stainless steel 316L.

4. Fixing and fastening: in stainless steel 316L

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §4.4 “Standards, codes and regulations” of P2_S5_Volume1: General requirements.

1.4.2. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3. Workshop inspections and tests:
   a) The seals and the embedded parts shall be presented separately and unpainted for checking.
   b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

      All dimensions shall be checked.
   a) Welds:

   Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy

2. Manufacture and quality assurance measures

3. Protective coating list of all parts

4. Commissioning tests list.

5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.

6. Internal wiring diagrams and control principle drawing of control box.

7. Weight and material of each component.

1.6. GUARANTEE

1.6.1. PERFORMANCES

The type of blade-paddles shall be decided by the supplier, with a proper rotary velocity efficient to allow either coagulation or flocculation or just an efficient mixing of the reagent.

1.6.2. DIMENSION TOLERANCES

1. Tolerances of the mixers inner assembling before installation (blade paddles, hollow shaft, driving device) shall be conform to the manufacturer instructions.

2. After installation, the deviation of the plane position of the driving axis shall be less than ± 5 mm. The verticality of this shaft shall be less than 1/1000.

3. The elevation deviation of paddles shall not exceed ± 5 mm.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. PADDLES AND AXIS

The agitators have a vertical axis and, depending on their use, may be fitted with a geared motor

The agitators operate continuously.

The materials used must take account of the very aggressive quality of the raw water. The Contractor must be fully aware of this quality. The Contractor shall propose the most suitable material for each component of the agitators.

The end stops shall be protected against any water infiltration occurring as a result of failure of the mechanical seals.

It must be easy to dismantle the various components.

The shaft shall be fitted with a casing made of stellite or any other metal of sufficient hardness, which withstands corrosion and friction passing through the mechanical seals.

The bearing shall be of the grease-lubricated sealed ball bearing type.

The seals shall be mechanical.

The Contractor shall submit a detailed note describing the lubrication and greasing system that he proposes.

2.1.2. MOTOR AND GEAR HEAD

The gear reducer motor shall fit with:

- Working outdoors,
- Working hours: 24 hours per day
- Protection grade IP68,
- Isolation class E
- 230V or 400 V,
- 3 phases,
- 50Hz,
- Rated power 20% higher than maximum actual power.

The service life of the convolution bearing for supporting the impellers shall be 20 years as a minimum. The bearings of reducer shall be well lubricated with working duration no less than 100,000 hours. The gears designed should comply with ISO or equivalent standard, with servo ratio no less than 2.0.

All fixing and fastening items will be made of stainless steel 304L and provided by the Contractor.

2.2. HANDLING

The Contractor shall design and provide a mobile handling device with hoist and chain able to supply each mixer.

They will be in accordance with specifications of section 16000- Conveying systems.

They shall allow the gathering of equipment in a common assembling area.

2.3. SPARE PARTS AND SPECIAL TOOLS

1. The Contractor shall specify and supply the special tools required for equipment maintenance and for 3 years of operation.

2. The Contractor shall supply 1 set of each of the following spare parts:
   a) axis,
   b) paddles,
   c) gear head
   d) gear box

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

1. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

2. The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:
   a) Holes position
   b) Flatness, verticality, horizontality of the embedded parts,

2. Erection tolerances:

   Refer to Section 01020.

3.2.2. DRY TESTS

1. Examination of paintwork.

2. Machine must run for two hours without water and without any noticeable problem (noise, axial position…).

3.2.3. COMMISSIONING TESTS

1. Examination of paintwork.

2. Checking of operation parameters (rotation speed), for each agitator tested individually.

3. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations (difference shall be less than 10cm).

4. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.

5. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

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SECTION 11221
SUBMERSIBLE HORIZONTAL SHAFT MIXERS

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of submersible horizontal shaft mixers equipment, including but not limited to:

1. Blade paddles,
2. Driving units,
3. Pre-embedded parts

   The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

4. Embedded parts

   Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

   The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

   Concreting of the embedded parts shall be covered by Civil Works Section.

5. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil WorksSpecifications;

B. Electrical works covered by the Electrical Equipment Specifications

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. OPERATING CONDITIONS

Submersible horizontal shaft agitators are used for circulating the fluids in the basins, putting them in suspension and creating currents in them.

The agitators may be adjusted horizontally, and have self-cleaning paddles. The agitators are fixed to guide rails and can be handled using mobile cranes fixed to the technical walkways.

The characteristics are detailed in the performance specifications.

Moreover the Contractor shall provide characteristics of the proposed equipment in the Schedules of Particular:

- Circulation speed of the fluids,
- Rotation speed,
- Absorbed power,
- Helix diameter and speed,
- Weight of the assembly and each equipment

1.3.2. CONTROL AND MONITORING

The operation mode of the mixers should have both:

1. Manual control and PLC automatic control.

2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the mixing chambers area. It will be IP 55 protected.

The box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator

2. Lighted button “ON”

3. Lighted button “OFF”

4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the mixers, namely:

5. The way water level in mixing chambers will be maintained constant regardless to the influent flow rate.

   Moreover the following detectors shall be installed and connected to the PLC:

6. High and low levels detection soundings in chambers.

7. Malfunctions and alarms.

1.3.3. MATERIALS

1. Agitator paddle: AISI 316L or inert materials
2. Motor casing: AISI 316L or cast iron with epoxy.
3. Secondary gear: 1.521 alloy steel.
4. Fixing and fastening: AISI 316L

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §4.4 “Standards, codes and regulations” of P2_S5_Volume1: General requirements.

1.4.2. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis to the Engineer for review.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests to the Engineer for review.

C. Workshop inspections and tests and controlled by the Client’s representative and the Contractor:

a. The seals and the embedded parts shall be presented separately and unpainted for checking.

b. The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c. Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…
2. Detailed performance specification of equipment and drawings of all parts
3. Hydraulic and process detailed calculation notes justifying that design criteria are respected.

4. Installation, maintenance and operation manuals with requirements of accuracy
5. Manufacture and quality assurance measures
6. Protective coating list of all parts
7. Commissioning tests list.
8. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
9. Internal wiring diagrams and control principle drawing of control box
10. Weight and material of each component

1.6. GUARANTEE

1.6.1. PERFORMANCES

The type of blade-paddles shall be decided by the supplier, with a proper rotary velocity efficient to create currents of the fluids and suspend matter.

1.6.2. DIMENSION TOLERANCES

A. Tolerances of the mixers inner assembling before installation (blade paddles, hollow shaft, driving device) shall be conform to the manufacturer instructions.

B. After installation, the deviation of the plane position of the driving axis shall be less than ± 5 mm. The verticality of this shaft shall be less than 1/1000.

C. The elevation deviation of paddles shall not exceed ± 5 mm.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. PADDLES AND AXIS

The materials used must take account of the quality of the raw water. The Contractor must be fully aware of this quality. The Contractor shall propose the most suitable material for each component of the agitators.

The end stops shall be protected against any water infiltration occurring as a result of failure of the mechanical seals.

It must be easy to dismantle the various components.

The shaft shall be made of stainless steel in order to prevent corrosion of the parts in contact with the water being treated. It shall be fitted with a casing made of stellite or any other metal of sufficient hardness, which withstands corrosion and friction in the mechanical seals.

The bearing shall be of the grease-lubricated sealed ball bearing type.

The seals shall be mechanical. The shaft shall be sealed using two tight mechanical seals fitted in tandem regardless of the direction of rotation.

The Contractor shall submit a detailed note describing the lubrication and greasing system that he proposes.

2.1.2. MOTOR AND GEAR HEAD

The gear reducer motor shall fit with:

- Working outdoors,
- Working hours: 24 hours per day
- Protection grade IP68,
- Isolation class F,
- 400 V,
- 3 phases,
- 50Hz,
- Rated power 10% higher than maximum actual power.

The service life of the convolution bearing for supporting the impellers shall be 20 years as a minimum. The bearings of reducer shall be well lubricated with working duration no less than 100,000 hours. The gears designed should comply with ISO or equivalent standard, with servo ratio no less than 2.0.

All fixing and fastening items will be made of stainless steel 304L and provided by the Contractor.

2.2. HANDLING

The Contractor will provide a monorail hoist and a chain able to supply each mixer.

They will be in accordance with specifications of section 16000- Conveying systems.

They shall allow the gathering of equipment in a common assembling area.

2.3. SPARE PARTS AND SPECIAL TOOLS

A. The Contractor shall specify and supply the special tools required for equipment maintenance and for 3 years of operation.

B. The Contractor shall supply 1 set of each of the following spare parts:

- **a.** axis,
- **b.** paddles,
- **c.** gear head
- **d.** gear box

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

A. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

B. The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

a. Holes position

b. Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.2.2. DRY TESTS

1. Examination of paintwork (ISO 12944-5).

2. Machine must run for two hours without water and without any noticeable problem (noise, axial position…) (as per NF EN 17877 or ISO 21630:2007).

3.2.3. COMMISSIONING TESTS

1. Examination of paintwork.

2. Checking of operation parameters (rotation speed, flow speed, absorbed power), for each agitator tested individually.

3. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations (difference shall be less than 10cm).

4. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.

5. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 11281
ONE THROUGH ELECTRO CHLORINATION SYSTEM

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the Brine based one through electro chlorination systeme.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

Supplies and works included under this section shall comply and be co-ordinated with all others parts and sections of the contract.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. SYSTEM DESCRIPTION

The system produces Sodium Hypochlorite solution by electrolysis process of synthetic brine solution.

The system consists of the electrolysis cell, degassing column, brine dosing pump, exhaust fan with quantitative air flow monitor for air dilution of the electrolysis chamber and a water softening system. In addition, the following equipment are required: a salt saturator, a storage tank for the generated solution, dosing pumps, and an acid cleaning system.

a. **Brine preparation and feed system**: Soft water shall be used for the preparation of saturated brine solution. Commun crystal NaCl salt shall be added in the brine tank to prepare a saturated solution. The saturated solution shall be injected by mean of forwarding pumps on to a static mixer and mixed with soft water in a specific ratio. The dilute brine shall be fed to the electrochemical cell.

b. **Electric conversion from AC power to DC power**: A dedicated transformer-rectifier shall be provided to feed the electrochemical cell with direct current.

c. **Electrolysis Cell and hydraulic chamber**: The electrolysis cell shall be installed in a separated chamber with a quantitatively monitored air flow.. The brine dosing pump shall have a wide adjustment range for precise dosing of the brine. The flow shall be measured by a flow meter with switch for safe process interruption in case the value falls below its critical minimum.

d. **Degassing column**: the hydrogen degassing column shall remove the formed hydrogen via the vent hole and prevent it from penetrating the storage tank. The hydrogen is piped through the outlet into the ambient air after appropriate dilution.

e. **Ventilation**: ventilation shall be forced in the electrolysis chamber and the storage tank. At the vent discharge point outside the building, dilution of the hydrogen shall be produced.

f. **Cleaning system**: scaling accumulated on the electrodes shall be removed periodically by dissolving it in acid solution. The complete cleaning system shall be provided with acid preparation tank, acid circulation pumps, neutralisation of the spent acid solution by caustic soda and pH meter.

1.3.2. OPERATING CONDITIONS

The water to be used for the brine preparation and the brine dilution shall be of drinking water quality. The water shall be softened and maintained in the operating temperature range by means of heating or chilling if necessary.

- Total hardness of softened water < 20 mg/l Ca CO3.
- Operating range of temperature: 7°C to 26°, with an optimum around 12°C

1.3.3. CONTROL AND MONITORING

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning the electro chlorination system control and the way this equipment will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install, namely:

1. Automatic tank refilling

2. Automatic switch off (low water flow rate, ventilation blockage).

Moreover the following detectors shall be installed and connected to the PLC: Malfunctions and alarms.

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §10.1 “Standards, codes and regulations” of P2_S7.1_General requirements.

1.4.2. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

C. Workshop inspections and tests:

a. Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation, and installation…
2. Detailed performance specification of equipment and drawings of all parts
3. process detailed calculation notes justifying that design criteria are respected.
4. Installation, maintenance and operation manuals with requirements of accuracy
5. Manufacture and quality assurance measures
6. Protective coating list of all parts
7. Commissioning tests list.
8. Assembler details for welding and building connections,
9. Internal wiring diagrams and control principle drawing of control box
10. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. ELECTRODES

The electrodes shall be made of titanium material with a very durable catalytic metallic oxide coating.

2.1.2. BRINE TANK

Brine tank shall be in polyethylene.

2.1.3. PRODUCT STORAGE TANK

For the storage of the hypochlorite solution, the tank shall be in Polyethylene and shall integrate a collecting tray in polypropylene.

2.2. SPARE PARTS AND SPECIAL TOOLS

A. The Contractor shall specify and supply the special tools required for equipment maintenance and for 3 years of operation.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

A. The different equipment of the system shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. DRY TESTS

1. Examination of paintwork.

2. Machine must run for two hours without water and without any noticeable problem (noise, axial position…).

3.2.2. COMMISSIONING TESTS

1. Examination of paintwork (ISO 12944-5).

2. Checking of operation parameters (rotation speed, flow speed, absorbed power), for each equipment individually.

3. The supplier shall provide effectiveness testing report, taking samples and measures of water and air flow rate, in order to check the hypochlorite production, energy and salt consumption, efficiency of ventilation Each equipment shall fit individually with requirements.

4. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 11286: UV DISINFECTION FOR WATER TREATMENT

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the UV disinfection equipment for water treatment.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

C. Electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

Supplies and works included under this section shall comply and be co-ordinated with all others parts.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

The UV system shall be designed to remove pathogens in order to avoid any possible risk for the end user.

The system shall be able to do not modify the chemical, physical and organoleptic properties of the water.

The UV disinfection shall be closed channel and the geometry shall be designed in order to have enough water to maintain the UV lamp submerged even in case of low flow.

The UV disinfection reactor can be designed with contact or non contact type configuration. The flow can be either perpendicular or parallel to the lamps. In the noncontact reactor, the UV lamps are suspended outside a transparent conduit which carries the water to be disinfected.

The UV system shall be provided with the cleaning system using mechanical wipers, ultrasonic equipment and chemical reagents. A combination of cleaning agents should be tested to find the most suitable agent for the plant characteristics without producing harmful or toxic by-products.

The Contractor shall provide characteristics of proposed equipment, including but not limited to:

- The UV transmission rate depending on wave length,
- The UV dose applied,
- The weight of each lamp module,
- The efficiency of the lamps according to the wave length applied,
- The life time of the lamps with an average flow rate.

1.3.2. OPERATING CONDITIONS

The maintenance of the reactor and the UV lamps has to be carried out in order to do not interrupt the normal operation of the whole plant.

1.3.3. CONTROL AND MONITORING

The UV ray shall be monitored properly in order to estimate the distribution of the UV in the whole reactor and the germinal irradiation.

The monitoring system shall include monitor device for temperature, UV density, UV transmittance and water flow.

The operation mode of the UV disinfection system should have both:

1. Manual control and PLC automatic control.

2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the equipments. It will be IP 55 protected.

It will be composed at least of the following controls and instructions, for each equipment:

3. Manual / auto commutator

4. Lighted button “ON”

5. Lighted button “OFF”

6. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both raking machines control and the way these equipments will be connected to the general computer.

Moreover the following detectors shall be installed and connected to the PLC:

7. Pressure release system,

8. Malfunctions and alarms.

1.3.4. MATERIAL

1. UV Reactor: stainless steel 316L

2. Fixing and fastening: in stainless steel 316L

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §4.4 “Standards, codes and regulations” of P2_S5_Volume1: General requirements.

1.4.2. DESIGN CRITERIA

The UV disinfection system shall be designed in order to meet the characteristics of the treated water (Refer to P2-S7.2_Performances Specifications). The intensity of UV radiation and the amount of time the microorganisms are exposed to the radiation are the main design parameters to be sized.

1.4.3. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3. Workshop inspections and tests:
   a) The seals and the embedded parts shall be presented separately and unpainted for checking.
   b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

      All dimensions shall be checked.
   c) Welds:

      Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…

2. Detailed performance specification and drawings of all parts

3. Hydraulic and process detailed calculation notes justifying that design criteria are respected.

4. Installation, maintenance and operation manuals with requirements of accuracy

5. Manufacture and quality assurance measures

6. Protective coating list of all parts

7. Commissioning tests list.

8. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.

9. Internal wiring diagrams and control principle drawing of control box

10. Weight and material of each component

1.6. GUARANTEE

1.6.1. PERFORMANCES

The Contractor shall provide a calculation note proving that the equipment he intends installing have an efficient capacity to remove bacteria in the water up to a certain degree as specified above, for a Q_{max} flow (of far future) and during 5 hours.

1.6.2. DIMENSION TOLERANCES

After installation, the deviation of the plane position of the equipment shall be less than ± 10 mm. The elevation deviation shall not exceed ± 10 mm.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. REACTOR EQUIPMENT

Each reactor is equipped with:

- UV lamps,
- an automatic system for cleaning organic and mineral deposits,
- an upstream and downstream water level regulation system in each reactor, interlocked to the flow rate,
- a system for varying the power diffused by the lamp, interlocked to the flow rate,
- a system for measuring the intensity of the UV light diffused,
- electrical connection cabinets,
- power monitoring and distribution electrical cabinets,

2.2. SPARE PARTS AND SPECIAL TOOLS

1. The Contractor shall specify and supply the special tools required for equipment maintenance and for 3 years of operation.

2. The Contractor shall supply the same quantity of lamps as installed.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:
   a) Equipment position
   b) Flatness, verticality, horizontality of the embedded parts,

2. Erection tolerances:

   Refer to Section 01020 and paragraph 1.6.2.

3.2.2. DRY TESTS

Examination of paintwork.

3.2.3. COMMISSIONING TESTS

1. Examination of paintwork.

2. The supplier shall provide a effectiveness testing report concerning the removal of bacteria, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of UV disinfection.

3. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

4. Leakage shall not be observed out of the pipes

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SECTION 11400
AIR BLOWERS

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of air blower system equipment, including but not limited to:

1) *Air blowers,*
2) *Step-up gear,*
3) *Motor,*
4) *Check valve,*
5) *Diffuser at delivery end,*
6) *Filter at inlet,*
7) *Silencer at delivery end,*
8) *Vent silencer,*
9) *Acoustic enclosure,*
10) *Control cabinet,*
11) *Pipes,*
12) *Pre-embedded parts*

    The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

13) *Embedded parts*

    Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.
    The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.
    Concreting of the embedded parts shall be covered by Civil Works Section.

14) *Covers above the slots shall be provided by the Contractor.*

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil Works Section;

B. Electrical works covered by the Electrical Equipment Section;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. OPERATING CONDITIONS

Air blowers are mainly used in the filtration treatment to guarantee the amount of air needed for the washing of the filters. An air flow at certain pressure shall be provided at the bottom of the filters. This air flow shall be homogenously distributed to be sure that the washing is effective.

Compressed air is provided thanks to an air compressor located near the filters. Compressor shall operate to all filters.

Air pipes shall be equipped with manual ball valves and solenoid valves.

The Contractor shall design air compressors and pipes dimensions and parameters, according to the filters designs. He shall provide a calculation note to ensure the efficiency of his overall aeration system, particularly concerning involved flows and levels.

Moreover the Contractor shall provide characteristic curves of proposed compressors in the Schedules of Particular:

- Pressure increasing in bars
- Input flow in m^3/min
- Absorbed power in kW

In addition, the following items shall be précised in his bid:

- Rotating speed in rd/min
- Nominal power of the driving motor
- Weight of the overall equipment and of each main part
- Input and output ports diameters
- Main operation loads, particularly when they are in relation with Civil works fastenings.

In addition, the Contractor shall specify the maximum reaction force at the delivery end with a view to designing the delivery end piping anchoring device. He shall also specify the maximum forces on the delivery end flange.

The Contractor's bid shall include:

- performance guarantees
- the simplified installation drawings of the proposed equipment

- the characteristics of the equipment
- the nature of the proposed materials
- the technical data sheets or manuals for the coatings used
- the coating procedure

1.3.2. CONTROL AND MONITORING

The operation mode of air compressors should have both:

1) Manual control and PLC automatic control.

2) Local control and distance control.

Air compressor local control facilities shall be located close to the filters.

The box will be composed at least of the following controls and instructions, for each equipment:

Manual / auto commutator

3) Lighted button "ON"

4) Lighted button "OFF"

5) Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the air blowing control.

Moreover the following detectors shall be installed and connected to the PLC:

Malfunctions and electromechanical and process alarms.

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §10.1 "Standards, codes and regulations" of P2_S7.1 General requirements.

1.4.2. DESIGN CRITERIA

- Air flow during washing : 45-50 $Nm^3/h/m^2$

1.4.3. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

C. Workshop inspections and tests:

a) The seals and the embedded parts shall be presented separately and unpainted for checking.

b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c) Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1) *Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…*

2) *Detailed performance specification of equipment and drawings of all parts*

3) *Hydraulic and process detailed calculation notes justifying that design criteria are respected.*

4) *Installation, maintenance and operation manuals with requirements of accuracy*

5) *Manufacture and quality assurance measures*

6) *Protective coating list of all parts*

7) *Commissioning tests list.*

8) *Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.*

9) *Internal wiring diagrams and control principle drawing of control box*

10) *Weight and material of each component*

1.6. GUARANTEE

1.6.1. PERFORMANCES

The Contractor shall provide a calculation note proving that the equipment he intends installing have an efficient capacity for filter air backwash, with only one blower in duty

Air compressor noise shall not exceed 80 dB at a distance of 1 meter from the equipment.

Vibrations amplitude shall not exceed values specified by the VDI 2055.

1.6.2. DIMENSION TOLERANCES

The deviation of the plane position shall be less than ± 20 mm. The elevation deviation shall not exceed ± 10 mm.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. AIR COMPRESSOR

The air compressor should be equipped with appropriate:

1) *Inlet dust filter,*
2) *Silencer,*
3) *Discharging pressure valve,*
4) *Pressure protection device,*
5) *Pipe flexible joints.*
6) *Motor*
7) *Acoustic housing*
8) *Control box*

2.1.1.2. CHARACTERISTICS OF STEP-UP GEARS

The step-up gear mechanism shall be single-stage helical. The shafts and gears shall be machined out of forged steel and the profiled teeth gears shall comply with the requirements of AGMA 11-13 (American Gear Manufacturers Association) or equivalent.

The slow-speed bearings shall be of the roller bearing type, and the high-speed bearings shall be of the oscillating sole plate bearing type.

The bearings shall be lubricated by pressurised oil from the lubrication plant.

The step-up gear housing shall be of 250-grade cast iron according to standard BS 1452, with a horizontal joint plane to simplify maintenance.

The shafts and gears shall be made of forged steel.

2.1.1.3. MOTOR

The motor shall be:

1) *IP55 protected*
2) *380 Volts,*
3) *50-Hertz*
4) *Class F*

The motor system should be installed on a public assembly type of steel foundation, and it shall be equipped with driving belt adjustable device, as well as the protection cover for the belt and the wheel.

The electric motors shall comply with the relevant standards and publications of the UTE and the IEC.

2.1.1.4. DRIVING HEAD

Gear box will be made of 250-graded cast iron according to BS1452.

Shafts and gear-wheels shall be made of stainless steel A 316 L.

2.1.1.5. WHEEL

Wheel shall be made of wrought aluminium.

2.1.1.6. VOLUTE

Volute will be made of 250-graded cast iron according to BS1452.

Blades will be made of stainless steel A 316L.

2.1.1.7. CONTROL CABINET AND INSTRUMENTATION

The booster pump assembly shall be controlled by a PLC during the start-up, shutdown and monitoring phases.

All alarm, tripping, indicator and monitoring functions shall be displayed on a local control board.

2.2. PIPES

Inlet and outlet pipes shall be made of stainless steel 316L.

2.3. SOUNDPROOFING

An acoustic chamber shall cover the volute, the step-up gear and the motor in order to reduce noise 1 m away from the unit to 85 dBΛ in a non-reverberating environment with four compressors in operation.

The installation will include a silencer system at the delivery end and a vent system.

2.4. HANDLING

The Contractor shall design and provide a mobile handling device with hoist and chain able to supply each blower.

They will be in accordance with specifications of section 14000- Conveying systems.

They shall allow the gathering of equipment in a common assembling area.

2.5. SPARE PARTS AND SPECIAL TOOLS

The contractor shall supply the spare parts which are necessary according to the manufacturer for 3 years of operation.

The Contractor shall specify and supply the special tools required for equipment maintenance.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

a) Equipment position

b) Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.2.2. DRY TESTS

A. Testing of all operation characteristics during 24 hours and without water:

a) For each compressor taken individually,

b) For each compressors combination eventually necessary to get the overall installation flow.

During these tests, vibrations, temperature increasing and noise shall particularly be checked.

B. Examination of paintwork.

C. Commissioning tests

Before the tests, the Contractor shall submit the detailed test procedure to be used to the Engineer for approval. This will notably include how he intends to measure the flows, pressures, powers, etc. indicating the type, brand, measuring range and precision class of the instruments he undertakes to use on the site.

1) Examination of paintwork.

2) Checking of operation conditions for nominal flow and during 24 hours. During this test, the vibration amplitude and heating shall be checked.
The amplitude of the vibrations will be measured. It will not exceed the threshold values set by the applicable standard.

3) Checking of the operating characteristics of the units individually and of any combination used to obtain the total flow rate of the installation.

4) The supplier shall provide effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of aeration. Each aeration system shall fit individually with requirements.

5) *If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.*

6) *Leakage shall not be observed out of the pipes.*

SECTION 11710
POLYMER PREPARATION

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of polymer preparation unit, including but not limited to:

1. Polymer storage,
2. Polymer preparation unit,
3. Polymer injection,
4. Inline dilution,
5. Driving units,

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. SYSTEM CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. OPERATING CONDITIONS

1.3.1.1. GENERAL

The preparation unit is designed for an automatic functioning as soon as the dewatering units are operating.

The operator is only required to load big-bags on the emptying station and to open the gate valve to load polymer powder in the automatic polymer feeding device. Polymer bags shall be lowered into the framework by an electrical stacker.

The preparation unit is divided into three separate chambers, so that a sufficient maturing time for the polymer solution can be ensured. The division of the reservoir largely prevents the matured and freshly prepared solution from mixing and ensures continuous discharge.

The contractor proposes all capacities to guaranty the reliability of dewatering operations.

All motors must be easily reached for maintenance operation.

Inspected panels must be enough sized to make cleaning operations easier.

Overflow and drainage devices must be connected to drain gutter.

A local control panel including all power supply (mixers, screws, solenoid valve, pumps) and automatism is also provided. Defaults must be sent to the SCADA.

1.3.1.2. AUTOMATIC POLYMER FEEDING

Dry polymer shall be fed by mechanical, positive displacement volumetric feeder. Motor shall be variable speed.

The discharge port of the volumetric feeder shall be completely enclosed in a chamber. The polymer/water initial wetting area shall be clearly visible. The acrylic barrel shall prevent inadvertent drifting of airborne polymer dust and protect feeder discharge from environment. The discharge port shall be fitted with a pneumatically operated valve to isolate dry polymer from the environment between cycles.

Dry polymer shall rely on gravity to transfer from feed device to wetting device. This shall eliminate the need for any type pneumatic conveying system.

1.3.1.3. DILUTION WATER

Dilution water flow for polymer batching shall be from drinking water supply equipped with reduced pressure backflow preventer. Dilution water shall be maintained at a constant rate by means of a flow control valve. A differential pressure indicator/switch shall be supplied to display water differential pressure. Low differential pressure switch shall shut down system and energize alarm at Local Control Panel after adjustable time delay. Water flow (on/off) shall be controlled by a solenoid valve with spring to close for fail-safe operation. Dilution water feed shall include rotameter to provide visual indication of flow.

1.3.1.4. MIXERS

The Contractor shall provide characteristics of the proposed equipment:

- Circulation speed of the fluids,
- Absorbed power,
- Weight of the assembly and each equipment

1.3.1.5. PUMPS

1.3.1.5.1. ***Pump Duties***

Each of the pumps shall be capable of operating continuously without damaging effects. If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.1.5.2. ***Pump Suction Ability (NPSHR)***

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid

cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.1.5.3. ***Pump Rated Speed (NR)***

The maximum rated speed of the pumps shall be designed by the Contractor.

1.3.1.5.4. ***Pump Shaft Power and Pump Efficiency***

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed. The pump efficiency at the design operating point shall be not less than 85%.

1.3.1.5.5. ***Reverse Rotation Capability***

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.3.1.6. POST DILUTION ASSEMBLIES

It shall provide additional dilution required by application. System shall include skid-mounted post-dilution units consisting of a static mixer in a clear PVC housing, rotameter-type flow indicator with rate-adjusting valve. The post-dilution water flow rate shall be adjustable. Provide rotameters to measure dilution water flow.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

C. Workshop inspections and tests:

a. The seals and the embedded parts shall be presented separately and unpainted for checking.

b. The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy

2. Manufacture and quality assurance measures

3. Protective coating list of all parts

4. Commissioning tests list.

5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.

6. Internal wiring diagrams and control principle drawing of control box

7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. MIXERS

The mixer shall utilize stainless steel impellers. The mix tank impeller shall be driven by a washdown duty motor coupled with a right angle gear reducer. The gear reducer and motor shall be mounted on a stainless steel or fiberglass channel crossing the mixing/holding tank. The impeller shall be coupled to the gear reducer.

The impeller diameter shall be as large as possible to fit inside the tank diameter, guaranteeing the most uniform distribution of mixing energy.

The mixer shaft shall be stainless steel with clear PVC sleeve to direct polymer slurry from the wetting device into hollow-bladed impeller.

2.1.2. PUMPS

2.1.2.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust lads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oilier with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed to operate without damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.1.2.2. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.1.2.3. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for

continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus of minus 10% the motor shall be designed for operation up to 40oC ambient temp. and with a temp. rise not to exceed 85oC. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

2.1.2.4. BEARING

The pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. Bearing life for all pump and motor bearings shall be 100,000 hours minimum

2.1.2.5. MECHANICAL SEAL

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.1.2.6. ROTOR AND STATOR

The pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

2.2. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are

- for each mixer :
  - Set of pressure gauge assembly
  - 1 mechanical seals

- 1 motor coupling

- for each size of pump furnished:
  - One stator,
  - One rotor,
  - One connecting rod,
  - One set connecting rod joint assembly,
  - One bearing assembly,
  - One set of V-belts,
  - Two sets of drive pins, washers, and screws,
  - Two sets of gaskets and o-rings,
  - One mechanical seal.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

A. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

B. The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out :

a. Holes position

b. Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

1. Examination of paintwork.

3.2.2.2. GENERAL

a. The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

b. The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.2.3. INSTALLATION INSPECTION

a. When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.

b. The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.2.4. PRE-COMMISSIONING TESTS

a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.

b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.

c. Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.2.5. COMMISSIONING TESTS

a. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.

b. For each pump set and shall include but not necessarily be limited to the following:

- performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
- vibration monitoring to demonstrate compliance with specified vibration severity limits;
- reverse rotation of the pump set due to backflow;
- simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.
- Performance proving tests shall be carried out on one pump set at a time by pumping clean water. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.

- Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.

c. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 11802
BELT THICKENER

GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of belt thickeners

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. General requirements;

B. Section 01010 - Corrosion protection;

C. Section 01020 - Basic mechanical requirements;

D. Section 16010 - Basic electrical requirements;

E. Section 15100 – Pipes and fittings;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil Works Section;

B. Electrical works covered by the Electrical Equipment Section;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

The belt thickener shall be installed in order to thicken the sludge before the drying beds.

1.3.2. CONTROL AND MONITORING

The operation mode should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up. It will be IP 55 protected.

The box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator

2. Lighted button “ON”

3. Lighted button “OFF”

4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the mixers, namely:

5. The way water level in mixing chambers will be maintained constant regardless to the influent flow rate.

Moreover the following detectors shall be installed and connected to the PLC:

1. High and low levels detection soundings in chambers.

2. Malfunctions and alarms.

1.3.3. MATERIALS

1) Frame: in stainless steel 304L

2) Collection hopper in stainless steel 315L

3) Belt thickener completely covered with inspection cap in stainless steel 304L

1.3.4. DESIGN CRITERIA

All equipment and constructional arrangements for which the Contractor is responsible under the terms of the Contract must be sufficient to achieve the treatment levels indicated in the Particular Technical Specifications. Unless otherwise specified, all the electrical equipment will be water proof registered IP55.

1.3.5. SHOP TESTS AND INSPECTION

1) Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2) Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3) Workshop inspections and tests:

a) The seals and the embedded parts shall be presented separately and unpainted for checking.

b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth. All dimensions shall be checked.

c) Welds:

Refer to Section 01020 – Basic mechanical requirements.

1.4. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1) *Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…*
2) *Detailed performance specification of equipment and drawings of all parts*
3) *Process detailed calculation notes justifying that design criteria are respected.*
4) *Installation, maintenance and operation manuals with requirements of accuracy*
5) *Manufacture and quality assurance measures*
6) *Protective coating list of all parts*
7) *Commissioning tests list.*
8) *Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.*
9) *Internal wiring diagrams and control principle drawing of control box.*
10) *Weight and material of each component.*

1.5. DIMENSION TOLERANCES

The requirements of Section 01020 – Basic mechanical requirements – will apply

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. BELT THICKENER

Each unit shall incorporate a suitable vessel and an agitator designed to promote flocculation. The mixing arrangement shall ensure that the entire contents of the tank are uniformly agitated and no short-circuiting occurs. The mixing tank shall be suitably sized to enable the sludge and polyelectrolyte to develop a good floc.

Sludge from the flocculation/conditioning tank shall be conveyed on to the filter belt in a manner to avoid excessive turbulence and consequent floc break up. The distributor shall spread the sludge evenly over the working width of the filter belt, in the gravity drainage section. Ploughs or other suitable mechanisms shall be provided to divide the sludge blanket in order to allow drainage of free surface water. A secondary mechanism (such as rolling or pressing) shall be included to ensure maximum de-watering. Sludge shall be contained in the gravity de-watering zone by side skirts fitted with suitable low-friction seals, to prevent side leakage.

The filter belt shall comprise a continuous weave high strength polyester. It shall be of the split type, allowing easy replacement without dismantling of the unit.

A belt washing system shall be provided to ensure adequate cleaning of the filter belt and to prevent blinding. It shall consist of high pressure spray nozzles directing wash water on to the clean side of the whole belt width via fan shaped jets. The nozzles shall be easily removable for cleaning or replacement.

All spray shall be contained within the machine to prevent aerosol transmission.

A straight through type diaphragm valve shall be provided in an easily accessible location for isolation of each spray bar. The valves shall be mounted on the belt thickener.

The belt thickener shall incorporate a means of maintaining a constant belt tension irrespective of sludge loading. The belt tensioning system shall be capable of accommodating an increase in belt length of at least 3 per cent. Tension shall be easily removed to permit replacement of belt or rollers, etc.

Belt alignment within inner band limits shall be achieved by means of sensing devices to detect and correct lateral movement, using an automatically controlled steering roller to continuously adjust the belt tracking maintaining accurate positioning and thus ensuring maximum belt life.

Belt breakage and 'out of band' limit lateral movement shall be detected and suitable signals provided.

Hydraulic systems, where used, shall include all pumps, pipework, valves, filters, reservoirs and controls for a complete and functional system. All hydraulic pipework shall be steel pipe firmly fixed to the structural frame of the belt filter.

The gravity section shall be supported on a grid of low friction material designed to support the weight of the belt with the flocculated sludge, and also designed to encourage free drainage by 'wiping' the lower surface of the belt. The filtrate drainage pipework shall have suitable access for removal of blockages.

A mechanism, comprising a pivoting scraper blade or ramp, shall be provided for removing the thickened sludge from the filter belt.

Sludge shall fall under gravity from the thickener via a discharge chute or chutes into a discharge hopper feeding the transfer pump. The hopper shall be designed such that sludge does not collect on its walls and it shall be sized such that the maximum number of starts per hour of the transfer pump is six.

The base of the hopper shall be designed to provide a suitable interface with the thickened sludge transfer system.

Where the belt thickener is enclosed, suitable provision should be made for visual checking during operation. Transparent panels shall not discolour with age. Suitable access shall be provided for adjustment and maintenance of equipment. Removable sections shall be handleable by one man.

All fixing and fastening items will be made of stainless steel 304L and provided by the Contractor.

2.2. SPARE PARTS AND SPECIAL TOOLS

The Contractor shall specify and supply the special tools required for equipment maintenance and spare parts for 3 years of operation.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.1.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1) The following inspections shall be carried out before and after concreting:

d) Holes position

e) Flatness, verticality, horizontality of the embedded parts,

2) Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.1.2. DRY TESTS

1) Examination of paintwork.

2) Machine must run for two hours without water and without any noticeable problem (noise, axial position…).

3.1.3. COMMISSIONING TESTS

1) Examination of paintwork.

2) Checking of operation parameters.

3) Checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations;

4) The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.

5) If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 13220
FILTER UNDER DRAINS AND MEDIA

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of filter underdrains and media, including but not limited to:

1) *Pipe laterals,*
2) *Blocks,*
3) *False bottom,*
4) *Porous bottom,*
5) *Filter media.*
6) *Pre-embedded parts*

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

B. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

C. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

C. Section 16010 - Electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil Works Section;

B. Section 15100 – Pipes and fittings;

C. Section 15150 – Valves gates and appurtenances;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. OPERATING CONDITIONS

1.3.1.1. UNDERDRAINS

An underdrain system has two purposes: to collect water that passes through the filter media and to distribute washwater (and air if used) uniformly across the filter bed. Support gravel is required when openings in the underdrain system are larger than the filter medium directly above it. Although the support gravel or other support method does not contribute to particulate matter removal, it aids in distribution of washwater.

1) Pipe laterals:

Pipe underdrain systems generally consist of a centrally located manifold pipe to which smaller, equally spaced laterals are attached. Lateral pipes usually have one ore two rows of perforations at their bottom sides. The lateral pipe may be fitted with nozzles.

Support gravel is required to cover a lateral network. Three to five graded layers are usually involved, with size variations. The bottom layer should extend to above the highest washwater outlet.

2) Blocks:

Block underdrain consists of hollow vitrified clay or polyethylene blocks. Orifices dispersed in general on the top of the block help to drain the water. A support gravel layer is put on top of the blocks to prevent clogging of the orifices.

3) False bottom:

False bottom underdrains are either constructed of concrete containing uniformly spaced inverted depressions filled with porcelain spheres and gravel or have impervious bottoms (concrete, polyethylene, tile blocks, monolithic concrete, steel plates) penetrated by nozzles

Characteristics and functional details are explained in the performance specifications.

Moreover the Contractor shall provide characteristics of the proposed equipment, including but not limited to:

- Pipe laterals:
  - Total area of orifices (surface area of bed),
  - Cross-section area of lateral (total area of orifices served),
  - Cross-section area of manifold (total area of laterals served),

  - Spacing of orifices and laterals.
- Blocks:
  - type of blocks,
  - drain characteristics (size and spacing of orifices),
  - type of support.
- False bottom:
  - false bottom type,
  - drain characteristics (type of nozzles, spacing),

1.3.1.2. FILTER MEDIA

The filter media (sand) is generally used in order to remove essentially suspended solids in the water. The flow direction can be both, top to bottom and bottom to top.

Filtration can be done on a layer of homogeneous or heterogeneous material. Some filters use a combination of different materials. In this case the sand may be combined with anthracite, garnet, schists of varying porosity, etc. provided that these materials have low friability and low loss in acid.

Performance characteristics are given in the performances specifications.

Moreover the Contractor shall provide characteristics of the proposed media, including but not limited to:

- grain size,
- depth of filter medium,
- head losses,
- direction of filtration,
- pressure/gravity filter,
- filter run and cycles.

1.3.2. CONTROL AND MONITORING

The operation mode of the filter underdrain and media system should have both:

1) Manual control and PLC automatic control.

2) Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the equipments. It will be IP 55 protected.

It will be composed at least of the following controls and instructions, for each equipment:

Manual / auto commutator

3) Lighted button "ON"

4) Lighted button "OFF"

5) Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both raking machines control and the way these equipments will be connected to the general computer.

Moreover the following equipment shall be installed and connected to the PLC:

High and low levels detection soundings in chambers,

6) *Cyclic working on clock or / and head losses detection,*
7) *Filtration rate measures,*
8) *Backwash rate,*
9) *Filter run length,*
10) *Airflow monitoring,*
11) *Malfunctions and alarms.*

1.4. QUALITY ASSURANCE

1.4.1. CODES AND STANDARDS

Refer to §4.4 “Standards, codes and regulations” of P2_S5_Volume1: General requirements.

1.4.2. DESIGN CRITERIA

Filtration shall respect the following requirements:

- Filtered water quality ≤ 0.5 NTU
- Wash water ≤ 4 %
- A washing every 48 hours maximum

1.4.3. SHOP TESTS AND INSPECTION

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

C. Workshop inspections and tests:

a) The seals and the embedded parts shall be presented separately and unpainted for checking.

b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c) Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1) *Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…*

2) *Detailed performance specification and drawings of all parts*

3) *Hydraulic and process detailed calculation notes justifying that design criteria are respected.*

4) *Installation, maintenance and operation manuals with requirements of accuracy*

5) *Manufacture and quality assurance measures*

6) *Protective coating list of all parts*

7) *Commissioning tests list.*

8) *Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.*

9) *Internal wiring diagrams and control principle drawing of control box*

10) *Weight and material of each component*

1.6. GUARANTEE

1.6.1. PERFORMANCES

The Contractor shall provide a calculation note proving that the equipment he intends installing has an efficient capacity for drainage as specified above, for a Q_{max} flow.

1.6.2. DIMENSION TOLERANCES

Tolerances and characteristics (filtration rate, head loss, back wash rate) of the filter underdrain and media equipment inner assembling before installation shall be conform to the manufacturer instructions.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. PIPE LATERALS

Manifold pipe are made of plastic or stainless steel. Lateral pipes usually have one ore two rows of perforations at their bottom sides and are made also of plastic or stainless steel. The lateral pipe may be fitted with nozzles generally mad of polyethylene or equivalent.

The size of the required support gravel varies from 38 to 3 mm. Gravel layers are graded, they are coarsest on the bottom and become finer with each layer.

2.1.2. BLOCKS

Blocks are either made of vitrified clay with dispersion orifices located across the top of each block (suitable only for water washing) or of polyethylene with a primary feeder lateral and a secondary compensating lateral, small control orifices open from the feeder lateral directly into the compensatory lateral (suitable for water and air washing). The feeder lateral is generally of triangular shape.

Support gravel is required for this type of underdrain. In the case of polyethylene blocks the support gravel can be replaced by an integral media support (IMS) cap made of plastic beds sintered together which are installed on top of the plastic blocks.

2.1.3. FALSE BOTTOM

False bottom underdrains are constructed of precast or cast-in-place reinforced concrete supported on concrete sills. Unglazed porcelain spheres are placed in the depressions. Depressions are then filled up with gravel. On to there are gravel layers finishing with silica gravel or coarse garnet gravel in the case of mixed media filter beds.

Nozzles are equipped with plunge pipes for air wash and are usually constructed of stainless steel, plastic of brass.

Plunge pipes adjust to allow for levelling after installation.

False bottom underdrains are constructed of concrete, polyethylene, or tile blocks, monolithic concrete or steel plates.

2.1.4. FILTER MEDIA

A. Sand

Quartz (river or sea) sand generally has an effective size of between 0.7 and 2 mm. The grain size must be approved by the engineer.

The sand may be replaced by anthracite (1 to 5 mm), garnet (0.35 mm) or marble.

B. Activated Carbon

The physical characteristics vary considerably depending on the product. Grain sizes vary from 0.25 to 0.3 mm. Specific surface area ranges between 500 and 1300 m²/g. Grain size has to be approved by the engineer.

Other materials are expanded schists, pouzzolana, garnet or other similar materials.

2.2. SPARE PARTS AND SPECIAL TOOLS

The Contractor shall specify and supply the special tools required for equipment maintenance and for 3 years of operation.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

a) Equipment position

b) Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.2.2. DRY TESTS

Examination of paintwork.

3.2.3. COMMISSIONING TESTS

1) Examination of paintwork.

2) The supplier shall provide a extraction effectiveness testing report, taking samples from incoming and outgoing water ditches, in order to check the effectiveness of filtration and drainage.

3) If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

4) Leakage shall not be observed out of the pipes.

oOo

SECTION 14000
CONVEYING SYSTEMS

1. GENERAL

1.1. WORK INCLUDED

The present specification shall apply to the conveying systems to be installed in the various plants and buildings, including but not limited to:

a. Single or double beam motorized brige cranes.

b. Motorized wire hoists with monorail truck.

c. Hand operated chain hoists with monorail truck.

d. Revolving jib cranes with motorized wire hoist.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:;

A. Section 01010 - Corrosion protection

B. Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Civil Engineering works and Building works;

B. Section 01010 – Corrosion protection

C. Electrical equipment;

1.3. QUALITY ASSURANCE

1.3.1. STANDARDS

1. Design standards

   AISC code and FEM rules or equivalent.

2. Materials

   ASTM, AFNOR standards or equivalent.

1.3.2. DESIGN CRITERIA

According to the FEM rules:

- Mechanisms: Group 1 am
- Structures: Group 1

1.3.3. WORKSHOP TEST

A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates shall be delivered by the Manufacturer.

B. Inspection and tests of standard products and cables: routine tests.

C. Workshop inspections and tests:

1. Rails and embedded parts

   The surface aspect of rails and embedded parts shall be examined and their dimensions checked. Rolling and sliding surfaces shall be perfectly flat and smooth;

2. All dimensions of systems members shall be checked;
3. The operation of the various motors and mechanisms shall be checked;
4. Welds:

   Refer to Section 01020 - Basic mechanical requirements.

D. Shop test shall be carried out for motorized bridge and in particular:

- Load test of 125% rated load with operation of lifting up and down, travelling and cross travelling.

1.4. SUBMITTALS

Submit for approval complete shop drawings and descriptive literature showing details of fabrication and erection of all material and equipment furnished under this Section. The shop drawings shall include but not be limited to the following data where applicable:

1. Length of bridge crane span.
2. Overhang of bridge trucks relative to crane rail.
3. Bridge wheel tread diameter and wheel base.
4. Limits of hook travel in relation to walls of structure.
5. Speeds of bridge drive, trolley and hoist.
6. Horsepower, full load amperes and number of motors.
7. Hoist capacity and length of lift.
8. Number and type of hoist brakes.
9. Length of track.
10. Installation of runway beams and crane rails.
11. Electric power supply and wiring.
12. Others.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. GENERAL REQUIREMENTS

a. Hoist drums

All drums shall be groved. The drums shall be supplied with cable clamps. The cable attachment points on the drums shall be easily accessible. The cable lengths shall be such that when the load is in its lowest position, at least three turns of cable remain on the drum.

b. Pulleys

Cable pulleys shall have machined grooves of a depth at least equal to one and a half times the cable diameter. The grooves must be designed to prevent any damage to the cables. The pulleys shall be made of steel (cast iron is not acceptable). The pulleys, lifting hooks and pulleys assemblies shall be designed with a safety factor greater than that used for the cables.

c. Lifting hooks

Lifting hooks shall be of forged or cast steel, or of welded plate. There must be no sharp angles nor curvatures of small radius, which could damage the cables. The hooks shall be supplied with hook safety catches to prevent any rope from becoming unhooked.

d. Chains and cables

The threads of cables strands shall be made of galvanised steel. The cables shall have a metallic central core and shall be grease-impregnated inside and outside so as to resist corrosion and wear. The cables shall be rolled up to a diameter conforming with their charateristics for shipment and storage purpose.

If, during any particular manoeuvre, several lengths are used, the tension on each cable shall be equally distributed by means of pulleys of balancing beams. The only exception to this rule will be the case where such a procedure could cause the lifted item to jam. In such a case, the possible overload due to lack of balance shall be taken into account at the cable design stage. Eyes, endsocket and other attachments for fastening the cables shall be galvanised and capable of with standing 90% of the guaranteed breaking stress of the cables to which they are fixed.

The cable manufacturers shall supply test cables of sufficient length so that samples may be cut off for destructive tensile test. Cost of these tests shall be borne by the supplier. The minimum cable breaking load shall be equal to at least six times the maximum design load of the cable. The minimum breaking load shall be equal to at least four time the maximum design load of the chain.

e. Breaks

All breaking mechanisms, whether of the clamp or disc type shall exert a braking torque of at least 1.5 times the nominal driving torque. The brakes shall also be capable of operating 600 times/hour.

f. Operating speed and loads

The operating speeds shall be guaranteed under normal operating conditions and at all loads within a 5% tolerance band. The maximum operating loads specified by the Contractor shall be considered as guaranteed.

g. Nameplates

All equipment shall have a permanent nameplate clearly showing all pertinent information regarding the equipment, in the English language, following:

- Manufacturer's name and address.
- Name, type, serial number and other equipment identification data.
- Rating and other design data.
- Date of manufacture.
- Lifting capacity.

The lifting capacity shall be indicated on the frame of bridge crane and on the hoist casing.

2.2. SINGLE OR DOUBLE BEAM MOTORIZED BRIDGE CRANE

a. General

The crane shall be a motor operated, single or double girder, overhead travelling bridge crane with motorized trolley and hoist, controls and all appurtenances necessary to operate the crane. Design and manufacturing the crane with all structural steel members, welding, mechanical and electrical materials and assemblies of the bridge crane shall conform to FEM rules as specified.

Steel to be used for all structural steel members shall be E 24 grade or better. All members of the crane shall have a minimum safety factor of 5 based on the ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load. The single beam motorized bridge crane shall be complete, including but not limited to the following components.

b. Components

1. Bridge

   The bridge shall consist of steel girder carried by end trucks. The girder shall be designed to safety carry the full rated load and proportioned to resist all vertical, lateral and torsional forces within conservative limits. End trucks shall be built up from structural shapes and plates welded fo form a rigid section.

   Trucks shall be precision bored to provide accurate alignments of wheel bearing assemblies. Wheel shall be finished to equal diameters in pairs and be double flanged hardened forged steel etc. Single travel speed of 10 meter per minute shall be provided. Each wheel shall be provided with anti-friction bearings and a sealed self-lubrication system.

2. Bridge Drive

   Each end truck shall be provided with the bridge drive unit having a completely sealed reduction gear and brake motor. The bridge drive shall be designed to ensure a smooth start and sudden stop and all gearing shall be totally enclosed and in an oil bath. Rubber type end bumpers shall be provided at each end of the trucks.

3. Motorized Trolley and Wire Hoist

Motorized trolley and wire hoist unit shall be low head type or normal head type and shall be designed and manufactured in accordance with FEM rules or equivalent. The trolley shall have motorized drive, single speed, push button control, four flanged induction hardened forged steel wheel either sealed ball or tapered roller bearing, thrust brake and forged steel fittings.

The hoist shall have a lift, motorized drive, dual speed, upper and lower limit switches, push button control, two independent brake systems (one a solenoid operated motor brake and one a mechanical load brake, or approved equal), double reeving for plumb vertical movement of hook with wire cable and swivel safety latch hook.

4. Rails and Runway Beams

Crane rails shall be of the size recommended by the crane manufacturer. The rails shall be installed with staggered splices, appropriate pairs of anchor bolts with rail clips every 60 cm and a continuous strip of 5 mm neoprene between the rail and runway beam. Rails and runway beam shall have sliding splice to provide for expansion joints in concrete structure.

Heavy duty, high impact, rubber faced bumper stop shall be provided at each end of the runway rails. Runway beams shall be of a standard type I steel or H beam. Maximum deflection of runway beams shall be 1:1000 span with given maximum wheel load. The runway beams shall be installed on concrete brackets.

5. Electrical Conductors

The electrical conductor for runway and bridge shall be a PVC enclosed conductor system, 100 ampere vertical mount, safety enclosed conductor. The current collectors shall be made of reinforced fibre glass plastic and shall have spring loaded carbon brushes maintaining uniform contract pressure with copper conductor with 60 amperes in the runway and 30 amperes in the bridge. All accessories for the proper mounting of conductors and collectors shall also be provided.

6. Power Supply System for Motorized Trolley and Hoist

The power supply system for motorized trolley and hoist shall be a heavy duty festooned cross conductor system and shall be designed to store cabtyre cable in uniform scallops. Messenger wire or guide rail and cable hanger with accessories shall be stainless steel. All accessories for proper mounting of the festooned conductor system shall be provided.

7. Controls

The control shall be push button pendant with a dust tight case, ballast resistor speed control and a pilot circuit to reduce the voltage at the push button to 24 volts. The pendant shall be suspended from the motorized trolley and hoist to the elevation required by the Engineer.

2.3. MOTORIZED WIRE HOIST

a. General

Motorized wire hoist, in all their parts, shall be of sufficient capacity to move the load, and shall be wired for electrical service.

Design and manufacturing the motorized wire hoist shall conform to FEM rules. All appurtenances necessary to operate the motorized wire hoist shall be provided. The motorized wire hoist shall be complete, including but not limited to the following components.

b. Components

1. Trolley

   The trolley shall have motorized drive, single speed, push button control, four flanged induction hardened forged steel wheels with sealed ball or tapered roller bearings, thrust brake and forged steel fittings.

2. Motorized Wire Hoist

   The hoist shall have a lift as required, motorized drive, single speed or dual speed, upper and lower limit switches, push button control, two independent brake systems (one a solenoid operated motor brake and one a mechanical load brake, or approved equal), double reeving for plumb vertical movement of hook with wire cable and swivel safety latch hook.

3. Truck

   Monorail truck shall be a standard I beam with non-peening rolling surface and maximum deflection of 1:1000 span with given maximum wheel load. Heavy duty, high impact rubber faced bumper stops shall be provided at each end of truck.

4. Electric Conductor

   Electric conductor system shall be enclosed conductor or festooned system.

   a) Enclosed Conductor System

      ❍ The electrical conductor shall be PVC enclosed conductor system, 100 ampere vertical mount, safety enclosed conductor. The current collectors shall be made of reinforced fibre glass plastic and shall have spring loaded carbon brushes maintaining uniform contact pressure with cooper conductors with 60 ampere capacity. All accessories for proper mounting of conductor and collectors shall also be provided.

   b) Festooned Conductor System

      ❍ The electrical conductor shall be heavy duty festooned conductor system and shall be designed to store cabtyre cable in uniform scallops. Messenger wire or guide rail and cable hanger with accessories shall be stainless steel. All accessories for proper mounting of the festooned conductor system shall be provided.

5. Controls

   The controls shall be push button pendant with a dust tight case, ballast resistor speed control and a pilot circuit to reduce the voltage at the push button to 24 volts. The pendant shall be suspended from the hoist to the elevation required by the Engineer.

2.4. HAND-OPERATED CHAIN HOISTS

a. General

Hand-operated chain hoist shall be plain or geared trolley with chain hoist. Design load and lifts shall be as required. Chain hoist shall be designed and manufactured in accordance with FEM Rules.

b. Construction and Materials

Chain hoist shall consist of frame, casing reduction gear and flanged load sheave with precision roller bearings, load and operation chain, overload limiter, mechanical brake safety latch hook. The reduction gears shall be ample proportioned and provided a positive drive between the driving shaft and the load. Pinions and spur wheels shall be made from high grade heat-treated alloy steel, and have precision machine cut-teeth.

The brake shall be of the screw and disc type where the brake pressure and the sustaining power increases in proportion to the load on the hook. Screwed brake sleeve shall be high grade steel and mounted on a splined driving shaft.

All chain shall be electrically welded steel, heat treated, polished and accurate to pitch. The geared trolley shall be the gear drive type with 4 ball-bearing pressed steel wheels, equipped with lifetime lubrication and hardened threads with a geared travel mechanism.

The push and plain trolley shall be of the hung-in travelling type with a forged steel bar held between the side plates of the trolley. The push and plain trolley shall have 4 ball bearings pressed steel wheels equipped with lifetime lubrication. Monorail truck shall conform to the requirements specified in previous Art. 2.3 - Motorized Wire Hoist.

2.5. JIB CRANE

a. General

Jib crane shall be 180° or 360° revolving type crane equipped with fixed motorized wire hoist.

b. Construction and materials

Jib crane shall preferably made up of fixed vertical support rigidly anchored in the concrete base and rotating arm.

The arm shall easily and smoothly rotate with minimum friction using lubricated sleeves or bearings. A locking device shall be provided to maintain the arm in any rotating position.

The controls shall be push-button pendant with a weather tight case and a pilot circuit to reduce the voltage at the push-button to 24 volts. The pendant shall be easily accessible in every rotating position.

2.6. SPECIAL TOOLS AND SPARE PARTS

a. The Contractor shall specify and supply the special tools required for maintenance.

b. The Contractor shall supply the following spare sparts:

- 1 coil of brake of each type,
- 1 set of brake linings for each brake,
- 1 motor of each type,
- 1 drive roller for crane translation,

- 1 drive roller for carriage drive,
- 1 free roller for the translation,
- 1 free roller for the carriage,
- 2 sets of three suspension clips with insulators,
- 1 set of flexible straight and ring connections of each type,
- 1 set of signal and lighting lamps,
- 2 relays of each type,
- 1 set of contacts for each contractor,
- 1 set of carbon brushes,
- 100% of the first filling of oil and grease.

3. EXECUTION

3.1. INSTALLATION

The conveying systems shall be installed-in strict conformity with the Manufacturer's instructions and as required by the Engineer.

Main switch for motorized equipment shall be wall-mounted in accessible location.

3.2. FIELD QUALITY CONTROL

The equipment shall be tested in accordance with BS 466 or equivalent international standard.

a. Rail-track

Rail-track position shall be checked before and after its definitive setting and clamping.

b. No-load test

During the testing manoeuvres, the following items shall be checked:

- Correct operation and efficiency of brakes and limit switches.
- Vertical and horizontal travelling distances and approach measurement.
- Synchronisation of pully operation when several hoists are used.
- Operating speeds.
- Operation and characteristics of manual and emergency control.
- Examination of paintwork.

c. Commissioning and acceptance tests

1. As far as possible, the load tests shall be carried out under the worst operating conditions in which the hoisting equipment shall be operated under its rated load. In the event of these conditions not being possible, the Contractor shall make provision for the additional loads necessary, in order to be able to simulate the required test conditions:

   Under the rated load, the same items shall be checked as in the no-load test. In addition, the brakes shall be checked, so as to ensure that they stop the hoisting equipment operating at its rated speed, with a maximum slip of 10 mm and that the load is held in a stationary position without sliding. The

bearings and other mechanical parts shall also be checked for temperature rise. The temperature of such mechanisms shall not exceed the value specified.

Under overload conditions, the overload safety system shall be checked.

After completion of the load tests, all suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication. Defective components shall be replaced at the Contractor's expense.

2. Testing of complete handling mechanism:

Static test:

- With the handling mechanism in a fixed position, the hoisting equipment shall be tested under an overload 50% greater than its rated load. This load shall be maintained for one hour. The load shall then be relieved gradually. No defect or permanent deformation shall remain after complete removal of the load.

Dynamic test:

- After satisfactory completion of the static test, the testing load shall be decreased to a value 20% greater than that of the rated load of the hoisting equipment. Under these conditions, all the lifting and lowering operations shall be carried out successively for a period of fifteen minutes of effective operation, without vibration, deformation of detrimental temperature rise. Translational movements of the handling mechanism shall be tested under the same conditions as above.

During these manoeuvres, the following shall be checked:

correct behaviour of the handling mechanism along its rolling track: the framework shall remain perpendicular to the track and shall under no circumstances give evidence of any defect or deformation,

correct operation and efficiency of the brakes and limit switches,

adjustment of the starting equipment, adherence of rollers on starting and braking.

After the dynamic tests, the hoist shall be located to its rated load and the following shall be checked:

The deflection.

The horiziontal and vertical travel distances.

Correct general operation of the safety mechanisms and accessories.

Synchronization of pulley operation when several hoists are used.

The operating speed.

The lifting and lowering movements, which shall be made in a continuous smooth manner so that all manoeuvres shall be possible with the desired accuracy.

Brakes and stopping distance: the hoist brakes shall be capable of stopping the rated load operating at a normal speed with a maximum slip of 10 mm and maintaining this load in a stationary position without slipping.

The bearings and other mechanical parts shall also be checked for temperature rise.

After the dynamic test, suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication; defective components shall be replaced at the Contractor's expense.

SECTION 14100
PIPES, FITTINGS & APPURTENANCES

1. GENERAL

1.1. WORK INCLUDED

This specification applies to the supply, assembly and testing of pipes and fittings.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Volume 2 – Part 1 – General Requirements;

B. Corrosion protection

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Volume 2 – Part 4A – General Technical Specifications Civil Works;

B. Section - Air blowers;

C. Section - Valves, gates & appurtenances;

D. Section – Dosing pumps;

E. Section - Cetrifugal and Miscellaneous pumps;

1.3. QUALITY ASSURANCE

1.3.1. STANDARDS

The following standards shall be adopted or approved equivalent:

Pipeline – General:

EN 1295 Section 1.81.12 - Structural Design of Buried Pipelines.

EN 805 – Water Supply – Requirements for Systems and Components Outside Buildings

BS 8010 British Standard Code of Practice for Pipelines - Part 2 Pipeline on Land: Design, Construction, and Installation

Steel Pipes & Fittings:-

EN 10224 Non-alloy Steel Tubes & Fittings for Conveyance of Water

ISO 559 – Steel Tubes for Water and Sewerage

AWWA C200 – Steel Water Pipe 6 in. and Larger

API 5L – Specification for Line Pipe

EN 1092 - Flanges and their Joints – Part 1: Steel Flanges

EN 10339 – Steel Tubes - Internal Liquid Applied Epoxy Lining

EN 10298 – Steel Tubes - Internal Lining with Cement Mortar

EN ISO 21809-1 – Buried Pipeline: 3-Layer Polyethylene Coating

Ductile Iron Pipes and Fittings:-

EN 545 – Ductile Iron Pipes, Fittings, Accessories for Water Pipelines

ISO 2531 – Ductile Iron Pipes, Fittings and Accessories

EN 1092 - Flanges and their Joints – Part 2: Cast Iron Flanges

ISO 4179 – Ductile Iron Pipes & Fittings – Cement Mortar Lining

EN 14901 – Ductile Pipes & Fittings – Epoxy Coating of Fittings

EN 15189 – Ductile Iron Pipes & Fittings – External Polyurethane Coating

Design Manual

AWWA Manual M11 – Steel Pipe, a Guide for Design & Installation

Ancillary Pipework

uPVC pipes ISO 4422 – Pipes & Fittings Made of PVC-U

EN 1452 – Plastics piping systems for water supply – PVC-U

HDPE Pipes & ISO 4427 - Plastics piping systems for water supply – PE

Fittings	EN 12201 – Polyethylene Pipes for Water Supply

All standards and references shall in any case be deemed to include the latest edition available 28 days before the deadline for submission of Bids.

All units of weight and measurements shall be based on the Metric System of Weights and Measurements.

1.3.2. DESIGN CRITERIA

All piping shall be designed for a minimum working pressure of 10 bar expect for the effluent pressure line which shall be designed for a minimum working pressure of 16 bar.

1.3.3. SHOP INSPECTION AND TEST

1. Inspection

The quality of all materials, the process of manufacture shall be subject to inspection and approval by the Engineer or by an independent testing laboratory selected by the Employer. Such inspection shall be made at the place of manufacture and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory.

2. Hydrostatic test

Before coating and lining each pipe with a service pressure higher than 6 bars shall be tested. The test pressure for steel pipes shall be given by the following formula:

$$P = \frac{20\ St}{D}$$

Wherein:

P = Hydrostatic test pressure in bar

S = 75% of yield point of steel used in MPa

t = Wall thickness in mm

D = Outside diameter in mm

Test pressure for PVC pipes and fittings shall be according to the applicable standards.

1.4. SUBMITTALS

1.4.1. GENERAL

In his proposal, the Contractor shall provide for all pipes and fittings all necessary guarantees concerning the nature of the materials used, the quality of execution and implementation, their stability during operation

in normal conditions of use, and the interior and exterior protective linings and coatings on the pipes, as well as all supporting calculation memoranda and characteristics.

1.4.2. CERTIFICATES

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilized in the work. The certifications shall contain the result of chemical and physical tests required by these specifications for the materials.

1.4.3. SHOP DRAWINGS

The Contractor shall submit detailed working and shop drawings and schedules of all pipe, fittings and appurtenances. Shop drawings shall include but not be limited to the following:

- Lists and schedules of material, linings and coatings.
- Schedules of pipe lengths and thicknesses.
- Details of proposed joints, hardnesses and installation details.
- Names of suppliers and identification of materials and equipment to be supplied.
- Shop drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The work of this section shall be completely co-ordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

1.5. DESCRIPTION

A. Networks materials shall be in accordance with the followings:

- Sewage network:
  - All inlet and internal main sewage pipes shall be in HDPE.
  - Outlet pipes for clarified water shall be made of steel or ductile iron.
- Industrial water network: HDPE or stainless steel.
- Sludge network: HDPE.
- Chemical networks: HDPE.

B. Steel pipes will not be allowed for outdoor purposes within the WTP.

C. The Raw Water Pumping Main shall strictly be Ductile Iron or Steel pipes and Fittings.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. STAINLESS STEEL PIPES

I.) General specifications

The general characteristics of stainless steel tubes must comply with the international standards in force.

II.) Assembly

Pipes shall consist of stainless steel tubes and connections welded together.

Welds more than 1.5 mm thick should preferably be done with filler metal.

Welds inside pipes shall be protected by injecting argon or nitrogen into the pipe.

All welds must be cleaned mechanically or chemically.

Air shall be used for cooling.

The Contractor shall use parts prefabricated in the factory for bends and tapers.

All supports, fixing accessories and screws shall also be made of stainless steel.

III.)Checking of welds

Welds shall be prepared, carried out, checked and repaired in accordance with the specifications of international standards.

Welds shall be prepared with hollow chamfers, V-shaped for single-side welds and X-shaped for double-side welds.

A straight root face at the base of the chamfer is only permitted if it is of regular height and small enough not to hamper penetration.

V-shaped welds will normally have chamfers opening outwards. They shall be repeated backwards after chipping.

The Contractor's checks shall include the following operations:

A. The appearance of all welds must be checked

The Contractor shall check that all welds are regular and properly connected to the part. Their width end-to-end must be no more than 1.8e + 5 mm, with e being the thickness of the sheet in the case of a V-shaped chamfer or half its thickness in the case of an X-shaped chamfer.

Average build-up is between the following limits:

$$\left(0{,}5+\frac{e}{20}\right)\text{mm et}\left(2+\frac{e}{10}\right)\text{mm}$$

Maximum difference in level is:

$\left(\frac{e}{20}+1\right)$mm

The length "a" of an apparent continuous defect (groove or lack of penetration) shall be less than 30 mm, the distance separating two defects less than 3a and the sum of all "a" values over the length of the joint L less than L/10.

B. Penetrant test

All welds shall be checked by means of a penetrant test as per international standard.

The Contractor shall carry out the penetrant tests himself.

The Engineer reserves the right to carry out additional tests if he considers it necessary. The corresponding costs shall be borne by the Engineer if the results should prove to be satisfactory and by the Contractor if not.

C. Acceptance or rejection of welds

Weld defect acceptance criteria shall be determined according to the nature, service conditions and importance of the equipment inspected, and in light of the danger and consequences involved in the event of a burst.

More generally, the criteria shall be derived from the standards in force and specific to each class of equipment.

D. Repairing welds

Defective welds shall be repaired by eliminating the defective area down to sound metal and repeating the weld. Repaired areas shall be re-inspected.

If the new inspection reveals unacceptable work, an additional inspection shall be carried out on either side of the area in question.

If this new inspection does not reveal any defect leading to rejection of the weld, only the area concerned by the first inspection shall be repaired. If not, a complete inspection shall be performed.

A welded area cannot be repaired more than twice in order to avoid changes in the structure of the metal resulting from repeated heating, unless specified to the contrary.

2.1.2. HDPE PIPES

A. General

The general characteristics of HPDE pipes must comply with the international standards in force.

B. Assembly

HDPE pipes shall be sawn perpendicular to the centre line and cleanly to avoid sharp edges, burrs and roughness.

The area shall be completely scraped and the surface cleaned with solvent.

Welds shall be made:

- **either by polyfusion:** an electrically heated mirror shall be used to reach a plasticising temperature at the ends of 200°C ± 10°C. The weld shall be made by pressing the ends together under a pressure of 1.5 to 2 kg/cm² to obtain a single length,
- **or by welding**, particularly in the case of shaped parts:
  - with a hot steel torch (controlled temperature and air flow) and HDPE filler rod,
  - with a heated wedge device, using HDPE filler wedges,
  - by extension to all HDPE parts.

Polyethylene connectors will also be joined by polyfusion, either by butt fusion or, in the case of fittings with a socket, by means of a heating sleeve or incorporated electrical heating resistance activated by an automatic welding device.

Connections to pipes made of traditional materials (steel, ductile iron, etc.) shall be made by means of a moulded HDPE collar polyfused to the end of the tube and by a coated backing flange.

For HDPE pipe connections to manholes, neoprene holes will be added to the end of the tube or manhole access fittings shall be provided, with a welded HDPE collar and gusset assembly embedded in the concrete.

Pipes shall be tested in accordance with articles 76, 78 and 79 of section 71 of the French General Technical Specifications. The test pressure shall be equal to the service pressure plus 50% (article 76.5).

2.1.3. DUCTILE CAST IRON PIPES AND CONNECTIONS

1. General

The Contractor shall prove that the proposed Ductile Iron Pipe manufacturer is able to supply pipes and fittings of the approved pressure class, with the specified socketed joints and with the specified lining and coating materials and that the manufacturing unit from where pipes and fittings will be supplied has at least five years of successful track record in supplying pipes and fittings with the required lining and coating materials.

The manufacturer shall demonstrate that the lining and coating materials provided withstand all the necessary tests as detailed in this Specification.

2. Material and Standards

Ductile Iron Pipes and Fittings shall comply with EN 545, ISO 2531 and other International Standards.

The minimum tensile strength shall be 420 MPa and the minimum 0.2% proof stress shall be 300 MPa. The minimum elongation at failure shall be 10% for nominal diameters DN 60 to DN 1000 and 7% for nominal diameters DN 1100 to 2000.

3. Manufacturing

Ductile Iron Pipes shall be centrifugally cast in accordance with EN 545.

Ductile Iron Fittings shall be produced in accordance with EN 545 by using sand moults and resin-sand cores.

4. Pressure Class and Wall Thickness

As defined in EN 545, the Preferred Pressure Class shall be :

- Class C30 for pipes DN 350 to DN 600
- Class C25 for pipes DN 700 and larger

The pipe wall thickness shall vary accordingly from 4.7 mm to 6.7 mm for Class C30 pipes and from 6.8mm to 11.1mm for Class C25 pipes (for DN 700 and DN 1200 respectively).

5. Pipe Length

Pipe length shall not be less than 6 m.

6. Factory Test

In accordance with EN 545, Ductile Iron Pipes shall be individually subjected to a factory hydrostatic test of not less than 10 seconds duration at a minimum pressure of 30 bar for Class 30 pipes and 25 bar for Class 25 pipes.

In accordance with EN 545, Ductile Iron Fittings shall be submitted either to a leak-tightness test carried out with air at a pressure of 1 bar or a hydrostatic test carried out with water at the minimum pressure of 16 bar for pipes DN 350 to 600 and 10 bars for pipes DN 700 and larger.

7. Socketed Joints

Socketed joints shall be of the push-on type to EN 545.

The material used for the gaskets shall be either natural rubber or synthetic elastomer to EN 681. Gaskets shall be stored in accordance with EN ISO 2230.

Except otherwise stated or proposed by the Contractor and approved by the Engineer, the Ductile Iron Pipes and Fittings will have Non-Anchored Socketed Joints

Non-Anchored Socketed Joints:-

Non-Anchored Socketed Joints shall not resist axial thrusts. On the other hand they shall enable angular deflections which shall not be lower than:

- 3.0° for DN 350 to 600
- 2.0° for DN 700 to 800
- 1.5° for DN 900 and larger

The Contractor shall inform the Engineer of the angular deflections offered by the proposed Ductile Iron Pipes.

Anchored Socketed Joints:-

To face particular constraints and under request from either the Contractor or the Engineer, Pipes and Fittings with Anchored Socketed Joints may be used at certain locations.

Anchored Socketed Joints shall resist to axial thrusts. The Manufacturer shall propose adequate locking technology depending on the diameter and the maximum targeted thrust.

Anchored Socketed Joint Pipes and Fittings shall accept similar angular deflections as those possible with Non-Anchored Joints.

8. Flanged Joints

Ductile Iron Flanged Pipes shall be centrifugally cast to EN 545, shall comply with EN 1092 and shall be drilled to PN16 except where otherwise indicated.

Gaskets shall be made of reinforced elastomer to EN 1514 and shall have a minimum thickness of 3 mm. They shall be stored in accordance with EN ISO 2230.

Bolts for flanged joints shall conform to ISO 4014. Exposed threads of all bolts shall be filled with a light plastic cap after flange assembly.

Flanged fittings shall be so installed that there are no stresses induced into the pipework, specials or fittings by forcing units into position or by bolting up flanges with faces not uniformly in contact with their gaskets over their whole faces.

9. Marking

Each pipe, fitting or accessory shall bear the mark of the manufacturer, and indication of its casting and be marked with its nominal diameter. As appropriate, each fitting shall bear an indication of its main characteristics. Pipes, fittings and accessories with a nominal diameter of 300 mm or more shall also bear the year of manufacture.

10. Pipe Coating

All coatings for Ductile Iron Pipes and Fittings shall be barrier coatings.

The normal coating of Ductile Iron Pipes shall be factory applied and shall consist in an alloy of zinc and aluminium, possibly with other metals, and a finishing layer of acrylic paint, all in accordance with EN 545. The zinc-aluminium layer shall have a mass of at least 400 g/m^2 in accordance with EN 545, Appendix D, paragraph D2.2 The thickness of the finishing layer shall be at least 70 micron. The finishing layer can alternatively be made of epoxy or bituminous paint.

In areas of highly corrosive soils (electrical resistivity lower than 500 ohm.cm and/or pH lower than 5), Ductile Iron Pipes shall be protected by a factory applied Polyurethane Coating complying with EN 15189.

11. Pipe Lining

Ductile Iron Pipes shall be internally lined at the factory with a cement mortar, centrifugally applied and conforming to EN545.

The cement shall be sulphate resistant blast furnace slag cement, CEM III type in EN197-1. The Contractor shall provide a sanitary certificate regarding the cement.

The thickness of the cement mortar lining will vary according to the pipe diameter as specified in EN 545.

12. Fitting Coating and Lining

Fittings shall be both internally and externally protected with a fusion-bonded epoxy layer to EN 14901, with a minimum dry film thickness of 250 micron, whatever the soil conditions.

2.1.4. STEEL PIPES AND CONNECTIONS

1. Materials and Standards

Steel Pipes and Fittings shall generally comply with EN 10224, ISO 559, AWWA C200, API 5L, AWWA Manual M11 and other International standards that specify superior pipe thickness and lining / coating materials. All latest and updated international standards pertaining to Steel Pipes and Fittings shall apply.

2. Pipe length

The normal pipe length shall be 12 meters but it may be adjusted as necessary to suit transport and site conditions, especially in areas with steep gradients and difficult access.

3. Fittings

Fittings shall in general conform dimensionally to the above standards, however where specifically required the lengths of straight barrel sections may exceed or be less than standard dimensions. They shall be manufactured from pipes that have themselves been manufactured to above standards and successfully passed all mechanical, dimensional, visual, pressure and non-destructive testing. All new welds made during the fabrication of the fittings shall be subject to non-destructive testing using either radiological, ultrasonic or dye penetrants dependent upon the geometry of the weld.

Where necessary, fittings shall be reinforced in accordance with AWWA C208-1 and AWWA M11. The cost of reinforcement of all fittings shall be assumed to be included in the Contractor's rates.

Fittings may be reinforced in various ways for resistance to internal pressure. Typical fitting reinforcements are collars, wrappers and crotch plates. The design stress in the reinforcement should not be greater than the hoop stress used in the design of the pipe.

The type of reinforcement can be determined by the magnitude of the pressure-diameter value (PDV) and the ratio of the branch diameter to the main pipe diameter d/D.

The pressure-diameter value is calculated as:

$$\text{PDV} = \frac{Pd^2}{D \sin^2 \Delta}$$

Where:

P = design pressure (psi)

d = branch outside diameter (in.)

D = main pipe outside diameter (in.)

Δ = branch diameter angle of deflection

For PDV values greater than 6000, the outlet reinforcement should consist of a crotch plate. For PDV values less than 6000, the outlet reinforcement may be either a wrapper or collar, depending on the ratio of the outlet diameter to the main pipe diameter d/D. For a d/D ratio greater than 0.7, a wrapper plate should be used; for a d/D ratio less than 0.7, either a collar or a wrapper plate may be used. The ratio d/D does not include the sin Δ as in the PDV determination because the controlling factor is the circumferential

dimensions. Wrappers may be substituted for collars, and crotch plates may be substituted for wrappers or collars.

Fitting ends for use with flexible couplings shall be true ended with the ends appropriately prepared for the type of coupling required.

Joints for site butt-welding shall comprise bevelled edges to BS 534 or EN 10311 such that the lining shall be undamaged during the welding.

Any horizontal / vertical deflection below 7^0 will require mitre cutting of the plain ended pipes (one end or both ends depending on angle of deflection required), before mating ends and carrying out field butt welding at the joints. The cost of mitre cuttings is deemed to be included in the Contractor's rates.

All bolts shall be hot dipped zinc coated and those for bolted sleeve couplings further protected with a topcoat of aluminium pigmented organic epoxy to their respective standards, unless otherwise indicated on the drawings or in the Bills of Quantity.

4. Steel Grade and Pipe Wall Thickness

The minimum Steel Grade including the minimum pipe wall thickness shall be determined by the Contractor.

The Contractor shall demonstrate that the thickness and steel grade are adequate for the pressure and other parameters. The thickness calculation shall take into consideration the following : operating pressure, test pressures, pressure transients or surges if applicable, external pressures, steel pipe strength characteristics, temperature, soil condition, trench width and depth and appropriate traffic load.

6. Deflection During Storage

During pipe storage, the out of roundness at a plane perpendicular to the pipe axis shall not exceed 4% of the minimum inside diameter, out of roundness being measured as the difference between the minimum and maximum inside diameter of the pipe at this point.

In case the above quality control on roundness of pipes and fittings is not achieved, the Contractor will provide stulls to all pipes and fittings at his own cost and to the approval of the Engineer.

7. Field Welding

All field welding shall only be done by welders who satisfy the requirements of EN 287-1 or API 1104 and who have been tested and approved by an Independent Testing Authority.

Before any welding of pipeline materials commences, the qualification of welders shall have been approved, all detailed welding procedure specifications with weld diagrams required for their completion shall have been submitted for approval in a neat form, and the welding procedure qualification tests shall have been successfully concluded all in accordance with the relevant Standard Specifications.

Sufficient records shall be kept by the Contractor to ensure that all field welds can be subsequently identified with the welder concerned.

No welding shall be carried out during rain or high wind or under dusty conditions unless the welder, the weld area and the weld are adequately protected and sheltered.

Only approved welding rods which have been kept dry and uncontaminated shall be used.

Welding rods shall be of a grade and quality such that the chemical composition of weld metal and parent metal is similar. All welding rods shall be approved prior to ordering. Inspection of storage areas, storage records for issuance of welding rods and confirmation of their use will be available to the Engineer as and

when required. Any contamination of supplies of such materials and use of unapproved welding rods will result in rejection of pipeline section and its replacement at Contractor's own cost.

8. Welded Joints

Pipes and specials shall be joined by field butt-welding for diameter 800 mm and larger and by field lap-welding for diameters lower than 800 mm.

Field welding of joints shall conform to EN 288 or API 1104.

All (100%) field welded joints shall be subjected to non-destructive testing which includes radiology, ultrasonic or dye-penetrants. At minimum, all welded joints must be tested using both dye-penetration and ultrasonic tests. Contractor's rates for supply and installation of welded steel pipes and fittings shall be deemed to cover the specified non-destructive testing as specified above and in accordance to BS EN 288 or API 1104. The testing shall be carried out by an Approved / Licenced Specialist Contractors approved by the Engineer. The records of all testing shall be maintained as specified.

Before proceeding to welding of joints, pipe ends shall be completely circular and properly mated up by means of backing rings/clamps. At least 4 tack welds equally spaced around the pipe perimeter shall be applied to maintain the root gap and position of the pipe for completion of welding. A protective plastic or rubber sheet shall furthermore be placed over the coating adjacent to the joints to protect the same from damage caused by welding spatter.

Root welds shall thereafter be carried out followed by successive filler passes, and capper passes, all in accordance with the approved welding procedure. Wherever it is possible to have entry into a pipe, inside welds shall be applied first. The inner weld bead shall not extend more than 1mm into the bore of a pipe or special.

Horizontal weld seams or spiral weld seams at pipe ends shall be placed near the horizontal diameter of the pipe or special and shall be staggered so that the circumferential distance between longitudinal or spiral welds intersecting the same circumference is greater than 90mm and not more than 130mm apart.

Defects caused by stray welding arc flashes, weld spatter etc. shall be removed by grinding provided that pipe wall thickness are not reduced to less than the specified minimum thickness, otherwise the portion containing the defect shall be cut out and repaired.

During welding of pipes, the pipe shall be protected with organic linings, mats of thick rubber felt or other suitable material which shall be placed along the pipe invert to protect the pipe lining for the full distance from the point of access up to the point of weld or weld inspection. The mats shall be of sufficient width and shall cover a sufficiently wide area of pipe invert to protect the lining against damage due to access by staff, equipment, inspectors or fall out from arc weld. Workmen shall wear soft, rubber-soled shoes before entering lined pipes.

Care shall be taken not to stroke arcs on epoxy-lined areas and protective tapes, if any, at ends of epoxy lined pipes shall only be removed immediately prior to welding.

Pipes may be welded together alongside the edge of the trench. For factory lined and coated pipes, the maximum length so welded together shall be such that:

i) the pipe can be subsequently stored, lifted or handled without damage to lining and coating

ii) the out of roundness at a plane perpendicular to the pipe axis at any point along the pipe length during storage, lifting or handling does not exceed 4% of the minimum inside diameter (out of roundness being measured as the difference between the minimum and maximum inside diameter of the plane at the point);

iii) safe and easy access to internal tie-in welds are assured for staff and Inspectorate with equipment;

iv) the maximum length does not exceed 36m

Snaking into the trench of butt welded sections of pipe shall be permissible for bare steel pipes, subject to approval by the Engineer of a complete and comprehensive method statement submitted by the Contractor and provided that the out of roundness as defined and measured above during any stage of the snaking operation, does not exceed 4% of minimum internal diameter.

The linings and coatings of pre-lined and coated pipes jointed together outside the trench shall be made good at these joints outside the trench.

9. Joints by Flexible Couplings

Flexible joints shall be bolted sleeve couplings to BS 534 and EN 10311 and of approved pattern. Flexible couplings shall be coated with fusion bonded epoxy layer 350 microns thick. Flexible couplings shall be of a mechanical type coupling consisting of a centre sleeve, two end ring flanges, two wedge shaped sealing rings of nitrile rubber, and with galvanised nuts and bolts. The main components shall be made from hot rolled steel for larger diameters and malleable cast iron to EN 1562 or ductile iron for smaller diameters.

Joints shall be made and couplings assembled to the manufacturer’s instructions

After jointing, the exposed part of bolts shall be provided with a tight protection cap unless capped nuts are used.

10. Flanged Joints

Where specifically called for or deemed appropriate, flanged joints shall be utilised. They shall conform to EN 1092, drilled to PN16 except where otherwise indicated, with gaskets made of reinforced elastomer rubber to EN 1514 and of minimum thickness of 3 mm. Gaskets shall be stored in accordance with EN 2230.

Bolts for flanged joints shall conform to ISO 4014. Exposed threads of all bolts shall be filled with a light plastic cap after flange assembly.

Flanged fittings shall be so installed that there are no stresses induced into the pipework, specials or fittings by forcing units into position or by bolting up flanges with faces not uniformly in contact with their gaskets over their whole faces.

11. Pipe Coating

The coating of Steel Pipes shall be factory applied Triple Layer Polyethylene Coating (3LPE) to EN ISO 21809 comprising triple wrap system of fusion bonded or sprayed epoxy primer, an intermediate polymer adhesive layer and an extruded polyethylene coat providing an overall total coating thickness that shall not be less than that specified in EN 21809 for each pipe diameter**.**

The manufacturer shall demonstrate that the adhesion of the coating to the substrate does not lessen to extent that the PE coating could be easily cut or removed with time underground. The manufacturer shall carry out abrasive blast cleaning immediately before applying epoxy primer during the same work shift.

All site welded joints shall be externally protected after welding in accordance with the next section of the Specification.

The Contractor will be responsible for verifying the integrity of the Pipe External Coating including at welded joints before trench backfilling. Damaged coating will be repaired at the Contractor's expense.

In addition to the protection by the 3LPE Coating, all Steel Pipelines may require a Cathodic Protection System but this requirement shall be determined by the Contractor.

12. Protection of Site Welded Joints

Protection of site welded joints shall be by tape wrapping to AWWA C214.

The Contractor will mobilize a technical representative of the tape manufacturer during the initial stage of the pipe laying work to assist or instruct the Contractor and the end-user coating inspector with the proper application of the coating system and the Contractor will subsequently apply the manufacturer's specifications.

The Contractor shall carry out cleaning and blasting of the pipe jointing area in accordance with AWWA C214 before installation of the wrapping system.

All coating material will be stored, handled and transported in accordance with the manufacturer's specification and in such a manner as to prevent damage to individual carton containers. Cartons, tape rolls or individual repair rolls removed from the storage pallets will not be dropped, rolled, or thrown in any manner as to damage the coating material.

Any defects in the steel substrate (i.e., slivers, laminations, etc.) will be highlighted to the Employer's representative for disposition before wrapping of the protective tape.

13. Pipe Lining

For pipe sizes up to and including DN 700, pipes shall be protected internally with Cement Mortar. Cement mortar lining shall conform to EN 10298 or AWWA C205.

The lining shall be factory applied by centrifugation.

The cement shall conform to ASTM C150 and shall be type I unless otherwise stated by the Engineer.

The thickness of the cement mortar lining shall comply with the requirement of the above referred standard depending on pipe diameter.

For pipe sizes DN 800 and larger, pipes shall be lined with Liquid Epoxy conforming to EN 10339 or AWWA C210.

The lining shall be factory applied, at hot or common temperature depending on the product used by the manufacturer.

Blasting of the internal pipe wall prior to epoxy spraying shall comply with the standards.

The dry film thickness of the epoxy lining shall comply with the requirement of the above referred standard.

After welding of epoxy lined steel pipes 800 mm dia. or larger, each internal jointing area shall be cleaned using sandpaper or a more elaborate tool and liquid epoxy shall be applied with a brush on the entire unprotected joint area.

14. Fittings - Coatings and Linings

Steel Fittings 800mm dia. and larger shall be protected externally and internally by Fusion-Bonded Epoxy to AWWA C213.

Steel fittings 700mm dia. and smaller shall be externally coated with Fusion-Bonded Epoxy to AWWA C213. Those with flanged ends shall be internally lined with epoxy as well. Those to be field welded shall be cement mortar lined to EN 10298 or AWWA C205.

2.1.5. PVC PIPES

A. General

The general characteristics of PVC tubes intended to convey fluids shall comply with international standard.

PVC tubes for pressurised or buried pipes: the characteristics of the tubes shall comply with the specifications of international standard.

B. Assembly

All pipes shall have sealed joints.

The dimensional characteristics of sealing-ring assemblies of pressurised pipe elements shall comply with the specifications of international standard.

Pipe elements include:

- PVC tubes
- Ductile iron fittings

The Contractor shall comply with standard describing the tests to be used for sealing-ring assemblies.

Elastomer sealing rings shall comply with international standard.

2.1.6. DISMANTLING JOINTS

These joints should enable all valves and other fittings on the pipes to be dismantled and reassembled.

They shall be made of ductile iron or steel and sized in accordance with the diameter of the pipes and maximum service pressure.

They shall consist of two sleeves sliding into one another and fitted with an assembly flange at each end. Watertightness at the point of sliding shall be guaranteed by a rubber seal compressed by an intermediate companion flange.

The dismantling joint shall be assembled on the pipe and fittings by means of threaded rods.

It shall be of "free" type if the pipe is not submitted to longitudinal stress, and otherwise of "self-abutting" type.

