Department of
Mineral and Petroleum Resources

THE CHAMBER OF MINERALS AND ENERGY OF WESTERN AUSTRALIA INC

WATER AND RIVERS COMMISSION

GUIDELINES FOR THE PROTECTION OF SURFACE AND GROUNDWATER RESOURCES DURING EXPLORATION DRILLING

CONTENTS

1.0 INTRODUCTION

These guidelines have been prepared with the aim of protecting groundwater aquifers, wetlands, waterways and associated lands from degradation resulting from exploratory drilling for groundwater, mineral resources or other investigatory purposes. The Department of Minerals and Energy identified a window of opportunity where these guidelines may be implemented in the renegotiation of the lease arrangements for existing mining tenements. The guidelines are intended to provide proponents, drilling companies and individuals with information relevant to exploratory drilling operations and the impacts they may have on the environment and water resources. The document provides advice on who to contact for information on protection and management initiatives required for protecting water resources.

These guidelines are additional to the regulations involving exploration drilling and construction of water bores in designated groundwater areas. In this situation in Western Australia, the land occupier must hold an appropriate groundwater licence and the driller must hold an appropriate drillers' licence (Classes 1, 2 or 3) issued by the Australian Drilling Association and applicable for the particular intended type of groundwater drilling and bore construction.

Adherence to the procedures described in this document will assist in the recording of hydrogeological data of high value in the assessment and delineation of State water resources.

2.0 POTENTIAL IMPACTS OF EXPLORATORY DRILLING

Exploratory drilling has the potential to impact on the environment in a variety of ways. Impacts of drilling may be exhibited in any of the following areas:

- Groundwater aquifers
- Wetlands
- Waterways – Estuaries, rivers and streams

In addition to aquifer protection requirements, abandoned open or unstable drillholes are a physical hazard to people, stock, native animals and to foundations of structures constructed over these drill sites.

2.1 Groundwater aquifers

Aquifers are vulnerable to degradation during and following exploration drilling in the following ways:

- Aquifers may be contaminated by entry through open boreholes by run-off water from the surface, such as in saline and industrial areas;

- Aquifers containing useable-quality water being connected by drillholes to aquifers with inferior-quality water or to leakage zones. Cross flow may be induced by natural pressure differences or pressure differentials induced by pumping;

- Uncontrolled flow of pressure aquifer water through drillholes between aquifers of different quality water or through uncontrolled flow to wastage at the surface.

Contaminated groundwater aquifers and wetland water regimes have the potential to affect the habitat and diversity of the aquatic flora and fauna.

2.2 Wetlands

Wetlands are often surface expressions of groundwater and therefore wetland water regimes may be vulnerable to degradation, both directly and indirectly, from exploratory drilling activities. These degradation impacts may be exhibited in the following ways:

- Groundwater aquifer contamination may potentially be exhibited in wetland water regimes;

- Exploratory drilling may also impact on wetland water regimes directly. There is the potential for contamination from activities draining directly into wetlands unless preventative measures are implemented. Contaminated wetland water regimes may potentially pollute groundwater aquifers;

- Potential riparian or fringing vegetation loss from infrastructure, drilling activities or access tracks.

Contaminated wetland water potentially impacts the wetland water quality, aquatic flora and fauna, as well as terrestrial habitat, riparian vegetation and terrestrial fauna, such as waterbirds.

2.3 Waterways

Waterways, such as rivers and streams are vulnerable to degradation from exploratory drilling activities in the following ways:

- Groundwater aquifer contamination may potentially be exhibited in the water regimes of waterways, as some streams and rivers may be fed by groundwater;

- Exploratory drilling may also impact on waterways directly. There is the potential for contamination from activities draining directly into wetlands unless preventative measures are implemented;

- Potential riparian or fringing vegetation loss from infrastructure, drilling activities or access tracks.

Contaminated waterways potentially affect water quality, aquatic flora and fauna, as well as terrestrial habitat, riparian vegetation and terrestrial fauna, such as waterbirds.

3.0 AQUIFER TYPES

Three broad types of aquifers can be identified in Western Australia: unconfined, multi-layered and confined. Different drilling methodology and abandonment procedures apply to each type of aquifer.

The general distribution of these aquifers in Western Australia is shown on the hydrological map of Western Australia issued by the Geological Survey of WA, 1989 edition, at 1:2.5 million scale.

