Engineering

Technical Guideline TG0638

General Technical Information for Geotechnical Design - Hydrogeology

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Only the current revision of this Guideline should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

This is the first issue of this Technical Guideline under the new numbering format. The original version of the document was last published in 2007 with the name of General Technical Information for Geotechnical Design Part E – Hydrogeology (TG 10e). A full version history of this document is given in Document Controls. The major changes in this revision include the following items:

- Minor revision of Section 3 (formerly Section 2 in TG 10e)
- Major revision of Section 4 (formerly Section 7 in TG 10e), with addition of Appendix A
- Major revision of Section 5 (formerly Section 3 in TG 10e)
- Sections 4, 5, and 6 of TG 10e are not included in TG 0638 and hereby are superseded.

Document Controls

Revision History

Revision	Date	Author	Comments
0	2004	Ed Collingham	First Issue of TG 10e
1	10/1/2007		Nil
2	12/03/2020	Moji Kan	Major Revision, Reformatting to TG 0638

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Contents

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1 Introduction

SA Water is responsible for operation and maintenance of an extensive amount of engineering infrastructure.

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

1.1 Purpose

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

1.2 Glossary

The following glossary items are used in this document:

Term	Description
CDS	Comprehensive Drainage Scheme
DEW	Department for Environment and Water – South Australia
MDBA	Murray-Darling Basin Authority
NUDLC	National Uniform Drillers Licensing Committee
SA Water	South Australian Water Corporation
TG	SA Water Technical Guideline
TS	SA Water Technical Standard

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:

Number	Title
NUDLC (2012)	Minimum Construction Requirements for Water Bores in Australia, Edition 3, February 2012

1.3.2 SA Water Documents

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

Number	Title
N/A	

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g. AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Responsible Discipline Lead	The engineering discipline expert responsible for TG 0638 defined on page 3 (via SA Water's Representative)

2 Scope

The scope of this document is to provide guidelines for the geotechnical aspects of hydrogeology studies for SA Water infrastructure.

3 Effectiveness of Cut-Off Walls

The following illustrations are presented to show the effectiveness of cut-off walls in centre or upstream of the water retaining structures, based on experiences in behaviour of piezometers in River Murray (MDBA) structures.

