



Assets Planning and Delivery Group  
Engineering

# **DESIGN STANDARD DS 32-01**

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## **Pump Stations – Borehole - Mechanical**

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VERSION 1  
REVISION 4

MAY 2022

## FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of WA OSH Regulations 1996 (Division 12, Construction Industry – consultation on hazards and safety management) to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

[Overview of Western Australia’s Work Health and Safety \(General\) Regulations 2022 \(dmirs.wa.gov.au\)](https://dmirs.wa.gov.au)

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## Head of Engineering

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**REVISION STATUS**

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	1/0	1.05.11	All	New part standard	EJP	SE
1	1/2	10.12.12	12, 14-16	Clauses 1.1, 1.1.1, 1.1.4, 1.6, 1.7, 1.8.1.1, 1.8.5 amended, 1.8.1.5 added	GWR	SE
1	1/3	11.04.14	12,15	Clauses 1.1.1, 1.83 amended	GWR	SE
All	1/4	16.05.22	n/a	Periodic review, no change required except minor change to Sec 7 pages 54-55 as detailed below (Clause 7.3.8 - DS25-01 replaced with DS40-08)	SE	SE

2	1/0	1.05.11	All	New part standard	EJP	SE
2	1/1	1.05.12	16, 21, 22-25	Clause 2.2.1, 2.2.7, 2.17, 2.24 2.26, amended; previous 2.4, 2.6 to 2.10, 2.23 deleted; 2.10, 2.11 added; previous 2.16, 2.18 2.20, 2.27, 2.28, 2.29.1, 2.29.4 transferred	EJP	SE
2	1/2	10.12.12	17-25	Clauses 2.1, 2.2, 2.2.2.1 to 2.2.2.5, 2.2.3, 2.12, 2.21, 2.28 amended, 2.10 added Clause 2.7 (incl. subclauses) amended and reformatted	GWR	SE
2	1/3	11.04.14	20-23	Clauses 2.7.1, 2.7.2, 2.15 amended	GWR	SE

3	1/0	1.05.11	All	New part standard	EJP	SE
3	1/1	1.05.12	26, 28	Clause 3.1, 3.7.1, 3.7.3 amended; 3.7.2 added	EJP	SE
3	1/2	10.12.12	26-31	Section reformatted Clauses 3.1(g(i)), 3.3, 3.5.1, 3.5.2, 3.6.4, 3.7, 3.8 amended Clause 3.6.3 added	GWR	SE
3	1/3	11.04.14	28-31	Clauses 3.5.1, 3.6.2, 3.6.3 amended	GWR	SE

4	1/0	1.05.11	All	New part standard	EJP	SE
4	1/1	1.05.12	32	Clause 4.2.1, 4.2.2 amended; 4.2.4, 4.2.5 added	EJP	SE
4	1/2	10.12.12	32-36	Clause 4.2.1 reformatted Clauses 4.1, 4.2.6, 4.2.7, 4.3,	GWR	SE

				4.4.1, 4.4.2, 4.4.3, 4.5 amended		
4	1/3	11.04.14	33-35	Clauses 4.2.1, 4.2.7, 4.2.8, 4.3	GWR	SE
5	1/0	1.05.11	All	New part standard	EJP	SE
5	1/1	1.05.12	38, 42	Clause 5.2, 5.5.2, 5.11.3, 5.12 amended; 5.3, 5.4 added	EJP	SE
5	1/2	10.12.12	37-43	Section reformatted Clauses 5.1, 5.1.1, 5.1.2, 5.2, 5.3, 5.4, 5.5, 5.7, 5.8 amended Clause 5.6.3 added	GWR	SE
6	1/0	1.05.11	All	New part standard	EJP	SE
6	1/1	1.05.12	44, 45-47	Clause 6.2.1, 6.2.2, 6.2.3.1, 6.2.3.2, 6.2.3.4 amended	EJP	SE
6	1/2	10.12.12	44-48	Clauses 6.1, 6.2, 6.3 and Notes amended and reformatted; 6.3.3 added	GWR	SE
6	1/3	11.04.14	45-46	Clauses 6.2.2, 6.2.3 amended	GWR	SE
7	1/0	1.05.11	All	New part standard	EJP	SE
7	1/1	1.05.12	50-58	Clause 7.2.1-7.2.4, 7.2.7, 7.2.8, 7.2.10.2, 7.2.11-7.2.16, 7.2.18, 7.3.1.1, 7.3.1.2 amended	EJP	SE
7	1/2	10.12.12	49-57	Clause 7.3 reformatted Clauses 7.1, Table 7.1 and Notes, 7.3.6, 7.3.6.3, 7.3.8.1 to 7.3.8.3, 7.3.9.2, 7.3.9.3, 7.3.9.4, 7.3.10, 7.3.11, 7.3.12, 7.4.1.1, 7.4.2, 7.4.4; 7.3.4(a)(i), 7.3.7 amended	GWR	SE
7	1/3	11.04.14	50, 52, 54	Clauses 7.1, 7.3.7, 7.4.2 amended	GWR	SE
	1/4	31.08.18	54-55	Clause 7.3.8 - DS25-01 replaced with DS40-08	SE	SE
8	1/2	10.12.12	All	New part standard –from Table 7.3 including amendments	GWR	SE
8	1/3	11.04.14	All	Table 8.1 amended	GWR	SE
App A	1/0	1.05.11	All	New part standard	EJP	SE
App A	1/2	10.12.12	All	Drawing schedule revised	GWR	SE
App A	1/3	11.04.14	All	Drawing references added	GWR	SE
App B	1/0	1.05.11	All	New part standard	EJP	SE
App B	1/2	10.12.12	All	Appendix designation changed	EJP	SE
App C	1/2	10.12.12	All	New part standard	GWR	SE



# DESIGN STANDARD DS 32-01

## Pump Stations – Borehole - Mechanical

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# 1 SCOPE AND GENERAL

## 1.1 Scope

Design Standard DS 32-01 is the second part of a three part standard which provides design requirements for various pump station types. The other parts of the Standard comprise:

- DS 30 Pump Stations – Conventional Water and Sewage - Mechanical,
- DS 30-02 Pump Stations – Packaged Pressure Booster System – Mechanical.

DS 32-01 sets out the Corporation’s mechanical standards, guidelines and preferred engineering practices for design of new borehole pumping plant, and associated pipework and ancillaries for water supply projects. The scope of this standard covers the following:

### 1.1.1 Pumpset Types

Requirements for the following borehole pump configurations will be addressed:

- (a) Conventional type submersible electric borehole pumps utilizing flexible or rigid columns;
- (b) Oilfield type submersible electric borehole pumps utilizing the production casing as the column. For the purposes of this Standard this configuration will be referred to as ‘columnless’. The suitability of this configuration for new bore projects is currently under review (refer to Note for details)
- (c) Diesel engine driven vertical turbine borehole pumps for small and medium sized pumpsets. These pumpsets are also referred to as lineshaft borehole pumps;

**NOTE:** Preliminary investigation work has been conducted and found that the conventional arrangement represents better value for money than the oilfield type arrangement for new high capacity bores (refer PM#10677201). Further investigation work is scheduled to be conducted with aims to confirm and verify the feasibility and suitability of the conventional arrangement for high capacity bores.

### 1.1.2 Bore Types

Requirements for both sub-artesian and artesian bores will be addressed in this Standard.

### 1.1.3 Operating Environment

Requirements with respect to the following operating environments will be addressed:

- (a) Non flood-prone bore sites;
- (b) Flood-prone bore sites which have been categorized as follows:
  - Local flooding or flood plane type e.g. relatively shallow and slow flowing flood waters,
  - Riverbed type e.g. fast flowing flood waters such as the Gascoyne River.

### 1.1.4 Sealing of Bore Headworks

Australian Drinking Water Guidelines (ADWG) 2004 recommends the sealing of bore headworks in order to prevent the ingress of vermin<sup>1</sup> and surface water which has the potential to cause contamination<sup>2</sup> of bore water for drinking water purposes and accordingly this issue has been addressed in the Standard in the design of the borehole pumping plant.

**NOTES:**

1. For the purpose of this Standard ‘vermin’ shall include medium to large insects (i.e. those incapable of passing through a gap 2mm or smaller)
2. There are other potential sources of contamination caused by inadequate installation and removal practices that should also be addressed as O&M issues as follows:

- Placement of borehole equipment on contaminated surfaces e.g. the ground, prior to installation or after removal from the bore
- Open boreholes and/or where items of equipment have been removed from the headworks pipework potentially allowing entry of vermin etc.

## 1.2 Purpose

The Corporation's mechanical design standards are documented in its DS 30 Standards series. Designers shall comply with these standards for the design and specification of mechanical components of assets being acquired for the Corporation (refer Note).

The purpose of the DS 30 Standards series is to provide:

- (a) Standards and guidelines applicable in the design of Corporation assets,
- (b) Explanatory or specific design information,
- (c) Information relating to Corporation preferences and practices which have evolved from over a century of experience in the water industry.

**NOTE:** Section 2 of this Standard covers general design requirements associated with borehole pumping plant most of which refer to the DS 30 Standards series.

## 1.3 Design Process

The Designer shall comply with the requirements of the relevant mechanical design process contained in DS 30.

## 1.4 Standards

All materials and workmanship shall comply with latest revisions of the relevant codes and standards.

Water Corporation Strategic Product Specifications (SPS), or in their absence the latest editions of Australian Standards, or Water Services Association of Australia (WSAA) Codes, shall be referenced for design and specification. In the absence of relevant Australian Standards or WSAA Codes, relevant international or industry standards shall be referenced.

## 1.5 Borefield Regulatory Reporting Requirements

The Department of Water (DoW) requires the Corporation to report the following parameters as part of its Operating Licence related to borefields.

### 1.5.1 Abstraction

- (a) Water meters are required to be closed conduit type fully charged complying with AS 4747.
- (b) The DoW requires abstraction volume readings to be taken using a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 for each bore under the licence.
- (c) Readings are to be taken as close as practicable to the end of each month. Should there be an unforeseen event preventing volume readings being taken then the Corporation is required to notify the DoW. Notification should include an estimated date when readings can be taken.
- (d) The abstraction readings are to be reported to the DoW annually in compliance with the Corporation's Operating Licence for borefields;
- (e) The bore abstraction readings are to be accurate (rounded) to the nearest 1 kilolitre;
- (f) Installation of water meters are required to comply with DoW "Guidelines for water meter installations 2009" and ATS 4747 (refer Section 7 of this Standard "Abstraction Flowmeter");

- (g) Water meters are required to be accurate to  $\pm 2\frac{1}{2}\%$  when laboratory tested or  $\pm 5\%$  when tested in situ and shall be tested in accordance with ATS 4747;
- (h) The DoW should be notified in writing of any water meter malfunction within 7 days of the malfunction being noticed;
- (i) Should a meter malfunction and/or is to be removed then the Corporation is required to formally notify the DoW providing a timeline to rectify the malfunction, or to replace the meter and explain how abstraction is proposed to be measured during period of meter removal.

**NOTES:**

1. This Standard complies with the DoW “Guidelines for water meter installation 2009” and the above represents a general summary. More detailed requirements are addressed in later parts of this Standard.
2. Verification of magnetic flowmeter accuracy is achieved via testing of the electronic meter head only as this is the only component that would normally be subject to change over time.

## 1.5.2 Water Levels

- (a) The DoW requires the water rest level (WRL) to be monitored for each production bore (where possible – refer Note 1). The frequency for monitoring is monthly or 3 monthly depending upon the frequency assigned for the particular borefield. The water rest level readings are required to be reported to the DoW annually in order to comply with the Corporation’s Operating Licence requirements for borefields.

**NOTES:**

1. Where WRLs are unable to be monitored because the bore is in continuous operation then monitoring of water pumping levels (WPL) is acceptable to the DoW
  2. The Corporation takes both WRL and WPL readings a number of times each year for production bores.
- (b) WRL readings for monitoring bores are ‘where required’ by DoW. The frequency for monitoring is monthly, 3 monthly or 6 monthly depending upon the frequency assigned for the particular bores. The readings are required to be reported to the DoW annually in order to comply with the Corporation’s Operating Licence requirements for borefields.
  - (c) The water level readings are to be accurate to the nearest 0.1 m.

## 1.5.3 Conductivity

- (a) The DoW requires conductivity (salinity) to be monitored for each bore. The frequency for monitoring is monthly or 3 monthly depending upon the frequency assigned for the particular borefield.
- (b) The readings are to be reported to the DoW annually in order to comply with the Corporation’s Operating Licence requirements for borefields.

## 1.5.4 Ion Analysis

DoW also requires a comprehensive ion analysis on production bores usually annually. Ion analysis is also required on some monitoring bores as specified in the licence.

## 1.6 Referenced Documents

A full list of Australian, International and Corporation standards, codes and technical specifications referenced in the DS 30 series of standards is contained at Appendix A in the “Referenced Documents” section of DS 30-01.

## 1.7 Notations

Statements expressed by the use of the word ‘shall’ are mandatory or ‘normative’ requirements of the Standard. Statements expressed by the use of the words ‘should’ or ‘may’ are ‘informative’ but not mandatory and are provided only for information and guidance. Notes in Standards text are informative however notes that form part of the Standards tables are normative.

## 1.8 Nomenclature

### 1.8.1 Engineering Definitions and Relationships

For definitions of the terminology and relationships referred to in this Standard the reader is referred to the Engineering Definitions and Relationships section of DS 30-01 and the following.

#### 1.8.1.1 Flood-Plane Bores

Bores that are located on flood planes and subject to shallower and less damaging flood waters than would otherwise be experienced for riverbed bores. The switchboard (elevated) and headworks are located at the bore head.

#### 1.8.1.2 Foot Valve

A poppet type (valve disc sliding on a central spindle) non return valve, which is fitted on the suction side of the pump e.g. lineshaft turbine pump.

#### 1.8.1.3 Pump Non Return Valve

A poppet type non return valve, which is fitted on the discharge side of the pump e.g. submersible electric borehole pump.

#### 1.8.1.4 Riverbed Bores

Bores that have been located in a riverbed, and subject to relatively deep and turbulent flood-waters. The switchboards and headworks are located beyond the river bank.

#### 1.8.1.5 Snifter Valve

A small vacuum breaker valve (one way ‘air in’) fitted upstream of the surface NRV designed to admit air in order to break vacuum that may form in the column pipe when the pump stops.

#### 1.8.1.6 Surface Non Return Valve

A dual plate or swing check type non return valve fitted above ground as part of the headworks pipework.

#### 1.8.1.7 Top of Bore Cover (TOBC)

Is the top of the:

- (a) Bore cover body top flange for column type submersible electric pumps;
- (b) Bore tee head body flange for columnless type submersible electric pumps;
- (c) Bore at the level where the discharge head baseplate is mounted for lineshaft pumps;

The top of bore cover shall be referenced to AHD. (Refer also Clause 3.6.1)

#### 1.8.1.8 Top of Casing (TOC)

Is the top of the production casing (or its flange if the production casing has one) when first installed by the drilling contractor. (Refer also Clause 3.6.1)



## 1.8.2 Preferred Terminology

For preferred mechanical terms to be used in Corporation designs, the reader is referred to the Preferred Terminology section of DS 30-01.

## 1.8.3 Abbreviations

For abbreviations referred to in this Standard the reader is referred to the Abbreviation section of DS 30-01 and the following.

<b>AC</b>	– Alternating current
<b>AV</b>	– Air valve
<b>BYS</b>	– Bronze ‘Y’ strainer
<b>DoW</b>	– Department of Water
<b>LT</b>	– Level transmitter
<b>MFM</b>	– Magnetic flowmeter
<b>NRV</b>	– Non return valve
<b>ODSS</b>	– Operational data storage system (for manual and low frequency data collection)
<b>OSH</b>	– Occupational safety and health
<b>PLC</b>	– Programmable logic controller
<b>PI</b>	– Plant information data storage system (for high frequency data collection)
<b>PRV</b>	– Pressure reducing valve
<b>PSV</b>	– Pressure sustaining valve
<b>RTD</b>	– Resistance temperature detector
<b>RTU</b>	– Remote terminal unit
<b>TOBC</b>	– Top of bore cover
<b>VB</b>	– Vacuum break valve
<b>WPL</b>	– Water pumping level

## 1.8.4 Standard Units and Relationships

The units and relationships used for mechanical designs shall be in accordance with those specified in the SI Units, Relationships and Prefixes section of DS 30-01.

## 1.8.5 Drawing Symbols

A comprehensive list of mechanical drawing symbols for mechanical equipment is referenced in DS 80.

## 2 GENERAL DESIGN CRITERIA

### 2.1 General

This section details the design criteria that should be applied (where relevant) during the design of borehole pumping plant and is arranged in alphabetic order for referencing convenience. It also includes explanatory notes and information both for record purposes and assistance to the reader. In addition to the following design criteria, the Designer shall also refer to relevant parts of DS 30, DS 30-01, DS 30-02, DS 31-01, DS 31-02, DS 35, DS 38-01 and DS 38-02.