More detailed information on the type of aquifer to be found in an area may be obtained by inspecting the limited number of 1:250 000 geological map series issued by the Geological Survey of Western Australia and the Water and Rivers Commission.

Further advice may be obtained by consulting the Water and Rivers Commission or, by contacting one of the numerous groundwater consultants in Western Australia.

A simplified State aquifer distribution map is shown in Figure 1.

A brief description of the three broad aquifer types in Western Australia follows:

3.1 Unconfined aquifers

Unconfined aquifers are also referred to as water table or phreatic aquifers. Their characteristic is that the groundwater body has free exchange of pressure and moisture with the atmosphere. Rainfall can percolate from the surface to the watertable or, the watertable can be open to evaporation. These aquifers usually do not show distinct strata layering. When holes are drilled, little change in water level occurs on hole completion. Although large increases in salinity may occur with depth, little natural salinity mixing takes place when drilling penetrates these aquifers.

These aquifers are highly susceptible to contamination from surface landuse, including the disposal of industrial waste, the use of agricultural fertilisers and sprays. The salinity of these aquifers may also be increased where the watertable is shallow.

Unconfined aquifers are usually present in the following situations:

- In the upper layers of coastal plains;
- in river valley alluvial deposits;
- in palaeoriver systems such as are associated with the main saltlake chains of the State;
- in the regolith, the soil and weathered hardrock layer that covers most of the inland part of the State, including the Goldfields, Ashburton, Pilbara and Kimberley regions. The regolith layer extends downward into the broken, fractured and jointed hardrock zone.

Drilling and abandonment procedures for drilling in unconfined aquifer regions of the State are described in this document.

3.2 Multi-layered aquifers

These aquifer systems are mostly associated with layered or stratified sedimentary rocks and are mostly found in the sedimentary basins of the State (Figure 1). These sedimentary basins include the Perth, Carnarvon, Fitzroy, Canning, Officer. Eucla, Bremer and Collie Basins.

A characteristic of multi-layered aquifers is that the penetration of each layer by a drillhole usually results in a change in water level. This indicates that water exchange between layers may be induced along a drillhole as a result of differential pressures. Specific facilities and techniques are required at the drill site if these aquifers are to be drilled. These techniques are described in this document.

3.3 Confined (artesian) aquifers

Confined or artesian aquifers are mostly found in deeper layered or stratified sediments in the large sedimentary basins of the State.

The most significant characteristic of these aquifers is that major changes in the water level may be encountered as a result of penetration by a drillhole to the extent that significant water flow may occur at the surface.

These aquifers, because of large pressure differentials, are highly susceptible to cross-aquifer contamination such as salt water invading a lower pressure, good-quality water aquifer. These aquifers can be subjected to major loss of water by free flow to the surface. They can also be significantly affected by environmental impact at surface.

Drilling in these aquifer systems requires detailed planning, special drilling techniques and abandonment procedure that are subject to controls by the Water and Rivers Commission.

3.4 Special cases

Although the general statewide distribution of the three aquifers types are described above, unusual or abnormal pressure situations occur in almost any part of the State, particularly in hilly ground or in the situation of perched aquifers on elevated plainlands. The driller is expected to be observant of these unusual conditions and immediately engage drilling techniques and abandonment procedures appropriate for these situations.

Unusual aquifer conditions should be reported in the standard logging procedure.

4.0 PROCEDURE

This procedure applies to any tenement holder who intends to conduct exploration drilling in Western Australia (ground disturbing operations).

4.1 Application for Ground Disturbance Permit

The tenement holder prepares the Ground Disturbing Approval Application- Exploration (Mining Act 1978)

4.2 Assessment of existing environmental protection measures

The tenement holder must ensure that any drilling program (or any other ground disturbing activity) complies with environmental legislation and policies and any other specific tenement conditions.

4.2.1 Public drinking water source areas

- Is the target covered by a Public Drinking Water Source Protection Plan and what is the priority protection designation (P1, P2 or P3)?
- What are the specific requirements of the priority area designation?
- Can these requirements be met by the drilling proposal?

Information on drinking water source areas is available from the Water Quality Protection Branch of the Waters and Rivers Commission.

4.2.2 Groundwater protection policies

- Is the target covered by Groundwater Protection Policy or within an Environmental Management Area?
- What are the requirements of the legislation or Government policies?
- Can these be met by the drilling proposal?

4.2.3 Groundwater Management Plan

- Is the target located in an area that has been assessed by a Groundwater Management Plan?
- Are there specific requirements for groundwater protection in this document?
- If yes, can these be met by the drilling proposal?

