SA Water

Engineering

Technical Standard

TS 0222 – Production Groundwater Bores and Submersible Pumps

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Documents superseded by this standard

None

Significant/major changes incorporated in this edition

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1 Introduction

SA Water is responsible for the construction and commissioning of an extensive amount of engineering infrastructure such that it is safe and functional.

This standard has been developed to assist in the design, maintenance, construction, and management of this infrastructure.

1.1 Purpose

The purpose of this standard is to detail minimum requirements to ensure that assets covered by the scope of this standard are constructed and maintained to consistent standards and attain the required asset life.

1.2 Glossary

Terms and Abbreviations utilised in this Standard are included in the following Sections. The definitions presented below are to be used when interpreting this Standard and actions undertaken in relation to this Standard. Where a conflict exists, clarification is to be sought from SA Water.

1.2.1 Terms and Definitions

The following is a list of Terms applicable to this document:

Term	Description
Accepted	Determined to be satisfactory by SA Water's Representative.
Allow	Means that the cost of the item referred to is the responsibility of the Constructor
Artesian	A confined aquifer. A flowing artesian bore flows to the surface when bore drilled through the upper confining layer. Bores that may be flowing initially but require pumping at a later stage may be categorised as flowing artesian. A confined bore that does not flow to the surface is defined as sub-artesian.
Artesian Valve	Referred to as 'Discharge Control Valve' in this document
Below Top of Casing	Datum point for depth measurements (in metres). Convention is TOC is zero, down hole is positive.
Bore	The terminology 'bore' and 'well' are used interchangeably in this Technical Standard and represent the same item. Under the Landscape South Australia Act 2019, well means: a. An opening in the ground excavated for the purpose of obtaining access to underground water; or b. An opening in the ground excavated for some other purpose but that gives access to underground water; or c. A natural opening in the ground that gives access to underground water.
Casing	Bore lining to protect and maintain the bore. Generally, extends above ground level and terminated with a flange to attach the headworks (particularly flowing artesian bores). The top of the casing (TOC) is used as a datum point for bore depth and level measurements, as well as pump setting. Convention is TOC is zero, down hole is positive.
Check Valve	Referred to as 'NRV' (Non-Return Valve) in this document
Confined aquifer	An aquifer below the surface, confined above and below by relatively impermeable material.

Term	Description
Constructor	The organisation responsible for constructing and installing infrastructure for SA Water whether it be a third party under contract to SA Water or an in-house entity.
Contract	A set of documents supplied to Constructor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.
Designer	The organisation responsible for designing infrastructure for SA Water whether it be a third party under contract to SA Water or a Constructor, or an in-house entity. A Designer is a person who effects design, produces designs or undertakes design activities as defined in the *Work Health and Safety Act 2012 (SA)*.
Design	The word design, refers to the requirement of Designers and/or Constructors to determine the equipment requirements for safe and reliable operation and ease of maintenance, inclusive but not limited to selection, physical size attributes, installation, and control, to achieve the required operational outcomes.
Discharge Control Valve	The main valve on the headworks. May be manual or automatically actuated (depending on requirements). Generally used to direct flow from the bore to discharge pipework when open, or to scour if closed. May be used for rudimentary flow control, particularly for flowing artesian installations.
Discharge Pipework	Main pipe downstream of the headworks.
Drawdown	Generally defined as the difference between the dynamic and static bore water levels, measured in metres, such as Drawdown = PWL – SWL. Convention = Down hole is positive.
Headworks	All aboveground pipework, valves, and appurtenances, from top of casing to discharge pipework.
Informative	Means “provided for information and guidance”.
Manufacturer	A person, group, or company that owns and operates a manufacturing facility that provides materials for use in SA Water infrastructure.
Must	Indicates a requirement that is to be adopted in order to comply with the Standard.
NPSHr	Net Present Suction Head Required
Person/s	Each word implying a person, or persons shall, where appropriate, also be construed as including corporations.
Provide	Means "supply and install".
Pump Intake Level	The level below top of casing (BTOCm) to the intake of the pump. Convention = TOC is zero, down hole is positive.
Pumped Water Level	The dynamic bore water level with the pump running. PWL = SWL + Drawdown. Measured in metres below top of casing (BTOCm). The maximum PWL (PWL_{max})is defined as the depth BTOCm at maximum drawdown. Generally considered as a steady state condition where the pump operates at its duty point and the bore recharges at an equivalent rate. Convention = TOC is zero, down hole is positive.
Responsible Discipline Lead	The engineering discipline expert identified in the ‘Approvers’ table (via SA Water’s Representative).
Riser	Pump discharge column, from the pump to the headworks.

Term	Description
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (for example AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Scour	Discharge from the bore that does not go into the main distribution network. Generally, discharge to drain or pit, sometimes to a discharge bore.
Shall	See 'must'
Should	Indicates practices which are advised or recommended, but is not required
Static Water Level	The static water level of the bore (unpumped). Measured in metres below Top of Casing (BTOCm). Convention = TOC is zero, down hole is positive.
Supplier	A person, group or company that provides goods for use in SA Water infrastructure.
Technical Dispensation Request Form	This form is part of SA Water's Technical Dispensation Request Procedure which details the process by which those required to comply, or ensure compliance, with SA Water's technical requirements may seek dispensation from those requirements.
Vacuum Breaker Valve	To protect riser and bore casing from vacuum. Generally installed in headworks, upstream of first headworks NRV.
Well	Refer to 'bore'. The terminology 'bore' and 'well' are used interchangeably in this Technical Standard and represent the same item.
Work(s)	Elements of a project which require design and construction

1.2.2 Abbreviations

The following is a list of Abbreviations, Acronyms and Initialisms used in this document:

Abbreviation	Description
AC	Alternating Current
ADWG	Australian Drinking Water Guideline
AS/NZS	Australian Standard / New Zealand Standard
AV	Air Release Valve
AWQC	Australian Water Quality Centre
BAL	Bushfire Attack Level
BEP	Best Efficiency Point
BSP	British Standard Pipe (Thread)
BTOCm	Below Top of Casing (measured in metres)
CCA	Copper Chromium Arsenate
DCS	Distributed Control System
DEW	Department for Environment and Water
DICL	Ductile Iron Cement (mortar) Lined
DOL	Direct Online
EWS	Engineering and Water Supply
FM	Flowmeter

Abbreviation	Description
FRE	Fibre Reinforce Epoxy
FRP	Fibreglass Reinforced Plastic
GRE	Glass Reinforced Epoxy
HMI	Human-Machine Interface
I/O	Input/Output
IP	Ingress Protection
IRP	Iron Removal Plant
LT	Level Transmitter
MAR	Managed Aquifer Recharge
MCC	Motor Control Cubicle
MFP	Major Framework Partner
MSB	Mains Switch Board
MSCL	Mild Steel Concrete Lined
MSDS	Material Safety Data Sheet
NPSHr	Net Pressure Suction Head (required)
NRV	Non-Return Valve (allows flow in one direction only)
ODS	Operational Data Store
PLC	Programmable Logic Controller
PM	Project Manager
PRV	Pressure Reducing Valve
PSV	Pressure Sustaining Valve
PVC	Polyvinylchloride
PWL	Pumped Water Level
RTU	Remote Telemetry Unit
SA Water	South Australian Water Corporation
SANTS	South Australia Native Title Search
SCADA	Supervisory Control and Data Acquisition
SiD	Safety in Design
SP	Self-Potential
SS	Stainless Steel (materials), Soft Starter (electrical)
SWL	Static Water Level
TDRF	Technical Dispensation Request Form
TG	(SA Water) Technical Guideline
TOC	Top Of Casing
TS	SA Water Technical Standard
UV	Ultraviolet
VSD	Variable Speed Drive
WQ	(SA Water) Water Quality
WTP	Water Treatment Plant
WWTP	Waste Water treatment Plant

1.2.3 Terminology

The following is a list of specific interpretations for Terminology used in this standard.

- Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Constructor.
- Directions, instructions and the like, whether they include the expression "the Constructor shall" or equivalent, shall be directions to the Constructor, unless otherwise specifically stated.
- Where a submission, request, proposal is required and it is not stated who the recipient should be, it is to be provided to SA Water's Representative for review.
- Each word imparting the plural shall be construed as if the said word were preceded by the word "all".
- "Authorised", "approval", "approved", "selected", "directed" and similar words shall be construed as referring to the authorisation, approval, selection or direction of SA Water's Representative in writing.
- "Submit" mean "submit to the SA Water Representative or their nominated delegate".
- Unless noted otherwise, submissions, requests, proposals are to be provided at least 10 business days prior to work commencing or material ordering (unless noted otherwise).

1.3 References

1.3.1 Australian and international

The following table identifies Australian and International standards and other similar documents referenced in this document:

Reference	Title
N/A	Minimum Construction Requirements for Water Bores in Australia, Fourth Edition (2020), National Uniform Drillers Licensing Committee 2020
N/A	General specification for well drilling operations affecting water in South Australia, Published by the Department for Environment and Water, Government of South Australia, July 2021
AS/NZS 1170 (Series)	Structural design actions
AS/NZS 1554 (Series)	Structural steel welding
AS/NZS 1680.2.1	Interior and workplace lighting
AS 1725.1	Chain link fabric security fences and gates
AS 1768	Lightning Protection
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008.1.1	Electrical installations – Selection of cables: cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions
AS/NZS 3010	Electrical installations – generating sets
AS 3100	Approval and test specifications – General requirements for electrical equipment
AS 3600	Concrete structures
AS/NZS 4020	Testing of products for use in contact with drinking water
AS 4041	Pressure piping
AS 4087	Metallic flanges waterworks purposes
AS 4100	Steel structures
AS/NZS 4671	Steel for the reinforcement of concrete
AS/NZS 4680	Hot dip galvanised (zinc) coating on fabricated ferrous articles
AS 4795	Butterfly valves for waterworks purposes
AS 5216	Design of post-installed and cast-in fastenings in concrete
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS/NZS 61439 (Series)	Low-voltage switchgear and control gear assemblies
ISO 9001	Quality Management System
Manual No. 32	SA Power Networks Service & Installation Rules
WSA 109	Bolt Tightening Procedure for Mechanical Plant

1.3.2 SA Water documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Reference	Title
SAWO-OPS-0006[1]	Bore Pump Removal & Installation Procedure
SAWO-WS-0003[1]	Bore Drilling Compliance Requirements
SAWO-WT-0053[1]	Bore Disinfection
SAWO-WT-0055[1]	Bore Drawdown Procedure
SAWP-WQ-0032[1]	Validation of Water Quality for a New Production Bore
SAWS-WQ-0004[1]	New/Modified/Refurbished Assets - Water Quality and Monitoring Requirements for Commissioning
DWQMS	Barrier Management - Bores
TG 0638	General Technical Information for Geotechnical Design - Hydrogeology
TS 0105	Quality requirements
TS 0100	Requirements for Technical Drawings
TS 0101	Safety in Design
TS 0109	Infrastructure Design
TS 0120	Electronic Security Installation Standards
TS 0121	Physical security site standards general definitions
TS 0132	Operating and Maintenance Manuals
TS 0133	Requirements for Asset Labelling
TS 0220	Requirements for Pump Specification, Procurement and Testing and The Preparation of Pump Datasheets
TS 0260	Requirements for Flow Meters
TS 0270	The Design & Construction of Small / Medium Gas Chlorination Systems
TS 0300	Supply and Installation of Low Voltage Equipment
TS 0350	SCADA Systems
TS 0351	IoT/IIoT Systems
TS 0360	PLC and HMI Systems
TS 0503	Authorised Products for Water Systems
TS 0522	Allowable pipe size, class, and materials for reticulation water mains
TS 0601	Design, Assessment and Retrofitting of SA Water Assets in Bushfire-Prone Areas
TS 0710	Concrete
TS 0800	Materials in Contact with Drinking Water
TS 147	Surge Mitigating Infrastructure
TS 15	Protection of Steelwork in Submersible Environments
TS 16	Protection of Steelwork in Atmospheric Environments
TS 18	Protection of Steelwork in Buried Environments
TS 59	Specification for EWS Departmental Flanges – 1983 (Reference Specification Only)

1 Available upon request from the Manager of Water Quality Improvement and Compliance.

Reference	Title
TS 98	Surface Preparation and Protection of Cast Iron Using Potable Water Approved Ceramic Filled Solventless High Build Epoxy

2 Scope

2.1 Scope and application of this Technical Standard

This Standard is applicable to new or existing ADWG compliant water and non-drinking water groundwater systems, including repairs, upgrades, operations, and maintenance.

The Technical Standard sets out the requirements for technical design, specification, procurement, testing, commissioning and delivery of groundwater bores and submersible pumping assets, to ensure SA Water achieves safe and reliable groundwater systems.

In the interests of public health protection, all SA Water employees and Constructor are responsible for the management and provision of water supplies, shall ensure compliance with the requirements of this document.

During the design or upgrade of any infrastructure in the future, this standard shall be complied with, together with the relevant Australian Standards, legislative requirements, and SA Water specifications.

2.2 Objectives of this Standard

1. Consideration for water quality design requirements at an early stage of the project development for standardisation.
2. Outline the process to achieve compliance.
3. Stipulate the responsibilities of various parties involved in the development of a project

2.3 Applications of this Standard

This Technical Standard is applicable to:

1. all bores constructed in ADWG compliant drinking water systems.
2. when repairs, upgrades, replacement, or refurbishments occur on existing bores in ADWG compliant drinking water systems.
3. for non-drinking and remote communities utilising bores, to achieve the best possible water quality.
4. WTP and WWTP process water bores.
5. Irrigation water bores.
6. This Technical Standard can also be used to specify submersible pumps for "Pump-In-Can" applications (bore style pump within a pipe, refer Appendix B1), however not all requirements listed in this Technical Standard will be applicable.