### 2.2 Air Valves

#### 2.2.1 General

For information relating to air entrapment in and its removal from pipework and pipelines refer to the Air Valves section contained in DS 31-02.

The bore head and collector main air valves shall be engineered by the Designer to suit each particular borehole pump.

#### 2.2.2 Bore Head Air Release and Vacuum Break Valves

##### 2.2.2.1 Past Practice

Air release and vacuum break valves have been traditionally fitted at or near the bore head for non flood-prone bore sites in order to prevent vacuum formation in the discharge column (for WRL >10m) by admitting air into the column on pump stop and then expelling air from the column on pump start.

**NOTE:** Pump manufacturers require the fitting of a vacuum breaker valve at the bore head to prevent vacuum formation in the column (refer clause below). In the past a small vacuum breaker valve (snifter valve) was fitted to the bore column. More recently proprietary combination air release and vacuum breaker air valves have been specified to deal with both vacuum formation and also to expel resultant column air.

##### 2.2.2.2 Vacuum Formation in the Column

Vacuum formation could occur because of the practice of drilling a hole in the pump non return valve (NRV) to allow drainage of flexible column (e.g. Wellmaster or equivalent) in order to facilitate its removal, or due to a leaking pump non return valve where the WRL >10m. A vacuum could cause damaging effects on the system and pumpset by way of:

- shock loading during pump start as a result of the advancing water column impacting on the stationary water upstream of the headworks NRV.
- An empty flexible column which becomes depressurized and subject to partial rotation due to ‘motor kick’ during pump start. Rotation has the potential to abrade the column, cable and bubbler tube, and dislodge cable straps.

Fitting of air release and vacuum break valves will address these problems but can introduce other issues as discussed below.

**NOTE:** Refer to Nomenclature in Section 1 for information on the various NRVs referred to in this Standard

##### 2.2.2.3 Air Valve Issues

Fitting air release and vacuum break valves has the potential to introduce the following issues if a pump non return valve or footvalve is not fitted or is subject to leakage:

- An empty discharge column above the WRL after pump shutdown will decrease the head on the pump and can induce a momentary up-thrust of the rotating element on restart, followed by a down thrust during pumping. Repeated cycling of this nature can damage the motor thrust

bearing due to the repetitive shock loading it induces. Where pumps run continuously this is not an issue;

- A decreased head on the pump can produce over-pumping on start which may exceed the flow capability of the bore screen, and surging of the bore due to the action of over-pumping and water backflow;
- Normal air valve cycling in a pipeline expels and admits small quantities of air due to air accumulation in the pipeline. The bore head air release and vacuum break valves by comparison can admit and expel relatively large quantities of air during each pumping cycle. This may represent a potential minor contamination risk where air admission occurs on bore sites which are located in dusty polluted environments e.g. where stock can roam. This risk is low and will not be addressed as to do so could adversely affect the performance of critical air transfer components.
- A two-way air valve (e.g. air in/air out) poses a potential contamination source from entry of flood waters if inundated and small wildlife e.g. small lizards and large insects. This issue has been addressed by specifying a one-way ‘air release only’ air valve in conjunction with a small vacuum break valve e.g. snifter valve. Since the air release valve is one-way ‘air release only’ there is no risk of admitting contaminants into the pump column through this valve. Also the small vacuum break valve incorporates small inlet holes which whilst admitting air would exclude all vermin except very small insects.

**NOTE:** During the development of this Standard the use of a bypass around the surface NRV to address potential pump NRV leakage was considered as a possible alternative to an air valve. However use of the bypass was dismissed because of the potential for bore contamination (e.g. iron bacteria) arising from backflow of water from the collector main into the bore in the event of pump NRV or footvalve failure.

#### 2.2.2.4 Requirements for Column Type Pumps

- (a) A bore head one-way ‘air release only’ air valve in conjunction with a small vacuum break valve (e.g. snifter valve) shall be provided for column type borehole pumps except for riverbed bores. These air valves shall be engineered for the application.
- (b) For flexible columns this Standard now requires that the pump NRV shall be un-drilled, and instead the column shall be fitted with a break-off plug system in order to facilitate column drainage when the pumpset is to be removed.
- (c) Theoretically there should be no need to provide a snifter valve to act as a vacuum breaker, or a bore head one-way air release valve to expel column air on pump start for column type pumps because they are fitted with a pump NRV. However the potential for a leaking pump NRV is high and in this event the potential for vacuum formation and the attendant risks to the system require the use of bore head air valves.
- (d) The air valve shall be metal bodied in vandal or damage prone locations.

**NOTES:**

1. Use of a one-way ‘air release only’ air valve addresses the issue of excluding entry of vermin and contaminants however the vacuum release function becomes disabled necessitating use of a separate vacuum breaker (snifter valve).
2. For flood prone sites the submerged valve will only operate if the pumping head at the air valve is greater than the immersed depth otherwise the air valve would need to be provided with a snorkel or be relocated above flood level e.g. on the switchboard elevated platform.

#### 2.2.2.5 Requirements for Columnless Pumps

- (a) A bore head one-way ‘air release only’ air valve in conjunction with a small vacuum break valve (e.g. snifter valve) shall be provided for columnless borehole pumps. These pumps are not usually fitted with a pump non return valve because of the high head loss characteristics of available valves relative to the flows they are required to pass.
- (b) The air valve shall be metal bodied in vandal or damage prone locations.

**NOTE:** The use of a pump NRV is preferred and provision of a suitable valve should be investigated (refer to Section 4.2.6 for further details).

### 2.2.3 Collector Main Air Valve

A collector main air valve is required downstream of the surface non return valve in order to expel small quantities of accumulated air from the collector main that has been liberated from dissolved gas in the bore water or other cause e.g. carry-over air from the bore head air valve.

The collector main air valve shall be a one way ‘air release only’ type. Since the air valve is not a vacuum breaker type there would be no risk of admitting potentially contaminated air into the collector main. The air valve shall be metal bodied in vandal or damage prone locations.

## 2.3 Ambient Conditions

The ambient operating conditions shall be determined in accordance with the Site Conditions section of DS 30-02.

## 2.4 Backflow Prevention

All designs shall comply with the Backflow Prevention Devices section contained in DS 31-02.

## 2.5 Cathodic Protection

Where conditions such as age, material, soil type, groundwater etc. require it the collector main shall be subject to cathodic protection treatment in accordance with DS 91.

## 2.6 Coatings

For general information relating to coatings refer to the Coatings section of DS 30-02.

## 2.7 Condition Monitoring

The following instrumentation shall be used or provided for the monitoring of the pumpset condition and ground water parameters, as applicable.

- (a) A dip tape;
- (b) A bubbler (airline) level monitor;
- (c) A level transmitter (LT);
- (d) A magnetic flowmeter;
- (e) Resistance temperature detectors (RTDs);
- (f) A pressure transmitter;
- (g) A conductivity meter;
- (h) A water sampling point;
- (i) An integrated monitoring system;
- (j) A packer low pressure switch.

**NOTE:**

- 1. The dip tape is not a permanently installed device whereas the other items are.
- 2. It is recommended that a tape reading be performed on WRL before pump installation and compared with LT and bubbler readings after the pump is installed.

## 2.7.1 Summary of Requirements

The following table summarises the conditions monitored and condition monitoring devices required for Corporation borehole pumpsets and headworks depending on the motor power rating.

**Table 2.1 Summary of Condition and Groundwater Monitoring**

Condition/ (Additional Stakeholder)	Detection Device	Conventional Type		Columnless	Lineshaft
		< 100kW	≥100kW		
Borehole water level (DoW)	Dip tape (manual as required)	M	M	M (using hanger pipe)	
	Bubbler (manual as required)	M	M		M
	Level transmitter (electronic)	M			
	Integrated monitoring system		M, P, A	M, P, A	
Abstraction volume (DoW)	Magnetic flowmeter (electronic)	M	M	M	M
low flow / no flow protection		A, P	A, P	A, P	A, P
Motor temperature	Resistance temperature detectors (electronic)	A, P - iron bacteria bores only	A, P	A, P	A, P
	Integrated monitoring system		M	M	
Low discharge pressure	Pressure transmitter (electronic)	*May be required for op. reasons	A, P	A, P	A, P
Discharge pressure			M	M	M
Water quality (DoW); (Dept of Health)	Conductivity meter (only as required)	M	M	M	M
	Water sampling point (includes conductivity and ion analysis)	M	M	M	M
Vibration	Integrated monitoring system		A, M	A, M	
Earth leakage			P	P	
Bore water temperature			M	M	
Packer low pressure	Pressure switch (columnless)			A	

**LEGEND:** A – Alarm; P – Protection; M – Monitoring

## 2.7.2 Detection Device Details

### 2.7.2.1 Dip Tape

For column type pumpsets a dip tape shall be used to obtain bore WRL readings manually from the top of the bore cover (dipping) prior to installation of the down-hole equipment. The readings are used primarily for calibrating the level transmitter. Dipping cannot be conducted after installation of the down-hole equipment unless the bore is fitted with a ground water level monitoring duct. A duct shall be fitted where well space permits. Dipping without the benefit of the duct could cause ‘hang up’ of the tape with the down hole equipment.

For columnless pumps both WRL and WPL can be dipped using a dip tape after installation of the down hole equipment via the hanger pipe, which is connected hydraulically to the bore upstream of the pump packer.

### 2.7.2.2 Bubbler Level Monitor

A bubbler level monitoring device shall be provided for all pumpsets utilizing pump delivery columns to allow bore WRL and WPL readings to be taken manually at the surface for Corporation operational and DoW licensing requirements. The bubbler tube is taped or strapped to the pump column during installation of the down hole equipment.

The bubbler installation and setting requirements are detailed in the “Rigid Column and Flexible Column” clauses contained in Section 4 and the “Level Monitoring Equipment” Clause in Section 5.

**NOTE:** Bubblers are not usually used for columnless pumps although they could be installed inside the hanger pipe.

### 2.7.2.3 Level Transmitter

- (a) For conventional type pumpsets <100kW a LT (e.g. Vegawell 52 or equivalent) is required in addition to the bubbler tube (where appropriate and well size permits). A LT electronically measures the WRL and WPL for Corporation operational and DoW licensing requirements.
- (b) A dip tape reading shall be done initially to confirm the electronic setup and calibration of the level transmitter. For recording systems refer to the Notes 3 to 5 below.
- (c) A LT duct shall be provided to facilitate installation and removal of the transmitter without removal of the down-hole equipment as follows.
  - for rigid columns the duct shall be unglued PN 12 UPVC. The duct design shall allow free water movement to the LT sensor via holes at the lower and upper ends and capped to capture LT sensor,
  - for flexible columns the duct shall be 1m of PN12 PE. The short length of duct does not fully encapsulate the LT sensor, but acts to direct the LT sensor smoothly from the casing cover top plate into the bore production casing.
  - the duct shall be taped to the pump discharge column.
- (d) The LT installation and setting requirements are detailed in the Rigid Column and Flexible Column clauses contained in Section 4.

#### NOTES:

1. Lineshaft pumps utilize a bubbler tube only for water level measurement.
2. The LT data is reported to PLC/RTU/SCADA and PI to represent the depth of water over the transmitter.
3. The distance from the datum (TOBC) to the transmitter is recorded in the standard location for this data (currently ODSS).
4. The level of the datum in relation to AHD is recorded in the standard location for this data (currently ODSS).
5. The location of the level transmitter needs to be recorded in Aqua with respect to the location of the pump and motor along with the details of the bore casing, casing depth, screens and the development together with the normal information contained on the bore log for the particular borefield.
6. Level monitoring can also be conducted as part of an integrated monitoring system detailed in Section 2.7.2.9

#### 2.7.2.4 Magnetic Flowmeter

The flowmeter primarily serves to measure instantaneous flow and accumulated flow to meet Corporation operational and DoW abstraction licensing requirements which are detailed in Section 7 of this Standard relating to Abstraction Flowmeter. The flowmeter also provides an alarm and protection function for the bore pump as specified in the following.

Borehole pump designs shall incorporate an alarm and protection function for a low-flow or no-flow condition utilizing the magnetic flowmeter. This functionality shall also prevent the pump from pumping ‘on the snore’ (which could otherwise occur if the water level was to drop to the suction inlet) by shutting down the pump on low-flow (refer to Notes below).

**NOTES:**

1. Pumping ‘on the snore’ causes snatch loading on the pumpset rotating element with high risk of component failure due to mechanical damage and/or motor overheating due to lack of cooling water flow past it.
2. Correct ranging and scaling of the flowmeter and its transmitter to achieve these functions is critical.

#### 2.7.2.5 Resistance Temperature Detectors

Where required, motor windings shall be fitted with RTDs, which shall be set to enable shut down of the pump in the event that the temperature exceeds the set point for pumpset motors >100 kW and all bores prone to iron bacteria build up. For further information regarding submersible motor winding temperature detection refer to Clause 4.7(c) contained in DS 22.

**NOTE:** RTD’s should not be used for low-flow or no-flow detection or protection of pumps because they are unreliable.

#### 2.7.2.6 Pressure Transmitter

Major borehole pump headworks shall incorporate a pressure transmitter to provide alarm, monitoring and protection functions configured to shut down the pump in the event of low discharge pressure.

**NOTE:** It may be necessary for operational reasons to provide a pressure transmitter for ≤100 kW pumpsets.

#### 2.7.2.7 Conductivity Meter

A conductivity meter shall only be provided for bores that have been specifically identified by the DoW or Corporation as requiring continuous conductivity measurement e.g. coastal borefields which are potentially subject to salt water intrusion. Normally, the requirements for conductivity monitoring can be provided by manual water sampling.

Where a conductivity meter is required it shall be in accordance with the requirements detailed in Section 7.3.9.4 of this Standard ‘Conductivity Meter Tapping’.

#### 2.7.2.8 Water Sampling Point

A stand-alone water sampling point shall be provided for sampling the ground water quality and as further detailed in Section 7 of this Standard ‘Water Sampling Point’

#### 2.7.2.9 Integrated Monitoring System

For large rigid column and columnless electric submersible pumps (e.g. ≥ 100 kW) an integrated monitoring system (Phoenix ESP/CTS or equivalent) should be provided. Information received from integrated monitoring systems shall be connected to SCADA and the data available in PI.

For large rigid column pumps the monitoring system is located just above the pump and strapped to the column. It uses a separate cable to the motor cable to transmit information to the surface.

For columnless pumps the monitoring system is located under the pump motor and attached to the motor windings. It utilizes the motor power cable to transmit information to surface for monitoring via the power cable taped to the pump column or hanger pipe.

The following parameters are typically measured:

- Vibration

- Earth leakage (columnless only)
- Motor temperature (columnless only)
- Water temperature
- Suction pressure – i.e. Water level (bore WRL or WPL)
- Discharge pressure (optional – measured via a tapping point installed in pipework just above the pump delivery to connect pump discharge (via a communication tube) to the integrated monitoring system transmitter port).

#### **2.7.2.10 Packer Low Pressure Switch**

The packer which is inflated via water pressure (to approximately 100 kPa) from a portable pump is part of a closed water hydraulic system that can be subject to leakage causing packer deflation. In order to address this issue a pressure switch shall be provided in the system at the surface to flag an alarm when the packer pressure reaches the low pressure set point.

### **2.7.3 Monitoring of Non AC Powered Sites**

For non-alternating current (AC) powered sites the Designer shall consider the power supply to be provided for the monitoring equipment e.g. battery, solar or DC power from the engine driving the pump.

For solar power the batteries required should not be oversized and as a rule of thumb have a capacity based on 5 days of ‘no sun’ conditions.

Generally the following would be required for SCADA/data collection:

- Magnetic flowmeter;
- Pressure transmitter (where fitted).

**NOTE:** For lineshaft pumps level monitoring would require automated bubblers which are available but require further investigation to determine suitability for Corporation purposes. For details on level monitoring see Section 5.3.4.

## **2.8 Confined Space**

For information relating to confined space refer to the DS 32-02 Confined Space section.

## **2.9 Corrosion Mitigation**

For information regarding corrosion mitigation refer to the Corrosion section in DS 30-02 and the Glossary.

## **2.10 Corrosion Resistant Materials**

Materials continuously in contact with, or immersed in, water shall be corrosion-resistant. The following materials shall be considered corrosion resistant for the purpose of this Standard:

- (a) Copper alloys complying with AS 1565, AS/NZS 1567 or AS/NZS 1568 and complying with AS 2345;
- (b) Stainless steels with a PREN of at least 22, complying with a recognised standard (e.g. AS, ASTM, EN etc.) for the relevant product form (e.g. casting, bar, forging, pressing etc.)

## **2.11 Dismantling Joints**

Dismantling pipework joints or couplings (where applicable) shall be of the restrained type in accordance with the Dismantling Joints section of DS 31-01.



## 2.12 Earthing

Headworks pipework, pipe specials, valves and appurtenances (including the bore head casing cover assembly), shall be earthed in compliance with the Earthing Section requirements contained in DS 21 and DS 22.