It is the responsibility of the applicant to ascertain whether specific conditions are applicable to drilling in these areas. The applicant should consult directly with the Waters and River Commission to determine any particular requirements.

4.2.4 Wetlands

- Are there any wetlands, sumplands, damplands etc in the proposal area?
- Are these wetlands RAMSAR or ANCA listed, registered with the National Estate registry, or have been identified as a conservation category wetland?
- What are the specific requirements of this wetland designation?
- Can these requirements be met by the drilling proposal?

Information is available from the Catchment and Waterways Branch of the Water and Rivers Commission.

4.2.5 Estuaries, rivers and streams

- Are there any waterways in the proposal area?
- Are any listed by RAMSAR or ANCA as priority protection areas for waterbirds?
- Do they contribute to public drinking water supplies?
- What are the specific requirements of any waterway designation?
- Can these requirements be met by the drilling proposal?
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Information is available from the Catchment and Waterways Branch of the Water and Rivers Commission.

4.2.6 Environmental water requirements of the system

- Analysis of the environmental water requirements of the system. This involves the relationship between groundwater, wetlands, waterways and the environment of the area. It involves determining how much and what quality of water is required by the system to maintain the environmental values of the system.

Information is available from the Catchment and Waterways Branch and the Allocation Branch of the Water and Rivers Commission.

4.3 Identification of potential hydrogeological conditions

An initial assessment of the potential for aquifer degradation can be made by referring to hydrogeological maps or by contacting groundwater consultants. Existing hydrogeological maps can help identify the most likely aquifer type in your area of investigation.

