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Pr9821 - Specification for Reservoir Design and Construction

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1. Purpose

The purpose of this Specification is to set out minimum requirements for the design, supply, construction, installation, testing, commissioning and hand-over to Unitywater of a new drinking water supply reservoir.

2. Scope

This Specification covers the Unitywater requirements on design and construction of ground level reinforced, prestressed or post-tensioned concrete water supply reservoirs. This specification does not cover Unitywater's requirements on steel reservoirs nor elevated reservoirs. The Specification shall apply to works being constructed directly for Unitywater, or other authority or for a contractor who will hand over the ownership of the constructed works to Unitywater.

This document does not relieve the designer's responsibility for compliance with relevant Australian and International standards. Any variation from the minimum requirements set out in this specification shall be justified by the designer in a design report.

2.1. Technical departures

Departures from any requirement of this Technical Standard shall be identified and submitted for review via F10996 - Deviation to Unitywater Technical Specification.

Unitywater requires enough information to assess dispensation requests and their potential impact. The onus is therefore on the proponent to justify deviation request submissions and provide suitable evidence to support them.

The Designer shall not proceed to document/incorporate the non-conforming work before the Unitywater has assessed and accepted the proposed action in writing via F10996.

3. Planning

3.1. Language and Units of Measurement

All drawings and documentation shall be written in English.

The units used throughout the project shall be the SI metric system of measurement, in accordance with AS ISO 1000-1998. Where units of another convention are nominated, conversion to SI units shall be made in accordance with AS 1376.

3.2. Site selection

The location of the reservoir will be specified by Unitywater and will be influenced by the considerations below. The order of preference for land choice for a reservoir site shall be:

1. Land provided by the developer; the freehold title or easement rights for any reservoir sites, access and services shall be given to Unitywater.
2. Unitywater-owned land.

The following factors shall be considered when selecting the site:

a) Ownership of the land is dedicated to Unitywater.
b) All weather access to the reservoir for routine and emergency operation and maintenance activities.
c) Availability of power facilities or able to be economically provided to the site.
d) Adequate radio communication access.
e) Provision of sufficient buffer from houses, built-up areas and future development.
f) Adequacy of stormwater management drainage from the site.
g) The site and access road shall not be liable to flooding during a 1 in 100-year flood event.
h) Control and safe discharge of scour, overflow and stormwater.

3.3. Site area

The size of the parcel of land shall be large enough to accommodate the infrastructure and its appurtenances, provide for maintenance and for the access and egress of vehicles large enough to maintain the infrastructure. Major inspections or refurbishments may require trucks, scaffold, and/or cranes to be located on site. Consideration on whether a crane pad might be required to allow a crane set-up such that a crane hook can be positioned directly over the centre of the (large) roof access.

A determination of whether a water booster pump station, re-chlorination or pH correction facilities are required must be considered early to allow for sufficient space for the facilities as well as operation and maintenance access for these facilities.

3.4. Easements

The site selection and layout shall minimise the number of easements required. Consideration should be made if easements are required for access to site, and for services, pipework, stormwater drainage and power supply to the site.

3.5. Geotechnical

If not provided by Unitywater, a geotechnical investigation is required to be undertaken by the design engineer to determine ground conditions.

The designer shall address reservoir foundations, pipework thrust restraint, access road and hardstand area and settlement issues. The report shall provide the details of investigation and findings.

The geotechnical report shall be prepared by a Registered Professional Engineer Queensland (RPEQ) who shall have recent experience in geotechnical engineering for large structures and who is employed by a consulting engineering practice having quality assurance certification to AS/NZS ISO 9001 for geotechnical engineering.

3.6. Site survey

If not provided by Unitywater, the reservoir site shall be surveyed by a registered surveyor to identify the surface contours, boundaries, and existing services in accordance with the *SEQ WS&S D&C Code*.

This information will be used by the designer in locating the reservoir, considering the operating levels for reservoir (top water level, bottom water level, etc.), pipework routes, water service, power supply, drainage, access roadway and turning areas.

3.7. Deliverables from the planning stage

The planning phase will prepare the design inputs for the subsequent design phase including but not limited to the following details:

Table 1: Planning parameters

Planning Parameter	Value
Asset ID	<< Site ID >>
Asset Name	<< Site Name >>
Asset Location: Address	<< Street Address >>
Asset Location: GPS Co-ordinates / GIS?	<< GPS Co-ordinates >>
Required storage capacity	<< ML >>
Number of storage tanks	<< # >>
Minimum supply HGL	<< m AHD>>
Bottom Water Level (BWL)	<< m AHD>>
Top Water level	<< m AHD>>

Table 2: Typical Design Parameter Requirements

Planning Parameter	Value
Reservoir Capacity	ML
Active Storage Volume	ML
Top Water Level (TWL)	<< m AHD>>
Overall Wall Height	<< m AHD>>
Total Storage Depth	<< m AHD>>
Outlet Level	<< m AHD>>
Bottom Water Level (BWL)	<< m AHD>>
Normal operating levels	<< m AHD>>
Floor slope	%
Inlet Pipe diameter NB	<<mm>>
Outlet Pipe diameter NB	<<mm>>
Overflow Pipe diameter NB	<<mm>>

Figure 1 below depicts the typical reservoir levels such as Top Water Level (TWL), overflow level, Bottom Water Level (BWL) and typical terms used.

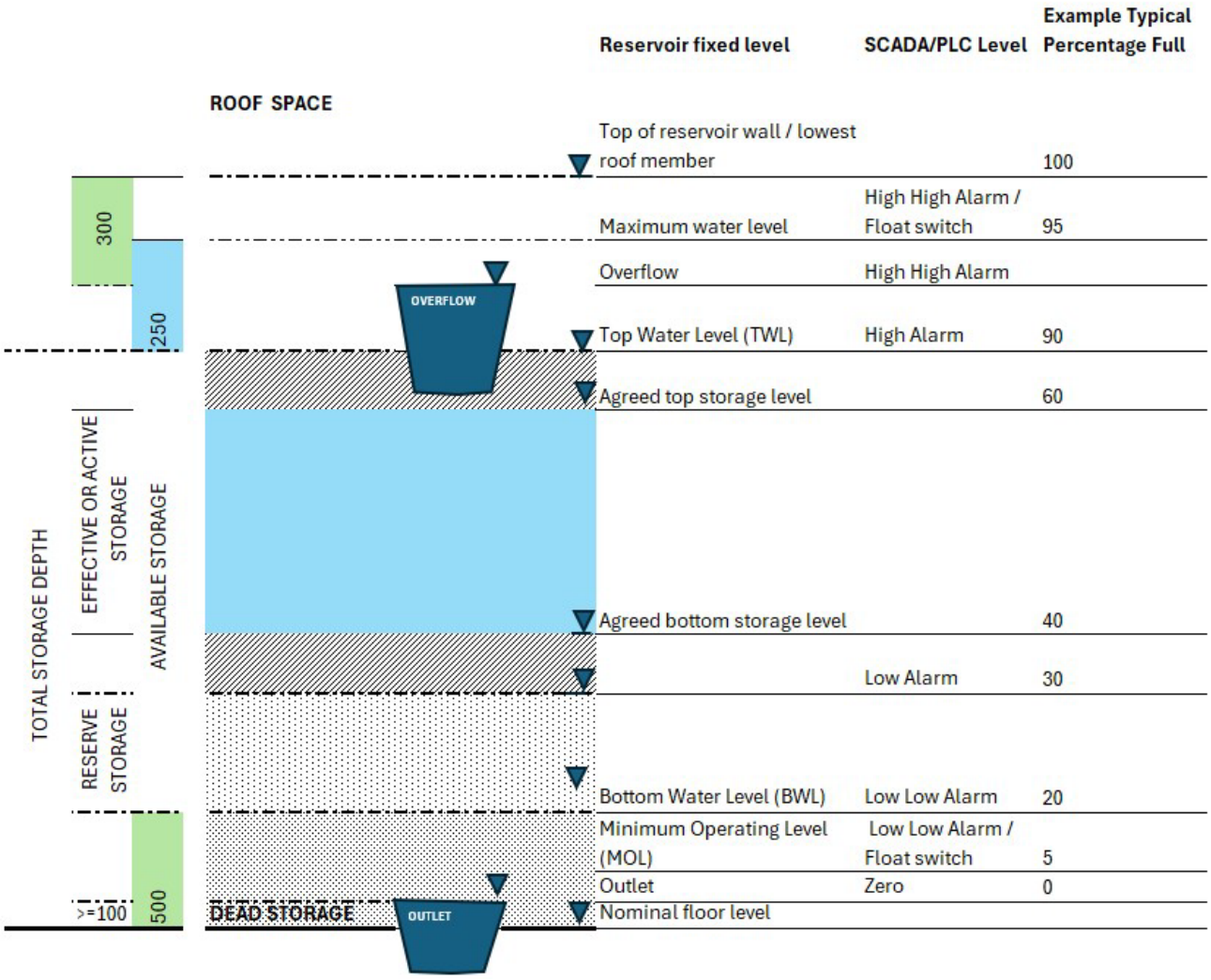

Figure 1: Typical reservoir levels

4. General design

4.1. Design scope

The scope of design shall include, but is not limited to, preparation of the following:

a. Engineering Reports
b. General Arrangement Drawings – to define each facility in general terms and to provide a basis for coordinating detail design engineering by other engineering disciplines
c. Arrangement Drawings – to define and locate all equipment in relation to other equipment, piping and structures
d. Assembly and Detail Design Drawings
e. Design calculations
f. Reliability analysis.

The design of the reservoir shall be in accordance with the requirements contained in the *SEQ WS&S D&C – Design Criteria* and *SEQ WS&S D&C – Water Supply Code*. The following factors, as a minimum, shall be considered for design of a new reservoir:

i. Operational site topographical, environmental and seismic characteristics and conditions:
   - Sufficient access for all construction activities
   - Sufficient vehicular and personnel access for all maintenance activities.
   - Design capacity for continuous operation with minimum downtime to meet prescribed service levels and availability.
   - Surge conditions and extreme excursions from the design operating point.
   - Robustness, and necessary de-rating, of reservoir and equipment to meet off design conditions for extended periods.
   - Energy efficiency not only at the design point but across the anticipated operational range.
   - Starting of equipment under fully loaded conditions.
   - Failsafe modes of operation during power outages and safe re-starting modes.
   - Standardisation of assemblies and components selected to reduce spare parts inventory and improve inter-changeability.

ii. Fit-for-purpose design characteristics:
   - Efficient receival, storage and on-delivery of water.
   - Water quality maintenance.
   - Reliable, effective and automated operations (reservoir normally unattended).
   - Incorporation of site security measures.
   - Low maintenance character with standard maintenance practices.
   - Remote monitoring, control, and telemetry alarms.
   - Regulatory requirements such as WH&S and environmental governance aspects.
   - Compliance with all current versions of the relevant Australian Standards and the SEQ WS&S D&C Code and Unitywater specifications.

- Minimisation of adverse environmental and community impact (such as aesthetic aspects, noise).
- Economy in capital and maintenance cost consistent with reliability and reasonable operating cost (minimising life cycle costs).
- Adequate weather protection and stormwater management, prevention of wildlife ingress.
- Sufficient ventilation and materials selection to minimise corrosion and contamination by providing adequate air turnover.
- Minimisation of sediment accumulation.

Full details of references, assumptions made, and details of computer programs used for the design shall be submitted to the Unitywater for review.

All equipment shall be of a sound and robust design, suitable for the specified capacity or the capacity necessary to achieve the performance requirements and provided with all minor and incidental items for proper functioning of the whole system. Equipment and components shall be to the manufacturer's normal design for the service specified with readily available replacement parts. The designer shall be responsible for assessing the specific operating and maintenance requirements, including chemical supply and loadings for each individual piece of equipment or facility.

4.2. Drawings

All drawings should comply with Pr8843 - Specification for Drawing, Document and Equipment Tag Numbering; and Pr9080 - Specification for CAD/BIM drafting and modelling standards.

Lists the typical drawings required at the end of the design stage are contained in Section 4.8 Design deliverables.

4.3. Safety in design

The designers shall undertake Safety in Design, HAZID, HAZOP, and CHAIR workshops as detailed in Pr8187 - Safety in Design Procedure.

