UK Technical Advisory Group on the Water Framework Directive

Paper 11b(ii) : Groundwater Quantitative Classification for the purposes of the Water Framework Directive.

This Guidance Paper is a working draft defined by the UKTAG. It documents the principles to be adopted by agencies responsible for implementing the Water Framework Directive (WFD) in the UK. This method will evolve as it is tested, with this draft being amended accordingly.

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1 Purpose

1.1 The UKTAG Groundwater Task Team has produced two papers describing the classification process for quantitative and chemical status of groundwater bodies during the 2nd River Basin Management Planning cycle.

1.2 Paper 11b(i) details the procedures for translating the definitions of good groundwater chemical status into an operational classification system. The classification system is divided into 5 tests using the criteria for good chemical status as set out in the Water Framework Directive (WFD) and the Groundwater Directive (GWD).

1.3 This paper provides the detailed procedures for the translation of the definitions of good groundwater quantitative status outlined in Annex V of the WFD into an operational classification system. The classification system is divided into 4 tests using the criteria for good quantitative status as set out in the WFD.

1.4 The criteria that define good groundwater quantitative status are fixed within the WFD and cannot be altered. These detailed classification papers use, and build upon, the principles outlined in EC CIS Guidance Document No. 18 (on Groundwater Status and Trend Assessments) to describe how these criteria have been taken and developed into a classification system.

1.5 Environmental standards[1] to be used in regulation and in the derivation of Programmes of Measures (PoM) have been developed from these detailed procedures. The links between classification and regulation are the subject of UKTAG paper11b(iii)[2].

2 Overview of Classification Process

2.1 Achieving ‘good status’ for groundwater involves meeting a series of conditions that are defined in Annex V of the WFD and applied to the whole of the groundwater body.

2.2 Groundwater status was assessed in 2009 for the 1st River Basin Management Planning cycle and the results were reported in the River Basin Management Plans for each River Basin District.

2.3 Future amendments of this classification guidance may be required as better data becomes available in each planning cycle.

2.4 Groundwater status objectives set by the WFD rely in part on the protection of, or objectives for, other associated waters and dependant ecosystems. ***The objectives for these must be known before groundwater classification can be fully completed.*** These associated waters and dependant ecosystems may have different sensitivities to water level and/or pollutants. As a result it is possible that different standards may apply within a single groundwater body to reflect these varying sensitivities.

2.5 In order to assess whether a groundwater body is meeting all the varying criteria for achieving good status, a series of classification tests have been developed for both quantitative and chemical elements. These are outlined in Table 1 and detailed in later sections.

2.6 There are five chemical and four quantitative status tests, some elements of which are common to both.

[1] For groundwater, the term “environmental standards” includes standards or conditions for water quantity, water quality standards, and the threshold values that are discussed in UKTAG Paper 11b(i).

[2] UKTAG Paper 11b(iii)v2 – Application of groundwater standards to regulationv2.

2.7 The variety of classification elements in Table 1 and the inherent uncertainties in our understanding of groundwater flow and quality, all contribute to uncertainty in the classification process. Whilst the WFD emphasises the use of monitoring data during classification, in practice a **weight of evidence** approach, with monitoring data complemented by conceptual understanding and risk assessment data, is essential to ensure reliable classification of groundwater bodies and subsequent proper targeting of measures in the River Basin Planning process.

2.8 For each groundwater body, the worst case classification from the five chemical tests is reported as the overall chemical status of the groundwater body, and the worst case classification from the four quantitative tests is reported as the overall quantitative status. This is the one-out all-out system, as required by the WFD. Thus, if any one of the tests results in poor status, then the overall classification of the body will be poor. The confidence associated with the worst case test result is also reported.

