6.2 General Specifications
6.3 Civil Engineering & Building Work
6.4 Electrical Works
6.5 Mechanical Works
6.6 Other Specifications

6. SPECIFICATIONS

6.2 – GENERAL SPECIFICATION

TABLE OF CONTENTS

1. General

1.1 Proposed Works

The detailed scope of works is set out in Section 8.2 and 8.3 of Employer's Requirement of this document. In general the proposed works consist of the following:

(a) For treatment process as appropriated:

- Screening (coarse, fine, micro)
- Raw water abstraction and pumping
- Raw Water Pipeline
- Pre filtration (roughing, …, etc)
- Aeration
- Pre-chlorination
- Chemical treatment (Coagulation, …, etc)
- Flocculation
- Clarification/Sedimentation/Dissolved air flotation
- Filtration
- Granular Activated Carbon treatment
- Treated Water Reservoir
- Post-chlorination
- pH Adjustment
- Treated Water Pumping
- Treated Water Pipeline (Pumping/Gravity)
- Sludge treatment and drying

(b) Associated Works at the Plant as appropriate:

- Washwater Storage/ Recycling
- Wastewater and Sludge Treatment
- Chemical Storage and Dosing
- Water Quality Monitoring
- Electricity Supply and Distribution, including all necessary light
- Potable and Service Water System
- Treatment Works Laboratory, Offices, Store and Workshop
- Surge Control Equipment
- Power Factor Correction Equipment
- Fire fighting system including hydrants and extinguishers
- Roads, pathways, fencing, site drainage, hand railing and landscaping etc.
- Staff quarters (these may be on a different site to the treatment plant)

1.2 Operating Philosophy

Water treatment facilities shall be designed to operate on a 22 hours per day basis at constant flow rate.

During early years of operation when demand in each distribution centre has not increased to the full design plant output, the plant will operate at less than design flow. This will be achieved by operation of only the necessary number of raw water pumps and/or by variable speed technique to approximately match works input to the desired output of treated water. As necessary, the output of raw water pumps shall be throttled to match the desired works input and

a suitable valve shall be provided for this purpose at a convenient location on the common delivery pipeline from each set of pumps.

The numbers and capacities of duty raw water pumps to be provided to meet the maximum specified design flow shall be determined by the Contractor. As noted above, when the treatment plant is operating at less than maximum design output, the inflow will be reduced by operating only some of the duty raw water pumps or by operating at reduced speeds. The actual raw water input delivered by the selected number of raw water duty pumps will be adjusted to that required by throttling of the combined pump output using valves to be provided under this Contract on common delivery mains. In order to avoid excessive waste of power and to keep pumps operating in their optimum efficiency ranges, the numbers and sizes of duty raw water pumps shall be selected such that by operation of a number of pumps or by varying speed of a less number of pumps, it is possible to achieve all raw water flows required without having to throttle the output of any pump to less than 80% of the output it would achieve for the numbers of pumps selected for duty when running un-throttled against average static conditions.

Chemical dosing requirements for coagulation and flocculation will be determined at least daily by laboratory analysis of raw water quality and the appropriate dosing rates set manually.

Following chlorination, treated water will be stored in a ground storage tank. This tank will provide sufficient contact time for disinfection as well as being the backwash storage tank. Operational storage will also be provided in the tank as specified. This will be used to provide a reserve of water to meet daily peak demands for treated water and also to compensate for small daily imbalances between works inflow and works outflow.

Treated water pumps will generally operate automatically in response to level signals from remote water storage towers and the reservoir which float on the distribution systems. Treated water pumps are generally sized to meet peak daily water demands in each distribution centre.

2. Performance of the Plant

2.1 Capacity of Treatment Plant

The treatment plant shall be capable of producing treated water to the specified quality, throughout the specified range of raw water qualities, for all output flows from 50% to 100% of the specified works output unless otherwise stated in the Particular Specification. The Plant shall be capable of a variation in output from minimum to maximum within 12 hours, without deterioration in treated water quality and shall be designed to operate efficiently throughout the above range of flows.

Treatment plant shall be capable of producing water to the specified quality at the maximum design output when the rapid gravity filter being backwashed.

2.2 Raw Water Quality

The plant shall treat water from the source described in the Particular scope of work. All sampling and analysis for raw water shall be carried out by the Contractor according to all parameters given in SLS 614:2013 and if any water quality parameters is not specified 614:2013, the guide line value of WHO is to be used. The raw water quality data given in

Appendix 2 of section 8.6 is provided only for guidance and Contractor is responsible for carrying out raw water quality analysis in order to cover dry and wet seasons.

2.3 Treated Water Quality

For clarified, filtered and final water the specified water quality is to be produced throughout the specified ranges of flows and when the specified number of process units is out of use.

Final Water

The final water shall comply with the following for the plant:

(a) As a minimum all water leaving a treatment plant shall comply with the values set out in Column B of Table 1.2.1 and 1.2.1a below and no sample tested shall exceed these values;

(b) For each parameter the mean values over one year shall not exceed the target values set out in Column A of Table 1.2.1;

(c) The operational parameters set out in Table 1.2.2.

Table 1.2.1 - Final Water Standards

Parameter	Units	A "Target"	B "Maximum"
(a) Physical Parameters - not directly related to health			
True Colour	Pt-Co units	5	15
Turbidity	NTU	1	2
pH	pH units	6.5- 8.5	To achieve effective disinfection but minimise corrosion to pipes
(b) Inorganic Parameters - not directly related to health			
Aluminium	mg/l Al	0.05	0.2
Total Iron	mg/l Fe	0.3	0.3
Total Manganese	mg/l Mn	0.05	0.1
(c) Microbiological Parameters - Health Related			
E-Coli	no/100ml	0	0
Total Coliforms	no/100 ml	0 (95% -ile)	3

In addition all water shall comply at all times with the following criteria relating to algal toxins (cyanotoxins) and shall have no objectionable taste or odour. The toxin levels stated refer to total concentrations, i.e. intracellular plus extracellular toxins:

Table 1.2.1.a –– Algal Toxins (Cyanotoxins)

Parameter	Units	Maximum Value
Microcystins *	µg/l	1.0
Cylindrospermopsin	µg/l	1.0

* total microcystins expressed as microcystin-LR toxicity equivalents

Table 1.2.2 - Operational Parameters

Parameter	Units	Value
Free Chlorine at outlet from treated water storage tank	mg/l	1 to 2

Additional Requirements for the Quality of Treated Water

Treated water shall comply with the following additional requirements:

(a) Clarified Water

The plants shall be capable of producing clarified water of the quality set out below, measured in the outlet channel of the clarifying units prior to any pre-filtration chemical dosing points.

Table 1.2.3 Clarified Water Quality Requirements

Parameter	Units	Target	Maximum
Turbidity	NTU	3	7
Total Aluminium	mg/l Al	1.0	2.0
Soluble Aluminium	mg/l Al	0.1	0.2
True Colour	Pt-Co	-	15

(b) Filtered Water

The plants shall also be capable of producing filtered water of the quality set out below, measured at the outlet from the rapid gravity filters.

Table 1.2.4 Filtered Water Quality Requirements

Parameter	Units	Target	Maximum
pH		7-8	6.5-8.5
True Colour	Pt-Co	5	15
Turbidity	NTU	0.5	1
Total Aluminium	mg/l Al	0.05	0.2

2.4 Water Losses

Water losses from the water treatment plant shall not exceed 5% of the treated water output. Water loss shall be defined as the difference between the raw water volume entering the plant and the treated water output from the plant measured on a weekly basis.

2.5 Chemicals to be used

The chemicals specified under the Section 8.4.5 of volume II of this document are available to the Employer and the processes for treatment of surface water shall be designed to achieve the specified water quality using those chemicals. The quality of all those chemicals shall be in accordance with the given specifications in Section 8.4.5.

The quality, dosing and residual limits in drinking water of Powdered Activated Carbon and Granular Activated Carbon and other chemicals which are proposed by the Contractor for the treatment process of water shall strictly comply with the appropriate British, AWWA standards and Sri Lankan Standards.

All dosing concentrations should not be exceeded as given Table 1.3.2 of Section 8.4.1. If not given the dosing concentrations, contractor shall follow the guidelines of WHO. The use of coagulant aids, flocculation aids or filtration aids in the water treatment process shall not be permitted unless specifically allowed or required by the Employer's Requirements.

3. Design

3.1 General Design Parameters and Criteria

The design criteria stated in Appendix-9 of Section 8.6 of Employer's Requirement, is given for the information of the Contractor. Designs incorporating criteria outside the stated ranges will not be accepted by the Engineer, unless the Contractor provides sufficient information to satisfy the Engineer that the Contractor's designs will meet the Employer's Requirement in all respects. Regardless of the information provided in this Section and the acceptance by the Engineer of the Contractor's designs the Contractor shall be solely responsible for designing and constructing a water treatment plant and associated facilities that meet the specified performance requirements and fulfil all of the Employer's Requirement.

3.2 Water Supply

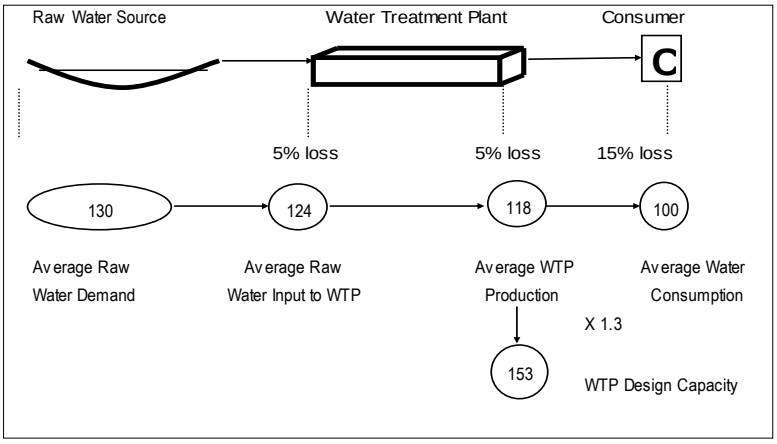
The basis on which water supply demands and water treatment production requirements for this Contract have been based is shown in the following table and diagram.

Table 1.3.1 Summary of Adopted Water Supply Design and Demand Estimation Criteria

Design Element	Criterion
Water Supply Design Horizon	30 years
Water Resource Design Horizon	Not less than 30 years
RW transmission and Water Treatment Plant losses	10 percent of treated water production
Average Raw Water Demand	1.474 x average water consumption

WTP Design Capacity Maximum Day Demand	1.3 x average required production capacity 1.1 x average day demand

Figure 1.3.1 Flow Diagram Showing Water Demands (L/c/c Revised on 24-06-2020



Note: The allowance to be made for water losses in the distribution system varies among towns. It is 15% as shown in Figure 1.3.1. Different allowances will result in different design ratios for water volumes to those shown in the above diagram.

The following table gives general guidelines for various process units which may be included in the Contractor's design.

Table 1.3.2 Process Unit Guidelines

Unit Operation	Design Criterion	Requirement
(i) Coagulation	Preferred Coagulant	Aluminium Sulphate (Alum)
	Dose Rates	Normal 50 mg/l (maximum 100 mg/l) as Alum. Actual dosage will vary with turbidity of incoming raw water.
	Storage Requirements	3 months at normal dose
	Handling Requirements	No. of Dissolving Tanks, 2 Dosing tanks with 30 hours combined storage at maximum dose: 2.
	Dosing Concentration	10 % maximum
	Control	Manual adjustment of pump speed with local start-stop and remote control
(ii) pH Adjustment	Preferred Chemical	Slaked Lime $Ca(OH)_2$ delivered as Quick Lime (CaO)
	Dose Rates	Normal maximum 30 mg/l as $Ca(OH)_2$ (maximum dose 60 mg/l)
	Storage Requirements	3 months at normal dose. (Note: 1kg CaO produces 1.32 kg $Ca(OH)_2$).
	Handling Requirements	Area for slaking Quick Lime or lime slaker tank, 2 Dilution Tanks, 2 Dosing tanks with 30 hours storage at maximum dose.
	Dosing	5 % maximum

Unit Operation	Design Criterion	Requirement
	Concentration Control	 Manual adjustment of pump speed with local start-stop and remote control.
(iii) Rapid Mixing		Preferably directly into pipe or channel employing an in-line static mixer/ mixing by mechanically as flash mixing.
(iv) Flocculation		Hydraulic or mechanical.
(v) Sedimentation	Type	Horizontal Sedimentation, unless algal problems are likely. Plate or tube settlers may be used.
(vi) Rapid Gravity Filtration	Media Size Range Depth of sand media Support media Depth Filter Control	Mono-medium sand. Dual media sand will also be allowed. Sand 0.5 -1.0 mm or 0.6 - 1.2 mm uniformity coefficient of less than 1.7 600 mm minimum 1000 mm maximum. 250 mm minimum (depends on type of under drain and nozzle system used). Constant level filtration with equal inlet flow splitting, level sensor controlling modulating outlet butterfly valve, or split influent rising level filtration.
(vii) Filter Backwashing	Type	Separate air scour and water wash. Consideration will be given to simultaneous air scour and water washing.
	Initiation Filter Backwash Water Recovery	Semi-automatic with manual initiation on time elapsed or head loss. To be provided where possible.
(viii) Disinfection	Chlorination Dose Range Storage Control	Chlorine Gas in 1 tonne drums. 0-10 mg/l (normal 5 mg/l). 2 months at normal dose. Manual adjustment of regulator. Automatic changeover of drums.

The following table sets out particular design guidelines used in sizing process units and ancillary equipment for the concept designs.