4.4. Design life

All elements shall achieve the design life specified in Table 3:

Table 3: Minimum Design Life

Element	Minimum Design Life (Years)
Concrete reservoir	100
Wall & floor construction joints with surface sealant **Wall & floor construction joints with waterstop**	25 (until major seal replacement) 100
Rafters and columns (aluminium)	50
Purlins	30
Roof sheets (including fasteners)	30-40
Roof ventilators & vermin screens	15-20
Pipework	100
Mechanical equipment	Refer Pr9693
Electrical equipment	Refer Pr9380
Instrumentation and control equipment	Refer Pr9380

4.5. Process, Civil and Mechanical Design

The design and construction of the civil works shall be in accordance with the requirements contained in this specification and the following Unitywater specifications:

- Pr9902 - Specification for Civil and Earthworks
- Pr9903 - Specification for Building and Structural Works
- Pr9693 - Specification for Mechanical Installations.

In addition to the above the design shall fully consider the relevant Australian, internationals and industry standards where relevant. The design shall consider the following minimum requirements:

- AS/NZS 1170 suite: Structural Design Actions
- AS 3735 Concrete Structures for Retaining Liquids
- AS 3735 SUPP 1 Concrete Structures for Retaining Liquids - Commentary (supplement 1)
- AS 3600Concrete Structures
- AS 3600 Sup 1 Concrete Structures - Commentary (supplement 1)
- AS 3959 Amd 2 Construction of Buildings in Bushfire Prone Areas.

4.5.1 Thermal effects

The thermal effects to the concrete structures, steel structures and aluminium structures and their combined use must be detailed correctly. Any expansion joint incorporated into the design shall require minimal maintenance and limit any contamination or debris accumulation.

During construction of expansion joints, consideration shall be given to the ambient temperature at the time of installation to ensure the correct setting of movement allowances. The Designer shall specify the allowable ambient temperature range clearly in their design documentation package if such a range is critical for the efficacy and longevity of the nominated/specified expansion joint type.

Heat of hydration in curing of concrete shall be controlled for thick and large pours to control temperature differential.

The temperature effects on the reservoir concrete wall between the inside temperature and outside temperature, the directional sun impact on the wall and roof with the use of different materials must be analysed and detailed in the design. Concrete Reservoirs shall be designed for the effects of temperature gradients in accordance with AS/NZS 3725 for both ‘Full’ and ‘Empty’ conditions.

4.5.2 Bushfire prone zones

Unitywater is responsible for operation and maintenance of infrastructure which may be in bushfire prone areas (BPA). Whilst there is the existing Australian Standard for the Construction of Buildings in Bushfire Prone Areas - AS3959 and Queensland guidance to design and construct residential properties within these BPA, these documents don’t fully consider the built form and criticality of Unitywater assets. However bush fire risk should be assessed according to AS3959.

The design shall allow for fire risks and the potential impact from bush fires based on BPA maps, distance from classified vegetation and other relevant bushfire risk factors at the reservoir location. Unitywater may require that the site area is cleared to ensure that there will be lower risk of direct flame contact on the reservoir and associated buildings from a bush fire.

4.5.3 Hydraulic design

In addition to the hydraulic design requirements contained in the SEQ WS&S D&C – Design Criteria and SEQ WS&S D&C – Water Supply Code, the hydraulic design shall be specific for each reservoir, include P&IDs and shall consider:

a. Pipework locations, orientation and size (refer Section 6 Pipework).

b. Water quality (refer Section 10 Water Quality aspects):

   i. Mixing – passive mixing is preferred.

   ii. Potential need to re-chlorinate or balance pH.

Each reservoir shall have the ability to be isolated for maintenance purposes.

4.5.4 Loading considerations

The design shall be based on the requirements described in Table 4 and Table 5 below. All Reservoir structures including the roof shall be designed for Importance Level 3 as defined in AS 1170, unless Unitywater advises otherwise in writing. **Note:** An importance level 4 may be applied to some reservoirs depending on location and supply zone.

Table 4: Reservoir design criteria

Design criteria	Minimum design requirements
Structure Importance Level	Importance Level 3 Public Utility (National Construction Code – Table B1.2a)
Wind	1/1000-year annual probability of exceedance
Wind (Serviceability)	1/25-year annual probability of exceedance
Earthquake	1/1000-year annual probability of exceedance
Internal wall and slab concrete surface finish	Class 2 to AS 3610
External wall concrete surface finish	Class 2 to AS 3610

Refer to **Table 5** below for permanent design load requirements.

Table 5: Reservoir design load requirements

Structural element	Dead load	Live load
Roof hatches and platforms	Weight of structural and fitting elements	2.5kPa 1.1kN point load
External stairs and walkways	Weight of structural and fitting elements	2.5 kPa 1.1kN point load
Non-trafficable roof areas	Weight of structural and fitting elements	0.25kPa
Provision to accommodate future solar panels on the Reservoir roof	Refer to project specific requirements	

Any temporary construction loading shall be identified and clearly documented during the design phase. Construction loading includes both temporary imposed loads and any reduced capacity of structural elements during staged installation. The Constructor is responsible for maintaining the stability of the structure during construction.

4.5.5 Road access

The business case development or concept design shall nominate the route into the reservoir regarding its suitability for all-weather access and manoeuvring by operations, maintenance, emergency and supply vehicles nominated by Unitywater (site specific). Access roadways and parking areas shall be trafficable in all weathers.

Unless agreed otherwise, all access roads shall have the same flood immunity criteria as required for the connecting road network. Where the reservoir does not front a public road, the land defined for transfer to the Unitywater shall embrace the access road. Where that is not practicable, a suitable access easement shall be created in favour of Unitywater.

Vehicular access from Council's/Road Authority's road shall be in accordance with the road authorities Access Standards. Road shall be designed in accordance with Council's/ Road Authority's Standard Specifications. New roads shall join neatly to existing roads by a straight line cut and any damage to existing roads shall be repaired as necessary.

The access road shall be designed as flexible pavement with asphalt seal or concrete pavement. The vehicle pavement width of the access road shall be a minimum of 4m wide.

4.5.6 Perimeter access

A reinforced concrete pathway 1500 mm wide shall be provided right around full extent of the base of the reservoir:

- The pathway shall provide safe access for an EWP around the reservoir for any maintenance activities required on the walls or roof.
- The pathway shall extend around all structures and pits where these restrict the continuity of the pathway.
- The Design Engineer shall ensure that the stormwater discharge from the site is non-worsening, in accordance with the latest edition of the Queensland Urban Drainage Manual (QUDM).

A minimum 4 m wide clear vehicular, crushed rock or gravelled, access way shall also be provided around the full perimeter of the reservoir and also around all maintainable items, on the outside of the concrete pathway where possible. If there is potential for dust to impact the water quality or surroundings, consideration shall be made to seal the access tracks.

4.5.7 Landscaping

The Landscape Plan must be designed to blend the reservoir site into the local area and require minimum maintenance. Choices of flora shall be suitable to the area, with Australian native trees and shrubs that require little post-planting maintenance. Lawns are not to be used in landscaping unless specified by Unitywater. No planting over infrastructure services or under overhead power lines is allowed. Special attention must be paid to the type of trees and shrubs planted in the vicinity of pipework (Unitywater has a brochure 'Planting Guide" which explains these details).

Consideration shall also be given to the location of plants in the vicinity of appurtenances.

Stable embankment slopes shall be designed to suit the materials in accordance with geotechnical requirements. Embankments shall also be designed to prevent scour from rainfall runoff.

4.6. Electrical design and control system design

The design and construction of the electrical works shall be in accordance with the requirements contained in Unitywater specification: Pr9380 - Specification for Electrical Installations at Network Sites. In addition to the above the design shall fully consider the relevant Australian, internationals and industry standards where relevant.

Reservoir sites shall be supplied with three phase low voltage power.

Typical requirements for the switchboards are contained in Section 12. Some sites will require a main switchboard and multiple motor control centres or control panels.

4.7. Whole-of-life costs

Where the requirements nominated in this document allow a choice in the selection of the materials and method of construction, pipework materials and arrangement, the choice shall be determined by the most cost-effective method of meeting the intent purpose using a net present value analysis of capital, access, maintenance and end of life costs over asset life. Section 4.8 Design deliverables provides further guidance. The factors that are required to be considered for this analysis are:

- cost of reservoir structure
- life and replacement cost of coatings, roof and ancillary items such as switchgear, telemetry, ventilation equipment, etc.
- access and maintenance cost
- where mixers are required, energy cost over the life of the reservoir
- net present values of alternatives.

4.8. Design deliverables

Drawings and specification shall be sufficiently detailed to cover all aspects of construction and operation of the reservoir. Detail Design is to create site-specific design drawings and design basis deliverables, for the design including:

a. Basis of Design Report – Civil and Structural sections
b. Basis of Design Report – Mechanical and Hydraulic sections
c. Basis of Design Report – Electrical and Control System Sections
d. Report and recommendations by the Geotechnical Engineer (if applicable)
e. Agreement to easement rights
f. Permit to enter land external to development
g. Where applicable approvals or letters of agreement from stakeholders/regulatory bodies
h. Whole-of-Life net present value analysis
i. Site Specific Functional Description
j. Equipment Schedules (Drives, Valves and Instruments etc.)
k. Safety in Design Register and Report
l. Civil and Mechanical Drawings – refer Table 6
m. Electrical Drawings – refer Table 7
n. Construction methodology including:
    - full details of the grouting operations, such as materials, bleed control additive, mixing equipment, pumping equipment and grouting procedures
    - full details of all stressing operations including cable type and size, sheath type and size, concrete strength at transfer, number of jacks required, cable stressing method (one end or both ends), cable stressing order, stressing load, allowable draw in and calculated cable extensions should a post tensioned reservoir be required
o. Commissioning plan.

Table 6: Typical civil and mechanical drawings list

Drawing Title
Cover Sheet, with Locality Plan and Drawing List
Site Specific P&ID
Notes pages
General Arrangement of Site Layout and Access
Elevation and Sections
Pipework layout at ground level
Pipework sections
Valve pit details
Reservoir Structural details
Reservoir Roof structural details, sheeting details, flashings
Roof platform(s), access hatches, davit details, external access
Access Road Plan, sections, control lines and cross sections
Site and Road Cut/Fill plans and sections
Site Drainage Plan, cross sections and details
Dosing Building General Arrangement, Elevations, Sections and Details
Truck Unloading bund plan and section

Table 7: Typical electrical drawings list

Drawing Title
Cover Sheer, with Locality Plan and Drawing List
Single Line Diagram(s)
Three line Diagram(s)
LV Distribution
ELV Distribution
Schematics for Pumps/mixers (if applicable)
Schematics and Termination Diagram(s) for Level Instrument(s)
RTU Termination Diagrams
Switchboard General Arrangement
Equipment & Cable Schedule
General Arrangement Drawing of Panel (if applicable)
Chemical dosing (refer appropriate Unitywater technical specification for drawing list)

4.9. Materials

Materials and equipment shall comply with the latest edition of the relevant Australian Standard unless otherwise specified. In cases where an applicable Australian standard is not published the applicable British, European, New Zealand or American standard shall be used.

All materials and equipment supplied shall be new and of the best industrial quality and manufacture and shall be suitable for its intended duty and its associated environment, with appropriate abrasive and corrosion resistance.

All materials and equipment shall be:

- of a duty rating appropriate to the application
- suitable for the purpose
- proven in service
- suitable for installation in the spaces allocated with suitable access and clearances for normal and long term maintenance requirements
- compatible with other materials and equipment to be used in the works
- supported by appropriate servicing facilities and locally available spare parts
- corrosion resistant
- wear resistant.

Where products of alternative manufacturers are proposed, their acceptability and acceptance must be obtained from Unitywater. All materials and equipment supplied must meet the specified performance, construction, quality, space and structural loading requirements. Material and equipment characteristics other than those specifically covered by the drawings and specifications, shall be at least equivalent to those of any mentioned trade name, or if no trade name is mentioned, typical of the respective material or equipment kind.

The Designer shall be responsible for ensuring that full allowance is made for the proper connection and interfacing of the materials and equipment with other portions of the works.

All equipment shall be free from contamination and appropriately sanitised in accordance with Unitywater's F9785 - Water Hygiene Field Guide (5 C's) prior to the installation and throughout the duration of works.

4.9.1 Compliance with AS/NZS 4020

All materials that form part of the proposed installation in a water tank interior, or to be in contact with drinking water, shall comply with the current version of AS/NZS 4020.

An AS/NZS 4020 compliance certificate not less than five (5) years old for all materials must be provided before the construction/installation works can proceed.

4.9.2 Durability

The design and detailing of the reservoir, its materials, finishes and protective coating systems shall consider the potential of accelerated corrosion due to humidity and the chemistry of the water to be stored. The current water analysis may be used as part of the detail design.