2.4 Works not in scope

1. Monitoring bores (refer TG 0638).
2. Springs, in-creek sumps or similar.
3. Discharge pipework.
4. Surge mitigation (refer TS 147).
5. Chlorination and other treatment systems (refer TS 0270).
6. Recycled and stormwater Managed Aquifer Recharge (MAR) systems that use injection and/or extraction bores.

2.5 Technical dispensation

Departure from any requirement of this Technical Standard shall require the submission of Technical Dispensation Request Form (TDRF) SAWT-ENG-0015 - Dispensation Request Procedure Template.docx for the review and approval (or otherwise) of SA Water Responsible Discipline Lead listed in Page 5, on a case-by-case basis.

The Designer shall not proceed to document/incorporate the non-conforming work before the Principal Engineer has approved of the proposed action in writing via the Technical Dispensation Request Form (TDRF).

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

Design works that are carried out without being appropriately sanctioned by SA Water shall be liable to rejection by SA Water and retrospective rectification by the Designer/Constructor.

2.6 Hazards

Hazards shall be identified and addressed in accordance with TS 0101.

3 Hold points and witness points

3.1 Hold points

Hold points applicable to this Technical Standard can be found in Appendix A. Please refer to TS 0105 for further detail on hold points.

3.2 Witness points

Witness Points applicable to this Technical Standard can be found in Appendix A. Please refer to TS 0105 for further detail on witness points.

3.3 Non-conformance

Please refer to TS 0105 for the requirements relating to non-conformance.

4 Water Quality and Testing Considerations

Construction of a bore water supply asset requires specialist knowledge and experience and shall be constructed under instruction from a qualified and experienced hydrogeologist. Reference shall be made to the document, Minimum Construction Requirements for Water Bores in Australia.

4.1 Site Selection

Site selection is a highly specialised activity and skillset. The site selection requires consultation with SA Water, specifically Hydrogeologist (Water Supply & Security), the Manager/Technical Support Officer (Production & Treatment) with the addition of environmental expertise, native vegetation, native title, and aboriginal heritage groups.

In most cases approvals are required and as such the fore mentioned groups / person(s) within SA Water shall be consulted (refer SAWO-WS-0003, Bore Drilling Compliance Requirements). SA Water Property Operations team will also need to be consulted to ensure legal access to the site, transfer, or purchase of land.

Native Title is managed through SANTS and will need to be considered for Native title sites, land where Native title not extinguished and crown land. The land ownership can be seen in Aquamap or via Property Team. Locating a bore in road reserve may be considered.

All water supply bores shall be positioned a suitable distance from any known sources of contamination or designed and constructed to eliminate all sources of contamination. Bore site selection shall consider the following factors:

Proximity to local pollution sources such as:

a. Septic tanks or other waste disposal systems.

b. Refuse dumps.

c. Storm water drainage and flood prone risks.

d. Commercial/Industrial enterprises (for example Chemical fertilizer stores and underground fuel tanks).

e. Stock and/or wildlife.

f. Old sheep dip sites (historically used chemicals containing arsenic).

g. Old sites where permapine posts were treated with CCA (Copper Chromium Arsenate).

The selection of a site shall be informed (in part) by process of a risk assessment, ensuring any existing or historical activity in proximity to the proposed bore site that may adversely affect water quality is assessed and eliminated and/or appropriately controlled.

Other factors (in brief) must be assessed in the appropriate selection of a bore water supply site, are (but not limited to):

1. Source water – DEW licence and permits.
2. Land ownership – SA Water or other.
3. Required pad size, including consideration for construction phase.
4. Native title – Commonwealth.
5. Heritage (European and First Nations) – State.
6. Proximity to residential (noise consideration).
7. Access conditions – road, driveway, vegetation.
8. Road verge proximity and on-going safety to SA Water staff and supporting personnel. If a bore site is to be located on a road verge, then the designer shall design and make allowance for any protective barriers to ensure safety for any on site works / activities.
9. Infrastructure proximity (existing and proposed), belonging to SA Water or Third Parties.

10. Overhead / aboveground assets / infrastructure – potentially impacting drilling operations.
11. Power supply provisions and type of service.
12. Site topology and stormwater drainage conditions.
13. Proximity of site to any existing bore.
14. The need for chlorine dosing for disinfection requirements and the proximity to any sensitive receptors.
15. Existing water supply network configuration, storage, and the resultant connection requirements.
16. Any existing bore(s) in the water supply network shall be capable of mixing with another source to ensure compliance with ADWG, ensuring pump hydraulics and water quality have been confirmed for such operation.
17. Groundwater flow direction (ideally bores should not extract water from up or down flow of another bore, for example in the 'shadow' of existing bore/s or downstream of potential contamination sources).
18. Proximity to coast- seawater intrusion can affect groundwater near coastal areas.
19. Water table depth.
20. Abstraction depth.
21. Confining layers.
22. Hydraulic conductivity.
23. Water characteristics and likelihood of iron bacteria.
24. Soil and rock characteristics.
25. Use of any irrigation in proximity.
26. Rate of drawdown and the potential:
    a. Flow of contaminants from shallower aquifers.
    b. Ground subsidence due to groundwater drawdown.
27. Environmental - Native vegetation & bushfire considerations.
28. Flood prone area and watercourses.
29. Environmental activities around unconfined or fracture rock aquifers cultural/historical significance.
30. Proximity to injection wells.
31. Underground services.
32. Hazards identified in SiD review workshops or other safety forums.

Once a bore site location has been finalised, a well construction permit will need to be sought from the Department for Environment and Water (DEW). The drilling must then be undertaken by an appropriately licensed driller. All drilling activity shall comply with all conditions of the permit approval.

Test bores/pilot holes also require a well construction permit from DEW for the drilling activity.

4.2 Water Protection Areas

Water protection areas can be included in State development planning and water allocation plans. Water licences/allocations are required in prescribed wells areas to be able to extract the water. The EPA establishes and manages Groundwater Prohibition Areas to prevent actual harm to human health or safety from site contamination that affects or threatens groundwater.

4.3 Bore Water Quality Considerations

It is a requirement that all components and materials used that will be in direct contact with drinking water shall comply with TS 0800 and testing to AS 4020.

For all new bore or major refurbishment, Project Managers should consult with SA Water's Hydrogeologist (Water Security) and the relevant Technical Support Officer (from Production & Treatment). Refer to Minimum Construction Requirements for Water Bores in Australia, for detail.

This Technical Standard does not replace the need to engage the appropriately experienced personnel for a bore water project or bore water refurbishment works. Refer Table 1 for responsibilities.

Table 1: Design and Construction Responsibilities

	Engineering	Hydrogeologist	WQ TSO	Project Manager
Bore site selection, bore drilling and decommissioning		Y		
Construction design details (for example screens)		Y		
Drilling advice		Y		
System knowledge, site specific for design and construction			Y	
Approval of headworks design, pump sizing and selection	Y			
Approval of materials used	Y			
Commissioning			Y	
Water samples				Y
Permits				Y

4.4 Bore Water Testing

At the earliest possible stage in the construction of a bore, the groundwater quality should be examined to determine the suitability of the supply prior to any bore head construction occurring (refer to "General specification for well drilling operations affecting water in South Australia").

If possible, and particularly if there will be considerable time between air lift and pump test stages of construction, a water sample should be collected at the air lift stage to assess water quality. A second suite of water samples should then be collected at the pump test stage to verify a broader range of parameters.

Water quality and chemical characteristics of the bore water shall be determined and issued to SA Water's representative. Water samples are taken by Hydrogeologist/PM/TSO and sent to AWQC for airlifting/development, and commissioning phases (typically at the completion of the pumping test).

Details of required steps and analysis test lists, along with final commissioning requirements can be found in:

- SAWP-WQ-0032 Bores – Validation of Water Quality for a New Production Bore - This procedure refers to determining and validating the water quality of a new bore as a water source. It is essential that this is completed PRIOR to the bore being equipped.
- SAWS-WQ-0004 New/Modified/Refurbished Assets - Water Quality and Monitoring Requirements for Commissioning - This guideline is to be followed once a new bore has been equipped and prior to the bore being brought on-line.

4.5 Mandatory Reporting

The Department for Environment and Water (DEW) requires the Corporation to report in line with the conditions of the water licence including some or all the following parameters:

1. Bore flowmeter readings (flow and totalised volumes).
2. Bore flowmeter serial numbers.
3. Monitoring bore water levels (Eyre Peninsula only).
4. Bore electrical conductivity (salinity).

5 Bore Drilling

Bore drilling and construction requires specialist knowledge and must be undertaken by appropriately licensed drillers (refer to Minimum Construction Requirements for Water Bores in Australia).

During construction of the bore, good practices must be adopted to eliminate the potential of cross contamination from the drilling process and prior to final commissioning.

5.1 Bore Drillers

It is a requirement that an appropriately licenced driller be used for the drilling operation of a new bore or modifications or decommissioning of an existing bore. Drilling licences are classified into three classes, as noted in clause 5.1.1.

The key considerations for bore drilling are dependent on the known aquifer type (non-flowing or flowing) and the required depth of the bore. Reference to the "Water Bore Driller's Licensing Handbook" can be made for further information.

To protect the groundwater source and the new bore from bacterial contamination during drilling, it is a requirement that all drilling equipment be cleaned and disinfected to prevent transfer of microbiological organisms (such as iron bacteria) between sites. Refer to SAWP-WQ-0032 forr further information.

To protect the groundwater source from chemical contamination during drilling operations, chemicals and other drilling fluid additives that could leave a residual toxicity shall not be added to drilling fluids or cement slurries used to drill and complete any water supply bores (MSDS needs to be provided prior to any chemical being used onsite and issued to the SA Water's representative for review and acceptance). Only approved chemicals shall be used in bore construction works. Advice on suitable chemicals can be obtained from WQ, in consultation with the Environmental Team. The drilling fluid will be removed from the borehole during development testing of the bore to allow the subsequent installation of pumping infrastructure and fittings.

5.1.1 Licence Classes

The system comprises three classes of licence listed in the drilling method endorsements, of Clause 5.2.

- **Class 1** – This class of licence permits work in non-flowing (sub artesian) single aquifer systems. They are not allowed to drill through the upper aquifer formation to tap deeper formations.
- **Class 2** – In addition to Class 1 work, a Class 2 licence permits work in non-flowing (sub artesian) multiple aquifer systems. Class 2 drillers are allowed to drill through the upper aquifer formation to tap deeper sub artesian formations.
- **Class 3** – In addition to Class 2 work, a Class 3 licence permits work in flowing (artesian) aquifer systems. Drillers working in artesian aquifers require a higher level of knowledge and skill than Class 2 drillers, because they need to construct water bores in ways that allow them to control hydrostatic pressures and undertake deeper pressure cementing.

SA Water requires drillers to be licenced accordingly to the type of aquifer to meet DEW permit conditions.

5.2 Drilling Method Endorsements

Water supply bore drilling licences are endorsed by the hydrogeologist for one or more of the following drilling methods:

1. Auger: bucket, hollow-stem, or solid-stem auger techniques.
2. Rotary air: pneumatic rotary drilling techniques including down-hole hammers.
3. Rotary mud: water or water-based hydraulic rotary drilling techniques (approved by WQ).
4. Non-drilling rig: spear point construction and the construction of water wells.
5. Sonic-drilling operations which use vibration (resonation) and downward force to advance the drill string and where the formation is retrieved via a core.
6. Dual rotary: uses two separately operated rotary-drive mechanisms; a top drive that rotates the drill string and bit, and a lower drive that rotates and advances steel casing.

For town water supply and monitoring wells SA Water generally drill with rotary air and/or rotary mud drilling rigs. A dual rotary rig (drilling with air) has been used in a sensitive area around the Blue Lake, Mt Gambier.

5.3 Formation Sampling

Formation samples (Figure 1) are taken to define the geology and hydrostratigraphy, determine the screen or open hole water producing zones, select screen aperture size and identify any potential contaminants or geological features to avoid. It is important to understand these zones as they will affect the direction of groundwater flow and/or contaminant transport beneath the site. If not nominated in the project specification, the samples are to be collected not less than once every 3m with samples collected every 1-2m in the aquifer. Not less than one sample will be collected from each identified geological unit. Consultation with SA Waters Environmental team is required to plan this formation sampling **HOLD POINT**.

Figure 1: An example of formation sampling

5.4 Logging

Logging shall be provided as requested by the Hydrogeologist. The following types of logging are commonly used. Note: This is not inclusive of all logging methods.

1. Geophysical:
   a. Natural gamma and self-potential (SP):
      - Used to detect lithological boundaries and to identify formations containing clays and shales.
      - Inform screen design and confirm placement of screen.

   b. Neutron:
      - Indicator of moisture content.
      - Inform screen design and confirm placement of screen.

   c. Calliper:
      - Continuous record of well or borehole diameter that can be used to detect broken casings, the location of fractures, solution development, washed-out horizons, and hydrated clays. Diameters are “sensed” using multiple feeler arms or bow springs.
      - Confirm casing installation.

   d. Electrical conductivity:
      - Indicator of salinity change with depth.
      - Used to detect seawater intrusion.

   e. Borehole magnetic resonance (BMR):
      - Measures water within the rock/sediment matrix.
      - Direct measurement of porosity, bound fluid (specific retention), free fluid (specific yield) and permeability (hydraulic conductivity)

   f. Verticality:
      - Borehole verticality will be continuously checked during drilling. Plumbness shall be of 1° maximum per 15m depth in any direction. Constructor to carry out rectification work (at their own cost) to correct any out of tolerance.

