

PROCUREMENT, SUPPLY, INSTALLATION, TESTING & COMMISSIONING REVERSE OSMOSIS WATER FILTRATION PLANTS AT NUST (H12 CAMPUS)

Capacity: 3,000 US Gallons per Day (GPD) Each

SECTION 1: INTRODUCTION AND SCOPE OF WORK

1.1 Background

The National University of Sciences and Technology (NUST) operates a large residential and academic campus at H-12, Islamabad. The campus drinking water supply is sourced from tube wells and/or municipal connections that exhibit Total Dissolved Solids (TDS) in the range of 400–1000 mg/L, hardness in the range of 400–700 mg/L as CaCO₃ and confirmed bacteriological contamination across sampled points. This combination of elevated mineralization and microbial risk necessitates a treatment solution that simultaneously reduces TDS to potable standards, controls hardness, and ensures complete disinfection.

NUST has determined that Reverse Osmosis (RO) technology with a partial-bypass blending stream is the appropriate treatment solution to achieve target product water quality while retaining a controlled level of natural minerals. NUST intends to procure such plants through open competitive bidding in accordance with the Public Procurement Regulatory Authority (PPRA) Rules 2004 (as amended).

1.2 Scope of Work

The scope of work under this tender includes, but is not limited to, the following:

- Design verification and detailed engineering of each RO plant for site-specific raw water quality
- Supply, delivery, and unloading of all equipment, materials, and accessories listed in Section 4
- Civil works (minor, if any) required for equipment foundation, drainage, and electrical connections at designated locations
- Installation, interconnection, and commissioning of all plants at locations designated by NUST
- Performance testing and verification against guaranteed output parameters
- Operator training (minimum two sessions per plant location)
- Supply of all commissioning chemicals, test kits, and consumables for initial operation
- Provision of an Operation & Maintenance (O&M) Manual and spare parts list
- Warranty support for a minimum of twelve (12) months from date of commissioning acceptance

SECTION 2: DESIGN BASIS — WATER QUALITY

2.1 Raw Water Quality — Design Parameters

Each plant shall be designed and guaranteed to treat raw water exhibiting the following parameters. The bidder must confirm performance at any raw water quality within the ranges stated.

S#	Parameter	Design Range (NUST Campus)
1	pH	7.0 – 8.5
2	Turbidity	3 NTU
3	Total Dissolved Solids (TDS)	1000 mg/L

4	Total Hardness (as CaCO ₃)	600 mg/L
5	Calcium Hardness	250 mg/L
6	Nitrates (as NO ₃)	50 mg/L
7	Sulphates	200 mg/L
8	Arsenic	0.05 mg/L
9	Iron (total)	0.5 mg/L
10	Manganese	0.1 mg/L
11	Bacteriological Status	Contaminated (E. coli / Total Coliforms detected)
12	Langelier Saturation Index (LSI)	Potential for scaling

2.2 Product Water Quality — Guaranteed Standards

The product water shall comply with the Pakistan Standard Specification for Bottled Drinking Water (PS:4639-2004(R) and, where more stringent, with WHO Drinking Water Guidelines (4th Ed.). The following are mandatory guaranteed parameters:

S#	Parameter	Guaranteed Limit	Reference Standard
1	pH	6.5 – 8.5	PS:4639 / WHO
2	TDS	200 – 300 mg/L	PS:4639
3	Total Hardness (as CaCO ₃)	≤ 200 mg/L	PS:4639
4	Turbidity	< 0.5 NTU	PS:4639 / WHO
5	Nitrates (as NO ₃)	< 50 mg/L	PS:4639 / WHO
6	Sulphates	< 250 mg/L	PS:4639
7	Chlorides	< 250 mg/L	PS:4639
8	Arsenic	< 0.01 mg/L	PS:4639 / WHO
9	Iron (total)	< 0.3 mg/L	PS:4639
10	Residual Chlorine	0.2 – 0.5 mg/L	PS:4639 (post-disinfection)
11	E. coli	0 / 100 mL	PS:4639 / WHO
12	Total Coliforms	0 / 100 mL	PS:4639 / WHO
13	RO Salt Rejection	≥ 97% (system level)	Manufacturer guarantee
14	System Recovery	≥ 70%	System-level design