## 2.13 Fasteners

Structural fasteners shall comply with the Fasteners for Structural Applications section of DS 30-01 and the Bolting Structural Joints section of DS 38-01. Flange fasteners shall comply with DS 38-02.

## 2.14 Financial Impact Statement

For information relating to financial impact statements refer to the Financial Impact Statement section contained in DS 30-02.

## 2.15 Flanges and Gaskets

Flanges and gaskets shall be in accordance with DS 38-02.

## 2.16 Induced Voltage Protection

Metallic borefield collector mains located in the vicinity and/or within the same easement as high voltage distribution power line(s) may be subject to unacceptable touch voltages. The Designer shall ensure that a study is carried out to investigate, analyse and mitigate by design, as required, any exposure to touch voltage hazards by the public and operational personnel. Reference should be made to Section 11 of DS 21 in this regard.

## 2.17 Installation

For information and specific requirements relating to installation and workmanship relating to mechanical plant refer to DS 38-01.

## 2.18 Materials

For general information regarding elastomers, metals and materials for sea water refer to the relevant Materials sections contained in DS 30-02.

## 2.19 Noise

Operating noise levels are not normally an issue for submersible electric borehole pumps, in fact this type of pump can be used to minimise noise in sensitive locations over conventional surface mounted pumps. Noise considerations relating to borehole pumps would normally be restricted to noisy headworks valves or diesel driven pumpsets e.g. engine driven lineshaft pumps or generating sets providing power to submersible electric borehole pumps.

The following noise reduction strategies should be considered where noise sensitivity may be an issue:

- (a) Endeavour to minimise the noise and vibration levels during selection of the equipment e.g. by use of water cooled engines in lieu of air cooled (noisier);
- (b) Provide a sound attenuated enclosure over the diesel engine;
- (c) Use of low slam non return valves.

For information relating to noise the Designer should refer to the 'Noise' section contained in DS 30-02.

## 2.20 Occupational Safety and Health

For detailed Occupational Safety and Health requirements the Designer should refer to the Occupational Safety and Health section in DS 30-02.

## 2.21 Redundancy

Maintenance requirements for the borefield shall be determined and documented as part of the design. The maintenance regime will impact on the level of built-in redundancy in the borefield operation and the design needs to address this.

For critical operational scenarios where repair times are likely to be unacceptably long, spare pumps, motors, spare rotating element, impellers or spare parts shall be considered for as follows:

- (a) A spare pump or pumpset should be considered for small production pumps in critical or remote situations in lieu of spare parts;
- (b) A spare pumpset should be considered for engineered pumps.

## 2.22 Signage and Labels

For general information relating to signage and labels refer to the Signage and Labels section of DS 30-02.

## 2.23 Statutory Authorities

Designs shall take into account compliance with the requirements of statutory authorities shown in the Statutory Authorities section of DS 30-02.

## 2.24 Valves

For information on valves refer to the relevant parts of the Pipework section of this Standard and DS 31-02.

## 2.25 Variable Speed Drives (VSD)

For information and requirements related to variable speed drives refer to the relevant parts of the 'Variable Speed Drives' section contained in DS 32.

## 2.26 Vibration

Mechanical equipment vibration values shall be designed to a minimum. The acceptable limits for particular equipment are detailed in the Vibration section of DS 30-02.

## 2.27 Water Hammer

The Designer shall comply with the relevant parts of Section 6 relating to Water Hammer contained in DS 60 and the relevant parts of the 'Water Hammer' section contained in DS 32.

## 2.28 Welding

Welding shall comply with the relevant parts of the 'Welding' section contained in DS 30-02.

## 3 PRODUCTION BORE SITES

### 3.1 General

This section covers general information and requirements relating to production bores and their sites.

The borehole pump site shall comply with the relevant requirements contained in the 'Site Conditions and Selection' section contained in DS 30-02 and optimal siting with respect to the following:

- (a) Fenced compounds shall be provided with clear access to the bore pump for service vehicles (pump lifting crane and bore development and drilling rigs);
- (b) Fenced compounds with limited access shall be provided with hard-standing outside the fence for the service vehicles such as the mobile crane;
- (c) Switchboards and cable disconnection cubicles shall be sited clear of the service vehicle access and shall comply with the requirements of the 'Orientation of Outdoor Switchboards' clause contained in DS 22. Decontactor plugs shall be similarly sited clear of the vehicle access;
- (d) Location of underground valves shall be sited clear of the service vehicle access;
- (e) Scour (where applicable) direction shall be optimally sited to suit site specifics;
- (f) Sufficient clearway should be provided for removal of the flexible borehole column where applicable
- (g) Vandal-prone sites shall be treated so as to protect otherwise vulnerable components e.g.
  - (i) air valve covers shall be metal bodied;
  - (ii) ball valve and butterfly valve handles shall be removed or locked off;
  - (iii) power cable and instrument cables shall be installed in conduits or ducts;
  - (iv) pressure gauge tapping shall be plugged.

### 3.2 Operating Environment

#### 3.2.1 Non Flood-Prone Bore Sites

Non flood-prone bores are sites not subject to any flooding, or in the event of minor local flooding the water will not encroach above the bore head casing cover cable gland, which being IP 67 rated is only capable of temporary immersion e.g. 30 minutes. Non flood-prone also includes flood-plane bore sites that have been elevated above the flood level via an earth pad or an elevated platform.

#### 3.2.2 Flood-Prone Bore Sites

##### 3.2.2.1 General

Flood-prone bores are sites that are subject to flooding above the bottom of the bore head casing cover cable gland. For the purpose of this Standard two flood-prone bore types have been designated:

- (a) Flood-plane bore sites located on flood planes subject to immersion from rising but relatively slow flowing waters and utilizing above ground headworks; and
- (b) Riverbed bore sites located in riverbeds and subject to deep and fast flowing floodwaters utilizing headworks installed above flood level on the river bank (Gascoyne River).

**NOTE:** Flooding would normally be related to the 1:100 year flood level, or alternatively based on local experience for the particular bore site

### 3.2.2.2 Flood-Plane Bores

The Designer should consider the options available for bore sites subject to flooding. For flood plane bore sites providing a purpose-designed elevated earth pad or a steel platform to accommodate the headworks pipework above the flood level, may be a feasible option. For lineshaft borehole pumpsets sited in flood plane areas the discharge head and diesel engine shall be raised above the flood level.

Where elevation is not feasible the components vulnerable to inundation shall be treated to withstand flooding events.

The elevated pad should be considered where appropriate and arranged as follows:

- (a) The height of the embankment to be above the long term flood level with the top compacted and graded;
- (b) The top of the embankment sized to accommodate:
  - (i) the bore and headworks across one end;
  - (ii) truck access and turning at the other end,
  - (iii) electrical cubicle;
  - (iv) security fencing and vehicular access gate and
  - (v) bollards as required;
- (c) Access to the pad via a ramp at one end;
- (d) External embankment faces graded and covered with a geomembrane and stone pitched rip rap.

In lieu of an elevated pad, an elevated steel platform sited above the flood level should be considered where appropriate and arranged as follows to accommodate:

- (a) The switchboard;
- (b) A borehead casing cover incorporating an IP 67 cable gland (Roxtec or equivalent) fitted to an extended production casing;
- (c) The bore head air valve and water sampling point;
- (d) A discharge bend to route the pipework back down to the headworks pipework above the ground level;

In lieu of either of the above options, an IP 68 glanded bore head casing cover shall be fitted to the concrete apron as further detailed in Section 6.

### 3.2.2.3 Riverbed Bores

For riverbed bores the following summarises the areas that should be addressed:

- (a) Above ground cable connection shall be fitted with a cable canister complying with IP 68 enclosure rating to AS 60529 as further detailed in Section 6;
- (b) The headworks pipework shall be located above the river bank above the floodwaters with the connecting pipework from the bore head buried in the riverbed to protect it from damaging floodwaters as further detailed in Section 7.

### 3.3 Borehole Contamination Entry Points

The following table summarises potential contamination sources and associated entry point prevention measures which shall be addressed for non flood-prone and flood-prone bores as further detailed in the Standard:

**Table 3.1 Summary of Contamination Entry Points/Sources**

Entry Point Prevention Measure	Contamination Sources				
	Surface Water	Shallow Groundwater	Animal & Insect	Air Borne	Ground Borne
Sealing of the concrete slab to the surface and production casings	X	X	-	-	-
Correct grading of the concrete slab at the bore head	X	-	-	-	-
Sealing of bore head cover to concrete apron	X	-	X	-	-
Sealing at the electrical cable and instrument cable entry points in the bore head cover	X	-	X	X	-
Sealing of sampling, monitoring or control equipment cables and tube entry points	X	-	X	X	-
Removal of air valves for riverbed applications	X	-	-	-	-
Provision of one-way ‘air release only’ air valves and a small vacuum break valve for non-flood and flood plane applications	-	-	X	X	-
Provision of casing vent ‘Y’ strainer (includes normally closed ball valve for flood-prone bores)	X	-	X	-	-
Correct bunding between diesel engine and bore head	X	X	-	-	-
Maintenance practices that eliminate contamination of the borehole and installed equipment (protection of openings, only clean equipment installed in borehole)	X	-	-	-	X

### 3.4 Borehole Location

Location of boreholes with respect to each other and the position of the pumpset in the bore are important factors in determining optimal long term performance. Where a borehole is equipped within close proximity of another operating borehole, due consideration shall be taken into account of the interference to each other’s cone of depression (or zone of influence) and effect on long term drawdown, when determining the pumpset placement setting.

### 3.5 Concrete Apron

#### 3.5.1 General

A reinforced concrete apron shall be provided around the bore protruding a minimum of 150 mm above the finished ground level for submersible electric borehole pump installations (for lineshaft pump foundation block refer to Section 3.5.3). There should be sufficient apron to allow a comfortable working area without the risk of personnel tripping off the edge of the apron. As a guide the apron should be constructed to the minimum dimensions specified in Table 3.2. The apron should be graded to the edge to facilitate run-off away from the bore head. The surrounding ground finished

level shall be graded up to the edge of the concrete apron to eliminate an otherwise tripping hazard and shall be stabilised to prevent wind or water erosion.

**Table 3.2 Minimum Concrete Apron Dimensions**

Headwork Size	Minimum Apron Size	Minimum Slab Depth
≤ DN150	2.5m x 2.5m	200mm
≥ DN200	3m x 3m	200mm

### 3.5.2 Design Loads

The concrete apron shall be designed to support the maximum static and dynamic loads being transmitted by the pumpset and pipework via the bore head casing cover or baseplate (lineshaft pumps).

In addition to the pumpset and pipework loads the concrete apron shall be designed to withstand the loads transmitted by a drilling rig or service truck. The load rating of the concrete apron shall be permanently marked with the maximum design load.

### 3.5.3 Pumpset Foundation Block and Grouting

For lineshaft borehole pumps the concrete apron shall be combined with an integral foundation block to accommodate the diesel engine/pumpset baseplate. The foundation block shall comply with the ‘Foundation Blocks’ section of DS 30-02 and grouting shall comply with the ‘Grouting’ section of DS 38-01.

### 3.5.4 Cable Chase

The concrete apron for non flood-prone column type bores shall incorporate a cable chase and removable cover plate to accommodate the motor drop cable from the bore to the outer circumference of the concrete apron. The chase shall be conveniently located with respect to the de-contacter plug assembly or switchboard cubicle. Instrumentation cables shall be run in conduits from the apron to their respective instruments.

**NOTES:**

1. The cable chase is required to prevent an otherwise tripping hazard that would exist with a loose cable draped across the apron.
2. Flood-prone bores incorporate a connection box or canister and columnless bores have a cable frame and accordingly don't require a cable chase and cover.

## 3.6 Surface and Production Casing

### 3.6.1 Top of Casing (TOC) and Top of Bore Cover (TOBC)

The TOC (refer to Section 1 Definitions) is the 00.00 datum point that the drillers' reference for the production casing at the surface from which all other bore levels are related e.g. top of screen, WRL, WPL etc. The TOC in turn needs to be referenced in terms of the Australian Height Datum (AHD) and reference coordinates. Subsequent level monitoring and other measurements which are taken or referenced from the TOBC (refer to Section 1 Definitions) shall be related to the TOC otherwise discrepancies will occur.

The TOC is a critical dimension, and any changes to casing height for engineering purposes should be fully notified to all stakeholders, and instruments and data sets adjusted to reflect the change in datum (refer Notes).

**NOTES:**

- 1 The TOC level should be determined by a surveyor, referenced to AHD and recorded on the original bore log before any changes to the production casing are made.
- 2 If the TOC is changed, it should be levelled again to AHD, or if small then measured and recorded. The original bore log would provide accurate measurement below the TOBC to the bottom of the bore or screens or transitions etc.
- 3 As the top of casing is usually 0.3 m to 0.5m or so above ground level for PVC bores and about 0.5 m or so for GRP bores, the cut off are usually small, say 0.1 to 0.3m. As drilling measurements below ground probably are no more accurate than this, it is probably rather academic, unless the TOC is changed a lot, e.g. bore is raised due to significant earthworks or due to rising above flood level.

### 3.6.2 Production Casing Sizing

The nominal production casing diameters shown in Table 3.3 are given for guidance and should be adopted where possible. These recommended sizes have been developed to ensure adequate space is provided for all down-hole components.

**Table 3.3 – Standard Production Casing Sizes**

Bore Flow Range	Production Casing Minimum Internal Diameter (mm)					
	Pumpset above Screens <sup>(3)</sup>		Pumpset in or below Screens <sup>(3)</sup>			
			Motor <37kW		Motor 38-110kW	Motor 111-183kW
ML/d	Flexible	Rigid	Flexible	Rigid		
0.0-0.5	200	200	200	200	250	300
0.6-0.8	200	250	200	250	250	300
0.8-1.0	200	250	250	250	250	300
1.0-1.3	200	250	250	250	300	300
1.4-1.8	250	250	250	250	300	300
1.9-2.0	250	300	250	300	300	350
2.1-2.2	250	300	250	300	300	350
2.3-2.8	250	300	300	300	300	350
2.9-3.5	250	300	300	300	350	350
3.6-3.9	300	300	300	300	350	350
4.0-4.8	300	350	350	350	350	400
4.9-5.1	300	350	350	350	400	400
5.2-6.0	350	350	350	350	400	400
6.1-6.5	350	350	400	400	400	400
6.6-6.8	350	350	400	400	400	450
6.9-7.2	350	400	400	400	400	450
7.3-8.2	350	400	400	400	450	450
8.3-8.9	350	400		450	450	450
9.0-9.6		400		450	450	500
9.6-10.0		400			450	500

**NOTES:**

- 1 Table 3.3 is primarily intended for bores utilising columns. For columnless bores the production casing is usually DN350 GRP (refer Section 1.1.1 regarding use of columnless bores).
- 2 For bore flow ranges >10ML/d, contact Principal Mechanical Engineer, IDB for advice before proceeding.
- 3 For pumpsets located above the screens the critical factor affecting casing sizing is generally the size of the pump column couplings with monitoring ducts. For pumpsets located in and below the screen the critical factor is generally the size of the pumpset motor plus a shroud (refer Section 4.2.7).

### 3.6.3 Borehole Construction

The following borehole construction is used by the Corporation:

- (a) The production casing is either PVC-U or GRP (or mild steel for some older existing bores only);
- (b) Slotted PVC-U production casing is used in smaller regional applications;
- (c) Larger boreholes are generally screened at an aquifer at the bottom of the borehole casing, or at an intermediate level, or both as relevant;
- (d) Production borehole casing ranges in size from DN 150 to DN 700;
- (e) Bores also generally incorporate an outer surface casing.

### 3.6.4 Casing Sealing

#### 3.6.4.1 PVC-U/GRP Production Casing Sealing

- (a) The mild steel surface casing should finish to a level which is approximately midway within concrete apron (e.g. 100 mm below the top of the concrete apron);
- (b) For bores where the surface casing is relatively short (i.e. ~2.5 m) a puddle flange shall be welded to the top of the surface casing (refer to Note 1);
- (c) The concrete apron shall be finished over the top of the puddle flange or surface casing and seal against the production casing;
- (d) The final section of the production casing shall extend above the concrete apron a minimum height of 150 mm. For GRP production casings (or where the casing is for a columnless type bore) the final section comprises a minimum 2.5m stainless steel casing fitted to the GRP casing. The exception in terms of the height of protrusion above the concrete apron would be for lineshaft borehole pumps, where the discharge head is mounted directly onto the concrete apron or on a foundation block, which would require the production casing to extend sufficiently to accommodate the grout and clear the underside of the discharge head;
- (e) For column type bores the bore head casing cover shall be secured directly to the concrete apron. Its bottom flange shall be bonded and sealed to the apron via a bed of high strength, non-shrink flexible epoxy grout suitable for potable water use. The bottom flange shall incorporate stud fasteners extending through the flange for keying into the concrete apron.
- (f) For columnless type bores a mating flange to suit the bore head casing tee bottom flange shall be fitted at the top of the production casing.