In coastal areas, within 1km from the coast, shall be classed as an exposure classification of B2 requiring:

- minimum concrete cover to reinforcement of 60mm, and
- aluminium shall be marine grade.

4.10. Workmanship

All workmanship shall:

- be in accordance with the best modern trade practice, relevant Standards and Codes of Practice
- be carried out by appropriately qualified and experienced trades personnel
- be carried out under the supervision of a competent supervisor
- result in a high standard of construction and leave a thoroughly efficient, robust, tidy and fully operational and safe installation.

4.10.1 Qualifications of operators and applicators for concrete surfacing

Personnel must be appropriately qualified to perform the required works as detailed in Pr9769 - Specification for Concrete Surface Protection.

4.10.2 Qualifications of welders

The Constructor shall ensure only qualified and competent personnel carry out welding work and, where necessary to meet Australian Standards, carry out non-destructive testing. Any periodic non-destructive testing and its interval, deemed necessary during normal operation of the equipment shall be advised by the Contractor.

4.10.3 Independent Quality Control Inspector/Technical Support

Subject to the project size and complexity and at Unitywater's discretion, an approved Independent Quality Control Inspector shall be appointed by the Constructor for the works.

The Independent Quality Control Inspector shall witness and monitor operations to ensure that they meet the specified requirements and standards, inspect, test, or measure materials to the prescribed criteria or standard, and audit the Constructor's quality documentation. The Constructor is not relieved of its own Quality Assurance/Quality Control and remediation / coating system performance responsibilities.

The Independent Quality Control Inspector shall be a professionally qualified person with no less than 5years experience and hold the following appropriate current certifications for the relevant scope of services or Unitywater' s agreed alternative, for the works they are responsible for inspecting. If the Independent Quality Control Inspector is an Engineer, they must be a certified RPEQ.

5. Types of Reservoirs

5.1. General

Historically Unitywater has several different types of drinking water reservoirs. The selection of materials is generally based on whole of life cost including operations, maintenance, water quality and security factors. Reservoir types include:

- cast in situ reinforced concrete tanks
- cast in-situ post tensioned and pre-cast post tensioned tanks (including tilt-up walls)
- pre-fabricated steel bolted panel tanks
- welded mild steel tanks
- elevated tanks.

Unitywater preference is that drinking water reservoirs shall be constructed from (reinforced, or post-tensioned) concrete walls and floor with a metal roof. Other reservoir types may be considered by Unitywater. Concrete works shall comply with Unitywater's Pr9903 - Specification for Building and Structural Works.

The reservoir structure is intended to have no external coating.

The reservoir shall be structurally designed for a water level at the top of the reservoir wall.

5.1.1 Reinforced concrete tanks

Reinforced concrete structures shall comply with AS3735, AS3610 and Unitywater's Pr9903 - Specification for Building and Structural Works.

5.1.2 Post-tensioned concrete tanks

Post-tensioned concrete structures shall comply with AS/NZS 1314, AS 3600, AS/NZS 4672 Parts 1 & 2, AS3610 and Unitywater's Pr9903 - Specification for Building and Structural Works.

Additional considerations for post-tensioned concrete tanks shall have:

a. tendons sheathed in ducts and grouted after tensioning
b. maximum curvature of tendons/sheaths
c. anchorages which comply with AS/NZS 1314
d. keyed profile joints between precast and in-situ concrete.

5.2. Finishes to formed concrete surfaces

Design and detailing of the reservoir and its finishes and /or coating shall consider the chemistry of the water to be stored. The finish to all exposed formed concrete shall be off-form Class 2 finish to AS3610.

Ensure a dense surface finish is attained on all internal surfaces of water retaining structures to minimise all surface irregularities which could retain sludge, silt, algae or other deleterious matter. The minimum accepted surface finish to internal surfaces shall be Class 2 to A S3610 regarding blow holes and Class 3 for tolerances.

5.3. Tank walls

No access hole in the wall of the concrete structure will be permitted. The reservoir shall be structurally designed for a water level at the top of the reservoir wall. The tank walls shall be vertical internal to the tank, with no corbel at the top.

5.4. Tank floor

The concrete floor slab shall have:

a. no abrupt changes in level, including at columns and any perimeter beams

b. minimum number of construction joints

c. movement joints are not permitted

d. If not post tensioned slab, a 1:200 fall from the centre towards the perimeter and towards scour. If post tensioned the floor should be flat and the scour flat to the floor.

5.5. Joint sealants and fillers

Joints are considered critical to the serviceability of the reservoir. Where possible, the design shall minimise/eliminate the need for joints in the floor and wall. Furthermore, joint sealants shall not be relied upon as primary seals.

All expansion and contraction floor slab joints, and internal and external wall joints shall receive a joint sealant application. Sealant products shall be subject to accepted for use by Unitywater.

Where designated in the design, joints are to be sealed with a high-performance joint sealant (or bandage) offering proven performance in contact with drinking water and cleaning solutions. The joint sealant must accommodate the designer specified joint movement and expected hydrostatic pressures (negative or positive) and should be accompanied by data confirming the level of resistance of the sealant to expected chemicals to be in contact.

All seals must be installed in accordance with the manufacturer's instructions. Attention shall be paid to:

a. surface preparation and priming requirements

b. the maximum allowable width, depth and thickness of the required seal.

Typical accepted sealing products are listed below noting that the designer is responsible for specifying the appropriate product for the application subject to review and acceptance by Unitywater:

i. Parchem – Nitoseal 600 SC (high performance polyurethane joint sealant)

ii. Sika – Sikaflex Tank N (high performance polyurethane joint sealant)

iii. Sika – Sikadur Combiflex SG (high performance bandage comprising modified flexible Polyolefin (FPO) Bandage with Sikadur 31 adhesive).

6. Pipework

6.1. General

Pipes and pipeline fittings shall comply with the relevant Australian Standards and the requirements of Unitywater's Pr11034 - Specification for Trunk water mains, Pr9904 - Pressure Pipeline Construction, Pr9875 - Non-Pressure Pipeline Construction, and Pr9693 Specification for Mechanical Installations except where otherwise specified in this Specification.

Reservoirs shall be fitted with the following pipework:

a. inlet pipework

b. outlet pipework

c. overflow pipework

d. scour pipework

e. bypass Pipework

f. chemical dosing pipework (if required)

g. other auxiliary pipework.

Where a site may have multiple or staged reservoir installations, the designers should consider how further reservoirs can be easily added to the pipework. This may include a "tee" junction for connecting to the other reservoir(s)

Whilst Unitywater will usually specify the pipe sizes, cast-in or built-in pipework shall be designed for ultimate flow rates. The opening of the outlet, scour and overflow shall have a bell mouth configuration to avoid wasting of energy and minimise unusable storage. All pipework going into or out of the reservoir shall be installed through the reservoir floor and not through the wall.

Chemical dosing pipework may be installed through the roof sheeting (over the wall) with approval from Unitywater. Ideally chemicals should be dosed on the inlet or outlet pipework depending on the mode of dosing. Generally, pipework shall be kept sufficiently clear of the reservoir floor to facilitate ease of cleaning during maintenance activities.

All pipes at penetrations shall be fitted with puddle flanges and a hydrophilic water seal such as 'Hydrotite' or an accepted equivalent water sealing material. Cover to reinforcement must be maintained. Polyethylene pipe is preferred inside the reservoir when applicable. The penetrations shall be rigid pipework through the floor. Rigid pipework shall be DICL and/ or MSCL 'Sintakote'. GRP pipe is not permitted.

Pipework situated underneath the reservoir (except under floor drainage) shall be concrete encased with Class N25 concrete a minimum cover (to pipework) of 230mm and extend 500mm beyond the reservoir footing.

The pipework shall allow for the removal and maintenance of valves and flowmeters.

6.1.1 Thrust restraint

In accordance with Pr9693 - Specification for Mechanical Installation, sufficient restraint shall be provided at all pipe penetrations to ensure forces are sufficiently restrained within the pipeline.

6.1.2 Gaskets

Gaskets must be supplied and installed in accordance with Pr9693 - Specification for Mechanical Installation.

6.1.3 Support brackets

Adequate pipework support shall be provided as per the requirements of Pr9693 - Specification for Mechanical Installation and Pr9903 - Specification for Building and Structural Works.

Internal pipe and ladder supports shall be 316SS or FRP to minimise corrosion.

6.2. Inlet pipework

The inlet pipe diameter will be sized by Unitywater.

The inlet pipe shall be terminated at least 90 degree around the reservoir perimeter from the outlet pipe and shall be arranged so that the incoming water directed away from the outlet pipe thus preventing short circuiting, stratification and stagnation even under low demand periods.

The inlet pipe shall be fitted with a Unitywater accepted mixing arrangement to promote effective mixing and promote efficient chlorine usage (refer Section 10 Water Quality aspects). The arrangement shall provide an FRP or 316 stainless steel safety screen for divers, which shall be trafficable (by persons) and removable. The screen should not dislodge under normal operations.

6.3. Outlet pipework

The outlet pipe diameter will be sized by Unitywater.

The outlet pipe shall be fitted with a bell-mouth and raised at least 100mm above the level of floor to minimise the risk of any accumulated sediment within the reservoir being disturbed and being discharged during reservoir operation.

The outlet pipe shall be covered by a grade 316 stainless steel or FRP screen/guard with opening of not more than 100 mm by 100 mm. The screen shall be trafficable (by persons), removable and bolted to the floor using stainless steel anchor bolts.

6.4. Combined inlet/outlet pipework

Combined inlet/outlet pipework shall not be used without written permission from Unitywater.

6.5. Bypass pipework

Pipework shall include a bypass between inlet and outlet for when the reservoir is out of service. This arrangement may be required to allow a connection for a temporary tank(s) if the reservoir is unavailable. The bypass isolation valves shall be flanged gate valves.

6.6. Overflow pipework

The reservoir overflow pipe shall be a vertical pipe inside the reservoir and fitted with a bellmouth. To prevent over topping, the overflow pipe diameter shall be sized to discharge the design maximum operational inflow from the supply source(s) without any reservoir outflow demands, with a maximum water level 250 mm above top water level (TWL) and with minimum of 300 mm freeboard between top of bellmouth and underside of the lowest roof members, wall support brackets or bolted connections (refer Figure 1: Typical reservoir levels).

A risk-based assessment of time for overflow shall be undertaken due to response times, telemetry back up, asset criticality and location. Consideration needs to be given to instrumentation time delays, accuracy and sensor calibration when selecting operating level.

A visual overflow level mark shall be provided at the roof entry hatch near the internal access ladder.

Sluice/stop valves shall not be fitted on the overflow line to ensure the overflow is always operational. Overflow pipework outlet shall include a non-return valve to restrict vermin from entering the pipeline. Overflow pipe shall not directly be connected to a stormwater drain without a properly designed airgap. Discharge end pipes must be located inside a pit where they can be routinely inspected.

6.7. Scour pipework

The scour point is to be located as to optimise scour and cleaning activities. Generally, scours should be able to drain the reservoir at a rate of 300mm depth per hour. Preferably the scour entry should be located near the reservoir wall to minimise the amount of pipe under the floor.

A suitably sized scour pipe should extend from scour point to a pit or other accepted location. Consideration shall be made for the downstream impacts. If the downstream infrastructure is not adequate, then appropriate downstream design and construction upgrades shall be undertaken.

The scour pipe inlet shall be fitted with a bell-mouth and covered by a grade 316 stainless steel or FRP screen/guard with opening of not more than 100mm × 100mm. The screen shall be trafficable (by persons), removable and bolted to the floor using stainless steel anchor bolts.

The scour pipe shall be fitted with a flanged tee, a flanged gate valve downstream of tee to discharge to a pit and a flanged gate valve (hand wheel operated) with Camlock flanged coupler, end cap and 316 stainless steel chain to scour into a tanker in the case it cannot be discharged into the pit.

6.8. Under floor drainage (slotted HDPE pipe)

The reservoir is to be provided with a system of underfloor drainage to prevent the establishment of any hydraulic pressure under the reservoir floor, either from reservoir leakage, groundwater or pipe-work leakage near the reservoir.

The underfloor drainage shall be designed to collect all leakage, groundwater, etc and discharge offsite. Consideration shall be made for the downstream impacts. If the downstream infrastructure is not adequate, then the contractor will be responsible for the appropriate downstream design and construction upgrades.

Underfloor drainage shall be DRAINCOIL® or similar accepted product with a corrugated profile and uniform slot spacing, supplied with a filter sock, in accordance with AS 2439, Part 1.

6.9. Water sample points

Water sample points shall be installed on inlet pipe, outlet pipe and at three different levels within the reservoir:

- 1m below TWL
- in the middle
- 1m above BWL.

