HUNTER CATCHMENT GROUNDWATER VULNERABILITY MAP

The Department of Land and Water Conservation (DLWC) considers that groundwater resources should be considered as valuable resources and hence should not be degraded purposefully by development.

Groundwater vulnerability maps are tools that allow planners, developers, regulatory agencies and the community to make better informed judgements on what the potential for contamination to groundwater is in a given area, from surface activities. These maps will assist the developer and planner alike in determining the appropriate level of investigation required to ensure that the threat of contamination of the groundwater resource is minimised. As groundwaters are directly linked to surface water bodies, they too are also indirectly protected by the correct positioning of potentially polluting industries on appropriate soil and geology.

Whenever groundwater is present there is the potential for it to be adversely affected by human activity as no soil or rock is completely impermeable, no pollutant completely immobile.

The concept of a groundwater vulnerability map recognises that risks of pollution from a given activity are greater in certain hydrogeologic, geologic and soil situations than in others. Vulnerability maps show the relative vulnerability of certain areas with respect to other areas, and do not represent absolute values.

The preparation of a groundwater vulnerability map necessarily involves the simplification of complex geologic and hydrogeologic situations. It is therefore important to take into account local site conditions when assessing a particular development. Vulnerability maps are designed only as a guide and are not intended to replace an environmental impact assessment.

The Hunter Valley Catchment Groundwater Vulnerability Map was developed using the Modified Weights of Evidence approach developed by CSIRO Land and Water, Perth. The map was developed using the combination of component classes refer to those particular features or attributes of the groundwater environment which are considered to be important when assessing the groundwater vulnerability of an area. Component classes include geology, depth to watertable and soil permeability.

The Weights Of Evidence (WOE) technique is a statistical approach to determine the likelihood of vulnerability based on the relationship between *component classes* (also known as *predictor variables)* and the *response variable.* The WOE technique determines the probability of a particular combination of component classes being vulnerable, relative to other combinations of component classes, within the study area.

The groundwater vulnerability rating is determined by assigning a probability of vulnerability, based on a statistical analysis of the relationship between the component classes and the response variable. The analysis is carried out by comparing the number of data points identified as being vulnerable, with the combination of component classes which makes up that particular geographical or hydrogeological environment. This is carried out for all combinations of component classes found within the study area, resulting in a probability of vulnerability for all possible combinations.

Depth to Watertable

The depth to watertable component map for the Hunter Valley Catchment was produced by plotting actual depth to watertable taken from the department's Groundwater Data System (GDS). The compilation of the final map was constructed by contouring data points with respect to topography. The final map provides an indication of the depth to watertable for the Hunter Valley Catchment and should be used as a guide to the likely depth to groundwater in the area. The water table for the area was then broken into the following classes; 0-5 m, 5-10 m, 10-15 m, and >15 m for input into the vulnerability assessment.

Surface Geology

The geology component map was used to dicretise the area into areas of similar geologic and hydrogeologic provenances. This component map was re-classified after the 1:250 000 geology sheets that cover the Hunter Valley Catchment. The eventual geology component map was classified into the following geologic groups;

- Carboniferous/Devonian sediments
- Early Permian sediments
- Late Permian sediments
- Triassic sandstone
- Tertiary basalts
- Quaternary alluvium

Soil Permeability Component Map

The soil permeability component map for the Hunter Valley Catchment was developed with the assistance of Regional Soil Scientists as well existing published soil maps for the Tamworth 1:250 000 sheet. The soil landforms were distilled and classified into 3 permeability classes, namely low, medium and high permeability for input into the vulnerability assessment. This method has proven effective in obtaining and incorporating local regional knowledge.

Aquifer Vulnerability Classification in the Hunter Valley

Five classes of vulnerability ranking have been chosen to describe the relative assessment of the probability of a groundwater resource to contamination; "low", "moderate", "moderately high", "high" and "very high". These classes are shown as distinct colours on the vulnerability map.

High vulnerability ranked groundwater resources are usually unconfined, shallow, highly permeable aquifers such as the Tomago sandbeds of Newcastle Bight, parts of the Hunter River and tributaries, and the low lying alluvium downstream of Maitland. Aquifers within this class require a high level of protection.

Moderately high vulnerability aquifers for the Hunter would include unconfined shallow alluvium aquifers associated with much of the Hunter River and its tributaries. The soils are often moderately to highly permeable with depth to water less than 10 metres.

Moderate vulnerable groundwater refers to a large classification within the Hunter Region. The areas dominated by this classification includes the area surrounding the Merriwa plateau, the

sandstone country in the southwest with its sandy and permeable soils, as well as some of the river flats along the Paterson and Allyn Rivers.

Low moderate vulnerability for groundwater is the dominant classification for much of the hilly county associated with the Paterson, Allyn and Barrington areas east of the Hunter River. These areas generally have moderate soil permeability with depth to water often greater than 10 metres providing the conditions suitable for some attenuation of the contaminant prior to it reaching the aquifer.