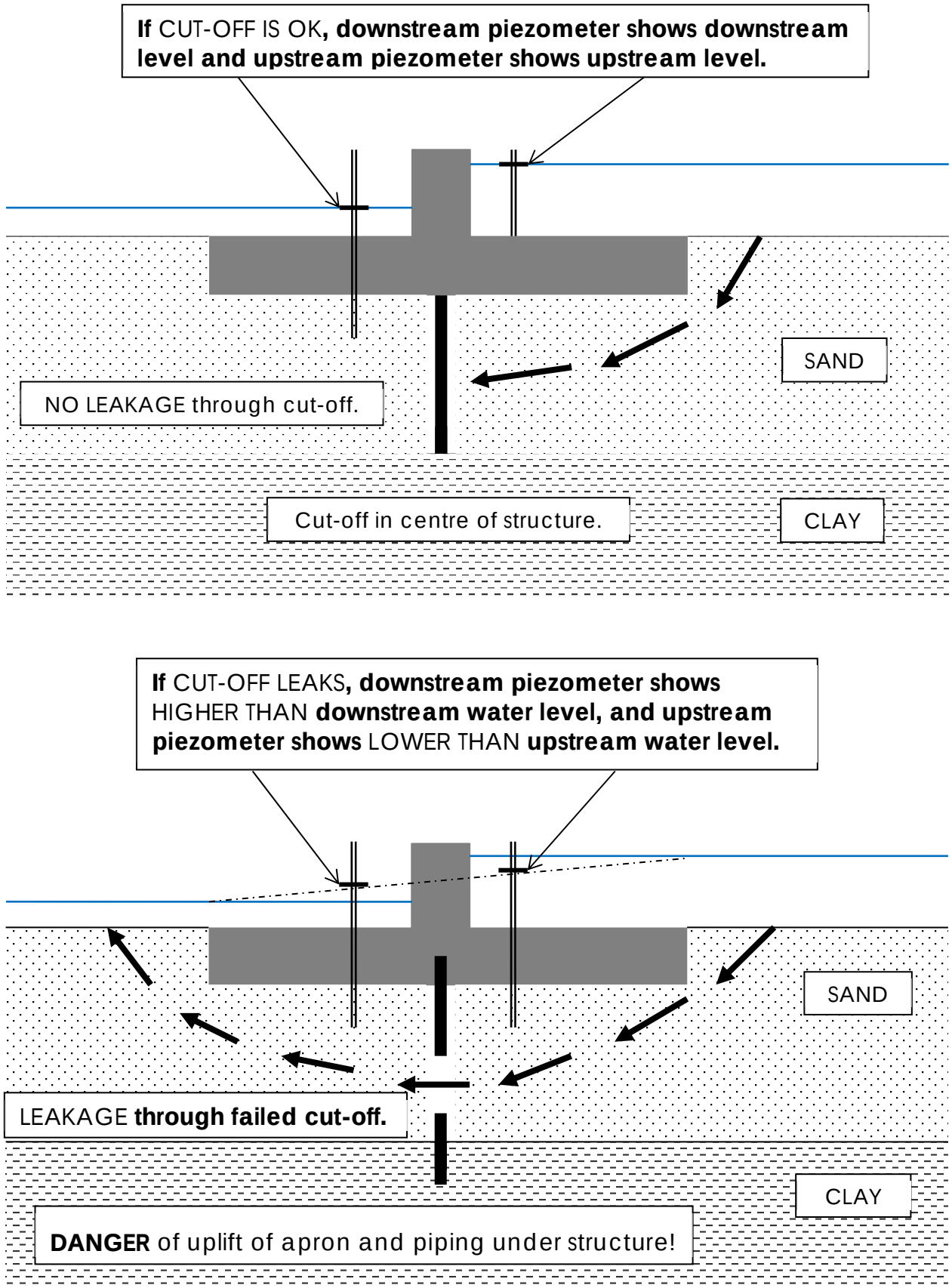

Figure 1: Illustration of centre cut-off effectiveness

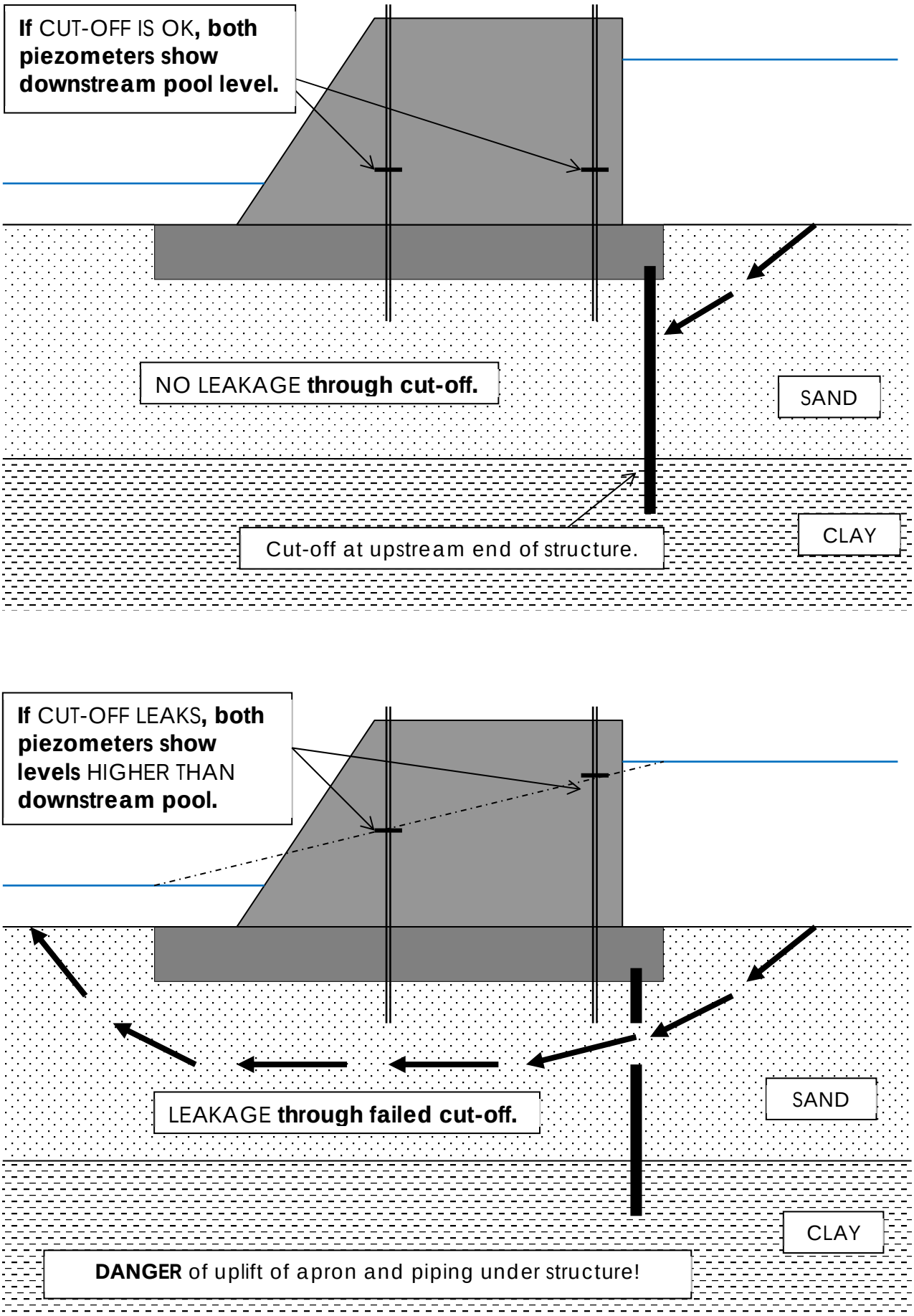

Figure 2: Illustration of upstream cut-off effectiveness

4 Production Wells

The most appropriate and economical type of well for extracting groundwater depends on (a) the depth to the aquifer, (b) the thickness of the aquifer, (c) the type of aquifer (confined or phreatic) and (d) the required yield.

Where the water table is deep (say deeper than 20 m), there would be little choice but to use a conventional drilled bore with a submersible or line-shaft pump in the bore. Most water bores fall into this category.

Where the water table is shallow (shallower than 6 m), there would be the opportunity to use a vacuum pumping system – with a single centrifugal pump at ground level drawing water from a group of simple, small-diameter wellpoints. Such an arrangement is typically used for construction dewatering. Permanent installations are used for groundwater control in, for example, the Mildura Irrigation Area and also the Rufus River Salt Interception Scheme at Lake Victoria.

Where the water table is very shallow (less than say 2 m), extremely simple surface trenches can be used - as is done by SA Water in the Polda Basin on the Eyre Peninsula.

NUDLC (2012) has published the minimum construction requirements for water bores in Australia. Design and construction of production wells for SA Water should be conducted in accordance with the requirements of NUDLC (2012).

Department for Environment and Water (DEW) manages the well construction and backfilling standard in South Australia via permits and licencing. All wells require DEW approval prior to works commencing. The permit controls the well construction and class of driller (class 2 or 3).

SA Water also has a more particular technical specifications for drilling of wells. This technical specification is an integrated part of drilling contracts. The generic version of these specifications is provided in Appendix A.

5 Groundwater Monitoring Wells

Monitoring wells are commonly used in hydrogeological investigations. They might be also called ‘observation well’ or ‘piezometer’. Monitoring wells include bores to:

- observe water levels
- observe water quality
- intersect and monitor contaminants such as hydrocarbons, coliforms, pesticides, herbicides, and heavy metals.

Monitoring wells are drilled specifically to obtain data on groundwater. They are equipped and used for taking water samples and/or monitoring water levels. Their basic characteristic is that they are normally of low-yield construction but provide for accurate water quality sampling and water level measurements from a particular zone of interest in an aquifer.

Annulus seals and gravel packs are used where necessary to isolate the zone being monitored. Care must be taken during drilling operations and in selecting the drilling method and materials used in bore construction.

It is essential to ensure that no contaminants are introduced that may affect the monitoring or sampling results. Similar requirements for sealing between aquifers are required outside the casing to prevent inter-aquifer flow.

NUDLC (2012) minimum requirements should be complied with in design and construction of monitoring wells for SA Water. An example of monitoring well construction is shown below in Figure 3.