The water sample points from the reservoir shall be externally plumbed to the surface at 1.0m height for ease of access. The reservoir sample point taps shall be accessible from ground level.

All sample points shall be enclosed within an aluminium lockable cabinet with each sample point clearly labelled. Refer to typical sample point arrangement shown on drawings (W6592-14 to 23).

6.10. Dosing lines

Dosing lines shall be designed, supplied, and installed for the appropriate dosing chemical(s). Dosing lines shall be installed neatly with all fasteners and supports to be adequately rated to resist corrosion.

Where re-chlorination is required, the chlorine solution injection point shall be on a tee on either the inlet or the outlet pipework, as determined in consultation with Unitywater.

6.11. Washdown provisions

Wash down hydrants shall be provided for manual wash down and cleaning of the reservoir. Wash down hydrants shall remain connected to the water supply network when the reservoir is isolated, usually on the upstream side of the inlet pipe. The pipe shall be DN100 and have a gate valve at the connection to the water main.

6.12. Site drainage and stormwater

The reservoir roof rainwater shall flow off the roof to the hardstand area around the perimeter of the reservoir at ground level. It shall be drained away from the reservoir hardstand and be connected to the site drainage system using pits and pipes. The site drainage design shall provide

a. adequate protection to the reservoir and its foundations

b. protect associated infrastructure, including access roads

c. provide a safe working environment for operations and maintenance personnel

d. meet the requirements of AS 3500.3

e. comply with local council and authorities' requirements.

The under-floor drain pipework shall be connected to the site stormwater network and shall have inspection openings in pits or maintenance holes where it is connected to the site stormwater network. The pit levels shall be checked to ensure that there is no backflow to the under-floor drains.

All surface and subsurface flows, any stormwater discharge from adjacent land, flows from sub-soil under floor drains, tank overflow and scour discharges shall be considered.

Site drainage shall be designed such that it provides adequate protection to the access road, reservoir and surrounds and also complies with Unitywater, local Council and other authorities' environmental management and WH&S requirements.

Erosion protection of all surfaces, including cut or fill slopes, shall be considered, including:

i. Minimising ongoing erosion to the reservoir site and surrounding areas

ii. Preventing sediment entering (and blocking) the stormwater drainage system.

6.12.1 Stormwater / overflow / scour drainage pipes and fittings

Rubber-ring-jointed (RRJ) precast reinforced concrete or polypropylene pipes suitable for stormwater drainage applications shall be used for drainage pipes.

Precast reinforced concrete pipes shall be manufactured, and factory tested for quality to AS/NZS 4058: 2007 Precast concrete pipes (pressure and non-pressure), minimum Standard-Strength Class 3 Load or higher as per design requirements. Polypropylene pipes shall be manufactured, and factory tested for quality to AS/NZS 5065 Polypropylene pipes and fittings for drainage and sewerage applications.

All stormwater drainage pipes shall be ensured that are designed with due consideration of either AS/NZS 3725: 2007 Design for Installation of Buried Concrete Pipes or ISO 8873 Plastic piping systems for non-pressure underground drainage and sewerage - Polypropylene.

The design loads shall be verified in consultation with Unitywater.

7. Valve and valve pits

7.1. General requirements

Valves shall comprise a complete operating unit incorporating all necessary supports and mechanical linkages and shall incorporate an actuator where necessary. Valves shall comply with the requirements specified in the Unitywater's Pr9693 - Specification for Mechanical Installation.

Design of a valve pit (including the valve pit lid and any void protection) or other restricted access area shall provide adequate room for personnel to safely access the structure and be able to dismantle equipment contained within them.

7.2. Gate valves

Gate valves shall comply with the requirements of Unitywater's Pr9904 - Specification for Pressure Pipeline Construction and the SEQ Code IPAM List.

Aboveground valves shall be fitted with hand wheel. If the torque required to operate the valve exceeds specified amount, planet reduction gear boxes shall be provided. Buried sluice valves shall be actuated by a valve key, constructed with an extension spindle.

Valves to be installed in below ground pipework shall be installed with cast iron surface boxes and precast concrete/plastic margin sets which shall be installed such that the margin set finishes 25 mm above finished ground level.

7.3. Ductile iron reflux / check valves

Ductile iron reflux/check valves in shall comply with the requirements of Unitywater's specifications Pr9904 - Pressure Pipeline Construction and Pr9693 - Mechanical Installation and the SEQ Code IPAM List unless otherwise specified in this Specification.

All check valves shall be Val-matic Flexi-check or similar accepted fitted with a disc position indicator and a SCADA compatible limit switch, entirely suitable for use in water or sewerage pressure mains. The bolted cap shall feature a plugged pressure tapping.

7.4. Control valve

Electronic control valves, with 2-way solenoid pilots that combine the advantages of a modulating, line-pressure driven, hydraulic control valve with the advantages of electronic control, thus suitable for flow and level control shall be utilised for reservoir design and construction.

The control valve shall include a self-flushing filter for the pilot tubes. The control valve shall be linked with the telemetry system. The control valve shall be fitted with needle/speed regulators for actuation damping and a third normally closed 'Emergency close' solenoid valve.

7.5. Valve pit and access cover

The designer shall place the inlet/outlet pipes and valves above-ground where there is sufficient space available to accommodate above-ground piping/valve without detrimentally impacting on access, traffic or maintenance activities.

Where the inlet/outlet/scour/overflow pipes and valves are installed underground, they shall be located inside a pit designed in accordance with SEQ-WAT-1308-1. Where possible, the valve chambers shall be in areas not subject to vehicle loading. If this is not possible and the valve chamber must be designed to be trafficable. Valve pit(s) deeper than 2m shall be fitted with suitable lighting and a suitably positioned a light switch.

The pit covers shall be materials suitable for the condition of the site (trafficable/non-trafficable) and complying with the local environmental requirements. The covers/support beams shall be designed to be completely removed to enable removal of pipes and/or valves. In areas with significant presence of trees, the valve pit shall be covered by aluminium solid chequer plate to prevent ingress of leaves into the pit. The weight of any access cover shall be considered in the design. The clear opening position and dimensions of access hatch are to be indicated in the project drawings. A vertical ladder with retractable handgrip stanchions shall be installed inside the valve pit and shall be fabricated from fibre-reinforced plastic (FRP). The cover shall include hinged and lockable access hatch and be designed for single man lift with ease of opening/ closing or removing. The access hatch shall be open flat on the ground. The covers shall be non-slippery and have their top surfaces danger marked with yellow and black stripe.

Valve extension spindles shall be provided to the underside of covers with openings provided for valve operation by valve key. A davit base complete with cap shall be provide inside the pit. A safety grille is not required under the valve pit's access hatch. Void protection post inserts ('rail safe' posts) shall be provided in positions that allow for safety protection of the void when the access hatch is fully opened, or the covers/support beams have been completely removed to enable removal of pipes and/or valves.

8. Reservoir roof

Roofs shall be either:

- an aluminium roof complying with AS/NZS1664 (beams and purlins) and AS1562.1 (cladding), or
- a concrete roof complying with the latest relevant Australian Standards

Other roof materials may be considered at the discretion of Unitywater. Roofs comprising a combination of steel and aluminium components are not considered suitable for use on reservoir.

8.1. Design objective

The reservoir roof design objectives are to meet the following requirements:

a. Structural (safe, sustainable and fit for purpose design, watertight roof with adequate weather protection and storm water management).
b. Designed and installed in accordance with manufacturers requirements to achieve the products' warranty.
c. Operation and Maintenance (ease, reliable and safe operations and ease of maintenance).
d. Access (sufficient access for inspection, maintenance and repair).
e. Ventilation (sufficient ventilation to minimise corrosion, prevent of entering vermin and contaminants into the reservoir).
f. Water Quality (no addition of any contaminant to the water).
g. Security (comply with security requirements).
h. WH&S (comply with Work Health and Safety requirements).
i. Environmental requirements (minimal adverse environmental and community impact).

8.2. General requirements

The roof shall be designed to fall to the wall with the sheeting projecting over the wall. The roof shall be designed with a minimum slope of 3 degrees (with 6 degrees preferrable). Gutters and downpipes are not required, unless specified otherwise. The roof run-off shall be drained away from the reservoir and connected to the site stormwater system.

Roofing elements should be selected to eliminate condensate collecting and causing possible corrosion. Internal gutter/box gutter are not allowed as the accumulation of leaves can permit entry of contaminants into the reservoir.

The roofing sheet and associated flashings shall be as directed in the design documents and installed in accordance with the manufacturer's technical data or instructions and in conjunction with plans, details and specification relating to the work.

The roof shall be particularly designed to cater for thermal effects, galvanic corrosion and corrosion due to coastal environmental conditions.

Provision shall be made for adequate fall arrest system for easy access by maintenance personnel.

8.3. Bolts and nuts, washers and masonry anchors

Bolts, nuts, washers and masonry anchors shall comply with the requirements of Unitywater's Pr9693 - Specification for Mechanical Installation.

All dissimilar metals shall be effectively insulated. Where dissimilar metals come into contact, the surfaces shall be kept from direct metal to metal contact by use of PTFE gaskets, high strength phenol washers or other accepted method of isolation.

Aluminium shall be isolated from any wet concrete by a moisture-proof coating, lining or gasket.

8.4. Aluminium roof

8.4.1 General

The roofing sheet and associated flashings shall be as directed in the design documents and installed in accordance with the manufacturer's technical data or instructions and in conjunction with plans, details and specification relating to the work.

Aluminium roofs are typically used to prevent corrosion to structural members in a chlorinated environment and the prevention of the entry of contaminants are major concerns to be considered throughout design.

Sheeting shall be kept dry in transit and on site to prevent water and/or condensation being trapped between adjacent surfaces. If stacked or bundled materials become wet, separate them and wipe them thoroughly with a clean cloth to dry. Handle materials carefully to avoid damage, materials shall not be dragged over rough surfaces, each other, or have tools dragged across them. Protect materials from swarf. No stained or damaged sheeting shall be built into the finished work. Packs of sheet standing on site shall be stored clear of ground. Sheets shall be handled using clean dry gloves.

8.4.2 Roof cladding

Roof cladding shall be formed from marine grade aluminium alloy 5251 or 5052 sheet to AS/NZS1734 of not less than 0.9mm thickness. The roof cladding shall be Permalite® Alspan Aluminium Roof Sheeting, or accepted equivalent, with one-sided polyester paint finish fixed in accordance with the manufacturers' recommendations. The finish shall be Stucco embossed

Full length roof sheet shall be used where practical. Thermal movement of the aluminium roof shall be designed into the roof beams and sheeting. Cladding which is cut or trimmed to shape shall be left with a clean-cut edge without jags and with no distortion of the profile or cross section.

All materials, finishings, flashings and fixings shall have protection from the effect of galvanic corrosion.

Installation of the aluminium roof shall comply all strictly in accordance with the cladding manufacturer's instructions for coastal environments. The design shall ensure minimal joints in roof to prevent the ingress of water; this also includes avoiding the creation of any unnecessary holes. The roof shall be completely watertight. Vermin and contaminants proofing shall be provided to all sheeting edges/ends

8.4.3 Purlins and bridging

Aluminium beams and purlins shall be roll formed from the following alloys: 5454-H34, 5052-H36, or accepted equivalent alloy.

Purlins shall be used with down-turned bottom lips to prevent accumulation of moisture. Main roof purlins shall be Z-section purlins with a down turned lip to the bottom flange for water shedding purposes. Purlins shall be installed to be self-draining.

Bridging shall be constructed from C-section purlins. In this application they are self-draining as they are aligned with the roof slope. Alternatively, channel bridging and bolted brackets may be used provided they are hot dip galvanised through a process such as 'Permagalv'.

Bridging shall be bolted at both ends to the purlins. Rivetted, spot welded, clinched or hook type systems shall not be used, as they have proven to be prone to corrosion in the tank environment.

Fasteners shall be grade 316 stainless steel self-tapping screws, aluminium alloy 5251 formed washers and full-size durable rubber sealing washers to provide effective isolation from dissimilar metals and avoid galvanic reaction leading to corrosion. The washers shall be slotted to allow for expansion. All fasteners, washers and sealing washers used are to be, in application and specification, as described in roofing manufacturer's current technical literature. Sources of supply from other than the roofing manufacturer are to be approved before procurement. Bolts joining aluminium members and bolts set into concrete shall be grade 316 stainless steel.

8.4.4 Roof flashings and accessories

Flashings shall be designed to provide a tight seal against water penetration, to prevent build-up and entry of debris into the reservoir and to accommodate movement of the roof and/or wall elements.

