UK Technical Advisory Group on the Water Framework Directive

Paper 11b(i)
Groundwater Chemical Classification for the purposes of the Water Framework Directive and the Groundwater Daughter 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) and the Groundwater Daughter Directive in the UK. This method will evolve as it is tested, with this draft being amended accordingly.

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WFD Requirement:	Classification schemes, environmental standards, groundwater	**UKTAG Review:**	Reviewed Feb 07

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.

1.2 This paper 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 WFD and the Groundwater Daughter Directive (GWDD).

1.3 Paper 11b(ii) provides the detailed procedures for the translation of the definitions of good groundwater quantitative status outlined in Annex V of the Water Framework Directive (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 status are fixed within the WFD/GWDD and cannot be altered. These detailed classification papers use, and build upon, the principles outlined in UKTAG Paper 11b (Outline classification under the WFD) to describe how these criteria have been taken and developed into a classification system.

1.5 Environmental standards to be used in regulation and in the derivation of Programmes of Measures (PoM) will be developed from these detailed procedures. The links between classification and regulation are the subject of UKTAG Paper 11b(iii)[1].

2 Overview of Classification Process

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

2.2 Groundwater status objectives set by the WFD rely <u>in part</u> 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 environmental standards[2] may apply within a single groundwater body to reflect these varying sensitivities.

2.3 The definition of 'good groundwater chemical status' in the WFD was incomplete and Article 17 of the WFD allowed for the elaboration of criteria via a Groundwater Daughter Directive (GWDD). As a Daughter Directive had not been approved by December 2005, Member States had the option to produce their own criteria to complete the definition or to accept a default position, which would have left significant uncertainty surrounding the meaning of chemical status. The UK Administrations decided to adopt the status requirements noted in the

[1] UKTAG Paper 11b(iii) – Application of groundwater standards to regulation.
[2] For groundwater, the term "environmental standards" includes standards or conditions for water quantity, water quality standards, and the threshold values that will be discussed later in this paper.

GWDD-CP[3]. Directions[4] were given to SEPA and the EA to this effect, and Northern Ireland and the Republic of Ireland adopted a similar approach. However, the GWDD as now published (2006/118/EC) does not make substantive changes to the classification requirements in the GWDD-CP and therefore the content of this paper. Criteria for good groundwater chemical status are set out within the WFD Annex V 2.3.2 and are elaborated in GWDD, Articles 3 & 4 and Annexes I - III.

2.4 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.

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

2.6 The variety of classification elements in Table 1, the volume and precision of groundwater monitoring data 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.

2.7 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. 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.

2.8 The results of the tests for quantitative and chemical status are then combined to give an overall classification of good or poor for each groundwater body (Figure 1). If either the chemical or the quantitative assessment is poor, then the overall class will be poor.

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[3] *Common position adopted by the Council with a view to the adoption of a Directive of the European Parliament and of the Council on the protection of groundwater against pollution*, Document no. 12062/05, 9th November 2005, Brussels

[4] Water Framework Directive (Groundwater Quality) Directions 2005, Scottish Executive, The Groundwater (WFD) Direction 2006, Defra

<table>
<tr><th colspan="2">Table 1 - Classification Elements</th></tr>
<tr><th>Classification Element</th><th>Classification Test</th></tr>
<tr><td>Common to both quantitative and chemical:</td><td></td></tr>
<tr><td>“No saline or other intrusion”

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)</td><td>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.</td></tr>
<tr><td>Surface water

No “Failure to achieve the environmental objectives specified under Article 4 for associated surface waters” nor “any significant diminution in the status of such waters”</td><td>No significant diminution of surface water chemistry and ecology.</td></tr>
<tr><td>Groundwater Dependent Terrestrial Ecosystems (Wetlands)

No “significant damage to terrestrial ecosystems which depend directly on the groundwater body”</td><td>No significant damage to GWDTE</td></tr>
<tr><td>Quantitative only:</td><td></td></tr>
<tr><td>Water Balance

“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)</td><td>Abstraction < (recharge-ecological needs of river bodies)</td></tr>
<tr><td>Chemical only:</td><td></td></tr>
<tr><td>No deterioration in quality of waters for human consumption (GWDD Article 4.2 b (iii)) and paragraph 4, Annex III)</td><td>Meet the requirements of WFD Article 7(3) - Drinking Water Protected Areas</td></tr>
<tr><td>No significant impairment of human uses (GWDD Article 4.2 b (iv))</td><td rowspan="2">General assessment of quality of the groundwater body as a whole.</td></tr>
<tr><td>No significant environmental risk from pollutants across a groundwater body. (GWDD Article 4.2 b (i) and paragraph 3, Annex III).</td></tr>
</table>

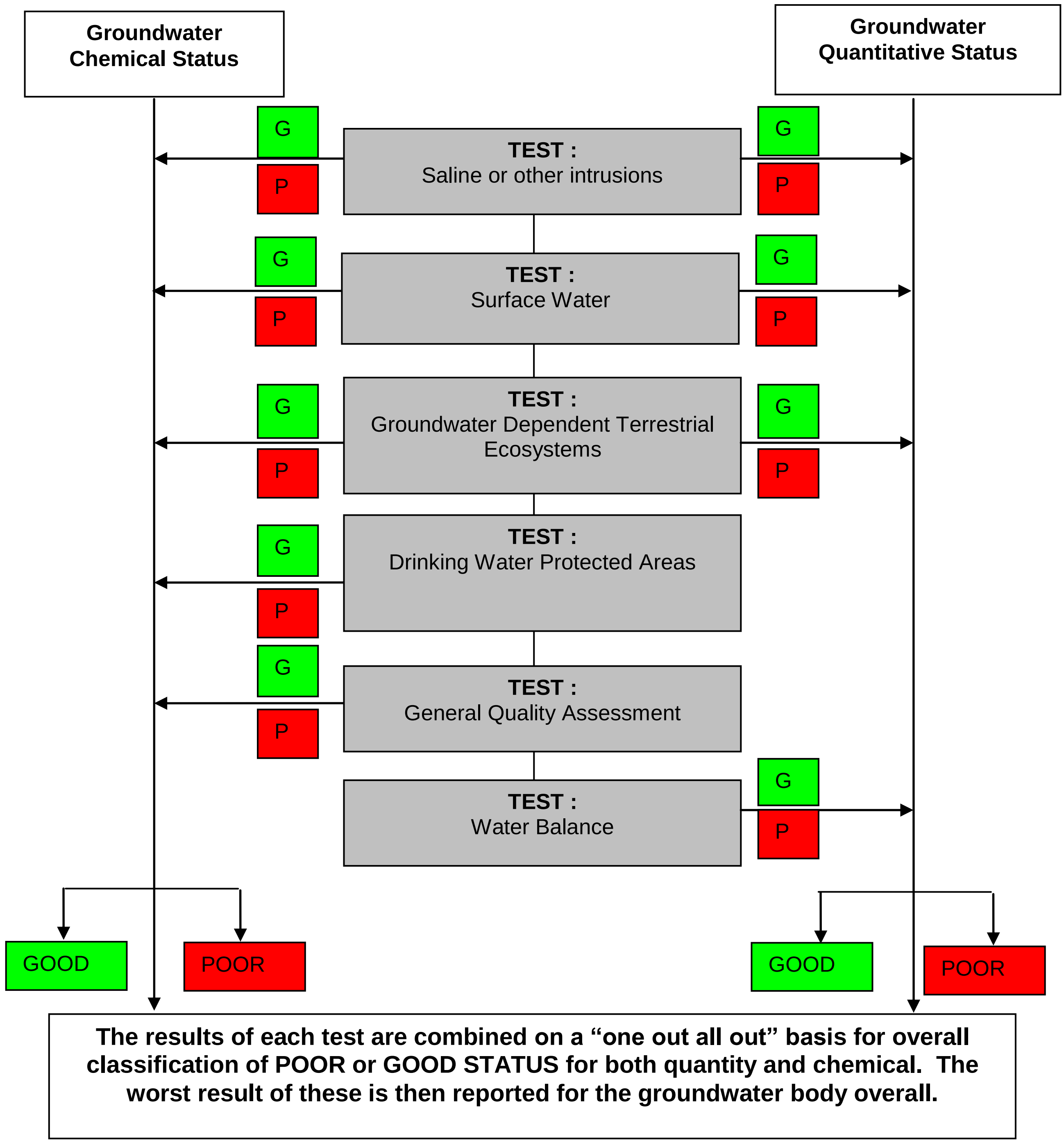


Figure 1 : Overview of the Classification Process.