2. Camera:
   a. At the completion of the new well construction, camera footage is taken as a baseline record of construction.

   b. SA Water may elect to undertake a camera audit of a borehole. The SA Water representative shall be advised not less than ten (10) working days prior to drilling to allow planning of the audit. The drilled shall be advised on the day if an audit shall take place.

3. Dummy pump test:
   a. For newly constructed wells, to test verticality of well and suitability for intended purpose.

5.5 Bore Casing/Screens

The bore casing is a pipe that protects the borehole from collapsing and provides a secure and leak-proof conduit from the aquifer (water source) to the surface. The space between the casing and the surrounding rock/sediments, the annulus, needs to be filled with flowable cement grout to which other additives (for example bentonite) may be added to enhance its properties to stop surface water or other groundwater contamination, transferring between aquifer zones and to protect the casing from soil (refer 4.6).

The bore casing must be designed and selected to withstand installation and construction activities, and dynamic operational cyclic pressures and to achieve the required design life.

The selected casing material and overall diameter of the bore casing shall be sufficient to accommodate for the following:

1. Size of the pump (diameter):
   a. Include required clearances for water flow (specified by manufacturer).
   b. Allow for a flow sleeve (shroud) around the outside of the pump motor (refer to clause 7.2.2).
   c. Additional clearance to allow for the casing not being perfectly straight.
2. Electrical and instrumentation control (if any) cables and associated fittings. Cables to be AS 4020 /potable water compliant and chlorine stable.
3. Airline for manual water level readings.
4. Polyline to allow hydrostatic level sensors to be easily removed for maintenance or replacement, without removal of the pump.
5. The possibility of weld edge, fasteners and fittings projecting inside the joints of the casing.
6. Any potential corrosion issues.

A range of casing materials are available, and casing selection depends on several major factors. These include:

a. Strength requirements.
b. Pressure and operating conditions.
c. Disinfection practices.
d. Potential to cause water quality issues.
e. Ease of handling.
f. Type of aquifer formation.
g. The specific bore design.

Groundwater can enter the bore from the water production zone via an open hole, slotted/perforated casing, or screen. Selecting the correct production zone on completion is especially important and it is required to be designed to maintain its integrity during the stages of construction, development, and ongoing operation. Screen openings and/or slot/perforation sizes, whether part of the casing or separately fitted shall be designed to optimise the water flow into the bore whilst allowing the bore to retain a stable formation over time and ensuring the ingress of unacceptable materials (for example excessive sand) is avoided. Screen length and length over which slots/perforations are provided on the casing shall be selected appropriately to the aquifer thickness being screened. Screen openings and/or slot/perforation sizes shall be designed and optimised such that there is no hydraulic restriction to flow, or limitation on supply to the submersible pump resulting in any potential for cavitation, low available suction pressure and the resultant reduction in hydraulic performance and reduced pump asset life.

Generally, the slot, perforation or screen opening size will be determined by a combination of:

1. Hydrogeological investigation and input from the drilling operation.
2. Analysis of the gradation of the aquifer materials, including via sieve analysis or other particle size distribution tests.
3. Entrance velocity of water based on flow requirement.
4. Hydraulic inlet conditions to the submersible pump.

Screen and casing slot/perforation materials whether part of the casing or separately fitted shall be selected to suit the expected water quality and characteristics of the bore and for the required design life of the bore.

Nominated screen materials are either slotted PVC, wound PVC, stainless steel (grade 316 minimum) or open hole (such as no screen, using natural rock). Slotted FRP/GRE screens are also available; however, these are not widely used and would need to be considered on a site-specific basis. Screens shall be free from defects and shall be corrosion resistance for the known water quality and chemical characteristics of the groundwater. Table 2 summarises the types of bore casing materials used in bores, including their advantages and disadvantages. Refer Minimum Construction Requirements for Water Bores in Australia, 2012, as listed in clause 1.3.1 for further information on casing material minimum grades and technical data related to collapse resistance of pipework used for casings.

The protruding casing should be elevated, and the first joint extend at least 3m down to prevent surface run-off or other potential contamination entering the bore (especially during the design rain events/flood).

Casings and screens should be kept in their protective covers (if available) until required for installation to protect the new bore from bacterial and other contamination.

The minimum requirement for welding procedures and welding qualifications shall be AS 1554.

Table 2: Bore Casing Materials Comparison

Material Type	Advantages	Disadvantages	Initial Inspection (years)[2]
PVC-U (Un-plasticised polyvinyl chloride) Minimum Class 12 (PN 12)	• non-corrosive • readily available in small diameters • light and easy to handle and join • inert	• Temperatures greater than 20°C can derate the pressure rating • Embrittlement of the PVC, causing "windows" to fall out • Low in compressive strength relative to mild steel • Requires care in handling, storage, and installation to prevent breakage/distortion, UV degradation and loss of mechanical properties. • Low mechanical impact strength (must be protected from damage, for example moving vehicles, contact with drilling tools and fire) • Can float in a bore during installation. • The material is prone to fatigue stress due to cyclic pressure variances. • Chemical attack of pipes in contact with Volatile organic compounds. • Only for up to 120-150m depth	25
FRP (Fibreglass-reinforced polyester resin) GRE (Glass-reinforced epoxy) GRVE (Glass-reinforced vinyl ester)	• Preferred casing material • Corrosion resistant • Does not require de-rating for temperatures below 80°C • Can be custom-made for applications (for example with specific collapse and tensile strengths) • Suitable for deep bores • GRE is stronger and has higher chemical resistance than FRP • Lightweight casing	• Mechanical impact damage to the external surface of the casing during installation or transport results in delamination within the material • Poor repairability • Resin type, breaking down dependent on temperature causing fibre-spars • FRP/GRE casings have bigger bells	25

[2] This is a suggested time period only, based on an information published by various agencies in Australia and Internationally.

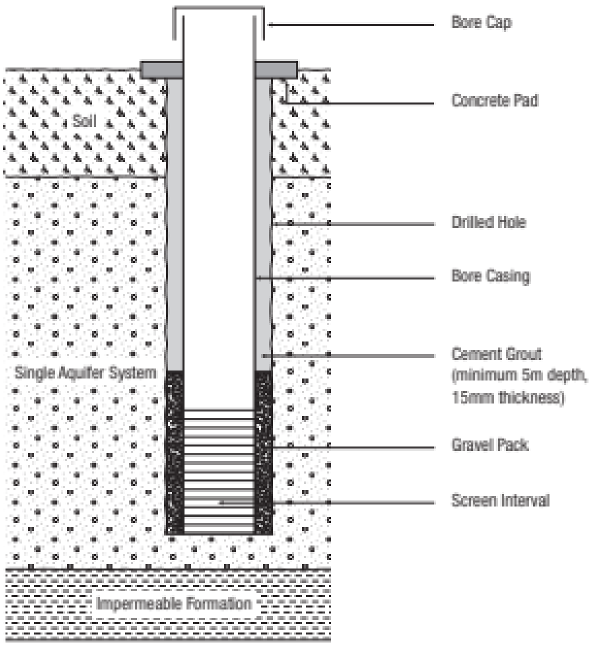
Material Type	Advantages	Disadvantages	Initial Inspection (years)[2]
Stainless steel (Minimum Grade 316)	• Grades matched to soil and water chemical characteristics and temperature providing a higher corrosive resistance than mild steel	• In the presence of high salinity (More than 1,000ppm of chloride), and elevated temperature corrosion conditions can be initiated. • Microbiological induced corrosion. Refer to TS 0730 for details. • Prefer not to have long lengths of stainless steel as could leach metals if water not pumped for long periods of time. • Galvanic corrosion can occur if not isolated from other metals	25

Historically steel/mild steel has been used for bore casings, however this is not allowed by SA Water due to corrosion, water quality and durability issues.

5.6 Seals

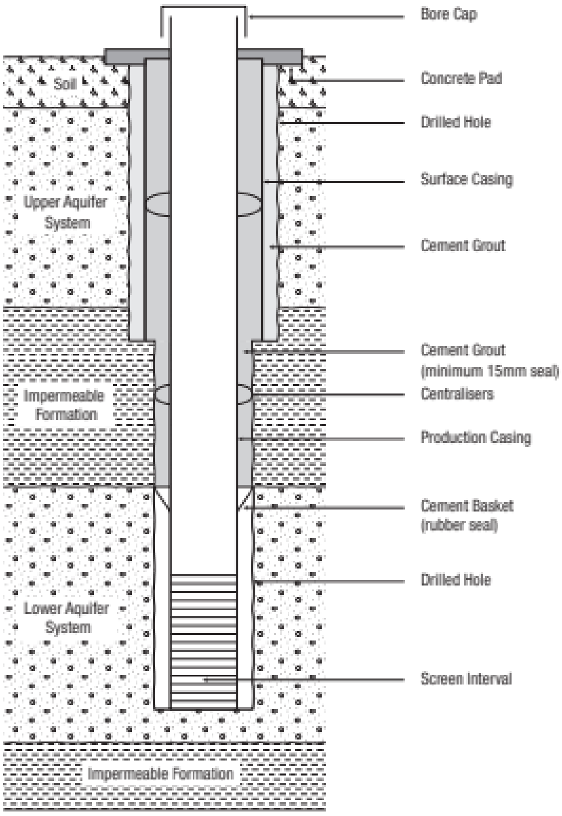
The production casing shall be fully grouted within the annulus space between the casing and surrounding drilled bore from casing bottom to ground level (refer Figure 2,

Figure 3 and Figure 4). Exceptions to this are in karstic environments (for example Unley South, or Mt Gambier) where voids exist resulting in large ‘annulus’ volumes which would require excessive volumes of cement grout. Alternative grouting methods for example ‘spot or slump grouting’ can be employed in agreement with the Water Security hydrogeologist.



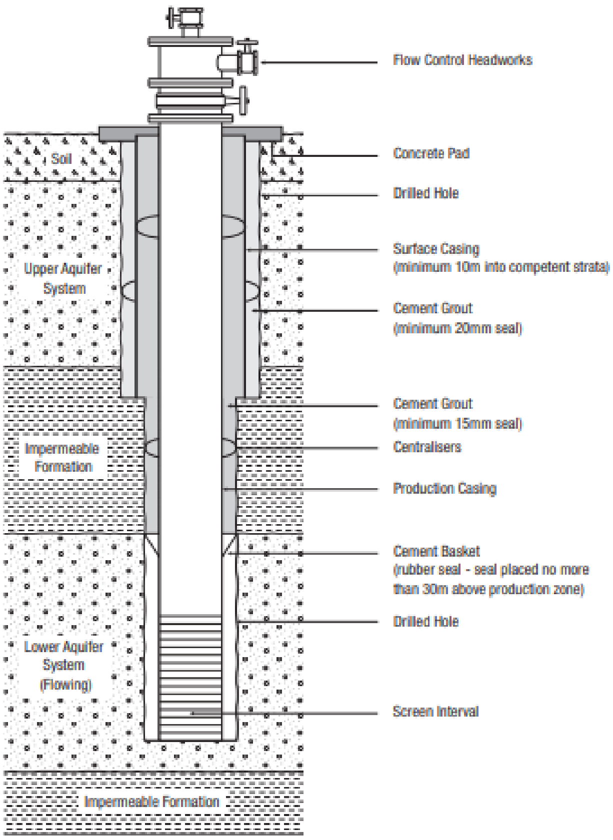
Minimum Construction Requirements for Water Bores in Australia, 4th Ed.

Figure 2: Single aquifer bore example



Minimum Construction Requirements for Water Bores in Australia, 4th Ed.

Figure 3: Multiple aquifer bore example



Minimum Construction Requirements for Water Bores in Australia, 4th Ed.

Figure 4: Flowing aquifer bore example

All bores should be sealed with a continuous dense lining to:

1. Protect the groundwater resource from any external contamination.
2. Maintain aquifer water pressures and quality.
3. To isolate the target production zone from other formations.
4. Prevent the transfer of groundwater between different aquifers.
5. Seal off poor-quality aquifers.
6. Prevent surface water run-off from reaching the aquifer.
7. Prevent shallow subsoil contamination or pollution from reaching the aquifer.

To prevent external surface run-off or other potential contaminates entering the bore (especially during significant rain events / flooding) sealing must be achieved:

a. In the annular space between the casing and the bore headworks. This is typically specified as grout as per the "Minimum Construction Requirements for Water Bores in Australia."
b. Between the casing and ground. This is typically bolted connection between the bore casing flange, adaptor flange and above ground pipework flange. The outside Section of the casing is protected by concrete plinth.

Seals should ensure the protection of the bore from human interference.

Head works pipework and concrete slab will control the flow of water and protect the bore from the entry of any contaminants. If the bore must be in an area subjected to potential flooding, the casing should be raised above the design flood level or, if it is not feasible, completely sealed to prevent the entry of any floodwater.

5.7 Bore Yield Testing

Bore Yield Testing (aquifer test or pumping test) is conducted by pumping a bore and observing the aquifer response or drawdown in the well (bore) and/or neighbouring observation wells (bores). Pumping tests are important and a requirement to determine the following components and system characteristics:

a. Ability of the aquifer to store and transmit water.
b. Identify hydraulic boundaries which may affect long term performance.
c. Long term pumping rate (or production capability of the bore).
d. Performance of the groundwater basin.

It is a requirement to complete two sequential pumping tests:

1. Step rate:
    a. Determines hydraulic behaviour of bore under pumping stress.
    b. Identifies pumping rates and yield drawdown curves.
    c. Identifies maximum sustainable pumping rate.
2. Constant rate discharge:
    a. Determines hydraulic behaviour of the aquifer under pumping stress.
    b. Identifies hydraulic boundaries which may affect long term performance on pumping.
    c. Dewatering of aquifer.
    d. Interference with neighbouring wells (bores).