Table 1.3.3 Particular Design Guidelines

Component	Criterion	Design Guideline
Raw water pumps	Pump capacity	1.10 x WTP capacity
Raw water mains	Flow velocity	1.5-2 m/s
Flocculant Mixing		
Hydraulic	Mixing time secs	1 – 3
Mechanical (flash mixer)	Velocity gradient G	500-3,000 sec-1
	Retention time secs	30-60 seconds
Coagulation/Flocculation	Flocculation time	20-30 minutes
	GT value sec-1	10,000-100,000 sec-1
Sedimentation Tank/Clarifier		

Component	Criterion	Design Guideline
Rectangular, Horizontal Flow	Retention time	2.5 - 4 hours (minimum 2.5 hours at plant design capacity)
	Surface loading	
	Plain tank	1.5 m/h ma Revised on 24-06-2020
	With lamella plates or tubes	5 m/h max
	Length:width ratio	4 min : 1
	Depth	3 m minimum (depth must be adequate for installation of tube or plate settlers and mechanical desludging equipment)
	Horizontal flow velocity	12-41 m/h
	Outlet weir overflow rate	10 L/s/m width max
Circular, radial flow	Retention time hours	3.5 hours min.
	Diameter metres	30 m max.
	Overflow rate	1.5 m/h
Circular, solids contact vertical flow	Velocity gradient G	100-25 sec-1
	Retention time	20-30 minutes
	Overflow rate	2 m/h
	GT value	104 -105
	Velocity	0.1-0.2 m/s
Rapid Sand Gravity Filters	Filtration rate	7 m/h max (9 m/h max with one filter being backwashed) for sand as specified.
		If only fine sand is available maximum rates are reduced to 6 m/s and 8 m/s respectively.
	Minimum number of filters	4
	Backwash frequency	Once per day per filter
	Backwash time minutes	air 3-5 minutes
		water 7-10 minutes
	Backwash rate	air 30-60 m/h
		water 40-60 m/h
Chlorine contact tank	Contact time	30 minutes
Clear water storage (total in system)	Storage volume	8 hours at average daily supply
Clear water storage at WTP	Storage volume	3 hours min, but sufficient for chlorine contact time, two backwash volumes and pump control
Sludge drying beds	Alum dosage rate for calculating solids production	20-50 mg/L depending on average turbidity of raw water
	Dry alum solids generated as a % of alum dose	25%
Sludge thickener (gravity)	Hydraulic loading m/h	2.5 m/h max.

3.3 Surface Water Plants

Acceptable Unit Processes

(a) Clarification

Unless otherwise specified in Particular Scope of the Work, the Contractor may offer one of the following alternative clarification options:

Horizontal flow sedimentation with lamella or tube settlers
Radial flow sedimentation
Solids contact upflow clarification

Where the use of lamella plates or tubes is used to assist settlement the clarifiers shall be designed to operate at not more than the maximum loading rates specified in Table 1.3.3 hereof.

(b) Filtration

Filtration shall be by gravity, down-flow, mono-media rapid sand filtration. Dual-media rapid sand filtration may be adopted only if it is essential in terms of raw water quality.

(c) Disinfection

Disinfection shall be by chlorine gas.

(d) pH Adjustment

pH adjustment shall be achieved using lime.

Process Design Parameters

Loading rates determined shall be calculated using the maximum design flow and the internal dimensions of the process units. Internal structures which reduce the effective area shall be accounted for in the calculations. Loading rate calculations for up-flow clarifiers shall exclude the area of any flocculation or re-circulation sections integral to the clarifier unit.

Calculated volumes shall exclude all connecting / inlet pipes or channels.

Where additional treatment units are provided, the process design criteria shall apply to the whole works including the proposed treatment units.

The Contractor shall determine the process design parameters and loading rates required to achieve the specified performance of the plants subject to the following:

(a) Inlet Flow Division

Flow splitting shall be achieved by hydraulic means only and shall ensure equal division of the flow between units in service. The maximum variation when all units are in operation shall be +/- 5% at design flow. When one unit is out of operation the maximum allowable variation shall be +/- 10%;

(b) Clarifiers

Maximum allowable surface loading rates shall be:

	Without Lamella Plates or Tubes	With Lamella Plates or Tubes
Horizontal flow sedimentation	1.5 m/hr	5.0 m/hr
Radial flow sedimentation	1.5 m/hr	Not practicable
Solids contact up-flow clarification	2.5 m/hr	5.0 m/hr

The minimum number of units shall be two units except where specified otherwise.

Lamella plates or tubes shall be constructed from materials resistant to deterioration from UV light. The supporting structure and all fastening and fixings shall be resistant to the corrosive effects of water dosed with alum. The installation shall be sufficiently robust to withstand the rigours of mechanical cleaning and able to support the weight of two operators standing on the plates or tubes with the aid of duck-boards to clean them.

The surface loading rates for lamella plates or tubes shall be calculated from the area of the settling tank covered by the plates or tubes, which is the overall plan area of the plate pack from the bottom of the first plate to the top of the last plate. The plates or tubes shall be inclined at an angle of 60 degrees to the horizontal and separated by not less than 50 mm effective separation, with a length of not less than one metre. Plates arranged parallel to the direction of horizontal flow shall occupy the whole area of the tank.

The facility sites under this contract are prone to periodic failures of power supplies. This shall be taken into consideration during design such that immediately upon resumption of mains power to the raw water pumps the clarifiers are able to resume operation and meet the specified water quality standards. No additional measures are required for clarifiers that rely only on settling under gravity for normal operation, but for all other designs of clarifier facilities must be included to enable the clarifier to immediately resume operation following restoration of mains power supply without loss of water quality. For clarifiers which rely on recirculation this will require sufficient standby power facilities and switchgear to be provided to immediately commence operation on power failure and maintain the necessary recirculation flows. For clarifiers which rely on an upflow of water to maintain a sludge blanket this will require sufficient standby power facilities and switchgear to be provided to immediately commence operation on power failure and maintain sufficient flow to maintain the blanket. Similar facilities shall be provided for other types of clarifier which do not rely only on settling under gravity for normal operation.

(c) Rapid Gravity Filters

The minimum total number of filters shall be four.

Maximum allowable filtration rates for sand media as specified shall be:

- when all filters are in operation 7 m/hr
- when one filter is being backwashed 9 m/hr

Where the use of finer sand is permitted by the Engineer the maximum allowable filtration rates shall be:

- when all filters are in operation 6 m/hr
- when one filter is being backwashed 8 m/hr

Media shall be:

- Size: Silica sand 0.5-1.0 mm or 0.6 – 1.2 mm with a
- Uniformity Co-efficient (i.e. ratio of 60% size to 10% size) less than 1.7;
- Minimum sand depth : 600 mm;
- Minimum gravel support media depth : 250 mm;

Media losses:

- Not greater than 2% per annum.

Flow control:

- The preferred flow control method is constant level filtration with equal inlet flow division based on level control linked to a modulating butterfly valve on outlet;
- As an alternative the Contractor may provide flow control using rising level with equal inlet flow division (no outlet control);
- The following flow control method is NOT acceptable:
    - Concentric siphon level controlled constant output type;

Backwash system:

- The backwash system shall comprise air and water washing. This may be either separate or combined air and water washing. If separate washing is adopted, the floor, nozzles and pipework system shall be designed to allow conversion to be combined air and water washing in the future if required;
- The backwash and air scour system design shall ensure all filters are air-scoured and washed equally. The difference in air or water flow shall not be greater than +/- 5% between any two filters;

Backwash frequency:

- 24 hours minimum between washes of each filter.

(d) Mixing of Chemicals

Mixing of chemicals into the works flow shall be by low head-loss, in-line static mixers. Alternatively mechanical flash mixers may be used where aerators are installed at the plant inlets.

(f) Flow Metering

Flow metering shall be carried out at the following points:

- Raw water inlet;
- Sludge flow from clarifiers
- Filter backwash water on delivery to filters;
- Treated water outlet;

– Service water.

(g) Chemical Storage Requirements

90 days at average dose and maximum flow.

3.4 Design Life Durability and Reliability of the Plant

The design of the works shall be based on proven technology for the particular application.

Each part of the works to be constructed and each item of plant to be installed under the Contract shall be designed to maximise reliability and minimise maintenance requirements and shall have a reliable operating life not less than the appropriate design life stated below.

Description	Design Life (Years)
Reinforced Concrete Structures	60
Buildings	60
Mechanical and Electrical Equipment	20
Instruments	10

"Design Life" shall mean the period of time for which an item or system is designed to operate at or in association with normal works full design output without major overhaul, serious corrosion or necessity for substantial renewal of any anti-corrosion system, reduction of efficiency or output in excess of 5%, or replacement of major components or components essential to the functioning of the item.

The renewal of wearing parts such as bearings, diaphragms, shaft sleeves, seals or any other parts, which by virtue of their design and purpose are expected to be renewed within the above periods are accepted as exceptions provided that those parts are manufactured to the requirements of the mechanical and electrical and instrumentation specification.

Where replacement parts are anticipated to be required for any item of the works during the appropriate design life, over and the above the renewal of wearing parts meeting the requirements of the Employer's Requirements, then these should be identified by the Contractor. All spares are to be readily available.

All items and systems shall be designed to allow replacement, major overhaul, etc at the end of the design life without requiring major work or dismantling of other items and systems which are of different design lives or interrupting the operation of independent items and systems.

3.5 Design Flows

The Contractor shall determine the maximum and minimum flow rates through each part of the works and these design flow rates shall be used for the design of the process units and pumping stations.

The maximum design flow shall be defined as the flow required to deliver the specified treated water output taking into account losses such as sludge, washwater and motive water, etc. In determining the maximum raw water design flow required to achieve the specified treated water outputs, the Contractor shall assume that no wastewater is recycled.

The specified design criteria shall apply at the maximum design flow rate. The process units shall be designed to operate efficiently over the full range of flow-rates through the works.

3.6 Hydraulic Design

Treatment units and interconnecting pipes and channels shall be designed to convey the maximum design flow when the following units are out of service:

- One clarifier out of use for maintenance;
- One rapid gravity filter being backwashed and one rapid gravity filter out of use for maintenance.

All interconnecting channels and pipes to, from and between treatment units shall be designed to convey the maximum design flow plus 10%.

Structures, pipework layouts and devices which may cause severe hydraulic restrictions are to be avoided.

Self-cleaning velocities are to be sought wherever practical. Friction losses shall normally be based on the Colebrook-White formula. Alternatively the Hazen-Williams formula may be used for pipe flow and the Manning formula for open channel flow. Additional consideration is required in estimating friction losses for sludge mains.

Overflows designed for the maximum overflow possible shall be provided at all locations that could overflow if a downstream valve was closed.

Care shall be taken in the design to avoid entrainment of air, either as a result of being downstream of weirs or from formation of vortices and eddies, at entry to pipes and conduits designed to run full.

A minimum freeboard of 300 mm shall be provided over calculated top water levels throughout the works at the maximum design flow with the units specified above out of service. Freeboard shall be in addition to the depth of flow over overflow weirs. All walkways and roof soffits over tanks shall be sited 150 mm clear of the allowance for freeboard. Where soffit slabs over channels and tanks have downstand beams the soffits shall be set to maintain at least the specified 300 mm freeboard specified.

3.7 Plant Layout

The Contractor may vary the arrangement of the plant process units layout to suit his own particular process designs and design of associated works subject to compliance with the Employer's Requirements. Where required the layout shall allow for future expansion of the water treatment plants within the current boundaries of each site.

3.8 Design Requirements

1. General Design Criteria

The Contractor is responsible for the design of the treatment units and all associated works and shall have due regard for the following:

(a) The design parameters in the Employer's Requirements;

(b) The hydraulic gradient through the plant. The design shall ensure that water flows through the process by gravity and/or pumping throughout the range of flows specified;

(c) The space required for expansion;

(d) Access between and around the treatment units and associated buildings for personnel and vehicles for maintenance and operation, including the provision of suitable hand-railing, safety barriers etc;

(e) The plant should operate efficiently over the full range of: flows through the plant and; surface loadings;

(f) Provision of easy access for maintenance and operation of the works;

(g) Routing of services, potable water pipes, drainage pipes, chemical and service ducts, electricity supply cables and signal cables for ease of maintenance;

(h) Adequate ventilation shall be provided within buildings to avoid condensation;

(i) The design to provide for safe systems of work for operation and maintenance staff;

(j) All materials shall be corrosion resistant and suitable for the particular application;

(k) All equipment shall be suitable for the environment in which it is to operate;

(l) All materials which come into contact with potable water, or water to be used for potable supply shall be approved for the purpose and shall have no detrimental effect on water quality and health;

(m) Tanks and compartments of tanks shall be capable of being drained and cleaned out easily;

(n) Not used.

(o) The design of the motor control centres shall allow for a minimum of 10% spare capacity for future additional motor modules. These will be left as blank spaces, that is no starter trays are required in these spaces;

2. Drainage of Structures

To allow individual inspection and maintenance of each treatment process structure, chamber or channel without necessitating a total shut-down of the treatment works, all such structures,

chambers and channels shall be provided with means of hydraulic isolation and washout drainage points enabling complete emptying within 8 hours. Where possible washout drainage points shall be arranged to discharge under gravitational flow. Where this is not possible pumps shall be provided in a fixed installation. Drainage pipework shall connect to the works' drainage system.

Basement floors and other floors that could be flooded by natural means or by other means such as pipe bursts, leakage or spillage, shall be graded with a slight fall to drainage channels and/or sumps which shall discharge by gravity. Where this is not possible sump pumps and level switches shall be provided to form a system which will automatically drain the floor following flooding or washing down.

3. Layout to Provide Access

The layout of all plant and services shall give easy access for operation, inspection, in-situ maintenance (including access onto and into tanks and other structures) and for removal of equipment.

The minimum clear distance around equipment for operational access and inspection and for maintenance and repair shall be 900 mm.

The minimum size for access manhole shall be 600 mm.

4. Walkways, Platforms, Ladders, Staircases and Covers

The Contractor shall provide adequate safe access to all items of Plant. All walkways more than 500 mm above the surrounding level or adjacent to water shall be fitted with hand railing. All emergency exits shall have clear accesses provided, if necessary using false flooring, stairs, handrails and the like to achieve this. Access shall be provided to all items of Plant to allow inspection, maintenance and removal to be effected. Stairways shall be provided where access is required on a regular basis. Vertical ladders shall be avoided wherever possible.

All provisions for external access, including surface boxes, manhole covers and duct covers shall be lockable and provided with padlocks or other appropriate locks.

All covers over channels, tanks or other parts of the Works which contain water that has been filtered shall be provided with seals or otherwise arranged so as to prevent the ingress of dirty water or any other contaminant.

5. Standby Facilities

Standby facilities shall be as specified in the Particular scope of the work of section 8.2. Failure of a duty unit shall initiate an audible and visual alarm at the relevant motor control panel. Changeover from duty to standby shall be manual.

