Water Quality Protection Guidelines No. 4

Mining and Mineral Processing

Installation of minesite groundwater monitoring bores

2000

1. Introduction

Monitoring is one of the most important aspects of protecting groundwater resources. This is best achieved by constructing a network of bores. Assessing groundwater quality before an operation commences can set the environmental management needs of a project. Monitoring undertaken during the Environmental Impact Assessment (EIA) process can also establish the baseline data by which the environmental performance of an operation can be assessed. Undesirable environmental impacts can thus be detected at an early stage and remedied effectively.

2. Purpose

These guidelines are designed to be used for the construction of bores which monitor groundwater at mineral and mining operations.

3. Scope

These guidelines apply to construction of bores for projects that have the potential to impact on groundwater levels and water quality. They also apply where baseline groundwater quality data are being established prior to the development of a project

4. Guidelines

4.1 General

a. Construction and completion procedures (including the location of the slotted/screened interval) depend on the type of soil strata and the purpose of monitoring (e.g. water levels, contamination plume). Some contaminants float on the water table, others mix with the waterbody and others sink into the aquifer. In some cases, a nest of bores will be needed for effective monitoring for contaminants at different depths.

b. Bores consist of a vertical cased hole with part of the casing screened or slotted to permit drawing of groundwater for analysis and to measure standing groundwater levels (SWLs).

c. Bore diameter will be influenced by the proposed methods for abstracting samples (refer to section 4.13 for sampling methods).

d. Bores used for production and sampling should be suitably equipped so that representative samples can be taken from them.

e. Drilling should be undertaken by experienced operators who are familiar with safe operating practices.

f. Water abstracted during drilling should not be disposed of in a way that adversely impacts on the environment.

4.2 Bore locations

a. Bores are normally required upstream and downstream (in the direction of groundwater flow) to monitor changes in water level and quality across a site and to monitor the performance and stability of tailings facilities.

b. In hard rock areas, bores must be located within geological features that are most likely to transmit groundwater (e.g. along fault lines, within weathered zones with coarse granular soil or in alluvial sand).

c. Where an existing water production bore is strategically located, it may be accepted for monitoring purposes in lieu of a new monitoring bore, provided the construction technique is unlikely to alter the concentration of contaminants.

d. Bores should be located as close as is practical to the site shown on the development plan. Any significant variation should be discussed with Commission staff before drilling occurs. Bore completion details should be provided to the Commission when drilling has been completed.

4.3 Drilling technique

a. The recommended drilling techniques for unconsolidated soils are hollow-flight auger, dual-wall reverse circulation, cable-tool rig or similar. For hardrock areas, a down-hole hammer or similar percussion technique is recommended. Drilling mud or other additives may be used after seeking agreement with the Commission.

b. Contamination of the bore hole and its surrounds is to be avoided during drilling and casing installation. Water contaminants, lubricants, oil, grease, solvents, coatings and corrodible materials may affect the suitability of the bore for groundwater monitoring.

c. Where monitoring for the presence of contaminants, all drilling and sampling equipment should be thoroughly cleaned before commencing drilling. Casing materials and drilling fluids also need to be free of contaminants.

4.4 Depth of bores

a. **Shallow** (S) bores should be drilled to monitor water quality at the top of the watertable or below the standing water level (SWL) in an unconfined aquifer. Where no defined SWL is determined, drilling should continue to a depth where a low-permeability soil horizon is encountered or to a depth agreed to by the Commission.

b. **Intermediate** (I) depth bores are used to monitor the water quality at the base of an unconfined aquifer.

c. **Deep** (D) bores are used to monitor water quality within a confined aquifer. Confined aquifers require isolation from an upper aquifer by use of packers and an impervious sealant.

d. Bore construction will vary depending on the purpose of monitoring and the hydrogeology of the site. Typical bore constructions are attached to this guideline.

e. In fractured rock areas, such as the Goldfields, it may be necessary to vary these guidelines where aquifer boundaries are not clearly defined.

4.5 Drill core samples and bore logging

An accurate bore log should be kept during drilling and a clean representative sample of the soil profile collected at all changes of strata or at least every 3 metres. Samples should be stored in calico sample bags for examination by personnel competent and experienced in hydrogeology. Logs and construction details of all licensed production bores must be forwarded to the Commission.