This information/data is required to determine the hydraulic characteristics associated with selecting the bore style submersible pump. Above ground motors are not typically used due to noise to adjacent neighbours.

The Designers/Constructors hydrogeologist shall specify what aquifer tests are required for proving the bore is fit for use.

The pump test may result in large volumes of water being discharged from the well and requires appropriate management to meet environmental and stakeholder expectations.

6 Production Bore Design Requirements

Design requirements refer to the specification, selection, and sizing of bore water supply equipment to achieve required hydraulic and operational outcomes.

The pad shall be laid out with due consideration for the operability and ongoing maintenance of the site. Refer to the Bore Pump Removal & Installation Procedure (SAWO-OPS-0006).

The following shall be considered, where applicable:

1. Bore headworks (including concrete slab).
2. Scour arrangement (if applicable).
3. Electrical building/hut (if required).
4. Security clearances and requirements.
5. Distribution considerations.
6. Pad layout miscellaneous:
   a. Bore pipe laydown area to allow safe storage and handling of bore pipes during construction, maintenance, demolition, and removal.
   b. Crane truck hard stand shall allow for:
      - Safe and clear access over bore for pump retrieval (through access for crane truck preferred), and turning area required for access & egress.
      - Hardstand area suitable for crane to safely deploy outriggers and life design loads to service the site.
   c. Spoil management area for.
   d. Surface drainage at the site shall be managed.
7. Clearance zones around the hardstand area to allow safe operation of the crane.
   a. Generator Pad
      - Safe access and egress for delivery and deployment of generator.
      - Generator pad shall be close to electrical building & adjacent to Main Switch Board (MSB).
      - Consideration shall be given to safe refuelling of the generator.
8. Consideration must be given to:
   a. Cable runs between the generator and the connection point.
   b. Site security and fencing.

All dimensions shall be determined on a case-by-case basis after determining the appropriately sized vehicles proposed to service the site. Nominated vehicle dimensions, lifting plans and clearance zones must be clearly identified and submitted to the SA Water Representative for approval.

Most bore sites are rural and remote. A Bushfire Attack Level (BAL) shall be considered on a case-by-case basis. Additional measures to protect hardware may be required (not covered by this Technical Standard), if warranted by the BAL assessment.

6.1 List of Applicable Regulations and Design Codes

The project (design, construction and documentation) shall be carried out in accordance with all the relevant and current, including (but not limited to):

1. Requirements prescribed by relevant Regulatory Authorities:
    a. Work, Health and Safety Act and Regulation 2012.
    b. WSAA Code and SA Water's Supplements (including Water Supply Construction Manual).
    c. Landscape SA Act 2019.
2. SA EPA Guidelines.
3. Australian Drinking Water Guidelines:
    a. Health-Based Targets for Drinking Water Safety, Water Services Association of Australia.
4. Australian Standards, International Standards & Guidelines, including (but not limited to):
    a. AS/NZS 1170(Series) Structural design actions.
    b. AS/NZS 1554(Series) Structural steel welding.
    c. AS/NZS 1680.2.1 Interior and workplace lighting.
    d. AS 1725.1 Chain link fabric security fences and gates.
    e. AS 1768 Lightning Protection.
    f. AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules).
    g. AS/NZS 3008.1.1 Electrical installations – Selection of cables: cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions.
    h. AS/NZS 3010 Electrical installations – generating sets.
    i. AS 3100 Approval and test specifications – General requirements for electrical equipment.
    j. AS 3600 Concrete structures.
    k. AS/NZS 4020 Testing of products for use in contact with drinking water.
    l. AS 4041 Pressure piping.
    m. AS 4087 Metallic flanges waterworks purposes.
    n. AS 4100 Steel structures.
    o. AS/NZS 4671 Steel for the reinforcement of concrete.
    p. AS/NZS 4680 Hot dip galvanised (zinc) coating on fabricated ferrous articles.
    q. AS 4795 Butterfly valves for waterworks purposes.
    r. AS 5216 Design of post-installed and cast-in fastenings in concrete.
    s. AS 60529 Degrees of protection provided by enclosures (IP Code).
    t. AS/NZS 61439 (Series) Low-voltage switchgear and control gear assemblies.
5. SA Water Technical Standards, including (but not limited to):
    a. TS 0100 Requirements for Technical Drawings.
    b. TS 0101 Safety in Design.
    c. TS 0109 Infrastructure Design.
    d. TS 0120 Electronic Security Installation Standards

e. TS 0121 Physical Security Site Standards
f. TS 0132 Operating and Maintenance Manuals
g. TS 0133 Requirements for Asset Labelling
h. TS 0280 Mechanical and Hydraulic Requirements During the Commissioning and On-Going Monitoring of Pumps and Associated Equipment
i. Flanged Connections
    - TS 59 Specification for EWS Departmental Flanges – 1983 (Reference Specification Only)
    - WSA 109 Bolt Tightening Procedure for Mechanical Plant
j. TS 27 Bolt Tightening Procedure for Mechanical Plant
k. TS 0220 Requirements for Pump Specification, Procurement and Testing and The Preparation of Pump Datasheets
l. TS 147 Surge Mitigating Infrastructure
m. TS 0260 Requirements for Flow Meters
n. TS 0300 Supply and Installation of Low Voltage Equipment
o. TS 0350 SCADA Net, SCADA and DCS Systems – Functionality
p. TS 0360 PLC and HMI Systems
q. Protection of Steelwork:
    - TS 15 Protection of Steelwork in Submersible Environments.
    - TS 16 Protection of Steelwork in Atmospheric Environments.
    - TS 18 Protection of Steelwork in Buried Environments.
    - TS 98 Surface Preparation and Protection of Cast Iron Using Potable Water Approved Ceramic Filled Solventless High Build Epoxy.
r. TS 0503 Authorised Products for Water Systems
s. TS 0522 Allowable pipe size, class, and materials for reticulation water mains
t. TS 0601 Design, Assessment and Retrofitting of SA Water Assets in Bushfire-Prone Areas
u. TS 0710 Concrete
v. TS 0800 Materials in Contact with Drinking Water

6. SA Water Technical Guidelines, including (but not limited to):
    a. TG 0638 General Technical Information for Geotechnical Design - Hydrogeology
7. SA Water Typical Drawings.

6.2 Design Life

The minimum design life for new assets shall be in accordance with TS 0109, the Technical Standard for infrastructure Design, unless notified otherwise by the SA Water Representative.

6.3 Bore headworks

The bore headworks generally includes all above ground pipework and associated equipment above ground (Figure 5). Refer Appendix B2 for an example of the headworks layout. For instrumentation requirements (flowmeter and sensors), refer to clause 8.2.

All components of the headworks in contact with the raw water extract shall comply with TS 0800 Materials in Contact with Drinking Water.

Figure 5: Typical view of a headworks and concrete slab / plinth

6.3.1 Slab concrete

Typically, SA Water has constructed concrete slab / plinths with at least 1.5m available either side of the bore head pipework. The required finalised dimensions of a slab shall be informed by completion of a Safety in Design (SiD) analysis and is the responsibility of the detailed designer and/or Constructor.

The slab shall be graded allowing water to freely drain away from the bore head riser. It is a requirement that the slab / plinth shall be constructed free of any tripping hazards from pipes, supports, conduits, step down/up to slab, all whatsoever.

The top Section of the bore casing shall be grouted, to prevent surface water entering the aquifer via the bore column (refer clause 6.3.3).

Above ground pipework shall not be constructed, terminated, or positioned within the concrete slab/plinth. Casting the discharge and scour discharge pipework in the slab limits the ease of completing a pipe repair or making any change to the pipework and fittings arrangements.

Pits located on the concrete plinth around the hut and bore pipework may not need to be trafficable, to be assessed. Lower rated pits are easy for operators to lift on site.

6.3.2 Pump riser

Pump risers are expected to be selected to suit the service conditions and water quality as specified on the submersible pump datasheet. Material selection considerations for the bore design life are expected to be based on the materials selection options and limitations listed in Table 2 for bore casings, where materials are either flexible or rigid. In any case, each riser shall constitute a flexible or rigid riser with anti-torque, non-rotating joints, and couplings as appropriate. The riser shall negate the pump's tendency to rotate and be able to withstand the maximum discharge pressures of the system.

The riser flange interfacing with the bore headworks shall be of standard size in accordance with AS 4087. Alternatively, an adapter shall be provided to satisfy these criteria.

The pressure rating of riser and headworks (prior to the discharge control valve) to be selected to handle maximum transient pressure conditions experienced during pump startup, but no less than PN 16.

6.3.3 Bore headworks pipework

The size of bore headworks pipework shall be determined by the designer and/or Constructor. The sizing shall be optimised to minimise head loss and achieve stable hydraulic function through the non-return valve and flowmeter.

All pipework shall be rated for the maximum and minimum operating pressures, and designed to withstand the static, gravity, pressure thrust, thermal loads, bending and dynamic forces transmitted from the pump (but no less than PN 16). These forces shall not exceed the loading limits of the installed pipework and flanging arrangements.

All above ground pipework shall be designed for ease of assembly and disassembly for the safety of SA Water operational and maintenance staff. Fabricated pipe supports or chairs are to be provided such that pipe can be supported throughout routine operation and during maintenance tasks. Determination of the type of pipe support (fixed, locking a section of pipe OR sliding, allowing axial movement) shall be the responsibility of the detailed designer and designed accordingly. Fabricated base frames of pipe supports shall be in-filled between the base plate and concrete slab with a non-shrink grout.

All flanges shall be supplied and fitted to SA Water bore headworks as per AS 4087.

Hold down anchors for the bore riser pipe fitting cast into the concrete plinth shall be specified to resist all static and dynamic loads generated by the pump, the aquifer and/or any other associated equipment that may generate a dynamic pressure response on the pipework.

SA Water bore headworks can be designed and constructed from the following materials:

1. Ductile Iron Cement Mortar Lined (DICL)
2. Mild Steel Cement Mortar Lined (MSCL)
3. Stainless Steel, Grade 316 SS. This is dependent on levels of chlorides, bore water temperature and other chemical characteristics. The SA Water Representative shall be provided with the results of groundwater quality testing to inform the final grade of stainless steel to ensure design life is achieved. Use of 316SS (or another higher grade of stainless steel) shall be subject to approval via a TDRF.

6.3.4 Air Release Valves

It is a requirement that all submersible pump water supply assets shall be fitted with an air release valve upstream of the headworks primary non-return valve. The air release valve shall be connected to the headworks via a ball valve. The discharge from the air release valves shall be directed away from the headworks and other equipment.

A second air release valve may also be considered downstream of the primary non-return valve, depending on the application. A ball valve shall be installed on top of the headworks pipe, downstream of the primary non-return valve, in case the need arises.

The air release valve shall meet the following performance and operational requirements:

1. Achieve controlled release of air from the submersible pump pipe riser during pump start-up.
2. A non-slam device – minimising any slamming potential and resultant pressure rise as the water column slams the air valve closed.
3. One way only on headworks (air release, not vacuum relief).

The bore casing also requires venting, for air movement both in and out. For non-flowing bores, a 1" BSP Stainless Steel Y strainer may be used. It has a fine strainer that will prevent the ingress of vermin and insects. Alternatively, for flowing and non-flowing bores, a two-way air release (combination) valve may be used. All bore casing vents shall be connected via a ball valve.

Designers and/or Constructors shall specify all operational and functional requirements of the air release valve in the form of a technical datasheet to be issued to air valve vendors. A datasheet shall be provided to vendors, with data associated with the physical, chemical characteristics of the water, installation conditions, and hydraulic operating conditions of the bore water supply pumping asset / facility. Air valve vendors shall return a fully completed datasheet with all requested data / information.

Furthermore, consideration shall be given to the proximity of residents. Air release valves can be noisy when operating. Additional soundproof mitigation may be required, if applicable (to be evaluated during concept design).

Air valves must be able to achieve the design life specified in this standard when exposed to, and operated in, the chemical and physical environment defined in the specification datasheet.

6.3.5 Vacuum Breaker Valve

Using a combination (two way) air release valve for vacuum relief on the headworks is not recommended as they may be an issue with contamination, pump life and ingress in flood prone areas. For new installations, the SA Water preference is for vacuum relief of the riser/headworks (upstream of the headworks NRV), to be provided by a vacuum breaker valve. The vacuum breaker shall be protected to allow air flow and avoid blockage from debris and insects.

6.3.6 Non-Return Valves

SA Water bore headworks can utilise up to two (2) Non-Return Valves (NRV) fitted within the pipework (refer Figure 6). The function of both NRV's:

1. Primary Headworks Non-Return Valve:
   a. This NRV is mandatory. It prevents backflow and potential contamination to the bore water supply and aquifer, in addition to ensuring the downstream pipeline remains charged and full of water.
2. Secondary Non-Return Valve: A duo check valve downstream, on the vertical section of the headworks just prior to discharge pipework. The secondary NRV may be installed for several reasons (to be determined during detail design phase):
   a. May be considered to prevent backflow from the pipeline through the scour. If the actuated butterfly valve or power failure were to occur during scouring (for example), there is the potential to drain downstream storage systems.
   b. After the salinity sensor (if required), to keep the sensor immersed in water to prevent build-up of calcium and representative salinity readings.