All flashing shall also be durable, weather resistant and compatible with adjoining materials. The flashing material shall be the same material used for roof sheeting and have sufficient overlap (minimum 200mm) to prevent water ingress. All flashing shall be installed to ensure self-cleaning with no ponding of water on the roof.

Closed cell polyethylene foam closure strips matching the profile of the sheet cladding shall be fitted at eaves and similar locations to seal against bird and vermin entry and dust emission.

Closure strips shall be permanently fixed in position.

All sheeting and flashing fasteners are to be in accordance with AS 3566.1 and hot dip galvanised in accordance with AS/NZS 4680. Pop rivets shall not be used. Concealed fastener type sheeting is not approved for use due to:

- crevice corrosion at the fastener
- inability to readily inspect fasteners
- difficulty in removing and reinstalling existing sheets.

8.4.5 Roof sealant

Sealant shall also be used to prevent water ingress around items installed, e.g. access hatches, etc. and shall meet the following requirements:

- Installed in accordance with roofing manufacturers requirements.
- Provide good adhesion to the roof surfaces.
- Resists extremes of both heat and cold.
- Resists to the damaging effects of sunlight (ultraviolet rays).
- Compatible with the performance of aluminium roof sheeting and flashing.
- Comply with the requirements of AS/NZS4020.

8.5. Concrete roof

Concrete roofs on reservoirs are not the preferred option and will only be considered for a specific project where they have an exceptional benefit over other construction materials. Concrete roofs shall be designed and constructed in a manner that ensures the structure is watertight.

Wherever applicable, all work carried out under this specification shall comply in all aspects (i.e. in design, construction, testing and performance) with the latest relevant Australian Standards listed in Appendix B and Section 5 Types of Reservoirs of this Technical Specification.

8.6. Roof support columns

Where possible the roof structure shall be designed without the use of internal columns. Roof support columns shall be constructed from pre-tensioned concrete or 316 Stainless Steel Circular Hollow section. The number of internal columns should be kept to a minimum, with the preference of one central column. The design shall allow ease of future maintenance or replacement.

GRP columns can be considered on a case-by-case basis.

8.7. Roof stormwater and overflow / scour management

The roof structure shall be designed to allow the rainwater flow-off from the roof to the hardstand area below around the reservoir and then be managed using a network of site drainage pits and pipes. The hardstand shall be designed to avoid splashing, erosion and property damage due to rainwater and runoff. The design shall ensure that all roof water drains away from the reservoir:

- Full length sheeting is to be used where practical, and gaps of roof sheeting are to comply with manufacturer's recommendations (to be minimised).
- Roof sheeting shall project minimum 150 mm beyond the external face of reservoir wall to prevent roof water ingress.
- Roof edge gutters shall not be used as the accumulation of leaves can permit entry of containments into the reservoir.
- Box gutters running across roof shall not be used as they may lead to significant contamination of the reservoir.
- Roof access hatches shall be designed to prevent the ingress of water run-off.
- Roof penetrations shall be carefully designed and constructed to provide watertightness and to allow effective drainage of storm water around the penetrations without any ponding.

Refer also to Section 6.12 Site drainage and stormwater. Overflow and scour flows shall be addressed in relation to discharge to the (existing) stormwater drainage systems.

8.8. Roof ventilation

Sufficient natural ventilation must be provided to:

a. allow for sufficient air movement during rapid filling or drawdown
b. reduce the build-up of a corrosive environment (i.e. humidity, chlorine gas) inside the reservoir
c. minimise biological growths within the roof structure
d. limit corrosion of the roof structure and components, and
e. assist in minimising WH&S risks during inspection, repair and maintenance to the roof/reservoir and confined space entry.

The design shall be done by an RPEQ and submitted to Unitywater for review and acceptance. The design shall include perimeter and passive static roof vents with consideration for:

i. 4mm aperture size mesh on all ventilation. Calculate reduced open area of vents due to mesh.

ii. Adequate allowance for air to be discharged during reservoir filling at maximum inflow and to ensure a minimum of six (6) air changes per hour based on the enclosed air volume above the Top Water Level (TWL). The roof vent(s) performance shall be based on the mean 9am wind speed for the reservoir location. TWL will depend on the reservoir design and operation. Coordination with Unitywater is required.

iii. Preventing birds roosting on the vents and the entry of:

- animal or bird droppings from entering the reservoir from the top
- wildlife, vermin, birds, insects and airborne dirt and debris
- rainwater, roof surface water and wind driven rain.

iv. Passive box vents are preferred and should be located on the windward and leeward sides to create the optimal pressure differential.

v. Mechanical or rotating ventilation can be considered in unusual instances where passive static ventilation cannot practically be achieved.

Roof ventilators shall be:

- Evenly distributed over the roof.
- Powder coated and comply with AS 4740.
- Provided with marine grade aluminium or stainless steel wire mesh screens with a nominal aperture of 4 mm for protection against flying insect, vermin, and windborne contaminants. The mesh shall be formed into replaceable panels with 25mm folded stainless steel edging.
- Installed in a manner to prevent water ponding.

Ventilators shall be rated and tested to resist rain and wind in accordance with AS 2428.1 and AS 2428.2. They shall provide sufficient physical security to minimise the potential for contamination due to vandalism or sabotage.

Cross ventilation of the reservoir shall be provided between the roof sheeting and the top of the reservoir wall. The area of this air intake shall be at least twice the cross-sectional area of the exhaust ventilators to provide satisfactory air turn over within the reservoir. The air intake shall be evenly distributed around the perimeter of the reservoir and shall be made vermin, insect and bird proof using corrosion resistant mesh (stainless steel or marine grade aluminium) with nominal aperture size of 4 mm. For ease of maintenance inspections, the ventilation mesh is to be horizontal and positioned so it is visible from ground level.

All shop detail drawings shall be supplied and cross-referenced to the relevant supplied drawings in the design documents.

9. Access

9.1. General

Each reservoir must have facilities which provide a safe access system for:

a. cleaning inside a reservoir
b. condition inspection
c. the provision, reading and repair of instrumentation or mixers
d. the return to ground level, outside the tank, of an injured person
e. if required, dosing and sampling
f. repair and maintenance of the reservoir.

Ideally, the facilities and system should allow items (a) to (e) of the above activities to be undertaken from ground level. Nonetheless the reservoir design should aim to eliminate the need to access the roof or reservoir interior and, where practical, the design should also aim to minimize or eliminate the need to access the roof access platform area.

9.2. External reservoir roof access

Roof access shall be provided for all reservoirs. This shall be done via a free- standing fabricated stairs/platform structure. Note on existing structures a ladder fitted with Lad-saf™ may be acceptable. The design, supply, and installation of external accesses shall comply with AS 1657.

Hand railing shall be provided on the sides of stairs. Handrails shall be fabricated from aluminium unless noted otherwise on the drawings.

A security enclosure shall be provided around perimeter of the access stairs or ladder to prevent unauthorised access. The security enclosure shall consist of cladding or precast panel walls without roofing. The enclosure shall be fitted with an access door and secured via padlock with cut protection or integrated deadlock configuration. Consideration shall be made for internal hinges to prevent vandals/intruders from climbing over. The security enclosure structure shall house the control panel and switchboard for the reservoir operation.

Sufficient clearance shall be provided between the stairs and the switchboard for personnel to safely undertake the maintenance activities. The Designer must consider the clearance requirements of AS 3000.

9.3. Roof access platform

The reservoir shall have a roof access platform. The platform and access hatch shall be designed in such a way to minimise the build-up of leaf and debris around the hatch to eliminate the accumulation of water around the hatch, so reducing its potential to enter the reservoir. This is critical to protect water quality of the reservoir.

The platform shall be constructed adjacent to and around the reservoir access hatch and be large enough to provide sufficient room for easy and safe access. This shall include adequate space for diver's breathing apparatus, confined space rescue personnel and all associated tools and equipment.

A permanent davit arm or winch to hoist equipment from the ground to the roof access platform is not required. However, consideration shall be made in the design for how equipment for inspections and divers will be hoisted up. The equipment includes inflatable rubber boats, electric boat motors, scuba gear, etc that could weigh up to 100kg.

The platform shall be finished as a constant level surface. The design, supply and fabrication of all platforms shall comply with AS 1657.

Hand-railing/guard-railing shall be provided on the perimeter of access platform except at points of access from a stairway. It shall comply with the requirements of AS 1657 and incorporate a toe-board. Handrails shall be fabricated from aluminium unless noted otherwise on the drawings. A self-closing gate with provision for a padlock shall be provided in the handrail to give access the roof for non-routine inspections or repairs.

Signage shall be provided on the gate to indicate restricted access as a high risk working at heights permit is required. Personnel needing access to the roof will have to develop a safe work methodology that is accepted by Unitywater. Figure 2 shows the typical warning sign for access to the reservoir roof. The sign shall be constructed from aluminium and be approximately 600mm by 450mm

Where dissimilar metals are to be clamped together, suitable neoprene or nylon shall be used to prevent galvanic action occurring.

Figure 2: Reservoir roof access warning sign

9.4. Roof access hatch

The reservoir roof shall be provided with a minimum of one (1) access hatch. The access hatch shall have a hinged cover which latches open in a vertical position. The hatch cover shall be fabricated from aluminium chequer plate, have a handle and lock and shall be sealed properly to prevent of water penetration through the lid. The access hatch shall be of sufficient size to allow safe access for divers and equipment (air tanks, remote operated vehicles, Inflatable boats, etc). An accepted size is 1550mm x 1100mm clear opening. The access hatch shall have a raised lip/edge around the hatch to protect against any direct drainage, ponding or debris build up. The aluminium access cover needs to overlap the framed opening and extend around the frame.

An aluminium or FRP safety grille shall be provided below aluminium lid to prevent personnel from falling through an open lid while inspecting the reservoir. The grille shall be capable of being latched open in a vertical position in the same direction as access hatch lid.

Depending on the size of access opening and weight, the lid and safety grille may need to be fabricated in more than one piece.

The access hatch shall be fitted with an accepted limit switch to notify of unauthorised opening of the hatch. The contact switch shall be cabled and connected to the telemetry and SCADA facilities in accordance with the requirements of Unitywater's Pr9380 - Specification for Electrical Installation at Network Sites.

9.5. Internal reservoir access by ladder

A vertical ladder with retractable handgrip stanchions shall be installed inside the reservoir and shall be fabricated from FRP: The ladder is not provided for (general) access purposes, so no cage or landing shall be installed, and the ladder may be longer than the 6m maximum nominated in AS 1657. Adequate platform space shall be provided for fall arrest / confined space rescue personnel and equipment. The design, supply and fabrication of ladders shall comply with AS 1657 apart from the relaxations noted above.

10. Water quality aspects

10.1. Mixing / circulation arrangement

The reservoir mixing/circulation shall be designed such a way to eliminate stagnated areas and promote efficient chlorine usage. Passive mixing is preferred, by positioning of the inlet and outlet pipework. An up-to-date water quality analysis can be provided by Unitywater prior to the commencement of detailed design to determine if chemical dosing will be required. The reservoir will require active mixing if chemical dosing is required. The arrangements which need to be considered include (as appropriate for each site's specific requirements):

a. Directing the inlet flow at an optimum angle to minimise stagnant areas.

b. Multiple inlets including Tideflex Mixing System (consisting of inlet nozzles discharging vertically upward and spaced along a horizontal manifold pipe and discharge Tideflex check valves).

c. Water re-circulation system.

d. Using mixer arrangements such as mixers contained within the preferred equipment list. Stainless Steel rope and fasteners are required and consideration for maintenance shall be considered. Mixers shall be connected to the telemetry and SCADA facilities in accordance with the requirements of Unitywater's Pr9380 - Specification for Electrical Installation at Network Sites.

e. Any combination of above measures or other similar products upon acceptance.

The design should avoid arrangements that are likely to disturb sediments on the reservoir floor and shall not hinder a diver's access to the reservoir for cleaning purposes.

Any mixer or equipment shall be of a size that fits through the roof access hatch.

If required by Unitywater, Computational Fluid Dynamics (CFD) shall be used to demonstrate that the proposed mixing arrangement will promote effective mixing. The CFD assessment shall be based on the different storage levels that the reservoir will move through from original provision to ultimate population. Refer to Appendix D for further details, however the CFD modelling should be used to understand the following aspects within the tank:

i. The effect of the mixing system to avoid short-circuiting and stagnant zones associated with stratification and low mixing velocities.

ii. Inflow jet behaviour within the tank via the use of visualisation methods such as streamlines.

iii. Average and maximum water age within the tank.

iv. A tracer model to understand disinfectant concentrations and deviation over the course of time.

