WFD Pressures and Impacts Assessment Methodology

GUIDANCE ON THE ASSESSMENT OF THE IMPACT OF GROUNDWATER ABSTRACTIONS

Paper by the Working Group on Groundwater

Guidance document no. GW5

This is a guidance paper on the application of a **Groundwater Abstraction Risk Assessment Methodology**. It documents the principles to be adopted by River Basin Districts and authorities responsible for implementing the Water Framework Directive in Ireland.

REVISION CONTROL TABLE				
Status	**Approved by National Technical Co-ordination Group**	**WFD Requirement**	**Relevant EU Reporting Sheets**	**Date**
Final	March 2005	Pressures and Impacts	GWPI 5	28 April 2004

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Guidance on the Assessment of the Impact of Groundwater Abstractions

1. Purpose of this paper

The paper sets out guidance on assessing the impacts of groundwater abstractions on bodies of groundwater and on groundwater dependent terrestrial ecosystems (GWDTEs), as part of 'initial characterisation'. It has been developed as part of a suite of guidance reports for the implementation of the WFD in Ireland as it relates to groundwater. The guidelines were drafted by the Working Group on Groundwater (see Section 9). The guidance assumes that the reader has a good working knowledge of groundwater and recharge, and consequently the text is not intended to be descriptive.

2. Background

The approach taken:

- uses risk-based analysis and the 'source-pathway-receptor' framework;
- uses the RBD GIS as the means of deriving results;
- requires a national approach to ensure consistency, but will not be overly prescriptive, to allow for varying datasets.

The general risk-based approach, as applied to groundwater abstractions, is summarised in Appendix 1.

The UK Technical Advisory Group (UK TAG) has produced 'Guidance on the Assessment of Abstraction and Recharge Pressures on Bodies of Groundwater' (2004). This guidance has general applicability to Ireland and is therefore included in this paper as Appendix 2. It covers general issues, which are not repeated in this paper. However, there are some differences in language and approach, and the methodology outlined here specifically suits the Irish situation, and therefore has precedence where necessary.

3. Terminology

Infiltration	The proportion of precipitation which infiltrates into the soil zone.
Effective Rainfall (ER)	The proportion of rainfall that is potentially available for recharge and/or runoff, i.e. precipitation minus actual evapotranspiration.
Interflow	Water that moves laterally within the soil and/or unsaturated zone and may later reach the ground surface, rather than travelling down to a groundwater body.
Recharge	The proportion of precipitation that reaches the water table. There are two main types of recharge: diffuse (or direct) and point (or indirect).
Diffuse recharge	Recharge due to vertical infiltration of precipitation where it falls on the ground.
Point Recharge	Recharge which starts as runoff and then infiltrates at a point. This is particularly important in karst areas, due to the presence of sinking streams.
Recharge coefficient	The proportion of ER that becomes recharge, expressed as a fraction or percentage of effective rainfall.
Rejected recharge	Recharge that cannot be accepted by a high transmissivity aquifer due to a high water table.

4. Known Impacts

An evaluation of existing monitoring data and information will enable some impacts to be recorded and mapped. The general use of monitoring data is illustrated in Figure 1.

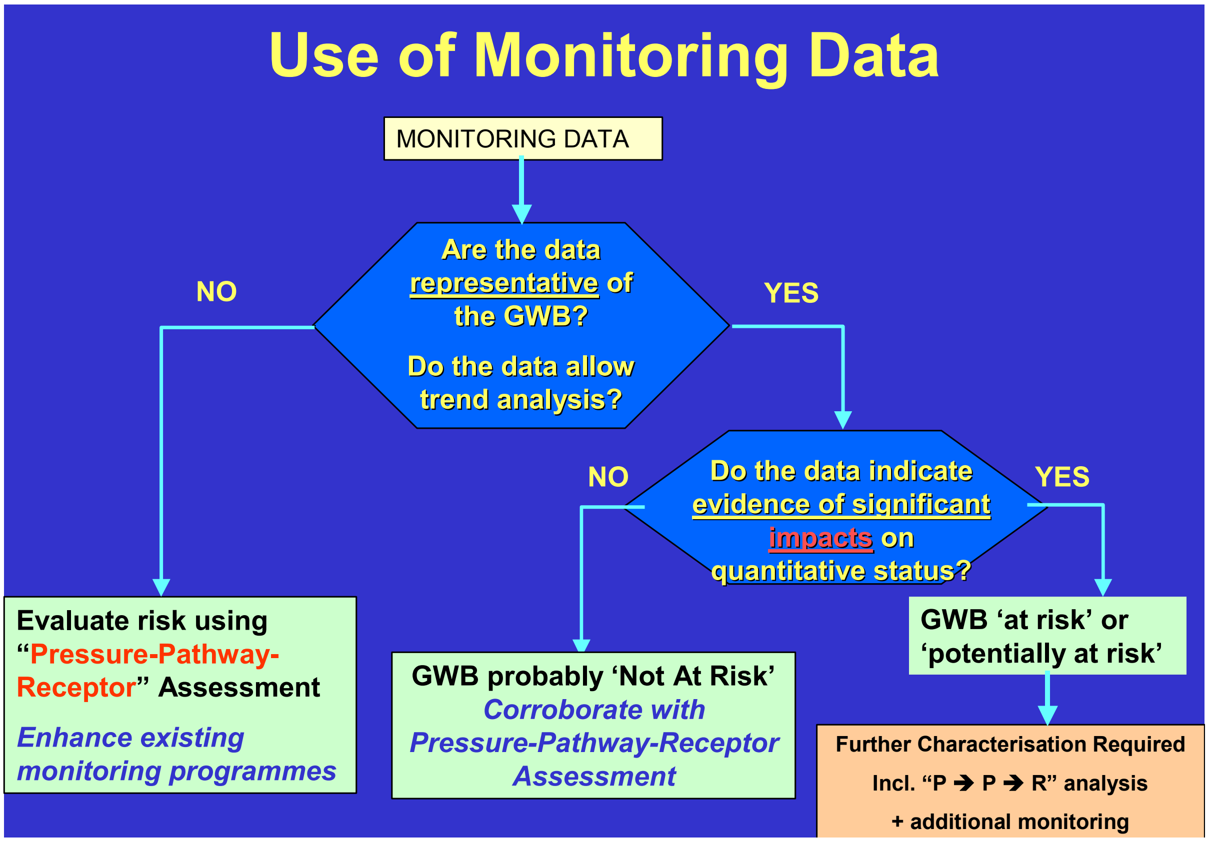

Figure 1 Flow chart indicating the use of monitoring data

While sufficient data may seldom be available, the following impacts may be observed in certain areas:

- Over-abstracted aquifers;
- Significant reduction in flow in known surface watercourses;
- Known damage to wetlands or GWTDEs;
- Known saline intrusion.