3 Classification and Threshold Values

3.1 Article 3 of the GWDD states that for assessing chemical status, Member States should use prescribed groundwater quality **standards** for nitrates and pesticides, and locally derived **threshold values** for other pollutants that have been identified as contributing to the characterisation of the groundwater bodies as being at risk. The GWDD provides a minimum list of pollutants that Member States are asked to consider when setting threshold values.

3.2 Threshold values are groundwater quality standards that are to be established by Member States and can be set nationally, or on a local groundwater body scale, for the purpose of assessing groundwater chemical status. Threshold values are triggers, such that their exceedance prompts further investigation to determine whether the conditions for good status have been met, rather than representing the boundary between good and poor status. The groundwater quality standards prescribed for nitrate and pesticides are used in the assessment process in the same way. However, if all standards and thresholds are met at all monitoring points then, under Article 4.2(b) of the GWDD, the groundwater body is considered to be at good status and no further investigation is necessary.

Note: the standards and conditions that are applied to environmental permits should reflect the need to meet all WFD objectives, including good chemical status, but these are not threshold values as described in this paper. UKTAG Paper 11b(iii) describes the link between groundwater classification and the standards used in permits.

3.3 The process of setting threshold values can be complex. Initially, component threshold values will be derived for the purpose of assessing each of the tests for good chemical status. Once each test has been conducted the individual tests must then be assessed together, on a one-out all-out basis. Effectively, the most stringent relevant threshold will apply as the final (reported) threshold. The thresholds will be applied at the strategic operational monitoring points[5] in the groundwater body. Threshold values for a single substance could accordingly vary across a groundwater body, particularly for those substances where there is a highly variable natural background concentration. For simplicity, variation of threshold values across a groundwater body should be avoided wherever possible.

3.4 The threshold value for each test will be appropriate to the receptor being considered in that test, e.g. a groundwater abstraction, an associated surface water body, or a groundwater dependent terrestrial ecosystem. The way in which monitoring data are compared to the thresholds values during classification (whether data are aggregated across the groundwater body or used in isolation) varies between the individual classification tests. This is essential to ensure a reliable assessment of status.

3.5 In accordance with good practice for risk assessment and as an aid to rapid assessment of the potential for not meeting good chemical status, it is also proposed to use **screening values**. They will be used as part of the further characterisation process to enhance and improve the risk assessments already undertaken for Article 5 of the WFD. Typically, the values will be lower and therefore more conservative than threshold values, and will be one of the following:

I. the limit of detection (for synthetic substances);

[5] *Guidance on the Selection of Monitoring Sites and Building Monitoring Networks for Surface Waters and Groundwater*, UKTAG Public Working Draft, May 2005

II. the upper limit of natural background concentrations[6];

III. a reference value that protects the receptor being considered from harm (e.g. EQS)

3.6 In order to compare data from each monitoring point with the screening value, the mean of the last 6 years data is calculated - tying the assessment to the River Basin Planning Cycle. For the first cycle, 6 years of monitoring data are unlikely to be available, so the assessment should be carried out using the best available data. This may lead to reduced confidence in the final assessment.

3.7 **Exceedance of a screening value is an indicator of a potential anthropogenic impact** and that the groundwater body is or might be at risk of failing to meet good status. It is a flag that threshold values might need to be calculated, whereas exceedance of a threshold is a flag that good status may be compromised and detailed investigation is needed.

3.8 If neither screening nor standards/threshold values are exceeded, then the groundwater body will not be characterised as "at risk" and will be classed at good status for that test. This follows Article 4.2 (b) of the GWDD. To ensure a consistent approach throughout classification, assessment under Article 4.2(b) of whether data from any monitoring point exceeds a standard or threshold will be based upon a 95%ile or equivalent, as described in Annex II.

3.9 Exceedance of a screening value should prompt a check whether this exceedance reflects naturally high concentrations in groundwater or whether it is a result of human activity.

3.10 **Exceedance of a threshold value will trigger further investigation** - an assessment of whether the pollution is of sufficient magnitude to prevent the groundwater body achieving its status objectives under the WFD (i.e. it is not just a localised impact). This will be undertaken, for example, using status assessments for surface ecosystems, assessments of loadings to surface receptors or aggregations of groundwater data.

3.11 Only if the concentration of pollutants exceeds the groundwater chemical threshold, **and** any supporting evidence confirms the presence of an impact that compromises the achievement of WFD status objectives, would the groundwater body be classified as poor status.

Note: Where there are insufficient data to conduct a particular test, then in the absence of contrary information, the groundwater body should be assigned good status for that test, but with low confidence in this assessment. In addition, additional monitoring and/or investigation should be put in place so that the test can be properly conducted at the next round of classification.

3.12 The wording of the GWDD implies that threshold values are needed (and therefore could be reported) for each test. Annex 1 outlines these screening and threshold values. For two tests (Saline/other intrusions and Drinking Water Protected Areas) thresholds are used in combination with trend assessments and should not be reported in isolation of these assessments.

[6] "Background Level" is defined in the GWDD as "the concentration of a substance or the value of an indicator in a groundwater body corresponding to no, or only very minor, anthropogenic alterations to undisturbed conditions

4 No saline or other intrusions.

Key concept:
Status, and the presence of an intrusion of poor quality water into the groundwater body, is determined through an assessment of trends in Electrical Conductivity (EC) or other indicator substances. The test is designed to detect the presence of an intrusion that is induced by the pumping of groundwater.

Threshold Values:
Set at the upper limit of the natural background range for key determinands. Threshold values are only used in combination with trend assessment.

The conditions for good chemical status are not met when:
Threshold values are exceeded **and** there is either a significant and sustained rising trend in one or more key determinands at relevant monitoring points or there is an existing significant impact on a point of abstraction as a consequence of an intrusion.

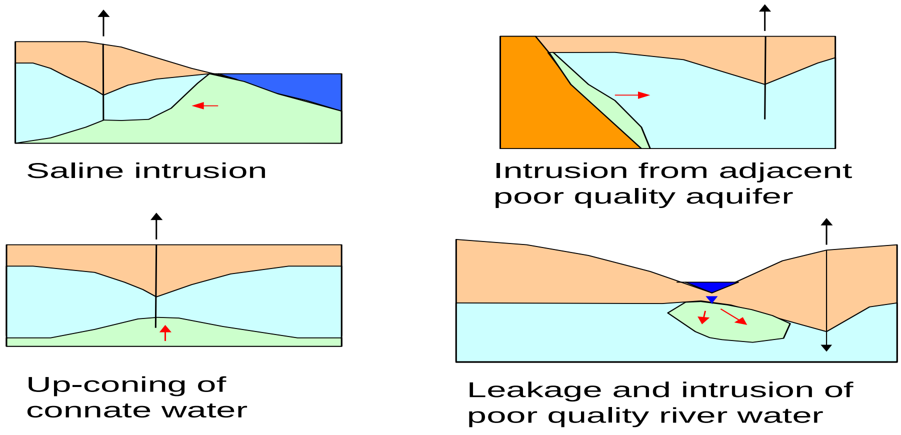
4.1 This test is also used in the assessment of groundwater quantitative status as it assesses a chemical impact caused by a quantitative pressure.

4.2 An intrusion is interpreted to be intrusion of poor quality water into a groundwater body from another water body, rather than the movement of a plume of poor quality water within the body. Types of intrusions that are considered in this assessment are illustrated in Figure 2.

4.3 The test outlined in Figure 3 should be repeated for all relevant chemical determinands where initial characterisation has identified that the groundwater body is at risk of not being at good status for saline or other intrusions. The test is conducted at those monitoring points that have been identified as being representative of potential intrusion conditions. The list of chemical determinands will depend on the results of risk characterisation and should be representative of the pressure acting on the groundwater body.

4.4 As a minimum, electrical conductivity should be assessed for all groundwater bodies where abstractions occur and there is a risk of saline or other intrusion. For groundwater bodies identified as being at risk from other intrusions, additional determinands can be selected as appropriate.

4.5 The WFD indicates that the presence of an anthropogenically induced intrusion in a groundwater body will result in it being at poor status. However, measuring the extent of an anthropogenic intrusion is complex, given that the influence of seawater is a natural feature of many groundwater bodies near the coast, and some groundwater bodies have naturally elevated levels of salinity due to the geochemistry of the aquifer. For this test, due to the complex fluctuation of groundwater quality adjacent to the freshwater-saline interface, numerical threshold values would not be definitive on their own. A “lines of evidence” approach is proposed to confirm the presence of such an intrusion.



4.6 In the first instance groundwater monitoring and pressure data should be screened against:

- The upper limit of natural background range in groundwater quality in the groundwater body on the “fresh” side of the freshwater/saline water interface, and/or
- Recharge versus abstraction ratios obtained from the quantitative assessment.

This evidence can then be used, in conjunction with characterisation and pressure data to assess the risk and likelihood of an intrusion.