Unitywater acceptance shall be obtained for the final design.

10.2. Chemical dosing facilities

A mixer will be required (refer Section 10.1 Mixing / circulation arrangement above) if a re-chlorination or pH correction facility is required for the site. The designer shall ensure that adequate land area is available for operation and maintenance of the chemical dosing system facility.

Refer to Pr11053 - Specification for Chlorine Dosing Systems Design and Construction for details if a site-specific chlorination facility is required to boost disinfection levels within the system.

11. Painting and corrosion protection

Corrosion protection and painting shall be undertaken in accordance with the requirements outlined in Unitywater's Pr9693 - Specification for Mechanical Installation and WSA 201.

Surface protection and protective coatings for all surfaces shall be designed for 15 years' service life without the need for replacement and shall comply with the latest revision of the relevant Australian Standards (in particular those relevant Australian Standards stated in Appendix B of this document), together with the requirements of competent Statutory Authorities having jurisdiction over all or part of the manufacture, installation and operation of the plant.

12. Electrical / telemetry

12.1. General requirements

The reservoir design and construction shall include all electrical and telemetry equipment required to operate and control all equipment on the site and shall be carried out in conjunction with the Scope of Works or the Principals Project Requirements or any other overarching document that details the specific requirements for the work. The design and installation must meet the requirements of this Specification and other relevant Unitywater specifications and equipment lists as shown in Appendix B. Typical electrical drawings are also available and these shall be used as the basis of design for electrical works.

The reservoir installation shall typically comprise of at least:

a. incoming three phase low voltage power supply
b. switchboard containing metering, main distribution section, RTU/PLC and telemetry equipment
c. motor starters (where applicable)
d. instruments for reservoir level, dosing and water quality etc.
e. dosing facilities (if required)
f. area lighting and general power
g. security system
h. lightning protection system (as required).

Note that some reservoir sites have additional tenants (typically telecommunications companies) who may need power supplies to their equipment. Where this is the case, separate electrical metering must be installed for each tenant. Metering must meet the requirements of the Electrical Supply Authority.

12.2. Power supply

All reservoir sites will be supplied with three phase low voltage power from the local Electrical Supply Authority's distribution network. The Designer shall consult with the Electricity Distributor as the earliest possible stage to discuss and confirm the requirements for the electrical supply.

Off-grid power solution (solar and batteries) shall not be accepted due to the critical nature of these assets. Unitywater may consider these options as supplementary to the grid.

12.3. Switchboard

The switchboard is to be located inside the security enclosure. Depending on the site, the switchboard may be installed outdoors, however if a building is provided the main switchboard should be installed indoors

Typically, the main switchboard and MCC, if required, for the site will house all electrical distribution, motor starters, instrumentation and control/telemetry equipment.

12.4. Telemetry and instrumentation

Telemetry and instrumentation sections within the switchboard shall be provided to house the telemetry equipment, control power supplies, GPO for technician's use and field wiring terminals. All telemetry equipment, motor starter control circuits, instrumentation and any other critical equipment used for monitoring shall be supplied from UPS backed systems and shall have all measurements integrated into the control system.

The telemetry equipment shall include remote/radio telemetry unit (RTU) that is connected to a digital radio and an aerial. This system shall allow for remote monitoring and control of the reservoir.

12.5. Radio path survey

On completion of the concept design, the designer shall engage a Unitywater approved supplier to undertake a radio survey to determine signal strength, antenna type, direction to be mounted and mounting height. The design must then incorporate these requirements.

12.6. Site lighting

Sufficient lighting facilities shall be provided within the reservoir security and for the reservoir roof access stairways and platform. Lighting shall be provided to site entry gate and reservoir access points

External lighting will be operated by appropriately located switches around the site.

12.7. Site GPOs

The 240V general purpose outlets (GPOs) shall be installed in convenient locations as developed during the design and shall be mounted within switchboards, on nearby structures or buildings where possible.

Where a single phase power outlet (10 amps) is installed inside a valve pit/s, it must be installed in such a way that inundation does not occur in the event the pit fills with water.

12.8. Lightning protection

A lightning study must be carried out to determine the requirements of lightning protection. Lightning protection shall be designed and installed in accordance with Pr9380 - Specification for Electrical Installations at Network Sites.

13. Instrumentation

13.1. Level sensor

The reservoir shall be provided with a radar type level transmitter with the following specifications:

- measuring range up to 35 m
- process fitting - G1½A, mounting strap or flange
- with encapsulated horn antenna ø40mm / PVDF / -40..80°C
- process temperature between - 40 and + 80°C
- process pressure between – 100 kPa and + 200 kPa
- measuring precision of +/- 2mm
- transmitting frequency - K band.

Alarms for high (overflow level) and low shall be set up in SCADA based on the physical levels of the reservoir. Refer also Section 3.6 and Figure 1.

The equipment shall include all the necessary documentation, fittings, antenna, housing, cables, and electrical connections required to complete the installation. The signal cables supplying the radar from the main Switchboard/RTU shall be terminated in a glanded IP66 stainless steel/marine grade aluminium junction box adjacent to the radar head. Any cables connecting back to the main switchboard which supply the radar shall be shielded twisted pair.

The equipment shall be mounted away from any internal reservoir walls stairs or other obstructions which may impede the radar signal. The antenna shall be mounted according to the instructions provided by the supplier with all clearances as recommended. The radar shall be commissioned on an empty/low level reservoir to allow any obstruction to be filtered out.

Installation shall be strictly in accordance with the manufacturer's specifications.

13.2. Level floats

Two ball level floats shall be provided for the purposes of alarming during high- and low-level conditions. The high-level float shall be positioned 500 mm below the overflow level of the reservoir or at a position determined/agreed during commissioning. The low-level float shall be positioned 500 mm above the floor of the reservoir or at a position determined/agreed during commissioning. The operation of these floats shall raise alarms in SCADA.

Level floats shall be terminated in a stainless steel/marine grade aluminium IP66 junction box adjacent to the maintenance hole entry for the reservoir.

Etched Stainless Steel labels shall be affixed to each ball float cable leaving the junction box before entering the reservoir with “High Float” and “Low Float” to allow for rapid identification during replacement/maintenance. Label requirements are detailed in Pr9380 - Electrical Installations at Network Sites.

In addition to overflow switch, it is recommended to mark the overflow level on the wall inside the reservoir near the internal access ladder.

13.3. Electromagnetic flow meters

Bi-directional magnetic flow meters shall be installed for all inlet and all outlet flows to the reservoir. Flow meters shall be suitable for accurate and reliable measuring of water under pressure over the entire expected flow range. The flow meter shall comply with Unitywater’s Pr9693 - Mechanical Installation, F10678 - Accepted Electrical Equipment List and the SEQ Code IPAM List unless otherwise specified in this Specification.

The flow meter shall be installed entirely as per the manufacturer’s instructions with particular attention to minimum straight distance before and after the flow meter relative to tees, bend and other obstruction. The flowmeter shall not be direct buried and shall not be installed in pits without adequate drainage. Unitywater’s preference is to have all electrical equipment above ground level and accessible to technicians where possible.

The lining of the flowmeter is to be elastomer or appropriate material for use with drinking water. The electrodes shall be Grade 316L stainless steel or appropriate material for use with drinking water. The detector shall have a stainless-steel metering tube suitably lined (Neoprene or EPDM) to resist wear and corrosion. Where negative pressure (i.e. vacuum) is possible, the lining shall be omitted.

14. Telecommunications (3rd Party)

Consideration shall be made in design for 3rd party telecommunications. When possible all 3rd party telecommunications equipment shall be installed on separate infrastructure. However, it is acknowledged that this is not always possible or practical.

In these situations, the telco equipment design and installation must:

- Conform to Unitywater’s Pr8777 - Telecommunications Facility Installation Procedure.
- Allow for safe access for routine maintenance without exposure to Radiation Hazards (RADHAZ) due to electromagnetic fields.
- Consider the community and visual aesthetics.

14.1. Power supply to third parties

When third parties have infrastructure on the reservoir, power will generally need to be provided from the main switchboard. Sub metering for each tenant will need to be installed in the main switchboard and the tenant will be responsible for their own supply from the outgoing circuit breaker/main switch. Unitywater and/or the Designer will need to liaise with tenants to ensure requirements of the Local Supply Authority are met for any metering and overall power supply to the site. Tenants/third parties may be charged for this through commercial agreements which are outside the scope of this document.

15. Site security requirements

15.1. Perimeter fencing

Fencing shall be erected around the perimeter of the reservoir to restrict unauthorised access to the site.

Approved suppliers of panel security fencing are listed in the SEQ code Civil IPAM list, panels shall be 2100mm height with a maximum panel length 2400mm, and to be Polyester powder coat to AS 4506 Metal finishing - Thermoset powder coatings.

Chain link type security fencing shall be in accordance with AS1725.1 Chain link fabric fencing – Security fences and gates – General requirements. The minimum height of the security fencing shall 2100 mm high 3.15mm heavy gauge chain wire mesh fencing with fixed bottom rail and topped with three strands of barbed wire set on a 45-degree outward crank. Black PVC coated heavy gauge wire is to be used with all posts and rails powder coated black to match.

Refer to Unitywater's Pr9903 - Specification for Building and Structural Works for further details.

15.2. Perimeter fencing entry points

The entry point shall be secured via a gate of construction to match the fence type. Refer to Unitywater's Pr9903 - Specification for Building and Structural Works for further details.

15.3. Security signage

The security signage shall be installed at 30 m intervals along perimeter fencing facing a public road and at 50 m intervals along other boundaries.

15.4. Intruder alarm and access control system

All new intrusion Alarm and Access Control system installations must be the Inner Range "Integriti" product and installed by Unitywater's current Electronic Security Contractor. They shall include the following at a minimum:

- An alarm panel with offsite monitoring.
- Proximity (Reed) switch installed on the reservoir's roof access hatch/s to monitor access to the hatch and to the entry door of the security enclosure to the stairway roof access.
- An alarm is to be raised when an unauthorized person opens the access hatch/s or enclosure entry door.

15.5. Key system

All mechanical locking shall be keyed to Unitywater registered Master Key system.

15.6. Locking

All mechanical locking shall where practical be deadbolt style locking integrated into the door / access point build. All padlock applications including pit applications shall incorporate lock shroud protection to provide protection against cutting. Locking recess pits or shrouds must allow water to freely drain away to prevent padlocks from becoming submerged.

16. Signage and labelling

16.1. Safety signage

All mandatory, caution, prohibition, danger, security and safety signage (e.g. confined space entry) shall be supplied and installed as required by current legislation.

16.2. Labelling

All equipment shall have the identification number affixed to the equipment to facilitate easy identification for operation and maintenance purposes.

All instruments shall be identified with tags mounted adjacent to but not directly on the instrument. All tags and labels shall be of stainless steel construction with engraved numbering and lettering and shall comply with the requirements of Unitywater's Pr8843 - Specification for Drawing, Document and Equipment Tag Numbering. Tags and labels shall be fixed in a prominent location by use of stainless-steel pins.

16.3. Piping identification

Above ground and in-pit pipework shall be provided with identification markers indicating contents and direction of flow in accordance with AS1345 (Identification of the contents of pipes, conduits and ducts) and Unitywater's Pr8843 - Specification for Drawing, Document and Equipment Tag Numbering. Markers shall be approved self-adhesive labels.

17. Testing, commissioning and post construction documentation

17.1. Commissioning

A Commissioning Management Plan in accordance with Pr11211 - Specification for Commissioning and Handover of Active and Passive Assets must be prepared prior to commencing any commissioning activities and no commissioning activities may commence until the Plan has been accepted.

Contingency planning during network interventions may be required during Testing and Commissioning.

Prior to commissioning, Unitywater must be supplied with a complete set of all foreseeable spare parts and consumables that may be expected to be required in the first 12 months of the asset's operation. The list shall include item, model, supplier and lead time. Unitywater will decide which spare shall be purchased.

Cleaning, disinfection, and water quality testing shall be done in accordance with this specification

Prior to commencement of any commissioning activities, the inlet main shall be checked for chlorine residual and flushed as required until a free chlorine satisfactory residual is obtained.

Follow the requirements as detailed in Unitywater's Pr8996 - Network Permit to Work Procedure.