2.3 TDS Blending Strategy

Pure RO permeate typically yields TDS < 50 mg/L. NUST requires product water in the range of 200–300 mg/L to retain beneficial minerals and ensure palatability. This shall be achieved by blending a controlled fraction of pre-treated but non-RO-processed feed water (bypass stream) with the RO permeate. The blending arrangement shall include:

- A manual or automatic blending valve / proportioning valve on the bypass line

- A bypass line originating downstream of the 1-micron cartridge filter
- An in-line TDS meter / conductivity probe on the product header to continuously monitor blended TDS
- A TDS set-point range of 200–300 mg/L, adjustable on site by a trained operator
- The blending ratio shall be calculated by the bidder at tender stage based on raw water TDS (design value 1000 mg/L) and shall be stated in the bid

The bidder shall provide blending ratio calculations in the technical proposal for the two bounding raw water scenarios (TDS = 400 mg/L and TDS = 800 mg/L).

SECTION 3: PROCESS FLOW DESCRIPTION

Each plant shall follow the treatment train described below. The sequence is mandatory; deviations require written justification and written approval from NUST prior to bid submission.

Raw (feed) water is received into a 500-gallon food-grade UV-stabilised storage tank (Raw Water Tank). This tank provides buffer storage to decouple the source supply schedule from plant operation. The tank shall be fitted with a float valve or level switch to control inlet flow and prevent overflow.

A horizontal centrifugal pump (~1 HP, 220 V, IP55) draws water from the raw water tank and delivers it through the pre-treatment train at 3–4 bar. A low-pressure switch on the suction side shall shut down the pump to prevent dry running.

Stage 1: Multi-Grade Sand Filtration

Water passes through an FRP pressure vessel packed with multi-grade silica sand (0.4–0.8 mm). The filter removes suspended solids, fine particles, and colloidal matter. An automatic multiport backwash valve (timer-programmable) periodically reverses flow to clean the media bed. An air-bleed-valve is provided to purge entrapped air.

Stage 2: Activated Carbon Filtration

A second FRP pressure vessel packed with coconut-shell activated carbon (iodine value ≥ 900 mg/g) removes residual chlorine, organic micropollutants, color, and odor. Chlorine removal efficiency shall be $> 95\%$. An automatic multiport backwash valve (timer-programmable) is provided.

Stage 3: 5-Micron Cartridge Filtration (Jumbo)

A 20-inch jumbo polypropylene spun cartridge (5 μm rating) provides gross particle interception as a transition stage. This filter acts as a sentinel to signal upstream media filter exhaustion when pressure drop rises.

Stage 4: 1-Micron Cartridge Filtration (Jumbo)

A second 20-inch jumbo cartridge (1 μm rating) provides fine particle removal immediately upstream of the high-pressure pump, ensuring the Silt Density Index (SDI) of feed water to the RO membrane is ≤ 5 (target ≤ 3).

Stage 5: Antiscalant Chemical Dosing

A diaphragm metering pump injects food-grade antiscalant chemical into the feed line upstream of the high-pressure pump. Dosing is interlocked to operate only when the high-pressure pump is running. The antiscalant prevents precipitation of carbonate, sulphate, and silica scales on the membrane surface, extending membrane life. Chemical type and dosage rate shall be specified by the bidder based on raw water chemistry.

A vertical multistage centrifugal pump (2–3 HP, 10–14 bar) delivers feed water at the operating pressure required for RO permeation. The pump is IP55-rated for dusty/humid environments. A high-pressure switch downstream provides overpressure protection.

