XXXVIII IAH Congress

Groundwater Quality Sustainability
Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **528**

topic: **1**
Groundwater quality sustainability

1.2
Groundwater vulnerability and quality standards

title: **Irelands national groundwater protection scheme**

author(s): **Monika Kabza**
TOBIN Consulting Engineers, Ireland, monika.kabza@tobin.ie

Monica Lee
Geological Survey of Ireland, Ireland, monica.lee@gsi.ie

Taly Hunter-Williams
Geological Survey of Ireland, Ireland, Taly.HunterWilliams@gsi.ie

Robert Meehan
Talamhireland, Ireland, talamh@ireland.com

Coran Kelly
TOBIN Consulting Engineers, Ireland, coran.kelly@tobin.ie

Melissa Spillane
TOBIN Consulting Engineers, Ireland, melissa.spillane@tobin.ie

Orla Murphy
TOBIN Consulting Engineers, Ireland, orla.murphy@tobin.ie

keywords: vulnerability, permeability

INTRODUCTION

The Groundwater Protection Schemes (GWPS) employed in Ireland (DELG/GSI/EPA, 1999) are based on the concept of groundwater contamination risk assessment and risk management and have been undertaken by the Geological Survey of Ireland (GSI) in partnership with Local Authorities as an effective means of protecting groundwater by informing planning and licensing processes.

The spatially related scheme allows a consistent protection policy approach across the Irish landmass, which is thorough, accurate and systematic, and employs the hazard-pathway-target model. The main components of the land surface zoning element of GWPS are Groundwater Vulnerability and Aquifer maps. This abstract focuses on the groundwater vulnerability.

The GSI has received National Development Plan funding which will allow the completion of a national subsoil permeability map and a depth to rock database. These data will allow groundwater vulnerability and groundwater protection zones coverage to be created, thus assisting in the completion of a National Groundwater Protection Scheme programme.

GROUNDWATER VULNERABILITY

Groundwater Vulnerability is defined as the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities (Daly, Warren, 1998). In general, little attenuation of contaminants occurs in the bedrock in Ireland because flow is almost wholly via fissures, therefore, the subsoils (sands, gravels, glacial tills (or boulder clays), peat, lake and alluvial silts and clays) are the single most important natural feature influencing groundwater vulnerability and groundwater contamination prevention. Groundwater is most at risk where the subsoils are absent or thin (areas where the subsoils are absent or thin equates to areas of bedrock outcrop (at surface) or subcrop (within c.1m of the surface)) and, in areas of karstified limestone where direct ('point') recharge occurs, e.g. where surface streams sink underground at swallow holes.

ATTRIBUTES THAT DETERMINE GROUNDWATER VULNERABILITY

The vulnerability of groundwater depends on 1) the time of travel of infiltrating water (and contaminants); 2) the relative quantity of contaminants that can reach the groundwater and; 3) the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate. These factors are a function of:

- the permeability/porosity of the subsoils overlying the groundwater,
- the thickness of the unsaturated zone through which the contaminant moves, and,
- the type of recharge (either point or diffuse).

In the majority of situations across the Irish landscape, recharge to the groundwater system takes place diffusely. The rates of infiltration and percolation will depend on how permeable the material is combined with how thick it is e.g. rates will be slow if there is thick clay, as opposed to thin gravels. The result is that the groundwater deep below the surface is protected intrinsically by the recharge mechanism itself as the soil and subsoil filter the recharging water, albeit at different rates and therefore to different degrees of purification.

Also considered is the 'type of recharge' i.e. diffuse verses point recharge. At locations of point recharge, there is rapid flow to the water table via a preferential flow pathway that bypasses the soil and subsoil filter. Mapped locations of point recharge comprise certain karst features such as swallow holes, cave entrances and collapse features.

THE GROUNDWATER VULNERABILITY MAP

The subsoil permeability and depth, and localities of point recharge are mapped and combined to provide a groundwater vulnerability assessment. Four groundwater vulnerability categories are defined: extreme (E), high (H), moderate (M) and low (L). A subset of the 'extreme' category is termed the 'X – extreme' category, and relates to areas of bedrock outcrop or subcrop, or within 30m of a location of point recharge. Vulnerability mapping guidelines are shown in Table 1 and an example of a vulnerability map is given in Figure 1.

Table 1. Vulnerability Mapping Criteria.