4.7 Exceedence of the screening values above indicates that there is a risk to the groundwater body. Threshold values shall be set as the screening values but only used in conjunction with a trend assessment. A trend assessment should be carried out for key elevated chemical substances at relevant monitoring points. When assessing trends, an indication of confidence should be included in order to determine that the trend is anthropogenic, rather than a function of natural variation. Where possible, statistical rigour should be applied to the assessment of confidence, as discussed in UKTAG paper 12a[7].

4.8 If there is a statistically significant and sustained upward trend, the body should be classified as being at poor status. An investigation should be made into the cause(s) of the trend to confirm the assessment. The reported threshold values in this instance are the upper limits of natural background range for the key determinands. However, they should only be reported in combination with the trend assessment.

4.9 If no upward trend can be identified, an assessment should be undertaken to assess whether there has been previously or is currently an impact on any point of abstraction. If it can be demonstrated that there has been a significant impact (taken for these purposes to be that the abstraction is rendered unsuitable for use without additional treatment), and that natural background concentrations continue to be exceeded, the body should be classified as being at poor status.

[7] *Guidance on the Selection of Monitoring Sites and Building Monitoring Networks for Surface Waters and Groundwater*, UKTAG Public Working Draft, May 2005

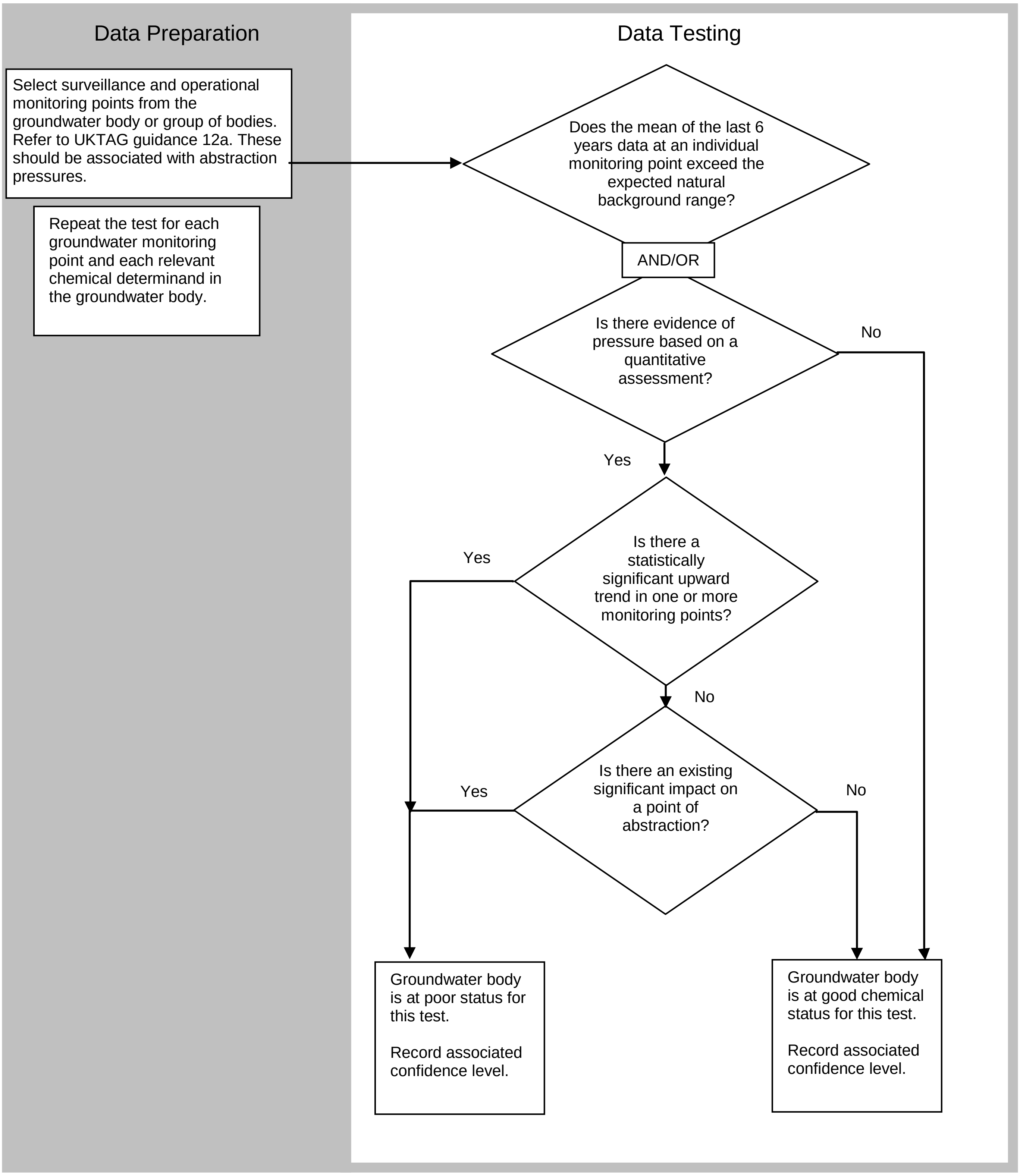


Figure 3 - Outline of procedure and data preparation for status test for saline or other intrusions

5 No significant diminution of surface water chemistry and ecology.

Key concept:
Status is determined through a combination of surface water classification results and an assessment of chemical inputs from groundwater bodies into surface water bodies. The surface water bodies can comprise rivers, standing waters, and transitional waters. The test is designed to determine whether the contribution from groundwater quality to surface water quality or any consequent impact on surface water ecology is sufficient to threaten the WFD objectives for these associated water bodies.

Threshold Values :
Surface water quality standards adjusted by dilution and, where appropriate, attenuation factors.

The conditions for good chemical status are not met when:
An associated surface water body does not meet its objectives, threshold values are exceeded and groundwater contributes at least 50% of the relevant surface water standard.

5.1 The test is outlined in Figure 4 and should be repeated for all relevant chemical determinands in groundwater bodies where the initial characterisation indicates that there is a risk of it failing these status objectives. The data may be aggregated across a groundwater body or bodies, or assessed at individual points depending on the nature of the pollution (see below). The list of chemical determinands will depend on the results of risk characterisation and the results of the surface water status assessments. Where a surface water body fails to achieve the relevant objectives set for it, the assessment should be carried out for the pollutants responsible for that failure.

5.2 Relevant objectives for surface water bodies will normally be good surface water status or, for artificial or heavily modified water bodies, good ecological potential or good surface water chemical status. However, where a lower objective has been set for the surface water, and this is not as a consequence of poor groundwater quality, then the groundwater body should not be classified as at Poor Status.

5.3 The groundwater quality monitoring data should be screened against the relevant surface water quality standard for each of the identified pollutants. These standards will be taken from the physico-quality elements of surface water status classification. Given the surface water standards that will be available in the first River Basin Planning cycle, the only determinands likely to be of relevance to groundwater are: phosphorous (primarily for diffuse pollution); ammonium (primarily for point source pollution); acidity; metals (primarily for mine water discharges); and Environmental Quality Standards for specific pollutants.

5.4 The above screening will identify where potential problems may exist. However, before proceeding to derive threshold values in detail there should also be a check that perceived impacts on surface water are not simply a reflection of natural baseline quality of the groundwater body. This should be flagged with those responsible for surface water classification.

5.5 If the impacts on surface water are due to anthropogenic pressures, threshold values can then be derived for each chemical determinand of concern. A single threshold can be derived for the catchment of the surface water body, or thresholds can be derived for subdivisions representative of variations in pressures or geological conditions. The threshold will be derived from the <u>higher</u> value of either:

- upper limit of natural background range; or
- a surface water quality standard, adjusted (by dilution and attenuation factors) to allow for the proportion of groundwater flow to total flow in the surface water body, and attenuation within the aquifer/stream sediments. The calculation should be performed using the most rigorous conceptual and numerical understanding available for groundwater - surface water interactions in the catchment.

5.6 Where more elaborate models are not available, dilution factors can be derived from simple indices such as baseflow index or the proportion of groundwater recharge to effective precipitation. In these instances, used:

$$\text{Threshold Value} = \frac{\text{Surface Water Quality Standard}}{\text{Dilution factor}}$$

Where the dilution factor is normally in the range between 0.1 and 0.9

5.7 Where attenuation factors cannot be derived, thresholds for non-conservative contaminants should only apply at monitoring points that are representative of the groundwater contribution to the surface water.

5.8 For standing waters, the relevant value can be calculated from the estimated groundwater input at the surface water outlet. For transitional waters, the value can be calculated from the estimated groundwater input at the tidal limit.