2.1.7. FLANGES

Flanges shall be determined in accordance with standardisation rules depending on the diameter of the pipes and the service pressure.

They shall be of flat type, made of steel or stainless steel, to be welded on to pipes with a perpendicular face and drill holes.

The seal bearing surface may be raised, with concentric grooves 8 mm apart and 0.4 mm deep, without rough edges, in order to improve the adherence of the seal and prevent it from slipping.

The sealing surfaces of the flanges shall be coated. Careful attention must be paid to the angular position of the flanges.

2.1.8. SEALS

Seals shall be fitted between flanges; they shall be of flat type and adapted to the characteristics of the flanges.

Seals shall be made of webbed rubber or synthetic rubber.

2.1.9. DIELECTRIC INSULATING SEALS

All fittings of a different nature shall be mounted between flanges with dielectric insulating seals.

These insulating seals shall be made of an insulating material such as bakelite. They shall be fixed with appropriate bolts, nuts and washers.

2.1.10. BOLTING

All assembly screws, bolts, pins, threaded rods, nuts and washers shall be made of Z2CN 18-10 L stainless steel and comply with standardisation regulations with regard to the diameters and cutting of threads, which must not offer resistance. Threads of screws and bolts used on parts subject to vibrations and shocks shall be locked.

2.2. APPURTENANCES

2.2.1. VALVES

Isolating valves up to and including DN 300 shall be gate valves, and valves larger than DN 300 shall be butterfly valves, unless otherwise approved by the Engineer.

All valves shall conform to EN 1074.

All valves shall bear an identification mark on the body that shall include:

i) Name of the manufacturer and/or his trade mark;

ii) Nominal diameter (DN);

iii) Nominal pressure (PN);

The manufacturer's full technical specifications shall be supplied to the Engineer by the Contractor for approval prior to confirmation of any order for valves.

The valve body shall be cleaned and shot blasted before being internally and externally protected.

All isolating valves shall be protected by fusion bonded powder epoxy or equivalent, internally suitable for potable water and to a minimum thickness of 300 microns.

All valves shall be designed to conform to the pressure rating of the pipeline section except where otherwise specified.

All valves shall close when the stem rotation is in a clockwise direction unless otherwise specified.

Bidders shall supply full technical details of the proposed valves to be supplied with their Bid. If the Engineer considers the proposed valves to be inappropriate, he will reject them and instruct the Contractor to provide a suitable alternative. No additional payment shall be made where such changes occur.

Gate Valves

Unless otherwise specified gate valves of nominal diameters up to and including DN 300 shall be resilient seated and made of epoxy coated cast ductile iron in accordance with BS 5163. The epoxy coating shall be not less than 150 microns thickness. The gate shall be ductile iron and completely rubber encapsulated, the gate valve being of pocketless type with a straight through port.

The gate sealing shall be ensured by compression of the rubber. Wedge/gate guides of wear resistant plastic with high gliding features shall be provided in the body, optimally placed to guarantee low wear and tear of the gate and low closing torques.

Gate valves of nominal diameter larger than DN300 shall be of metal seated design with replaceable bronze facing seal/seat rings.

Gate valves shall be provided with integral flanged ends unless otherwise indicated.

Unless otherwise specified the face to face dimensions of gate valves with integral flanged ends shall be in accordance with ISO 5752 (short series).

Gate valves shall be of the non-rising stem type except where specifically indicated otherwise. The stem seal shall be of toroidal sealing rings (O-rings) with at least two such seals. Seals shall be capable of being replaced with the valve under pressure and in the fully open position.

The bonnet gasket shall be of elastomer (suitable for potable water). The bonnet studs or Allen screws shall be corrosion-protected. In addition the studs/Allen screws shall be placed in countersunk holes in the bonnet and completely sealed with wax or a suitable material, which could be removed by low-temperature melting in case they have to be disassembled.

The gate valve body shall be cleaned and shot-blasted before being coated internally and externally. The body, the bonnet and the gate of the valve shall be made of ductile iron to EN 1564, the gate being encapsulated with elastomer EPDM, nitrile or equivalent.

The operating stem shall be made of stainless steel at least equivalent to EN 10088 Part 1.4021, except in areas of aggressive soils where this shall be to ISO 10088 Part 1.44404.

The stem nut shall normally be made of high tensile brass to BS 1981, except in areas of aggressive soils where this shall be aluminium bronze to EN 12167.

Furthermore and in aggressive soils, outside bolts and nuts shall be made of stainless steel to EN 10088 Part 1.4301 or as detailed on drawings.

All valves shall be suitable for operation from the closed position by a 13 kg "push-pull" effort (total 26 kg) at the rim of the hand-wheel or tee key. Gearing and by-pass arrangement shall be provided for Gate Valves > 400mm dia.

Gate valves shall be of approved manufacture and pressure rating shall be as indicated on Drawings or in the Bill of Quantities.

They shall be tested to 1.5 time the normal working pressure.

Butterfly Valves

Butterfly valves for manual operation shall comply with EN 593 and shall be double flanged, resilient and metal seated tight shut-off design and of the double eccentric disc type supported from two shafts placed in self-lubricating bearing bushes.

Butterfly valves shall be of approved manufacture and pressure rating shall be as indicated on Drawings or in the Bill of Quantities.

Butterfly valves shall operate with a clockwise closing direction. The valve disk shall rotate though an angle between 0^0 and 90^0 inclusive. Butterfly valves shall be installed with shaft in horizontal position and the bottom half of the disc opening in the direction of flow.

The sealing ring shall be made of EPDM rubber and shall be attached at the disk edge circumference by a retaining ring without adjustment to form a resilient and durable seal.

The valve disc seal shall be replaceable without dismantling the operating mechanism, disk or shafts, and without removing the valve from the pipeline.

Butterfly valves shall be equipped with an operating gear mechanism placed in a waterproof housing. **The design of the gear mechanism shall be such that once the handwheel has been operated over around 50% of the total number of turns the valve disc rotates at a lower speed if the handwheel continues to be operated at the same pace**.

The time of closure of line-valves on the transmission pipeline and inlet valves at the downstream reservoir, from valve fully open to valve fully closed, **shall not be less than ten (10) minutes.**

For this purpose, the total number of handwheel turns from valve fully open to valve fully closed shall not be less than 100 turns for butterfly valves DN 400 and larger.

The operating mechanism shall be permanently lubricated, not in contact with the water, and provided with an indicator of the disk angular position.

Valve body, disk and disk retaining ring shall be in ductile "SG" iron casting to EN 1563. Disk shafts shall be in stainless steel to EN 10088:1.4021, complete with non-corrodible bearings.

The valve body shall be cleaned and shot blasted and internally and externally protected by an epoxy coating with a minimum thickness of 150 microns.

Butterfly valves shall be works pressure tested in accordance with EN 12266 Parts 1 and 2.

i) Body test at a minimum pressure of 1.5 times the maximum permissible pressure

ii) Seal test at a minimum pressure of 1.1 times the maximum permissible pressure.

Valves shall allow flow in either direction and shall be satisfactory for duties including isolation of pipeline section, frequent operation, and for applications involving valve operation after long periods of inactivity.

The Contractor shall ensure that there is sufficient clearance between the disc and the adjoining pipework to ensure that all Butterfly Valves operate freely, from fully open to fully closed and vice versa, under all conditions.

Air Release and Vacuum Break Valves

Automatic air release and vacuum break valves (air valves) shall be of the anti-shock anti-surge type designed to meet the following requirements. The required valves shall provide all of the functions described below.

Pipeline Filling - Uninterrupted high volume air discharge through the large orifice.

Pipeline Draining or Column Separation - Uninterrupted high volume air intake through the large orifice.

Pipeline Full and Operating - Discharge of dis-entrained pressurised air through the small orifice.

The air release and vacuum break valve shall be of a compact single-chamber design or of a twin-chamber design, with solid cylindrical High Density Polyethylene control floats or rubber encapsulated steel floats. These shall be housed in a stainless steel or corrosion protected body with epoxy powder coated cast iron, or stainless steel ends secured by means of stainless steel tie rods.

The valve shall have an integral surge alleviation mechanism which shall operate automatically to limit transient pressure rise or shock induced by closure due to high velocity air discharge or the subsequent re-joining of separated water columns. The limitation of pressure rise must be achieved by deceleration of approaching water prior to valve closure.

Discharge of pressurised air shall be controlled by the seating and unseating of a small orifice on a natural rubber seal affixed to the control float.

The air intake/discharge area shall be equal to the nominal size of the valve i.e. a 150 mm valve shall have a 150 mm intake/discharge orifice.

The valve construction shall be proportioned with regard to material strength characteristics, so that deformation, leaking or damage of any kind does not occur when exposed to 1.5 time the designed working pressure.

The air valve shall be provided with a built-in isolating valve.

Unless otherwise specified all air valves shall be provided with an integral flanged inlet with studs appropriate to EN 1092 PN 16 or as the installation demands and complying with the appropriate nominal pressure.

Air valves shall be of approved manufacture and pressure rating shall similar to the main pipeline.

Hand-Wheels and Valve Caps

Where hand-wheels are specified, they shall have the words 'open' and 'close' cast on them, together with an arrow indicating the direction for such opening or closing.

Valves for tee-key operation shall be provided with valve caps.

2.2.2. FLOW METER

The Flow meters shall be Electro-Magnetic type with local and remote displays with 4-20mA outputs and Modbus communication protocol capabilities.

The flowmeters shall be supplied complete with earthing rings and shall be installed in correct location as stipulated by manufacturer.

2.2.3. VALVE CHAMBERS

New chambers shall be constructed in accordance with the drawings, and where indicated, shall incorporate thrust walls.

Notwithstanding the size and shape of the valve to be supplied, the Contractor shall ensure that the minimum clearance as indicated on the drawings are provided within the chamber, and that where

chambers have pre-cast roofs the manhole cover provided shall be of a size sufficient to allow for the removal and replacement of the valve without disassembly and dismantling.

2.2.4. VALVE CHAMBER COVERS

All valve chamber covers shall be antitheft lockable ductile iron or antitheft lockable reinforced concrete with a weight of minimum 50 kg per piece and provided with embedded steel device for lifting at each end. They shall be supplied complete with antitheft locks and lifting keys. Except where a chamber is provided with pre-cast roof slabs to facilitate placing and removal of the valve or valves within the chamber, the clear opening in the chamber cover shall in all cases allow for this. It will be the Contractor's responsibility to ensure that the covers provided are of an appropriate clear opening size.

2.2.5. SURFACE BOXES

These shall be of cast iron, (hinged and locked) and from an approved manufacturer to BS 5834. They shall be sized to suit the purpose required and as otherwise shown on the relevant drawings.

2.3. SPECIAL TOOLS AND SPARE PARTS

Refer to Volume 2 – Part 1 - General Requirements

3. EXECUTION

3.1. HANDLING OF PIPES

Pipes of all types must be handled with care. Pipes shall be placed on the ground or laid in trenches gently, avoiding rolling them on stones or on rocky ground without first creating a runway using planks.

Any pipe accidentally dropped from any height whatever must be considered as suspect and may only be laid after further inspection. With regard to steel pipes, the coating shall be protected against friction wear by packing straw or other soft material between them. They must rest on planks and not on round timber.

All the above stipulations also apply to connections and fittings.

3.2. CUTTING PIPES

Depending on laying requirements, the Contractor shall be entitled to cut pipes. However, all necessary precautions must be taken to ensure that this is only done in cases of absolute necessity and as infrequently as possible.

Pipes may be cut by any process suited to the material in question, so as not to disturb its physical state and obtain a clean cut.

The Contractor shall do his utmost to ensure that the new spigot ends resulting from such operations are smooth and that they produce assemblies that are as reliable as ordinary pipe ends.

3.3. LAYING PIPES

Pipe interiors shall be inspected at the time of laying and carefully cleared of all foreign bodies that may have entered them. The ends shall be carefully cleaned.

Whenever work is interrupted, pipes being laid shall be blocked with a plug to prevent foreign bodies or animals from entering.

Tubes and connections shall be inspected before being assembled to ensure, in particular, that the outer protective coating and possible inner protective lining is intact or restored to its original condition.

Coatings and linings must be carefully repaired whenever they have been removed or damaged.

3.4. TESTING PIPES

A. Preparing the tests

Testing operations on joints and pipes shall be carried out by the Contractor at his own expense in accordance with the Engineer's instructions.

Tests are carried out in conditions that allow the pipe and especially all the joints to be properly examined. In particular, the Contractor shall provide and place all blank plates, thrust blocks supply pipes and any other accessory installations required for carrying out the tests, as stipulated, and all necessary equipment.

B. Test methods

All new pipelines shall be pressure tested. For pipelines within a trench, such tests shall be made before backfilling is reinstated. Unless otherwise approved, all joints shall be clear of earth, timber, etc. to allow visual inspection during the test. Testing shall commence immediately upon completion of installation and preliminary backfill, and construction of thrust blocks. Pressure testing shall be carried out for sections of convenient length which shall be approved by the Engineer prior to testing. Such lengths shall not exceed 1.2 km.

On completion of pipeline testing in sections and completion of all valving connections and other works, the whole pipeline shall be pressure tested up to the maximum working pressure of the pipeline.

The Contractor shall supply all necessary materials to carry out the test in accordance with the requirements including force pumps, water pressure gauges, as well as tools for the use of the Engineer, interconnecting pipework, feeding tank, blank flanges, temporary stop-ends, struts and water for the test. The test section shall be capped or flanged off at each end and all branches. Testing shall not take place against closed valves.

For a pipeline incorporating joints which cannot resist to axial thrusts, testing shall not commence until after all the permanent thrust blocks along the pipeline have been constructed, cured, and soil around them backfilled and compacted. Capped or flanged ends along the pipeline shall also be anchored adequately to withstand the force due to test pressure. The Contractor shall submit his proposals for temporary anchoring to the Engineer's approval.

After the main has been clear of debris, and all necessary stop-ends and gauges fitted to the Engineer's approval, the Contractor shall fill up the pipe with water free from silt, sand and grit and bring steadily up to the future working pressure of the pipeline under steady regime and this shall be maintained with a force pump for 24 hours.

The pressure shall then be increased steadily in increments of 1.0 kg/cm^2 with a pause of one minute between each increment to the specified test pressure for the section. Unless otherwise specifically mentioned, the applied test pressure shall be measured at the lowest point along the section being tested.

The test pressure shall be 50% in excess of the maximum pressure, the maximum pressure being 2 bar (for surge allowance) higher than the pressure under steady regime at the lowest point of the section being tested.

After a period of half an hour, the fall in test pressure shall be recorded and sufficient water again pumped into the line under test to bring the pressure back to the test pressure. The procedure shall be repeated every half-an-hour for a total period of 3 hours, or longer if the Engineer so directs, and the amount of water pumped in shall be recorded.

The rate of leakage shall be calculated from the amount of water pumped in during testing and if it is less than 1 litre of water per 10 mm diameter of pipe, per km of length of pipeline, for each 24 hours and for every 100m head, the pipeline will be considered to have passed the test.

C. Compliance and additional tests

The Contractor shall make good any faulty sealing observed during the tests, by immediately and at his own expense making any repairs whatsoever that the tests have shown to be necessary. However, he shall not bear the cost of replacing, supplying and placing parts not supplied by him if any weakness is shown to be due to the poor quality of the materials or faulty manufacture. The same is true of the cost of the preliminary investigations if such defects should be confirmed.

D. Report

A report is drawn up jointly by the Engineer and the Contractor for each test.

E. Height setting

Before any backfilling operations, the height setting of the pipes shall be checked systematically by a surveyor; this work will be paid for by the Contractor and submitted to the Owner for approval.

F. Inspection

All pipes of ≥1200 mm diameter shall be inspected visually prior to filling.

All pipes of <1200 mm diameter shall be inspected by video camera prior to filling.

All these inspections shall be recorded and sent to the Engineer. The cost of such inspections shall be borne by the Contractor.

3.5. FLUSHING AND STERILISATION

This shall be done in accordance with the recommendations set out in EN 805. All tested pipework shall be flushed, cleaned and sterilised.

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SECTION 15150
VALVES, GATES & APPURTENANCES

1. GENERAL

1.1. WORK INCLUDED

The present specification shall apply to the valves, gates and appurtenances as designed by the Contractor.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01000 - General requirements;

B. Section 01010 - Corrosion protection

C. Section 01030 – Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Civil Engineering works and Building works;

B. Section 01010 –Corrosion protection

C. Section 15100 – Pipes and fittings;

D. Electrical equipment specifications;

1.3. QUALITY ASSURANCE

1.3.1. STANDARD

International standards when available shall apply for valve construction and materials:

- AWWA standards
- ASTM standards
- API standards
- ISO standards
- DIN standards

Others standards (NF, BS, JIS, etc.) may be accepted.

1.3.2. DESIGN CRITERIA

1. All valves of the same type shall be from one manufacturer.

2. The Contractor shall make evidence of the hydraulic performance of the valves proposed and particularly the following:

   - Air valves.
   - Flow control valves.
   - Altitude valves (level control valves).
   - Overspeed valves.
   - Check valves.

1.3.3. SHOP TESTS

1. Performance Tests

   Each valve, gate and appurtenance shall be operated three times from the fully closed to the fully opened position and the reverse, under a no-flow condition to demonstrate that the complete assembly is workable.

2. Hydrostatic Test

   Valves specified shall be hydrostatically tested as follows:

   - Upstream/downstream Leak-tightness test at 1.1 times the maximum admissible working pressure at 20°C.

   - Body strength test at 1.5 times the maximum admissible working pressure at 20°C.

1.4. SUBMITTALS

The Contractor shall submit detailed shop drawings and working drawings with relevant calculation notes.

a. Calculation notes

The Contractor shall provide documentary evidence of the performances of the valves for the service as required.

b. Shop drawings

Shop drawings shall include but not limited to the following:

1. Lists and schedules of valves.

2. Dimensions, and materials.

3. Instructions for installation.

2. PRODUCTS

2.1. GENERAL

a. Construction

All valves of the same type shall be from one manufacturer.

All valves shall have following markings and they shall be designed cast in raised letters upon some appropriate part of the body:

- name of mark of manufacturer,
- year of manufacturing,
- working pressure,
- arrow direction for valves designed for one-way flow only.

Valve ends shall be flanged ends except where otherwise specified. Where flanged ends are used, mating dimensions and drilling shall be in accordance with the pipe and fitting flange as specified in section 14100 – Pipes and fittings.

Thickness of flanges shall be determined as based on the working pressure specified and shall conform to internationally accepted standards.

All materials which will be specified hereunder shall conform to AFNOR, ASTM, BS, DIN or other internationally accepted standards.

Valves shall be equipped with hand lever, manual actuator, pneumatic actuator or electric actuator as shown on the drawings or as required for the operation.

Actuators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

Valves 50 mm in size and smaller shall be all bronze, unless otherwise specified, except for hand wheels which shall be of cast or malleable iron and provided with screw ends.

The minimum working pressure of valve shall be as specified herein unless otherwise shown in the valve schedule.

b. Painting

All valves, gates and appurtenances, unless otherwise specified shall be shop primed on the exterior in accordance with the applicable specification of Section 01010 - Corrosion protection.

All valves, gates and appurtenances, shall have an inside lining certified by the recognized authorities for linings in waste water service.

2.2. GATE VALVES

All gates valves will have screw and yoke rising stem.

2.2.1. GATE VALVES

Gate valves shall be designed and manufactured in accordance with AWWA C500 or other internationally accepted standards. Working pressure shall be 10 bar.

The valve body and bonnet shall be of DIN 1693 grade GGG-40 ductile cast iron.

The stuffing box shall be the same materials of the body as specified above and shall be tight in the open position. The depth of the stuffing box shall be not less than the diameter of the valve stem. Packing for the stuffing box shall be made of suitable materials approved by the Engineer. Asbestos shall not be used. O-ring stem seals may be used, subject to the approval of the Engineer and these seals shall have a minimum of two (2) "O" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stem shall be stainless steel, DIN 17 440 grade I-4462.

2.2.2. RESILIENT-SEATED GATE VALVES

Resilient-Seated (RS) gate valves shall be designed and manufactured in accordance with AWWA C509 or other internationally accepted standards. Working pressure shall be 10 bar.

RS type gate valves shall be DIN 1693 grade GGG-40 ductile cast iron-body resilient-seated gate valves with non-rising stems (NRS) and outside screw-and-yoke rising stems. Valves shall be designed to provide an unobstructed waterway having a diameter of not less than the full nominal diameter of the valve when in the open position.

For stem seals, either gland packing or O-rings included other pressure-actuated stem seal shall be provided. The stuffing box or O-rings packing plate shall be the same materials of the valve body. Gland packing for the stuffing box shall be made of suitable materials approved by the Engineer. Asbestos shall not be used. O-ring seals shall be designed to have a minimum of two O-ring seals, of which at least one shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stems shall be stainless steel DIN 17 440 grade I-4462.

All valves shall be equipped with handwheels.

Resilient seats shall be applied to the gate and shall seat against a corrosion-resistant surface. The surface shall be non-metallic applied in a manner to withstand the action of line fluid and operation of the sealing gate under long-term service. Resilient seats shall be bonded or mechanically attached to the gate. All exposed mechanical attaching devices and hardware used to retain the resilient seat shall be of corrosion-resilient material.

Bolts and nuts to be used for bonnet, packing plate, gland and others shall be stainless steel unless otherwise noted.

All interior and exterior ferrous parts of the valve except for finished or seating surfaces shall be finished with fusion bonded epoxy protective coating conforming to AWWA C213. Total dry film thickness on the interior and exterior surface shall be more than 400 microns and not less than 300 microns respectively.

2.2.3. BRONZE GATE VALVES

Bronze gate valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar. Valves shall be equipped with either screw ends or flanged ends. Valves in size 50 mm and smaller shall be bronze body, screw bonnet, gate valves having a solid wedge, inside screw and rising stem.

Valves in size 65 mm and 80 mm shall be bronze body, flanged bonnet, gate valves having a solid wedge, inside screw and non-rising stem.

The body shall be bronze casting having tensile strength not less than 196 N/mm². Disc shall be bronze casting specified above or copper having tensile strength not less than 314 N/mm². Stem shall be copper specified above.

2.2.4. STAINLESS STEEL GATE VALVES

Stainless steel gate valves shall be solid wedge disc type gate valves with outside screw-and-yoke rising stems and designed for handling acids or other chemicals. Valves shall have hand wheels and flanged ends. Working pressure shall be 10 bar.

Unless otherwise specified, major parts of the valve such as body, bonnet, stem, disc, gland with gland bolts and nuts, bonnet bolts and nuts and other parts which may contact with handling liquid shall be made of AISI 316 stainless steel and stainless steel casting.

2.3. BUTTERFLY VALVES

2.3.1. FLANGED BUTTERFLY VALVES

Valves shall be cast iron or ductile iron disc elastomer-seated, tight closure butterfly valves and shall be designed and manufactured in accordance with AWWA C504. Valves shall be designed for a maximum nonshock shut off pressure of 10 bar. Flanges shall conform to ISO PN 10 and flange to flange dimensions shall conform to ISO 5752 series 14. Valves body shall be ductile iron and shall conform to DIN 1693 grade GGG-40.

Valve shafts shall be made of AISI 316 stainless steel or Monel. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of "stub shaft" construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Elastomer seats shall mate with the following seat surfaces which shall conform to AWWA C504: Stainless steel, Monel or bronze. Sprayed or plated mating seat surfaces shall not be used. Deposit seat surfaces may be acceptable if approved by the Engineer.

Elastomer seat for valves, 600 mm and smaller shall be clamped, mechanically secured, bonded, or vulcanized to the valve body.

Rubber seats for valves, 700 mm to 1,800 mm shall be mechanically clamped or secured to the valve body or disc.

All clamps and retaining rings for elastomer seats shall be of corrosion-resistant material with a maximum zinc content of 16 per cent and a maximum aluminium content of 3 per cent. All nuts and screws used with clamps and retaining rings shall be of stainless steel, and shall be secured with resin.

Valve disc shall be of a cast or fabricated design with no external ribs transverse to the flow. Valve discs shall be of ductile iron, or stainless steel. They shall conform to these as specified below:

- Ductile iron: DIN 1693 grade GGG-40.
- Stainless steel: AISI 316 or other type approved by the Engineer.

Shaft seals shall be provided wherever shafts project through the valve body. Shaft seals shall be preferably designed for standard O-ring seals. O-ring seals shall be contained in a removable corrosion-resistant recess.

2.3.2. WAFER BUTTERFLY VALVES

Wafer butterfly valves for water shall meet the applicable requirements specified in 2.3.a) above for flanged Butterfly valves except as otherwise specified herein.

Valves shall be designed to fit between two pipe flanges and for the maximum nonshock shut-off pressure of 10 bar.

Valves shall be either seat-in-body and have elastomer seat which shall be designed to lap over both faces of the valves, or designed in compliance with watertightness specifications of paragraph 2.3.a).

2.4. CHECK VALVES

2.4.1. SWING CHECK VALVES

Swing check valves shall be DIN 1693 grade GGG-40 ductile cast iron body and disc, and bronze seating type. The valves shall be designed and manufactured in accordance with AWWA C508. Working pressure shall be 10 bar. Flanges shall conform to ISO PN 10 and flange to flange distance shall conform to ISO 5752 series 14.

Valves shall be suitable to operate in a horizontal or vertical position with flow upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valve shall be furnished with hinge arms, levers and springs or weights and when necessary, furnished with a by-pass pipe and by-pass valves.

2.4.2. SPLIT DISC WAFER CHECK VALVES

Split disc wafer check valves shall be dual plate, two spring-loaded, semicircular plates type. The valves shall be designed and manufactured in accordance with API 594, equally or more stringent internationally accepted standards.

Valves shall be designed to fit between two pipes flanges and for a working pressure of 10 bar.

Valve body and plates shall be of cast iron, ductile iron or AISI 316 stainless steel. Bronze casting plates may be permitted. Hinge pin, stop pin and springs shall be of AISI 316 stainless steel. Valves shall have resilient seating in the valve body unless otherwise specified. Seat materials shall be EPDM or high content nitrile (BUNA "N") elastomer.

2.4.3. BRONZE SWING AND LIFT CHECK VALVES (50 MM AND SMALLER)

Bronze swing and lift check valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar. Valves shall be equipped with screwed ends.

Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Lift check valves shall be suitable to operate in a horizontal position with flow upward when fully open. Both of swing and lift check valve shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be bronze body, screwed bonnet and disc. Valves shall be designed to have bronze seatings or resilient seating. Resilient seats shall be made of Teflon.

The body shall be bronze casting, and bonnet and disc shall be of bronze casting or copper. The said bronze casting and copper shall conform to the requirements specified in 2.2 c) above.

2.4.4. AXIAL SPRING LOADED CHECK VALVES

The axial spring loaded check valves shall be low stroke, low inertia check valve consisting of a body in the form of concentric rings supported by spacers and a mobile sealing assembly incorporating a similar arrangement of concentric rings to those in the body. Working pressure shall be 10 bar. Valves shall be equipped with flanged ends. The body shall be cast iron conform to ASTM A48-64-35B. The sealing assembly shall be made of polyurethane. The spring shall be stainless steel conform to AISI 316L or equivalent.

2.5. PLUG VALVES

Plug valves shall be DIN 1693 grade GGG-40 ductile cast iron body, non-lubricated, resilient faced eccentric plug type valves. Valves shall be designed for a working pressure of 10 bars.

Port areas of valves shall be at least 80% of the full pipe area.

The valves body and bonnet shall be cast iron or ductile iron or a corrosion resistant, cast-iron alloy containing 1% to 1.5% nickel. The materials specified above shall have a minimum tensile strength of 216 N/mm². If the body is cast iron, the seat shall have a welded-in everlay of not less than 90% pure nickel on all surfaces contacting the plug face. The seat face shall be machined. If the body is corrosion resistant cast-iron alloy, the raised seat shall be machine finished and protected with an approved epoxy coating.

The plug shall be cast iron as specified for the body and shall have a resilient coating to provide bubble-tight shutoff. The resilient coating shall be chloroprene (Neoprene).

2.6. GLOBE VALVES

2.6.1. ANGLE HOSE VALVES

Angle hose valves shall be bronze body Y-Globe valves with renewable composition disc. Valves shall have rising stem and screwed ends with stainless steel replaceable quick coupling and cap. Working pressure shall be 10 bar. Valves shall be designed and manufactured in accordance with standards approved by the Engineer.

Discs shall be hard but sufficiently resilient to maintain tight seal within the pressure and temperature range and have high flexural and impact strength. Discs shall be made of Teflon or other materials approved by the Engineer.

Disc holder shall be made of bronze casting or copper.

2.6.2. HOSE BIBS

Hose bibs shall be bronze body globe valves with renewable composition disc. Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 10 bar. Valves shall be designed and manufactured in accordance with standard approved by the Engineer and shall be swivel nose faucet, faucet with hose coupling or lawn faucet.

Stem with disc and disc nut shall be bronze, bronze casting or copper. Disc shall be medium soft composition as recommended by the manufacturer for the intended use.

2.7. DIAPHRAGM VALVES

Diaphragm valves shall be of the weir or straightway type as noted, with cast iron body, resilient reinforced rubber diaphragm and cast iron bonnet. They shall be fitted for spoked hand wheel operation.

The valves shall be used in water, air, and weak chemical service lines.

The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide an adequate water-way for minimum pressure loss. Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of easy replacement without removing the valve body from the pipe line.

The valves shall be protected against corrosion with a minimum 3.0 mm thick neoprene lining suitable for the service intended and consistent with associated piping unless otherwise noted.

2.8. BALL VALVES

2.8.1. BALL VALVES FOR WATER LINES

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for a working pressure of 10 bar and shall have screwed ends. Valves shall be wrench operated.

Major parts of the valve such as body, steam and ball shall be made of AISI 304 or 316 stainless steel and stainless-steel casting.

2.8.2. STAINLESS STEEL BALL VALVES FOR CHEMICAL SERVICE

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for handling chemicals and for working pressure of 10 bar. Valves shall have flanged ends.

Valve ports shall be at least the area of a circle of diameter equivalent to the nominal size of the valve. Valves, 100 mm and smaller in diameter shall be wrench operated. Valves, 125 mm and larger shall be hand wheel operated through a worm gear. Port position shall be plainly visible to the operator by means of an indicator.

Unless otherwise specified, major parts of the valve such as bodies, stem, ball, gland with gland bolts and nuts and other parts which may contact with handling liquid shall be made of AISI 316 stainless steel and stainless steel casting.

2.9. OVERSPEED VALVE

The overspeed valve shall be self-operating automatic shut-off valve consisting of:

- hydraulically controlled butterfly valve, opened by hand operated hydraulic actuator and closed by counterweight with adjustable dash-pot,
- mechanical overspeed detection system with adjustment facilities,
- shut-off mechanism ensuring irreversible closing of the valve upon overspeed condition is detected.

The valve shall be double flanged type and shall comply with the specifications related to butterfly valve as far as design and materials are concerned.

The valve shall be equipped with a set of limit switches in IP67 enclosure.

2.10. PRESSURE REDUCING VALVES

Pressure reducing valves for plant water service shall be DIN 1693 grade GGG-40 ductile cast iron body, self-contained, direct-acting, spring-loaded type. Valves shall operate at a primary pressure range of 0 to 10 bar and at an adjustable secondary pressure range of 1.5 to 6 bar. Valves shall have flanged ends and the working pressure shall be 10 bar.

All parts subject to wear shall be accessible for repair or replacement without removing the valve from the line. Secondary pressure of valve shall be designed to be adjustable without any use of special tools while it is in service.

Two (2) manometers one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided.

2.11. AIR VALVES

2.11.1. SINGLE ORIFICE TYPE AIR VALVES

Single orifice type air valves shall be DIN 1693 grade GGG-40 ductile cast iron body and single float actuated air valves with flanged ends. Valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar.

Valves shall automatically operate so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

Each valve shall be furnished with integral bronze casting stop valve and cast iron flange.

Floats and balls shall be stainless steel, DIN 17 440 grade I-4301.

2.11.2. DOUBLE ORIFICE AIR VALVES

Double orifice air valves shall be DIN 1693 grade GGG-40 ductile cast iron body and double float actuated air valves with flanged ends. Double orifice type air valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure of all air valves shall be 10 bar.

Double orifice shall be designed to automatically operate so that they will:

- Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation.
- Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation.
- Exhaust accumulated air under pressure while the pipe is flowing full of water.

Each double orifice type air valve shall be furnished with stop valve, same size as air valve.

Floats and balls shall be stainless steel, DIN 17 440 grade I-4301.

2.12. PRESSURE RELIEF VALVES

2.12.1. FUNCTION

The pressure relief valves will limit pressure surges in the mains. The pressure relief valves shall discharge water as soon as the water pressure becomes greater than the watertightness pressure which shall be field adjustable.

2.12.2. CONSTRUCTION

The pressure relief valves shall consist of:

- a fixed bevelled horizontal nozzle,
- a flat mobile disc,
- a steel spring working in compression and pushing the disc downwards against the nozzle,
- a metallic hood diverting the discharge flow downwards.

The disc shall have no mechanical guides and shall centre hydraulically itself on the water jet. The mechanical characteristics of the valve shall be calculated in the purpose to contribute to this self centering. There shall be no possibility of friction or jamming because of incrustations or deposits. The movement of the self-centering disc shall be perpendicular to the contact plane between disc and nozzle. Moving parts shall be of low inertia.

Watertightness shall be obtained by very carefull machining of the rigid corrosion-resistant metal contact surfaces.

Provision shall be made for adequate aeration of the discharge flow.

Watertightness must be obtained as soon as disc and nozzle are in contact without requiring additional compression.

Access to wear parts shall be quick and easy, and their replacement shall not require disassembling or disadjustment.

The valve shall be equipped with a connecting flange according to ISO PN 10.

2.12.3. MATERIALS AND PROTECTION

All active components such as nozzle, disc, springs, etc. shall be made of stainless steel.

The hood shall be painted with a red oxyde primer and additional finishing coats.

2.12.4. PERFORMANCE

The pressure relief valves shall be watertight until the sealing pressure specified in the Schedule is reached. When the valve is fully open the pressure below the disc shall not exceed the maximum pressure specified in the Schedule for a given discharge (also specified in the Schedule) throught the valve.

2.12.5. FACTORY TESTS

The valves shall be tested at the design working pressure with the disc in the closed position to demonstrate the tightness of the disc and seats. Leakage shall not exceed 200 ml per-minute.

2.13. VALVES ACTUATORS

2.13.1. GENERAL

Actuators shall be capable of seating, unseating and rigidly holding the valve disc in any intermediate position under the maximum design unbalanced head and water velocity.

Means for holding the valves in intermediate positions shall be furnished.

The operating mechanism of butterfly valve actuators shall incorporate worm gears bronze and worms of hardened steel operating in a lubricating bath totally enclosed in a sealed water tight gear case.

All valves shall be equipped with adjustable mechanical stop limiting devices to prevent over travel of the valve disc in the open or closed position.

Actuator housing, supports and connections to the valve shall be designed with a minimum safety factor of five (5) based on the ultimate strength, of three (3), based on the yield strength, of the material used.

Each actuator shall be provided with a position indicator to show the position of the valve disc at all times. The indicators shall be read in per cent (0-100%) with minimum graduation of 5%.

Manual actuators shall require an input force of not greater than 18 daN pull on either hand wheel or crank. Hand wheels shall be of cast iron, clearly marked with an arrow and the work "open" and "close" cast in relief on the rim. Hand wheels shall be of the spoke type only. Webbed or disc type shall be used.

2.13.2. MANUAL ACTUATORS

1. Manual Actuators for Gate Valves (500 mm and smaller)

   Manual actuators for gate valves, 500 mm and smaller including resilient-seated gates, non rising stem type shall be wrench nuts and hand wheels type without reducing gear. Rising stem type resilient-seated gate valves shall be equipped with hand wheels without reducing gear. Wrench nuts and hand wheels shall be made of cast iron or ductile cast iron.

2. Manual Actuators for Gate Valves (600 to 1,000 mm)

   Manual actuators for gate valves, 600 to 1,000 mm shall be bevel gear type, totally enclosed actuators. Actuators shall be equipped with hand wheel and linear position indicator which shall be read in per cent (0-100%) with minimum graduation of 5%. The hand wheel shall be cast iron or ductile cast iron, and spoke type of suitable size. Operators shall be designed so that a pull of not more than 18 daN on a hand wheel which will produce an output torque equivalent to the maximum valve shaft torque required to operate the valve under actual line pressure and velocities.

3. Manual Actuators for Butterfly Valves

   Manual actuators for butterfly valves shall be essentially an integral part of a butterfly valve. The rated torque capability of each actuator shall be sufficient to seat, unseat and rigidly hold in any intermediate position the valve disc. All valves shall be equipped with an adjustable mechanical stop-limiting devices to prevent over-travel of the valve disc in the open and closed positions. Actuator housings, supports, and connections to the valve shall be designed with a minimum safety factor of five (5), based on the ultimate strength, or three (3), based on the yield strength, of materials used.

Each manual actuator shall have all gearing totally enclosed. Actuators shall be designed to produce the specified torque with a maximum pull of 36 daN on hand wheel. Stop-limiting devices shall be provided in the actuators for the open and closed positions.

All gears actuators shall be self-locking and designed to transmit two (2) times the required actuator torque without damage to the faces of the gear teeth. Each manual actuator shall be equipped with a position indicator which shall be read in per cent (0-100%) with minimum graduation of 5%. The graduation shall be engraved on actuator cover plate.

Unless otherwise specified, the minimum number of handweel turns to rotate the disc from the fully open to the fully closed position, or vice versa, shall be as follows:

DN (mm)	Number of turns
300	25
400 to 600	30
800 to 1500	50

Butterfly valves with diameter lower than 100 mm may be operated by levers.

4. Gearing

Gears shall be of ductile iron, steel, or bronze, accurately machined with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings of ample size.

All gears and bearings shall be enclosed in a cast iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated.

2.13.3. ELECTRIC ACTUATORS

1. General

Two (2) types of electric actuators such as type A, integral control type and type B, standard type shall be specified hereinafter.

Each type of electric actuator shall be furnished in weatherproof construction. The motor shall operate on 380 volt, 3-phase, 60 hertz, service for open-close service.

Each type electric actuator shall be mounted by the valve manufacturer, tested and adjusted prior to shipment:

- Type A integral control type.

  Electric actuator, Type A shall be integral control type and shall include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, pushbutton station, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

  The valve control units shall have pushbutton stations furnished in enclosures suitable for flush panel mounting or field mounting as required. The stations shall include pushbuttons, status lights, and a selector switch all as required.

- Type B standard type.

  Electric actuator, Type B shall be standard type and shall include, but not be limited to, the electric motor, limit switches, torque switches, space heaters, valve position potentiometer if specified, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

2. Electric Actuators for Butterfly Valve

Gear case shall be of cast iron. Flanges for actuator attachment shall be integrally cast, fully machined, and template drilled.

Motors for electric valve actuator shall be capable of producing not less than 1.5 times the required operating torque.

Any gearing in direct association with the electric motor drive shall be totally enclosed and shall operate in a lubricant.

Actuator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the valve has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel.

Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the driving mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the adjustable type capable of being set to trip at the fully open and fully closed valve positions or at any point between. All electrical interconnections between limit switches, torque switches, indicator lights, and so forth, shall be factory wired and ready for operation. All gearing used in connection with limit switches shall be factory-lubricated.

Actuator shall be provided with a position indicator to show the position of the valve at all times. The indicator shall be read in per cent (0-100%) with minimum graduations of 5%.

Actuator shall be equipped with a hand wheel for manual operation. The hand wheel shall be connected so that operation of the motor will not cause the hand wheel to rotate and the operation of the hand wheel shall not cause the motor rotor to rotate. The hand wheel shall be engaged by an exterior level or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases. Should the power return to the motor while the hand wheel is in use, the design of the unit shall prevent the power from being transmitted to the hand wheel.

An arrow and the word "open" and "close" shall be placed on the hand wheel to indicate direction of resultant valve movement. Lettering shall be in the English language.

2.14. SPECIAL TOOLS AND SPARE PARTS

Refer to General Requirements

3. EXECUTION

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SECTION 15 200
STOP LOGS

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the sliding stop logs of the Plant.

The supply shall include the following main items:

1. Embedded parts including lateral guides,
2. Stop log leaf ,
3. Equipment for storing and holding in position the stop log.
4. The anchoring system of the built-in parts embedded in the secondary concrete,
5. The corrosion protection work,
6. The anchoring and support parts to be held or embedded in the primary concrete.
7. The special tools and the spare parts.

1.2. RELATED WORKS

A. Supplies and works included under this section shall comply with the requirements of the following:

1. Section 01010 - Corrosion protection
2. Section 01020 - Basic mechanical requirements
3. Section 14000 – Conveying systems

B. Work under this section shall be co-ordinated with:

1. Civil Engineering works and Building works;

1.3. QUALITY ASSURANCE

1.3.1. DESIGN CRITERIA

The stop logs shall be designed to withstand without damage an MCE (maximum credible earthquake).

1.3.2. SOURCE QUALITY CONTROL

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
   a) At the end of manufacture, the stop log shall be presented, unpainted, for checking. The seals and the embedded parts shall be presented separately.
   b) Stop logs and embedded parts:
   The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.
   All dimensions of stop log members shall be checked.
   The operation of by-pass valves shall be checked.
   The Engineer reserves the right to participate in these tests.
   a) Welds:

   Refer to Section 01020.

1.4. SUBMITTALS

The Contractor shall submit detailed shop drawings and working drawings with relevant calculation notes.

a. Calculation notes

The Contractor shall provide documentary evidence of the performances of the valves for the service as required.

b. Shop drawings

Shop drawings shall include but not limited to the following:

1. Lists and schedules of valves.
2. Dimensions, and materials.
3. Instructions for installation

1.5. GUARANTEE

A. Vibration

The operation of the stop log shall be guaranteed free of vibration. No tolerances are allowed.

B. Sealing

1. The equipment shall satisfy the guarantees specified hereunder, without any special means having to be used for sealing.
2. Local leaks and average leaks per linear metre of seal shall not exceed the following values:
   a) local leaks: 0.025 litres per second,
   b) average leaks: 0.010 litres per second.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURE

2.1.1. EMBEDDED PARTS

1. The lower embedded parts shall include:
   a) On the downstream (or upstream) side the sliding beams and the stainless steel sealing plates,
   b) On the upstream (or downstream) side the back rails,
   c) The sill made of a steel section fitted with a stainless steel support plate and mating with the shape of the skin plate,
   d) The lintel cross beam on the downstream (or upstream) side, fitted with a stainless steel sealing plate. The top part of this lintel beam shall be provided with a funnel to ensure an efficient sealing contact when the stop log reaches the end of the closing operation,
   e) Lateral guide rails.
2. The upper embedded parts shall include:
   a) The lateral guide rails up to the top of the slot.
   b) At the top of the slot, the system to store the stop log in open position. This system shall include the movable wedging pieces and their fixed supports together with anchors.
   c) Above the top of the slot, the systems used for wedging the stop log during storage of the stop log in maintenance position. This system shall include the movable wedging pieces and their fixed supports together with anchors.

2.1.2. STOP LOG LEAF

1. The stop log shall be of welded construction and, to facilitate transport and operation, could be in two parts.
2. The stop log shall have downstream (or upstream) skin plate and seals,
3. The leaf shall be supplied with the necessary supports for storage of the stop log in open and maintenance position.
4. The upper girder of the leaf shall accommodate the necessary lifting lugs for connection to the lifting equipment. Lifting lugs shall be in the same plane as the centre of gravity of the stop log.
5. Two guide blocks shall be provided on each side of each stop log or section.

   Their location shall be such that the highest and lowest bumper plates are separated from each other as much as possible.
   The stop log shall be provided with sufficient space for sideward movement but the bumper plates shall hold the stop log in a centered position, no more than 5 mm from the centerline of travel.
   All stop log members shall have a minimum clearance from embedded parts of 10 mm.
6. The Contractor shall take the necessary steps to allow easy dismantling of the seals.

2.2. SPECIAL TOOLS AND SPARE PARTS

The Contractor shall supply the following spare parts:

1. One complete set of seals with 20% stainless steel bolts for the stop log leaf.
2. One complete set of seals for the by-pass valve.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

A. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

B. The Contractor shall check the dimensions and setting of the sluice.

3.2. FIELD QUALITY CONTROL

A. Inspections before and after concreting

1. Inspections:
   a) Position of the sill,
   b) Distance between the lateral embedded parts,
   c) Perpendicularity of the lateral embedded parts with the sill and the frontal beam,
   d) Flatness of the embedded parts, verticality, horizontality,
   e) Position of storage and maintenance systems.
2. Erection tolerances: refer to Section 01020.

B. Dry tests

1. Testing of the various operations required for sluice closure and opening (Seal friction surfaces shall be wetted),
2. Checking the position of seals with respect to lateral embedded parts and sill,
3. Checking the position of lateral guide systems with respect to lateral embedded parts,
4. Checking the position and operation of the storage system,
5. Examination of paintwork.

C. Final tests

With the normal operation water level:

1. Inspection of seals and seal leakage.
2. Testing of the various operations required for closure and opening of the sluice.
3. Examination of paintwork.

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SECTION 15600
AIR COMPRESSORS

1. GENERAL

1.1. SCOPE

The present specification shall apply to units producing compressed air for various uses, especially pneumatic operation and air lift systems. They apply for the whole unit of compressor, air reservoir, filters and valves.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

A. Section 01010 - Corrosion protection;

B. Section 01020 - Basic mechanical requirements;

C. Electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

A. Concrete works covered by the Civil Works Section;

B. Electrical works covered by the Electrical Equipment Section;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

Compressors shall be electrically driven, piston, type. They shall deliver oil free air and shall be fitted with suction filter and silencer, automatic unloading device for starting at no load and safety relief valve.

One air cooled after-cooler shall be installed between the compressor and the air receiver.

The compressor, the motor and air reservoir should be mounted at a common bedplate.

The compressor should be automatically operated by a manostat measuring the air pressure in the air reservoir.

The compressor should be fitted with a security valve big enough to evacuate the entire airflow of the machine.

1.4. QUALITY ASSURANCE

A. Standards

The BS, AFNOR, ASTM and ISO standards shall apply.

B. Design criteria

Compressors shall be designed for the specified performances and shall operate whitout overheating, excessive vibration or strain.

Air flow capacities and pressures shall be chosen for the application in order to not overcharge the equipment.

C. Workshop test

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3. Workshop inspections and tests:

   a) The seals and the embedded parts shall be presented separately and unpainted for checking.

   b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

      All dimensions shall be checked.

   a) Welds:

      Refer to Section 01020.

1.5. SUBMITTALS

The Contractor shall submit calculation notes, characteristics, shop drawings and part lists for approval.

2. PRODUCT

2.1. FABRICATION

2.1.1. COMPRESSOR

The compressor casing and the piston shall be in ductile cast iron. The shaft shall be in stainless steel.

2.1.2. AIR RESERVOIR

The air reservoir shall be in stainless steel. The reservoir shall be factory tested for a pressure of at least 1.5 times operating pressure. The volume of the reservoir shall be chosen in a manner to minimize the number of starts of the compressor to 15 per hour.

2.1.3. PIPING

Pipework shall be done with stainless steel or UPVC pipes.

2.1.4. NAMEPLATE

Each compressor shall bear a nameplate indicating capacity and pressure, serial No., type or model and other pertinent information.

2.2. SPARE PARTS AND TOOLS

The following spare parts shall be furnished for each compressor for 3 years of operation and maintenance:

a. One (1) check valve.

b. One (1) complete set of bearings.

c. One (1) complete set of V-belt.

d. Two (2) complete sets of all gaskets.

e. Three (3) complete sets of all packing required for the compressor.

f. One (1) lantern rings, complete set of piston rings.

g. Two (2) complete sets of all special bolts, screws and nuts.

h. One (1) complete set of special tools required for maintenance of the compressor.

i. One (1) pressure switch.

j. One (1) pressure gauge.

In addition to the above mentioned, the contractor shall propose and furnish the necessary spare parts for three years operation.

3. EXECUTION

3.1. INSTALLATION

The compressors can be fixed, used only for one specified purpose, or portable, multipurpose.

Fixed compressors shall be mounted on a concrete foundation. All handling and placing of the equipment including levelling and alignment shall be done by the Contractor. The compressor shall be fixed by expanding bolts or anchor bolts furnished by the Contractor.

3.2. SHOP AND FIELD PAINTING

The compressors and belplates shall have shop and field coating. Painting shall be conform to the requirements as specified in section 01010 – Corrosion protection.

3.3. FIELD TESTS

As soon as convenient after the equipment is installed, each unit shall be field tested to determine that the units have been properly installed, to verify factory test, and to demonstrate that the complete units will operate continuously without overheating and that the drives are not overloaded.

The portion of the test to demonstrate satisfactory continuous operation shall be for five (5) continuous hours. During the field test operation total pressure shall be as near the condition point total head as conditions at the site will permit.

Reading off of all essential data shall be taken and recorded at 30 minutes intervals. All instruments required for the readings shall be acceptable calibrated devices furnished by the Contractor at no additional cost to the Employer. Readings required include, but are not limited to, voltage, amperage, power factor, RPM, discharge pressure, flow, temperatures and vibration. Full details of test procedures will be as determinated or approved by the Engineer based on conditions existing in the field at the time of the tests. The Contractor shall submit six (6) copies of all results arranged and neatly presented for the approval of the Engineer.

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SECTION 16010
BASIC ELECTRICAL REQUIREMENTS

1. GENERAL

1.1. SCOPE

This section specifies general requirements applicable to all electrical equipment to be supplied unless different requirements are specified in the subsequent Sections.
In case of conflict between the requirements of this general specification and those of the specific equipment specifications, the latter shall have precedence.

1.2. QUALITY ASSURANCE

1.2.1. GENERAL

All items of equipment shall be designed giving due consideration to the most recent technical advances. They shall include the necessary back-up facilities to ensure reliable execution of the services specified not only during normal operating periods but also in the event of faults.
The aesthetic aspect of the equipment shall be studied with particular care in order to be sure that it blends in with the general architecture of the works.

1.2.2. SAFETY SYSTEMS

The installations shall be designed and manufactured to achieve the highest possible level of safety to both operating personnel and equipment. The equipment shall offer access without danger for inspection and maintenance purposes.
Low-voltage circuits shall be installed in such a manner that no live component comes within normal reach.
The design and erection of the electrical installations shall conform with IEC 60364 and the latest edition of BS 7671 18th Edition Requirements for Electrical Installations.

1.2.3. INTERLOCKING

Provision shall be made for all necessary interlocking systems to prevent potential accidental operations.
Switchgear cubicles shall be designed in the following manner:

1. Door opening shall be mechanically linked to the position of the switch and control gear so that internal access to the compartment concerned shall be possible only if all the devices therein are disconnected and if this compartment is physically separated from neighbouring compartments possibly containing live devices.

2. A cylinder lock and three keys shall be supplied by the Contractor for all cabinets or cubicles.

Electrical devices shall be interlocked mechanically, electrically or by means of keys, thereby making it impossible to operate a device until all other devices on the same circuit are in a configuration allowing such operation.
A general panel shall give details of all these instructions, and for this purpose shall include an explicit diagram.
All these instructions shall be submitted for the prior approval of the Engineer.

1.2.4. DISASSEMBLY

The equipment shall be designed so that any item or part of the equipment can be easily dismantled for maintenance, possible repairs or handling. Dismantling and maintenance of any or all parts of electrical equipment shall be made as simple as possible, without any need to interrupt the operation of neighbouring equipment.

1.2.5. INTERCHANGEABILITY - STANDARDISATION

With a view to standardising the equipment installed and reducing the number of spare parts, the Contractor shall as far as possible minimise the number of appliance ratings used by including the maximum number of standard electrical and mechanical components.
Interchangeability of electrical appliances of equivalent rating shall also apply to their auxiliary contacts.
If certain modifications are made to the equipment during manufacture or erection, these modifications must be approved by the Engineer and, in this case, shall be applied to all the appliances of the same type.

1.2.6. MARKINGS

The various components of the electrical installations: appliances, conductors, cables, etc. shall be given material markings and rating plates giving information on their nature and the section to which they belong.
Marking standards shall be submitted for the Engineer's prior approval. They shall be based on the following rules.
All marking and labels shall be in English.
Markings on diagrams shall be designed to make such diagrams easier to read and understand and to indicate the exact location of appliances and terminals which may have to be inspected, especially for troubleshooting purposes.
The material markings used must enable the corresponding components of the installation to be located rapidly and without ambiguity both on the diagram and in the actual installation.
Markings shall be given on:

1. The main installation centres such as the machine room, control room, outdoor substation, etc...
2. Items of the installation which form functional assemblies or subassemblies, such as parts of boards or cubicles allocated to a section, distribution boxes, cells, isolated switchgear and controlgear cabinets.
3. Main appliances (pumps, motors, transformers, etc.).
4. Secondary appliances (relays, switchgear, control gear, etc.).
5. Intermediate wiring terminals.
6. Connections.
7. Conductors.

8. Cables.

Unless indicated to the contrary, the markings of the main installation centres shown on the diagrams do not need to be materialised in the actual installation.
The "installation components" must be very clearly identified by means of their complete composite marking with, in addition, an indication for identifying the section to which they belong. "Common items" must be identified by their functional markings with, in addition, a clear indication of their nature wherever possible.
The main appliances shall be provided with their functional marking with indication of the section to which they belong and, where needed, the diagram sheet number on which they are fully represented.
If necessary, they must also be provided with a rating plate clearly indicating their nature and exact function. This will be the case, for example, for contactors or circuit-breakers on the auxiliaries distribution board.
Devices which are fixed to panels and are back connected shall be identified both at the front and at the back of the panel. This will be the case, for example, for push buttons, switches, etc.
Secondary appliances are always provided with their functional identification mark. In addition, they are identified as follows:

1. With their position marker if they are fitted inside an installation component and the main installation centre marker if they are installed alone.

2. With the sheet number of the diagram on which they are fully represented.

Terminal strips are identified by means of the lower-case letter used on the diagrams for identifying the terminals in the strip. In a given installation component, terminal strip identification marks follow in order from top to bottom if they are horizontal, and from top to bottom and left to right if they are vertical; Intermediate wiring terminals are identified only by their order number on the terminal strip from 01 to 99.
Each end of all cables is marked with an indelible label showing its number and an indication of the section to which the cable belongs.
Each end of each conductor shall be provided with:

1. The terminal number (appliance terminal, or intermediate wiring terminal) to which the conductor is connected.

2. Terminal tags arranged so that markings are easy to read.

The choice of marking systems whether, dependent, independent or composite, shall be the subject of discussion between the Engineer and the Contractor, but generally as follows:.

1. Indoor Type Labels

   i) Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws.

   ii) Labelling inside equipment shall be as above except that a flexible self adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

2. Weatherproof Labels

   i) These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions found at site.

ii) Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

3. Cable Labels

i) At each end of each cable, in a uniform and visible position a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels may be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corroding binding wire passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

4. Name and Rating Plates

i) Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as may be required by the Engineer. All indicating and operating devices shall have securely attached to them or marked upon them designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of manufacture.

5. Warning and Instruction Labels

i) Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on a yellow background and to internationally recognised standards.

ii) Instruction labels shall be provided where safety procedures such as wearing of protective clothing are essential to protect personnel from hazardous or potentially hazardous conditions.

iii) These labels shall have inscriptions or graphic symbols in white on a blue background.

iv) Plant liable to start automatically without warning shall be clearly labelled in a prominent position. The label shall read:

v) DANGER. XXXXX IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION.

vi) or other approved notice.

vii) Where groups of equipment are under automatic control a common notice may be acceptable where it can be clearly defined which drives are under automatic control.

1.2.7. DESIGN LIFE

All materials and equipment shall be designed for long life and continuous operation during prolonged periods with a minimum of maintenance, and the Contractor may be called upon to

demonstrate this for any component, either by the service records or similar equipment elsewhere, or by records of extensive type tests.
Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.
The materials of construction of the Plant shall be selected, taking into consideration their location and duty, such that the economic life of the Plant is not less than 20 years.
Except for consumable items such as gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than one year of continual operation. Where major dismantling is required to replace a part, such life shall be not less than five years.
Summary of minimum design life required for the plant and equipment:

1. Economic life 20 Years.

2. Parts of equipment which requires major dismantling 5 Years.

Parts subject to wear 1 Year.

1.2.8. SPARE PARTS

Where required the Contractor shall supply all spare parts necessary for the continuous operation of the Plant for a minimum period of one year, and shall describe such spare parts in the Schedule of Spares.
The spare parts shall comply with the Specification and be new, unused and readily interchangeable with the parts for which they are replacements.
Spare parts shall not be packed with any items of plant for erection or installation.
Each spare part shall be clearly marked with its identification reference and a detailed list shall be enclosed with them.
They shall be treated and packed to afford adequate protection during transit and for an extended period of storage at the Site. All containers shall be clearly marked "SPARE PARTS" together with sufficient information to allow complete identification of the spares and date of supply or packing.
Electrical and mechanical spares shall be packed and crated separately. Spares for different items of plant shall not be mixed in the same container.
All cases, containers or other packages are liable to be opened for such examination as the Engineer may require, and packings shall be designed to facilitate opening and subsequent repacking.

1.2.9. DESIGN CRITERIA

In his dimensional design calculations, the Manufacturer shall allow for the most adverse conditions to be withstood by the structures, whether in normal operation or during manufacture, transport or erection.
All parts shall be made with a sufficient safety coefficient to stand up to alternating forces, vibration, electrodynamic forces induced by short-circuit currents under the most adverse conditions as well as to the corresponding temperature rise until tripping of protection systems.
Water level conditions:, climatic conditions and earthquakes are given in General Requirements Specification.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. GENERAL

The degree of protection of enclosures (boards, cubicles, cabinets, etc) within which electrical equipment is to be installed, shall be as follows:

1. IP 31 for indoor LV equipment in air conditioned rooms;

2. IP 54 for indoor equipment;

3. IP 55 for outdoor equipment.

All mechanical and electrical equipment installed both indoors and outdoors shall be designed to resist the effects of atmospheric agents and specified climatic conditions in total safety.
The equipment shall be subjected to "tropicalisation" treatment. All steel parts will be cadmium plated and passivated. Insulating parts will be made from anticreeper and antimould products.
All electrical equipment components subject to normal or accidental wear shall be provided with removable parts for easy or economical replacement, if possible without requiring the total replacement of the components concerned.
All assembly bolts and screws shall be locked after tightening.
These bolts and screws shall be effectively protected from corrosion by cadmium plating, sherardisation or by any other process approved by the Engineer. All bolts subjected to sewage and its vapours shall be in stainless steel without declination from design calculation for materials used in sewage.
The ISO metric system shall be adopted for all threads.

2.2. CORROSION PROTECTION

2.2.1. GENERAL

All electrical equipment shall be given factory protection against the corrosive effects of atmospheric agents and the sun's ultra-violet rays.
During equipment handling operations both in the workshop and during transport and erection, the Contractor shall, insofar as possible, take all precautions to avoid damaging or blemishing the protective coatings already applied.
The Contractor shall be responsible for touching up work where necessary and, in extreme cases, may be required to replace cubicles or boards with damaged paintwork.
Regardless of the place where protective coatings are applied or repairs made, the Contractor shall bear the cost of all facilities required.
All bolts in contact with aggressive solution and/or atmospheres will be of stainless steel.
Corrosion protection systems shall be selected considering the shipment, site storage and final use conditions. In particular, all equipment shall be given marine protection.

2.2.2. PROTECTION OF CUBICLES AND BOARD

Frames and outer partitions shall be made of galvanised steel plate protected by:

1. An epoxy coating for frames, rear panels and end panels.

2. Oven-fired glycerophthalic paint for front panels.

Internal partitions made of steel shall be treated in the same way or galvanised. Aluminium partitions may be left unprinted.
The bus-bars shall be and colour coded

2.2.3. PROTECTION OF MOTORS

Machines shall be protected by a three-coat system, including two chromate primers and a polyurethane lacquer top coat.
Rotors shall be protected by an epoxy or polyurethane varnish; rating plates shall be made of stainless steel.

2.2.4. PROTECTION OF TRANSFORMERS

Both the inside and outside of metallic parts shall be corrosion protected.
Prior to painting, the surfaces shall be treated either chemically or mechanically.
The chemical treatment shall consist of dipping the pieces into a cleaning mixture then, after rinsing, by dipping the pieces into bichromate of zinc.
The mechanical treatment shall consist of shot-blasting plus a coat of bichromate of zinc if the surface cannot be painted immediately after the shot-blasting.
Exterior surfaces shall be protected with one coat of chromate of zinc primer and two coats of glycerophtalic paint.
Interior surfaces shall be protected with one coat of chromate of zinc primer.

2.3. ACCESSORY ELECTRICAL EQUIPMENT

2.3.1. VOLTAGES TO BE USED

The voltages, A.C. equipment shall operate at:

1. 415 V three phase ± 10%.
2. 240 V single phase ± 10%.
3. 33000 three phase ±10%
4. 3300 three phase ±10%

At frequency of 50 Hz ± 5%.
If another voltage is required for certain special items of equipment, the Contractor shall provide the necessary transformers.
The low voltage D.C. equipment shall operate at rated voltage of 110 V. All low voltage equipment shall be submitted to a minimum test voltage of 2000 V for a period of one minute (Electronic equipment shall be disconnected during the test).

2.3.2. CONTACTORS

All contactors shall conform to the IEC standards and recommendations specified in the IEC standard No. 947-4. (IEC 60947)
Their nominal ratings shall be chosen 20% above the highest service currents.
Under no circumstances shall the contactor operation in any way disturb or affect other relays installed on the same chassis.
Thermal or thermo-magnetic protection relays shall be installed on every phase; they shall be temperature compensated and shall include a single phase protection.
In addition to the auxiliary contacts necessary for normal operation of the installation, each contactor shall be provided with a block of at least two extra instantaneous contacts (opening + closing).

2.3.3. CIRCUIT BREAKERS

The installation of all A.C. and D.C. circuit-breakers shall comply with the IEC standard No. 947-2. (IEC 60947)
The circuit-breakers shall be of the fast operating type with manual closing and automatic tripping. They shall be provided with thermo-magnetic relays on each line phase.
Suitably calibrated high breaking capacity fuses or other limiting devices shall provide a back-up protection when the capacity of the circuit-breakers is insufficient to break short circuits.

2.3.4. PROTECTION AND AUXILIARY RELAYS

The relays shall be of the 'plug-in' type. They shall be protected by a sealed cover and shall be mounted in a cubicle, on a relay chassis preferably made of aluminium or folded steel plate.
The protection relays shall be carefully installed so that they shall not be affected by shocks or vibrations. The protection relays shall have their adjustment devices on their front face and each relay shall be supplied with a corresponding calibration curve.
The auxiliary relays shall be of the electro-magnetic coil type,

1. A.C. supplied at 220 V or 48 V,

2. D.C. supplied at 48 V or 110 V.

The making and breaking capacity of the contacts shall not be less than 10 A at 48 V, 4 A at 110 V, 2 A at 220 V (resistive load and AC supply) and 5 A at 48 V - 0.6 A at 110 V, 0.4 A at 220 V (inductive load and DC supply).
The auxiliary relays must be able to function satisfactorily when the voltage variation is +10% and -20% of the rated supply voltage.

2.3.5. CHANGE-OVERS SWITCHES AND PUSH BUTTONS

The change-over switches and push buttons shall be of the normal enclosure type, unless otherwise stated in the specifications. The minimum rated current shall be 10 A.
All isolating switches and push buttons shall have an engraved metal indicator ring describing their function.

2.3.6. FAULT ANNONCIATION – SIGNAL LAMPS

Fault or operating mode signal boxes shall be of the multiple type consisting of a series of rectangular windows placed side by side both horizontally and vertically. Each box shall be fitted with one or several lamps and a translucent cover engraved with the corresponding function.
Each signal box assembly shall have at least two boxes in reserve. All external connections shall be of the screw terminal type. All signal lamps shall be able to withstand a voltage 15% greater than the rated voltage.
The fault signalling sequence shall be the following:

1. When a fault occurs, the lamp flashes (signal stored) and the audible alarm starts up.

2. The horn stops when the acknowledgment button is depressed.

3. When the 'Reset' button is depressed:

   i) if the fault persists, the fault signal lamp changes from a flashing light to remain permanently lit,

   ii) if the fault has disappeared, the signal lamp goes off (regardless of whether it was flashing or permanently lit).

2.3.7. TERMINAL BLOCKS

In general, the connection of the control and monitoring circuits to the different items of equipment, such as the indicators, recorders, relays, signal boxes, etc. shall be made with screwed fork-clip connections.
The electrical boards, panels, cabinets, cubicles or chassis mountings shall have terminal blocks grouped in one or several rows, located in an easily accessible place. The terminal blocks for external circuits shall be located in the low voltage compartment of each board, panel, cabinet and cubicle.
The terminal blocks shall be of the screw type and shall be made of insulating materials mounted on special steel supports. The parts of terminal blocks of different voltage ratings shall be

separated by insulated compartments. The distance between any two adjacent terminals shall not be less than 6 mm. As far as possible terminals with isolator switches will be used.
No more than one conductor shall be connected to any one terminal, the terminals being bridge connected for parallel connection. Each terminal block shall have approximately 10% spare terminals. For the purpose of connection the cable end shall be fitted with crimped terminals.

2.3.8. LOW VOLTAGE EQUIPMENT CABINETS, BOARDS AND PANELS

All boards, panels, cabinets and cubicles shall be of the enclosed, dust and vermin-proof type. When installed outdoors or in humid places, they shall be designed to be weather-proof and be galvanised or zinc-plated.
In order to avoid oxidation caused by condensation, resistance heaters with thermostat shall be provided.
The access doors shall be lockable from the outside although it shall always be possible to open them from the inside.
A corrosion resistant metal name plate, with an engraved description of the panel, shall be fixed to the top of the front face. The inscriptions shall be in English.
The busbars shall be made of copper.
Copper cables shall be used for the internal wiring. All cable wires shall have end-lugs and shall be connected by one side only to the terminal block.
Glands will be used for all cable inlets into the panels. The diameter of cable glands shall be determined as a function of the outside diameter of the cable. The gland plate shall be drilled only at the time of installation of the gland.
The front panels shall house the indicators, measuring instrument, recorder push buttons, control switches and the signal lamps and fault signal boxes.
All equipment placed on the outside of the panels shall be of the built-in type, of standard dimensions, connected from behind.

2.3.9. MOTORS

2.3.9.1. GENERAL

Electric motors shall comply with the recommendations of IEC codes 34.1 to 34.9, 72.1 and 72.2 (latest edition). (IEC 60034 & IEC 60072)
The motors shall be capable of starting under a voltage 10% below the rated voltage.
Motor windings shall be Class B insulated.
The motors shall be designed (as per IEC recommendations 34.1): For pumps, fans, compressors and other equipment: continuous running duty type (S1).
Vibration: The maximum values of RMS velocity at design operating speed shall not exceed the 1.8 mm/s criterion of VDI 2056 Group K.
The following class will be chosen:

1. N (normal) for machines up to a shaft height of 225 mm.

2. R (reduced) for machines of shaft height between 225 and 315 mm and, by extension, above a shaft height of 315 mm.

   Once installed, the uncoupled machine shall not be subjected to vibration in excess of these tolerances.

The permissible noise levels will be measured in dBA. They shall be expressed in sound pressure and measured in accordance with French standard NF C 51 111 (or equivalent).

2.3.9.2. MANUFACTURE - DESIGN

1. Frame:

Motor frames and end plates shall be made of cast metal or of thick welded plate and shall be provided with:

i) Lifting hooks for machines weighing more than 50 kg.

ii) An ISO threaded terminal of 8 mm minimum diameter for connection to the earthing circuit; this terminal shall be located on a fastening lug, on the opposite side to the coupling or, if applicable, on the fastening plate.

Provision shall be made for one or more condensation water drain holes in the bottom of the frame or bearings.

2. Bearing blocks:

   Ball bearings with prestressing springs shall be used in preference to roller bearings. The bearings shall be guaranteed for 30 000 hours of operation without incident at the rated speed of the machine.

   Lubrication shall be preferably by grease, and shall not require grease replacement during the guaranteed period of operation.

3. Cooling:

   The motors shall be of the self-cooling type with shaft-mounted fan.

   The cooling air shall be directed towards the coupling side (fan mounted on the opposite side to the coupling).

4. Terminal box:

   The Contractor shall provide terminal boxes which shall be adapted to the types of cable powering the motor. The boxes shall have the same degree of protection as that of the motor. The terminals shall be clearly marked. One earthing terminal shall be provided.

5. Windings:

   Windings shall be made of annealed copper.

2.3.9.3. NAME PLATE

Each motor will be provided with a corrosion free nameplate marked with the following motor characteristics:

1. Name of manufacturer.
2. Type, serial number and manufacturing number.
3. Rated power and frequency (in Hz).
4. Speed under load (in rpm).
5. Rated voltage in volts according to star or delta connection.
6. Full-load or no-load current according to star or delta connection.
7. Rated power factor (cos f).

8. Insulation class and degree of protection.

2.3.10. METERING INSTRUMENTS, CONTROL SWITCHES AND AUXILIARY DEVICES

2.3.10.1. METERING INSTRUMENTS

Indicating instruments shall be flush-mounted and of the direct reading back-connected, dust proof switchboard type, having e removable transparent dust-tight window cover with non-reflective glass and with a dull black finish.

The normal size of instruments unless otherwise specified, shall be 96 mm x 96 mm. Scale plates shall have a permanent white finish with black graduation and numerals, and with the instrument transformer ratio for wich the instrument had been graduated prominently marked. The zero adjuster shall be provided outside the instrument wherever applicable.

Volt – Amps – Watts and Vars meters shall be supplied from metering transducers having a output current of 0 to 5 mA or – 2.5 + 2.5 mA for centre zero scale instruments. The transducer power supply shall be from the DC distribution system.

The accuracy of switchboard instruments, unless otherwise specifically stated, shall be class 1.5 for ammeters, voltmeters, mega-watt meters, and mega-Varmeters.

The full scale values of ammeters for use with current transformers shall be 130% of transformer primary rating.

The full scale values of voltmeters shall be 120% of transformer primary value.

Frequency meter shall be self contained and its size shall be 144 x 144 mm.

The wattmeter and varmeters shall have a full scale range corresponding to about 125 per cent of the rated power they shall measure. The watt-meters and varmeters shall have a centre zero scale.

A name plate written in English shall be attached to the instrument to indicate:

1. Rated values.
2. Specification number.
3. Manufacturer’s name with country of origin.
4. Percentage error.

The energy meters shall be of the direct reading type with a minimum of 5 dials or digits calibrated in primary quantities with a suitable multiplier. They shall be provided with ratchets to prevent negative registration

The registration errors of the energy meters for both unity and the 50 per cent lagging power factor shall not exceed those listed below when tested at rated voltage, frequency, temperature, and full load current, except if otherwise stated.

1. One per cent at 10 to 50 per cent of the rated currentand one half of one per cent at 50 to 150 per cent of the rated current.
2. One half of one per cent over a range of plus or minus 10 per cent of the rated voltage.
3. Four thenths of one per cent between 49 and 51 Hz.
4. One half of one per cent over a range of 20 to 40 degrees centigrade.

Power factor meter shall consist of a phase angle transducer and associate DC indicator with a power factor measuring range from 0.5 (lead) to 0.2 (lag). Its rated accuracy shall not exceed +1.5% of full-scale length.

2.3.10.2. CONTROL SWITCHES AND AUXILIARY DEVICES

The annunciator unit shall be of the multi window type with individual alarm indicated by illumination of an inscribed transparent window. The dimension of the windows of the annunciator

unit for trip functions shall be 65 x 30 mm minimum and those for other units shall not be less than 30 x 30 mm.
Each annunciator unit shall have its own “Acknowledge”, “Reset” and “Test” push buttons.
The indicating lamps shall be provided for the supervision of DC supplies, annunciators, discrepancy and control switch indications. Except in the event of healthy trip (control/proection supply) indications they shall normally remain off and shall only light up on the appearance of a discrepancy, alarm or change in condition. Healthy trip indications shall be connected so as to give continuous supervision of the trip circuit and give an audible alarm. The supply supervision lamps shall be neon type.
Lamp test facilities shall be provided so that all indicating lamps on each panel can be tested simultaneously by operation of a common push button, under “test” the lamps shall flash and the audible alarm shall sound.
The lamp glasses shall be in standard colours. The colour shall be in the glass and not an applied coating and the different coloured glasses shall be replaceable. Suitable transparent synthetic materials may be used instead of glass.
Lamps shall be easily removed and replaced from the front of the panel by manual means. The lamp fittings shall allow adequate ventilation and shall not incorporate materials subject to deterioration under high ambient temperatures. The voltage rating of the lamps shall be at least 33 per cent higher than the nominal supply voltage to avoid frequent fusing.
The miniature circuit-breakers shall be double-pole with normally closed auxiliary contacts ans suitable for surface mounting. They shall be of the plastic moulded type with arc chamber, overload and short-circuit protections and terminal boards.

2.3.11. INSTRUMENT TRANSFORMERS

2.3.11.1. GENERAL

Instrument transformers shall be of the dry-insulated type.
They will be very largely dimensioned to ensure measurement accuracy, taking into account the consumption of appliances to be supplied, circuit losses and possible connection of additional appliances.

2.3.11.2. CURRENT TRANSFORMERS

Current transformers shall comply with IEC standard 185.
Measuring instruments and protective relays shall be separately supplied by different current transformer windings.
Accuracy classes:

1. Protection.
2. Differential — Class X.
3. Overcurrent/earth fault — 5P10, 5P15, 10P10, as DWG. SGH HP203.
4. Metering — Class 0,5.

The rated secondary current shall be 5 or 1 A for all CTs.

2.3.11.3. VOLTAGE TRANSFORMERS

Voltage transformers shall comply with IEC standard 186.
Depending on the standards used by the Manufacturer, the voltage transformers may be of the single or dual insulated pole type, the rated secondary voltage shall be 110 or 240V.
Voltage transformers shall be protected by upstream HRC fuses and downstream miniature circuit breakers.
The accuracy class shall be Class 0,5 in all cases.

3. SPECIFIC REQUIREMENTS FOR THE RAW WATER PUMPING STATION

3.1. 33 KV PANEL SWITCHBOARD / SWITCHGEAR

The 33kV switchboard shall be located in its own switchroom at the RWPS. The contractor shall supply a 110 VDC battery tripping unit sized to suit the requirements for the switchboard and manufacturers' requirements.
The 33kV Switchgear shall meet the following minimum requirements:

- Panel to be metal clad minimum rating IP3X
- Circuit Breakers to be Vacuum type
- Circuit Breakers all to be fully withdrawable.
- Busbar to be air insulation.
- Panel shall be modular and expandable
- All cable entry and exit to be bottom.
- All outgoing Panels to have earth switches.
- Fused protected suitably rated VT to be installed on each incomer
- All panels to have Overcurrent, Short Circuit and Earth fault protection.
- Transformer Feeders to have Bucholz (Main and Tap Changer tanks), Oil and Winding Temperature, Oil level (Main and Tap Changer tanks), pressure relief alarm and trip signals and annunciator on the panel
- Transformer feeders to inter-trip with 3.3kV Switchboard Incomers.
- All panels to have Network Analysers to provide Voltage, Current, MWhrs, MVA, MW, Power Factor and to be Modbus protocol compatible.
- Nominal voltage – 36 kV
- Lightning Impulse Voltage – 170 kV
- Network Frequency – 70 kV (1 min)
- Short Circuit Current – 31.5 kA t= 3 sec
- Short circuit Peak – 80 kA

3.2. 3.3 KV PANEL SWITCHBOARD / SWITCHGEAR

The 3.3kV switchboard shall be located in its own switchroom at the RWPS at the WTP. The contractor shall supply a 110 VDC battery tripping unit sized to suit the requirements for the switchboard and manufacturers' requirements.
The 3.3kV Switchgear shall meet the following minimum requirements:

- Panel to be metal clad minimum rating IP3X
- Circuit Breakers to be Vacuum type
- Circuit Breakers all to be withdrawable
- Busbar to be air insulation
- Panel shall be modular and expandable
- All cable entry and exit to be bottom
- All outgoing Panels to have cable earth switches.
- Fused protected suitably rated VT to be installed on each incomer.
- Provision for Voltage and current readings for Tap changer control panels on incomers.
- All panels to have Overcurrent, Short Circuit and Earth fault protection.
- Incomer Panels to have inter-trip with 33kV Transformer feeder.

- Transformer Feeders to have Oil and Winding Temperature, Oil level, pressure relief alarm and trip signals and annunciator on the panel
- Transformer feeders to inter-trip with 415V Switchboard Incomers.
- All panels to have Network Analysers to provide Voltage, Current, MWhrs, MVA, MW, Power Factor and to be Modbus protocol compatible.
- Nominal voltage – 12 kV
- Lightning Impulse Voltage – 75 kV
- Network Frequency – 28 kV (1 min)
- Short Circuit Current – 31.5 kA t= 3 sec
- Short circuit Peak – 80 kA

3.3. 110 VDC BATTERY TRIPPING UNIT

The DC power supplies will consist of an online type charger/rectifier. The rectifier will be 2 phases thyristor supplying floating battery.
The contractor shall size the BTU to suit the requirements for the switchboards, which shall include all protection, operation and motorized spring charging.
The main characteristic will be as follows:

- Equipped with a 3 position switch MAINS-FLOAT-BOOST (for fast change)
- Automatic voltage regulation to within plus or minus 1%
- For a load variation from 0 to 100%
- For a change in voltage of more than 10% or less than 25%
- For a frequency variation of plus or minus 2%
- Adjustment of the floating voltage
- Relay with adjustable minimum voltage
- Relay with adjustable maximum voltage

The charger/rectifier 110VDC panel will be equipped with the following components (non-exhaustive list):

- Voltmeter for 110VDC
- Voltmeter for 240VAC
- Ammeters
- Thyristor modules
- Diode modules
- Alimentation modules
- Regulation modules
- Capacitors
- Resistors
- Contactors
- Fuses
- Relays
- Lights and switch buttons
-

3.4. 415 V AUXILIARY SWITCHBOARDS

A 415V Auxiliary Power Switchboard shall be installed at the RWPS and WTP to provide low voltage power for building services and ancillary equipment.
The 415V Switchgear shall meet the following minimum requirements:

- Panel to be metal clad minimum rating IP41
- Incoming Circuit Breakers to be Withdrawable Air Circuit Breakers
- Bus Coupler to be Withdrawable Air Circuit Breaker
- Panel shall be modular and expandable

- All cable entry and exit to be bottom
- All panels to have Overcurrent, Short Circuit and Earth fault protection.
- Incomer Panels to have inter-trip with 3.3kV Transformer feeder.
- Incomers to have Network Analysers to provide Voltage, Current, kWhrs, kVA, kW, Power Factor and to be Modbus protocol compatible.

3.5. TRANSFORMERS

The sizing of the transformers shall be based on the Contractor's final loadings for all equipments. The main transformers are to have On Load Tap Changers to maintain a steady output voltage. The number of steps and range of + and – steps shall be decided after determining from Kenya Power the possible expected voltage fluctuations.
Transformer shall meet the following minimum specification:

33/3.3kV Transformer:

- Primary Voltage – 33kV
- Secondary Voltage 3.3 kV
- MVA Rating – 5 MVA
- Outdoor installation
- Vector Dyn11
- Oil Filled with Conservator
- On Load Tap Changer – 17 Steps +10 – 6 Steps at 2,5%
- Bucholz, Oil and Winding Temperature, Oil Levels, Pressure Relief protection alarm and trip settings.
- IEC Standard 60076-1

3.3/0.433 kV Transformer:

- Primary Voltage – 3.3kV
- Secondary Voltage 433 V
- kVA Rating – 1000 kVA and 1250 kVA
- Outdoor installation
- Vector Dyn11
- Oil Filled with Conservator
- Of Load Tap Changer – 5 at 2,5%
- Oil and Winding Temperature, Pressure Relief protection alarm and trip settings.
- IEC Standard 60076-1

Other Requirements are as follows:

General Transformer Ratings	• Three phase double wound, oil immersed with natural oil and air cooling (ONAN). • May be overloaded to 150% during emergencies of its continuous ratings in accordance with IEC - 354. • Designed for continuous operation. • Nominal operating frequency 50HZ + 3%
Core and Winding:	• Core: high grade, non-aging, cold rolled grain-oriented silicon steel laminations. • Windings & connections: - Braced to withstand shocks during transportation, switching, short circuit etc. - Uniformly insulated and the LV neutral points shall be insulated for full voltage. • Stacks of windings: adequate shrinkage treatment. • Winding conductor: electrolytic copper.
Transformer Oil:	• Class 1 mineral oil, conforming to IEC 296 or equivalent. • The dielectric strength of the oil shall not be less than 60kV
Frequency:	• The average noise level of the transformer shall not exceed 57 dB (in accordance to IEC551)
Impedance Voltage:	• at 85 degrees C and on the principal tap shall be 6.5% at 75 degrees with tolerance of +-10% • Impedance / Tolerance: 5% on principal tap; Voltage/ freq ratio:

Design Features to be included	• Sealed tank design • Core type construction shall be used • Lifting ring • Filler cap • ON –Load tap changer • Earthing connection
Tank	• Welded low carbon steel material • Designed for a continuous internal pressure of 0.35 kg/sq.cm over normal hydrostatic pressure of oil • Bolted connections - weatherproof hot oil resistant gasket • nuts & bolts: hot-dip galvanized or cadmium plated or zinc passivated steel • Designed so as to allow easy filling of the transformer without a major disassembly • Adequate jacking bosses shall be provided • Base of the tank shall be fabricated of adequately sized steel members arranged to permit skidding or rolling in any direction. No flat bases shall be used. • Provision shall be made for convenient connection of filter press system while the transformer is energized. • Manholes and hand-holes shall be located in the top cover only • Suitable drain and sampling valves complete with plugs shall be provided
Tap changer	• A Seventeen (17) position, Sixteen Steps (16) on load tap changer shall be provided. The rating of the tap changer shall be based on full load rating of the transformer. • Taps shall be +5% to -15% in steps of 1.25%.
Pressure Relief Device	• An adequate pressure relief device shall be provided and shall be of the re-closable type.
Liquid Level Gauge	• dial type magnetic liquid level gauge complete with alarm contacts for low level condition. • The dial shall show MAXIMUM, NORMAL, MINIMUM; oil level at 250C.
Nameplates and Equipment Number Plates	• Stainless steel nameplates shall show standard specified information plus tested impedance with engraving system.
Liquid Thermometer	• The top liquid indicating thermometer shall be provided with high temperature alarm contact and a resettable type maximum temperature pointer.
Bushings and Terminations:	• outdoor type and easily replaceable. • sufficiently robust to withstand normal transport and erection hazards. • Provide ground terminal comprising of an M12 metric bolt and nut and shall include a spring washer and a lock washer.
Fittings and Safety Devices:	Standard fitted with: • Oil temperature sensor • Dehydrating breather complete with silica gel crystals • Standard Buchholz relay fitted. • Drain/sampling valve with plug • Weather proof indelibly marked rating plate • Terminating marshalling box
Transformer Voltage Regulator	• Desired voltage level 1 to 4 100 to 135 V • Bandwidth ±0.5 to ±9 % • Delay time T1 1 to 600 s • Delay time T2 1 to 30 s • Switching pulse duration 1.5 s • LDC Ur = 0 to ±25 V Ux = 0 to ±25 V

	• Z compensation selection Voltage rise 0 to 15 % of desired voltage level Limitation 0 to 15 % of desired voltage level • Under voltage blocking Overvoltage detection with high speed return control (interruptible) 95 to 135 V 100 to 140 V • Pulse signal 1.5 / 1.5 s Overcurrent blocking 50 to 210 % Voltage transformer 0.1 to 999.0 kV / 120 V • Current transformer 1 to 10,000 A / 0.2 A • Power supply AC 85 to 140 V DC 12 V Power consumption approx. 12 VA • Operating temperature* - 13° F to + 158° F (- 25° C to + 70° C) Storage temperature - 40° F to + 185° F (- 40° C to + 85° C).
Additional Details	• Ambient temp: 50 Degree C; • Temperature rise: - Design ambient temp.: 50 Degree C. - Temp. rise of top of: 50 Degree C. oil by thermometer - Temp. rise of wdg. : 55 Degree C by resistance method. • Class of insulation: Class - “A”; • Relative Humidity: 100 %; • Terminal arrangement: HV Terminal boxes on both primary and secondary side, suitable for termination of HT XLPE cable with Raychem type heat shrinkable terminating kits. • 4mm thick MS blank (undrilled) gland plates to be supplied with primary and secondary sides on the bottom surface and Marshalling boxes. • The secondary neutral shall be brought out and be fitted with suitable rated CT. • The minimum length between cable gland plate and cable Lugs should be 550 mm for both primary and secondary sides of cable Boxes.

The transformer shall be tested by the manufacturer in accordance with the latest applicable standards. Certified copies of all test certificates shall be provided to the client. The following tests shall be included:

- Resistance measurement of all windings
- Ratio test on all five tap connections
- Polarity and phase relation test on the rated voltage connection
- No-load losses and excitation current
- Load losses
- Applied potential test
- Induced potential test
- A pressure test of at least 12 hours duration shall be applied to the transformer leak and radiators to detect possible leaks
- Operational test on all devices
- Insulation tests on auxiliary devices and wiring
- Core insulation test

4. EXECUTION

4.1. WORKSHOP ERECTION PROCEDURES

Except where otherwise approved by the Engineer, each machine, device, appliance and assembly shall be completely erected in the Contractor's workshops, with each part marked in order to be sure of correct assembly during site erection. All possible adjustments shall be made in the workshop thereby minimising those required on site.
Erected assemblies shall be submitted for the Engineer's inspection.

4.2. SITE ERECTION PROCEDURES

Foundation blocks, steel reinforcement for concrete, concrete slabs, pipe ducts, cable ducts and temporary erection blocks shall be covered by Civil Engineering works and building works specifications. The Contractor shall be responsible for installation of the equipment on the foundations; all necessary adjustments and levelling operations for proper seating of the equipment shall be carried out by the Contractor before final stage concreting. If foundation drawings and necessary information such as general erection drawings relevant to civil engineering works are not furnished at the proper time, all modifications in excavations or foundations shall be executed at the Contractor's expense.
Arrangements for protecting the facilities from damage due to site works in the vicinity (covers, protection chambers, etc.) shall be provided by the Contractor.

4.3. ELECTRICAL TESTS

The Contractor shall also carry out tests of all electrical equipment. The tests shall include insulation resistance and earth continuity for all cabling, polarity of switches and resistance of main earths. Tests, as applicable, shall be carried out on electrical installations and electrical panels prior to their use; such tests shall include:

(i) Visual inspection
(ii) Test relays with Variable controlled supply to ensure relays close at 85% nominal voltage and hold closed down to 65% nominal voltage
(iii) Test tripping of relays occurs at 60% nominal voltage
(iv) Insulation resistance
(v) Injection testing of current transformers for correct polarity and ratio and protection relays for correct operation
(vi) Functional testing including simulation of sequence and automatic controls
(vii) Checking of time delay and protection relay settings
(viii) Checking of fuses for correct type and rating
(ix) Tests for cable insulation and earthing
(x) Any other tests as may be required by the Engineer.

oOo

SECTION 16120
CABLES, WIRING AND CABLE TRAY AND TELEPHONE

1. GENERAL

1.1. SCOPE OF SUPPLY

The work covered by this section concerns the supply and installation of all cables required for connection of equipment included in this Contract.

This work shall concern cables of all types, of all duty voltages and cross-sections, as well as all supports, terminal boards, ducts and fastening and marking accessories. The works covered by this section excludes fire detection circuits, which are included in the relevant section.

1.2. QUALITY ASSURANCE

1.2.1. REFERENCE STANDARDS

IEC 60227 : Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V.

IEC 60228 : Conductors of insulated cables.

IEC 60287 : Electric cables - Calculation of the current rating.

IEC 60502 : Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.

IEC 60840 : Extruded solid dielectric insulated power cables for rated voltages from 30 kV up to 150 kV.

The new telephone equipment and installations shall comply with the recommendations of the International Consultative Committee for Telephony and Telegraphy (CCITT) and with local regulations in force.

