DUBBO LGA GROUNDWATER VULNERABILITY MAP

Introduction

The fundamental concept of a groundwater vulnerability map recognises that risks of pollution from a given activity are greater in certain hydrogeological, geological and soil situations than in others. The ultimate goal of the vulnerability map is a subdivision of an area into several units showing the differential potential for a specified purpose and use. The differentiation between these units is arbitrary because vulnerability maps only show 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 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.

The Dubbo groundwater vulnerability map was developed using a special modelling technique termed "Weights Of Evidence" 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). Five classes of vulnerability have been chosen to describe the relative assessment of the probability of a groundwater resource to contamination; *"low", "low-moderate", "moderate" "moderately high" and "high"*. These classes are shown as distinct colours on the vulnerability map.

A two week reconnaissance field trip was undertaken to obtain a greater spatial extent of water quality and depth to watertable information. This data was then used to to augment the response variable and depth to watertable component maps.

Weights of Evidence Methodology

Response Variable

The response variable is used to determine if the groundwater at a particular data point is vulnerable or not vulnerable. A response variable must have both a good spatial distribution within the study area and be representative of the vulnerability of groundwater to surface activities.

Electrical Conductivity, EC, measures the electrical conductance of the groundwater and is readily available as a water quality parameter within the State.

It is generally held that the longer the time that groundwater is in contact with a particular geologic unit the greater the potential that the groundwater will have to take on the chemical characteristics of that particular geologic unit or medium. Groundwater chemistry is altered as geochemical processes cause ions to be taken into solution. Generally the more ions in solution the greater the EC value. The longer the residence time, the slower the groundwater movement or the greater the distance between recharge and discharge points. The slower the groundwater movement, or the longer the pathway, the greater the potential for dispersion, sorption, and biochemical transformations to reduce concentrations of the contaminants of interest.

Electrical conductivity is used as a surrogate to indicate the relative residence time between groundwaters within the study area. This is used in lieu of data which specifically indicates groundwater contamination, or determines the relative ages of groundwaters. The basic premise assumed is that the greater the EC value the longer the residence time. The longer the residence time, the greater the potential for processes to occur which reduce the concentrations of the contaminants and therefore the impact on the groundwater and hence the lower the susceptibility to groundwater vulnerability.

The *response variable* used for the Dubbo LGA groundwater vulnerability map was 1400 EC (µS/cm).

Component Maps

Component maps are a spatial representation of information of those physical parameters which help determine the susceptibility of groundwater to contamination. Factors which need consideration include the composition of the soils and geologic materials in the unsaturated zone, the depth to the water table, the recharge rate, and environmental factors influencing the potential for biodegradation.

The component represented in a component map is grouped into classes. For example, a depth to water table map was classified into three classes; ie 0-5 metres, 5-15 metres, and greater than 15 metres. The probability of any one of these particular classes being vulnerable is determined with respect to the response variable. This class and probability is then compared to classes within the same component map, as to classes within the other component maps. In this way a relative probability is determined for the study area of those classes and combinations of classes which are statistically more likely to be vulnerable.

The Dubbo LGA groundwater vulnerability map utilised, 1:100,000 geology, depth to water table, and soil permeability component maps to determine groundwater vulnerability.

Dubbo LGA Groundwater Vulnerability Classification

"Low" vulnerability ranked groundwater resources are predominantly associated with hydrogeologic characteristics associated with sandstones and some fractured volcanic rocks north of the Talbragar River. Depth to watertable is usually greater than 15 metres and overlying soils have a moderate permeability.

"Low-Moderate" vulnerability ranked groundwater resources are predominantly associated with sandstone aquifers of the Pilliga Sandstone with soils of moderate-high permeability and depth to water usually exceeding 15 metres.

"Moderate" vulnerability ranked groundwater resources are predominantly associated with sandstone aquifers of the Pilliga Sandstone coupled with a depth to watertable of 5-15 metres and highly permeable soils.

"Moderately High" vulnerability ranked groundwater resources are predominantly associated with highly transmissive aquifers of the Pilliga Sandstone with a depth to watertable of less than 5 metres as well as some alluvial aquifers east of the City centre coupled with highly permeable soils and a depth to watertable of greater than 15 metres.

"High" vulnerability ranked groundwater resources are predominantly associated with the alluvial aquifers of the Macquarie and Talbragar Rivers with highly permeable soils and a depth to watertable of less than 15 metres.

Use of the Dubbo Groundwater Vulnerability Map

Groundwater vulnerability maps do not directly consider the chemical nature of the pollutant or the existing groundwater quality when assessing vulnerability, they are concerned only with the hydrogeological setting which makes the groundwater susceptible to contamination from a surface source. All groundwaters regardless of their quality or beneficial use to the community are assessed for their vulnerability.

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. Where development is located close to a groundwater vulnerability boundary, then the level of investigation required will be that of the higher level of vulnerability, unless a detailed site assessment demonstrates otherwise.

This map indicates the groundwater vulnerability for the area covered by the Dubbo LEP. Although not within the maps bounds, the map indicates that the area directly downstream of Dubbo on the Macquarie River, in particular the alluvial floodplain downstream of Dubbo, is likely to be highly vulnerability thus requiring an equivalent level of protection.

The areas of highest vulnerability are those areas along the alluvial flats which by their nature are more transmissive and dynamic groundwater systems containing fresher and more valuable groundwater resources, such as Dubbo's town water supply. These areas should be afforded the highest level of protection, restricting development to non contaminating light industries. Potentially polluting industries such as sewerage treatment plants, piggeries and abattoirs should be directed to areas of the lowest vulnerability.

The scale limitations of the Dubbo Groundwater Vulnerability Map are set to the largest scale of the component maps used to produce it. The Department of Land and Water Conservation does not endorse the expansion of the scale of the Dubbo Groundwater Vulnerability Map beyond a scale of 1:100 000 as its reliability deteriorates rapidly thereafter.

Level of Assessment Required

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

When a development application is being prepared or considered, it is important that the impact of the development on both surface water as well as and groundwater is assessed. It is important to know who uses these resources (beneficial use) and what the current quality of the water is. Potentially polluting 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 to the groundwater system.

The following Table, modified after the Australian Water Resources Council (AWRC), Draft Guidelines for Groundwater Protection, 1992, is a guide to the amount of groundwater assessment required for a development that requires consent in 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 hydrogeological report would most likely result.
Low-moderate	**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

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