2.9 **Note:** The Groundwater Task Team believes that the production of separate chemical and quantitative assessments (and maps) is more useful than producing "overall" status for each groundwater body because the individual outcomes are easier to communicate and use when implementing measures. However, if the production of a single "overall" status map is a requirement for an Agency, the results of quantitative and chemical status could be combined; if either the quantitative or chemical status is poor, then the overall classification for that groundwater body is poor.

Table 1 - Classification Elements

Classification Element	Classification Test
Common to both quantitative and chemical:	
“No saline or other intrusion” Element And alterations to flow direction resulting from level changes may occur temporarily, or continuously in spatially limited area, but such reversals do not cause salt water or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions. (WFD Annex V 2.1.2) Changes in conductivity are not indicative of saline or other intrusion into the groundwater body (WFD Annex V 2.3.2)	Entry into the groundwater body of either: a) saline water of higher conductivity/salinity from connate or sea water; or b) water of different chemical composition from other groundwater bodies or surface waters and which is liable to cause pollution.
Surface water element No “Failure to achieve the environmental objectives specified under Article 4 for associated surface waters Any significant diminution in the status of such waters”	No significant diminution of surface water chemistry and ecology.
GWDTE element No “significant damage to terrestrial ecosystems which depend directly on the groundwater body”	No significant damage to GWDTE
Quantitative only:	
Water Balance element “Available Groundwater Resource” means the long term annual average rate of overall recharge of a body of groundwater less the long term annual average rate of flow required to achieve the ecological quality for the associated surface waters specified under Article 4, to avoid any significant diminution in the ecological status of such waters and to avoid any significant damage to associated terrestrial ecosystems. (WFD Art. 2 Definitions 27)	Abstraction < (recharge-ecological needs of river bodies)and there are no significant environmental impacts on the groundwater body itself or dependent surface water system
Chemical only:	
No deterioration in quality of waters for human consumption (GWD Article 4.2 b (iii)) and paragraph 4, Annex III)	Meet the requirements of WFD Article 7(3) – Drinking Water Protected Areas
No significant impairment of human uses (GWD Article 4.2 b (iv))	General assessment of quality of the groundwater body as a whole.
No significant environmental risk from pollutants across a groundwater body. (GWD Article 4.2 b (i) and paragraph 3, Annex III).	