4.6 Permanent casing

a. Casing material will be dictated by bore diameter, bore depth and the type of contaminants to be monitored. Steel and glass fibre casings are suitable for monitoring most organic substances where bores exceed 50 metres in depth.

b. Polyvinyl chloride (PVC) or glass fibre casings are suited to monitoring most inorganic substances particularly in corrosive waters. Class 9 PVC casing is generally used for bores less than 60 metres deep, while Class 12 PVC should be used for deeper bores.

c. Where monitoring for organic materials, bore casing should have mechanical joints (with locking mechanism) to avoid contamination by solvents such as PVC glue. Lubricants should not be used on casing joints.

d. All bores should be cased with a pipe of at least **80 millimetre internal diameter (ID)** placed to the depth described in section 4.10. Bore casing as small as 50 millmetres ID may be acceptable where a suitably sized submersible sampling pump is available on site at all times. Larger bore diameters are suitable where the bore is used for water production or recovery. The bore casing should extend 500–700 millimetres above the ground surface.

e. The bottom of the casing should be sealed with cement grout or a cap. Any over-drilling below the bottom of the casing should be backfilled with materials equivalent to the original strata that were overdrilled.

4.7 Screen / slotted casings

a. Screens should have the following properties:

- corrosion resistance to groundwater or bore maintenance chemicals;
- screen aperture size suited to the monitored soil type.

b. Generally, slotted PVC casing will have at least 100 horizontally cut slots every metre. Slot length should be about 50 millimetres. Slot aperture will vary according to the material size being screened, ranging from 0.2 to 1 mm. A common size is 0.4 mm. External filter socks may be used to exclude very fine soil from the

casing. The slots should be horizontal when the casing is installed, 25 mm apart in the vertical direction, arranged in three equi-spaced columns around the casing.

c. Bore construction and casing details need to be recorded in a schedule similar to that shown below.

Schedule

Bore number	Depth of bore (metres below ground level)	Depth to screen top (metres below ground level)	Depth of screen (metres below ground level)	Comments
MB1 MB2 MB3 etc.				

4.8 Granular pack

a. A granular ('gravel') pack should be used to avoid siltation occurring when fine-grained aquifers are encountered. The bore annulus should be carefully and evenly filled to a minimum of 2 metres above the screened interval with a graded granular pack. The level of the granular material should be kept above the bottom of the temporary outer casing as it is withdrawn.

b. The pack should be uniformly graded between a minimum sized material retained on a 1 to 1.6 mm sieve and a maximum size passing a 3.2 mm sieve (unless otherwise approved). The granular pack should consist of clean coarse silica sand or a similar material that will not contaminate the bore.

4.9 Sealing of annulus above or between monitored intervals

A cement slurry or bentonite seal at least 1 m high should be placed on top of the granular pack to seal the bore casing annulus to prevent water movement down the casing from the surface or between aquifers. The bentonite seal should be constructed using bentonite pellets slowly inserted down the annulus with the depth to the top of the pellets regularly checked. Where necessary, and before filling, sufficient clean water should be poured down the annulus to allow the bentonite pellets to fully hydrate.

4.10 Centralising casing

The permanent casing should be inserted inside any temporary casing. The temporary casing should be withdrawn vertically as the hole is evenly backfilled to ensure the permanent casing remains centrally located, straight and vertical.

4.11 Development

Bores should be fully developed by pumping, bailing, valve surging or air lifting and cleaned prior to cementing around the top of the bore. Where any nearby soil strata may be contaminated, the annulus must be cemented to prevent contaminated water recirculating via the bore annulus to the screened interval.

Contaminated groundwater should be disposed of in a tailings storage area or, alternatively, carted off-site for safe disposal at a location approved by Department of Environmental Protection.

Uncontaminated groundwater may be discharged provided it meets the criteria set out *Water Quality Protection Guidelines No. 11 – Mine dewatering.*

4.12 Bore completion

a. Bores that intersect confined aquifers or are slotted at the middle and lower levels of an unconfined aquifer require backfilling with cement grout. The casing annulus should be backfilled from above the slotted section to 1.5 metres below the surface.

b. A 1.3 metre minimum length of steel casing protruding a maximum 700 millimetres above the surface should be cemented in around the top of the bore for protection. Type A borehead (see attached diagrams) should be used in non-trafficked areas while type B should be used in trafficked areas.

c. The steel protection casing should be fitted with a lockable steel cap or other vandal-resistant device (refer to attached figure).

d. Each bore should have its registration number permanently affixed to the outer casing by either embossed plaque or welded characters. The number should be painted to prevent corrosion occurring.

e. Survey control stations should be set-up to ensure that bore locations or bore top of casing can be re-established if required. The control stations should use a datum confirmed from a permanent survey mark. The permanent survey mark should be checked against nearby solidly-placed reference marks or against control marks established on previous surveys.

f. Contaminated drill cuttings are to be disposed of to tailings areas or a site approved by the DEP.