Stage 6: RO Membrane Separation & Permeate / Concentrate Split

Feed water passes through two 4" $\times$ 40" polyamide thin-film composite (TFC) RO membrane elements housed in FRP/SS pressure housings (one membrane per housing). Each membrane element (DuPont FilmTec BW30 PRO-4040 or approved equivalent) rejects $\geq 99\%$ of dissolved salts (individual element basis). Permeate (product) and concentrate (reject) flows are separately controlled. A high-pressure concentrate control valve on the reject line regulates system recovery (target $\geq 70\%$). Rotameter-type flow meters on both permeate and reject lines enable recovery calculation and adjustment. A manual high-flow flush arrangement allows flushing accumulated scaling/fouling agents from the membrane surface.

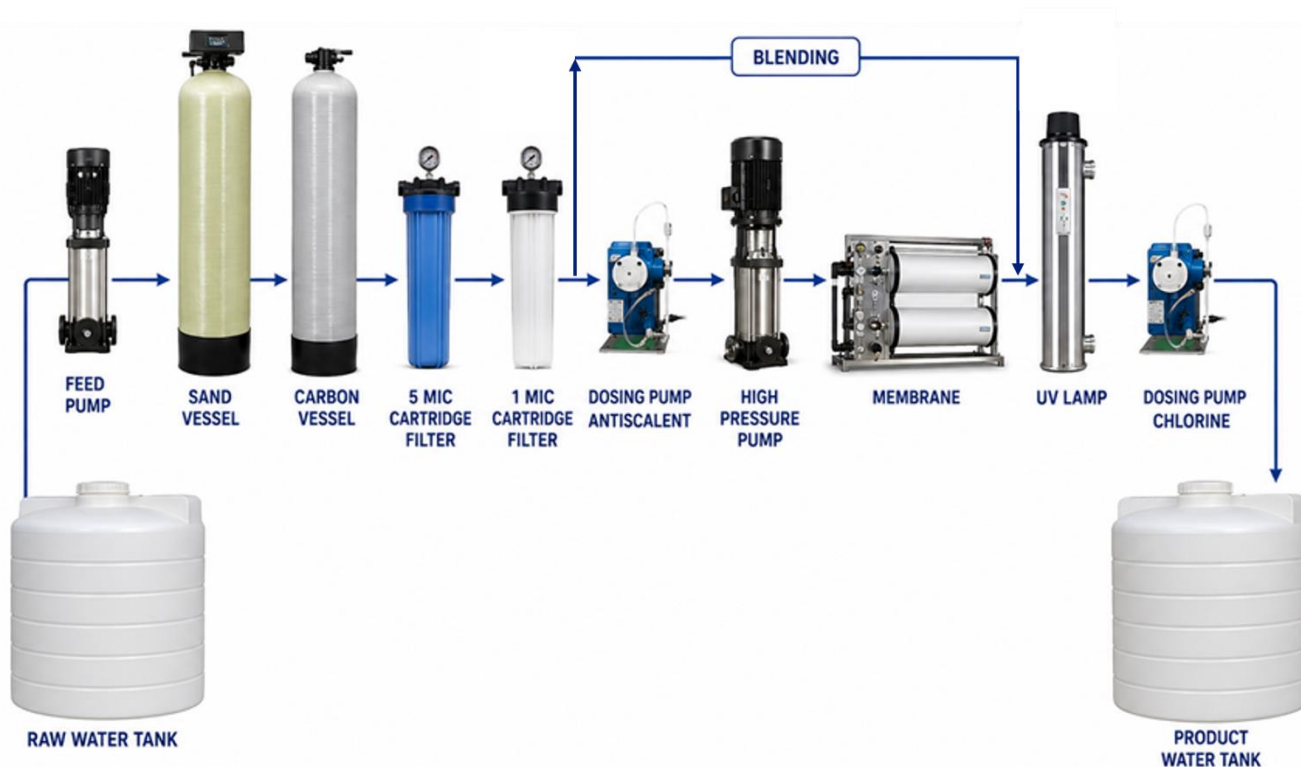
A calibrated bypass stream of pre-treated feed water (post Stage 4 quality) is blended with the RO permeate to raise TDS from < 50 mg/L to the target range of 200–300 mg/L. An in-line TDS meter continuously monitors product water TDS. The blending valve is adjustable by the operator and lockable at the set point.