5. Pressure Magnitude

A receptor (e.g. a river or a GWDTE) may be affected by groundwater abstraction from a GWB. Hence, the pressure magnitude is defined by the total volume of groundwater abstracted from a GWB. The impact is manifested by a diminution of groundwater flow to receptors, and/or by reduced groundwater levels in the GWB.

5.1 Nature of Pressures

There are a number of human activities that act as the drivers for groundwater abstraction. Primarily, these are:

- Public and Group drinking water supplies
- Industrial use of water
- Dewatering, e.g. of mines, quarries, or for construction projects
- Drainage

5.2 Quantification of major abstractions

Abstractions below $10m^3/d$ are not taken into consideration.

For abstractions >$10m^3/d$, the RBD consultants collected data from various sources (there is no comprehensive register of abstractions). The primary data sources are the Local Authorities, large mines and quarries, and water consuming industries. The RBD consultants also utilised available local knowledge of significant abstractions which fall outside the data sources above.

All abstractions are assigned to the relevant GWB and the volume of each individual abstraction is summed to give the total for the GWB.

5.2.1 Springs and infiltration galleries

Careful attention is paid to water supplies from springs. Pumping of the overflow from springs will not lower the water levels in the groundwater body. However, it may impact on downstream groundwater dependent rivers and lakes.

Water supply from infiltration galleries is included in the pressure magnitude, as they reduce the water level in the aquifer and hence are a pressure on the GWB.

5.2.2 Arterial drainage

Arterial Drainage is considered a pressure to GWDTE receptors. The proximity of the GWDTE to the arterial drainage is used as a surrogate for actual volume of groundwater abstracted. Further details are given in risk assessment sheet GWDTERA1 in Guidance Document GW 8.

5.3 Sources of potential error in abstraction quantification

Care is required that the abstraction is allocated to the correct GWB. The following complications can lead to errors:

- *Inaccurate Abstraction Point Grid Reference* – If an abstraction lies near to a GWB boundary, even a small inaccuracy could cause error. It is essential that such abstractions are considered on a case by case basis.
- *Confined GWBs* – Although not common in Ireland, in some instances an abstraction point penetrates through the uppermost bedrock to abstract from an aquifer confined below it. The consultant should contact the GSI for advice in such instances.
- *Sand and Gravel Aquifers* – It is probable that abstraction points which plot within a Gravel GWB are actually abstracting from the bedrock GWB beneath the gravel deposit.
- *Large Abstractions* – for some very large abstractions it is possible that the cone of depression extends into another GWB. GWB boundaries are defined by topography and aquifer classifications. Where the boundary is defined by topography, if the hydraulic gradient is low and/or the abstraction is large, it is possible that the groundwater divide has moved and is no longer coincident with the topographic boundary. Where the GWB boundary is defined by aquifer classifications it is possible that the boundary does not constitute a "no flow boundary" and hence it is possible for water to pass from one aquifer into another. If the cone of depression does extend significantly outside the GWB boundary the GWB boundaries must be changed. The RBD consultant should contact the GSI for guidance in this instance.

6. Recharge Estimation

6.1 General Approach

The recommended methodology for initial characterisation is as follows:

1. Estimate effective rainfall (ER);
2. Multiply ER by a recharge coefficient to give the recharge amount;

3. In areas underlain by poorly productive aquifers, apply a maximum recharge figure (or recharge 'cap'). This takes account of the limited capacity of such aquifers to accept recharge.
4. Where point recharge is present, use information on the local situation to estimate its significance and the likely catchment area of the point.
5. If possible, corroborate results with an assessment of baseflow from local rivers

Where further characterisation is required, a more comprehensive assessment of recharge will be necessary, which will require more detailed analysis of ER and baseflow.

6.2 Effective Rainfall (ER)

- The data layers needed for calculating ER are rainfall (R) and potential evapotranspiration (PE).
- Use the (digital) national average annual rainfall map (based on 1961-90 averages or 1971-2000, if available). During further characterisation, monthly rainfall data may be required.
- Use 30 year average PE map from Met Éireann (not yet available digitally). During further characterisation where the GWB is deemed to be 'at risk', the soil moisture balance will need to be calculated using the Penman-Monteith/FAO method. (The SNIFFER (Entec UK, 2003) calculation spreadsheet may be helpful.)
- Actual evapotranspiration (AE) should be estimated by multiplying PE by 0.95, to allow for the reduction in evapotranspiration during periods when a soil moisture deficit is present.
- ER = R-AE.

6.3 Recharge Coefficient (r_c)

6.3.1 General Comments

The proportion of ER that becomes recharge depends largely on the permeability and thickness of the soils, subsoils and bedrock overlying groundwater. This proportion was called infiltration coefficient in previous calculations of recharge undertaken in Ireland, but is now called **recharge coefficient (r_c)**.

The recharge coefficient (r_c) depends on the properties of the layers overlying groundwater – the soil, subsoil and unsaturated bedrock.

6.3.2 Influence of Soil

The Teagasc soil map distinguishes between 'poorly drained' and 'well drained' soils. The presence of 'poorly drained' soils, such as gleys, will be the limiting factor as some runoff will occur irrespective of the underlying layers.

6.3.3 Influence of Subsoil

As groundwater 'vulnerability' and vulnerability maps depend on the same geological and hydrogeological properties that control recharge, namely permeability and thickness of subsoil, recharge coefficients may be based on vulnerability maps.

The recommended recharge coefficients for the various hydrogeological settings, that are based largely on vulnerability categories, but take account of the influence of soils, are given in Table 1. Details on the vulnerability categories are given in Table 2. The recharge coefficient values are given as ranges for each hydrogeological setting, thereby facilitating the use of local knowledge and expert judgement.

Full vulnerability maps are not available for ~55% of the country. Maps of soils, subsoils and extremely vulnerable areas are available for all of the country. Outside the areas of extreme vulnerability the term "High to Low" vulnerability is used to indicate where the vulnerability is undifferentiated. These areas have been incorporated into the hydrogeological settings in Table 1.

In counties where a complete vulnerability map is not available there will also be no subsoil permeability map. To overcome this problem an interim map can be derived from the FIPS subsoil categories. For certain subsoil categories defined by the FIPS programme it is possible to define a presumed permeability. For instance gravel deposits are assumed to be highly permeable. Table 3 gives a list of the FIPS Subsoil categories and a predicted permeability. It would be advisable to take a precautionary approach, unless there is local knowledge or information.

6.3.4 Influence of Unsaturated Bedrock

Poorly productive aquifers are not capable of accepting all the recharge that may be available, due to their low transmissivity. Therefore, a maximum limit or 'cap' is used to take account of this.