4.13 Sampling methods

a. In order of preference, the following sampling methods may be used:

- Dedicated pump, i.e. each bore has its own pump.
- Mobile borehole pump, i.e. pump is used to sample several monitoring bores at the site.
- Through-flow bailed sampler (sampling tube fitted with flap valve in base which closes when the bailer is raised).
- 'Bucket-style' tube bailer.

b. Care should be taken to ensure sampling equipment is decontaminated after each sample is taken. Recommended quality practices include progressing from upstream to downstream monitoring points, use of blank samples of known analysis between successive samples, and holding of sampling equipment in a clean dust-free container when not in use.

c. Details of water sampling methods, containers and sample preservation requirements are presented in the *Water Quality Protection Guidelines No.5 – Minesite water quality monitoring*.

4.14 Bore acceptability

It is the responsibility of the construction superintendent (or equivalent) to ensure that upon completion:

- bores meet the above specifications (except where otherwise agreed to by the Commission);
- bores are free of sand and foreign materials;
- bore sites have been returned to a clean and level state having regard to natural contours;
- all materials and rubbish have been removed from the drill site.

4.15 Decommissioning bores

Bores should be decommissioned in accordance with the Agriculture and Resource Management Council of Australia and New Zealand's *Minimum Construction Requirements for Water Bores in Australia.*

5. Useful references

Some components of these guidelines have been based on work already undertaken and reported in the following publications:

1. Environment Protection Agency (1995). *Best Practice Management in Mining – Environmental Monitoring and Performance Module*, Commonwealth of Australia, Canberra.

2. Driscoll, F.G. (1986). *Groundwater and Wells*, 2nd ed., Johnsons Filtration Systems Inc., St Paul, Minnesota.

3. Agriculture and Resource Management Council of Australia and New Zealand (1997). *Minimum Construction Requirements for Water Bores in Australia*.

Glossary and Abbreviations

1.	Aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
2.	Bentonite	A clay-type material, usually highly colloidal and, which swells and shrinks with changes in water content. Used in reducing seepages in mines and channels and also as a major component of drilling mud.
3.	Confined aquifer	A formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations. Confined groundwater is generally subject to pressure greater than atmospheric.
4.	Drilling mud (or fluid)	A water- or air-based fluid used in a water-well drilling operation to remove cuttings from the hole, to clean and cool the bit, to reduce friction between the drill string and the sides of the hole, and to seal the borehole.
5.	Grout	A fluid mixture of cement and water of a consistency that can be forced through a pipe and placed as required. Various additives such as sand, bentonite and hydrated lime, may be included in the mixture to meet certain requirements.
6.	Hydrogeology	The geological science associated with the occurrence, distribution, movement and quality of groundwater.
7.	Packer	A special fitting that provides a sand-tight seal between the top of the telescoped screen assembly and the casing. Two types of commonly used packers are neoprene rubbers and lead.
8.	Permeability	The capacity of a porous rock, sediment or soil for transmitting a fluid when subjected to unequal pressure.
9.	Unconfined aquifer	An aquifer where the watertable is exposed to the atmosphere through openings in the overlying material.

Further enquiries

Any project where the proponent/operator is unable to comply with these guidelines, or where site conditions prevent the application of these guidelines, should be submitted to the Commission as early as possible in the development of the proposal so that the matter may be resolved.

Any queries relating to the **content of these guidelines** should be directed to:

Program Manager Assessment and Advice
Water Quality Protection Branch
Water and Rivers Commission
Level 2, Hyatt Centre
3 Plain Street
EAST PERTH, WESTERN AUSTRALIA 6004
Phone (08) 9278 0300
Fax (08) 9278 0585

For further enquiries on any matter relating to the **management of water resources**, please contact the Water and Rivers Commission's regional offices.