Stage 7: Disinfection (UV + Chlorination)

Blended product water passes through an ultra-violet disinfection unit (30–40 W, 254 nm, lamp life ≥ 9,000 hours, quartz sleeve) that inactivates any residual bacteria, viruses, and protozoa. This is the primary disinfection barrier.

A diaphragm dosing pump injects a dilute sodium hypochlorite (NaOCl) or calcium hypochlorite solution into the product water downstream of the UV unit to maintain a residual chlorine concentration of 0.2–0.5 mg/L in the storage tank and distribution network. Dosing is interlocked to operate only during product water flow.

Treated and disinfected water is collected in a 500-gallon food-grade UV-stabilised product water storage tank. A distribution pump (or gravity feed, as dictated by site conditions) delivers water to the point(s) of use.



SECTION 4: TECHNICAL SPECIFICATIONS OF COMPONENTS

The following specifications are minimum mandatory requirements. Bidders offering equipment of superior specification are encouraged to declare the enhancement and provide supporting data. All materials in contact with drinking water shall be food-grade and non-toxic.

S#	Component	Minimum Technical Specifications	Qty (per Plant)
1	Raw Water Storage Tank	Type: Vertical cylindrical; Material: Food-grade polyethylene (PE), UV-stabilised; Capacity: 500 US Gallons (1,893 L) minimum; Fittings: Inlet float valve, outlet gate valve, overflow, drain valve, vent, manhole or inspection port; Certification: Shall be food-grade compliant with PSQCA or equivalent	1 per plant
2	Low-Pressure Feed Pump	Type: Horizontal end-suction centrifugal; Motor rating: 1 HP (0.75 kW), 220 V, 50 Hz, single-phase; Discharge pressure: 3–4 bar; Material: Cast iron/stainless steel wetted parts;	1 per plant