1.2.2. DESIGN CRITERIA

1.2.2.1. DUTY VOLTAGE, SPECIFIED VOLTAGE OR RATED VOLTAGE

1. HV power cables:

   i) duty voltage: 3300 to 33000 V

   ii) rated voltage: 7500 to 40000 V

2. LV power cables:

i) duty voltage: 400 - 230 V

ii) rated voltage: 1000 V

3. LV monitoring cables:

i) duty voltage: <150 V, AC or DC

ii) rated voltage: 750 V

4. LV monitoring cables:

i) duty voltage: 10,5 kV AC

ii) specified voltage: 6/10 (12) kV

1.2.2.2. DESIGN RULES

The conductor core cross-section shall be determined according to the following criteria:

1. Permissible current under steady operating conditions, with necessary corrections for temperature conditions and laying conditions.
2. Permissible current under overload conditions.
3. Permissible current in the event of a short-circuit.
4. Permissible voltage drop in cable links :

i) Maximum 3% during steady operation,

ii) Maximum 10% during starting of motors.

5. Potential gradient for HV cables.

1.2.2.3. MINIMUM CROSS-SECTIONS OF LOW VOLTAGE CABLES

1. Power circuits: ..... 2.5 mm²
2. CT circuits: ..... 4 mm²
3. VT circuits: ..... 6 mm²
4. Monitoring circuits: ..... 1.5 mm²
5. Low level links: ..... 0.6 mm²

1.2.2.4. ARMOURING

All AC and DC LV cables laid outside the power plant or structures, shall be protected from electromagnetic interference by steel armouring.

The steel armour shall be linked to the earth system by a flexible copper connection welded to the armour.

1.3. SUBMITTALS

The Contractor shall submit for the Engineer's approval his design notes for cable links together with all substantiating documents concerning design rules used. These design notes shall include, in particular:

1. Calculation of currents under steady operating conditions in relation to connected loads.
2. Calculation of fault currents under the most severe conditions.
3. Cable routes.
4. Dimensional design of cables according to specified criteria.
5. Calculation of voltage drops.
6. Detailed documentation on the telephone sets.

1.4. DELIVERY, STORAGE AND HANDLING

Cable ends shall be carefully covered to avoid damage during transport, storage and handling before installation.

2. PRODUCT, COMPONENTS AND SUB ASSEMBLIES

2.1. MATERIALS

2.1.1. CABLES

Cables shall be supplied by an approved manufacturer and where possible the same manufacturer shall be used for all cables.

All cables shall be delivered with cable ends effectively sealed. When a cable is cut from a drum both cable ends shall be immediately sealed to prevent ingress or moisture.

2.1.1.1. RATING

The Contractor shall ensure that each cable is adequately rated for its duty under normal and possible fault conditions.

The rated voltage of the cables shall not be less than the operating voltage and when assessing the rating and cross section of each cable the following factors shall be taken into account:

1. Maximum voltage drop permissible.
2. Type and magnitude of load.
3. Fault level and duration related to circuit protection relays and fuse gear.
4. Overcurrent setting of relays and circuit-breakers.
5. Route length and disposition of cables.

6. Ambient temperature.

7. Method of laying.

2.1.1.2. CONDUCTORS

Conductors for all types of cable shall be of high conductivity copper. All cores shall be at least 2.5 sq.mm cross-section. With the exception of mineral insulated cables all conductors in excess of 2.5 sq.mm shall be stranded.

2.1.1.3. CONDUCTORS - ALTERNATIVE

The Contractor may offer cables incorporating aluminium conductors as an alternative to copper conductors providing that the cross section of each cable is adequate to meet its rating requirements in accordance with sub-clause (2) and that due provision is made to prevent corrosion at connections between dissimilar metals. Full details of such precautions shall form part of the alternative proposal.

2.1.1.4. TYPES

Cables complying with BS or IEC approved equivalent standards will be accepted provided all cables which are supplied for a specified operating voltage are to the same national standard. Standards specified in the following clauses indicate the type of cables used in the design: if the Contractor wishes to use cables to an alternative standard then details of current carrying capacity, derating factors etc, shall be submitted to the Engineer for approval.

1. XLPE/SWA/PVC, BS 6346

   Power cables specified as cross linked polyethylene insulated steel wire armoured and PVC sheathed are hereafter referred to as XLPE/SWA/PVC.

   All such cables shall be terminated with mechanical glands which shall be of a type as to provide adequate mechanical support by positively locking on the armour and shall at the same time give a high level of earth continuity.

2. PVCSWAPVC, BS 6346

   Power and control cables specified as PVC insulated and sheathed, galvanised single wire armoured cable with an overall PVC sheath are heinafter referred to as PVCSWAPVC.

   All such cables shall be terminated with mechanical glands which shall be of a type as to provide adequate mechanical support by positively locking on the armour and shall at the same time give a high level of earth continuity.

3. PVCPVC

   Power cables specified as single core insulated and sheathed are hereinafter referred to as PVCPVC cable. Such cables shall be terminated by mechanical glands similar to that specified for PVCWAPVC cable.

4. MICC/PVC

   Certain control and miscellaneous circuits shall be carried out in mineral insulated copper clad cable with an overall extruded PVC sheath, hereinafter referred to as MICC/PVC cable.

   All saddles, clips and accessories shall be of the type specially designed for MICC/PVC cable.

For the purposes of core phase identification coloured PVC core sleeves or coloured PVC extension sleeves shall be used. Core sleeves and extension sleeves shall only be used on the core sizes for which they are intended. Coloured adhesive tape shall not be used for this purpose.

The Contractor shall ensure that any special tools required for the installed MICC/PVC cable are made available to his operatives and they understand and are competent in their use.

The ends of all cables shall be at all times temporarily sealed to prevent the ingress of moisture.

When MICC/PVC cables are used in conjunction with equipment liable to vibrations, suitable terminal boxes shall be provided in the vicinity of such motors or equipment and the final interconnections shall be made by means of flexible cable or multi-strand wiring in flexible conduit.

Cable glands shall be protected by corrosion-resistant PVC hoods.

2.1.2. POLARITY

The polarity of all apparatus used for the works specified shall be arranged as follows:

1. For two pole apparatus the phase or "live" pole at the top (or left hand side) and the neutral or "earthed" pole at the bottom (or right hand side).

2. For three or four pole apparatus the phases in order, red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts, respectively, as viewed from the front.

All cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence or phase colours are preserved in the system.

All cable cores shall be identified with phase colours for three and four wire circuits and red and black for single phase circuits.

The neutral shall always be black. Where more than one phase is incorporated on a common system in one room then the live cores shall be red, yellow, blue as appropriate and fittings and switch accessories shall be permanently labelled and segregated.

2.1.3. EARTHING

A complete earthing system shall be provided comprising a copper tape earth network, earth continuity conductors and earth electrodes and shall comply with the requirements of BS 7430: 1991.

2.1.3.1. NETWORK

The earth network shall comprise a main tape earth conductor run around the "electrical" perimeter of the installation with separate subsidiary branched copper tape connections taken from the main conductor to earth item of electrical plant, metal frame Work and casings, the neutral points of power transformer secondary windings, and other equipment as specified.

Where specified a main earth busbar shall be installed in a convenient location. This shall comprise a 50 mm x 6 mm minimum copper bar supported on porcelain barrel type insulators and well- mounted. The bar shall be of sufficient length to accommodate bolted copper tape connections to plant items and to connections to the electrodes and shall be so arranged to permit disconnection of any individual earth conductor for testing or isolation.

The earth conductor shall comprise annealed high conductivity hard drawn copper tape 25 mm x 4 mm minimum which shall be supported on structures, trench walls and such like by stand-off type saddles at intervals not exceeding 600 mm.

The earthing of each item of electrical plant shall be effected by bonding the earth tape to the special terminal provided thereon.

All joints and connections in the earthing network shall be rivetted, tinned and soldered, or brazed to the approval of the Engineer. All exposed joints shall be protected against corrosion by means of anti-corrosive paint and PVC tape.

2.1.3.2. ELECTRODES

Subject to determination by tests at site two earth electrodes shall be provided, each comprising a conductor system of vertical rods interconnected with copper conductors. The two electrodes shall be physically arranged and spaced to be electrically independent and leads from each shall be brought to a common concrete disconnection chamber set in the ground, or to a main earth busbar when specified. Two bolted copper links shall be provided in the disconnection chamber to enable each electrode to be disconnected from the system for test purposes. Each electrode shall be capable of providing an effective earth of resistance not greater than the value specified, with the second disconnected.

Earthing rods shall be steel cored with a metallic bonded copper outer surface of thickness not less than 0.38 mm and total diameter not less than 16 mm. Rods shall be provided with special hardened tips and caps to avoid distortion when driving into the ground. The rod extension length shall be of the screwed type arranged so that the diameter of the rods is not greater at the point of extension.

Each rod shall be provided with an approved non-ferrous clamp for the connection of the copper conductor and these connections shall each be housed in individual chambers set flush to ground level.

The earthing conductors shall be a minimum of 95 sq.mm stranded copper covered PVC green.

All excavation of trenches for the installation of the earth electrodes and the disconnection chamber will be carried out by the Contractor. The Contractor shall be responsible for the supervision of the back-filling of the trenches and the setting and alignment of the disconnection and inspection chambers. After the earth installation has been completed the Contractor shall demonstrate to the Engineer that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the position of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

2.1.3.3. EARTH CONTINUITY CONDUCTORS

An earth continuity conductor shall be provided between all electrical plant, mechanical plant, exposed steelwork and the like as required to meet the requirements of BS 7430: 1991. This can be as follows:

1. Copper tape connections forming part of the earth network.

2. Where the distribution is an armoured cable the metal sheath and/or armouring of the cable it shall be securely bonded at each end to the metalwork of the apparatus or to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated with a cable run and should the design of such items of apparatus

not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection of the termination gland prove inadequate.

Any additional earthing clips shall be fitted within the apparatus wherever possible.

3. Where the distribution system is PVC single cable in conduit, a separate conductor shall be installed. Where under special circumstances rigid or flexible conduit is incorporated into the Contract Works an external earth conductor shall be run which shall be securely bonded to the terminating or intermediate apparatus by means of a special earth terminal.

4. Where the distribution system is PVC single cable in trunking, a separate conductor shall be installed.

5. Where the distribution system is mineral insulated copper sheathed cable, the sheath can be used.

2.1.3.4. CONNECTIONS

1. Terminations on PVC single core cable shall be made using crimped or soldered cable lugs, brass nuts, bolts and washers.

2. Connections to cable armour wire shall be made using an approved earthing clamp.

3. All exposed steelwork shall be bonded to the earth continuity conductor.

4. Where trunking is installed, bonding of sections shall be made using an approved earth link.

2.1.4. CABLE IDENTIFICATION

Each and every cable shall be permanently identified at each end in accordance with an associated cable schedule. Approved type cable markers shall be used, fixed to the cable by corrosion resistant straps. Cable markers shall also be installed at entries of buildings and buried ducts and at other points as are necessary to identify the route of any cable.

Cables shall be so connected to items of plant that standard phase sequence and colour coding is maintained throughout the system. Cable cores shall be identified by phase colours on 4 wire and 3 wire systems and by red and black on 2 wire systems. Where it is impractical to connect cable cores to the identified terminals special markers shall be fitted as appropriate to individual cores.

In addition control cables shall have individual cores identified by approved type ferrules bearing the same numbers at both ends, the numbers reading from the terminal outwards.

Where the wiring system makes a change of number necessary at connecting points ferrules bearing both numbers shall be used. All numbering shall be in accordance with and shown on associated wiring diagrams.

2.1.5. CABLE TRAYS AND LADDER RACKING

Following types of cable trays and cable ladders shall be used:

2.1.5.1. GALVANISED STEEL CABLE TRAY

1. Scope.

   Galvanised cable tray shall conform to the following material and performance requirements.

2. General.

   Galvanised Cable tray to be manufactured conforming to BS EN 10346:2009, BS EN 61537:2007 and BS 6946

   Cable trays are to be sized to suit the installation and cable requirements. Correct spacing factor and loading factor to be adhered to. Pre-manufactured accessories i.e. bends Tees risers shall be used.

   Tray edges and interior shall be free from sharp edges and projections which could cause harm to cables.

2.1.5.2. GALNVANISED CABLE LADDER

1. Scope.

   Cable ladder shall conform to the material and performance requirements mentioned below.

2. General.

   Cable ladder shall be manufactured to BS EN 10346:2009, BS EN 61537:2007 and BS 6946

   Cable ladders are to be sized to suit the installation and cable requirements. Correct spacing factor and loading factor to be adhered to. Pre-manufactured accessories i.e. bends Tees risers shall be used.

   Rung spacing shall be either 500 mm standard or 300 mm optional.

   Radius of fittings shall be 300 mm standard, other radii options.

   All ladder fittings (i.e. bends, risers, tees, crosses, reducers) shall be pre-fabricated and these and all lengths of ladder will be provided with pre-drilled coupling holes to accept standard coupling plates.

   Ladder interior shall be free from sharp edges and other projections which could cause harm to cables.

   Fasteners used in the manufacture and assembly of the system shall be either 316 stainless steel MB nuts and bolts.

2.1.6. CABLE TRUNKING

Where large multiple parallel conduit runs could occur, use may be made of galvanised cable trunking.

The trunking shall be constructed from heavy gauge sheet steel and galvanised. All bends, tees and intersections shall be purpose made.

Trunking shall be fixed to ceilings or walls or supported in trenches by purpose made brackets fabricated from galvanised steel and cast into the structure.

Where cut edges cannot be avoided these shall be treated at the time of erection with a cold galvanising paint.

2.1.7. HEAVY GAUGE STEEL SCREWED CONDUIT

Unless otherwise stated, all conduits shall be galvanised heavy gauge, solid drawn or welded screwed steel type, and be in accordance with BS 31 and subsequent amendments.

Accessories shall either be malleable cast iron screwed type or pressed steel.

Conduit of less than 20 mm diameter will not be permitted. The tubing is to be perfectly smooth inside and out and free from flaws and intersections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp ends removed before erection.

Where a number of conduits coverage, large malleable cast iron or approved heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass brushes and couplings. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/or fittings are attached to switch and/or fuse casings, steel or cast iron boxes, or other equipment, the material or case of the box shall be tapped for a depth of not less than 10 mm or if this is not possible male bushes and flanged couplings shall be used.

Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories.

All junction boxes, draw-in boxes and inspection fittings shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

Generally, not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints in the cable will be only at switches, isolators, etc. Intermediate joints in the cable will only be allowed by agreement with the Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and cement, plugs shall be fitted on all boxes.

Conduit passing through extremes of temperature, e.g. inside and outside the buildings or into heating chambers, shall have the high temperature side isolated by means of a conduit box filled with an approved permanently plastic compound.

Generally conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a galvanised flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

2.1.7.1. SURFACE INSTALLATION

Surface conduits shall be fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends.

Conduits shall be run in a square and symmetrical manner but efficient means shall be adopted to provide for the drainage of condensation. Runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out.

Conduits installed on structural steelwork shall be secured at spacings not exceeding those for surface conduit by girder clips in accordance with Figure 11 of BS 31, otherwise fixings shall be as for surface conduits on wall, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Engineer. Any drilling or access which is required through any structural member of the building shall be agreed with the Engineer before carrying out the work.

Exposed threads and places where galvanising has been damaged shall be cleaned and then painted with two coats of an approved metallic lead paint. This treatment shall be applied as the work proceeds.

2.1.7.2. CONCEALED INSTALLATION

Concealed conduits shall be securely fixed to prevent movement before the laying of screeds, floating or plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit.

Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Routes of conduit shall generally follow the requirements for surface conduits.

Conduit installed behind voids, false ceilings, etc, shall be installed as specific for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed.

The conduit installation shall be inspected by the Engineer before building operations conceal the work.

Conduit installed in floors shall be sealed against ingress of moisture.

2.1.7.3. FLEXIBLE CONDUIT

Flexible conduit shall be of the waterproof galvanised type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be kept to a minimum.

Flexible conduit shall not be used as the sole means of providing earth continuity. A separate earth wire shall be run within the conduit as required by IEE regulations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid fixing screws, etc. for this purpose will not be permitted.

Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

2.1.7.4. CABLES

Cables for drawing into conduit shall be single core PVC insulated non-sheathed. In no case shall the number of cables enclosed be more than 60% of the conduit capacity.

3. EXECUTION

3.1. ERECTION

3.1.1. CABLES

3.1.1.1. GENERAL

As a general rule, cables shall be classified as follows:

1. Category 1: power cables with a voltage greater than 415 V.
2. Category 2: power cables with a voltage between 127 V and 415 V, including DC power cables (e.g. for field flashing).
3. Category 3: monitoring cables with a voltage between 24 and 127 V.
4. Category 4: instrumentation, measuring cables, etc.

Cables of different categories shall, wherever possible, be laid separately.

Cables connecting up to individual items of equipment may be laid either on individual supports or directly in tubing on walls or on metal structures.

3.1.1.2. INSTALLATION ON CABLE TRAYS

The cables shall be laid neatly, whether horizontally or vertically, avoiding cross-overs wherever possible and respecting the minimum bending radii specified by the supplier. The cables shall be attached to the cable trays at approximate intervals of two metres horizontally and one metre vertically as well as at bends using suitable cable ties or similar. Cables of different categories shall be laid on separate trays.

When several trays are installed on top of one another, the arrangement on the different trays shall be as follows from the top to the bottom:

1. Category 4.
2. Category 3.
3. Category 2.
4. Category 1.

Cables leading off from the traps shall be installed in cable ducts attached to the walls by clips, except for short upward or downward lengths not exceeding 500 mm. Cables of categories 1 and 2 shall be laid in a single layer and cables of categories 3 and 4 in several layers.

3.1.1.3. SINGLE-CORE CABLES

Single-core cables shall be laid in trefoil and firmly fastened together and to the support by means of insulating clips or treated wood cable clamps.

3.1.1.4. PROTECTION FROM SHOCKS OR SUNSHINE

All cables likely to be exposed to shocks or to the sun's radiation must be protected by galvanised sheet screens.

All cables crossing floors shall be protected by galvanised steel tubing or any other galvanised steel protection system at a minimum height of 1.50 m above floor level.

3.1.1.5. CABLES INSTALLED IN THE GROUND

Cables between structures shall be installed in underground duct systems. The Contractor shall prepare drawings showing his precise requirements for cable duct and trenchwork. The drawings shall detail the number of ducts required, the width and depth of trenches and the number and location of drawpits. These drawings shall be prepared in consultation with the Engineer and shall be approved before issue.

The excavation and backfilling of trenchworks and the supply and installation of all cable ducts shall be the responsibility of the Contractor.

The cable trench shall be dug to a depth of 800 mm and shall be of sufficient width in relation to the diameter of the cables and their spacing. The bottom of the trench shall be carefully finished and covered with a 100 mm thick bed of sand before laying the ducts.

The ducts shall be covered with a layer of sand of 10 cm minimum thickness and the trench will then be backfilled using the loose excavated material with prior screening if necessary to remove any materials likely to damage the cables. A cable warning system, yellow coloured polyethylene tape nominaly 150 mm wide and 100 microns thick, shall be placed approximately 40 cm above the cables.

Concrete marker posts shall be provided at ten meter intervals along the cable run, each fitted with a suitably inscribed metal plate showing the voltage and the cable marked. Similar plates shall be provided and fitted to the outer walls of buildings at the points of entry. Marker posts shall also identify the position of any cable joints.

Under roads, the cable ducts shall be encased in concrete.

3.1.1.6. CABLES LAID IN CONCRETE TROUGHS

All the cables laid in troughs shall be supported by cable clamps or laid on trays and raised with respect to the floor of the trough. The Contractor shall be responsible for removing and reinstalling trough covering slabs as required during cable-laying operations.

3.1.1.7. JUNCTIONS

Each cable shall be laid in a single continuous length, unless the cable link length exceeds the standard cable manufacturing capacity. In such cases, junctions must be made using a non-soldered connector and according to the supplier's instructions. The junctions must be made only by experienced personnel, whose experience and qualifications shall have received the prior certification and approval of the Engineer.

3.1.1.8. CABLES PASSING THROUGH WALLS

After laying the cables, holes in walls must be filled in with cement or plaster to prevent the penetration of fire, air and dust.

3.1.1.9. CONNECTIONS

Connections shall be made using an approved model of non-soldered connector.

For low voltage cables, crimped cables lugs shall be used.

For medium voltage cables, connections shall be made using indoor or outdoor cable ends of insulation class 6 kV.

3.1.2. CABLE TRAYS

3.1.2.1. SUPERPOSED TRAYS

The minimum free vertical space between two horizontal trays shall be 250 mm.

3.1.2.2. TRAYS INSTALLED AGAINST WALLS

Provision shall be made for a 100 mm minimum distance to allow cables to be attached to the wall behind the tray.

3.1.2.3. CUTTING

Trays shall be cut with a saw and saw barbs shall be removed. If trays are steel made, one coat zinc epoxy paint shall be applied on trays extremities. Oxyacetylene cutting shall not be permitted.

3.1.2.4. DISTANCE BETWEEN SUPPORTS

The maximum distance between supports shall be two metres.

3.1.2.5. EARTHING

Cable trays shall be connected to the general earth network. The trays supporting power cables shall include a separate earthing cable laid on the tray to which the other possible trays shall be earthed. Steel-copper connections shall be made by the use of appropriate connectors.

3.1.3. CONDUITS

1. All conduit ends shall be closed with caps, plugs, or blank discs during construction.
2. Conduit runs which cannot be provided with drainage shall be sealed with a sealing compound at each end after the cables are installed.
3. Where applicable airtight sealing plugs, sealing bushings, or sealing compounds shall be used to seal around the cable to prevent transmission of air, moisture, and smoke from the conduit into the electrical housing enclosures.
4. All conduits shall be swabbed immediately before cables are pulled.
5. Unused conduits shall be closed by plugs.

3.2. FIELD QUALITY CONTROL

Insulation resistance measurements shall be carried out:

1. On each circuit for category 1 cable according to IEC 502 standard.
2. On each circuit for category 2 cables at 500 V for U < 400 V.
3. By sampling for categories 3 and 4 cables at 500 V.
4. Telephone sets operating tests.

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SECTION 16250
MOTOR STARTER EQUIPMENT

1. GENERAL

1.1. SCOPE

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of the motor starter equipment, and shall be applicable to these works unless stated to the contrary in the specification application clauses.

1.2. QUALITY ASSURANCE

1.2.1. CODES AND STANDARDS

The design, manufacturing, construction, installation, test and commissioning of motor starter equipment shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60038 IEC	standard voltages
IEC 60051 and their accessories	Direct acting indicating analogue electrical – measuring instruments
IEC 60071	Insulation co-ordination
IEC 60085	Electrical insulation - thermal evaluation and designation
IEC 60255	Electrical relays
IEC 60529	Degrees of protection provided by enclosures (IP-Code)
IEC 60664	Insulation co-ordination for equipment within low voltage systems

As far as the power supply authority and permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.3. GENERAL REQUIREMENTS

1.3.1. COMPONENTS AND EQUIPMENT

The Contractor has to take care, that all components and equipment are selected considering easy maintenance, simple and quick diagnosis and long maintenance intervals.

Standard industrial high performance systems and components of suppliers standard lists shall be used as far as possible. Components and equipment of same kind and type shall be selected for equivalent functions. The interchangeability must be guaranteed.

1.3.2. TAGGING

All components, equipment and installations shall receive the respective tagging plates, labels, etc., which have to be of extremely durable material resistant against the environmental conditions. Tagging plates or labels on fronts of enclosures shall be fixed with screws.

1.3.3. UNIT AND SCALES

The metric system on basis of SI-units shall be used for all scales and indications.

1.3.4. WIRING

The wires shall be selected according to load, insulation level, function and operating requirements. The wires shall be adequately rated and equipped with fuses / circuit breakers of adequate size.

The wiring shall be carried out solid and safe against damages. Wires shall be bundled and fixed. The wiring shall be laid inside of wiring channels, preferably. If wiring channels will be used, they must be from halogen-free type and a spare of 20 % shall be foreseen.

All circuits and auxiliary contacts including not used contacts for disconnecting devices and relays shall be terminated on terminal strips. Terminal strips shall have 10 % spare terminals. If wires with different potential will be terminated on one terminal strip the respective terminals shall be separated by means of isolating plates. The termination of multiple stranded wires has to be carried out by means of multiple core cable ends.

Terminals shall be marked durable and easy readable, corresponding to the drawings. Wires shall be marked on the termination of each wire with the number of the corresponding connection point.

1.4. DESIGN REQUIREMENTS

1.4.1. GENERAL

The motor starter equipment shall start-up centrifugal pipeline pumps, which will be driven by low voltage asynchronous squirrel cage motors.

The motor starter equipment per motor consists of the following main parts:

1. Switchgear panel.
2. Auto-transformer.
3. Control devices.

For each applicable pump motor unit a separate starter shall be provided. All parts of the motor starter equipment for one motor shall be assembled to a common unit, exchangeable to each other for the same motor size.

1.4.2. NUMBER OF STARTS

The motors are designed to allow 4 starts successively from cold (max. Ambient temperature) or 3 starts successfully from hot service temperature without tripping of any protection device.

The starting time sequence is as follows:

1. (1) – (2) immediately.
2. (3) after 20 min.
3. (4) after further 20 min.

The motor starting transformer equipment shall be designed and constructed to meet these requirements.

1.4.3. STARTING PROCEDURE AND LIMITATIONS

For the motor starter equipment the following starting procedure and limitations shall be valid:

1. The pump units will be started against fully closed or partial closed discharge valve, to be defined and co-ordinated with the pump manufacturer, depending on the final hydraulic requirements.
2. The motor start-up time shall be in the range of 20 seconds, but shall not exceed 30 seconds.
3. The motor start-up current shall be reduced to a value ≤ 3 times of the rated motor current.
4. The motor start-up torque shall not be lower than 0.3 of rated torque, the available torque difference between motor and driven pump shall not be lower than 15%.

The detailed pump and motor data and the actual curves shall be requested by the respective manufacturer.

1.4.4. SAFETY AND INTERLOCKING DEVICES

The motor starter equipment shall be equipped with safety and interlocking devices to prevent the following:

1. Closing of the circuit breakers in the service position, if they are not connected to the auxiliary circuit.
2. On-load operation of the isolation and earthing apparatus.
3. Access to the live parts.

2. EQUIPMENT CHARACTERISTICS

2.1. SWITCHGEAR PANEL

2.1.1. MECHANICAL REQUIREMENTS

2.1.1.1. GENERAL

The switchgear panels shall be air insulated, industrial type, metal-clad, factory assembled, type tested panels with self standing cubicles and fix mounted switching devices. The cubicles shall only be accessible from the front.

The switchgear panels shall be suitable for indoor installation on cable cellar. The bottom shall be covered with galvanised steel sheets, which are to provide with holes for cable entry. The cable entries shall be designed in a manner such that a sealing after cable laying is possible without any problem. Further, each cover sheet shall be equipped with a grounding connection to the steel frame of cubicle.

The cubicles of the switchgear panels shall be equipped with hinged doors, which are able to swing out more than 90°.

All nuts for fixing of components shall be welded on the steel structure or threads will be cutted in the steel structure. The use of loose nuts or self cutting screws shall be avoided as far as possible. Screws, nuts and washers shall be galvanised or tinned.

2.1.1.2. SEPARATION

The switchgear panel shall consist of cable termination cubicle(s), cubicles for bypass circuit breaker and star-point circuit breaker and the necessary bus bar, surge arrestors and cabling accessories. The circuit breakers may be installed in a common cubicle.

Each cubicle shall be equipped with a low voltage compartment, which is to placed in the upper part.

The different cubicles and the low voltage compartment shall be separated against each other by means of steel sheets. The isolation must be arc-proof.

All cubicles shall be equipped with separate pressure relief flaps. The pressure relief shall be carried out upwards.

2.1.1.3. CABLE TERMINATION CUBICLE

The cable termination cubicles shall be supplied with suitable metal fastenings for connection of cable ends, or if necessary for bus bars. These fastenings shall be adapted, for each cubicle, to the number and type of cables or bus bars used.

The cable connecting and fastening bars shall be arranged in such a way to allow easy and safe connection of the number and type of cables and cores, designed for the particular switchgear panel.

Suitable cable fixing supports must be foreseen to secure the cable termination from any pull tension.

2.1.1.4. LOW VOLTAGE COMPARTMENT

All measurement instruments, push buttons, switches, indication and alarm lamps, etc. shall be mounted in the hinged front door and flexibly wired to the fixed part of the LV compartment. All relays, miniature circuit breakers, etc. Within the LV compartment shall be rail mounted.

The LV compartment shall have a layout and arrangement to allow easy access to all installed devices. On the door of the LV compartment a mimic diagram withposition indication of switching devices shall be placed.

For the wiring from the low voltage compartment to the bottom a covered cable duct shall be foreseen.

2.1.2. ELECTRICAL REQUIREMENTS

2.1.2.1. PROTECTION

The system of protection shall be selected and co-ordinated in line with the feeding switchgear data and the connected equipment requirements:

1. To guarantee personnel and plant safety.

2. To ensure a sufficient protection against damages of the equipment, which may arise from the internal and external short circuits as well as from possible atmospheric discharges.

3. To ensure as far as possible the continuity of operation for those parts not concerned by the fault. This will be achieved by selecting the setting in a way such that in case of a fault the closest protection device to the fault operates at first.

2.1.2.2. BUS BARS

The bus bars shall be selected according to the electrical requirements and shall be of high-conductivity electrolytic copper.

The bus bar cross section shall be the same throughout the panel. It shall be adapted to service and installation conditions. Flexible joints shall be provided wherever necessary to avoid displacement due to expansion, or transmission of shocks and vibrations from the switchgear panel to the connections.

The utmost care shall be taken in the design of the position of the bus bar supports and the layouts of the connections taking into consideration the following:

1. Electro-dynamic stresses in disturbed conditions.

2. Resonance phenomena.

3. Isolation distances.

4. Temperature rises of conductors in these conditions.

2.1.2.3. CIRCUIT BREAKERS

Circuit breakers shall be selected and equipped according to the requirements and will be fix mounted. Only one type of circuit breaker for each making and breaking capacity shall be used. The circuit breakers shall be three pole vacuum type.

The operation of circuit breakers shall be carried out via motor driven spring loaded buffers. In case of control voltage fault, the buffers shall be manually operable. The circuit breaker position shall be visible with closed front doors.

Each circuit breaker shall be equipped with the following devices:

1. Electrical control, closed contact operated, with anti-pumping device andelectric resetting device.
2. Tripping coil with supervision relay.
3. Auxiliary spare contacts, at least 4 NO and 4 NC brought out to terminals.
4. Mechanical position indicators for switching position.
5. Indications for tripping and failure.
6. Operating push buttons for “On” and “Off” (easy operable from front door, “On” push button with lockable cover against maleoperation).
7. The necessary interlocks to prevent any fault operation.

The circuit breakers shall be suitable for short-time interrupt. For switching of the circuit breakers the respective secondary releases and locking magnets shall be provided.

2.1.2.4. AUXILIARY RELAYS

Auxiliary relays shall be of plug-in type and shall be provided with test plugs for measurement on the front side. The test facilities shall be provided to permit testing without interruption of the entire installation and service (on service testing).

Auxiliary relays shall be of the electromechanical type. Auxiliary contacts shall be able to carry the maximum foreseen current. In any case their contact load shall be suitable for 230 V AC/DC.

The relays shall be suitable for tropical climate and must be dust proof.

2.1.2.5. OVERVOLTAGE PROTECTION

The switchgear panels shall be designed and rated in a manner such that overvoltages caused by switching and flashes, do not impair the safety in operation of the units.

The circuit breakers shall be provided with surge arrestors, equipped with easy visible indicators for the healthiness of arrestors. The equipment inside of low voltage compartment shall be separately protected against overvoltages.

2.1.2.6. EARTHING

All exposed conductive parts likely to be accidentally charged shall be joined together by an earthing circuit. For this purpose a minimum mm² cross section bare copper earthing bus shall be installed.

This earthing bus shall be connected to the general grounding system by means of conventional cable connection terminals.

Within the panels, electric continuity shall be ensured by fastening screws and bolts. The opening type panels, assembled on hinges shall be bonded to the

enclosure by a tinned copper braid, or hinges shall be certified for this purpose.

The following shall be also connected to the earthing circuit:

1. Secondary side of surge arrestors.
2. Leads of braid of the MV cables.
3. Operating handles, mounting plates, doors, etc.

In addition, two ends of the switchgear panel shall be terminated to the general grounding system by separate cables.

2.1.2.7. CONTROL VOLTAGE

The control voltage supply shall be 110 or 240 VAC and be supplied from an auxiliary transformer in the switch board. It shall be rated for the total load of the control equipment + 20%. The primary and secondary circuits shall be protected by suitably rated MCB's. A control fuse shall be installed in each motor circuit for protection and isolation purposes.

All other necessary control and signal voltage levels shall be generated inside the switchgear panel of motor starter.

2.1.2.8. ANTI-CONDENSATION HEATERS

The switchgear panels shall be equipped with anti-condensation heaters, which shall be fed from the 230 V, 50 Hz level. Each switchgear panel will be provided with one power supply, protected by means of a 16 A miniature circuit breaker situated in a LV distribution board.

The heaters shall be humidity or temperature controlled.

2.2. PAINTING

All components and devices shall have a resistant, long term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

An additional painting at location of installation is not allowed.

3. EXECUTION

3.1. INSTALLATION

The delivery, installation and commissioning of the motor starter equipment shall include, but not limited to the following items:

1. Transport to location of installation (if necessary storage), and the complete mounting.
2. Grounding and potential equalisation for the cubicles, including connection with the next grounding bus bars.

3. Termination of all cables at the switchgear panels.

4. Commissioning of the functioning motor starter equipment, including voltage feeding of the bus bars and adjustment of all relays, protection devices, etc..

5. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase and during a training on site.

For transport and site installation purpose the transformer enclosure shall be segregated from the switchgear panel, if necessary the transformer itself may be shipped separately.

3.2. TESTS

3.2.1. WORKSHOP TESTS

All components of the motor starter equipment shall be tested completely and detailed in manufacturers workshop. All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted prior to start of the tests in accordance with the Project Procedure Manual.

The following tests shall be carried out, at least:

1. Test of all functions.
2. Voltage withstand tes.t (1)
3. Short circuit withstand test. (1)
4. Test of warming. (1)
5. Partial discharge measurements.
6. Check of degree of protection.
7. Check of protection against touching.
8. Power frequency voltage dry test, 1 minute.
9. Voltage test on auxiliary circuits, 1 minute 2 kV r.m.s.
10. Mechanical operation test on circuit breakers, including all adjacent equipment.
11. Operation test of the relays.
12. Test of auxiliary electrical devices.
13. Verification of wiring and terminal blocks.
14. Check of mechanical details.
15. Compliance with the specifications.

(1) only type test certificates necessary

Detailed test protocols of all tests performed have to be submitted prior to shipment.

3.2.2. SITE TESTS

The site tests shall include the following steps:

1. Pre-commissioning (including “loop testing”).
2. Commissioning and test on completion.
3. Performance test.

The workshop tests described in item except the power frequency voltage shall be repeated on site by the Contractor after erection and before connection to outside sources.

Special care shall be taken for setting of protection devices, relays and timers, setting must be done according to the approved start-up procedure, considering the data of the connected pump motor equipment and the feeding switchgear.

The aim of the tests is to ensure the proper function of the complete scope.

3.3. DOCUMENTATION

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the motor starter equipment and their components.

All documents shall be in English language.

The documentation of the motor starter equipment shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all devices, cubicles and enclosures.
3. Layout drawings for the whole motor starter equipment.
4. Single line diagrams.
5. Block diagrams.
6. Wiring diagrams.
7. Termination drawings.
8. Cable lists.
9. Spare parts list.
10. List of used devices with manufacturer.
11. Software and software description.
12. Operation and maintenance manual.

13. Reports of tests and commissioning with protocols.

The documents listed above shall be handed over for approval.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

3.4. SHIPPING

All equipment, material and spare parts shall be sufficient packaged. Each unit should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

3.5. SPARE PARTS AND SPECIAL TOOLS

The Contractor shall deliver all spare parts, which are necessary for commissioning and two years operation time (see “General Description of Project and Works”).

Spare parts shall be available until ten years after commissioning.

All necessary special tools for operation and maintenance of the motor starter equipment shall be supplied for each location, at least consisting of:

1. One (1) set of all special tools required for operation and maintenance of switchgear panel and transformer.

2. One (1) set of circuit breaker tools and consumables.

3. Key set for cubicle doors and locks.

4. One (1) set of grounding equipment (ground rope and spider including fastening bolts and clamps, connections tongs etc.).

5. Software for the PLC.

For storage of the above mentioned special tools per location a suitable cabinet, shelf or console shall be delivered.

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SECTION 16260
LOW VOLTAGE VARIABLE FREQUENCY DRIVE UNIT

1. GENERAL

1.1. DESCRIPTION

Provide complete IGBT (Insulated Gate Bipolar Transistors) type variable frequency drive (VFD) units and appurtenances including drive reactors, transformer, DC chokes, harmonic filters, enclosures, and certain auxiliary items in one integral line-up, as indicated and as specified, to provide a complete operating system. Provide all drive components specified housed within one enclosure.

The Contractor shall provide only one VFD drive manufacturer for all drives under this Contract. The Contractor to coordinate the VFD units with the driven equipment manufacturers.

VFD units shall be manufacturer's standard technology and in production for no less than 5 years.

Provide control system operation, input and control signals, status signals and devices as specified herein and as indicated.

Provide Underwriter's Laboratories listed drive or equivalent IEC/BS Standards.

Coordinate VFD input harmonic filter with results of final harmonics study outlined in Paragraph 2.2.

VFD units rated at 75 HP and larger shall be 18 pulse type. VFD units smaller than 55 kW shall be 6 pulse type. Drives up to 18.5 kW shall be provided with 5% impedance line reactor. Drives larger than 18.5 kW and less than 55 kW shall be provided with integral input harmonic filter pre-wired in the same enclosure.

Provide each VFD unit as one complete line-up, complete with main circuit breaker, inverter section, phase shifting transformer, power converter, harmonic filter, output filter, and control circuit as indicated. Floor mounted VFD units provided shall be secured to a concrete pad.

1.2. REFERENCES

As specified herein or equivalent IEC or BS Standards:

1. Underwriter's Laboratories Inc. (UL):

   i) 1. UL-508 Electrical Industrial Control Equipment.

2. National Electrical Manufacturers Association (NEMA): MG 1.

3. National Fire Protection Association (NFPA):

i) 1. NFPA-70 National Electric Code.

4. Equivalent British/European codes and standards may be used; however, the equivalency shall be demonstrated and submitted by the Contractor and approved by the CM/CS.

1.3. SUBMITTALS

Shop Drawings: Submit the following in accordance as specified herein.

1. Shop Drawings: Provide a complete list of equipment components, and materials, including the manufacturer's descriptive and technical literature, and catalog cuts. Provide complete wiring, system interconnection, and schematic diagrams for the equipment and controls furnished including external interlocked and controlled components, equipment layout, time versus current curves for protective devices, and any other details required to demonstrate that the system and the required external controls have been coordinated and will function as specified and indicated.

   i) a. Provide data to verify that drives can be used for motor lead lengths up to 100 meterswithout output filters. Include information from the VFD manufacturer or output filter manufacturer stating that the motor terminal voltage limitations as defined by NEMA Standard MG-1 are met. For VFDs located more than a cable length of 100 meters from the motor load provide an output filter at VFD.

   ii) b. Provide enclosure drawings and details showing all dimensions and construction details.

2. Submit a statement from each driven equipment manufacturer indicating that the VFD drive submitted is compatible with driven equipment and is rated for the specified application.

3. Harmonic Analyses Report: Provide harmonic analysis report as outlined in Paragraph 2.2.

4. Provide installation and anchoring details to meet earthquake requirements as specified and indicated on the structural drawings.

5. Submit the manufacturer’s printed installation instructions.

6. Spare Parts Data: Submit a list of spare parts.

7. Operating and Maintenance Instruction Manuals:

   i) Operating instruction manuals outlining step-by-step procedures required for system startup and operation.

   ii) Manufacturer's name, model number, and service manual parts list.

   iii) Brief description of the equipment and basic operating features.

   iv) Maintenance instruction manuals outlining maintenance procedures.

   v) Troubleshooting guide listing possible reasons for breakdown(s) and repair(s).

   vi) Point-to-point connection wiring diagram for the system.

8. Performance Test Reports: Upon completion of installed system, submit in booklet form all shop and field tests performed to prove compliance with specified performance criteria.

2. PRODUCTS

2.1. MANUFACTURERS

The manufacturer shall have five years, all within the last 10 years, of commercial experience in the manufacture, operation, and servicing of equipment of type, size, quality, performance, and reliability equal to that specified.

2.2. HARMONIC ANALYSIS

The VFD manufacturer shall provide a detailed harmonic analysis as described under this section.

The VFD system shall be provided such that there is less than 5% voltage total harmonic distortion at the point of common coupling (PCC).

Obtain the available short circuit current at PCC from the electrical short circuit study. Provide this information to the VFD manufacturer to perform the harmonic study.

Provide the standby generator unit data to the VFD manufacturer.

The harmonic analysis performed shall be based on the following cases:

1. Case 1 – Point of common coupling 415 VAC main bus supplied by utility transformer.

2. Case 2 – Point of common coupling 415 VAC main bus supplied by the standby diesel generator.

The study shall include an explanation of all assumptions, sources of data, methodologies and formulas used in the study and a summary of the study results.

Based on the harmonic study results, supply the VFD units with any additional filtering equipment required to meet the harmonic requirements specified herein.

2.3. PROVISIONS

2.3.1. SERVICE CONDITIONS

Service conditions shall be as follows:

1. Ambient Temperature Range: 0 deg. C to 40 deg. C.

2. Operational Humidity: Up to 90 percent non-condensing.

3. Environment: As indicated on the enclosure schedule.

4. Altitude: Below 1000 m. above sea level.

5. Input Power:

i) a. Nominal voltage - 415 volts (plus 10 percent or minus 10 percent), 3-phase, 3 wire

ii) b. Nominal Frequency - 50 Hertz (plus or minus 2 Hz.)

2.3.2. DRIVE SYSTEMS

2.3.2.1. GENERAL

Furnish solid state variable frequency, microprocessor type with Pulse Width Modulated (PWM) output waveform converter. The VFD shall employ a full-wave rectifier, a DC bus choke, DC bus capacitors, and Libya Infrastructure Master Spec 16260-7 20-Nov-08 Insulated Gate Bipolar Transistors (IGBT) as the output switching device to convert nominal 415 volts, 3 phase, 50 Hertz, 3 wire input power into adjustable-frequency 3 wire system at 0 to 415 volts, 3 phase, 0 to 50 Hertz output power.

Motor control circuits shall be wired in accordance with the requirements specified herein and as indicated.

The Contractor shall be responsible for the successful compatibility and operation of the entire drive and control system serving the motor and driven equipment. This includes the responsibility for obtaining all loads, torque, speed and performance requirements from the pump and motor manufacturers and integrating these into a variable frequency drive system that fulfills the requirements of this Specification.

Provide constant torque drives or variable torque drives based on the type of the driven equipment load.

Provide VFD control so that there is accurate zero to full load torque control at low frequencies, including zero speed, with torque repeatability accuracy of 2% or better and torque response time less than 20 ms.

Provide on drive thermal-magnetic type, 415 volts circuit breaker to be used as main disconnecting device and fixed diode input rectifier for a constant power factor.

For 55 kW units and larger, provide VFD with three phase, PWM rectifier section, 18-pulse, or higher full wave diode bridge. Provide phase shifting transformer within enclosure at input bridge to provide appropriate phase shift.

1. The transformer shall provide for the cancellation of the positive and negative sequence harmonic currents at the primary connection.

2. The transformer shall reduce voltage and current distortion on the primary side and voltage distortion on the secondary side.

3. The VFD shall be optimized for harmonic rich and high neutral current environment.

4. Harmonic cancellation shall be by electromagnetic means only, capacitors or electronics shall not be used.

5. Provide a primary to secondary phase shift by use of multiple secondaries.

RMS harmonic output of the drive not to provide more than 5 percent increase in motor heating over similar operation of the motor with zero harmonics in the current.

The unit shall withstand drive output terminal line-to-line and line-toground short circuits without component failure during start-up and during operation. Drive to safely shutdown until short is cleared.

Provide drives with NEMA-1 gasketed type cabinet for VFD units located in indoor air conditioned spaces. Provide NEMA-4X enclosures for VFD units located outdoor or in non air conditioned spaces. NEMA-4X VFD enclosures shall be designed with ventilation/air conditioning system to dissipate the heat generated inside the enclosure.

Provide drive output such that the motors have a base rating voltage less than or equal to 600 volts and that the peak instantaneous voltage shall be limited to 1600 volts or less, with a voltage rise time greater than or equal to 0.1 micro-seconds per NEMA Standard MG-1, Part 31.40.4.2.

The drive unit shall be of modular design to provide for ease and speed of maintenance.

Control circuits shall be isolated from power circuits. Unit to accept a 4-20 mA DC speed control signal from an isolated, ungrounded transmitter with the unit in remote mode and from local door-mounted manual speed potentiometer or micro-processor type keypad with unit in local mode. The input 4-20 mA signal is to be optically isolated from the drive run control circuit. Furnish door-mounted switch on the enclosure for local/remote mode. Manual speed potentiometer or keypad controls to have adjustable minimum speed setting of 10 to 80% of full speed and maximum speed setting of 50 to 100% of full speed. The total speed setting to follow a linear time ramp, adjustable from 1-300 seconds for acceleration and deceleration control. Provide output 4-20mA signal for VFD speed statues.

Harmonic filters shall be provided with contactors and controlled by the VFD to remove them from the line when the drive is not operating. Contactors shall be provided with spare contacts for remote alarm and to energize status lamp at VFD enclosure.

VFD shall be capable of full rated output when powered by incoming voltage with Total Harmonic Distortion (THD) in excess of 10%.

Furnish series choke and capacitors on DC bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

Size enclosure to dissipate heat generated by VFD within limits of specified service conditions. Provide integral fans or cooling systems. VFD enclosures to have keypad controls located on the exterior of the enclosure. Provide visual alarm indicator on the cabinet door.

Provide oversized cable lugs for incoming and outgoing cables. Cable lugs size shall be per cables as indicated.

2.3.2.2. PERFORMANCE CHARACTERISTICS

Continuous current rating (amps): Minimum of 110 percent of motor rated full load amps, continuous.

Acceleration time to top speed, 1-60 seconds, adjustable.

Deceleration time from top speed, 1-60 seconds, adjustable.

Frequency stability: +/- 0.5% (at 25 degrees C, +/- 10 degrees C) after reaching operating temperature.

Output voltage: Proportional to frequency with low speed boost.

Combined drive/and filtering efficiency, defined as VFD output kW divided by VFD input kW, shall meet the following requirements at the specified operating points:

1. (1) 96 percent minimum at 50 Hz VFD output and 100 percent load.

2. (2) 92 percent minimum at 40 Hz VFD output and 60 percent load.

VFD fundamental power factor shall be 0.95 or higher at all speeds and loads.

The VFD shall be capable of sustaining continued operation with a 30% dip in nominal line voltage.

Losses to be utilized in drive system efficiency calculation shall include the input isolation transformer, harmonic filter and power factor correction if applicable. Auxiliary controls such as internal VFD control boards and cooling fans shall be included in all loss calculations.

2.3.2.3. DRIVE PROTECTION

1. General :

   i) Fault detection and trip circuits shall protect VFD and connected motor against line voltage transients, single-phase, power line over-voltage and under-voltage, output overvoltage and overcurrent, and VFD over-temperature. The VFD shall employ three (3) current limit circuits to provide trip-free operation. The slow current regulation limit circuit shall be adjustable to 125% of the VFD's variable torque current rating. The rapid current regulation limit shall be adjustable to 170% of the VFD's variable torque current rating. The current switch off-limit shall be fixed at 225% of the VFD's full load current rating.

2. Internal Protection: Provide circuitry as follows:

   i) Current limiting, fast acting, semiconductor input fuses for protection of internal power semiconductors.

   ii) Instantaneous output over-current trip max. - 200 percent.

   iii) DC bus and control circuit transformer fusing.

   iv) Grounded control chassis.

   v) Under and over voltage trip, 3 phases.

   vi) Motor overload protection, with solid state relays.

   vii) Main circuit breaker, with door interlocked handle. Provide means to allow entry into panel by authorized personnel. Circuit breaker to be rated 65,000 AIC.

   viii) Fault reset push button.

   ix) Line to ground faults.

   x) Input metal oxide varistor and input line reactor for transient protection.

   xi) VFD over-temperature.

3. Troubleshooting: Provide diagnostic aids to indicate the cause of fault; used to assist in troubleshooting circuit problems. Isolated Form C contacts for remote indication of alarms to include the following:

   i) Over/under voltage indication.

   ii) Over-current trip indication.

   iii) DC bus charged indication.

   iv) Fault detection indication.

   v) Recycle start indication (to indicate that the unit tried to pick up load for three previous tries and failed).

4. Provide power loss ride-through capability which will allow the logic to maintain control due to load inertia without faulting.

2.3.3. AUXILIARY SYSTEMS

Provide variable frequency drive unit with appropriate power circuitry and auxiliary contacts, etc. for energizing and controlling the variable frequency drive as indicated.

2.3.4. CONTROL FEATURES

Provide VFD control circuit as indicated on Contract Electrical Drawings.

Accept a grounded, isolated, 4-20 mA input remote speed control signal from an external device.

Provide a 4-20 mA output signal proportioned to VFD output frequency for remote speed indication.

Jog permissive input. When activated along with remote run contact, VFD will run at a pre-set speed.

2.3.5. DEVICES

Provide operating, monitoring or alarm indicating devices, door mounted, as indicated on Contract Electrical Drawings and as follows:

1. System speed control selector switch (LOCAL/AUTO) (When in LOCAL position, speed controlled by manual speed potentiometer).

2. Manual speed potentiometer or keypad controls to set speed in manual mode.

3. Speed indicating meter in percent speed to indicate speed of the powered motor.

4. Control relays as indicated.

5. Alarm and status lights. Provide LED cluster type.

Tie all instrument transformer outputs to motor protection relay.

2.4. SHOP TESTING

Provide a factory performance test for each variable frequency drive unit. The test to consist of simulating the expected load to be driven. The drive to operate the actual motor load through the expected speed ranges. Test length to be two hours.

Provide a factory burn-in test and a control and alarm test on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.

Provide prototype factory test data for a similar size and type VFD unit for short circuit testing. Data to verify that each drive can be started into a line-to-line fault and line-toground fault on the drive terminals. Each drive can be operating at full load and be subjected to a line-to-line fault and line-to-ground fault on the drive terminals. All phases (A, B & C) to be included in test data.

Provide certified documentation of all tests performed.

Provide above stated tests in addition to routine factory tests.

2.5. SPARE PARTS

Provide three spares pilot lamps, power fuses, and control fuses of each type and size installed.

Provide one keypad for every size VFD, of the same model.

3. EXECUTION

3.1. INSPECTION

Examine VFD location for preparation in accordance with manufacturer's written instructions. Check conduits and raceway location for connection to units.

Visually inspect the delivered unit(s) and accessories for conformance with specifications and drawings.

Verify availability of appropriate pacing signal and program motor protection relay settings.

3.2. INSTALLATION

The VFDs shall be installed as indicated and in accordance with the manufacturer's installation instructions.

Factory-trained service technicians, other than sales representatives, shall supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and instrument equipment until this equipment has been field tested.

3.3. FIELD TESTING

Perform testing checkout, and start-up for variable frequency drive equipment under technical direction of manufacturer's service technician.

Coordinate all testing with electrical testing performed under Section 16998.

Field Tests:

1. Test each drive over the total speed range that it will be required to operate through for the load being driven for two hours. Determine for each drive, motor, and load combination the following at minimum speed, maximum speed, and at 1/3 and 2/3 points between the minimum and maximum speeds:

   i) Input power (kW), voltage, current and RMS power factor on the line side of the drive isolation device.

   ii) Output to the driven load in kilowatts.

   iii) For each drive, measure the harmonic voltage distortion and harmonic current distortion for each harmonic at the main distribution bus for maximum and minimum load conditions.

   iv) Measure the total harmonic voltage distortion and total harmonic current distortion at PCC, while all drive loads are running, for Case 1 and Case 2 as described under Paragraph 2.2. The test results shall confirm the harmonic study results and have to shall prove that harmonic distortion limits specified in Paragraph 2.2 have been met. If testing results are not within the specified limits, provide any additional necessary filtering equipment to meet the harmonic distortion limits specified.

2. Test each drive by using the actual control signal for remote and local operation.

3. Test each driver alarm functions.

4. Perform all tests in the presence of the Owner’s representative.

5. Perform the above test in addition to the manufacturer's normal field tests and driven equipment testing.

6. Submit final test report with summary comparing field test data with harmonic analysis design calculated values for each drive.

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SECTION 16290
EMERGENCY DIESEL GENERATOR SET AND STEEL FUEL-OIL STORAGE TANK

1. GENERAL

1.1. SCOPE

This document covers the requirements for the design, manufacturing, construction, installation, test and commissioning of low voltage emergency diesel generator sets for the Ngorongo Water Treatment Plant.

1.2. CODES AND STANDARDS

The design, manufacturing, construction, installation, test and commissioning of emergency diesel generator sets shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60034 Rotating electrical machines

IEC 60044 Instrument Transformers

IEC 60072 Dimensions and output series for rotating electrical machines

IEC 60085 Electrical insulation - thermal evaluation and designation

IEC 60255 Electrical relays

IEC 60269 Low-voltage fuses

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60896 Stationary lead – acid batteries, ventilated types general requirements and methods of test

IEC 60947 Low-voltage switchgear and control gear

ISO 3046 Reciprocating internal combustion engines – Performance

ISO 8528 Reciprocating internal combustion engine driven alternating current generating sets

As far as the power supply authority or permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.3. ENVIRONMENTAL CONDITIONS

The emergency diesel generator sets shall be designed and constructed for continuous operation at full load under the local climatic and environmental conditions.

The emergency diesel generator sets shall be installed inside specific container, which will be equipped with ventilation.

1.4. FUEL REQUIREMENTS

The emergency diesel generator shall be capable of operating as specified with diesel fuel that is in compliance with the applicable local requirements.

1.5. GENERAL REQUIREMENTS

1.5.1. COMPONENTS AND EQUIPMENT

The generator shall be sourced from a company with a local dealership the last 5 years with known and reputable after sales service capability.

The Contractor has to take care, that all components and equipment are selected considering easy maintenance, simple and quick diagnosis and long maintenance intervals.

All components and equipment shall be designed for continuous duty at rated load and under the given climatic conditions. Standard industrial high performance systems and components of suppliers standard lists shall be used as far as possible. Components and equipment of same kind and type shall be selected for equivalent functions. The interchangeability must be guaranteed.

1.5.2. TAGGING

All components, equipment and installations shall receive the respective tagging plates, labels, etc., which have to be of extremely durable material resistant against the environmental conditions. Tagging plates or labels on fronts of enclosures shall be fixed with screws.

1.5.3. UNIT AND SCALES

The metric system on basis of SI-units shall be used for all scales and indications.

2. EQUIPMENT CHARACTERISTICS

2.1. GENERAL

The emergency diesel generator sets shall consist of the following main parts:

1. Diesel engine.
2. Generator.
3. Starter equipment.

4. Fuel system.
5. Lubrication system.
6. Air intake and exhaust system.
7. Control and monitoring system.

Diesel engine and generator shall be placed on a common base frame and connected with a dry flexible coupling.

The emergency diesel generator sets shall be provided in a manner such that 10 sec after initiation of start the full load can be taken over.

2.2. ENGINE

2.2.1. MOTOR

The engine shall be equipped with a water cooled, turbo-charged, four-stroke diesel motor suitable for indoor installation.

2.2.2. COOLING

The engine shall be provided with a closed loop, jacket cooling water system. The system shall be sized for continuous maximum load with ambient temperature.

The engine shall be furnished with a thermostatic control valve in the jacket cooling system to maintain a constant jacket coolant temperature to the engine.

The cooling water heat exchanger shall be of the finned radiator type equipped with fan. The radiator shall be mounted on the engine skid. The fan shall be preferably driven from the engine. A separate electrical motor for fan driving will be also accepted.

For the engine a standstill heating system shall be provided.

2.2.3. LUBRICATION SYSTEM

The engine and if necessary the generator shall be fully pressure-lubricated. The main oil pump shall be gear-driven from the main shaft.

2.2.4. STARTING SYSTEM

For engine start an electrical starting system with starter motor, 24 V lead-acid battery set and battery charger shall be provided.

The capacity of the battery shall allow six consecutive starts of the engine within 10 minutes. After the mentioned number of starts the battery shall have 50% capacity.

The charger shall be sized for recharging of the batteries within 8 hours.

2.3. GENERATOR

For the low voltage diesel generator unit a 3 phase, air cooled generator with shaft driven ventilator shall be provided.

The generator shall tolerate the sudden application or rejection of 50% of it's rated power without unacceptably high voltage fluctuations in excess of ± 5%.

The generator winding shall be according to insulation class F; the utilisation shall not exceed the figures for class B insulation. Insulation class H, utilised according to F will also be accepted.

The stator windings shall be equipped with six Pt 100 temperature sensors, which shall be wired to a common terminal box.

For the generator a brushless rotating exciter and a solid-state type voltage regulator shall be provided. The voltage regulator shall be with automatic and manual control to within a deviation of ± 0.5% from no-load to full load at rated frequency.

The excitation and de-excitation control equipment shall be combined with the voltage regulation equipment and shall be placed inside of generator unit control panel.

The generator shall be sized to withstand short circuit currents (three phase, line to earth, two lines to earth) for one second.

The generator shall be equipped with a standstill heater with automatically initiation when the generator unit is being out of service.

2.4. BASE FRAME

The diesel engine, the generator and the cooler will be placed on a common welded base frame. To minimise vibrations the engine, the base frame shall be fixed via rubber-metal elements or equal shock absorbing materials on the foundation.

2.5. PIPES AND CABLING ON THE EMERGENCY DIESEL GENERATOR SET

External pipe connections (air intake, exhaust, fuel, etc.) to the vibrating parts of the unit shall be made with compensator tubes, flexible connections or hoses.

Cables and electrical connections shall be mechanically protected and resistant against oil, heat and vibration.

As far as practicable, the power and instrumentation cables shall be terminate in junction boxes, located at one edge of the skid. For power and instrumentation cables separate junction boxes shall be used.

2.6. INTAKE AIR SYSTEM

The engine shall be fitted with an outdoor installed oil wetted foam air filter, preferably. The filter and the air intake duct shall be sized to suit engine requirements at 100% of rated full load.

The filter shall be equipped with louvers, which shall automatically open during start of generator unit. The louvers shall be controlled via the diesel generator set control panel and shall operate with 24 VDC.

2.7. EXHAUST SYSTEM

Temperature-resistant materials shall be used for the exhaust piping and the required expansion bellows. Exhaust silencers shall be galvanised. Expansion joints in the exhaust pipe shall be made of metal.

The exhaust pipe and the silencer are to be heat insulated in the room and in the wall bushing. Silencer to achieve the required noise dampening to at least 85 dB(A) shall be provided.

2.8. FUEL SYSTEM

For the emergency diesel generator set a seven-day tank shall be provided, which will be installed near the generator. The volume of the tank shall be suitable for seven-day full load operation of the emergency diesel generator set. Fuel tanks, incorporated in the base frame are not allowed.

The fuel tank shall be fitted with visual level indicator and level alarm devices for remote indication.

The suction of the extraction line shall be arranged at least 10 cm above the fuel tank bottom or otherwise suitable positioned in order not to take in sludge or water which may have accumulated. Furthermore, a flame trap shall protect the ventilation openings of the tank.

The fuel tank shall be equipped with all necessary devices (pumps, pipes, filters etc.) to allow the filling from an external fuel system.

2.9. ENGINE GAUGE PANEL

On the emergency diesel generator set a local panel shall be installed which is vibration isolated from the engine.

The following instruments shall be provided:

1. Lube oil pressure.
2. Engine cooling water temperature.
3. Lube oil temperature.
4. Speed.
5. Running hours.

If the control cabinet will be installed within the emergency diesel generator set room the placement of the above mentioned instruments on the door of this cabinet is also allowed.

2.10. CONTROL AND MONITORING SYSTEM

2.10.1. GENERAL

The control and monitoring system shall be realised by means of highly available and highly reliable programmable logic controller (PLC), preferably.

The system shall protect control, monitoring and emergency operation of the diesel generator set during start-up, operation, load change and normal shutdown.

The protective functions shall also be active during all operation modes.

The control functions shall essentially be required for start-up and normal shutdown, and the regulating functions shall mainly be needed for unit operation during the normal operating phase.

The unit regulating functions shall be designed for the adjustment of all key operating data which may be kept constant for any desired length of time. Load changes shall be effected safely.

For switch over to emergency diesel generator set supply and back to network supply the LV switchgear will be equipped with an "automatic change over device" (by switchgear manufacturer). Via this device the normal network will be monitored to initiate the start and stop of the emergency diesel generator set.

The control and monitoring system shall be provided with a serial interface to the station control system. Emergency stop functions and the connection to the automatic change over device of LV switchgear shall be hardwired.

2.10.2. EMERGENCY STOP

The unit shall be provided with an automatic stop via fail-safe controls. All process criteria and measures initiating emergency stop shall be transferred to the station control system.

The emergency diesel generator set must be stopped with blocking at least inncase of the following conditions:

1. Emergency stop push button.
2. Overspeed.
3. Low lube oil pressure.

And all other abnormal conditions which can be dangerous for the diesel generator unit.

The overspeed sensing element and emergency stop mechanism shall be independent from the regulator governor apparatus and governor drive. The overspeed trip shall act on the injection pump, preferably.

2.10.3. CONTROL CABINET

The equipment for the control and monitoring system and the necessary auxiliaries shall be placed inside of a metal enclosed, self standing cabinet.

The control cabinet shall be equipped with the following main parts:

1. Circuit breaker for generator main circuit.
2. Sub distribution panel.
3. Battery charger.
4. Control unit.

5. Measuring instruments.
6. Display or indicator panel.
7. Switches, push buttons.

The cabinet shall also include the facilities for automatic synchronising and manual/automatic voltage regulation.

The supply voltage for sub-distribution panel, which shall feed standstill heater, battery charger and may be air conditioning for control cabinet shall be 230/400 V, 50 Hz. The voltage level for control, protection and monitoring shall be 24V DC, fed from the internal charger/battery.

On the hinged front door of the control cabinet the following devices shall be installed:

1. Instruments:
   - **i)** Operating hour meter.
   - **ii)** Lube oil pressure.
   - **iii)** Generator voltage (with selector switch).
   - **iv)** Battery voltage.
   - **v)** Current (all three phases).
   - **vi)** Frequency.
   - **vii)** Active power.
2. Switches, push buttons:
   - **i)** Selector switch for operating modes (off-manual-test-automatic).
   - **ii)** Manual/automatic voltage regulation selector switch.
   - **iii)** Push buttons for voltage regulation.
   - **iv)** Push button for initiation of automatic synchronisation.
   - **v)** Push buttons for emergency diesel generator set unit ON/OFF.
   - **vi)** Emergency stop push button with latching function.
   - **vii)** Push button for lamp test.
3. Display or indicator panel with the following indications:
   - **i)** Fuel tank empty (20% level).
   - **ii)** Lube oil low pressure alarm.
   - **iii)** Lube oil high temperature alarm.
   - **iv)** Generator windings over temperature alarm.

v) Cooling water high temperature.

vi) High speed alarm.

vii) Generator overload alarm.

viii) Generator synchronised to network.

For all indications, measurings and alarms the respective sensors shall be installed on the emergency diesel generator set and it's auxiliaries.

To the station control system the following signals shall be transferred:

4. Fuel tank empty (20% level).
5. Fuel tank full.
6. Emergency diesel generator set in operation.
7. Control voltage fault.
8. Emergency stop (diesel generator blocked).
9. Summary alarm.

From/to automatic change over device in the LV switchgear the following signals shall be transferred:

1. From automatic change over device to emergency diesel generator set:

   i) Emergency diesel generator set "Start"

   ii) Emergency diesel generator set "Stop",

   iii) Reference voltage for synchronisation.

2. From emergency diesel generator set to automatic change over device:

   i) Emergency diesel generator set not available.

   ii) Emergency stop.

   iii) Emergency diesel generator set ready for taking over of load.

   iv) Emergency diesel generator set synchronised to network.

   v) Switching over to generator supply / network supply.

For all remote signals potential free contacts or the respective coupling relays shall be provided and shall be wired to a separate terminal stripe.

The main circuit shall be equipped with protection relays or releasers for generator windings high temperature.

The protection relays shall be of the latest state-of-the-art technology, electronic type, programmable with display.

2.11. MODES OF OPERATION

For the diesel generator unit the following operation modes shall be provided:

1. Off

The control logic is blocked, all signals will be indicated. A switching into this position during running engine will initiate a stop command.

2. Manual

All functions (start/stop, voltage regulations, automatic synchronisation, etc) shall be initiated from the control cabinet. In case of network power failure an automatic switch over to emergency supply shall not be executed.

3. Test

The diesel generator unit starts and synchronises automatically and initiate a signal "Switching over to generator supply" to the change over device. After switching the selector switch to manual or automatic diesel generator unit synchronised and initiate the signal "Switching over to network supply" to the change over device. After this the engine stops with a respective time delay. If during test run the normal network fails the diesel generator unit shall switch over automatically to emergency supply (via start signal from automatic change over device).

4. Automatic

In case of network interrupt all functions (start, synchronising, etc.) shall be carried out automatically. After return of normal network the synchronisation and stop shall also be carried out automatically, but with manual initiation from remote or from control cabinet.

During automatic mode no other orders can be given from the control panel, the initiation of stop can only be given if the normal network is available.

The selector switch for operation modes shall be lockable.

2.12. WIRING

The wires shall be selected according to load, insulation level, function and operating requirements. The wires shall be adequately rated and equipped with fuses/circuit breakers of adequate size.

The wiring shall be carried out solid and safe against damages. Wires shall be bundled and fixed. The wiring shall be laid inside of wiring channels, preferably. If wiring channels will be used, they must be from halogen-free type and a spare of 20 % shall be foreseen.

Terminal strips shall have 10 % spare terminals. If wires with different potential will be terminated on one terminal strip the respective terminals shall be separated by means of isolating plates. The termination of multiple stranded wires has to be carried out by means of multiple core cable ends.

Terminals shall be marked durable and easy readable, corresponding to the drawings. Wires shall be marked on the termination of each wire with the number of the corresponding connection point.

2.13. PAINTING

All components and devices shall have a resistant, long term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

An additional painting at location of installation is not allowed.

2.14. CABLES AND CABLE LAYING

For connection between different parts of the emergency diesel generator set or one distribution board copper cables with PVC insulation shall be used.

All cables shall be selected according to load, insulation level, function and operating requirements. The minimum cross section for power and signal cables shall be according to specification “Basic electrical requirements”. Signal cables shall be provided with copper screen.

3. STEEL FUEL-OIL STORAGE TANK CHARACTERISTICS

3.1. STEELS FUEL-OIL STORAGE TANKS

Steel fuel-oil storage tank: A horizontal, cylindrical tank of all welded construction with not less than 3/16-in.(18 mm) thick steel plate shell and heads, bearing UL's "Approved" underground label. Align suitable tappings axially at top of shell (of each tank) for fill, vent, alarm, level gage, suction, and necessary return piping.

Provide manholes for tanks over 4,000 gallons (15 m3)in capacity.

The fuel tank shall be provided with an appropriate fuel band for management of spillages.

The contractor shall provide the necessary tanks capacity for all sites in accordance with the consumption of the diesel generator rated for seven days of functionning.

3.2. APPURTENANCES

Supply appurtenances for steel fuel-oil storage tank including a fill connection, a suitable vent alarm, a vent cap, and a remote reading tank gage.

Pipe for fill and vent lines: Standard weight black steel pipe using malleable-iron screwed fittings.

Fill box: Watertight, combination flush cast-iron manhole type with a quick-closing lock-type cap and tight-fill connection, with a cast-brass, threaded, flush cover with suitable wrench or key. Provide cover with an identification plate labeled FUEL OIL in letters 1/2-in.(15 mm) high, and of a style that can be easily read.

Vent cap: Double-opening type with threaded center connection and without screen.

Vent alarm: Type suitable for installation in an underground tank.

Provide sufficient communicating tubing to make an unbroken connection between tank and gage dial in containers.

Install communicating tubing in a protective galvanized steel conduit.

Provide fuel-oil storage tank with a gage chart calibrated to show tank capacity in gallons per inch (m3/m) of depth and a gage stick calibrated in feet, inches, and eighths.

4. EXECUTION

4.1. INSTALLATION

The delivery, installation and commissioning of the emmergency diesel generator sets shall include, but not limited to the following items:

1. Transport to location of installation (if necessary storage), and the complete mounting inclusive all accessories.

2. Cable connections between the different parts of the emergency diesel generator set and to the accessories.

3. Grounding and potential equalisation, including connection with the next grounding bus bars.

4. Filling of emergency diesel generator set with lube oil and cooling water.

5. Filling of fuel tank with fuel.

6. Termination of all cables at the parts of emergency diesel generator set and at the accessories.

7. Commissioning of the functioning emergency diesel generator sets, including voltage feeding and adjustment of all relays, protection devices, etc.

8. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase and during a training on site.

The required lube oil and cooling water shall be supplied by Contractor. The diesel fuel will be delivered by Client.

The installation and as well the tests and the commissioning shall be carried out with Contractors own staff and with own tools and measuring/test devices.

4.2. TESTS

4.2.1. WORKSHOP TESTS

The emergency diesel generator sets shall be entirely tested prior to shipment in order to permit verification of the construction and the efficient operation, e.g. the response to control and the correct transmission of the signals to the external circuits.

All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted at least 3 weeks prior to start of the tests.

The following tests shall be carried out, at least:

1. Full load run with measurement of all output data.
2. Check of all unit data under full load conditions.
3. Vibration check.
4. Mechanical operation test on circuit breakers.
5. Functional tests to prove all alarms, signals, indications, shut downs, etc..
6. Operation of speed governor, overspeed trip and voltage regulator.
7. Test of auxiliary devices.

Detailed test protocols of all tests performed have to be submitted prior to shipment.

4.2.2. SITE TESTS

The site tests shall include the following steps:

1. Pre-commissioning (including “loop testing”).
2. Commissioning and test on completion.
3. Performance test.

The workshop tests described above test shall be repeated on site by the Contractor after erection.

Special care shall be taken for setting of protection devices, relays, setting must be done according to the approved selectivity study.

The aim of the tests is to ensure the proper function of the complete scope.

4.3. DOCUMENTATION

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the emergency diesel generator sets and their components.

All documents shall be in English language.

The documentation of the emergency diesel generator sets shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all devices and cabinets.
3. Drawings for the whole emergency diesel generator set.

4. Distribution board schedules.
5. Single line diagrams.
6. Block diagrams.
7. Wiring diagrams.
8. Termination drawings.
9. Cable lists.
10. Spare parts list.
11. List of used devices with manufacturer.
12. Software and software description.
13. Operation and maintenance manual.
14. Reports of tests and commissioning with protocols.

The documents listed above shall be handed over for approval.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

4.4. SHIPPING

All equipment, material and spare parts shall be sufficient packaged. Each emergency diesel generator set should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

4.5. SPARE PARTS AND SPECIAL TOOLS

Spare parts provision must comply with the requirements given in section 7.1, item 29.

All necessary special tools for operation and maintenance of the diesel generator sets shall be supplied for each emergency diesel generator set, at least consisting of:

1. One (1) set of all special tools required for operation and maintenance.
2. One (1) set fuses (6 fuses of each used size).
3. Key set for cabinet doors and locks.
4. Magnetic warning labels in sufficient number, English and Local language.

5. Software (if any).

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SECTION 16320
HIGH VOLTAGE POWER TRANSFORMERS

1. GENERAL

1.1. SCOPE

This document covers the requirements for the design, manufacturing, construction, installation, test and commissioning of high voltage power transformers for the Mwache Water Treatment Plant.

1.2. CODES AND STANDARDS

The design, manufacturing, construction, installation, test and commissioning of High Voltage Transformers shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60060 High voltage test techniques.

IEC 60071 Insulation co-ordination.

IEC 60076 Power transformers.

IEC 60085 Electrical insulation - thermal evaluation and designation.

IEC 60137 Insulating bushings for alternating voltages above 1000V.

IEC 60214 Tap-changers.

IEC 60270 High voltage test techniques – partial discharge measurements.

IEC 60422 Supervision and maintenance guide for mineral insulating oils in electrical

equipments.

IEC 60529 Degrees of protection provided by enclosures (IP code).

IEC 60616 Terminal and tapping markings for power transformers.

As far as the power supply authority or permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.3. ENVIRONMENTAL CONDITIONS

The transformers shall be designed and constructed for continuous operation at full load under the local climatic and environmental conditions.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. POWER TRANSFORMERS GENERAL

a. Power transformers shall comply with IEC 60076 unless otherwise specified. They shall be suitable for General use on a three-phase system.

b. The materials used and the method of construction shall be of the first class quality and shall be such as to ensure optimum performance and uniform temperature throughout the transformer.

c. In the design of the transformer, special attention shall be paid to reduce noise level to a minimum.

d. Each transformer shall be provided with a main frame earthing terminal which shall be separate from the neutral terminal of a star connected winding.

Where the neutral of a star connected winding is to be separately connected to earth, an insulated neutral connection shall be brought out via a separate neutral chamber having provision for housing one or more current transformers for earth fault protection. A removable cover shall permit access to the current transformers and their secondary wiring.

e. Main cable terminations shall be provided to suit the type of cable used.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable and cores.

The boxes shall provide sufficient space for segregating the cores and maintaining the minimum insulation clearance and creepage distances applicable.

Cable boxes to accommodate low voltage (up to 1 000 volts) PVC or XLPE insulated cables shall be air insulated, designed to exclude direct ingress of moisture and dirt.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

f. Auxiliary wiring from current transformers, Buchholz relays, winding temperature indicators, pressure switches, etc., shall be marshalled to a separate termination chamber with separate access cover. The terminal boards or blocks shall be as specified for switchboard components. Removable, undrilled cable gland plates shall be provided.

2.2. OIL FILLED TRANSFORMERS

a. Oil filled transformers shall be suitable for outdoor service and arranged for natural air cooling (Type ONAN) and shall comply with the specification for power transformers.

b. Constructional steelwork shall be shot blasted or chemically pickled internally and externally and shall be thoroughly descaled and degreased before being given the first coat of a comprehensive painting process which shall, for the interior, be of paint or varnish able to

resist the action of oil. The exterior shall be primed with one coat of zinc-enriched paint followed by two undercoats of contrasting colour followed by one top coat of durable, oil resisting and weather resisting paint.

c. Main connections shall be brought out through oil-tight bushings into their respective connecting chambers and shall be provided with disconnecting links to facilitate cable testing and complete removal of the connecting chamber from the transformer without the necessity of breaking the cable termination.

d. Each transformer shall be delivered filled with oil.

e. Temperature sensing devices shall operate a dial type indicator with a red line showing maximum permissible operating temperature. The indicator shall incorporate adjustable alarm and trip contacts to operate on excess temperatures.

Silica-gel breathers shall be fitted with indicators and shall be conveniently located for regular inspection and ease of silica-gel renewal.

Buchholz relays shall have their gas sampling cocks conveniently placed for operation from ground level.

2.3. TAP-CHANGERS

On load tap-changers shall comply with IEC 60214-1, unless otherwise specified.

Tapping on HV side (%) shall be in stepps of ± 2.5%

Tap-changers shall be delivered filled with oil and be compelte with motor driven unit

A remote tap-changer control panel shall be installed in the relevant switchroom the transformer is supplied from.

2.4. PAINTING

All components and devices shall have a resistant, long term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

2.5. MARKING

The following plates (may be combined also) shall be mounted on the low-voltage side of each transformer tank at a height of about 1.5 m above ground:

a. A rating pate as specified in IEC 60076, including space for Owner’s serial number, and alpha-numerical identification number.

b. A diagram plate with internal connectionqs of windings.

c. A general plate showing the layout of the transformer covering the locations of terminals, control devices, valves and all essential transportation details.

All above plates shall be made from brass or stainless steel. Inscriptions shall be written in English language.

3. EXECUTION

3.1. INSTALLATION

The delivery, installation and commissioning of the power transformers shall include, but not limited to the following items:

1. Transport to location of installation (if necessary storage), and the complete mounting of transformer and protection and control panel.

2. Filling of insulation liquid if not already factory-fillrd prior to shipment.

3. Grounding and potential equalisation, for the transformers and control panels.

4. Termination of all cables at the transformers.

5. Termination of all cables at the protection and control panels.

6. Commissioning of the functioning transformers and adjustment of all protection devices.

7. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase.

Fire barrier wall of minimum two hour fire rating shall be provided betwenn two adjacent transformers and also betwenn transformer and any close-by building. These walls shall be of adequate height and constructed such that free air ventilation of transformers shall not be affected.

Transformers installed outdoors and exposed to sun shall be provided with sunshade cover of fibre-glass material such that there shall be no restriction to free air ventilation. The sunshade cover shall be supported on tubular, lightweight, ready to assemble and easy to disassemble type galvanised steel structure.

The transformers shall be mounted after erection of the oil catch bassin and the fire protection walls. Sun shades and protection fences can be installed later, but before energising of the transformers.

The installation and as well the tests and the commissioning shall be carried out with Contractors own staff and with own tools and measuring/test devices

3.2. TESTS

3.2.1. WORKSHOP TESTS

All transformers shall be tested completely and detailed in manufacturer’s workshop.

All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted at least 3 weeks prior to start of the tests.

Test in the factory shall be carried out in accordance with the requirements of the relevant standards.

These are according to IEC regulations mainly but not limited the following:

1. Measurement of winding resistance.
2. Measurement of ratio.
3. Measuring of short circuit voltage, short circuit impedance and short check of on-load circuit losses.
4. Measuring of no-load losses and no-load current.
5. Operation tests of the measuring equipment.
6. Test of tranformer oil.
7. Test of auxiliary electrical devices.

Detailed test protocols of all tests performed have to be submitted prior to installation.

3.2.2. SITE TESTS

The site tests shall include the following steps:

1. Pre-installation testing.
2. Pre-commissioning (including “loop testing”).
3. Commissioning and test on completion.
4. Test runs.
5. Performance test.

The aim of the tests is to ensure and prove the proper function of the complete scope.

3.3. DOCUMENTATION

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the transformers and its components.

All documents shall be in English language.

The documentation of the transformers shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all transformers and devices.

3. Block diagrams.
4. Wiring diagrams.
5. Termination drawings.
6. Cable list.
7. List of used devices with manufacturer.
8. Spare parts list.
9. Operation and maintenance manual.
10. Reports of tests and commissioning with protocols.

The documents listed under a) to f) shall be handed over for approval, too.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

3.4. SHIPPING

All equipment, material and spare parts shall be sufficient packaged and should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

3.5. SPARE PARTS AND SPECIAL TOOLS

To comply with provisions of 7.1 – General Requirements, Section 29 – Spare Parts.

The Contractor is to supply all the recommended spare parts by the manufacturer. As a minimum, the following spare parts are to be provided:

- 2 Sets of Silica Gel for each transformer
- 220 l (1 drum) of Transformer Oil.
- Manufacturers Recommended spare parts for On-load Tap Changers.

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SECTION 16390
GROUNDING AND LIGHTNING PROTECTION SYSTEMS

1. GENERAL

1.1. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

The work covered by this section concerns the supply and installation of all cables required for the connection of equipment included in this Contract.

This work shall concern cables of all types, of all duty voltages and cross-sections, as well as all supports, terminal boards, ducts and fastening and marking accessories. The works covered by this section excludes fire detection circuits, which are included in the relevant section.

1.1.1. GROUNDING SYSTEM

The main grounding protection system shall consist of a minimum of:

1. one earth earth mat,
2. continuous main upper earth bar systems,
3. branch upper connections between the main earth bars and all electrical equipment.

Earthing of electronic circuits shall be connected to a separate earth electrode which shall be connected to the main earth system through removable links.

1.1.2. LIGHTNING PROTECTION SYSTEMS

The lightning protection system of the pumphouse buildings and shall be designed in accordance of the building type i.e steel structure or brickwork concrete structure.

Each rod shall be connected to a specific earthing electrode by means of copper bars.

The specific earth electrodes shall consist of three earth rods.

1.2. QUALITY ASSURANCE

1.2.1. REFERENCE STANDARDS

The grounding system shall be in accordance with IEC 364.

The lightning protection system shall be in accordance with IEC 1024.

1.2.2. DESIGN CRITERIA

The contractor shall carry out a soil resistivity test for the area of the pumphouse and buildings. The contractor shall submit a design for the earth mat and grounding system based on the results of the soil resistivity test

The earth resistance of the grounding system shall not be greater than one (1) ohm.

The lightning protection system shall be designed in order to protect all equipment and buildings.

The earth resistance of the lightning protection earthing electrodes shall not be greater than ten (10) ohms.

Sections of conductors given in the present specifications shall be considered as the minimum sections to be used.

All switchboards, equipment transformers, pump motors, cable trays, and electrical equipment, etc. shall be bonded to the earth mat and earth bars. Each switchroom or MCC room shall have an earth bar suitable designed mounted in the cable trench or on the wall. All earth cables from various equipment shall terminate on this earth bar and all earth bars should be bonded together. The sizing of earth cables and earth bars shall be in accordance with the fault level calculation carried out by the contractor.

Submittals and Approvals

The Contractor shall submit for the Engineer's approval the earthing and lightning protection diagrams.

Number, dimensions and characteristics of the lightning rods shall be shown on the relevant diagram.

2. PRODUCT, COMPONENTS AND SUB ASSEMBLIES

2.1. GROUNDING PROTECTION CABLES

1. Isolated copper cable for the connection to the new earth electrode, and bare copper cables and bars.

2. Minimum cross-section:

   i) 25 x 3 for main earth bars for grounding and lightning protection systems,

   ii) 70 mm^2 single core cables for individual earth connections for grounding protection system.

2.2. LIGHTNING RODS

Circular sections, copper coated steel cored .

2.3. GROUND RODS

Circular section, copper rods with steel core, diameter ≥ 15 mm, length ≥ 2 m.

3. EXECUTION

3.1. ERECTION

1. Lightning protection earth electrodes

   The distance between specific earth electrodes and any metallic pipe or electric cable shall not be less than 5 m.

2. Lightning protection earth bars

   The lightning protection earth bars shall be protected, from the ground level up to 2.5 m high along the walls of the building by means of a galvanized steel protective tube.

3. Earth tapes

   i) Earth tapes shall make maximum use of the cable troughs and ways and shall be given maximum protection from mechanical and chemical damage.

   ii) Under no circumstances shall a machine earth wire or frame be connected in series with the earth circuit so as to avoid any risk of interrupting circuit continuity the day the machine is moved or replaced.

   iii) The number of connections forming circuit continuity shall be reduced to the absolute minimum and all such connections shall be made with the lowest possible contact resistance.

   iv) All connecting nuts and bolts used shall be corrosion-proof.

3.2. TEST ON SITE

After installation and connection of the earthing circuits, the following measurements will be carried out :

1. Measurement of the resistance of the earth electrodes.

2. Test of continuity of the earthing circuits.

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SECTION 16425
AC LOW VOLTAGE DISTRIBUTION SYSTEM

1. GENERAL

1.1. GENERAL DESCRIPTION OF THE DISTRIBUTION BOARD AND PANEL

The distribution board and panel shall be supplied fully equipped for power supply, protection, control, and monitoring of all the circuits and devices to which it is connected.

In particular, they shall include:

1. One incoming circuit breaker or a set of circuit breakers for changing over supplies from one source to the other.

2. Power circuits equipped with circuit-breakers or contactors with a fused isolator, depending on the case, each of the circuits being carefully rated in relation to the equipment powered.

3. Auxiliary control, monitoring, and measuring instruments required to meet the operating conditions specified or defined by the Manufacturer responsible for supplying the equipment concerned.

4. In particular, each motor feeder will be equipped with:

5. an ammeter with motor scale,

6. an operating time counter.

7. Monitoring and power circuit terminal connection plates, including terminal strips reserved for remote control, telemetering, or remote indication circuits.

8. Spare circuits equipped.

1.1.1. SYSTEM EARTHING

The system earthing shall be as follows:

1. 400 - 230 V circuits, 4 conductors with 4 pole circuit-breakers, system earthing TN-S including protections as per CEI 364.3, and additional protection by residual current devices for lighting and small power circuits.

1.2. QUALITY ASSURANCE

1.2.1. REFERENCE STANDARDS

1. IEC 60269-1: Low voltage fuses
2. IEC 60364: Electrical installation of buildings
3. IEC 61439: Low voltage switchgear and control gear assemblies
4. IEC 60529: Degree of protection provided by enclosures
5. IEC 60947: Low voltage switchgear and control gear

1.2.2. DESIGN CRITERIA

1. Duty frequency: 50 Hz
2. Duty voltage: 415/240 V, 3 phase
3. Earthing system: Neutral solidly earthed
4. Fault current: 50 kA (1 s)

1.3. WORKSHOP TESTS

1. Type tests:

   A type test certificate for each type of circuit-breaker shall be submitted by the Contractor.

2. Routine tests:

   Each switchboard, cubicle, and cabinet shall be subjected to routine tests after erection and wiring. These tests will include as a minimum:

   i) Dielectric strength test.

   ii) Operating test on each of the appliances.

   iii) Cable check on each appliance.

   iv) Interchangeability check for draw-out appliances.

   v) Check for earthing circuit continuity.

2. PRODUCTS

2.1. EQUIPMENT

2.1.1. CIRCUIT-BREAKERS

The circuit-breakers shall comply with the requirements of IEC standard No. 6060947-2.

The circuit-breakers shall be of air-break type.

The draw-out type circuit-breakers shall be carriage-mounted with the possibility of at least three positions: "plugged in", "test" and "withdrawn" with locking in the last position.

The circuit-breakers shall be equipped with instantaneous - operation magnetic release mechanisms, operating in the event of short-circuit closure, short time-lag magnetic release mechanisms with an adjustable time-lag, and adjustable extended time-lag release mechanisms.

The outgoing secondary circuit-breakers (for power distribution to A. C. auxiliaries) shall be of the high-speed, current-limiting, trip-free type with manual closing mechanism. They shall be equipped with magneto-thermal tripping devices on each pole.

The breaking capacity of the circuit-breaker shall be sufficient to eliminate maximum short-circuit currents.

2.1.2. SWITCHES, DISCONNECTORS, SWITCH-DISCONNECTORS, AND FUSE-COMBINATION UNITS

The switches, disconnectors, switch-disconnectors, and fuse-combination units shall comply with the requirements of IEC standard No. 60947-3.

They shall be three-pole and their rating shall be at least 20% above the duty current.

The number of different rating values shall be reduced to the absolute minimum in order to minimize the volume of spares to be held in store.

2.1.3. CONTACTORS AND MOTOR-STARTERS

The contactors and motor-starters shall comply with the requirements of IEC standard No. 60947-4.

They shall be three-pole and their rating shall be at least 20% above the duty current.

The number of different rating values shall be reduced to the absolute minimum in order to minimize the volume of spares to be held in store.

The contactors shall operate without excessive noise or vibration; their operation shall under no circumstances have an adverse effect on the operation of relays fitted inside the same chassis.

The AC and DC coils shall be designed to allow satisfactory operation of the contactor for a voltage varying between +10% and -20% of the nominal voltage and must be capable of remaining energized indefinitely at a voltage equal to 1.1 times the nominal voltage.

Thermal or magneto-thermal protective relays shall be fitted on all the poles. They shall be temperature-compensated and incorporate single phasing protection.

In addition to the auxiliary contacts required for normal operation of the installation, each contactor shall include a set of instantaneous-operation "O + C" contacts (a minimum of two of each type).

2.1.4. INSTRUMENT TRANSFORMERS

The instrument transformers shall be of the dry-insulation type with a rated insulation voltage of 1000 volts.

Their rated load shall be sufficient to provide the required accuracy, giving due consideration to the power of the apparatus to be supplied (with a 10% margin), circuit losses, and a possible

supply of additional apparatus. Current transformers shall comply with IEC standard No.185. Voltage transformers shall comply with IEC standard No.186.

Transformers designed to power measuring instruments, indicators or recorders shall have a precision class of 1. Transformers designed to supply protective relays shall be compatible with the supplied relays.

The overcurrent class of current transformers with a primary shall be coordinated with the maximum short-circuit current in the corresponding circuit.