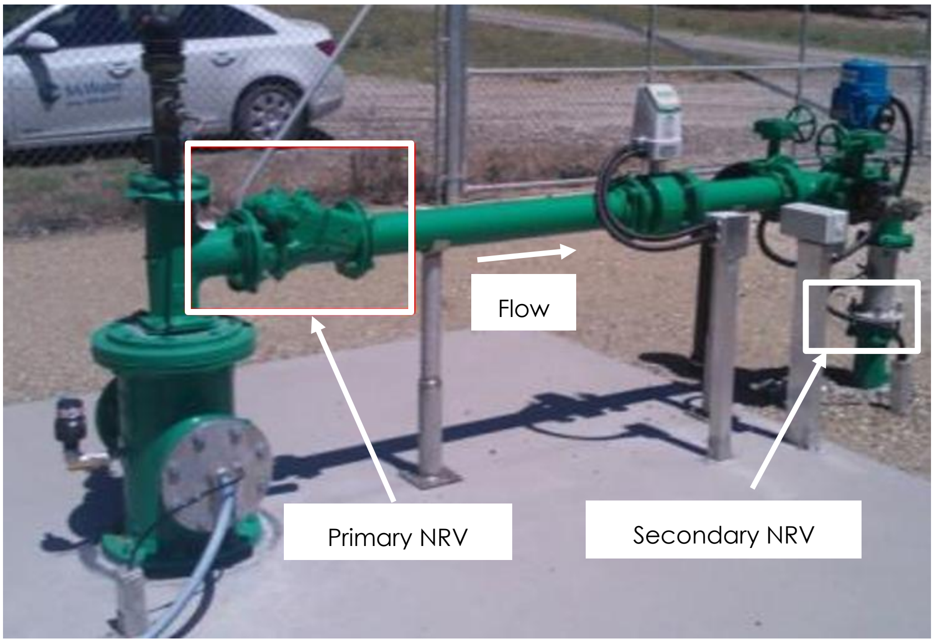


Figure 6: Bore headworks indicating primary and secondary NRV's

6.3.6.1 Primary NRV

For efficient pumping operation, the proper selection of the primary NRV is required. NRV's shall be installed with allowance for pipe lengths upstream and downstream to ensure the smooth function and disc stability throughout the full range of flow (min and max) from the submersible pump. Designers and/or Constructors shall ensure NRV's are sized according to the required hydraulic conditions of the submersible pump system and optimised against size and style/type for minimised hydraulic head loss across the valve.

A NRV must function automatically under controlled and uncontrolled hydraulic operation of the pump. A NRV shall open to allow forward flow and automatically return to its closed position to prevent reverse flow when the submersible pump is called to stop (under controlled conditions) and when under uncontrolled conditions.

The selection of a NRV shall be made against the specific percent open versus flow and pressure loss curve for the non-return valve in consideration of the operating parameters, flow rate, pressure, and velocity. The NRV performance curve shall be obtained from the check valve vendor and used in the calculation of flow and pressure loss for all system conditions identified.

The following data is also required from the non-return valve vendor and shall be presented and issued to valve vendors in the form of a NRV datasheet (a returnable schedule form):

1. Percentage open vs flow per unit pressure loss.
2. Percentage open vs flow and velocity.
3. Minimum and maximum fluid velocity required to first open and then fully open the NRV, respectively.
4. Differential pressure required for NRV to open and close.
5. Response time for check valve to reach minimum and maximum opening positions under minimum and maximum flow conditions.
6. Response time of check valve to rapid pressure fluctuations (see TS 147).
7. Requirements for lever arms, counterweights, and/or hydraulic cushioning systems (where applicable). Ensure procedure to setup counterweights is followed, to minimise flow resistance.
8. Requirements for NRV disc position monitoring.

NRV's must be selected to ensure the minimum velocity is achieved (flapping is to be avoided) and the maximum velocity through the valve is not exceeded.

There are a variety of NRV's that could be used within a drinking supply bore water system. Additionally, there are significant differences in performance, head loss and resultant pressure responses during sudden loss of power or sudden pump fault. Typically, most (if not all of SA Water) bore water supply headworks have been historically fitted with swing check (non-return) valves. This style of NRV, when used in pressure piping systems, can lead to a check valve slam event in the situation of a sudden stop in pumped forward flow. Swing NRV's can swing through a 90° stroke path and can typically fitted with external lever arms and counterweights. The long-swept path or stoke of the disc, coupled with its inertia and mass will cause the disc to slowly close, which may result in a slam condition generating on a sudden stop. The use of counterweights may minimise the likelihood of a slam event, if the additional weights can limit the degree of disc stroke (or percentage opening), but this has an on-going negative impact on SA Water's operating cost through additional head loss and resultant power usage. The counterweight, if installed, shall be set up to minimise resistance to the water flow.

Designers and/or Constructors shall select a NRV against the following criteria, presented in Table 3.

Table 3: Non-Return Valve (NRV) Selection Criteria

Selection Criteria	Comment
Head loss co-efficient	Valve selection shall be optimised to minimise the head loss experienced on the pump and ultimately to the cost of operating the system.
Non-slam characteristics	Designers and/or Constructor shall seek to develop understanding of the closing characteristics of the nominated NRV against the dynamics of the pumping systems. Proper valve selection can reduce or eliminate water hammer and slamming
Source Water Compatibility	Designer and/or Constructor shall establish physical and chemical water quality parameters of the target bore water source. This shall be achieved through a sampling regime at the bore to identify physical and chemical characteristics of the water. All physical and chemical characteristics shall be documented in the form of a technical datasheet for procurement of valves, pumps, and pipework.
Maintenance	Valve selection shall consider the need for ease of maintenance and/or repair on the valve over the design life of the installation. This shall be inclusive of the need to easily remove the valve and/or replace critical wearing components.
Supplier Support	Valve selection shall consider the likelihood of part or component replacement within the design life of the valve and the ability of the vendor to provide local technical representation and supply of parts and/or components.

A fast-acting NRV shall be used when designing and constructing a bore water pumping system within any of the following hydraulic systems:

a. Hydraulic transient analysis determines the need for a fast-acting NRV.

b. Where surge vessels are in use to protect the pipeline or distribution system

c. The estimated or measured rate of deceleration warrants the use of a fast-acting NRV to minimise the formation of any reverse velocity profile.

d. In circumstances with high discharge pressure, steep slope on the discharge pipeline, or vertical pipe on the discharge pipeline.

NRV's must be selected to ensure that the opening and closing times match within appropriate time inhibit periods/limits applying to the submersible pump during a ramp up (start) and ramp down (stop). Opening times on a NRV shall consider the requirements associated with submersible pumps and maximum ramp duration to minimum speed and forward flow.

The NRV used on a bore water arrangement is not needed to be a testable backflow prevention device according to Australian Standards.

6.3.6.2 Secondary NRV

The secondary NRV should, where plausible, comply with the requirements of the primary NRV. However, as it is typically a wafer valve, this may not be possible.

In higher salinity risk bore fields, there is typically one secondary NRV (associated with the salinity sensor). The bore least susceptible to slam events should be selected for the secondary NRV.

6.3.7 Discharge Control Valve

Refer clause 6.3.8 Isolation Valves.

6.3.8 Isolation Valves

SA Water's submersible pump headworks arrangement requires several isolation valves to be used for operational requirements.

Submersible pump headworks pipework shall be designed for the use of butterfly isolation valves. Designers and/or Constructors shall refer to SA Water's TS 0230, Gate and Butterfly Valve Requirements.

With regards to the specific requirements for isolation valves on bore headwork arrangements the following minimum requirements shall be achieved:

1. An isolation butterfly valve shall be used to isolate the bore headworks. All manual butterfly valves shall be fitted with a gearbox and manual hand wheel actuator (this is a mandatory safety requirement).
   a. A manual butterfly valve may be utilised as the Discharge Control Valve (for non-flowing bores) and Scour valve.
   b. if the bore is flowing artesian, an additional manual butterfly valve shall be fitted on the headworks; upstream of the headworks NRV.
2. An automated (electrically actuated) isolation butterfly valve may be utilised. A modulating automated Discharge Control Valve is preferred, to control flow and/or to improve pump startup conditions for pumped bores. An automated valve may be applicable:
   a. As the Discharge Control Valve, if the bore is flowing artesian. However, in the case of a power failure, water shall not be allowed to discharge to customers without treatment, or to overflow tanks. Therefore, a means to shut off flow automatically shall be included in the design (for example spring return actuator, or a float valve in a break tank).
   b. As the Discharge Control Valve, dependent on project requirements.
   c. As the Scour Valve, if required (dependent on project requirements).
3. All butterfly valves shall be rated as suitable for "end of line" sealing. They shall be to the appropriate pressure class rating, but no less than PN 16.
4. Butterfly valves shall be supplied with lugged or double flange (short body) flanging arrangements.
5. Shall be positioned with consideration for ease of access and ease of use.
6. Seal and body liner arrangement and requirement for shall be determined against the requirements as per TS 0230.
7. All butterfly valves shall be procured by development and issue of an SA Water standard form valve technical datasheet, to be issued to a valve vendor. The technical datasheet shall detail all technical, functional, physical, and chemical characteristics of the water, and the operational requirements, as specified in TS 0230.

The requirements in SA Water's Technical Standard TS 0230 for gate and butterfly valves are to be included in the specification of submersible pump and headworks installations.

6.3.9 Bore Disinfection

Like any water supply system, bore water systems for drinking water applications shall be disinfected prior to any supply to customers. There shall be provision for disinfection of the bore (refer SAWO-WT-0053 Bore Disinfection). The procedure is for all drinking and non-drinking water supply bores. It includes flushing, scouring, disinfecting, and analysing water quality from a bore during any of the following events:

1. During commissioning of a new bore.
2. Where the bore has not been used for a period of 4 weeks or greater.
3. Where the bore has been refurbished.
4. Maintenance on materials in contact with source water has been conducted (such as "down hole" work on bore casing or pumping equipment).
5. If repeated / elevated microbial detections occur at a bore outside of normal water quality conditions.

It is a requirement that all bores shall be designed with the provision for a re-circulation loop designed for disinfection purposes of the bore and associated pipework. This circulation loop enables faster and easier disinfection of a bore.

Bores fitted with a recirculation system shall be dosed by injecting neat hypochlorite using a chemical metering pump or diluted hypochlorite by way of a normal dosing pump into the top of the bore head while the bore pump is running. The water will be recirculated around the bore by travelling down through the inside of the bore casing and up through the bore riser via the use of the pump.

The recirculation loop (Figure 7) for disinfection needs shall be designed to ensure the submersible pump can maintain satisfactory hydraulic operation. It is a requirement for designers to provide a means to generate sufficient backpressure allowing the submersible pump to operate within an acceptable range on their performance curves. Artificial backpressure in the closed loop system shall be generated by means of an orifice plate, butterfly valves and/or a combination of both, designed to simulate the typical operating conditions of the pump. Provision in the form of gauges and instrumentation shall be provided, allowing SA Water operational staff to monitor the performance of the pump, in pressure, flow and temperature.

Recirculation to achieve disinfection can result in elevated operating temperature within the submersible pump and motor. A recirculation loop can be designed with temperature monitoring on the submersible pump – ensuring operation of the submersible pump is maintained within vendor operating guideline and warranties.

Figure 7: Provision of headworks recirculation loop

Provision of a recirculation loop within a bore pipe headworks arrangement shall consist of the following:

1. Connect the submersible pump discharge to the bore riser (or casing) and flowing down into the bore casing.
2. Utilise standard available connection fittings (typically Cam-lok fittings).
3. Valve prior to camlock fittings (especially for flowing artesian bores).
4. Sized such that operational staff can manually fit a temporary pipe or hose. For large flows/pipework consider permanent pipe for re-circulation (for example, Mt Gambier bore 10).

A disinfection facility as required for public health on water supplied to customer connections shall be placed on the outlet of the bore upstream of any customer connection. The disinfection facility shall be designed to achieve a controlled rate of dose across the entire range of operational flow rates and automatically adjust accounting for any changes in chlorine demands in the source water (for example iron, arsenic and ammonia). The detailed requirements of a disinfection facility shall be referenced within SA Water's Technical Standard TS 0270 (and is beyond the remit of this Technical Standard).

6.3.10 Sampling Tap

Installation of a sampling point/tap which is representative of the water leaving the individual bore and going to distribution is required (to assess the quality of the water in the bore). The ability to sample the bore without discharging water to supply shall be provided. This may also assist in determining the chlorine residual post disinfection (should disinfection of a bore be required) prior to bringing a bore back into service.

An additional sample tap, for pressure relief purposes, shall be located on the vertical pipework, either adjacent or opposite orientation to the salinity sensor (if fitted), to confirm isolation from network by the duo check valve downstream.

All sample taps shall be fitted with consideration for operator access and to discharge away from the headworks.

6.4 Scour Arrangement

Scours are required so that water can be removed from the bore without being put into the network distribution system (in the event of possible contamination). Scours shall be installed such that the discharge conditions do not present erosion issues to the local environment. Scoured water from the bore headworks pipework shall not be allowed to pool on the surface near the bore headworks arrangement as this may lead to possible contamination of water within the bore. Scour pipework shall not be constructed or positioned within the concrete slab/plinth. An appropriate discharge point shall be provided when constructing any new bore.

The most common scour types that SA Water uses to protect against scouring and erosion:

1. A Rip-Rap system consisting of rock or other material.
2. A scour pit/dissipater structure, which allows scoured water to freely spill over the top of the structure and gently flow to the local environment or drain. Generally used for higher flow applications.

The scour function of water from the bore arrangement can be manual (on site opening of valve) and/or automatic. Clarification on scour function arrangement to be sought from the SA Water Representative if not stated in the Project Requirements. The scour outlet from the bore headworks is required to be downstream of the flowmeter to ensure that all water extracted from the aquifer is measured and recorded. It is important to consider the scour function relative to the network/tank connection, to ensure undesirable reverse flow does not occur.