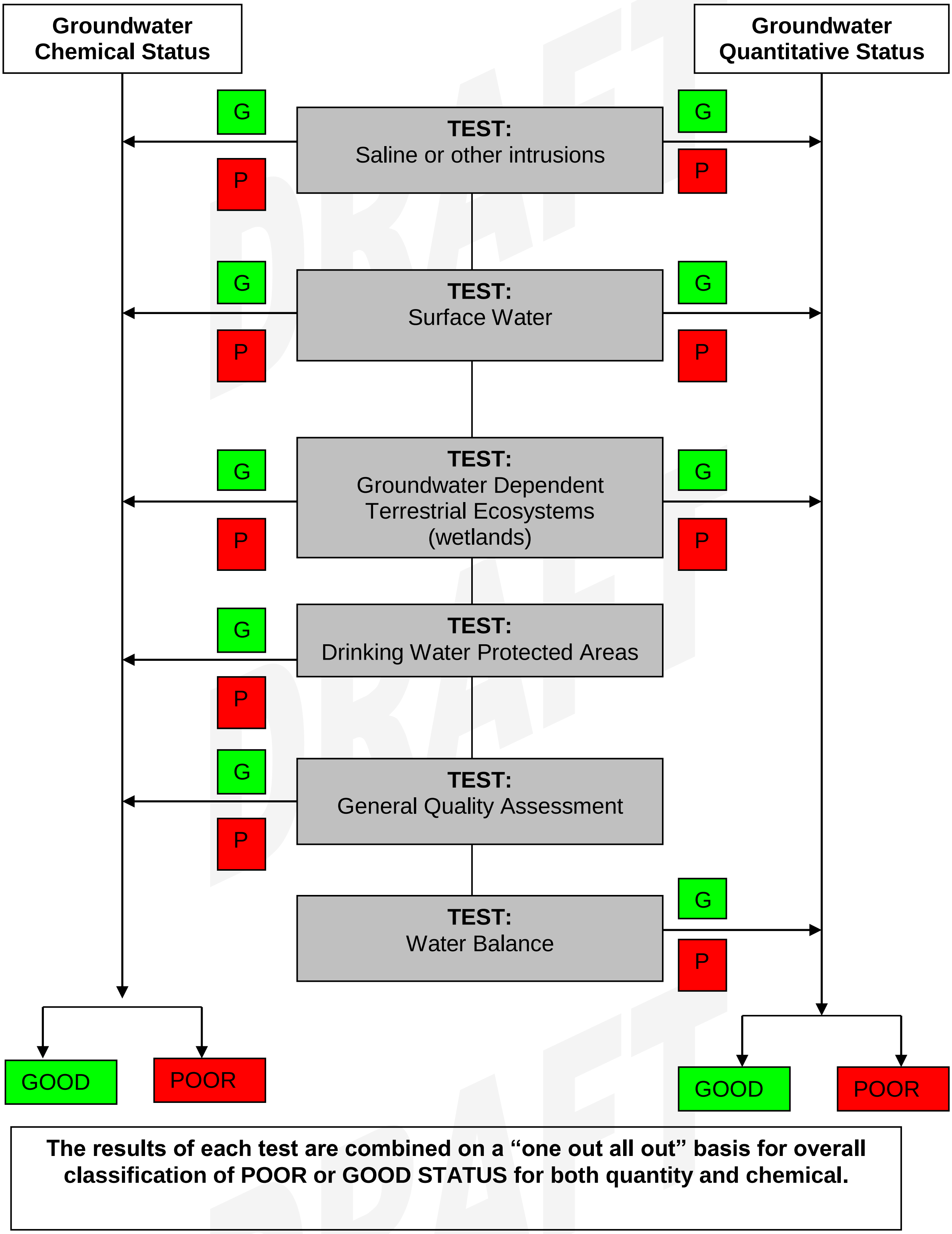

Figure 1.Overview of the Classification Process.

3 Definition of Quantitative status

3.1 The definition of Quantitative status is set out in WFD Annex 5 2.1.2.

3.2 As noted in this Annex, Good groundwater quantitative status is achieved when:

"The level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long term annual average rate of abstraction.

Accordingly, the level of groundwater is not subject to anthropogenic alterations such as would result in:

- *failure to achieve the environmental objectives specified under Article 4 for associated surface waters;*
- *any significant diminution in the status of such waters; and*
- *any significant damage to terrestrial ecosystems which depend directly on the groundwater body.*

and alterations to flow direction resulting from level changes may occur temporarily, or continuously in a spatially limited area, but such reversals do not cause salt water or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions."

3.3 The Quantitative Status definition is framed in terms of the relationship of a range of factors to groundwater level. The use of groundwater level alone does not lead to reliable classification. Groundwater flows are equally important but these cannot be measured directly, but only estimated on the basis of hydrological and meteorological measurements. For this reason it is considered that groundwater levels alone should not be determinative of quantitative status. Annex 1 suggests how they might be used in practice.

3.4 In order to derive a viable classification system, it is necessary to break down the different elements of this definition and interpret this text into elements that are capable of assessment, whilst retaining a meaning that adheres to the spirit of the Directive.

3.5 The above definition of Quantitative Groundwater Status is divided into two parts. The initial section defines an overall measure of the water balance of the groundwater body that can be used as a general indication as to whether current levels of abstraction are satisfactory. The second part of the definition sets out more detailed aims that must be satisfied for the groundwater body to be at good status

3.6 Based upon the definition, this paper sets out a framework of four tests designed to lead to the determination of groundwater quantitative status. A failure to achieve the requirements of any one of these tests will give rise to an overall quantitative status classification of "poor".