**NOTE:**

For bore where the surface casing is extensive there is no requirement for the puddle flange e.g. Yarragadee Bore G7 where the surface casing length is approximately 70 m and is set in grout.

#### 3.6.4.2 Mild Steel Production Casing Sealing

- (a) The surface casing shall finish at a level which is approximately midway within the concrete apron (e.g. 100 mm below the top of the concrete apron);
- (b) The concrete apron shall extend over the surface casing and seal against the production casing.
- (c) The production casing shall extend above the concrete apron by 100 mm and finish in a DN 500 flange designed to match the bore head casing cover bottom flange. The exception would be for lineshaft borehole pumps where:
  - (i) the discharge head is mounted directly onto the concrete apron which would require the production casing to be extended sufficiently to accommodate the grout and clear the underside of the discharge head;



- (ii) the discharge head is mounted on a fabricated steel base which would require the production casing to extend above the concrete apron by 100 with a plain end (not flanged).

### 3.7 Bore Development

Bores shall be properly developed before installation of the pumpset in order to minimise the amount of solid particles to be pumped which have the potential to produce severe wear on the pump components. The maximum acceptable sand content discharged from bores for drinking water purposes shall not exceed 5 mg/L.

**NOTE:**

Information source – National Groundwater Association (US) and United States EPA

### 3.8 Flow Capacity for Specific Aquifers

The following flow capacity limits generally apply to the nominated aquifers:

- (a) 5 ML/d for superficial bores;
- (b) 10 ML/d for Leederville aquifer;
- (c) 25 ML/d for Yarragadee aquifer.

## 4 SUBMERSIBLE ELECTRIC BOREHOLE PUMPS

### 4.1 General

This section covers submersible electric centrifugal borehole pumps and their associated down-hole equipment.

Submersible electric borehole pumps are used for groundwater pumping, and are also used for transfer or booster pump applications which will not be covered by this Standard (refer to the Booster Pump Application clause DS 32-02 for further information on booster pumps).

General information and specific requirements on boreholes is contained in Section 3 of this Standard.

### 4.2 Pumpsets

#### 4.2.1 Pumpset Selection

Pumpset selection shall comply with the relevant parts of the ‘Water Pump Stations - Pumpset Selection’ section contained in DS 32.

#### 4.2.2 Pumpset Technical Requirements

- (a) Submersible electric borehole pumps shall comply with SPS 507
- (b) The pumpset motor duty and rating shall comply with the relevant sections of DS 26-15 or DS 26-20 Type Specifications as applicable.

#### 4.2.3 Pumpset Features

The following summarises the features relating to submersible electric borehole pumps used by the Corporation:

- (a) Production or engineered type pumpsets for use on borehole pump applications to a maximum of 700 kW;
- (b) Multi-stage end suction centrifugal pumps with mixed flow impellers (or radial for low flows) located in radially-split stage casings each incorporating a diffuser and bearing (except for small pumpsets) and generally fitted with an integral non return valve (refer Pump Non-Return Valve clause below);
- (c) Close-coupled to low or high voltage submersible electric motors for 2 pole, 4 pole or multispeed operation;
- (d) Low operating noise level characteristics.

#### 4.2.4 Pump Testing

Factory testing shall be conducted for all borehole pumps supplied to the Corporation assets in accordance with SPS 507. For further information relating to all aspects of pump testing refer to the ‘Water Pump Stations - Pump Testing’ section of DS 32.

#### 4.2.5 Condition Monitoring

For pump condition monitoring requirements and information refer to ‘Condition Monitoring’ contained in the General Design Criteria section of this Standard.

## 4.2.6 Pump Non-Return Valve

Except for columnless pumps (refer Note 4 below) the pumpset shall be fitted with either:

- (a) An integral, purpose-designed, fast dynamic response, poppet type, resilient seated non-return valve at the pump outlet; or
- (b) A separate fast dynamic response, poppet type, resilient seated non return valve fitted immediately above the pump discharge.

Traditionally for flexible discharge column installations (e.g. Wellmaster) the non return valve disc was drilled to allow column drainage to facilitate removal of the pump. This practice shall no longer be employed and a break-off plug system fitted in the column shall be used instead. Refer to the notes below regarding the adverse issues relating to column drainage.

For potentially high water hammer situations the pump non return valve shall be selected for the appropriate dynamic response e.g. spring loaded poppet etc.

### NOTES:

1. A pump NRV keeps the discharge column full of water rather than it draining back to the WRL after the pump stops. An empty column reduces the head on the pump is undesirable as repeated cycling can damage the motor thrust bearing due to the repetitive upthrust and downthrust induced shock loading.
2. A pump non return valve prevents backflow of water down the bore which otherwise could have a number of potentially damaging consequences such as over pumping on pump start, high rotating element speed due to backflow, possible seizing of pump due to settling of solid particles and undesirable surging of the bore screen.
3. A pump non return valve prevents vacuum formation in the column for WRLs >10 m (providing the NRV does not leak) thus preventing water hammer during start-up. Otherwise on pump start the column of water would move at high velocity to fill the vacuum thus impacting on the stationary water on the downstream side of the surface NRV, producing water hammer and shock loads on the system
4. Pump non return valves were originally fitted to the first of the columnless pumps (non integral type) however they failed in service due to turbulence. Enquiries with the pump manufacturer at the time (Centrilift) indicated the pumps could operate without a non return valve so pumps have since been installed without one. This is not preferred by the Corporation and investigations have been undertaken to provide a suitable alternative however remains unresolved because of relatively high NRV head losses.

## 4.2.7 Motor Shroud

The Designer shall comply with the following motor shroud requirements:

- (a) A motor shroud shall be fitted where:
  - i. the velocity of water flow past the motor is less than the minimum flow requirements specified by the manufacturer (normally of the order 0.5 to 0.75 m/s minimum flow);
  - ii. a submersible pump is placed at a level within or lower than a cascading screened aquifer.

**NOTE:** This is done in order to direct flow past the motor for cooling. Without a shroud flow would otherwise be directed over the pump end only with the potential for motor overheating.

## 4.2.8 Pump Setting

Placement of a borehole pump suction inlet should be sufficiently below the long term drawdown level or WPL such that the NPSHA is always greater than the pump's NPSHR.

## 4.3 Pumpset Down-hole Components

Submersible borehole pumpset and ancillary equipment shall generally comprise the following:

- (a) A submersible electric pumpset;
- (b) A motor shroud (if applicable);

- (c) For column type boreholes the pumpset shall be suspended on a flexible or rigid corrosion resistant discharge column (refer also Pump Discharge Column section below); or
- (d) For columnless boreholes the pumpset shall be supported by an inflatable packer assembly and hanger pipe (refer Pump Discharge Column section below);
- (e) Electric drop cable and pump earth cable;
- (f) Motor temperature transmitter (as required);
- (g) Bubbler tube (except columnless);
- (h) Groundwater level monitoring ducts (for column type pumpsets) including;
  - (i) duct for dip tape (well space permitting);
  - (ii) duct for level transmitter (well space permitting);
- (i) Level transmitter (well space permitting);
- (j) Integrated monitoring system for large rigid column pumps (eg. CTS system) and columnless pumps (e.g. Pheonix)

## 4.4 Pump Discharge Column

Borehole pumpsets shall be either fitted with a rigid column pipe; or a flexible column; or for columnless pumpsets with an inflatable packer utilising the production borehole casing as the discharge column. Pump column shall be corrosion resistant and comply with one of the following types:

### 4.4.1 Rigid Column

Rigid column shall comply with the following:

- (a) FRP twist and lock type e.g. ‘Permaglass’ pump column incorporating couplings pressure sealed via an O-ring and retained via a 316 stainless steel locking cable e.g. ‘Kwik-Lok’ (or equivalent) shall be used in accordance with the manufacturer’s requirements;
- (b) Rigid column is preferred in local flood-prone situations because the cable gland (e.g. Roxtec) would be located higher than for flexible column e.g. the bore head casing cover for rigid column is 350 mm higher than the flexible column cover;
- (c) Column design and installation shall be in accordance with the manufacturer’s requirements;
- (d) The electric drop cable, ground water level monitoring ducts (well space permitting) and bubbler tube shall be taped to the column. The bubbler tube and strapping tape are detailed in Section 4.4.4 and Section 4.4.5;
- (d) The bubbler tube and level transmitter (where fitted) shall be located at the commencement of the column i.e. immediately above the pump non return valve unless otherwise specified for special cases. The bubbler tube shall be cut at an angle at the sensor end e.g. 45°;

### 4.4.2 Flexible Column

Flexible column shall comply with the following:

- (a) ‘Wellmaster’ flexible column (or equivalent) shall be used where appropriate (Note 1);
- (b) A break-off plug system shall be used to allow column drainage to facilitate pumpset retrieval (Notes 2 and 3);
- (c) The column design and installation shall be in accordance with the manufacturer’s requirements;

- (d) The electric drop cable, ground water level monitoring ducts (well space permitting) and bubbler tube shall be secured to the column using the manufacturer's cable straps;
- (e) The bubbler tube end shall be taped to the stainless steel fitting at the commencement of the column and fed through the cable straps to the surface. Accordingly the bubbler tube will be the same length as the column. The location of the tube end may be moved closer to the pump inlet for special cases and the position recorded e.g. marginal production bores. The bubbler tube shall be cut at an angle at the sensor end e.g. 45°.
- (f) The flexible column stretch under the pump operating conditions shall be factored into the design and installation of the down-hole components using the manufacturer's stretch formula.

**NOTES:**

1. Flexible column requires a site which has sufficient space to allow installation and removal of the pumpset and column.
2. The break-off plug is fitted internally at the bottom of the flexible column. Prior to removal of the pump a torpedo is lowered down the column to impact the plug causing it to break-off and allow the column to drain. The deflated column is then able to be pulled over a roller at the surface to facilitate removal of the pump.
3. The break off plug system replaces the previous method of column drainage which was to drill a small hole in the pump NRV prior to installation. This practice is no longer desirable for the reasons previously stated in the Pump Non Return Valve clause and associated Notes.

### 4.4.3 Production Casing Column (Columnless)

- (a) Bores utilizing the production casing as the discharge column shall incorporate a stainless steel inflatable packer assembly fitted to the pump discharge outlet and which seals on the bore casing after inflation. The packer assembly shall incorporate hanger pipe and fittings to facilitate inflation and deflation of the packer from the surface level;
- (b) The packer assembly shall incorporate a discharge outlet to the casing column. The discharge outlet shall be fitted with a stainless steel hanger pipe which is connected to the bore head casing cover at the surface. The hanger pipe facilitates pump installation and removal and provides a support for the electric drop cable (Note 1);
- (c) The electric drop cable shall be taped to the hanger pipe. Strapping tape is detailed in Section 4.4.4;
- (d) For bores subject to significant deviation the packer assembly shall be fitted with a bore centralizer;
- (e) All pumpset motors shall be fitted with bore centralizer to prevent contact with the production casing which can cause hot spots and premature motor failure;
- (f) The inflatable packer assembly shall comply with the 'Riserless Pump Packer' supplied by Age Developments Pty Ltd (or equivalent);

**NOTES:**

1. The water level transmitter shall be part of the integrated monitoring system which utilises the electric drop cable for transmission to the surface.
2. Columnless pumps are not usually fitted with a pump NRV

### 4.4.4 Strapping Tape

The strapping tape shall be "Advance" AT10 PVC Heavy Duty Pipewrap Tape, 48mm x 33m or equivalent.

**NOTE:** It is important that the correct tape specification be used as substandard products have failed in service causing tape to be ingested into pumps requiring very costly rectification.

#### 4.4.5 **Bubbler Tubing**

The bubbler tube shall be ¼", "SMC", black, low density polyethylene tubing (TE1400) in 100m coils or equivalent.

**NOTE:** It is important that the correct bubbler tube specification be used as substandard products have and failed in service e.g. tube becomes brittle requiring very costly rectification.

#### 4.5 **Casing Cover and Headworks**

Aboveground requirements for submersible electric borehole pumps shall comply with Section 6 and Section 7 of this Standard, which specify requirements for bore head casing covers, headworks pipework and collector main connecting pipework.

## 5 LINESHAFT BOREHOLE PUMPS

### 5.1 Scope and General

This section of the Standard covers the surface and down-hole equipment associated with diesel engine driven lineshaft type multi-stage centrifugal pumps as used on Corporation boreholes for groundwater pumping. Lineshaft type multi-stage centrifugal pumps are commonly referred to as vertical turbine pumps.

For the purpose of this Standard it will be assumed:

- Lineshaft pumps will be diesel engine driven;
- The discharge head, right angle gear drive, transmission shafting and diesel engine will not be subject to flooding (albeit they may be installed on an elevated platform above the flood level) in accordance with Section 3.

Electric motor and diesel engine driven helical rotor lineshaft borehole pumps are also used by the Corporation for groundwater pumping for small borehole pump applications, and whilst referred to below will not be covered in detail in this Standard.

The following requirements for lineshaft pumps in some instances are deliberately detailed and prescriptive because of the absence of a related product specification at this stage.

General information and specific requirements on boreholes is contained Section 3 of this Standard.

#### 5.1.1 Vertical Turbine Pumps Considerations

The Designer should seriously consider use of a diesel generating set and submersible electric borehole pump in lieu of a diesel driven lineshaft borehole pump because of the design and O&M issues associated with the latter as detailed below. Also the generating set would provide power for the instrumentation such as the magnetic flowmeter, level transmitter and pressure transmitter.

The Corporation would generally only use a vertical turbine pump for a bore site where electric power was not available and accordingly a diesel engine drive would be required. Submersible electric borehole pumps would normally be used where electric power was available. However vertical turbine pumps can be useful in order to maximise the output from a bore where limited space precludes the use of an optimal sized submersible electric motor.

There are issues with use of turbine pumps which makes them less attractive than submersible electric borehole pumps and these should be considered by the Designer. These particularly relate to:

- Lack of power to run monitoring instrumentation. The Designer should identify the equipment and instrumentation required and prepare a power budget to determine the total power load. The equipment required should have low power requirement characteristics;
- Additional major components required such as the discharge head, right angle drive gearbox and universal drive shaft;
- A more complex column assembly which comprises column sections and couplings, lineshaft and shaft couplings, bearing housings, bearings and bearing retainers, which can be vulnerable to draining of the column (e.g. leaking foot valve);
- Corrosion of the discharge column (which is generally not corrosion resistant) in even mildly corrosive waters. Corrosion is exacerbated by the column joint configuration, which embodies potentially corrosion prone features such as screw threads and the presence of dissimilar metals e.g. two steel column sections, a steel or ductile iron joint coupling and a bronze bearing housing, all clamped together. This arrangement in the presence of water can readily form a galvanic couple causing severe corrosion of the column sections and in particular joint threads which may result in catastrophic failure;

- Maintenance of the packed gland, gearbox and setting positions for impellers etc, which in combination with the added complexity and a multiplicity of components contributes to a potentially higher failure risk and higher operation and maintenance costs;
- Further, bore straightness is more critical for the proper operation of. a lineshaft pump than for a submersible pump

### 5.1.2 Helical Rotor Pumps Considerations

For smaller borehole applications lineshaft helical rotor pumps are sometimes used for electric powered and un-powered sites. At this stage helical rotor borehole pumpsets will not be covered in this Standard. However it should be noted that most of the issues relating to lineshaft pumps would equally apply to helical rotor pumps.

It should be noted that headworks pipework for helical rotor pumps would require additional protection because of this type of pump's positive displacement characteristic. Accordingly a pressure relief valve shall always be fitted upstream of an isolating valve in order to prevent damage in the event of the pump being started against a closed valve.

## 5.2 Pumpsets

### 5.2.1 Pumpset Selection

Pumpset selection shall comply with the relevant parts of the 'Pumpset Selection' section contained in Clause 4.2.1 of this Standard, and as amended by the following.

#### 5.2.1.1 Pump Selection

High bore water temperature can be a factor for deep lineshaft borehole pumps where differential expansion of the shafting with respect to the column could cause pump damage. Differential expansion will occur after pump start or pump stop until the water temperature stabilizes either hot or cold respectively. The Designer shall take this into account when selecting pumps.

### 5.2.2 Pumpset Technical Requirements

The lineshaft pump shall be multi-stage end suction centrifugal with mixed flow impellers fitted to a stainless steel shaft and located in radial-split stage casings each incorporating a diffuser and bearing. Materials and components shall equivalent to those contained in SPS 507 as applicable.

### 5.2.3 Pumpset Features

The following list of features and components relate to lineshaft borehole pumps used by the Corporation:

- (a) Lineshaft pump incorporating a foot valve and strainer fitted below the pump inlet;
- (b) Pump suspended on a rigid steel discharge column and lineshaft drive assembly;
- (c) The column is attached to a discharge head at the surface through which the lineshaft passes for connection of the pump to the driver;
- (d) A right angle gearbox which is flange mounted to the discharge head and connected to the diesel engine via a universal drive shaft (and for large diesel engines a clutch).