The rated secondary currents of current transformers shall in all cases be 1 amp.

The rated secondary voltages of voltage transformers shall in all cases be 110 Volts.

2.1.5. SWITCHBOARDS - CUBICLES

The switchboard shall be of the prefabricated, modular construction type consisting of contiguous columns assembled together, each column isdivided into compartments containing the switchgear and control gear fitted to draw-out carriages or rack modules.

Switchboard construction shall comply with IEC standard 61439, with a minimum degree of protection as stated in Section 16010.

The main set of busbars shall be accessible by removing a cover plate. electric-electric busbars shall be isolated against sewage gases and the surrounding conditions, taking into consideration the applicable colour coding

Distribution circuit-breakers: distribution circuit-breakers shall be the base-mounted draw-out type with front panel controls.

Relays are grouped together:

1. on a fixed vertical strip for accommodating mounted flush-mounted direct-reading measuring and monitoring instruments, ammeter, voltmeter, indicator lights, insulation controller, etc. or,

2. on a removable mounted slide-mounted drawer accommodating, in addition to the direct-reading instruments, the auxiliary servo relays or,

3. inside a cabinet installed in place of the mounted guard-mounted equipment if the relays are too voluminous.

The auxiliary monitoring circuits shall be housed in a box in the front part of the board.

Power and auxiliary connections are made from the rear of the column, in a compartment with a door, designed to facilitate connection operations. This compartment includes:

4. The connector strips of the power cables.

5. The connection terminal plates for the auxiliary circuits.

6. Where applicable, the current transformers shall be fitted to the connector strips.

Supports shall be provided for clamping cables and outgoing lines in ducts or hoppers through the bottom.

In the event of a large number of large-section cables, the provision shall be made for a cable duct at the rear of the switchboard.

2.2. SPECIAL TOOLS – SPARE PARTS

The following equipment shall be provided for each pumping station.

2.2.1. SPECIAL TOOLS

1. Carriage for handling the main circuit-breakers.
2. Complete set of operating and draw-out cranks and levers.

2.2.2. SPARE PARTS FOR EACH SITE

1. One circuit-breaker resetting mechanism motor.
2. One coil of each type.
3. One circuit-breaker of each type and each rating.
4. One set of contactors and motor-starters of each rating.
5. Two auxiliary contact blocks for the contactor.
6. Two complete sets of fuse cartridges of each rating.
7. Two complete sets of indicator lights.
8. One relay of each type.
9. One set of each type of LV CTs and VTs.

3. INSTALLATION

3.1. INSTALLATION OF SWITCHBOARDS AND CUBICLES

Switchboards and cubicles will be installed in the places indicated on the drawings. Unless otherwise indicated, the switchboards and cubicles will be placed on the floor, on a cable duct. Depending on conditions, switchboards and cubicles will be accessible from the front and rear or only from the front. Any change in the layout must be submitted for the Engineer's prior approval.

3.2. FINAL TESTS

After erection and assembly of the equipment, further routine tests will be carried out on each switchboard and cubicle. The dielectric strength test will be replaced, however, by measurement of the insulation.

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SECTION 16427
DC AND AC-UPS DISTRIBUTION SYSTEM

1. GENERAL

1.1. SYSTEM DESCRIPTION

1.1.1. DC DISTRIBUTION SYSTEM

Two separate 110 V DC battery systems, one for 33kV Switchgear and one for 3.3kV Switchgear shall be installed in the electrical room, in order to supply the following duties:

1. Circuit breaker motor charging spring closing mechanism,
2. Switchgear protection and auxiliary control relay circuit,
3. Shunt trip circuits,
4. Switchboard indicating lamp and alarm circuits.

Battery duties (b), (c) and (d) shall cover all HV and MV switchgear except 415 V motor control circuits, where control and indication shall be 110 V AC from integral control transformers.

The battery systems shall incorporate self-regulating battery charging equipment and failure of either charger or battery output shall initiate an alarm in the associated monitoring system. The battery chargers shall be capable to operate within variations of the supply voltage from -15% to +10%.

Under normal operation, each charger shall supply its associated battery, and only one charger shall supply the total DC load through the common DC distribution panel.

Three charging modes shall be possible:

5. floating mode: under normal conditions;
6. equalisation charge following main power cut lasting more than five minutes;
7. manual boost charge.

The 110 V systems shall be unearthed.

The outgoing feeder circuits shall be individually protected by circuit-breakers.

The capacity of each 110 V battery shall not be less than 200 Ah. The contractor is responsible for sizing the battery capacity to suit the switchgear requirements.

1.1.2. UPS

One 230 V AC fully ininterruptable power source (UPS) shall be installed in the general control room of the site, in order to supply the computer system.

Under normal operation, the UPS shall be fed from the existing small power distribution system.

In case of the failure of normal AC source, it will be supplied from a 110 V DC system to be part of the UPS equipment.

The outgoing feeder circuits shall be individually protected by circuit-breakers.

1.2. QUALITY ASSURANCE

1.2.1. REFERENCE STANDARDS

1. Batteries: IEC 60622 and 60623 - Nickel-cadmium single cells.
2. Battery chargers/UPS: IEC 60146 - Convertors.

The battery chargers proposed shall be of a model recommended by the battery suppliers.

1.2.2. DESIGN CRITERIA

1.2.2.1. 110 V BATTERY SYSTEM

1. Battery charger rating: each battery charger shall be capable of supplying the total DC load under normal operating conditions as well as the charge required for its relevant battery.
2. Rated voltage of battery: 110 V.
3. Float voltage: 121 V.
4. Battery duty: should the normal supply fail, each battery shall be capable to ensure the emergency operation of DC equipment for twelve (12) hours.
5. Terminal voltage: at the end of the emergency discharge, the terminal voltage shall not be less than 102 V.

1.2.2.2. UPS SYSTEM

1. Rated output voltage: 230 V.
2. Duty: the UPS shall be capable of supplying the standing load for an emergency discharge period of twenty minutes.

1.2.3. FACTORY TESTS

1.2.3.1. ROUTINE TESTS

1. Testing of the charger-battery system in manual and automatic modes.
2. Tesing of the correct operation of the UPS.

1.2.3.2. TYPE TESTS

One or several elements of each battery shall be subjected to a discharge test up to the cut-off voltage, in order to check the guaranteed capacity. During the test, voltage, electrolyte density and temperature shall be recorded.

1.3. SUBMISSIONS

The Manufacturer shall submit for the Engineer's approval his calculation notes for the dimensional design of the battery and charger as well as the ventilation system of the room according to applicable standards. He shall also submit the battery charge and discharge curves for various operating conditions.

1.4. DELIVERY

The batteries shall be delivered dry with the necessary quantity of electrolyte for two complete fills.

1.5. GUARANTEES

1. Batteries: the capacity (C10) of the batteries under site conditions shall be guaranteed.
2. Battery charger: voltage regulation for the entire adjustment range shall be guaranteed.

2. PRODUCTS

2.1. EQUIPMENT

2.1.1. BATTERIES

The batteries shall consist of cells of the high-performance cadmium-nickel type, in completely closed, high-shock-resistant transparent plastics containers.

The battery elements shall be assembled inside a cabinet. Only one cabinet may be used for one battery charger and its relevant battery.

The batteries shall be delivered complete with all necessary connection accessories, cables, cadmium-plated nuts and bolts, etc.

2.1.2. BATTERY CHARGERS

2.1.2.1. TYPE AND PERFORMANCE

1. Static, thyristor-controlled type with automatic voltage and current limitation regulation system.
2. Voltage regulation: ± 1% for a supply voltage variation of ± 10%.
3. Current limitation: 1.01 to 1.06 nominal current.
4. Power supply: 415/240 V, 50 Hz.

2.1.2.2. OPERATING MODES

Two modes: automatic and manual with changeover switch located inside the cubicle.

1. Automatic operation:

   i) Normal floating operation at constant voltage.

   ii) After a main power cut lasting more than 5 minutes, automatic changeover to equalisation charge at constant voltage and adjustable time with automatic return to floating operation.

2. Manual boost charge at adjustable current with cut-out voltage limitation. When a battery is on manual boost charge the corresponding circuit breaker shall be opened in order to avoid connection to DC consumers.

2.1.2.3. ADJUSTMENTS

1. Floating voltage.
2. Equalisation voltage.
3. Charge current in manual mode.

2.1.2.4. PROTECTION – ALARMS - SIGNALLING

1. Protective devices on AC and DC sides, comprising individually mounted circuit-breakers.
2. Signalling: On/Off - Manual Charge - Boost Charge.
3. Alarm: Regulator fault with output for remote alarm.
4. Earth leakage indication and alarm.
5. Low volt relay.
6. Instruments: DC voltmeter and ammeter.

2.1.3. DISTRIBUTION SWITCHBOARD

Each set of both batteries and chargers shall be associated with a common free standing distribution board. Distribution board shall include:

1. Switchgear and control gear of the fixed (contactors) or base-mounted draw-out type (circuit-breakers) with front panel controls;
2. Instruments for voltage and current indication.

2.2. SPECIAL TOOLS – SPARE PARTS

The following equipment shall be provided for each pumping station.

2.2.1. SPECIAL TOOLS

The following special tools shall be supplied:

1. A complete set of monitoring and maintenance accessories including:

   i) A suction hydrometer with approximate range from 1.17 to 1.24.

   ii) A central-zero 3-0-3 V voltmeter.

   iii) A thermometer, 0 to 50□C measurement range.

   iv) An electrolyte level controller.

   v) A filler gun.

2. A set of special spanners for tightening connections.

3. Instruction chart for wall mounting in the battery room.

2.2.2. SPARE PARTS FOR EACH SITES

1. 2 spare cells for each battery,
2. 1 charge of electrolyte,
3. 2 set of diodes, thyristor, resistor for the battery charger,
4. 2 sets of printed circuit cards for the regulator,
5. 5 sets of cell connectors,
6. 1 incoming circuit breaker,
7. 2 outgoing circuit breaker,
8. 6 insulators,
9. 100% of fuses installed,
10. 100% of bulbs installed.

3. INSTALLATION

3.1. INSTALLATION

The battery, battery chargers, distribution board, and UPS shall be located in the attributed room. After installation and connection of all the equipment, the Contractor shall proceed with initial charging of the batteries in accordance with the manufacturer's instructions.

The Contractor shall indicate the requirements of the batteries with respect to the room and its fittings, in particular: ventilation, lighting with switch, wall and floor lining, special safety water tap dimensions.

3.2. SITE TESTS

After installation, the DC and UPS equipment shall be subject to the following inspection and test procedure:

1. Circuit insulation check.
2. Check of correct operation of the chargers/UPS.
3. Capacity measurement.
4. Check of correct operation of protection relays.

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SECTION 16500
LIGHTING AND SOCKET OUTLET SYSTEM

1. GENERAL

1.1. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

The number of fittings shall be defined in order to meet in any case the minimum service illuminance required in the following sub-sections.

Lighting circuits shall be supplied from distribution boards integral to the local 415 V switchboards and incorporating manually reset miniature circuit breakers. Separate distribution boards may be provided for serving discrete areas.

The arrangement of circuits shall be such as to provide balanced loading of the phases.

1.1.1. INTERIOR LIGHTING

The lighting design shall take into consideration:

1. The operating environment.
2. The type and style of architectural finish.
3. The activities to be performed in the areas concerned.
4. Access for maintenance.
5. Operating life.

Switching shall be convenient to doors and entrances, two way switches or push-buttons being provided where areas have more than one entrance.

1.1.2. EXTERIOR LIGHTING

The lighting shall be controlled from single internal switchpoints adjacent to the area access doors.

1.1.3. EMERGENCY LIGHTING

The emergency lighting system shall comprise exit and escape route luminaires to facilitate the safe evacuation of personnel from the pumping station buildings in the event of power failure.

Emergency luminaires located above or adjacent to escape doors shall be supplied with "EXIT" labels.

The emergency exit lighting luminaires shall be bulkhead fluorescent, non maintained type, incorporating self-contained battery/charger/inverter modules.

In areas where fluorescent pattern type luminaires shall be installed, selected luminaires shall incorporate a conversion pack comprising 12 V, 4 Ah nickel cadnium battery, solid state inverter/charger, and change over sensor.

The emergency luminaires shall be direct connected to the respective area main lighting circuits, in order to cover both total power and sub-circuit failures.

Emergency lighting circuits shall incorporate test switches to simulate failure of the normal supply. Test switches shall be situated in a position within the area covered by the lighting system to be tested and shall be suitably identified. Switches situated in positions accessible to unauthorised persons shall be of the tamper-proof, key operated type. All such switches shall be operated by a common key.

1.1.4. SOCKET OUTLETS

240 volt 13 A single phase Britishtype socket outlets shall be installed throughout each pumping station. A minimum of two socket outlets shall be provided in each room. In the pump motor room, the outlets shall be spaced so that no point is greater than 8 m from a socket.

Except in the offices, the socket outlets shall be weatherproof.

Socket outlets shall be supplied from distribution boards integral to local 415 V switchboards, incorporating manually reset miniature circuit breakers. The distribution boards may be common with those for lighting circuits.

All socket outlets shall be discretely supplied on radial type circuits.

One plug shall be provided for each socket outlet.

1.2. QUALITY ASSURANCE

1.2.1. DESIGN CRITERIA

Lighting intensity levels shall be as follows:

Location	Lighting intensity level	Lighting fitting
Indoor:		
- Offices	300 lux	
- Motor and switch rooms	200 lux	
Outdoor except service roads	50 lux	

1. The indicated illumination values in lux shall be measured at 1 m above floor and calculated in relation to a depreciation factor of 1.4.

2. All luminaries shall be installed in a position where glare is minimum. Where necessary grids shall be fitted to the luminaries.

3. All outdoor luminaries and fittings shall be of watertight type.

4. The maximum voltage drop between the head of the circuits and the users shall be as follows:

i) Lighting appliances: 3%.

ii) Socket outlets: 5%.

1.2.2. WORKSHOP TESTS

Distribution boards and cabinets shall be subjected to routine workshop tests.

1.3. SUBMITTALS

The Contractor shall submit the following documents for the Engineer's approval:

1. Lighting calculation notes.
2. Detailed manufacturer's technical leaflets for each item of equipment, including the photometric characteristics of the light fittings.
3. Voltage drop calculations.
4. Detailed drawings and schematic diagrams.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. LIGHT FITTINGS

2.1.1. FLUORESCENT TUBE LIGHT FITTINGS

1. General:

   Switchstart lighting appliances with power factor correction $\cos \varphi \geq 0.90$.

   Standard 36 W tube. Rated service life: 1,800 hours minimum.

2. Open industrial reflectors:

   i) White lacquer steel sheet casing containing electrical switchgear.

   ii) White lacquer steel sheet reflector with high reflecting capacity.

   iii) White lacquer steel sheet cut-off (or 'diffuser') screen.

   iv) Tube fittings: one, two or three 36 W tubes.

   v) Enclosure protection index: IP 20.

3. Watertight industrial reflectors:

   i) Glass-fibre reinforced polyester body.

   ii) Transparent Plexiglass trough with seal, fastened by non-removable hinged lock.

   iii) Tube fittings: one or two 36 W tubes.

iv) Enclosure protection index: IP 54.

4. Watertight ceiling fittings with opal trough:

   i) Glass-fibre reinforced polyester or lacquered steel plate body.

   ii) Rapid-closing methyl methacrylate opal trough, with neoprene seal.

   iii) Tube fittings: one or two 36 W tubes.

   iv) Enclosure protection index: IP 563.

2.1.2. INCANDESCENT LAMP LIGHT FITTINGS

1. Industrial-type fixed lights for technical rooms:

   i) Round or oval cast-iron body.

   ii) Tempered glass prismatic cover with seal.

   iii) Protective grating.

   iv) Enclosure protection index: IP 55.

   v) Ceiling fitting or wall fitting.

2. Watertight fixed lights for damp rooms:

   i) Double-insulated fixed lights with no external metal parts.

   ii) Body made of polypropylene or equivalent material.

   iii) Tempered-glass prismatic cover.

   iv) Enclosure protection index: IP 45.

3. Wall-mounted light fittings for sanitary blocks:

   i) Double-insulated rectangular wall fittings with built-in insulation transformer and 20 VA socket outlet.

   ii) Body made of polypropylene or equivalent material.

   iii) Enclosure protection index: IP 42.

2.1.3. HALOGEN LAMP FITTINGS

1. Compact floodlights for exterior lighting.

2. Body of die-cast aluminium with cooling fins.

3. Hinged frame of die-cast aluminium with stainless steel fasteners.

4. Toughened safety glass, sealed in a silicone joint between the body and the frame.

5. Reflector of hammered, polished aluminium, anodised for protection.
6. Lamp holder mounted on a support and pre-wired to the connecting box.
7. Watertight connecting box of aluminium.
8. Stirrup of galvanized steel for mounting and aiming.

2.1.4. HIGH PRESSURE SODIUM LAMP FITTINGS

1. Public-lighting type fitting with built-in switchgear.
2. Polypropylene or equivalent fairing.
3. Optics made of corrosion-proof treated aluminium.
4. Transparent methacrylate trough with neoprene seal.
5. Enclosure protection index: IP 55.
6. Fitted to lamp post socket or to end of tubular bracket.
7. Circular or hexagonal section galvanised steel lamp posts.
8. Galvanised steel wall brackets.

2.2. SOCKET OUTLETS

2.2.1. SOCKET OUTLETS FOR OFFICE USE

1. 13A - single phase 240 V + E, surface mounted with ivory-colour plastic body.

2.2.2. SOCKET OUTLETS FOR INDUSTRIAL PREMISES

1. Three-phase 415 V + E with plug top, 32 A rating.
   i) Enclosure protection index: IP 54.
   ii) Individually mounted or cabinet-mounted.
2. Single-phase 240 V + E with plug top, 13 A rating.
   i) Enclosure protection index: IP 54.
   ii) Individually mounted or cabinet-mounted.

2.3. SPARE PARTS AND SPECIAL TOOLS

2.3.1. NORMAL LIGHTING APPLIANCES

1. 5% of the quantity of appliances of each type installed, with a minimum of one appliance.
2. One lamp post.

3. One wall bracket.

4. 100% of lamps, tubes of each type and each power rating.

2.3.2. SOCKET OUTLETS

1. Five socket outlets of each type.

2. Ten 240 V + E, 13 A plugs.

3. Five 415 V + E, 32 A plugs.

3. EXECUTION

3.1. ERECTION

Cables shall be laid into ducts when existing or directly buried for outdoor lighting. They shall be laid on horizontal or vertical slabs in surface-mounted rigid tubing for connections to appliances, except in offices.

In rooms with false ceiling, the direct laying of cables on the framework of the false ceiling shall not be authorised.

3.2. FIELD QUALITY CONTROL

After installation, the lighting and socket outlet circuits shall be subjected to the following inspection and test procedures:

1. Continuity of circuit conductors.

2. Continuity of protective conductors.

3. Insulation resistance.

4. Polarity.

5. Operation of protective devices.

6. Illumination measurements.

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SECTION 16600
HIGH AND LOW VOLTAGE SWITCHGEAR

1. GENERAL

1.1. SCOPE

This document covers the requirements for the design, manufacturing, construction, installation, test and commissioning of High and Low Voltage Switchgear Mwache Water Treatment Plant.

1.2. CODES AND STANDARDS

The design, manufacturing, construction, installation, test and commissioning of emergency diesel generator sets shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60265-1 Switches for rated voltages above 1 kV and less than 52 kV

IEC 60947-4-1 Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60898 Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations

IEC 60947-2 Low-voltage switchgear and controlgear - Part 2: Circuit-breakers

IEC 60298 - Enclosures for high voltage switches-fuses

IEC 60129 Alternating current disconnectors and earthing switches

IEC 60282-1 High-voltage fuses - Part 1: Current-limiting fuses

IEC 60470 - High-voltage alternating current contactors and contactor-based motor-starters

As far as the power supply authority or permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. ENCLOSURES FOR ELECTRICAL POWER APPARATUS

a. Enclosures shall be fabricated from sheet Electrical Power steel of adequate thickness, suitably braced to form a rigid structure. The thickness of medium voltage boards and low voltage boards shall be 2 mm as a minimum. Exterior corners and edges shall be rounded to give a smooth overall appearance. Designs involving the use of externally visible assembly bolts and screws or rivets will not be acceptable.

Enclosures mounted indoors and outdoors shall provide a degree of protection not less than lP54 to IEC 60529 unless otherwise specified. The design of the enclosures shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Cable entries shall be closed and made vermin proof.

Unless otherwise specified, enclosures shall be suitable for floor mounting.

Where wall mounting enclosures are provided, the fixing details shall preferably comprise externally welded brackets but internal fixing arrangements will be acceptable provided that they prevent ingress of moisture. With either arrangement, the rear of the enclosure shall be not less than 10 mm from the wall.

Lifting eyebolts shall be removed after installation and replaced by bolts.

b. Enclosures shall be pleasing in appearance, extensible, and symmetrically arranged as far as possible with projections kept to a minimum.

Where two or more enclosures are fitted together, they shall form a flush fronted continuous suite of uniform height. Instruments, relays, and control devices shall not be mounted at a height greater than 2 000 mm nor less than 300 mm from floor level.

All individual components of equipment associated with a single item of plant shall be contained in a single enclosure. Where a number of plant items are in close proximity, the use of individual enclosures shall be avoided and composite enclosures shall be provided. Enclosures for multi-circuit switchboards shall be subdivided into single circuit compartments. Compartments shall be segregated by rigidly braced steel sheets and screens arranged so that, in the event of internal fault conditions, the fault damage is entirely confined to the faulted compartment.

c. The arrangement of the equipment within each enclosure shall be such that all normal maintenance can be carried out from the front through a hinged door. Composite enclosures shall be provided with a hinged access door for each compartment.

Enclosures containing switchgear and motor control gear shall be fitted with hinged front access doors to each compartment and, where rear access is available, bolted removable covers or hinged access doors at the rear.

Enclosures not requiring front access doors shall be fitted with hinged access doors at the rear.

Access doors shall have a flush appearance, and shall be fitted with locks or lockable handles. Front access doors shall be of rigid construction and free from distortion when equipment is mounted and supported on the door. Rear access doors shall have lift-off hinges arranged so that one shank engages before the other to permit ease of fitting. No instruments, relays or other equipment shall be mounted on rear access doors or removable covers.

d. Panels and cubicles shall be provided with earthing arrangements.

On single cubicles, an earth stud shall be provided.

Multi-panel switchboards or composite enclosures comprising a suite of individual sections or cubicles shall incorporate a continuous earth busbar.

The earth busbar shall extend to all panel/cubicle sections. All panels and individual sections/cubicles shall be earthed by direct connections to the earthing busbar, which shall also include extensions and terminations for the earthing of the metal cladding and armouring of all incoming and outgoing power cables.

On equipment having only front access, the main earth busbar shall be internally mounted but readily accessible.

The earth busbar shall incorporate an external terminal assembly for the connection of a copper tape or cable from the station earthing system.

A positive earthing conductor and termination shall be provided on all enclosure doors on which electrical equipment is mounted.

The short-time rating of the earth busbar and connections shall be not less than that of the associated switchgear equipment, or the maximum through-fault current of the power source, and under fault conditions, the temperature rise of the busbar and connections shall not cause damage to the connections or any equipment to which they may be connected.

For main distribution and plant control switchboards the cross-sectional area of the earth busbar and connections shall be not less than 25 x 3 mm.

No earth terminal bolts or studs shall be less than 8 mm diameter.

e. Panels and cubicles shall be provided with anti-condensation heaters.

2.2. BUSBAR AND PRIMARY CONNECTIONS

Busbars and primary connections shall be of electrolytic copper and shall be rated for continuous operation. The mechanical and dielectric strengths of busbar and connection insulators and supports shall be able to withstand the worst conditions of electrical surge which can occur on the installation, for any system fault condition internal and external to the switchboard.

Busbars and primary connections shall be housed in air-insulated enclosures which shall be arranged such that no direct access to or contact with live conductors is possible via slots or apertures.

All bars and contacts shall be coated with tin or any suitable paint resistant to hydrogen sulphide. Suitable baffles shall be provided to prevent the accidental entry of tools, etc., whilst maintenance work is being carried out in the vicinity of the chambers which shall be fitted with suitable warning labels.

The busbar shall be divided for both high voltage and medium voltage to provide maximum security and easy maintenance.

The busbars and primary connections shall have a short-time rating of not less than that of the associated switchgear.

All busbars, primary connections and power circuit conductors and wiring shall be colour coded.

Phase sequence indicator shall be provided at the main feeders.

2.3. CABLE TERMINATIONS AND CABLE BOXES

a. On multi-circuit switchboards and control panels, the power and control cables shall be glanded and terminated directly to the panel/circuit or compartment concerned.

The cable boxes or gland plates for individual circuits shall be designed and located to permit the termination of the circuit cable without impeding access to the cable terminations of other circuits or sections of the switchboard.

The use of common cable termination compartments on multi-circuit and low voltage switchboards will be approved only when the equipment location or mounting arrangement impedes direct access to individual circuits.

Common cable termination compartments shall be complete with cable core terminations, with permanent wiring or cable riser connections to the individual circuits. Cable gland plates shall be arranged or split to permit the independent termination of individual circuit cables.

Cable gland plates and/or supports for cable sealing boxes shall be provided and positioned to provide a minimum gland height of 250 mm from the surrounding floor level.

b. Cable boxes to accommodate PVC or XLPE insulated cables for voltages up to 1 000 volts shall be air insulated and designed to exclude direct ingress of moisture and dust.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

Cable termination methods shall be as specified.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable cores.

The boxes shall provide sufficient space for segregating cores and maintaining the minimum insulation clearances and creepage distances applicable.

2.4. CIRCUIT BREAKERS – GENERAL

a. Circuit breakers for indoor installation on systems having a nominal voltage up to 33 or 3.3 kV shall be of the air, vacuum, or sulphur hexafluoride (SF6) filled type and, unless otherwise specified, shall be of the withdrawable pattern incorporated in metal-clad switchgear.

Circuit breakers for installation on systems having a nominal voltage up to 36 kV shall be of the minimum vacuum or SF6 pattern.

Circuit breakers shall be capable of interrupting all faults up to their maximum rating without damage to equipment or danger to personnel.

Test evidence of the normal current rating, and certification by an independent switchgear testing authority of the symmetrical breaking capacity of circuit breakers shall be submitted when required.

Isolating facilities shall be provided for all circuit breakers. Means shall also be provided for testing the normal operation of the circuit breaker when in the fully isolated position.

b. Circuit breaker operating mechanisms shall be of the following types:

- independent manual spring;
- hand-charged spring with manual release;
- motor-charged spring with electrical release;

- direct current (dc) solenoid.

All operating mechanisms shall be trip-free and shall have mechanical "ON" and "OFF" indicators and a manual trip device fitted with locking facilities. Hand charged and motor charged spring mechanisms shall have "SPRINGS CHARGED" and "SPRINGS DISCHARGED" indicators.

Operating mechanisms of the hand-charged and motor-charged spring types shall be arranged so that release of the spring energy to close the circuit breaker can only be achieved by deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor-charged spring mechanisms shall be arranged so that the charging is initiated automatically following a discharge and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand-charge a motor-charged spring mechanism.

The closing solenoids of d.c. solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage, and shall not mal-operate or cause excessive vibration when energised at a voltage equal to that of the closing battery with the charger set at the maximum rate, or equal to that from a full wave rectified source designed for multiple simultaneous operation. Unless otherwise specified or agreed, this higher voltage shall be taken as 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to "slow-close" the circuit breaker, but this operation shall only be possible in the fully isolated position. Any necessary operating handle or lever shall be supplied.

c. Circuit breakers shall be provided with interlocks to ensure that:

- the breaker shall be open before operation of the circuit isolation device is possible;
- the breaker cannot be closed until the circuit isolation device has been fully operated;
- the breaker cannot be closed in the service position without completing the auxiliary circuits;
- the breaker cannot be "slow-closed" except in the fully isolated position;
- with hand charged or motor charged spring mechanisms, the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected.

Where key interlocking (Castell or similar) is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.

d. A set of safety shutters shall be provided on indoor metal-clad switchgear to cover each three-phase group of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn, each set shall be capable of being individually operated and of being padlocked in the closed position.

To facilitate high voltage and current injection testing via the isolating contacts, a device shall be provided for fixing (not locking) the shutters in the 'open' position and for releasing them into the 'closed' position. The device shall be arranged to be cancelled by the circuit breaker moving portion to ensure the restoration of the automatic features of the shutters.

Busbar shutters shall be coloured red and labelled "BUSBARS" in large white letters. Shutters in bus-section units shall be coloured red and shall be labelled with a large white arrow pointing in the direction of the section of busbars to which the isolating contacts are connected.

e. Indoor circuit breaker moving portions shall be fitted with positive guides so as to ensure correct alignment of the isolating contacts.

f. Indoor high voltage circuit breakers shall be provided with circuit and/or busbar earthing facilities. Circuit and busbar earthing shall be carried out through the circuit breaker and so arranged that the earthing operation is completed on closing the breaker by its normal local means of operation.

Selection of either circuit or busbar earthing shall only be possible after the circuit breaker has been fully isolated, and by means of a fully interlocked and labelled "SERVICE/EARTH" position selector which shall be designed to permit padlocking in any position.

Facilities shall be provided on all incoming feeder circuit breakers for earthing, the circuit side. On at least one circuit breaker panel in any section of busbar facilities shall be provided for busbar earthing. Where the switchboard incorporates a busbar sectionalising panel, this panel shall have the busbar earthing facility and it shall be possible to earth either section from this panel.

When the circuit breaker is connected to an earthing location, tripping shall only be effected by the manual device on the operating mechanism and automatic tripping shall be inhibited. The manual tripping device shall be capable of being locked to prevent unauthorised operation.

The mechanical interlocks on the breaker shall remain operative when the circuit breaker is in either earthing position.

Indoor fixed pattern high voltage circuit breakers shall be provided with three-phase test sockets on the circuit side for high voltage and current injection testing. Test sockets shall be provided with a hinged, lockable access cover which shall be mechanically interlocked to prevent it being opened until the circuit breaker has been opened and isolated.

2.5. HIGH VOLTAGE CIRCUIT BREAKERS

a. High voltage circuit breakers shall mean circuit breakers working at above 1 000 volts. They shall comply with the requirements given below.

b. Vacuum circuit breakers shall incorporate means of measuring contact wear in-situ without the necessity to dismantle the breaker or mechanism assembly.

c. SF6 circuit breakers shall be fitted with pressure switch contacts for remote initiation of a gas failure alarm. Easily accessible means shall be provided for refilling the breaker with dry SF6 gas at the correct operating pressure after carrying out maintenance.

d. Enclosures for high voltage switches-fuses shall be metal-clad conforming to IEC 60298.

2.6. LOW VOLTAGE CIRCUIT BREAKERS

Low voltage circuit breakers (up to 1 000 volts) shall be of the air break horizontal withdrawable pattern.

Earthing facilities through the circuit breaker are not required.

2.7. MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers (MCB's) and moulded case circuit breakers (MCCB's) shall comply with IEC 60898 and IEC 60947-2 and shall be fitted with thermal over-load and instantaneous magnetic short-circuit protection; this protection to be adjustable in frame sizes above 63 amps. Where earth leakage protection is specified, it shall be of the current operated type.

Current limiting fuses shall be fitted where necessary to provide the specified interrupting capacity. The ratings of MCB's and MCCB's shall be correctly coordinated with fuse ratings to achieve the necessary degree of discrimination. MCB's shall be rated in accordance with IEC 899.

MCCB's shall be operated by a toggle type handle and shall have a quick-make quick-break over-centre switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against abnormal currents. Tripping due to overload or short circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual on and off positions. All latch surfaces shall be grounded and polished. All poles shall operate simultaneously.

MCCB's shall be completely enclosed in a moulded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be of non-welding material. Arc extinction shall be accomplished by means of arc chutes, consisting of metal grids mounted on an insulating support.

The protective actions shall be so coordinated that overcurrents will be cleared by the thermal action; short circuits of relatively low magnitude will be cleared by the magnetic action; high fault currents above a pre-determined point will be cleared by the current limiting fuses. The current limiting fuses shall not be affected when the thermal and/or magnetic trip functions clear the circuit. Regardless of which tripping device serves to clear the circuit, all poles of the breaker shall simultaneously open automatically.

The breaker shall not be resettable until current limiting fuses which have functioned have been replaced by an identical or similar fuse and the cover refastened. The current limiting fuse shall have a visual means to determine which has operated and requires replacement when the cover is removed.

MCCB's used for motor protection shall provide instantaneous short circuit protection by means of a front adjustable magnetic element on each pole of the breaker. The adjustment button(s) shall have main setting points and mid-setting points following a linear scale so that each point has a significant value within calibration tolerances. Current limiting fuse may be incorporated into the circuit breaker where required, to cater for high interrupting currents.

All MCCB's shall be ambient temperature compensated. Compensation shall be accomplished to allow the breaker to carry rated current between 25°C and 50°C with tripping characteristics that are approximately the same throughout this temperature range.

2.8. HIGH VOLTAGE SWITCHES AND SWITCH - FUSES

High voltage switches shall mean switches operating above 1 000 volts. They shall conform to IEC 60265-1 as general purpose switches category II with normal service conditions adjusted as specified. Switches shall have rated voltages, normal current, breaking capacity and making capacity suitable for the system and load circuit being switched, or as specified.

Closing and opening mechanisms shall be of stored energy pattern both manually charged and released or as an independent manual operation.

The assembly shall incorporate an earthing switch connected to the feeder cable side of the main switch. This shall comply generally with IEC 60129 with a minimum continuous current rating of 200 amps and making capacity and short time current rating to suit the system, or as specified. The operating mechanism shall be independent manual for both closing and opening. Mechanical interlocks shall be provided to:

- prevent closing of the earth switch unless the main switch is open;

- prevent closing of the main switch unless the earth switch is open;

High voltage combinations of switches and fuses shall conform to IEC 420. The switches shall conform to IEC 60265-1 except that the rated breaking current shall be seven times the rating of the largest size fuse in the combinations. The switch closing mechanism shall be independent manual and shall provide stored energy for opening mechanically by fuse-striker or by manual release.

High voltage fuses shall be cartridge type, current limiting with striker pins, conforming to IEC 60282-1. Current ratings shall be as required for the circuit protection or as specified. Fuses shall be accommodated within an air insulated chamber, the access door or cover of which shall be interlocked so that it can only be opened if the main switch is open and the feeder connections are earthed. It shall not be possible to open the earth switch or close the main switch if the fuse access door/cover is open.

Earthing switches for high voltage switch-fuses shall earth the feeder cable side of the fuse and shall otherwise be as required for high voltage switch units.

2.9. AIR BREAK ISOLATORS AND FUSE SWITCHES

Air break isolators and fuse switches mounted indoors or incorporated in indoor metal-clad switchgear shall comply with IEC 60947-3 and shall be of the “on-load” type.

Operating mechanisms shall be fitted with mechanical “ON/OFF” indicators. Operating handles shall be of semi-flush or telescopic pattern to reduce front projection to a minimum.

Fuses in fuse-switches shall be of the HRC cartridge type.

Isolators and fuse switches shall be provided with means of locking in the “OFF” position.

Access to outgoing terminals of isolators and fuse switches shall not expose live incoming supply terminals or contacts.

2.10. CONTACTOR TYPE MOTOR STARTERS

a. Contactor starters shall incorporate air break, SF6 or vacuum contactors. Contactors shall be selected to suit the particular duty and application but shall have a minimum standard of mechanical endurance of 3 million operations and electrical endurance of 150 000 on-load operations. The utilisation category and duty class shall be as specified.

Vacuum contactors shall be provided with means of measuring contact wear, and any necessary gauges or other measuring devices shall be provided.

Starters shall incorporate HRC fuses unless otherwise specified. These fuses may be incorporated in the starter isolator as a composite fuse switch assembly. Overcurrent and earth leakage protection shall be incorporated together with all necessary auxiliary relays, contactors, timers, auxiliary fuses, wiring and terminals. Control and indicating facilities shall be provided on each starter.

b. Low voltage starters up to 1 000 volts shall comply with IEC 60947-4-1 and shall incorporate contactors complying with IEC 60947-4-1.

Low voltage starters shall incorporate a triple pole fully interlocked load breaking isolating switch capable of breaking the stalled motor current. Moulded case circuit breakers may be fitted, where specified.

Where low voltage starters incorporate moulded case circuit breakers, fault switching coordination between the circuit breakers and the contactors shall comply with IEC 60947-4-1.

Isolators shall be provided with an external operating handle, mechanical "ON/OFF" indication and facilities for locking in the "OFF" position. Operating handles shall be of the telescopic or semi-flush pattern to reduce front projection to a minimum.

Starters shall be of the fixed or withdrawable pattern as specified. If withdrawable, facilities shall be provided for testing the starter control circuits and operation when withdrawn without the necessity for complete removal of the starter chassis.

Where control circuit supplies and interlock circuits are broken via plugs on withdrawal of the starter, at least one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn (isolated) position.

Three-phase motor starters shall be complete with a triple pole hand reset thermal overload device with single phasing protection unless otherwise specified.

c. High voltage contactor starters above 1 000 volts shall incorporate contactor complying with IEC 60470.

High voltage starters shall be of the fixed or withdrawable pattern as specified and shall incorporate facilities for earthing outgoing cables. Fixed pattern starters shall incorporate a fully interlocked triple pole off-load pattern isolator having three positions 'CLOSED'/'OPEN'/'EARTHED'. Interlocks shall be provided to ensure off-load operation.

On withdrawable pattern starters, cable earthing shall be effected by means of a fully interlocked integral earthing switch arranged so that cables can only be earthed when the starter is withdrawn (isolated). Re-entry of the starter shall be prevented whilst the cables are earthed.

Means shall be provided to permit control circuit testing with the main isolator open.

2.11. SWITCHBOARD

a. All individual components of control equipment associated with any item of plant shall be contained in a single control cubicle or panel.

Instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubicle in a neat, functional and logical manner. Similar items shall be of the same type, style, pattern or appearance throughout.

Instruments, controls and relays mounted on different panel sections but having similar functions shall be located in a physically similar position.

b. All instruments, gauges and meters which perform similar duties shall be of uniform type and manufacture. They shall be flush pattern, dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks. Indicating instruments shall be of the dial or digital type fitted with zero adjuster externally accessible from the front, have no parallax error and normal maximum reading at approximately 60% full scale. Dials shall be white with black scales and lettering not subject to fading. Scales shall be of such material that-no peeling or discolouration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

c. Unless otherwise specified, all control circuit supplies for contactor starters shall be obtained from a 110 volts 50 Hz integral control transformer contained in the starter cubicle. In the case of multi-motor and composite boards, one or more master control circuit transformers

shall be provided for each section of busbars in the switchboard to feed a group of outgoing starters via bus wires in the board. Each control transformer shall be busbar connected and shall be provided with isolation facilities, and primary and secondary MCB's.

Transformers shall be of the double wound pattern and shall be provided with earth screens between primary and secondary windings. One end of the secondary winding shall be earthed.

d. Indicating lamps on panels shall be rated to withstand not less than 10% continuous over-voltage. Alternatively lamps shall be transformer operated or of a low voltage with series dropping resistors. On DC operated lamp circuits, suitably rated resistors shall be connected across each lamp operating contact.

Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit.

e. Electrically operated circuit breakers shall be fitted with control switches of the pistol grip type, with spring return to the "neutral" position, and with an interlock to prevent repetitive closing without moving first to the "trip" position. They shall be capable of being padlocked in the "neutral" or "trip" position.

Switches for control selection, motor control and other purposes shall have spade, tee or other approved shape handles.

f. Pushbuttons shall be coloured as follows:

- START - green.
- STOP - red.

"START" pushbuttons shall be effective only in selected circuits, primarily hand control circuits.

"STOP" pushbuttons for motors controlled by circuit breakers shall be arranged to trip the circuit breaker and shall have an additional contact to interrupt the breaker closing circuit.

g. Where practicable, all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.

h. Terminal boards or blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal blocks will not be acceptable. The minimum size of terminal shall be suitable for a 4 mm conductor. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled, and the voltage grouping and terminal board layout shall correspond with the wiring diagrams. Where approved, barrier-pattern screw or stud-type terminal boards are used, covers of transparent insulating material, which does not sustain combustion, shall be provided.

Terminals which may be live when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact. All terminals shall bear a permanent identification number or letter.

Terminal boards shall be located adjacent to the point of cable entry and adequate space shall be allowed for terminating the cable tails on site.

An extra 25% spare terminal shall be provided for terminating spare cable cores.

i. Fuses or MCB's and links shall be provided to enable any circuit to be isolated as necessary for maintenance and test purposes without isolating the whole panel. All fuses shall be of the HBC cartridge type. Fuse carriers and solid link carriers and bases shall be made of plastic moulded insulating material of an approved make. Ceramic materials will not be accepted.

Accessible live connections shall be efficiently shrouded and it shall be possible to change fuses with the circuit live without danger of contact with live metal. The fuses shall be rated to give maximum protection to the apparatus in circuit and the rating shall be inscribed on the fuse label.

Earthing and neutral links in main supply circuits shall be of the solid copper bolted pattern.

Fuses or MCB's and links functionally associated with the same circuit shall be mounted side by side.

Descriptive circuit/function labels shall be mounted adjacent to all fuses or MCB's, the layout of which shall correspond to the wiring diagram.

j. Auxiliary switches shall be supplied as required for indication, protection, metering, control, interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dustproof cover. Adequate secondary disconnects shall be included where appropriate to enable the auxiliary switch to be wired to the fixed portion of the equipment.

Two normally open and two normally closed spare auxiliary contacts shall be provided and shall be wired to suitably identify spare terminals.

k. Where volt-free contacts are specified on any equipment, e.g. a circuit breaker or contactor starter, they shall comprise contacts operated directly by the equipment but electrically separate such that no potential derived from the equipment appears at the contacts. Volt-free contacts shall be used to complete external control, alarm or indication circuits, the supplies for these circuits being obtained from an external source.

Unless otherwise stated, these supplies will be from low voltage ac or dc sources and auxiliary isolating poles, e.g. on starter isolators, need not be provided.

l. Switchboard and panel wiring shall be carried out in 1 000 volts grade PVC insulated cable. Flexible wiring shall be 600 volts grade.

Wiring shall be carried out in a neat and systematic manner and securely fixed by insulated cleats or other approved methods and arranged so that access to any apparatus or connection point is not impeded. Wiring installed in trunking shall have a space factor not greater than 50%.

Where wiring passes between compartments, the access hole shall be fitted with a suitable grommet.

Sleeve type identification ferrules shall be fitted on all wires at both ends. The numbers and letters used shall correspond with the appropriate wiring diagram and shall read from terminals outwards.

The wires shall not be joined or broken into between terminal points.

Terminations for screw or stud terminals shall be of the claw washer pattern or equal, or of the crimped-on-ring type, the latter being preferred. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

Wiring for future equipment shall be provided as far as possible and all wires shall be terminated.

Not more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

m. Switchboard cubicles shall incorporate anti-condensation heaters. The heater circuits shall be energised from a single-phase supply obtained from an independent power source.

Individual floor mounting cubicles shall each be fitted with an anti-condensation heater together with a suitably positioned adjustable thermostat, rotary "ON/OFF" heater switch and MCCB protection.

Multi-tier type cubicles shall have a cubicle heater and thermostat for each vertical panel section except that multi-tier motor starters may have individual heaters controlled by a normally closed contact on the contactor auxiliary switch in place of the controlling thermostat.

Switchboard for outdoor installation shall be provided with suitable sunshade for protection against direct sunlight.

2.12. SWITCHBOARD SAFETY ARRANGEMENTS

Switchboards, control panels and all items of electrical control equipment shall be designed and constructed to provide a maximum standard of safety for all Operation and Maintenance procedures.

Multi-circuit switchboards shall be fully sectionalised and provided with dividing sheets and screens to give safe access to individual switchboard circuits, and to permit all normal Operation and Maintenance procedures to be carried out without interference to, or risk of accidental contact with live conductors or components of independent circuits within adjacent switchboard sections.

Access to circuit compartments or cubicles through hinged doors shall be inhibited by a positive interlocking arrangement, until the isolator or switching device feeding unscreened or exposed conductors or equipment terminals within the cubicle is switched to the "off" position.

Isolators, clearly labelled, shall be provided in such positions and connected so that maintenance can be carried out with maximum safety. This particularly applies to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition when the isolator is in the "off" position such apparatus shall be screened and labelled to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energised.

Terminals, connections, relays and other components which may be live when front access doors are open shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

Where several outgoing circuits occupy a common termination chamber, all copper work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be carried out with other circuits live.

2.13. PROTECTION TRANSFORMERS

Protection and instrument transformers shall comply with the following:

a. Current transformers shall be of the bar primary pattern where practicable. Current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar primary current transformers, this rating shall be for a period of 3 seconds and for wound primary designs, the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the approval of the Engineer.

Current transformers for high voltage equipment shall be resin encapsulated, except that for bar primary designs with ring type cores mounted on resin insulated bushings, alternative secondary winding insulation will be accepted, provided that an earthed screen is introduced between

the toroidal winding and the bushing and that the toroid is adequately clamped either to the bushing or to the main structure.

Where multi-ratio current transformers are supplied, a label shall be provided, clearly indicating the connections required for the alternative ratios. These connections shall also be shown on panel wiring diagrams.

Secondary winding currents shall be 1A or 5A.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels shall be fitted on the exterior or the mounting chambers suitably located to enable reading without the removal of any cover.

Current transformers for balanced earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault current of the units.

Where attracted armature relays are employed, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetisation characteristics, calculated performance and protection setting shall be provided by the Contractor.

Current transformers for use in conjunction with a portable precision kWh meter shall be of class 0.2 accuracy. Other metering current transformers shall be of class 0.5 accuracy.

b. Voltage transformers (up to 1 000 volts) shall be supplied where test metering connections are required to terminate at test terminal blocks. They shall have a winding ratio to give a three-phase voltage between lines of 110 volts. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meters to which they may be connected via test blocks.

The primary circuit shall be protected by HRC fuses having a short-circuit rating not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross-section and be supported to withstand the short-circuit rating of the switchgear.

The secondary circuit shall be protected by HRC fuses mounted as closely as possible to the secondary terminals. The fuses shall have safe access for renewal without the necessity for complete isolation of the switchgear.

c. Voltage transformers on high voltage (1 000 volts and above) systems shall have a rated burden, at the stated accuracy, in accordance with the requirements of all instruments and meters to which they may be connected via test blocks. The windings shall be resin encapsulated. Voltage transformers for metal-clad switchgear shall be housed in naturally air-cooled, totally-enclosed sheet-steel enclosures which shall be of the isolatable pattern capable of being padlocked in the plugged-in position.

Safety shutters shall be provided to cover automatically the fixed isolating contacts when the transformer is isolated, the means shall be provided to padlock the shutters in the closed position. The shutters shall be coloured yellow, when the isolating contacts are connected to the feeder side of the circuit, and red, inscribed “BUSBARS” in large white letters, when connected to the busbars side of the circuit.

Connections to the primary isolating contacts shall have a short-time rating equal to that of the switchgear and shall be capable of carrying 200 amps continuously.

The primary winding shall be connected through cartridge type fuses incorporating current limiting resistances. These fuses shall be removable only when the transformer is isolated.

Secondary circuit fuses shall also be provided and shall be readily accessible for renewal.

2.14. PROTECTION RELAYS

Protection relays shall fully comply with the requirements of BS 142 or equivalent IEC.

Relays shall be contained in dustproof cases, shall be mounted on the front of the switchgear or relay panel. Auxiliary relays may be mounted within the panel but shall be accessible for inspection and wiring. Plug-in pattern relays shall have a positive means for retaining them in the service position.

Relay contacts shall be capable of making and breaking the maximum current which can occur in the circuit they control. Contacts for remote alarms and indications shall be volt-free, hand reset type.

Operation indicators shall be fitted to tripping relays and such other protection relays or relay elements as will enable the type of fault condition to be identified. Indicators shall be capable of being reset without the relay case being opened.

2.15. PAINTING

All components and devices shall have a resistant, long term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

2.16. MARKING

3. EXECUTION

3.1. INSTALLATION

The delivery, installation and commissioning of the motor starter equipment shall include, but not limited to the following items:

1. Transport to location of installation (if necessary storage), and the complete mounting.

2. Grounding and potential equalisation for the cubicles, including connection with the next grounding bus bars.

3. Termination of all cables at the switchgear panels.

4. Commissioning of the functioning motor starter equipment, including voltage feeding of the bus bars and adjustment of all relays, protection devices, etc..

5. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase and during a training on site.

For transport and site installation purpose the transformer enclosure shall be segregated from the switchgear panel, if necessary the transformer itself may be shipped separately.

3.2. TESTS

3.2.1. WORKSHOP TESTS

All components of the motor starter equipment shall be tested completely and detailed in manufacturers workshop. All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted prior to start of the tests in accordance with the Project Procedure Manual.

The following tests shall be carried out, at least:

1. Test of all functions.
2. Voltage withstand tes.t (1)
3. Short circuit withstand test. (1)
4. Test of warming. (1)
5. Partial discharge measurements.
6. Check of degree of protection.
7. Check of protection against touching.
8. Power frequency voltage dry test, 1 minute.
9. Voltage test on auxiliary circuits, 1 minute 2 kV r.m.s.
10. Mechanical operation test on circuit breakers, including all adjacent equipment.
11. Operation test of the relays.
12. Test of auxiliary electrical devices.
13. Verification of wiring and terminal blocks.
14. Check of mechanical details.
15. Compliance with the specifications.

(1) only type test certificates necessary

Detailed test protocols of all tests performed have to be submitted prior to shipment.

3.2.2. SITE TESTS

The site tests shall include the following steps:

1. Pre-commissioning (including “loop testing”).
2. Commissioning and test on completion.
3. Performance test.

The workshop tests described in item except the power frequency voltage shall be repeated on site by the Contractor after erection and before connection to outside sources.

Special care shall be taken for setting of protection devices, relays and timers, setting must be done according to the approved start-up procedure, considering the data of the connected pump motor equipment and the feeding switchgear.

The aim of the tests is to ensure the proper function of the complete scope.

3.3. DOCUMENTATION

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the motor starter equipment and their components.

All documents shall be in English language.

The documentation of the motor starter equipment shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all devices, cubicles and enclosures.
3. Layout drawings for the whole motor starter equipment.
4. Single line diagrams.
5. Block diagrams.
6. Wiring diagrams.
7. Termination drawings.
8. Cable lists.
9. Spare parts list.
10. List of used devices with manufacturer.
11. Software and software description.
12. Operation and maintenance manual.
13. Reports of tests and commissioning with protocols.

The documents listed above shall be handed over for approval.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

3.4. SHIPPING

All equipment, material and spare parts shall be sufficient packaged. Each unit should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

3.5. SPARE PARTS AND SPECIAL TOOLS

To comply with provisions of the 7.1 - General Requirements, Section 29 – Spare Parts.

All necessary special tools for operation and maintenance of the motor starter equipment shall be supplied as pr the manufacturers recommendations, at least consisting of:

33kV Switchgear:

- 1 No. of each Protection relay used
- Manufacturers recommended spares for 33kV Switchgear, i.e., fuses and MCBs.
- 2 Sets of each colour of indication lights complete with lamp.
- 2 No of each selector switch used
- 2 Sets of each Pushbutton or opening closing switch used.
- 10 No. of each rating and type of fuse used in Switchgear

3.3kV Switchgear:

- 1 No. Circuit Breaker Protection Relay.
- 1 No. Motor Protection relay (if provided separately).
- Manufacturers recommended spares for 3.3kV Switchgear.
- Manufacturers recommended spares for 3.3 kV Variable speed drives, i.e. HMI Fuses, control cards, etc.
- 6 Sets each colour of indication lights complete with lamp.
- 2 No of each selector switch used.
- 6 Sets of each Pushbutton used.
- 10 No. of each rating and type of fuse used in Switchgear.

415V Switchboard:

- 1 No. Spare of Multi-function meter.
- 6 Sets each colour of indication lights complete with lamp.
- 2 No of each selector switch used.
- 6 Sets of each Pushbutton used.
- 1 No. of each contactor used.
- 1 No. of each thermal overload used.
- 10 No. of each rating and type of fuse used in Switchgear.
- Spares for Power Factor correction – fuses, contactors and 2 of each capacitor size installed.

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SECTION 16290
HIGH VOLTAGE POWER TRANSFORMERS

1. GENERAL

1.1. SCOPE

This document covers the requirements for the design, manufacturing, construction, installation, test and commissioning of high voltage power transformers for the Mwache Water Treatment Plant.

1.2. CODES AND STANDARDS

The design, manufacturing, construction, installation, test and commissioning of High Voltage Transformers shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60060 High voltage test techniques.

IEC 60071 Insulation co-ordination.

IEC 60076 Power transformers.

IEC 60085 Electrical insulation - thermal evaluation and designation.

IEC 60137 Insulating bushings for alternating voltages above 1000V.

IEC 60214 Tap-changers.

IEC 60270 High voltage test techniques – partial discharge measurements.

IEC 60422 Supervision and maintenance guide for mineral insulating oils in electrical

equipments.

IEC 60529 Degrees of protection provided by enclosures (IP code).

IEC 60616 Terminal and tapping markings for power transformers.

As far as the power supply authority or permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.3. ENVIRONMENTAL CONDITIONS

The transformers shall be designed and constructed for continuous operation at full load under the local climatic and environmental conditions.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. POWER TRANSFORMERS GENERAL

a. Power transformers shall comply with IEC 60076 unless otherwise specified. They shall be suitable for General use on a three-phase system.

b. The materials used and the method of construction shall be of the first class quality and shall be such as to ensure optimum performance and uniform temperature throughout the transformer.

c. In the design of the transformer, special attention shall be paid to reduce noise level to a minimum.

d. Each transformer shall be provided with a main frame earthing terminal which shall be separate from the neutral terminal of a star connected winding.

Where the neutral of a star connected winding is to be separately connected to earth, an insulated neutral connection shall be brought out via a separate neutral chamber having provision for housing one or more current transformers for earth fault protection. A removable cover shall permit access to the current transformers and their secondary wiring.

e. Main cable terminations shall be provided to suit the type of cable used.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable and cores.

The boxes shall provide sufficient space for segregating the cores and maintaining the minimum insulation clearance and creepage distances applicable.

Cable boxes to accommodate low voltage (up to 1 000 volts) PVC or XLPE insulated cables shall be air insulated, designed to exclude direct ingress of moisture and dirt.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

f. Auxiliary wiring from current transformers, Buchholz relays, winding temperature indicators, pressure switches, etc., shall be marshalled to a separate termination chamber with separate access cover. The terminal boards or blocks shall be as specified for switchboard components. Removable, undrilled cable gland plates shall be provided.

2.2. OIL FILLED TRANSFORMERS

a. Oil filled transformers shall be suitable for outdoor service and arranged for natural air cooling (Type ONAN) and shall comply with the specification for power transformers.

b. Constructional steelwork shall be shot blasted or chemically pickled internally and externally and shall be thoroughly descaled and degreased before being given the first coat of a comprehensive painting process which shall, for the interior, be of paint or varnish able to

resist the action of oil. The exterior shall be primed with one coat of zinc-enriched paint followed by two undercoats of contrasting colour followed by one top coat of durable, oil resisting and weather resisting paint.

c. Main connections shall be brought out through oil-tight bushings into their respective connecting chambers and shall be provided with disconnecting links to facilitate cable testing and complete removal of the connecting chamber from the transformer without the necessity of breaking the cable termination.

d. Each transformer shall be delivered filled with oil.

e. Temperature sensing devices shall operate a dial type indicator with a red line showing maximum permissible operating temperature. The indicator shall incorporate adjustable alarm and trip contacts to operate on excess temperatures.

Silica-gel breathers shall be fitted with indicators and shall be conveniently located for regular inspection and ease of silica-gel renewal.

Buchholz relays shall have their gas sampling cocks conveniently placed for operation from ground level.

2.3. TAP-CHANGERS

On load tap-changers shall comply with IEC 60214-1, unless otherwise specified.

Tapping on HV side (%) shall be in stepps of ± 2.5%

Tap-changers shall be delivered filled with oil and be compelte with motor driven unit

A remote tap-changer control panel shall be installed in the relevant switchroom the transformer is supplied from.

2.4. PAINTING

All components and devices shall have a resistant, long term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

2.5. MARKING

The following plates (may be combined also) shall be mounted on the low-voltage side of each transformer tank at a height of about 1.5 m above ground:

a. A rating pate as specified in IEC 60076, including space for Owner’s serial number, and alpha-numerical identification number.

b. A diagram plate with internal connectionqs of windings.

c. A general plate showing the layout of the transformer covering the locations of terminals, control devices, valves and all essential transportation details.

All above plates shall be made from brass or stainless steel. Inscriptions shall be written in English language.

3. EXECUTION

3.1. INSTALLATION

The delivery, installation and commissioning of the power transformers shall include, but not limited to the following items:

1. Transport to location of installation (if necessary storage), and the complete mounting of transformer and protection and control panel.
2. Filling of insulation liquid if not already factory-fillrd prior to shipment.
3. Grounding and potential equalisation, for the transformers and control panels.
4. Termination of all cables at the transformers.
5. Termination of all cables at the protection and control panels.
6. Commissioning of the functioning transformers and adjustment of all protection devices.
7. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase.

Fire barrier wall of minimum two hour fire rating shall be provided betwenn two adjacent transformers and also betwenn transformer and any close-by building. These walls shall be of adequate height and constructed such that free air ventilation of transformers shall not be affected.

Transformers installed outdoors and exposed to sun shall be provided with sunshade cover of fibre-glass material such that there shall be no restriction to free air ventilation. The sunshade cover shall be supported on tubular, lightweight, ready to assemble and easy to disassemble type galvanised steel structure.

The transformers shall be mounted after erection of the oil catch bassin and the fire protection walls. Sun shades and protection fences can be installed later, but before energising of the transformers.

The installation and as well the tests and the commissioning shall be carried out with Contractors own staff and with own tools and measuring/test devices

3.2. TESTS

3.2.1. WORKSHOP TESTS

All transformers shall be tested completely and detailed in manufacturer’s workshop.

All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted at least 3 weeks prior to start of the tests.

Test in the factory shall be carried out in accordance with the requirements of the relevant standards.

These are according to IEC regulations mainly but not limited the following:

1. Measurement of winding resistance.
2. Measurement of ratio.
3. Measuring of short circuit voltage, short circuit impedance and short check of on-load circuit losses.
4. Measuring of no-load losses and no-load current.
5. Operation tests of the measuring equipment.
6. Test of tranformer oil.
7. Test of auxiliary electrical devices.

Detailed test protocols of all tests performed have to be submitted prior to installation.

3.2.2. SITE TESTS

The site tests shall include the following steps:

1. Pre-installation testing.
2. Pre-commissioning (including “loop testing”).
3. Commissioning and test on completion.
4. Test runs.
5. Performance test.

The aim of the tests is to ensure and prove the proper function of the complete scope.

3.3. DOCUMENTATION

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the transformers and its components.

All documents shall be in English language.

The documentation of the transformers shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all transformers and devices.

3. Block diagrams.
4. Wiring diagrams.
5. Termination drawings.
6. Cable list.
7. List of used devices with manufacturer.
8. Spare parts list.
9. Operation and maintenance manual.
10. Reports of tests and commissioning with protocols.

The documents listed under a) to f) shall be handed over for approval, too.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

3.4. SHIPPING

All equipment, material and spare parts shall be sufficient packaged and should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

3.5. SPARE PARTS AND SPECIAL TOOLS

To comply with provisions of 7.1 – General Requirements, Section 29 – Spare Parts.

The Contractor is to supply all the recommended spare parts by the manufacturer. As a minimum, the following spare parts are to be provided:

- 2 Sets of Silica Gel for each transformer
- 220 l (1 drum) of Transformer Oil.
- Manufacturers Recommended spare parts for On-load Tap Changers.

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SECTION 16720
SERVICES AND BUILDING FIRE FIGHTING SYSTEM

1. GENERAL

1.1. SCOPE

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of services and building fire fighting system equipment, and shall be applicable to these works unless stated to the contrary in the specification application clauses.

1.2. CONTRACTOR'S RESPONSIBILITY

The Contractor shall be responsible for:

a) All aspects of design, application and subsequent operation of the equipment, monitoring facilities and control circuits in accordance with all the operational requirements of this specification.

b) Liaison between subcontractors to ensure complete compatibility of all equipment at both component and system interface levels.

c) Overall systems engineering to ensure that all equipment, components and systems together form a consistent, rational and fully integrated monitoring and control installation.

d) Ensuring that each system is handed over complete in all detail and in perfect working order.

e) The supply and installation of all components, such as signal amplifiers, isolators, interference suppressors, line protection devices etc. which may be necessary to achieve the correct and specified function or to provide a safe and reliable installation, whether or not such components are specifically called for in the specifications.

The approval by the Engineer of any drawing shall not relieve the Contractor from his complete design responsibility.

1.3. GENERAL DESIGN REQUIREMENTS

The Equipment shall be designed:

a) Such that routine and occasional maintenance through its life shall be a practical minimum, compatible with the preservation of maximum reliability.

b) To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.

c) And constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable.

The degree of environmental protection for all equipment and enclosures shall be in accordance with BS 5490 or IEC 529 as follows:

a) IP54 for internal applications.

b) lP55 for equipment in pumping stations and similar locations.

c) IPW55 for external applications.

d) IP67 for transducers and equipment mounted within valve or meter chambers or similar locations.

All instrumentation, monitoring and control equipment shall be designed and guaranteed suitable for operation under the environmental conditions.

Equipment in air conditioned locations shall be rated for continuous operation in ambient temperatures up to 40°C. External equipment and internal equipment not in air conditioned locations shall be rated for continuous operation over the ambient temperature range 0°C to 45°C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

External equipment shall be protected from direct sunlight by a well ventilated cabinet, canopy or other approved type of sunshade.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. BUILDING FIRE FIGHTING SYSTEMS

2.1.1. GENERAL

Fire fighting systems shall comprise portable hand extinguishers.

2.1.2. FIRE EXTINGUISHERS

Portable hand extinguishers shall be provided, wall mounted and located as required and shall be in accordance with the local standards.

All extinguishers shall be clearly marked with operating instructions in Local language and English.

2.1.2.1. CARBON DIOXIDE FIRE EXTINGUISHERS

CO_2 gas fire extinguisher containers shall be made of manganese steel conforming to BS 1288. The container/cylinder shall be pressure tested for 236 bars. The extinguishers shall be "seize and squeeze" operation type. The extinguishers shall be provided with directional horn which shall be made of anti-static and non-conductive material. The fire extinguishers shall be in conformity with BS 5423.

2.1.2.2. FOAM FIRE EXTINGUISHERS

The portable fire extinguisher shall be suitable for use aqueous film forming foam and the shell shall be pressed and welded steel pressure vessel tested to 22.5 bar. The interior of the vessel shall be polythene lined making it suitable for use with all foam making liquids. The unit shall be provided with polyester reinforced flexible hose with moulded foam nozzle from ABS. The head cap shall be all metal squeeze grip action with controlled discharge facility.

2.1.3. LABELLING

Each component shall be fitted with a permanently attached stainless steel label embossed with a unique identifying number. All labels shall be in both English and Local languages.

3. EXECUTION

3.1. GENERAL

Except where otherwise approved by the Engineer, each machine, device, appliance and assembly shall be completely erected in the Contractor's workshops, with each part marked in order to be sure of correct assembly during site erection. All possible adjustments shall be made in the workshop thereby minimising those required on site.

Erected assemblies shall be submitted for the Engineer's inspection.

3.2. INSTRUMENTS GENERAL

Unless otherwise specified, indicating and recording instruments shall be of the flush mounted pattern with dust and moisture-proof covers and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

All instruments within one contract shall be of matching types and manufacture as far as possible in order to facilitate maintenance and stocking of spare parts.

Indicating instruments shall be provided with a readily accessible zero adjustment.

Dials in general shall be with black markings to BS 3693. Scales shall be of such material that no peeling or discolouration can take place with age, or under adverse conditions.

Wherever possible, the use of iron and steel screws shall be avoided in instruments and electrical relays.

When used, steel screws shall be zinc, cadmium or chromium plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel.

All wood screws shall be dull nickel plated brass or of other approved finish. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting materials such as phosphor-bronze or nickel-silver, as far as possible.

Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

Unless otherwise stated, each transmitter or recorder shall be supplied complete with any bracket, stand, supporting steelwork or enclosure necessary for securing it in a position accessible for maintenance and suitable for its environment.

Panel mounted indicating instruments shall be of the electrically operated miniature flush mounting type unless otherwise stated.

Where applicable, each instrument chassis shall be easily withdrawable from its housing for chart changing and maintenance without interrupting its circuit.

Recorders shall be supplied with enough charts, pens and ink to operate the instrument continuously for two years to the approval of the Engineer.

3.3. SPECIAL TOOLS AND TEST EQUIPMENT

The Contractor shall supply a complete set of special tools and test equipment necessary for maintenance or testing of any part of the Plant to be carried out during the life of the Plant, whether of an electrical, mechanical or any other nature.

The tools and test equipment shall not be used for the erection of the Plant and shall be handed over in a new and unused condition excepting that the Engineer may call upon the Contractor to prove their effectiveness.

The tools and test equipment shall be boxed separately in suitable containers marked or labelled with their contents.

All cases, containers or other packages shall be designed to facilitate opening and subsequent repacking.

When specified, tools and test equipment for internally sited plant shall be mounted in suitable cabinets with lockable doors. Racks or clips shall be provided for individual items with outline markings and labels showing which tools or equipment are missing. The cabinets shall be wall mounted with best quality finish and appearances.

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SECTION: 17010
SCADA SYSTEM REQUIREMENTS

1. GENERAL

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all SCADA equipment, and shall be applicable to these works unless stated to the contrary in the specification application clauses.

1.1. FUNCTIONAL DESIGN SPECIFICATION

The Contractor shall submit a Functional Design Specification (FDS) to be approved by The Engineer prior to manufacture and purchasing of equipment.

The FDS shall be submitted in English on A4 size sheets numbered within each section and page within section, to include, but not limited to, the following for each Treatment Area and item of packaged plant:

a) Content List.

b) Reference to supporting standards, manuals and specifications.

c) Description of the design and design criteria.

d) Relevant details of associated mechanical, electrical and instrumentation equipements.

e) Control philosophy (functional description).

f) Complete set of supporting drawings.

g) Design documentation, including:

- A description of each major element of the control scheme.
- A flow-chart or pseudo-code description of each sequential element of the controle scheme.
- Analysis of failure modes and shutdown procedures.

h) Calculations.

i) Quality control procedures and approvals.

j) Outline of test procedures.

k) Manufacturer’s literature for each item of equipement supplied.

All drawing shall be on A4 or A3 sized paper as appropriate to ensure legibility include a title block detailing:

a) Purchaser’s Name.

b) Contract Title.

c) Contractors Name.

d) Drawing Title.

e) Drawing Number.

f) Date.

g) Author.

h) Verification and approval by the Contractor prior submission.

2. SYSTEM OVERVIEW

A control centre should be established in a location to be agreed with the Engineer to accommodate the Dispatcher equipment and operator workstations.

The system implemented should be able to operate within the control strategy described but shall be flexible enough to be easily changed should the control philosophy change.

The proposed system shall provide:

a) A centralised Dispatcher processing function, complete with standby facilities and local workstations.

b) Distributed intelligence using microprocessor based Programmable Logic Controllers (PLC's) for monitoring and data logging. Under normal operating conditions, the PLCs shall monitor and control plant to given schedules and record the installations operational/performance data e.g. pump start/stop, inlet flow, storm tank level etc.

c) The PLCs shall have programmable alarm limits for discrete and rate of change settings. This shall apply to both real and derived values. There shall be a facility for high and low priority alarms, e.g. low, very low, high and very high.

In order to cater for communications failures, the PLC shall be capable of holding 8 days' worth of data as follows:

a) Analogue, totalised and derived signals - on significant change/15 minute intervals.

b) Digital signals on change of state.

c) The data gathered from the PLCs shall be incorporated into the Dispatcher database and shall also be made available to applications programs written by the client.

d) Where PLCs are programmed to perform local control of plant it shall be possible for the programmes, schedules, set-points etc. to be downloaded from the Dispatcher. Subject to being assigned suitable privileges, system users shall have the facility to make short term alterations to PLC control schedules via the control centre, e.g. to implement remedial action when an alarm occurs.

SCADA Control shall be effected at two levels, these being:

a) PLC local control via programs stored locally at the PLC, e.g. pump start, fallback control.

b) Supervisory control from the control centre. An authorised user, at the control centre shall be able to modify the control routines at any PLC by downloading new control (start/stop) schedules, new performance criteria e.g. increase/decrease flow/pressure or operating individual items of plant e.g. open/close valve, start/stop pump.

c) There shall be a requirement to download control programs and schedules to the PLCs from the dispatcher via the communications network.

d) The preferred method of communication with site based PLC's is cable with low power UHF radio for remote sites. As future developments may require different forms of

communication at specific sites, the equipment shall be capable of operating in all modes with minimal software changes.

e) The system shall operate using 'management by exception' techniques. The PLC shall monitor and control the site and record operational data. When an alarm condition is detected the PLC will dial into the master station immediately to announce the alarm and forward any data collected. Where alarm conditions arise, individual alarm presentation with alarm lists, mimic and tabular diagrams, and help pages shall be available to assist the operator.

3. DISPATCHER SYSTEM HARDWARE

3.1. GENERAL

A centralised SCADA Dispatcher shall be provided for the SCADA system unless otherwise specified within the particular specification.

All equipment required to fulfil the requirements shall be industry standard proven computing equipment with a demonstrable long-term life cycle and support.

To permit other manufacturer's equipment, e.g. PLCs, to be added to the SCADA system, all equipment shall, wherever possible, interface using open-system communications protocols.

3.2. SYSTEM AVAILABILITY

3.2.1. GENERAL

The strategic importance of the SCADA system requires a high level of system availability, i.e. not less than 99.9% availability for each calendar year. The SCADA system shall therefore be provided with the following.

3.2.2. HOT STANDBY

The system shall be provided with a master and standby Dispatchers where the standby Dispatcher shall be continually updated and automatically assume responsibility within 30 seconds following failure of the master Dispatcher.

Synchronisation of the databases following system recovery shall be automatic i.e. shall not require manual intervention.

3.2.3. UNINTERRUPTIBLE POWER SUPPLY (UPS)

The system shall be provided with a UPS capable of supporting all the main computer equipment (central processing units, discs, communications processors etc.), operating consoles and the alarm/event printer for a period of not less than 4 hours. The UPS shall be provided to cater for a 50% increase in load without the need for additional hardware.

Note: Essential services, e.g. UPS, generator and security etc. shall be monitored by the SCADA system.

3.2.4. MAINTENANCE

The Dispatcher equipment shall be subject to a maintenance contract where a competent engineer shall attend site within 8 hours from the time the failure was reported, twenty four hours a day, 365 days a year.

3.2.5. COMMUNICATIONS EQUIPMENT

The Dispatcher equipment shall be provided with all necessary communications equipment to support:

a) All operator workstations.

b) All printing devices.

c) The communications network comprising:

- Communications to all on-site PLCs.
- All remote equipment.
- Equipment as detailed in the particular specification.

3.2.6. DATA STORAGE

Each master station shall be provided with the following storage media:

a) Random Access Memory – to store the “real–time”/instantaneous database.

b) Hard discs – to store the system configuration, mimics and local short–term (One year) historical database etc.:

- Digital points on change of state.
- Analogue points at 15 minute intervals.
- Derived points.

c) Optical disc - to store off-line (greater than 365 days old) historical database, system backups, data transfer etc.

d) IBM PC flexible diskette - to transfer data to off-line PC equipment.

3.2.7. OPERATOR WORKSTATION

The operator workstations shall be the main Man-Machine Interface (MMI) and shall consist of 21 inch (minimum) Visual Display Units (VDUs) capable of displaying graphical and alphanumeric characters in at least sixty-four colours in all foreground/background combinations.

The VDU shall have an associated keyboard consisting of a standard typewriter QWERTY alphanumeric set, with additional numeric and special function keys, augmented by a mouse or tracker-ball.

3.2.8. PRINTING DEVICES

The system shall be provided with two types of printing device:

a) Alarm/Event Printer:

- To provide a hard copy log of all alarms and significant events, e.g. operator sign-on or control override issued a medium speed dot matrix printer shall be provided. The printer shall be capable of 300 characters per second, 132 characters per line, multiple colours (to differentiate alarms and level of alarms from events) and operating on continuous fan fold stationery.

b) Colour Printer:

- To provide high quality printed output for report summaries, programme development, copies of mimic displays, historical trends etc., issued a high speed colour ink-jet printer shall be provided.

3.3. REMOTE DATA TRANSFER

The SCADA system shall be capable of processing the data received from operational sites e.g. into daily minimum, maximum and means, and forwarding the raw and processed data to off-line packages e.g. Microsoft Excel.

4. SYSTEM FEATURES

4.1. GENERAL

The Purchaser requires a low risk system supplied with proven software.

4.2. SYSTEM ACCES

Users of the system shall be allocated individual passwords allowing each user an appropriate level of access commensurate with their requirements, responsibilities and areas of knowledge and interest.

Three general categories of access have been identified:

a) Data only.

b) Data and Control.

c) Data and System Management.

Data only shall be generally available to all system users. Data and control shall be limited to those personnel with the knowledge and responsibility to take control actions.

4.3. COLOUR GRAPHICS DISPLAYS

The following display types shall be available on all colour graphics terminals:

a) Mimic diagrams.

b) Help pages.

c) Graphs.

d) Bar charts.

e) Alarm and event log listings.

f) System configuration and maintenance displays.

1.1.1. MIMICS DIAGRAMS

Mimic diagrams are required to present a pictorial representation of the plant and its present status. Features required are as follows:

a) Display of fixed (background) diagrammatic plant information and text.

b) Display of variable information i.e. symbols or text displaying plant status.

c) Easy picture creation, possibly using a CAD style package.

1.1.2. DISPLAY OF VARIABLES

Variables can be considered as digital on/off parameters, analogue or totalisers.

Digitals may be either status (e.g., running/stopped) or alarm points, and shall be displayed by:

a) Text changing.

b) Symbol colour changing.

c) Symbol shape changing.

d) Text or symbol flashing.

It must be possible to associate more than one digital point with a symbol, so that more than two colours/shapes can have operational meaning. For example, a pump may be shown in four colours indicating running/stopped/failed/non-operational.

In addition, it shall be possible to associate any number of symbols within different mimics with a particular digital point.

Analogues and totalisors shall be displayed by:

a) Numeric value.

b) Bar chart.

c) Graph.

It shall be possible to display all these three types of indication in mimic diagrams. Colour changes shall be used to indicate further information about a point, e.g. if an alarm limit has been exceeded.

1.1.3. DISPLAY ATTRIBUTES

Using the display facilities described above, the mimic diagrams shall indicate the following attributes for analogue, digital and totaliser points:

Attribute	Point Type
Status On/Off	Digital Status
Alarm/Normal	Digital Alarms
1st Stage Alarm (High, Low)	Analogues
2nd Stage Alarm (High-High, Low-Low)	Analogues
Communications Failure	All
Alarm Manually Suppressed (out of service)	All

Alarm Automatically Suppressed	All
Out of Range	Analogues

1.1.4. PICTURES CREATION

It is essential that picture creation is a straightforward procedure, a CAD type package would be suitable. It must be possible to create symbols which may then be used in any orientation, size and colour and to create a symbol library, i.e. a part of a diagram which may then be used many times. It must be possible to display, on any single mimic diagram, information from anywhere within the system.

4.4. HELP PAGES

Help pages shall be available within the system, to assist the operators in dealing with received alarm conditions. These pages will be compiled by the plant managers and will provide advice as to which staff shall be notified of which alarms.

Help pages may be presented as individual pages accessed from a mimic, or as a window superimposed on a mimic.

4.5. GRAPHS

Graphical representation of historical data is required, with a selectable time base and the ability to put up to four graphs on display at once on the same axes, using different colours.

The system must be easy to use, with automatic default facilities so that only a minimum of instructions need be given to the system to obtain each plot.

Features that will be required are:

a) Pre-configured and ad-hoc trend displays.

b) Ability to compare graphs over different time spans, e.g. today's flow compared against yesterday's flow.

c) Read-out of the actual value of a graph at a given time point.

d) Ability to roll a graph forward and backwards in time.

e) Ability to set the scale for each graph.

f) Trend graphs giving a plot of the selected variable up to the last scan, updating when a new value is received.

g) Ability to incorporate a trend graph as a feature on a mimic diagram.

h) Graphical output of both analogue and digital signals (real and derived). Digital signals will produce a square wave type plot indicating for instance when a pump started and stopped.

i) Auto ranging scale unless manually overridden.

j) Ability to display data from different sites within the same trend display.

4.6. BAR CHARTS

A bar chart type representation of analogue variables is required. This is required on mimic diagrams, and must be capable of horizontal or vertical orientation, with selectable scaling.

Width of bars must be selectable so that the feature can also be used for such items as tank level pictorial representations.

4.7. ALARM AND EVENT LOG LISTINGS

All alarms and changes of status (i.e. digital events) in the system shall be logged to disc. It shall be possible to recall this information to the screen via a select and sort programme. This programme shall sort and display information on at least the following bases:

a) Process Area.

b) Site type.

c) Site name.

d) Time period.

e) Signal identification numbers.

f) Signal state (on/off).

g) Alarm status i.e. cleared, accepted and unaccepted.

h) Alarms or status occurrences required.

Any sort parameters not entered shall default to "all".

4.8. SYSTEM SET-UP AND MAINTENANCE DISPLAYS

Suitable displays of information shall be provided to display all set-up features of the system. These displays will be closely associated with the SCADA system set-up facilities.

4.9. LOGGING ON/OFF

Every user of the SCADA system shall be required to log on (i.e. activate) his terminal when he wishes to operate on it. The system will be aware of which terminals are logged on and the access rights of the user and will therefore be aware of where to send certain information.

4.10. ALARM FACILITIES

1.1.5. GENERAL

Digital points within the system shall be capable of operating as either status (e.g. running/stopped) or alarm points (e.g. normal/failed). A digital alarm point shall enter the Alarm State when it is either a logical ‘1’ or logical ‘0’ as designated in the system set-up for each point, the opposite state being the normal condition.

Analogue points shall be provided with two high alarm limits (high and high–high), and two low alarm limits (low and low–low). Should an analogue value either rise or fall from a value considered to be normal, a first stage high or low alarm limit will be encountered resulting in a new alarm condition. Should the value continue to rise (or fall) it will then encounter the second stage high–high or low–low alarm limit again resulting in a new alarm condition.

1.1.6. ALARM PRIORITIES

Every alarm generated within the system shall be allocated an alarm priority to indicate the importance of the alarm. Whereas a digital point will have only one alarm priority, an analogue point will have three. This will allow the relative importance of the first and second stage high and high–high (low and low–low) alarms to be set. The alarm priority is used in conjunction with the 'area of interest' of the users logged onto the system to determine where and when a new alarm is enunciated. The priority of an alarm shall change if required depending on the time and date.

1.1.7. ALARM ANNUNCIATION

Alarms are to be enunciated on the operator workstation both visually and audibly, and have clear and unambiguous acceptance procedures. High priority alarms shall be presented for acceptance before low priority ones.

1.1.8. ALARMS FILTERING

The SCADA system shall have a "tool–kit" of facilities that may be applied to individual points in the system in order to prevent unnecessary annunciation of alarms. These shall typically include:

a) Analogues:
   - Dead Band.
   - Delay before initial alarm.
   - Minimum alarm repeat interval.
   - Logical suppression of new alarm if other conditions are presents.
   - Averaging values in PLC.

b) Digitals:
   - Delay before initial alarm.
   - Minimum alarm repeat interval.
   - Logical suppression of new alarm if other conditions are presents.

Users, subject to authorisation (i.e. correct level of access), shall be able to manually suppress an alarm, e.g., if a transducer is faulty and is being particularly troublesome. The suppression of alarms shall be logged to the event list.

1.1.9. DERIVED ALARMS

A combinational and sequential logic package is required within the SCADA system, allowing signals to be combined to form derived alarms. These may be combinations of analogue and digital information obtained from different sites (e.g., a pump may be running at a pumping station but no flow entering the associated inlet works resulting in a derived alarm indicating a potential burst).

4.11. HISTORIC INFORMATIONS

1.1.10. PLCS

PLCs will sample and store values of analogue parameters at predetermined intervals to cater for loss of communications. These will normally be 15 minutes but shall be user configurable between 1 minute and 24 hour intervals.

1.1.11. MASTER STATION

In addition to the raw operational data, a long-term archive of analogue max/min/mean values, pump hours run etc. will be maintained. Values stored will be as detailed within the Particular Specification.

4.12. CONTROLS

1.1.12. MANUAL CONTROL

It shall be possible to perform control operations (e.g. remote start/stop of pump) from any of the operator consoles. Access to controls will be limited by the access rights assigned to the individual passwords for various operatives (see System Access).

The issuing of control instructions shall take precedence over the scanning for alarms.

A well organised select check and execute system is required.

1.1.13. AUTOMATIC CONTROLS

Automatic control features shall be available within the SCADA system, and fall into two categories:

a) Profile type controls where a working pattern (e.g. of reservoir level) is downloaded to a PLC for use by a local control system. New profiles may be sent for each day or week etc., as required.

b) Combinational and sequential control:

There are circumstances where the only practicable way of closing a control loop is via the SCADA system, although this should be avoided whenever possible. The package used for alarm derivation will also fulfil the automatic control requirements. The following facilities shall be provided as a minimum:

- Logical AND/OR/NOT/EXOR/EQUALS.
- IF-THEN-ELSE Constructions.
- Arithmetic operations including >, $, >, #, =, +, -, H,), /.
- Logical constructions including time and data.
- Look-up tables, with interpolating facilities.
- Input to functions from any system point including digital, analogues, totalisors, controls from a keyboard, set-point input from a keyboard.
- Output from functions to be available as digital, analogue or totaliser points, or transmitted to any PLC as a control or set point.
- Access to point attributes in addition to present value, including:

Suppressed, telemetry failed, in alarm (and for analogues, which alarm level).

4.13. TERMINAL TIME OUT

When a terminal is used for control purposes, it shall have to be logged on specifically for that function. If it is not used for a user configurable period of time (e.g. 5 minutes) in this mode, it shall automatically revert to a display only mode. A warning should be provided one minute prior to the auto log off.

4.14. SYSTEM RECORD

A record shall be kept on disc within the system of all operator actions, such as alarm acceptance or control actions performed on the system. The record shall include:

a) Time and date.

b) Action.

c) Operator.

This record shall be retrievable from the system using a similar select and sort routine to that specified for status and alarm logs.

4.15. REPORT GENERATION

The system shall be capable of generating both regular and individual reports. Reports must be easily configured and altered in order to maintain their relevance.

An example of a regular report which may be produced from the system is the following, designed to be made available to the works manager each morning:

a) Treatment works: previous day's output.

b) Alarms that have occurred during the night.

4.16. SYSTEM TIME

The system shall support:

a) Greenwich Mean Time (GMT/UCT).

b) Daylight Saving Time (DST).

c) Leap Years.

All data shall be logged at GMT/UCT + 2 hours, but automatically displayed in the appropriate local time adjusted for daylight saving.

4.17. SYSTEM DATA CONFIGURATION

The system shall be provided with privileged and secure on-line database building utilities i.e. it shall not be necessary to stop the scanning and alarm presentation facilities. Any configuration shall not be installed into the active database until completed, verified and authorised by the user. A reliable verification procedure shall be required to prevent the creation on invalid files and the deletion of in-use files.

It shall be possible to define process point files, calculated/derived point files, remote PLC files, to include:

a) Meaningful point identification and description.

b) Allocation of points to groups/locations.

c) Range of analogue values in Engineering Units.

d) Alarm limits/categories.

e) Scan control/frequency.

f) Report control (whether change of state is to be logged to the alarm/event printer).

g) Save control (whether values are to be archived).

h) MIS control (whether values may be transferred to other systems).

4.18. SYSTEM RESPONSE TIMES

The Dispatcher provided under this contract shall meet the following performance criteria:

Item	Description	Response (seconds)
1	From change of state of plant being detected by PLC	0.5
2	From change of state being detected by the Dispatcher to updating the SCADA database	0.5
3	From change of state in the SCADA database to updating the alarm list	0.5
4	From change of state in the SCADA database to updating the active mimic	0.5
5	All requests for mimic displays, alarm lists and help pages from the completion of the operator request.	3
6	All requests for trend displays and event lists shall from the completion of the operator request.	10
7	Time to perform screen dump from completion of the operator request	30

5. PLC EQUIPMENT

5.1. GENERAL

a) Programmable logic control devices (PLC's), where specified, shall be used to effect the monitoring and control of the plant or process.

b) They shall be capable of operating as either a standalone unit providing local operator interface information or form part of a supervised system complete with communications facilities.

c) The PLC shall be a modular unit capable of expansion. It shall support a minimum of 32 input/outputs but shall be capable of expansion upto 512 I/O.

d) The PLC shall operate from a nominal power source of either 110V or 230V AC 50 Hz. and incorporate its own integral 24V DC power supply for driving auxiliary modules.

e) The programmable controller shall have adequate memory and I/O ports to receive all control and sequencing signals and drive all indicator lamps, relays or solenoids as may be required to accurately control all the necessary functions of the control system.

f) The controller shall indicate the operating state of the outputs by means of light-emitting diodes (L.E.D.'s) and be equipped with sets of L.E.D.'s to indicate the controller status and to notify of any internal faults.

g) An integral means of turning all outputs off and ceasing the processor operation shall be fitted.

h) The PLC shall perform the majority of sequential functions and shall drive, either directly or by interposing relays, all the necessary outputs as detailed elsewhere.

i) Where the output load exceeds the rated capacity of an output port of the controller, suitably rated, D.I.N. rail mounted interposing relays shall be installed in the cabinet to amplify output controls signals. The maximum control voltage of the relays shall be 110 volts Ac.

j) D.I.N. rail mounted terminals shall be fitted in the bottom of the cabinet to allow the termination of all control and sequencing cabling. The terminals shall accept up to 4mm2 stranded conductor.

k) All output ports from the controller shall be correctly fused in order to protect the controller (by means of fused terminals). Fuse links shall be to BS 1362 or BS 4265 where fast action or semi conductor fuse links are required.

l) The PLC shall be capable of supporting the following component parts either inherently or via expansion when required and shall support all the required process I/O as detailed elsewhere:

- Power supply.
- Central Processor.
- Digital input.
- Digital output.
- Analogue input.
- Analogue output.
- Communications.
- High speed pulse counter.

5.2. POWER SUPPLY REQUIREMENTS

a) The equipment shall be designed to operate from one of the following power supplies:

- Mains power supplies shall be either (a) 230V AC or (b) 110V AC, 50 Hz. The mains operating voltage range shall be user selectable by a switch or selection link.
- Mains power supplies as defined in sub-clause (a) above, but having an additional facility for operation directly from a 24V DC standby supply.
- 24V DC supply with full protection against accidental reversal of the supply polarity.

b) The system circuitry shall be fully isolated from its power supply, using isolating barriers having resistances of not less than 2 megohms, measured at 500V DC to the requirements of BS 4743.

c) Depression of the mains supply voltage by 25% for a period of 5 seconds or interruption of the supply for 25 cycles shall not cause the system alarms to operate.

d) Mains borne transients of up to 1000V with energy levels of 1 joule shall not initiate system alarms or cause the system to operate outside the performance requirements of this specification after the occurrence of the transient.

e) Distortion of the AC mains supply waveform as defined in BS 6438 Clause 5.4.3 for a rated range of use III (B = 0.10) shall not cause system malfunction.

f) System cable terminations shall be made in a discrete termination section, housing terminal blocks sized, barriered and uniquely identified, to suit the voltage and current demands of the circuitry. Pinch screw type terminals are not acceptable.

g) Within the following ranges variation of the power supply to any system shall not cause it to operate outside the performance requirements of this specification as required under BS 6438.

h) -12% to +10% of the nominal 110V AC or 230V AC and a variation of the frequency within the range 45 Hz to 55 Hz.

i) -12% to +10% of the nominal 24V DC supply.

5.3. DIGITAL INPUT REQUIREMENTS

a) Two classes of input are acceptable:
   - Nominal 24V DC input rating, opto-isolated, reverse polarity protected.
   - Nominal 110V AC input rating, opto-isolated.

b) Mixing of 110V and 24V input ports in any given single installation shall not be acceptable.

c) Field contact inputs shall be debounced such that status changes will not be recognised unless the contact condition is maintained for at least 25 milliseconds.