3.7 The tests to determine the presence of adverse saline or other intrusions are needed for both the quantitative and chemical status assessments. These tests are intimately connected and therefore have been combined. The Saline or other intrusions test is presented in the Chemical Status Classification paper.

4 Water Balance test

4.1 For this test we must assess annual average abstraction against the available groundwater resource in the groundwater body. This test is applied at the groundwater body scale, in contrast to the Surface Water Test (in Section 5), which is applied at the surface water body scale. This test and the Surface Water Test are complementary tests but are carried out at different scales. In addition to the Surface Water test, this test is also concerned with picking up possible quantitative problems:

- Where a groundwater body may be poorly connected to dependent surface water bodies, and so impacts may not be readily apparent by flow reductions or
- To predict groundwater resources problems, for example by using modelling to understand if groundwater resources are being depleted.

Given the difference in scale it is entirely possible and acceptable to pass this test and fail the Surface Water test. Note: Groundwater bodies are normally large and often have several surface water bodies crossing them.

4.2 The available groundwater resource is calculated from the difference between recharge[3] and the flow required to support the ecology in surface water bodies that are dependent on the groundwater body.

4.3 The annual average recharge should be estimated for the whole of the groundwater body including any recharge water deemed to enter the groundwater body from outside (e.g. run off from adjacent impermeable strata). If there are significant flows between groundwater bodies these should be taken into account in the recharge assessment. However, as most groundwater bodies are likely to have been delineated as hydraulically distinct units (in accordance with UKTAG guidance on the delineation of water bodies), there should not normally be significant flows between them.

4.4 The annual average abstraction rate should include all abstractions from the groundwater body, including any connected confined sections of the aquifer. Abstracted groundwater that has been locally returned to the aquifer or to a river should be discounted (for example, this may occur at a quarry / mine dewatering operation).

4.5 We must determine both the surface water ecological flow requirements, and the impacts of groundwater abstraction on these flows. The method used can depend on the degree to which abstraction pressures affect the groundwater body. Ecological flow needs can be estimated on the basis of:

- local specialist technical knowledge or simple tools such as SNIFFER research project WFD53[4]
- the aggregated flow requirements of individual river water bodies. This should be done using nationally adopted surface water flow 'standards'.
- more sophisticated modelling tools.

4.6 Notably, this comparison of the Available Groundwater Resource with groundwater abstraction **ignores other influences on surface water body flows** – i.e. surface water

[3] Recharge is calculated over a sufficiently long period of time to differentiate between short term perturbations in recharge (e.g. droughts) and the long term average annual recharge

[4] SNIFFER Report WFD53 - Criteria For WFD Groundwater Good 'Quantitative Status' And A Framework For The Assessment Of Groundwater Abstractions

abstractions or discharges. These influences may result in a failure to achieve Good Ecological Status, and they are considered separately as part of the Surface Water Test, as described in Section 5.

4.7 Wherever possible, the abstraction pressure estimates and the discharge estimates that are used in the following tests should be based on our best estimate of what is actually being abstracted or discharged at the time of classification.

4.8 In undertaking this assessment there needs to be a good level of evidence to provide confidence that groundwater resources are being depleted as there are inherent uncertainties in simple bulk (whole groundwater body) recharge and flow needs. Where simple calculations have been used for this test, additional lines of evidence are needed, these are:

- Clear imbalance between recharge and abstraction (i.e. abstraction is greater than recharge)
- Dropping groundwater levels;
- More accurate recharge, abstraction and flow needs values as a result of specific investigations or modeling studies
- Results of modeling studies

Confidence in the assessment is detailed in the table below.

Classification

The steps involved in classification are detailed in (i) to (viii) below:

(i) Calculate the annual average recharge to groundwater.

ii) Calculate the annual average abstraction from groundwater.

(iii) Estimate the groundwater contribution as an annual average needed to support all river ecosystems across the groundwater body.