### 5.2.4 Pump Testing

Factory testing shall be conducted for all borehole pumps supplied to the Corporation assets in accordance with SPS 507. For further information relating to all aspects of pump testing refer to the 'Pump Testing' section of DS 32.



## 5.2.5 Condition Monitoring

For pump condition monitoring requirements and information refer to ‘Condition Monitoring’ contained in the General Design Criteria section of this Standard.

## 5.2.6 Foot Valve and Strainer

A foot valve shall be provided in order to maintain a full discharge column of water so the lineshaft bearings, which are water lubricated, are immersed at all times and as detailed in the following.

- (a) The pump shall be fitted with a poppet type, resilient seated foot valve located below the pump inlet;
- (b) For potentially high water hammer situations the foot valve shall be selected for the appropriate dynamic response e.g. spring load etc;
- (c) A conical strainer manufactured from grade 316 stainless steel and shall be fitted on the foot valve inlet;
- (d) Components shall be corrosion resistant and equivalent to component materials for the non return valve contained in SPS 507 e.g. housing, resilient seal and stem,

### NOTES:

1. Other methods of pre-lubricating the lineshaft bearings may be via a pre-lubrication tank, or piping from the headworks connected to the discharge head incorporating a solenoid and timer set to operate pre-engine start. These methods are not considered appropriate and are discounted in favour of a foot valve as discussed in the following notes.
2. A foot valve keeps the discharge column full of water rather than it draining back to the WRL after the pump stops. An empty column reduces the head on the pump which is undesirable as repeated cycling can damage the drive head thrust bearing due to repetitive upthrust and down thrust induced shock loading.
3. A foot valve prevents backflow of water down the bore which otherwise could have a number of potentially damaging consequences such as over pumping on pump start, possible seizing of pump due to settling of solid particles and undesirable surging of the bore screen.

## 5.2.7 Pump Setting

Placement of a borehole pump suction inlet should be a minimum of 5 m below the long term drawdown level or WPL where practicable.

## 5.3 Discharge Column Assembly

The pump shall be suspended on a rigid steel discharge column assembly comprising column pipe sections; column couplings; bearing housings and bearings fitted at each column section joint; and lineshaft and couplings assembly, as detailed in the following.

### 5.3.1 Discharge Column

The discharge column assembly shall be manufactured from heavy-duty carbon steel pipe sections. Each column section shall be accurately cut to length and shall incorporate precision machined threads at each end to provide correct alignment of the assembly. Each column section shall be fitted with a coupling which shall be accurately machined from ductile iron or heavy duty seamless steel tubing. Threads shall be of the correct hand to prevent unscrewing during pump operation.

**NOTE:** Flanged columns are available but not used by the Corporation due to space constraints within the borehole.

### 5.3.2 Column Bearings Housings and Bearings

Bearing housings shall be manufactured from a bronze listed in Table 2.1 of SPS 507. The housing shall retain the bearing using a positive locking system e.g. stainless steel circlip or retaining nut. The housing shall be designed with an optimal waterway profile to minimize hydraulic losses across it.

The housing bore, rim threads and lands shall be precision machined to provide accurate alignment and positive sealing between the adjacent column sections.

The bearing housings shall be fitted with water lubricated, removable elastomeric bearings to provide vibration-free radial support.

**NOTE:** Oil lubricated lineshaft bearing are available but not used by the Corporation because water lubricated bearings are considered effective and to reduce potential oil contamination of the borehole.

### 5.3.3 Lineshaft

The lineshaft shall be manufactured from smooth-ground stainless steel conforming to ASTM A276 grade 431 or 316. Each lineshaft section shall incorporate precision machined threads at each end to provide correct alignment of the assembly. The lineshaft couplings shall be manufactured from stainless steel of a minimum PREN of 22 and of hardness sufficiently different to avoid galling (e.g. 50 HBW). Couplings shall be accurately machined with internal threads of the correct hand to prevent unscrewing during pump operation.

For information relating to calculation of the PREN refer to ‘Pitting Resistance Equivalent Number’ in the ‘Definitions’ section of DS 30-01.

### 5.3.4 Bubbler Tubing

The level monitoring equipment shall comprise a water bubbler monitoring tube and gauge complying with the relevant requirements contained in Section 2 for ‘Condition Monitoring’. The bubbler tube sensor end shall be taped to the commencement of the column i.e. immediately above the pump. Strapping tape and bubbler tube shall comply with Clauses 4.4.4 and 4.4.5 of this Standard respectively.

**NOTES:**

1. A ground water level dip tape and duct cannot generally be fitted as there is no provision for it in the discharge head which is normally a cast iron proprietary item.
2. Similarly a level transmitter and duct cannot generally be fitted as there is no provision for it in the discharge head. Further the level transmitter requires electric power which is not available on most lineshaft borehole pump applications which are normally diesel engine driven.

## 5.4 Discharge Head

### 5.4.1 Discharge Head Features

The discharge head shall comply with the following:

- (a) Heavy duty construction manufactured from close-grained cast iron;
- (b) Designed to support the mass of the pump and gearbox and to withstand the transmission forces and associated vibration associated with a diesel engine driver;
- (c) Precision machined, true to line and concentric;
- (d) Provide accurate location and alignment of the right angle drive gearbox and drive shaft;
- (e) Incorporate a precision machined, fully adjustable packed gland fitted with a high grade packing complying with the requirements of the ‘Seals – Packed Glands’ section contained in DS 30-02 (refer to Notes);
- (f) Incorporate an integral or detachable baseplate with a machined bottom face and precision machined internal screwing to accommodate the top discharge column section. The baseplate shall be provided with holding down bolt holes;
- (g) Provision of large hand-holes opposite each other to facilitate access to the packed gland;
- (h) Incorporate a discharge flange complying with AS 4087;

- (i) Incorporate provision for a water level bubbler monitoring tube assembly complete with a sealing gland where the tube exits the discharge head. The bubbler tube shall terminate in a ‘Swagelok’ quick connector and mounting bracket fitted to the discharge head;
- (j) Incorporate a DN 25 BSP casing vent fitted with a DN 25 bronze ‘Y’ strainer oriented horizontally.

**NOTES:**

- 1. A mechanical seal would be preferred providing it is an option available from the pump manufacturer.
- 2. Refer also to the Clause ‘Discharge Head Sealing’ in this section of the Standard.

## 5.4.2 Discharge Head Sealing

The discharge head with the exception of the packed gland (refer to Note below) shall be sealed at the bore head to an IP 67 rating in accordance with AS 60529 as follows:

- (a) Where the discharge head is mounted directly onto the concrete apron it shall be placed onto a bed of high strength, non-shrink flexible epoxy grout suitable for potable water use. An elastomeric gasket shall be placed between the grout and discharge head (or secondary baseplate). The baseplate shall not be grouted-in as it has to be removed periodically for maintenance purposes;
- (b) Where the discharge head is installed directly onto a fabricated steel baseplate (separate or in common with diesel engine), which in turn is mounted onto the concrete apron, it shall be designed to provide a sealed system at the bore head end. The sealing system shall provide:
  - (i) grout sealing of the fabricated baseplate to the concrete apron;
  - (ii) enclosure and sealing of the fabricated baseplate at the discharge head end;
  - (iii) provision of a removable secondary mounting plate under the discharge head that fits onto the baseplate with a sealant;
  - (iv) provision of a resilient gasket between the discharge head baseplate and the secondary baseplate.

**NOTE:** It is not considered practicable or necessary to address sealing of the packed gland in the discharge head, other than possible provision of a mechanical seal, providing it is an option available from the pump manufacturer. Provision of the pump foot valve eliminates backflow of the water down the discharge column and therefore the admission of potentially contaminated air via the packed gland.

## 5.5 Right Angle Gearbox

The right angle gearbox shall comply with the following requirements:

- (a) Designed to withstand the transmission forces and associated vibration from the diesel engine;
- (b) Heavy duty construction utilizing high tensile strength, close grained castings;
- (c) Precision machined components, true to line and concentric;
- (d) Provide accurate location and alignment with the discharge head and drive shaft;
- (e) Heavy duty anti-friction ball or roller bearings;
- (f) Case hardened alloy steel bevel gear and pinion, lapped in pairs;
- (g) High tensile strength alloy steel input and output shafts;
- (h) A robust and positive anti-reverse ratchet;
- (i) Air-cooled heat exchanger;
- (j) Pressure type lubrication;
- (k) Input and output shaft fitted with elastomeric spring type or lip type oil seals;

- (k) Oil level sight glass or level plug, filler plug and drain plug;
- (l) Lifting points to facilitate installation and removal;
- (m) High efficiency e.g. exceeding 95%.

## 5.6 Engine to Gearbox Transmission

### 5.6.1 Universal Drive Shaft

The transmission drive shall be via a proprietary industrial rated heavy duty universal drive shaft. The operating angle should be between 2° and 3° maximum (for reciprocating engines) to initiate joint needle bearing rotation.

### 5.6.2 Drive Couplings

The drive couplings shall be manufactured from solid high tensile strength steel or cast iron. The couplings shall be accurately machined with keyways for connection to the gearbox input shaft and the engine output shaft. A precision machined spigot and tapped holes shall be provided on each coupling to accommodate the universal drive shaft flanges.

### 5.6.3 Clutch

Large diesel engines shall incorporate a clutch to enable uncoupled engine warming up and cooling down periods.

### 5.6.4 Safety Guards

All exposed rotating engine and pump components, or other hazardous components (hot exhaust) shall be guarded to provide protection to operators and other personnel.

A robust safety guard(s) shall be provided for the transmission shafts and couplings in accordance with 'Guards' section of DS 30-02.

## 5.7 Driver

### 5.7.1 Electric Motor

Electric motor drives are not addressed in this Standard as the pump would normally be diesel engine driven for new installations.

### 5.7.2 Diesel Engine

Engine selection shall comply with the requirements detailed in the Diesel Engines section of DS 35 and the following:

- (a) The engine shall be selected in accordance with the power requirements specified in AS 4594 using the relevant derating requirements for altitude, temperature and humidity.
- (b) After de-rating and application of any service factors for the transmission e.g. belt or gearbox the maximum available reserve power available should not exceed 10% (refer Note).
- (c) A torque speed curve shall be developed by the Designer taking into account the specific speed of the pump, the system resistance curve and any relevant valve operation during the starting run-up.

**NOTE** Excessive reserve power can lead to light loading of the engine and for diesel engines this can cause glazing of the cylinders, causing piston blow by and loss of power.

### **5.7.3 Baseplate**

The diesel engine shall be mounted on a fabricated steel baseplate complying with the design and construction requirements contained in the ‘Baseplates’ section of DS 30-02.

### **5.7.4 Fuel Tank**

For information relating to the fuel tank and bund refer to the ‘Fuel Tank and Bund for Fixed Diesel Plant’ section of DS 35.

## **5.8 Headworks**

Aboveground pipework for lineshaft borehole pumps shall comply with Section 7 of this Standard, which specifies requirements for headworks pipework and collector main connecting pipework, but shall exclude:

- (a) The bore head casing cover assembly;
- (b) The headworks 90° bend.

## 6 BORE HEAD CASING COVER

### 6.1 General

This section details the requirements for the bore head casing cover (casing cover) designed for conventional submersible electric borehole pumps and bore head casing tee (casing tee) for columnless submersible electric borehole pumps.

The casing cover lower flange shall be bonded and sealed to the apron via a bed of high strength, non-shrink flexible epoxy grout suitable for potable water use.

**NOTE:** The bore head casing cover is not relevant for lineshaft borehole pumps which utilize a proprietary flanged discharge head which forms part of the complete pumpset as detailed in Section 5.

### 6.2 Casing Cover for Column Type Submersible Borehole Pumps

The casing cover referred to below forms part of the bore head fittings required for column type submersible electric borehole pumps.

#### 6.2.1 Casing Cover Assembly

The casing cover assembly shall:

- (a) Support the maximum static and dynamic loads expected from flexible and non flexible columns, pipework and pumpsets;
- (b) Be designed for the appropriate enclosure rating for the application;
- (c) Incorporate a casing cover body as further detailed in this section;
- (d) Incorporate a casing cover top plate as further detailed in this section;
- (e) Incorporate a cable cover as further detailed in this section (as required)
- (f) Incorporate earthing studs in accordance with the 'Earthing' clause contained in the General Design Criteria section of this Standard.

#### 6.2.2 Casing Cover Body

The casing cover body shall:

- (a) Be manufactured from:
  - (i) Schedule 40 mild steel hot dip galvanized to AS/NZS 4680, or
  - (ii) Schedule 40S stainless steel tube grade 304L to ASTM A269 which has been pickled and passivated after manufacture in accordance with ASTM A380;
- (b) Incorporate non-standard flanges at each end in accordance with the Drawings;
- (c) Incorporate:
  - (i) for non flood-prone applications a cut-out at the top to accommodate the cable gland assembly (Roxtec or equivalent) as separately detailed in this section;
  - (ii) for riverbed applications a DN 50 Schedule 40 galvanised pipe to accommodate the cable connection canister.
- (d) Be constructed to the following diameter:
  - (i) DN500 for headworks  $\leq$ DN150, or
  - (ii) DN700 for headworks  $\geq$ DN200;
- (e) Be constructed to the following height:

- (i) 400 mm high for flexible column applications in order to accommodate the bore head roller; or
- (ii) 750 mm high for rigid column applications (in order to provide a convenient working height for servicing requirements);
- (f) Incorporate cable cover mounting brackets (as required).
- (g) Incorporate a drain plug.

## 6.2.3 Casing Cover Top Plate

### 6.2.3.1 General

The casing cover top plate shall comply with the following requirements and as further specified for the particular bore types as applicable:

- (a) Be constructed from grade 316L stainless steel complying with ASTM A240M, pickled and passivated after manufacture in accordance with ASTM A380;
- (b) Be drilled to suit the body top flange and incorporate a flanged outlet stub at the top for connection to the bore head bend, and an earth stud;
- (c) Incorporate an inlet stub below for connection to the pump discharge column.
- (d) Incorporate a DN 25 BSP boss for the casing vent which for:
  - (i) non flood-prone bores shall be fitted with a DN 25 bronze ‘Y’ strainer oriented horizontally (refer Notes 1 and 2);
  - (ii) riverbed and flood-plane bores shall be fitted with a normally closed right angle ball valve complying with SPS 254 and a DN 25 bronze ‘Y’ strainer oriented horizontally at the valve outlet (refer Notes 2 and 3). A permanent label shall be affixed stating “VALVE NORMALLY CLOSED”;
- (e) Incorporate a lifting facility designed to accommodate the maximum loads expected for flexible and non flexible columns and pumpsets (including water for rigid column type pumps).

#### NOTES:

1. Also includes flood-plane bores where the headworks are elevated above flood level (refer Section 3).
2. The casing vent ‘Y’ strainer is required to prevent ingress of contaminants into the borehole.
3. The normally closed isolating ball valve is required to allow release of vacuum within the bore in order to reset the WRL before taking bubbler readings (riverbed and immersed flood-plane bores only).

### 6.2.3.2 Non Flood-Prone Bores

In addition to the items in the General clause above the top plate shall:

- (a) Incorporate DN 40 BSP boss for the level transmitter (Note 1);
- (b) Incorporate DN 40 BSP boss for the dip tape (Note 1);

#### NOTES:

1. Level transmitter and dip tape conduits would only be fitted where space permits.
2. The bubbler tube exits through the cable gland rather than through the casing cover top (as required for riverbed and immersed flood-plane bores) which would otherwise produce an increased OSH installation risk.
3. The above requirements would equally apply to flood-plane bores where the headworks are raised above the flood level.

### 6.2.3.3 Immersed Flood-Plane Bores

In addition to the items in the General clause above the top plate shall:

- (a) Incorporate DN 40 BSP boss for the level transmitter (refer Note);

- (b) Incorporate DN 40 BSP boss for the dip tape (refer Note);
- (c) Incorporate a removable gland plate incorporating bosses sized to accommodate the power cable(s), earth cable and level transmitter cable (if fitted) and bubbler tube.

**NOTE:** Level transmitter and dip tape conduits would only be fitted where space permits. The level transmitter would have to be protected for flooded conditions.

#### **6.2.3.4 Riverbed Bores**

In addition to the items in the General clause above the top plate shall incorporate a DN 10 BSP tapping for the bubbler tube (refer Notes).

**NOTES:**

1. A level transmitter is not normally fitted to riverbed bores.
2. The bubbler tube to be protected by a copper pipe.

### **6.2.4 Cable Sealing**

#### **6.2.4.1 Cable Gland for Non Flood-Prone Bores**

The cable gland shall be designed to accommodate the motor power cables, earth cable, RTD cable (where applicable) and bubbler monitoring tube. The cable gland shall be a Roxtec or equivalent, rated to IP 67 in accordance with AS 60529.

The cable gland dimensions and module sizes cannot be standardised for all bores because the cable size depends on the motor size. Accordingly the cable and module size shall be determined by the Designer for each bore on a project by project basis.

