River Basin Management Plans (2015 - 2021)

Groundwater Classification Methodology
Water Balance

December 2015

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Introduction

All groundwater bodies in Northern Ireland were classified in 2014-2015 to establish whether they are at good or poor status utilising monitoring data for the past 6 years (2009 to 2014). Status is divided in qualitative and quantitative status and a number of tests are carried out for each, see Figure 1.

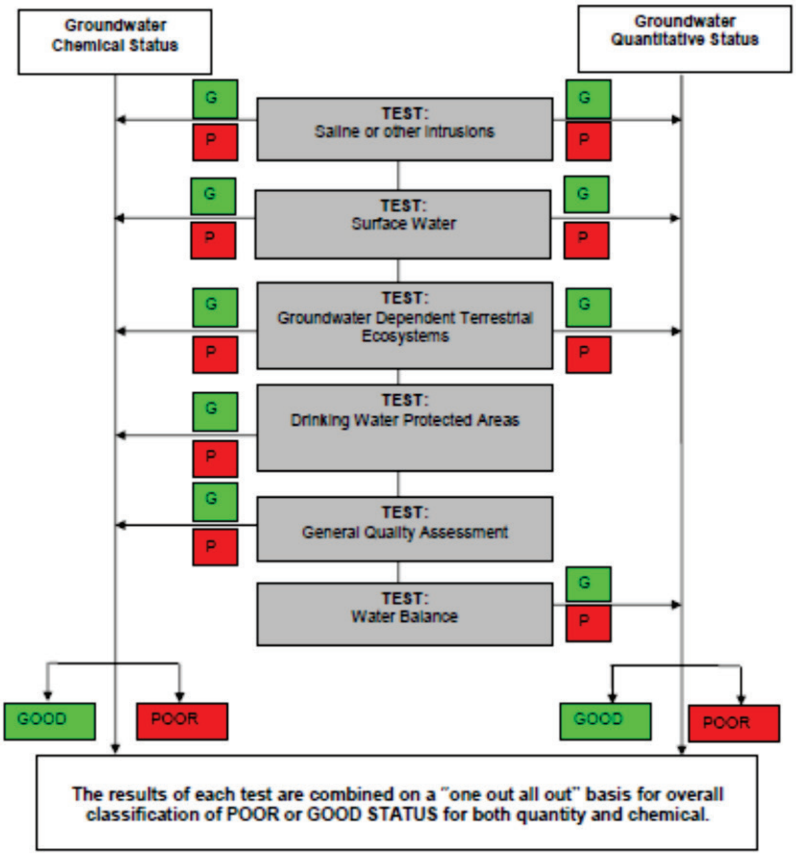

Figure 1: Overview of classification tests [from UK Technical Advisory Group paper 11b(i)].

Water Balance classification

The method for water balance classification is derived from the UKTAG guidance for quantitative classification, updated for the second River Basin Planning (RBP) cycle (UKTAG, 2012). For the water balance test actual abstracted volumes for each groundwater body are compared with estimated recharge values for each groundwater body.

1. Calculate the annual average recharge to groundwater body

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2. Calculate the annual average volume abstracted from each groundwater body over the last 6 years based on licence returns. Exclude returned water, e.g. quarry dewatering.

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3. Estimate groundwater contribution as an annual average to support all river ecosystems across the groundwater body

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4. Subtract 3 from 1 to get the available groundwater resource

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5. Does 2 exceed 4? If yes, then proceed to step 7, otherwise groundwater body is at good status.

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6. Are there other lines of evidence indicating poor status of the groundwater body? Groundwater body is at poor status.

Recharge Estimation

Estimating recharge to groundwater is complex and difficult. It is dependent upon rates of rainfall, evaporation, transpiration, permeability and thickness of soil, and various hydrogeological properties of the saturated material that constitute the groundwater body.