Swan-Goldfields-Agricultural Regional Office
849 Albany Highway
VICTORIA PARK WA 6100 Phone (08) 9362 0555 Fax (08) 9362 0500

Or
254 Fitzgerald St
NORTHAM WA 6401 Phone (08) 9690 2821 Fax (08) 9622 7155

North West Regional Office
Chiratta Road
KARRATHA WA 6714 Phone (08) 9144 2000 Fax (08) 9144 2610

South West Regional Office
U2 Leschenault Quays,
Austral Parade
BUNBURY WA 6230 Phone (08) 9721 0666 Fax (08) 9721 0600

Or
'Sholl House'
21 Sholl St
MANDURAH WA 6210 Phone (08) 9535 3411 Fax (08) 9581 4560

Mid-West Gascoyne Regional Office
Pass Street
Geraldton WA 6530 Phone (08) 9964 5978 Fax (08) 9964 5983

South Coast Regional Office
5 Bevan Street
ALBANY WA 6330 Phone (08) 9842 5760 Fax (08) 9842 1204

These guidelines are also available from the Water and Rivers Commission's web page at:
http://www.wrc.wa.gov.au/protect/policy/

Other related guidelines in this series include:

WATER QUALITY PROTECTION GUIDELINES NO. 1
Water quality management in mining and mineral processing: An overview

WATER QUALITY PROTECTION GUIDELINES NO. 2
Tailings facilities

WATER QUALITY PROTECTION GUIDELINES NO. 3
Liners for waste containment

WATER QUALITY PROTECTION GUIDELINES NO. 5
Minesite water quality monitoring

WATER QUALITY PROTECTION GUIDELINES NO. 6
Minesite stormwater

WATER QUALITY PROTECTION GUIDELINES NO. 7
Mechanical servicing and workshop facilities

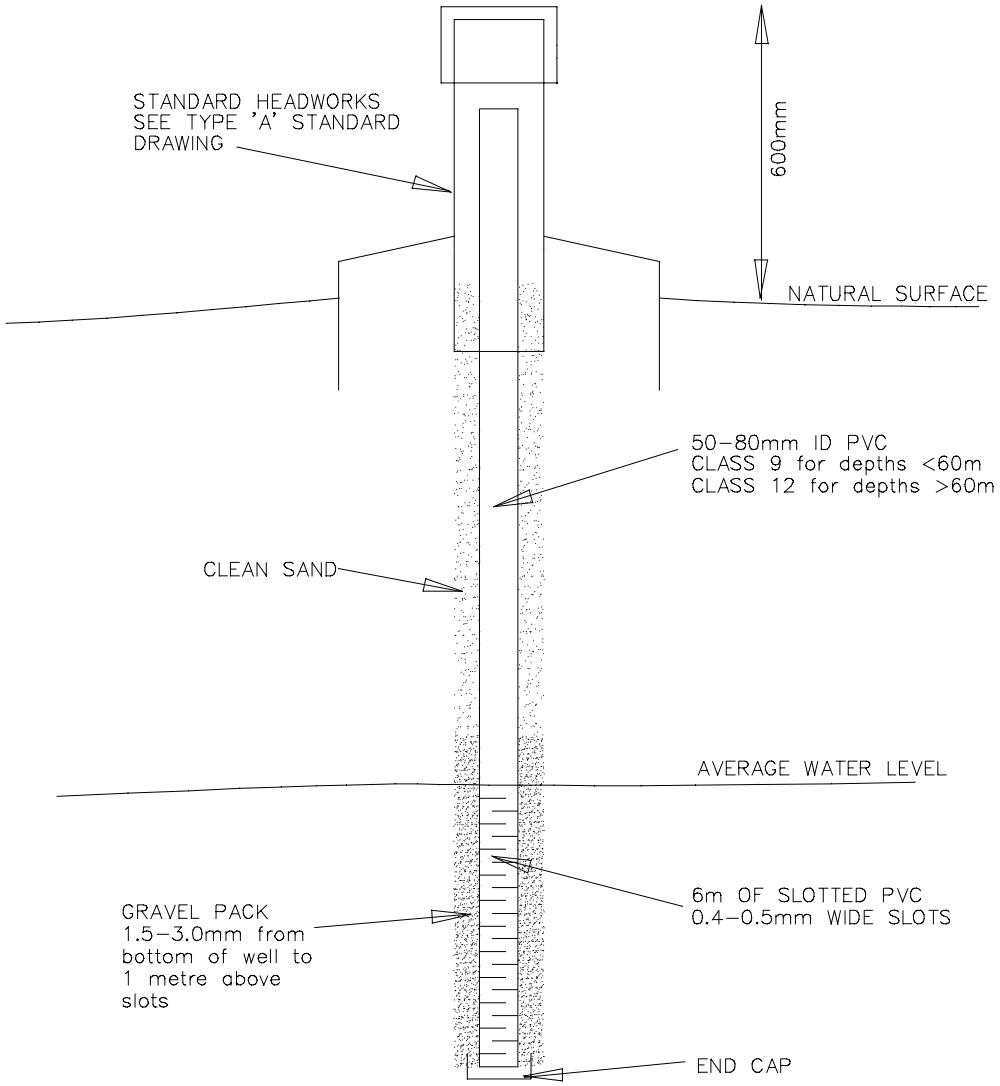
WATER QUALITY PROTECTION GUIDELINES NO. 8
Laboratory waste discharge