5.9 For consistency, all the data measurements in this test are based on long-term averages. Thus, the monitoring data should be averaged over a six-year timescale, baseflow contribution is generally calculated on an annual average basis, and compliance against surface water standards is also carried out based on annual averages.

5.10 When comparing monitoring results with the thresholds, an indication of confidence should be included. Where possible, statistical rigour should be applied to the assessment of confidence, as discussed in UKTAG paper 12a (Monitoring).

5.11 With reference to Figure 4, groundwater results can be compared with the relevant thresholds as follows:

5.11.1 Six-year averages from relevant groundwater monitoring points are calculated and, where appropriate (see below), aggregated across the groundwater body. Where hydrogeological conditions are relatively uniform and impacts are distributed along a surface water body (typically due to diffuse pollution), a simple aggregation across the catchment of the surface water body can be used. Results can then be compared with the thresholds identified in paragraph 5.5

5.11.2 Where significant variations in hydrogeological conditions occur, the surface water catchment should be subdivided into representative areas (refer to paragraph 8.7). Groundwater monitoring points (including suitable points from outside the catchment) can be associated with these areas. Aggregate concentrations can then be estimated in each representative area, using a 6-year average at individual monitoring points. The overall pollutant loading in the surface water due to groundwater can then be estimated from an understanding of groundwater / surface water dilution factors and attenuation rates.

5.11.3 Where more elaborate conceptual models are not available, dilution can be incorporated for each representative area using average annual groundwater recharge estimates. The pollutant loading to surface water from groundwater can be calculated as follows:

$$\text{Concentrations in SW due to GW} = \frac{(\text{GW Flow from Area}_1 \times \text{average conc in Area}_1 + \ldots\text{GW flow from Area}_n \times \text{average conc in Area}_n)}{\text{Average annual flow in surface water}}$$

In this example, the result is an estimate of concentrations in the surface water due to groundwater, taking account of dilution in the receiving water. The results can therefore be compared directly with the relevant surface water quality standard.

Where impacts from groundwater are confined to discrete reaches along the surface water body (possibly because the pollution is from a more restricted area or point source), the assessment may be restricted to a comparison of appropriate surface and groundwater monitoring points close to where they interact. Aggregations across a catchment will not be necessary. The assessment should determine whether the loading of pollutants from groundwater is of sufficient magnitude to result in exceedance of the surface water thresholds, taking into account dilution in the receiving watercourse.

5.11.4 Where groundwater inputs to surface water are more obvious (e.g. mine water resurgences), classification can be based on a comparison of surface water quality upstream and downstream of the point of impact. In these instances, groundwater monitoring data can be used as qualitative supporting information to indicate the substances to be monitored in surface water.

5.12 Once these loading calculations have been undertaken, and the predicted concentrations in the surface water body have been defined, they should then be compared directly with the relevant surface water standard. The groundwater body would be at poor status if:

- The surface water body is at less than good status; and
- The pollutant loading from groundwater results in a concentration in surface water of at least half of the relevant surface water standard. For example, if the surface water standard is 1 mg/l, then the groundwater must give rise to a concentration of at least 0.5 mg/l in the river.

It is assumed that in these circumstances both the groundwater body and the surface water body will be at less than good status.

5.13 Where mine water impacts on surface water have been identified, expert judgement can be used regarding the relationship of the mine to the groundwater body. The emission of pollutants from the mine must be associated with the groundwater body for it to have any bearing on classification of that groundwater body.

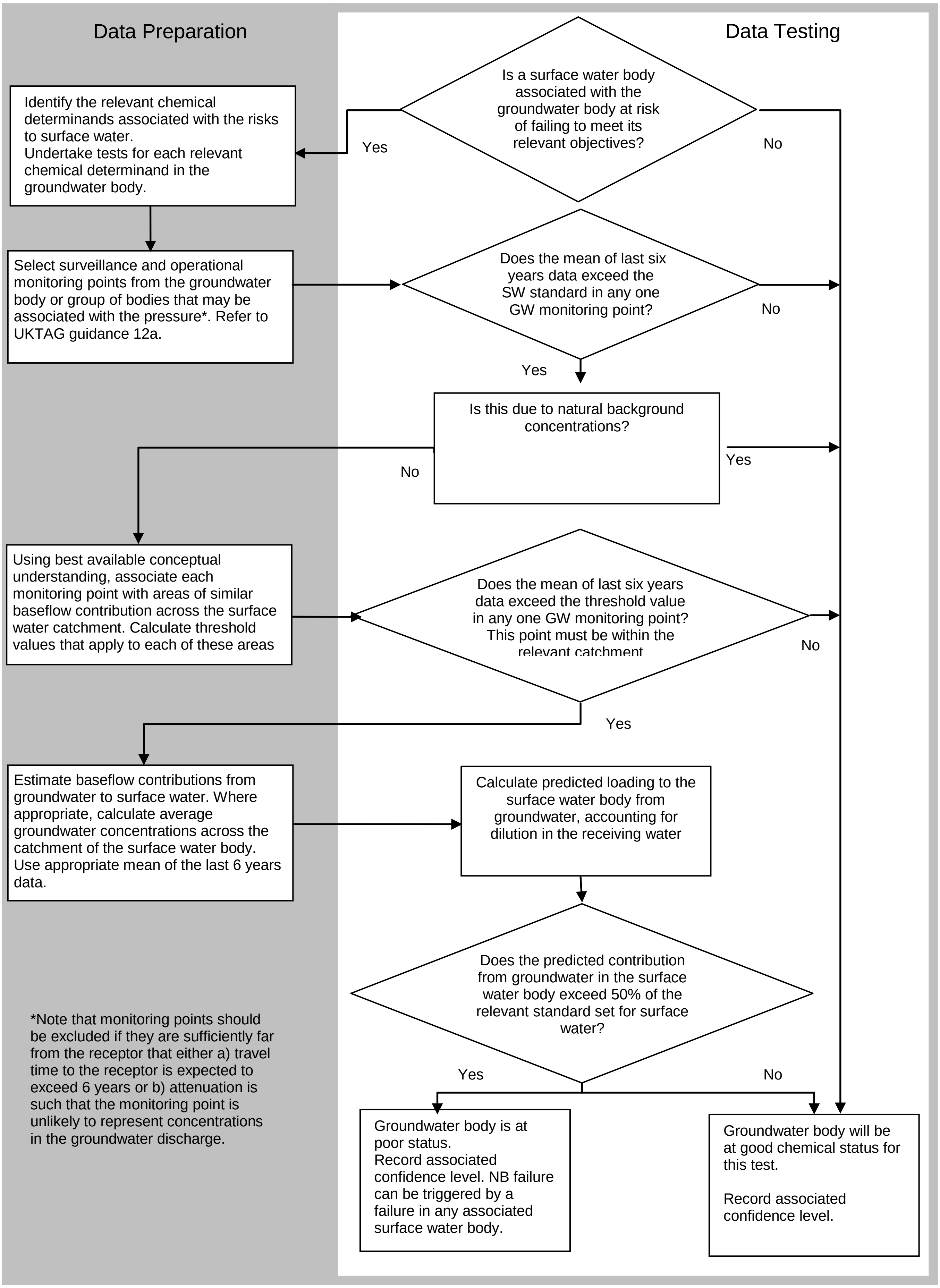


Figure 4 - Outline of procedure and data preparation for status test for significant diminution of surface water chemistry and ecology

6 Groundwater Dependent Terrestrial Ecosystem (GWDTE).

6.1 As the chemical and quantitative assessments for this test are intimately connected, they are described in the Quantitative classification paper.

7 Drinking Water Protected Areas (DWPA).

Key concept:
Good chemical status requires an assessment at the point of abstraction for water intended for human consumption, of whether there is a deterioration in groundwater quality due to anthropogenic influences that could lead to an increase in purification treatment. Note: the stated aim of the DWPA objective in the WFD is to provide the necessary protection to avoid deterioration in water quality in order to reduce the need for purification treatment. This has been interpreted as a minimum requirement to prevent deterioration in groundwater quality at the point of abstraction for drinking water supply. (Note: more general or widespread deterioration in groundwater chemical quality is dealt with by other WFD objectives.)

Threshold Values :
An appropriate percentage (see Annex II) of Drinking Water Standards or any other requirements to ensure that drinking water is free from contamination that could constitute a danger to human health (in accordance with the Drinking Water Directive)

The conditions for good chemical status are not met when:
There is a significant and sustained rising trend in one or more key determinands at the point of abstraction and threshold values are exceeded.

7.1 This test is designed to assess groundwater quality trends from the current baseline and the relationship of this baseline to drinking water standards. It is not influenced by the treatment plans of water suppliers. It is not an assessment of whether groundwater is suitable for drinking water purposes. A groundwater body could be at good status but contain water that is only suitable for drinking with purification treatment.