In addition to NUDLC (2012) requirements, a well construction design needs to be submitted by the Contractor for approval by the Superintendent’s Representative. The design should also comply with the following additional criteria:

- The drill hole to extend a minimum of 3 m below the static groundwater level observed during drilling.
- The well screen to extend from 50 mm above the base of the drill hole to a minimum of 1 m and a maximum of 1.5 m above the groundwater level encountered during drilling.
- The well screen to have no sump or dead space at the bottom and to be sleeved with geotextile if required. Watertight casing to extend from the top of the screen to the ground surface.
- Appropriate gravel pack to extend from the base of the drill hole to a minimum of 0.5 and a maximum of 1 m above the top of the screen.
- The drill hole above the gravel pack to be backfilled with cement/bentonite grout to the surface.
- The top of the well to be finished with an appropriate protective cap and marker post.

The function or philosophy behind such well needs to be carefully considered through the following steps, to be followed by the Designer:

- Study of the local hydrogeology.
- Decide for the particular site and the particular local hydrogeology what impacts irrigation and other users may have on the quality of the water in the aquifer.
- Decide what levels of impacts are acceptable/unacceptable.
- Work out a sampling and testing protocol to measure those impacts.
- Study what the response might be if the observed impacts are unacceptable (e.g. changed irrigation operation).

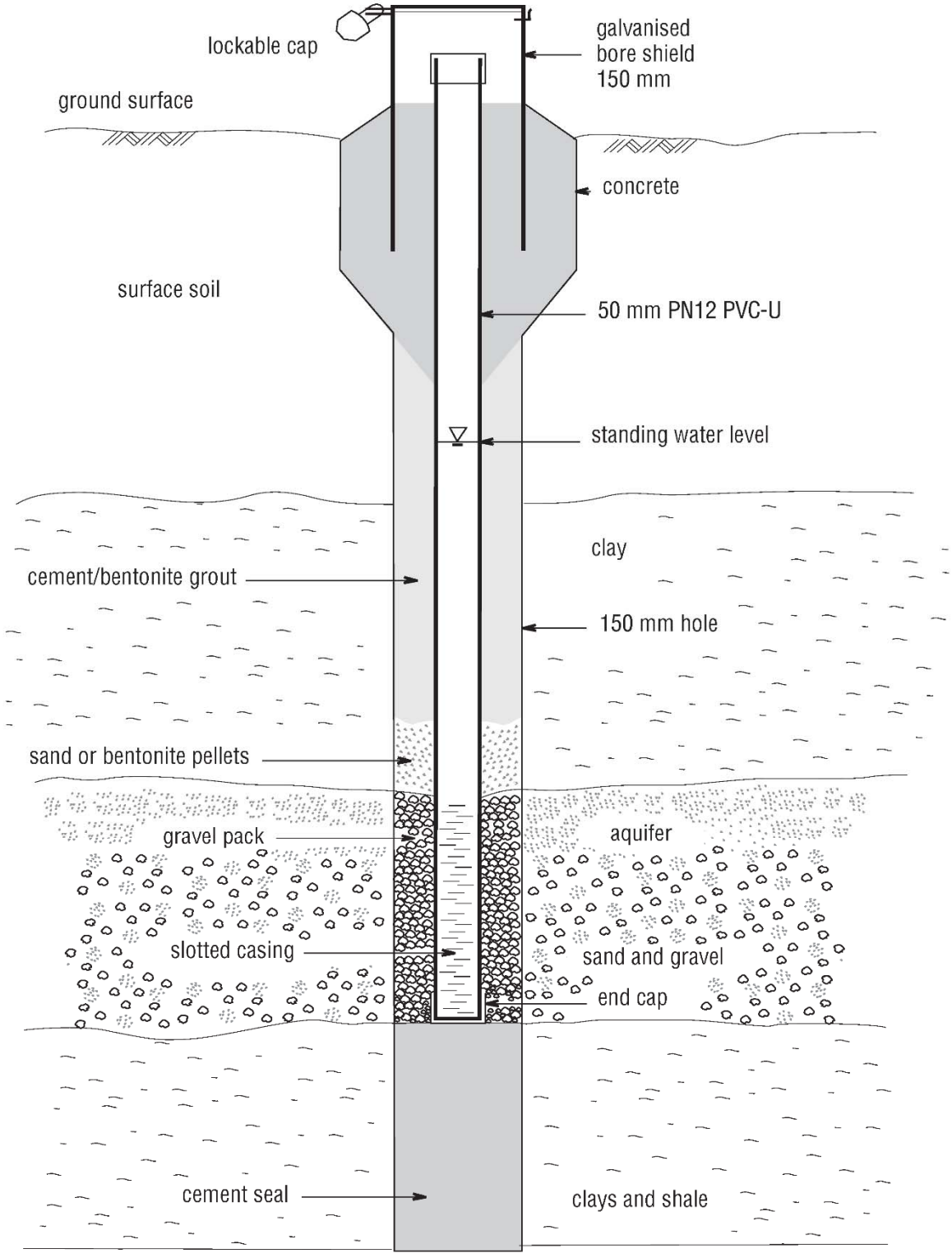

Figure 3: Minimum construction requirements of monitoring well (NUDLC, 2012)

Appendix A: General Specifications for Drilling and Construction of Wells

1. INTRODUCTION

1.1 [Optional – insert if applicable]

2. AGREEMENT FOR DRILLING AND CONSTRUCTION OF WELLS

2.1 The Contractor is advised it should refer to the Agreement for Drilling and Construction of wells for sections in relation to:

2.1.1 Defective Work – including “Lost Wells’ (Section 24).

2.1.2 Defects Liability (Section28); and

2.1.3 Latent Conditions (Section 29).

3. PROJECT GOVERNANCE

The Contractor must seek approval for bore works from SA Water’s Hydrogeologist.

4. SITE INFORMATION

4.1 The Contractor is responsible for assessing and allowing for the actual conditions present at each drilling site, as part of its contractual risk management.

4.1.1 [Optional – delete/modify if applicable] Unsaturated gravels, shells, sands, silts and clays.