#### **6.2.4.2 Cable Gland for Artesian and Immersed Flood-Plane Bores**

This arrangement shall apply to artesian bores, and to flood-plane bores where other options such as raising the bore head casing cover above the flood level are not feasible (e.g. elevated pad or platform per Section 3 of this Standard). Accordingly a bore head casing cover incorporating a multi-gland plate shall be fitted as detailed in the following:

- (a) The gland(s) shall comply with an IP 68 rating to AS 60529;
- (b) The cable gland(s) shall accommodate the power cable(s), earth cable and level transmitter cable (if fitted) and bubbler tube;
- (c) The cable gland bosses shall be incorporated into a detachable plate with resilient gasket bolted to the bore head casing cover top plate.

Where a bore is sited in a flood-plane area and an IP 68 rated cable gland option is to be used the following shall apply:

- (d) Switchboards shall be raised above the flood level via a roofed elevated platform located as close as practicable to the bore head;
- (e) The platform shall incorporate a slack cable pit and decontactor cubicle for the motor drop cable.

#### **6.2.4.3 Cable Connection Canister for River Bed Bores**

The electric cable connection canister shall be:

- (a) Designed to accommodate a single cable for a maximum submersible electric motor size of up to 50 kW;
- (b) Designed for an IP 68 rating in accordance with AS 60529 for a 15 m submergence for 72 hours;
- (c) Designed to enable air to be trapped within the canister to isolate it from the bore water;



- (d) Designed to facilitate simple connection of the electric drop cable to the above ground power cable;
- (e) Manufactured from:
  - (i) mild steel, which shall be hot dip galvanized in accordance with AS 4680 after manufacture, or
  - (ii) stainless steel grade 316 to ASTM A480M which has been pickled and passivated after manufacture in accordance with ASTM A380.

**NOTES:**

1. The cable connection canister is specifically designed for riverbed bore sites subject to relatively high levels of submergence and fast flowing waters e.g. Gascoyne River with the switchboard located remotely on the riverbank above flood level. Riverbed bores are limited to pumpsets  $\leq 50$  kW.
2. The installation should incorporate a slack cable provision to facilitate withdrawal at 90° to the canister.
3. The cable connection canister has been used in Carnarvon for some 25 years without major problems and accordingly the design is deemed to comply with IP 68 to AS 60529. Condensation has not been an issue.

## 6.2.5 Protective Cable Cover

Where required (refer Note) a protective cable cover shall be fitted to the bore head casing cover assembly. The cable cover shall be:

- (a) Designed to protect electric power and monitoring cables, bubbler tube and vent from vandalism, or impact damage from flood debris in flood-prone areas;
- (b) Designed for quick and easy removal (incorporating a pad lockable feature if necessary to deter unauthorized removal) in order to gain access to the bubbler monitoring point and the casing vent isolating valve;
- (c) Constructed from:
  - (i) mild steel which shall be hot dip galvanized in accordance with AS 4680 after manufacture, or
  - (ii) stainless steel complying with ASTM A480M grade 304, which has been pickled and passivated after manufacture in accordance with ASTM A380; or
  - (iii) 3 mm aluminium sheet complying with ASTM B209 grade 5005 H34.

**NOTE:** A protective cover is not necessarily required for a bore site where a security compound has been provided to exclude access by unauthorized personnel.

## 6.3 Casing Tee for Columnless Submersible Borehole Pumps

The casing tee referred to below forms part of the bore head fittings required for columnless type submersible electric borehole pumps.

**NOTE:** Columnless bores are not sited in flood prone areas so the casing cover, headworks pipework and fittings need only comply with an immersion rating of IP 67.

### 6.3.1 Casing Tee Assembly

The bore head casing tee assembly shall:

- (a) Be designed to support the maximum static and dynamic loads expected from pumpsets;
- (b) Be designed for an enclosure rating of IP 67 in accordance with AS 60529;
- (c) Incorporate a casing (tee) body as further detailed in this section;
- (d) Incorporate a casing (tee) top plate as further detailed in this section;
- (e) Incorporate a cable cover as further detailed in this section (as required)

- (f) Incorporate earthing studs in accordance with the ‘Earthing’ clause contained in the General Design Criteria section of this Standard.

### 6.3.2 Casing Tee Body

The casing tee body shall:

- (a) Comprise a flanged tee with the off-take configured in the horizontal position;
- (b) Be manufactured from DN 400 Schedule 40S stainless steel pipe, grade 316L complying with ASTM A269, which has been pickled and passivated after manufacture in accordance with ASTM A380;
- (c) Incorporate DN 400 flanges;
- (d) Incorporate cable cover brackets (as required).

### 6.3.3 Casing Tee Top Plate

The casing tee top plate shall:

- (a) Be constructed from grade 316L stainless steel complying with ASTM A240M, pickled and passivated after manufacture in accordance with ASTM A380;
- (b) Be drilled to suit the body flanges;
- (c) Incorporate a DN 50 BSP boss for the casing air valve;
- (d) Incorporate a DN 15 BSP boss for the vacuum breaker;
- (e) Incorporate a tapped boss to accommodate the electric cable gland;
- (f) Incorporate a support frame for the HV motor cable;
- (g) Incorporate a fitting to accommodate the DN 50 stainless steel hanger pipe;
- (h) Incorporate lifting arrangement designed to accommodate the maximum loads expected for pumpset and packer assembly.

### 6.3.4 Cable Gland

The cable which passes through the casing tee top plate shall be sealed with a minimum IP 67 rated gland complying with AS 60529.

**NOTE:** Cable glands normally comply with a minimum immersion rating of IP 68.

### 6.3.5 Protective Cable Cover

Where required a protective cable cover shall be fitted and shall comply with the relevant parts of the ‘Protective Cable Cover’ section contained in Section 6.2.5 of this Standard.

## 7 PIPEWORK AND ANCILLARIES

### 7.1 General

- (a) Pipework in this section refers to the aboveground headworks and collector main pipework, and also buried pipework connecting the bore head to the headworks pipework for river bed applications;
- (b) The pipe specials and ancillaries contained in this section have been specified in consecutive order, commencing immediately downstream from the bore head casing cover, casing tee or discharge head (lineshaft pumps). Table 8.1 in Section 8 provides a summary of the pumpset type and associated pipework and ancillary combinations to assist in clarification
- (c) In the case of riverbed applications a virgin main, buried in the river bed, shall connect from the bore head to the headworks pipework located beyond the river bank and above the flood level. The main shall be buried to protect it from damaging floodwaters.
- (d) In vandal-prone locations such as parks and reserves vulnerable components shall be protected and manual operating equipment such as valves shall be rendered inaccessible and/or inoperable to unauthorised personnel (refer Section 3.1 (g)).
- (e) Headworks pipework and ancillaries shall be installed at a nominal working height of between 900 mm and 1100 mm depending on the pump type (refer Table 8.1) referenced to the top of the non return valve (refer note regarding lineshaft pumps).
- (f) Pipework flanged connections which are of dissimilar metals shall incorporate appropriate isolation to prevent galvanic corrosion.

**NOTE:** For lineshaft pumps other factors may dictate the working height e.g. accommodating the discharge head dimensions and engine drive.

### 7.2 Design and Manufacture

- (a) Pipework design shall comply with the relevant requirements of AS 4041, Class 2P;
- (b) The maximum flow velocities shall not exceed 2.5 m/s for the discharge pipework;
- (c) Pickling and passivation of stainless steel pipework shall comply with WS-1. Where pipework component internal welds (threadolets, sockets, offtakes etc) are inaccessible using the brushing technique the pipework shall be acid dipped.
- (d) Pipework shall be coated (where applicable) in accordance with the requirements of the ‘Coatings’ section of DS 30-02. Stainless steel pipe specials and appurtenances shall not be coated other than where colour coding bands or identification labels are required.
- (e) Fabricated pipework shall be hydrostatically tested in accordance with AS 4037. Water used for testing shall be clean and non-corrosive in accordance with Clause 17.3.1(b) of AS 4037.

### 7.3 Headworks Pipework

#### 7.3.1 Pipework, Valves and Appurtenances

For additional information relating to pipework, valves and appurtenances refer to the DS 31-01 and DS 31-02 respectively.

#### 7.3.2 Standard Headworks Pipework Sizes

The nominal pipework diameters shown in the following tables should be adopted.

**Table 7.1 – Standard Copper and Stainless Steel Headworks Pipe Sizes**

Pipework Dia - mm		Velocity	Flow Range				
Nominal I/D	Actual I/D		m/s	L/s		ML/d	
	Copper <sup>1</sup>	S/steel <sup>1</sup>		Copper	S/steel	Copper	S/steel
50	48.4	52.48	2.5	0 - 4.5	0 - 5.5	0 - 0.4	0 – 0.5
80	73.0	77.92	2.5	4.6 - 10.5	5.6 – 12.0	0.5 - 0.9	0.6 – 1.0
100	97.6	102.26	2.5	10.6 – 18.7	12.1 - 20.5	1.0 – 1.6	1.1 – 1.8
150	-	154.06	2.5	-	20.6 - 46.8	-	1.9 – 4.0
200	-	202.82	2.5	-	46.9 - 80.8	-	4.1 – 7.6
250	-	254.51	2.5	-	80.9 - 127.2	-	7.7 – 11.0
300	-	304.79	2.5	-	127.3 - 182.4	-	11.1 – 15.8
400	-	387.36	2.5	-	182.5 - 294.6	-	15.9 – 25.5

**NOTES:**

- Flow calculations based on actual I/Ds for Type B copper for sizes ≤DN 80, Type A for size DN 100 and schedule 40S stainless steel.
- The shaded rows highlight the overlap with respect to MSCL pipework (Table below), which would normally be used.

**Table 7.2 – Standard MSCL Headworks Pipe Sizes**

Pipework Dia - mm		Velocity m/s	Flow Range	
Nominal I/D	Actual I/D		L/s	ML/d
200	191	2.5	52.0 - 71.6	4.4 - 6.2
250	245	2.5	71.7 - 117.9	6.3 - 10.2
300	290	2.5	118.0 -165.1	10.3 -14.3
400	372	2.5	165.2 - 271.7	14.4 - 23.5

**NOTE:** Flow calculations based on Actual I/Ds and a velocity of 2.5 m/s.

### 7.3.3 Pipe Specials

- Pipe special materials shall be manufactured from either:
  - copper complying with the relevant parts of AS 1432 (refer Note 1);
  - stainless steel complying with ASTM A312M grade 316L (refer Note 2), for pipe sizes ≤DN 150;
  - MSCL for pipe sizes DN 200 and greater. MSCL bends and other pipe specials shall be flanged to facilitate restoration of cement mortar lining after fabricating (refer Note 3);
- Copper pipe shall not be exposed to a pressure greater than the relevant safe working pressure  $P_{sw}$  shown in Table C2 of AS 1432 for the pipe type selected e.g. DN 80 Type B -  $P_{sw}$  = 1520 kPa and DN 100 Type A -  $P_{sw}$  = 1500 kPa
- Horizontal pipe specials shall incorporate various tapped bosses and flanged stubs as identified in the following clause and detailed later in this Standard;
- Pipe specials shall be flanged in accordance with AS 4087 unless otherwise specified;

- (e) Pipe specials shall be manufactured to standard dimensions and diameters;
- (f) Earth studs shall be fitted on pipe specials as required to enable compliance with the ‘Earthing’ clause contained in the General Design Criteria section of this Standard.

**NOTES:**

1. Copper would be acceptable where water quality was suitable and where there was a preference for copper because of field jointing constraints that would otherwise apply to stainless steel (refer Note 2).
2. Stainless steel pipe specials should be fully manufactured before delivery to site. This is to obviate the requirement for pickling and passivation which cannot be readily undertaken on site for OSH and process reasons. If this is unavoidable the fitting should be modified on site then returned for pickling and passivation. Alternatively the components could be manufactured in copper.
3. DN 200 is the minimum size considered suitable to allow cement mortar lining reinstatement.

### 7.3.4 Tapping Points

- (a) The following tapping points shall be provided on the headworks pipework. They are listed in consecutive order downstream from the bore head:
  - (i) vacuum breaker (refer Note 1);
  - (ii) bore head air valve (refer Note 1);
  - (iii) water sampling (refer Note 1);
  - (iv) headworks pressure gauge;
  - (v) pressure transmitter;
  - (vi) sand sampling;
  - (vii) conductivity meter;
  - (viii) collector main air valve;
  - (ix) collector main pressure gauge;
  - (x) chlorine injection (as required).
- (b) All tapping points shall be located outside the 10 and 5 diameters of straight pipe length upstream and downstream respectively from the magnetic flow meter.
- (c) All water abstracted from the bore shall be subject to measurement in accordance with DoW requirements. Accordingly potential water take-off points shall be located downstream of the magnetic flowmeter. The bore head air valve and water sampling point (refer Note) shall be the only tapping points located upstream of the flowmeter.
- (d) Where applicable tapping points shall be threadolet type manufactured from the same material as the pipework.

**NOTES:**

1. In order to minimise the potential for ‘draw off’ of unmetered water the air valve, vacuum breaker and water sampling point are the only tappings permitted upstream of the flowmeter and are required to be located at these locations for operational purposes.
2. The water sampling point should be located as close to the bore head as possible to minimize the effect of instability.

### 7.3.5 Bore Head Flanged Bend

The bore head bend applies to column type submersible electric borehole pump applications only, as follows:

- (a) A 90° flanged bend shall be fitted to the bore head casing cover (except riverbed applications);
- (b) Riverbed applications shall employ two 45° bends to allow the pipework to be buried in the river bed for protection immediately downstream of the casing cover;

- (c) Where 45° bends are used to achieve the correct working height for the headworks they shall be double flanged for MSCL applications.

**NOTE:** The bore head flanged bend is not relevant for columnless submersible electric or lineshaft borehole pumps. Columnless borehole pumps utilize a flanged bore head tee fitted directly onto the production casing. Lineshaft borehole pumps utilize a proprietary discharge head incorporating an integral flanged bend. In both instances the headworks pipework take-off is via a horizontal flange.

## 7.3.6 Bore Head Tapped Pipe Special

This pipe special is the commencement of pipework common to submersible electric column type or lineshaft borehole pumps, being located immediately downstream of the bore head flanged bend (refer Note), or flanged discharge head as appropriate.

**NOTE:** The bore head flanged bend may be combined with all or part of the bore head tapped pipe special.

### 7.3.6.1 Vacuum Breaker Tapping

For non-flood prone bores a DN 15 vacuum breaker (snifter valve) shall be fitted to a DN 15 tapping point upstream of the bore head air valve.

Riverbed bores shall not be fitted with a vacuum breaker.

For flood-plane bores subject to immersion a continuously rising metallic pipe shall be run from the DN 15 tapping to the switchboard platform and fixed above the flood level at an accessible location. A vacuum breaker shall be fitted to the pipe end at the platform.

### 7.3.6.2 Bore Head Air Valve Tapping

At the bore head, a one-way ‘air release only’ air valve, suitable for submerged operation in flood conditions to a depth of 10 m (ARI BARAK or equivalent), shall be fitted in accordance with the requirements specified in the following clauses. For further air valve information refer to the Clause on ‘Air Valves’ in Section 2 of this Standard and DS 31-02. Air valves shall comply with SPS 200.

For non-flood prone bores the bore head tapped pipe special shall incorporate a DN 25 or DN 50 BSP tapping (depending on air valve size) for the bore head air valve located on top of the pipe special and fitted with an isolating ball valve complying with SPS 252.

Riverbed bores shall not be fitted with a bore head air valve

For flood-plane bores the bore head tapped pipe special shall incorporate a DN 25 or DN 50 BSP tapping (depending on air valve size) for the bore head air valve located on top of the pipe special. The tapping shall be fitted with an isolating ball valve complying with SPS 252.

#### NOTES:

1. The ideal working height for servicing the air valve (an infrequent requirement) of 1100 mm is not feasible for pipework  $\geq$ DN150. Therefore a portable platform or some other safe means would need to be provided to access the air valve.
2. Use of a one-way ‘air release only’ air valve disables the vacuum breaker function necessitating use of a separate vacuum breaker e.g. snifter valve.
3. For non flood-prone bores an acceptable alternative to the one-way ‘air release only’ air valve and snifter valve combination would be an air release and vacuum breaker valve fitted with a Y-strainer.
4. For columnless pumps the air valve tapping point is provided on the casing tee top plate.

### 7.3.6.3 Water Sampling Point

A DN 20 tapping shall be provided on the side of the pipe special for the purpose of attaching a stand-alone water sampling point which is referred to in Section 2 of this Standard relating to ‘Condition Monitoring’. The tapping shall be fitted with a needle valve and a simple gooseneck. The water sampling point shall be fitted with a lockable cover. The location of the tapping shall be upstream of the non return valve and at a nominal working height complying with Clause 7.1(e).

