# GROUNDWATER SAMPLING AND ANALYSIS

## INTRODUCTION

This Technical Note provides an overview of how groundwater can be sampled from bores and includes information on the minimum sampling for common characteristics of groundwater quality.

This Technical Note may be used as a starting point to understand the basic operations a consultant should perform in the field to determine the quality and quantity of groundwater on a site.

## BACKGROUND AND WATER LICENCE

Groundwater is investigated for three main reasons; as a source of water for use (drinking, stock water, industrial use), to determine the effect proposed construction will have on groundwater (potential effects on other users and environment), and to determine the potential impact upon proposed construction.

Groundwater is normally investigated by constructing boreholes (bores) and investigating the groundwater that is encountered. All bores are subject to requirements of the Department of Sustainability and Environment (DSE) and the relevant Water Authority. Bores for monitoring groundwater or constructed with the purpose of drawing water for some use, require a water licence from the appropriate Water Authority (refer to the DSE website). Only licensed water well drillers can be used for this type of work. Refer to the Australian Drilling Industry Association (ADIA) website for a list of licensed drillers.

Most bores for VicRoads purposes are for geotechnical purposes to investigate the impact of groundwater on proposed construction. Bores of this nature do not normally require a water licence, although this is currently under review by DSE. The relevant Water Authority should be contacted to clarify individual cases. This Note concentrates on bores for geotechnical purposes.

Bores may be referred to as ‘wells’ or ‘piezometers’. Piezometers can also be referred to as ‘standpipe piezometers’ when a plastic or metal tube (piezometer casing) is placed down the bore to allow measurement and extraction of the water. Unfortunately, ‘piezometer’ is also used to refer to electronic monitoring equipment that is placed inside the bore to measure groundwater characteristics. This Note refers to the hole in the ground as the ‘bore’, and the insert as the ‘piezometer casing’.

## BORE DESIGN

The design of bores to investigate groundwater is based on relevant information gathered from many sources; existing groundwater information, geological information, trial trenches, and investigatory bores. A basic number of bores and expected depth of bore can be determined, but it is important to remember that the number, location and depth of the bores may have to be altered to suit the soil/rock conditions that are encountered. The scope of bores may also be altered to suit the number and depth of aquifers (layers of soil or rock which are capable of either storing or allowing the movement of water) which are encountered.

Bores of greater than 200mm diameter are common for water extraction, while bores for groundwater investigation (only) should typically be 100mm diameter. The depth of bores can vary markedly from 5m to greater than 100m depending on the ground conditions.

Design of bores for water extraction must be submitted to the relevant Water Authority as part of the licence application. The general requirements are outlined in reference 1. Bore designs for geotechnical purposes do not currently require review by the relevant Water Authority.

## COMMISSIONING TESTS

All borehole drilling operations cause some smearing of material on the sides and base of the bore. The smeared material is pushed against the sides of the bore during construction, and fine material tends to block the pores of the bore wall. Material affecting the sides and base of the bore can reduce groundwater inflow, and can alter the chemical characteristics of the groundwater. In the case of water assisted bore construction, the water used (which includes additives) for the works does not represent the existing groundwater, and should be removed to ensure representative sampling.

Most groundwater monitoring bores are designed to have a piezometer casing (nominally 50mm diameter) placed into the borehole. The piezometer casing has openings to allow water ingress at discrete depths, and may include areas where no openings are provided to prevent water ingress at

other depths. It is crucial the groundwater is able to move directly from the existing soil/rock and into the piezometer casing so that measurements and water quality results are representative.

The space between the piezometer casing and the bore wall is normally backfilled using coarse sand or grit (<5mm aggregate) to provide free drainage between the bore and the piezometer casing. The backfill material may be simply placed into the annular space from ground level for shallow bores. Backfill material should be delivered by tremie (where the material is poured into a pipe and delivered to the base of the bore) for deeper bores.

It is considered good practice to commission the bore by removing any smeared material, and this is recommended for VicRoads works. Commissioning can be achieved by injecting air, or flooding the bore with water to ensure the bore is reasonably clean. Where water is used, the bore must be purged using three times the volume of water that the bore can accept to ensure all disturbed material is removed. Commissioning groundwater extraction bores requires a different process not covered by this Note.

Where the bore is used for periodic groundwater sampling, the bore should be purged before each set of samples is extracted.

## SAMPLING GROUNDWATER

Groundwater bores are normally tested for the flowrate of groundwater at different depths. The determination of flow rates is considered a specialised skill and involves interpreting the bore output with the existing ground conditions. Only an experienced groundwater specialist should be employed for this task.

The quality of the groundwater can be affected by the geology of the area and the direction of flow, and this can influence the use or disposal of the groundwater in construction. The frequency of sampling depends on a variety of factors, with many sites using a monthly sampling regime. The method of sampling can affect the quality of the results and should be undertaken in a systematic manner.

Groundwater sampling should be undertaken in accordance with Environmental Protection Agency (EPA) Groundwater Sampling Guidelines (reference 7), and Australian Standards. Samples should always be placed in clean containers immediately after extraction. Suitable containers are detailed in the EPA Guide and may include glass and different types of plastic to ensure the chemical characteristic being investigated is not affected (degraded or enhanced) by the container. In some cases, it is necessary to place chemical preservatives into the containers to avoid degradation of the sample (especially for bicarbonate and ferrous irons).

The use of NATA accredited laboratories will normally ensure the laboratory provides suitable containers, with preservatives as required, for the testing regime. Microbiological testing requires special sampling methods and protocols to prevent cross-contamination. Only experienced personnel should perform microbiological sampling.