4.1.2 Saturated gravels, shells, sands, silts and clays.

4.1.3 Hard fractured Limestone

4.1.4 Hard fractured rock including granite

5. SCOPE OF WORK

5.1 The Scope of Work includes drilling and construction of investigation drillholes and observation, production and injection wells and includes:

5.1.1 supply and installation of well casings, screens or slotted casing and gravel pack etc.;

5.1.2 site preparation;

5.1.3 [Optional – delete/modify if inapplicable] construction of holding dams for water produced during well development;

5.1.4 drilling of holes including supply of drilling materials;

5.1.5 grouting of wells including supply of grouting materials;

5.1.6 [Optional – delete if inapplicable] checking plumbness and alignment of wells;

5.1.7 [Optional – delete if inapplicable] checking final depth of wells;

5.1.8 development of wells;

5.1.9 sterilisation of wells;

5.1.10 supply and installation of headworks;

5.1.11 backfilling of wells or drillholes where required;

5.1.12 site remediation to the satisfaction of the Wellsite Hydrogeologist with the approval of the appropriate SA Water representative;

5.1.13 disposal of water and cuttings produced during drilling and development; and

5.1.14 mobilisation of plant and equipment to the next well site.

5.2 The Contractor must execute and complete the Works set out in this Specification in accordance with the Program of Works and Work Method Statement.

5.3 This work must be undertaken in a timely and expedient manner including the completion of designated project deliverables within specified project milestone dates.

5.4 Any requirement set out in this Specification for the Contractor to rectify a specific Defect is deemed to be “for the avoidance of doubt”, and does not limit or derogate from the Contractor’s obligation under this Agreement to rectify any Defect that may arise in respect of the Work at no cost to SA Water.

6. OVERSIGHT OF CONTRACTOR

6.1 SA Water’s Wellsite Hydrogeologist will oversee and monitor the Contractor’s daily drilling activities with the approval of the appropriate SA Water representative.

6.2 The Contractor must liaise with the Wellsite Hydrogeologist as part of the daily drilling activities and must follow the guidelines and instructions specified by the Wellsite Hydrogeologist with the approval of the appropriate SA Water representative.

6.3 The Contractor must coordinate the Work with the Wellsite Hydrogeologist to ensure he is able to observe all drilling activities, unless the Contractor receives the written approval or direction otherwise from the Wellsite Hydrogeologist with the approval of the appropriate SA Water representative.

6.4 The activities of the Wellsite Hydrogeologist in overseeing, monitoring, approving or issuing directions in relation to the Work does not limit, derogate from, or transfer the Contractor’s responsibility for undertaking the Work in accordance with this Agreement.

6.5 The Contractor must ensure that all of the activities listed below (and any other activities as directed by the Wellsite Hydrogeologist from time to time) are witnessed [Optional - delete if inapplicable] and certified in writing by the Wellsite Hydrogeologist with the approval of the appropriate SA Water representative (at the time of completion of the activity) before proceeding with other work:

[Optional – delete/modify if inapplicable]

(a) Drilling of new ground;

(b) Installation of casing and (pressure)) grouting;

(c) Plugback grouting;

(d) Installation of screens or slotted casing and fittings;

(e) Installation of gravel pack;

(f) Plumbness and alignment testing;

(g) Development;

(h) Final depth testing;

(i) Water sample collection;

(j) Mechanical integrity testing;

(k) Sterilisation of wells;

(l) Installation of headworks;

(m) Backfilling of drillholes or wells; and

(n) Site remediation.

7. SUPERVISION OF DRILLING OPERATIONS AND LICENSE REQUIREMENTS

7.1 The Contractor must ensure on-site supervision of drilling operations in accordance with the following minimum South Australian Drilling License requirements:

[Optional – delete/modify if inapplicable]

7.1.1	unconfined aquifers	Class I driller;
7.1.2	confined aquifers	Class II driller;
7.1.3	confined artesian aquifers	Class III driller; and
7.1.4	GAB confined artesian aquifers	Class III licensed driller + heat endorsement.

8. COMPLIANCE WITH WELL PERMITS

8.1 The Contractor must comply with the well permit obtained under section 135 of the Natural Resources Management Act (2004) to carry out the drilling or backfilling activities (including any conditions placed upon the permit) and must comply with all applicable State and Commonwealth government statutory and regulatory requirements. The Contractor must comply with all applicable standards and legal requirements (as referred to in clause 2 of this Specification) required for undertaking the Work.

9. AUSTRALIAN STANDARDS

[Optional – delete/modify if inapplicable]

9.1 The Work must be undertaken in accordance with all applicable Australian Standards, including:

9.1.1 AS-1554 – Structural steel welding

9.1.2 AS-2129 – Flanges for pipes, valves and fittings

9.1.3 AS-4801 – Occupational health and safety management systems - Specification with guidance for use ISO 9001, 9002 and 9003

9.1.4 ISO 14001 – Environmental management systems - Requirements with guidance for use Accreditation System of Australia and New Zealand (JAS-ANZ)

9.1.5 AS-3879 (2011) – PVC primers and glues

9.1.6 AS-1477 (2006/Amdt 1- 2009) – PVC Pipes and Fittings for Pressure Application

9.1.7 AS-3792 (2010) – Grout cement

9.1.8 API RP 13B-1 – Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids

9.1.9 API-598 (1996, Addendum 1997) – Valves testing and Inspection requirements

9.1.10 AS-1628 (1999/Amdt 1- 2001) – Water Supply – Metallic gate, Globe and Non-return Valves

9.1.11 AS-3579 (1993) – Cast Iron Wedge Gate Valves for General Purpose

9.1.12 AS-1742 (Set 2014) – Manual of Uniform Traffic Control Devices

9.1.13 AS-4020 (2005) – Testing of products for use in contact with drinking water

9.2 [Optional – delete/modify if applicable] Where an applicable Australian Standard ceases to or does not exist or apply to an element of the Work, then a suitable accredited alternative standard may be used subject to the Contractor obtaining the prior written approval by SA Water.

10. ACTS AND GUIDELINES

10.1 The Work must be undertaken in accordance with all applicable laws, including:

10.1.1 Minimum Construction Requirements for Water Bores in Australia (Edition 3 February 2012), National Water Commission;

10.1.2 General Specification for Well Construction Modification and Abandonment in South Australia Pursuant to Well Construction Permit Issued Under the Natural Resources Management Act 2004;

10.1.3 Natural Resources Management Act (2004);

10.1.4 Environment Protection and Biodiversity Conservation Act (1999);

10.1.5 South Australian Road Traffic Act (1961) as modified by the Code of Practice for the Installation of Traffic Control Devices in South Australia;

10.1.6 Environment Protection Act (1993), and any applicable regulations and policies established under this Act, including the Environment Protection (Water Quality) Policy 2003.