(iv) Calculate the available groundwater resource. This is the result of step 1 minus the result of step 3.

(v) All those bodies where the available groundwater resource exceeds annual average abstraction will be classified as good status.

(vi) For those where the available groundwater resources does not exceed annual average abstraction, undertake further investigation to improve confidence using lines of evidence as detailed in 4.8 above..

(vii) Expert judgment will be used to assess if these lines of evidence give us sufficient confidence to fail the water balance test.

(viii) Only those which both show that groundwater resource does not exceed annual average abstraction AND that there are additional lines of evidence support this will a groundwater body be classified as poor status for this test.

Table 1: Summary status and confidence table for Water Balance test

Status	Confidence	Criteria
Good	High	Risk characterisation indicates that the groundwater body is not at risk for this test AND Groundwater abstraction impacts are less than the aggregated natural low flow resource.
	Low	Groundwater abstraction impacts exceed the aggregated natural low flow resource but there is no or uncertain evidence of current or predicted groundwater resources depletion (e.g. via modelling) and there is no evidence of existing groundwater resources depletion
Poor	Low	Risk characterisation indicates that the groundwater body is at risk for this test AND Groundwater abstraction impacts exceed the naturally available low flow resource AND There is some evidence that groundwater resources may be depleted at current abstraction volumes (for example using numerical or conceptual models).
	High	Risk characterisation indicates that the groundwater body is at risk for this test AND Groundwater abstraction volumes exceeds recharge volume OR Groundwater abstraction exceeds the naturally available low flow resource and this is corroborated with existing evidence of groundwater resources depletion (falling groundwater levels, disconnection between groundwater and surface water).

5 Surface Water dependent test for Groundwater Quantitative Status

5.1 Surface water and groundwater bodies are intimately connected and pressures on one may impact on the other. This test addresses whether, at a local scale, the pressures from groundwater are having a significant effect on an individual surface water body, taking into account all the pressures on that surface water body. The impacts from groundwater are usually difficult to measure, and in practice they will be determined on the basis of models of the systems or on expert judgement. Where the effects are believed to require remediation, such expert judgement should be tested, usually by some form of modelling or monitoring.

5.2 As part of the surface water characterisation, flow standards for the associated surface water bodies will be set on the basis of recommended flow criteria, or using expert judgement.

5.3 It is rarely possible to make precise or timely measurements of the reduction in flow caused by groundwater pressures, as these increase slowly over extended periods after a new groundwater pressure is applied. The component of the surface water failure due to groundwater will therefore need to be estimated as in 5.4.

5.4 A failure to meet the required flow standard in any surface water body may be due to either groundwater or surface water abstractions. This significance test assesses the proportion of the problem that can be attributed to groundwater abstraction within the total upstream catchment. If greater than 50% of the allowable abstraction can be attributed to groundwater then the groundwater body fails to meet good status for this test

Classification

The steps involved in classification are detailed below:

(i) Associate each groundwater body with a related surface water body or bodies.

(ii) Are any of these related surface water bodies failing their WFD flow standards (e.g. WFD48)?

(iii) If the flow standards are not being met for a surface water body, determine whether groundwater abstraction impacts on this surface water body are a significant component of the failure to achieve flow standards.

(iv) If groundwater abstractions are considered to be significant in <u>any</u> related surface water body that is failing to meet its flow standards, then the groundwater body is at poor status for this test.

(v) If the flow standards are being met or groundwater abstractions are not considered to be causing a significant diminution of flow, then the groundwater body is at good status for this test.