There is no 100 % fail safe method to calculate recharge rates. The most accurate way of estimating or monitoring recharge is to have an entire groundwater body densely covered by observation boreholes that record accurate changes in groundwater levels, whilst having a very clear understanding of how the storage properties of the saturated groundwater body material vary both spatially and with depth. A groundwater level increase of 1 m in a sandstone aquifer with a storage coefficient of 20 % would equate to a recharge of 0.2 m^3 or 200 litres. Over 1 km^2 this would be 200,000 m^3. Most groundwater bodies tend to be heterogeneous and therefore the properties at one location may be very different than those somewhere else.

This ideal scenario is unrealistic and therefore different methods are required using spatial data to estimate groundwater recharge. It is important to note that any recharge values derived from spatial data are only estimates. Verification using groundwater levels can help to improve confidence in estimates but it is important to consider the level of confidence in the estimation methods when using them as part of a decision making tool.

A research project was undertaken by Gibson (2010) and Neary (2012) to study different methods of estimating groundwater recharge on a regional scale. The result of this was to apply a method recently adopted by the Republic of Ireland using groundwater vulnerability as a proxy for rates of groundwater recharge. Infiltration coefficients were derived following targeted research on different sub-soil types. Different groundwater vulnerability systems are applied in the Republic of Ireland than are in Northern Ireland so expert judgement was required to link the Northern Ireland categories to the Republic of Ireland system. Once this was applied, a potential recharge map was derived.

It was found that the average groundwater recharge per groundwater body was markedly different from the previous method applied for 2009 classification. This in itself does not conclude that one method is more accurate than the other but it did initiate a more detailed analysis of the two methods. It was found that the base flow index method was likely to be more accurate as it relied upon the HOST dataset which was itself derived from 1:50,000 scale soils mapping. The groundwater vulnerability mapping was derived from less accurate 1:250,000 scale superficial geology mapping. The application of infiltration coefficients to the groundwater vulnerability mapping was also thought to be a potential source of error.

The base flow indices method was applied to derive a secondary potential recharge map. It was recognised that all of the input datasets were spatially distributed and it was decided to apply the method on a 1 km^2 grid to allow the spatial distribution to remain. Upper limits of 200 and 100 mm/annum were placed on low and poorly productive aquifers grid squares respectively due to their likely inability to receive all of the groundwater recharge.

A multiplication factor of 0.82 was applied to actual evapotranspiration (AE). This was previously 0.95 from studies by Daly (1994) which suggested that annual AE for grassland in Ireland is typically about 95% of potential evapotranspiration (PE). However more recent studies (Kennedy, 2010) indicated that this factor was more likely 0.82.

The equation used to derive recharge was:

$$\text{Groundwater Recharge} = \text{Base Flow Index} \cdot (\text{Rainfall} - 0.82 \cdot \text{PE})$$

Groundwater Abstractions

The licensing of abstractions was introduced in Northern Ireland in 2007 and the current abstraction licensing database was queried for all groundwater abstractions. This would exclude spring or spring fed abstractions. The annual average volume abstracted volume of abstraction was over the last six years for each groundwater body.

Available Groundwater Resource

Available groundwater resource means the long term annual average rate of overall recharge of the groundwater body less the long-term annual rate of flow required to achieve the ecological quality objectives for associated surface water. Associated waters specified under Article 4 are considered when determining the available groundwater resource to avoid any significant diminution in their ecological status and to avoid any significant damage to associated terrestrial ecosystems.

The available groundwater resource is the volume of water that can be abstracted before the abstractions will impact on low flows of surface water features. It is during periods of low flows when surface water features are most dependent upon groundwater as base flow to maintain a minimum flow that will sustain surface water ecosystems. By protecting this volume and ensuring that it is not abstracted, groundwater abstractions can be sustainably abstracted without affecting dependant surface water ecosystems.

Available groundwater resource is calculated by subtracting the total of all ecological flow standards of surface water features within a groundwater body from the annual average groundwater recharge estimate. The total of all ecological flow standards is estimated by identifying all of the surface water bodies that are likely to be in connection with the groundwater body and summating all of their defined Q_{95} values. A groundwater body is at good status when its available groundwater resource is not exceeded by the long term annual average rate of abstraction (UKTAG, 2007).

References

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