6. Chambers for Static Mixers, Flow Meters, Valves

All in-line strainers, static mixers, actuated valves, manual valves over 300 mm nominal bore and all primary transducers for flow measurement, and other monitors and controls that are

installed below ground, shall be housed in chambers with adequate access and working space around the device. Flow meters shall be installed so that they are removable with the minimum of disturbance by disconnecting an adjacent flange adaptor or adjacent coupling. The chambers shall be provided with drainage systems.

Where valves, flow measuring devices and mixers are to be located outside the main treatment structures, chambers shall be constructed to provide protection and access for maintenance. All equipment within the chambers shall be supported on plinths. Flange adapters shall be provided to allow removal of pipe work, valves and flow meters. The chambers shall be constructed from reinforced concrete and shall be designed to exclude ground water, surface water and rain water. Each chamber shall have a personnel access with cover and access ladder. In addition suitable provision shall be made for removal of items of equipment from the chambers for maintenance and repair. All chambers shall include a sump within the chamber base.

7. Pump Protection

All pumps shall be provided with a low level and/or low flow protection system to prevent the risk of running dry.

8. Lifting Facilities

Where equipment provided under the contract is housed inside a building and where the equipment is heavier than 100 kg and will require frequent maintenance (e.g. pumps), permanent hand operated lifting equipment shall be provided of sufficient capacity to lift the heaviest item of installed plant and arranged so as to be able to transport the item to an internal or external loading bay and lift it onto and off a lorry.

The preferred installation is a single lifting beam with manual travelling lifting tackle positioned over the centre line of the equipment. The lifting tackle shall be manually operated. Travelling lifting gantry cranes and/or electrically - operated lifting equipment shall only be provided where specified.

9. Noise

The Plant, including the existing works, shall be designed such that under normal operating conditions the noise levels in the working areas shall not constitute a temporary or permanent health hazard to plant operators, maintenance personnel or others, or constitute or cause a nuisance outside the boundary of the site.

The noise levels within the buildings shall not be greater than 85 decibels “A” scale, when measured along a contour 3 m from any single item of plant during starting, running and stopping, subject to a tolerance of - 5% on this over the audible frequency spectrum measured at mid band.

Noise test measurements shall be made on completion of the installation of the plant at site to verify that it complies with the Employer’s Requirements. Equipment which does not comply with the Employer’s Requirements shall be modified at the Contractor’s expense. Suitable calibrated measuring equipment shall be made available by the Contractor for carrying out the testing.

10. Tanks for Process Water

The design and construction of tanks holding treated water or process water (eg chlorine contact tank, pump sump, clear water reservoir, etc) shall be so as to hold the process water or treated water in a secure pollution free environment which shall not impair or affect the quality of the water in any way.

Underground tanks shall be designed using the following criteria and shall incorporate the following features:

(a) Tanks shall be totally enclosed and constructed in reinforced concrete;

(b) If internal baffle walls are included they shall extend above maximum top water level and gaps shall be incorporated at the base of each baffle wall at regular intervals, to allow drainage and sludge removal during cleaning;

(c) The floor shall be graded and a sump provided to ensure the tank can be fully drained. A valved drain pipe shall be provided to connect the sump to the plant drainage system;

(d) The soffit of the roof slab shall be located at a position above the maximum top water level to ensure that water cannot pressurise the roof;

(e) Ventilation shall be provided and fitted with insect proof screens. Possible ventilation through the overflows shall be ignored;

(f) Each tank or group of tanks shall have an overflow system capable of passing the maximum design flow to the plant overflow system. If overflow pipes discharge to the open, they shall be designed to exclude animals and insects;

(g) The covering to the reinforced concrete roof of underground tanks (other than tanks beneath other structures) shall consist of a waterproof membrane and drainage layer. Embankments shall not be used to structurally support the walls;

(h) Stainless steel access ladders shall be provided within each compartment and high security galvanised steel reservoir type access covers for the roof provided for personnel and plant access;

(i) A perimeter drainage system shall be provided, positioned clear of the walls, to carry water away from the structure. Water flows down the outside of the walls to a low level drain will not be permitted. The perimeter drain shall connect to the surface water system;

(j) The roof shall be designed to carry the imposed load due to light agricultural machinery. It shall be laid to a minimum fall of 1 to 100 to prevent ponding of water and roof perimeter shall be provided with proper rain-water disposal arrangement with lead-way pipes to the site drainage system;

(k) Valves or penstocks shall be positioned so that the spindles do not rise through the roof.

3.9 Structural Design Criteria

1. General

The structural analysis and design shall be based on one of the latest versions of computer packages "Prokon" or SAP2000.

Designs shall be based on

(a) Concrete Liquid Retaining Structures

Concrete liquid retaining structures shall be designed in accordance with British Code, BS 8007: 1987, and Design of Concrete Structures for Retaining Aqueous Liquids.

(b) Other Concrete Structures

Other concrete structures shall be designed in accordance with BS 8110: Part 1: 1985, Structural Use of Concrete: Code of Practice for Design and Construction.

Other equivalent codes or standards may be used as approved by the Employer.

(c) Steel Structures

Steel structures shall be designed in accordance with BS 5950.

Other equivalent codes or standards may be used as approved by the Employer.

2. Design Loads

All loads and load combinations shall be determined as required by the specified codes, occupancy, environmental effects, equipment and processes with the following minimum requirements:

(a) Live Loads

1.	Inaccessible roofs	2.5 kN/m^2
2.	Roof with mechanical equipment	As per BS 6399 -using actual weights but not less than 7.5 kN/m^2
3.	Floor of mechanical rooms	Actual weight but not less than 10 kN/m^2
4.	Floors accessible to trucks	Two axles of 9.5 tonnes each, at 1.2m centres with a minimum uniform load of 20 kN/m^2
5.	General public access and Personnel Assembly area	5.0 kN/m^2
6.	Offices, platforms, walkways	3.0 kN/m^2
7.	Electrical rooms	Actual weight but not less than 10 kN/m^2
8.	Laboratories and Chemical Rooms and control Rooms	5.0 kN/ m^2
9.	Storage Rooms	7.5 kN/m^2
10.	Plant Rooms	Allow for live loads as appropriate but not less than a minimum super load of 5.0 kN/ m^2.
11.	Areas subjected to loading by cars	Minimum super loads of 3.0 kN/m^2 or minimum wheel load 1300 kg

(b) Overhead Travelling Cranes

All pumping stations and other structures where electrical and mechanical equipments are needed, to facilitate installation and maintenance of the equipment, electrically operated overhead gantry crane of lifting capacity not less than 1.5 times the heaviest equipment shall be provided.

- Vertical load impact factor applied to the maximum static wheel load shall be:
  - Motor driven cranes 1.25
  - Hand driven cranes 1.10
- Horizontal load acting transverse to the rails as a percentage of the combined weight of the crab, safe working load and lifting appliances shall be:
  - Motor driven crane 10%
  - Hand operated crane 5%
- Horizontal loads acting along the rails as a percentage of the static wheel loads shall be:
  - Motor driven or hand operated cranes 5%

(c) Monorail Support

All buildings and facilities where there is a need for a monorail the lifting capacity of the monorail and the lifting arrangement shall be not less than 1.5 times the static load of the equipment which should be lifted at the installation stage and/or under operational conditions.

- Vertical load impact factor applied to the maximum static wheel load shall be:
  - Vertical load impact factor
  - based on hoist capacity 25%
  - Horizontal load acting longitudinally as
  - a percentage of the static wheel load 10%

The monorail shall be extended to outside of the building so that it can vertically access the load from a loaded truck parked outside the building. The access door shall have sufficient width and height so that monorail can comfortably move the load through the door opening. The clear width of the door opening shall be not less than 1200 mm.

(d) Machinery

Impact factors for machinery supports shall be designed for the manufacturers' recommendation, with the following minimum values:

- Light machinery, shaft or motor driven 20% of operating weight.
- Reciprocating machinery or power-driven units 50% of operating weight.

(e) Construction Loads

The design load shall accommodate loads from construction activities.

(f) Loads on Buried Reservoir Roofs

Reservoir roofs shall be designed for the weight of saturated earth or 300 mm river pebble that will be placed on the structure plus a live load (minimum of 1.5 kN/m^2) based on the use of the area. Consideration should be given to loads from equipment and stockpiling that will occur during the placement of the fill.

- Wind Loads
  - Structures shall be designed for a basic wind pressure due to a wind speed of 125 metres per second (mps) and the calculations shall be based on 'Design of Buildings for High Winds –Sri Lanka –Ministry of Local Govt. Housing and Construction -1980' or BS CP 3 –Chapter V.
  - Wind forces on structures shall be based on the basic wind pressure and modifying factors based on the shape of a structure and its exposure.
- Process Liquid Loads
- Lateral Soil and Groundwater Loads
  - The structures shall be designed for loadings based on the interpretation of the data contained in the geotechnical report for each site, with the following minimum values:

1.	Compacted soil density	20.0 kN/m^2
2.	Active lateral soil pressure coefficient.	0.333
3.	Passive earth pressure coefficient.	3.0
4.	At-rest earth pressure coefficient.	0.50
5.	Lateral surcharge from vehicles	20.0 kN/m^2
6.	Water head at bottom of walls	Groundwater level, if present or as stated below
7.	Density of water	10.0 kN/m^3
8.	Allowable bearing pressure	Based on soil investigation reports

Structures shall be designed for groundwater at surface level, except for the following conditions:

- Foundation material is self draining;
- Drainage lines are installed around the structure;
  - Walls where vehicles can approach within a distance equal to half the wall height shall be designed for a surcharge of $20kN/m^2$. Consideration shall also be given to any surcharge effects due to adjacent footings or the intended use of the area.

(g) Load Combinations

The Structural Design shall be based on Limit State criteria as stated in BS 8110 and BS 8007. The load combinations shall be as stated in BS 8110 and BS 8007.

The effects of any load type (other than dead load) shall not be used to reduce the effects of another load type. A maximum of 90 percent of the dead load in any combination where it reduces the effects of another load type shall be used.

Structures which contain liquids, extend below grade, or both, shall be designed for the following load combinations:

- Liquid-containing compartments full, with no backfill for liquid containing compartments. No relief will be given for any passive soil pressure on a structure on the face remote from a contained liquid unless otherwise approved.
- Backfill and groundwater, with liquid-containing compartments empty and full.
- Any liquid-containing compartment empty or full in combination.

(h) Flotation

All structures shall be designed to resist upthrust due to flotation.

(i) Handrail Loads

Handrails shall be designed to withstand whichever of the following live loads produces the most adverse effect:

- A force of 550 N acting outwards or downwards at any point on the top rail or post.
- A force of 330 N/m acting outwards or downwards on the top rail.

3. Anticipated Structural Facilities

It is anticipated that the following facilities (but not limited to these) will need to be provided:

- Ground level water storage reservoirs with possible integrated water sumps and pump stations.
- Low lift and high lift pump stations
- Intake structure;
- Water treatment plant;
- Ancillary structures such as pipe supports, valve pits, facility buildings etc.

4. Concrete

Concrete for all water retaining structures and pump stations comprising reinforced non-pre-stressed, cast in place construction shall be grade 35A, having a characteristic strength of 35 N/mm. Concrete for pre-stressed elements, if required, shall be factory controlled grade 40 concrete (40 N/mm^2). Blinding concrete under footings and slabs of water retaining structures shall be grade 20 (20 N/mm^2). Prior to laying structural concrete a polythene film of thickness not less than 0.2 mm shall be laid on all blinding concrete surfaces with lapping not less than 300 mm for water retaining structures. In general, the cement to be used should be ordinary Portland Cement; however, sulphate resisting Portland Cement shall be used for foundations at locations where soluble sulphate content of ground water is excessive if confirmed by soil

investigations. Cast in situ blinding concrete Grade 20, 75 mm thick, shall be provided below all bases and foundations.

The structural concrete for all building structures shall be grade 25 (25 N/mm^2).

5. Reinforcement

Non-pre-stressed reinforcement will be high strength deformed bars with a specified characteristic strength of 460 N/mm^2 or mild steel bars with a characteristic strength of 250 N/mm^2.

6. Structural Design Standards

BS 5950	Structural Steel
BS 5400	Bridges and related structures
BS 8110	Reinforced Concrete Framed building structures
BS 8007	Water retaining structures
BS8004	Foundations
BS 6399 Part 1	Design loading for building - Live Loads
BS6312	Basic data for the design of buildings - Wind Loads
"Design of Buildings for High Winds –Sri Lanka –Ministry of Local Govt. Housing and Construction -1980" and BS CP 3 –Chapter V.	
BS 4449	Guide to selection of constructional sealants
BS4461	Hot rolled steel bars for reinforced concrete
BS 5328	Cold worked steel bars for reinforced concrete
	Specifying concrete including ready-mixed concrete

The above standards will be used as applicable; however, other British or other internationally recognized equivalent standards will be used for specific areas of design.

7. Pre-stressed Concrete

(i) Concrete

Concrete for pre-stressed pre-cast elements, if required, shall be factory controlled grade 50 concrete (50 N/mm^2). Concrete for in-situ post tensioning structures shall be grade 45 concrete (45 N/mm^2).Curing of concrete shall be done effectively using methods approved by the engineer.

(ii) Reinforcement

Non-pre-stressed reinforcement will be high strength deformed bars with a specified characteristic strength of 460 N/mm^2 or mild steel bars with a characteristic strength of 250

N/mm^2. Pre-stressing steel will be grade 270, low relaxation strands with an ultimate guaranteed tensile strength of 1860 N/mm^2. Steel wires for pre-stressed concrete shall conform to requirements of BS 2691. Seven wire strands for pre-stressed concrete shall be stress relieved strands conform to requirements of BS 3617.

Stressing of wires shall be applied by approved jacking system and suitable allowances shall be made for friction in the jacks and cable ducts.

(iii) Analysis and design

The analysis and design shall be carried out in accordance with the limit state design philosophy of BS 8110 and BS 8007.

(a) The structural designs shall be carried out according to Limit State of Serviceability and Ultimate limit state.

(b) The partial safety factor for retained water, surcharge and earth pressure shall be 1.4 for most at Ultimate limit state (ULS) and 1.0 at Serviceability limit state (SLS).

(c) The structures shall be designed with a factor of safety of at least 1.1 against flotation.

(d) The maximum crack widths shall be:

- Reinforced concrete – all faces of liquid containing – 0.2 mm max and where aesthetic appearance is critical – 0.1 mm max.

- Pre-stressed concrete – limited to requirements of BS 8110; however, refer to Section 4.3 of BS 8007 for particular rules for cylindrical tanks.