Depth to rock	Hydrogeological Requirements for Vulnerability Categories				
	Diffuse recharge			Point Recharge	Unsaturated Zone
	high permeability (*sand/gravel*)	Moderate permeability (*sandy subsoil*)	low permeability (*clayey subsoil, clay, peat*)	*(swallow holes, losing streams)*	*(sand & gravel aquifers only)*
0–3 m	**Extreme**	**Extreme**	**Extreme**	**Extreme (30 m radius)**	**Extreme**
3–5 m	**High**	**High**	**High**	**N/A**	**High**
5–10 m	**High**	**High**	**Moderate**	**N/A**	**High**
>10 m	**High**	**Moderate**	**Low**	**N/A**	**High**

i *N/A = not applicable.*
ii *Release point of contaminants is assumed to be 1–2 m below ground surface.*
iii *Permeability classifications relate to the engineering behaviour as described by BS5930.*
iv *Outcrop and shallow subsoil (i.e. generally <1.0 m) areas are shown as a sub-category of extreme vulnerability.*

(amended from Deakin and Daly (1999) and DELG/EPA/GSI (1999))

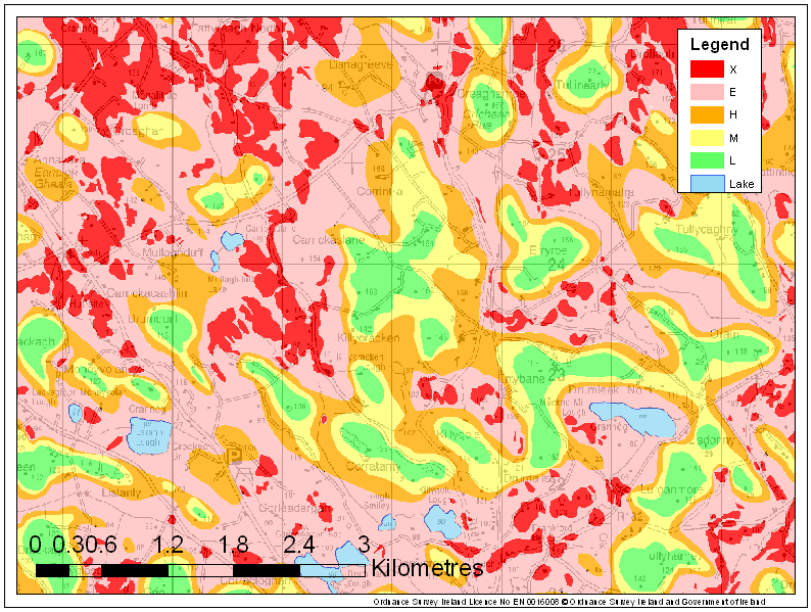

Figure 1. Sample Extract from Groundwater Vulnerability map.

THE SUBSOIL PERMEABILITY MAP

The subsoil permeability map is a critical component of the vulnerability map. Compiling information on permeability of subsoils involves assessing the infiltration capacity of these by direct and indirect means, which is based on the broad question 'can water and contaminants reach groundwater easily?', and results in classifications of 'high', 'moderate' or 'low' subsoil permeability.

High permeability subsoil materials are generally sands and gravels. Moderate permeability subsoils are silty to sandy glacial tills that are generally quite free draining. Low permeability subsoil materials are clayey tills, peats and lake clays.

The GSI and Trinity College Dublin have completed a body of research in recent years on permeability assessment, developing proxies for assessing permeabilities at specific locations and to identify secondary indicators that provide an indication of recharge acceptance and vulnerability as a whole, across a particular area (Swartz et al, 2003; Swartz, 1999; Lee, 1999).

The GSI Vulnerability Mapping Guidelines (Fitzsimons et al., 2003) outlines the approach taken in subsoil permeability mapping. This is a holistic method involving:

- field description/classification/analysis of texture using British Standards 5930;
- sampling and detailed grain size analysis at 'type' localities;
- examination of soil type, particularly presence or absence of mottling;
- presence of 'wet'/'dry' vegetation indicators in the areas examined;
- data on artificial and natural drainage density;
- parent bedrock characteristics and;
- topographic data.

Subsoil permeability mapping is not undertaken within areas where the depth to bedrock is interpreted as less than three metres. In these areas, subsoil matrix and permeability are considered to be unpredictable due to the influence of bedrock, the influence of in-situ weathered bedrock and preferential flow paths.

THE DEPTH TO BEDROCK MAP

For vulnerability mapping, total subsoil thickness is assessed using contours at 3 m, 5 m and 10 m. The contours provide general approximation of broad trends across an area at a regional scale. The contouring process is not an automated process; the contours are drawn based on a combination of data, expertise and experience, and the data include:

- Outcrop and shallow rock locations from the GSI databases and the Teagasc Subsoil Mapping Project.
- Depth to bedrock from borehole databases (includes well data from GSI Groundwater Section; borehole data from GSI Minerals and Geotechnical Sections; borehole records from road schemes, site investigations, academic studies, well surveys and other site data from consultants; Bord na Móna peat depth maps; Local Authority well grant records; and mineral exploration drilling).
- Karst data from GSI databases.

- Geophysical surveys.
- Elevation and slope of ground surface.
- Landscape morphology.

CURRENT STATUS OF GROUNDWATER VULNERABILITY MAPPING

The National Groundwater Protection Scheme, and thus National Groundwater Vulnerability map, will be completed by 2012 as part of the National Development Plan II. Figure 2 shows the coverage to date.