- In areas underlain by poor aquifers (Pl and Pu), the maximum recharge should be taken as 100 mm/yr, irrespective of the vulnerability category.
- In areas underlain by locally important aquifers that are generally unproductive except for local zones (Ll), the maximum recharge should be in the range 150-200 mm/yr depending on local knowledge, irrespective of the vulnerability category.

6.3.5 Methodology, using RBD GIS

1. Produce a layer estimating ER.
2. Using soils and vulnerability maps, calculate recharge coefficients (r_c).
3. Estimate recharge using the equation: Recharge = ER x r_c
4. Amend recharge calculation in areas underlain by poorly productive aquifers, as described in Section 6.3.4.

Table 1: Recharge coefficients for different hydrogeological settings.

Vulnerability category		Hydrogeological setting	Recharge coefficient (rc)		
			Min (%)	Inner Range	Max (%)*
Extreme	1.i	Areas where rock is at ground surface	60	80-90	100
	1.ii	Sand/gravel overlain by 'well drained' soil	60	80-90	100
		Sand/gravel overlain by 'poorly drained' (gley) soil			
	1.iii	Till overlain by 'well drained' soil	45	50-70	80
	1.iv	Till overlain by 'poorly drained' (gley) soil	15	25-40	50
	1.v	Sand/ gravel aquifer where the water table is ≤ 3 m below surface	70	80-90	100
	1.vi	Peat	15	25-40	50
High	2.i	Sand/gravel aquifer, overlain by 'well drained' soil	60	80-90	100
	2.ii	High permeability subsoil (sand/gravel) overlain by 'well drained' soil	60	80-90	100
	2.iii	High permeability subsoil (sand/gravel) overlain by 'poorly drained' soil			
	2.iv	Moderate permeability subsoil overlain by 'well drained' soil	35	50-70	80
	2.v	Moderate permeability subsoil overlain by 'poorly drained' (gley) soil	15	25-40	50
	2.vi	Low permeability subsoil	10	23-30	40
	2.vii	Peat	0	5-15	20
Moderate	3.i	Moderate permeability subsoil and overlain by 'well drained'soil	25	30-40	60
	3.ii	Moderate permeability subsoil and overlain by 'poorly drained' (gley) soil	10	20-40	50
	3.iii	Low permeability subsoil	5	10-20	30
	3. iv	Basin peat	0	3-5	10
Low	4.i	Low permeability subsoil	2	5-15	20
	4.ii	Basin peat	0	3-5	10
High to Low	5.i	High Permeability Subsoils (Sand & Gravels)	60	85	100
	5.ii	Moderate Permeability Subsoil overlain by well drained soils	25	50	80
	5.iii	Moderate Permeability Subsoils overlain by poorly drained soils	10	30	50
	5.iv	Low Permeability Subsoil	2	20	40
	5.v	Peat	0	5	20

Acknowledgement: many of the recharge coefficients in this table are based largely on a paper submitted by Fitzsimons and Misstear (in press).

Table 2: Vulnerability Mapping Subsoil Permeability and Depth Criteria (adapted from DELG/EPA/GSI, 1999)

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**

N/A = not applicable

Table 3: Predictive Permeability of FIPS Subsoil Categories

Subsoil Category	Subsoil Code	Subsoil Type	Predicted Permeability
Gravels	**G** **Esk** **G***xxx*	Sands and Gravels (undiffentiated) Esker Sands and Gravels Any other Type of Gravel	High
Shale Tills	**T**CS **T**LPS **T**NSSs	Shale Till (Cambrian/ Precambrian) Shale Till (Lower Palaeozoic) Shale and sandstone till (Namurian)	Low
Irish Sea Tills	**IRS***xxx*	Irish Sea Till deposits	Low
Other Tills	**T***xxx*	Any other Till deposit	Moderate
Peat	Bkt**Pt** Rs**Pt** Fen**Pt** Cut**Pt**	Blanket Peat Raised Peat Fen Peat Cut over Peat	Low
Marine	**M**	Marine Undifferentiated	Moderate
	MGs **M**bs **M**bg	Marine sands and gravels Beach raised/beach sand Beach raised/beach gravel	High
	Msi **M**c **ME**sc	Marine Silts Marine Clay Estuarine sediments (silts/ clays)	Low
Alluvium	**A**	Alluvium undifferentiated	Moderate
	Ag **A**s	Alluvial gravels Alluvial sands	High
	Asi **A**c	Alluvial silts Alluvial clays	Low
Lacustrine	**L**	Lacustrine Undifferentiated	Moderate
	Lg /**L**s	Lacustrine gravels / sands	High
	Lsi / **L**c	Lacustrine silts / clays	Low

7. Receptor Sensitivity

Apart from the groundwater body itself and groundwater abstractions in that body, the receptors at risk from abstraction are as follows:

1. Main river channels;
2. 'Large' lakes;
3. Stream headwaters;
4. 'Small' (need definition of these) lakes (say, <10ha);
5. GWDTEs.

The first two – main river channels and large lakes – are relatively insensitive in comparison to stream headwaters, small lakes and, in particular, GWTDEs. However, the sensitivity of GWDTEs will vary, depending on the importance of groundwater relative to surface water, as the source of water. For instance, fens and turloughs are more sensitive than raised bogs.

8. Assessment of Impact and Assignment of Risk Categories

8.1 General Approach

The general approach is based on a comparison of the abstraction pressure in each groundwater body (calculated as an average annual quantity anticipated in 2015, but based on existing abstraction rates) with the recharge to that body. The decision on the degree of risk posed by the abstraction is based on an evaluation of abstraction as a proportion of annual average recharge, and is indicated as a threshold, which depends on the sensitivity of the receptors. The percentage thresholds are intended to leave sufficient recharge to meet ecological needs.

8.2 Thresholds for Rivers

The thresholds in Table 4 are based on the work on the Environment Agency (England and Wales). In Ireland all our bedrock aquifers have a low (<5%) specific yield, whereas the specific yield of our sand/gravel aquifers is >10%.

Table 4: Thresholds for rivers and large lakes

	Average Specific Yield or Storage of GW Screening Unit	
GWABS/Average Recharge	**Low Storage (<5%)**	**High Storage (>=10%)**
>30%, i.e., if groundwater abstraction is greater than 30% of long term average recharge	High Potential Impact	High Potential Impact
20 to 30%	High Potential Impact	Mod Potential Impact
10 to 20%	Mod Potential Impact	Low Potential Impact
2 to 10%	Low Potential Impact	Low Potential Impact
<2%	No Potential Impact	No Potential Impact

Acknowledgement: this table is based on UK TAG Guidance.

8.3 Thresholds for Sensitive Receptors

Assessing the impact of abstraction on sensitive receptors and setting thresholds is complicated for the following reasons:

1. Sensitive receptors have varying degrees of dependency on groundwater, thus making generalisations difficult.
2. The ecological significance of differing degrees of groundwater abstraction in the zone of contribution (ZOC) of receptors is seldom known, particularly at low levels of abstraction.