**NOTE:** A sparge is not required because pipework is designed for a velocity 2.5 m/s.

### 7.3.7 Non Return Valve

A non return valve (NRV) shall be fitted to the headworks and located 5D of straight pipe downstream from the 90° or 45° bend (whichever is the case). The NRV shall comply with the following requirements:

- (a) For DN 50 pipework a dual plate wafer type NRV complying with SPS 226;
- (b) For pipework  $\geq$ DN 80:
  - (i) a double flanged ductile cast iron resilient disc non return valve complying with SPS 223, or
  - (ii) a non-slam type NRV complying with SPS 230. This type of valve would only usually be used where water hammer analysis identifies the need for an NRV with low slam characteristics.

**NOTES:**

- 1. The headworks NRV is required to be fitted in addition to the pump NRV to prevent drainage of the collector main in the event of pump NRV failure and also to isolate collector main surges from the bore column and pumpset;
- 2. The headworks NRV is located upstream of the magnetic flowmeter in order to keep it and associated pipework flooded under all conditions;
- 3. Ductile iron resilient disc non return valves are preferred over the dual plate wafer type because: their internals can be serviced from the top without removal of the valve from the pipeline; lower pressure drop characteristics and less susceptible to failure compared with dual plate types. These valves are limited to DN 80 therefore requiring a dual flap NRV for DN 50 pipework.

### 7.3.8 Abstraction Flowmeter

#### 7.3.8.1 General

The headworks pipework shall be fitted with a flowmeter located downstream of the non return valve for Corporation operational and DoW abstraction monitoring purposes. The flowmeter shall also provide an alarm and protection function for the bore pump as detailed in “Condition Monitoring – Magnetic Flowmeter” contained in Section 2 of this Standard.

#### 7.3.8.2 Technical Requirements

The abstraction flowmeter shall comply with DS 40-09, the relevant parts of DoW “Guidelines for water meter installation 2009”, relevant parts of ATS 4747 and the following:

- (a) It shall be a magnetic full bore type complying with ATS 4747.2;
- (b) Suitable for low flow/no flow conditions;
- (c) The same diameter as the adjacent pipework;
- (d) Located in pipework that it is always full of water (Note 1);
- (e) Installed as close as possible to the abstraction point except for riverbed applications and upstream of any tees, takeoffs, diversions or branches in order to record all water abstracted from the bore;
- (f) Installed above ground and in the case of riverbed applications locate the meter and other headworks components on the riverbank above the flood level;
- (g) Treated to provide an IP 68 rating to AS 60529 for flood-prone bore sites;
- (h) Installed in accordance with ATS 4747.5 and located in the pipework so that there are a minimum of 10 diameters of straight pipe immediately upstream of the flowmeter and a minimum of 5 diameters of straight pipe immediately downstream of the flowmeter (Note 2);
- (i) Protected from direct sunlight;

- (j) Accurate to within  $\pm 2\frac{1}{2}\%$  when tested under laboratory conditions and  $\pm 5\%$  for in-situ testing conditions in accordance with DoW requirements and ATS 4747.8 (refer Notes 3 and 4).
- (k) Related instrumentation components shall be rated for the ambient conditions e.g. relatively high summer temperatures existing in the North West regions.

**NOTES:**

1. The magnetic flowmeter is located downstream of the surface non return valve in order to remain submerged under all operating conditions e.g. in the event of the use of an upstream air valve.
2. The upstream and downstream straight pipe lengths are a DoW requirement in accordance with Australian Technical Standard ATS 4747 (and DS 40-09). ATS 4747.5 specifies the straight pipe lengths to the manufacturer's specifications shown from the vertical centreline of valves and the meter (e.g. not necessarily the connecting flanges). The Corporation specifies flange-to-flange pipe lengths for new works which exceeds DoW requirements. This Standard specifies 10 D x 5D to cover a worst case scenario e.g. a 5D x 3D meter can be later changed to a 10D x 5D meter without having to extend the headworks pipework.
3. Verification of accuracy of magnetic flowmeters in-situ should be conducted in accordance with Corporation Generic Work Instruction No. E00016
4. Currently older style magnetic flow meters require "simulation" calibration of the active electronic components at 12 month intervals and newer style magnetic flow meters "verification" calibration at commissioning and thereafter yearly for first two years, then at 5 years if demonstrated to be stable at the previous "simulations". The latter interval should be reviewed as these types of meters age. This methodology has been accepted by the DoW in their letter WT1609 of 8/2/2011.

### 7.3.8.3 Flowmeters for Non AC Powered Bore Sites

For remote non AC powered bore sites that are rarely visited the magnetic flowmeter shall be low power requirement type designed to operate via an internal battery which shall be charged via a battery charger system operated from an external source e.g. solar or the pumpset diesel engine alternator. The flowmeter shall be a Siemens SITRANS FM MAG 8000W or equivalent.

**NOTE:**

For non AC powered bore sites that are regularly visited there is no need to provide a battery charging system as the battery can be replaced periodically e.g. annually, or as required (by incorporating a low battery voltage indicator).

## 7.3.9 Central Headworks Tapped Pipe Special

This pipe special is located downstream of the flowmeter and incorporates the following tappings.

### 7.3.9.1 Headworks Pressure Gauge Tapping

A DN 15 BSP tapping shall be provided on the top of the pipe special located  $\geq 5$  pipe diameters downstream of the magnetic flowmeter and comply with the following:

- (a) The pressure gauge tapping shall be fitted with a DN 15 ball valve complying with SPS 252;
- (b) Pressure gauges shall comply with the 'Bourdon Tube Pressure Gauges for Water Service' section of DS 31-02;
- (c) For vandal-prone areas valves shall comply with Clause 3.1(g)(iv).

**NOTE:** The purpose of the pressure gauge tapping is to enable pump performance testing.

### 7.3.9.2 Pressure Transmitter Tapping

A DN 25 BSP tapping shall be provided on the side of the pipe special immediately downstream of the headworks pressure gauge tapping to enable connection of the pressure transmitter tapping. The tapping shall be fitted with a DN 25 ball valve complying with SPS 252 and plugged.

For vandal-prone areas valves shall comply with Clause 3.1(g)(ii).

### 7.3.9.3 Sand Sampling Point

A DN 50 flanged stub located on the side of the pipe special shall be provided for sand sampling. The sand sampling point shall be located downstream of the pressure transmitter tapping.



### 7.3.9.4 Conductivity Meter Tapping

- (a) A DN 50 BSP conductivity tapping point shall be provided downstream of the sand sampling point and fitted with a plug. Where a conductivity meter is to be fitted the tapping point shall be bushed to accommodate the 3/4" NPT male or ISO 7 – I/R 3/4 male sensor.
- (b) Pipework  $\leq$ DN 80 shall be fitted with an expanded section of pipe to accommodate the sensor. The Designer shall determine the required pipe and fittings required to accommodate the conductivity sensor length when fitted to the tapping point.

## 7.3.10 Control Valve

### 7.3.10.1 Pressure Sustaining Valve

Where low or negative back pressure in the collector main is likely a pressure sustaining valve shall be provided downstream of the conductivity tapping point. Pressure sustaining valves shall be:

- (a) Located a minimum of 10D of straight pipe downstream of the magnetic flowmeter.
- (b) Located preferably 7D (minimum of 5D) of straight pipe upstream from the isolating valve if it is a butterfly valve (or a gate valve could be provided instead).

### 7.3.10.2 Flow Control Valve

Where it is necessary to:

- (a) Control production flows to ensure that WPLs are not exceeded; and
- (b) A pressure sustaining valve is not provided;

Then a wafer type flow control valve (Maric or equivalent) shall be provided downstream of the conductivity tapping point.

## 7.3.11 Scour

Where required for operational purposes (refer Note 1) the headworks shall incorporate a scour to enable bore flushing and pump performance testing. The scour shall comprise a line size branch off-take and isolating valve as follows:

- (a) The takeoff tee for the scour shall be provided downstream of the conductivity tapping point (or where provided, downstream of the control valve);
- (b) A stainless steel orifice plate or wafer flow control valve (Maric or equivalent) shall be fitted to the scour for susceptible bores to restrict the flow from the pump in order to avoid over-pumping when scouring (refer Note 2);
- (c) Scour isolating valve shall be a butterfly valve as follows (refer Note 3):
  - (i) for pipe sizes  $\leq$ DN 150 the scour outlet pipe shall be fitted with a lugged manually operated butterfly valve complying with SPS 260 located immediately after the scour branch tee;
  - (ii) for pipe sizes  $\geq$ DN 200 the scour outlet pipe shall be fitted with a lugged or double flanged) manually operated butterfly valve complying with SPS 260 or SPS 261 respectively located immediately after the scour branch tee;
  - (iii) for vandal-prone areas valves shall comply with Clause 3.1(g)(ii);
- (d) Scour discharge pipework shall be run to an underground sump or to self draining open ground as appropriate. The open ground discharge point shall be designed to prevent soil erosion during operation of the scour.

#### NOTES:

1. Some bore headworks do not incorporate a scour however are provided with an alternative scour point nearby in the collector main.
2. An orifice plate or flow control valve on scour is not required where a flow control valve or pressure sustaining valve is installed upstream on the main headworks pipeline.
3. Use of a butterfly valve as the scour isolating valve allows throttling to facilitate bore flow and pump performance testing.

### 7.3.12 Isolating Valve

An isolating butterfly valve shall be provided on the pipeline located downstream of the conductivity tapping point (or where provided, downstream of the control valve and scour offtake) as follows:

- (a) For pipe sizes  $\leq$ DN 150 a lugged manually operated butterfly valve complying with SPS 260 shall be fitted;
- (b) For pipe sizes  $\geq$ DN 200 a lugged or double flanged) manually operated butterfly valve complying with SPS 260 or SPS 261 respectively shall be fitted;
- (c) For vandal-prone areas valves shall comply with Clause 3.1(g)(ii).

**NOTE:** Alternatively a gate valve may be used for the isolating valve (also refer Section 7.3.10.1).

## 7.4 Collector Main Pipework

### 7.4.1 Collector Main Tapped Pipe Special

This pipe special shall incorporate an air valve and a pressure gauge tapping for the collector main as detailed in the following.

#### 7.4.1.1 Collector Main Air Valve Tapping

A DN 25 or DN 50 tapping (depending on air valve size) shall be provided on the top of the pipe special upstream of the first collector main bend to allow fitting of a collector main air valve refer Note). The tapping shall be fitted with an isolating ball valve complying with SPS 252.

An ‘air release only’ air valve, suitable for submerged operation in flood conditions to a depth of 10 m (AMIAD BARAK or equivalent), shall be fitted to the ball valve (for further information refer to the Clause on ‘Air Valves’ in Section 2 of this Standard and DS 31-02). Air valves shall comply with SPS 200.

**NOTE:** The collector main air valve is required to prevent air accumulation (from dissolved gas or air carry-over from the bore head air valve) in the pipework which otherwise could adversely affect the accuracy of the abstraction flowmeter.

#### 7.4.1.2 Collector Main Pressure Gauge Tapping

A DN 15 BSP tapping shall be provided on the top of the pipe special immediately upstream of the first collector main bend in order to obtain collector main pressure readings. The tapping should be fitted with a DN 15 ball valve complying with SPS 252 and plugged. Where fitted the pressure gauge shall comply with the ‘Bourdon Tube Pressure Gauges for Water Service’ section of DS 31-02.

### 7.4.2 Collector Main Flanged Bends

One above ground 90° flanged long radius bend; and one below ground 90° flanged long radius bend shall be provided on the collector main for non pigging installations downstream of the pressure gauge tapping.

Below ground metallic pipework shall be primed and then externally wrapped with System B in accordance with Coating Specification L1. The tape shall extend a minimum of 100mm above the finished ground level. This wrapping system shall be applied for the purpose of corrosion prevention on all below ground metallic pipework unless it can be demonstrated in a specific application that it is not required.

**NOTE:** 45 ° bends are not preferred as they are a potential tripping hazard above ground.

### 7.4.3 Pigging Tee Pipework

Where a pigging tee is required it shall replace the above ground 90° flanged bend on the collector main and comply with the following:

#### 7.4.3.1 Pigging Tee

A flanged pigging tee shall be provided as required for Metropolitan bores installed in shallow aquifers subject to iron bacteria presence as follows;

- (a) It shall comply with the relevant parts of the ‘Pipework’ section above;
- (b) The tee shall be line size and incorporate a blank flange on the upper tee end;

**NOTE:**

Country borehole pump headworks don’t require pigging tees as air scouring is used in lieu of pigging.

#### 7.4.3.2 Isolating Gate Valve

Collector mains incorporating a pigging tee shall be provided with an additional isolating valve in the collector main pipeline which shall be located downstream of the below ground long bend. The gate valve shall be buried with the spindle vertical and comply with SPS 272.

**NOTES:**

1. The isolating gate valve is required downstream of the pigging tee to enable isolation of the collector main to allow insertion of the pig. A gate valve is required to facilitate passing of the pig.
2. The isolating BV upstream of the pigging tee is required for OSH reasons in order to provide isolation from the pump whilst pigging.

### 7.4.4 Chlorine Injection Point

Chlorine injection points shall comply with the following:

- (a) Only fitted to the pipework as required;
- (b) The injector shall be removable for cleaning
- (c) Location shall be downstream of critical infrastructure to prevent damaging corrosion.

## 7.5 Pipework Supports and Restraints

Pipework shall incorporate all restraints necessary to withstand hydraulic forces imposed by the pump and valves and maximum anticipated pressure surges. Pipework supports shall comply with the requirements of the Pipework Supports section detailed in DS 31-01 and the following.

## 8 SUMMARY OF PUMPSET, PIPEWORK AND ANCILLARIES

The following Table 8.1 provides a summary of the major borehole pumpset components, pipework, ancillaries and assumptions which are specified in this section of the Standard in order to clarify the relationships between the various pump types and operating conditions.

**Table 8.1 - Summary of Pumpset, Pipework and Ancillaries**

Item	Submersible Electric Borehole Pumps			Lineshaft Borehole Pumps
	Flexible Column	Rigid Column	Columnless	
<b>Bore site type:</b>	Non flood-prone; Flood-prone e.g. immersed flood-plane or riverbed		Non flood-prone	Non flood-prone
<b>Submersible borehole pumpset:</b>	Conventional type		Oilfield type	Vertical turbine type
• Pumpset technical specification	SPS 507		SPS 507	SPS 507 (relevant parts)
• Electric motor or engine drive	Low voltage electric motor or High voltage electric motor		High voltage electric motor	Diesel engine
• Pump non return valve (NRV)	Integral or separate pump discharge NRV		Usually none (refer 4.2.6)	Inlet footvalve and strainer
• Column type	Flexible (Wellmaster) with break-off plug drainage system	GRP (Permaglass) with Kwik-lock couplings	GRP production casing and inflatable packer incorporating hanger pipe	Steel column incorporating stainless steel lineshaft drive
• Bubbler and LT setting	Normally at commencement of column e.g. just above pump NRV; NOTE: Large pumpsets $\geq 100\text{kW}$ should CTS monitoring system		N/A – Uses integrated monitoring system (Pheonix ESP)	At start of column (above pump)
<b>Casing cover/tee/discharge head:</b>	Bore head casing cover		Bore head casing tee head	Manufacturer's discharge head
• Height	400 mm	750 mm	1100 mm to top of tee	Manufacturer's standard
• IP rating	- IP 67 for non flood-prone bores including non immersed flood-plane (elevated site); - IP 68 for immersed flood-plane and riverbed		IP 67	IP 67
• Electric motor cable gland	<i>Non flood-prone:</i> IP 67 Cable gland assembly (Roxtec or equivalent)		IP 67 Cable gland	
	<i>Artesian, flood-plane:</i> IP 68 Gland plate fitted on casing cover top			
	<i>Riverbed:</i> Pumps $\leq 50\text{ kW}$ – IP 68 Electric cable connection canister			
• Casing vent boss	<i>Non flood-prone:</i> Casing vent fitted with bronze 'Y' strainer (BYS)		No casing vent requirement	Discharge head tapping & BYS
	<i>Flood-plane and riverbed:</i> Casing vent fitted with ball valve and BYS			
• Bubbler tube gland	<i>Non flood-prone:</i> Routed through cable gland (Roxtec or equivalent)			Routed through IP 67 rated gland
	<i>Artesian and flood-plane:</i> Gland plate fitted to the casing cover top			
	<i>Riverbed:</i> Gland fitted to casing cover top with protective tube			