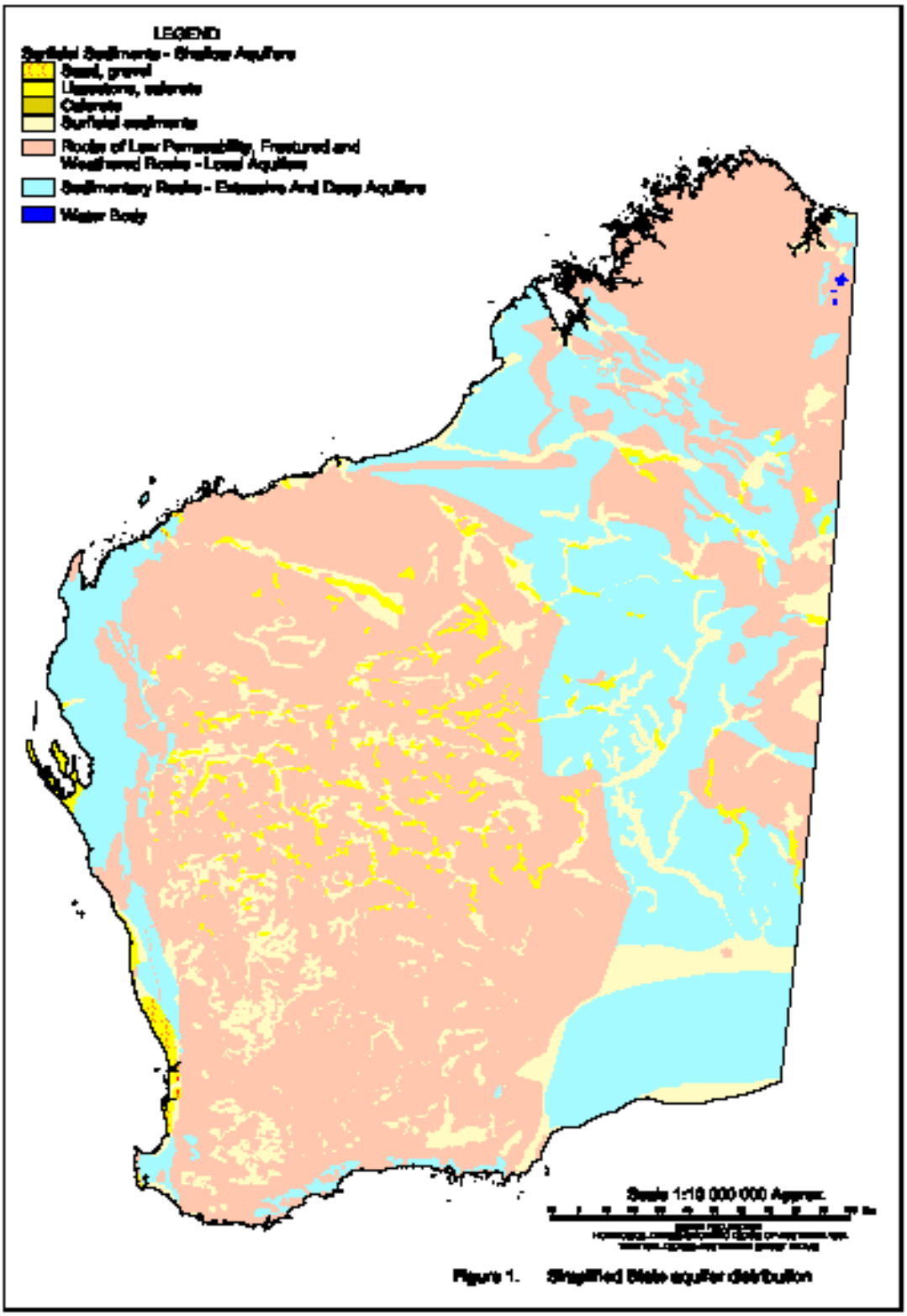

Figure 1. Simplified State aquifer distribution

- 1:2.5 million scale hydrological map of Western Australia published by the Geological Survey of Western Australia:
- 1:250 000 scale hydrogeological maps published by the Geological Survey of Western Australia or Water and Rivers Commission;
- Groundwater consultants.

These maps will help identify the most likely aquifer type, but the potential for aquifer degradation will still need to be decided at the drill site.

4.4 Identification of aquifer types and potential for aquifer degradation

The aquifer type and therefore potential for aquifer degradation can be reasonably assessed at the drill site by combining knowledge of the geological conditions of the site with the following hydrogeological information:

- Depth to the top of each aquifer as evident from increases and reductions in air-lifted natural water flows, drill core or by very damp rock chip samples;
- Depth to which the water level rises in the drillhole. The aquifer top and water levels are at the same depth in unconfined aquifers; the water level is between the aquifer top and ground surface in multi-layered and confined aquifers; and the water level may rise above the surface in artesian aquifers[1];
- Multi-layered aquifers will also require the depth to base of each aquifer[2].

In addition, the following information will allow assessment of the importance of the aquifer as an economic source of useable water.

- An estimate of the maximum water flow, either during drilling or at hole completion;
- Collection of a sample at hole completion to determine aquifer water quality.

Once an aquifer type is determined, a drillhole abandonment procedure is chosen to minimise potential for aquifer degradation.

4.5 Drillhole abandonment procedures

The procedure to abandon an exploration drillhole is based on the type of aquifer.

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[1] Single confined aquifers are not considered vulnerable to degradation other than by inflow of contaminated surface water. They should therefore be abandoned in the same manner as unconfined aquifers. Multiple confined aquifers however can be degraded if the drillhole is not completed properly.
There are also other major aquifer types called semi-unconfined and semi-confined. The latter can also exist as single or multiple types. For the purpose of these guidelines, the single-layered type of these aquifers should be treated the same as the single unconfined and confined aquifer as they cannot be readily differentiated from drilling information and have similar vulnerability to degradation. For the same reason, multi-layered semi-confined aquifers should be treated the same as multi-layered confined aquifers. Unconfined and semi unconfined aquifers can only exist as single aquifers as they are by definition linked to the surface.

[2] Multi-layered aquifers are only vulnerable to degradation if water moves from one aquifer to another under the influence of differential pressure. Several aquifer zones intersected in the one drillhole will not necessarily be part of a multi-layered aquifer system if they are locally split from the one aquifer. These aquifers would be hydraulically connected elsewhere and not contain differential pressures at the drillhole.

4.5.1 Unconfined or single confined aquifers or no identifiable aquifer

This procedure should prevent entry of any surface water that could contaminate the aquifers. It should also remove any physical hazard caused by abandoned open or unstable drillholes to people, stock and native animals as well as to foundations of structures placed over the drill sites.

- Remove PVC surface casing;
- Install a pre-cast or in-situ cement plug to a minimum depth of 0.3m below ground level with plastic pipe breather to extend above ground level. Alternately install a plastic plug ("Octo-plug" or equivalent) to a depth of 0.3m below ground level. Alternately completely backfill drillhole with cuttings to the surface allowing for settlement;
- Tag the drillhole for future identification;
- Place topsoil over the drillhole to encourage growth of natural vegetation. Complete to a height of 0.2m above surface to compensate for settlement.