3. The connection between groundwater and receptors, such as GWTDEs, is usually not well understood, and is seldom investigated for individual receptors.

8.3.1 UKTAG Guidance

Consideration of these issues in Britain is not completed, and therefore we cannot 'piggy back' readily on the approach of UK TAG. However, UKTAG Task 7(h) Guidance recommends the following approaches (text copied from Guidance report):

1) *Identify the simple presence or absence of any groundwater abstractions within a specified buffer distance (or distances) from the wetland or lake (e.g. 5 km would be consistent with Habitats Directive); or/and*
2) *Estimate the total rates of groundwater abstraction present within the same specified buffer distances; or/and*
3) *Estimate the proportion of the buffer areas occupied by the abstraction source centred equivalent recharge circles ; or/and*
4) *Estimate the cumulative drawdown at the wetland associated with groundwater abstraction based on 'no recharge' time period assumptions and T and S estimates specified by receptor or abstraction source or aquifer type where appropriate ; or/and*
5) *Identify known impacts or the results of existing detailed assessments: List and map those wetlands or lakes where groundwater abstraction impacts are considered to have been damaging to dependent ecologies or to groundwater quality. This could include the results of any more detailed investigations previously undertaken (e.g. results of Habitats Directive assessments).*

The existence of dependent surface water bodies or wetland receptors where groundwater abstraction pressures (e.g. predicted drawdown) are above threshold levels but evidence of ecological impacts is not available will be given less weighting in determining the final risk category but will flag the need for further monitoring.

8.3.2 Recommended Approaches for GWTDEs

1. Categorise GWTDEs into those with a 'high'[1] dependence (e.g. fens) and those with a 'moderate' or 'low' dependence (e.g. blanket and raised bogs).
2. If ZOCs of GWTDEs are known or can be readily estimated, include in GIS.
3. For GWTDEs where the ZOC is not known, create a buffer zone. The buffer zone may be varied depending on local knowledge. For example, a buffer zone of 5 km radius is recommended around highly dependent GWTDEs, whereas 1 km may be sufficient around GWTDEs that have a moderate or low dependency on groundwater.
4. Apply thresholds in Table 5.
5. Groundwater abstractions in the immediate vicinity (say 250 m) of GWTDEs may pose a particularly high threat. We need to develop an approach to deal with this situation, perhaps by estimating drawdowns.
6. Check assessment with any existing impact data/information.

[1] As defined in UKTAG WP 5a-b draft guidance on the identification of GWTDEs.

Table 5: Relationship between the potential impact to a sensitive habitat of groundwater abstraction.

GWABS as a % of average recharge in 'catchment' of GWTDE	GWTDE with 'high' dependency on groundwater	GWTDE with 'moderate' or 'low' dependency on groundwater
>20%	High Potential Impact	High Potential Impact
10 to 20%	High Potential Impact	Mod Potential Impact
5 to 10%	Mod Potential Impact	Low Potential Impact
<5%	Low Potential Impact	Low Potential Impact

8.4 Assignment of Risk Category

The risk category is obtained from the combination of the potential impact derived from the risk screening process, the presence or absence of monitoring data, and where available, the results of the monitoring, as shown in Table 6.

Table 6: Thresholds and risk categories

Potential Impact	Evidence for GW level decline	No/ insufficient evidence for GW level decline	Evidence of no GW decline
High	At Significant Risk (1a)	Probably at risk (1b)	Not at significant risk (low confidence) (2a) to Not at significant risk (2b) based on confidence in the data
Moderate	At Significant Risk (1a)	Not at significant risk (low confidence) (2a)	Not at significant risk (2b)
Low	At Significant Risk (1a) to Probably at risk (1b) based on confidence in the data	Not at significant risk (low confidence) (2a)	Not at significant risk (2b)

9. Membership of the Working Group on Groundwater

Organisation	**Representative(s)**
Geological Survey of Ireland (GSI)	Donal Daly (Convenor) Geoff Wright Vincent Fitzsimons Coran Kelly Taly Hunter Williams Monica Lee
Camp Dresser McKee (CDM)	Henning Moe
Compass Informatics Ltd.	Paul Mills
Department of the Environment, Heritage and Local Government (DEHLG)	Pat Duggan Jim Ryan (NPWS) Aine O'Connor (NPWS)

Environment and Heritage Service/ Geological Survey of Northern Ireland (EHS/GSNI)	Peter McConvey
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O'Neill Groundwater Engineering (OGE)	Shane O'Neill
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Southeastern River Basin District (SERBD)	Colin Byrne
Teagasc	Karl Richards
Trinity College, Dublin (TCD)	Paul Johnston Catherine Coxon

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UK Technical Advisory Group Task 7h(01) (2004) *Draft Guidance on the Assessment of Abstraction and Recharge Pressures on Bodies of Groundwater* (P2v3.24-01-04), 10 pp.

Working Group on Groundwater and Working Group on Characterisation and Reporting (2003) *Guidance on Pressures and Impacts Assessment Methodology*. August 2003, 40 pp.

11. Appendix 1 Application of Risk-based Analysis to Abstraction Pressures

The risk assessment process involves background, source, pathway and receptor factors, undertaken in a series of steps[2] and combined together to give the required outcomes. The overall approach is outlined in Figure 1.

In undertaking risk assessment, as part of River Basin District projects, all compilation of relevant information and analyses will be undertaken using, as far as practicable, a GIS.

Initial Factors

1. Delineation, evaluation and description of water bodies (step 1).
2. Development of a 'conceptual understanding' of the river basin as a 3-dimensional entity, where emphasis is placed on the interconnection and interdependencies between the various components of the water cycle (step 2).
3. Assessment of existing monitoring data (step 3). Where data are adequate to enable conclusions on impact and/or trends, classify water body into the appropriate category – either 'at risk', 'potentially at risk' or 'not at risk'.

Source (pressure magnitude) Factors

1. Identification of pressures (step 4).
2. Estimation of volume of abstracted groundwater (step 5).
3. Development of threshold values for particular pressure magnitudes and receptors, in the form of matrices (e.g. more than a certain % of recharge abstracted in relation to main river channels) (step 6).

Pathway Factors

1. Compilation and characterisation of relevant elements, such as rainfall, evapotranspiration, soils, subsoils, aquifers, vulnerability (step 7).
2. Estimation of recharge for different hydrogeological settings (step 8).

Receptor Factors

1. Evaluation of the sensitivity of different receptors to pressures (abstraction), e.g. fens are more sensitive than raised bogs to groundwater abstraction (step 9).