7.2 The test is outlined in Figure 7. It comprises two basic elements, firstly an assessment of whether existing untreated water quality exceeds a threshold and secondly whether there is a deterioration (increasing trend) that could result in the need for new or additional purification treatment. The trend should be predicted forward for at least one River Basin Plan cycle and any assessment of status should take account of predictions for the current cycle. The existing groundwater quality must be defined in order to set a baseline against which future trends may be assessed.

7.3 The assessment point for this test is in the raw water at the point of abstraction of “water intended for human consumption” (as defined in the Drinking Water Directive). Not all such abstractions need to be assessed. Representative assessment (abstraction) points should be selected, based on the conceptual model of the groundwater body, the pressures and impacts assessment and knowledge of the pattern of abstraction.

7.4 Not all changes in groundwater quality are anthropogenic or are significant for the supply of drinking water. Purification treatment (including blending between sources) may be installed to deal with both anthropogenic and natural contamination. Moreover, treatment that is already installed for one determinand can mask a significant deterioration in another determinand, which if assessed on its own, would require new or additional treatment. Figure 5 illustrates this point.

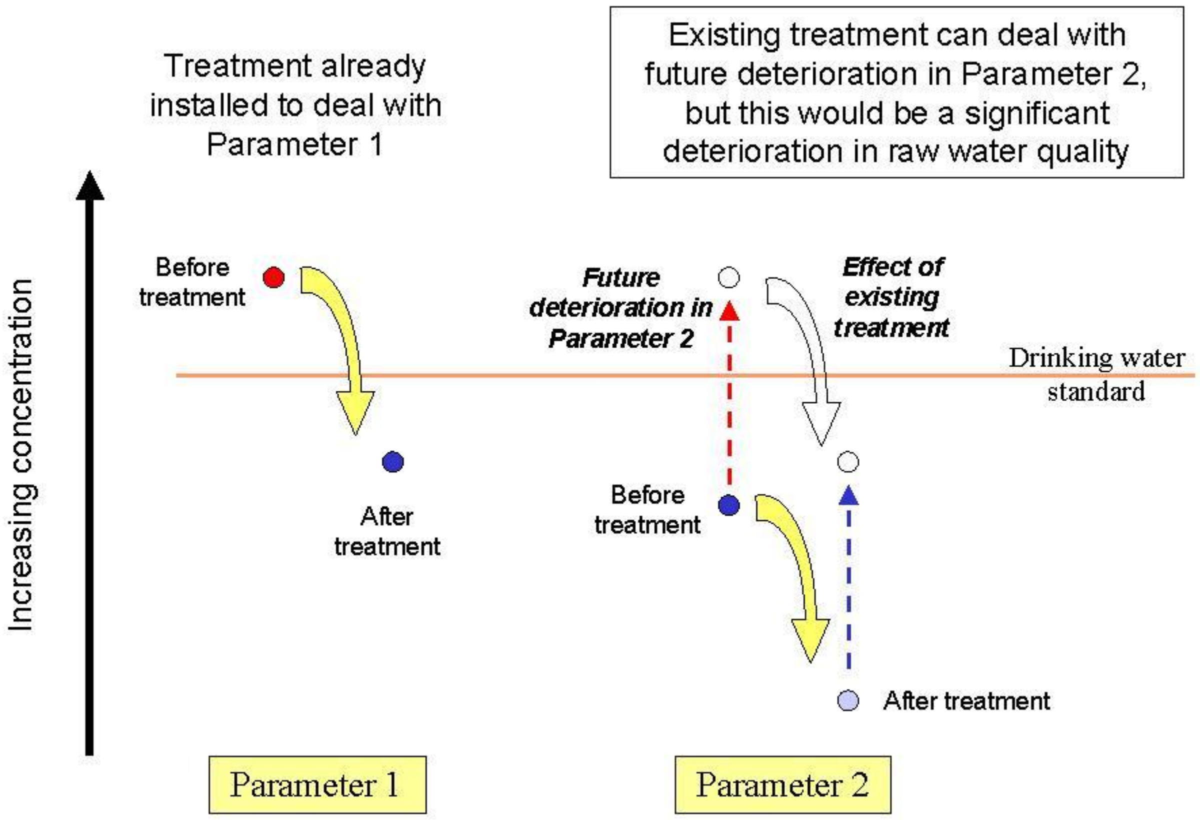


Figure 5 - Significant deterioration and treatment

7.5 Data on existing treatment systems, their purpose and effect is complex and subject to change for many reasons. As the focus is on changes in raw water quality, knowledge of treatment systems is unnecessary to conduct the basic test, and treatment data will not be used routinely in this test. However, evidence of the presence and nature of treatment may be useful supporting data in some circumstances.

7.6 Note: all determinands within the scope of the Drinking Water Directive, including chemical, microbiological and radiological determinands should be assessed, on a risk basis (this may require further characterisation to adequately define such risks). For some determinands there may not be a formal DWD drinking water standard. However, in order to meet the DWD's need to take account of "any other requirements to ensure that drinking water is free from contamination that could constitute a danger to human health", responsible bodies may have defined a value that represents no risk to human health. In this text both the formal drinking water standards and these "local" standards are referred to as relevant standards.

7.7 **Initial screen**: determine if mean concentrations from raw water data for the relevant individual monitoring points (as noted in 7.3) are less than the threshold value defined in accordance with Annex II and based on relevant standards. If so, the data pass this initial screen and the groundwater body is at good status for this test. Note: the default 75% noted in Annex II may be used if the detailed analysis to produce an "appropriate percentage" has not been conducted or is not possible.

7.8 During the initial screen determinands should be identified where the mean concentration in groundwater quality is a high proportion (for example, 50%) of the relevant standards and/or have been identified as contributing to the "at risk" designation of the groundwater body. This is to identify, for the purposes of conducting trend assessment, those determinands that could trigger the need for purification treatment should any deteriorating trends continue, but to screen out substances where there is no such risk and trend assessment is unnecessary.

7.9 For the determinands so identified the monitoring data should be compared with the natural background concentration. If any failure of the initial screen or any elevated concentration is entirely due to natural concentrations, then the body is at good status and further assessment is not required for this parameter. Natural quality could fail the relevant standards. The reported threshold value should therefore be adjusted to reflect the upper limit of the natural background range for that parameter. As a consequence some threshold values may be above the relevant standards due to natural circumstances.

7.10 **Main test** : where one or more determinands fail the initial screen and are identified as being a risk due to anthropogenic influences then the following should be undertaken:

a) Set an existing baseline condition for each parameter, ideally using existing quality assured raw groundwater quality monitoring data. Where insufficient existing data exist then this requirement should be incorporated into WFD monitoring programmes so that a baseline can be set as soon as possible.

b) Conduct a trend assessment on the raw groundwater quality data for each parameter to determine whether there is a statistically significant trend. The level of confidence in this trend should be determined.

7.11 If the data are sufficient to detect trends with confidence and no deterioration is observed, the groundwater body is at good status for this test (Case 1 – Figure 6).

7.12 If there is a statistically significant deterioration, further assess the data to confirm that the deterioration is due to anthropogenic influences (which will normally be the case where there is confidence in the trend).

7.13 Where the thresholds defined for the initial screen are exceeded **and** there is a statistically significant trend (with sufficient confidence) due to anthropogenic influences then the groundwater body does not meet good status (Case 2).

7.14 Where the thresholds are not exceeded but there is a statistically significant trend then predict forward for at least one River Basin Plan cycle from the existing baseline. This is to determine whether any deterioration in quality due to anthropogenic influences is significant in terms of triggering the need for purification treatment. If the trend is predicted to cause an exceedence of a threshold in the current plan cycle, before measures are due to be implemented, then the groundwater body does not meet good status (Case 3). If the exceedence is predicted to take place beyond this point then the body is good status for the present but should be flagged as being at risk of failing good status in the future (Case 4).

7.15 In some cases and in particular during the first cycle of River Basin Planning there may be insufficient data to identify statistically significant trends or there may be low confidence in the trend. However, there may be other evidence of deteriorating quality. This may be pressure data from characterisation, evidence of the installation of treatment or increased treatment at abstraction sources etc. Where there are multiple lines of evidence from both pressure and impact data that all point to deteriorating quality and a need for increased treatment, then if thresholds are exceeded, the groundwater body does not meet good status (Case 2 – determined on weight of evidence). Where thresholds are not exceeded the groundwater body does meet good status but is at risk of failing good status (Case 4 – determined on weight of evidence).