A schematic representation of the sealing requirements for single unconfined aquifer systems is given in Figure 2 (reproduced from ARMCANZ, 1997).

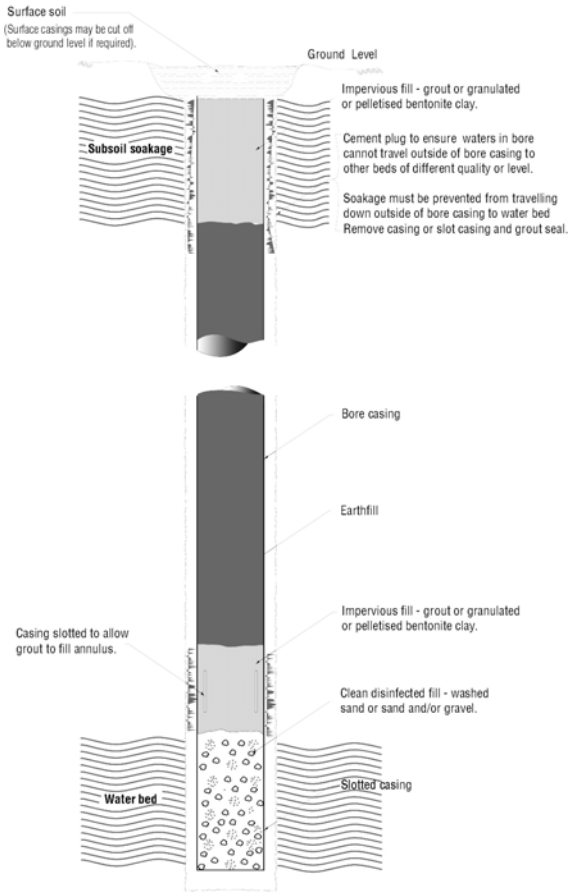

Figure 2: Sealing requirements for single unconfined aquifer systems

4.5.2 Multi-layered aquifer systems

This procedure should prevent mixing of waters from one aquifer to another as well as entry of any surface water that could contaminate the aquifers. It should also remove any

physical hazard caused by abandoned open or unstable drillholes to people, stock and native animals as well as to foundations of structures placed over the drill sites.

- Sealing material is placed across each aquifer-confining unit[3] so that each aquifer layer is separated from the aquifer above and below it. The sealing material can be concrete, cement grout, clay grout, sealing clay or neat cement provided that the material prevents the movement of water from one aquifer to another. The material should be placed from the bottom upward by methods that avoid segregation or dilution of material and unnecessary contamination of the aquifer. It is recommended that the material be placed in the drillhole by a tremie line or similar. The base of the tremie line should be run to the same depth that the base of the seal is required. The base of the seal should extend a minimum of 2m below the confining unit. The seal should extend not less than 5m above the top of the confining layer and should be a minimum of 20m in length.

- It will be necessary to ensure that sealing material does not migrate down the drillhole during or after installation. This may require the installation of bridge plugs or packers at the base of each seal.

- The top of the drillhole should be completed in the same manner as unconfined or single confined aquifers or the case where there is no identifiable aquifer.

A schematic representation of sealing requirements for multi-layered aquifer systems is given in Figure 3 (reproduced from ARMCANZ, 1997).

[3] The confining unit is the geological rock unit or formation that occurs at the top of a confined aquifer and keeps the water in the aquifer under pressure.