10.1.7 [Optional – delete if inapplicable] Anangu Pitjantjatjara Yankunytjatjara Land Rights Act 1981

11. VEHICLES & SITE SECURITY

11.1 The Contractor must assess the specific site conditions as part of drilling the wells at each location and must arrange suitable vehicles.

11.2 The Contractor is responsible for site control and security during the works. This includes the Contractors equipment.

12. DRILLING PLANT & EQUIPMENT

[Optional – delete/modify if inapplicable]

12.1 The Contractor must provide the following drilling equipment:

(a) Front End Loader;

(b) mud tanks;

(c) flush drill pipe;

(d) collars and stabilisers; and

(e) piloted hole openers.

(f) shale-shaker to be used; and

(g) de-silter / sander to be used.

(h) Bog mats

13. PRE-REQUISITES FOR WELL DRILLING & CONSTRUCTION

13.1 [Optional – delete/modify if inapplicable] The Contractor must ensure that the following activities are complete, and that the relevant approvals are obtained in writing from the Wellsite Hydrogeologist with approval of the appropriate SA Water representative, prior to commencing any drilling activities (except where expressly stated otherwise).

(a) Drilling permits (SA Water to provide);
(b) Safety Management Plan (Contractor to provide);
(c) Identification of risks and preparation of JHAs (Contractor to provide);
(d) Work Method Statement and Layout Sketch (Contractor to provide);
(e) Environmental Management plan (Contractor to provide);
(f) Site inductions (Contractor to provide);
(g) Dial Before You Dig and pot holing to locate Telstra cables, etc. (Contractor to undertake); and
(h) Program of Works (Contractor to provide).

14. DRILLING PROGRAM

14.1 [Optional – delete/modify if inapplicable] The Wellsite Hydrogeologist will not be responsible for the Contractors programming and scheduling of the Work.

14.2 [Optional - delete if inapplicable] The Contractor must prepare and maintain a Program of Works to be developed and agreed with the Wellsite Hydrogeologist with approval of the appropriate SA Water representative that identifies and tracks each well to be drilled (typically in the form of a Gant Chart). The Program of Works must be forwarded to SA Water for written approval prior to commencing the drilling works.

15. DISPOSAL OF DRILLING FLUIDS, CUTTINGS & DEVELOPMENT WATER

15.1 [Optional - delete if inapplicable] The Contractor must document, for SA Water's approval, a safe and environmentally acceptable procedure for containment and disposal of drilling fluids, cuttings and saline groundwater produced during the drilling process, and development and sterilisation process. The Contractor must have regard to environmental guidelines when developing these disposal management procedures so as to avoid delays in obtaining approval.

15.2 The Contractor must undertake field disposal of the drilling fluids in strict accordance with the approved procedures and any deviation(s) and/or environmental damage caused must be rectified by the Contractor at no additional cost to SA Water and without any delay to the project program.

16. DRILLING METHOD, DRILLING FLUIDS & CONTROL OF LOST CIRCULATION

16.1 [Optional - delete if inapplicable] The Contractor must specify, for SA Water's approval, its proposed drilling methods and drilling fluids to be used. If lost circulation occurs during the drilling of a well, this may be controlled with the addition of Bran, Pollen or Chaff to the drilling fluid. In the event of extreme lost circulation, the drillhole may require grouting. If grouting is required, the Contractor must consult with and obtain the approval of the Wellsite Hydrogeologist with approval of the appropriate SA Water representative with regard to the grouting procedures to be used.

17. CONSTRUCTION AND MATERIAL CERTIFICATION FOR THE WELLS

17.1 [Optional - delete/modify if inapplicable] The Contractor must provide, for SA Water's approval, all manufacturer test / material certification documentation for materials used for construction of the wells including related construction method statements / installation procedures.

18. WELL DRILLING AND CONSTRUCTION

18.1 The Contractor must ensure that the drilling of each drillhole and well is in accordance with the depths, plumbness, diameters, apertures and materials specified in the Drilling Schedule and Well Construction Diagrams, unless the Contractor receives the written approval or direction otherwise from the Wellsite Hydrogeologist with approval of the appropriate SA Water representative.

18.2 The Contractor must ensure that the drilling of each drillhole and well is in accordance with the Work Method Statement for each well attached to this Specification, unless the Contractor receives the written approval or direction otherwise from the Wellsite Hydrogeologist with approval of the appropriate SA Water representative.

18.3 The Contractor must ensure that installation of casing and screens or slotted casing, and grout, complies with all applicable standards and legal requirements (as referred to in clause 2 of this Specification), and without limiting this requirement the Contractor must ensure all procedures detailed within the following sections are followed.

18.4 The Contractor must ensure that construction of each well complies with specifications described in Minimum Construction Requirements for Water Bores in Australia (Edition 3 February 2012).

18.5 The Contractor must ensure that all materials used for drilling are new and comply with the specified and/or applicable recognised industry material standards.

19. STERILISATION OF DRILLING EQUIPMENT

19.1 The Contractor must sterilise all drilling equipment prior to mobilisation ex-depot by the following method:

19.1.1 Steam clean all drilling plant and equipment;

19.1.2 Sterilise all drill rods, drill bits, drill tools, pumps, riser lines, storage tanks and hoses using sterilising agent containing a minimum of 100 milligrams per litre of free available chlorine;

19.1.3 Store all drill rods and bits so there is no direct contact with the ground.

19.1.4 Drilling rigs and equipment must be disinfected before and after mobilising to each new bore site.

20. PLUMBNESS AND ALIGNMENT OF DRILLHOLES

20.1 The Contractor must ensure that each well is drilled straight and vertical by:

20.1.1 Drilling with flush drill pipe;

20.1.2 using collars and stabilisers; and

20.1.3 [Optional – delete if applicable] reaming using piloted hole openers.