Integrating Source, Pathway and Receptor Factors (step 10)

1. Where impact/monitoring data for the receptor are adequate to determine the water body risk category, combining the factors enables a sufficient conceptual understanding to provide the basis for designing the monitoring network and deciding on the Programme of Measures.
2. Where impact data are inadequate, combining the factors will enable the risk category to be determined and will provide the basis for designing the monitoring network and deciding on the Programme of Measures. Existing monitoring data can be used to refine the analysis and confirm the risk category.

Acknowledgement
This is a summary of a draft report "Pressures and Impacts Assessment Methodology" (August, 2003), prepared by a sub-committee of the WFD Working Group on Characterisation and Reporting, chaired by Micheál Lehane, EPA. The sub-committee members included: Donal Daly, Grace Glasgow, Garrett Kilroy, Martin McGarrigle, Jim Bowman, Francis O'Beirn, Thomas Quinlivan and Paul Mills.

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[2] Some of these steps may be undertaken simultaneously and can be in a different order

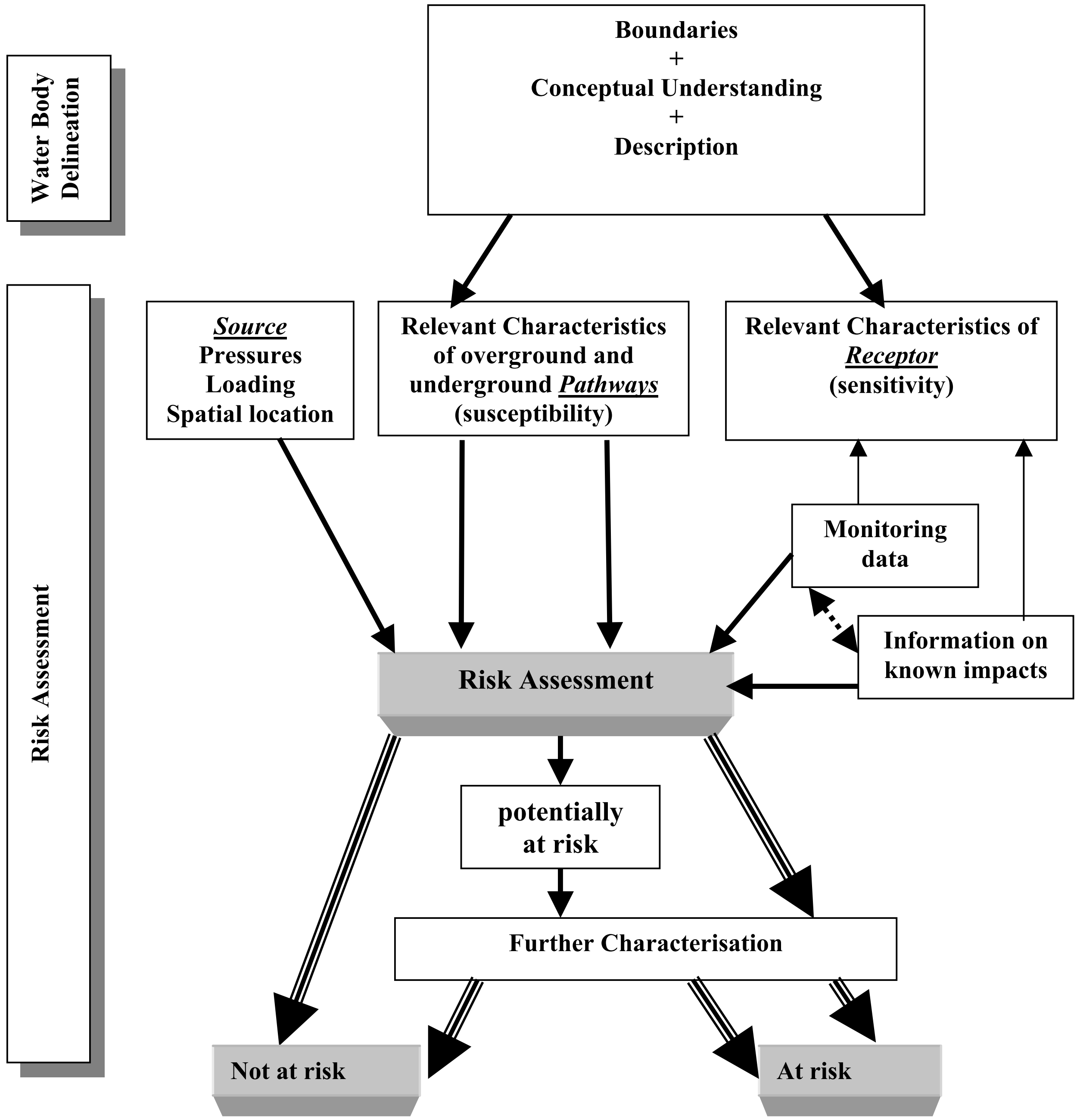

Figure A.1 Summary of risk assessment approach

12. Appendix 2 UKTAG Task 7(h) Guidance on the Assessment of Abstraction and Recharge Pressures on Bodies of Groundwater

UK TECHNICAL ADVISORY GROUP ON THE WATER FRAMEWORK DIRECTIVE

UKTAG Task 7(h) Guidance on the Assessment of Abstraction and Recharge Pressures on Bodies of Groundwater

(Groundwater Task Team)

1. Purpose of this paper

This paper sets out guidance on the assessment of abstraction and recharge pressures on bodies of groundwater for the purposes of initial characterisation [UKTAG Task 7(h)].

2. Background

As part of the characterisation of bodies of groundwater required under Article 5 of the Directive, Member States must: (a) identify the pressures to which bodies of groundwater, or groups of such bodies are subject; and (b) carry out an assessment of the risk of failing to meet the Directive's environmental objectives. For those bodies identified as being at risk on the basis of the initial characterisation, and for any bodies that cross the boundary between Member States, specific information on pressures must be collected and maintained.

Member States must complete the first risk assessment by 22nd December 2004, and report the results to the Commission by 22 March 2005. The assessments are therefore urgent priority tasks in the implementation of the Directive.

3. Common description of pressure and purpose types

The UKTAG Drafting Group 7h remit includes the task of producing a common descriptive classification of the main abstraction and recharge alteration pressures liable to affect the levels/flow regime of bodies of groundwater. The aim of this task is to establish a common system for describing, and referring to, the pressures. In undertaking this task, it is recognised that options based on existing UK classification systems have been summarised in the drafting for Task 7b (surface water body abstraction and flow regulation pressures). The Task 7b guidance should be adequate for the classification of groundwater abstraction pressures and is not repeated here. This paper will, however, consider pressures, such as alterations to natural recharge, which are not covered under the remit of drafting group 7b.