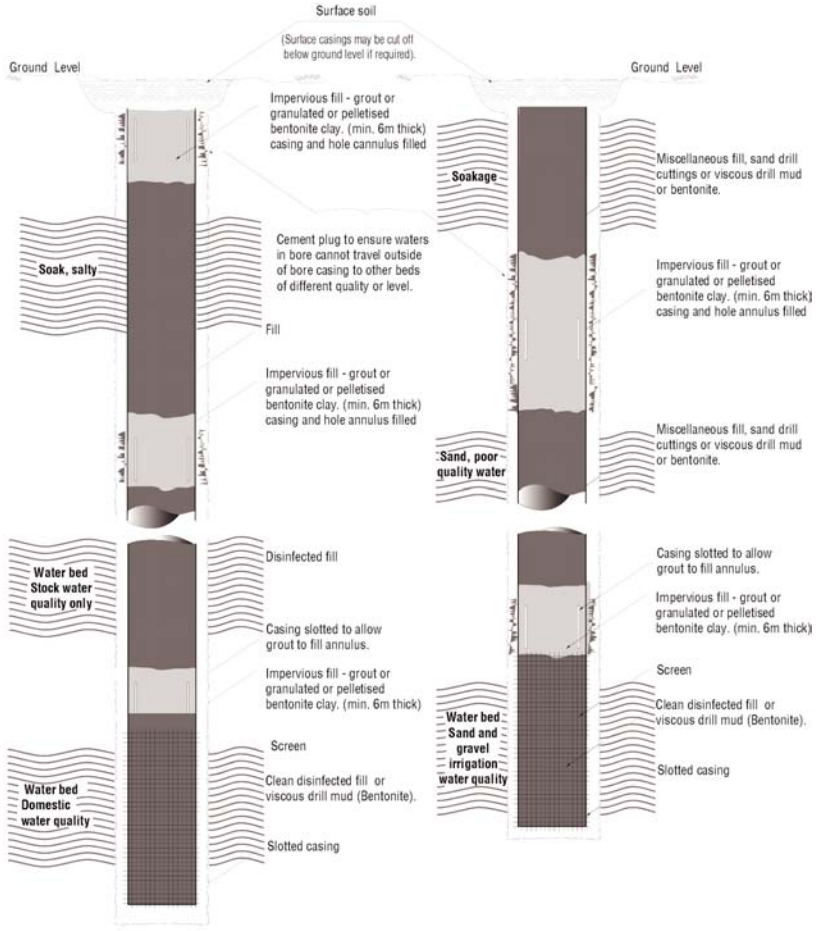

Figure 3: Sealing requirements for multi-layered aquifer systems

4.5.3 Confined (artesian) aquifers

This procedure should prevent groundwater discharging to surface in an uncontrolled manner causing waste of the water resource and potential contamination of the surface environment. It should also remove any physical hazard caused by abandoned open or unstable drillholes to people, stock and native animals as well as to foundations of structures placed over the drill sites.

- Drillholes that are to be drilled into areas where artesian aquifers are known to exist must be precollared with surface casing set to an adequate depth and cemented in place to enable the control of water pressure blow outs.

- Sealing material is installed across the aquifer-confining unit so that water pressure is maintained in the artesian aquifer and no water movement up the drillhole occurs. The sealing material should be concrete, cement grout, clay grout, sealing clay or neat cement provided that the material prevents the movement of pressurised water. The material should be placed from the bottom upward by methods that avoid segregation or dilution of material and unnecessary contamination of the aquifer. It is recommended that the seal be placed in the drillhole by a tremie line or similar. The base of the tremie line should be run to the same depth that the base of the seal is

required. The base of the seal should extend a minimum of 2m below the confining unit. The plug should extend not less than 5m above the top of the confining layer and should be a minimum of 20m in length.

- It will be necessary to ensure that sealing material does not migrate down or move up the drillhole under pressure during or after installation. The sealing material should therefore be of adequate specific gravity to overcome aquifer pressure and may require the installation of bridge plugs or packers at the base of the seal as a further precaution.

- The top of the drillhole should be completed in the same manner as unconfined or single confined aquifers or the case where there is no identifiable aquifer.

A schematic representation of the sealing requirements for artesian aquifers is given in Figure 4 (reproduced from ARMCANZ, 1997).