17.2. Hydrostatic pressure testing

Hydrostatic Pressure Testing shall be carried out in accordance with the requirements stipulated in Unitywater's Pr9903 - Specification for Building and Structural Works, including:

- Management of drained test water in accordance with Water Services Association of Australia (WSAA) Guideline: *Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019*.
- Disposal of flushing water in accordance with Unitywater's Pr9137 - Internal Reservoir Inspection and Cleaning Work Instruction and WSAA Guideline: Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019.
- Determining acceptability of all new mains associated with the reservoir construction in accordance with Unitywater's Pr9032 - Procedure for Managing Water Quality During Mains Commissioning.

Prior to filling of the reservoir, the inside surfaces of the reservoir must be cleaned to remove all swarf and debris. The reservoir shall then be washed down to remove any remaining dirt, and dust using high pressure equipment and water containing a minimum 5mg/L chlorine for disinfection.

The wash down water shall be disposed of through the scour outlet and into the on-site stormwater pipework in accordance with Unitywater's Pr9137 - Internal Reservoir Inspection and Cleaning Work Instruction and WSAA Guideline: Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019.

During filling of the reservoir, sufficient sodium hypochlorite solution (10% available chlorine) shall be added into the incoming water to ensure that approximately 3 mg/L of free chlorine is retained in the water body after the filling. Consideration must also be made to ensure the added 10% sodium hypochlorite is adequately mixed throughout the water body.

Unitywater will provide water for cleaning purposes and filling at no cost to the Contractor.

17.2.1 Hydrostatic test

The testing shall be in accordance with AS 3735 Concrete Structures for Retaining Fluids and AS3735 Supp 1 2001 Concrete Structures for Retaining Fluids – commentary (supplement to AS3735) and comprise the following:

- Filling the reservoir shall be at a uniform rate not exceeding 2m maximum per day and a rate of no greater than 200mm per hour. Consideration shall be made for how the reservoir is filled to avoid the risk of backflow or potential contamination into the drinking water network. The fill rates for reservoir commissioning may be limited by available capacity in the upstream/supplying network. Filling rates should be authorised by Network Operations to ensure no negative impacts to upstream network and its existing customers.
- The reservoir shall be filled to the design TWL and allowed to stabilise for a minimum seven (7) day period. During this period the Contractor shall monitor the water level on a daily basis to confirm that absorption and autogenous healing process are proceeding as expected. If the reservoir has to be emptied or the water level drops more than 300 below TWL for longer than 24 hours, the stabilisation period must recommence from Day 1.

- On completion of the stabilisation period, the water tightness testing of the reservoir over a seven (7) day period shall be commenced in accordance with AS 3735 Concrete Structures Retaining Fluids. The reservoir shall be considered fit for purpose if the net drop in water level does not exceed 10 mm over the seven (7) day test period.
- If, however, the reservoir fails the water tightness test, and the reservoir has to be drained or emptied, the Contractor shall be solely responsible for its disposal. Upon refilling the Contractor shall pay Unitywater the current water rate.
- The load/settlement behaviour of the foundations shall be carefully monitored during the water testing phase by accurate survey compared to baseline survey prior to filling.
- If the total settlement at any control point exceeds 10 mm or the differential settlement between any two adjacent control points on the perimeter exceeds 5 mm, then filling shall be immediately terminated and the testing procedure shall be modified or abandoned.
- All survey work associated with testing shall be carried out by an independent registered surveyor, with a report summary of results presented to Unitywater on completion.

The Contractor shall be responsible for maintaining the water quality, in accordance with the acceptable range detailed below, until the reservoir has been completely commissioned and handed over to Unitywater.

Final commissioning and handover shall include all activities required to fill the reservoir, satisfy all testing requirements and make the new reservoir operational.

17.3. Water quality testing

Testing for final water quality to demonstrate the water is safe to send to consumers shall occur no less than three (3) days after the commencement of hydrostatic testing and prior to the water within the reservoir being released into the network and available for consumption.

Samples for final water quality testing must be collected no earlier than 24 hours after filling has been completed and the sodium hypochlorite has been added and mixed.

The final water quality ‘certificate’ will only be valid up to ten (10) days post the date the sample was collected and if there has been no further entry into the reservoir after the date the water sample was collected for microbiological testing. **Note the exception** regarding benzene, toluene, ethylbenzene and xylenes (BTEX) and metals testing outlined in Table 8 and Section 17.3.1 below.

If it is unlikely the reservoir will be able to go ‘live’ within this period, arrangements to maintain water quality and turnover shall be made. Additionally, retesting for final water quality acceptability shall be undertaken.

The water in the reservoir shall be sampled and tested by a NATA registered laboratory accepted by the Unitywater (this service can be provided by Unitywater’s Scientific Services or an external laboratory). Tests shall be considered satisfactory when they fall within the water quality limits specified below.

Table 8: Water quality acceptance criteria

Analysts	Unit	Required Result Range
pH	pH Units	6.5 – 8.5
Apparent Colour	PCU	<15
Turbidity	NTU	<5
EC	(µS/cm)	<1250
Free chlorine residual	mg/L	>0.5
Total chlorine residual	mg/L	>0.5
Total Coliforms	mpn/100mL	<1
E.coli	mpn/100mL	<1
Heterotrophic Plate Count	cfu/mL	<100
THMs	µg/L	<250 individually and also as a sum
Chlorate	mg/L	<0.8
Metal Scan (heavy metals – mercury, lead, nickel, aluminium, copper and manganese)		The results must not exceed health or aesthetic values stated in the Australian Drinking Water Guidelines for the tested analyte/parameter.
BTEX (benzene, toluene, ethylbenzene and xylenes)		The results must not exceed health or aesthetic values stated in the Australian Drinking Water Guidelines for the tested analyte/parameter.

Chlorine residuals while commissioning the reservoir need to be within the range of normal supply to downstream customers before being released (i.e. if the downstream network normally only has maximum chlorine residuals of 2.0mg/l, water from the commissioning reservoir should not be released until below this level or as permitted by Network Operations).

17.3.1 Water quality results

Both metal scan and BTEX tests may take up to 14 days so this should be considered prior to final testing outlined in table above. These results are not subject to the 10-day acceptance criteria outlined above. The following is a suggested protocol that may assist in meeting the above requirements.

- Late week 1 – fill/dose reservoir
- Monday week 2 – BTEX and metals sampling
- Monday week 3 – bacteriological and physical /chemical sampling (results back Thurs/Fri of week 3)
- Monday week 4 – BTEX and metals results available (assuming they take the full two (2) weeks).
- Bring reservoir online if all results pass testing.

Note: this means that water needs to be dosed to a sufficient level for chlorine decay and to provide a residual after 2.5 weeks. 3mg/L of free chlorine, as outlined earlier, may be sufficient for this period of time, however this is still the responsibility of the Contractor to manage. If there are difficulties reaching the free chlorine residuals (e.g. chloraminated incoming water) contact the Water Quality (WQ) Section for assistance with the breakpoint.

Water Quality results shall be submitted to the WQ Section for review and acceptance.

The samples collected must be representative of the body of water within the reservoir. As a minimum, samples are to be collected at three different levels within the reservoir:

- near the surface
- in the middle
- near the bottom.

Dependent on the diameter of the reservoir, consideration should also be made with respect to adequate representation spatially across the reservoir.

Should any of the microbiological analyses not comply with the water quality limits shown above, the reservoir shall be re-disinfected and re-tested for all analytes, except Metal Scan and BTEX (where they have been demonstrated to meet the specifications in Table 8) until the test results are satisfactory.

Should any of the chemical or physical analytes not comply with the water quality limits shown above, the water will be considered unsuitable for drinking and the Contractor shall develop an action plan for acceptance by the Unitywater's Representative along with consultation with Unitywater's Water Quality Section. The Contractor shall be solely responsible for implementation of the accepted action plan.

17.4. Civil and mechanical inspection and testing

For general inspection and testing requirements for civil, structural, and mechanical works refer to Unitywater's Pr9902 - Specification for Civil and Earthworks, Pr9903 - Specification for Building and Structural Works and Pr9693 - Specification for Mechanical Installations.

17.5. Building certification

The Contractor shall provide all building certification documents for design and certification of any buildings to Unitywater.

17.6. Electrical and control system inspection and testing

The Contractor shall undertake all inspection and testing for electrical and control system works in accordance with the requirements contained in Unitywater's Pr9380 - Unitywater Specification for Electrical Installations at Network Sites. The testing will include as a minimum the following Electrical ITPs, FAT and SAT requirements:

- Switchboard Electrical Testing
- Switchboard Visual check
- Equipment Isolation Checks
- All protection and Control equipment settings
- Instrument calibration and settings
- Control System Functionality Checks
- SCADA control and alarm Tests.

18. Handover requirements

The Contractor shall provide commissioning documentation and information in accordance with

- Pr11211 - Commissioning and Handover of Active and Passive Assets
- Electrical test certificate.

18.1. Project completion

Provide final project cost and confirmation that all identified works have been completed.

A completed Unitywater Asset Template of all active and decommissioned assets on site shall be returned to Unitywater.

All relevant QA documentation to be provided through Objective Connect.

18.2. As constructed information

The As Constructed drawings shall be prepared and supplied in accordance with Pr11211 - Specification for Commissioning and Handover of Active and Passive Assets and the SEQ WS & S D & C Code Asset Information Specification.

Asset information data shall be recorded on the 'As-Constructed Asset Record for Water Supply Assets' spreadsheet will be provided by Unitywater. This asset data shall include full asset details including installed value of all items.

18.3. Asset manuals

Asset manuals shall be prepared and provided in accordance with the SEQ WS & S D & C Code Asset Information Specification.

A draft Operating and Maintenance (O&M) Manual for the facility must be prepared and submitted prior to process commissioning. It must be finalised and re-submitted after successful commissioning of the facility and incorporate any learnings or changes required during commissioning and proof of performance.

19. Appendices

Appendix A – Definitions/Acronyms

The following definitions, abbreviations and acronyms are used throughout this specification.

Term	Meaning
Actions	'Shall', 'will' or 'must' indicates mandatory action 'Should' indicates preferred/recommended action 'May' or 'can' indicates possible or optional action.
ADAC	Asset Design As Constructed
AS	Australian Standard
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CFD	Computational Fluid Dynamics
CSE	Confined Space Entry
CSP	Construction Safety Plan
FAT	Factory Acceptance Test
FRP	Fibre-reinforced plastic
GPO	General Power Outlet
IO	Input/ Output
IPAM	Infrastructure Products and Materials
ITPs	Inspection and Test Plans
O&M	Operations and Maintenance
QUDM	Queensland Urban Drainage Manual
P&ID	Piping & Instrumentation Diagram
PLC	Programmable Logic Controller
RPEQ	Registered Professional Engineer of Queensland
RTU	Remote Telemetry Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control & Data Acquisition
SEQ	South-East Queensland
SEQ WS&S D&C Code (SEQ Code)	South-East Queensland Water Supply & Sewerage Design & Construction Code
WHO	World Health Organisation
WH&S	Work Health and Safety
WQ	Water Quality
WSAA	Water Services Association of Australia

Appendix B – References

B1. General

All works shall be completed in accordance with this Specification, the Project Specification and stated supplementary specifications.

Reference to specific clauses of the various codes is intended to highlight those points and shall not be taken to imply a lesser importance for all other applicable clauses. All the works shall conform to the Rules and Regulations of the Statutory Authorities having jurisdiction over the Site.

If the requirements of this Specification do not comply with the minimum requirements of the statutory regulations and standards, the Statutory regulations and standards shall apply. If the requirements of this Specification are more exacting than the minimum requirements of the statutory regulations and standards, this Specification shall apply.

All Contractors have an obligation to comply with all relevant legislation and regulations. As a minimum the following legislation, related Regulation and Codes apply to this specification:

- *Building Act 1975* (Qld)
- *Building Regulation 2021* (Qld)
- *Electrical Safety Act 2002* (Qld)
- *Electricity Regulation 2006* (Qld)
- *Electrical Safety Regulation 2013* (Qld)
- *Electricity Act 1994* (Qld)
- *Environmental Protection Act 1994* (Qld)
- *Professional Engineers Act 2002* (Qld)
- *Queensland Building and Construction Commission Act 1991* (Qld)
- *Water Supply (Safety and Reliability) Act 2008* (Qld)
- *Work Health and Safety Act 2011* (Qld)
- *Work Health and Safety Regulation 2011* (Qld)
- Managing Noise and Preventing Hearing Loss at Work Code of Practice 2021 WorkSafe Qld
- Scaffolding Code of Practice 2021, WorkSafe Qld
- National Construction Code (NCC)
- Queensland Development Code
- South-East Queensland Water and Sewerage Design and Construction Code (SEQ WS & S D & C Code) includes SEQ Asset Information Specification and SEQ Infrastructure Products and Materials lists (Civil and Mechanical) available via the SEQ Code website: www.seqcode.com.au
- WSA 201 Manual for Selection and Application of Protective Coatings
- WSAA Guideline: Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019.