21. DEPTH, DIAMETER AND INTEGRITY OF DRILLHOLES

21.1 The Contractor must ensure the integrity of each drillhole by cleaning it and maintaining the condition of the drilling fluids so that:

21.1.1 geophysical logging tools can be run to total depth; and

21.1.2 casing, grout, screens or slotted casing and gravel pack can be installed.

21.2 The final depth is the decision of the Wellsite Hydrogeologist with approval of the appropriate SA Water representative, based on interpretation of strata samples, [optional – delete/modify if inapplicable] borehole CCTV camera

footage and geophysical logs.

21.3 If an obstruction or blockage is encountered which prevents the successful completion of tasks for any well, the Contractor must rectify the problem by re-establishing the required depth, diameter rand integrity of the drillhole at no additional cost to SA Water.

- [Optional - delete if inapplicable] Where no diameters are specified, the Contractor must ensure that the drilling of each drillhole so that:

  21.3.1 geophysical logging can be conducted following the completion of each drillhole by running geophysical tools to total depth;

  21.3.2 casing, grout, screens or slotted casing and gravel pack can be installed in drillholes in accordance with depths specified in the Drilling Schedule and Well Construction Diagrams; and

  21.3.3 Drillhole diameters are sufficient to ensure adequate grout and gravel pack thickness.

22. INSTALLATION OF CASING

22.1 The Contractor must ensure during installation of casing in each well that:

22.1.1 UPVC casing

(a) joints are fastened by priming and solvent welding (follow manufacturers specifications);

(b) PVC primers and glues are Type ‘P’ PVC conforming to AS-3879 (2011);

(c) stainless steel screws, or stainless steel or PVC dowels (neither of which will protrude internally) are used to support joints while glue cures;

(d) ensure glued UPVC / PVC joints are airtight and will not leak from the joints.

(e) [Optional - delete if inapplicable] Each floodplain well will be subjected to vacuum test that will confirm all joints will hold -80 kPa (Vacuum) for minimum of 10 minutes. A well required as part of the Work may be declared “Lost” by SA Water if it fails the pressure test.

22.1.2 FRP casing

(a) joints are fastened by high-pressure O-rings;

22.1.3 Steel or stainless-steel casing

(a) The Contractor must provide, for SA Water’s approval, details of the procedures that will be used to hoist the casing;

(b) Casing is held in position using clamps which correctly align the upper and lower casings;

(c) joints are bevelled; and

(d) joints are welded in accordance with the minimum specified welding and manufacturing standards and procedures;

22.1.4 commercially available inert Kwik-zip™ centralisers are set as required to centrally locate the casing in the drillhole when pressure grouting is used; and

22.1.5 [Optional - delete if inapplicable] casing extends 1 metre above ground surface for an observation well and 300 millimetres above ground surface for a production or injection well.

22.2 The Contractor must ensure that subsequent drilling within the casing is undertaken with flush drill pipe.

23. GROUT

23.1 The Contractor must ensure in grouting of each well that:

23.1.1 The grout volume mixed for use is the calculated volume plus 50%.

23.1.2 cement complies with AS-3792 (2010);

23.1.3 normal cement grout consists of a maximum 27 litres of water per 40 kilograms cement;

23.1.4 bentonite used conform to API RP 13B-1;

23.1.5 A 5% bentonite cement consists of 2 kilograms of bentonite and 49 – 55 litres of water per 40 kilograms of cement used (i.e. 11 litres of water per kilogram of bentonite) and that bentonite is premixed before adding cement to mix;

23.1.6 cement accelerators are not used, unless the Contractor receives the written approval or direction otherwise from the Wellsite Hydrogeologist with approval of the appropriate SA Water representative; and

23.1.7 water used for grout is potable, cool, clean and free of contaminants.

23.2 If return of grout to surface does not occur, or slumping occurs, the Contractor must rectify the problem by pumping additional grout to fill the annulus between the drillhole and the casing to ground level at no additional cost to SA Water.

24. PRESSURE GROUTING CASING

24.1 The Contractor must ensure in pressure grouting casing of each well that:

24.1.1 cement grout is positively emplaced into the annulus between the casing and the drillhole so that it provides a continuous dense sheath completely surrounding the casing isolating the production zone from overlying aquifers;

24.1.2 observation, production or injection well casing is pressure grouted by displacement grouting through the inside of the casing, or by pumping through tremie line set at the required depth, or by reverse circulation grouting;

24.1.3 [Optional - delete if inapplicable] injection well casing is pressure grouted by preparing and circulating a new batch of drilling fluid and then displacement grouting through the inside of the casing or by pumping through tremie line set at the required depth, or by reverse circulation grouting;

24.1.4 when pressure grouting through the casing ensure a 5 m grout plug remains within the casing; and

24.1.5 at least **24 hours** elapses to allow grout to cure before re-entering the well.

24.2 If return of grout to surface does not occur, or slumping occurs, the Contractor must rectify the problem by pumping additional grout to fill the annulus between the drillhole and the casing to ground level at no additional cost to SA Water.

25. PLUGBACK GROUTING OF DRILLHOLE

25.1 The Contractor must ensure in plugback grouting of each drillhole that:

25.1.1 cement grout is positively emplaced into the drillhole in the interval to be plugged back by pumping through tremie line set at the required depth so that it provides a continuous dense plug that completely seals the drillhole and (if required) isolates the production zone from any underlying aquifers.

26. INSTALLATION OF SCREENS OR SLOTTED CASING AND GRAVEL PACK

26.1 The Contractor must ensure during installation of screens or slotted casing in each well that:

26.1.1 drilling fluids are conditioned prior to the installation;

26.1.2 fittings will not cause corrosion;

26.1.3 stainless steel screens are welded in accordance with the minimum specified welding and manufacturing standards and procedures;

26.1.4 the sump is sealed with an end cap;

26.1.5 screens or slotted casing are seated on a competent base not hung;

26.1.6 Telescopic screens or slotted casing

(a) they are run on the drill string (not on the sand line);

(b) they are fitted with a J-latch at the top so they can be pulled if necessary;

(c) the riser pipe is sealed to the casing with a K-packer fixed with glue and/or stainless-steel banding;

26.1.7 In-line screens or slotted casing

(a) commercial inert Kwik-zip™ centralisers are placed at the top and bottom of the screen or slotted casing, and as required in between;

(b) where gravel pack is used with in-line screens:

(i) it consists of commercial washed, round, graded quartz gravel;

(ii) it is introduced by tremie line (polypipe or drillpipe), by reverse circulation method, or gravity method;

(iii) [Optional – delete/modify if applicable] it extends 1

m above the screen for short screens or 10% of the screen length above the screen for longer screens;

(iv) [Optional – delete/modify if applicable] the annulus immediately above is sealed with a bentonite plug a minimum of 2 m in length.