5.4. DIGITAL OUTPUT REQUIREMENTS

a) Digital output shall be of the volt-free contact type.

b) Each output shall be electrically isolated from other outputs, the rest of the circuitry and earth. It shall have an insulation resistance to the rest of the circuitry and earth of greater than 2 megohms, when tested for 1 minute with 500V DC insulation tester.

c) System functionality shall be maintained when each output terminal is earthed in turn.

5.5. ANALOG INPUT REQUIREMENTS

The preferred input signal is 4-20mA; continuous; linear supporting a fully floating max 250 ohm input impedance load. Analogue/Digital conversion shall have a minimum 8 bit resolution, linear to ±1%, accepting signals in the range 0-10mA and 0-20mA and voltages 1-5V, 0-1V and 0-100mV as required.

5.6. ANALOG OUTPUT REQUIREMENTS

a) Analogue output shall be 4 to 20mA DC electrical signal with a linearly increasing output for increasing measurand value, complying with the requirements of BS 5863 Part 1, excluding Clause 3.6.

b) When the load resistance across the output terminals is varied from 0 to 1000 ohms the output signal current shall not change by greater than 0.1% of span, over the full output range.

5.7. COMMUNICATION PORTS

Communication ports will only be necessary on the PLC when its use is specified as part of an overall networked system. When required they shall provide the communication link between the PLC and other PLC's or PC based system.

5.8. PROTOCOLS

a) Provision of the communication required to satisfy this Specification shall include all necessary protocols for its successful operation.

b) A serial RS 232 port shall be available to enable interfacing to local PC's for MMI purposes to allow local database and control sequence loading, interrogation or modification. The port shall cater for communication with a suitable encoding device.

5.9. HIGH SPEED PULSE COUNTER

This input module shall accept voltage level input signals of either 5, 12, or 24 volt and have counting speeds up to 50 kHz. Encoded count signals of either 16 or 32 bit, bidirectional, shall be selectable and a minimum of 2, source or sink, independently configurable outputs shall be provided.

6. COMMUNICATIONS

6.1. GENERAL

The Contractor shall supply install and commission all necessary communications equipment and software to provide a complete integrated communications network for the SCADA system.

6.2. EMPLOYER LIAISON

The Employer will be responsible for the processing the licences required from the national licensing agencies.

The Contractor shall, however, provide all detail design calculations, equipment characteristics, equipment approval certificates and completed application forms for the Employer to enable the Employer to process all applications for communications circuits, frequencies etc. as an administrative task.

The Tenderer shall, within his bid, allow for all necessary tests to prove compatibility of the offered equipment with the national licensing agencies and communications standards.

6.3. SCAN TIMES

The Contractor shall prepare a detailed assessment of the PLC scan times for his system and submit this to the Engineer for approval. The assessment shall assume the use of UHF polling to gather operational data from PLCs located at remote sites.

The longest scan time for PLCs with radio communications shall not exceed two minutes under full system utilisation.

6.4. DATA RATES

The Contractor shall ensure that the data rates are not less than the following:

a) Public Switched Telephone Network (PSTN) Direct Exchange Lines (DEL) connection: 2400 Baud.

b) UHF Radio network: 1200 Baud.

6.5. TRANSMISSION AND PROTOCOL

The Contractor will have to use an industry standard transmission protocol. The Contractor shall provide details of the proposed protocol to be used at the time of Tender.

6.6. ELECTRONIC EQUIPMENT

All communications equipment used in the communications system shall be of high reliability and shall comply with the most recent edition of appropriate National and International Standards Specifications and recommendations at the time of Tender.

6.7. LIGHTNING PROTECTION

1.1.14. LIGHTNING PROTECTION DEVICES

The Contractor shall provide lightening and surge protection devices at each PLC on each communications circuit, base station and at all other parts of the radio network to ensure isolation and automatic resetting of the system being subject to high surge currents. Devices shall be unfused.

Lightning protection shall conform to the appropriate sections of BS6651, code of practice for protection of structures against lightning.

Lightning protection shall be selected to provide the highest degree of protection possible for the circuit being protected i.e. the clamp voltage shall be the lowest possible commensurate with normal operation of the circuit.

The type and manufacturer of the Lightning Protection Unit (LPU) shall be subject to the approval of the Engineer.

LPUs shall be earthed to the nearest earth reference bar, as direct as possible without inductive loops by a single unjointed cable.

Individual LPUs shall bolt directly onto a lightning earth bus bar. Cables and cores containing the circuits to be protected shall not be loomed or grouped together until the circuits subject to induced lightning energy have passed through the protection units.

Where two or more LPUs are mounted on the same Din rail mounted earth bar, the cable shall be sized as follows:

a) Cables less than 6 metres: 10 sq. mm.

b) Cables greater than 6 metres: 16 sq. mm.

The whole assembly shall be mounted inside an insulated box, if not already mounted separately from other equipment, close to the chosen earth termination in order to achieve a short, straight connection.

LPUs that are mounted in an enclosure supplied with an a.c. electrical power supply that utilise Din rail mounted earth bars shall have either:

a) The earth bars insulated by means of proprietary stand-offs or.

b) The Din rail insulated in an approved manner from the electrical power earth or any earthed conducting surface.

The route for the earth conductor shall be as far away as possible from the vicinity of the signal cables.

The earth conductor shall be copper, no greater than 16 sq. mm in section, it's route shall be as short and direct as possible and, in any case, no longer than 10 metres.

Ideally the cable route should be straight, but any necessary bends shall have a long radius.

The earth termination and the method of connection shall be subject to the approval of the Engineer.

1.1.15. EARTH ELECTRODES

The Contractor shall provide an earth electrode system in cases where the contract provides for the facility of lightning surge diversion equipment. The system shall be cabled to the main protective conductor system at the common point of connection of the distribution system that it serves.

Earth electrode systems shall be provided where specified in the particular Specification.

Where the provision of lightning protection is specified, the Contractor shall provide an earth electrode system in accordance with the relevant code of practice.

1.1.16. EARTH ELECTRODE INSTALLATION

Earth electrode installation shall connect earthing conductors to the general mass of the earth. The installation shall comprise one or more earth rods, mesh or combination thereof to obtain the required earth electrode resistance.

Earth rods shall be of proprietary manufacture, 16 mm outer diameter, made up of sections of 1.2 metres long with internal screw and socket joints and fitted with hardened steel tip and driving cap. They shall be driven into the ground to a minimum of 2.4 metres.

A minimum of two earth rods or other electrode shall be provided for each main earthing system and the conductor brought back to the main earth bus bar for each earth rods.

Connections to the electrodes are to be readily accessible for periodic inspection and shall be protected against mechanical damage and corrosion. The actual connection to the rod shall be by means of a purpose made non ferrous clamp and shall be made below ground level in a concrete inspection pit having a removable cover.

When the installation is complete, soil resistivity or other tests shall be performed and witnessed by the Engineer, to ensure that the required earth loop impedance figure of less than 5 ohms is attained.

6.8. TESTING

The Contractor shall allow for the following tests with regard to communications equipment:

a) Factory testing of sub-assemblies.

b) Factory testing of complete units.

c) Factory simulated system tests to prove the performance of all elements of the integrated communications network.

d) Commissioning tests of all installed radio equipment to record the characteristics for future maintenance of the network.

Test certificates shall be provided at each stage and for each complete unit and sub-system. The Contractor shall supply all test equipment and shall provide seven days notice prior to testing to the Engineer.

The tests must meet the following standards:

a) ETSI EN 302 085 V.1.2.2: Fixed Radio Systems; Point-to-Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 3 GHz to 11 GHz band.

b) IEC 61100-4: Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques.

e) IEC 60529: Degrees of protection provided by enclosures (IP Code).

f) IEC 62262: Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).

g) IEC 60068-2: Environmental testing – Part 2: Tests.

h) ASTM G53: Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials (Withdrawn 2000).

i) UL94: Flame classifications and flammability tests.

6.9. RADIO EQUIPMENT

1.1.17. STANDARDS REQUIREMENTS AND APPROVAL

All equipment shall comply with the appropriate CCIR recommendations and shall be approved by the national licensing agency. The equipment shall comply with the most recent editions of the appropriate National and International Standards Specifications and Recommendations.

Type approval numbers issued by the National Frequency Allocation Committee in the country of manufacture shall be supplied, together with appropriate CCIR recommendations, appropriate National and International Standards Specification met by the equipment at the time of Tender.

International Standards Specification:

c) IEC 60096 Radio frequency cables.

d) IEC 60169 Radio frequency connectors.

e) IEC 60196 IEC standard frequencies.

f) IEC 60215 Safety requirements for radio transmitting equipment.

g) IEC 60315 Methods of measurement on radio receivers for various classes of emission.

h) IEC 60487 Methods of measurement for equipment used in terrestrial radio-relay systems.

i) IEC 60605 Equipment reliability testing.

j) IEC 60864 Standardization of interconnections between broadcasting transmitters or transmitter systems and supervisory equipment.

k) IEC 60966 Radio frequency and coaxial cable assemblies.

l) IEC 61000 Electromagnetic compatibility (EMC).

m) IEC 61169 Radio frequency connectors.

n) IEC 61196 Coaxial communication cables.

o) IEC 62151 Safety of equipment electrically connected to a telecommunication network.

p) IEC 62273 Methods of measurement for radio transmitters.

q) IEC 62439 Industrial communication networks – High availability automation networks.

r) IEC 62443 Industrial communication networks – Network and system security.

s) IEC 63404 Switchgear and controlgear and their assemblies for low voltage – Integration method of radiocommunication device into an equipment.

1.1.18. RADIO SYSTEM

The radio system shall conform to the latest regulations and requirements current at the time of delivery. The radio system shall be of the following type:

a) Frequency: UHF as allocated by the Frequency Committee.

b) Modulation : FM.

c) Base Mode: Full Duplex.

d) PLC Mode: Two-Frequency Simplex.

e) Channel Spacing: 12.5 Khz.

1.1.19. RADIO PATH PROFILES

The Contractor shall provide path profiles and subsequent technical examinations prior to detailed design of the radio system.

1.1.20. PCL RADIO TRANSMITTERS/RECEIVERS

PLC transmitter/receiver radio units shall be units with standby facilities. These units shall have sufficient battery backup for the system to function for 4 hours in the event of mains failure. The units may either be wall mounted or installed in the PLC enclosure (the preferred option).

The alarm signal shall be transmitted to the SCADA system when a changeover occurs due to a radio failure.

The R.F. output of the radio units shall be variable from maximum down to 0.5 watt. Attenuation pads shall be provided in the transmit leg only, and the radio output set to maximum in the final system configuration.

1.1.21. BASE STATION RADIO TRANSMITTERS/RECEIVERS

Base station transmitter/receiver radio units shall be located adjacent to the Works Control Centre (WCC) and shall be of a dual main/standby type with auto-changeover of the duty units. The Contractor shall supply within the tender document an explanation of how this is to be accomplished. An alarm signal shall be transmitted to the SCADA system when a changeover occurs. The base station shall be provided with power supply equipment, including: nickel cadmium battery and 230 volts 50 Hz a.c. mains fed battery charger and have sufficient battery backup to allow the system to operate for eight hours on the event of mains failure. The charger shall be capable of recharging the battery to full capacity within 8 hours while the radio equipment continues to operate at full duty.

The alarm signal shall be transmitted to the SCADA system when a changeover occurs due to a radio failure.

The R.F. output of the radio units shall be variable from maximum down to 0.5 watt. Attenuation pads shall be provided in the transmit leg only, and the radio output set to maximum in the final system configuration.

The base station radio shall be forced to change the duty radio at a user definable interval (normally every 24 hours).

1.1.22. AERIAL AND AERIAL STRUCTURES

The Contractor shall supply and install all aerials and aerial support structures and shall provide typical drawings to show how each type of aerial mast is to be mounted (including free standing, guyed stub etc.) with the tender document. The base station shall have omni-directional aerials plus any associated duplexers.

PLCs shall have a single 12 element, yagi aerial with a gain of 12dB with respect to a half wave dipole on the corresponding base station.

The aerial and support structure shall be capable of withstanding winds gusting to 160 km/hour without damage. The Contractor shall provide all supporting calculations.

The Contractor shall supply to the Engineer all necessary calculations and information to demonstrate the aerial wind performance and structural integrity of it's support and all necessary documentation and calculations to enable the appropriate planning approvals to be obtained for the aerial and it's support structure.

The Contractor shall supply and install all necessary low loss coaxial down leads for connection to the radio unit and lightning protection for the aerial system. The aerial masts shall be earthed in accordance with BS CP 326. The lightning protection system shall include use of aerial elements at earth potential, the aerial support structure, the test link and the earth rods/spikes.

1.1.23. MAST STRUCTURES

The Contractor may use the following mast types, however the Contractor shall assess the requirements for the mast structure and suitable alternatives for approval may be provided:

f) 3m or 5m Pole

- A 50mm diameter aluminium pole with a 300mm stand-off bracket kit for building mounting, aerial clamps and 15 metres of low loss coaxial cable.

g) 6m pole

- A free standing circular or octagonal column aluminium finish with bottom flush fitting door opening, tamper proof lock and stainless steel earth stud. Poles may be flange mounted or cast in a concrete foundation. A 35mm diameter PVC duct shall be installed between the pole and the PLC building. 25 metres of low loss coaxial cable shall be allowed at each 6m pole.

h) Guyed pole

- A 50mm diameter aluminium pole secured by stainless steel guyed lines mounted on a concrete base. A 35mm diameter PVC duct shall be installed between the pole and the PLC building. 25 metres of low loss coaxial cable shall be allowed at each guyed pole.

i) Lattice

- Lattice structures shall be constructed of steel and shall be hot dip galvanised to BS 791/71 to provide a maintenance free finish. The coaxial down-lead shall be enclosed within a galvanised steel conduit to a height of 2m above ground level. A 35mm diameter PVC duct shall be installed between the pole and the PLC building. 25 metres of low loss coaxial cable shall be allowed at each lattice structure.

6.10. PSTN COMMUNICATIONS

1.1.24. GENERAL

All equipment for connection to the PSTN lines shall be offered:

a) To comply in all respects to the National and Local regulations and approvals.

b) To comply with the most recent editions of appropriate CCITT Recommendations, National and International Standards Specifications and Recommendations.

c) Such that any line sending and receiving sensitivity controls shall be capable of alteration by removal of the unit by authorised maintenance personnel.

d) With evidence of prior use by major national telecommunications networks, together with type approval numbers and full details of CCITT Recommendations, National and International Standards Specifications and Recommendations met.

1.1.25. MODEMS

The Contractor shall supply and install all modems and interconnecting wiring to the SCADA system and telephone equipment as appropriate.

PLC equipment modems shall form part of the PLC unit and shall be compatible with the associated 'line connection' modules.

All modems shall be approved by the national and local service provider and shall comply with V21, V23, V26, and V29 (III-1) as appropriate.

1.1.26. ON SITE COMMUNICATIONS CABLES

On-site communications networks shall be by Belden type 9463 cable or similar approved.

7. TESTING

The Contractor shall provide for system testing as detailed. The tests shall conform to BS 5887 (code of practice for testing of computer based systems) and BS 6238 (code of practice for performance monitoring of computer based systems).

The Engineer shall approve all acceptance procedures for inclusion within the system specification.

7.1. FACTORY ACCEPTANCE TEST

7.1.1. GENERAL

The Tenderer shall provide for full Factory Acceptance Test of the fully configured system, to include:

a) The complete system network.
   Support for all PLCs with all points over an integrated network, simulated to include all types of communications units and interfaces.

b) Mimic display pages on the system as defined within the particular specification.

c) Test 1 - Simultaneous occurrence of:
   - The control centre polling outstations in normal (i.e. daytime) operational mode receiving 50% of data from each PLC with 10% of points in alarm conditions.
   - Operator workstations performing:
     * Simultaneous access.
     * Access staggered by 2 seconds.

d) Test 2:
   - As test 1.
   - Performing daily system archive.

e) Test 3:
   - As test 1.
   - Performing archive data recovery.
     * Full daily archive recovery.
     * Four data points for one week (15 minute intervals).

f) Test 4:
   - As test 1.
   - Performing screen dump.
   - Printing daily report.

The simulation package shall use the SCADA system to demonstrate proper performance under full utilisation conditions.

The Contractor shall record the following:

a) DISPLAY RESPONSE: This shall be no greater than as specified.

b) PERCENTAGE CPU UTILISATION.

c) SCAN TIME: This shall be no greater than 1 minute for full system scanning.

d) TIME TO CLEAR BACKLOG: The Contractor shall also record any adverse conditions that become apparent.

The Contractor shall substantiate the validity of the simulation to the Engineer and shall confirm, at the time of Tender, by what means such simulation will be carried out.

a) The PLC to demonstrate:

   All control and failure recovery sequences, simulating all digital and analogue inputs and outputs on each system.

b) The communications system to demonstrate:

   Full simulation utilising all interface nodes, with PLCs connected, in order to prove the performance over the network. Communications failures shall be simulated in order to prove the automatic re-routing of communications to SCADA system.

7.1.2. FACTORY ACCEPTANCE TEST - WITNESSING

The Factory Acceptance Test shall be conducted in the presence of witnesses, who shall be nominated, in writing, by the Employer and the Contractor respectively. The witnesses shall be empowered to act during the Factory Acceptance Test, on behalf of the parties they represent, to judge the success or failure of a particular test. Either party as necessary, in writing may appoint nominated Deputies.

The Contractor shall provide evidence that the tests (FAT/SAT) have been successfully performed prior to the witnessing by the Engineer.

Factory acceptance tests must comply with standard IEC 62381: Automation systems in the process industry - Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT).

7.1.3. FACTORY ACCEPTANCE TEST - PROCEDURES

The testing procedures shall be designed such that each separate testable entity (e.g. hardware configuration, picture building) consists of a well-defined series of tests.

Each test shall be documented to include:

a) The purpose of the test.

b) Any pre-requisites required allowing the test to be completed successfully.

c) Any hardware required allowing the test to be performed successfully.

d) A detailed schedule of activities to be performed within the test.

7.1.4. FACTORY ACCEPTANCE TEST - RECORD

A log shall be maintained during the Factory Acceptance Test. This log shall record for each test performed:

a) The test results.

b) Any faults which occur.

c) Any remedial action taken.

d) Re-test results.

e) Decisions taken by the witnesses which may affect the test results.

The witnesses of both parties shall initial all entries within the log.

Copies of the log shall be provided to the Employer on completion of the Factory Acceptance Test.

7.1.5. FAILURE AND RE-TEST

The success or failure shall be determined as follows:

a) If the system performs as laid down in the Functional Design Specification the test shall be deemed successful.

b) The tests shall not be failed due to external conditions, e.g. power fail, provided the system fulfils the resilience criteria detailed within this tender document and any subsequent project specification.

c) The tests shall not be failed through incorrect operation provided the fault can be corrected by normal operating procedures and provided the test performed satisfactorily in all other aspects (e.g. printer ribbon failure).

Any test that is deemed unsuccessful may be retried following any remedial action that may be necessary.

If the system should fail any test and it is apparent that the fault may have affected the result of tests previously regarded as successful any or all of the tests affected may be re-tested.

To allow all participants to fully understand all aspects of the Factory Acceptance Test, the Factory Acceptance Test Specification as agreed between all parties shall be issued with the Contractor's Project Specification (CPS).

7.1.6. SYSTEM MANAGEMENT

The Factory Acceptance Test shall include, but not be limited to, the following as defined within Contractor's Project Specification.

a) Hardware

The hardware configuration being tested shall be fully detailed and cross-referenced against the Tender Return Document.

b) System Start-up and Shut-down Procedures

These tests shall exercise the system start-up and shut-down commands including:

- System start-up commands.
- Operator log-in and log-out commands.
- Password verification.
- Any special function command keys.
- Orderly system shut-down.

c) System Back-up and Recovery

These tests shall exercise the system back-up and recovery procedures, including:

- System back-up to archive media.
- System re-build from system archive media.
- Synchronisation of the Master Station and outstations.

7.1.7. SCADA DATA BASE CONFIGURATION

These tests shall exercise the database commands including:

a) Password and level of access maintenance.

b) The creation and amendment of PLCs.

c) The maintenance of PLC communications parameters, e.g. telephone numbers, radio characteristics, change of media, scanning intervals, on/off telemetry scan.

d) Regions of interest.

e) Creation and amendment of SCADA points:

- Name.
- Type, e.g. status, analogue, derived.
- Alarm limits.
- Historic data recording and characteristics.
- Re-transmission of value to associated points.
- Scaling factors.
- Calculation formulae maintenance.
- Set output control parameters for digital, analogue and derived controls.

7.1.8. PICTURE CONFIGURATION

The tests shall exercise the picture configuration commands available to the privileged operators, including:

a) The creation of picture pages, to include foreground/dynamic and background/static picture elements.

b) The modification of picture pages, to include foreground/dynamic and background/static picture elements.

c) The deletion, copying and renaming of pictures.

d) Any function control key usage.

e) Examples of all picture types, e.g.:

- Static information pages (e.g. indices).
- Mimic pictures for information display and control monitoring.
- Alarm list pages.
- Statistical pictures (e.g. trends, histograms).
- Help/text pages.

f) The display and printing of pictures.

7.1.9. DATA COLLECTION

These tests shall exercise the data collection commands available to the privileged operators, including:

a) The collection of digital, analogue and derived parameters.

b) The collection of all data from outstations at frequencies defined by the privileged operator.

c) The manual entry of data.

d) The inhibition of data collection from a PLC.

e) The inhibition of data collection from an individual point.

f) The editing of stored data (subject to correct level of access).

7.1.10. SUPERVISORY CONTROL

These tests shall exercise the supervisory control commands, including:

a) The creation and downline loading of control sequences.

b) Digital, e.g. open/close, and analogue, e.g. set point, controls of individual control points.

c) Revertive checks to ensure the correct control point is addressed.

7.1.11. ALARM/EVENT HANDLING

These tests shall exercise the alarm and event reporting procedures, including:

a) Digital and analogue alarms:
   - Reported on the alarm/event printer.
   - Logged to disc.
   - Reported to the appropriate operator consoles.

b) Events, e.g. issue remedial control command:
   - Are only issued from appropriate operator consoles.
   - Logged to the alarm/event printer.
   - Logged to disc.
   - Are subject to correct level of access and regions of interest.

c) Alarm acceptance/acknowledgement procedures.

d) Alarm list interrogation procedures.

e) Alarm list printing.

f) Alarm inhibit for an individual point.

7.1.12. DATA LOGGING

These tests shall exercise the data logging and archiving procedures including:

a) Tests to ensure all data/alarms collected are logged to the on-line archive storage.

b) Tests to ensure data can be archived to and recalled from long term archive media.

7.1.13. PLC PROGRAMMING

These tests shall exercise the PLC sequence programming procedures, including:

a) Sequence program editing, compilation and loading.

b) The ability to load new sequences on demand by a privileged operator.

7.1.14. MANAGEMENT INFORMATION SYSTEM DEVELOPMENT

These tests shall demonstrate the use of the enquiry package and the applications programs development tool kit, including:

a) The editing and compilation of programs.

b) The abstracting of data from the SCADA database.

c) The automatic scheduling of programs as a result of time of day queues and as a result of a SCADA event/alarm.

7.2. SITE ACCEPTANCE TETS

The Contractor shall provide for full site acceptance tests for each item of plant to be provided under the Contract. This shall include the interface to the marshalling unit, the communication system, the earthing system and full functionality as demonstrated at the Factory Acceptance Test.

7.3. SYSTEMS ACCEPTANCE TESTS

The Contractor shall provide for full system test on completion to include tests as stated above.

All special test equipment relevant to the Contractor supplied equipment shall become the property of the Employer on completion.

8. TRAINING

The Contractor shall at time of tender state any minimum levels of training/experience required for participants, prior to attending the appropriate course.

The Contractor shall provide training for the Purchaser's staff as detailed. The Tenderer may offer training courses structured to meet his technical offering. These courses shall be subject to the approval of the Engineer and shall be detailed at the time of Tender.

In general training courses shall be provided at Purchaser’s offices as detailed within the particular specification. However some courses may be held at the manufacturer’s works as agreed by the Purchaser.

The Contractor shall provide all course materials and equipment needed.

The training shall be organised such that the Purchaser shall be able to operate and maintain the SCADA scheme following completion of all training courses.

8.1. SYSTEM OPERATORS

The Contractor shall provide for the number of attendees as specified within the Particular Specification with 4 no. operators attending each course.

This purpose-designed course is to be held at the Works Control Centre. Training must be provided in advance of commissioning to enable the Purchaser's user staff to participate in the full process commissioning of the system and safely operate the plant and maintain the SCADA system.

System take-over shall not take place until satisfactory training has been provided.

This course shall be designed to familiarise the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

a) Loading and starting up the Operating System.

b) System Operators interface.

c) Operator control of program/task execution.

d) Operator control of disc files.

e) File transfer tasks - archiving, retrieval.

f) Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.

g) SCADA system interrogation facilities - alarm lists, log printouts select mimic and trend displays etc..

h) Alarm acknowledge accept/delete.

i) Control actions, e.g. start pump, close valve.

j) All functions associated with each access level of the SCADA system.

8.2. SYSTEM SUPERVISOR PERSONNEL

The Contractor shall provide a five-day course for the number of attendees as specified within the Particular Specification.

To be held at the Works Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

a) Basic systems design overview.

b) The use of computers to perform diagnostics and to tune other parts of the system.

c) Changing passwords and access control.

d) Sequence verification.

e) Preventative maintenance.

8.3. SYSTEMS DEVELOPERS/PROGRAMMERS/ENGINEERS

The Contractor shall provide 1 no. five day course with the number of attendees as specified within the Particular Specification.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

a) The system database structure.

f) System database building/configuration.

g) Mimic building.

h) Applications program interface to the system database.

i) Management information system interface.

j) Downtime loading of control programs/sequences to PLCs.

k) Advanced operating features.

8.4. SITE TRAINING

The Contractor shall liase with the Engineer and the Purchaser on site as new areas of plant are to be changed over to the new system, to establish the following:

a) What training is required for operating and maintenance staff?

b) Who is to be trained?

c) Who will provide the training and when?

The Contractor shall supply O & M documentation prior to training. A section of the plant shall not be handed to the Purchaser for operation until training on the control systems has been completed. Should defects occur prior to Take-over of the whole scheme the Contractor shall be responsible for rectifying the fault prior to any other phased hand-over of the scheme.

This training course/workshop shall be designed as a "reference" course rather than a formal educational course, i.e. the Contractor's personnel shall be present to assist the Purchaser's personnel, as necessary, with any technical difficulties.

9. OPERATIONS & MAINTENANCE DOCUMENTATION

9.1. GENERAL

This contract shall include full documentation for all equipment and software provided under this contract. The documentation shall be written in a clear and concise manner which is fully formatted and indexed to provide documentation that is easy to understand and friendly to use. It shall be capable of incorporating upgrades and amendments to information in an efficient and effective manner. Generally the documentation shall be compiled in A4 ring binders. Liaison will be required with the Engineer regarding the contents of the individual manuals.

The manuals should not be confused with manufacturer's literature which shall form part of the O and M documents.

All documentation shall also be provided on disk in the Employer standard format current at the letting of the contract. The Employer shall hold the copyright for these documents.

All drawings, unless within word-processing documents, shall also be provided in AutoCAD format on disk, or other media agreed with the Purchaser. All documentation shall conform to ISO 6592 Code of Practice for Documentation of Computer Based Systems. The Tenderer may offer manuals structured to meet his technical offering. These manuals shall be subject to the approval of the Engineer and shall be detailed at the time of Tender. The documentation shall be submitted to the Engineer for approval.

9.2. FULL SYSTEM OPERATING PROCEDURES (6 NO. COPIES)

The Contractor shall provide full operating procedures detailing how to use the SCADA system, to include but not limited to:

a) Loading and starting up the Operating System.

b) System Operators interface, including:

- System mimic navigation.
- SCADA system interrogation facilities - alarm lists, event log printouts and trend displays etc.
- Alarm acknowledge accept/delete.
- Control actions, e.g. start pump, close valve.
- All functions associated with each access level of the SCADA system.

c) Operator control of program/task execution.

d) Operator control of disc files.

e) File transfer tasks - archiving, retrieval.

f) Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.

9.3. FULL SOFTWARE DOCUMENTATION

The complete software specification shall be provided and shall include the system design specification, flowcharts, logic diagrams, system software definitions, program index, system build definition, and system data for each system and module. The information shall not be disclosed to any third party without the author's consent. Six (6) copies shall be submitted.

9.4. HARDWARE MANUALS

The Contractor shall provide documentation for all equipment supplied within the Contract. Two (2) copies shall be submitted.

9.5. PLC PROGRAMMING DOCUMENTATION

The Contractor shall provide one copy of all necessary PLC programming documentation as supplied by the PLC manufacturer.

10. QUALITY ASSURANCE

10.1. GENERAL

The SCADA Contractor shall be registered to ISO9001.

10.2. QUALITY PLAN

The Contractor shall provide a quality plan within 4 weeks of award of the contract.

10.3. SOFTWARE DEVELOPMENT

All software development shall be carried out under an EU-recognised quality system compatible with ISO 9001 that is defined in the quality plan.

10.4. PRODUCT AUDIT

The Engineer shall have the right to audit the product at any time during the contract period.

10.5. QUALITY RECORDS

The Contractor shall maintain quality records in line with the quality plan throughout the period of the contract. These will provide an audit trail for the design and implementation of the technical solutions adopted for the project.

10.6. SUB-CONTRACTORS

The Contractor shall be responsible for the quality of any sub-contracted work and the quality plan shall incorporate all the work undertaken by sub-Contractors.

The Tenderer shall nominate his sub-Contractors in his tender return. The Contractor shall be required to obtain the Engineers approval (which will not be unreasonably withheld) to change any nominated sub-Contractor.

10.7. DELIVERY AND INSTALLATION

10.7.1. SCOPE

The Contractor shall be responsible for all costs involved with the delivery and installation of the equipment for the system.

10.7.2. DELIVERY

The Contractor shall provide all personnel and equipment necessary to unload the equipment and transport the equipment to its' final location.

10.7.3. INSTALLATION

The Contractor should be aware that there may be periods such as flood events or for operational reason, that the Contractor will not be allowed to work on the system or some particular part of the system or PLC, for some specified period.

The Contractor shall make due allowances for this in his costing and programming of his installation and commissioning works.

10.8. SYSTEM RECOVERY

The Contractor shall supply a full backup set of the supplied software, on suitable archival media (e.g., CD-ROM, magnetic tape, optical disk, etc.). The Contractor shall also himself keep a full backup of the supplied software for the life cycle of the supplied equipment.

10.9. CONSUMABLES

The Contractor shall supply all consumables for the SCADA equipment for the duration of the contract, including, but not limited to:

a) Printer paper.

b) Printer ribbons/ink cartridges.

c) Storage media.

d) Cleaning materials.

10.10. SPARES AND TEST EQUIPMENT

The Contractor shall provide a list of recommended list of spares and test equipment required to the SCADA system.

To minimise the spares holding, the Contractor's design should consider the benefits of standardisation.

Spare parts must be supplied for a period of operation of ten years.

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MEDIUM VOLTAGE AIR-COOLED VARIABLE FREQUENCY DRIVE SPECIFICATION

1.0 SCOPE

1.1 This specification covers the complete labor, materials, equipment, and incidentals required to place into operation an integrated medium voltage variable frequency drive (VFD) system. This specification may be applied to any type of medium voltage (MV) AC motor application.

1.2 Every variable frequency drive system shall meet the performance, protection, safety, testing, and certification criteria of this specification. This system may include an incoming harmonic filter/power factor correction unit, input isolation transformer, VFD converter/DC link/inverter, and output filter.

1.3 The VFD system must:

1.3.1 Represent a fully integrated and serviceable package.

1.3.2 Include all material necessary to interconnect any VFD system elements, even if shipped separately.

1.4 Any modifications to a standard product provided to meet this specification shall be performed by the VFD manufacturer only.

1.5 The VFD system as defined (1.2 above) shall be completely factory pre-wired, assembled, and then tested as a complete package by the VFD manufacturer, before delivery, to assure a properly coordinated, fully integrated drive system.

1.6 Any 3rd party certification, safety, or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.

2.0 GENERAL

2.1 Codes and Standards

2.1.1 Provide equipment in accordance with the latest applicable rules, regulations, and standards for medium voltage drives:

2.1.1.1 American National Standards Institute (ANSI)

2.1.1.2 National Electrical Manufacturers Association (NEMA)

2.1.1.3 Institute of Electrical and Electronics Engineers (IEEE)

2.1.1.4 International Electrotechnical Commission (IEC)

2.1.1.5 North American 3rd Party Nationally Recognized Test Lab [e.g. Underwriters' Laboratories (UL), Canadian Standards Association (CSA)

2.1.2 VFDs shall be manufactured, assembled, tested and designed in accordance with UL, CSA, or CE standards as applicable.

2.2 Quality Standards

2.2.1 Variable frequency drives shall be manufactured by the VFD supplier at its own facility which has an Integrated Management System, certified in accordance with ISO Standard 9001, 14001 and OHSAS 18001.

2.3 Acceptable Manufacturers

2.3.1 Variable frequency drives shall be ABB ACS1000 Series or approved equal, meeting the exact requirements of these specifications.

2.3.2 The VFD manufacturer shall be able to demonstrate at least 15 years of experience in manufacturing VFDs at medium voltage and their capability to provide parts and service support. A user's list of similar design equipment, complete with contact names and telephone numbers, shall be furnished upon request.

2.3.3 To ensure timely onsite support, spare parts availability and product life cycle support drives that are manufactured by a third party and/or "brand labeled" shall not be acceptable.

2.4 Product Experience

2.4.1 It is the intention of this specification to purchase dependable and reliable equipment offering the best performance available from currently proven technology. All equipment furnished under this contract must, therefore, have documentation showing proof of actual operation for a minimum of 15 years in similar service.

3.0 PERFORMANCE

3.1 Operating Envelope

3.1.1 VFD shall meet the following speed and torque requirements:

3.1.1.1 The VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 20-100% speed range. The VFD must be capable of operation at 1/10 speed to facilitate checkout and maintenance of the driven equipment. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without a motor connected to the VFD output.

3.1.1.2 VFD shall be capable of operating any standard AC motor of equivalent rating (horsepower and speed) over the specified speed range.

3.1.1.3 The VFD shall be able to produce full rated torque at any speed in the operating range (constant torque capability).

3.1.1.4 If high breakaway/starting torque is required, the VFD shall provide full rated torque at breakaway.

3.1.1.5 One minute overload capability (1 minute every 10 minutes) shall be provided consistent with the application requirements defined in this specification.

3.2 Input Harmonics

3.2.1 VFDs shall comply with the latest edition of IEC 61000-2-4 and IEEE 519 for total harmonic current distortion, calculation, and measurement, and meet the above distortion limits without causing the VFD to operate at a leading input power factor from 30% to 100% of rated speed.

3.2.2 Voltage Harmonics: individual or simultaneous operation of the VFDs shall not add more than 3% total harmonic voltage distortion while operating from the utility source, or more than 5%

while operating from the standby generator (if applicable).

3.2.3 Total harmonic current distortion limits for each individual VFD shall not exceed 5% as calculated and measured at the point of common coupling, defined as the input connection of each VFD.

3.2.4 The VFD converter section shall be 18 or more pulse to eliminate the need for harmonic filters. Harmonic filters are highly undesirable due to resonance problems, and they require tuning whenever other inductive/capacitive loads are placed on the system or when the power system changes.

3.2.5 Upon request compliance shall be verified by the VFD manufacturer with field measurements of harmonic distortion differences at point of common coupling with and without VFDs operating. The point of common coupling (PCC) for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the input connection of each VFD. In the event the initial field measurements do not meet the latest edition of IEC 61000-2-4 or IEEE-519, the VFD manufacturer shall be responsible for any additional equipment needed for compliance.

3.2.6 Power quality metering shall be inherent to the VFD system to continuously monitor and display input and output power quality. This will allow easy customer verification of power quality and efficiency for the VFD system. The power quality data shall include the following:

3.2.6.1 Input voltage (average rms value)
3.2.6.2 Input current (individual phase rms values and average rms value)
3.2.6.3 Input frequency
3.2.6.4 Input power factor
3.2.6.5 Input kW, kVAr
3.2.6.6 Input kWHr
3.2.6.7 Input current THD (average of 3 phases)
3.2.6.8 Calculation of total input current or voltage harmonic demand distortion
3.2.6.9 Drive efficiency
3.2.6.10 Motor voltage (rms)
3.2.6.11 Motor current (rms)
3.2.6.12 Motor speed (in RPM or %)
3.2.6.13 Motor flux (%)
3.2.6.14 Motor torque current (%)
3.2.6.15 Drive output power (kW)
3.2.6.16 Output kW-Hr

3.3 Motor Compatibility

3.3.1 VFD system shall provide an output waveform that will allow utilization of standard motors, without the need of any special insulation or de-rating. Motor life expectancy should not be compromised in any way by operation with the VFD system. The system must comply with all elements of the output harmonics section of this specification. The VFD must provide motor overload protection in any operating condition.

3.3.2 VFD output waveform shall be suitable for operating a squirrel cage induction motor without de-rating or requiring additional service factor. To ensure that there are no problems with motor heating, VFD output current waveform, as measured at the motor, shall be inherently sinusoidal at all speeds, with a total harmonic current distortion not exceeding 3% referenced to the full load output current fundamental between 10% and 100% speed.

3.3.3 The system design shall not have any inherent output harmonic resonance in the operating speed range.

3.3.4 The VFD output shall produce minimum electrically-induced pulsating torque to the output shaft (less than 1%) of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations. VFD systems or other types which produce individual torque pulsations across speed range are <1% of rated w/out over-modulation and <3.5% of rated w/ over-modulation.

3.3.5 VFD shall inherently protect the motor from high-voltage $\delta v/\delta t$ stress, independent of cable length to the motor. VFD shall not require non-standard insulation systems or insulation ratings above the VFD output voltage rating. The VFD system shall be designed to produce no standing waves or over-voltage conditions based on cable lengths below 7500 feet (2300 m). This is a typical length which will cover most application requirements and allow for potential future cable run changes from VFD to the motor. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system.

3.3.6 An integral input transformer shall be included with the VFD system to provide common-mode voltage protection and allow the use of a standard motor. Special high-voltage motor insulation is not an acceptable method for protection against common-mode voltages. VFD systems that do not include an integral input transformer will not be accepted.

3.4 VFD System Efficiency

3.4.1 Guaranteed minimum VFD system efficiency (ηsys) shall be above 96% at 100% load, and above 95% in the 100% to 50% load range. Efficiency evaluation shall include input transformer, harmonic filters, and power factor correction (if applicable), VFD converter, and output filter, as indicated below.

The VFD system efficiency is as follows: $\eta_{sys} = \eta_{VFD} \times \eta_{xfmr} \times \eta_{pfc} \times \eta_{harm} \times \eta_{filter}$

Converter/Inverter (VFD)	η_{VFD}
Input Transformer	η_{xfmr}
Power Factor Correction	η_{pfc}
Input Harmonic Filter	η_{harm}
Output Filter	η_{filt}

VFD System Efficiency (η_{sys}) must be 96.0% at full load and 95% at 50% load.

3.4.2 If required, a factory test shall be performed at the VFD manufacturer's facility certifying that efficiencies have been met. A penalty (in dollars per kW) will be assessed if efficiency is not achieved and will be deducted from the contracted price.

3.5 System Input Power Factor

3.5.1 VFD system shall maintain a 0.95 minimum power factor from 30% to 100% of rated speed. VFD system including power factor correction and/or harmonic filter shall never have a leading power factor under utility or generator operation. VFD manufacturer is to supply a power factor correction system, if required, to meet this requirement. Power factor correction unit shall include a separate input isolating contactor with fuses, power factor correction grade capacitors (voltage class shall be consistent with the VFD system input voltage), and series harmonic de-coupling reactors, all integrated into VFD system and mounted within the VFD enclosure.

3.5.2 For VFD systems employing a capacitive input filter, an electrical system analysis shall be

performed by the VFD vendor to ensure the VFD will not create a leading power factor or a resonant condition while operating on utility or back-up generator power. This analysis shall be provided with the bid.

3.6 Speed Regulation

3.6.1 VFD control system speed regulation shall be ±0.5% without encoder or tachometer feedback.

4.0 DESIGN CALCULATIONS

4.1 Torsional Analysis

4.1.1 If a torsional analysis is required, as defined by the output waveform section (see Section 3.3), the price of the torsional analysis shall be included in the base price of the VFD system. The total rotating system shall be analyzed to determine its natural resonant frequencies. Stresses are to be calculated for elements of the rotating system, utilizing torsional excitation data from the drive and driven system, taking into account potential transient or fault conditions, and appropriate amplification and damping factors of the rotating system. A written report on the analysis shall detail the procedures used and the assumptions that were considered shall be provided. The results of the analysis must be presented in both detailed and summary form. Specific data presented shall include the following:

4.1.1.1 A diagram of the frequencies of the torque pulsations and the mechanical resonant frequencies showing their coincident points

4.1.1.2 A plot of total shaft stress versus operating speed for the most highly stressed areas of the rotating system

4.1.1.3 A diagram of the rotating system model and mode shapes for resonance(s) of interest

4.1.1.4 Tables summarizing total calculated stresses for each element of the rotating system at operating speeds where interference(s) exist between torsional excitations and torsional resonance

4.1.1.5 Details of the rotating system used in the analysis, including the specified or a recommended alternate coupling

4.2 Harmonic Study (Performed on request)

4.2.1 A preliminary harmonic calculation shall be performed by the VFD system manufacturer if required for specific project. A power system short circuit ratio of 10 shall be assumed, with all VFDs operating at maximum speed and maximum load.

4.2.1.1 The harmonic calculation, submitted by the VFD system manufacturer, should include all voltage and current harmonics up to the 99^{th}. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the primary connection of each VFD.

4.2.1.2 A separate calculation shall be performed on the basis of the standby generator system data.

5.0 AVAILABILITY

5.1 Firing Signals

5.1.1 All internal firing signals and other communications with power components, such as status and diagnostic signals, must meet noise immunity and safety requirements as defined by the applicable standards referenced in Section 2.1.

5.2 Multi-cell H-bridge topology

5.2.1 Drives with multi-cell H-bridge topology shall have 750V cells for the nominal output voltage of 4kV and above to offer best reliability.

5.3 Failed Power Electronic Ride-Through Capability

5.3.1 If power-electronic bypass feature is included, the failure of any power switching device (SCR, diode, IGBT, IGCT, etc.) in both the converter and inverter sections and/or switching device control circuitry shall not result in a process trip and shall allow for continued operation of the VFD system. In the event of a device or device control failure, the VFD shall annunciate and identify the specific location of the failed device and allow for continued operation until such time as repairs can be scheduled.

5.3.2 The power-electronic bypass feature shall meet the following requirements:

5.3.2.1 Only mechanical bypass is acceptable to improve bypass reliability. If electronic bypass is offered, independent communication between the bypass system and the drive control is required.

5.3.2.2 In case of a fault bypass shall engage within 250 milliseconds or less.

5.3.3 With a single power module in bypass system shall maintain as a minimum 83% of output voltage without extra modules, the VFD shall maintain the required speed. Output voltage shall be optimized when VFD is in bypass without inducing torque pulsations.

5.3.4 Extra rank of cells/modules/section shall be available as an option to provide 100% of current and voltage.

5.3.5 The feature shall be demonstrated and documented during the factory acceptance testing of the VFD system.

5.4 Power Interrupt Ride-Through

5.4.1 In case of medium voltage line loss**,** the user shall be able to select either 0.5 seconds ride-through with all cells functional or to maintain flux on the machine to reduce restart time depending on customer application. The VFD system must be capable of continuous operation in the event of a power loss of a minimum of 5 cycles with 1 or more cells not functional.

5.4.2 The VFD system must be capable of automatically restarting in the event of a momentary loss of power. The VFD system shall provide the user with the choice of automatically restarting or not. A safety device (hard key or password) must be available to allow enabling, disabling, and setting changes to this feature only by authorized personnel. The user shall be able to selectively apply this feature and have the ability to set the allowable restart time applicable to some (but not necessarily all) conditions as determined by the user to be appropriate for the specific application.

5.5 Power Sag Ride-Through

5.5.1 The VFD system shall be capable of maintaining continuous operation with a 35% voltage sag on the input power line. Such operation shall be maintained as long as medium voltage is absent (or below 65%). If enabled, the control shall monitor the motor flux (both magnitude and phase) as it decays based on the motor open-circuit time constant. If the drive is restarted and the motor flux is still above 4% of rated, the drive shall re-magnetize the motor and follow the speed ramp without any delay.

5.6 "Catch-A-Spinning-Load" Capability

5.6.1 The VFD system must be able to catch and take control of a spinning load if started while rotating equipment is already spinning in a forward direction. Appropriate safeguards must be included in this operation to prevent damaging torque(s), voltages, or currents from impacting any of the equipment. The user shall have the option of employing this feature or disabling it. This option shall be hardkey or password-protected to avoid unwanted changes by unauthorized personnel.

5.7 Auto-Restart Capability

5.7.1 The VFD system must be capable of automatically restarting in the event of a process or drive trip as long as input MV is present. The VFD system shall provide the user with the choice of automatically restarting or not. The user shall be able to selectively apply this feature to some (but not necessarily all) conditions as determined by the user to be appropriate for the specific application. This option shall be hardkey or password-protected to avoid unwanted changes by unauthorized personnel.

5.8 Ground Faults

5.8.1 In the event of an input or output ground fault, the VFD shall be capable of annunciating the ground fault condition, safely operating, and by user selection, either trip or continue operation.

5.8.2. The VFD shall be capable of detecting output ground fault of 10 mA to ensure personal safety. The manufacturer shall provide a valid type test to show that protection and detection works as described.

5.8.3. In order to prevent erroneous operation of the site's ground fault relay protection system, the VFD system shall not contribute more than 0.3 amp input ground fault when operating under normal operation.

6.0 SERVICEABILITY / MAINTAINABILITY

6.1 Front Access

6.1.1 VFD system should be designed for front access only. VFD manufacturer shall state in their proposal if rear or side access is required. An explanation of reason and specified distance for any required rear or side access shall be given.

6.2 Power Component Accessibility

6.2.1 All power electronic components in the converter sections shall be designed for rack-out accessibility for ease of maintenance and to minimize repair downtime. Alternate access options must be described in the proposal for purchaser's review and evaluation.

6.2.2 Those systems that employ a single integrated power conversion module that is not readily site-repairable or easily accessible by site maintenance personnel are not acceptable.

6.3 Voltage Isolation

6.3.1 All low voltage components, circuits, and wiring shall be separated with physical barriers from any sources of medium voltage and shall be compliant with IEC 61800-5-1.

6.4 Remote Diagnostics

6.4.1 The VFD system shall be provided with the capability for remote diagnostics via Ethernet link.

6.5 Marking/Labeling

6.5.1 Self-laminating vinyl labels or other acceptable means of permanent identification shall be applied to power and control wiring. Individual labels shall be provided for all major components of the VFD system. Labels shall match equipment drawings.

6.6 Mean Time To Repair (MTTR)

6.6.1 In the event of a power electronic failure, removal and replacement should take an average of 20 minutes, after capacitors have discharged and safe working conditions have been established.

7.0 PHYSICAL REQUIREMENTS

7.1 Environmental Requirements

7.1.1 VFD system shall be capable of continuous operation in an average ambient temperature between +5°C and 40°C at an elevation up to 3300 feet (1000 meters) above MSL without de-rating. The VFD system shall also be simultaneously suitable for continuous operation with the humidity between 0 and 95% non-condensing.

7.2 Heat Dissipation/Cooling System

7.2.1 VFD system shall be forced air-cooled and when required, shall be provided with fan redundancy and automatic switchover in the event of a fan failure for enhanced reliability. If a fan fails, the system must automatically switch to the alternate fan and generate an alarm to notify operator of initial fan system failure. During normal operation, the system must periodically cycle between the redundant fan systems to “exercise” them and prevent drying out of bearings, seals, etc., and to ensure availability of all systems. VFD system manufacturer shall provide heat dissipation data necessary to design all auxiliary HVAC systems.

7.3 Enclosure

7.3.1 All VFD system components, including transformer, shall be mounted and wired by the VFD system manufacturer in a grounded enclosure meeting the following requirements without exception:

7.3.1.1 Input filters, transformer, power conversion, and output filters shall be IP-21 design (or NEMA equivalent), or better degree of protection, with gasketed doors. Ventilated enclosure shall have cleanable filter media covering all air inlets. Inlet air filters shall be 100% washable with a corrosion-free media. Filters shall be front replaceable (for cleaning) while the VFD is in operation without exposing maintenance personnel to any of the power components. Cabinet color shall be ANSI 61 gray. Paint procedures and materials shall be manufacturer's system, designed and proven for resistance to chemical attack in industrial power-house environments.

7.3.1.2 Microprocessor and control logic boards and their power supplies shall be safely accessible without exposure to high voltages and without drive shutdown. All low voltage wiring shall be fully isolated from medium voltage compartments by metal barriers.

7.3.1.3 Cabinets and doors shall be fabricated using heavy gauge formed or structural steel for sturdy construction for dimensional integrity to assure long-term fit and function. All doors shall be gasketed to provide environmental protection and secure fits.

7.3.1.4 Enclosures must be designed to avoid harmonic and inductive heating effects.

7.4 Installation/Cabling

7.4.1 Owner will provide labor to set equipment in place. All VFD system wiring (power, control, and protection) shall be located internally within the VFD system enclosure. All external power conductors (bus or cable) shall be insulated. Power wiring shall be isolated by voltage class. Control and protection wiring shall be isolated from power wiring.

No more than two wires shall be terminated at any terminal point.

7.5 Space Limitations - Footprint

7.5.1 The VFD system must fit in the space indicated on project drawings.

7.6 Interlocks

7.6.1 Mechanical key interlocks shall be provided on all MV hinged doors. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including transformer, filters, or any switchgear that is part of the supply, when line power is applied to the VFD system. Interlocks must be mechanical to provide positive lock-out prevention and safety.

7.6.2 If requested, electrical interlocks should be provided in addition to mechanical key interlocks, as added safety measure to prevent access to energized sections in the VFD.

7.7 Auxiliary Power

7.7.1 To power the VFD cooling system and control circuits, a 3-phase low-voltage auxiliary power will be provided by the customer. Means for isolation shall be provided to allow for isolation of this power supply source as needed. This auxiliary power voltage shall be determined by the customer and must be indicated at time of order.

7.8 Control Power

7.8.1 All VFD internal control circuits shall be 110/240 VAC single phase unless otherwise specified. VFD manufacturer shall provide provision for deriving control power from auxiliary power.

8.0 PROTECTIVE DEVICES / DIAGNOSTICS

8.1 Drive Short Circuit Protection

8.1.1 The VFD with an integral transformer that has 9 secondaries and above shall have built-in short-circuit detection and protection. Software shall include protective functions which detect abnormal conditions due to an internal power circuit sub-component failure(s). And as such, VFD will fault if abnormal conditions are present. Protective functions shall include:

8.1.1.1 Excessive Input Reactive Current Detection (One Cycle Protection)

8.1.1.2 Excessive Drive Losses Protection

8.1.2 The manufacturer shall provide a valid type test to show that protection and detection works as described.

8.1.3 An upstream protecton device is required

8.2 Power Component Protection

8.2.1 VFD system shall include distribution class surge arrestors to protect the converter and its input transformer against voltage surges.

8.2.2 The VFD system shall include power fuses on the input to the converter devices to protect the secondary of the transformer from any potentially harmful fault currents.

8.3 Protective Features and Circuits

8.3.1 The controller shall include the following alarms and protective features:

8.3.1.1 Static instantaneous over-current and over-voltage trip

8.3.1.2 Under-voltage and power loss protection

8.3.1.3 Over-temperature protection

8.3.1.4 Electronic motor inverse time overload protection

8.3.1.5 Responsive action to motor winding temperature detectors or thermostatic switches, a dry contact (NC) input to the VFD is required motor protection relay is by the customer.

8.3.1.6 When power is restored after a complete power outage, the VFD shall be capable - if this function has been enabled - of catching the motor while it is still spinning in a

forward direction and restoring it to proper operating speed without the use of an encoder

8.3.2 The VFD system shall be protected from damage due to the following, without requiring an output contactor:

8.3.2.1 Single-phase fault or 3-phase short circuit on VFD system output terminals

8.3.2.2 Power device failure to commutate/switch due to severe overload or other conditions

8.3.2.3 Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation

8.3.2.4 Loss of one phase of input power

8.3.2.5 Induction motor regeneration due to backspin or loss of VFD input power

8.3.3 The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:

8.3.3.1 Failure to connect a motor to the VFD output

8.3.3.2 VFD output open circuit that may occur during operation

8.3.3.3 VFD input or output ground fault

8.3.3.4 VFD input or output single-phase

8.3.4 The VFD shall be provided with integrated control provisions to operate or trip an incoming power disconnect device.

8.4 Data Displays

8.4.1 A door-mounted LCD display shall be furnished, capable of displaying the VFD operational status and drive parameters. The digital display must present all diagnostic message and parameter values in plain language/engineering units when accessed, without the use of codes. English is the default language unless noted otherwise.

8.4.2 As a minimum, the following door mounted digital indications with a resolution of at least ±0.01% and an accuracy of 1%, shall be supplied:

8.4.2.1 Speed demand in percent

8.4.2.2 Input current in amperes

8.4.2.3 Output current in amperes

8.4.2.4 Output frequency in Hertz

8.4.2.5 Input voltage

8.4.2.6 Output voltage

8.4.2.7 Total 3-phase kW output

8.4.2.8 Kilowatt hour meter

8.4.2.9 Elapsed time running meter

Note: A minimum of four indications must be displayed simultaneously and display indications must be available at the indication panel.

8.5 Diagnostics and Fault Recording

8.5.1 The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors.

8.5.2 Fault log data storage memory shall be stored in non-volatile memory or be supported by a UPS sized to provide a minimum of 48 hour data retention

8.5.3 The VFD shall include a comprehensive microprocessor-based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

8.5.4 A “FAULT LOG” shall record, store, display, and print upon demand, the following for the 256 most recent events:

8.5.4.1 VFD mode (Auto/Manual)

8.5.4.2 Date and time of day

8.5.4.3 Type of fault

8.5.4.4 Reset mode (Auto/Manual)

8.5.5 A “HISTORIC LOG” shall record, store, display, and print upon demand, the following control variables at an adjustable time interval for the 50 intervals immediately preceding a fault trip and 100 intervals following such trip:

The historic log records operating data of the drive and is frozen upon detection of a fault. A new fault will overwrite the recorded historic log. The event log includes the option to copy and record the historic log so that all fault events are recorded. The historic log is stored in memory with a total of 512 records. Non-volatile memory is used to store the most recent 78 records. Snapshots are recorded at the slow cycle update rate:

- Most snapshots are recorded before a fault occurs.
- 20 snapshots are recorded after a fault occurs.

8.5.5.1 VFD mode (manual/auto/inhibited/tripped/etc.)

8.5.5.2 Speed demand

8.5.5.3 VFD output frequency

8.5.5.4 Demand (output) amps

8.5.5.5 Feedback (motor) amps

8.5.5.6 VFD output volts

8.5.5.7 Type of fault

8.5.5.8 Drive inhibit (On/Off)

8.5.5.9 The fault log record shall be accessible via an Ethernet port, as well as, line by line on the keypad display

8.5.6 With the VFD, a Windows®-based graphical tool suite shall be provided at no additional charge to customer. This graphical PC tool shall be able to plot and display up to 8 different VFD parameters and have the ability to freeze plotting and print hard-copy versions of the plots. Capability to display at least 8 different VFD system parameters is required, and all parameters displayed on the PC tool shall be synchronized with the standard keypad display.

9.0 PROGRAMMING AND COMMUNICATIONS

9.1 User Input/Keypad

9.1.1 The door of each power unit shall include manual speed device, a mode selector marked "Manual/Automatic", a "POWER ON" light, a VFD "FAULT" light, a VFD "RUNNING" light, start pushbutton, stop pushbutton, and reset pushbutton.

9.1.2 A door-mounted keypad with integral digital LCD display shall be furnished, capable of controlling the VFD and setting drive parameters. The display must present all diagnostic message and parameter values in standard engineering units when accessed, without the use of codes. The keypad shall allow the operator to enter exact numerical settings in standard engineering units. A plain language (English or other language, as noted on the data sheet) user menu (rather than codes) shall be provided in software as a guide to parameter setting. This device shall be fully compliant with applicable Norms related to enclosures.

9.1.3 Drive parameters shall be factory set in non-volatile EEPROM registers and re-settable in the field through the keypad. A minimum of 6 levels of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred for programming of new or spare boards.

9.1.4 The VFD system shall have the user selectable option of programming up to 3 speed avoidance bands. This gives the user the ability to block out and prevent operation at any undesirable speed, such as one that may be coincident with a mechanical resonance condition. The loss of the keypad or display shall be annunciated as a fault but shall not result in a VFD trip.

9.2 Serial Communication/Protocols/Modem or Cable

9.2.1 VFD shall be capable of digital communication for setup of parameters, fault diagnostics, trending, and diagnostic log downloading. An Ethernet port shall be door-mounted.

9.2.2 The drive shall support duplicate communications channels without the use of protocol bridges. In case of failure, the use of bridges increases maintenance complexity as local expertise is required to reprogram the bridge.

9.2.3 The VFD shall be provided with digital communication capability to allow direct control and status communication with a PLC, SCADA, or other control system. Provisions for a redundant channel shall be provided as an option. The control system must be able to communicate with various protocols as determined by the customer.

10.0 COMPONENT REQUIREMENTS

10.1 Printed Circuit Boards

10.1.1 All printed circuit boards in the VFD power circuit shall be new. They shall be conformal coated for moisture and chemical resistance, in addition to any dielectric coating properties. All control boards must be tested in accordance with Section 11.1.1.

10.2 Power Bus and Wiring

10.2.1 Main power bus shall be high-conductivity and plated for chemical and corrosion resistance and low losses. Bus shall be appropriately sized for the VFD continuous current rating and braced to withstand the mechanical forces caused by a momentary short circuit current. All connections shall be bolted or continuously welded. Main grounding of the VFD system shall have a common loop consisting of copper cable placed in the enclosure base. This cable will ground the base and will be attached to stainless steel grounding pads welded to the base on two locations, one at each end of the enclosure.

10.2.2 All control wiring shall be physically separated from the power wiring. Low and high voltage cables shall be physically isolated from each other. The VFD system shall be pre-wired within the enclosure. Spade type connectors are not acceptable. No soldering shall be used in connection with any wiring. Wiring shall be adequately supported to avoid tension on conductors and terminations. All wiring shall be run in surface mounted conduit or wire-ways. Any section of wiring outside of conduit or wire-way shall be securely tied with cable ties at intervals not exceeding 6 inches. No cables shall be tied off to or in any way supported from power busses. Wherever wiring passes metal edges or through holes, suitable guards, grommets, or chamfers shall be provided to prevent cutting or chafing of the insulation.

10.2.3 All wiring shall be tagged with permanent labels at each termination, junction box, and device. Labels shall correspond to the schematic and wiring diagrams.

10.2.4 Standard corrosion resistant bus pads with NEMA hole patterns are provided for input/output customer connections.

10.3 Ground Connection

10.3.1 Corrosion resistant, stainless steel ground pads shall be provided in each power cabinet.

10.4 Input Isolation Transformer

10.4.1 The VFD system must be supplied with a drive isolation transformer to provide common mode voltage protection and phase shifting (for 18 pulse or higher converter bridge, if employed to meet the power quality requirements of Section 3.2). VFD systems utilizing input AC line reactors which require motors equipped with special higher voltage rated insulation systems are not acceptable and will not be allowed as an alternate bid.

10.4.2 Transformer design to be a rectifier grade isolation type with a K-Factor of 12 for variable torque loads or a K-Factor of 20 for constant torque loads when applied to a SCR converter, in accordance with current EPRI recommendations and ANSI/IEEE Standard C57.110. A K-Factor of 6 is required for diode rectifier converters. Transformers shall have a BIL rating in accordance with the requirements of ANSI/IEEE Standard C57.12.01-2005, C57.110-1998, and IEC 60076-11.

10.4.3 Isolation transformers shall be air-cooled dry type construction, insulation Class H (220°C insulation, 130°C rise), with over-temperature protection.

10.4.4 The requirements listed in this section shall be considered in conjunction with Section 3.4, VFD System Efficiency.

10.5 DC Link Inductors

10.5.1 DC link inductors, if required, shall be air core to prevent saturation. Separate inductors (split dual winding type) shall be provided in the positive and negative leg of the DC link to minimize stray magnetic fields. Inductors shall be Class H insulation (220°C insulation, 150°C rise) with over-temperature protection. To minimize cabling costs, the inductors shall be integral to the VFD system lineup. If it is not possible to integrate the inductors into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system supplier, and approved by the customer's engineer. Inductors shall be designed to prevent saturation under maximum fault current conditions.

10.5.2 The requirements listed in this section shall be considered in conjunction with Section 3.4, VFD System Efficiency.

10.6 DC Link Capacitors

10.6.1 Capacitors used in the converter DC link shall be integral to the VFD system lineup to minimize cabling costs.

10.6.2 Capacitors used in the converter DC link shall contain discharge resistors and capable of reducing the residual charge to 50 volts or less within 10 minutes after the capacitor is disconnected from the source of supply.

10.7 Input Harmonic Filters

10.7.1 If, after meeting Section 3.2 above, harmonic filters are still required to meet power factor requirements, stricter local requirements, or telephone interference factor restrictions, the VFD manufacturer must provide the filter, upstream filter isolation, protection, and protection coordination. As harmonic filters are power system dependent, the VFD supplier is responsible for maintaining and providing any required upgrades required for the first 10 years of operation at zero cost to the owner. To minimize cabling costs, the harmonic filter components shall be integral to the VFD system lineup, but isolated from other components, such that they can be disconnected from the power source and accessed for maintenance/repair while the VFD is in operation. If it is not possible to integrate the filters into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system supplier, and approved by the customer's engineer. Harmonic filters must be located on the primary side of the input isolation transformer and must be switchable with the VFD, to prevent their remaining on the power line in the event of a VFD trip which could create a damaging leading power factor condition. The complete filter must have independent protection for over-current, phase differential, and ground fault.

10.7.2 Capacitors used in any harmonic filter banks shall be provided with a method of shorting the phases to ground once power has been removed and the capacitors have been discharged to a safe voltage level. Where oil-filled capacitors are required and the total volume of oil exceeds 500 gallons or 2000 liters, the oil sump and containment provisions shall be supplied as part of the VFD system.

10.7.3 Any reactors used shall be iron-core with Class H (220°C insulation, 130°C rise) insulation and over-temperature protection. Reactors shall be designed to prevent saturation under maximum fault current conditions.

10.7.4 The requirements listed in this section shall be considered in conjunction with Section 3.4, VFD System Efficiency.

10.8 Output Filters

10.8.1 If an output filter is required to meet the output harmonics requirements of this specification or to meet any special requirements of the application, they must be fully incorporated into the VFD system design and added to overall VFD line-up. Cabling and connection of filter to VFD must be supplied and performed or contracted by the VFD system supplier and approved by the customer's engineer.

10.8.2 Where potential exists for self-excitation between the output filter and the motor system, a fully (voltage and current) rated output contactor shall be provided by the VFD supplier as part of the VFD system delivery.

10.8.3 Any reactors used shall be iron-core with Class H (220°C insulation, 130°C rise) insulation and over-temperature protection. Reactors shall be designed to prevent saturation under maximum fault current conditions.

10.8.4 The requirements listed in this section shall be considered in conjunction with Section 3.4, VFD System Efficiency.

10.9 Input / Output Power Terminations

10.9.1 Input and output power connections shall be made to isolated, supported, and plated bus strap connections. Sufficient space shall be provided for termination connections from the top or the bottom of the VFD cabinet. Space provisions shall be provided for application of standard stress cones, and provisions shall be provided for grounding of shielded cabling

11.0 TESTING

11.1 Subassembly Tests

11.1.1 Printed circuit boards shall be visually inspected and functionally tested. Boards must be tested individually prior to assembly to minimize any impact faulty boards may have on delivery schedules and system reliability. Boards shall be load and temperature cycled from no load to full load and from ambient to +60°C during a 48-hour burn-in test. Any board that changes function outside of design parameters shall be replaced with a properly functioning board.

11.1.2 Power module subassemblies shall be visually inspected and then HIPOT tested. Complete diagnostics and logic shall be tested. Each complete power conversion module shall be thoroughly tested at 100% load for a minimum of 15 minutes and then tested for 1 minute at momentary overload rating, to reduce potential problems in advance of final system testing.

11.2 System Level Tests

11.2.1 The system (as defined in Section **Error! Reference source not found.**) shall be given preliminary checks for verification of electrical connections, including ground connections and power and control wiring, and resistance checked point-to-point. E-prom and EE-prom shall be checked for correct revision level. Visual check shall be performed to verify degree of protection for cabinets, input isolation is lockable in the off-position, marking of terminals and wiring, space availability for cable termination, accessibility of components, and ease of maintenance and repair. The VFD system shall be fully checked against the approved drawings for compliance and correct physical dimensions.

11.2.2 Power circuit and all control circuits shall be HIPOT tested to ground.

11.2.3 All control voltage levels are to be checked and verified against stated acceptable levels.

11.2.4 A no load test is to be performed on the system. Drive is to be connected to an unloaded motor and feedback signals shall be verified. Output voltage shall be calibrated. All logic and interlocks, including customer logic and instrumentation, shall be tested.

11.2.5 Drive shall be given a full power test at rated current and rated voltage (simultaneously) for a minimum of 2 hours on a dynamometer or reactor load. This test shall be performed as an integrated system including all supplied input switchgear (if supplied), input transformer, input filter (if supplied), power section, and output filter (if supplied).

11.2.6 The VFD manufacturer shall offer an option for additional system level testing to measure the total system efficiency, power factor, and harmonic distortion, to ensure customer specified limits are met. Total system efficiency shall be measured on both the input and the output of the VFD system. System shall not be shipped unless specified performance criteria are met. Certified test data of all tests conducted shall be provided with final documentation.

11.2.7 The VFD manufacturer shall offer an option for testing to be witnessed by customer's representative(s). A projected test schedule and a copy of proposed test procedures shall be provided at least 1 month in advance of test date. Customer shall be given at least 1 week notice or confirmation of actual test date(s).

12.0 DOCUMENTATION

12.1 With Proposal

Proposal information shall include, but not be limited to:

12.1.1 Preliminary spare parts list

12.1.2 Certification of compliance with this specification

12.1.3 Warranty

12.1.4 Preliminary dimensions and weights

12.1.5 VFD system continuous current and voltage rating

12.1.6 VFD system one minute current rating

12.1.7 Efficiency and power factor at 100%, 75%, 50%, and 25% load

12.1.8 Input current at 100%, 75%, 50%, and 25% load

12.1.9 Current and voltage harmonic distortion calculation with the point of common coupling located at the input connection of each VFD

12.1.10 External interconnection one-line wiring diagram showing all power, control, and protection cabling required to complete the VFD system on-site

12.2 After Order Submittals

12.2.1 Submittals shall be custom prepared by the VFD system manufacturer for this specific application.

12.2.2 Submittal information shall include, but not be limited to:

12.2.2.1 General arrangement drawings

12.2.2.2 Overall outline dimensions and Maintenance Clearances

12.2.2.3 Weights and Lifting Drawings

12.2.2.4 VFD System Description & Customer Information (Including Input / Output Voltages, Current, Heat Loss, Control Voltages)

12.2.2.5 Anchor Bolt Details

12.2.2.6 Terminal Block Location and Connections

12.2.2.7 Input / Output Power Locations

12.2.2.8 Conduit Entrance Space and Locations

12.2.2.9 Three-Line diagrams

12.2.2.10 Electrical schematics and wiring diagrams

12.2.2.11 Cooling system drawings

12.2.2.12 Mechanical Interlock Scheme

12.2.2.13 Cable and piping locations

12.2.2.14 Location of ground pads

12.2.2.15 Grounding and Shielding requirements

12.2.2.16 Project schedule

12.2.2.17 Final O&M manuals

12.3 Final Documentation

12.3.1 Start-up and commissioning instructions and data

12.3.2 Certified as-built drawings of all equipment with information listed above

12.3.3 Operation and maintenance manual

12.3.4 Manufacturer’s service and repair support during and after warranty

12.3.5 Spare parts lists

13.0 DELIVERY

13.1 VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable. Cabling for connection across shipping splits shall be neatly coiled and identified. Exposed sections of equipment shall be fully protected from damage during shipment. All necessary hardware for reconnecting shipping splits shall be provided.

13.2 Setting equipment in place, aligning, and anchoring will be done by others. The VFD system manufacturer shall be responsible for all system interconnections across shipping splits at the site.

13.3 Complete instructions for handling and storage shall be provided prior to delivery of the equipment.

14.0 WARRANTY

14.1 All equipment furnished under this section shall be warranted by the contractor and the equipment manufacturer(s) for a minimum period of 24 months after shipment. Warranty shall include all parts, labor, and expenses to perform necessary work.

15.0 TRAINING

15.1 If required, the VFD system supplier shall offer a factory training school for customer's operations, maintenance, and service personnel. The training school shall include classroom discussion on the theory of operation of the equipment, as well as, maintenance and service methods for the purchased equipment. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, software mapping, programming, setup, configuration, control loop tuning, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance. Hands-on training shall be provided on equipment of the same design as that provided. Documentation shall be provided, which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

16.0 START-UP

16.1 VFD system manufacturer shall provide the field services of a technician, as necessary, to supervise/inspect installation, test, and start-up all equipment provided as part of the fixed price proposal. The firm price shall include all travel and living expenses, in addition to, the engineer's time required to complete supervision of the installation, testing, and start-up. All equipment required for testing, start-up, and performance verification shall be provided by the start-up technician.

16.2 Verification of VFD input harmonic voltage and current distortion limits specified must be verified at rated speed and rated power as part of final startup and acceptance. A recording type Fluke, Multilin PQM, BMI, or equivalent harmonic analyzer displaying individual and total harmonic currents and voltages must be utilized.

17.0 SPARE PARTS

17.1 The following spare parts shall be furnished and replaced only by appropriate qualified personnel:

17.1.1 One field replaceable phase module (including but not limited to rectifier, inverter, and DC link power and control components)

17.1.2 One phase module input fuse

17.1.3 One of each control circuit board, including all diagnostic system printed circuit boards

17.1.4 One keypad and keypad adapter

17.1.5 One controller power supply

17.1.6 Door filters

17.2 In addition to the spare parts listed in 17.1, the following spare parts shall be furnished and replaced only by appropriate qualified personnel, if power module bypass feature is included:

17.2.1 One phase module bypass contactor assembly

17.2.2 One bypass power supply and power supply fuse

17.2.3 One bypass controller board

17.3 Those systems that do not allow for individual repair or replacement of parts at the site will not be accepted.

17.4 All parts supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair. Manufacturer shall state closest point where spare parts are stocked and where service can be obtained. Minimum response time for trouble calls shall be 2 hours. A qualified service technician shall be on site within 24 hours of a qualified request. Manufacturer shall warrant that all parts shall be available for a minimum of 10 years.

**********END OF SECTION**********

SECTION 17100
CATHODIC PROTECTION SYSTEM

1. GENERAL

1.1. WORK INCLUDED

This Specification covers the requirements for the design, supply, installation, testing and commissioning of the Cathodic Protection System (CPS).

1.2. DESCRIPTION

1.2.1. MAIN CHARACTERISTICS

The Cathodic Protection System (CPS) shall be of the impressed current type.

All activities regarding the CPS will be carried out by a specialized Sub-Contractor. The relevant certifications and references of the proposed Sub-Contractor shall be submitted to the Employer at the time of bidding for the Contract.

1.2.2. CODES AND STANDARDS

The design, manufacturing, installation, testing and commissioning of CPS shall be in accordance with the following codes and standards or equivalent standards submitted to the Engineer's approval. The latest revision of the publication referred to shall apply.

EN 12954 Cathodic protection of buried or immersed metallic structures – General principles and application for pipelines.

EN 13509 Cathodic protection measurement techniques

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60989 Separating transformers, autotransformers, variable transformers and reactors

IEC 61558 Safety of transformers, reactors, power supply units

SP0 169 Control of external corrosion on underground or submerged metallic piping systems (National Association of Corrosion Engineers – NACE)

1.3. DESIGN REQUIREMENTS

All components of the CPS shall be designed and constructed for continuous operation at full load under the climatic and environmental conditions in the region of Mombasa.

The Contractor shall carry out a complete survey along the proposed pipeline route to identify special points, foreign lines, crossings, HV installations and other existing particularities, which may have an impact on the design of the CPS. A further purpose will be the pre-selection of possible rectifier locations.

The impressed current CPS shall be designed to provide sufficient current to achieve an “OFF” potential over the pipeline to be protected, equal to or more negative than – 1 V (measured against a Cu/CuSO4 reference electrode). “OFF” potentials with a value more negative than – 1.5 V shall be avoided.

The CPS shall be designed for a current density (mA/m2) based on soil data and site conditions derived from the survey and the expected characteristics of the pipeline coating.

The service life time of the CPS shall not be less than fifty (50) years. For anode groundbeds a life time of twenty five (25) years will be accepted.

2. PRODUCTS (COMPONENTS AND SUB-ASSEMBLIES) & EXECUTION

2.1.1. RECTIFIERS

400 V or 230 V AC power will be available at the Project Facilities. They will be the preferred source of power supply to the CPS rectifiers. The Contractor may also consider the use of a solar-powered photo voltaic system with battery back-up.

The locations and characteristics of the rectifiers will be selected by the Contractor in accordance with the calculations of the detail design established further to the above mentioned survey.

The transformer rectifiers shall be naturally oil cooled units complete with sunshades and rated to deliver maximum power output continuously at their maximum power rating. Output shall be controlled manually and facilities for monitoring output current and voltage shall be provided.

2.1.2. ANODES

The anode type and the number, dimensions and weights of anodes per groundbed shall be selected by the Contractor in accordance with the calculations of the detail design established further to the above mentioned survey.

The anode groundbeds shall be of the high silicon-iron type or equivalent, installed in a horizontal trench at approximately 2m depth. The anodes shall be completely surrounded by a high conductivity granular carbonaceous coke backfill to minimize groundbed resistance.

2.1.3. TEST STATIONS

Test stations shall be installed at all particular points where defaults of the CPS may occur (such as CPS current drain points, pipeline end points, other ferreous pipeline crossing, HV line crossing, etc.).

The test stations shall be of a conventional design consisting of a lockable terminal box on top of a vertical galvanized iron pipe with a concrete foundation and an ID plate.

2.1.4. CABLES

All cables shall be one to five core cables with stranded copper conductors and HMWPE insulation. For feeder cables of transformer/rectifiers, cables with solid copper conductor may be used.

The cables outside of buildings shall be buried directly in ground. If cable routes are running outside of the right of way or outside of fenced stations, the cables shall be covered with concrete plates (W x H: 30 x 3 cm). The concrete plates shall be placed 10 cm above the cable layer. Inside of buildings, shafts, etc. the cables will be laid in pipes or on cable racks.

2.1.5. FACTORY TESTS

All components of the CPS shall be tested before shipment.

All tests required by the codes and standards shall be performed. The rectifiers and other pre-assembled equipment shall be completely tested. For devices such as anodes, surge arrestors, cables, heads of test posts, etc. a type test shall be performed.

The test program for transformer/rectifiers and other pre-assembled equipment must be submitted in advance in accordance with the Project Procedure Manual.

Detailed test reports have to be submitted prior to shipment.

2.1.6. COMMISSIONING

During commissioning the following measurements/verifications shall be carried out (minimum requirements):

- current, voltage and potential of rectifiers,
- calibration of all current test stations
- resistance of isolation couplings,
- ON/OFF potential at all test stations,
- high voltage influence if any HV line,
- resistances between pipeline and steel casing (if any),
- current distribution along the current test stations,
- interference between the Pipeline equipped with CPS and other pipelines,
- polarisation potential at test coupons,

2.1.7. SPARE PARTS AND TOOLS

The Contractor shall deliver all spare parts which are necessary for commissioning and for five years of operation (excludes the two year operation period).

Spare parts shall be available until ten years after commissioning.

All necessary special tools for operation and maintenance of the CPS shall be supplied, at least consisting of:

- two (2) sets of all special tools required for operation and maintenance
- two (2) sets of fuses (one set = 12 fuses of each used size),
- two (2) sets of keys for cabinet doors and locks,
- three (3) complete sets of measuring instruments and portable reference electrodes (gel filled) for the operation staff to carry out all the routine measurements on the CPS

2.1.8. MAINTENANCE DURING THE LIABILITY PERIOD AND TRAINING

During the Liability Period the Contractor shall periodically assist the Client's staff in verification of the performance of the CPS, identification of defaults if any and maintenance as required.

These activities will be the occasion to implement on-the-job training of Client's staff.

Upon completion and testing of the CPS, the Contractor shall submit a detailed Assistance and Training Program During the Liability Period.

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Republic of Kenya

Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.6 – SPECIFICATIONS FOR ENVIRONMENTAL, SOCIAL, HEALTH AND SAFETY (ESHS) MANAGEMENT OF THE WORKS

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1. ESSENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS AND MITIGATION

The Mwache Dam Project is being implemented by The Ministry of Water and Sanitation and Irrigation (MWS&I) through the Kenya Water Security and Climate Resilience Project (KWSCRP). In 2016, KWSCRP commissioned an Environmental and Social Impact Assessment (ESIA). The assessment main focus was on environment and social impacts associated with the Dam and the Lower Check dam. Further an Environment License NEMA/EIA/PSL/5204 on 18th September 2018 was issued by the National Environment Management Authority (NEMA).

The proposed site for the WTP and associated components are within the land acquired for the Dam proponent. CWWDA and MWS&I requested NEMA to include the WTP and associated components in license and an addendum to the NEMA license was issued on 09th December 2022. The Contractor must abide by the terms and conditions of issuance of the NEMA license. The Contractor may be required to carry out additional Enviornmental and Social Impact Assessment studies as per AFD, World Bank and NEMA guidelines for specific work components / sites including camps and borrow areas. The cost of compliance, including payments demanded by authorities, in regard to this shall be deemed to be covered in the Contractor's financial proposal.

The Employer is committed to the construction of the Project in a manner that results in the least impact on the natural and social environment. The Contractor will pursue a policy of incorporating and integrating environmental considerations into his operations for the project and different types of mitigation measures to be adopted by operator before construction/at construction/operations phase as per the Environmental and Social Management Plan (ESMP).

The Contractor shall plan and adopt his work methods and equipment in such a way that the construction activities shall have the least possible social and environmental impacts. This will include management of air quality, water quality, groundwater, noise and vibration protection of flora and fauna, labour management, labour influx management and Gender Based Violence protection and response. The Contractor will undertake his operations and monitor them in accordance with the requirements of the Environmental Management and Monitoring Plan or other instructions issued by the Employer or Engineer.

Following the award of the Contract and prior to construction commencing the Contractor will review the ESMP (provided in ESIA Addendum No.1 Report) and develop this into a detailed Site Specific Environmental and social Management Plan/Worksite ESMP which will be accompanied by the following sub plans: Site specific waste management plan, Site specific dust management plan, Site specific surface water management plan, Site specific excavated material management plan, Site Specific Soil Erosion and Sedimentation Control Plan, Labour Management Plan, Site specific biodiversity management plan, Site specific traffic management plan, Site specific health and safety management plan, Community health and safety plan including mitigating measures, adoption of which is mandatory for the Contractor (contents of worksite ESMP is provided as appendix 1) that amplifies the conditions established in the ESIA and EMP that are specific for the site and the tasks involved. The Site specific ESMP together with sub plans listed above will be submitted to the Employer for approval at least 28 days before taking possession of any work site. No access to the site will be allowed until the S-ESMP is approved by the Employer / Engineer.

The Contractor will appoint Environmental, Social, Health and Safety Manager / Expert who will be the primary point of contact for all matters relating to environmental and social management. The ESHS Manager / Expert will have two independent officers i.e Environmental and Social Officer (1Nr.) and Health and Safety Officer (1Nr.). The ESHS Manager and Officers will have the authority to instruct any area of the Contractors' operations to implement the requirements of the ESMP and any instructions from the Employer / Engineer.

The Contractor's ESHS Manager and Officers are required to have qualifications in Environmental, Occupational Health and Safety and social Sciences or similar discipline and be able to complete the preparation of the site specific (worksite) environmental and Social management plans.

The Contractor will ensure that all personnel employed by or contracted to him are given induction training in environmental, Health and Safety and social issues and the requirements for environmental and social management. The Contractor will keep records of attendance of all trainings.

2. ESHS REQUIREMENTS

2.1. RESPONSIBILITY OF THE CONTRACTOR

Key responsibilities of the Contractor (through the ESMP) are as follows:

- Preparing the site specific environmental and social management plan (S-ESMP) for approval by the Employer / Engineer prior to the Contractors taking possession of the construction site (see below)
- Ensuring the S-ESMP is implemented effectively throughout the mobilisation, construction and operation service period.
- Preparing, getting approval and implementing the following plans:
    - Site specific waste management plan;
    - Site specific dust management plan;
    - Site specific surface water management plan;
    - Site specific excavated material management plan;
    - Site specific biodiversity management plan;
    - Site specific traffic management plan;
    - Site specific health and safety management plan including and not limited to construction safety, working at heights, scaffold safety, use and maintenance of PPE, chemical/hazardous materials management, water safety, electrical safety, manual handling etc.
    - Community health and safety plan
    - Labour Management Plan, including Labour Influx Management Monthly Tracking Template.
    - Soil Erosion and Sedimentation Plan
- Administer the GBV prevention and response Code of Conduct to all direct and indirect labour employed by the Contractor.
- The Contractor must abide by the OSHA 2007 and all its subsidiary legislations including all provisions of the Kenya laws.
- Obtain all statutory legals requirements for the worksite provided under ESIA license conditions for the Mwache Dam project and all site specific ESIA license conditions for the auxillary facilities. This includes all statutory requirements under EMCA (waste management, Environmental audits, water quality, air quality, noise and vibration, OSHA 2007 and its subsidiary legislations, Public Health Act, Energy Act, WIBA, Kwale County Bylaws).
- The Contractor shall always maintain an up to date legal register containing all the required license, permits and approvals.
- Establishing and maintaining site records of:
    - weekly site inspections using checklists based on S-ESMP, environmental accidents/incidents including resolution activities
    - environmental, social, health and safety monitoring data,
    - non-compliance notifications issued by the Health and Safety Team
- Maintain Corrective action plans in response to identified non compliance notices/environmental and social violations and non-conformances.
- Undertake community relations activities including maintaining GRM register for all the received grievances.
- Prepare monitoring reports on compliance with S-ESMP.

2.2. ESSENTIAL ESHS ISSUES OF WORKSITE MANAGEMENT

The ESHS topics identified during the Environmental and Social Impact Assessment study of the project, which present a major risk for the worksites management are:

a) ESHS resources and facilities and ESHS monitoring organization
b) Project Areas management (base camps, quarries, borrow pits, storage areas)
c) Health & Safety on worksites
d) Local recruitment and ESHS trainings of local staff (capacity building), ESHS trainings of subcontractors and local partners (transfer of knowledge)
e) Relations with stakeholders, information and consultation of local communities and authorities
f) Traffic management
g) Hazardous products
h) Wastewater (effluents)
i) Protection of water resources
j) Atmospheric emissions, noise and vibrations
k) Waste management
l) Biodiversity: protection of fauna and flora
m) Site rehabilitation and revegetation
n) Erosion and sedimentation
o) Control of infectious and communicable diseases (HIV/AIDS, malaria, etc.)
p) Risk of Gender Based Violence
q) Labour Influx
r) Labour and working conditions
s) Workers Transport Management including fleet management

2.3. PROJECT SPECIFIC ESHS REQUIREMENTS

The ESHS norms, standards and discharge limit values recommended by the specialised international organisations affiliated to the United Nations shall apply to the Contract:

No

Only the country's regulations are applicable.

The following Clauses/articles of the ESHS Specifications are modified as follows:

Clause / Article	Modifications
2 – ESHS Planning Document	**Sub-clause 2.1.8** is modified as follows: "During the execution of Works, each time there is a change in works method statement, a dangerous occurrence/serious near miss or incident indicating incomplete or inexhaustive ESMP to manage the hazard, or as otherwise maybe instructed by the Engineer, the Worksite – ESMP will be updated by the Contractor and reissued to the Engineer. The revised version shall highlight the new elements incoprorated in the document."
4 – Resources allocated to environmental management	**Sub-clause 4.1.1** is ammended as follows: "The Contractor will appoint Environmental, Social, Health and Safety Manager / Expert who will be the primary point of contact for all matters relating to environmental and social management. The ESHS Manager / Expert will have two independent officers i.e Environmental and Social Officer (1Nr.) and Health and Safety Officer (1Nr.). The ESHS Manager and Officers will have the authority to instruct any area of the Contractors' operations to implement the requirements of the ESMP and any instructions from the Employer / Engineer."
6 - Reporting	**Sub-clause 6.3.7**, **item (g)** is modified to include Tool Box Talks (TBTs), other ESHS Trainings conducted, Risk Assessments (RAs) conducted and Safety Management Systems (SMS) execiuted, inspection undertaken etc.
7 – Rules of procedure	**Sub-clause 7.1** is ammended to include health rules such as handwashing, sanitary hygiene, food safety etc.
	Sub-clause 7.5 is modified to include: e) Wilful disregard, bypass or damage of provisions of the ESHS.
9 – Standards	**Sub-Clause 9.1** remains applicable : The Contractor shall be required to comply with applicable norms, standards, and discharge limit values according to the Kenyan regulations. **Sub-clauses 9.2** and **9.3** are not applicable.
10 – Protection of adjacent areas	**Sub-clause 10.2** is not applicable. Wetland areas are not within the Project site.
11 – Selection of borrow areas, backfill material stockpile sites and access road	**Sub-clause 11.1** is modified to include: (iii) how access to these areas will be restricted to prevent inadvertent access.
12 – Effluents	**Sub-clause 12.4** is modified to include: "Any effluent discharged to the enviornment must comply with NEMA gudielines".

Clause / Article	Modifications
15 – Waste	**Sub-clause 15.2** is not applicable. **Sub-clause 15.3** is modified to include…"In addition to the waste register, the Contractor shall maintain ID of manifest documents which are proof of the handover of the waste to the NEMA licensed waste handler."
	Subclause 15.11 - the following is not applicable "Documented prior audit of the waste treatment service providers by the contractor." **Sub-clause 15.11** is modified to include…. "The waste treatment service providers should hold relevant permits/licences as prescribed by NEMA , for the operations they offer to the Contractor. Third party servicies should be provided based on the service contracts."
	Sub-clause 15.13.2 is modified as follows…"Non-hazardous waste should be disposed to the official landfills and holding relevant permit for waste disposal from the NEMA. The service for waste disposal should be officially documented. If contractor wishes to arrange the landfill by himself, contractor has to follow the procedures defined by Environmental Assessment Code of Kenya and Waste Management Code of Kenya. All information on waste management should be reflected into the Waste Management Plan that Contractor has to prepare and submit for approval."
30 – Health care centre and medical personnel	**Clause 30** is modified as follows… "The Contractor will be required to obtain an agreement with a nearby hospital to evacuate and treat staff in case of an accident."
32 – Emergency medical evacuations	The provision of a designated well equiped first aid vehicle for medical evacuation remains applicable.
40 – Transport and accommodation	**Subclause 40.2** is modified to include… "all vehicles provided by the Contractor for transportation of personnel must be in full compliance of the Traffic Act. Cap 403 including but not limited to provision of safety belts, speed limits etc. Transportation of personnel at the bed / cargo area for pickups and trucks is prohibited. The issue of safe transportation of workers is of serious concern to the Employer."
	Subclause 40.3 is modified to include.. "The Contractor shall organise and pay for transport. Provision of transport allowance is not acceptable".

2.4. SOCIAL INCLUSION REQUIREMENTS

As part of the social inclusion requirements specified at Article 39.12 of the ESHS Specifications, the targeted number of hours of social inclusion is **10,800 *hours (15 persons, 3 months)***.