A scour function shall be designed to ensure the operating submersible pump operates within a satisfactory operating point (or range) on the pump performance curve. This could be achieved by designing additional head loss or backpressure devices to achieve a satisfactory pump operating condition that does not risk the integrity of the bore/aquifer. Designers and/or Constructors shall determine or seek understanding of the operating water level (or inlet supply pressure to the submersible pump) during all possible scouring functions. The inlet condition to the submersible pump shall be used to design, size and select an appropriate device to provide sufficient backpressure on the pump (according to the hydraulic requirements of individual aquifer / bores and the scouring needs).

6.5 Electrical Building

An electrical building is preferred for bores fitted with a submersible pump, particularly for VSD applications. The design shall consider the following:

1. Design approval from SA Water Security Team, including electronic security and hardware requirements.
2. Single entry/exit may be considered (risk assessment required).
3. Fire detection and suppression should be considered (risk assessment required).
4. Bushfire Attack Level assessment (BAL) compliant, refer TS 0601.
5. Air conditioning/ventilation.
6. An antenna pole may be mounted on the building (refer drawing TYP-07-00026_01).
7. Vent louvres on door and walls to have mesh screening to prevent vermin, snakes etc from entering. Maximum aperture size 5mm, diameter 1.25mm.
8. Building to be installed and anchored to ground as per manufacturers requirements.

6.6 Security Clearances and Requirements

For new installations, SA Water' physical security standard TS 0121 shall be consulted for fencing and gate requirements. Security should be such that the public are not able to impact the quality of the water supply by contamination of the bore itself, or the surrounding land or by tampering with the bore. The exclusion of animals (such as livestock) from the immediate area is also required to protect the asset and protect from potential contamination.

For new fencing, consideration needs to be given to vehicle access for future pump maintenance in terms of lifting submersible pumps out of their respective casings. Maintain 2m clearance inside & outside of fence. Trees and surrounding shrubs shall be cleared and or trimmed to suit (pending environmental permission). Additional setback distances are required for chlorination facilities (refer TS 0270).

The Security Team in SA Water conducts "Security Risk Assessments" including desk top assessment to review existing security measures at an asset and providing advice on a new asset. These are considered sufficient to address Water Quality Risks.

6.7 Distribution Considerations

The bore design and pump sizing shall consider the downstream requirements. These include (but not limited to):

1. Direct connection to network, including customer take off prior to tank.
2. Pumping to tank/IRP vessels.
3. Primary supply or emergency supply.
4. In situ Chlorination/Chloramination and contact time.

6.7.1 Discharge Pipework

The Discharge pipework is downstream of the headworks, connecting the headworks to the tank or network. While Discharge Pipework is excluded from the bore Technical Standard, it shall be considered when sizing the pump and evaluating the hydraulic response.

It is important that the discharge pipework remains full while the submersible pump is offline. Therefore, a PSV may be required downstream, prior to the connection to the tank or network, particularly if the headworks is elevated above the discharge connection.

7 Submersible Pump Design Requirements

7.1 General

The submersible pump shall consist of a vertical close-coupled submersible multistage centrifugal pump and electric motor complete with cable guard and designed for continuous submerged operation.

The submersible pump shall be supplied with all associated equipment required for its installation and operation as detailed in this Technical Standard.

The selected pump shall have a proven record in similar installations. The bore shall be sized for a bore pump fitted with a shroud, plus additional clearance (refer clause 7.2.2).

All above ground equipment and fittings shall be rated for continuous operation in an outdoor environment, inclusive of electrical equipment.

All equipment supplied shall be fit for purpose, complete, maintainable, and operable.

7.2 Pump Intake Requirements

7.2.1 Pump Intake Level

The pump intake level is measured (in metres) below the top of casing (BTOCm).

The installation depth of the submersible pump intake shall be no less than the pump NPSHr + 0.5m below the maximum PWL. For additional safety margin, the NPSHr should be determined at maximum flow.

Therefore, minimum Pump Intake Level (BTOCm) = PWLmax + (NPSHr + 0.5m)

7.2.2 Pump Intake Flow

To ensure sufficient motor cooling at low speeds/flows, a flow shroud shall be specified and installed for any bore that is not cased past the motor or where the well screen is above the pump. The hydrogeologist shall inform engineering if a flow shroud is required. Sizing of the flow sleeve/shroud shall ensure fluid velocity across the pump motor for cooling is optimum for the pump operating conditions. Pump manufacturer's guidelines shall be followed to ensure velocities are within a permissible range.

7.3 Materials

Materials supplied for the submersible pump assemblies shall be suitable for the given water quality (physical and chemical) characteristics as specified through bore sampling. The designer, Constructor or pump vendor must confirm in writing, using a standard submersible pump datasheet, the materials proposed for all key components of the submersible pump before the purchase or procurement of any bore style pump. A minimum material grade and selection for use of submersible bore style pumps within a SA Water system or network shall be 316 stainless steel. This minimum nominated material requirement should not be varied. It is the responsibility of the designer and/or Constructor to qualify the technical reasons for the departure from this minimum material requirement and specifically obtain from the pump vendor a statement that the alternative material offered will meet the design life, hydraulic performance, and warranty requirements of this Technical Standard. In some applications this minimum material requirement (316 SS) will not be sufficient, with the understanding some applications may warrant duplex grades of stainless steel or another material and/or coating approach given the challenges associated with the physical and chemical water characteristics. A higher grade of 904SS may be required in some situations.

Elevated temperatures can be experienced in the bore water systems. The designer and/or Constructor shall consider these conditions and other characteristics of the water quality when nominating a pump and motor selection. Under conditions of elevated temperatures and/or in combination with elevated level of chlorides, stainless steels can be susceptible to corrosion damage in the form of crevice and pitting corrosion, which can lead to pinholes and stress corrosion cracking.

Designers and/or Constructors shall consult with SA Water Engineering, Material Science for acceptance of material.

The designer and/or Constructor must ensure that the vendor completes all responses, including material specification responses, as required in the submersible pump returnable datasheet. The technical datasheet shall form part of the basis for entering a supply contract to purchase the submersible pumps.

Dissimilar metal corrosion that will reduce the design life of the bore and/or associated components or fittings must be identified by the designer, Constructor, and/or vendor.

7.4 Pump Construction

The submersible pump configuration, water quality parameters/temperature ranges and individual duty points shall be specified in a Submersible Pump Datasheet. Preliminary pump selection shall be based on the nominated duty flow rate(s) and pressure(s) provided in the Submersible Pump Datasheet. The duty point(s) for the submersible pump are required to be provided based on detailed hydraulic design analysis of the downstream system and available pressure (if any) from the bore. Submersible pumps shall be selected such that the duty points are as close to the Best Efficiency point (BEP) of the selected pump as possible. Pump manufacturer restrictions on pump operation at low flows shall be provided, including any restrictions on maximum time the pump can operate below the minimum flow such that pump starting and stopping speeds can be assessed.

Pumps shall have a stable H-Q (Head vs Flow Rate) curve with head rising from the BEP to the shut off head.

Submersible bore style pumps can be supplied with a threaded coupling fitting or a flanged connection. Additionally, adapter fittings can be used to transition a threaded coupling to a flanged connection.

The pump shall readily fit into the bore casing and to the depth of bore specified. The pump clearance within the casing shall allow an acceptable water velocity past the motor to meet the motor cooling requirements.

Pumps and major components shall be provided with suitable means, such as eye bolts, lugs, or similar devices, to facilitate lifting and disassembly. All lifting points shall be clearly and permanently marked with the safe working load of that lifting point.

The pump and motor shaft shall be connected by a splined shaft end and coupling. This connection shall be self-aligning.

The correct direction of rotation shall be clearly marked on all pumps in a suitable location. The pump-motor coupling and drive shaft shall be capable of transmitting the total torque and total thrust of the unit in either direction.

Submersible pumps and associated equipment shall be handled, stored and transported in a manner complying with the manufacturer’s recommendations and in such a way that the materials are not damaged.

7.4.1 Pump motor

Refer to clause 8.1.1.

7.4.2 Pump bowl

The pump bowl (stage casing) assembly shall consist of the number of stages required to develop the total bowl pressure head. The pump shall be capable of modification prior to installation by the addition or removal of one or more stages. Advice shall be supplied regarding the detail of how the pump and motor assembly can be modified to achieve the required operating parameters.

Pump bowls shall be interchangeable across stages and each bowl shall incorporate intermediate shaft bearing housings. It is expected that any replaceable metallic bowls shall be readily available for routine maintenance. If not, these items shall be nominated as critical spares.

7.4.3 Impellers

Impellers shall be of the enclosed type, statically and dynamically balanced. A balance grade of G2.5 is recommended for pump and motor.

Where possible, impellers shall be supplied in standard sizes without trimming modifications to meet the required duty.

It is expected that any replaceable impeller wear rings shall be readily available for routine maintenance. If not, these items shall be nominated as critical spares.

7.4.4 Inlet Screen/strainer

Suction screens/strainers may be provided integral with each pump. They shall be of heavy-duty construction and shall be corrosion resistant to the liquid pumped.

Suction screens/strainers on pumps shall be sized with consideration of the particulate and solids size of the bore casing screen or slotted/perforated holes, if installed and potential for sand to be present in the pumped liquid.

The design life of the screen material shall ensure pump protection is offered for the life of the pump. Incorrect screen material selection can cause early deterioration eventually leading to pump internal component failure.

7.4.5 Bearings

SA Water workshops have reported specific issues/failures with bearing life on submersible pumps in the past. There may be several reasons for the failures, which shall be considered in design:

1. The minimum cooling flow past the motor, as specified by the manufacturer.
2. If pumps are operating in an uncased Section of a bore, or if the screen is above the pump intake, the pump shall have a shroud fitted.
3. The pump needs to ramp to minimum speed (such as 30Hz) in no less than 3 seconds (or as specified by the manufacturer), or vice versa.
4. Do not allow the pump to operate with a PWL within the pump NPSHr (+ 0.5m) level, as specified by the manufacturer.
5. The downforce on the bearing is excessive. This may be due to continuous operation at a duty point with low flow and therefore high pressure. Furthermore, do not operate the pump with both the Discharge Control Valve and Scour Valves closed (or partially closed for extended periods).
6. If pump needs to stop and start repeatedly, the sudden up and down thrust acting on the bearing as the water fills the riser may lead to premature failure. Consider not drilling the pump NRV (such as do not allow the riser to drain).

7.4.6 Pump Non-Return Valve

Bore style pumps are typically fitted (or supplied) with an axial NRV, fitted within the pump outlet and downstream of all pump discharge stages. This NRV is fitted to prevent backflow in the bore riser. Typically, these valves are fast acting to prevent any sudden flow reversal within the discharge pipe riser and resultant transient pressures.

There may be a need to drill a hole within the disc of the submersible pump non-return valve to aid in the ease of draining of the discharge riser when removing the submersible pump for maintenance needs. However, this practice may lead to premature pump bearing failure (refer clause 7.4.5 above). Any drilling of the factory fitted non-return valve shall be subject to a proof of requirement from the designer and/or Constructor and issued to the SA Water Representative for review and acceptance, **HOLD POINT**. Documentation submitted to SA Water Representative shall be inclusive of a written summary of the technical requirement, coupled with confirmation of any operational and/or warranty impact from the pump vendor. This shall be submitted to SA Water Representative for consideration and acceptance.

If drilling the pump NRV is required, the hole(s) shall be sized to only allow a slow release. As the riser does not drain rapidly during operation, a 'vacuum breaker' valve may be used on the headworks upstream of the headworks NRV, to allow for any vacuum that may form in the riser. The discharge through the NRV drilling should be sized to match the vacuum breaker capacity.

If the NRV is not drilled, a break off plug system may be used to drain the riser and recover the pump. This requires operational acceptance, as the pump recovery method must be considered. An undrilled pump NRV shall be considered if there has been a history of bearing failures on a particular submersible bore pump installation.

7.5 Pump Testing and Commissioning

7.5.1 Factory Acceptance Testing - Pumps

Pump vendors shall confirm their published pump performance curves have been developed against factory testing results (or equivalent) and are representative of expected hydraulic performance. Pump vendors shall be aware that hydraulic system design shall be informed against their published reference performance curves.

Factory acceptance testing requirements consistent with the clauses of SA Water's TS 0220 are generally not applicable for the supply of bore style submersible pumps. The designer and/or Constructor shall seek confirmation of factory acceptance testing from SA Water Engineering.

SA Water Engineering reserves the right to request such factory acceptance testing, should either the criticality, pump size and/or complexity of system installation warrant the need for proof of performance through factory acceptance testing. Such testing requirements will be referenced against the requirement of SA Water's TS 0220, where applicable to bore style submersible pumps.

Procurement should be arranged so that the pump warranty commences from pump installation date (not purchase date), to ensure warranty is valid for commissioning and first year of running.

7.5.2 Site Testing – Local Commissioning

In this Section, this Technical Standard must be read in conjunction with SA Water TS 0280. Local commissioning describes the testing of the installed bore style submersible pump system (including all local controls and headworks valves and pipework) in an arrangement not hydraulically connected to the water network or downstream system (for example storage tanks) to enable proving of the installation without operational impacts and prior to transitioning to system wide commissioning. The scour (with orifice plate) can also be recirculated without being chlorinated for pump flow/pressure testing, but environmental approval is required. The arrangement for local commissioning assumes all commissioning precedents and plans have been completed in accordance with the high-level guideline in SA Water TS 0280 Technical Standard.

Local commissioning loops must be established using either offtakes on new or existing pipework, with the use of temporary pipework, hoses and/or scouring arrangements. A valve or other device used to create additional pressure head loss, either permanent or temporary, must be provided in this loop to enable simulation of system head characteristics. Pump cavitation must be avoided during re-circulation. Any installed flowmeter must be included in the flow re-circulation loop to enable flow measurement during the commissioning tests.