7.16 The four outcomes are represented in the following diagram.

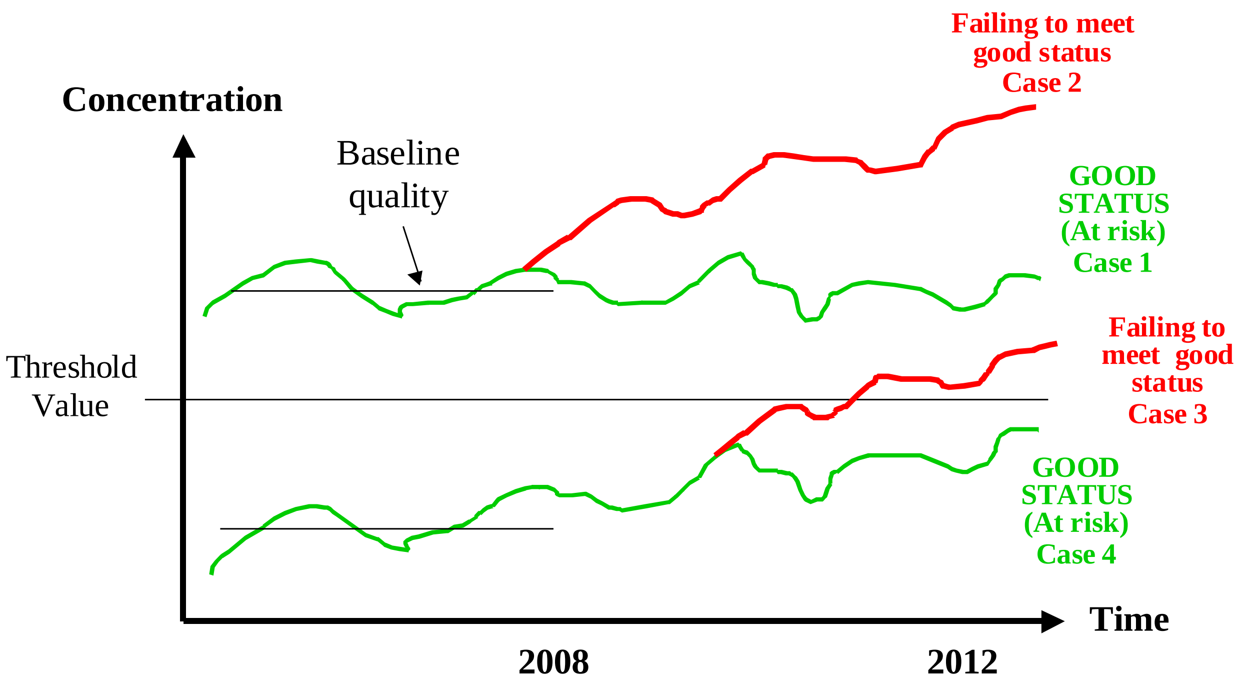


Figure 6 - Different outcomes for this test

7.17 In both of the cases noted above where the groundwater body is at risk but of good status, it would be a priority within the River Basin Planning process to consider measures to prevent any potential deterioration in status.

7.18 This test relies on both threshold values and a trend assessment used **in combination**. The reported threshold values (which should not be used in isolation of the trend assessment) are the concentrations that are exceeded for each relevant parameter for each monitoring point. They will normally be an "appropriate percentage" of the relevant standard, as noted in Annex II.

7.19 An indication of confidence should be included in the assessment of thresholds and trends. Where possible, statistical rigour should be applied to the assessment of confidence, as discussed in UKTAG paper 12a (Monitoring).

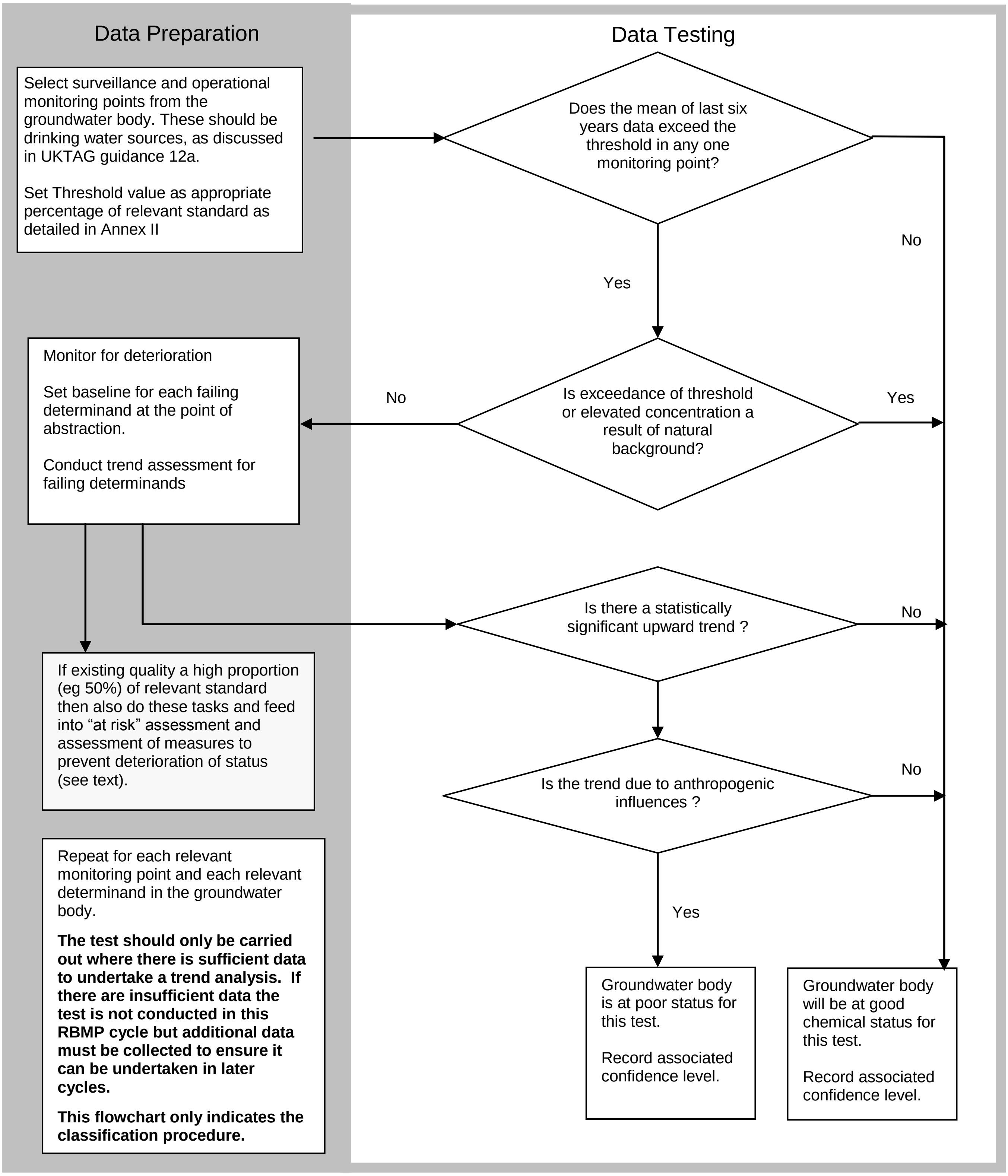


Figure 7. Outline of procedure and data preparation for status test for drinking water protected areas.

8 General assessment of quality.

Key concept :
Status is determined through an assessment of the areal extent of a groundwater body exceeding a threshold value for a pollutant. It is only conducted for determinands for which:

- an EU prescribed standard is set; or
- the risk characterisation process has indicated that pollutants may cause significant impairment of human uses of groundwater.

Threshold Values :
An appropriate percentage of the EU prescribed standards for nitrates and pesticides or a use-related standard that is appropriate for existing or planned use of the groundwater body.

The conditions for good chemical status are not met when:
Threshold values are exceeded at individual monitoring points, and a representative aggregation of the monitoring data at the groundwater body scale indicates that there is a significant environmental risk or a significant impairment of human uses of the groundwater body.

8.1 The test is outlined in Figure 8. It is designed to assess whether pollution in a groundwater body is of sufficient extent to compromise either the prescribed standards or human uses of the groundwater body as a whole. It is not intended to assess local pollution impacts. Data are aggregated from sites representative of the groundwater body or group of groundwater bodies and compared with standards or thresholds. The aim is to identify if the combination of the spatial extent and degree of exceedance of the threshold represents a significant environmental risk. Examples of acceptable approaches to aggregation are presented below.

8.2 The test should be undertaken for nitrates and pesticides (as prescribed common standards) and those pollutants that have been identified in the risk characterisation process as causing the groundwater body to be at risk.

8.3 This test should only be carried out where there is sufficient monitoring across the groundwater body or group of groundwater bodies to assess the potential for widespread impact of pollutants.

8.4 Screening will be undertaken at individual monitoring points using an appropriate mean of the last 6 years data to identify how widespread a problem might be. The screening values for different determinands can be found in Annex I of this paper and include the groundwater quality standards for nitrate and pesticides prescribed within Annex I of the GWDD.