WATER QUALITY PROTECTION GUIDELINES NO. 9
Acid mine drainage

WATER QUALITY PROTECTION GUIDELINES NO. 10
Above-ground fuel and chemical storage

WATER QUALITY PROTECTION GUIDELINES NO. 11
Mine dewatering

DEVELOP BORE FOR
MINIMUM 2 HOURS BAILING OR AIRLIFT



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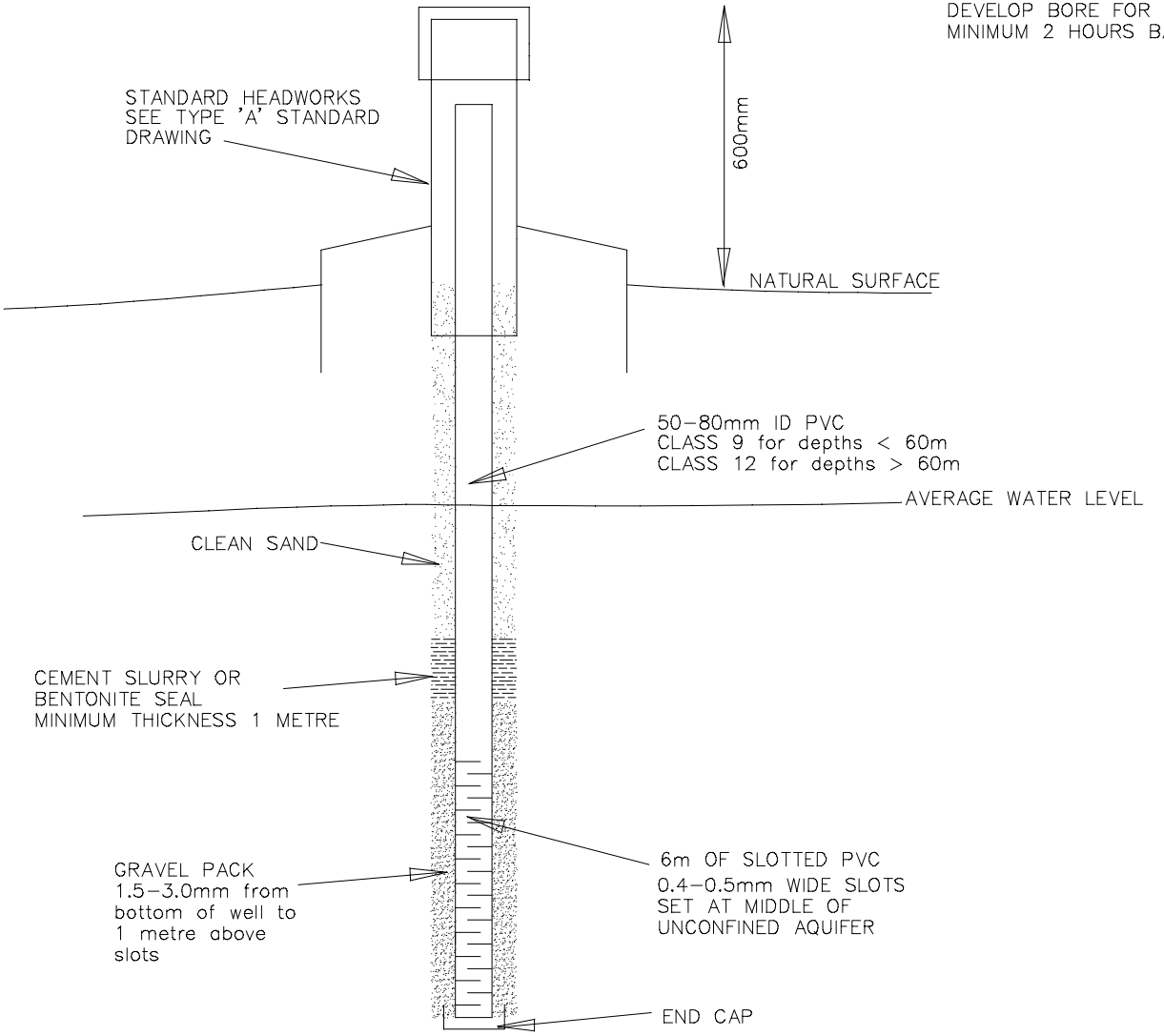