Alternatively, water can be re-circulated from the pump discharge pipework back to the borehole pump intake through the bore casing provided that the temperature increases in the loop due to the pump heating the water can be monitored along with bore water level, should the effects of other submersible pumps operating in the vicinity have any detrimental effects, such as the pump running dry.

A local commissioning plan must be provided to SA Water's representative in writing not less than ten (10) working days before the first start of any equipment **WITNESS POINT**. This local commissioning plan shall provide the following information relating to mechanical and hydraulic infrastructure (non-exclusive list):

1. A statement confirming that all 'dry' (instrumentation and I/O testing) and 'wet' (water pumping) commissioning tests identified as per the requirements in TS 0280 will be undertaken along with any other dry and wet tests that are required as identified.
2. A statement describing the duty operating points for the submersible pump station and how they will be simulated (using a control valve or otherwise)
3. A statement describing the start and stop procedure for the pumps during local commissioning including the requirements for operating any control valve(s).
4. A statement describing the proposed operation of any VSD's, including ramp up and down rates and proposed pump operating speeds.
5. A statement describing the operation of the pump control system to demonstrate starting, stopping and the operation of pump on variable speed drive to track fixed system setpoints including minimum and maximum flows.
6. A statement describing the operation of any non-pump infrastructure including actuated valves, check valves and air valves to demonstrate opening position, stability, and/or times to open and close (and hydraulic sealing in the case of air valves).
7. A statement describing the failure mode tests that can be safely conducted, without risk to the equipment, at the local commissioning stage (see TS 0280 for a full list of commissioning failure mode tests).
8. A statement of the length of time over which local commissioning will be undertaken (water and pump temperature to be considered during recirculation).
9. A statement describing any effects on SA Water's existing operational system.
10. A schedule of proposed test dates and periods with communication plan for SA Water Operations and SA Water Engineering.

7.5.3 Site Testing - System Wide Commissioning

In this Section, this Technical Standard must be read in conjunction with SA Water TS 0280. System commissioning describes the testing of the installed borehole pump system (including all controls and headworks valves and pipework) in an arrangement hydraulically connected to the water network or downstream system (for example storage tanks) to enable proving of the installation with direct operational impacts.

The arrangement for system commissioning assumes all local commissioning tests have been successfully completed and that the factory tested submersible pump assembly can operate at the nominated duty point or along the system curve as previously validated.

The system commissioning requirements as described in TS 0280 must be followed. Liaison with SA Water Engineering, SA Water Operations and any other stakeholders deemed necessary by the SA Water representative is essential prior to undertaking any system commissioning activities as is the provision of the relevant documentation to enable review.

Failure mode tests as described in TS 0280 must be conducted at the system commissioning stage. Along with this, as part of the bore project or refurbishment works, Performance Acceptance Tests as described in TS 0280 must be successfully conducted after system commissioning has been completed.

8 Bore Electrical and Control Requirements

8.1 Electrical Requirements

The electrical and instrumentation system design, wiring and installation shall comply with TS 0300 requirements and generally follow the circuit guidance of Typical drawings provided by SA Water. Contact SA Water Electrical Engineering for more detail. SA Power Networks Service & Installation Rules (Manual No. 32) shall also be followed.

Monitoring sensors shall be provided for the motor to ensure continuous feedback to the control system to ensure the motors are operating in a healthy state, with alarming to be provided. If there is a risk the water level could be drawn down to the suction inlet of the pump (below NPSHr), then some form of motor protection to avoid dry running of the motor and pump is required. Preferred type of level sensor is discussed in clause 8.2.5. There also shall be protection provided in the control system to ensure the pump does operate when no flow is detected (note starting conditions may require a time delay).

The power cable (approved for drinking water application) may be supplied in one continuous length. The pump manufacturer shall advise on the details of the motor cable and the proposed connection system. All sensor cables may likewise be supplied as a continuous length for connection to a junction point. Power and sensor cable fittings and terminals shall be watertight (IP68 rated waterproof joint to the motor) at the expected full-bore pressure.

Barrier crip links are required for artesian bores to prevent water ingress from the bore.

Supply cable support down hole shall be based on recommended maximum spans using 316 stainless steel banding or clamps or secured using other alternative taping for FRP bore riser. The material used for banding, clamps or cable protection shall be resistant to the effects of the bore water taking into consideration its salinity, pH, and temperature.

8.1.1 Submersible Motor

Motors shall be selected for 110% of maximum power consumption along the manufacturer supplied curve and shall be de-rated for operation at the maximum fluid temperature at the site. Limits on maximum number of pump starts per hour shall be based on manufacturer data. Ideally a target of well under this number should be considered. Motors shall be provided in accordance with SA Water TS 0300 and shall be suitable for starting and operation using a VSD.

Motor failure can be caused by insufficient cooling flow past the motor during operation. This may be due to the bore construction or from insufficient pump output. It is the designer's responsibility to ensure the minimum flow past the motor (as specified by the manufacturer) is met. A flow shroud should be used (refer clause 7.2.2) and minimum discharge flow calculated and specified. The minimum discharge flow shall not be calculated at a motor speed less than 30Hz. The pump needs to ramp to the minimum speed (such as 30Hz) in no less than 3 seconds (or as specified by the manufacturer), or vice versa when ramping down.

Motors shall be provided with a potted power and control cable as required to avoid water ingress at cable connections.

Temperature sensors required, refer clause 8.2.3.

8.1.2 Pump Drives

If the bore does not require flow control, the default type of bore drive can be a soft starter, unless determined otherwise by WS, WQ or SA Water Engineering.

Variable Speed Drive (VSD) units can be used on bore water supply pumping systems. They can be used to provide smooth hydraulic conditions during starting, stopping and transitions between duty and/or assist pumping operations. Use of VSDs can provide an operational benefit of controlling the duty flowrate from a submersible pump. Flow rates from a submersible pump can vary seasonally, between each pump duty cycle, and over the life of the bore. Control of flow can also be required because of a combination submersible pump operation, or a need to match (flow pace) any treatment needs downstream of the submersible pumping asset(s). It may also be used to shandy multiple sources.

The suitability of using VSD units shall be determined by understanding and confirming the hydraulic system curve in which the pump(s) will be operating within. That is, the hydraulic system curve(s) shall intersect across the full range of pump speed curves, from allowable minimum speed to maximum speed. Designers and/or Constructors shall ensure the duty pump will not suddenly stop pumping on reducing pump speed and the loss of pump curve intersection with the hydraulic system curve.

It is a requirement of Designers and/or Constructors to inform pump vendors if the pump motors are to be operated using VSDs. This shall be defined within a technical datasheet and specification.

Designers and/or Constructors shall seek confirmation from pump vendors on the required starting and stopping hydraulic conditions for the submersible pump.

Specifically, Designers and/or Constructors shall confirm the following:

1. Starting conditions:
   a. confirm allowable minimum pump speed for the nominated hydraulic conditions and motor cooling. This shall be as per the manufacturer's specification as a minimum, which is generally ramping to 30Hz within 3 seconds.
   b. confirm allowable ramp rate from minimum speed and allowable duration to achieve the vendor nominated minimum pump speed, but generally no greater than 50Hz (from a minimum of 30Hz) and no longer than 30 seconds.
2. Stopping conditions:
   a. confirm the allowable rate for decreasing pump speed to the minimum pump speed (generally 30Hz). This shall be considered against single and multiple (parallel) pump operations and determined to ensure no transient pressure conditions are initiated (across the pump and connected downstream network or system).
   b. Time for stopping a pump (or pumps in parallel) from minimum speed. This shall not be longer than the manufacturer's specification (nominally 3 seconds for submersible pumps).

8.2 Instrumentation

Instrumentation on headworks are generally outdoor installations. All sensors and associated connections and cables shall be protected from ingress (IP) and vermin, as per TS 0300. Furthermore, material selection and protection from UV exposure shall be considered.

All new instruments shall have the following characteristics:

1. New instruments to be supplied via 24VDC.
2. Digital signal: 24VDC.
3. Analogue signal: 4-20mA.
4. Approved communication protocol.

The Instrumentation listed in this Section shall be considered as the minimum requirement for all new installations (salinity sensor to be advised). Additional sensors may be required, depending on the application, as determined by groundwater hydrogeologists and relevant Technical Support Officer (WQ). All sensors shall be visible on the HMI and SCADA.

8.2.1 Flowmeter

Flowmeters shall be used within the submersible pump headworks pipework. All bores (fitted, serviced, tested or repaired) after 1 July 2019 must have an approved compliant flow meter installed that is a pattern approved, validated by a certified person following installation and is maintained in accordance with national metering standards.

Flowmeter requirements are outlined in the South Australian Licensed Water Use Meter Specification and must be met to comply with Landscape South Australia (Water Management) Regulations 2020 and the Landscape South Australia Act 2019.

In addition, the specification, function, configuration, and other requirements are provided in SA Water's Technical Standard TS 0260. Designers and/or Constructors shall reference this technical standard for all matters concerning the use of flowmeters in submersible pump installations.

Flow meters used for compliance monitoring must have a five yearly inspection as per the South Australian Licensed Water Use Meter Specification. In addition to this, DEW must be notified of any faults, or changes to the meter and it may need to be revalidated.

Submersible pump installations shall support the use of an approved serial communications protocol, allowing the flowmeter totaliser values to be mapped to SCADA and ODS with accuracy for reporting, analysis, and monitoring requirements. The SCADA flowmeter totaliser value shall be validated against site flowmeter value as part of routine annual bore inspections.

8.2.2 Pressure Sensor

The headworks shall have a pressure sensor fitted upstream of the Discharge Control Valve. The pressure in the headworks shall be monitored, to ensure pressure does not exceed the ratings of hardware, or that the pump does not operate at excessive pressures for prolonged periods (for example operation against a closed valve).

Pressure monitoring may also be used as feedback to drive Discharge Control Valve opening sequence during pump startup (if required), to be determined during detail design.

8.2.3 Motor temperature

The pump motor shall have embedded thermistors, to provide an alarm and shut off the pump if the motor windings get too hot.

8.2.4 Salinity Sensor

For all new bores/upgrade of existing bores, discuss requirement for online salinity monitoring with groundwater hydrogeologists and relevant Technical Support Officer (WQ).

Some pumped aquifers are between two brackish aquifer units (for example Kingston and Robe) separated by aquitards of weak sandy clay units or near the coastal zone where there is a risk of enhanced seawater intrusion. Other bore fields, such as in Bordertown, contain a freshwater lens with brackish water surrounding and underneath. Excessive and prolonged pumping causes drawdowns to circulate these brackish/saline waters into the production zone increasing salinity. This is a gradual process and any changes within a brief period may not be noticed.

A salinity probe, if required, will require a secondary NRV downstream of the salinity probe, to keep the probe immersed in water to prevent build-up of calcium and representative salinity readings. Workshops also prefer a small tap upstream of the secondary NRV, to drain.

8.2.5 Water Level Sensor

It is a requirement that the dynamic water level within a bore is continuously monitored. It is important to have a water level sensor or device as it helps identify the status of the bore, aquifer, recharge and discharge, cones of depression and upstream extractions. The level sensor is generally preferred but will depend on site and operational requirements.

8.2.5.1 Manual level monitoring

A method to determine the water level is required, regardless of type of level sensor installed. This is to enable manual water levels to be measured to function as a verification (or calibration) of any automated water levels. An 8mm nylon airline is required to be installed, strapped or taped to the riser during installation. For 'Bore Drawdown Procedure,' refer to SAWO-WT-0055.

8.2.5.2 Level sensor

The level sensor is an analogue device used for continuous hydrostatic level measurement in bores. For SA Water applications, the sensor should be no greater than 22mm diameter, to allow installation in DN25 conduit. The design shall enable easy maintenance and cleaning. The designer shall specify the measuring range and cable length. The capillary tube shall be vented.

The level sensor shall be calibrated on installation against pump intake depth and static water level (measured as mBTOC).

Equipment preferences to be confirmed with workshops / operations during the design phase.

8.2.5.3 Bubbler

The bubbler is a measurement device that uses compressed air to determine the water level in the bore. It requires an air compressor (in the vicinity of the bore), and a tube strapped or taped to the riser during installation.

During operation, the compressor runs for several seconds and charges the tube with a high flow sequence. This is followed by a dwell sequence, where the pressure in the tube equalises with the hydrostatic pressure. The pressure is then processed by the PLC, scaled, and displayed on SCADA/HMI to determine the bore water level.

8.3 Telemetry

Submersible pump installations shall be configured to be connected to SA Water's telemetry systems, refer to TS 0350 and TS 0351. The Designer shall confirm with the SA Water Representative which telemetry system shall be utilised at each installation.

Telemetry is required, with appropriate alarms, to control and monitor the submersible pump installation(s) and trend flow rates and other system characteristics.

Submersible pump installations shall be monitored and controlled locally on the site through the installation and use of an HMI (virtual or physical) within the control building. A local HMI facility allows improved chlorine dosing (monitoring and control) and overall submersible pump control and network overview because the sites are often spread out and remote from one another. All PLC and HMI systems shall comply with TS 0360.

Mobile antennas or other structures should not over-hang the bore or concrete skirts, as this allows nesting or roosting locations above the bore leading to a potential build-up of bird faeces or other contaminant sources from birds.

8.4 Submersible Pump Control Philosophy

The Control Philosophy shall consider single pump operation, as well as the complexity of operating multiple bores. The Control Philosophy shall allow for the maintenance of blend ratios, as well as consider aquifer yield. This may be achieved by scoping the control capability for a bore field and ensure individual installations can be adapted to the wider control system.