Table 2 Status and confidence table for surface water element test

Status	Confidence	Criteria
Good	High	Groundwater body is not at risk for this test due to (i) there being no dependent surface water bodies or (ii) all surface water bodies being at good ecological status OR Information is available and supporting lines of evidence agree that the groundwater body is not contributing to a surface water body being at less than good status
	Low	Failure of some part of the criteria but all three parts not failed
Poor	Low	Risk characterisation indicates that the groundwater body is at risk for this test AND 1) There is a surface water flow 'deficit', i.e. the river flow is less than the flows needed to support GES AND 2) groundwater abstraction impacts 'are a significant contribution (>50%) of the failure to achieve flow standards'
	High	Risk characterisation indicates that the groundwater body is at risk for this test AND All criteria for this test are failed and there is strong evidence that groundwater abstraction is causing deterioration or impacting on flows so they do not support GES in any of the dependent surface water bodies supported by the groundwater body.

6 Groundwater-Dependent Terrestrial Ecosystems (GWDTE) test

Introduction

6.1 Groundwater dependent terrestrial ecosystems (GWDTE) are wetlands which critically depend on groundwater flows and/or chemical inputs to maintain them in favourable ecological condition (EU CIS Technical Report on GWDTEs, 2011). As part of the assessment of groundwater status, we are required to assess if a GWDTE has been significantly damaged and if the pressure that is causing this damage is from the groundwater body

This section describes the GWDTE[5] test for quantitative status.

Classification

6.2 For groundwater bodies with GWDTEs, the body can be classified using the process outlines in steps (i) – (iv) below:

(i) *Assess relevance of ecological impact:* Assess which wetlands a) contain groundwater dependent communities and b) are significantly damaged which is likely due to a quantitative pressure from groundwater abstractions. The assessment of significant damage is an ecological evaluation of the significance of the ecosystem itself and the magnitude of the damage. This is defined within UKTAG, 2005 'Draft Protocol for determining "Significant Damage" to a "Groundwater Dependent Terrestrial Ecosystem" (GWDTE). If a groundwater body does not have wetland which meets these ecological criteria, then the groundwater body is at good status for this test. Otherwise, proceed to step (ii).

(ii) Further assessment of risk: Identify whether groundwater abstractions could impact on the site, using a number of desk-based methods. This step is a national screening level assessment and uses techniques such as applying a generic conceptual understanding of the groundwater body and whether there is likely to be a direct hydraulic linkage to the site, equivalent recharge circles from the abstraction to predict if any likely impacts and outputs from any any pre-existing studies etc. If there is no evidence that groundwater may be causing the significant damage, then the groundwater body is at good status for this test. Otherwise, proceed to step (iii).

(iii) *Carry out further investigation and classify:* For those sites where there is both 1) relevant ecological damage and 2) evidence that a groundwater could be the cause, further investigation is needed. This step is a site specific assessment. This investigation is to determine whether the GWDTE has been significantly damaged by pressures on the groundwater body. This investigation may require an ecological assessment to confirm the cause of damage and environmental supporting conditions, and/or a more detailed hydrogeological investigation to confirm a connection between the wetland and the groundwater body. This further investigation can include a simple walkover survey of the site, work between expert ecologists and hydrogeologists. The level of investigation required will depend on the ecological evidence and the confidence in the hydraulic linkage between the site and the groundwater body.. If it is confirmed that the necessary environmental supporting conditions for the GWDTE are not being met as a result of pressures transmitted through the groundwater body, and this is the most significant

[5] A GWDTE is a wetland ecosystem on the land surface that is directly dependent on a groundwater body and which is not part of a surface water body.

reason for the failure to meet the environmental supporting conditions, then the body will be at poor status for this test.

(iv) *Assign confidence:* Knowledge of the conditions causing ecological damage in GWDTEs, and of GWDTE interactions with groundwater, remains a developing field. Assessments of confidence will always be site specific involving a subjective evaluation of overlapping hydrogeological and ecological lines of evidence:

- *Poor status classification*: High confidence will be assigned where hydrogeological and ecological monitoring has been undertaken and all supporting lines of evidence validate the conceptual model to confirm that the pressures on the groundwater body are contributing significantly to the damage in the GWDTE.
- *Good status classification:* High confidence will be assigned where either there are no significantly damaged GWDTEs in the groundwater body, or where at least one GWDTE is significantly damaged but site specific information is available and supporting lines of evidence agree that the pressures on the groundwater body are not contributing to the damage.
- For many sites, groundwater level monitoring close to the site may not be available, or it will be difficult to define supporting conditions required within the GWDTE with a high degree of confidence. Under these circumstances the classification will be assigned a low confidence and available evidence should be used to decide if sites are considered ‘at risk’.