- The Cylindrical pre-stressed structures (see section 4.3 of BS 8007), the Tensile stress in the concrete shall be limited in accordance with the recommendations of Section 2.2.3.4.2 of BS 8110: Part 1. However, it is recommended that pre-stressed, pre-cast elements be designed as class 1 (zero tensile stress).

8. Structural Analysis and Design Procedures

The analysis and design shall be carried out in accordance with the limit state design philosophy of BS 8110 and BS 8007. The structures shall be checked for compliance with requirements for strength at the ultimate limit state using factored loading with maximum liquid levels. To ensure satisfactory serviceability, the limit states of crack-width and deflection shall then be checked with unfactored loading at normal working levels.

The crack width at the serviceability limit state will be limited to 0.20mm. For areas where aesthetics are an important factor, the crack width will be limited to 0.10mm. Deflections will be controlled by limiting the allowable span to depth ratio in accordance with the requirements of BS 8110. If pre-stressed/pre-cast elements are needed for any of the structures, these elements will be designed as class 1 (zero tensile stress) pre-stressed elements for all loading conditions.

9. Design of Water Retaining and Ancillary Structures

(a) Ground Reservoirs

Ground Reservoirs will be semi-buried reinforced concrete (RC) or pre-stressed concrete (PSC) structures. The shape of reservoirs will be determined taking into consideration economic and site factors, and designed as a continuous structure or with full expansion joints at regular intervals to cater for stresses due to temperature variations and long term creep and shrinkage of concrete. As far as possible, expansion joints that in general are potential places for leaks if not treated properly will be minimized. RC roof slabs will be flat slabs supported on columns and freely supported on RC walls. Roof slabs will be properly isolated and movement joints will be provided where necessary.

(b) Pumping Stations

Pumping stations using suction pumps will have floor elevations suitably below the Formation Ground Level (FGL) to satisfy the positive suction criteria. Building plans will be extended at an elevation above FGL to provide areas for electrical control panels, loading and unloading bays and generator and control facilities. Overhead gantry cranes will be provided for pump removal and working areas.

Asbestos cement sheets or other approved material on steel lipped C channel purlins shall be used for roofing. The thickness of asbestos cement roofing sheets shall not be less than 5.6 mm.

The access door for loading and unloading shall have sufficient width and clear height so that the pumps and/or any other accessories loaded on to a truck can freely move into the loading bay. The clear width shall be not less than 4.0 meters. The clear height shall be as such the pump or other accessories loaded on to the truck can move in with a minimum clearance of 300 mm at top to the load.

10. Foundations

Design of footings for structures and foundation preparation shall be based on the Contractor's Foundation Specialist's interpretation of the data contained in the reports of the geotechnical investigation for each site and any further geotechnical information obtained from investigations arranged by the Contractor.

11. Water Retaining Structures

(a) Design Specification

Concrete water retaining structures shall be designed in accordance with BS 8007 - 1987 British Standard Code of Practice for Design of Concrete Structures for Retaining Aqueous Liquids.

For the purposes of defining the serviceability crack width limit state, the maximum design surface crack width, for direct tension, flexure or restrained temperature and moisture effects shall be 0.2mm, calculated in accordance with Appendices A and B of BS 8007.

For ultimate limit state conditions, liquid levels shall be taken to the tops of walls assuming that the liquid outlets are blocked. For serviceability limit state conditions the liquid level shall be taken to the working top liquid level or the overflow level as appropriate to working conditions.

Testing for water-tightness as specified in section 6.0 shall be carried out prior to any backfilling around the structures is carried out. Following satisfactory testing and immediately before being brought into use the inside of the structures shall be cleaned and disinfected in a manner approved by the Engineer.

(b) Technical Requirements.

The concrete grade for water retaining structures shall be 35A with the 28 day characteristic cube strength shall not be less than 35N/mm^2.

The minimum clear cover to reinforcement shall be

- 50mm on the water face;
- 50mm on the air face;
- 75mm where concrete is deposited against a blinding concrete.
- 75 mm where concrete is deposited against a polyethylene waterproof membrane with a minimum thickness of 0.2mm.

All reinforcement shall be as stipulated in the relevant section of this specification.

Minimum wall thickness shall be 150mm for walls with a single layer of reinforcement except for low walls.

Walls with two layers of reinforcement shall generally be a minimum 250 mm thick. The contractor shall consider the requirement to insert a concrete vibrator of the diameter not less than 40 mm freely through the reinforcement in deciding the minimum wall thickness.

(c) Joints

Joints in water retaining structure comprise the following:

- Movement joints - Expansion joints
  Complete contraction joints
  Partial contraction joints
- Construction joints

The location of joints in the structure and the minimum reinforcement shall be in accordance with Appendix A of BS 8007 which takes into account the effect of joint spacing.

Water-stops shall be located in every construction joints and expansion joints in water retaining structures.

12. Building Materials and Finishes

Water treatment plant and pump station structures and ancillary buildings and structures shall have the following materials and finishes. Construction and material specifications shall be in accordance with the requirements of Civil Engineering and Building Works or in Other Specifications in Section 8.4 of Employer's Requirement.

Item No	Category	Requirements
(a)	Masonry Work General	Rubble masonry wall foundation minimum depth 750 mm with 1:5 cement sand mix up to a height of 200 mm above formation ground level. 20 mm thick damp proof course (DPC) for rubble wall foundation. Plinth plaster in 1:3 cement sand mix above formation ground up to DPC in all external walls. Provide expansion and construction joints as required in ground floor.
(b)	Pavement	1.2m wide pavement along outer perimeter of buildings with 300 x 300 x 50 mm (minimum dimensions) thick RC paving slabs with cement joints right around all structures.
(c)	Roof cladding and ceiling	**Roof Cladding** Roof cladding is to be clay flat tiles (calicut pattern) to Sri Lankan ICTAD (by CIDA) standards laid over purlins to manufacturer's specifications. Roof cladding is to be carried out with standard types of fasteners conforming to the latest Sri Lankan ICTAD (by CIDA) standards or equivalent. Eave gutters and down pipes are to be Zink Aluminium [with Total coating thickness (TCT) not less than 0.47 mm] materials to Sri Lankan standards. Necessary fasteners, brackets etc are to be provided. **Ceilings** Industrial Buildings: Asbestos cement to Sri Lankan standards. Office and Laboratory: Asbestos cement to Sri Lankan standards. Suspended ceilings beneath concrete floors are to be provided with 20 mm thick mineral fibre panels of 4 x 2 feet with powder coated aluminium frames and adaptable hanger rods in laboratory and office areas. Residential Buildings: Asbestos/fibre cement to Sri Lankan standards.
(d)	External Walls	Industrial buildings: External walls are to be of 200 mm hollow cement block work or 225 mm brick work. Residential buildings: External walls are to be 225 mm brick work. External wall surfaces are to semi rough finished cement plaster in cement mortar 1:5 mix and finished with two coats of approved weather resistant Emulsion paint.

Item No	Category	Requirements
		External plinth surfaces are to semi rough finished cement sand plaster, painted with two coats of weather resistant floor paint.
(e)	Internal walls and Partitions	Industrial Buildings: All internal walls and partitions are to be of 100 mm solid cement block or 115 mm brick and surfaces are to be smooth finished cement sand plaster painted with two coats of Emulsion paint. Residential Buildings: 115 mm brick walls with the same finishes. Industrial and Office Buildings: Toilet partitions are of 100 mm solid cement block work or 115 mm brick and surfaces are to be smooth finished cement sand plaster painted with two coats of Emulsion paint. Residential Buildings Toilet partitions are of 115 mm brick and surfaces are to be smooth finished cement sand plaster painted with two coats of Emulsion paint. The toilets shall be well ventilated, with ceramic wall tiles up to 1.5 m height in walls. Area above to be plastered with smooth finish plaster and painted with two coats of emulsion paint.
(f)	Floors and Floor Finishes	1000 gauge polythene sheets under ground floor concrete. Industrial Buildings: Power trowelled smooth finished. Residential Buildings: All floors are to be of 100 mm (minimum) Grade 25 concrete. All areas to be tiled. Skirting to be provided. Toilets: Non skid ceramic floor tiles are to be provided for toilets. Skirting to be provided.
(g)	Doors and Windows	Industrial Buildings: All doors, door frames, windows and window frames shall be aluminium, powder coated or anodized, to Engineer's approval. Residential Buildings: All doors, door frames, windows, and window frames shall be of approved timber to Engineer's approval. Necessary rails, trolleys, guides, rollers with sealed type bearing etc required for the door arrangement to be provided. Doors are to be weather sealed.

Item No	Category	Requirements
		All bath room and toilet doors and door frames shall be of PVC of approved quality.
		Doors are to be equipped with outside and inside locking devices and handles. Fire doors with approved handles to be provided as required by Fire Regulations.
(h)	Sanitary Fittings	All fittings to be of American Standard or equivalent. Wash basins to be inclusive of inlet pipes, water connection and stainless steel bottle traps. Taps and fittings – Approved quality for Engineer's approval. All required accessories such as soap holders, mirrors, towel rails etc to be provided. Hand bidets to be provided.
(i)	Rest Rooms, Kitchens, Tea rooms and Pantries	Tiled washing tops with appropriate plumbing/ discharge with grease traps. Stainless steel sink to the rest rooms to be inclusive of inlet pipes, water connection and stainless steel bottle traps. Food processing area to be tiled.
(j)	Water Supply, Sewerage and Sanitation	Water connection and sewer connection to be provided. Water supply piping to be provided including necessary valves. <u>Plumbing System</u>: Internal plumbing system to required discharge points in adequately sized network to Engineer's approval to be provided with required valves, taps and fittings. <u>Wastewater System</u>: Catchpits with stainless steel heavy duty gratings discharges to external waste water system to be provided as required to enable floor washing internally. <u>Sewer System</u>: Discharge of waste from toilets to be provided and connected to permanent septic tank and soakage pit. Septic tanks and soakage pits to be constructed by the contractor.
(k)	Laboratory and Office	Tiled washing tops with appropriate plumbing/discharge with grease traps.

Item No	Category	Requirements
		Stainless steel sink to the office to be inclusive of inlet pipes, water connection and stainless steel bottle traps.
		Porcelain sink to the laboratory to be inclusive of inlet pipes, water connection and stainless steel bottle traps
(l)	Security hut	Doors: Timber framed marine plywood spray painted doors. 150 mm hollow concrete block walls. Internal and external plastered and painted surfaces with emulsion paint. Grade 20 concrete floor 75 mm thick. Aluminium framed glazed windows Roof to be steel framed covered with zinc aluminium roofing sheet Colourbond sheets. Counter in MDF board with Perstop (or equivalent) laminate allow for shelving, drawers, access door etc as required.
(m)	Car park	Spaces for minimum 4 (four) vehicles to be roofed. Roof to be steel framed covered with zinc aluminium colour bond sheets. Floor to be concreted and have a crossfall to drain rain water.
(n)	Gates	Swing Gates: GI framed gate with minimum 4.0 m clear width colour bond cladding double sashed, side hung door inclusive of gate columns and locking arrangements inclusive of bottom rails, gate columns, guide wheels with self lubricated heavy duty ball bearing inclusive of gate columns and locking arrangements. Sliding Gates: GI framed gate with minimum 4.0 m clear width colour bond cladding, openable to both sides. Inclusive of gate columns and locking arrangements inclusive of bottom rails, gate columns, guide wheels with self lubricated heavy duty ball bearing inclusive of gate columns and locking arrangements.
(o)	Fence	All sites to be completely fenced.

Item No	Category	Requirements
		3.0 m height PVC coated chain link fence of gauge 8, on 50 mm dia GI pipes, planted at 3.0 m intervals with top and bottom and intermediate horizontal GI pipes. Inclusive of PVC coated tension wire (4 rows length wise) strut poles and rubble curb wall 300 mm wide and 450 mm below ground (minimum), 300 mm above ground (minimum dimension) with plastered surface. Top of GI poles to be covered with PVC riveted caps.
(p)	Loading bays	Construction of rubble masonry walls, sand fill and grade 20 RCC cement 200 mm with plastered external surfaces. Suitable surface drains shall be provided to discharge surface water to external system.
(q)	Retaining walls	Rubble masonry retaining wall to all areas within the site where level differences are existing or created by the designer.
(r)	Anti-termite Treatment	To be provided Engineer's approval. It shall be covered with a 10 year written warranty to Engineer's approval
(s)	Colour scheme	Entire Colour scheme to be Engineer's approval.
(t)	Water Proofing	Water proofing to toilets, drains etc for Engineers approval.

3.10 Fire Protection System

In water treatment plant site, the Contractor shall provide a fire protection system. This shall include fire hydrants with a ring main and portable fire extinguishers. The system shall take into account the needs of the finished works and good practice, and the requirements of the Fire Regulations of Sri Lanka and relevant Sri Lankan or British Standards or their equivalents.

As a minimum the fire protection equipment as listed in Table 1.3.11.1 shall be provided at the water treatment plant and pumping station as appropriate. The equipment shall be complete with all mounting brackets, fixings and instruction and warning labels. The extinguishers shall be manufactured to BS 5432 or equivalent.

The carbon dioxide fire extinguishers shall be the steel bodied type.

The multipurpose foam spray extinguishers shall be the aqueous film forming foam type in a steel bodied enclosure.

Fire hydrants shall be positioned as shown on the Drawings and supplied via a ring main connected to the delivery pipeline from the Treated Water Pumping Station.

Table 1.3.11.1 Schedule of Fire Protection Equipment

Location	Type	Capacity Rating	Quantity
Administration Building (Control Room)	CO_2	5kg	1
Workshop	CO_2	2kg	1
Store	Foam	6l	1
Laboratory	CO_2	2kg	1
Transformer Room	CO_2	5kg	2
Filter Gallery	CO_2	2kg	1
Pump Room	CO_2	5kg	1
Pump Room	CO_2	2kg	1
Chlorine Store	CO_2	2kg	1
Chemical Room	CO_2	2kg	1
Chemical Room	Foam	9l	1
Pumping Station	CO_2	5kg	1
	Foam	9l	1
Switchgear Room	CO_2	5kg	1

4. Raw Water Abstraction and Pumping Stations

4.1 Layout

Unless specified otherwise raw water abstraction shall be by means of direct intakes of reinforced concrete construction.