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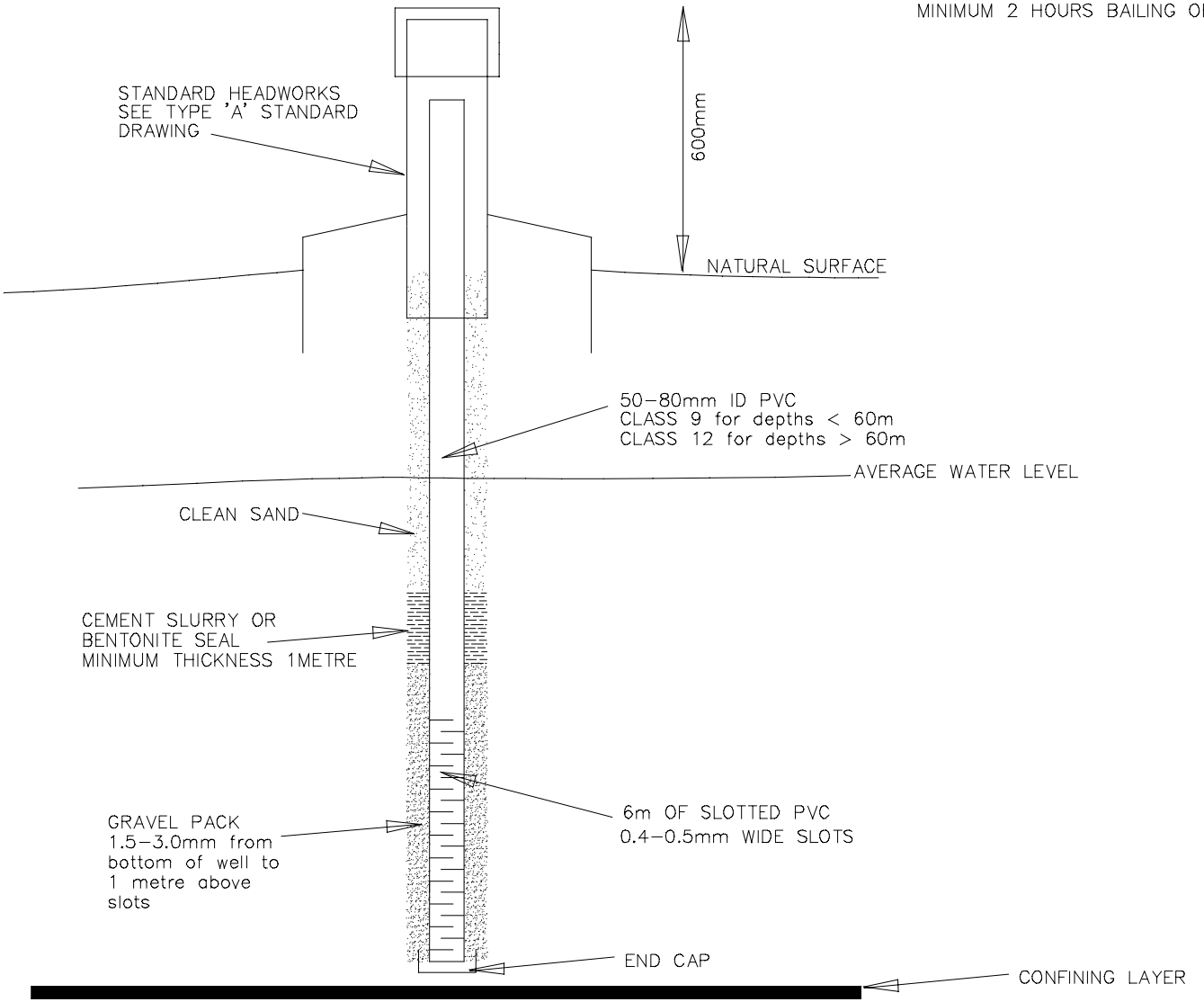
DEVELOP BORE FOR
MINIMUM 2 HOURS BAILING OR AIRLIFT