Low vulnerability is restricted to areas where the aquifer is greater than 15 metres from the surface and where the soil permeability is considered to be low with the presence of clays providing attenuation potential for the contaminant. For the Hunter "low" vulnerability is broadly confined to the hills found in the central part of the valley outside of the Hunter floodplain. An additional area in the west of the region is the result of low permeable soils.

Level of Assessment Required

The preparation of a groundwater vulnerability map necessarily involves simplification of complex geological and hydrogeological situations. It is therefore important to take into account local site conditions when assessing a particular development. Vulnerability maps are designed only as a guide and are not intended to replace an environmental impact assessment.

Groundwater vulnerability maps do not directly consider the chemical nature of the pollutant in assessing vulnerability, they are concerned only with the hydrogeological setting which makes the groundwater susceptible to contamination from a surface source.

The Hunter groundwater vulnerability map was developed using was produced via a statistical method to overcome much of the subjectivity often associated with groundwater vulnerability mapping. The map was developed from the combination of groundwater salinity data and three maps; (depth to water, soil permeability, and geology.

When a development application is being prepared or considered it is important that the impact of the development on both surface and groundwater resources are assessed. It is important to know who uses these resources (beneficial use) and what the current quality of the water is. Certain developments should not be allowed within highly vulnerable areas. Where such activities are proposed significant engineering measures would be necessary to minimise the risks of pollution.

The following Table, modified after AWRC, Draft Guidelines for Groundwater Protection, 1992, is a guide to the amount of groundwater assessment required for a development that requires consent in either of the five aquifer vulnerability classes.

Vulnerability Classification	Groundwater Assessment Requirements
Low	**Groundwater Contamination Assessment Report** A desk study is required to identify the concerns and potential risk to groundwater or the environment and the need for any further action to be presented in the development application. A standard format hydrogeologic report would most likely result.
Moderately Low	**Site Investigation with Monitoring** A potential risk is indicated by the vulnerability map requiring site investigation and groundwater monitoring. The extent of work should involve a limited amount of site investigation, soil and water sampling and testing, definition of flow systems and reporting, in addition to a desk study.
Moderate	**Detailed Site Investigation and Monitoring** For moderate vulnerability areas, or where the previous levels of investigation indicate a demonstrated risk to groundwater, a detailed groundwater site investigation is required. The work should include an ongoing monitoring program, details on the protection design factors, (natural attenuation, physical barriers, etc) in addition to the previous levels of investigation.
Moderately High	**Demonstrated Groundwater Protection System** The risk to groundwater, as demonstrated by the vulnerability map, is an area in which contamination to groundwater cannot be tolerated. The work should include a desk study, detailed site investigation, and implementation of an on-going monitoring program, as indicated above. In addition, the protection design system incorporating natural attenuation, hydraulic barriers, physical barriers etc, needs to be demonstrated, to be effective. The proposal will need to include a feasibility plan for a clean-up, in addition to a detailed monitoring and ongoing assessment program.
High	**Demonstrated Remedial Action Plan/Prohibition** This classification identifies the area as having a potential risk so great as to warrant a demonstrated remedial action plan. The work should include a desk study, site investigations, ongoing monitoring, plus a demonstrated remedial action plan for clean-up, which analyses the effectiveness of the remediation approach in achieving designated water quality criteria. The financial capacity of the responsible party to enact the plan should also be evaluated. In the event that the risk to groundwater is unacceptable, an activity may be banned by the responsible authority.

REFERENCES

Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council, (1995), *Guidelines for Groundwater Protection in Australia*.

Bates, L.E., Barber, C. and Otto, C.J.(1996), *Aquifer Vulnerability Mapping using GIS and Bayesian Weights of Evidence.* International Conference on Application of GIS in Hydrology and Water Resources Management. Poster Paper Volume. Vienna, Austria April 1996, 7-14.

National Research Council, (1993), *Ground Water Vulnerability Assessment - Contamination Potential Under Conditions of Uncertainty*. National Academy Press Washington, D.C.

Water Resources Commission, New South Wales, (1984), *Groundwater in New South Wales.*

NSW Department of Mines, Sydney, *Dubbo 1: 250 000 Geology Sheet, Geological Series Sheet SH 55-7, First Edition 1968,* NSW Department of Mines.

NSW Department of Mines, Sydney, *Singleton 1: 250 000 Geology Sheet, Geological Series Sheet SH 55-1, First Edition 1969,* NSW Department of Mines.

NSW Department of Mines, Sydney, *Newcastle 1: 250 000 Geology Sheet, Geological Series Sheet SH 56-2, First Edition 1966,* NSW Department of Mines.

NSW Department of Mines, Sydney, *Tamworth 1: 250 000 Geology Sheet, Geological Series Sheet SH 56-13, First Edition 1971,* NSW Department of Mines.