The motor control centres (MCCs) for the control of the equipment shall be mounted at ground level in the raw water pumping station, with the associated transformers located outside adjacent to the building. The Contractor shall site all MCCs and transformers above flood level as approved by the Engineer.

4.2 Mechanical Plant

Pumps

The pump speed shall not exceed 1450 rpm.

The pipework arrangement for each pump shall incorporate:

(a) A non-return valve, an isolating valve and a tied dismantling joint on the delivery side.

The Contractor shall ensure that under all operating conditions pumps will start under stable hydraulic conditions such that the intended operating condition is quickly reached. If necessary automatically actuated butterfly valves against which the pump can start shall be installed on the delivery of each pump to achieve this.

The Contractor shall note that flow capacities specified include an allowance of 5% above the nominal requirement to allow for manufacturing and testing tolerances and a safety margin. Where the system head curves are based on maximum and minimum static head conditions the

relevant pumps shall have their best efficiency duty point at the average between the two system head curves.

5. Aerator, Inlet Chamber, Dosing and Mixing of Chemicals

5.1 Aerator and Inlet Chamber

Where aeration is required, raw water shall be pumped to the top chamber of a cascade aerator from where it cascades down through several steps into a collecting chamber. From this collection chamber raw water is delivered through a pipeline into an inlet chamber at the water treatment plant which shall be connected to the clarifiers.

An overflow weir shall be provided, capable of passing the maximum design flow.

Facilities for measuring the inlet flow to the clarifiers using either a flow meter, measuring weir or flume shall be provided.

Following chemical mixing a flow division chamber shall be provided to distribute the flow equally between the clarifiers. The flow division weirs shall have adjustable stainless steel weir plates.

5.2 Mixing

A) General

The methods used for chemical mixing shall provide uniform dispersion of the chemical in the main flow of water at all times over the entire range of flows through the works. A high degree of turbulence is considered necessary for satisfactory mixing. The power or head loss requirement to achieve satisfactory and efficient mixing shall be optimised to ensure the minimum energy consumption at each mixing location.

B) Static Mixers

Static mixers shall be in-line mixers comprising fixed mixing elements installed in a housing of equal diameter to the pipe. This type of mixer shall be used in preference to mechanical flash mixers unless the inlet water passes through an aerator before chemical dosing takes place.

Mixer internals shall be of material resistant to the chemicals to be used on the plant. Inlet and outlet connections of the housing shall be plain ended suitable for flexible couplings.

C) Chemical Dosing at Mixers

Except where stated below, dosing of chemicals into pipelines shall be by lance type injectors extending into the pipeline for at least one quarter of the pipe diameter. Injection lances shall be provided with nozzles to give an efflux velocity not less than 1 m/s. The injectors shall be stainless steel or lined as appropriate and shall be provided with isolating and non-return valves.

Lime dosing shall be by distributor onto the water surface arranged to optimise mixing over the whole width of the channel. The distributor shall be an open trough with v-notches cut into the side, allowing easy access for sweeping out and flushing. Adequate precautions shall be taken to prevent problems being caused by wind.

Distributors for dosing slurries shall be designed so as to minimise clogging. Dosing lines shall be provided with flushing connections and service water supplies local to the injection point.

Means of access shall be provided at the mixing points for adjustment of hoses, operation of valves, flushing and cleaning of injectors and distributors and for maintenance purposes.

D) Protection of Pipes and Structures against Chemical Attack

At points where chlorine is injected into pipelines the length of the pipeline extending from 2 pipe diameters upstream of the injection point to 15 pipe diameters downstream of the injection point shall be protected internally by suitable coating.

Where coagulant may be dosed, the concrete surfaces in the proximity of the distributor shall be protected against chemical attack.

6. Clarification

6.1 General

Clarification shall comprise facilities for flocculation, sedimentation or flotation, decantation and sludge separation and removal as required to meet the specified clarified water quality.

The primary objective of the clarifiers shall be the reduction of turbidity to a satisfactory level for the subsequent filtration stage.

Provision shall be made for isolating any one of the clarifiers.

As specified in Clause 1.3.1.2 (b), standby power facilities and associated switchgear shall be provided for all types of clarifier which do not rely only on settling under gravity for normal operation. Where required diesel alternators and associated equipment shall be housed in a purpose designed building on site.

6.2 Flocculation

The intensity of mixing in the flocculation zone shall be variable and the degree of any sludge recirculation (if applicable) shall also be adjustable. Hydraulic flocculators with the use of horizontal/vertical baffles or mechanical mixing can be used. All agitators for flocculation shall be readily accessible and easily adjustable with drive units positioned above water level. The flocculation chamber and equipment shall be designed to achieve optimum G value under minimum energy usage for all flow conditions. The Contractor shall provide design calculations to show that effective performance will be achieved at all flow rates expected during the period from 2012 to 2025.

6.3 Clarifiers

The clarifiers shall continuously and efficiently remove suspended solids from the influent with the minimum water loss.

The clarifiers shall be a proven design, constructed mainly in reinforced concrete, of a type previously installed by the Contractor. Tube or plate type settlers will be accepted.

Horizontal flow sedimentation tanks shall have a minimum length to width ratio of 4: 1, a minimum depth of 3 m and a clarified water outlet weir loading of up to 10 litre/sec/metre length of weir at the maximum allowable surface loading rate. Dimensions and proportions of other types of clarifier shall be subject to the submission by the Contractor of acceptable evidence as part of his bid that they will produce satisfactory results.

No provision for by-passing any clarifier shall be provided.

Clarified water shall be fed direct to the filters.

The general design shall place importance on simplicity of operation and the ease with which routine work and maintenance can be carried out.

Adequate means shall be provided for the uniform collection of the settled water and facilities for vertical adjustment of level of decanting orifices or notches in collecting launders shall be provided.

Clarifiers shall have perimeter walkways to enable the works staff to inspect the settlement process and the decanting weirs. Walkways shall have a minimum width of 1.2 m or such other width as required by Occupational Health and Safety regulations.

6.4 Sludge Removal

Manually operated hydraulic de-sludging and cleaning of tanks are acceptable, and the minimum number of horizontal flow sedimentation tanks specified is based on this method. Where the Contractor proposes to include mechanical methods of de-sludging, the number of horizontal flow tanks may be reduced, provided that the number of tanks shall not be less than two. The depths of tanks shall be adequate to allow for the future installation of both tube or plate settlers and mechanical de-sludging equipment where either of these is not proposed to be installed by the Contractor. The Contractor shall provide sufficient information with his designs to satisfy the Engineer that the depths of such tanks are adequate for such future installation.

Where specified, tanks shall have a positive means of removing sludge from the bottom of each tank with scrapers or skimmers and discharge arrangements designed for loadings up to the maximum suspended solids. The design should allow for starting up under a sludge sit down situation. The scrapers shall extend to the entire width or diameter of the tank including the centre well where applicable. Tank scrapers shall be suitable for continuous operation by adequately powered electric drives and shall direct sludge to concentrators or holding pockets for piping from the tanks to a system of sludge collection chambers and disposal pipe work.

Sludge collection chambers shall be located adjacent to the tank and arranged to enable operational staff to readily inspect the flow and consistency of the sludge being withdrawn. Separate manually operated draw-off pipes and valves shall be arranged from each internal sludge pocket. Sludge discharge pipes shall be individually valved.

All routine sludge withdrawal controls and discharge points shall be readily accessible. Where low level chambers are provided for occasional access, stairways shall be arranged and sufficient space allowed in the surrounding structure for rodding the draw-off pipe work. All sludge draw-off chambers shall be adequately ventilated and well lit. Hose connections for cleaning shall be provided at each chamber.

All sludge pipes shall be roddable with the facility for scouring out with water at high velocity.

Sludge discharges and drainage from the tanks shall be arranged to discharge by gravity. The sludge drainage system shall operate at adequate velocities to be self cleansing and deposition of sludge shall be avoided.

The de-sludging system shall be capable of intermittent operation during periods of low turbidity. During periods of temporary shutdown, mechanical sludge scrapers and sludge discharge systems shall continue to operate until all heavy solids have been removed.

Hose down points shall be provided for manual hosing down.

7. Filters

7.1 General

The filters shall be conventional down-flow rapid gravity filters with single size sand media. The filters shall be a proven design, constructed mainly in reinforced concrete, of a type previously installed by the Contractor.

All new filters shall be of identical shape and size. The filters shall be open-topped, rectangular in plan with an adjacent covered upper control gallery and a lower pipe gallery.

The design of the filter outlets shall permit visual inspection of the water leaving each filter through either transparent covers to prevent contamination of the filtered water by dirt and insects or through sight glasses in the pipe work.

The filter media, bed, floor, outlet arrangements and control system shall be designed to avoid pressures less than atmospheric occurring in the beds under all operating conditions and to prevent ‘dry bedding’ during or following a wash cycle.

The filters shall be designed such that each individual filter shall operate continuously for a minimum period of 24 hours between backwash operations under all conditions of flow and while maintaining the filtered water quality standards.

The design shall eliminate as far as possible any tendency to scour the media particularly during filling and to prevent the loss of filter media during washing.

Manual filter drains shall be provided to enable each filter to be completely drained for maintenance purposes.

Filter feed channels, vertical shafts, chamber floors etc. shall have valved drains which shall discharge to the drainage system.

The air scour blowers and backwash pumps shall be housed in a plant room provided at one end of the filter block or in the treated water pumping station. A crane shall be provided in the plant room.

7.2 Filter Control

Filters shall be of the constant rate type.

In the constant rate type the filter inlets shall allow for equal division of flow between the filters in use, and each filter shall be fitted with an automatic outlet flow controller to maintain the outflow equal to the inflow fluctuation, and to maintain the water level in the filter.

7.3 Filter Floors and Underdrains

The filter floors shall either comprise laterals and nozzles set in a concrete screed or be of the suspended floor type with nozzles or the Contractor's own equivalent. The filter floor design including the number, type and design of nozzles shall be based on proven practice.

The design of the floors shall ensure uniform distribution of the incoming filtrate, air and washwater over the complete filter bed area.

Fittings forming part of the filter floor shall be of corrosion resistant material. Metal fittings including bolts and clamps for holding down floor plates shall be of stainless steel.

The nozzles shall be of the screw-in type and shall be designed to prevent loss of filter media through the filter floor, either with or without the use of gravel layers.

Replacement filter nozzles shall either be available from a representative of the manufacturer in Sri Lanka or be interchangeable with nozzles manufactured in Sri Lanka. The Contractor shall demonstrate this to the satisfaction of the Engineer prior to supplying the nozzles.

Access ports and covers shall be provided to give access to the spaces below the filter floors for inspection and maintenance. The access ports shall have an internal dimension of not less than 600 mm and shall pass through and be built in to the filter walls. Covers shall normally be bolted in the closed position and sealed with a gasket of a suitable material.

The following tests shall be completed to the satisfaction of the Engineer:

(a) Filter floor and nozzle level checks within each filter and between filters;

(b) Air Pattern Tests on all the filters before and after installation of the media. The test shall demonstrate that air can pass through the under drain over the whole filter area;

(c) Pressure Tests on all the filters. All the nozzle (or equivalent) outlets shall be plugged and a test pressure applied to the underside of the filter floor. The test pressure shall be the lower of:

- twice the head loss through the nozzles if half of the slots were blocked, at maximum backwash pump delivery flow;
- the closed valve backwash pump pressure;

(d) Pressure distribution on a selected filter. Manometers shall be installed in selected nozzle holes to check that the pressure distribution between nozzles is within + 5%.

7.4 Filter Media

Filter media shall be sand and comply with the Standard for the Specification, Approval and Testing of Granular Filtering Materials produced by the British Effluent and Water Association (BEWA) reference BEWA:P.19.93.

The sand shall be greater than 98% silicon dioxide demonstrating a weight loss not exceeding 2% on acid washing carried out with 40% hydrochloric acid over 24 hours at 20°C.

The uniformity coefficient (UC) for the sand shall be calculated using the results of fractionation tests to determine the particle size distribution.

Filter media shall be of a material and grading readily available in Sri Lanka.

The Contractor shall furnish the Engineer with samples of media and results of tests on all batches of media and gravel supporting layers before the media and gravel are dispatched from the works where they are sieved, and again before they are placed in the filters. The tests shall comprise sieve analyses, acid solubility tests, and specific gravity and friability tests.

7.5 Filter Washing

Filter washing shall be designed for efficient cleaning of the media without excessive washwater consumption and shall incorporate sequential air scour and water washing.

The Contractor shall design his filter wash regime and the sequence and automatic control of wash operations based on proven experience with his chosen media.

The Contractor may, if appropriate to his own design, incorporate a surface cross wash to assist waste removal from the surface of the bed.

Control desks for each filter shall be located in the filter control gallery. The control desk shall incorporate a loss of head gauge indicating the head loss across the filter media.

The control and operation of the backwashing system shall be carried out semi-automatically using a PLC controller, with manual initiation of backwashing as follows:

(a) On receipt of an alarm to show the head loss across the media has reached a preset adjustable value;

(b) On receipt of an alarm when the time since the previous backwash sequence reaches a preset adjustable time;

(c) Manual initiation, by means of a selector switch and push button, located on the control desk.

The backwash control system shall include features as follows:

(a) Backwash queuing, so that only one filter can be washed at a time. It shall not be possible to commence a wash cycle until the previous wash cycle has been completed and the filter is fully back on line or taken out of service;

(b) Interlocks to prevent manual wash control during an automatic wash cycle;

(c) A capacity check. Interlocks shall prevent commencement of a wash cycle unless adequate water is available in the wash water tank for a complete wash cycle;

(d) The duration of any stage of the process shall be capable of adjustment on site and overriding hand control shall be provided to permit prolongation or curtailment of any part of the process at the discretion of the operator without the necessity of making a permanent adjustment to the equipment;

(e) Backwash fail alarm. If the backwash cycle is not complete within an adjustable preset time, the backwash operations shall be terminated, the filter closed down, and an alarm initiated to indicate backwash failure;

(f) Slow start. The control system shall provide slow starting of filters over an adjustable period of up to 90 minutes after routine backwashing or after being off line for any reason. Filters that have been off line shall be backwashed before being restarted. It shall be possible to de-select the "slow start" option and start or increase the flow rapidly;

(g) Complete manual control of the system.

The air required for air scour of the filters shall be supplied by a suitable number of identical rotary air blowers delivering oil-free air. The blower speed shall not exceed 1450 rpm.