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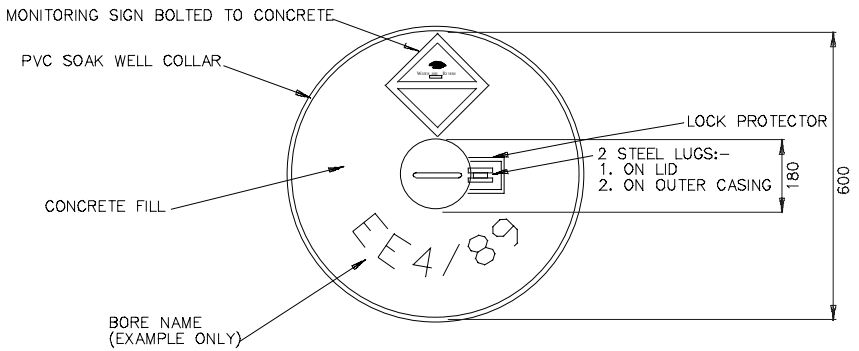
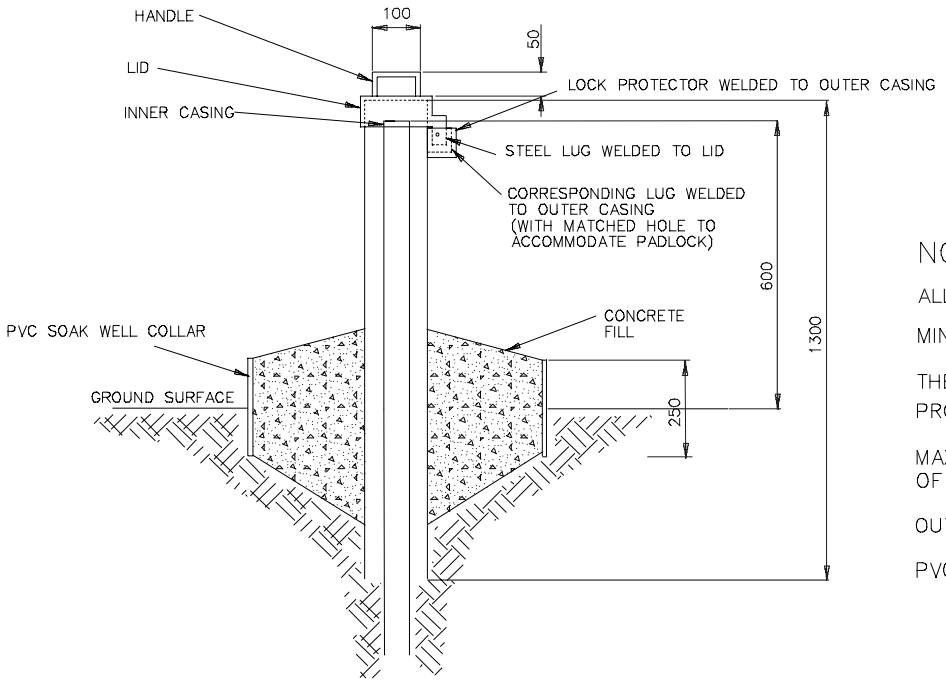
PLAN



ELEVATION



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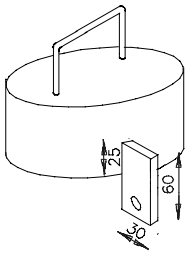
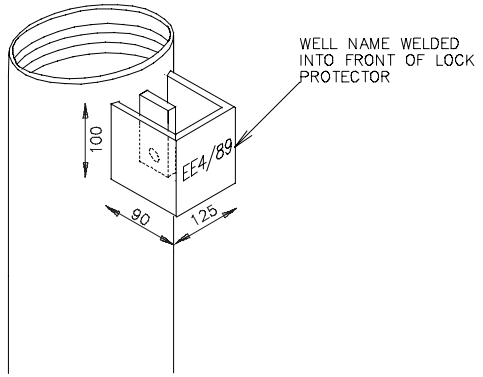