People targeted by these requirements are:

☒ **Disadvantaged or marginalized communities**: *[Residents of **Kasemeni and Mwavumbo Wards**)*

In terms of employment, these people are currently*:*

☒ **Persons outside the labour force**

Among the people benefiting from these requirements, there shall be at least:

☒ **Low-skilled people:** *[unskilled and semi-skilled, 80 %]*
☒ **People with disabilities***: [registered with National Council for Person with Disabilities, 20%]*

Technical trainings shall be organized for people benefiting from social inclusion requirements on the following topics:

☒ **Trainings on specific construction trades**: *[minimum 80% of trainees]*
☒ **Support to foster entrepreneurship**: *[how to set up a business, administrative management etc.) for minimum 20 % of trainees.*

The equipments funded by the project that will be donated to the beneficiaries of social inclusion requirements in accordance ESHS Specifications – Article 39.12.1 are:

No.	Tool Description	Quantity
1.	Assorted general construction hand tools (Hammer, screwdrivers, wrenches, pliers etc.)	12 sets
2.	Safety equipments (hard hats, safety googles, ear protection, respirators, reflective vests etc.)	12 sets

Note: Contractor to allow **Kshs. 500,000.00** for any other tools not listed above that may be deemed necessary in the course of the social inclusion activities.

All the equipments listed above shall be included in the Price Schedules (Bill of Quantities) provided by the Bidder in its Bid.

2.5. ESHS SPECIFICATIONS

Throughout the present ESHS Specifications (hereinafter called "**the ESHS Specifications**"), a reference to Conditions of Contract, abbreviated by CC, means a reference to both the General Conditions of Contract and the Particular Conditions of Contract. Readers should apply due care, when being referred to a specific Clause or Sub-Clause, to:

- Read first the Clause or Sub-Clause text from the General Conditions of Contract;
- Then check whether this text has been amended by the Particular Conditions of Contract, and if so, to which extent.

As per CC Sub-Clause 1.5 – Priority of Documents, when interpreting the Contract, the terms of the Particular Conditions of Contract prevail over those found in the General Conditions of Contract.

Any term in these ESHS Specifications which is identical to a term in the Conditions of Contract shall have the same meaning as the one defined in the Conditions of Contract.

Any term in capital letters in these ESHS Specifications is defined in CC Sub-Clause 1.1 – Definitions.

A. Environmental, Social, Health and Safety Management System

1 Responsibilities and Liabilities

1.1 In conjunction with his obligations defined under the Contract, the Contractor will plan, execute and document construction works pursuant to the Environment, Social, Health and Safety (ESHS) Specifications.

1.2 The Contractor is liable for all damages to natural resources caused by the execution of the Works or the methods used for execution, unless it is established that the execution or methods were necessary, according to the provisions of the Contract or an Engineer's instruction.

1.3 Under the Contract and as introduced by the ESHS Specifications, the term "Project Area" means:

a) The land where work will be carried out; or

b) The land necessary for the implantation of construction facilities (work camp, workshops, offices, storage areas, concrete production plants) and including special access roads; or

c) Quarries for aggregates, rock material and riprap; or

d) Borrow areas for sand and other selected material; or

e) Stockpiling areas for backfill material or other demolition rubble; or

f) Any other location, specifically designated in the Contract as a Project Area.

The term "Project Area" encompasses any individual Project Area or all Project Areas.

For the sake of clarity, Project Area is a different concept than Site under CC Sub-Clause 1.1.6.7.

Project Area defines an area within which the Contractor is to comply with environmental, social, health and safety obligations defined in the ESHS Specifications.

Site is the places where the Permanent Works are to be executed and to which Plant and Materials are to be delivered, and where right of access to, and possession of, is to be given by the Employer to the Contractor. The Employer is under no similar obligation for any area located outside the Site, even if within the Project Area, where access is at Contractor's risk.

In term of physical footprint, the CC Sub-Clause 1.1.6.7 Site is included in the Project Area. The Project Area is then of greater geographical extent than the Site.

1.4 The ESHS Specifications refer to the entire area of influence for the Works:

a) Protection of the natural environment (water, air, soil, vegetation, biological diversity) in areas within any Project Area and its surroundings, i.e. including but not limited to access roads, quarries, borrow areas, stockpiling of backfill material, camps or storage areas;

b) Health and safety conditions to be maintained for the Contractor's personnel and any other person present on the Project Areas, or along access routes;

c) Working practices and the protection of people and populations living near the Project Area, but exposed to the general disturbance caused by works.

1.5 Subcontractors:

The ESHS Specifications apply to the Contractor and unless explicitly agreed with the Engineer, all Subcontractors used for the execution of the Works. Pursuant to Sub-Clause 4.4 of the CC, the Contractor is fully liable for all actions, non-compliance and negligence by Subcontractors, their representatives, employees and workers, to the same degree as it would be held liable for its own actions, non-compliance or negligence or that of its own representatives, employees or workers.

1.6 Applicable regulations:

The Contractor must identify all regulations in relation to the protection of the environment (water, air, soils, noise, vegetation, fauna, flora, waste, groundwater) and, pursuant to Clauses 4 and 6 of the CC, the protection of people (labour law, indigenous populations, standards on occupational exposure, other). The Contractor must list all texts, standards and other regulatory limitations in its Worksite Environmental and Social Management Plan (Worksite - ESMP as specified in Sub-Clause 2.1 of the ESHS Specifications) and specify the means taken for compliance.

2 ESHS Planning Document

2.1 Worksite Environmental and Social Management Plan (Worksite - ESMP)

2.1.1 The Contractor prepares and ensures prior validation by the Engineer, implementation and regular update of a Worskite Area Environmental and Social Management Plan (Worksite - ESMP).

2.1.2 The Worksite - ESMP represents the unique reference document in which the Contractor defines in detail all organisational and technical provisions implemented to satisfy the obligations of the ESHS Specifications.

2.1.3 The Contractor defines in the Worksite - ESMP the number, the locations and the type of Project Area as defined in Sub-Clause 1.3 of the ESHS Specifications. For each of the identified Project Area, unless otherwise agreed by the Engineer, the Contractor establishes an Environmental Protection Plan (EPP). The EPP(s) are annexed to the Worksite - ESMP.

2.1.4 The Worksite - ESMP covers the entire period from the Contract Agreement signature date to the date of issue of the Performance Certificate by the Engineer.

2.1.5 Unless agreed otherwise by the Engineer, the Worksite - ESMP is written in the language of communication defined under Sub-Clause 1.4 of the CC.

2.1.6 The first draft version of the Worksite - ESMP is to be provided by the Contractor to the Engineer within 28 days from the date of execution of the Contract Agreement.

2.1.7 No physical work or activity shall commence on any Project Area until such time the Worksite - ESMP, and the annexed EPP corresponding to the Project Area, are approved by the Engineer.

2.1.8 During the execution of the Works, whenever instructed by the Engineer, the Worksite - ESMP will be updated by the Contractor and reissued to the Engineer. The revised version shall highlight the new elements incorporated in the document.

2.1.9 The Worksite - ESMP (and the EPP) is structured according to the plan specified in Appendix 1 to the ESHS Specifications.

3 Management of non-conformities

3.1 In application of Clause 5, non-conformities detected during inspections carried out by the Contractor or Engineer are subject to a process adapted to the severity of the situation. The non-conformities will be defined as deviations from the requirements of the applicable regulations, the ESHS Specifications, the ESMP, and the Worksite - ESMP. Non-conformities are divided into 4 categories as follows:

3.1.1 Notification of observation of minor non-conformities. The non-conformity results in a notification to the Contractor's Representative, followed-up by a signed notification of observation prepared by the Engineer. The multiplication of notifications of observation at the Project Area, or absence of corrective actions by the Contractor, can result in the severity of the non-conformity being raised to that of level 1.

3.1.2 Level 1 non-conformity: Non-conformities that present a moderate and non-immediate risk for health, environment, social or safety. The non-conformity is identified in writing to the Contractor and shall be resolved within five (5) days. The Contractor addresses to the Engineer the proof explaining how the non-conformity has been corrected. Further to an inspection and a favourable evaluation of effectiveness of the corrective action, the Engineer validates in writing the close-out for the non-conformity. In all cases where a non-conformity of level 1 is not resolved within one (1) month, the severity of the non-conformity is raised to level 2.

3.1.3 Level 2 non-conformities: applies to all non-conformities that represent a moderate and immediate risk or with significant consequences to health and/or the environment, social or safety. The same procedure as for level 1 non-conformities is applied. Corrective action shall be taken by the Contractor within three (3) days. All level 2 non-conformities which are not resolved within one (1) month, are raised to level 3.

3.1.4 Level 3 non-conformities: applies to all non-conformities that have resulted in damage to health or the environment, or which represent a high risk for health, safety, environmental or social hazards. The highest levels of the Contractor's and Engineer's hierarchies present in the Employer's country are informed immediately and the Contractor has twenty-four (24) hours to bring the situation under control. Pursuant to Clause 14.7 of the CC, a level 3 non-conformity results in the suspension of interim payments until the non-conformity has been resolved. If the situation requires, and in pursuance to Clause 8.8 of the PC, the Engineer can order the suspension of work until the resolution of the non-conformity.

4 Resources allocated to environmental management

4.1 ESHS supervisors and Manager:

4.1.1 Pursuant to Sub-Clause 4.18 of the CC and in addition to the provisions of Sub-Clause 6.7 of the CC, the Contractor appoints one (or two depending on the case) Environment, Social, Health and Safety Manager(s) in charge of implementing the ESHS Specifications. Several experts may be assigned to fulfill this position. The manager(s) will be the Key ESHS Personnel identified in the bidding process, if any.

4.1.2 The ESHS Manager is permanently based at the Project Area for the full duration of the Works as of Contractor's mobilisation until Taking-Over Certificate is issued.

4.1.3 This manager holds the power within the Contractor's organisation to be able to suspend the Works if considered necessary in the event of level 2 or 3 non-conformities, and allocate all resources, personnel and equipment required to take any corrective action considered necessary.

4.1.4 The ESHS Manager speaks fluently the language of communication of the Contract, and the official language of the Employer's country, if the language of communication of the Contract is not the official language. The ESHS Manager will hold a relevant University degree or a significant experience of at least five (5) years in designing and monitoring the implementation of an environmental and social management plan for construction works.

4.1.5 ESHS supervisors are appointed in sufficient numbers and represent the ESHS Manager within work teams. Their role is to ensure that the Works are carried out pursuant to the ESHS Specifications and notify the ESHS Manager of any detected non-conformities.

4.2 Person in charge of relations with external stakeholders:

4.2.1 The Contractor appoints a person responsible for relations with external stakeholders: local communities, administrative authorities, religious and other representatives. If necessary, a team will be created.

4.2.2 Administrations and local authorities will be informed of the existence of this person as of the start of works and will be provided with contact details so as to be able to contact this person if a problem arises during the execution of works, or concerning the behaviour of the Contractor's Personnel, inside or outside the Project Area.

4.3 The team, including the ESHS supervisors and manager, and the person in charge of relations with external stakeholders, will be allocated the necessary resources to operate independently (travel, office equipment and communication).

5 Inspections

5.1 In addition to the ESHS Manager's own inspections, an ESHS inspection will be carried out on the facilities and Project Area on a weekly basis jointly with the Engineer.

5.2 A written report will be drafted for each weekly inspection, in a format approved by the Engineer, addressing non-conformities detected on the Project Area as specified in the ESHS Specifications.

5.3 Each non-conformity will be documented by a digital photograph with captions to provide a visual illustration, explicitly indicating the location, date of inspection and the non-conformity in question.

6 Reporting

6.1 As part of the Progress Report specified in Sub-Clause 4.21 of the CC, the Contractor submits an ESHS activity report summarising all ESHS initiatives implemented in relation to the execution of the Works during the reporting period to the Engineer on a monthly basis. The activity report is a separate document from the update of the Worksite - ESMP, which is updated at the intervals indicated in Sub-Clause 2.1.8 of the ESHS Specifications.

6.2 The ESHS activity report is written exclusively in the language of communication defined under Sub-Clause 1.4 of the CC.

6.3 Pursuant to Sub-Clause 4.21 of the CC, the ESHS activity report is submitted at the latest 7 working days after the last day of the month in question. The report contains the following information.

6.3.1 List of ESHS personnel present at the Site at the end of the month.

6.3.2 Construction works activities conducted during the month.

6.3.3 Inspections carried out (location and intervals).

6.3.4 Non-conformities detected during the month with descriptions of the root cause analysis and corrective actions taken.

6.3.5 Description of actions conducted and measures taken during the month to remedy non-conformities and to manage environmental, social, health and safety risks and impacts.

6.3.6 Description of stakeholder engagement activities undertaken with neighbouring populations, local authorities, governmental agencies.

6.3.7 Monitoring results for the following indicators:

a) Effluent quality (Sub-Clause 12.5 of the ESHS Specifications), if applicable;

b) Drinking-water quality, if applicable;

c) Hazardous and non-hazardous waste generation;

d) Air and noise emissions, if applicable;

e) Project Area state (Sub-Clause 20 of the ESHS Specifications);

f) Recruitment, number of positions and hours worked by local Contractor's Personnel (Sub-Clause 39.3 of the ESHS Specifications);

g) Health & safety statistics: in pursuance to Clauses 4 and 6 of the CC, number of fatal accidents, lost-time accidents, number of accidents without lost-time, serious illness, frequency of accidents, and serious misconduct by Contractor's Personnel (record sheet attached as an appendix to the activity report, pursuant to Sub-Clause 7.7 of the ESHS Specifications); including root cause analysis and corrective actions taken.

6.3.8 Where appropriate, description of the formal or informal complaints (negative media attention, strikes or labour disputes,

protests, complaints from communities, NGO or workers or formal notice from authorities, etc.) related to environmental, social, health and safety risks and impacts of the Works; including root cause analysis and corrective actions taken.

6.3.9 Report on training activities (topic, number and duration of sessions, number of participants).

6.3.10 Provisional environmental, social, health and safety actions for the coming months.

6.3.11 Social inclusion measures monitoring indicators as defined in Article 39.12.2 of the ESHS Specifications, if applicable.

6.4 Notification of ESHS events:

6.4.1 The Engineer is informed within one hour of any accident, (i) involving serious bodily injury to a member of personnel, a visitor or any other third party, caused by the execution of the Works or the behaviour of the personnel of the Contractor, or (ii) any significant damage to private property, or (iii) any significant damage to the environment.

6.4.2 The Engineer is informed as soon as possible of any near-accident relating to the execution of the Works which, in slightly different conditions, could have led to bodily injury to people, or damage to private property or the environment.

7 Rules of Procedure

7.1 Rules of procedure are established by the Contractor for the Project Areas, addressing the following: safety rules, zero tolerance for substance abuse (refer to Clause 37), environmental sensitivity of areas around the Project Areas, the dangers of STDs with HIV/AIDS, gender issues (in particular sexual harassment) and respect for the beliefs and customs of the populations and community relations in general (drawing special attention to the risks of prostitution and human trafficking).

7.2 The rules are clearly displayed at the different Project Areas.

7.3 The rules confirm the Contractor's commitment to implementing the ESHS provisions provided for in the Contract.

7.4 New Contractor's Personnel and existing Contractor's Personnel are made aware and acknowledge their understanding of the rules of procedure and the associated provisions. Rules of procedure document are initialed by all Contractor's Personnel prior to the start of any physical work at any Project Area.

7.5 Pursuant to Clauses 6.9 and 6.11 of the CC, the rules of procedure include a list of acts considered as serious misconduct and which must result in dismissal from any Project Area by the Contractor, or by the Engineer if the Contractor is not acting in due course, should a Contractor's Personnel repeatedly commit an offence of serious misconduct despite awareness of the rules of procedure, and this is without prejudice to any legal action by any public authority for non-compliance with applicable regulations:

a) Drunkenness during working hours;

b) Drug use;

c) Punishable statements or attitudes, and sexual and mental harassment in particular;

d) Violent behaviour;

e) Intentional damage to the assets and interests of others, or the environment;

f) Repeated negligence or imprudence leading to damage or prejudice to the environment, the population or properties, particularly breaching provisions intended to prevent the spreading of STD with HIV/AIDS;

g) Possession and/or consumption of meat or any other part of an endangered animal or plant as defined in the Washington convention (CITES) and national regulations.

7.6 Serious misconduct, such as organization of sex trade (pimping), committing pedophilia, rape, physical aggression, drug trafficking, deliberate and severe pollution, trading and/or trafficking in all or part of protected species, shall lead to immediate dismissal as of the first report of misconduct is detected, in application of the rules of procedure and labour laws.

7.7 The Contractor establishes a record for each case of serious misconduct, and a copy will be provided to the Contractor's Personnel in question, indicating all action taken to terminate the misconduct by the Contractor's Personnel in question and to bring the attention of other Contractor's Personnel to the type of incident detected. This record will be provided to the Engineer as an attachment to the ESHS activity report (see Sub-Clause 6.3 of the ESHS Specifications).

8 ESHS Training

8.1 The Contractor prepares a training and capacity building program for its Contractor's Personnel, as described in the Worksite - ESMP and documented each month in the ESHS activity report.

8.2 The Contractor also details in the training program the actions and ESHS training for Subcontractors and other members of the joint venture when applicable.

8.3 Training sessions are two-fold: introductory sessions for starting work at the Project Area, and technical training as required in relation to the execution of the Works.

8.3.1 Starting work sessions are organised for each Contractor's Personnel and shall cover as a minimum:

a) Rules of procedure;

b) Safety rules on Project Areas;

c) Protection of areas adjacent to Project Area;

d) Risks relating to sexually transmitted diseases (Sub-Clause 6.7 of the CC), prostitution, human trafficking, and sexual harassment;

e) Basic health: combating malaria (if prevalent) and waterborne diseases, improving hygiene;

f) Emergency response procedures or evacuation.

8.3.2 Technical training:

a) Training in the skills needed for tasks requiring a work permit (Clause 24 of the ESHS Specifications);

b) Training in first aid and transporting the injured in order to achieve the targets defined in Sub-Clause 29.1 of the ESHS Specifications on the number of first aid officers per Project Area and per team;

c) Ability to drive on rough ground.

8.4 The Contractor prepares an awareness program, where applicable, for local communities adapted to the main risks relating to the Works. This program will be included in the training program described in Sub-Clause 8.1 of the ESHS Specifications.

9 Standards

9.1 The Contractor complies with all norms, standards and discharge limit values defined in the national regulations of the Employer's country regulations and pursuant to Sub-Clause 1.6 of the ESHS Specifications.

9.2 The Contractor comply with norms, standards and discharge limit values recommended by the specialised international organisations affiliated to the United Nations, as described in Sub-Clause 9.3 below of the ESHS Specifications. In the event of discrepancies in between international standards and national regulations, the Contractor shall comply with the most stringent requirements.

9.3 The specialised international organisations affiliated to the United Nations referred to in Sub-Clause 9.2 of the ESHS Specifications include:

- World Bank, including the IFC and its Environmental, Health and Safety guidelines available from http://www.ifc.org/ehsguidelines.

For matters not addressed in the IFC above document, the most stringent of the norms, standards and discharge limit values of the following institutions shall apply:

- World Health Organization (WHO);
- International Labour Organization (ILO) (in particular in pursuance to Sub-Clauses 6.20, 6.21, 6.23 and 6.24 of the CC);
- International Maritime Organization (IMO).

B. Protection of the Environment

10 Protection of adjacent areas

10.1 Pursuant to Sub-Clause 4.18 of the CC, and unless instructed otherwise by the Engineer, the Contractor uses construction methods and means of protection in order to avoid or minimize adverse effects that are incurred on vegetation, soils, groundwater and surface water, biodiversity, natural drainage and the water quality in areas within any Project Area and its surroundings for the entire duration of the Works.

10.2 Wetland areas include marshes, fens, mires or natural or artificial bodies of water, whether permanent or temporary, where water is stagnant or flowing, fresh, saline or briny, including seawater with a low-tide depth of six metres or less. Filling of all or part of a wetland area is not permitted, unless the Works are necessary according to the provisions of the Contract or the instructions of the Engineer.

10.3 With the exception of access roads, or unless instructed otherwise by the Engineer, the entire perimeter of land sites with a surface area of less than 2 hectares is physically demarcated with a fence or tape. For Project Area with a surface area of more than 2 hectares, the perimeter will be physically demarcated by a perimeter track, road, signs or any other means leaving no possible ambiguity as to the location of the Project Area perimeter.

10.4 Unless instructed otherwise by the Engineer, the Contractor defines the perimeter of the Project Area at a distance of at least:

a) 50 m from any permanent water course and outside of floodable areas;

b) 300 m from sensitive urban services and buildings (health centre, school centres, water supply for populations);

c) 200 m from any housing; and

d) 300 m from housing in the specific case of work requiring the use of explosives.

10.5 If the footprint of the Works do not respect the distances mentioned in the situations a) to d) of Sub-Clause 10.4 above of the ESHS Specifications, and unless agreed upon otherwise by the Engineer, the Contractor will contract a bailiff to make a sworn statement regarding the existence and conditions of residential buildings situated around the Site with a distance specified in paragraph b) to d) of Sub-Clause 10.4 of the ESHS Specifications. The bailiff's sworn statement is prepared and provided to the Engineer with the EPP.

11 Selection of borrow areas, backfill material stockpile sites and access road

11.1 The Contractor will submit to the Engineer for prior approval, within the framework of the EPP (provided in Clause 2.1.3), (i) the location of proposed borrow areas or areas to be excavated, (ii) proposed backfill material stockpile locations or zones designated for the rubble from demolition works.

11.2 The access routes to the Project Areas will be shown on a map and approved by the Engineer prior to the start of the corresponding Works.

12 Effluents

12.1 Effluents consist of liquid discharges, including infiltration, from Project Area, transporting a pollutant (dissolved, colloidal or particles).

12.2 A pollutant is a given chemical compound that is at a concentration that is greater than the limit values recognised for that compound according to Clause 9 of the ESHS Specifications.

12.3 If no recognised threshold exists pursuant to Sub-Clause 12.2 of the ESHS Specifications, the Contractor provides proof that the charges are harmless.

12.4 No effluent is discharged by the Contractor into water courses, soils, lakes or the marine environment without prior treatment and without monitoring of the treatment's performance to guarantee the absence of pollution.

12.5 The Contractor carries out or contracts the monitoring of the effluent quality pursuant to Sub-Clause 12.4 of the ESHS Specifications. In the first case, the Contractor provides the ESHS Manager with the means and skills to carry out in-situ monitoring and laboratory analysis of the performance indicators. In the second case, the Contractor establishes a contract with

a specialised contractor, accredited with the Employer's country authorities for this activity.

12.6 The physical and chemical parameters of the effluent that are monitored are those that are listed in the applicable regulations according to the provisions of Clause 9 of the ESHS Specifications. The parameters have prior approval from the Engineer.

12.7 The Contractor will list, locate, and characterise (flow, expected quality, discharge frequency) all sources of effluents and outlets in the natural environment in the Environment Protection Plan(s).

12.8 The Contractor will submit to the Engineer an effluent monitoring report on a monthly basis, including documentation for the following for each effluent discharge point: (i) average flow rates of discharged effluents, (ii) discharge frequencies and durations over the month, and (iii) the physical and chemical quality of the effluent discharged, for the conformity parameters listed in Sub-Clause 12.1 above of the ESHS Specifications.

12.9 The special case of rainwater run-off:

12.9.1 Run off consists of the rainwater flow on the surface or the soil and other technical surfaces at Project Areas.

12.9.2 In the context of the Contract, run-off is considered as an effluent and will be treated in accordance with Sub-Clause 12.4 above, unless demonstrated otherwise, as documented and substantiated by the Contractor, and approved by the Engineer.

12.9.3 Particular attention will be given to all platforms with installed generators, hydrocarbon storage tanks, refuelling stations and concrete plants (cover, containment, settling, pH neutralization).

13 Atmospheric emissions and dust

13.1 Emissions refer to any discharge into the air of solid substances, aerosols, gases, radiation, or energy, whether point sources (e.g. incineration stack) or diffuse (e.g. fugitive dust emissions from road use by trucks).

13.2 The Contractor will use equipment and adopt construction and transport methods with atmospheric emissions which are not in excess of the threshold emission values recommended in the applicable regulations according to the provisions of Clause 9 of the ESHS Specifications.

13.3 The fleet of vehicles or equipment emitting combustion gases will be maintained at the intervals and according to the methods specified by the manufacturer.

13.4 The Contractor will document the maintenance records for its fleet of vehicles, machinery and equipment. The records will be in the language of communication defined under CC Sub-Clause 1.4, or any other language approved by the Engineer, and will be at the disposal of the Engineer.

13.5 On unpaved roads used by the vehicles and machinery of the Contractor:

13.5.1 The Contractor takes action to abate fugitive dust emissions generated by vehicles or mobile equipment in residential areas and on roads within the Project Area perimeter.

13.5.2 The Contractor will implement the necessary measures, as described in the Worksite - ESMP, to avoid or limit dust generation:

dust removal, regular watering, reduction of Contractor's vehicles speed as specified in Sub-Clause 44.9 of the ESHS Specifications.

13.6 When storage, handling and transportation of bulk materials is made in the open air and exposed to the wind, the Contractor implements the necessary dust abatement measures, including one or several of the following techniques: vegetation of the surface, covering of the surface, humidification of the surface, covering the trucks, etc.

14 Noise & vibration

14.1 The Contractor uses equipment and adopts construction and transport methods so not to generate noise levels in excess of values recommended in the applicable regulations according to the provisions of Clause 9 of the ESHS Specifications.

14.2 Except as otherwise provided in the Contract or unless waived by the Engineer, high noise generating works (e.g. pile driving, blasting, rock clearing, drilling, percussion drilling) which may impact occupied receptor areas are carried out during normal working days, but prohibited at night. A receptor area is defined as an area used for nocturnal socioeconomic activities (e.g. accommodation camps, residential areas, hotels, health centres).

14.3 The use of heavy vehicles at night is specified in Sub-Clause 44.9 of the ESHS Specifications.

15 Waste

15.1 The Contractor is responsible for identifying, collecting, transporting and treating all waste produced on the Project Areas by its personnel, Subcontractors and visitors.

15.2 Waste management should be based on the following hierarchy: prevention of waste generations, reuse, recycling and disposal. The Contractor selects suppliers having a voluntary and documented policy to reduce the volume and weight of packaging, and to select recyclable or biodegradable packaging.

15.3 The Contractor establishes and maintains a waste register which is at the disposal of the Engineer. This register will record all waste management operations: production, collection, transport, treatment. The following aspects are documented in this register:

a) Type of waste, using the nomenclature specified in Sub-Clause 15.7 of the ESHS Specifications;

b) Waste quantities;

c) Name and address of the third party waste management facilities receiving waste or parties taking possession of the substances no longer considered as waste;

d) Name and address of waste transport contractors;

e) Planned waste treatment.

15.4 The Contractor files and maintains at the disposition of the Engineer the waste manifests for the collection, transport, treatment and/or elimination of waste.

15.5 The waste register is established and available as of the Contractors mobilisation to any Project Area. This register will be archived for at least 1 year after the Taking-Over Certificate for the Works is issued.

15.6 The Contractor implements specific waste management practices adapted to the level of danger for human health or the natural environment. Three waste categories are identified for Project Areas and in tracking documents:

a) Hazardous waste: any waste with one or several dangerous properties as listed in Appendix 2 to the ESHS Specifications;

b) Non-hazardous waste: any waste with no properties rendering it hazardous. Non-hazardous waste contaminated by hazardous material will be considered as hazardous waste, unless instructed otherwise by the Engineer;

c) Inert waste: any waste unaffected by any significant physical, chemical or biological modifications, which does not decompose, burn or produce any physical or chemical reaction, is not biodegradable and does not damage any substance with which it comes into contact in a manner likely to cause damage to the environment or human health.

15.7 The Contractor assesses, document and effectively implements any local recycling or re-use options for its waste.

15.8 Waste is categorised and stored separately prior to removal from the Project Areas, depending on the level of danger, phase (liquid, solid or gas), the waste management solution to be applied and its potential in terms of recycling or reuse.

15.9 Waste is collected from each Project Area at the same rate that it is produced and is placed in temporary locations meeting the following criteria:

a) Located at a distance of over 100 m from any natural sensitive area and over 500 m from any socioeconomic sensitive area (school, market, healthcare centre, water well or catchment area), with the exception of waste storage area in camps;

b) Protected from moving machinery and vehicles, but easy to access for regular collection;

c) Located on a flat impervious surface to prevent infiltrations;

d) Under cover for non-inert waste;

e) Stored in containers of the appropriate size, tightness and level of resistance depending on the danger and phase (solid, liquid, gas) of the waste;

f) Liquid wastes storage is equipped with secondary retention with a volume at least equal to the greater of the following two values (i) 100% of the capacity of the largest reservoir and (ii) 50% of the overall capacity of the associated reservoirs;

g) Hazardous waste stored pursuant to Sub-Clause 26.8 of the ESHS Specifications.

15.10 Waste is removed from Project Areas and transported to recycling, treatment and waste management facilities on a regular basis. The frequency of removal, approved by the Engineer, guarantees:

a) No overflow from containers;

b) No unpleasant odour or emissions which are dangerous for human health;

c) No proliferation of insects, rodents, dogs or other animals which are harmful or dangerous for human health;

d) Regular cleaning of containers and surfaces on which they are located.

15.11 Unless otherwise specified in the Contract or instructed by the Engineer, waste incineration is prohibited on Project Areas. Two exceptions are medical waste and green waste, which unless instructed to the contrary by the Engineer, are managed pursuant to Clauses 15.15.1 and 16.1.3 of the ESHS Specifications.

The use of third party waste management services is subject to a documented prior audit of the treatment, storage and recycling facilities by the Contractor, to guarantee the conformity with the provisions of the ESHS Specifications on waste.

15.12 Pursuant to Sub-Clause 1.5 of the ESHS Specifications, the provisions applicable to the Contractor regarding waste management also apply to any third party waste management Subcontractor. The Engineer reserves its right to inspect third party waste management facilities and prohibit the Contractor from using the facilities if considered unacceptable.

15.13 The management of non-hazardous waste complies with the following conditions:

15.13.1 Inert waste is removed or treated on-site and can be disposed in a permanent or temporary landfill with unused backfill material. The location, capacity and environmental protection measures, particularly for water courses, implemented by the Contractor or any Subcontractor, will comply with the provisions of the ESHS Specifications, and will be described in the EPP and validated by the Engineer.

15.13.2 Non-hazardous waste that cannot be recycled is disposed of to landfill, complying with the following criteria:

a) Walls and base sealed by a geo-membrane or a layer of compacted clay with a permeability 10^{-7} cm/s;

b) Drained for the recovery of leachates, which are routed to a lagoon aerobic/anaerobic treatment prior to discharge into the natural environment or collected in a temporary storage prior to regular collection and transfer to a treatment unit (septic tank or wastewater treatment plant);

c) Regularly compacted and covered by earth to limit odours and the proliferation of insects;

d) When the landfill has reached full capacity, vents are installed to evacuate gases, and the landfill covered by a geo-membrane with a minimum thickness of 1 mm, or a layer of compacted clay, and a top layer of 1.5 m of topsoil, which is revegetated.

Any other proposal must first be validated by the Engineer.

15.14 The Contractor's hazardous waste is managed by a specialised waste Subcontractor, accredited in the Employer's country for this activity.

15.15 In the absence of an existing waste management solution for hazardous waste satisfying the provisions of Sub-Clause 15.14 of the ESHS Specifications, the Contractor takes the following action:

15.15.1 Medical waste is incinerated in a specific facility constructed and accredited for this purpose. The Contractor will submit the technical specifications of the facility to the Engineer before importing or procuring the equipment.

15.15.2 Hydrocarbons, lubricants, paints, solvents and batteries are transported in drums to the capital city, or any other city where suitable waste management facilities are available. Sludge from settling tanks/ponds, septic tanks or oily water skimmers will also be managed in the same way.

15.15.3 Contaminated soils from construction/demolition and drilling muds will be treated, stabilised and disposed of to landfill. Prior approval is required from the Engineer regarding the method and site location. The Contractor obtains authorisation from the competent local authorities prior to any disposal to landfill.

15.15.4 Prior approval from the Engineer is required before implementing waste management solutions on any other hazardous waste.

15.15.5 Prior to the issue of the Taking-Over Certificate for the Works, the Contractor provides documentation on hazardous waste landfilled at other sites than accredited third party waste management facilities. The documentation includes a plan showing the location of landfill sites. The document is provided to the competent local authorities whose jurisdiction covers the landfill sites.

16 Vegetation clearing

16.1 The Contractor describes in the Worskite - ESMP the planned methods and schedule for vegetation clearing. Specific agreement from the Engineer is obtained prior to any clearing works.

16.1.1 Vegetation clearing using chemicals is not permitted.

16.1.2 Vegetation clearing using bulldozer is not permitted in zones less than 30 m from areas designated as sensitive by the Engineer, where only manual clearing is authorised.

16.1.3 Unless otherwise specified in the Contract or if otherwise instructed by the Engineer, burning vegetation is not permitted. Green waste can be burnt with prior approval from the Engineer regarding the location, method and schedule.

16.2 Areas cleared prior to undertaking earthworks are shown on a plan with a minimum scale of 1/10,000. Plans are submitted to the Engineer for validation prior to starting clearing works.

16.3 The Contractor undertakes physical demarcation of zones to be cleared using a method approved by the Engineer.

16.4 Trees not to be cut down are identified in relation with the Engineer. Such trees are marked with paint and protected against clearing machinery using a method approved by the Engineer.

16.5 Clearing is undertaken without damage to adjacent non-cleared areas. Topsoil is stored within the cleared areas at the edge of the cleared zone. Clearing is undertaken working from the edge of the zone inwards.

16.6 Wood with economic value:

16.6.1 During clearing, the Contractor stockpiles separately: (i) tree trunks with a diameter at chest height greater than the size defined by the Engineer, and (ii) trunks with a smaller diameter, branches, leaves, stumps and roots.

16.6.2 Unless instructed otherwise by the Engineer when validating the plans of Sub-Clause 16.2 of the ESHS Specifications or unless specified otherwise in the Employer's country regulations, the trunks of trees exceeding the diameter defined by the Engineer are made available to the local communities, according to the methods defined with the Engineer.

17 Biodiversity

17.1 The Contractor shall ensure that all personnel are informed and aware of the importance to protect fauna and flora. Information and awareness training is documented.

17.2 The Contractor shall ensure that all personnel are informed and aware of wildlife encounters procedures. Information and awareness training is documented.

17.3 The Contractor shall define in the Worksite – ESMP the method with regards to fauna and flora management prior to clearing activities. This method must notably address the work schedule, which sometimes can be adjusted to limit impacts on fauna and flora.

17.4 Where possible, areas shall be cleared from one side to another, or from the inside out, to prevent animals becoming trapped.

17.5 The Contractor personnel shall not approach, injure, hunt, capture, possess, feed, transport, rear or trade wild animals and/or collect eggs while working on the Project Areas.

17.6 The Contractor personnel shall not collect flora species while working on the Project Areas.

17.7 The Contractor shall report any sighting or finding of wounded or dead wildlife to the Engineer immediately.

17.8 The Contractor shall protect excavations to prevent injury to animals.

17.9 The Contractor shall release any trapped uninjured animals immediately.

17.10 The Contractor shall not disturb natural habitats outside the Project Areas.

17.11 The Contractor shall only use designated roads or paths and abide by speed limits.

17.12 The Contractor shall not start forest fires.

17.13 The Contractor shall not introduce Invasive Alien Species (IAS).

17.13.1 All construction machinery imported from overseas shall be inspected to detect IAS and washed before dispatching to the Project Areas.

17.13.2 If the presence of topsoil contaminated with IAS is detected, that topsoil shall only be stored or re-spread in the area from where it was removed.

17.13.3 When earthworks are carried out in IAS contaminated areas, vehicles shall be washed before moving them to other areas.

17.13.4 Where necessary, the Contractor shall develop IAS control procedures (e.g. physical removal, slashing, mulching, herbicides, etc.). Methods used to control or prevent such species shall not cause adverse impacts on the environment or communities.

17.13.5 To limit the risk of introducing marine invasive species, the Contractor shall control the ballast water and anti-fouling systems of vessels arriving from other bioregions in accordance with International Maritime Organization (IMO) conventions and guidelines.

18 Erosion and sediment transport

18.1 The Contractor plans earthworks and optimises the management of space to ensure that all cleared surfaces and areas exposed to soil erosion are minimised on all Project Areas.

18.2 Topsoil:

18.2.1 Unless indicated otherwise by the Engineer, the top 25 centimetres of the soil will be considered as topsoil.

18.2.2 Earthworks for the temporary occupation of the Project Area are preceded by the clearing of topsoil and the storage of this soil separately from the underlying sterile soil.

18.2.3 Topsoil is stored according to the provisions approved by the Engineer to enable reuse during Project Area rehabilitation.

18.2.4 The refurbishment must be done in accordance with the provisions of Clause 19.

18.3 Draining and treatment of rainwater run-off:

18.3.1 The gradient of Project Areas allows the collection and drainage of rainwater from the entire surface area to one or several discharge points. No pools of water are created.

18.3.2 Suspended solids in rainwater are removed using sediment traps / settling ponds. Rainwater from vehicle parking areas, machinery areas, workshops is subject to treatment with oily water separators.

18.3.3 Rainwater treatment units are sized, cleaned, maintained and accessible to ensure compliance with the effluent quality criteria defined in Sub-Clause 12.9 of the ESHS Specifications and to allow monitoring of performance.

18.4 Sediment control:

18.4.1 The Contractor installs sediment control barriers to slow the flow of water and control sediment transport at Project Areas with (i) a gradient of more than 20%, and (ii) where land is disturbed by the Works or where stockpiled mineral material are susceptible to erosion.

18.4.2 Sediment control barriers are installed on the slope or at the base of the slope to protect the natural drainage system from sediment accumulation at levels higher than the natural situation. These barriers comply with the following principles:

a) Made with geotextiles or straw bales or any other means pre-approved by the Engineer;

b) Deployed before the start of works and removal of topsoil. Barriers can be used for the physical demarcation of working areas;

c) Installed, cleaned, maintained and replaced according to manufacturer recommendations;

d) Drainage surface area does not exceed 1,000 m² per 30 m of barrier. The length of the slope behind the barrier is less than 30 m, and is not used for flows in excess of 30 l/s.

18.4.3 For the dredging of marine sediments, unless specified otherwise in the Contract, or instructed otherwise by the Engineer, and particularly if the working area is exposed to currents, the Contractor will install a geotextile silt curtain, or any other technique approved by the Engineer to control turbidity clouds.

18.5 Backfilling and stockpiling of backfill materials:

18.5.1 In the EPP of these temporary and permanent stockpiles, the Contractor defines the proposed arrangements (height, slope, drainage, revegetation, etc.) to guarantee stability and erosion resistance.

18.5.2 For permanent backfill material stockpiles, the stockpile is shaped and compacted to ensure long-term stability.

18.5.3 Temporary stockpiles likely to result in strong erosion (duration of storage, rainy season, presence of downstream issues, etc.) are protected against runoff erosion by (i) revegetation using fast growing grass species, either by direct seeding or by hydro-seeding, or (ii) using other natural anti-erosion cover with prior approval from the Engineer.

19 Site rehabilitation

19.1 Unless instructed otherwise by the Engineer, the Contractor will rehabilitate all Project Areas disturbed by the Works, prior to the provisional acceptance of the Works.

19.2 All buildings and free standing and underground structures (e.g. piping, underground tanks, sumps and basins) are removed pursuant to the provisions of Sub-Clause 4.23 of the CC. All waste and rubble is removed in accordance to the provisions of Clause 15 of the ESHS Specifications. After removal of buildings structures and rubble, the Contractor returns Project Areas to their original condition, according to the following provisions.

19.2.1 Land is adjusted to ensure that run-off water drains without eroding soil or stagnating in pools. Unless instructed otherwise by the Engineer, the gradients of restored sites (excluding backfill as defined in Sub-Clause 18.5 of the ESHS Specifications) must be as for the adjacent undisturbed land.

19.2.2 Rehabilitated Project Areas do not represent hazards for people. Areas near steep drops at quarries are indicated with permanent concrete signs. Holes are refilled. Sharp or unstable items are rendered inoffensive.

19.2.3 Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, the Contractor undertakes revegetation of all Project Areas disturbed by the Works and bears the cost of such work.

19.2.4 Topsoil set aside during initial earthworks pursuant to Sub-Clause 18.2 of the ESHS Specifications, is evenly spread over cleared areas. The surface of compacted soils on Project Areas is loosened by scouring (using rakes or other acceptable methods).

19.2.5 The Contractor describes in the Worskite - ESMP the planned revegetation works to ensure sustainable Project Area rehabilitation: methods, plant species to be used and their origins, activity schedule based on a progressive taking over of Project Areas.

19.2.6 Prior approval by the Engineer is required regarding the origin of seeds and plants proposed by the Contractor. The species used for revegetation must be suitable for the local environmental conditions, and selected according to the rehabilitation program: stabilisation of backfill, landscaping, drainage, prevention of erosion, etc.

19.2.7 Revegetation is undertaken throughout the duration of construction Works, and is not limited to the rehabilitation of Project Areas at completion of the Works.

20 Documentation on the Project Area condition

20.1 The Constructor documents changes in condition of all Project Areas from the start of Works until the Performance Certificate is issued. Documentation comprises dated and geo-referenced colour photographs taken from a constant angle and viewpoint.

20.2 The Project Area condition is documented as a minimum for the following stages:

a) Before any Project Area disturbance at the start of works;

b) On completion of Works, but prior to starting rehabilitation;

c) On completion of rehabilitation and revegetation, if necessary, but prior to the Taking-Over Certificate issuing;

d) After the end of the Defects Notification Period and prior to the Performance Certificate issuing.

20.3 The Contractor specifies in the Worskite – ESMP: (i) the list of viewpoints to be used, (ii) areas to be photographed, and (iii) methods used for taking and archiving photographs.

20.4 Adjacent areas (100 m from the perimeter of the Project Area) are included in photographic documentation.

20.5 Unless instructed otherwise by the Engineer, structures to be buried are photographed weekly until covered. As a minimum the structures are photographed twice for Works with duration of less than 7 days, and at least once a week for Works with a longer duration.

20.6 Photographs subject to the present Clause 20 are archived in digital format and provided to the Engineer on a monthly basis under the CC Sub-Clause 4.21 monthly progress report.

20.7 The nomenclature of electronic files for photographs explicitly indicates the Project Area, date and structure documented.

C. Health & Safety

21 Health and Safety Plan

21.1 In application of Clauses 4 and 6 of the CC, the Contractor describes in the Health and Safety Plan section of the Worskite - ESMP its organisation for managing health and safety (section 7 of Worksite – ESMP as described in Appendix 1 to the ESHS Specifications), pursuant to its Health and Safety Management System (HSMS).

21.2 Pursuant to Clause 6 of the CC, the plan identifies and specifies:

a) All health and safety risks relating to the execution of the Works, by also identifying gender-specific risks;

b) Prevention and protection measures to control risks related to the execution of the Works, by differentiating, where necessary, measures concerning the protection of women and men;

c) Human and material resources involved;

d) Works requiring work permits; and

e) Emergency plans to be implemented in the case of an accident.

21.3 In addition, this Health and Safety Plan describes how workers are trained in health and safety aspects.

21.4 The Contractor implements prevention, protection and monitoring measures, as described in the Health and Safety Plan.

22 Daily and weekly meetings

22.1 The Contractor organises as a minimum one health and safety meeting per Project Area per week (or at another frequency approved by the Engineer) with all the personnel assigned to the Project Area. This applies only to Project Areas where work is ongoing. At the meeting accidents and incidents that occurred in the previous week are discussed and feedback provided. Means of improvements are identified, documented and assessed to establish corrective actions. The Engineer is invited to participate at all health and safety meetings. Meeting reports are provided to the Engineer.

22.2 The Contractor organises daily (or at another frequency approved by the Engineer) health and safety meetings per team at all Project Areas, prior to the start of the daily work. The meeting establishes the health and safety risks associated with the day's tasks and activities, and means of prevention and protection to be implemented. Minutes of the meetings shall be recorded.

23 Equipment and operating standards

23.1 The facilities and equipment used by the Contractor are installed, maintained, revised, inspected and tested pursuant to the manufacturer's recommendations. The recommendations are available in the language of communication defined under CC Sub-Clause 1.4 (or any other language approved by the Engineer).

23.2 The Contractor lists and describes in the Health and Safety Plan the national and international standards, guidelines and industry codes of practice, applied during the execution of works.

24 Work permit

24.1 Unless otherwise provided in the Contract, or unless otherwise instructed by the Engineer, work requiring work permits are defined in the Health and Safety Plan. Work permits will be documented and saved.

24.2 The Contractor puts in place a work permit procedure to manage risks through the implementation of prevention and protection measures prior to the starting of work. This procedure is subject to validation by the Engineer.

25 Personal protective equipment

25.1 The Contractor ensures that all personnel, visitors or third parties entering a Project Area are equipped with Personal Protection Equipment (PPE) pursuant to the practices and standards specified in Clause 9.

25.2 The Contractor describes in the Health and Safety Plan the PPE to be used per Project Area and per activity.

25.3 Personnel and visitors to Project Areas are equipped with a safety helmet, safety shoes and a reflective jacket as a minimum.

25.4 Adequate quantities of PPE are available on the Project Areas. Storage conditions must be compatible with usage pursuant to the provisions of Sub-Clause 23.1 of the ESHS Specifications.

25.5 Contractor personnel are trained in how to use and care for PPE and the Engineer must be able to obtain the training reports.

26 Dangerous substances

26.1 A substance is considered dangerous if one or several of its properties render it dangerous, as defined in Appendix 2 to the ESHS Specifications. The Contractor identifies and manages dangerous substances planned for use on the Project Area in the manner described in the present Clause 26.

26.2 Details of risks and related prevention and protection measures are included in the Health and Safety Plan.

26.3 The assessment of the impact of the toxicity of dangerous substances on the reproductive functions of women and men must be taken into account.

26.4 The transport to the Project Area and use of dangerous substances requires prior authorisation from the Engineer.

26.5 The Contractor obtains all necessary authorisations and/or licenses for the storage and use of dangerous substances from local authorities. A copy of the authorisations is provided to the Engineer.

26.6 For each dangerous substance used, the Contractor will implement the recommendations described (i) in the Material Safety Data Sheets (MSDS), and (ii) by the Globally Harmonized System of Classification and Labelling of Chemicals established by the United Nations for hazardous chemicals.

26.7 Copies of MSDSs are kept on the Project Area, and made available to personnel. The Contractor's staff is aware of the health and safety risks related to hazardous materials. The Contractor provides the Engineer with copies of all MSDSs and training reports.

26.8 Storage of dangerous substances

26.8.1 Storage area are designed and equipped by the Contractor based on the chemical and physical properties of the substances, on the types of containers stored, the number of people requiring access, the ventilation requirements, the quantities of the substance used and potential chemical reaction with other substances (see Sub-Clause 26.8.5 of the ESHS Specifications).

26.8.2 Pursuant to Sub-Clause 15.6 of the ESHS Specifications, the Contractor anticipates and plans for the storage and management of hazardous waste.

26.8.3 Storage areas for dangerous substances are subject to strict rules, which are regularly checked by the ESHS Manager appointed pursuant to Sub-Clause 4.1.4 of the ESHS Specifications. The rules include the following as a minimum:

a) Access to the storage area is limited to trained and authorised individuals;

b) An inventory is maintained up-to-date;

c) MSDSs must be available for all stored dangerous substances, and the substances must be clearly labelled;

d) A strict and methodical storage system is implemented (storage plan posted, large or heavy packaging may not be stored at heights, equipment and tools may not be stored in the dangerous substance storage room);

e) Compliance with product expiry dates and implementation of a disposal procedure for substances which are not needed or which have expired;

f) Entrances, exits and access to emergency equipment are kept clear at all times.

26.8.4 Storage areas are clearly identified with warning signs at the entrance. The Contractor displays the storage plan (location of the different products, maximum inventory), a summary of labelling system and information on chemical incompatibilities.

26.8.5 Chemicals which could react together (leading to explosions, fire, projections or the emission of dangerous gases) are physically separated.

26.8.6 Products that react violently with water are stored so as to prevent contact with water, even in the event of flooding.

26.8.7 Inflammable products are stored separately in a dedicated area with adequate ventilation at all times.

26.8.8 Buildings used to store large quantities of dangerous substances are isolated from other buildings to avoid the spreading of fire. Such buildings are constructed using solid and non-combustible building materials, and are equipped with evacuation systems and the appropriate firefighting equipment. Access to the buildings is clear, allowing for rapid evacuation in the event of an accident. The electrical systems are reduced to the essential minimum, and access points are equipped with adequate lighting (300 lux).

26.8.9 All storage areas are equipped with secondary retentions. Each storage area acts as a general secondary retention. Suitable

absorbents (neutralising and non-combustible) are available in the storage area to clean up any spills and leaks.

26.8.10 The Contractor maintains the storage area at a suitable temperature for storing dangerous substances at an appropriate level to avoid any deterioration of the containers.

27 Planning for emergency situation

27.1 The emergency plan required in application of Sub-Clause 21.2 of the ESHS Specifications covers the following emergency situations as a minimum:

a) Fire or explosion;

b) Structural failure;

c) Loss of the containment of dangerous substances;

d) Safety incident or malicious act;

e) Natural disasters.

27.2 The Contractor details the emergency plan in the Health and Safety Plan.

27.3 The Contractor ensures that all personnel are informed and aware of how to react in an emergency situation, and responsibilities are defined. Information and awareness training are documented, and available on all Project Areas.

27.4 The Contractor organises and documents emergency simulation exercises within 3 months of the physical start of the Works, and subsequently once every 12 months up to the issue of the Taking-Over Certificate. The Engineer is invited to participate in each of these exercises.

27.5 Fire extinguishers are made available in each building at clearly identified locations.

28 Medical check-ups

28.1 The Contractor organises medical check-ups for all Contractor's Personnel prior to the initial mobilisation to the Project Area to check aptitude for the work. Medical check-ups are adapted to the anticipated occupied positions and carried out pursuant to the recommendations of the International Labour Organization. Subsequent to the check-up, a written medical certificate is issued declaring the aptitude of the worker for the allocated tasks.

28.2 Hearing tests are conducted for the Contractor's personnel exposed to specific risks (such as noise levels above 80 dB(A), exposure to hazardous materials, etc.) in order to establish an initial state of health. Annual tests are carried out to monitor any changes and detect any deterioration.

28.3 The Engineer can request additional medical examinations for the Contractor's Personnel if considered necessary, and all associated costs shall be borne by the Contractor.

28.4 A medical examination is carried out on any Contractor's Personnel returning to work after leave caused by a work related accident. A written medical certificate is issued confirming the Contractor's Personnel's aptitude to return to work at the designated workstation.

28.5 The Contractor can produce a copy of its Contractor's Personnel's work aptitude certificates at the request of the Engineer or any competent authority.

28.6 Specific arrangements for tasks' assignments or workstations shall be made for pregnant Personnel.

29 First aid

29.1 The Contractor ensures that at least one first aid officer is present at all times during working hours per Project Area and per team of 10 to 50 workers present, and one extra first aid officer for each additional 100 workers.

29.2 The Project Area must be equipped with a communication system available immediately and primarily for the purposes of communication with the first aid services. Information on how to communicate with the first aid services is clearly indicated near the communications equipment.

30 Health care centre & medical personnel

30.1 For Project Areas with more than 35 workers present at any one time and where it is not possible to reach a hospital, medical clinic or the Contractor's health centre within a period of 45 minutes, by land and in normal conditions:

30.1.1 The Contractor sets up a health care centre at its own cost. This centre is:

a) Operational and easy to access all times;

b) Kept clean and in good condition;

c) Equipped with appropriate heating or air-conditioning;

d) Equipped with sanitary facilities and drinking water;

e) Equipped with instruments, equipment, medicines and material required to examine and treat injured or sick workers in emergency conditions;

f) Equipped with the supplies and furnishing required to allow medical personnel to provide first aid and fulfil their other functions.

30.1.2 A doctor is present on-site at all times, working full-time during normal day hours. The doctor is on-call when more than 20 workers are working simultaneously outside of normal day hours.

30.1.3 The doctor has the following profile:

a) At least 5 years' experience on large-scale construction works at sites located at a distance from a hospital;

b) Trained in infectious diseases, waterborne and epidemiological diseases prevalent in the Employer's country;

c) Able to lead training sessions on occupational health and first aid;

d) Trained in management and logistics for a remote health care centre;

e) Able to speak the same working language used by most members of personnel fluently (communication in emergency situations);

f) In good physical condition, able to access remote working areas.

30.1.4 The Contractor allocates a road or air vehicle for first aid purposes to the first aid station pursuant to standard NF EN 1789/2007.

30.1.5 The Contractor ensures the presence of at least one nurse to assist the doctor per team with 200 - 800 workers allocated, and one extra nurse for each additional 600 workers allocated to this team. Over and above 500 workers per team, the Contractor ensures the presence of an extra doctor for each additional 500 workers allocated to this team.

31 First aid kits

31.1 Each Project Area must be equipped with an adequate number of first aid kits to ensure that all workers can access these kits in approximately 5 minutes. Kits must be available at all times.

31.2 Each vehicle is equipped with a first aid kit.

31.3 First aid equipment complies with attached specifications.

32 Emergency medical evacuations

32.1 The Contractor establishes, and provides the Engineer within one month of the physical start of works a copy of an agreement with a specialised company for the handling of personnel in the event of a serious accident requiring an emergency medical evacuation, which cannot be organised using the first aid vehicle specified in Sub-Clause 30.1.4 of the ESHS Specifications without endangering the life of the patient.

32.2 The agreement includes a convention with a referring hospital where the member of personnel evacuated in emergency conditions will be treated.

32.3 The agreement covers the use of air transportation in order to evacuate the injured patient(s) to the referring hospital.

33 Access to health care

33.1 The Contractor guarantees access to health care as defined in Clause 30 for all personnel in necessary cases of accident or illness occurring during the execution of the Works, i.e.:

a) Medical check-ups: initial (recruitment), annual and upon returning to work after sick leave;

b) Screening, vaccinations and preventive healthcare;

c) General healthcare during the execution of the Works;

d) Medical assistance in the event of an accident and assistance for emergency evacuations.

33.2 Subcontractor's personnel, other contractors, the Employer or the Engineer, present at the Project Area, must never be refused medical assistance, under the pretext that they are not directly employed by the Contractor. The Contractor may however define a unit rate cost per medical act for personnel, other than its own Contractor's Personnel, display this rate in the healthcare centre and forward the information to the Engineer.

33.3 In the event of accident or serious illness, medical personnel must be trained, available and equipped with the necessary material, medicines and consumables to provide first aid for the patient, stabilise their condition, until the patient is:

a) Either treated or discharged; or

b) Hospitalized at the camp or in a larger hospital; or

c) Evacuated to a medical centre which is well equipped for intensive care, if necessary.

34 Health monitoring

34.1 The Contractor cannot recruit workers in poor health.

34.2 The initial pre-recruitment examination must confirm that applicants carry no infectious diseases and are physically able to carry out the tasks required for the position.

34.3 The detection of pregnancy during the initial pre-recruitment examination of female applicants shall not constitute grounds for declining recruitment, unless medical risk is proven.

34.4 The Contractor organises annual medical check-ups for its Contractor's Personnel and keeps up to date a medical record for each Contractor's Personnel. The presence of Contractor's Personnel for medical check-ups, treatment and hospitalisation is incorporated into the Contractor's planning.

34.5 The Contractor provides the Contractor's Personnel with prophylaxis and vaccinations against local diseases and vectors. In particular, the Contractor will promote the use of impregnated mosquito nets by its Contractor's Personnel in camps or off-site lodging, and distributes these nets appropriately.

34.6 The Health and Safety Plan includes a Contractor's Personnel health risk assessment based on exposure to specific risks (such as noise levels above 80dB(A), exposure to hazardous materials, etc.) and describes the medical monitoring implemented.

35 Sanitary repatriation

35.1 The Contractor is responsible for the sanitary repatriation of Contractor's Personnel in the event of a serious injury or illness. The Contractor will take out the necessary insurance to cover the cost of the sanitary repatriation of its Contractor's Personnel.

36 Hygiene, accommodation and food

36.1 Drinking water:

36.1.1 Pursuant to Sub-Clause 6.14 of the CC, the Contractor provides personnel with drinking water at all Project Areas. The quantity and quality of this water complies with the standards of the World Health Organization at supply points.

36.1.2 Unless the supply of drinking water is provided by a certified supplier, the quality of the drinking water provided to workers is tested at least at the start of the Works and then on a monthly basis. The protocol for taking and analysing samples is based on the recommendations of the World Health Organization. The results shall be documented and made available on the Project Areas.

36.2 Accommodation conditions:

36.2.1 The accommodation provided for non-resident Personnel in a camp or an alternative structure outside of the Project Areas, such as a hotel or rented house, will comply with the conditions of Sub-Clause 36.2 of the ESHS Specifications in pursuance of Sub-Clause 6.6 of the CC.

36.2.2 Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, Personnel are housed in rooms. Rooms do not host more than 4 individuals, with no bunk beds, and with 0.5 m^3 of storage space available per person.

36.2.3 Rooms shall not be mixed: separate rooms must be made available for both men and women.

36.2.4 Rooms are lit and equipped with power sockets, beds and windows fitted with mosquito nets. Flooring is of a hard and impervious material.

36.2.5 The temperature in rooms and common areas shall be kept at an appropriate level during occupied hours.

36.2.6 Night-time noise levels to which personnel are exposed comply with the limits recommended by the World Health Organization.

36.2.7 The Contractor provides one drinking water tap per 10 Contractor's Personnel, one shower per 10 Contractor's Personnel as a minimum, one individual toilet for 15 Contractor's Personnel as a minimum, and one urinal per 25 Contractor's Personnel at accommodation camps. Separate showers, toilets and locker-rooms must be made available for women.

36.2.8 The Contractor constructs and maintains a shared leisure area in each camp and a sports field for use by Personnel.

36.3 Hygiene in shared areas:

36.3.1 Sanitary areas (showers, sinks, urinals, toilets) are cleaned and disinfected by the Contractor's cleaning service at least once every 24 hours. Cleaning operations are documented.

36.3.2 The canteen, kitchen and kitchen utensils are cleaned after each meal service.

36.3.3 The number and location of toilets on Project Areas shall be adapted to the number of employees and the configuration of the Project Areas (distance, isolated area, etc.). Separate toilets will be made available for women.

36.4 Food:

36.4.1 In application of Sub-Clause 6.13 of the CC and Sub-Clause 41.1 of the ESHS Specifications, the Contractor provides meals at a reasonable cost to its Contractor's Personnel in a canteen area and according to a procurement system which complies with the provisions of Sub-Clause 36.4 of the ESHS Specifications.

36.4.2 The Contractor defines and implements actions in order to guarantee (i) the quality and quantities of food stuffs, (ii) compliance with health rules when preparing meals, (iii) fitting out and servicing premises and equipment, both in the kitchen and food storage areas.

36.4.3 The Contractor inspects the cleanliness of food transport vehicles, temperature control and the cold chain, as well as best before dates, and takes the necessary corrective actions. The temperatures of chillers are regularly checked.

36.4.4 The Contractor checks that health requirements are met for food storage conditions in the kitchen or other locations, food cooking times and temperatures, and the conditions in which prepared products are left prior to consumption, to ensure no health risks. No food remains are to be reused.

36.4.5 The Contractor recruits trained canteen personnel and ensures that supervisors monitor compliance with sanitary instructions. The Contractor ensures that canteen personnel have means of ensuring compliance with health rules (changing rooms, linen, hand washers, the condition of flooring and paint, and the existence of a cleaning plan).

36.5 The ESHS Manager carries out an audit on all Project Areas every 3 months, and documents the results, and includes the conditions of hygiene in which meals are prepared and food conserved. The results of this audit are provided to the Engineer.

36.6 The ESHS Manager regularly informs Contractor's Personnel on appropriate behaviour in terms of workplace hygiene. This information is documented and saved.

37 Substance abuse

37.1 Pursuant to Sub-Clause 6.16 of the CC, the use, possession, distribution or sale of illegal drugs, controlled substances (as per local regulations) and alcohol is totally prohibited on the Project Areas. The Contractor implements a zero tolerance policy for the consumption of these substances.

37.2 Any person suspected by the Engineer to be under the influence of alcohol or controlled substances on any Project Area is immediately suspended from his position by the Contractor, pending the results of medical tests.

D. Local Labour and Relations with Local Communities

38 Labour conditions

38.1 The Contractor should ensure decent labour conditions for workers and notably compliance with applicable law and regulations in the country of implementation of the contract, and with the fundamental conventions of the International Labour Organisation (ILO). This includes workers' rights related to wages, working hours, rest and leave, overtime, minimum age, regular payment, compensation and benefits. The Contractor should respect and facilitate workers' rights to organise and provide a grievance mechanism for all direct and indirect workers. The Contractor should implement non-discrimination and equal opportunity practices, and ensure prohibition of child or forced labour.

39 Local recruitment

39.1 Local recruitment is defined as the number of positions actually allocated to people residing in the region of the Works, which must be defined by the Contractor in its offer according to relevant criteria by giving priority to populations living in the area of influence or in the immediate proximity of the Project Area.

39.2 Pursuant to Sub-Clause 6.1 of the CC, the Contractor implements a voluntary local recruitment policy for its personnel for the duration of the Works and shall enforce this policy to its Subcontractors.

39.3 The Contractor demonstrates the effective implementation of this voluntary policy to the Engineer in its monthly activity report as defined in Sub-Clause 6.3 of the ESHS Specifications.

39.4 Pursuant to Clause 8 of the ESHS Specifications, the Contractor shall develop a training program. This training program must be open to women and men and be adapted to their level of education and needs of each group to occupy the positions proposed during the Works.

39.5 Local labour needs are estimated prior to the start of Works and described in the Worskite - ESMP with the following information:

a) Identification of positions that could be filled by local staff and the level of qualification required;

b) Definition of the planned procedure for the effective recruitment of these members of staff;

c) Establishment of mechanisms to ensure non-discrimination of women in accessing recruitment procedures. This mechanism must cover the definition of the positions, the methods of communication on the positions to be filled, etc.;

d) Deployment schedule for these positions;

e) Initial training to be provided by the Contractor for each job description.

39.6 In order to prevent outsiders from entering the Project Area, local recruitment at the Project Area, including at the entrance, is prohibited.

39.7 Local recruitment office:

39.7.1 Prior to the start of works, the Contractor establishes a local recruitment office in the district where the main Project Area is located, at a location pre-approved by the Engineer.

39.7.2 A representative of the Contractor is present in this office at least two mornings each week, from the start of the Works to a date pre-approved by the Engineer.

39.7.3 The representative provides information on job vacancies with the Contractor for the execution of the Works (required qualifications, duration, and location) and on the information to be provided in applications.

39.7.4 Lists of local candidates are drafted by the representative allocated to the office and forwarded to the Contractor's humans resources manager on a weekly basis.

39.8 The Contractor's Human Resources manager selects candidates listed by the local recruitment office based on requirements for the Works and the Contractor's recruitment procedures. A written contract between the Contractor and the local Contractor's Personnel is drafted, signed and archived by the Contractor.

39.9 If the Project Areas are located near to several different communities, the Human Resources manager ensures a fair distribution of local recruitment between the different communities, by giving priority to the people affected by the project.

39.10 The Human Resources manager will ensure that recruitment campaigns in local communities have been spread to women and that the latter have not been discriminated in recruitments.

39.11 Pursuant to Sub-Clause 6.22 of the CC, the Contractor maintains one record per local Contractor's Personnel indicating the hours worked per person allocated to the Works, the type of tasks carried out, the wages paid and any training taken. Records are available at the main Project

Area at all times, so the Engineer and the authorised representatives of the government can assess the content.

39.12 Social inclusion requirements

The Contractor shall contribute to achieving the Employer's objective which consists in creating suitable conditions for concerned persons to the return to employment, by complying with the requirements specified in paragraph 3. of the introduction to the ESHS Specifications. These requirements consist in social inclusion actions that may include technical trainings.

Depending on the requirements specified in paragraph 3. of the introduction to the ESHS Specifications, the implementation of employment-intensive work programs may constitute part of the approach to comply with these requirements.

39.12.1 Social inclusion technical assistance

If a Social Supervisor is designated in Article 1.1.2.4 of the SCC, it will provide technical assistance and will act as an intermediary between the groups targeted by these social inclusion requirements, employment professionals and/or vocational training experts, the Contractor (and its Subcontractors, if any) and the Employer.

It will be in charge of:

- Assisting the Contractor in implementing social inclusion requirements, in relation with the Engineer,
- Identifying, with specialized bodies' support, the potential beneficiaries of social inclusion measures,
- Approving profiles selected by the Contractor before they start any work,
- Monitoring training and assistance measures for beneficiaries in the workplace and ensuring that the Contractor meets the social inclusion requirements,
- Assisting the Contractor (employment contracts, recruitment process, individual social follow-up, group-based coaching, site visits and meetings, grievance mechanism implementation, etc.),
- Approve the distribution methodology and the profiles selected by the Contractor to benefit from equipment donation as stated in paragraph 3. of the introduction to the ESHS Specifications.
- Monitoring and assessing the social inclusion requirements'implementation (follow-up of activities, educational assessments, trainings undertaken, jobs needed for construction work, assessment of social inclusion in the long-term...). The Social supervisor will also support the Contractor in reporting on its implementation of social inclusion requirements to the Employer.
- Monitoring and assessing the implementation of the ESHS clauses related to gender issues (Articles 26.3, 28.6, 36.2.3, 36.2.7, 36.3.3, 39.4, 39.5 and 39.10) and decent work (Article 38.1).

39.12.2 Social inclusion follow-up

The Social Supervisor will monitor the implementation of social inclusion activities which the Contractor has committed.

The Contractor will send to the Social Supervisor the following supporting documents for all employees involved in social inclusion activities: proof of eligibility (if applicable, according to the conditions set out in the introduction to the ESHS Specifications, paragraph 3. "Social inclusion requirements"), employment contracts, pay slips and monthly statements showing the days or hours worked, information on implemented training programs and socio-professional support.

In case of secondment of staff or using a Subcontractor, social inclusion hours or days shall be considered from the date of the actual payment made to a third party. The Social Supervisor should receive the same supporting documents as mentioned above, just as in the case of a direct hire.

During the works, several meetings will enable to discuss social inclusion follow-up. The Social Supervisor may attend these meetings.

In the event of implementation difficulties (employment protection plan, receivership or compulsory liquidation), the Contractor must inform the Employer. It will also provide all supporting documents that demonstrate it cannot achieve its commitment, regardless of the reason.

In such cases, the Employer and the Contractor will explore ways to achieve the social inclusion objectives or suspend the obligations.

39.12.3 Social inclusion reporting

Every six months, the Contractor shall provide a short review that summarizes the social inclusion approach and its results.

A final report is also due once the works are completed. The final report shall include qualitative and quantitative indicators of social inclusion measures implemented by the Contractor. The Contractor shall specify career prospects and provide a statement of completion for each beneficiary.

39.12.4 Special provisions for maintaining social inclusion activities:

Subcontracting: if any part of the work is subcontracted, the Contractor shall ensure that its subcontractors working on tasks targeted by social inclusions requirements per this Contract also meet such requirements.

Delay or suspension of works: if the works are delayed or suspended for any reason (technical or financial) beyond the Employer's control, the Contractor shall commit to continue to deliver to the best extent possible social inclusion activities by reassigning affected beneficiaries among its other construction sites.

Early leaving: In case of dismissal or voluntary departure of any social inclusion beneficiary, the Contractor shall inform the Employer within eight calendar days at the latest, specifying the reasons for ending the contract. A replacement person shall be hired as soon as possible, who shall to the best extent possible also be among targeted people per the conditions set out in the introduction to the ESHS Specifications, paragraph 3. "Social inclusion requirements").

40 Transport & accommodation

40.1 Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, the Contractor provides or enables access to daily transport for

Contractor's Personnel living more than 15 minutes' walk from the Project Area and more than one hour by land transport.

40.2 The transport is organised under conditions which comply with local regulations and which ensure the safety of the people transported.

40.3 The Contractor organises collective transport: pick-up times and locations are defined and services organised appropriately.

40.4 If the Project Area is moved during the working season and if the Contractor retains the local personnel trained at the start of the Works, the accommodation of the Contractor's Personnel is managed by the Contractor:

a) Within a mobile camp with the other non-local Contractor's Personnel; or

b) In villages located near to the mobile Project Area, in this case, each local Contractor's Personnel will receive a housing allowance in addition to his wages.

41 Meals

41.1 Food supplies for the meals of the Contractor personnel will exclude any meat obtained from hunting or poaching, with the exception of fish.

41.2 The Contractor provides at least two meals per day to local Contractor's Personnel pursuant to the hygiene conditions specified in Clause 36 of the ESHS Specifications, at reasonable price.

42 Damage to people and property

42.1 The Contractor shall not disturb or interfere with the inhabitants of local communities close to or in the Project Area, and shall respect their houses, cultures, animals, properties, customs and practices.

42.2 Pursuant to Sub-Clauses 4.14 and 17.1 of the CC, the Contractor is responsible for damages to people and property caused by the execution of the Works or the procedures used for execution.

42.3 Access to the Project Areas is prohibited to unauthorized persons. The Contractor is responsible for the security and access control of the Project Areas.

42.4 The Engineer is informed of any damage caused to people, or the property of individuals, other than the Contractor's personnel, within 6 hours of the event, regardless of the value of the prejudice.

42.5 Housing existing before the start of the Works, located within a minimum radius of 800 m around the perimeter of the quarries and within a minimum radius of 500 m around the other Project Areas that will be subject to blasting, will be examined by a bailiff unless agreed upon otherwise with the Engineer.

42.6 The bailiff's sworn statement is prepared and provided to the Engineer with the EPP.

42.7 Should any problems be detected due to the intensity of blasting, the Engineer is entitled to request that the Contractor carry out seismic measurements of the intensity of the vibrations induced by the blasting, at variable distances from the blasting points, under the supervision of the Engineer, and at the cost of the Contractor.

43 Land acquisition and land take

43.1 Pursuant to Sub-Clause 7.8 of the CC, the Contractor will cover (i) occupancy indemnities for the extraction or use of construction

materials and (ii) the cost of acquiring or temporarily occupying the necessary land to stockpile excess backfill material.

43.2 The Contractor provides compensation for any prejudice suffered by the owners and users of this land, if these users are not the same parties as the owners.

43.3 The Contractor demonstrates to the Engineer (i) who are the owner and the users, if different parties have been identified, and (ii) a written agreement governing the temporary occupancy or acquisition of this land has been negotiated and duly paid up to the two parties, if different.

44 Traffic

44.1 The Contractor defines a Traffic Management Plan in Worksite - ESMP (section 11 as defined in Appendix 1 to the ESHS Specifications).

44.2 The Traffic Management Plan:

a) includes the characteristics of its fleet of vehicles and site machinery; and

b) defines the itineraries used on a map for each route between the different Project Areas that must be validated by the Engineer.

44.3 The Contractor requests that the Employer obtain the authorisations of the competent administrative authorities if public roads are used. Any Engineer's instruction to update the Traffic Management Plan shall be implemented.

44.4 Within one month of the physical start of Works, the Contractor informs the administrative authorities of areas crossed by the Contractor's vehicles, of the itinerary and characteristics (frequency of passing, size and weight of trucks, materials carried) of the Contractor's fleet of vehicles.

44.5 If public roads are used, and unless approved otherwise by the Engineer, the Contractor mandates a bailiff to make a sworn report regarding the state of the road prior to use by the Contractor's vehicles. The report is annexed to the Traffic Management Plan.

44.6 The Contractor describes in the Traffic Management Plan the expected traffic created by its fleet of vehicles (frequency of trips between Project Areas, working hours, convoys).

44.7 The Contractor also describes the number and positioning of flagmen.

44.8 Unless specified otherwise in the Contract or instructed otherwise by the Engineer, heavy vehicles (i.e. with a GVWR of more than 3.5 tons) may not be used at night between 22:00 and 06:00.

44.9 Speed limits:

44.9.1 The Contractor takes action to limit and check the speed of all vehicles and machinery used to execute the Works.

44.9.2 The maximum speed of all machinery and vehicles of the Contractor comply with the lowest of the following: the speed limit defined according to the Employer's country regulations or the following limits.

a) 10 km/h within the Project Area;

b) 30 km/h in villages or hamlets, in towns, from 100 m before the first house;

c) 80 km/h on unpaved roads outside of towns, villages, hamlets and camps.

44.9.3 Pursuant to Sub-Clause 4.15 of the CC, and in coordination with the competent Employer's country authorities, the Contractor provides and installs signs for the fleet of vehicles along public roads, when public signs are inadequate.

44.9.4 The Contractor provides each of its drivers with a map at the appropriate scale of the roads authorised for the execution of the Works, clearly indicating the maximum speeds authorised, and ensures their understanding.

44.10 It is strictly prohibited to transport people, equipment or products other than those required for the Works and the management of Project Areas, on board any of the Contractor's vehicles. This provision also applies to the transport of live animals and meat obtained from hunting, fishing or poaching.

44.11 The trailers and skips used to carry materials which could be projected (sand, crushed material, aggregates, selected materials) are covered with a tarpaulin for the entire itinerary between two Project Areas.

44.12 The Contractor carries out regular inspections along the roads used by its fleet of vehicles to ensure compliance with the provisions of Clauses 44.8 to 44.11 of the ESHS Specifications. The Contractor records these inspections and the results and transmits a summary of checks carried out for the previous month to the Engineer on a monthly basis.

APPENDIX 1 – Contents of Worksite - ESMP

1.	**ESHS policies**	➢ OSH,Environmental and Human Resource policies ➢ Declaration of ESHS policy signed by the managing director of the Contractor and clearly defining the commitment of the Contractor in terms of (i) ESHS management for its construction sites and (ii) compliance with the ESHS Specifications of the Contract.
2.	**Worksite -ESMP**	➢ Target and content of the Worksite Environmental and Social Management Plan ➢ Preparation and updating schedule ➢ Quality assurance and validation
3.	**ESHS resources**	➢ Human resources: — ESHS Manager / Expert — Environmental and Social Officer — Health and Safety Officer — Person in charge of relations with stakeholders — Medical personnel ➢ Logistics & communications: — ESHS vehicles — IT stations — In situ noise, vibration, air and water measuring equipment — Analysis laboratory used ➢ Reporting: — Weekly inspections — Monthly — Accident / Incident
4.	**ESHS regulations**	➢ Definition of standards for the applicable national ESHS regulations and the ESHS recommendations of institutions affiliated to the United Nations (WHO, ILO, IMO, IFC), applicable to the execution of works: — Noise and vibrations limits — Ambient air quality limits — Drinking water quality limits — Discharge standards — Minimum wage — Day and/or night traffic restrictions — Other (exposure limits, speed limits, axle limits, load limits) ➢ Definition of ESHS standards for the industry applied
5.	**ESHS operational inspection resources**	➢ Site tracking procedure: — Frequency — Personnel — Assessment criteria ➢ Non-conformity handling and detection procedure: — Distribution information — Notification depending on the level of importance allocated to non-conformities — Tracking of the closing of the non-conformities ➢ Management of data on tracking and non-conformities: — Archiving — Use as a performance indicator
6.	**Project Areas**	➢ Description of Project Areas (as per definition in Sub-Clause 1.3 of the ESHS Specifications): — Number

		— Location on a topographical map — Activities — Opening & closing schedule — Access ➢ Reference to the Appendix: an Environment Protection Plan (EPP) for each Project Area
7.	**Health and Safety Plan**	➢ Hazard prevention and control by undertaking risk assessments ➢ Identification and characterisation of health and safety risks, including the exposure of personnel to chemicals, biological hazards and radiation ➢ Description of working methods to minimise hazards and control risks as per hiearachy of controls ➢ List of the types of work for which a work permit is required. ➢ Personal protection equipment (PPE) and PPE issuance and replacement policy. ➢ Presentation of the medical facilities at Project Areas: — Healthcare centre, medical equipment and allocation of medical staff — Medical acts that can be carried out on-site — Schedule of periodic exposure monitoring — Ambulance, communications — Referring hospital ➢ Evacuation procedure for medical emergencies. ➢ Description of the internal organisation and action to be taken in the event of an accident or incident.
8.	**Training plan**	➢ Basic training for non-qualified staff ➢ Specific Environment, Social, Health & safety trainings covering all work hazards/risks identified during the ESIA process and updated following operational Risk Assessments conducted during contract implementation.
9.	**Labour Management**	➢ Detailed of Human Resource Policy for construction works of direct and indirect workers which includes but not limited to workers GRM, condictions of employment, salaries and renumeration procedures, separation procedures, leave days, conduct and discilplinary procedures etc.
10.	**Local recruitment**	➢ Local labour requirements: — Job descriptions and the levels of qualifications required — Detailed recruitment procedures (includes feedback mechanisms for applicants) and deployment schedule — Initial training to be provided by the Contractor for each job description ➢ Location and management of the local recruitment office(s) ➢ Social inclusion plan: — Description of social inclusion activities: characteristics and number of beneficiaries, social inclusion objectives, nature of the works invoved, proposed methodology (employment-intensive work programs …), recruitment process, resources to be deployed to give access to a stable employment or relevant training courses corresponding to the professional objectives of each person at the end of the works, specific actions to prevent harassment, to promote gender equality and to establish a dialogue with affected communities, monitoring and reporting mechanisms, results obtained dealing with similar activities in other contexts… — Management and support staff resources dedicated to social inclusion activities — Specific supporting activities in case beneficiaries of social inclusion requirements and other employees are not employed for the same tasks in the works. — Approach envisaged for the completion of works regarding employees — Suggested technical trainings
11.	**Traffic Management Plan**	➢ Description of the fleet of vehicles/machinery used for the execution of the Works ➢ Deployment (Project Area & schedule) and maintenance sites for each vehicle and machine ➢ Mapping of itineraries, travel times, and areas where speeds are limited ➢ Drivers management plan – to include recruitment, practical tests, training (regular/routine & defensive), code of conduct, breath alcohol tests

		➢ Dust suppression: — Mapping or road sections where dust reduction initiatives apply — Water points identified or to be created for refilling tanker trucks — Capacity of the tanker trucks used and calculation of the number of trucks required — Width of the track to determine if one watering run or equivalent is adequate (narrow track) or if two runs are required (wide track) — Number of watering or equivalent operations proposed per day depending on the climate
12.	**Dangerous products**	➢ Inventory of dangerous products per Project Area and per period ➢ Transport and storage conditions and chemical incompatibility ➢ Procedures for handling of hazardoues and dangerous materials ➢ Emergency provision in cases of spills, explosions, asphyxiation, drowining etc
13.	**Effluents**	➢ Characterisation of effluents discharged to the receiving environment ➢ Facilities for the treatment or pre-treatment of effluents ➢ Measures for reducing the sediment content of rainwater runoff ➢ Measures for monitoring the efficiency and performance of facilities for reducing sediment content of rainwater runoff ➢ Resources and methods for monitoring effluent and rainwater runoff quality
14.	**Noise and vibrations**	➢ Identification of potential sources of noise pollution activities ➢ Estimation of the frequencies, duration, days of the week and noise levels per Project Area ➢ Measures to minimise noise pollution and monitoring frequencies
15.	**Waste**	➢ Waste management strategy including site specific waste management plans that includes but not limited to the following: o Inventory of waste per Project Area and per period o Collection, intermediate storage, handling and treatment/disposal methods for ordinary or inert waste o Storage, handling and disposal methods for dangerous waste o Tracking manifest to be maintained.
16.	**Clearing and revegetation**	➢ Methods & schedule for clearing vegetation and earthwork activities ➢ Methods, species and schedule for the revegetation of Project Areas disturbed by the Works
17.	**Biodiversity**	➢ Schedule for adequate fauna and flora management ➢ Measures for minimizing impact on fauna and flora species based on the Contracting Authority procedures ➢ Measures for monitoring the efficiency and performance of the plan in place ➢ Measures for limiting IAS ➢ Measures for monitoring the efficiency and performance of the plan in place
18.	**Prevention of erosion**	➢ Location of zones suffering from erosion ➢ Methods and schedule for the implementation of anti-erosive actions, including topsoil storage ➢ Monitoring and evakuation, monitoring frequency and monitoring indicators

19.	**SEA/SH prevention and response**	➢ Prevention of SEA/SH by developing Code of Conduct detailing: o Definitions of SEA/SH and including examples of SEA/SH, o Roles and responsibilities of project personnel, o Prohibited behaviour including committing SEA/SH o Mandatory reporting, protocols for protection of whistle blowers and prohibition of retaliation against survivors o Grievance reporting and case management and applicable sanctions both administrative and disciplinary for breach of the code of conduct The Code of Conduct must be written in plain language and signed by each employee that they have received a copy of the code of conduct, the code of conduct has been explained to them and acknowledge adherence of the code of conduct as a condition of employment and understood sanctions for violating the code of conduct that include dismissal or referral to legal authorities. ➢ Map out GBV multisectoral support services that are available and assessable to provide quality and timely support to survivors ➢ Establish SEA/SH referral pathways that include protocols and forms for safe and confidential referral of cases to survivors ➢ Set up gender sensitive Grievance Mechanism detailing: o Specific procedures for handling SEA/SH and GBV complaints including key guiding principles, roles and responsibilities, timeframe, steps, and possible sanctions, o Procedures for reporting SEA/SH and GBV incidents, including available safe channels for targeted communities and project staff o Guiding principles for the safe, ethical, and confidential management of SEA/SH and GBV complaints. o Protocols on responding to survivors, applying the survivor-centered approach, including a referral pathway to refer survivors to appropriate support services. o Specific provisions to address allegations involving children who are survivors of SEA/SH, including the consideration of the best interest of the child, specialist support services, and the role of parents/guardians in the response process. o Protocols to comply with mandatory reporting requirements, if applicable under national law, including to inform survivors (at the point of disclosure) of this obligation and any limits on confidentiality. ➢ Develop workers and community awareness training plan for the project SEA/SH /GBV risks ➢ Measures to ensure safe workplace for women and men e.g. separate facilities for women and men ie gendered toilets, separate sleeping areas, well-lit work sites ➢ Display of IEC materials on zero tolerance to SEA/SH /SH/GB.
19.	**Documentation on the Project Area condition**	➢ List and cover of viewpoints ➢ Imaging method ➢ Archiving photographs ➢
20.	**Labour Influx Plan**	➢ Identify social and environmental risks associated with labour influx in the project area ie social conflicts, increased illicit behaviour, increased pressure on existing resources e.g. water, accommodation, spread of communicable diseases etc. ➢ Provide mitigation measures on the identified risks, monitoring frequency and monitoring indicators
21.	**HIV Prevention**	➢ Provide sufficient plan to raise awareness to workers and community and provide materials to help workers on prevention of such infections.eg distribution of condoms etc. ➢ Provide monitoring and evaluation measures, monitoring frequency and indicators
22.	**Campsite Management plan**	➢ Detailed Identification of environmental, social health and safety risks associated with the construction, operation and decommissioning of the worker's campsite. ➢ Detailed provision of measures for campsite management, monitoring and evaluation measures, monitoring frequency and indicators ➢ Including Solid and liquid waste management.

23.	**Stakeholder Engagement Management plan**	➢ Identify people, groups or communities that may be directly or indirectly affected by the Project or have an interest in it. ➢ Identify the nature, frequency and timing of each stakeholder engagement which must be free, prior and informed consultation of impacted communities and facilitate their informed participation in the project construction and operation. The plan to focus on early, long term and proactive stakeholder engagements. ➢ Undertake monitoring to evaluate effectiveness of the plan, provide monitoring indicators and frequency of monitoring
24.	**Community GRM Plan**	Provide an accessible and functional community GRM process with clear process for receipt, acknowledgement of grievance forms the community, assess, respond and resolve grievances. ➢ Provide clear timeliness for resolution of grievances, methodology of resolving grievances and escalation procedures. ➢ Monitoring and evaluation process on the effectiveness of the plans, monitoring indicators.
25.	**Chance find procedures**	➢ Management of chance find ➢ Training in chance find procedures
26.	**Community health and safety plan**	➢ Identify specific risks the community is exposed to as a result of construction activities and strategies to minimize the impacts. ➢ Identify monitoring and performance indicators.
27.	**Rehabilitation**	➢ Method and schedule for Project Area rehabilitation
28.	**Appendices**	➢ Environment Protection Plans (number and location specified in Section 6 "Project Areas" above): — Marking out of the Project Area perimeter on a map — Definition of zones for vegetation clearing, zones for the storage of usable timber, zones for burning of green waste — Definition of on-site activities: construction, storage areas, accommodation areas, offices, workshops, concrete making units — Layout of activity areas on the Project Area: construction works, production/operation areas, rehabilitation and closure — Zones for the storage of topsoil, spoil from earthworks, materials — Access routes and checkpoints — Project Area occupancy schedule — Organisation of Project Area preparation — Liquid discharge outlet points — Proposed sampling points for monitoring water quality, air quality and noise — Atmospheric emission outlet points — Location of the storage site for dangerous products — Location and mapping of waste treatment facilities when handled by an external service provider — Any other information relating to the environmental management of the Project Area — Accident reporting forms — Risk assessment forms — Safe work method statement forms — Permit to work forms — ESHS safety audit forms — ESHS checklists

		— Grievance acknowldgement forms — Chance find form — Stakeholders engagement log template — Grievance engagement log template — List and location of emergency equipment ➢ Emergency plan: — Description of facilities — Characterisation of hazards — Emergency situations — Organisation structure - roles and responsibilities — Emergency procedures — Human and material resources — Triggering of the plan — Reporting ➢ Bailiff's sworn reports as specified in Sub-Clauses 10.5, 42.4 and 44.5 of the ESHS Specifications.

APPENDIX 2 – Properties rendering a product dangerous[1]

1.	**Explosive**	substances and preparations which could explode in the presence of a flame or which are more sensitive to impacts and friction than dinitrobenzene.
2.	**Combustive**	substances and preparations which, when in contact with other substances, particularly inflammable substances, undergo strongly exothermic reactions.
3.	**Easily inflammable**	substances and preparations (i) in liquid phase (including extremely inflammable liquids), with a flash point below 21°C, or which can heat up to the extent of spontaneous combustion in ambient air; or (ii) in solid phase, which can burst into flames easily in the brief presence of a source of inflammation and which will continue to burn after the removal of the source of inflammation or (iii) in gaseous phase, which are inflammable in air at normal pressure; or (iv) - which, when in contact with moist air or water, produce dangerous quantities of gases which are easily inflammable.
4.	**Inflammable**	liquid substances and preparations, with a flash point equal to or above 21°C and less than or equal to 55°C.
5.	**Irritant**	non-corrosive substances and preparations which, when in immediate, extended or repeated contact with the skin and mucosa, can cause inflammation.
6.	**Harmful**	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to risks of limited severity.
7.	**Toxic**	substances and preparations (including highly toxic substances and preparations), which, in case of inhaling, swallowing or cutaneous penetration, can lead to serious, acute or chronic risks, and even death.
8.	**Carcinogenic**	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to or increase the frequency of cancer.
9.	**Corrosive**	substances and preparations which, in case of contact with living tissues, can destroy the latter.
10.	**Infectious**	substances containing viable micro-organisms or their toxins, for which it is known or we have good reasons to believe that they cause disease in humans or other living organisms.
11.	**Harmful to reproduction function**	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can induce or increase the frequency of undesirable non-hereditary effects in offspring or have a negative effect on reproductive functions and abilities.
12.	**Mutagenic**	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to hereditary genetic disorders or increase the frequency of these disorders.
13.	**React with water**	substances and preparations which, in case of contact with water, air or an acid, release a toxic or highly toxic gas.
14.	**Sensitising**	substances and preparations which, in case of inhaling or cutaneous penetration, can lead to a hypersensitisation, so that renewed exposure to the substance or preparation will cause characteristic harmful effects. This property can only be considered if test methods are available.
15.	**Ecotoxic**	substances and preparations with inherent or potential immediate or deferred risks for one or several environmental components.
16.	**Dangerous for the environment**	substances and preparations which are likely, after elimination, to lead to another substance, by any means, e.g. a lixiviation product, with one of the above characteristics.

[1] Source: French Environment Law (*Code de l'environnement*) / Articles R541-8

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.7 – SECURITY SPECIFICATIONS

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6. ALERT MANAGEMENT AND CRISIS MANAGEMENT 6

1. PREAMBLE

Regarding security risk, international recommandations usually divides the country in two (see map below): a northern half considered high risk (4/5) and a southern half assessed as moderate risk (3/5) where is located Mombasa.