The water required for washing the filters shall be supplied by a suitable number of identical pumps drawing water from the wash water storage tank. Pumps shall be horizontal split case or end suction type. The pump speed shall not exceed 1450 rpm.

The Contractor's filter washing design shall include facilities for controlling and adjusting the wash water and air flow rates to adequately compensate for changing water temperatures during the year.

7.6 Washwater Storage

A storage volume containing filtered water for backwashing the filters shall be provided in the clear water reservoir.

The effective capacity of the washwater storage shall be determined by the Contractor. The tank shall have sufficient capacity to backwash all of the filters at the minimum run time between washes and at the maximum backwash rate and maximum duration subject to a minimum capacity of two wash volumes.

7.7 Washwater Disposal

The dirty washwater outlet arrangement from each filter shall be designed to ensure free flow from the filter and avoid flooding of the washout weir. The dirty washwater shall be collected in a common channel and discharged by gravity to the common sludge and drainage channel system or to a backwash recovery tank if required.

8. Clear Water Reservoir

8.1 General

A single separate tank having two compartments shall be provided downstream of the filters incorporating chlorine contact time, treated water storage and filter washwater storage. The volume of the clear water reservoir shall not be less than 3,000 m^3.

The tank shall be longitudinally baffled and shall incorporate a perforated baffle or similar device at the inlet to disperse the inflow in order to maximise plug flow efficiency. The Contractor shall submit calculations to the Engineer to justify his selection of length to width ratios, etc to ensure plug flow and the chlorine contact time specified below.

8.2 Chlorine Contact Time

Chlorine shall be thoroughly mixed with the process water prior to entering the contact tank.

The contact tank shall be designed to provide an effective retention time of 30 minutes at the maximum design flow. Water level cut-outs shall prevent the treated water pumps and washwater pump from diminishing this volume at any time.

Prior to the contact tank, an in-line static mixer shall be provided to ensure thorough mixing of dosed chemicals.

8.3 Treated Water Storage

The treated water storage shall be in addition to the chlorine contact volume and wash water storage and shall be available for the treated water pumps. Outlets shall be designed to ensure cavitation free operation of pumps.

8.4 Wash water Storage

A separate wash water storage tank shall be provided storing un-chlorinated water for filter backwashing and shall be available only to the wash water pumps. The volume of the tank shall not be less than 700m^3.

9. Treated Water Pumping Stations

9.1 Layout

Treated water pumping stations shall be dry well pumping stations located where possible near the clear water reservoirs. The pumping station shall house all the treated water pumping plant and ancillary plant.

The MCC for the control of the equipment within the treated water pumping station shall be mounted at ground level in the pumping station, with the associated transformers located outside adjacent to the building.

9.2 Pumps

Except where otherwise specified in the Particular Specification the pumps shall be of a split case centrifugal type either vertically or horizontally mounted as specified. The pump speed shall not exceed 1450 rpm.

The pipework arrangement for each pump shall incorporate:

(a) An isolating valve and tied dismantling joint on the suction side;

(b) A non-return valve, an isolating valve and a tied dismantling joint on the delivery side.

9.3 Pump Controls

Pump controls shall be as specified in the Employer's Requirements in section 6.0

10. Pipelines and Surge Suppression

The Contractor shall design all required pipelines in accordance with the relevant British standards or internationally recognised equivalent, and shall take into account the relevant guidelines and requirements of the National Water Supply and Drainage Board and of the pipe manufacturer. Where applicable the design shall comply with NWSDB standard drawings and details. The design shall include all necessary air valves, scour valves, control valves, valve pits and other structures, corrosion protection, thrust blocks, and all other works and ancillaries to ensure the designs meet the relevant standards and guidelines and the Employer's requirements in every respect. Pipelines in soft ground areas shall be supported on reinforced concrete pillars and saddles as required, supported on deep foundations such as friction piles or end bearing piles. Where particular materials and/or minimum pipe diameters are specified in the Employer's Requirements these shall be complied with. Details of the Contractor's design including network models and results of network analyses and structural computations shall be provided to the Engineer for acceptance as part of the Construction Documents.

The Contractor shall design, manufacture and install surge suppression equipment in association with pumping stations where the Contractor's calculations show this to be necessary. The Contractor shall consider the need for this equipment at all pumping stations, whether or not it is specifically mentioned in the Particular Specification. It is envisaged that surge suppression will be accomplished where needed by the use of air vessels in most cases. However the Contractor may propose alternative equipment and methods. Should the Contractor propose the use of fly wheels at any pumping station, then appropriate allowance shall be made in sizing motors and associated starters for the increased starting torque requirements of the units.

The successful bidder will be required to commission an independent assessment of pressure transients, including determination of air vessel sizes and inflow/outflow characteristics as part of the design. Computer modelling of system transients will be required. A report detailing system design pressures and air vessel sizes and inlet /outlet details is to be presented for acceptance by the Engineer before detailed design of the vessels and pipework commences. Additional information will be given to the Contractor to assist in this analysis, including computer files containing pipe network analysis models and more detailed guidelines for the analysis to be carried out.

The name of the person or organisation proposed for carrying out the independent assessment and analysis is to be stated in the Technical Proposal, together with an outline of their credentials. The approval of the Engineer to such person or organisation shall be obtained before the analysis is commenced.

Each air vessel shall be supplied with two air compressors of suitable size (one duty, one standby).

If the Contractor proposes alternative types of surge suppression equipment, similar analysis and reporting as described earlier in this clause shall be undertaken by the Contractor to justify his proposals.

11. Chemical Plant

11.1 General

A) Scope

The chemical plant shall be designed for receiving, handling, storage, solution/slurry preparation, metering, transfer and dosing to points of application of the chemicals to be used in the treatment process. The chemical plant shall be located and arranged in chemical buildings as specified.

The Contractor shall design, supply and install the complete system for each chemical and shall include chemical solution/slurry preparation and storage plant, chemical transfer systems, pumps, pipe work, valves, overflows, drains, filter equipment, chemical handling, lifting equipment, weighing equipment, fittings, power and water supplies (including appropriate treatment where necessary to minimise carbonate precipitation effects), instrumentation and control systems together with systems for administering chemicals to the points of application and all other accessories specified and required to provide a comprehensive chemical plant in all respects.

B) Chemicals to be used

Chemicals to be used are given in Clause 2.5 hereof.

The dose ranges for which the facilities are to be designed are given in the Particular Specification.

C) Chemical Storage

Sufficient areas shall be provided for 90 days' storage of each solid chemical, based on the assumed average dosing rate stated in the Particular Specification and the maximum design capacity of the water treatment plant. Storage areas for bagged chemicals shall be divided into two for each chemical by a wall 2 m high to encourage the rotational use of the chemicals. A wall at least 2.5 m high shall separate storage areas for different chemicals. A mechanical dust extraction system shall be provided in all chemical storage areas. Storage requirements for chlorine shall be as stated in the Particular Specification.

Chemical facilities shall be designed to receive supplies of chemicals by road transport and shall provide for unloading, hoisting as required and transfer to storage. Lorry hard-standings shall be provided for all chemical unloading areas. The packaging and delivery of the chemicals to the site is expected to be as detailed below. The Contractor shall confirm the mode of chemical delivery for each chemical in his tender.

Chemical	Form	Packaging/Delivery Consignment Size
Aluminium Sulphate	Kibbled	50 kg bags
Lime	Hydrated lime	50 kg bags
Chlorine	Liquid	1-tonne/900 kg drums or 80 kg cylinders as specified.

The layout of the chemical buildings shall include space for storing the quantities of chemicals required.

Bags of alum and lime are usually supplied loose (not on pallets) and they shall not be stacked more than 2 m high.

D) Chemical Building - Drainage

All drainage in the chemical building shall be drained by gravity to the site general drainage or where this is not possible by automatic sump pump designed for the materials to be handled.

E) Layout

Chemical storage shall be under cover. The chemical building shall incorporate all plant necessary for the transfer of chemicals from storage either by hoist or hand operated bag trolley, preparation of solutions, dosing plant and associated local control and motor control centres.

Interconnecting ducts and service ways shall be of adequate size to enable wet chemicals and electrical services to be segregated and to facilitate ready access for maintenance purposes.

Service ducting shall be drained.

The layout of the chemical storage and the associated dosing plant shall facilitate easy access by the operating staff and shall be arranged in a logical sequence. Particular care shall be taken in the segregation of lime, PAC or other dirty and dusty chemical handling areas from machinery or clean areas. The layout of chlorine plant shall conform to the relevant technical standards and literature by chlorine manufacturers and plant manufacturers.

There shall be adequate washdown points at all levels of the chemical building, with drainage points provided throughout.

Lorry access shall be provided up to all chemical storage areas including the chlorine drum store. The main doors to the chlorine drums store shall be fitted with folding shutter doors to permit unloading of drums using an overhead crane system.

Outward opening emergency exit doors fitted with panic latches shall be provided from the chlorine drum stores.

Provision shall be made for the protection of all floors, ducts, drains, sumps and other surfaces including walls to a height of 1m above floor level, against chemical attack due to chemical

leakages and splashes. The method of protection shall be subject to the approval of the Engineer before installation.

F) Chemical Handling

Manually operated bag handling systems shall be provided in the chemical buildings to assist in the handling of chemicals.

The tanks shall be at a height above operator floor level convenient for manual loading of chemicals from bags.

G) Preparation of Solutions

Batch mixing of solutions and slurries shall be carried out manually including changeover from empty to full service tanks, transfer of chemicals and dilution to pre-selected solution strengths where required.

Solution and slurry tanks shall be of reinforced concrete. Alum tanks shall be protected from acid attack by a suitable coating on all surfaces exposed to both solid and liquid alum.

H) Dosing Pumps

Chemical dosing pumps shall be of the piston diaphragm type with electronically controlled dosing, each with digital stroke adjustment and its own motor, with the exception of chlorine which shall be by pressure injection.

Dosing pumps shall be provided with standby units but the selection of duty and standby pumps shall be by manual selection by the operator. When a changeover from a duty pump to a standby pump is required, the appropriate suction and delivery isolating valves will be manually operated. All dosing pumps shall work against pressure sustaining load valves.

Dosing pumps shall be selected taking into account the chemical being dosed, wear, leakage, resistance to corrosion and accuracy of dosing necessary. The stated accuracy of dosing pumps shall be tested during the Tests on Completion.

Flushing connections shall be provided for each dosing pump and each pump shall be provided with drip trays piped to waste.

Pump stroking speeds shall be selected to minimise wear taking into account the chemical being dosed.

Each dosing pump shall be provided with all necessary valves to suit the application. Any connecting manifold system shall be provided with flushing and drain connections. Means shall be provided for calibration of the pumps by direct measurement just downstream of the loading valves. Tapings off the service water supply, suitable for hose connections, shall be provided in each chemical area for flushing chemical spillage and for general cleaning purposes. Provision shall be made for drainage of the area and for protection of surfaces against chemical attack.

Dosing pumps and metering units shall meet the requirements of the general mechanical and electrical specification. The Contractor shall confirm with pump manufacturers that pump materials and design are suitable for the specific application and arrangement proposed. The

Contractor shall also confirm with the manufacturer his recommendations for location/sizing of pulsation dampers, type of load valve and pipework configuration.

Pump outputs will be adjusted by manually changing the stroke length.

I) Chemical Transfer Pumps

Pumps for transferring chemicals shall be of the end suction centrifugal or progressive cavity or reciprocating type. Pumps of plastic construction will not be acceptable.

Pumps shall be provided with facilities for draining and flushing with water manually.

J) Chemical Pipework and Valves

Chemical pipework and valves shall meet the requirements of the general technical specifications and shall be suitable for the chemical being handled.

Dosing pipelines shall be provided in duplicate (1 duty, 1 standby) with manual changeover facilities. Lime slurry delivery lines shall be in clear reinforced polyethylene tubing.

Dosing lines external to buildings shall be located in reinforced concrete trenches with removable reinforced concrete covers, for ease of access. The tops of the trench walls without the covers shall be set 25 mm above finished ground level. The covers shall be designed for pedestrian traffic. Under roads the lines shall be laid in ducts.

All alum solution and lime slurry pipework shall be fitted with flushing facilities permanently connected to the plant water supply.

Chlorine lines shall not be laid inside buildings (except the chlorination building).

K) Mimic Diagrams

A static mimic diagram of dimensions not less than 1.0 m x 2.0 m shall be provided for each chemical, indicating the main elements, interconnecting pipe work and instrumentation.

The material shall be melamine laminate/phenol resin bond cross webbed having a press bonded aluminium centre core. Low molecular weight melamine formaldehyde laminating inks of various colours shall be used in a screen printed process on laminating paper, laminated into the diagram material. The diagram and legends shall not be affected by mild abrasion or acid conditions, condensation, grease, oil or similar substances. The diagram surface shall be finished in silk-matt.

Different colours shall be used to represent different chemicals and services.

Full size drawings shall be submitted for the approval of the Engineer before preparation of the artwork.

The diagrams shall be suitable for wall mounting in the chemical buildings and shall be located as directed by the Engineer.

Additionally mimic diagrams to the same specification and of dimensions not less than 500 mm x 500 mm depicting each area of operation shall be provided and installed local to the respective area.

L) Safety Equipment

The following minimum safety equipment shall be provided at each treatment plant:

(a) Eyewash bottles and irrigators

Eyewash bottles each of 450 ml capacity and irrigators each holding 10 litres of boric saline solution. Eye wash bottles and irrigators shall be housed in cabinets mounted local to the chemical plant areas.

(b) Safety showers and eye baths

Safety showers and eye baths shall be provided at the following locations:

- adjacent to alum saturators
- lime bag handling areas (eye bath only)
- chlorine building exits

The showers and eye baths shall be connected to the service water mains and shall have header tanks to permit use in the event local of mains water not being available.

(c) Protective clothing

Four sets of overalls, gauntlets, gloves, goggles and boots housed in storage lockers shall be provided.

(d) Portable gas detectors

Four portable gas detectors (two each for oxygen deficiency and chlorine detection) shall be provided.

One of the oxygen deficiency monitors shall indicate whether the atmosphere is safe by indicating 'go/no go'. The other monitor and the chlorine monitor shall display gas concentration and alarm messages.