- Purpose types for groundwater abstractions should be recorded according to the guidance paper for Task 7b.
- In general, discharges to groundwater are unlikely to have a major impact on quantitative status, with the possible exception of artificial recharge for water resource management. For the purposes of initial characterisation, discharges to groundwater will therefore be ignored unless the discharge is for artificial recharge purposes.
- For the purpose of calculating the groundwater balance for initial groundwater characterisation, it is conservatively assumed that all groundwater use is consumptive. This approach still allows account to be taken of the return of groundwater to another surface water catchment or to a downstream discharge point. Where use is non-consumptive, e.g. the local return of groundwater

abstracted for sand and gravel washing to the aquifer from which it was pumped this may be relevant to further characterisation.

- Minewater rebound (associated with abstraction cessation) is a major issue in terms of quality, and in this instance the rising groundwater (rebound) is one of the pressures. Areas identified as having rising water tables associated with abandoned mines should be identified as at risk from groundwater pollution. Rising groundwater associated mostly with the decline of industrial abstractions in cities and towns should also be identified; though these represent positive quantitative pressures the body should be considered to be at risk of failing to meet its chemical objectives if this is likely to result in poor groundwater quality.

Other 'Recharge Pressures' might be considered to include impacts on recharge associated with land use e.g. impermeable paving associated with urbanisation or effective rainfall reductions associated with increased evapotranspiration following a crop switch from wheat to maize. For initial characterisation, however, it is suggested that the recharge associated with 'current landuse' should be considered as a benchmark to which any major planned changes to land use should be additionally considered (to 2015). Any planned or predicted changes from current land use at any scale - such as changes to urban drainage, crop types, or forestry cover - should be listed but would only need to be considered as part of further characterisation if other pressures or impacts suggest that the groundwater body is at risk. Taking into account the potential impact on recharge of planned changes in land use (2015) is consistent with the proposed approach for groundwater abstractions which first considers current rates of abstraction and then goes on to consider potential increase in abstraction rate to 2015 (using a more detailed assessment for further characterisation).

4. Common specification of data needs.

This guidance focuses on information that will be required to assess the risks to groundwater bodies associated with groundwater abstraction and discharge pressures. This will include the collation of sufficient abstraction and discharge data to assess the potential impact of groundwater abstractions and discharges on dependent terrestrial ecosystems (Task 5b) and associated surface water body flows (Task 7b).

Assessment of the deterioration of groundwater quality associated with over-abstraction and flow direction changes near coastal or other saline interfaces is also addressed here as an essential part of groundwater resources assessment, although its impacts are on groundwater quality (Paper 7i).
Information is also required on the extent and rate of rising groundwater associated mostly with the decline of industrial abstractions in cities and towns.

This paper identifies both 'minimum' data collection requirements, which should be aimed for by all responsible authorities, as well as data sets which are desirable where available. It must be considered that some sites/areas/Agencies will have considerable data whilst others will have very little data. This will need to be taken into account when considering confidence. The assessment should be such that it can be undertaken irrespective of data availability. For all data sets some consideration of reliability and uncertainty will be required so that a degree of confidence can be assigned to the assessment results. Data and assumption audit trails will also be essential to support the assessments.

Where a particular groundwater abstraction pressure type is known to exist but there is insufficient data pertaining directly to the operation at that point, generic data related to the purpose/industry sector/usage may be used to enable the risk assessment to be completed. The level of confidence in, and effort exerted in collecting relevant data should reflect the level of risk to which the water body may be subject. As an example, although Annex II requires that data on sources greater than 10 m3/d for human consumption are to be held, there are currently no abstraction licensing data in Scotland or Northern Ireland. Equally, NALD abstraction licensing data for England and Wales will not include unlicensed sources (licence exempt areas and small sources). Information on such sources down to 10 m3/day will have to be collated, estimated or derived for WFD. Methods have been outlined & trialled in 'Small Licence Exempt Groundwater Sources' - NGWCLC, EA 1999, and in the joint

EA/BGS R&D project P2/260, Phase 1 & 2 reports, and some areas hold registers from Local Authority Environmental Health records of private supplies.

Data needs for groundwater abstraction and discharge pressures

For each groundwater abstraction or discharge the following should be aimed for as a minimum. It is, however, recognised that this will not be achievable by all agencies in all areas:

<u>Abstraction or discharge</u>

- Location (national grid reference): generally one source, one location, but may aggregate together boreholes which are 'very close' (say within 100 m);
- Purpose (e.g. public water supply, spray irrigation etc.), 'pressure type' (GW abstraction or GW discharge) and 'source type' (borehole, spring or well)
- Abstraction or discharge rate: either 'licensed' or '2015 estimated'

Additional optional information may also be useful as follows (e.g. for further characterisation):

- Further reference information (e.g. licence number, site name etc.);
- The aquifer 'type' and GW Body from which the water is abstracted and the existence of any overlying drift or confining layers. This would need to relate to the 'aquifer types' mapped as part of the initial hydrogeologically based step of groundwater body delineation (see Task 6a guidance);
- Consumptiveness of abstractions, if known; and
- Aquifer parameters (T and S) – for optional calculation of associated drawdown impacts.
- Construction details/performance data

<u>Minewater rebound (and other industrial areas where rebound is an issue) also future lowering of water table due to mine pumping</u>

- Location (possibly including an area drawn on a map),
- Rate of rise
- Former pump locality
- Connectivity of workings (where applicable)

<u>Changes to natural recharge</u>

- Landuse – assumed current landuse benchmark presented plus major land use changes planned to occur between now and 2015 (as obtained through planning consultations) in map form.
- Anticipated changes to recharge – optionally presented as map annotations, though this is likely only to be used for further characterisation

<u>Evidence of intrusion of saline or poor quality water</u>

- Location (possibly including an area drawn on a map), these data can be collected where an intrusion is known to be occurring from liaison with local hydrogeologists. In the absence of these data it is possible to determine whether this may be occurring by assessing quantitative status as for example saline intrusion will only occur in an area that is overabstracted.
- Rate of movement/dynamics (if known)

<u>Artificial recharge</u>

- Location,
- Discharge type,
- Volumes/rates of discharge,
- Receiving strata/aquifer.

'Natural' recharge data needs to set thresholds

An annual average recharge estimate is needed for each groundwater body, or a map of distributed annual average recharge, or an estimate of recharge appropriate for each groundwater abstraction. This is required to enable comparison of recharge with groundwater abstraction through the use of appropriate impact thresholds, as part of the risk assessment (see Section 5). Estimates of recharge should reflect available data held by the respective agencies as well as the likely significance of the abstraction pressure. The approach should be such that the potential for assessing groundwater bodies as not at risk by, for example, over-estimating recharge, is minimised.

A record of the assumptions used to derive recharge estimates and the method used, including current landuse assumptions where relevant, is particularly important as these estimates may be refined through further characterisation, or may be modified by future changes in land use which could be considered as recharge 'pressures'.