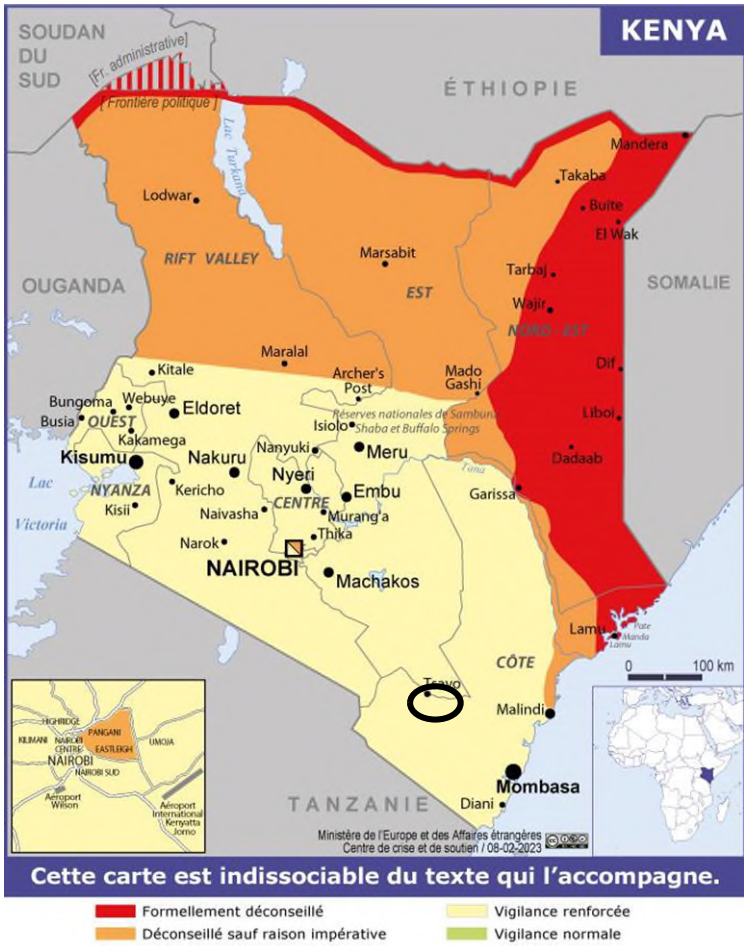

Figure 1-1: Kenya security situation from French Ministry of Europe and Foreign Affairs (May 2024)

The Contractor must show the care it exercises to protect its employees who perform Works in the country. Therefore, it must identify the risks and, in light of this analysis, define prevention and protection resources, incorporating additional resources therein, which may be organisational, technical or human resources. These elements shall be described in a methodology, which for each of the headings below must address and describe what the Contractor has planned.

Disclaimers:

1 - Although the specified admissibility requirements endeavour to correlate with the potential risks to which the Contract may be exposed, they are intended to be used solely to evaluate Bids in order to eliminate Bids that do not meet a minimum set of requirements. They are in no event to be understood to constitute sufficient measures to ensure the security of persons and property in connection with the Contract. **The risk assessment and security measures to be defined in consequence thereof are the responsibility of the Contractor, who shall explain them in its security methodology.**

2 - **A methodology that fails to meet any one of the admissibility requirements set out in the sections below will be declared non-compliant and the Bid of the Contractor will be rejected.**

2. ANALYSIS OF SECURITY ISSUES AND THREATS

The Contractor shall describe its view of the security environment and threats in the area where the Contract will be performed and/or the danger area, and present a security analysis for the relevant area and for the activities it will perform therein. It shall specify the method and references used to perform this analysis and describe the main threat scenarios that can be identified at the bidding stage.

In addition, it shall at all times be able to share information learned from its country watch by its local organisation or head office.

Admissibility requirements:

- Document describing the method used to carry out this analysis;
- At least one identifiable reference source must be used;
- Identification and evaluation of security threats in relation to the contract;
- Description of measures planned to monitor local security.

3. GENERAL SECURITY ORGANISATION

The Contractor shall define the general security roles and responsibilities within its organisation and the allocation of the associated tasks for this Contract (including subcontractors and co-contractors), and shall designate a security reference person. It shall define the planned organisation and resources. In the event of a Joint Venture (JV), the leader shall designate a security officer as the JV's sole contact for this Contract.

Admissibility requirements:

- Description of the organisation;
- The Contractor (and each member in the case of a JV) shall provide the name of the company's internal security officer, who shall be responsible for defining and monitoring the measures implemented for the Contract.

4. SPECIFIC SECURITY MEASURES PLANNED

Based on its own security analysis and the main threat scenarios it may have identified, the Contractor shall plan specific and appropriate measures. These measures shall cover at least the following matters:

4.1. SECURITY ORGANISATION

The Contractor shall describe its local security organisation in the country where the Works will be performed. In particular, it shall specify whether this organisation relies on internal resources, using its own resources already existing in the country, or whether it uses a local partner, a security services provider or a "Security Officer" dedicated to the Contract, or whether it relies on the country's State resources and whether it can request them directly. It shall describe the respective roles planned for each participant operating locally.

Admissibility requirements:

- Description of the organisation and resources mobilised in the country of the Contract;
- The Contractor (and each member in the case of a JV) shall provide the name of the person who will be its contact for all security issues in relation to the Contract. This person may be the same person identified in Article 3 above;
- In the event of a JV, describe the coordination and distribution of responsibilities among the members;
- Designation:
  - **of a "security officer" (CV to be provided); OR**
  - **a security service provider (references to be provided), with experience in the region where the Contract will be performed.**

4.2. TRAVEL WITHIN THE COUNTRY AND TO THE RELEVANT AREA

Depending on the security analysis, special measures may be required to ensure secure travel within the country. These means may include the use of aircraft of national companies or private aircraft, the use of passenger vehicles, or maritime or inland waterways.

The Contractor shall describe the resources and measures planned to protect itself against security risks (crime, kidnapping, etc.) during these trips. These provisions may be technical, organisational or human. It shall distinguish between measures concerning protective actions and measures deemed forward-looking actions.

The Contractor shall describe the planned transport logistics, including human, technical and organisational resources and mechanisms for monitoring travel. It shall also define its requirements for maintenance management and rules of conduct.

Admissibility requirements:

- Description of modes of travel, the physical means of travel and the security measures planned in connection with such travel;
- Distribution of roles and measures planned for the Contractor itself, for external participants and those expected from the Employer and local authorities, identifying each actor;

4.3. ACCOMMODATION DURING ASSIGNMENTS

If the accommodation and security measures of the Contractor are not provided by the Employer, the Contractor shall describe the type of accommodation and the measures planned to ensure the security of teams (security guards, physical means, etc.).

Admissibility requirements:

- Description of the accommodation selection criteria and security measures planned for each overnight stay;
- Provision of the names and addresses of hotels or accommodation venues planned for overnight stays;

4.4. ACCOMMODATION AND SECURITY ON PROJECT SITES AND WORKSITES

The Contractor shall ensure the security of project sites (living camps, technical base, quarries, etc.), and worksites by describing the security system applicable to each of these sites.

The Contractor shall describe the passive security measures and means planned to protect itself from security risk (fencing, embankments, alternating entry/exit, safe haven, etc.) as well as active means and measures (security guards, defence forces, etc.).

Admissibility requirements:

- Identification and location of each project site (living camp, technical base, quarry, etc.), with a description of the active and passive measures that are planned to be implemented at each site;

4.5. COMMUNICATION

The Contractor shall implement a communication and exchange process between the various Contract participants, to ensure reporting of security events, and that preventive or corrective actions deemed necessary are properly carried out. It shall describe the means enabling it to ensure effective communication.

Admissibility requirements:

- Description of the planned means of communication and measures taken to ensure their reliability;

5. INFORMATION, AWARENESS-RAISING AND TRAINING BEFORE DEPARTURE

The Contractor shall make arrangements to inform, raise awareness and train its employees prior to departure on assignment. These arrangements shall be in the form of formal communication actions. It shall describe the provisions specifically planned for this Contract, in the form of "service orders" or similar documents.

Admissibility requirements:

- Description of essential instructions provided to employees (welcoming, briefings, updating of instructions booklets, etc.);
- Provision of the list of emergency numbers (local numbers and service providers, repatriation, head office on-call security service) furnished for the Contract's assignments;

6. ALERT MANAGEMENT AND CRISIS MANAGEMENT

The Contractor shall prove that it has set up a crisis management process involving the local organisation and its head office. It shall describe the main procedures for triggering this process and its key operating procedures.

For this purpose, the Contractor shall describe the alert process, from the local organisation to its head office, and the interaction with the Employer.

Admissibility requirements:

- Summary of the crisis management procedure dedicated to security, describing triggers, roles and responsibilities.

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.8 – TENDER DRAWINGS

MWACHE DAM WATER SUPPLY SYSTEM

N

Legend

- Proposed Raw Water Pumping Station
- Proposed Reservoir
- Existing Reservoir
- Proposed Mwache Dam
- Standard Gauge Railway (SGR)
- Meter Gauge Railway
- Major Roads
- Rivers
- Proposed Mombasa Northern Bypass
- Mombasa Southern Bypass
- Proposed Bamburi Link Road
- County Boundary

Mwache Dam
Proposed Mwache WTP
Proposed Raw Water Pumping Station
Twin Mwache Trunk Main (Section 1) (2 x DN1000)
Mwache Trunk Main (Section 2) (DN1000)
Mazeras Reservoirs
Pipeline to Mazeras (DN800)
West Mainland Reservoir (14,000m³)
DN1200 (2.7Km)
North Mainland Transmission Main (DN700)
Proposed Mombasa Northern Bypass
Proposed Bamburi Link Road
Nguu Tatu Reservoirs
DN1000 (2.9Km)
DN900 (1.8Km)
DN400 (4.2Km)
West Mainland Transmission Main,
Changamwe Transmission Main (DN700)
Changamwe Reservoir (14,000m³)
Moi International Airport
Mombasa Southern Bypass
Freight Station
Mombasa Island
South Mainland Transmission Main (DN1000)
Dongo Kundu Reservoirs (28,000m³)
Dongo Kundu Pipeline (DN900)
Kaya Bombo Reservoirs
Kombeni River
Tudor Creek
Tsalu River
Mwache River
Pemba River
Indian Ocean
KILIFI COUNTY
KWALE COUNTY
MOMBASA COUNTY
MAZERAS
Miritini
Changamwe
Kipevu
Kisauni
Likoni
Kiteje
To Nairobi
To Kaloleni
To Kwale
To Kilifi
To Ukunda
0 2.5 5 Km

Note:
For Information Only

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
		CHECKED			
		BY			
		CHECKED			
		BY			

CLIENT:

THE CHIEF EXECUTIVE OFFICER,
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

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PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

Contract No. CWSB/AFD/MWCE/C/4/2017

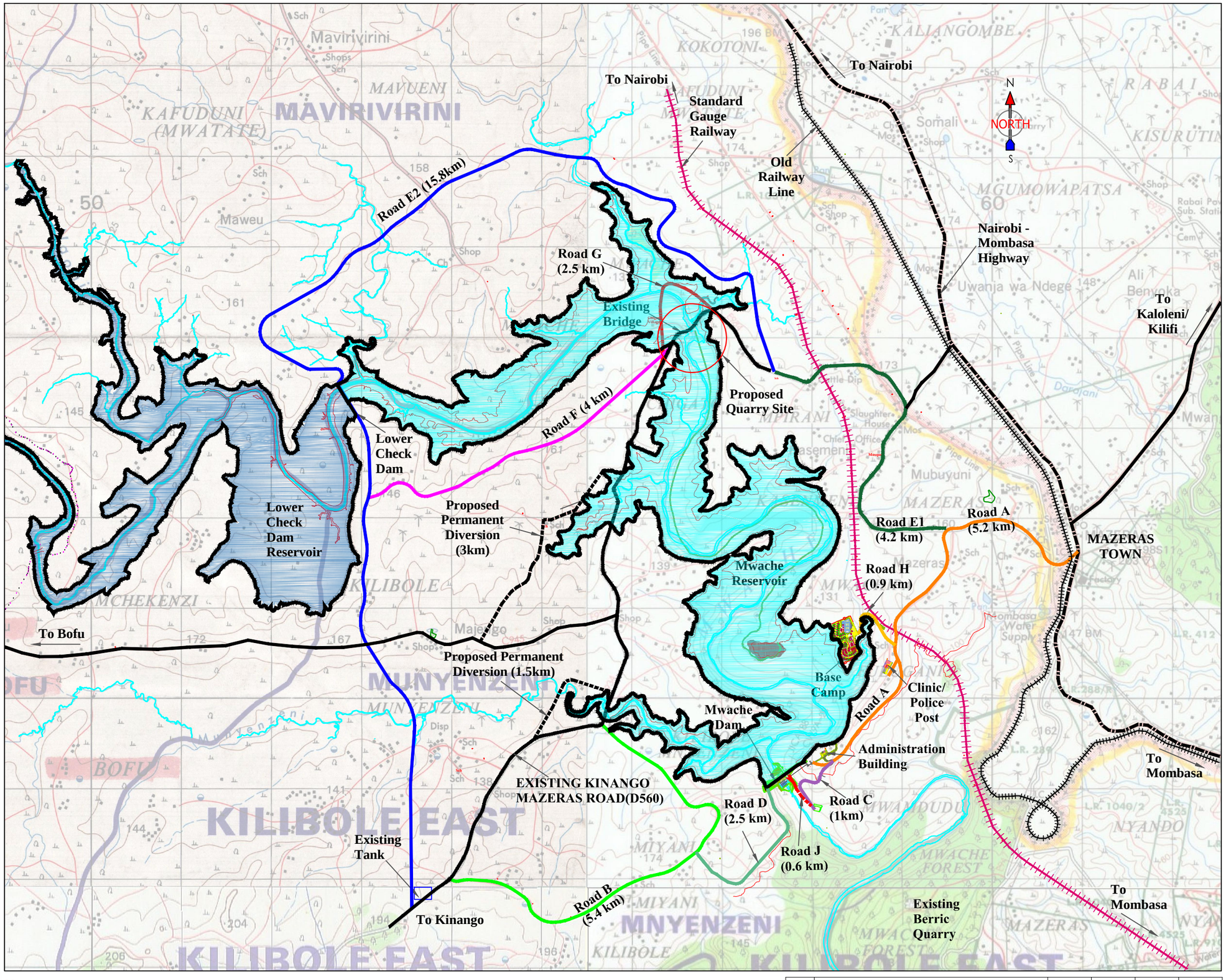
PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA and RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

DRAWNG TITLE:

MWACHE DAM WATER SUPPLY SYSTEM

Designed by:	O.N.M	Drawn by:	S.J.O
Checked by:	N.H/R.S.R	Approved by:	G.F.Y
Scale:	AS SHOWN	Date:	MAY 2022

DRG No. ART-8773361-PRE-DWG-442 REV.0



LEGEND

- MAIN DAM AND BUFFER ZONE (30m)
- LOWER CHECK DAM AND BUFFER ZONE(30m)
- ROAD A
- ROAD B
- ROAD C
- ROAD E1
- ROAD E2
- ROAD F
- ROAD G
- ROAD H
- ROAD J
- NEW RAILWAY LINE (SGR)
- OLD RAILWAY LINE
- MOMBASA ROAD
- EXISTING ROADS

Note:
For Information Only

SCALE 0 0.5 1.0 Km

Rev. No.	Revision	Prepared	Checked	Approved	Date

MINISTRY OF WATER & IRRIGATION
KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

CONTRACT NO: MOWI/KWSRP-2/001/2017-2018

MWACHE MULTI - PURPOSE DAM PROJECT

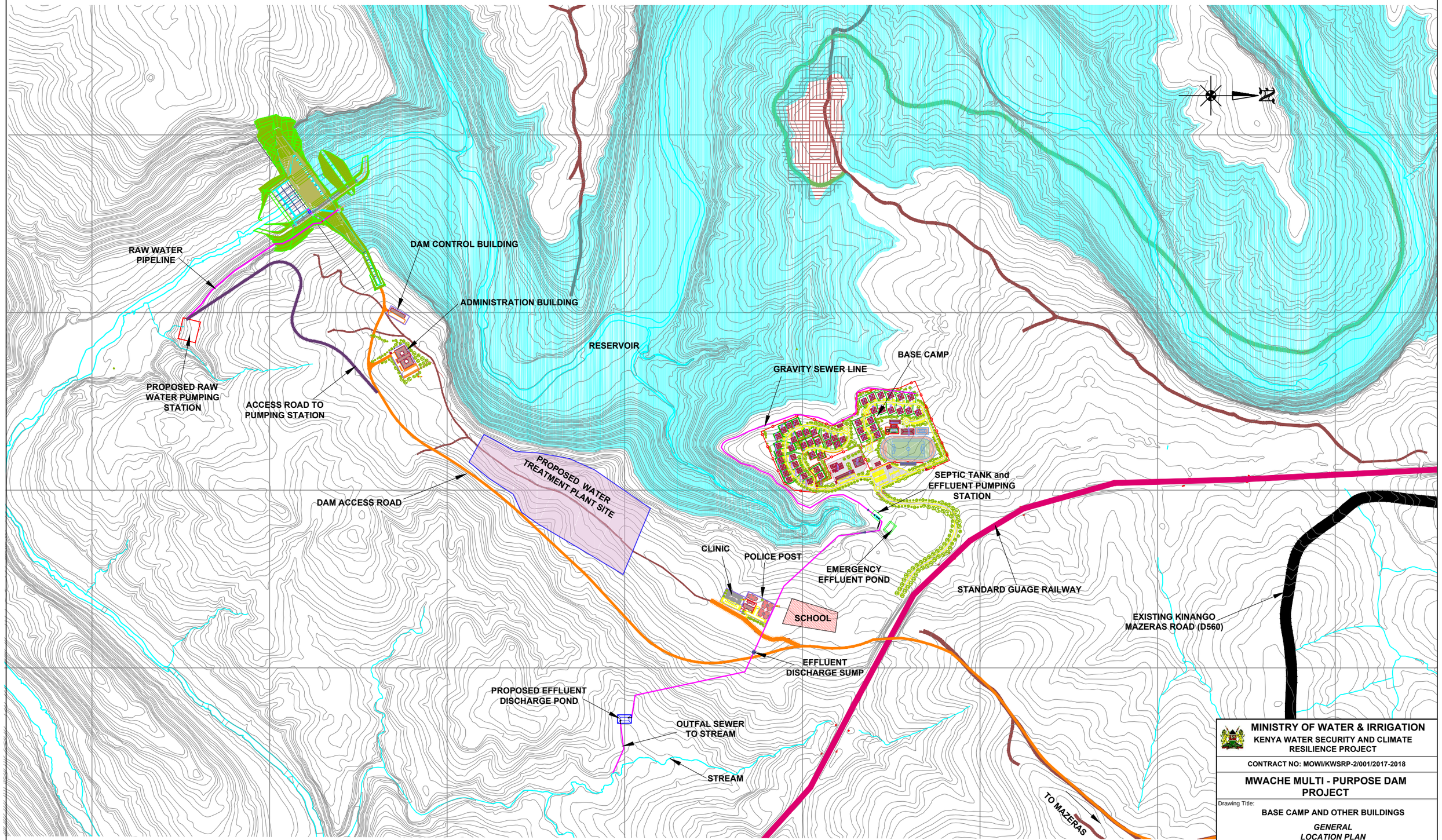
Drawing Title:

ACCESS/RELOCATION ROADS AND WATER SUPPLY

GENERAL LAYOUT PLAN

Prepared:	Checked:	Approved:	Drawing No:	Rev No:
SC	RSR	RSR	910 - 001A2	
Date: 12/2017	Date: 12/2017	Date: 12/2017		

NIPPON KOEI CO., LTD.
IN ASSOCIATION WITH MANGAT I.B. PATEL (MIBP) LIMITED AND AF - CONSULT SWITZERLAND LTD



Note:
For Information Only

SCALE 0 0.25Km 0.5 Km

NOTE:
The Figure has been extracted from Mwache Dam Detailed Design Report (NK,MIBP & Af,2017)

Rev. No.	Revision	Prepared	Checked	Approved	Date

MINISTRY OF WATER & IRRIGATION
KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

CONTRACT NO: MOWI/KWSRP-2/001/2017-2018

MWACHE MULTI - PURPOSE DAM PROJECT

Drawing Title:

BASE CAMP AND OTHER BUILDINGS

GENERAL LOCATION PLAN

Prepared:	Checked:	Approved:	Drawing No:	Rev No:
Date:	Date:	Date:	810- 001	

NIPPON KOEI CO., LTD.
IN ASSOCIATION WITH MANGAT I.B. PATEL (MIBP) LIMITED AND AF - CONSULT SWITZERLAND LTD

Republic of Kenya
Coast Water Works Development Agency

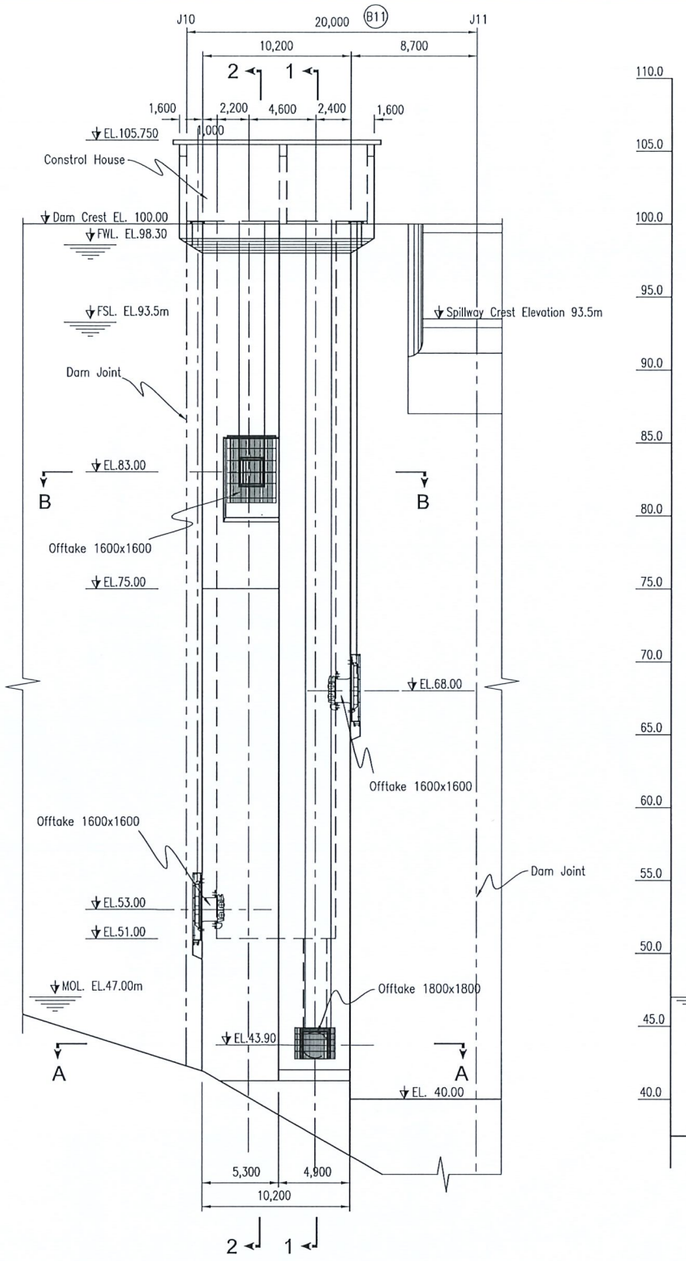
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

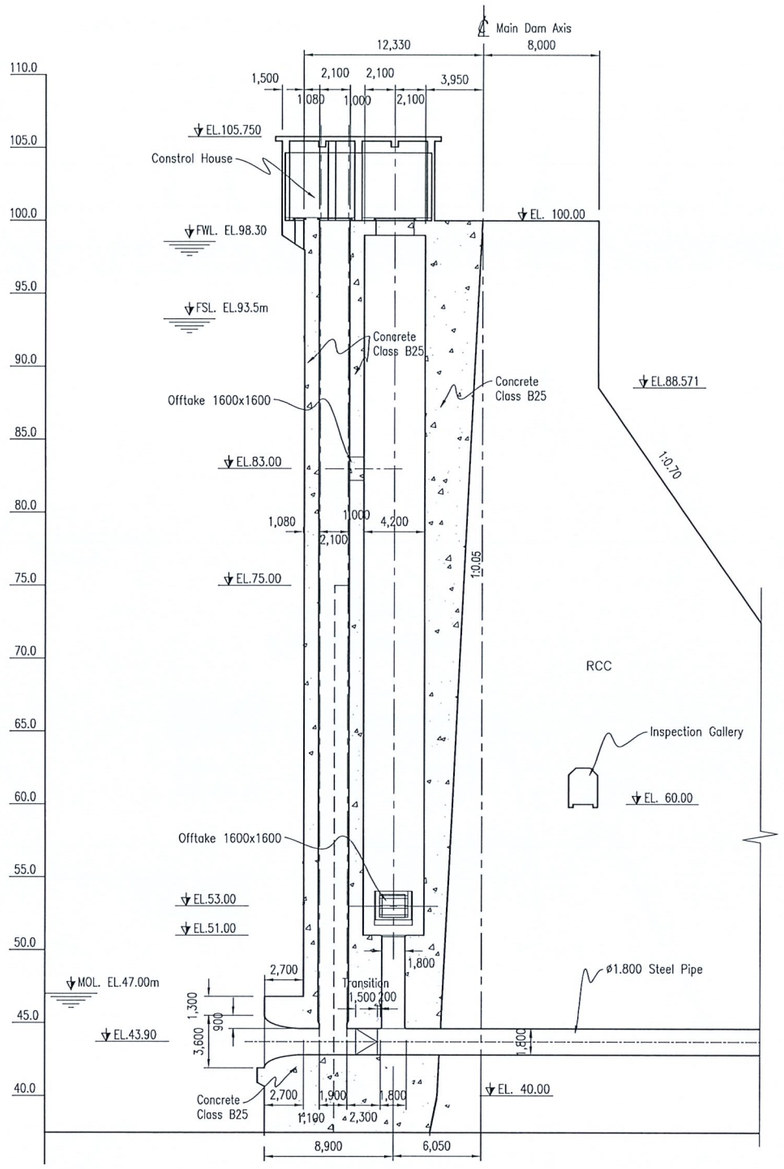
PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.9 – DRAWINGS FOR INFORMATION

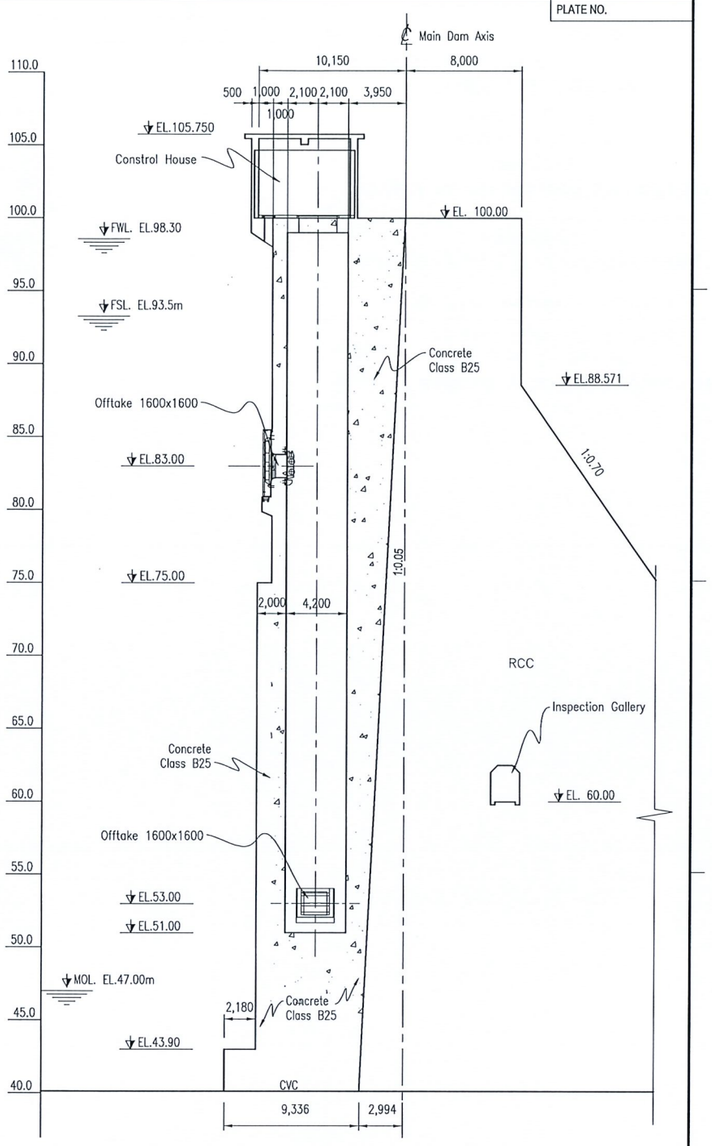
PLATE NO.



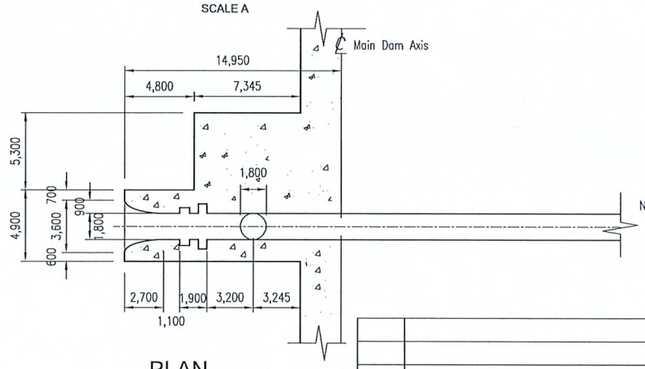
UPSTREAM VIEW
SCALE A



SECTION 1-1
SCALE A



SECTION 2-2
SCALE A



PLAN
SCALE A

NOTES:
1) All dimensions are expressed in millimeters.
2) All elevations are expressed in meters.

SCALE A 0 4.0 8.0 20.0 m

Rev. No.	Revision	Prepared	Checked	Approved	Date

Note:
For Information Only

MINISTRY OF WATER & IRRIGATION
KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

CONTRACT NO: MOWI/KWSRP-2/001/2017-2018

MWACHE MULTI - PURPOSE DAM PROJECT

Drawing Title:
DAMS AND APPURTENANT STRUCTURES
INTAKE FACILITIES
INTAKE TOWER
PROFILE & SECTIONS (1/2)

Prepared:	Checked:	Approved:	Drawing No:	Rev No:
Date:	Date:	Date:	360 - 101	

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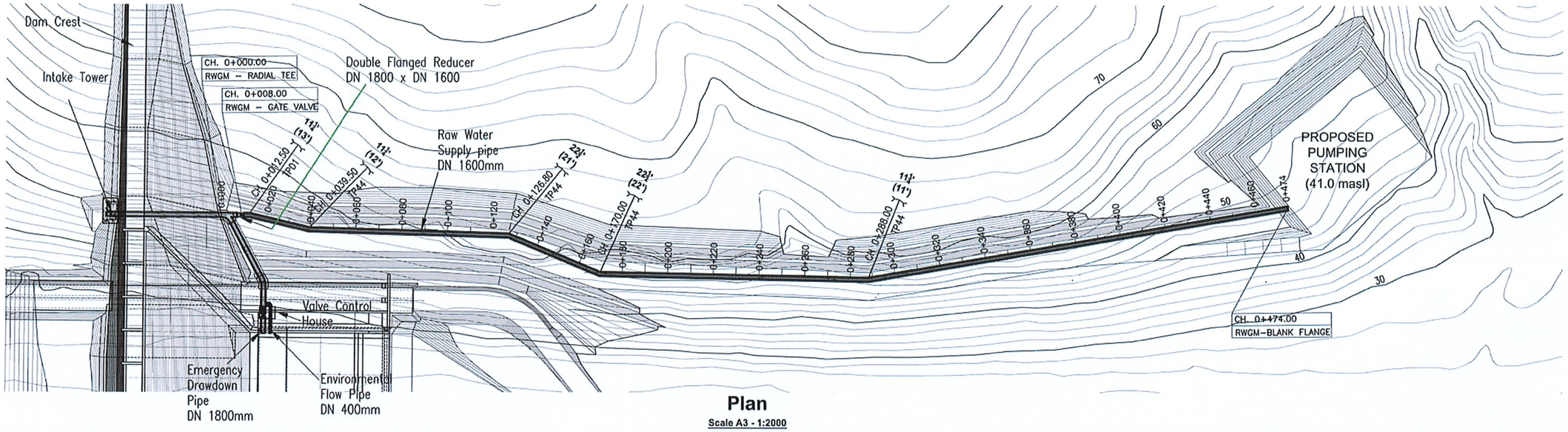
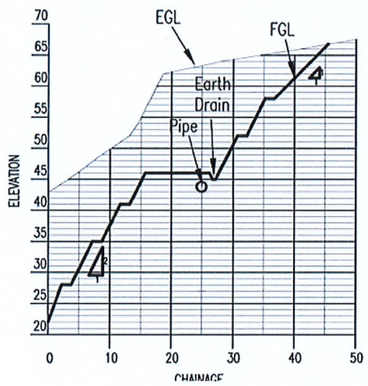
IN ASSOCIATION WITH MANGAT I.B. PATEL (MIBP) LIMITED
AND AF - CONSULT SWITZERLAND LTD



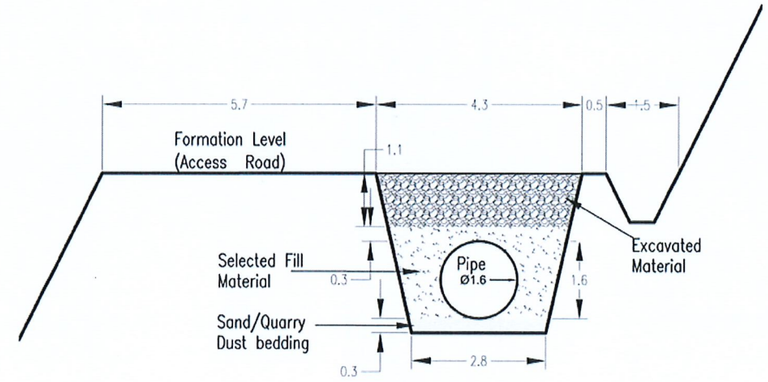
Plan

Scale A3 - 1:2000



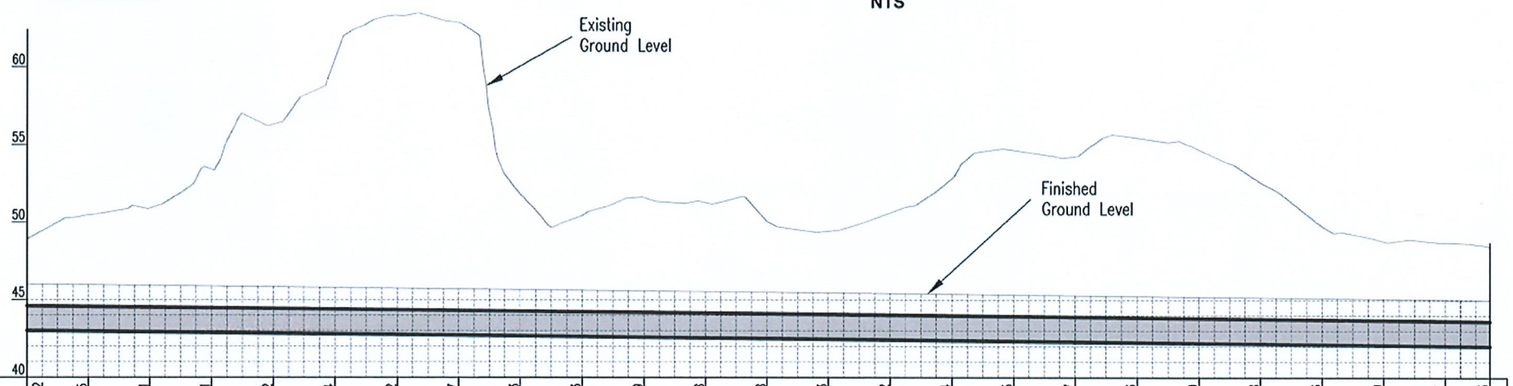
Typical Transverse Section at Ch 0+120

Scale A3 - 1:1000



Typical Trench Cross-Section

NTS



Chainage (m)	Existing Ground Levels (m)	Invert Levels (m)
0+000	49.92	43.00
0+020	50.45	42.96
0+040	50.91	42.92
0+060	53.41	42.88
0+080	56.32	42.83
0+100	60.54	42.79
0+120	63.32	42.75
0+140	62.87	42.71
0+160	51.83	42.67
0+180	50.43	42.63
0+200	51.59	42.58
0+220	51.28	42.54
0+240	50.08	42.50
0+260	49.43	42.46
0+280	50.62	42.42
0+300	52.84	42.38
0+320	54.65	42.33
0+340	54.27	42.29
0+360	55.46	42.25
0+380	54.70	42.21
0+400	52.58	42.17
0+420	49.76	42.12
0+440	48.79	42.08
0+460	48.71	42.04
0+474	48.43	42.00
Type and Size of Pipe	DN 1600mm PN 10 FLANGED STEEL PIPE	

Longitudinal Profile

Scale A3
Hor - 1:2000
Ver - 1:400

Note:
For Information Only

Rev. No.	Revision	Prepared	Checked	Approved	Date

MINISTRY OF WATER & IRRIGATION
KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

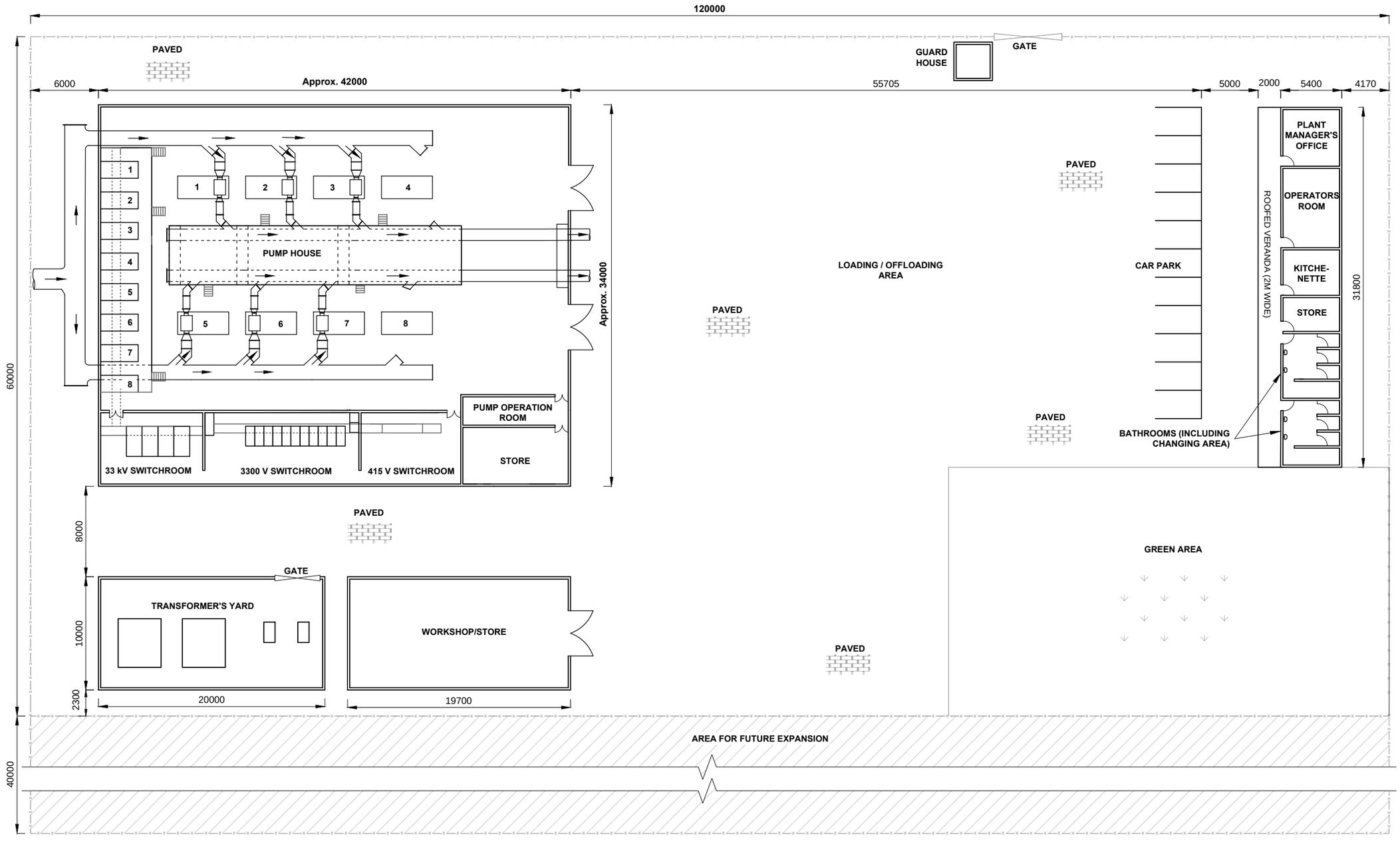
CONTRACT NO: MOWI/KWSRP-2/001/2017-2018

MWACHE MULTI - PURPOSE DAM PROJECT

Drawing Title:
DAMS AND APPURTENANT STRUCTURES
MAIN DAM
INTAKE FACILITIES
GENERAL LAYOUT
Profile and Sections

Prepared:	Checked:	Approved:	Drawing No:	Rev No:
Date:	Date:	Date:	360 - 001	

NIPPON KOEI CO., LTD.
IN ASSOCIATION WITH MANGAT I.B. PATEL (MIBP) LIMITED
AND AF - CONSULT SWITZERLAND LTD AS SUBCONSULTANTS



GENERAL LAYOUT PLAN

SCALE 1:350

Note:
For Information Only

NOTES :-

1. All Dimensions are in Millimeters (mm) unless otherwise stated.
2. The Layout Plan is a Preliminary Design and should NOT be used for construction purposes.

	REVISIONS		DATE	DATE	APPROVED
		BY			
		CHECKED			
		BY			
		CHECKED			
		BY			
		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY			
0	FIRST DIFFUSION	CHECKED			

CLIENT:
THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O BOX 90417-80100
MOMBASA

CONSULTING ENGINEERS:
JOINT VENTURE
ARTELIA - Water, Climate and Solid Waste
6 rue deLorraine - 38130 Echirolles - FRANCE
Tel : +33(0)476334000

MANGAT, I.B. PATEL LIMITED
P.O. BOX 48674,
00100 - GPO, NAIROBI, KENYA
TEL : +254-20-2710500

PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA : MWACHE CKE 1103

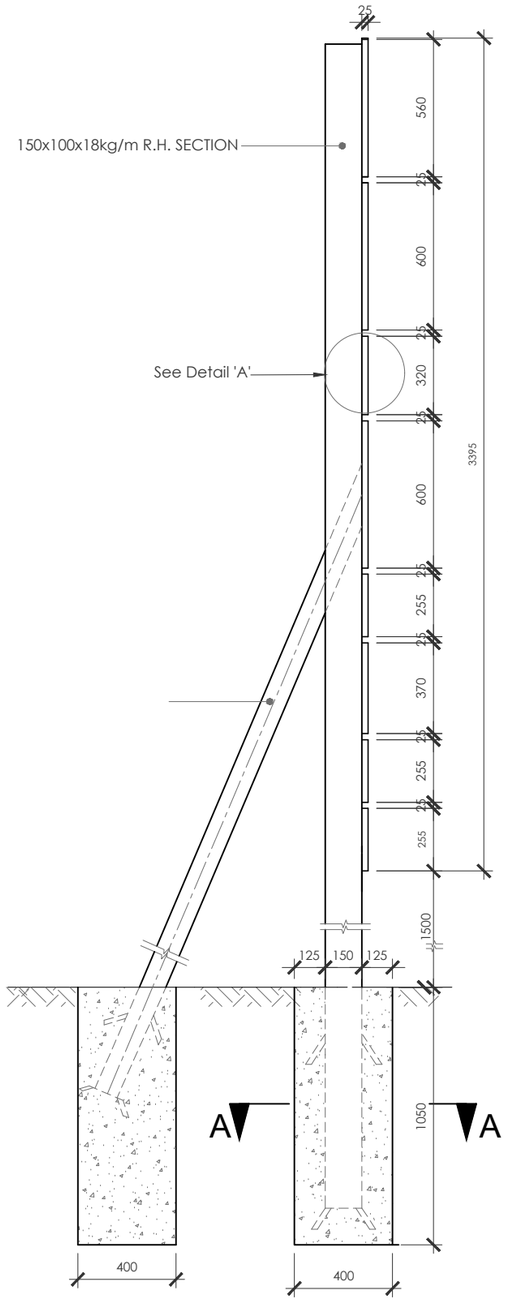
CONTRACT NO. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

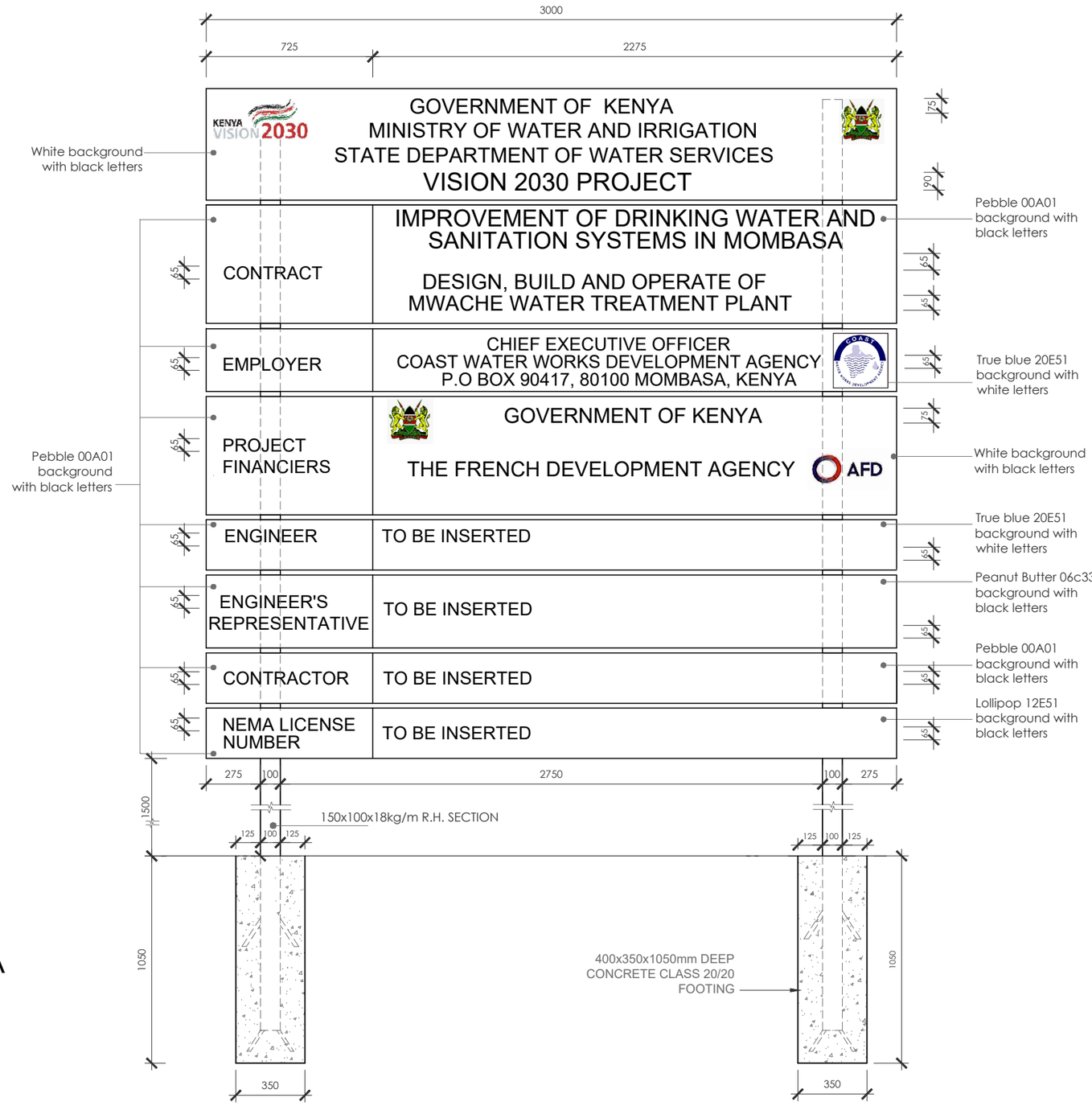
PRELIMINARY DESIGN

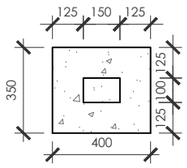
DRAWING TITLE:
MWACHE PUMPING STATION
GENERAL LAYOUT PLAN

DESIGNED BY:	O.N.M	DRAWN BY:	O.N.M
CHECKED BY:	GFY/RSR	APPROVED BY:	CRR
SCALE:	1:350	DATE:	OCTOBER 2021
DRAWING No.	ART-8773361-PRE-DWG-433		REV 1

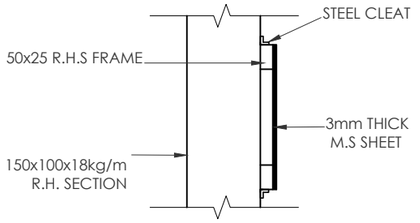


SIDE ELEVATION





SECTION A - A



DETAIL 'A'
N.T.S

NOTES

1. DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED
2. INSTALLATION LOCATIONS
   a. TO BE INSERTED
   b. TO BE INSERTED
   c. TO BE INSERTED

AS BUILT

REVISION	DESCRIPTION	DATE

CLIENT:
THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

ARTELIA
6 RUE DE LORRAINE
38130 ECHIROLLES, FRANCE
E-MAIL: artelia@arteliagroup.com
TEL: +33 (0)4 76 33 40 00

MANGAT I.B PATEL (MIBP) LIMITED
P.O BOX 48674,00100-GPO,
NAIROBI, KENYA
E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

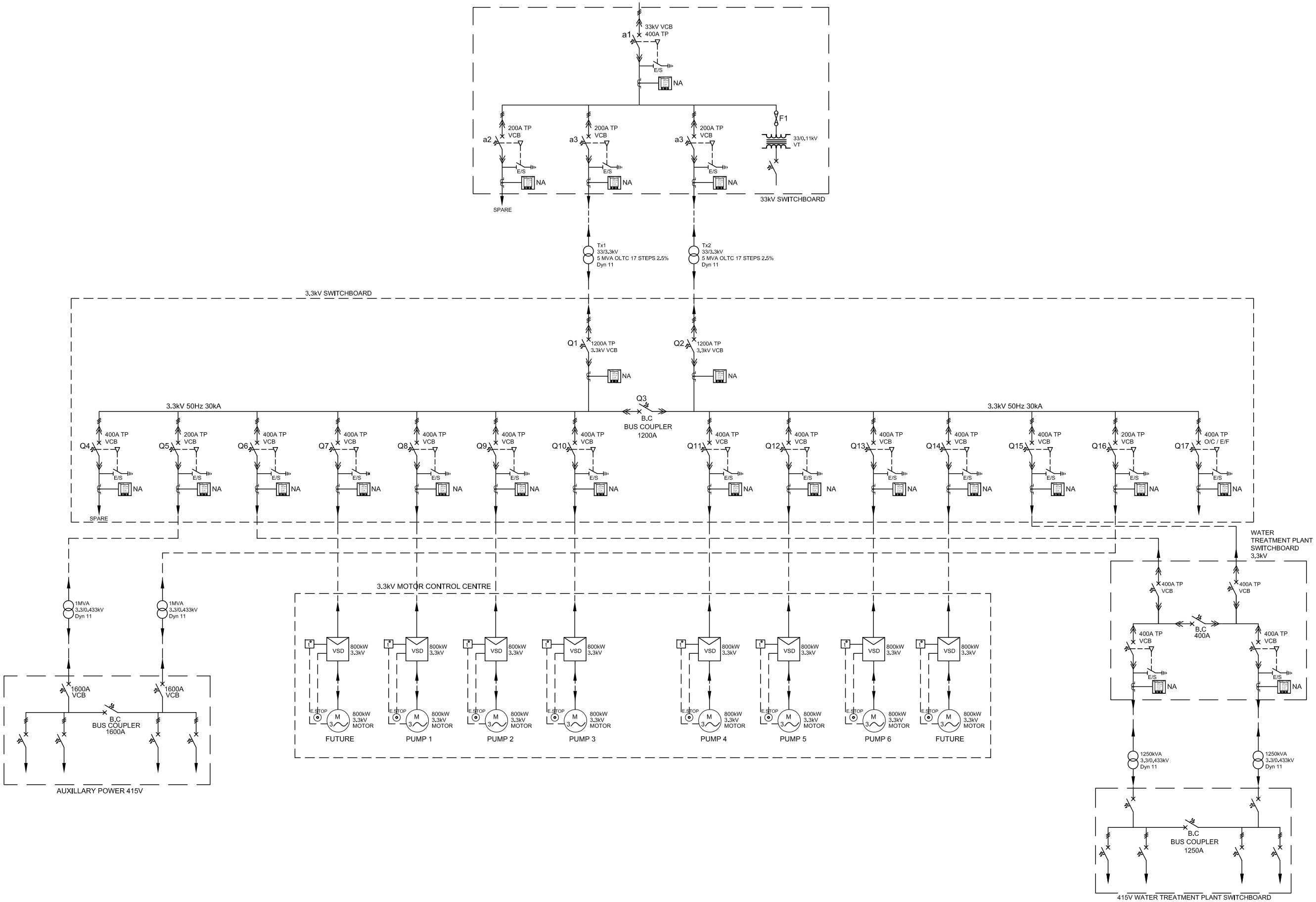
CONTRACT No.CWWDA/AfD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

DRAWING TITLE:
STANDARD DETAIL
PROJECT SIGNBOARD DETAILS

DESIGNED BY: J.M.K	DRAWN BY: I.O.N
CHECKED BY: N.H	APPROVED BY: R.S.R
SCALE: 1:25	DATE: MAY 2022
DRAWING No.	

Note:
For Information Only



OVERALL NETWORK SINGLE LINE DIAGRAM

NTS

Note:
For Information Only

	REVISIONS		DATE	DATE	APPROVED
		BY			
		CHECKED			
		BY			
		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY			
0	FIRST DIFFUSION	CHECKED			

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O BOX 90417-80100
MOMBASA

CONSULTING ENGINEERS:

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MANGAT, I.B. PATEL LIMITED
P.O. BOX 48674,
00100 - GPO, NAIROBI, KENYA
TEL : +254-20-2710500

PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA : MWACHE CKE 1103

CONTRACT NO. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

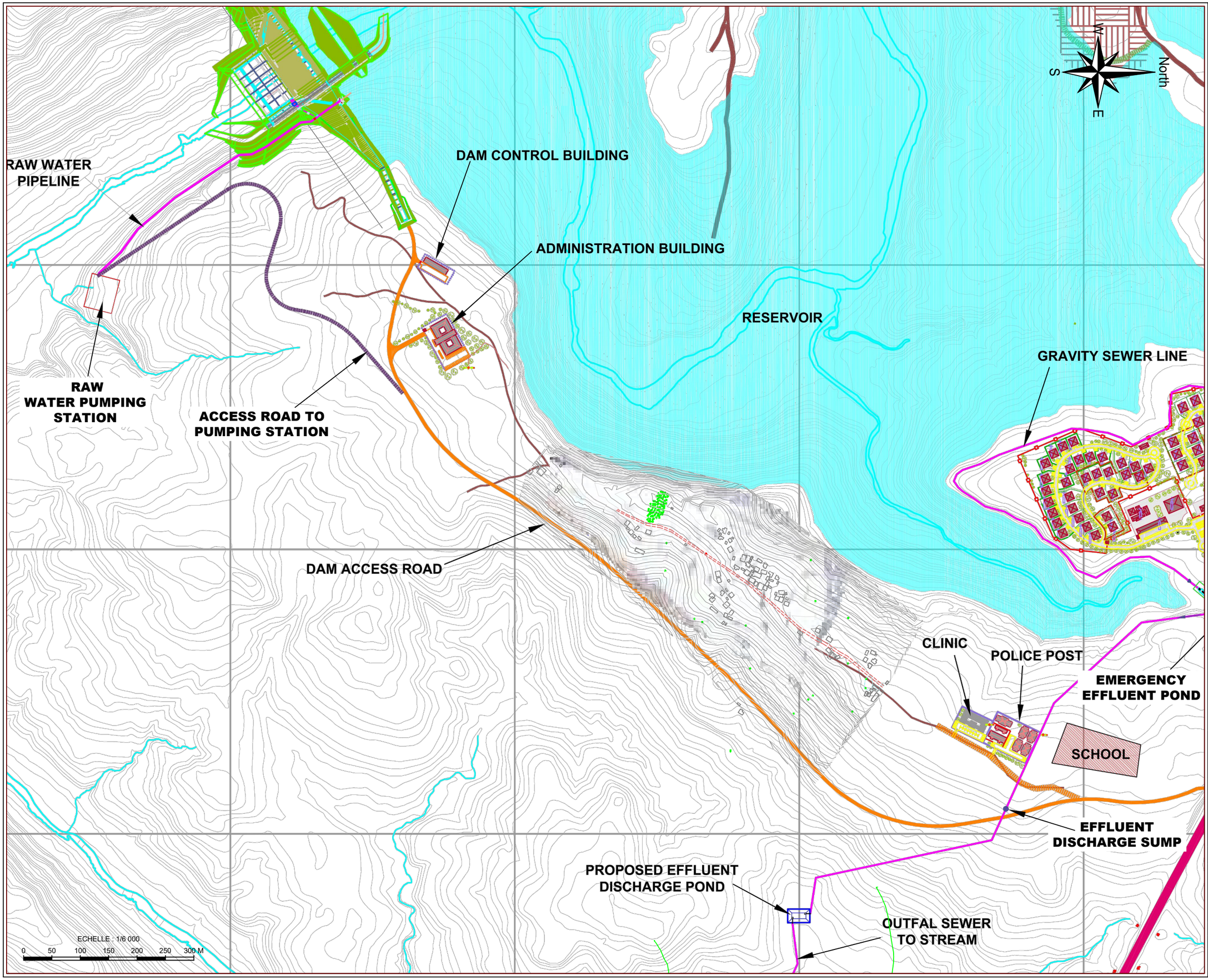
PRELIMINARY DESIGN

DRAWING TITLE:

MWACHE PUMPING STATION

OVERALL NETWORK SINGLE LINE DIAGRAM

DESIGNED BY:	G.B	DRAWN BY:	G.B
CHECKED BY:	GFY/RSR	APPROVED BY:	CRR
SCALE:	NTS	DATE:	JUNE 2022
DRAWING No.	ART-8773361-PRE-DWG-434		REV 1



NOTES:

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

ARTELIA
6 RUE DE LORRAINE
38130 ECHIROLLES, FRANCE
E-MAIL: artelia@arteliagroup.com
TEL: +33 (0)4 76 33 40 00.

MANGAT I.B PATEL (MIBP) LIMITED
P.O BOX 48674,00100-GPO,
NAIROBI, KENYA
E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:

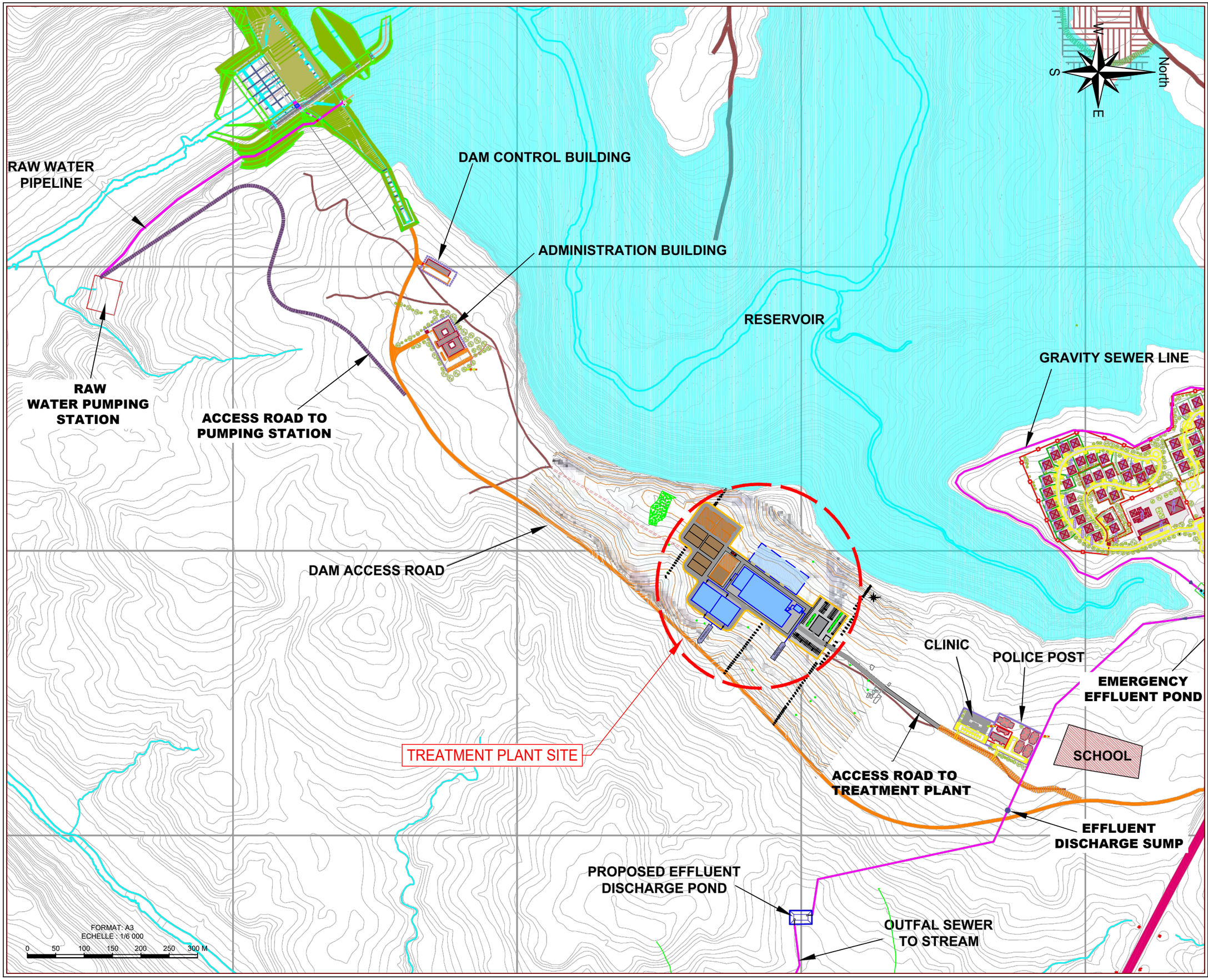
.

General plan

.

Designed by:	LBC	Drawn by:	LBC
Checked by:	RAR	Approved by:	GFY
Scale:	1/6000	Date:	APRIL 2024

DRG N°: ART-8773361-PD-DWG-400 REV. 0



NOTES:

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

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38130 ECHIROLLES, FRANCE
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MANGAT I.B PATEL (MIBP) LIMITED
P.O BOX 48674,00100-GPO,
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E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

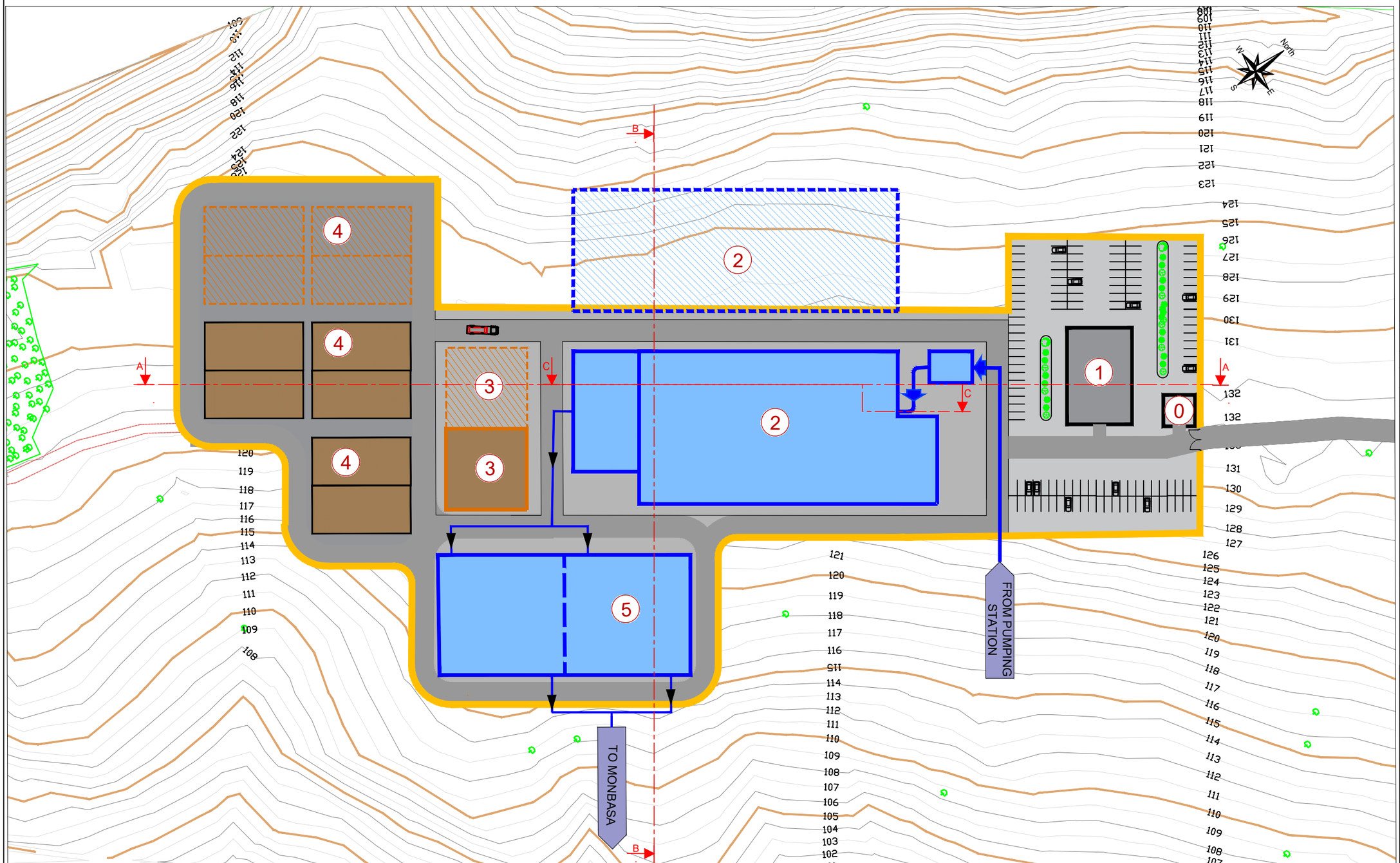
Drawing title:

Site layout plan

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/6000	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-401 REV. 0

WATER TREATMENT PLANT LAYOUT PLAN



NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

- 0 GATEHOUSE
- 1 ADMINISTRATIVE BUILDING
- 2 WATER LINE BUILDING
- 3 SLUDGE BUILDING
- 4 SLUDGE DRYING BEDS
- 5 RESERVOIR

ACCES ROAD
LIMITS OF THE WATER TREATMENT PLANT
FIRST PHASE
SECOND PHASE - EXTENSION

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

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TEL: +33 (0)4 76 33 40 00.

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P.O BOX 48674,00100-GPO,
NAIROBI, KENYA
E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

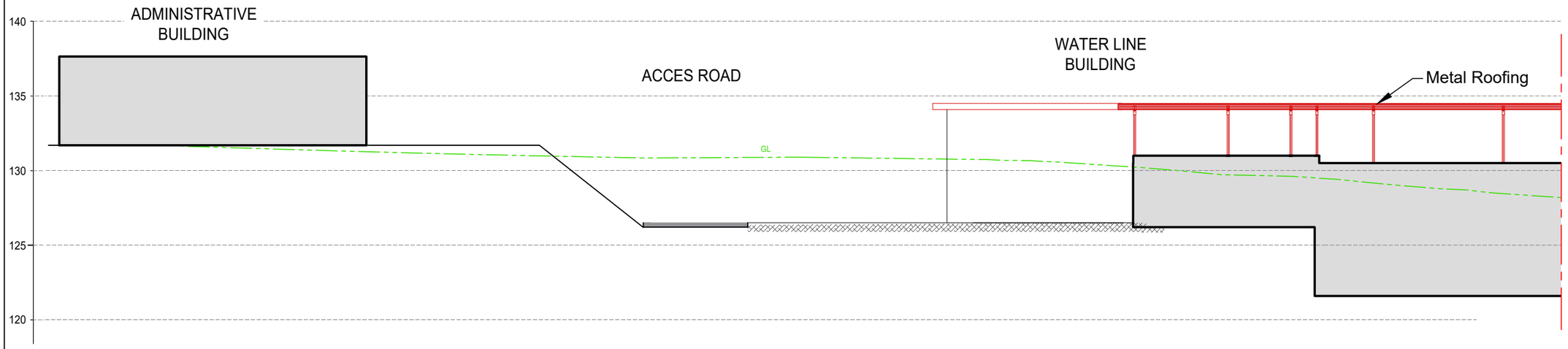
Drawing title:
Water Treatment Plant Layout Plan
Plan view

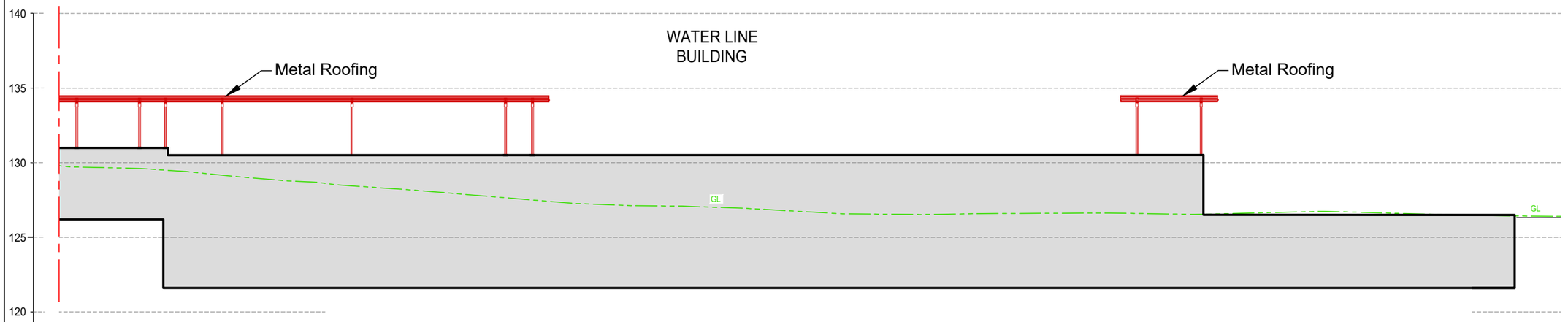
Designed by:	LBC	Drawn by:	LBC
Checked by:	RAR	Approved by:	GFY
Scale:	1/1250	Date:	APRIL 2024

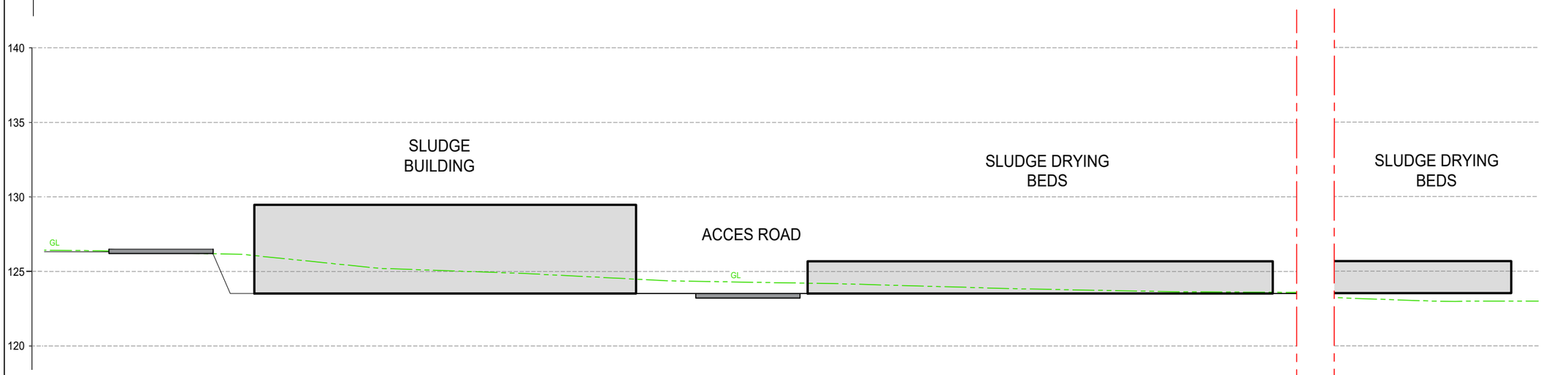
DRG N°: ART-8773361-PD-DWG-402 REV. 0

NOTA:
For information only

WATER TREATMENT
SECTION AA







NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

Ground Level

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

ARTELIA
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38130 ECHIROLLES, FRANCE
E-MAIL: artelia@arteliagroup.com
TEL: +33 (0)4 76 33 40 00.

MANGAT I.B PATEL (MIBP) LIMITED
P.O BOX 48674,00100-GPO,
NAIROBI, KENYA
E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

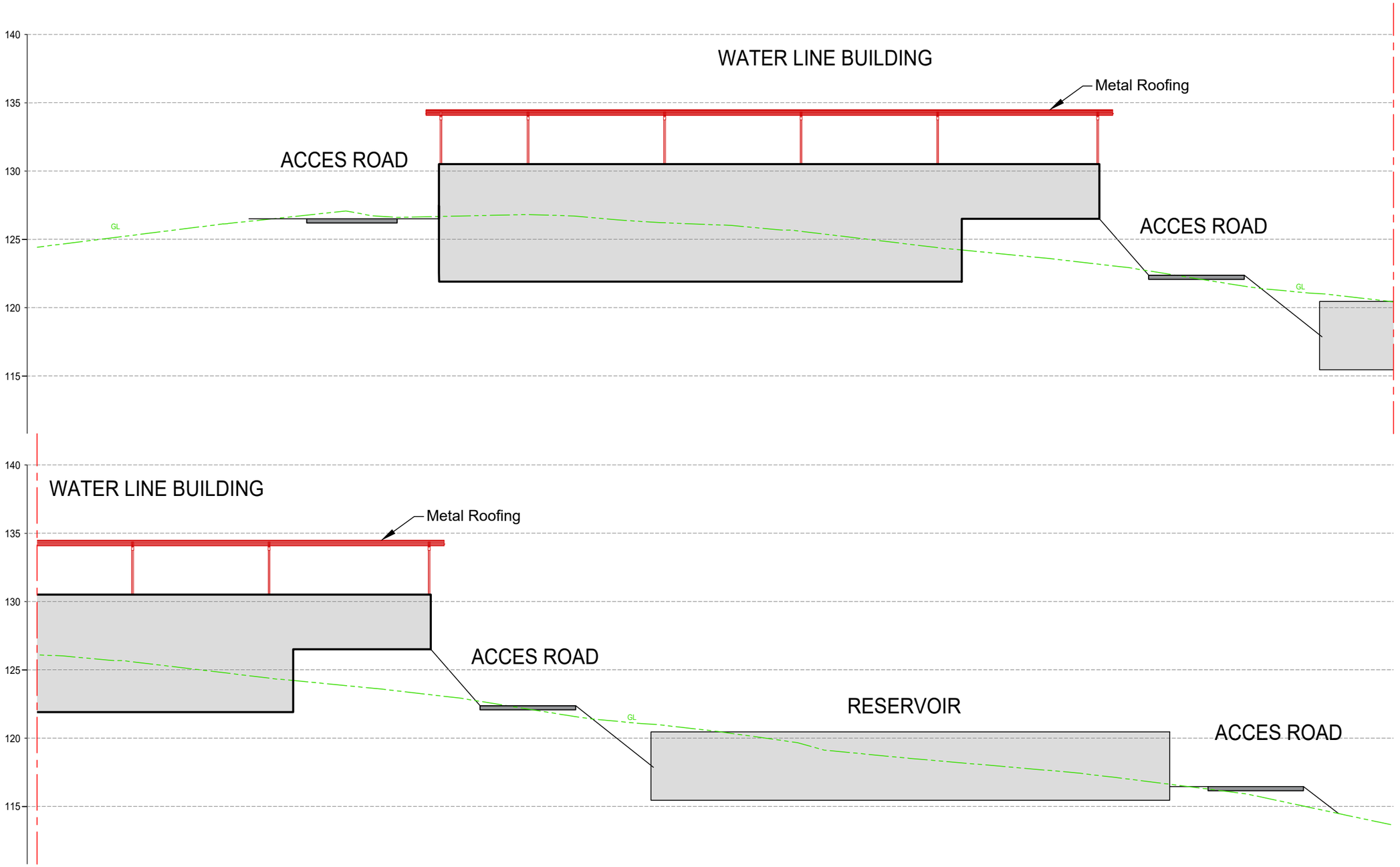
Drawing title:
Water Treatment Plant Layout Plan
Longitudinal profile
Section AA

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/300	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-403	REV. 0

FORMAT: ISO FULL BLEED A3 (420.00 X 297.00 MM)
ECHELLE : 1/300

0 1 5 10 M

WATER TREATMENT
SECTION BB



NOTA:
For information only

FORMAT: ISO FULL BLEED A3 (420.00 X 297.00 MM)
ECHELLE : 1/300

0 1 5 10 M

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

Ground Level

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

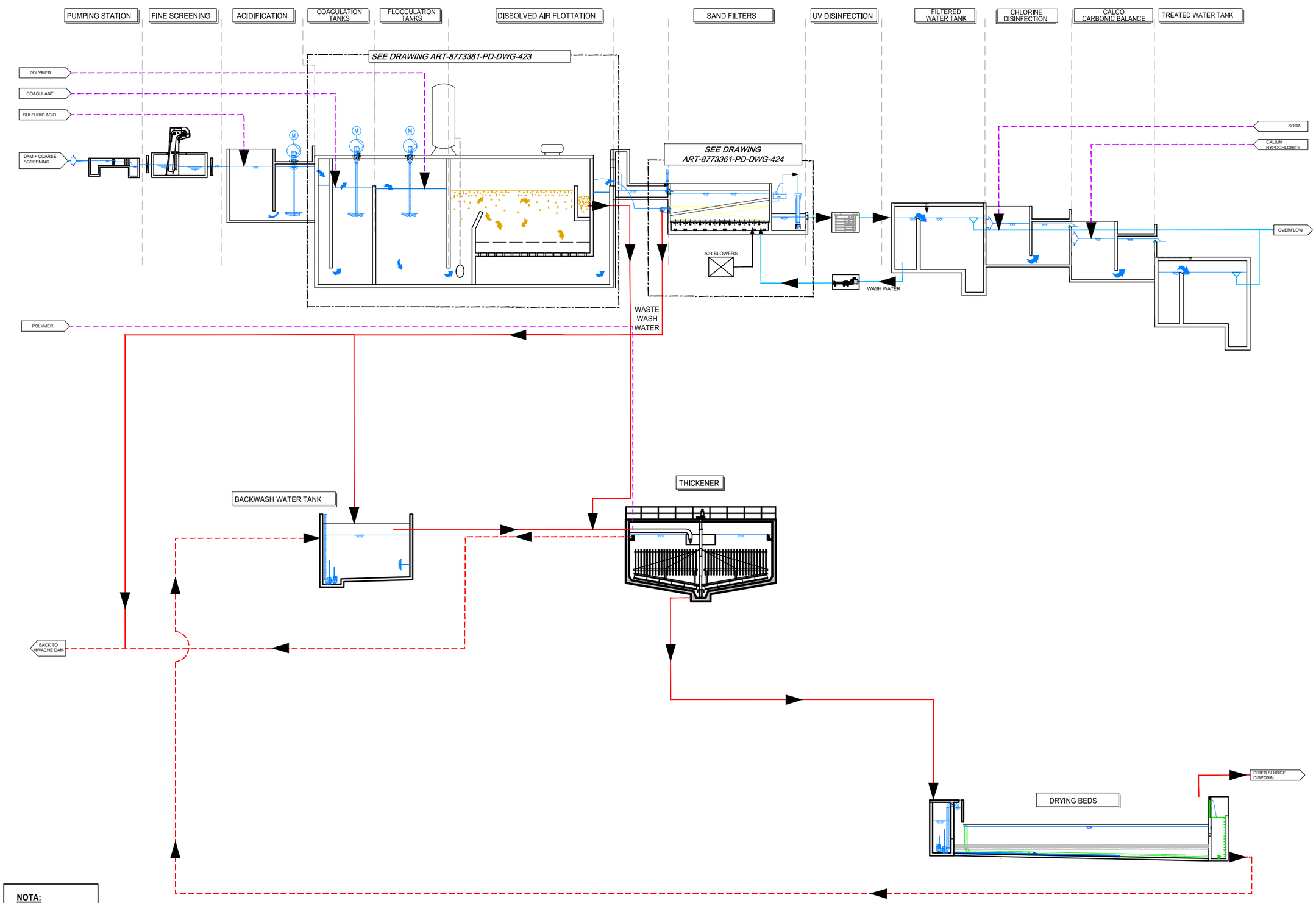
Phased WTP implementation

Drawing title:
Water Treatment Plant Layout Plan
Transverse profile
Section BB

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/300	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-404 | REV. 0

PROCESS FLOW DIAGRAM WATERLINE AND SLUDGE LINE



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

- REAGENTS
- WATER PIPES
- SLUDGE PIPES
- WATER RECOVERY

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

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P.O. BOX 90417 - 80100
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

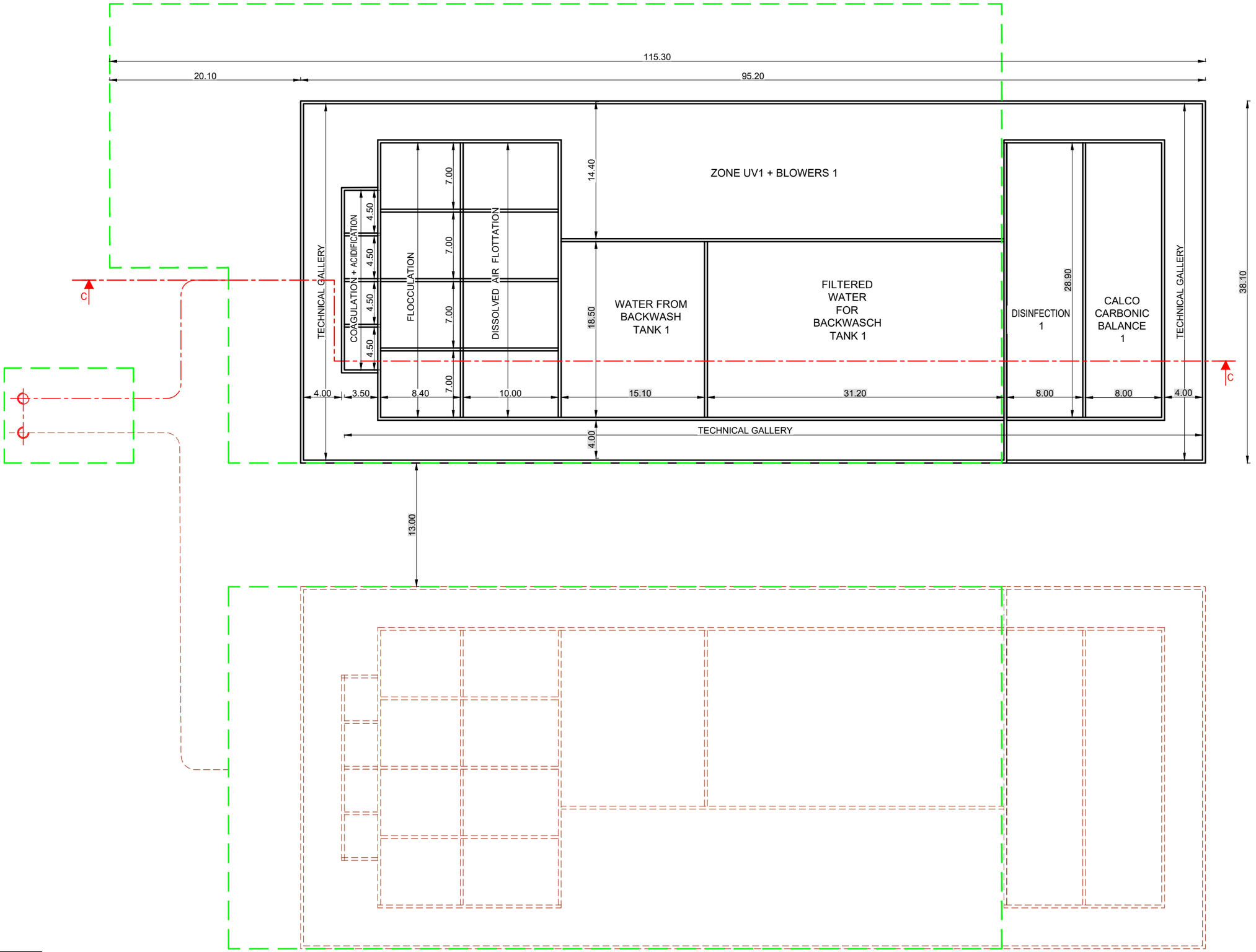
Phased WTP implementation

Drawing title:
Process Flow Diagram Waterline and sludge line

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale:	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-410 | REV. 0

WATER LINE BUILDING
BASEMENT FLOOR



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

- First phase
- Second phase Extension
- Footprint of the ground floor above the basement

	REVISIONS	SIGN	DATE	APPROVED
	BY			
	CHECKED			
2	BY			
	CHECKED			
1	BY			
	SECOND DIFFUSION CHECKED			
	BY	LBC	15.04.24	
0	FIRST DIFFUSION CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

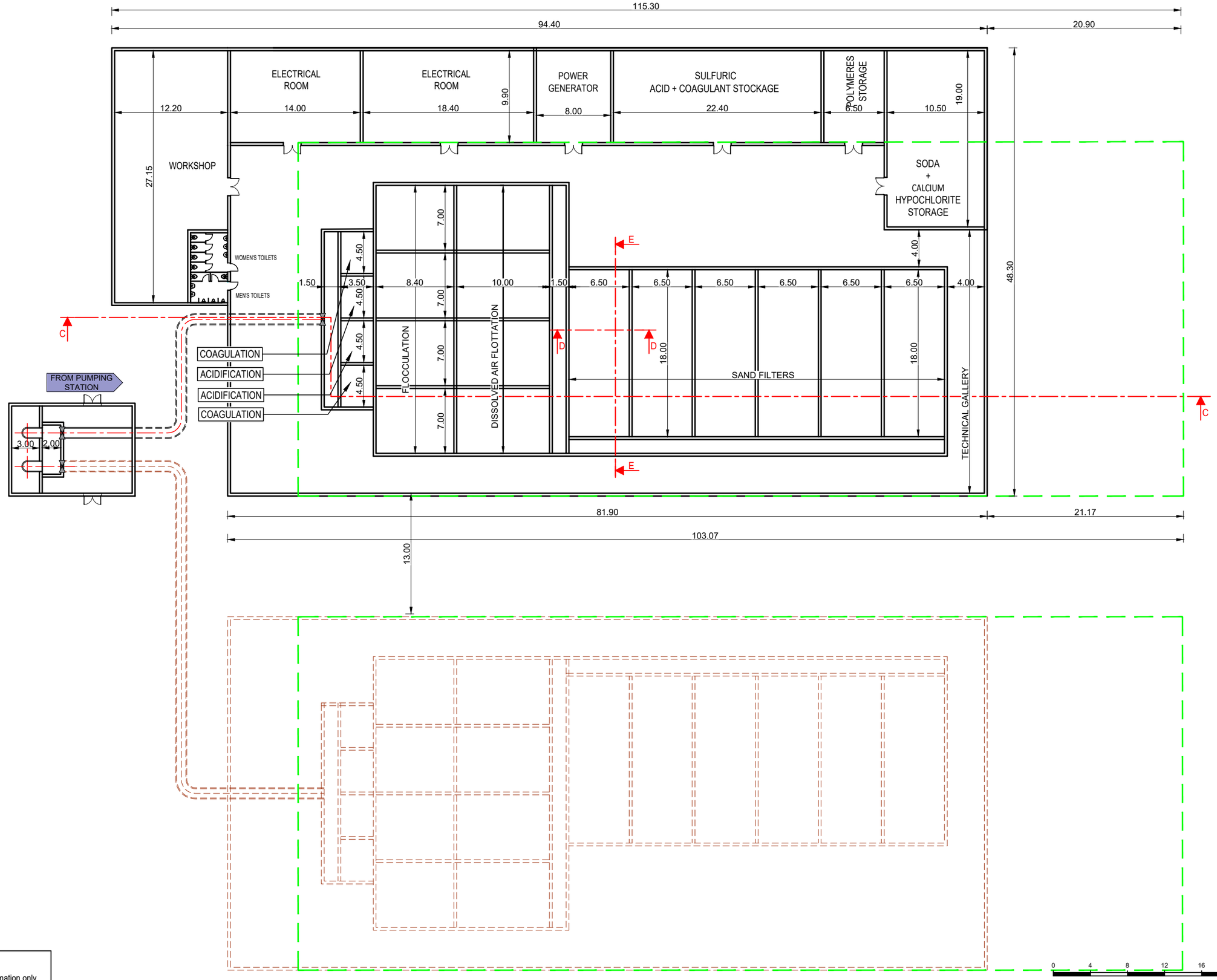
Phased WTP implementation

Drawing title:
Water line building
Basement floor
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/400	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-420 REV. 0