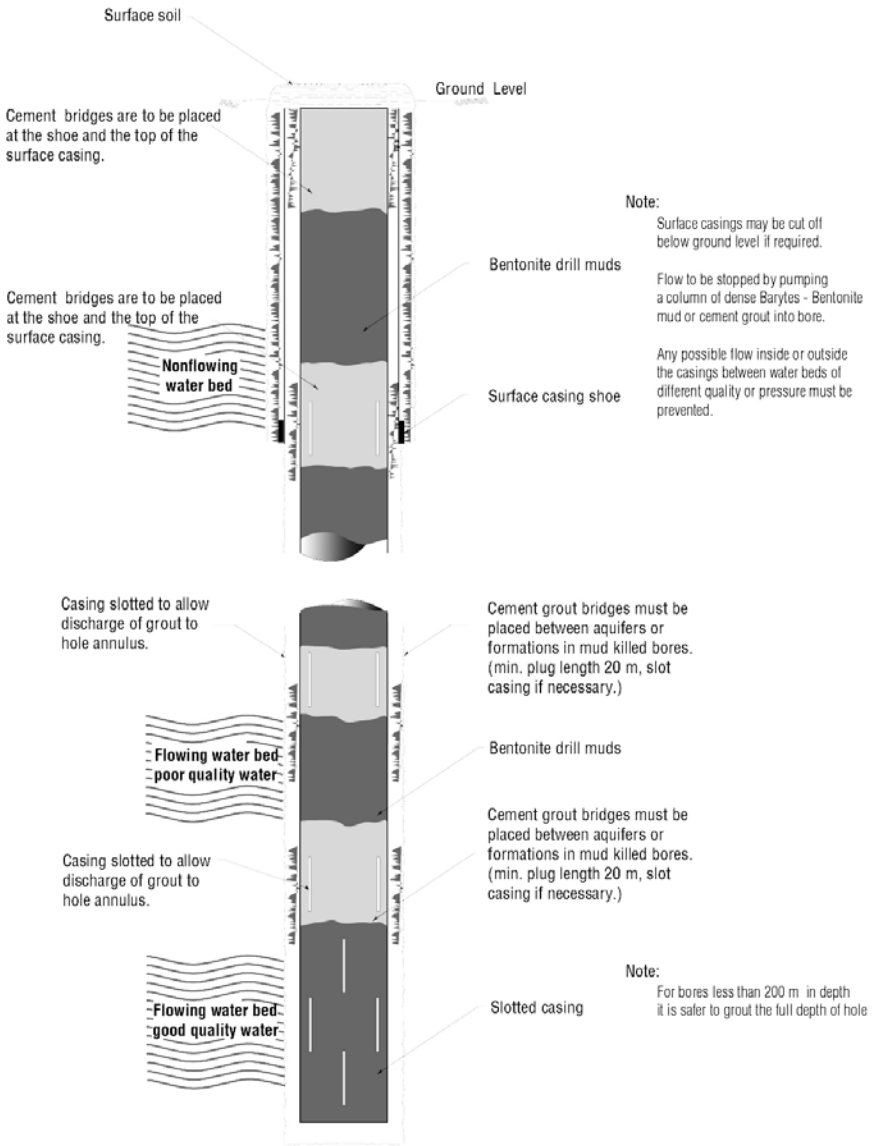

Figure 4: Sealing requirements for artesian aquifers

4.5.4 Circumstances where decommissioning procedures may be delayed or waived

There are legitimate circumstances where a hole may be left for a limited period in a safe condition but not permanently sealed. These circumstances include:

- Where a hole is to be downhole-logged;
- Where a hole is to be enlarged in diameter or depth;
- Where further sampling and testing is to be carried out;
- Where no potential water source exists.

However, where there is a potentially useable aquifer present, precautions must be taken to avoid possible contamination. These precautions would include prevention of runoff into the hole and placement of temporary plugs or seals between aquifers of different water quality or pressure head.

Because of the risk to stock and people from an open hole or hole where fill has settled, final decommissioning of the hole should include a permanent plug near the surface with backfill to proud of the surface.

4.6 Reporting of hydrogeological data

Hydrogeological information collected during drilling programs is an important data source for the assessment and delineation of State water resources.

Hydrogeological data should be included in the statutory mineral-exploration reports required under Section 115A of the Mining Act.

Most of the data would be collected by the drilling contractor in his logbook. It is the responsibility of the tenement holder that these data are included in the mineral exploration report.

The Guidelines for Mineral Exploration Reports on Mining Tenements list the reporting requirements for drilling programs under Note 55. The following list gives more details to explain requirements under Note 55 (f).

Drill logs should contain:

(a) Aquifer type;
(b) Depth to first water zone;
(c) Depths to additional water zones;
(d) Lithology or characteristics of the aquifer (fracture zone, rock jointing, oxidised zone, contact, etc.);
(e) Salinity of water;
(f) Water analysis if carried out;
(g) Yields;
(h) Standing water levels after several hours of completion;
(i) Hole completion details (ie. cement plug, bore cap, foamit plug, etc.).

5.0 REFERENCES

AGRICULTURE AND RESOURCE MANAGEMENT COUNCIL OF AUSTRALIA AND NEW ZEALAND (ARMCANZ), 1997, Minimum construction requirements for water bores in Australia.

DEPARTMENT OF MINERALS AND ENERGY WESTERN AUSTRALIA, 1995, Guidelines for mineral exploration reports on mining tenements.