27. STRATA AND WATER SAMPLES

27.1 The Contractor must provide strata samples during drilling:

27.2 Sample requirement

[Optional – delete/modify if inapplicable]

27.2.1 Strata samples every 2 m

27.2.2 Bulk samples 2 kilograms in weight every 2 m

27.3 Procedure

[Optional – delete/modify if inapplicable]

27.3.1 Circulate to clear drillhole as required at the end of each rod;

27.3.2 advise the Wellsite Hydrogeologist and appropriate SA Water representative in regard to the lag times and the correct depth placement of samples;

(a) shale-shaker to be used; and

(b) de-silter / sander to be used.

27.4 [Optional - delete if inapplicable] The Contractor must provide water samples at intervals requested when drilling with air.

28. PLUMBNESS AND ALIGNMENT OF WELLS

28.1 [Optional - delete if inapplicable] The Contractor must check the plumbness and alignment of each cased well in the presence of Wellsite Hydrogeologist with approval of the appropriate SA Water representative by running a rigid dummy of no less than 12 metres in length, and no less than 80% of the internal diameter of the casing which must be lowered freely under its own weight to the lowest proposed pump setting within the casing.

28.2 The final well will be required to accept a pump of a diameter as directed by the appropriate SA Water representative.

28.3 [Optional - delete if inapplicable] A well required as part of the Work will be considered defective and may be declared a “Lost Well” by SA Water ~~if~~ the dummy pump fails to reach the required depth (refer to clause 24 of the Agreement).

29. DEVELOPMENT OF WELLS

29.1 The Contractor must ensure the following development procedure for each well:

29.2 Mud-drilled wells with stainless steel screens

29.2.1 jetting with water over the entire length of the production zone using an approved jetting tool at a pressure of [insert detail] psi with the tool in constant vertical and rotational movement for a minimum of 1 hour per metre of screen;

29.2.2 [Optional - delete if inapplicable] chemical methods include the use of proprietary brand dispersants and non-phosphate detergents to wet, break down and carry clayey materials, polymers and fines out of the formation; and

29.2.3 final air-lifting for a minimum of 15 minutes until the groundwater is clear and free of suspended solids at the full flow capability of the bore.

29.3 Mud-drilled wells with slotted casing

29.3.1 airlifting and surging through the drill string, polypipe or galv. pipe until the groundwater is clear and free of suspended solids at the full flow capability of the bore; and

29.3.2 [Optional - delete if inapplicable] chemical methods include the use of proprietary brand dispersants and non-phosphate detergents to wet, break down and carry clayey materials, polymers and fines out of the formation.

29.4 Air-drilled wells

29.4.1 airlifting and surging through the drill-string until the groundwater is clear and free of suspended solids at the full flow capability of the bore.

30. GROUNDWATER SAMPLE COLLECTION

30.1 The Contractor must collect a sample of groundwater from each well following development.

31. FINAL DEPTH OF WELLS

31.1 The Contractor must check the final depth of each well in the presence of the Wellsite Hydrogeologist to ensure the full length of the production zone and sump are open.

31.2 [Optional – delete/modify if inapplicable] The Contractor must conduct borehole CCTV camera logging to the full depth of the well in the presence of the Wellsite Hydrogeologist and supply camera footage to the appropriate SA Water representative.

31.3 If an obstruction or blockage is encountered in a well, the Contractor must rectify the problem by clearing the well at no additional cost to SA Water.

32. MECHANICAL INTEGRITY TESTING

32.1 [Optional - delete if inapplicable] The Contractor must conduct mechanical integrity (pressure) testing for each well to confirm casing integrity in the presence of Wellsite Hydrogeologist by the following method:

32.1.1 Setting a packer at the bottom of the well casing;

32.1.2 filling the casing to the top with water and pressurising the casing with compressed water (not air);

32.1.3 pressurising in accordance with the casing manufacturer recommended ratings and procedures; and

32.1.4 maintaining the pressure for a minimum of 10 minutes with a maximum loss of 5%.

32.2 [Optional - delete if inapplicable] A well required as part of the Work will be considered defective and may be declared a “Lost Well” by SA Water if it fails the pressure test (refer to clause 24 of the Agreement).

33. STERILISATION OF WELL

33.1 The Contractor must ensure that sterilisation of each well by the following method:

33.1.1 introducing a volume of sterilising agent (containing a minimum of 100 milligrams per litre of free available chlorine) twice the volume of groundwater in the well, agitating by bubbling with air for a period of 15 minutes; and

33.1.2 purging the sterilising agent by airlifting after at least 1/2 hour.

34. HEADWORKS

34.1 The Contractor must complete the wellhead according to the following specifications and the Drilling Schedule and Well Construction Diagrams attached to this Specification:

34.2 [Optional - delete if inapplicable] The Wellsite Hydrogeologist will engrave the well Permit Number and any other relevant details on a stainless-steel name plate and will fix to the standpipe or casing with stainless steel screws.

34.3 Non-Artesian Production and Injection Wells up to and including 150 mm diameter

[Optional - delete if inapplicable]

34.3.1 an externally fitting flange conforming to Australian Standard AS-2129 drilled to Table D of the same material as the well casing;

34.3.2 a hot dipped galvanised steel cover plate conforming to Australian Standard AS-2129 drilled to Table D and drilled with a nominal 25 mm hole which is tapped with a BSP thread fitted with polymer plug of same thread having a hexi-head; and

34.3.3 bolted using M20 galvanised steel nuts, bolts and washers.

34.4 Non-Artesian Production and Injection Wells above 150 mm diameter

[Optional - delete if inapplicable]

34.4.1 an externally fitting flange conforming to Australian Standard AS-2129 drilled to Table E of the same material as the well casing;

34.4.2 a hot dipped galvanised steel cover plate conforming to Australian Standard AS-2129 drilled to Table E and drilled with a nominal 25 mm hole which is tapped with a BSP thread fitted with hexi-head polymer plug; and

34.4.3 bolted using M20 galvanised steel nuts, bolts and washers.