		Protection class: IP55; Features: Automatic low-pressure cut-off switch on suction, thermal overload relay on motor	
3	Multi-Grade Sand Filter	Vessel: FRP pressure vessel rated for 10 bar working pressure; Working volume: 110–120 L; Media: Multi-grade silica sand, size 0.4–0.8 mm, depth ≥ 600 mm; Control valve: Automatic multiport valve (6-position or equivalent), timer-based, programmable backwash/rinse cycle; Accessories: Air bleed valve, pressure gauge ports (inlet/outlet), drain/backwash connection; Backwash flow rate to be sized for 10–15 m/h superficial velocity	1 set per plant
4	Activated Carbon Filter	Vessel: FRP pressure vessel, rated 10 bar working pressure; Working volume: 110–120 L; Media: Coconut-shell activated carbon (granular, 12×40 mesh); Media specifications: Iodine value ≥ 900 mg/g, Moisture content < 5%, Hardness (ball-pan) ≥ 80%, Ash content < 8%; Chlorine removal efficiency: > 95% at rated flow; Control valve: Automatic multiport valve, timer-based, programmable; Accessories: Air bleed valve, pressure gauge ports, drain connection	1 set per plant
5	Cartridge Filter — 5 Micron (Jumbo)	Housing: 20-inch jumbo type, durable food-grade reinforced plastic or SS316 (specify); Cartridge: Polypropylene spun-bonded depth cartridge; Micron rating: 5 µm nominal; Filtration efficiency: ≥ 95% for particles > 5 µm; Accessories: Relief/bleed valve, pressure gauge connections (inlet and outlet)	1 set per plant
6	Cartridge Filter — 1 Micron (Jumbo)	Housing: 20-inch jumbo type, durable food-grade reinforced plastic or SS316 (specify); Cartridge: Polypropylene spun-bonded depth cartridge; Micron rating: 1 µm nominal; Filtration efficiency: ≥ 95% for particles > 1 µm; Accessories: Relief/bleed valve, pressure gauge connections (inlet and outlet)	1 set per plant
7	Antiscalant Dosing System	Pump: Diaphragm-type metering pump; Dosing range: 2–6 LPH (adjustable); Chemical tank: HDPE or polypropylene, 80–100 L capacity; Interlock: Dosing to activate only when high-pressure pump is running (flow-actuated or relay-controlled); Dosing chemical: NFPC (non-phosphate, food-compatible antiscalant) suitable for carbonate / sulphate scale — type and dose to be specified by bidder based on raw water analysis; Accessories: Suction strainer, injection check valve, calibration column	1 set per plant
8	High-Pressure Pump	Type: Vertical multistage centrifugal pump; Motor rating: 2–3 HP (1.5–2.2 kW), 220/380 V, 50 Hz; Operating pressure: 10–14 bar (minimum rated pressure 15 bar); Flow rate: 500–1,000 LPH at design pressure; Efficiency: ≥ 70% at duty point; Shaft seal: Mechanical seal; Material: SS304/316 wetted parts; Protection class: IP55; Note: Must be rated for continuous operation	1 per plant
9	RO Membrane Elements + Manual Flush System	Type: Polyamide thin-film composite (TFC), brackish water grade; Dimensions: 4-inch diameter × 40-inch length (standard 4040); Permeate flow: ≥ 2,300 GPD per element at standard test conditions; Salt rejection: ≥ 99% per element (NaCl, standard test conditions); Maximum operating pressure: 40 bar; Operating pH: 2–11 (cleaning pH 1–12); Operating temperature: 5–45°C; Brand: DuPont FilmTec BW30 PRO-4040, Hydranautics ESPA, Toray TM720, or equivalent premium-grade — brand and model shall be stated in bid; Flush system: Manual bypass flush valve	2 per plant

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		(UPVC ball valve) and flush line for periodic low-pressure, high-flow flush to remove scale/foulants	
10	RO Membrane Pressure Housing	Material: FRP (filament-wound) or SS316; Diameter: 4-inch (to accept standard 4040 elements); Operating pressure: Rated 15–20 bar minimum (burst pressure $\geq$ 60 bar); Operating temperature: 1–45°C; Operating pH: 2–12; End caps: Side port, 1-inch connections for permeate and concentrate; Certification: ASME or equivalent pressure vessel standard	2 per plant (1 membrane element per housing in series configuration)
11	UV Disinfection Unit	UV Lamp: Low-pressure mercury lamp; Power: 30–40 W; UV wavelength: 254 nm (germicidal); UV dose: $\geq$ 40 mJ/cm ² at rated flow and end-of-lamp-life condition; Chamber material: SS316; Sleeve: Quartz glass; Lamp life: $\geq$ 9,000 hours (with lamp replacement indicator/hour meter); Rated flow: $\geq$ 500 LPH at guaranteed UV dose; Features: Lamp failure alarm, UV intensity indicator/alarm (preferred); Power: 220 V, 50 Hz; Certification: NSF/ANSI 55 Class A or equivalent	1 set per plant
12	Chlorination (Residual Disinfection) Dosing System	Pump: Diaphragm-type dosing pump; Chemical: Sodium hypochlorite (NaOCl) solution, food-grade; Dosing capacity: 1–6 LPH (adjustable); Tank: HDPE chemical tank, minimum 80 L capacity; Interlock: Dosing activates only during product water flow; Accessories: Suction strainer, injection check valve; Target residual: 0.2–0.5 mg/L free chlorine in product tank	1 set per plant
13	Product Water Storage Tank	Type: Vertical cylindrical; Material: Food-grade polyethylene (PE), UV-stabilised; Capacity: 500 US Gallons (1,893 L) minimum; Fittings: Inlet float valve or level switch, outlet gate valve, overflow, drain valve, vent, manhole or inspection port; Certification: Food-grade compliant with PSQCA or equivalent	1 per plant
14	Piping & Fittings	Pre-treatment (low-pressure) sections: UPVC Schedule 40 or equivalent, suitable for 10 bar; High-pressure sections (post high-pressure pump): High-pressure UPVC or SS304/316 tube rated for 20 bar minimum; Fittings: UPVC solvent-weld or threaded (low pressure); compression/flanged (high pressure); Permeate and product lines: Food-grade UPVC or PE; Reject/concentrate line: UPVC, rated 20 bar; All joints fully pressure-tested prior to commissioning	Complete per plant
15	Pressure Gauges	Type: Glycerin-filled bourdon tube; Dial: 100 mm minimum; Scale: 0–16 bar (pre-treatment) / 0–25 bar (high-pressure sections); Accuracy: $\pm$ 2% of full scale; Locations mandatory: (i) After feed pump outlet; (ii) Sand filter outlet; (iii) Carbon filter outlet; (iv) After high-pressure pump; (v) Reject/concentrate line	5 per plant (minimum)
16	High-Pressure Concentrate Control Valve	Type: Needle valve or globe valve, manual; Maximum working pressure rating: 20–25 bar; Material: SS316 body and trim; Size: As per system design (typically ½" – ¾"); Function: To regulate reject/concentrate flow rate and maintain system operating pressure and recovery	1 per plant
17	Pressure Switches	Low-pressure switch: Adjustable, mounted on suction side of high-pressure pump; trips on low pressure to protect against dry run / cavitation; High-pressure switch: Adjustable, mounted downstream of high-pressure pump; trips on overpressure; Both switches: Rated for the respective	2 per plant