B2. Relevant Unitywater documents that relate to this specification

Relevant Unitywater documents that relate to this specification are listed in Pr11231 - Unitywater Technical Specification Reference Guide.

B3. Internation and Australian Standards

International and Australian Standards referenced within this specification

Standard	Title
Quality Systems	
AS 2990	Quality Systems for Engineering and Construction Projects
AS 3901	Quality Systems for Design/Development, Production, Installation and Servicing
AS 3902	Quality Systems for Production and Installation
AS 3903	Quality Systems for Final Inspection and Test
Drawings	
AS 1110	Technical Drawings
AS 1101	Graphical Symbols for General Engineering
AS 1102	Graphical Symbols for Electrotechnology
Materials and Workmanship	
AS 1012	Methods of Testing Concrete
AS 1111	ISO metric hexagon commercial bolts and screws
AS 1112	ISO metric hexagon nuts, including thin nuts, slotted nuts and castle nuts
AS 1170.4	Structural design actions
AS 1180	Methods of test for hose from elastomeric materials
AS 1214	Hot dip galvanised coatings on threaded fasteners (ISO metric coarse thread series)
AS 1311	Steel tendons for prestressed concrete – 7 wire stress relieved steel strands for tendons in prestressed concrete
AS 1314	Prestressing anchorages
AS 1319	Safety signs for the occupational environment
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1379	The Specification and Supply of Concrete
AS 1478.1	Chemical admixtures for concrete, mortar and grout – Admixtures for concrete
AS 1478.2	Chemical admixtures for concrete, mortar and grout – Methods of sampling and testing admixtures for concrete
AS 1554	Structural steel welding
AS 1562.1	Design and installation of sheet roof and wall cladding, Part 1: metal
AS 1627	Metal finishing - Preparation and pre-treatment of surfaces - Method selection guide
AS 1646	Elastomeric seals for waterworks purposes
AS 1654	ISO System of Limits and Fits

Standard	Title
AS 1657	Fixed platforms, walkways, stairways and ladders — Design, construction and installation
AS 1664	Aluminum structures
AS 1683	Methods of test for elastomers
AS 1734	Aluminum and aluminum alloys – flat sheet, coiled sheet and plate
AS 1891.3	Industrial fall-arrest system and devices
AS 2032	Installation of UPVC pipe systems
AS 2033	Industrial fall-arrest system and devices
AS 2280	Ductile iron pipes and fittings
AS 2312	Guide to the protection of iron and steel against exterior atmospheric corrosion
AS 2350	Methods of testing Portland and blended cements
AS2439.1	Perforated plastics drainage and effluent pipe and fittings, Part 1: Perforated plastics drainage pipe and fittings
AS 2528	Bolts, studbolts and nuts for flanges and other high and low temperature applications
AS 2549	Cranes (including hoists and winches) - Glossary of terms
AS 2566	Plastics pipelaying design
AS 2638	Resilient Seated Gate Valve
AS 2700	Colour standards for general purposes
AS 2728	Prefinished/pre-painted sheet metal products for interior/exterior building applications - Performance requirements
AS 2758	Aggregates and rock for engineering purposes
AS 2865	Safe working in a confined space
AS 2885	Pipelines - Gas and liquid petroleum - General requirements
AS 3000	Electrical Installations
As 3500.3	Plumbing and drainage, Part 3: Stormwater drainage
AS 3566.1	Self-drilling screws for the building and construction industries -
AS 3600	Concrete Structures
AS 3610	Formwork for concrete
AS 3725	Design for installation of buried concrete pipes
AS 3735	Concrete Structures Retaining Liquids
AS 3972	General purpose and blended cements
AS 4020	Products for use in contact with drinking water
AS 4037	Pressure equipment - Examination and testing
AS 4041	Pressure piping
AS 4058	Precast concrete pipes (pressure and non-pressure)
AS 4087	Metallic flanges for waterworks purposes
AS 4024	Safeguarding of Machinery

Standard	Title
AS 4100	Steel structures
AS 4158	Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
AS 4600	Cold-formed steel structures
AS 4671	Steel reinforcing materials
AS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS 4791	Hot-dip galvanized (zinc) coatings on ferrous open sections, applied by an in-line process
AS 4792	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
AS 4991	Lifting devices
AS 4998	Bolted unrestrained mechanical couplings for waterworks purposes
AS 5065	Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications
ISO 8873	Plastic piping systems for non-pressure underground drainage and sewerage - Polypropylene

Appendix C – Sample Outline for Drinking Water Quality Protection Plan

Example Table of Contents for a Drinking Water Quality Protection Plan:

- Introduction
- Purpose
- Objectives
- Document References
- Project Description and Scope of Works
- Roles and Responsibilities
- Water Management
- Overview
- Isolation and Network Map
- Draw down of Reservoir
- Release of water and discharge points
- Reservoir External Works
- Detail of works
- Reservoir Internal Works
- Detail of works
- Other works on site (that may affect water quality)
- Detail of works
- Reservoir Disinfection
- Filling of Reservoir
- Commissioning
- Chlorine Residual Testing
- Commissioning Planning.

Appendix D – Computational Fluid Dynamics

D1. General

The CFD assessment shall be based on the different storage levels that the reservoir will move through from original provision to ultimate population. The CFD modelling should be used to understand the following aspects within the tank:

- The effect of the mixing system to avoid short-circuiting and stagnant zones associated with stratification and low mixing velocities.
- Inflow jet behaviour within the tank via the use of visualisation methods such as streamlines.
- Average and maximum water age within the tank.
- A tracer model to understand disinfectant concentrations and deviation over the course of time.

D2. Successes of CFD models

For a CFD model to validate the design of a reservoir, it must show successful mixing at different water levels and flow conditions. These are defined in the following sections.

D2.1 Criteria for Successful mixing

There are a number of reasons that mixing of drinking water reservoirs is required: eliminate stagnated areas, promote efficient chlorine usage, ensuring low water age, and reductions in temperature stratification. Criteria to show successful mixing to reduce each of the issues is listed below. It is noted that for each of the criteria listed below, simulations should be performed at different water levels and flow conditions (refer to Section D2.2).

1. Eliminate stagnated areas:
   - To ensure stagnated areas are eliminated, velocity profiles (i.e. magnitude and direction) should be provided. Detailed sections of areas that promote stagnation should also be provided, e.g. square columns, and access hatch.
   - An analysis showing the ratio of stagnated to mixed water by volume should be used. i.e. 1 is a fully mixed tank and 0 is a stagnated tank.
2. Efficient Chlorine usage:
   - To ensure a homogenous chlorine concentration in the reservoir, the inlet concentration can be used as an initial input condition. The reservoir concentration can then be tracked and analysed to ensure a homogeneous concentration out the outlet.
   - Tracer particles (streamlines) can be used to track the flow path of the chlorine and other dosing agents, ensuring there is effective mixing.
3. Eliminate Temperature Stratification:
   - Temperature profiles of the tank can be used to show and analyse the temperatures of the water throughout the reservoir. This should show a homogenous temperature of the water in the reservoir with no stable stratified conditions.
4. Water Age:
   - To ensure water is not in the reservoir for longer than necessary, the flow can be tracked to determine the amount of time it takes inflow water to reach the outflow. A maximum water age of five (5) days should not be exceeded.

D2.2 Water levels to be modelled

The reservoir should be modelled at different water levels to ensure the mixer will be effective at all operational capabilities. This can be achieved in two different ways:

1. Construct separate models to capture low, nominal, and peak water levels.
2. Use a single model with a dynamic mesh (Refer Section D3.1) to capture fluctuating water levels in the reservoir within a single model.

For each of these methods, different inflow and outflow conditions should be simulated. These are listed below:

a) Zero inflow and outflow – i.e. isolate mixer to verify operational capabilities.
b) A dynamic simulated diurnal pattern to model a daily flow. This should be done at the original provision and at ultimate population.
c) Peak hourly flow from original provision to ultimate population.

D3. Model setup and simulation

The setup of CFD simulations is critical to ensure accurate results are produced and are based on correct assumptions. The setup of the model includes the computational domain (mesh), the turbulence model used, and if necessary, verification and validation.

D3.1 Mesh

The computational domain (mesh) can be a structured or unstructured grid of polyhedron elements. Additionally, depending on the CFD program being used, dynamic meshes (or equivalent) may be available to allow dynamic changes in the computational domain during a simulation. For any mesh developed, a grid convergence study should be performed to verify density of the mesh and then to verify the order of accuracy of the solver being used (Section D3.3).

D3.2 Turbulence models

It is important to confirm the turbulence model being employed to simulate the turbulent flow field inside the reservoir. As the flows are transient in nature due to time-dependent boundary conditions, steady-state models cannot be used. The table below provides an outline of the most common turbulence models used, the computational cost (and subsequently monetary cost), and the advantages and disadvantages of each model for simulations of a reservoir flow field.

Model	Computational Cost	Accuracy	Time-Dependence	Advantages	Disadvantages
RANS (Reynolds-Averaged Navier-Stokes)	Low	Moderate	Steady-State	Computationally efficient	Cannot be used for transient solutions
URANS (Unsteady RANS)	Moderate	Higher than RANS	Transient	Captures unsteady behaviours	Still relies on turbulence models, so not as accurate as LES and DNS

Model	Computational Cost	Accuracy	Time-Dependence	Advantages	Disadvantages
LES (Large Eddy Simulation)	High	High	Transient	Captures turbulence better than URANS	High computational cost
DNS (Direct Numerical Simulation)	Very High	Very High	Transient	No turbulence models required, most accurate form of CFD	Computationally infeasible for high Reynolds number flows

RANS and URANS require a turbulence closure model to be chosen in order to resolve the turbulent flows. The three most common models are shown in the table below. Each of the models are suitable for the simulation of reservoir mixing, however will require different considerations.

Model	Characteristics	Best Application	Limitations
$k-\epsilon$	Far field model	Suitable for high Reynolds number flows	Weak for near-wall flows.
$k-\omega$	Near wall model	Internal flows including boundary layers and low Re flow.	Sensitive to freestream conditions, can lead to overprediction of turbulence
SST $k-\omega$ (Shear Stress Transport)	Hybrid model combining near wall and fair field for improved accuracy	Can be used for both far-field flow and near wall flow	More computationally expensive

D3.3 Accuracy of simulations

For any CFD simulation, the accuracy of the results must be verified and may also require validation.

D3.3.1 Verification

Verification is the process of ensuring there is sufficient accuracy of the numerical code representing the mathematical model of a physical event. There are multiple different verification techniques that may be used, however the most common and applicable are:

- **Grid convergence study (mesh refinement study):** This ensures the solution is grid independent, by increasing the fineness of the grid until the solution converges and the discretisation error asymptotically approaches zero.
- **Order of accuracy estimation:** This is a comparison of error norms from successive grid refinements. The order of accuracy quantifies the rate of convergence of a numerical approximation to an exact solution.
- **Examine consistency:** This is a simple check to ensure the solution is consistent. For example, flow through a duct should maintain mass conservation (i.e. flow into a mixer is equal to the flow out of a mixer).

D3.3.2 Validation

Validation may not be necessary depending on the CFD programs being used. Validation is the process of determining how accurate a model is compared to a real-world form. As such most commercial solvers will not require validation. However, untested, uncommon, and/or proprietary CFD programs will require validation against real world data.

D4. Requirements

To show effective mixing of the reservoir, the CFD model and report provided should show the following, unless approved otherwise by Unitywater:

To show evidence of effective mixing **at least one** (1) of the following four (4) criteria must be satisfied.

a) velocity profiles show no major stagnated areas and a stagnate water to mixed water ratio by volume of less than 5%
b) particle tracers are used to show no areas of nonhomogeneous concentrations of chlorine and other dosing agents
c) temperature profiles show no stable stratified conditions, or
d) water age of less than five (5) days.

A dynamic mesh should be used to allow for fluctuations in the water level. At least two (2) separate flow conditions should be modelled:

- no in or out-flow, to isolate and evaluate the mixer, and
- diurnal flow at original provision and at ultimate population.

The turbulence model to be used is a URANS with an SST $k-\omega$ model.

The CFD report should include verification studies including grid convergence studies and an order of accuracy estimation. If a proprietary CFD program is being used a validation study should be provided.

Appendix E – Preferred Equipment List

Refer to F11439 - Drinking Water Reservoir Accepted Products and Materials List.