## TESTING REGIME

It is recommended that a hydrogeologist be consulted to provide advice on the testing regime for groundwater, as it can be of highly variable chemistry. Some tests should be performed in the field due to time constraints and degradation of the samples – such as testing for pH, temperature, electrical conductivity, and dissolved oxygen. Some of the onsite testing may be repeated in the laboratory to check sample stability. Most of the sample analysis is completed in a laboratory due to equipment requirements.

General groundwater chemistry is assessed using the concentration of a number of principal ions, which can provide an indication of the chemical environment through which the groundwater has travelled. Table 1 shows twenty-six common chemical components that should form part of any testing regime.

**Table 1. Basic Testing Regime**

| Property | Cation (positive charge) | Anion (negative charge) |
|---|---|---|
| pH* | Sodium (Na) | Chloride (Cl) |
| Conductivity* | Potassium (K) | Fluoride (F) |
| Temperature* | Calcium (Ca) | Bicarbonate (HCO3) |
| Redox Potential* | Magnesium (Mg) | Carbonate (CO3) |
| Dissolved Oxygen* | Aluminium (Al) | Nitrate (NO3) |
| Alkalinity | Total Iron (Fe) | Nitrite (NO2) |
| Hardness | Ferric & Ferrous Iron (Fe3+ & Fe2+) | Sulphate (SO4) |
| | Magnesium (Mn) | Silica (SiO2) |
| | Ammoniacal Nitrogen (NH4-N) | Phosphate (PO4) |
| | | Boron (B) |

Items marked with '*' are those which should also be measured at the bore. These test should be completed either insitu, or immediately after extraction, to assess degradation.

Analysis to determine the relative concentrations of different ions of the same element is often appropriate. The results can be used to check the field readings and check the

changes in the groundwater chemistry after removal from the bore. In areas where mineral mining has occurred (or landfills exist), it may be necessary to test for additional chemicals.

The need for microbiological testing should be carefully considered, as the testing can be expensive and specific. A specialist can advise on the appropriate microbiological testing.

The State Environmental Protection Policy (reference 4) provides a preliminary classification of groundwater in terms of potential use. The potential use depends on the Total Dissolved Salts (TDS) as shown in Table 2.

**Table 2. Australian Groundwater Classification (TDS and beneficial use)**

| Segment | Quality (mg/l TDS) | Highest Acceptable Level of Use |
|---|---|---|
| A1 | 0 – 500 | Potable water (desirable) |
| A2 | 501 – 1000 | Potable water (acceptable) |
| B | 1001 – 3500 | Potable mineral water & irrigation |
| C | 3501 – 5000 | Stock Water |
| D | >5000 | Industrial Use |

The 'Industrial Use' category in Table 2 refers to low grade water that can be used for washing equipment and plant. Although groundwater may be Segment D (industrial use), it does not automatically mean that this water is suitable for road and civil construction sites. In some cases, Segment D water is not suitable for road construction due to incompatibility with bituminous surfacings, or other aspects of works. Details of the requirements for water are provided in VicRoads Codes of Practice and VicRoads Standard Sections for Roadworks and Bridgeworks.

The bore may also be investigated for the flowrate of the groundwater. This testing is completed onsite and most of this information is generally available after the first sampling.

## DECOMMISSIONING BORES

When bores for groundwater monitoring are no longer required, the following steps may be taken to decommission the bore:

- Inform DSE – this department may provide specific requirements for the bore,
- The piezometer casing may be removed,
- The bore may be filled with cement/bentonite to provide a waterproof plug for the length of the bore,
- The plug ensures no water movement within the bore, or movement from one aquifer to another aquifer,
- The bore may be permanently capped.

## PREPARING CONTRACT DOCUMENTS FOR GROUNDWATER SAMPLING AND ANALYSIS

Groundwater sampling and analysis is considered a specialised field and contracts for this type of work should be reviewed by an independent specialist. The specialist can provide a scope of drilling works, and sampling and analysis regime. The specialist and contract administrator can also determine the level of risk for extending both the extent of drilling works, and the frequency and extent of water sampling and analysis.

Where works are conducted by contract, it is recommended an independent groundwater specialist be engaged to review the onsite progress and laboratory results.

## REFERENCES


1. *Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Minimum Construction Requirements for Water Bores in Australia (Edit.2), 2003*
2. *Australian Standards 2368 –1990: Test Pumping of Water Wells. Australian Standards Institute.*
3. *Driscoll, F.G. (1986). Groundwater and Wells (2nd edit.). Johnson Screens Ltd., Minnesota.*
4. *Environment Protection Act 1970, State Environmental Protection Policy 1997 - Groundwaters of Victoria (SEPP).*
5. *Environment Protection Act 1970, Variation to State Environment Protection Policy (Waters of Victoria) 2003.*
6. *EPA Victoria, Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes. Publication 441, 2000.*
7. *EPA Victoria, Groundwater Sampling Guidelines. Publication 669, 2000.*
8. *Hem, J.D. (1985). Study and Interpretation of the Chemical Characteristics of Natural Water (3rd edit.). USGS Water Supply Paper 2254.*


## WEBSITES


1. *ADIA website; www.adia.com.au*
2. *DSE website (for Water Authorities); www.vicwaterdata.net/vicwaterdata*


## CONTACT OFFICERS

For further information on groundwater sampling and analysis please contact the following officers:


*Adam Farr* *Phone: (03) 9881 8952*
*E-mail* *adam.farr@roads vic.gov.au*
*Bill Waite* *Phone: (03) 9881 8755*
*E-mail* *bill.waite@roads.vic.gov.au*

*Technical Consulting-Burwood East*
*Fascimile* *(03) 98818900*