Contextual information on groundwater bodies

The list of information which follows is proposed as a minimum which should be aimed for so that the pressures and impacts on groundwater bodies can be assessed. However, it is important to emphasise that the process of groundwater body delineation and characterisation described in guidance for Task 6a is inherently iterative as it partly depends on the distribution and types of pressures and impacts acting on it. It is possible, for example, that a concentration of groundwater abstraction pressures on one part of an initially delineated groundwater body may justify sub-dividing it to facilitate better targeted programmes of measures. At the end of this iteration (as well as during it) the following information will be needed for risk assessment:

- The boundaries and size of the groundwater bodies – needed to estimate the recharge to them, to identify the abstractions from (and discharges to) them, and to determine an appropriate groundwater balance.
- The location and extent of dependent terrestrial ecosystems and surface water bodies within them (including rivers, lakes and transitional waters) – needed as part of the 'dependent receptor' focussed element of risk assessment for groundwater bodies ;
- The aquifer type of the groundwater bodies and the predicted degree of connection between them and the dependent surface water or wetland eco-systems; and
- The location of any boundaries with natural groundwaters of poorer, or more saline quality, where the prevention of over abstraction is important to avoid quality deterioration within the groundwater body.

5. Approach to risk assessment for abstraction and recharge pressures on groundwater bodies.

Aim

The aim is to provide an overview of an appropriate approach for initial characterisation of groundwater bodies with respect to abstraction and recharge pressures. This framework should ensure consistency across the UK whilst being sufficiently flexible to accommodate the wide variety of groundwater body types, pressures and information which may exist between the UK states.

The approach takes account of:

- The need to rapidly screen large numbers of water bodies;
- The susceptibility of the groundwater body and the sensitivity of any associated dependent ecosystems to abstraction or recharge pressure (though these assessments may be detailed in UKTAG Paper 5b); and
- The methods available, or likely to be available, to the agencies for risk assessment work, and the timetable for applying those methods.

Map the aquifers, pressures and receptor data

GIS layers could be prepared to show:

- the location, type and magnitude of all the groundwater abstraction and recharge pressures (including artificial recharge schemes and large scale sewage treatment works discharging to the ground but noting that recharge is based on current land use assumptions);
- the river network and delineated surface water bodies;
- catchment boundaries;
- the location of the significant 'dependent terrestrial ecosystem' sites, lakes and coastal salinity boundaries which will also be considered as 'receptors' as part of the groundwater body pressures and impacts screening; and
- areas where rising water levels due to cessation of pumping, such as in abandoned mines, may lead to quality problems.

Groundwater abstraction pressures could be represented by:

- Symbols indicating the presence of an abstraction, optionally classed according to its purpose based 'type'; or/and
- Symbols sized or classed according to the abstraction rate; or/and
- Source centred 'equivalent recharge' circles. These circles have an area which, when multiplied by the average annual recharge to the aquifer, is equivalent to the annual volume of water abstracted. When coloured according to the number of overlapping circles they provide a simple representation of the areas of ground where natural recharge is potentially committed to abstraction.

Risk assessment pressure thresholds for GW bodies and dependent receptors

The initial risk assessment of groundwater bodies with respect to abstraction pressures is undertaken in stages. The first step is to assess the groundwater balance by reference to the balance of groundwater abstraction pressures versus recharge to the groundwater body with the intention of protecting the main surface watercourses. The second step is develop predictions of risk and impacts, based on assessments of the susceptibility (storage) and sensitivity of key receptors. Where impact evidence is available, this step should also incorporate the assessment of groundwater dependent terrestrial ecosystems (GWDTEs) and surface water bodies (rivers, lakes and transitional waters) to determine whether any impacts are due to groundwater. This latter assessment is receptor focussed to assess the evidence of local impact due to any pressure, and this will include consideration of groundwater dependent terrestrial ecosystems (together with some upland streams and lakes). The third step also focuses on evidence for impacts by identifying areas where groundwater levels are re-bounding and areas where there are poorer quality waters resulting for e.g. from saline intrusion or up-coning. In the case of these intrusions, they will be subject to further analysis to assess their likely impact on groundwater quality, dependent surface waters and terrestrial ecosystems.

<u>Pressures Assessment: GW abstraction as a % of GW body recharge</u>

For initial characterisation purposes and to protect the main surface water courses, significance thresholds for abstraction pressures are likely to be defined as a percentage or series of percentages of average annual recharge (see Table 1 below). These pressure thresholds will be combined with evidence for overabstraction impacts on the groundwater body (Table 2) to map the perceived risk of failure of quantitative status objective in 2015. The percentage thresholds are intended to leave sufficient recharge to meet ecological needs irrespective of the sensitivity of the dependent river reach. It is recognised that a water balance approach may not necessarily protect sensitive areas such as headwater streams (where flows would naturally be low), however:

- the surface water body flow screening assessment should also flag-up the impacts of particularly large groundwater abstractions on headwater streams (paper 7b);
- large abstractions are less common in upland areas; and
- where there is concern about the close proximity of groundwater abstractions to headwaters etc, then a more localised assessment of the likely impact could be made.

The thresholds shown in the table below are suggested as appropriate groundwater balance thresholds on the basis of groundwater resource estimates carried out as part of completed and ongoing CAMS assessments in England and Wales. These previous studies suggest that appropriate percentage recharge thresholds are likely to depend on the hydraulic properties of the GW body. A minimum abstraction threshold of a 10% ratio of abstraction to long term average recharge to indicate a moderate pressure, whilst appropriate to maintaining acceptable summer baseflow from a low storage aquifer (e.g. a fissured limestone), may thus be over precautionary for a higher storage aquifer (e.g. a sandstone). In the table below it is therefore proposed to distinguish GW Bodies with a high specific yield (Sy) from those with a lower Sy, but alternative splits may also be applied (e.g. based on the speed of aquifer flow response). The suggested thresholds (10% abstraction to long term average recharge for lower Sy aquifers, and 20% abstraction to long term average recharge for higher Sy aquifers for moderate pressure and 20% and 30% respectively for high pressure) may not be appropriate for all GW Bodies and may need to be revised or refined in the light of the results of the broader, more representative data set which will become available through the risk assessment for initial characterisation and/or local knowledge. Account may also need to be taken of the reliability and availability of abstraction data when undertaking the pressure assessment, with the thresholds adjusted to reflect poor data availability.