WATER LINE BUILDING
GROUND FLOOR



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

- First phase
- Second phase Extension
- Footprint of the basement below the ground floor

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
2		BY			
		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

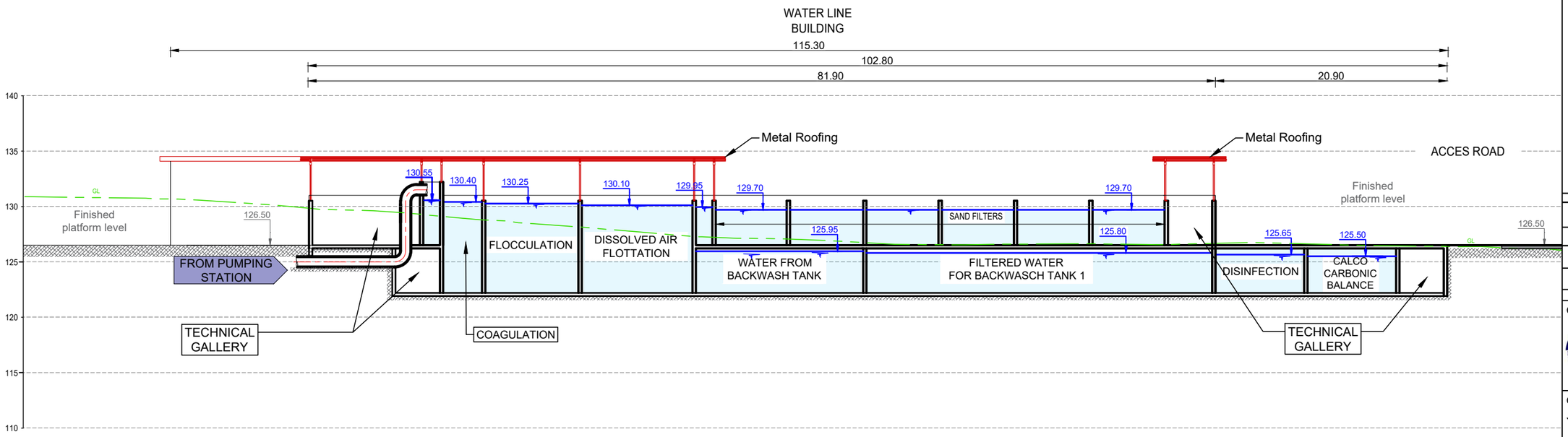
PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:
Water line building
Ground floor
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/400	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-421	REV. 0

WATER TREATMENT
SECTION CC



NOTA:
For information only

0 4 8 12 16 20 M

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

Ground Level

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
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MOMBASA, KENYA

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TEL: +254-2-2710500

PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

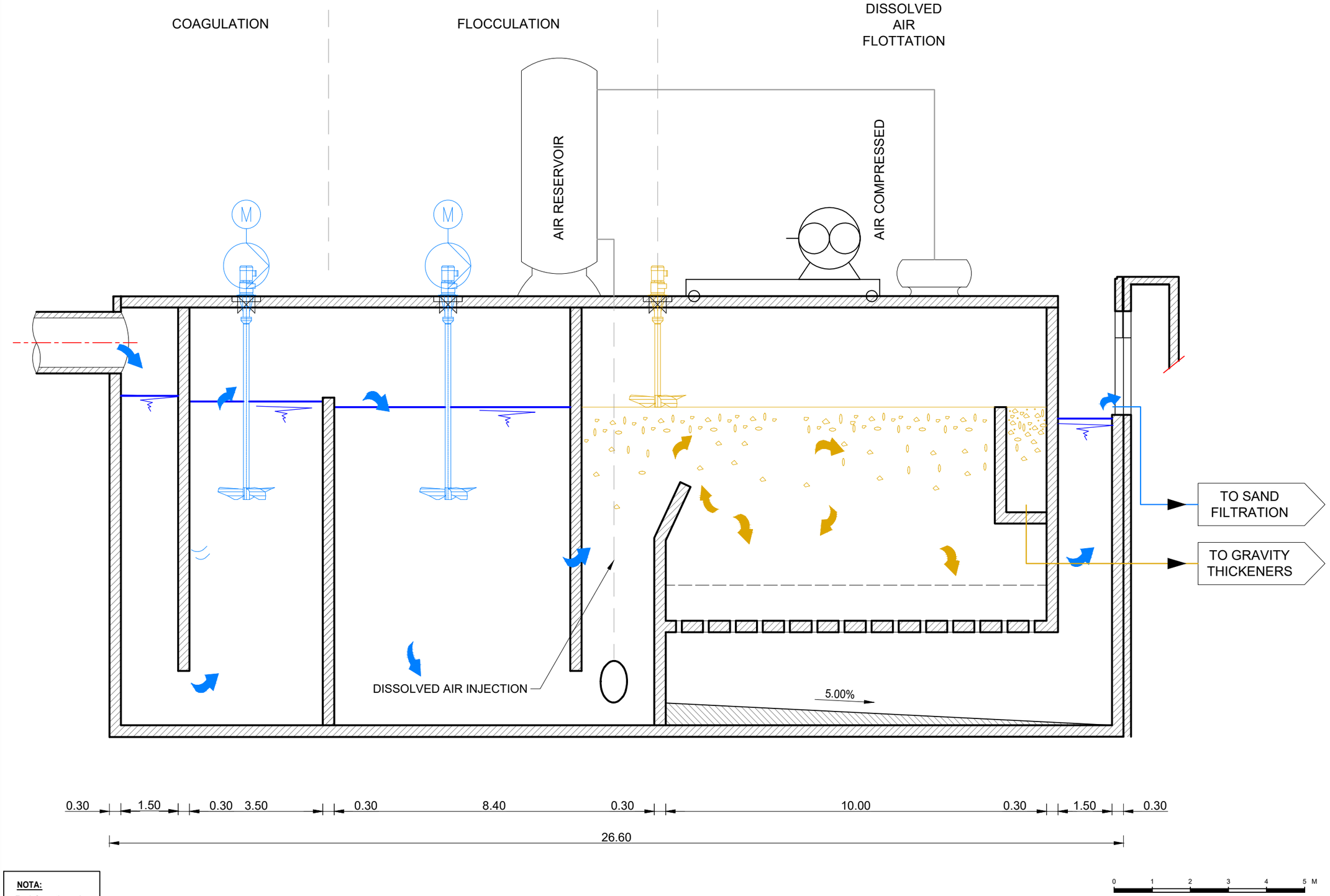
Phased WTP implementation

Drawing title:
Water line building
Water treatement
Section CC

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/400	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-422 REV. 0

CLARIFICATION
SECTION CC



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

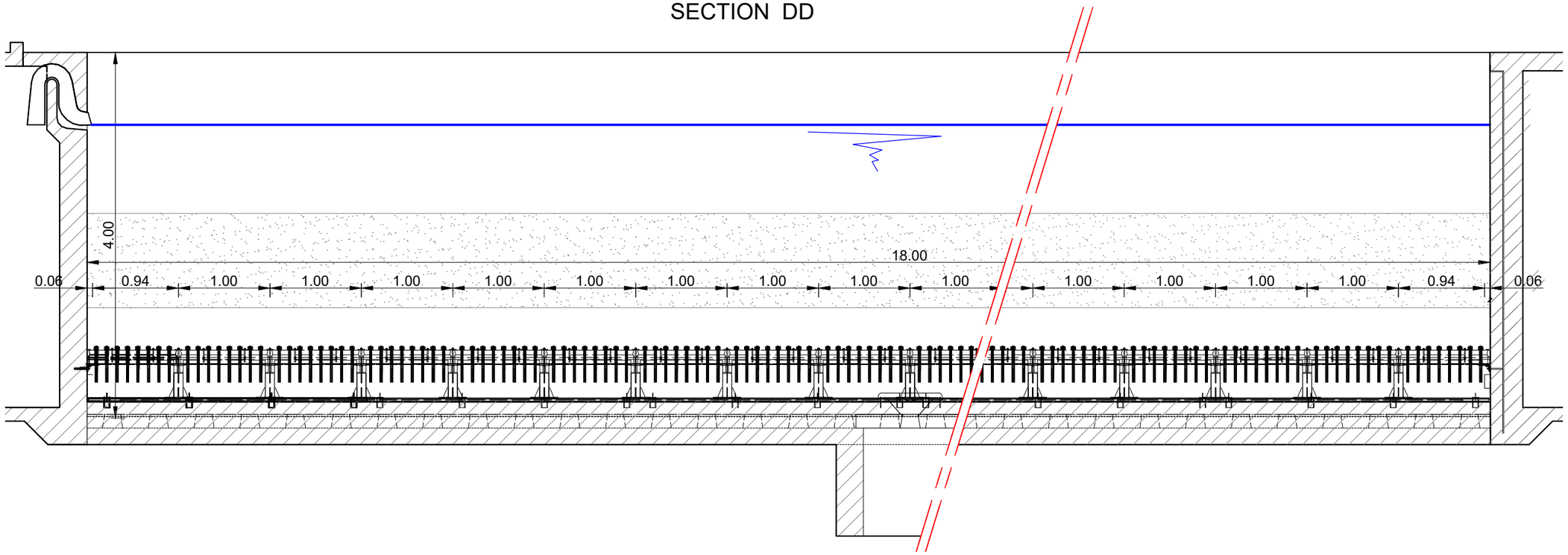
Phased WTP implementation

Drawing title:
Water line building
Clarification
Section CC

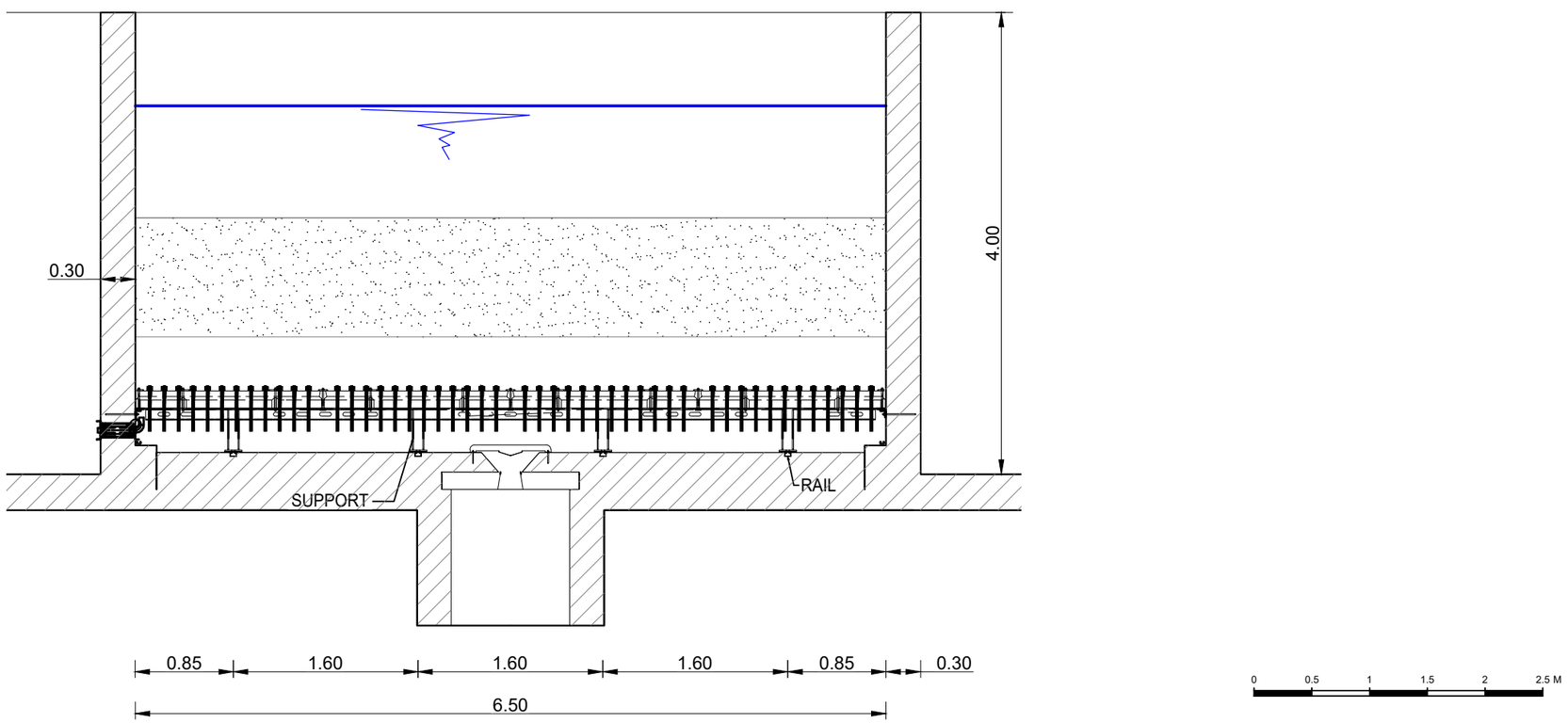
Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/100	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-423	REV. 0

SAND FILTERS

SECTION DD



SECTION EE



NOTA:
For information only

0 0.5 1 1.5 2 2.5 M

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

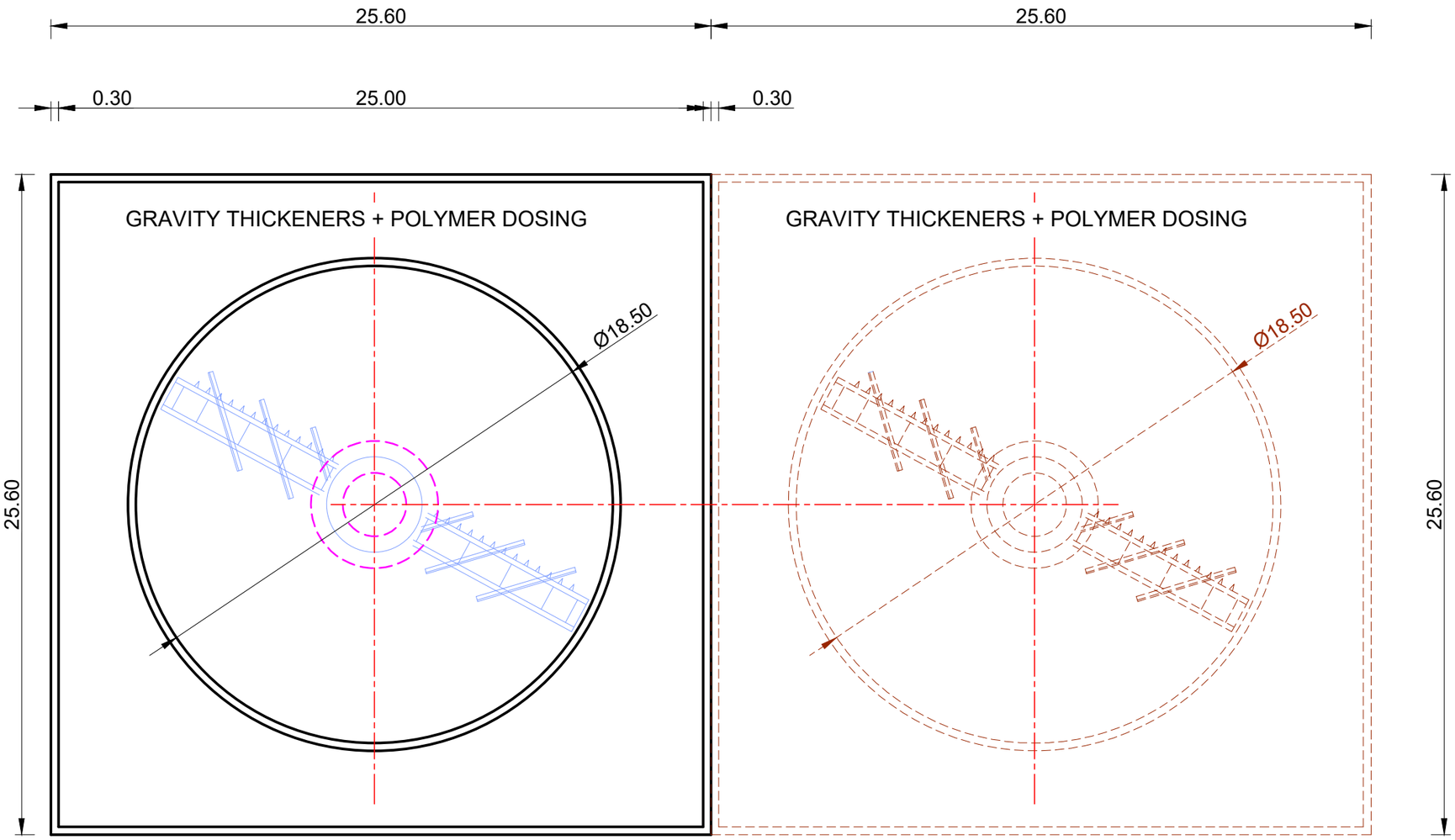
PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:
Water line building
Sand filtration
Sections DD & EE

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/50	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-424	REV. 0

SLUDGE BUILDING



NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

First phase
Second phase Extension

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:

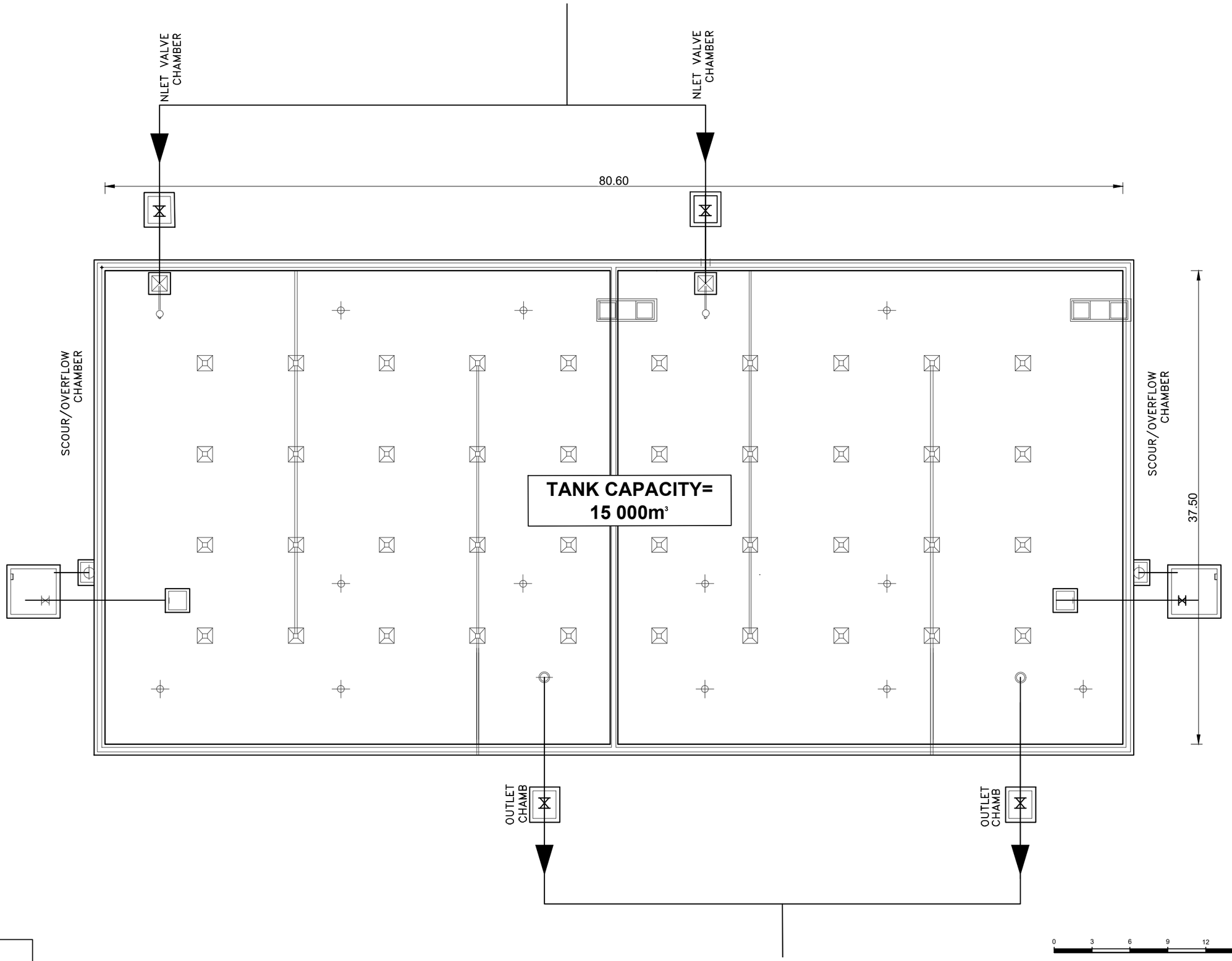
Sludge building
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/200	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-425	REV. 0

NOTA:
For information only

0 2 4 6 8 10 M

TREATED WATER RESERVOIR



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

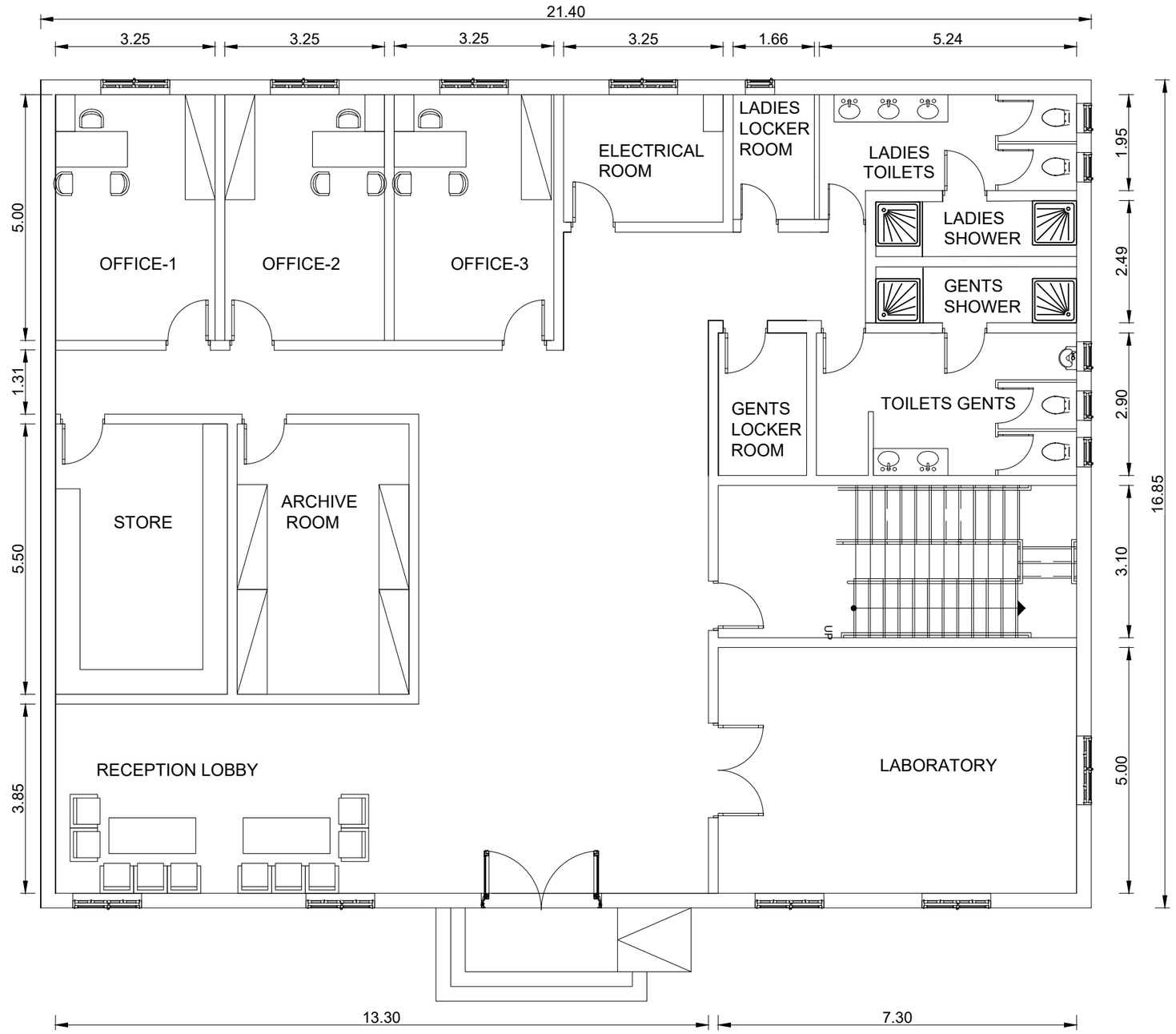
PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:
Treated water reservoir
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/300	Date: APRIL 2024
DRG N°: ART-8773361-PD-DWG-426	REV. 0

ADMINISTRATIVE BUILDING
GROUND FLOOR



NOTA:
For information only

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
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TEL: +254-2-2710500

PROJECT NAME:

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

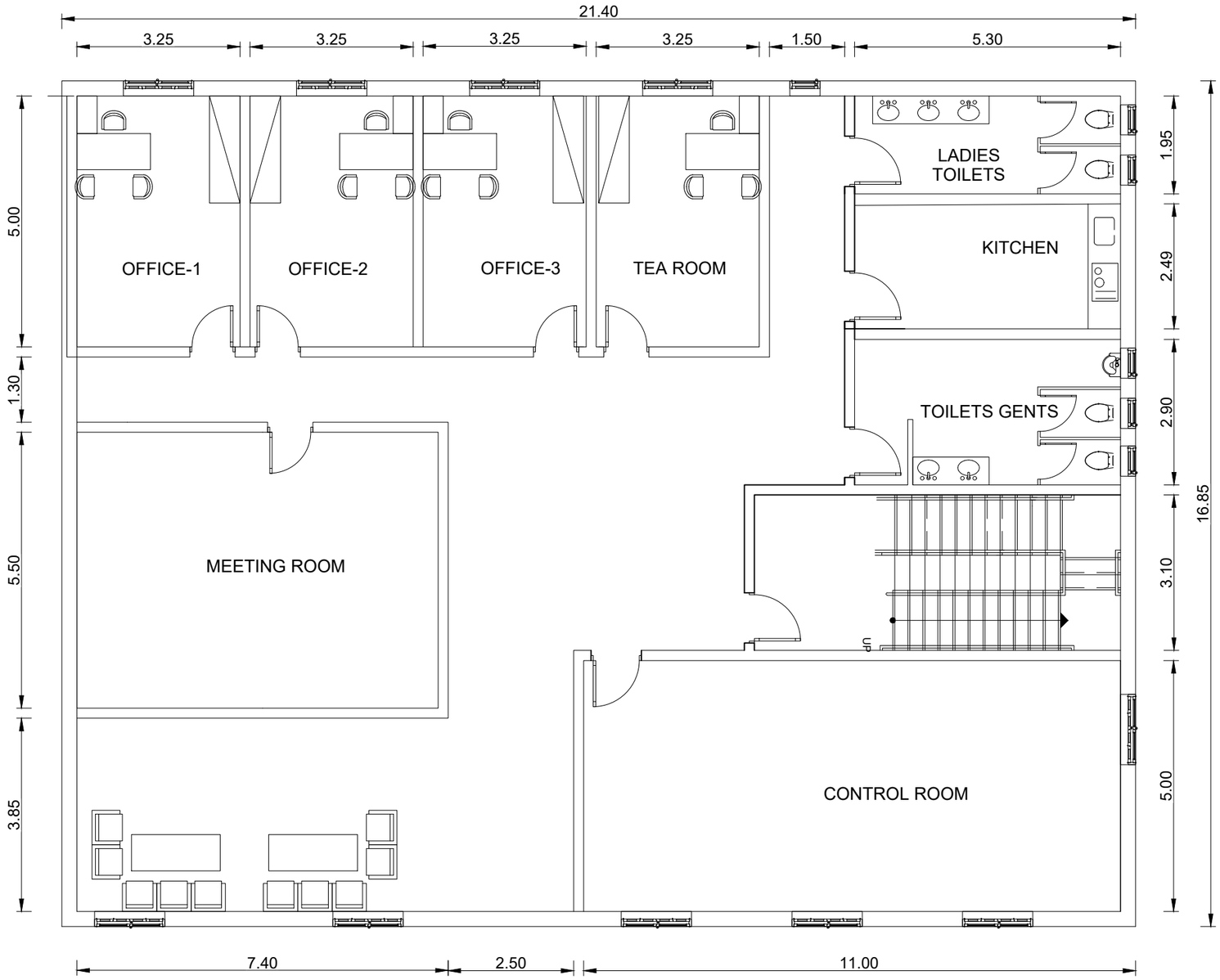
Drawing title:
Administrative building
Ground floor
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/100	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-430 | REV. 0

0 1 2 3 4 5 M

ADMINISTRATIVE BUILDING
FIRST FLOOR



NOTA:
For information only

0 1 2 3 4 5 M

NOTES:

1. Z ET CONTOUR LEVELS ARE IN METERS AT 5 METER INTERVALS
2. GRID VALUES ARE IN METERS AT 50 METER INTERVALS

LEGEND

	REVISIONS		SIGN	DATE	APPROVED
		BY			
		CHECKED			
		BY			
2		CHECKED			
		BY			
1	SECOND DIFFUSION	CHECKED			
		BY	LBC	15.04.24	
0	FIRST DIFFUSION	CHECKED	RAR	15.04.24	

CLIENT:

THE CHIEF EXECUTIVE OFFICER
COAST WATER WORKS DEVELOPMENT AGENCY
P.O. BOX 90417 - 80100
MOMBASA, KENYA

CONSULTING ENGINEERS:
JOINT VENTURE

ARTELIA
6 RUE DE LORRAINE
38130 ECHIROLLES, FRANCE
E-MAIL: artelia@arteliagroup.com
TEL: +33 (0)4 76 33 40 00.

MANGAT I.B PATEL (MIBP) LIMITED
P.O BOX 48674,00100-GPO,
NAIROBI, KENYA
E-MAIL: mibp.nairobi@mibpp.com
TEL: +254-2-2710500

PROJECT NAME:
IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA: MWACHE CKE 1103

CONTRACT No. CWSB/AFD/MWCE/C/4/2017

PRELIMINARY DESIGN, TENDER DOCUMENTS, SAFEGUARDS (ESIA AND RAP) REPORTS AND CONSTRUCTION SUPERVISION OF MWACHE WATER TREATMENT PLANT

PRELIMINARY DESIGN

Phased WTP implementation

Drawing title:
Administrative building
First floor
Plan view

Designed by: LBC	Drawn by: LBC
Checked by: RAR	Approved by: GFY
Scale: 1/100	Date: APRIL 2024

DRG N°: ART-8773361-PD-DWG-431 REV. 0

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA

DESIGN, BUILD AND OPERATE OF MWACHE WATER TREATMENT PLANT

PART 2 – EMPLOYER'S REQUIREMENTS

SECTION 7.10 – WATER ANALYSIS FOR INFORMATION

Republic of Kenya
Coast Water Works Development Agency

IMPROVEMENT OF DRINKING WATER AND SANITATION SYSTEMS IN MOMBASA - MWACHE CKE 1103

Preliminary Design, Tender Documents, Safeguards (ESIA and RAP) Reports and Construction Supervision of Mwache Water Treatment Plant

Contract No : CWSB/AFD/MWCE/C/4/2017

WATER QUALITY MONITORING TESTS

MAY 2022

ARTELIA

MIBP CONSULTING ENGINEERS

MAY 2022 / 877 3361

WATER QUALITY MONITORING TEST

According to our contract, Artelia/Mangat should provide monitoring test.

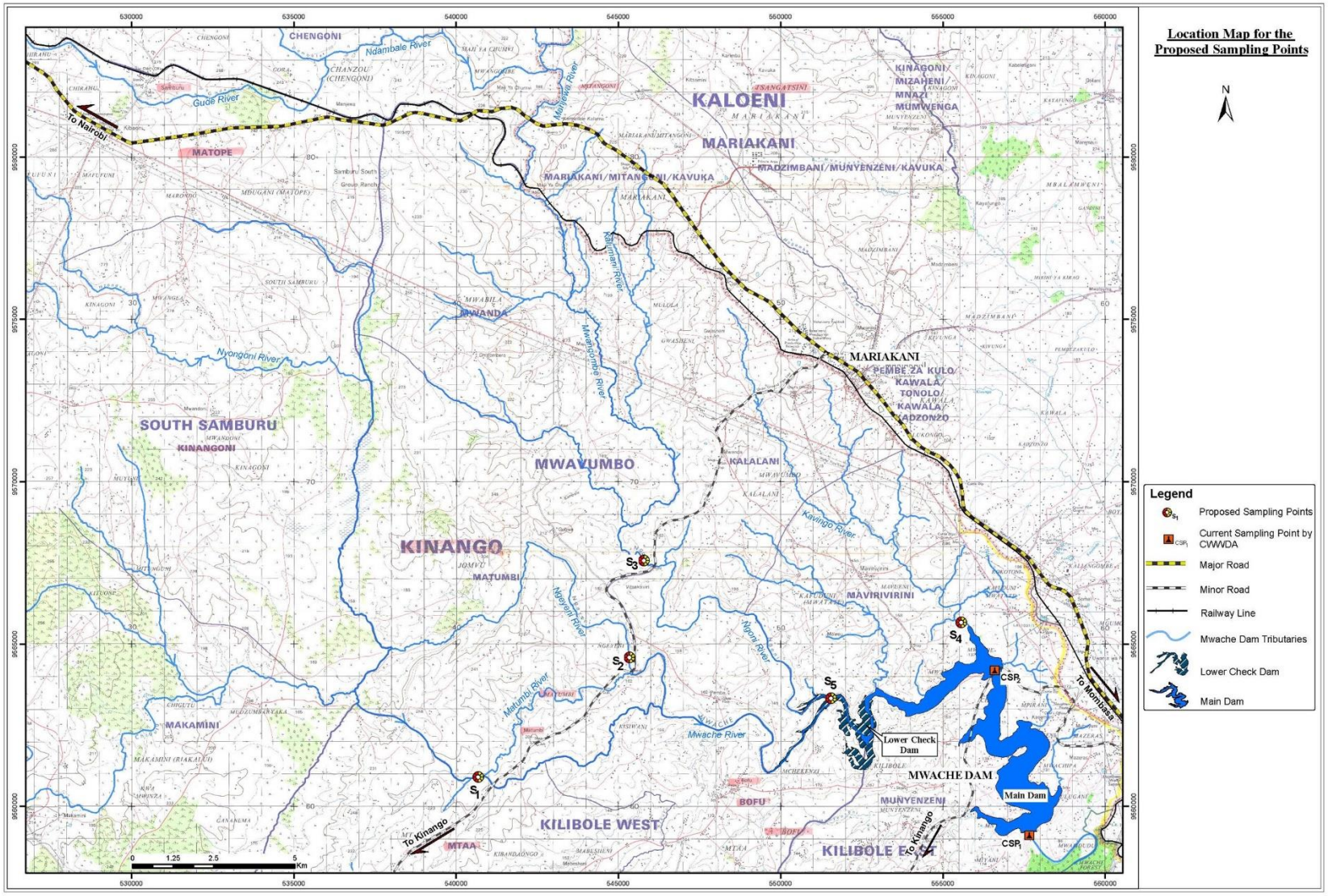
Five sampling location was defined at the beginning of the project in accordance with CWWDA.

Map illustrating the sampling locations denoted as S1 to S5 is presented hereafter.

Few water quality samples were taken in the year 2021 majorly due to dry streams at the sampling points.

We intend to continue sampling depending on the availability of flows at the sampling points.

SAMPLING LOCATION



MWACHE RAW WATER QUALITY – SAMPLING

No.	Sampling Date	Sampling Points		Analysis	Testing Laboratory
		Location	Number		
1.	12th January 2021	S 1,2,3,4,5	5Nr	Chemical & Biological	SGS
2.	12th May 2021	S 2,3,4,5	4Nr	Chemical & Biological	SGS
3.	6th December 2021	S 3,4	2Nr	Chemical	WRA
4.	22nd December 2021	S 2,3,4,5	4Nr	Chemical	WRA
5.	11th April 2022	S 2,3,5	3Nr	Chemical	WRA

MWACHE TEST RESULTS

See attached to the email.

FORM F/9/1/5

WATER RESOURCES AUTHORITY

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Central Water Testing Laboratories
P.O. Box 45250, 00100, Off Dunga Road, Nairobi
Tel: +254 773903729
Email: cwtl@wra.go.ke; centralwatertestinglabs@gmail.com

Wastewater Laboratory Results Certificate

Report Issue Date:	06/01/2022	**Sample No:**	WRA/HQ/CWTL-13590	**Year:**	2021
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	15/12/2021		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/12/2021		
Sample submitted by:	CLIENT	**Source of sample:**	River Muache at S3		
Purpose of Sampling:	Monitoring	**Received by:**	Jackson Kingori		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**6.6**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**235**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**250**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**411**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**1.5**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**<0.01**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**27**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**11**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**62**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.15**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**288**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**7.2**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.3**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**6.3**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**39**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**0.9**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**114**	Not Applicable	Not Applicable
Temperature	°C		**22.6**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.03**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**134**	30	250

APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable

Comments:
Monitoring.

WATER RESOURCES AUTHORITY
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cwtl@wra.or.ke

Rachel Olonga
Laboratory Analyst

John Muasya
Assistant Technical Coordination Manager

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

Printed on 06/01/2022 14:58:16

FORM F/9/1/5

WATER RESOURCES AUTHORITY

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Wastewater Laboratory Results Certificate

Report Issue Date:	20/01/2022	**Sample No:**	WRA/HQ/CWTL-13670	**Year:**	2021
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/12/2021		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/12/2021		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Muache River S4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**7.30**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**120**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**175**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**953**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**1.7**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**<0.01**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**56**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**9.3**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**40**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.13**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**282**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**1.2**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.5**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**4.5**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**134**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**1**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**192**	Not Applicable	Not Applicable
Temperature	°C		**23.5**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.06**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**20**	30	250

APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable

Comments:
Monitoring.

WATER RESOURCES AUTHORITY
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cwtl@wra.go.ke

Nicky Sitati
Laboratory Analyst

John Muasya
Assistant Technical Coordination Manager

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

Printed on 20/01/2022 13:48:31

FORM F/9/1/5

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Email: cwtl@wra.go.ke; centralwatertestinglabs@gmail.com

Wastewater Laboratory Results Certificate

Report Issue Date:	24/01/2022	**Sample No:**	WRA/HQ/CWTL-13812	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	05/01/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/12/2022		
Sample submitted by:	Nandu Hirani	**Source of sample:**	Muache River at S2		
Purpose of Sampling:	Water Treatment Design	**Received by:**	Prisila Julia		
County:					

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**6.53**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**718**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**625**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**512**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**5.2**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**0.02**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**35**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**2.9**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**60**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.4**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**104**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**0.3**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.5**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**7.1**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**68**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**1.8**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**100**	Not Applicable	Not Applicable
Temperature	°C		**23.5**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.03**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**357**	30	250

APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable

Comments:
The analytical results are as indicated above.

WATER RESOURCES AUTHORITY
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cwtl@wra.or.ke

Dennis Ochieng
Laboratory Analyst

John Muasya
Assistant Technical Coordination Manager

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

Printed on 24/01/2022 09:20:52

FORM F/9/1/5

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Tel: +254 773903729
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Wastewater Laboratory Results Certificate

Report Issue Date:	24/01/2022	**Sample No:**	WRA/HQ/CWTL-13813	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	05/01/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/12/2022		
Sample submitted by:	Nandu Hirani	**Source of sample:**	Muache River at S3		
Purpose of Sampling:	Water Treatment Design	**Received by:**	Prisila Julia		
County:					

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**6.78**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**314**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**625**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**455**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**2.8**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**0.04**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**19**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**10**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**74**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.2**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**99**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**3.4**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.6**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**5.2**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**61**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**1.4**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**90**	Not Applicable	Not Applicable
Temperature	°C		**23.6**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.06**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**110**	30	250

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Comments:
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Dennis Ochieng
Laboratory Analyst

John Muasya
Assistant Technical Coordination Manager

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FORM F/9/1/5

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Wastewater Laboratory Results Certificate

Report Issue Date:	24/01/2022	**Sample No:**	WRA/HQ/CWTL-13814	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	05/01/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/12/2022		
Sample submitted by:	Nandu Hirani	**Source of sample:**	Muache River at S4		
Purpose of Sampling:	Water Treatment Design	**Received by:**	Prisila Julia		
County:					

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**6.68**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**26**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**70**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**1246**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**0.5**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**0.1**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**39**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**37**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**72**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.11**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**370**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**4.7**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.8**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**4.7**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**168**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**2**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**248**	Not Applicable	Not Applicable
Temperature	°C		**23.4**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.05**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**7**	30	250

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Comments:
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Dennis Ochieng
Laboratory Analyst

John Muasya
Assistant Technical Coordination Manager

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Printed on 24/01/2022 09:21:27

FORM F/9/1/5

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Email: cwtl@wra.go.ke; centralwatertestinglabs@gmail.com

Wastewater Laboratory Results Certificate

Report Issue Date:	24/01/2022	**Sample No:**	WRA/HQ/CWTL-13815	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	05/01/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/12/2022		
Sample submitted by:	Nandu Hirani	**Source of sample:**	Muache River at S5		
Purpose of Sampling:	Water Treatment Design	**Received by:**	Prisila Julia		
County:					

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	EFFLUENT DISCHARGE STANDARDS (MAX.)	
				ENVIRONMENT (NEMA 2006)	PUBLIC SEWERS (NEMA 2006)
pH	pH Scale	APHA 4500-H+ B	**7.07**	6.5-8.5	6-9
Turbidity	N.T.U	APHA 2130 B	**89**	Not Applicable	Not Applicable
Color	mgPt/l	APHA 2120 B	**250**	15	40
Conductivity(25°C)	µS/cm	APHA 2510B	**722**	Not Applicable	Not Applicable
Iron	mg/l	APHA 3500-Fe B	**1.1**	10	Not Applicable
Manganese	mg/l	APHA 3500-Mn B	**0.02**	10	Not Applicable
Calcium	mg $CaCO_3$/L	APHA 3500-Ca B	**30**	Not Applicable	Not Applicable
Magnesium	mg $CaCO_3$/L	APHA 3500-Mg B	**14**	Not Applicable	Not Applicable
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**78**	Not Applicable	Not Applicable
Total Phosphorous	mg/l	APHA 4500-P E	**0.09**	2 guideline values	Not Applicable
Chloride	mg/l	APHA 4500-Cl- B	**167**	250	Not Applicable
Nitrate (NO3-N)	mgN/l	APHA 4500-NO3-D	**5.5**	Not Applicable	20
Fluoride	mg/l	APHA 4500-F- C	**0.7**	1.5	Not Applicable
Potassium	mg/l	APHA 3500-K B	**7.0**	Not Applicable	Not Applicable
Sodium	mg/l	APHA 3500-Na B	**101**	Not Applicable	Not Applicable
Ammonia (NH3-N)	mgN/l	APHA 4500-NH3 D	**1.7**	Not Applicable	20
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**130**	Not Applicable	Not Applicable
Temperature	°C		**23.5**	±3 ambient temp.	20-35
Oil & Grease	mg/l	APHA 5520 B	**0.04**	Nil	5 or 10
Total Suspended Solids	mg/l	APHA 2540 D	**58**	30	250

APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable

Comments:

The analytical results are as indicated above.

Dennis Ochieng
Laboratory Analyst

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John Muasya
Assistant Technical Coordination Manager

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

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FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	28/04/2022	**Sample No:**	WRA/HQ/CWTL-15327	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	14/04/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	11/04/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-2		
Purpose of Sampling:	Water Treatment	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**6.96**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**375**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1195**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**581**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**14**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**88**	500**
Total Phosphorus	mgP/L	APHA 4500-P E	**0.56**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**14**	250
Iron	mg/l	APHA 3500-Fe B	**5.8**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**0.2**	45
Flouride	mg/l	APHA 4500-F- C	**0.38**	1.5
Calcium	mg/l	APHA 3500-Ca B	**27**	150
Manganese	mg/l	APHA 3500-Mn B	**0.3**	0.1
Potassium	mg/l	APHA 3500-K B	**8.3**	50
Sodium	mg/l	APHA 3500-Na B	**71**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**138**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.8**	-
Total Suspended Solids	mg/l	APHA 2540 D	**240**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.0**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

The analytical results are as indicated above.

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Rachel Olonga
Laboratory Analyst

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John Muasya
Assistant Technical Coordination Manager

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	28/04/2022	**Sample No:**	WRA/HQ/CWTL-15326	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	14/04/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	11/04/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-3		
Purpose of Sampling:	Water Treatment	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	6.64	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	625	50(15)*
Turbidity	N.T.U	APHA 2130 B	476	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	333	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	17	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	86	500**
Total Phosphorus	mgP/L	APHA 4500-P E	0.16	No Standard
Chloride	mg/l	APHA 4500-Cl- B	47	250
Iron	mg/l	APHA 3500-Fe B	3.0	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	<0.01	45
Flouride	mg/l	APHA 4500-F- C	0.94	1.5
Calcium	mg/l	APHA 3500-Ca B	7.2	150
Manganese	mg/l	APHA 3500-Mn B	0.2	0.1
Potassium	mg/l	APHA 3500-K B	4.9	50
Sodium	mg/l	APHA 3500-Na B	33	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	58	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	0.7	-
Total Suspended Solids	mg/l	APHA 2540 D	120	-
Ammonia	mgN/l	APHA 4500-NH3 D	0.9	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

The analytical results are as indicated above.

Rachel Olonga
Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	28/04/2022	**Sample No:**	WRA/HQ/CWTL-15325	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	14/04/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	11/04/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-5		
Purpose of Sampling:	Water Treatment	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**6.90**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**875**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1625**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**371**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**1.5**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**64**	500**
Total Phosphorus	mgP/L	APHA 4500-P E	**1.02**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**58**	250
Iron	mg/l	APHA 3500-Fe B	**4.3**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**0**	45
Flouride	mg/l	APHA 4500-F- C	**0.34**	1.5
Calcium	mg/l	APHA 3500-Ca B	**19**	150
Manganese	mg/l	APHA 3500-Mn B	**0.3**	0.1
Potassium	mg/l	APHA 3500-K B	**8.2**	50
Sodium	mg/l	APHA 3500-Na B	**56**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**78**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.7**	-
Total Suspended Solids	mg/l	APHA 2540 D	**762**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**0.68**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

The analytical results are as indicated above.

.....

Rachel Olonga

Laboratory Analyst

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John Muasya

Assistant Technical Coordination Manager

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	14/06/2022	**Sample No:**	WRA/HQ/CWTL-15797	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	12/05/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	03/05/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River No S1 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	7.50	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	500	50(15)*
Turbidity	N.T.U	APHA 2130 B	648	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	265	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	8.8	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	66	500**
Total Phosphorus	mgP/L	APHA 4500-P E	0.38	No Standard
Chloride	mg/l	APHA 4500-Cl- B	45	250
Iron	mg/l	APHA 3500-Fe B	1.2	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Flouride	mg/l	APHA 4500-F- C	0.35	1.5
Calcium	mg/l	APHA 3500-Ca B	14	150
Manganese	mg/l	APHA 3500-Mn B	ND	0.1
Potassium	mg/l	APHA 3500-K B	5.8	50
Sodium	mg/l	APHA 3500-Na B	25	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	70	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	0.01	-
Total Suspended Solids	mg/l	APHA 2540 D	200	-
Ammonia	mgN/l	APHA 4500-NH3 D	2.0	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Loycephillis Kemunto
Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	14/06/2022	**Sample No:**	WRA/HQ/CWTL-15796	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	12/05/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	03/05/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River No S2 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	6.98	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	85	50(15)*
Turbidity	N.T.U	APHA 2130 B	86	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	651	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	19	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	66	500**
Total Phosphorus	mgP/L	APHA 4500-P E	0.09	No Standard
Chloride	mg/l	APHA 4500-Cl- B	149	250
Iron	mg/l	APHA 3500-Fe B	0.6	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Flouride	mg/l	APHA 4500-F- C	0.27	1.5
Calcium	mg/l	APHA 3500-Ca B	28	150
Manganese	mg/l	APHA 3500-Mn B	ND	0.1
Potassium	mg/l	APHA 3500-K B	5.7	50
Sodium	mg/l	APHA 3500-Na B	78	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	148	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	0.02	-
Total Suspended Solids	mg/l	APHA 2540 D	100	-
Ammonia	mgN/l	APHA 4500-NH3 D	1.0	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	14/06/2022	**Sample No:**	WRA/HQ/CWTL-15795	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	12/05/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	03/05/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River No S3 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.33**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**625**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**2290**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**231**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**12**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**66**	500**
Total Phosphorus	mgP/L	APHA 4500-P E	**0.37**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**33**	250
Iron	mg/l	APHA 3500-Fe B	**7.9**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Flouride	mg/l	APHA 4500-F- C	**0.45**	1.5
Calcium	mg/l	APHA 3500-Ca B	**15**	150
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Potassium	mg/l	APHA 3500-K B	**3.5**	50
Sodium	mg/l	APHA 3500-Na B	**11**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**88**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.01**	-
Total Suspended Solids	mg/l	APHA 2540 D	**1300**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**2.4**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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John Muasya
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The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	14/06/2022	**Sample No:**	WRA/HQ/CWTL-15794	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	12/05/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	03/05/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River No S4 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	6.55	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	100	50(15)*
Turbidity	N.T.U	APHA 2130 B	240	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	477	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	14	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	42	500**
Total Phosphorus	mgP/L	APHA 4500-P E	0.19	No Standard
Chloride	mg/l	APHA 4500-Cl- B	125	250
Iron	mg/l	APHA 3500-Fe B	0.61	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	0.9	45
Flouride	mg/l	APHA 4500-F- C	0.64	1.5
Calcium	mg/l	APHA 3500-Ca B	18	150
Manganese	mg/l	APHA 3500-Mn B	ND	0.1
Potassium	mg/l	APHA 3500-K B	2.0	50
Sodium	mg/l	APHA 3500-Na B	61	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	100	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	0.02	-
Total Suspended Solids	mg/l	APHA 2540 D	133	-
Ammonia	mgN/l	APHA 4500-NH3 D	0.9	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	14/06/2022	**Sample No:**	WRA/HQ/CWTL-15793	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	12/05/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	03/05/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River No S5 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	7.41	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	750	50(15)*
Turbidity	N.T.U	APHA 2130 B	1865	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	237	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	8.8	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	66	500**
Total Phosphorus	mgP/L	APHA 4500-P E	0.31	No Standard
Chloride	mg/l	APHA 4500-Cl- B	36	250
Iron	mg/l	APHA 3500-Fe B	1.0	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	11	45
Flouride	mg/l	APHA 4500-F- C	0.44	1.5
Calcium	mg/l	APHA 3500-Ca B	14	150
Manganese	mg/l	APHA 3500-Mn B	0.1	0.1
Potassium	mg/l	APHA 3500-K B	3.7	50
Sodium	mg/l	APHA 3500-Na B	19	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	70	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	900	-
Ammonia	mgN/l	APHA 4500-NH3 D	1.2	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16352	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	24/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	7.8	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	175	50(15)*
Turbidity	N.T.U	APHA 2130 B	79	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	504	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	16	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	100	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	4.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.13	No Standard
Chloride	mg/l	APHA 4500-Cl- B	98	250
Iron	mg/l	APHA 3500-Fe B	0.3	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Total Dissolved Solids	mg/l	APHA 2510 A	312	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	34	400
Flouride	mg/l	APHA 4500-F- C	0.28	1.5
Calcium	mg/l	APHA 3500-Ca B	32	150
Manganese	mg/l	APHA 3500-Mn B	0.15	0.1
Potassium	mg/l	APHA 3500-K B	4.3	50
Sodium	mg/l	APHA 3500-Na B	46	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	144	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	50	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16352	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	24/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16353	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.8**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**75**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**70**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**462**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**14**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**150**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.11**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**73**	250
Iron	mg/l	APHA 3500-Fe B	**1.1**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**286**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.54**	1.5
Calcium	mg/l	APHA 3500-Ca B	**26**	150
Manganese	mg/l	APHA 3500-Mn B	**0.28**	0.1
Potassium	mg/l	APHA 3500-K B	**2.7**	50
Sodium	mg/l	APHA 3500-Na B	**48**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**122**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**80**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16353	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.7**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16354	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**8.2**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**38**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**55**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**695**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**19**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**146**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**1.9**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**141**	250
Iron	mg/l	APHA 3500-Fe B	**1.1**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**431**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**19**	400
Flouride	mg/l	APHA 4500-F- C	**0.81**	1.5
Calcium	mg/l	APHA 3500-Ca B	**26**	150
Manganese	mg/l	APHA 3500-Mn B	**0.02**	0.1
Potassium	mg/l	APHA 3500-K B	**4.4**	50
Sodium	mg/l	APHA 3500-Na B	**91**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**142**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.02**	-
Total Suspended Solids	mg/l	APHA 2540 D	**30**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16354	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.3**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16351	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	24/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.7**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**500**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**186**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**347**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**6.8**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**90**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**6.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.12**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**53**	250
Iron	mg/l	APHA 3500-Fe B	**4.6**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**215**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**17**	400
Flouride	mg/l	APHA 4500-F- C	**0.39**	1.5
Calcium	mg/l	APHA 3500-Ca B	**31**	150
Manganese	mg/l	APHA 3500-Mn B	**0.09**	0.1
Potassium	mg/l	APHA 3500-K B	**4.4**	50
Sodium	mg/l	APHA 3500-Na B	**29**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**106**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**10**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/07/2022	**Sample No:**	WRA/HQ/CWTL-16351	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/06/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	24/06/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.9**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/08/2022	**Sample No:**	WRA/HQ/CWTL-16623	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.41	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	125	50(15)*
Turbidity	N.T.U	APHA 2130 B	47	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	622	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	20	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	122	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	2.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.04	No Standard
Chloride	mg/l	APHA 4500-Cl- B	119	250
Iron	mg/l	APHA 3500-Fe B	1.5	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	0.09	45
Total Dissolved Solids	mg/l	APHA 2510 A	386	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	43	400
Flouride	mg/l	APHA 4500-F- C	0.43	1.5
Calcium	mg/l	APHA 3500-Ca B	30	150
Manganese	mg/l	APHA 3500-Mn B	0.2	0.1
Potassium	mg/l	APHA 3500-K B	5.9	50
Sodium	mg/l	APHA 3500-Na B	67	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	156	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	43	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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For John Muasya
Assistant Technical Coordination Manager

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/08/2022	**Sample No:**	WRA/HQ/CWTL-16623	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.02**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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For John Muasya
Assistant Technical Coordination Manager

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16622	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**8.0**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**375**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**158**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**535**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**19**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**168**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.03**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**80**	250
Iron	mg/l	APHA 3500-Fe B	**1.5**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**332**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.74**	1.5
Calcium	mg/l	APHA 3500-Ca B	**24**	150
Manganese	mg/l	APHA 3500-Mn B	**0.2**	0.1
Potassium	mg/l	APHA 3500-K B	**4.1**	50
Sodium	mg/l	APHA 3500-Na B	**56**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**136**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**140**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16622	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**2.2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16621	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.9**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**20**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**30**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**1025**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**26**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**106**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**ND**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.01**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**269**	250
Iron	mg/l	APHA 3500-Fe B	**1.1**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**0.6**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**636**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**23**	400
Flouride	mg/l	APHA 4500-F- C	**0.97**	1.5
Calcium	mg/l	APHA 3500-Ca B	**30**	150
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Potassium	mg/l	APHA 3500-K B	**4.5**	50
Sodium	mg/l	APHA 3500-Na B	**149**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**182**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**27**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16621	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.01**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16620	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.3**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**200**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**145**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**443**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**15**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**112**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.05**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**68**	250
Iron	mg/l	APHA 3500-Fe B	**5.5**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**275**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**25**	400
Flouride	mg/l	APHA 4500-F- C	**0.68**	1.5
Calcium	mg/l	APHA 3500-Ca B	**25**	150
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Potassium	mg/l	APHA 3500-K B	**4.8**	50
Sodium	mg/l	APHA 3500-Na B	**42**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**124**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.01**	-
Total Suspended Solids	mg/l	APHA 2540 D	**130**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	10/08/2022	**Sample No:**	WRA/HQ/CWTL-16620	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	26/07/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	22/07/2022		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.72**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

.....
Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/01/2023	**Sample No:**	WRA/HQ/CWTL-18516	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.0	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	375	50(15)*
Turbidity	N.T.U	APHA 2130 B	373	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	674	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	15	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	92	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	6.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.18	No Standard
Chloride	mg/l	APHA 4500-Cl- B	132	250
Iron	mg/l	APHA 3500-Fe B	3.2	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	5.4	45
Total Dissolved Solids	mg/l	APHA 2510 A	418	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	35	400
Flouride	mg/l	APHA 4500-F- C	0.4	1.5
Calcium	mg/l	APHA 3500-Ca B	30	150
Manganese	mg/l	APHA 3500-Mn B	0.3	0.1
Potassium	mg/l	APHA 3500-K B	7.6	50
Sodium	mg/l	APHA 3500-Na B	87	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	138	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	24	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

.....

Rachel Olonga

Laboratory Analyst

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John Muasya

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/01/2023	**Sample No:**	WRA/HQ/CWTL-18516	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.5**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

.....

Rachel Olonga

Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	15/12/2022	**Sample No:**	WRA/HQ/CWTL-18514	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.15	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	625	50(15)*
Turbidity	N.T.U	APHA 2130 B	312	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	326	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	8.8	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	146	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	6.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.2	No Standard
Chloride	mg/l	APHA 4500-Cl- B	4.0	250
Iron	mg/l	APHA 3500-Fe B	3.4	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	2.2	45
Total Dissolved Solids	mg/l	APHA 2510 A	202	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	<0.3	400
Flouride	mg/l	APHA 4500-F- C	0.5	1.5
Calcium	mg/l	APHA 3500-Ca B	16	150
Manganese	mg/l	APHA 3500-Mn B	<0.01	0.1
Potassium	mg/l	APHA 3500-K B	5.3	50
Sodium	mg/l	APHA 3500-Na B	36	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	6.0	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	12	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

.....
Julia Prisila
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	15/12/2022	**Sample No:**	WRA/HQ/CWTL-18514	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Laboratory Analyst

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Principal Water Quality & Pollution Control Officer

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	15/12/2022	**Sample No:**	WRA/HQ/CWTL-18515	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	1.3	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Julia Prisila
Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	15/12/2022	**Sample No:**	WRA/HQ/CWTL-18515	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.07	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	250	50(15)*
Turbidity	N.T.U	APHA 2130 B	101	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	635	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	15	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	92	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	8.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.07	No Standard
Chloride	mg/l	APHA 4500-Cl- B	154	250
Iron	mg/l	APHA 3500-Fe B	1.6	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Total Dissolved Solids	mg/l	APHA 2510 A	394	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	3.1	400
Flouride	mg/l	APHA 4500-F- C	0.7	1.5
Calcium	mg/l	APHA 3500-Ca B	27	150
Manganese	mg/l	APHA 3500-Mn B	<0.01	0.1
Potassium	mg/l	APHA 3500-K B	4.0	50
Sodium	mg/l	APHA 3500-Na B	75	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	130	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	10	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Julia Prisila
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/01/2023	**Sample No:**	WRA/HQ/CWTL-18517	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.1	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	438	50(15)*
Turbidity	N.T.U	APHA 2130 B	826	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	449	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	15	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	126	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	4.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	1.0	No Standard
Chloride	mg/l	APHA 4500-Cl- B	67	250
Iron	mg/l	APHA 3500-Fe B	4.9	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	0.4	45
Total Dissolved Solids	mg/l	APHA 2510 A	278	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	<0.3	400
Flouride	mg/l	APHA 4500-F- C	0.4	1.5
Calcium	mg/l	APHA 3500-Ca B	22	150
Manganese	mg/l	APHA 3500-Mn B	0.3	0.1
Potassium	mg/l	APHA 3500-K B	9.3	50
Sodium	mg/l	APHA 3500-Na B	44	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	118	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	25	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	17/01/2023	**Sample No:**	WRA/HQ/CWTL-18517	**Year:**	2022
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	08/12/2022		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	05/12/2022		
Sample submitted by:	Mangat I.B Patel Limited	**Source of sample:**	Mwache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**1.2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19040	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 2 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**8.3**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**175**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**22**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**1923**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**59**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**108**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.2**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**450**	250
Iron	mg/l	APHA 3500-Fe B	**0.4**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**0.8**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**1192**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**136**	400
Flouride	mg/l	APHA 4500-F- C	**0.6**	1.5
Calcium	mg/l	APHA 3500-Ca B	**37**	150
Manganese	mg/l	APHA 3500-Mn B	**0.2**	0.1
Potassium	mg/l	APHA 3500-K B	**9.9**	50
Sodium	mg/l	APHA 3500-Na B	**281**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**336**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**7.0**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19040	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 2 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.9**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19041	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 3 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.8**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**250**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**86**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**548**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**22**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**102**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.3**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**81**	250
Iron	mg/l	APHA 3500-Fe B	**1.8**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**340**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**22**	400
Flouride	mg/l	APHA 4500-F- C	**0.6**	1.5
Calcium	mg/l	APHA 3500-Ca B	**17**	150
Manganese	mg/l	APHA 3500-Mn B	**0.1**	0.1
Potassium	mg/l	APHA 3500-K B	**5.5**	50
Sodium	mg/l	APHA 3500-Na B	**61**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**132**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**10**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19041	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 3 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19042	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 4 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**8.1**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**175**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**67**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**682**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**22**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**100**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.1**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**131**	250
Iron	mg/l	APHA 3500-Fe B	**0.8**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**423**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**7.2**	400
Flouride	mg/l	APHA 4500-F- C	**0.7**	1.5
Calcium	mg/l	APHA 3500-Ca B	**18**	150
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Potassium	mg/l	APHA 3500-K B	**5.2**	50
Sodium	mg/l	APHA 3500-Na B	**91**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**136**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**5.0**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Principal Water Quality & Pollution Control Officer

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19042	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 4 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.5**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19043	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 5 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	8.3	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	200	50(15)*
Turbidity	N.T.U	APHA 2130 B	65	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	901	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	27	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	128	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	4.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.9	No Standard
Chloride	mg/l	APHA 4500-Cl- B	173	250
Iron	mg/l	APHA 3500-Fe B	0.6	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Total Dissolved Solids	mg/l	APHA 2510 A	559	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	34	400
Flouride	mg/l	APHA 4500-F- C	0.7	1.5
Calcium	mg/l	APHA 3500-Ca B	22	150
Manganese	mg/l	APHA 3500-Mn B	ND	0.1
Potassium	mg/l	APHA 3500-K B	5.8	50
Sodium	mg/l	APHA 3500-Na B	127	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	168	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	8.0	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	09/02/2023	**Sample No:**	WRA/HQ/CWTL-19043	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	31/01/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	28/01/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S - 5 Water		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.3**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19885	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	14/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 1		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**9.0**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**1125**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1115**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**323**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**0.02**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**204**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**8.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.76**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**370**	250
Iron	mg/l	APHA 3500-Fe B	**15.7**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**73**	45
Nitrite (NO2- N)	mgN/l	APHA 4500-NO2- B	**<0.01**	0.9
Total Dissolved Solids	mg/l	APHA 2510 A	**200**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.82**	1.5
Calcium	mg/l	APHA 3500-Ca B	**36**	150
Manganese	mg/l	APHA 3500-Mn B	**0.3**	0.1
Potassium	mg/l	APHA 3500-K B	**8.9**	50
Sodium	mg/l	APHA 3500-Na B	**28**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**90**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19885	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	14/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 1		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Suspended Solids	mg/l	APHA 2540 D	**600**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19886	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 2		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**6.9**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**313**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**151**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**1553**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**33**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**80**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**6.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.59**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**360**	250
Iron	mg/l	APHA 3500-Fe B	**1.93**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Nitrite (NO2- N)	mgN/l	APHA 4500-NO2- B	**0.03**	0.9
Total Dissolved Solids	mg/l	APHA 2510 A	**963**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**96.9**	400
Flouride	mg/l	APHA 4500-F- C	**0.72**	1.5
Calcium	mg/l	APHA 3500-Ca B	**51**	150
Manganese	mg/l	APHA 3500-Mn B	**0.28**	0.1
Potassium	mg/l	APHA 3500-K B	**15**	50
Sodium	mg/l	APHA 3500-Na B	**226**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**264**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19886	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 2		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Suspended Solids	mg/l	APHA 2540 D	**200**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**2.5**	0.5

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19887	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 3		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**6.9**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**438**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1170**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**415**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**24**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**72**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**8.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.57**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**70**	250
Iron	mg/l	APHA 3500-Fe B	**14.3**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Nitrite (NO2- N)	mgN/l	APHA 4500-NO2- B	**<0.01**	0.9
Total Dissolved Solids	mg/l	APHA 2510 A	**257**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.80**	1.5
Calcium	mg/l	APHA 3500-Ca B	**8.8**	150
Manganese	mg/l	APHA 3500-Mn B	**0.38**	0.1
Potassium	mg/l	APHA 3500-K B	**8.8**	50
Sodium	mg/l	APHA 3500-Na B	**47**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**198**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19887	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 3		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Suspended Solids	mg/l	APHA 2540 D	**1500**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Nicky Sitati

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19888	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 4		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**6.6**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**750**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**467**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**514**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**16**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**68**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**12**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.57**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**93**	250
Iron	mg/l	APHA 3500-Fe B	**12.7**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Nitrite (NO2- N)	mgN/l	APHA 4500-NO2- B	**0.04**	0.9
Total Dissolved Solids	mg/l	APHA 2510 A	**319**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**53.7**	400
Flouride	mg/l	APHA 4500-F- C	**0.58**	1.5
Calcium	mg/l	APHA 3500-Ca B	**27**	150
Manganese	mg/l	APHA 3500-Mn B	**0.8**	0.1
Potassium	mg/l	APHA 3500-K B	**10**	50
Sodium	mg/l	APHA 3500-Na B	**51**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**134**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19888	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 4		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Suspended Solids	mg/l	APHA 2540 D	**400**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.6**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19889	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 5		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**6.7**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**563**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**990**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**485**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**14**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**66**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**8.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.68**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**95**	250
Iron	mg/l	APHA 3500-Fe B	**20**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**11.9**	45
Nitrite (NO2- N)	mgN/l	APHA 4500-NO2- B	**0.10**	0.9
Total Dissolved Solids	mg/l	APHA 2510 A	**301**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.50**	1.5
Calcium	mg/l	APHA 3500-Ca B	**26**	150
Manganese	mg/l	APHA 3500-Mn B	**5**	0.1
Potassium	mg/l	APHA 3500-K B	**15**	50
Sodium	mg/l	APHA 3500-Na B	**358**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**124**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	25/04/2023	**Sample No:**	WRA/HQ/CWTL-19889	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	24/03/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	21/03/2023		
Sample submitted by:	CLIENT	**Source of sample:**	River Mwache S 5		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Suspended Solids	mg/l	APHA 2540 D	**1000**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	03/05/2023	**Sample No:**	WRA/HQ/CWTL-20205	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S2		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.0**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**750**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**875**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**324**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**3.0**	0.3
Manganese	mg/l	APHA 3500-Mn B	**1.0**	0.1
Calcium	mg/l	APHA 3500-Ca B	**22**	150
Magnesium	mg/l	APHA 3500-Mg B	**9.7**	100
Sodium	mg/l	APHA 3500-Na B	**25.4**	200
Potassium	mg/l	APHA 3500-K B	**8.8**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**94**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**70**	500**
Chloride	mg/l	APHA 4500-Cl- B	**42**	250
Fluoride	mg/l	APHA 4500-F- C	**0.5**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**ND**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**201**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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John Muasya
Principal Water Quality & Pollution Control Officer

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	08/05/2023	**Sample No:**	WRA/HQ/CWTL-20209	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S2		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Phosphorus	mgP/L	APHA 4500-P E	**0.9**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**0.4**	-
Total Suspended Solids	mg/l	APHA 2540 D	**600**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.3**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	03/05/2023	**Sample No:**	WRA/HQ/CWTL-20204	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S3		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.2**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**225**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1280**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**248**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**3.4**	0.3
Manganese	mg/l	APHA 3500-Mn B	**1.5**	0.1
Calcium	mg/l	APHA 3500-Ca B	**33**	150
Magnesium	mg/l	APHA 3500-Mg B	**6.3**	100
Sodium	mg/l	APHA 3500-Na B	**3.0**	200
Potassium	mg/l	APHA 3500-K B	**7.4**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**108**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**80**	500**
Chloride	mg/l	APHA 4500-Cl- B	**21**	250
Fluoride	mg/l	APHA 4500-F- C	**0.6**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**20**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.6**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**154**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	08/05/2023	**Sample No:**	WRA/HQ/CWTL-20208	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S3		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Phosphorus	mgP/L	APHA 4500-P E	**0.8**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**0.4**	-
Total Suspended Solids	mg/l	APHA 2540 D	**1800**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**2**	0.5

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Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	03/05/2023	**Sample No:**	WRA/HQ/CWTL-20203	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S4		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.4**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**150**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**139**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**663**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**2.0**	0.3
Manganese	mg/l	APHA 3500-Mn B	**<0.01**	0.1
Calcium	mg/l	APHA 3500-Ca B	**29**	150
Magnesium	mg/l	APHA 3500-Mg B	**17**	100
Sodium	mg/l	APHA 3500-Na B	**84**	200
Potassium	mg/l	APHA 3500-K B	**4.3**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**144**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**94**	500**
Chloride	mg/l	APHA 4500-Cl- B	**135**	250
Fluoride	mg/l	APHA 4500-F- C	**0.7**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.02**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/i	APHA 4500-CO2 C	**4**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**411.1**	1500 (1000)*

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Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	08/05/2023	**Sample No:**	WRA/HQ/CWTL-20207	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S4		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Phosphorus	mgP/L	APHA 4500-P E	**0.7**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**0.03**	-
Total Suspended Solids	mg/l	APHA 2540 D	**160**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.1**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	03/05/2023	**Sample No:**	WRA/HQ/CWTL-20202	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S5		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.4**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**225**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**3585**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**331**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**3.0**	0.3
Manganese	mg/l	APHA 3500-Mn B	**2.0**	0.1
Calcium	mg/l	APHA 3500-Ca B	**34**	150
Magnesium	mg/l	APHA 3500-Mg B	**8.0**	100
Sodium	mg/l	APHA 3500-Na B	**18**	200
Potassium	mg/l	APHA 3500-K B	**5.6**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**116**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**106**	500**
Chloride	mg/l	APHA 4500-Cl- B	**43**	250
Fluoride	mg/l	APHA 4500-F- C	**0.8**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.2**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	4	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**205**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Dennis Ochieng
Laboratory Analyst

John Muasya
Principal Water Quality & Pollution Control Officer

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

Printed on 03/05/2023 14:07:06

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	08/05/2023	**Sample No:**	WRA/HQ/CWTL-20206	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	20/04/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	20/04/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River S5		
Purpose of Sampling:	monitoring	**Received by:**	Nicky Sitati		
County:	KILIFI				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Total Phosphorus	mgP/L	APHA 4500-P E	**0.9**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**0.4**	-
Total Suspended Solids	mg/l	APHA 2540 D	**4000**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**1.2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	30/05/2023	**Sample No:**	WRA/HQ/CWTL-20584	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-1		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**8.0**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**500**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**421**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**232**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**3.7**	0.3
Manganese	mg/l	APHA 3500-Mn B	**7.9**	0.1
Calcium	mg/l	APHA 3500-Ca B	**17**	150
Magnesium	mg/l	APHA 3500-Mg B	**7.8**	100
Sodium	mg/l	APHA 3500-Na B	**15**	200
Potassium	mg/l	APHA 3500-K B	**6.7**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**74**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**54**	500**
Chloride	mg/l	APHA 4500-Cl- B	**43**	250
Fluoride	mg/l	APHA 4500-F- C	**0.6**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.1**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**144**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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John Muasya
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	02/06/2023	**Sample No:**	WRA/HQ/CWTL-20584	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-1		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**8.00**	5.5-9.5 (6.5-8.5)*
Total Phosphorus	mgP/L	APHA 4500-P E	**0.26**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**260**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**3**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Nicky Sitati
Laboratory Analyst

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Principal Water Quality & Pollution Control Officer

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	30/05/2023	**Sample No:**	WRA/HQ/CWTL-20585	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.2**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**625**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**679**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**418**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**2.3**	0.3
Manganese	mg/l	APHA 3500-Mn B	**20**	0.1
Calcium	mg/l	APHA 3500-Ca B	**29**	150
Magnesium	mg/l	APHA 3500-Mg B	**13**	100
Sodium	mg/l	APHA 3500-Na B	**34**	200
Potassium	mg/l	APHA 3500-K B	**5.9**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**126**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**54**	500**
Chloride	mg/l	APHA 4500-Cl- B	**93**	250
Fluoride	mg/l	APHA 4500-F- C	**0.4**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.1**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**20**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**259**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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John Muasya
Principal Water Quality & Pollution Control Officer

The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	02/06/2023	**Sample No:**	WRA/HQ/CWTL-20585	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-2		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.20**	5.5-9.5 (6.5-8.5)*
Total Phosphorus	mgP/L	APHA 4500-P E	**0.45**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**620**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

.....

Nicky Sitati

Laboratory Analyst

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John Muasya

Principal Water Quality & Pollution Control Officer

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/06/2023	**Sample No:**	WRA/HQ/CWTL-20586	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.0**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**750**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1945**	25 (5)*
Conductivity (25°C)	µS/cm	APHA 2510B	**149**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**6.1**	0.3
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Calcium	mg/l	APHA 3500-Ca B	**18**	150
Magnesium	mg/l	APHA 3500-Mg B	**1.3**	100
Sodium	mg/l	APHA 3500-Na B	**5.5**	200
Potassium	mg/l	APHA 3500-K B	**9.4**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**50**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**32**	500**
Chloride	mg/l	APHA 4500-Cl- B	**25**	250
Fluoride	mg/l	APHA 4500-F- C	**0.4**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**1.5**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.5**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**6.0**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**92**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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Principal Water Quality & Pollution Control Officer

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	02/06/2023	**Sample No:**	WRA/HQ/CWTL-20586	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-3		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.00**	5.5-9.5 (6.5-8.5)*
Total Phosphorus	mgP/L	APHA 4500-P E	**0.35**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**1500**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**2**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Nicky Sitati

Laboratory Analyst

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John Muasya

Principal Water Quality & Pollution Control Officer

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	30/05/2023	**Sample No:**	WRA/HQ/CWTL-20587	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**7.8**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**150**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**47**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**709**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**0.9**	0.3
Manganese	mg/l	APHA 3500-Mn B	**ND**	0.1
Calcium	mg/l	APHA 3500-Ca B	**38**	150
Magnesium	mg/l	APHA 3500-Mg B	**43**	100
Sodium	mg/l	APHA 3500-Na B	**34**	200
Potassium	mg/l	APHA 3500-K B	**5.2**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**272**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**80**	500**
Chloride	mg/l	APHA 4500-Cl- B	**183**	250
Fluoride	mg/l	APHA 4500-F- C	**0.7**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**3.0**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.02**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**440**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Rachel Olonga
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John Muasya
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The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out are as detailed in these results. The information contained here reflects the laboratory's findings as at the time of analysis and based on the samples submitted by the client.

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	02/06/2023	**Sample No:**	WRA/HQ/CWTL-20587	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-4		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.80**	5.5-9.5 (6.5-8.5)*
Total Phosphorus	mgP/L	APHA 4500-P E	**0.33**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**850**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**4**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Nicky Sitati

Laboratory Analyst

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John Muasya

Principal Water Quality & Pollution Control Officer

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	05/06/2023	**Sample No:**	WRA/HQ/CWTL-20588	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	KS EAS 12:2018 STANDARDS (MAX.)
pH	pH Scale	APHA 4500-H+ B	**6.8**	5.5-9.5 (6.5-8.5)*
Colour	mgPt/l	APHA 2120 B	**625**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**1615**	25 (5)*
Conductivity (25˚C)	µS/cm	APHA 2510B	**159**	2500 (1500)*
Iron	mg/l	APHA 3500-Fe B	**6.1**	0.3
Manganese	mg/l	APHA 3500-Mn B	**11**	0.1
Calcium	mg/l	APHA 3500-Ca B	**14**	150
Magnesium	mg/l	APHA 3500-Mg B	**0.5**	100
Sodium	mg/l	APHA 3500-Na B	**14**	200
Potassium	mg/l	APHA 3500-K B	**9.0**	50
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**37**	600 (300)*
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**34**	500**
Chloride	mg/l	APHA 4500-Cl- B	**31**	250
Fluoride	mg/l	APHA 4500-F- C	**0.3**	1.5
Nitrate	mg/l	APHA 4500-NO3-D	**ND**	45
Nitrite	mg/l	APHA 4500-NO2- B	**0.1**	0.9
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	Not Applicable
Total Dissolved Solids	mg/l	APHA 2510 A	**99**	1500 (1000)*

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	02/06/2023	**Sample No:**	WRA/HQ/CWTL-20588	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	25/05/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	23/05/2023		
Sample submitted by:	CLIENT	**Source of sample:**	Mwache River at S-5		
Purpose of Sampling:	Monitoring	**Received by:**	Loycephilis Onchari		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**6.80**	5.5-9.5 (6.5-8.5)*
Total Phosphorus	mgP/L	APHA 4500-P E	**0.38**	No Standard
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**1600**	-
Ammonia	mgN/l	APHA 4500-NH3 D	**5**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Nicky Sitati

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21233	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S1		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.7	5.5-9 5 (6 5-8.5)*
Color	mgPt/l	APHA 2120 B	225	50(15)*
Turbidity	N.T.U	APHA 2130 B	588	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	349	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	9.2	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	78	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	8.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.5	No Standard
Chloride	mg/l	APHA 4500-Cl- B	49	250
Iron	mg/l	APHA 3500-Fe B	46	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	0.8	45
Total Dissolved Solids	mg/l	APHA 2510 A	216	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	<0.3	400
Flouride	mg/l	APHA 4500-F- C	0.6	1.5
Calcium	mg/l	APHA 3500-Ca B	18	150
Manganese	mg/l	APHA 3500-Mn B	0.1	0.1
Potassium	mg/l	APHA 3500-K B	3.3	50
Sodium	mg/l	APHA 3500-Na B	40	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	84	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	0.2	-
Total Suspended Solids	mg/l	APHA 2540 D	440	

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater, "<": value below method detection limit, ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21233	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S1		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	2	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21232	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**8.0**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**50**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**62**	25 (5)*
Conductivity(25˚C)	µS/cm	APHA 2510B	**827**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**25**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**170**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**4.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.2**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**204**	250
Iron	mg/l	APHA 3500-Fe B	**9.8**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**7.0**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**513**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.4**	1.5
Calcium	mg/l	APHA 3500-Ca B	**51**	150
Manganese	mg/l	APHA 3500-Mn B	**0.2**	0.1
Potassium	mg/l	APHA 3500-K B	**3.2**	50
Sodium	mg/l	APHA 3500-Na B	**82**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**232**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.07**	-
Total Suspended Solids	mg/l	APHA 2540 D	**120**	-

**Maximum limits for treated potable water; **WHO maximum guideline value, APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21232	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**ND**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value: APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21231	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.7**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**200**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**190**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**437**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**1.0**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**110**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**10**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.3**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**79**	250
Iron	mg/l	APHA 3500-Fe B	**16**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**4.8**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**271**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.5**	1.5
Calcium	mg/l	APHA 3500-Ca B	**34**	150
Manganese	mg/l	APHA 3500-Mn B	**0.1**	0.1
Potassium	mg/l	APHA 3500-K B	**3.1**	50
Sodium	mg/l	APHA 3500-Na B	**58**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**90**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.03**	-
Total Suspended Solids	mg/l	APHA 2540 D	**120**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21231	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	**0.5**	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21230	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.8**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**45**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**39**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**1809**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**73**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**136**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**8.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.2**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**489**	250
Iron	mg/l	APHA 3500-Fe B	**5.7**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**10**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**1122**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**13**	400
Flouride	mg/l	APHA 4500-F- C	**0.7**	1.5
Calcium	mg/l	APHA 3500-Ca B	**62**	150
Manganese	mg/l	APHA 3500-Mn B	**0.1**	0.1
Potassium	mg/l	APHA 3500-K B	**7.3**	50
Sodium	mg/l	APHA 3500-Na B	**200**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**456**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.1**	-
Total Suspended Solids	mg/l	APHA 2540 D	**70**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21230	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500 NH3 D	ND	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Rachel Olonga
Laboratory Analyst

John Muasya
Principal Water Quality & Pollution Control Officer

FORM F/9/1/3

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21229	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.9**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**88**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**208**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**553**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**9.7**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**120**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**8.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.4**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**102**	250
Iron	mg/l	APHA 3500-Fe B	**19**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**2.6**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**343**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Flouride	mg/l	APHA 4500-F- C	**0.5**	1.5
Calcium	mg/l	APHA 3500-Ca B	**43**	150
Manganese	mg/l	APHA 3500-Mn B	**0.1**	0.1
Potassium	mg/l	APHA 3500-K B	**2.4**	50
Sodium	mg/l	APHA 3500-Na B	**58**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**148**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**0.3**	-
Total Suspended Solids	mg/l	APHA 2540 D	**170**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	01/08/2023	**Sample No:**	WRA/HQ/CWTL-21229	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	13/07/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	13/07/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Mwache River S5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
Ammonia	mgN/l	APHA 4500-NH3 D	2	0.5

**Maximum limits for treated potable water; **WHO maximum guideline value, APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater, "<": value below method detection limit; ND: Not detectable*

Comments:

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	28/11/2023	**Sample No:**	WRA/HQ/CWTL-22883	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	07/11/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/11/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S2		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.2	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	250	50(15)*
Turbidity	N.T.U	APHA 2130 B	68	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	914	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	27	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	72	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	2.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.12	No Standard
Chloride	mg/l	APHA 4500-Cl- B	239	250
Iron	mg/l	APHA 3500-Fe B	3.9	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	ND	45
Total Dissolved Solids	mg/l	APHA 2510 A	567	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	38	400
Fluoride	mg/l	APHA 4500-F- C	0.5	1.5
Calcium	mg/l	APHA 3500-Ca B	27	150
Manganese	mg/l	APHA 3500-Mn B	0.19	0.1
Potassium	mg/l	APHA 3500-K B	5.3	50
Sodium	mg/l	APHA 3500-Na B	124	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	180	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	50	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
Laboratory Analyst

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	29/11/2023	**Sample No:**	WRA/HQ/CWTL-22884	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	07/11/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/11/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S 3		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	7.1	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	1125	50(15)*
Turbidity	N.T.U	APHA 2130 B	3285	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	257	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	11	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	64	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	2.0	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	0.13	No Standard
Chloride	mg/l	APHA 4500-Cl- B	45	250
Iron	mg/l	APHA 3500-Fe B	19	0.3
Nitrate (NO_3-)	mgN/l	APHA 4500-NO3-D	ND	45
Total Dissolved Solids	mg/l	APHA 2510 A	159	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	<0.3	400
Fluoride	mg/l	APHA 4500-F- C	0.7	1.5
Calcium	mg/l	APHA 3500-Ca B	14	150
Manganese	mg/l	APHA 3500-Mn B	1.1	0.1
Potassium	mg/l	APHA 3500-K B	8.7	50
Sodium	mg/l	APHA 3500-Na B	17	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	80	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	ND	-
Total Suspended Solids	mg/l	APHA 2540 D	2600	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<": value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

Rachel Olonga
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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	28/11/2023	**Sample No:**	WRA/HQ/CWTL-22885	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	07/11/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/11/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S 4		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.0**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**250**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**291**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**849**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**32**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**68**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.09**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**247**	250
Iron	mg/l	APHA 3500-Fe B	**2.0**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**526**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**1.4**	400
Flouride	mg/l	APHA 4500-F- C	**0.6**	1.5
Calcium	mg/l	APHA 3500-Ca B	**27**	150
Manganese	mg/l	APHA 3500-Mn B	**0.1**	0.1
Potassium	mg/l	APHA 3500-K B	**4.1**	50
Sodium	mg/l	APHA 3500-Na B	**100**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**198**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**220**	-

**Maximum limits for treated potable water; **WHO maximum guideline value; APHA: American Public Health Association (2005) - Standard methods for the examination of water & wastewater; "<". value below method detection limit; ND: Not detectable*

Comments:

Monitoring.

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Physical-Chemical Laboratory Results Certificate

Report Issue Date:	29/11/2023	**Sample No:**	WRA/HQ/CWTL-22886	**Year:**	2023
Name of Customer:	Mangat I.B Patel Limited	**Date Received:**	07/11/2023		
Email Address:		**Type of Sample:**	River water		
Telephone Number:	0725321201	**Date of Sampling:**	06/11/2023		
Sample submitted by:	Mangat I.B Patel Ltd	**Source of sample:**	Muache River at S 5		
Purpose of Sampling:	Monitoring	**Received by:**	Dennis Onyango		
County:	KWALE				

PARAMETERS	UNIT	ANALYTICAL METHOD	RESULTS	POTABLE WATER STD[MAX] (KEBS, KS EAS 12:2018)
pH	pH Scale	APHA 4500-H+ B	**7.2**	5.5-9.5 (6.5-8.5)*
Color	mgPt/l	APHA 2120 B	**1125**	50(15)*
Turbidity	N.T.U	APHA 2130 B	**2040**	25 (5)*
Conductivity(25°C)	µS/cm	APHA 2510B	**238**	2500 (1500)*
Magnesium	mg/l	APHA 3500-Mg B	**5.8**	100
Total Alkalinity	mg $CaCO_3$/L	APHA 2320 B	**64**	500**
Free Carbon Dioxide	mg/l	APHA 4500-CO2 C	**2.0**	No Standard
Total Phosphorus	mgP/L	APHA 4500-P E	**0.23**	No Standard
Chloride	mg/l	APHA 4500-Cl- B	**37**	250
Iron	mg/l	APHA 3500-Fe B	**19**	0.3
Nitrate (NO3-)	mgN/l	APHA 4500-NO3-D	**ND**	45
Total Dissolved Solids	mg/l	APHA 2510 A	**148**	1500 (1000)*
Sulphate	mg/l	APHA 4500-SO42- E	**<0.3**	400
Fluoride	mg/l	APHA 4500-F- C	**0.6**	1.5
Calcium	mg/l	APHA 3500-Ca B	**9.6**	150
Manganese	mg/l	APHA 3500-Mn B	**0.28**	0.1
Potassium	mg/l	APHA 3500-K B	**6.4**	50
Sodium	mg/l	APHA 3500-Na B	**29**	200
Total Hardness	mg $CaCO_3$/L	APHA 2340 C	**48**	600 (300)*
Oil & Grease	mg/l	APHA 5520 B	**ND**	-
Total Suspended Solids	mg/l	APHA 2540 D	**1400**	-

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Comments:

Monitoring.

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