The oxygen deficiency monitors shall have:

- Measurement range : 0 to 25 %
- Resolution : not greater than 0.1% vol
- Accuracy : within 0,3% vol oxygen in the range 18% - 24%
- Instantaneous alarms : Oxygen deficiency 19 %
  Oxygen enrichment 23%

The chlorine monitors shall have:

- Measurement range : 0 to 99.9 ppm
- Resolution : not greater than 0.1 ppm

– Accuracy : within 1 ppm at 20 ppm
– Instantaneous alarms : 5ppm
– Alarm for short term exposure limit of 15 minutes : 1 ppm
– Alarm for time-weighted average over 8 hours : 0.5 ppm

Alarm shall be indicate by a flashing light and audible alarm. The alarm reset function shall be capable of being initiated only within a short preset time (e.g. 60 seconds) of the instrument being switched on.

Each detector shall be pocket size and housed in a tough, durable case and sealed against dust and water ingress to IP 65. They shall have liquid crystal displays have software compatible with year 2000.

The detectors shall be powered by rechargeable batteries and supplied complete with:

– Battery charges;
– Carrying cases and straps;
– Sensor filters;
– Gas calibration kit for each gas;
– Bulb operated hand aspirator to facilitate pre-entry checks (oxygen deficiency detectors only);
– Ball floats to prevent water being drawn into the detector (oxygen deficiency detectors only).

(e) First aid kits

Two first aid kits shall be provided and installed in the laboratory and the administration building.

Each first aid kit shall be supplied in a green hard-plastic carrying case clearly marked with a white cross and with the words FIRST AID KIT in appropriate Sri Lankan languages and English. A wall mounted cabinet shall be provided in which the first aid kit can be stored.

Each kit shall comprise:

– 10 Assorted Plasters
– 3 Medium sized Sterile Dressings
– A large Sterile Dressing
– 1 Extra Large Sterile Dressing
– 1 Sterile Eye Pad
– 1 Triangular Bandage
– 6 Safety Pins
– 1 Pair Rubber/Plastic Gloves
– Antiseptic Wipes
– 2 Saline Solution Eye Pods
– 3 Rolls of Tape
– 1 Resusciade
– 1 Pair of Scissors

11.2 Coagulant

A) General

Plant for the storage, preparation and dosing of coagulant shall be provided under the Contract.

The preparation and dilution of aluminium sulphate in a desired solution strength shall be undertaken manually and transferred to points of application by metering pump.

B) Coagulant Preparation

In chemical building tanks shall be constructed for 30 hours' storage of alum solution at a strength of 7.5% w/w, calculated on the bases of dosing at 75% of the specified maximum dose. Where new facilities are being provided at existing water treatment plant the Contractor shall ensure that the existing and new storage tanks are sufficient to provide this level of storage to match the combined output of the existing plant. A minimum of two new tanks shall be provided. The tanks shall include a trough with perforated hardwood floors in which to load the kibbled alum to be dissolved. The tanks shall be filled with water by spray bars over the dissolving troughs.

Each solution tank shall be provided with a suitably protected turbine agitator with motor and reduction gear unit. The agitator shall be mounted so that the gearbox may be removed easily and replaced without entry of personnel into the service tank.

The turbine agitator control gear 'stop/start' push buttons shall be located adjacent to the service tanks on the local control panel. The service tanks shall be provided with a suitably valved outlet manifold assembly serving the dosing pumps.

The following pipework together with all necessary valves shall be provided as a minimum on each tank:

Water inlet spray bar

Solution outlet with guard valve

Overflow to drain

Drain

In-line plastic strainers or other approved mesh screens shall be provided on each outlet pipe at an accessible point external to the tank. Adequate valves shall be included to allow screens to be removed for cleaning. Drains shall not be less than 50 mm diameter.

Each tank shall be fitted with a direct reading level gauge (float and calibrated gauge type).

The design shall include a minimum freeboard of 300 mm and the tank floors shall be at least 150 mm below the top of the solution draw-off pipes.

C) Chemical Saturator Tanks

A system of perforated pipes shall be mounted on the tank floor to effect uniform draw-off of the saturated liquor across the whole area of the tank. They shall be raised above the floor to provide sufficient space underneath for the accumulation of sludge. All pipes and fittings shall be of non-corrodible materials and secured by means of stainless steel fixings. The perforated pipes shall be protected from the solid alum by a suspended perforated hardwood floor of panels that can be easily removed for cleaning. The Contractor shall take into account possible future use of block alum in his design.

The following pipework together with all necessary valves shall be provided as a minimum on each saturator:

Water inlet

Solution outlet with guard valve

Recirculation inlet

Overflow to drain

Drain

The water supply shall allow each tank to be filled in not more than six hours. The water supply pipe shall include a manually operated valve and shall terminate in a ball float valve with suitable reinforced protective guard. A hose point shall be provided local to the saturators with a hose of not less than 30 m length.

Recirculation pumps shall be provided for recirculation of solution from the saturator outlet to a high level inlet in order to assist dissolution of alum.

The saturated solution shall be transferred to batching tanks by valving on the recirculation pump delivery pipework.

D) Coagulant Recirculation/Transfer Pumps

At least two recirculation/transfer pumps (one duty/one standby) shall be provided for recirculation and transfer of coagulant solution from the saturators to the batching tanks. Each pump shall be rated for a flow that allows transfer of sufficient saturated solution to provide 12 hours supply in 1 hour.

Suction and delivery pipework shall be arranged so that by manual operation of valves solution can be pumped from any saturator to any service tank.

E) Batching Tanks

Each tank shall be provided with all necessary water inlets, overflow, drain and outlet pipework, manual valves and fittings, and a direct reading level gauge (float and calibrated gauge type).

In-line plastic strainers or other approved mesh screens complete with valves to permit screen cleaning shall be provided on each outlet pipe at an accessible point external to the tank. Drains shall not be less than 50 mm diameter.

Each service tank shall be provided with a suitably protected turbine agitator with motor and reduction gear unit. The agitator shall be mounted on girders so that the gearbox may be removed easily and replaced without entry of personnel into the service tank.

The turbine agitator control gear 'stop/start' push buttons shall be located adjacent to the service tanks on the local control panel. The service tanks shall be provided with a suitably valved outlet manifold assembly serving the dosing pumps.

The tanks shall be re-fitted with all necessary coagulant inlet and outlet, overflow and drain pipework, and a service water inlet. Each tank outlet shall be fitted with an in-line strainer and guard valve.

F) Coagulant Dosing

A suitably valved outlet manifold assembly shall permit coagulant to be drawn direct from one batching tank at a time by all dosing pumps and delivered to the point of application.

A minimum of two piston diaphragm type dosing pumps (one duty/one standby) shall be provided. The number and capacity of the pumps shall be selected to ensure that the specified dosing accuracies can be maintained in the operating range at the flow and dose rate turndown ratios specified.

Dosing pumps shall be provided with suction and delivery isolation valves, pump calibration facilities, suction valves, pressure relief valves, pressure sustaining valve and pulsation dampers on the pump delivery.

The suction and delivery pipework shall be arranged so that the duty dosing pump(s) serving the stream may draw from the duty batching tank via one of the dosing lines and deliver to the point of application by the manual operation of valves.

Duplicate dosing lines shall be provided for each point of application.

Pumps shall be arranged for manual dosage adjustment by the selection of stroke length according to the dose chosen and flow treated. Chemical dosage rate setting charts shall be provided for various alum solution strengths and shall be included in the operating and maintenance instructions.

11.3 Lime

A) General

Facilities shall be provided for the storage of lime, lime slaking, preparation of lime slurries and dosing of hydrated lime.

Facilities shall comprise the following principal parts:

(a) Area for delivery of bagged lime

(b) Bag handling and weighing
(c) Lime slaking
(d) Slurry preparation
(e) Dosing facilities

A lime batch will be prepared by emptying a known weight of quicklime into a slaking tank and adding sufficient water for the most efficient conversion to calcium hydroxide. The amount of quicklime shall be the weight required to make up a 5% w/w slurry. Because of the impurities in the quicklime available in Sri Lanka the concentration of calcium hydroxide in the slurry will be considerably less than 5% and the Contractor shall take this into account in the capacity of the facilities provided.

On completion of the slaking process a handstop will be removed and the slaked lime washed into a slurry tank with the use of water from a hand-held hose. The slurry tank shall be made up with water to make the 5% slurry specified in the preceding paragraph.

B) Slaking Tanks

One slaking tank shall be provided for each slurry tank. The tanks shall be of reinforced concrete and with a minimum size to make up one slurry tank at 5% w/w solids content. A freeboard of not less than 300 mm shall be allowed.

Each tank shall have floor sloping to an outlet with a handstop for flushing the slaked lime into the slurry tank. The floor of the slaking tank shall be a minimum of 100 mm above the top water level in the slurry tank.

In his designs for the slaking tanks the Contractor shall give due consideration to the effects of the heat generated by hydration of the quicklime.

C) Slurry Tanks

In new chemical buildings, tanks shall be constructed for 30 hours' storage of lime slurry at a strength of 5% w/w (solids/liquid), calculated on the bases of dosing at 75% of the specified maximum dose. A minimum of two tanks shall be provided.

Each slurry tank shall be provided with a top entry motor driven mixer of stainless steel construction of adequate power for mixing and keeping lime and impurities in suspension. Support bearings (if required) shall be located at the middle level and shall be water lubricated to prevent ingress of particulate material. The mixer shall be mounted so that the gearbox may be removed easily and replaced without entry of personnel into the service tank.

The mixer control gear 'stop/start' push buttons shall be located adjacent to the slurry tanks on the local control panel. The slurry tanks shall be provided with a suitably valved outlet manifold assembly serving the dosing pumps.

The following pipework together with all necessary valves shall be provided as a minimum on each tank:

(a) Inlet make-up water
(b) Solution outlet with guard valve
(c) Overflow to drain

(d) Drain

A duplex strainer shall be provided on each outlet pipe at an accessible point external to the tank. The strainers shall be designed to remove any larger impurities in the lime that could damage the dosing pumps. Strainers shall be fitted with isolating valves to facilitate cleaning

Drains shall not be less than 100 mm diameter and the tank floor designed for ease of cleaning out settled material.

Each tank shall be fitted with a direct reading level gauge (float and calibrated gauge type) with isolating valve and rodding and flushing facilities.

The design shall include a minimum freeboard of 300 mm and the tank floors shall be at least 150 mm below the solution draw-off pipes.

D) Slurry Dosing Pumps

Lime slurry up to a concentration of 5% w/v (50 g/1) shall be drawn from any one selected duty tank.

When operating with a 5% slurry carrier water shall be used serving each injection point. The diluted slurry concentration shall not be more than 2.5% w/v.

Carrier water shall be taken from the service water supply and shall be provided with all necessary pipework, fittings, valves and flowmeters.

Piston diaphragm type dosing pumps shall be provided with pump suction and delivery guard valves, valved flushing lines, drain valve, delivery pressure relief valve and pressure sustaining valve.

The maximum stroking speed of the pump shall be selected to minimise wear, but care shall be taken in selecting the minimum speed in order to avoid settlement in the pump head mechanism.

As an alternative option to reciprocating type dosing pumps to be considered by the Employer, the Contractor may offer progressive cavity type dosing pumps, which shall have an accuracy of +3% within an operating range of 10:1. The number of pumps required for each duty shall be selected to ensure that the complete range of doses to the range of throughput could be maintained within the operating range for the pump.

11.4 Chlorine

A) General

The following items of chlorination plant shall be supplied by the same manufacturer:

(a) Automatic drum changeover panel;
(b) Chlorine gas pressure-reducing and shut off valves;
(c) Chlorine drum headers, catch pots, isolating valves and fittings;
(d) Chlorinators, vacuum devices, vacuum lines and injectors;
(e) Chlorine leak detector units.

B) Layout and Design

Each chlorination installation shall comprise a separate self contained chlorine drum storage building and a separate chlorinator room.

Chlorine gas drawn from the duty drum shall be transferred to the chlorinators and to the ejectors entirely under vacuum pressure.

The drum store shall be constructed with a travelling hoist for drum handling, the hoist rail extending outside the building for loading and unloading drums from lorries. The chlorinator room shall house the chlorinators, injectors and ancillary equipment. Where necessary it shall also house the motive water pumps and the associated motor control centre.

Chlorine gas shall be transferred from the store to the chlorinators in duplicate (duty/standby) vacuum lines and from the chlorine room to the points of application in duplicate (duty/standby) solution lines. The vacuum lines shall be at least 32 mm internal diameter.

Storage cupboards for an emergency drum repair kit and personnel safety equipment shall be provided and installed in a location convenient to the chlorination building.

The chlorinator room and the drum store shall be provided with emergency exit doors opening outwards to the open air and fitted with pushbar operated panic bolts. Wall mounted lighting shall be provided outside all emergency exit doors.

Adequate angle iron or channel iron protection shall be provided at all protruding corners, frames or openings to prevent damage to structures during drum handling.

In the chlorinator room gas-tight glazed panels shall be provided so that it can be observed from outside as a safety measure in the event of a chlorine leak.

Special consideration shall be given to the floor drainage of the chlorinator room to carry away any water that may reach the floor during operation, maintenance or repair. Adequate traps to ensure chlorine gas cannot escape into other systems shall be provided.

All threader tubes and ducts carrying cables and pipes respectively out of the chlorine drum store and chlorinator room shall be sealed to prevent any chlorine gas leaking out.

C) Chlorine Drum Storage and Handling

It is intended that chlorine shall be delivered to the plant in drums containing liquid chlorine. The Contractor shall provide full chlorine drums at the date of handing over of the works. The numbers of drums to be provided are given in the Particular Specification.

The Contractor shall provide all the necessary equipment to transfer drums to and from lorries from and to the store, and for moving drums within the store.

An overhead manually operated travelling hoist shall be provided for mechanical handling of the drums. The minimum safe working load (SWL) shall be 2 tonnes complete with a suspended weigher (0 to 2 tonnes) and a drum lifting beam.

D) Chlorine Draw-Off System

The duty/standby drums shall be arranged in the drum store, mounted on plinth-set castors, four rollers per set. The remaining drums shall be stored on plinths spaced as closely as possible, subject to adequate access to the remainder of the store.

Dwarf concrete walls shall be provided to protect chlorine gas pipelines in the drum store from damage.

The installation shall include all necessary chlorine headers including floor supports, power actuated valves and manual isolating valves for connection of drums to the chlorine automatic drum changeover device.