Estimates of GW abstraction/recharge percentages could be carried out for each groundwater body in a number of ways as part of a tiered screening process as follows:

- The simple absence of any pressures (e.g. no existing groundwater abstractions or new sources predicted before 2015) would immediately suggest that the groundwater body was at no pressure and therefore not at significant risk of failing to achieve good quantitative status in terms of recharge and abstraction pressures; or
- An estimate of recharge input to the groundwater body (in Ml/d) can be compared to abstraction rates (in Ml/d) for sources located within it to determine the pressures as shown in Table 1 and then followed by an assessment of impact to determine the risk; or
- The proportion of the groundwater body occupied by the abstraction centred equivalent recharge circles could be calculated in GIS to determine the exposure pressure and again followed by an assessment of groundwater level impacts to determine the risk.

Having mapped the groundwater abstraction pressures consideration must be given to their distribution. Clusters of borehole abstractions could trigger further, more localised assessments of potential impact using, for example, catchment or sub-catchment boundaries (e.g. Hydrometric Areas or CAMS boundaries or SW body typology catchment boundaries). Scale is very important to get the right balance between manageability and pressure recognition and local knowledge could be sought, where available, to reduce iterations by rapid identification of abstraction hotspots.

Table 1

	Average Specific Yield or Storage of GW Screening Unit	
2015 GWABS/Average Recharge	**Low Storage (<5%)**	**High Storage (>=5%)**
>40% i.e. if groundwater abstraction is greater than 40% of long term average recharge	High Pressure	High Pressure
30 to 40%	High Pressure	High Pressure
20 to 30%	High Pressure	Mod Pressure
10 to 20%	Mod Pressure	Low Pressure
2 to 10%	Low Pressure	Low Pressure
<2%	No Pressure	No Pressure

NB Note that the assessment of pressure may also need to take account of distance from particular pressures in certain receptors. Where data availability is poor the thresholds for high and moderate pressure may need to be more stringent.

Dependent Terrestrial and surface water body ecosystem assessments and impact evidence
The combination of this pressures assessment and evidence of groundwater abstraction related impacts will be used to determine the risk category (which is currently based on the risk classifications in UKTAG Paper 7a). The pressure assessment is summarised in Table 1. An example of the combined pressure and impacts assessment is given in Table 2 for recharge and abstraction pressures.

The long term average abstraction/recharge assessment results provide an indication of the abstraction pressure acting on the groundwater body (High/Moderate/Low/No). In order to determine the risk of failing to achieve Good Quantitative Status, other assessments of the evidence for overabstraction impacts will be made. These include any groundwater level monitoring evidence of long term declining groundwater levels. Groundwater level decline is regarded as significant where it is felt to indicate an imbalance between groundwater recharge and groundwater abstractions.

Assessment results from groundwater dependent terrestrial ecosystems (UKTAG Paper 5b) and surface water bodies (UKTAG Paper 7b) will be used to amalgamate the results from all the assessments for the groundwater body, including abstraction and recharge pressures as detailed here.

The individual assessments on GWDTEs and surface water systems will be based on the sensitivity of the receptors and the combining of pressures will only be undertaken to assess whether the pressure/impact on the GWDTE or surface water system is due to groundwater (See Section 6)

Table 2

Exposure Pressure	**Evidence for GW level decline**	**No/ insufficient evidence for GW level decline**	**Evidence of no GW decline**
High Pressure	At Significant Risk (1a)	Probably at risk (1b)	Not at significant risk (low confidence) (2a) to Not at significant risk (2b) based on confidence in the data
Moderate Pressure	At Significant Risk (1a)	Not at significant risk (low confidence) (2a)	Not at significant risk (2b)
Low Pressure	At Significant Risk (1a) to Probably at risk (1b) based on confidence in the data	Not at significant risk (low confidence) (2a)	Not at significant risk (2b)

NB Note that the assessment of risk may vary in receptors known to be of a very high or very low sensitivity.

<u>GW Dependent Ecosystem Receptors</u>
It is intended that detailed guidance will be provided in TAG Paper 5b. In the absence of specific guidance in these papers the risk screening might include the following approaches, depending on data availability across the different UK Agencies:

- Identify the simple presence or absence of any groundwater abstractions within a specified buffer distance (or distances) from the wetland or lake (e.g. 5 km would be consistent with Habitats Directive); or/and
- Estimate the total rates of groundwater abstraction present within the same specified buffer distances; or/and
- Estimate the proportion of the buffer areas occupied by the abstraction source centred equivalent recharge circles ; or/and
- Estimate the cumulative drawdown at the wetland associated with groundwater abstraction based on 'no recharge' time period assumptions and T and S estimates specified by receptor or abstraction source or aquifer type where appropriate ; or/and
- Identify known impacts or the results of existing detailed assessments: List and map those wetlands or lakes where groundwater abstraction impacts are considered to have been damaging to

dependent ecologies or to groundwater quality. This could include the results of any more detailed investigations previously undertaken (e.g. results of Habitats Directive assessments).
The existence of dependent surface water bodies or wetland receptors where groundwater abstraction pressures (e.g. predicted drawdown) are above threshold levels but evidence of ecological impacts is not available will be given less weighting in determining the final risk category but will flag the need for further monitoring.

Groundwater Rebound or Abstraction Related Saline Intrusion
Areas known to be adversely impacted by contamination from rising groundwater level pressures (e.g. in former mining areas) should be identified and mapped based on local knowledge. Areas at risk of groundwater quality deterioration (e.g. saline intrusion) by changing flow directions due to over-abstraction should also be identified and mapped, prompted by a review of the distribution of known abstraction pressures and groundwater quality boundaries. For initial characterisation purposes, such impact evidence will be taken into account alongside the abstraction/recharge pressure assessment results to determine the risk category for the groundwater body (Table 2) and flag the need for further characterisation. Groundwater monitoring data can be used to validate risk assessment.

6. Further GW Body Delineation and Characterisation

The results of pressures and impacts assessments for both for the groundwater body as a whole (7h) and for the GW dependant ecological receptors (7b and 5b) will need to be combined to determine whether the groundwater body would be considered to be at risk of failing to achieve good quantitative status in 2015. The final assessment will determine whether the risk that has been identified at the wetland or surface water system is likely to be due to groundwater. An additional paper or matrix will be used to combine the assessments from 7b, 5a, and 7h to determine whether the groundwater body is at risk of failing to achieve good quantitative status in 2015.

At this stage, further sub-division may also be an option, although it should be remembered that the pressure thresholds are likely to depend on the size of the groundwater body to which they are applied.

7. Relationship with other pressures

The results of the assessment of groundwater abstraction and recharge pressures will be fed into the overall risk assessment framework where they will be combined with the assessment of surface water body flow impacts and water quality impacts. Surface water abstractions from dependent river reaches may, for example, exacerbate the impacts of groundwater abstractions on river flows. Abstraction related flow reductions will also reduce dilution and may therefore exacerbate water quality problems. An iterative approach is needed whereby groundwater abstraction pressure assessment informs surface water assessment which in turn feeds into the next iteration of groundwater assessment.

Annex 1 Flow chart describing overall approach to pressures and impacts assessment