		pressure ranges; wired to Electric Control Panel for automatic shutdown	
18	Flow Meters	Type: Variable-area (rotameter), acrylic body or metal (specify); Permeate flow meter: Sized for permeate flow range (0–500 LPH minimum); Reject flow meter: Sized for reject flow range (0–1,000 LPH minimum); Accuracy: $\pm 5\%$ of full scale; Connections: Threaded UPVC or SS fittings	2 per plant
19	In-Line TDS / Conductivity Meter	Type: In-line probe (4-electrode conductivity cell) with digital display; Range: 0–2,000 $\mu\text{S}/\text{cm}$ (equivalent TDS range 0–1,000 mg/L approx.); Accuracy: $\pm 2\%$ of reading; Location: Product water header (post blending point, before UV disinfection); Function: Continuous monitoring of blended product TDS; Features: Digital LCD display visible at plant level; optional high/low TDS alarm relay	1 per plant
20	Electric Control Panel (ECP)	Enclosure: IP54 powder-coated mild steel enclosure; Components: Main isolator / MCB; Individual MCBs / starters for all pumps and dosing systems; Relay for low-pressure and high-pressure switch interlocks; Timer relays for backwash cycles; Contactors (where applicable for 3-phase loads); Indicating lamps: Power ON, Pump Run, Fault; Terminals for future connectivity; Supply: 220 V, 50 Hz, single-phase (or 380 V three-phase if HP pump is 3-phase — confirm in bid); Operation: Fully automatic with manual override; all interlocks hard-wired	1 per plant
21	TDS Blending Valve & Bypass Line	Type: Manually adjustable needle valve or proportional ball valve on bypass line; Lock-ability: Set-point lockable after commissioning; Bypass line: Post 1-micron filter, to product header; Accessories: Isolation valves to enable bypass line isolation for maintenance; TDS meter (Item 19) provides feedback for set-point adjustment	1 set per plant

SECTION 5: PERFORMANCE GUARANTEES & ACCEPTANCE CRITERIA

The successful bidder shall guarantee the following system-level performance parameters. Performance shall be verified during a commissioning acceptance test witnessed by NUST and the bidder's representative. A written test protocol shall be submitted at least 14 days before the acceptance test.