E) Automatic Drum Changeover

A mechanically operated automatic chlorine drum changeover device shall be provided. The duty changeover shall be initiated by low pressure in the chlorine pipework to the chlorinators. Electrically operated changeover panels arrangements will not be acceptable.

F) Chlorinators

Chlorinators shall be provided as follows:

(a) Pre-chlorinators: Two chlorinators (duty and standby) shall be designated for pre-chlorination duty. These chlorinators shall independently serve the raw water application points;

(b) Post-chlorinators: Two chlorinators (duty and standby) are to be designated for post-chlorination duty. These chlorinators shall independently serve the filtered water application point.

The whole installation shall be designed to be 'fail-safe' and the closing down of any duty chlorinator whether by failure of gas or operating water shall initiate an alarm indicating which chlorinator has failed. Alarms indicating low chlorine gas pressure and loss of vacuum pressure shall also be provided on the local monitoring panel. The initiation of any of these alarms shall also transmit a common alarm to the filter gallery.

The proportional control or automatic start up of standby chlorinators on failure of a duty chlorinator is not required. Doses are to be set manually.

Chlorinators shall be supplied complete with external injectors, ejectors, vacuum devices, vent pipes, drain pipes and all components necessary to provide a complete and safe installation.

Chlorine vent pipes shall not be manifolded but instead run as discrete lines to a suitable high level discharge point outside the building.

G) Ejector Motive Water Supply

Ejector water supply shall be designed to suit the maximum rated output of the chlorination equipment provided.

The installation shall include the provision of the necessary pumps, pipework, valves, pressure gauges, strainers, flow indicators and ejector fittings to serve the chlorinators, vacuum regulation and metering devices.

One pump shall be provided for each chlorinator and ejector. The pumps may be connected to a common suction manifold but each shall be provided with individual delivery lines to each chlorinator ejector.

The ejector water pumps shall draw water from the works service water system. The draw-off point shall have a non return valve to prevent potential back siphonage of chlorine solution.

H) Chlorine Delivery Pipework and Injection Fittings

All necessary chlorine delivery pipework, valves, fittings, supports, solution distribution and/or injection fittings, etc shall be provided as specified.

Separate chlorine solution lines to each application point shall be provided. Rigid PVC pipework where provided shall be designed with adequate supports and due regard to thermal expansion effects likely in the site environment.

I) Chlorine Leak Detection

Plant is required to detect abnormal concentrations of chlorine in air such as would occur on significant leakage or failure of chlorinating plant or chlorine drums.

The minimum requirement for detectors shall be as follows:

- Each drum store - one detector
- Each chlorinator room - one detector.

The equipment shall incorporate low and high level alarms to give the following sequence of operations:

(i) Low level alarm

Should the concentration of chlorine in the atmosphere reach a level of 5 µl/l (micro litres per litre) the leak detector shall activate:

- An alarm light mounted externally over the entrance doors. The alarm shall be red in colour and display a steady light;
- A visual alarm on the alarm enunciator in the filter gallery.
- The ventilation fan

(ii) High level alarm

Should the concentration of chlorine in the atmosphere reach a level of 15 µl/l (micro litres per litre) the leak detector shall:

- Activate a visual alarm mounted externally over the entrance door.
- The visual alarm shall be the flashing operation of the red alarm light described in the low level section;

- Activate an audible klaxon alarm located alongside the alarm light above the entrance door;
- Activate a visual alarm on the alarm enunciator in the filter gallery.
- Shut down the ventilation fan

The supply and installation of the alarms, fans and all necessary wiring between these items and the detector units shall be included in the Contract.

The alarms lights shall be clearly visible at a distance of 20 metres under strong sunlight conditions.

The alarms shall have an audible range of not less than 50 m. All alarms shall remain in operation at all times while the chlorine concentration is above the alarm levels and necessary relays with cancellation buttons shall be supplied. The detectors shall be sufficiently sensitive to detect increases in concentrations of 0.1µl/l (micro litres per litre). They shall incorporate test buttons on their front panels facilitating quick checks of satisfactory operation of the electronic circuits.

The chlorine leak detectors and associated alarm circuits shall be supplied from an uninterruptible power supply source.

In addition to the above, a rear engraved Perspex label having white letters on a red background shall be mounted at each door. The lettering shall be a minimum of 50 mm high, and the legend shall read in Sinhala, Tamil and English:

DANGER
SELF CONTAINED BREATHING APPARATUS MUST BE
WORN BEFORE ENTERING WHEN RED LIGHT IS SHOWING

12. Ventilation of Chlorine Buildings

Rooms in which chlorine gas may be present shall be provided with high rate forced ventilation systems detailed as follows:

(a) Chlorine Drum Stores

High rate emergency ventilation facilities shall be designed to give 20 air changes per hour when all fans installed in each room are working. Start/stop push button stations in weatherproof housings shall be provided at each entrance door to control the fans in addition to the automatic starting and stopping specified in sub-clause 2.11.4.9. The starter/controller units for all fans in chlorine areas shall be located within remote control panels outside the chlorine buildings.

Inlets to the exhaust system shall terminate at a low level within the building with the bottom of the vertical trunking being terminated at an angle of 45 degrees and fitted with suitable rust proof grille. The bottom of the grille shall be 200 mm above floor level.

Each fan shall be installed at higher level complete with aluminium or PVC trunking. Access through the trunking for maintenance and removal of fans shall be provided. A flanged galvanised box shall be supplied for building into the wall to provide passage and fixing for the

trunking. Trunking shall terminate externally to a building at a high level with weather proof heavy duty louvers, bird and sand guards.

All necessary ducting, extractor fans with external mounted control gear and fan running lights shall be provided. Special attention shall be given to materials of construction, particularly motor protection.

A starter/controller unit shall be provided for each fan incorporating HRC fuses, magnetic and thermal overload and single phasing protection and interlocked isolation switching.

(b) Chlorinator Room

The chlorinator room shall be provided with a single low level extractor fan capable of producing ten air changes per hour.

13. Potable and Service Water System

13.1 General

Water for use on each treatment plant site shall be supplied by distribution mains fed from the treated water pump delivery main delivered through a pressure reducing valve as necessary.

The mains shall be sized to supply water for plant use (referred to as service water) and potable use.

The Contractor shall design and provide complete systems including all pipework and valving from the delivery main in the treated water pumping station to the distribution system outlets, including pipework laid in structures, buried pipework, thrust blocks, valve chambers and washouts as necessary to provide a complete system.

13.2 Potable Water

The potable water supply and distribution system (including as necessary pipework laid in the ground and within structures) shall be designed by the Contractor to provide the necessary quantity of water at the required flow and pressure to the administration building and any other areas requiring potable water.

The average daily use and maximum instantaneous demand shall be estimated based on the projected staffing required to operate and maintain the works.

13.3 Service Water

The service water storage and distribution system shall to provide all the needs for water throughout the works not provided by the portable water system.

The uses shall include the following:

(i) Preparation of chemical slurries and solutions;

(ii) Dilution of chemical slurries and solutions to assist with the dosing and mixing of same with the process stream;

(iii) Motive water to provide chlorine solution;

(iv) Flushing of plant and pipework;

(v) Hose points for cleansing of tanks, channels and general hosing down activities.

14. Water Quality and Process Instrumentation

14.1 Water Quality Monitoring

Continuous on-line water quality monitors shall be provided for pH, turbidity and free chlorine. The sampling point for these monitors shall be at the outlet from the treated water reservoir. Continuous on-line water quality monitoring shall also be provided on the raw water transmission main for pH, turbidity, dissolved oxygen and conductivity. All other process control and performance monitoring shall be by manual sampling at relevant points in the plant for analysis in the plant laboratory. Facilities shall be provided to enable samples to be taken at specified stages in the treatment plant for monitoring water quality.

Water quality monitoring requirements are detailed in Table 1.15.1.

14.2 Sampling

The location of the sample abstraction points and sampling taps shall be determined by the Contractor to meet the requirements of the Employer's Requirements. The installations shall include for making the abstraction points and providing, installing and fixing all necessary valves, pipework and sampling taps and the provision and fixing of all necessary supporting racks and fasteners.

Care shall be taken to ensure that manual sampling points provide a representative sample with attention being paid to pipework material and sample flows.

All sample points shall be clearly and unambiguously labelled to identify the origin of the sample. The minimum size of sampling lines, valves and taps shall be 13mm, except for sludge where the minimum size shall be 25mm. Sampling lines may be either flexible or rigid and shall be kept as short as possible. Flexible sample lines shall be laid on horizontally mounted trays and shall be held in position using releasable ties/clips to give a neat appearance and to prevent movement under flow conditions.

14.3 Process Instrumentation Requirements

In addition to instruments specified as incorporated in particular parts of the Plant, the Contractor shall provide process instrumentation to monitor specified parameters at the specified locations as set out in Table 2.15.2. These are the minimum requirements and the Contractor shall provide any additional instrumentation required to suit his particular equipment or design and to enable the plant operators to monitor the performance and sufficiency of the treatment process.

Table 1.15.1: Water Quality Monitoring Requirement

Sample Point	Parameters	Frequency
Raw Water	Temperature	Daily
	Colour	Daily
	Conductivity*	Daily
	Turbidity*	Daily
	pH*	Daily
	Ammonia	Daily
	Alkalinity	Daily
	Dissolved Oxygen*	Daily
	Jar Testing	Weekly
Dosed Water	Total Aluminium	Daily
	pH	Daily
Clarified Water (on individual units)	Turbidity	Daily
	Colour	Daily
	Total Aluminium	Daily
	Soluble Aluminium	Daily
Clarified Water (after lime dosing)	pH	Daily
Filtered Water (on individual filters)	Turbidity	Daily
Combined Filtered water	Turbidity	Daily
	Colour	Daily
	Total Aluminium	Daily
	Soluble Aluminium	Daily
Filtered water (single point after addition of lime or/and chlorine)	pH	Daily
	Free & Total	Daily
Final treated water *	pH	Twice per day
	Colour	Twice per day
	Turbidity	Twice per day
	Free & Total	Twice per day
	Conductivity	Twice per day
	Total Aluminium	Twice per day
Dirty backwash water	Turbidity	Monthly
Clarifier sludge (on individual units)	Total Dried Solids	Monthly or as required

Note * In addition to continuous on-line monitoring

Table 1.15.2 - Process Instrumentation

Key:

I = Local indication
R = Recording and transmitting to Administration Building with repeat indicators in the filter control gallery
T = Totalisation

Location	Parameter	Key	Alarms
Raw water prior to flash mixing	Flow	IRT	
Sludge flow from clarifiers	Flow	IRT	
Each individual filter	Loss-of-head	I	high
Filter washwater on common delivery to filters	Flow	IRT	
	Pressure	I	
Washwater storage tank	Level	I	
Filter air scour	Flow	I	
	Pressure	I	
Filtered water	Flow	IRT	
Chlorine contact tank	Level	IR	high
TW Res. - each compartment	Level	IR	high
- each compartment	Level	IR	low
- common outlet	pH	R	
- common outlet	Turbidity	R	
- common outlet	Free chlorine	R	
Service water	Flow	T	
Treated water output from plant	Flow	IRT	

Instrumentation located external to buildings (e.g level monitors on reservoir roofs) shall be housed in weatherproof chambers with adequate access for maintenance and removal.

14.4 Alarms

Visual and audible alarms shall be provided for the parameters indicated in the above table. The alarms shall be initiated locally on the appropriate switchboard or instrument panel and also in the Administration Building.

15. Treatment Plant Laboratory

15.1 Laboratory

A Laboratory shall be provided with a minimum floor area of 30 m^2 within the control building.

The laboratory shall be fitted with sufficient bench area (not less than 7.5 m^2) and storage cupboards to accommodate the equipment and chemicals listed below. There shall be a minimum of eight double electrical sockets distributed round the laboratory. The laboratory shall have a hot and cold water supply and sinks discharging to the works drainage system. Each laboratory shall be supplied with four laboratory stools

The laboratory shall be equipped with all necessary apparatus to enable the works operators to carry out the following analytical tests:

- pH
- Turbidity
- Free and Total Chlorine
- Conductivity
- Colour
- Total Alkalinity
- Temperature
- Ammonia
- Aluminium (total and dissolved)
- % Dried solids
- Total Suspended Solids
- "Jar Testing"
- Algal counting including cyanobacteria (blue-green algae)

All laboratory equipment suitable for operation on 220 volts, 50 Hz supply shall be supplied as necessary.

All such equipment shall be properly calibrated by an authorised laboratory to the satisfaction of the Engineer. This equipment is to be used by the Contractor to fully train the operators and is to be available at the water treatment plant for use by the Employer and his operators. It shall also be used by the Contractor during Tests on Completion and Tests after Completion.

15.2 Equipment

Laboratory Equipment shall be supplied as in the Section 6.0

(q) Where specified, equipment for identifying and counting algae and cyanobacteria (blue-green algae) shall be provided as follows:

- Standard optical binocular microscope and illuminator suitable for use with counting chambers and having magnification up to and including 1000x
- Sedgwick-Rafter and Palmer-Maloney counting chambers
- Electronic particle counter

All necessary reagents to carry out analytical tests described above for a period of one year.

All reagents used and any breakages occurring prior to Take-Over shall be replenished or replaced by the Contractor.

16. Office Building, Workshops, Stores, Garages and Staff Accommodation Buildings

16.1 Office Buildings

Office buildings shall be provided as required by the Particular Specification. They shall be provided with lighting, general power, potable water and air conditioning.

16.2 Workshop and Store

Workshops and stores shall be provided as required by the Particular Specification. They shall be provided with lighting and general power.

16.3 Garages

Garages shall be provided as required by the Particular Specification. They shall be provided with lighting and general power.

16.4 Staff Accommodation Buildings

Staff quarters shall be provided as required by the Particular Specification. They shall be provided with lighting and general power.

17. Power Supplies

Power supplies are required at all sites for operation of pumps & equipment, lighting & fire control systems.

All work to provide new high voltage supplies and transformers shall be done by the contractor.

The Contractor will be directly responsible for all transformers, high voltage & low voltage cabling necessary for the Works. This will include all HV equipments, transformers, cables & accessories on HV side the cables from the low voltage terminals of the power supply transformer to switchboards and motor control centres being provided under the Contract. Cost for all low voltage cabling work shall be included in the amounts entered by the Contractor in the Price Schedules.