8.5 In accordance with the GWDD, threshold values need only be derived for other relevant pollutants where there is the potential for widespread impact across the groundwater body. Where applicable, they will be derived from the higher value of either:

- upper limit of natural background range; or
- an “appropriate” percentage of any relevant use based standard (see Annex II)

This assessment is required to address the ability of the groundwater body to support human uses. As the protection of water intended for human consumption is primarily covered by the drinking water protected area test, human uses other than drinking water will be a particular focus.

8.6 With reference to the procedure outlined in Figure 8, data preparation and testing should be based on an understanding of the variation in risk and measured impacts across the groundwater body or relevant group of groundwater bodies, within the context of a conceptual model. The groundwater body may be subdivided into areas representative of the distribution of chemical pressures, flow characteristics and vulnerability.

8.7 Where more elaborate models are not available, data aggregation can be undertaken on the basis of either:

- Area-weighted aggregation using representative areas. These are areas representative of the variation in conditions across the body (or group of groundwater bodies) and can be identified on the basis of land use pressure, vulnerability, and groundwater flow type. Monitoring data can be aggregated across each representative area and the results for all representative areas in a groundwater body can then be combined through an area weighted average as follows:

$$\text{Weighted average} = \frac{\text{Area}_1 \text{ x average conc}_1 + \text{area}_2 \text{ x average conc}_2 + \ldots \text{area}_n \text{ x average conc}_n}{\text{Total Area of all representative areas in the groundwater body}}$$

or:

- Area-weighted aggregation using the zone of contribution of each monitoring point. The zone of contribution (or groundwater catchment area) of each point can be calculated from an understanding of recharge and abstraction rate at that point. A relative weighting can be assigned to the data from each monitoring point based on the relative size of the zone of contribution. Monitoring data from all points can then be combined into a single area weighted average. It should be noted that individual monitoring points should be selected so as to be collectively representative of the land use pressure, vulnerability, and flow type across a groundwater body.

or:

- If no significant variations exist across a groundwater body of group of groundwater bodies, the calculation becomes a simple aggregation across all relevant monitoring points.

8.8 In summary, this test involves three broad steps:

i) Set and apply screening and threshold values at individual monitoring points.

ii) Where monitoring data exceed the threshold value, carry out further investigation to assess if there is significant environmental risk or a significant impairment of human uses of the groundwater body. This investigation comprises an appropriate aggregation of monitoring data based on a conceptual model. If the aggregated result exceeds an appropriate percentage of the relevant use based standard, then the groundwater body will be at poor status.

iii) Confidence in the assessment should be provided, where possible, applying statistical rigour, as discussed in UKTAG paper 12a (Monitoring). Confidence will be increased where there is additional evidence such as actual impacts (pollution incidents, closure of abstractions or installation of treatment due to quality problems arising from anthropogenic influences), the presence of existing action programmes (e.g. extensive nitrate vulnerable zones), good quality risk assessment data etc.

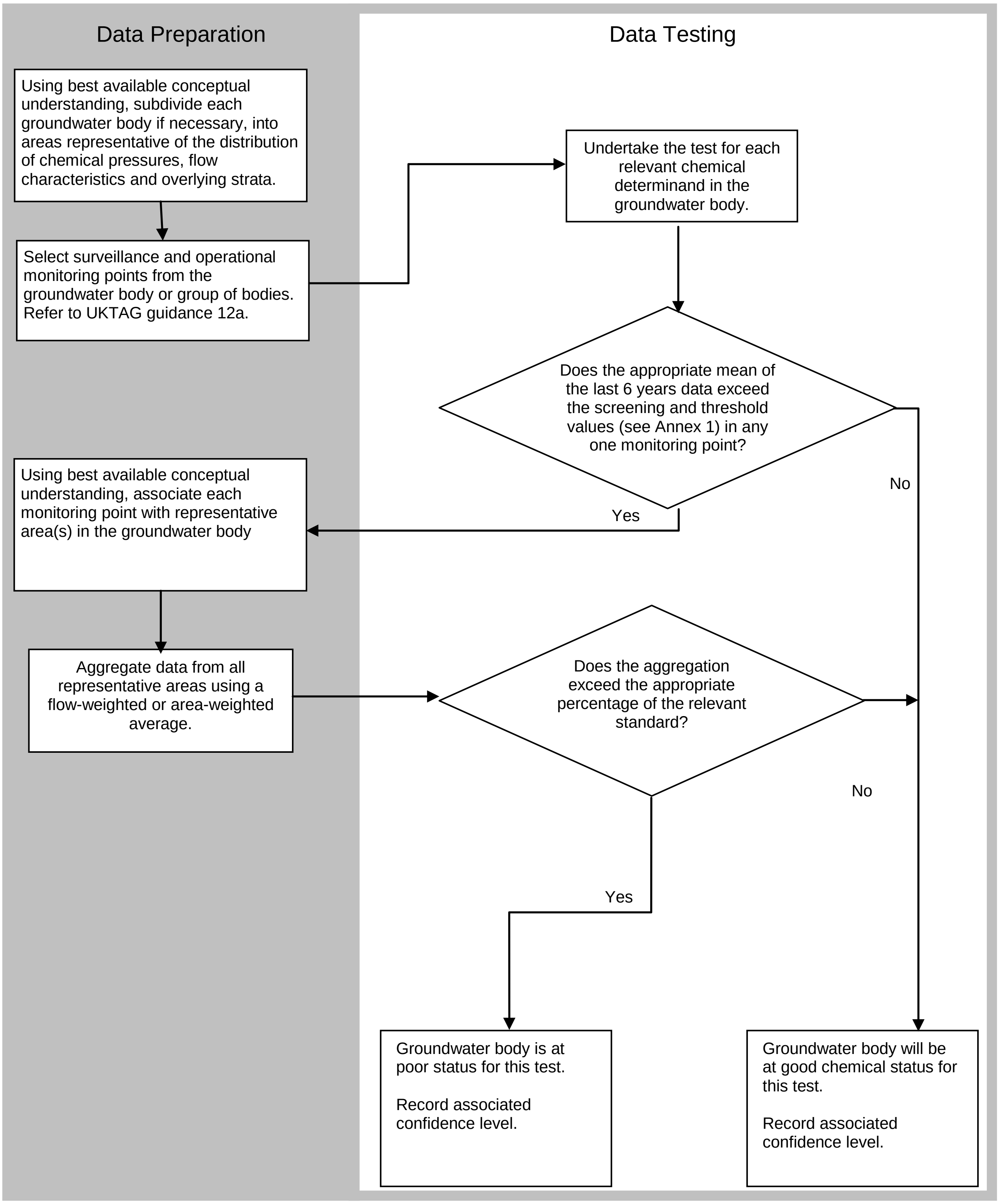


Figure 8. Outline of procedure and data preparation for status test for general groundwater quality

Annex I: Threshold Values and Lists of Indicator Determinands

Trigger for test	***Screening Values***	***Threshold Values***
Saline or Other Intrusions		
Elevated chloride and/or Electrical conductivity and abstraction pressure RBC risk data	Natural Substances – upper limit of natural background range relevant for each monitoring site	As screening values but only used in combination with trend assessments and must be reported as such.
SW Ecological & Chemical Status		
SW < Good Status	EQS (with a check against natural background)	EQS/Dilution Factor; or Upper Limit of NBL
GWDTE		
A damaged wetland	TV related to Damage (e.g. EQS)	Not yet determined
DWPA		
Threshold exceedance due to anthropogenic inputs	Appropriate percentage of DWS or other Drinking Water Directive requirement (see Annex II)	Appropriate percentage (see Annex II) of DWS etc. but not used in isolation of trend assessments and must be reported as such.
General Chemical Assessment		
River Basin Characterisation risk data and pollutant concentrations elevated above background.	Measured at individual monitoring points (mean of last 6 years data) Nitrate – 37.5 mg/l Pesticides - 0.075ug/l (individual) 0.375 ug/l (total) Natural Substances – upper limit of natural background range Synthetic – Limit of detection	For individual monitoring points (mean of last 6 years data) the appropriate percentage of: (a) the nitrate standard (50 mg/l) (b) the pesticide standard (0.1ug/l (individual) 0.5 ug/l (total)) (c) any relevant use based standard for synthetic substances; and (d) for natural substances, the upper limit of natural background range or relevant use based standard, whichever is the most stringent. *If exceedance:* Compare weighted aggregated concentration across the groundwater body with: (i) an appropriate percentage of the relevant use related standard; or (ii) for substances other than nitrate and pesticides, the upper limit of natural background (if applicable), whichever is the most stringent.– see note 1 below

Note 1: For nitrate and pesticides, the standards for this test are those set by the GWDD. For other substances and for this test only, thresholds should be set for the whole groundwater body. The resource value will often be dictated by the current or future potential of the groundwater body to provide water for human consumption. Other widespread uses such as irrigation should also be considered. The most stringent standard applies. Occasionally, the groundwater body is, and will not be, used for drinking water supply (for example, due to the poor natural quality of the groundwater).