Item	Submersible Electric Borehole Pumps			Lineshaft Borehole Pumps	
	Flexible Column	Rigid Column	Columnless		
<ul style="list-style-type: none"> <li>Level transmitter gland</li> </ul>	<i>Non flood-prone:</i> Gland located in the casing cover top				
	<i>Artesian and flood-plane:</i> Gland plate fitted to the casing cover top				
<b>Headworks pipework:</b>	Working area (for pump removal) ~ 900 mm		Working area ~1100 mm	Working area ~900 mm	
<ul style="list-style-type: none"> <li>Working height above apron</li> </ul>	900mm - 1100 mm		900 mm (200 mm below T head)	~1100 mm	
<ul style="list-style-type: none"> <li>Air transfer components:                             <ul style="list-style-type: none"> <li>- Bore head one-way 'air release only' air valve (AV), and</li> <li>- Vacuum breaker (VB) (snifter valve)</li> </ul> </li> </ul>	<i>Non flood-prone:</i> Separate AV & VB located on the pipe special downstream of bore head bend		Separate AV and VB located on the casing tee head cover	Separate AV & VB fitted to pipe special downstream of the discharge head	
	<i>Riverbed:</i> No AV or VB fitted (bosses plugged)				
	<i>Flood plane:</i> Separate AV located on headworks & VB located above flood level at platform via a pipe				
<ul style="list-style-type: none"> <li>Water sampling point boss</li> </ul>	Water sampling point assembly				
<ul style="list-style-type: none"> <li>Headworks non return valve</li> </ul>	<i>For DN 50:</i> Dual plate wafer check valve; <i>For <math>\geq</math> DN 80:</i> Double flanged resilient disc swing check valve or: Non-slam NRV		Double flanged resilient disc swing check valve or Non-slam NRV	Double flanged resilient disc swing check valve or Non-slam NRV	
<ul style="list-style-type: none"> <li>Abstraction flowmeter (MFM)</li> </ul>	<i>Non flood-prone:</i> IP 67 MFM <i>Immersed conditions:</i> IP 68 treated MFM		IP 67 MFM	IP 67 MFM with battery	
<ul style="list-style-type: none"> <li>Headworks pressure gauge</li> </ul>	Tapped boss with ball valve (plugged) located in the pipe special downstream of flowmeter				
<ul style="list-style-type: none"> <li>Pressure transmitter tapping</li> </ul>	Tapped boss				
<ul style="list-style-type: none"> <li>Sand sampling</li> </ul>	Flanged stub to accommodate sand sampling point				
<ul style="list-style-type: none"> <li>Conductivity sampling</li> </ul>	Conductivity sensor tapping (only if required)				
<ul style="list-style-type: none"> <li>Pressure sustaining (as required)</li> </ul>	Hydraulically operated automatic control valve complying with SPS 240				
<ul style="list-style-type: none"> <li>Flow control (as required)</li> </ul>	Wafer type flow control valve (Maric or equivalent)				
<ul style="list-style-type: none"> <li>Scour valve</li> </ul>	<i>For <math>\leq</math> DN 150:</i> Lugged butterfly valve (BV); <i>For <math>\geq</math> DN 200:</i> Lugged or double flanged butterfly valve (DFBV)		DFBV	<i>For <math>\leq</math> DN 150:</i> Lugged BV; <i>For <math>\geq</math> DN 200:</i> Lugged or DFBV	
<ul style="list-style-type: none"> <li>Isolating</li> </ul>	Collector main	<i>For <math>\leq</math> DN 150:</i> Lugged BV;		DFBV	<i>For <math>\leq</math> DN 150:</i> Lugged BV;

Item		Submersible Electric Borehole Pumps			Lineshaft Borehole Pumps
		Flexible Column	Rigid Column	Columnless	
valve	(CM)	For $\geq DN 200$ : lugged or DFBV, upstream of CM bend			For $\geq DN 200$ : lugged or DFBV
	Pigging CM	Requires an isolating DI gate valve downstream (below ground)			
• CM air valve		Boss located in the pipe special upstream of CM bend to accommodate one way 'air release only' air valve			
• CM pressure gauge		Boss (plugged) located on top of the pipe special upstream of collector main bend			
<b>Condition monitoring equipment</b>		Refer to Table 2.1			

## APPENDIX A - SCHEDULE OF DRAWINGS

Table A1 –Schedule of Drawings

Drawing Title			Drawing Number	Status	
<b>Common Drawings</b>					
	Bore Headworks Concrete Slab - DN50 to DN150		LB61-5-1	Current	
	Bore Headworks Concrete Slab – DN200 and greater		LB61-5-2	Current	
	Bore Design Summary		LB61-90-1	Current	
<b>Non-Flood Prone Bores</b>					
	Submersible Electric –Flexible Column				
	DN 50	Headworks Pipework - Stainless Steel 316	General Arrangement	LB61-70-1	Current
			Installation Detail	LB61-70-2	Current
			Casing Cover Specials – Fabrication Details	LB61-70-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-70-4	Current
			Water Sampling Point	LB61-70-5	Current
		Headworks Pipework - Copper	General Arrangement	LB61-71-1	Current
			Installation Detail	LB61-71-2	Current
			Casing Cover Specials – Fabrication Details	LB61-71-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-71-4	Current
			Water Sampling Point	LB61-71-5	Current
	DN 80	Headworks Pipework - Stainless Steel 316	General Arrangement – Views	LB61-72-1-1	Current
			General Arrangement – Notes	LB61-72-1-2	Current
			Installation Detail	LB61-72-2	Current
			Casing Cover Specials – Fabrication Details	LB61-72-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-72-4	Current
			Water Sampling Point	LB61-72-5	Current
		Headworks Pipework - Copper	General Arrangement – Views	LB61-73-1-1	Current
			General Arrangement – Notes	LB61-73-1-2	Current
			Installation Detail	LB61-73-2	Current
			Casing Cover Specials – Fabrication Details	LB61-73-3	Current
Headworks Pipe Specials – Fabrication Details			LB61-73-4	Current	
Water Sampling Point			LB61-73-5	Current	
DN 100	Headworks Pipework -	General Arrangement - Plan	LB61-74-1-1	Current	



Drawing Title				Drawing Number	Status	
	Stainless Steel 316	General Arrangement - Elevation	LB61-74-1-2	Current		
			Installation Detail	LB61-74-2	Current	
			Casing Cover Specials – Fabrication Details	LB61-74-3	Current	
			Headworks Pipe Specials – Fabrication Details	LB61-74-4	Current	
			Water Sampling Point	LB61-74-5	Current	
		Headworks Pipework - Copper	General Arrangement - Plan	LB61-75-1-1	Current	
			General Arrangement - Elevation	LB61-75-1-2	Current	
			Installation Detail	LB61-75-2	Current	
			Casing Cover Specials – Fabrication Details	LB61-75-3	Current	
			Headworks Pipe Specials – Fabrication Details	LB61-75-4	Current	
	Water Sampling Point		LB61-75-5	Current		
	DN 150	Headworks Pipework - Stainless Steel 316	General Arrangement	LB61-76-1	Current	
			Installation Detail	LB61-76-2	Current	
			Casing Cover Specials – Fabrication Details	LB61-76-3	Current	
			Headworks Pipe Specials – Fabrication Details	LB61-76-4	Current	
			Water Sampling Point	LB61-76-5	Current	
	<b>Submersible Electric – Rigid Column</b>					
		DN 50	Headworks Pipework - Stainless Steel 316	General Arrangement	LB61-77-1	Current
Installation Detail				LB61-77-2	Current	
Casing Cover Specials – Fabrication Details				LB61-77-3	Current	
Headworks Pipe Specials – Fabrication Details				LB61-77-4	Current	
Water Sampling Point				LB61-77-5	Current	
DN 80		Headworks Pipework - Stainless Steel 316	General Arrangement – Views	LB61-78-1-1	Current	
			General Arrangement – Notes	LB61-78-1-2	Current	
			Installation Detail	LB61-78-2	Current	
			Casing Cover Specials – Fabrication Details	LB61-78-3	Current	
			Headworks Pipe Specials – Fabrication Details	LB61-78-4	Current	
			Water Sampling Point	LB61-78-5	Current	
DN 100		Headworks Pipework - Stainless Steel 316	General Arrangement - Plan	LB61-79-1-1	Current	
			General Arrangement - Elevation	LB61-79-1-2	Current	
			Installation Detail	LB61-79-2	Current	

Drawing Title				Drawing Number	Status
			Casing Cover Specials – Fabrication Details	LB61-79-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-79-4	Current
			Water Sampling Point	LB61-79-5	Current
	DN 150	Headworks Pipework - Stainless Steel 316	General Arrangement	LB61-80-1	Current
			Installation Detail	LB61-80-2	Current
			Casing Cover Specials – Fabrication Details	LB61-80-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-80-4	Current
			Water Sampling Point	LB61-80-5	Current
	DN 200	Headworks Pipework - MSCL	General Arrangement - Views	LB61-81-1-1	Current
			General Arrangement – Notes	LB61-81-1-2	Current
			Installation Detail	LB61-81-2	Current
			Casing Cover Specials – Fabrication Details	LB61-81-3	Current
			Headworks Pipe Specials – Fabrication Details	LB61-81-4	Current
			Water Sampling Point	LB61-81-5	Current
	<b>Flood Plane Bores</b>				
	Elevated Headworks Pad	DN80	General Arrangement	TBD	N/A
			Installation Detail	TBD	N/A
	Elevated Platform	DN80	General Arrangement	TBD	N/A
			Installation Detail	TBD	N/A
	IP68 Glanded Borehead Cover	DN80	General Arrangement	TBD	N/A
			Installation Detail	TBD	N/A
<b>River Bed Bores</b>					
	River Bed	DN80	General Arrangement	TBD	N/A
			Installation Detail	TBD	N/A

## APPENDIX B (Informative) – INSTALLATION OF LEVEL MONITORING DEVICES

### B1 General

The following precautions and measurements should be taken before the installation of the pump, water level transmitter sensor, bubbler airline and columns in the bore.

- Temperature variation does affect the water level transmitter sensor readings. It is recommended to leave the sensor in a bucket of water for a while before installation or if removed.
- A zero check should be taken for the sensor shortly before the installation. This check also should include the current output from the sensor. Check to see that when suspended in air the transmitter output is 4mA or 0m H<sub>2</sub>O.
- Measure each column length prior to installation.
- Measure the height between the top of the pump and the water inlet screen of the pump.

### B2 Installation Guidelines

The following represents a step-by-step approach to the installation of the pump, water level transmitter sensor, bubbler tube and columns in the bore

- (a) Measure the water level in the bore from the top of the spool piece (riser), on the bore column, with a dip tape. A typical dip tape could be a GEO Systems GSDM Series Tape.
- (b) Insert the bore pump in the bore.
- (c) Before inserting the first column in the bore, attach the water level transmitter sensor to the column immediately above the bore pump outlet by the use of heavy duty pipewrap tape suitable for underwater use. This does not apply to columnless pumps which have the sensor located under the pump and readings transmitted via the power cable.
- (d) Locate the submerged end of the bubbler tube (cut at 45 °C) at the same level as the tip of the water level transmitter sensor which is attached to the column.
- (e) Install the rest of the columns in the bore as required.
- (f) After all the columns have been installed the static water level will change as the water in the bore is displaced by the submerged pump and submerged part of the columns. It will take a few minutes before the static water level stabilises in the bore.
- (g) After allowing static water level in the bore to rest, check the reading of the sensor and also the current output of the sensor.
- (h) Take a measurement of the water level using the bubbler tube. This reading should be the same as the water level transmitter sensor.
- (i) Check the reading is displayed at the Operations Centre at Leederville.

### B3 Sample Calculation

The following provides sample calculation that would be required to determine the water level in the bore from the top of the riser.

**Assume:**

- The total length of the columns installed = 27.665 m made up as follows;  
Length of Each Column:  
Column 1 = 5.922 m

Column 2 = 5.925 m

Column 3 = 5.930 m

Column 4 = 5.918 m

Column 5 = 5.915 m

Column 6 = 3.975 m

Total Length = 33.585 m

- Length of the top of the pump from the inlet of the pump = 1.00 m (say)
- Height of the sensor, on the first column, above the pump = 0.00 m
- Sensor Reading of Water Level in the Bore = 12.655 m (which should also correspond to a bubbler reading of 124.1 kPa)

**Calculation:**

- The depth of the sensor from top of the riser on the bore column =  $33.585 + 1.000 - 0.000$   
= 34.585 m
- Sensor Reading of Water Level = 12.655 m
- Calculated water level from the top of the RISER on the bore column =  $34.585 - 12.655$   
= 21.930 m

**NOTES:**

1. Measured water level from the top of the bore head casing cover on the bore column should be equal to 21.930 m.
2. The measured water level should be referenced in terms of the Australian Height Datum.

## APPENDIX C (Informative) – UNDERSTANDING BOREHOLE HYDRAULICS

In boreholes the well water level can vary dramatically. This has a dramatic impact on the head requirements of the pumpsets. As such it is important to have at least a basic understanding of well hydraulics and the factors affecting well water level.

For shallow, unconfined wells the water level corresponds directly to the local water table. As such it can be subject to regular fluctuations which should be considered, for example seasonal fluctuations. For deep, confined wells the water level corresponds to the hydraulic grade or the piezometric level of the pressurised water contained in the confined aquifer.

When a well is at rest (i.e. no water is being extracted from the well) the water level in the well will be at a certain level. This level is called the Water Rest Level (WRL).

When water starts to be extracted from the well, the water level in the well begins to fall. In the area around the well the water level, hydraulic grade or piezometric level also begins to fall in relation to its distance from the well. The level forms a depressed cone shape concentrated at the bore well, called the cone of depression.

This drop in water level inside the well relative to the WRL is called drawdown and the water level during pumping is referred to as the Water Pumping Level (WPL). At a given extraction rate, the drawdown will continue to increase over time. The speed with which this happens is called the rate of drawdown. The rate of drawdown is a characteristic of the well and the extraction rate used. When drawdown is graphed against a logarithmic time scale the drawdown quickly reaches a time period where it forms a linear relationship against logarithmic time. Using the Jacob straight line method of analysis on this section of the graph one can obtain the rate of drawdown. The units for the rate of drawdown are  $x$  meters of drawdown per log cycle at an extraction of  $y$  m<sup>3</sup>/day (where one log cycle is the interval  $T_1$  to  $10T_1$ ). Note that the rate of drawdown is for a specific flow rate and so may be different for different flow rates. In place of actual data the rate of drawdown at one flow may be used for other flow rates but it must be done with some caution as the further away from this test rate, the greater the potential deviation. For this reason tests used to calculate the rate of drawdown should be conducted as close as possible to the intended flow rate of the bore. This particularly important for bores where large rates of drawdown exist.

So long as the extraction remains, the well level proceeds to drawdown over time. But when the extraction is stopped the well level recovers over time. This recovery relationship is almost the exact mirror of the drawdown process. That is the rate of recovery is roughly the same as the rate of drawdown.

Therefore when the water level of bore is measured after a bore pump has been switched off, the observed level may not be the WRL. There may still be residual drawdown which will take time to disappear and consideration and allowance for residual drawdown should be made when taking WRL measurements. As a guide the time taken for the bore to fully recover is roughly equal to the amount of time the pump has been running. For a bore which has run continuously for months, it will take months for the WRL to be fully reached.

Given that the drawdown increases over time during water extraction and recovers during shut off, this has implications for the pump selection. Where a pump is not expected to operate continuously and is switching on and off and therefore allowing time for recovery the drawdowns experienced will be very different conditions than where a pump runs continuously.

For unconfined aquifers consideration should also be given for the time effects of delayed yield. Delayed yield is a slower or slowing in the rate of drawdown and is unique to unconfined aquifers. It varies from bore to bore and can happen instantly upon pumping or may take days to occur. Given the time to become apparent, it is likely the effect of delayed yield might not present itself in the bore test data. The slowing of the drawdown is caused by the fact that as the water table draws down around a borehole, the ground which was saturated and below the water table gradually is brought above the

water table. Overtime the water held in suspension within the pores of the saturated ground is overcome by the force of gravity and this water drains down into the cone of depression. This water has a re-charging effect thereby slowing the rate of drawdown.

If a well is pumped continuously, and we assume the aquifer is also being recharged from some external source, then the drawdown will eventually reach a level where it reaches equilibrium and stabilises. At this point the water extracted equals the water re-charged into the wells area of influence, the WPL remains constant and the rate of drawdown equals zero. This point is called the long term drawdown and is defined at a given flow rate.

To obtain an accurate estimate of the long term drawdown at a given flow is a difficult task because of the complexities involved in well hydraulics and the difficulty in being able to quantify and model the many variables. For this reason the Water Corporation generally takes a simplified approach to obtain a general indication of the long term drawdown. This simplified approach is as follows. Using the well's rate of drawdown at a given flow together with a measured reference point of the drawdown at some time the drawdown is extrapolated out to a period of 1 year. This value is termed the long term drawdown.

What this drawdown actually represents is the drawdown after 1 year of continued operation at a given flow, if the rate of drawdown remained constant. The validity of using this value as the long term drawdown is based on the following:

- After 1 year aquifer re-charge will roughly be occurring at a rate which will either significantly reduce or bring to zero the rate of drawdown.
- Even if there was absolutely no re-charge at all into the aquifer the next log cycle of drawdown will not be felt for another 9 years of continuous pumping.

Once the long term drawdown at a given flow is determined, two key terms can be derived. They are specific capacity and specific drawdown.

The specific capacity is how much flow (m<sup>3</sup>/day) a well can deliver per meter of long term drawdown.

The specific drawdown is how many meters of long term drawdown a well will experience at a unit flow of (1 m<sup>3</sup>/day).

(Note: specific capacity and specific drawdown usually relate to long term drawdown figures. However they can also be based on short term drawdowns where required).

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