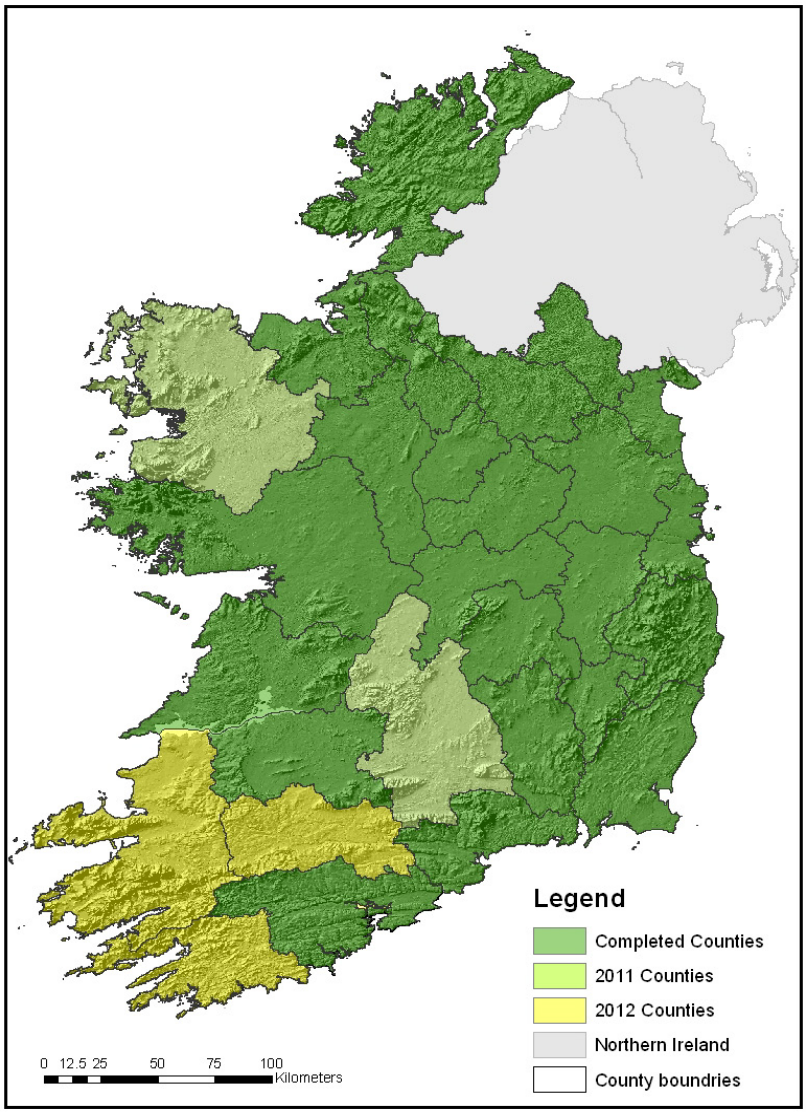

Figure 2. National Groundwater Protection Schemes Status 2010.

CONCLUSIONS

The ongoing vulnerability mapping will continue to improve the national groundwater vulnerability and groundwater protection scheme datasets. Apart from groundwater protection, the underpinning layers, in particular the subsoil permeability map, have been proven to be necessary components for other derived maps, such as the recharge maps. All of these maps are essential to make appropriate decisions in a spatial planning context, which is becoming increasing important with the continuation of the Water Framework Directive process, and to model the impacts of changing environmental parameters on future resources.

ACKNOWLEDGEMENTS

This paper is submitted with the permission of Dr. Peadar McArdle, Director, Geological Survey of Ireland.

REFERENCES

British Standards, 5930: *1999. Code of practice for site investigations*. British Standards Institution, London.

Daly D., Warren W., 1998: *Mapping Groundwater Vulnerability: the Irish perspective*. In: Robins NS (ed) Groundwater Pollution, aquifer recharge, and vulnerability, Geological Society, London, Spec. Publication. 130 pp 179-190.

Department of Environment and Local Government (DoELG), 1999: *Groundwater Protection Schemes*. Department of Environment and Local Government, Environmental Protection Agency, Geological Survey of Ireland.

Fitzsimons V., Daly D., Deakin J., 2003: *GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination*. Geological Survey of Ireland, 75pp.

Lee M., 1999: *Surface indicators and land use as secondary indicators of groundwater recharge and vulnerability*. Unpublished (Research) MSc. Thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Swartz M., 1999: *Assessing the permeability of Irish subsoils. Unpublished (Research) MSc*. Thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Swartz M., Misstear B.D.R., Daly D., Farrell E.R., 2003: *Assessing subsoil permeability for groundwater vulnerability*. QJ Eng. Geol. Hydrogeol. 36(part 2):173–184

Teagasc, 2005: *National Subsoils Map produced under FIPS-IFS Project*, 1998-2001; EPA Soil and Subsoil Mapping Project, 2002-2005.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0