S#	Parameter	Guaranteed Value	Test Method / Condition
1	Net Product Flow (treated & blended water)	$\geq 3,000 \text{ GPD (12,492 L/day)}$	Measured over 4-hour continuous run; rotameter + volumetric check
2	System Water Recovery	$\geq 70\%$	Permeate flow $\div$ feed flow $\times 100$; measured by flow meters
3	RO Salt Rejection (system level)	$\geq 97\%$	Feed TDS and permeate TDS measured; $(1 - \text{TDS_permeate}/\text{TDS_feed}) \times 100$
4	Product TDS (blended)	200–300 mg/L	In-line TDS meter and handheld verification at raw water TDS 400–800 mg/L

5	Product Total Hardness	≤ 200 mg/L as CaCO₃	Titration (EDTA), PS:4729 method
6	Product Turbidity	< 0.5 NTU	Nephelometric turbidimeter, PS:4729
7	E. coli	0 / 100 mL	Membrane filtration, ISO 9308-1 or equivalent
8	Total Coliforms	0 / 100 mL	Membrane filtration, ISO 9308-1 or equivalent
9	Residual Chlorine (product tank)	0.2–0.5 mg/L	DPD colorimetric method or photometer
10	Continuous Operation (minimum)	8 hours uninterrupted	4-hour run during acceptance test; 8-hour guarantee during warranty
11	Power Consumption	To be stated by bidder	Measured by energy meter during acceptance run

Acceptance Criteria: All parameters must be met simultaneously during the acceptance test. Failure on any single guaranteed parameter shall constitute non-acceptance, and the bidder shall rectify at no additional cost within 14 days and repeat the test.

SECTION 6: WARRANTY, OPERATION & MAINTENANCE, AND TRAINING

6.1 Warranty

- The complete system shall carry a minimum twelve (12) month comprehensive warranty from the date of issuance of the Commissioning Acceptance Certificate by NUST.
- Warranty covers all parts, labour, and travel costs for defect rectification.
- RO membrane elements shall carry the original manufacturer warranty (minimum 1 year), which the bidder shall transfer to NUST.
- UV lamp(s) shall be replaced at no cost if lamp life guarantee is not met within the warranty period.
- The bidder shall respond to warranty callouts within 48 hours of notification and restore the plant to full operation within 7 working days.

6.2 Spare Parts

The following minimum spare parts shall be supplied with each plant at the time of delivery:

- RO membrane elements: 1 spare element per plant
- Cartridge filter elements (5 µm and 1 µm): 6 of each per plant (12 months' supply estimate)
- UV lamp: 1 spare lamp per plant
- UV quartz sleeve: 1 spare sleeve per plant
- Multiport valve diaphragm/seal kit: 1 set per plant
- Dosing pump diaphragm / valve kit: 1 set per dosing pump
- O-rings and gaskets: 1 complete set per pressure housing
- Antiscalant and sodium hypochlorite: 6 months' commissioning supply per plant

6.3 Operation & Maintenance Manual

The bidder shall supply a comprehensive O&M Manual for each plant (hardcopy and soft copy) covering:

- System description and process overview

- Start-up and shutdown procedures
- Normal operating parameters (pressures, flows, TDS readings, chlorine dose)
- Backwash / cleaning-in-place (CIP) procedures for RO membranes
- Preventive maintenance schedule (daily, weekly, monthly, quarterly, annual)
- Troubleshooting guide
- Spare parts list with supplier contact details
- Safety data sheets (SDS) for all chemicals used

6.4 Operator Training

The bidder shall conduct a minimum of two (2) formal operator training sessions per plant location. Training shall cover:

- Safe operation of all equipment
- Routine monitoring, readings, and log-keeping
- Backwash and filter maintenance
- RO membrane care and cleaning
- Chemical handling and dosing adjustment
- Identification of alarms and fault conditions
- Basic troubleshooting

Training shall be conducted in Urdu and/or English as required by NUST. A record of attendees and a training acknowledgement certificate shall be submitted to NUST.