OUTER CASING SHOWING
LOCK PROTECTOR



NOTES

ALL DIMENSIONS IN MM

MINIMUM STEEL THICKNESS 4mm

THE BORE NAME IS TO BE WELDED ONTO THE LOCK PROTECTOR AND INSCRIBED ONTO CONCRETE BASE

MAXIMUM DISTANCE BETWEEN TOP OF INNER CASING AND TOP OF OUTER CASING = 200MM

OUTER CASING 165MM O.D. STEEL PIPE

PVC SOAK WELL COLLAR 600MM I.D.

DES REF DATE DRN CHD		RECOMMENDED APPROVED	WATER AND RIVERS COMMISSION	STANDARD MONITORING BORE HEADWORKS TYPE "A"	ORIGINAL SHEET SIZE A3	
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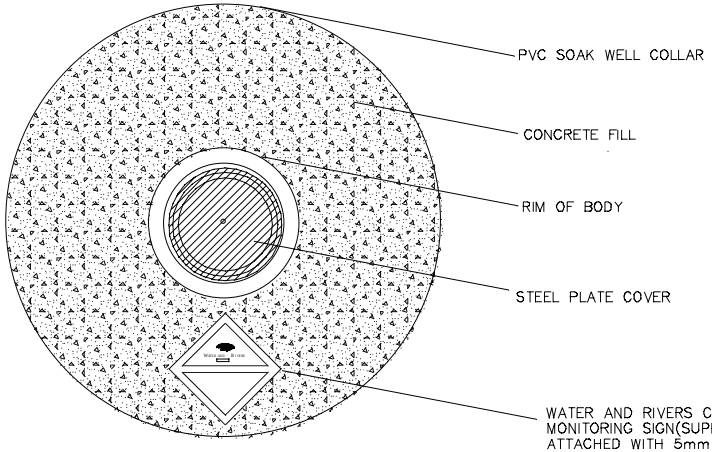
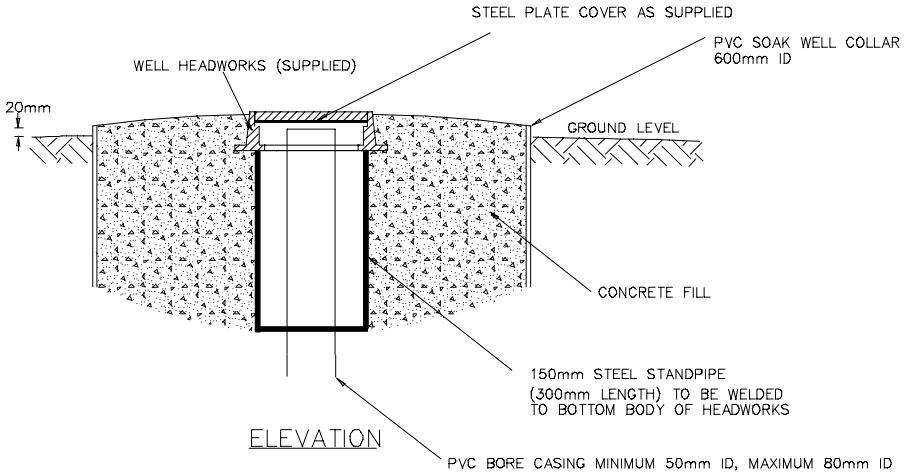


PLAN



ELEVATION

NOTES

ALL DIMENSIONS ARE IN MM

THE WELL NAME IS TO BE INSCRIBED INTO THE TOP OF THE CONCRETE BASE WHILE STILL WET.

STEEL CASING STANDPIPE TO BE 150mm DIAMETER AND 300 MM LONG.

THE MAIN BODY IS TO BE WELDED ONTO THE STEEL STANDPIPE. CONCRETE IS TO BE POURED TO A MINIMUM DEPTH OF 300 MM AROUND THE STANDPIPE TO PROVIDE SUPPORT FOR THE HEADWORKS AND STANDPIPE.

DES REF DATE 16/05/96 DRN N HOLMES CHD		RECOMMENDED APPROVED	WATER AND RIVERS COMMISSION	STANDARD MONITORING BORE HEADWORKS TYPE "B" TYPICAL INSTALLATION			ORIGINAL SHEET SIZE A4
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