Annex II: Thresholds for the Groundwater Classification Tests - The Use of Mean and 95th Percentile Values.

Introduction

This Annex explains the principles for assigning groundwater classification threshold values for:

- the Drinking Water Protected Area Test;
- the General Assessment of Quality Test.

Drinking Water Protected Area Test

Drinking water standards are expressed as maximum acceptable concentrations in the Drinking Water Directive and should be compared to peak concentrations found in groundwater. However, we cannot assume that monitoring data will identify these peaks. Threshold values are needed for this test that are related to peak concentrations measured in abstracted water.

A 95th percentile is routinely used in compliance assessment for surface water quality standards in UKTAG guidance, even though the standard is referred to as an 'Absolute Limit'. This is because the use of 95th percentile allows confidence of failure to be calculated.

Normally, groundwater quality data are collected less frequently than for rivers (see UKTAG monitoring guidance). As a result, our ability to routinely use the 95th percentile as the threshold for groundwater assessment is constrained because the 95th percentile cannot be calculated with any degree of reliability. This is due not only to sparsity of data but also to the variability in groundwater concentrations in different hydrogeological settings and measurements that are below the level of detection for some parameters.

If the 95th percentile cannot be used, we need an alternative. This should establish a threshold value against which the monitoring data can be compared with adequate confidence. The outcome should, as far as possible, be equivalent to using a 95th percentile.

Work carried out for designation of Nitrate Vulnerable Zones in England and Wales concluded that well over 50% of monitoring sites have insufficient records to reliably estimate anything other than the mean concentration. Given that nitrate is the parameter for which we have most groundwater quality data, the situation will be even worse for other determinands. As a consequence, groundwater thresholds should be set as values against which mean concentrations (or other relevant parameter value) can be compared. However, in setting the threshold it is important to ensure that the risk of misclassification is kept as low as possible.

The following approach is recommended for setting threshold values for groundwater chemical status assessment:

1. Where there are sufficient reliable monitoring data for each individual site (adequate frequency/time series) and non-detects are infrequent, calculate 95th percentile values along with confidence intervals. Compare these directly with the DWS or other relevant standard, as appropriate.

   NOTE: Taking into account the earlier discussion, we are unable to apply this approach in the first river basin cycle.

2. Where data are insufficient to calculate 95th percentiles for individual sites, compare the mean concentration (or relevant parameter value) of the monitoring data at a site against the threshold value. This threshold must be set so that, if it is not exceeded by the mean of a dataset, there is a reasonable expectation that the 95th percentile would not exceed the Maximum Admissible Concentration, if those 95th percentiles could be calculated.

   Calculate the threshold value as follows:

- **Option 1**: where there are sufficient data, examine the difference between the mean value and the 95th percentile value (and associated confidence limits, where appropriate) for **all** monitoring sites. Calculate the threshold value by subtracting the average difference between the mean values and the 95th percentile values (or lower confidence limit, if appropriate) from the relevant standard. This calculated threshold can be expressed either as an absolute value or as a percentage of the relevant standard.

  Note: although there are insufficient data to calculate 95th percentile values for individual sites, we are able to estimate a 95th percentile from sparse data. For this we need to make an assumption about the shape of the underlying distribution based on the behaviour of larger data sets from other supposedly similar sites. This is an *approximation* rather than a 'robust' approach. It means that we can estimate the average difference between the mean and the 95th percentile (or lower confidence limit if appropriate) for the whole population of data. For example, Figure 1 shows the relationship of the mean and the 95th percentile for a selection of nitrate data from England and Wales. The dotted line of best fit indicates that if the mean is used, then the threshold value would be set at 37 mg/l, compared to 50 mg/l if the 95th percentile was to be used. Note that the data and derived threshold value are for illustrative purposes only and there is no statistical or hydrogeological basis to assume the same numeric relationship will apply for other substances or even nitrate in either Scotland or Ireland.

- **Option 2** : Where there are insufficient data (for a particular region or substance) to estimate a 95th percentile for individual or groups of sites, assign a default threshold value that is lower than the relevant standard and compare against the mean concentration (or parameter value). Without the benefit of statistics, this can only be assigned using best judgement. On this basis it is proposed that, the threshold should be set at a value of 75% of the relevant standard (Maximum Admissible Concentration). This value has been selected taking into account the large variability in hydrogeological settings, potential temporal variability in parameter values and because it introduces what is believed to be an adequate degree of protection such that the risk of misclassification is acceptable. If applied to individual pesticides, this would lead to a threshold value of 0.075 μg/l.

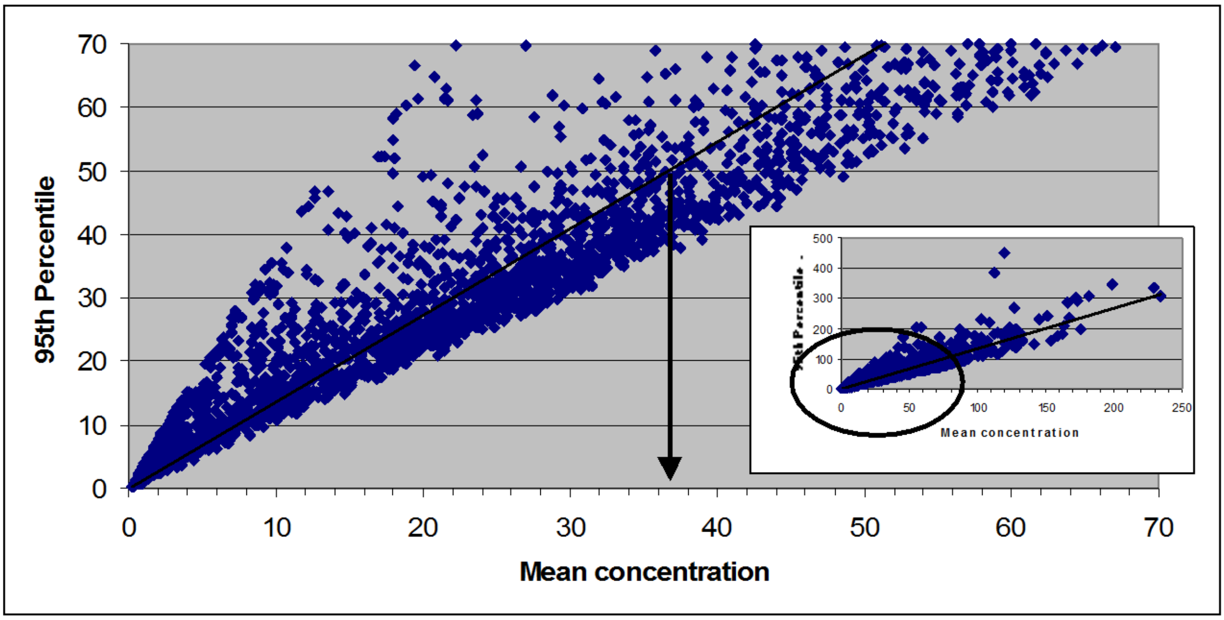


Figure A1. Comparison of mean nitrate concentrations and the 95th percentile for selected groundwaters in England and Wales.

General Assessment of Quality Test: Rationale

This test requires us to examine the extent of impact of one or more pollutants on a groundwater body. The GWDD requires us to set thresholds for pollutants that are relevant to this body-wide assessment. It also defines thresholds/standards for nitrates and pesticides and requires Member States to set values for other pollutants as necessary. However, the GWDD does not prescribe whether these standards relate to Maximum Admissible Concentrations, mean parameter values or some other measure.

In order to ensure consistency between Nitrates Directive and the WFD/GWDD, it is considered that the standards prescribed should relate to 95th percentiles. As a result the same issues that apply to Drinking Water Protected Areas (DWPA) apply here and it is proposed that the same principles for assigning thresholds should be used.

One difference is noted: the General Assessment of Quality Test requires the aggregation of data from a number of sites within a groundwater body or group of bodies. UKTAG guidance 12a examines the most appropriate method for addressing this issue and has concluded that comparing the threshold against an appropriate aggregation of the means from appropriate sites is the correct approach. Where data are aggregated in this way, 95th percentiles cannot be calculated and so the direct use of 95th percentiles, as described in the DWPA section (where the assessment relates to individual points) is not possible. Further guidance is presented in the main body of this paper.