For non-flowing bores, the pump startup conditions need to be carefully considered. The Discharge Control Valve may require modulation during startup (to be determined during detail design).

Refer to Table 4 below for the standard modes of operation for a single bore.

Table 4: Control modes of operation

Mode	SCADA	Description
Off	N/A	Off (No operation of pump)
Manual	N/A	Pump start and stop control via local panel pushbuttons located at the MCC
Remote/Auto	yes	Control via PLC logic and sequencing considering operational mode selections and setpoints

8.4.1 Manual Control

Manual control of the submersible pump will be available at the MCC (via mode selector switch, push buttons and indicators). When manual mode is selected, a 'manual selected signal' will be indicated on both HMI and SCADA, and that the pump is unavailable for remote control.

8.4.2 Remote/Auto Control

The same selector switch shall select 'Auto mode' at the motor control centre to enable remote control via the PLC. In Auto mode, HMI setpoints are used to start/stop or ramp the pump.

Following a site power supply cycle there is a delay before a reset is initiated (to be determined during detail design phase when pump selected). Motor duty cycle to be considered, accounting for allowable pump starts per hour, as provided by the manufacturer. Auto operation will then commence after a delay. When the mode selector is switched from 'Off' to 'Auto', there shall be a delay before Auto operation commences.

8.5 Controlling Parameters

If a bore requires flow control and is fitted with a VSD (or other flow controlling device), PID loop control shall be used with feedback from the flowmeter. For some installations, pressure control may be required, where PID loop control shall be used with feedback from the relevant pressure sensor.

Automatic pump shutdown or ramping shall be considered for any of the following conditions:

1. Low flow detected for a set period (feedback from flowmeter). There may be a time delay required to exclude startup conditions.
2. Flow shall also be limited or the pump ramp to stop if the water level in the bore drops below the required level, PWL max.
3. Pressure exceeds a programmed limit, which may be set to protect downstream systems. This may be on the main discharge pipeline or the scour (particularly if discharging to injection bores).
4. Duty setpoints are achieved (refer clause 8.5).
5. Pump input parameter shall not allow the pump to operate below the manufacturer's specification (nominally 30Hz), or above the defined upper limit.
6. The motor reports a fault (as per manufacturers requirements).

8.6 Duty Setpoint

The bore should receive a digital signal to instruct whether to RUN or NOT RUN. This signal is derived from setpoints which are adjustable via HMI or SCADA (Table 5).

Table 5: Example of duty control selection (based on tank levels)

Setpoint	Description	Selection Source
Setpoint A	Start at 60% tank level, Stop at 90% tank level	HMI/SCADA
Setpoint B	Start at 80% tank level, Stop at 90% tank level	HMI/SCADA
Setpoint C	Level Independent	HMI/SCADA

The final submersible pump operations and setpoints shall be confirmed with the SA Water Technical Support Officer during construction and commissioning.

9 End of Bore Productive Life

9.1 Monitoring

If a production bore reaches the end of its productive life, it may be maintained as a monitoring bore.

Decommission all hardware associated with the production bore, including headworks. Fit the bore with a lockable, heavy duty monitoring well cover.

9.2 Decommissioning

If a production or observation bore has 'failed' or is no longer required, the bore should be adequately sealed to stop introduction of contamination into the aquifer.

The following steps shall be completed:

1. Initially consult with SA Water's Hydrogeologist and Manager Water Expertise, via SA Waters Representative. Consultation with SA Waters Hydrogeologist is essential prior to decommissioning.
2. Seek decommissioning well permit from Department for Environment and Water (DEW).
3. Consult with key stakeholders to determine action plan.
4. Engage a licensed driller to complete the works. Refer to Minimum construction requirements for water bores in Australia.

The casing shall be cut off approximately one metre (1m) below ground level and filled with grout/cement. Make good the ground works above the bore.

Furthermore, if the discharge pipeline cannot be reused for other production bore installations, it shall be decommissioned by backfilling. Remove all headworks, valves and other hardware. Cut pipe off well below ground level at each end and fill with grout. Make good the ground works above the pipeline. Update the drawings to show the pipeline has been decommissioned (dotted line).

A Schedules of hold points, witness points and identified records

A1 Schedule of hold points and witness points

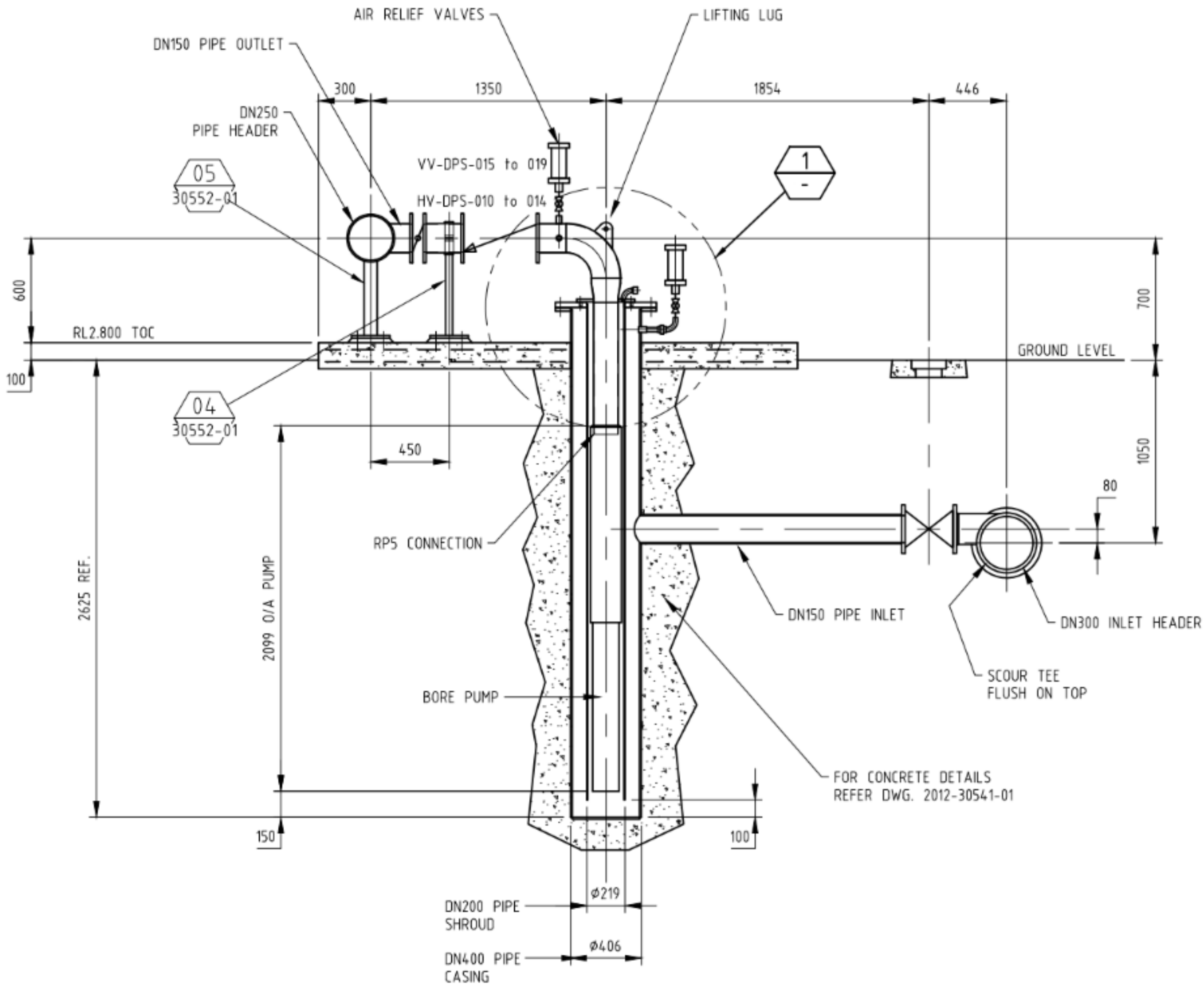
Section	Type	Description
5.3	Hold	Consultation with SA Water Environmental Team to plan formation sampling.
6.3.3 (1)	Hold	Selection of Grade 316 Stainless Steel for the fabrication of the Bore Headworks pipework.
7.4.6	Hold	Review and acceptance of any proposed drilling of the factory fitted non-return valves, having demonstrated the requirement to drill from the Designer / Constructor.

A2 Schedule of identified records

Section	Description of Identified Record
7.5.2	A local commissioning plan must be provided to SA Water's representative in writing not less than ten (10) working days before the first start of any equipment.

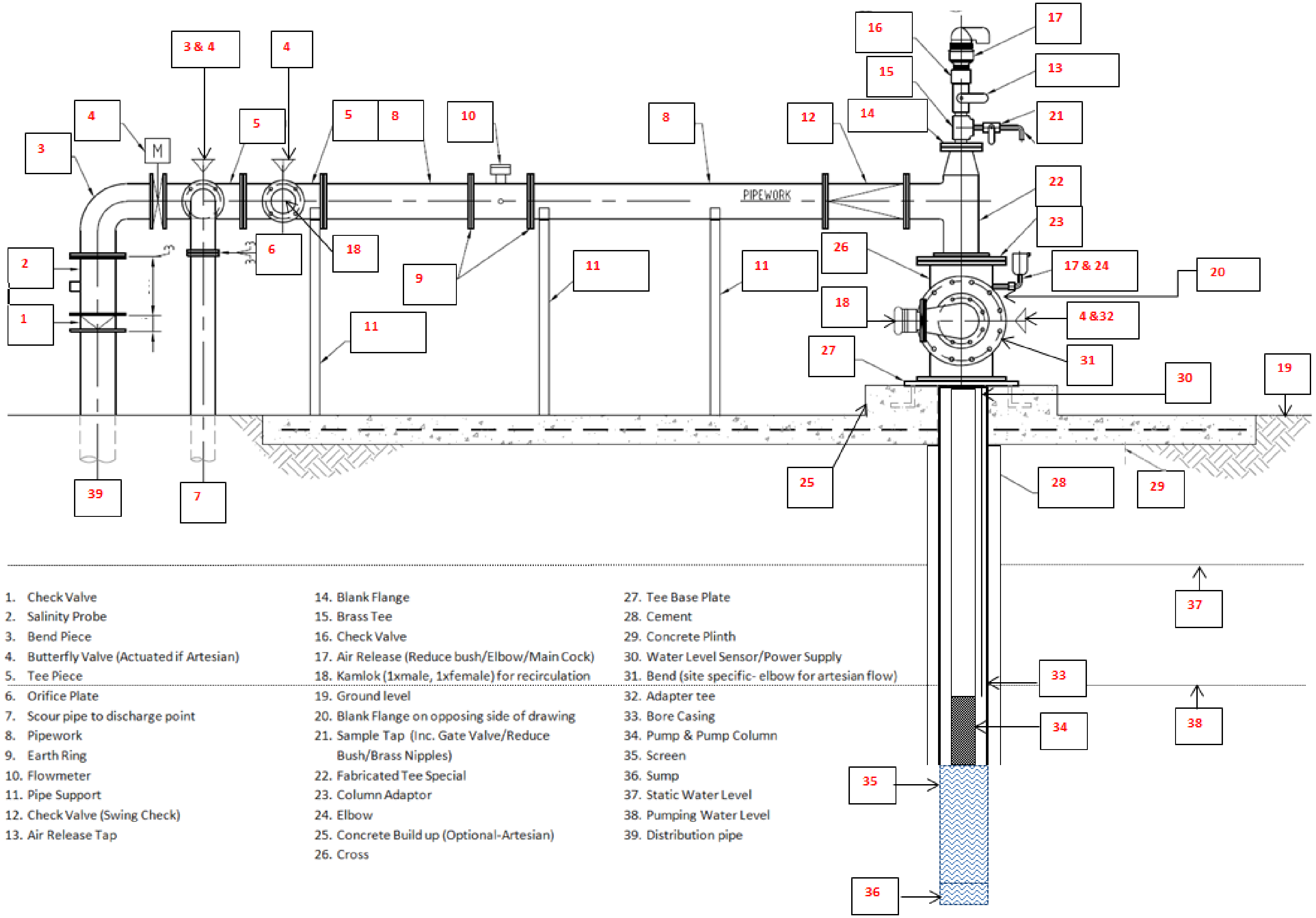
B Installation Examples

B1 Example of Pump-in-can[3]



[3] Source: drawing 2012-30587-02

B2 Example of Bore Headworks



1. Check Valve
2. Salinity Probe
3. Bend Piece
4. Butterfly Valve (Actuated if Artesian)
5. Tee Piece
6. Orifice Plate
7. Scour pipe to discharge point
8. Pipework
9. Earth Ring
10. Flowmeter
11. Pipe Support
12. Check Valve (Swing Check)
13. Air Release Tap
14. Blank Flange
15. Brass Tee
16. Check Valve
17. Air Release (Reduce bush/Elbow/Main Cock)
18. Kamlok (1xmale, 1xfemale) for recirculation
19. Ground level
20. Blank Flange on opposing side of drawing
21. Sample Tap (Inc. Gate Valve/Reduce Bush/Brass Nipples)
22. Fabricated Tee Special
23. Column Adaptor
24. Elbow
25. Concrete Build up (Optional-Artesian)
26. Cross
27. Tee Base Plate
28. Cement
29. Concrete Plinth
30. Water Level Sensor/Power Supply
31. Bend (site specific- elbow for artesian flow)
32. Adapter tee
33. Bore Casing
34. Pump & Pump Column
35. Screen
36. Sump
37. Static Water Level
38. Pumping Water Level
39. Distribution pipe