Table 3: Status and confidence table for GWDTE test

Status	Confidence	Criteria
Good	High	Risk Characterisation indicates that the groundwater body is not at risk for this test due to no significantly damaged GWDTE in the groundwater body OR Information is available and supporting lines of evidence agree that the groundwater body is not contributing to significant damage at a GWDTE.
	Low	Risk Characterisation indicates that the groundwater body is at risk for this test due to the presence of a significantly damaged GWDTE in the groundwater body AND Insufficient monitoring is available to confirm the conceptual model of pressures and impacts or there is uncertainty surrounding the environmental supporting conditions for the GWDTE OR Further investigation validates the conceptual understanding and confirms that the pressure from the groundwater body is not sufficient to cause the significant damage in the GWDTE. However there is a discrepancy between available monitoring and the conceptual model of pressures and impacts.
Poor	Low	Risk Characterisation indicates that the groundwater body is at risk for this test due to the presence of a significantly damaged GWDTE in the groundwater body AND Further investigation validates the conceptual understanding and confirms that the pressure from the groundwater body is contributing to the significant damage in the GWDTE. However there is a discrepancy between available monitoring and the conceptual model of pressures and impacts.
	High	Risk Characterisation indicates that the groundwater body is at risk for this test due to the presence of a significantly damaged GWDTE in the groundwater body AND All supporting lines of evidence, including groundwater monitoring, validates the conceptual model and the pressure from the groundwater body is significantly contributing to the significant damage in the GWDTE

7 No saline or other intrusions

6.1 The test to determine the presence of adverse Saline or Other Intrusions is needed for both the quantitative and chemical status assessments. It is presented in the Chemical Status Classification paper.

Annex 1 : Discussion on the Use of Level Monitoring

A1.1 **Water balance element.** If groundwater levels are falling in a sustained long-term manner, this will confirm that more water is being abstracted than is recharged during the period of the record, thereby indicating poor status from this element. However, long-term, sustained water levels do not necessarily indicate good status, since the water required to maintain this constant level could be drawn from surface water, potentially causing ecological damage.

A1.2 **Surface Water Element.** If there is 100% surface water / groundwater connection, the rivers tend to anchor the groundwater level to the river level so that variation is minimal. In these circumstances groundwater level is not useful in indicating surface water / groundwater interaction. If there is no surface water / groundwater connection, the level in the aquifer can be above, at or below the river level and by itself does not indicate anything about the effects of groundwater on the river.

A1.3 **GWDTE element.** The groundwater level at or around terrestrial ecosystems is fundamental for improving the conceptual model of how a GWDTE functions. It is an essential tool to confirm groundwater connection but there is no single signal from the level monitoring which implies or confirms this. Rather, it is a combination of absolute level measurements, of accounting for variations in the aquifer properties and flow conditions, wetland strata and the open water area. It will almost certainly involve some sort of model developed to confirm the conceptual understanding. This model will include surface water, groundwater or both.

A1.4 **Intrusion Element.** The determination of intrusion is to be based upon quality rather than level measurement.

A1.5 In low permeability aquifers and karst aquifers, monitoring boreholes may not give a true reflection of the piezometric surface and in some areas, the concept of a piezometric surface will have no relevance. In these circumstances, it may be better to use other indicators of quantitative (and qualitative) status such as river flows and spring flows.

A1.6 It is proposed that the best use of level data is to confirm the functioning of the groundwater body and then use the knowledge to inform the determination of status.