34.5 Artesian Production, Injection & Obs. Wells

[Optional - delete if inapplicable]

34.5.1 an externally fitting flange conforming to Australian Standard AS-2129 drilled to Table E of the same material as the well casing;

34.5.2 a nitrile gasket seal for salt solution application;

34.5.3 for higher pressures, a gate valve with cast iron body with 316 stainless steel trim and spindle and with nitrile gasket seals for salt solution application, conforming to AS-1628 or AS-3579 and API-598, drilled to Table E;

34.5.4 for lower pressures, a hot dipped galvanised steel cover plate conforming to Australian Standard AS-2129 drilled to Table E; and

34.5.5 bolted using M20 galvanised steel nuts, bolts and washers.

34.6 Non-Artesian Observation Wells

34.6.1 [Optional - delete if inapplicable] a capped, lockable galvanized steel standpipe (or end cap + bar + padlock).

35. BACKFILLING OF WELL

35.1 The Contractor must ensure that the backfilling of a well is in accordance with the General Specification for Well Construction Modification and Abandonment in South Australia Pursuant to Well Construction Permit Issued under the Natural Resources Management Act 2004 and complies with specifications described in Minimum Construction Requirements for Water Bores in Australia (Edition 3, February 2012).

35.2 The Contractor must develop and discuss the procedure for backfilling of a well with the Drilling Inspector on an individual basis [Optional - delete if inapplicable] and obtain written approval for the procedure from the Wellsite Hydrogeologist with approval of the appropriate SA Water representative prior to commencing the backfilling of any well.

35.3 Sealing material and placement

The Contractor must ensure that all materials used for sealing comply with the specified and/or applicable recognised industry material standards.

Concrete, cement grout, clay grouts, sealing clay, bentonite chips or neat cement shall be used as primary sealing materials and shall be placed from the bottom upward by methods that will avoid segregation or dilution of material and unnecessary contamination of the aquifer zone.

The sealing material shall be more impermeable than the material encountered during the drilling of the bore. In the limestone aquifer environment (especially karstic limestone), no part of the decommissioned bore shall remain as an open hole.

36. BACKFILLING OF DRILLHOLE

36.1 The Contractor must ensure that the following methods are adopted for backfilling of each drillhole:

36.2 Backfill a Drillhole in Unconfined Aquifer

36.2.1 backfill the lower part of the drillhole with cuttings;

36.2.2 set an octaplug a depth of 2 metres below surface; and

36.2.3 backfill the drillhole with cutting above the octaplug.

36.3 Backfill a Drillhole penetrating one or more Confined Aquifers

36.3.1 set a continuous dense cement plug over each confining bed extending a minimum of 5 metres into both the underlying and overlying aquifers so that it completely seals the drillhole and isolates the confined aquifer from all other aquifers; and

36.3.2 backfill the upper part of the drillhole as for an unconfined aquifer.

37. REMEDIATION OF DRILLING SITE

37.1 The Contractor must undertake site remediation to the satisfaction [Optional - delete if inapplicable] and obtain written approval of the Wellsite Hydrogeologist before vacating the site, which includes but is no not limited to:

37.1.1 removing all temporary site services and facilities installed for construction purposes;

37.1.2 removing and disposing waste materials in accordance with prior approved procedures conforming to minimum EPA regulations;

37.1.3 backfilling excavated pits; and

37.1.4 levelling the ground surface to allow vehicle access.

38. REPORTS

38.1 Daily Drilling Report

The Contractor must prepare and submit a Daily Drilling Report to the Wellsite Hydrogeologist [Optional - delete if inapplicable] for verification and countersigning. The report must detail activities for the day, including:

38.1.1 drilling details, which must include:

(a) metres drilled;

(b) drill string details;

(c) drilling bit diameters;

(d) drilling fluids and additives;

(e) mud viscosity;

(f) mud weight;

(g) penetration rates;

(h) circulation losses;

(i) materials used (casing, screens or slotted casing);

38.1.2 drilling returns and major lithological changes observed during drilling;

38.1.3 groundwater flow on airlifting;

38.1.4 work progressed / completed against the scheduled works; and

38.1.5 breakdown time.

38.2 Drillers Well Construction Report (The Schedule 8)

The Contractor must prepare and submit a Drillers Well Construction Report on the completion of each drillhole or well detailing major lithological changes and a summary of the well construction.

38.3 Bore Completion Report

The Contractor must prepare and submit complete and accurate records of the decommissioning procedure including details of bore cementing to verify that the hole was properly sealed.

39. COMPLETION VERIFICATION CERTIFICATE

39.1 [Optional - delete if inapplicable] Before leaving any well site, the Contractor must ensure that completion of the headworks for each well is in accordance with the requirements of the Drilling Schedule and Well Construction Diagrams attached to this Specification and obtain a Well Completion Verification Certificate for each well to be issued by the Wellsite Hydrogeologist.

39.2 [Optional - delete if inapplicable] If the Contractor leaves the site prior to being issued a Completion Verification Certificate for each well, the Contractor remains responsible for the care of the well until a Completion Verification Certificate has been issued, and this includes responsibility for the loss of or damage to the well, and for any act of vandalism. As part of the procedure for issue of a Completion Verification Certificate by the Wellsite Hydrogeologist with approval of the appropriate SA Water representative the Contractor will be required to return to the site of each well awaiting certification and prove the well at its cost.

40. OTHER

40.1 The Contractor acknowledges that the terms and conditions of this Agreement includes, amongst other things, obligations in relation to the following matters:

(a) provision of resources;

(b) care of the Work and reinstatement of damage;

(c) environmental requirements;

(d) occupational health, safety and welfare requirements;

(e) traffic management;

(f) defective work;

(g) defects liability;

(h) liability and indemnity;

(i) insurance,

41. WORK BY OTHERS

41.1 The following listed items are outside the scope of the Works, and are not to be undertaken by the Contractor:

(a) negotiating with landholders for access;

(b) determining of well locations;

(c) obtaining well drilling permits;

(d) obtaining site clearances; and

(e) arranging geophysical logging.

42. PROJECT MILESTONES

42.1 [Optional – insert if applicable]