



# Development of an Open-Access Stewardship Risk Map to Assist Growers in Management of Bentazone

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## Introduction

As a result of bentazone being detected in water bodies in England, the Better Bentazone Together Group (BBTG, comprising BASF, Sharda International and NuFarm) was formed to encourage responsible product use and protect groundwater and surface water. The BBTG commenced the 'Know the Bentazone Risk' initiative and published Bentazone Water Stewardship Guidance.

The stewardship guidance includes recommendations as to suitability for bentazone applications based upon the following conditions:

1. Condition 1: local field-scale conditions;
2. Condition 2: weather factors; and
3. Condition 3: the wider environmental setting and its sensitivity.

Growers have understanding of Conditions 1 and 2 as listed above in terms of the local factors relating to their fields (e.g. locations of field drains and watercourses), and ready access to weather forecast information immediately prior to planned bentazone applications. However, the information required to assess the suitability of the environment for bentazone applications (Condition 3) is more difficult to access, particularly outside of England. Those conditions relating to the wider environmental setting and its sensitivity are shown in Table 1 and, for the purposes of discussion, have been divided into four key categories (Table 2), as follows:

- Category 1: Geology
- Category 2: Groundwater
- Category 3: Soils
- Category 4: High Risk Areas

Since accessing and assimilating these data is complex, potential barriers to take-up of the guidance by growers can occur. Indeed, in some instances, pertinent data are not readily available to growers at all. A summary of information availability within the stewardship guidance, and broader Great Britain (GB) wide datasets is provided in Table 2. Due to the difficulties in accessing and assimilating suitable data, the objective was to assimilate suitable and representative data in order to produce a risk map that would show various outcomes in accordance with the stewardship guidance relating to environmental setting and sensitivity. The risk map tool was developed with the intention of it being used at a screening level, supplemented by grower's local knowledge.

## Map Development

To facilitate enhanced grower take-up of the stewardship guidance, an easily interpretable and interactive risk map showing zones of bentazone application suitability (relative to the guidance) was developed. This map was derived based on the stewardship guidance environmental setting only as field-scale and weather dependent aspects could not be mapped. Three primary zones relating to Bentazone use are defined:

- Use subject to restrictions
- Avoid use
- Do not use

Digital GIS datasets, available via Open Data sources, were reviewed to ascertain those which would be most suitable for application to assessment of these zones. Consideration was given to geographical coverage, scale of data, and suitability of data attributes to the risk map application.

By their very nature, open source data are not specifically designed for the purpose of the risk map development and, as such, once suitable datasets were identified, selection of relevant information from those datasets was required.

Identification and use of relevant data corresponding to the stewardship guidance was not simple to achieve. Data difficulties were encountered in sourcing suitable free datasets and in extracting relevant data from those datasets to meet the requirements of the stewardship guidance categories. These data difficulties are summarised in Table 2, together with solutions employed to identify relevant land areas which apply to each of the four categories that describe the environmental setting and sensitivity within the stewardship guidance.

For Categories 1, 2 and 3, data were either extracted from relevant broader datasets, were calculated, or similar datasets had to be used where a lack of directly comparable data could be sourced. For Category 4, readily available data were only available to determine high-risk areas in England and Wales.

Screening of geological strata was particularly challenging. To achieve this, all chalk/limestone and sandstone formations were considered as 'eligible strata', and from these eligible strata, 'key strata' were taken forward for inclusion as defined chalk/limestone or sandstone in the context of the guidance. In particular:

- 'Highly productive' aquifers were considered to be 'key strata'.
- 'Moderately productive' aquifers do not typically support public water supplies so were not typically included as 'key strata', with the following exceptions for aquifers which:
- directly overlie 'highly productive' aquifers, such as the Thanet Sand Formation (which overlies the Chalk),

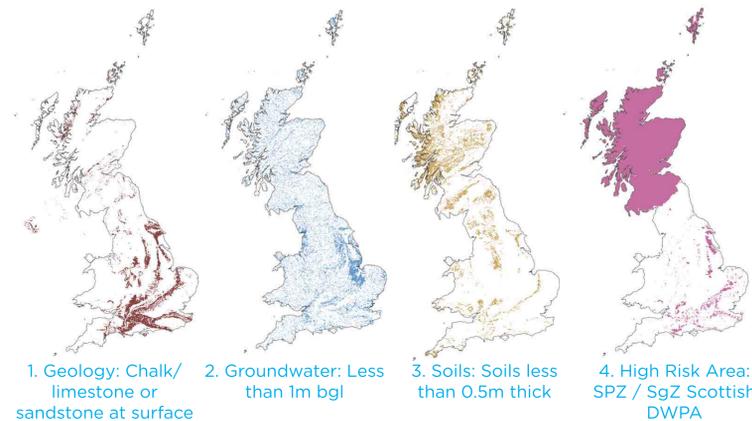
	High Risk Areas*	All Other Areas
<b>Soils</b>		
Shallow (<30-35cm) and stony (>10% of surface area) soils on chalk/limestone	<b>Do Not Use</b>	<b>Avoid Use</b>
Shallow (<30-35cm) soils on sandstone		
Shallow groundwater (<1m below surface)		
Other soils	Use Subject to Restrictions: OK to use after 1st April if soil organic carbon >1%, otherwise 'Do Not Use'	Use Subject to Restrictions: OK to use if soil organic carbon >1%, otherwise 'Avoid Use'
<b>Rate</b>		
All soils	Do not use > 1000 g ai/ha/year	Avoid use of > 1000 g ai/ha/year

Table 1 Bentazon Stewardship Guidance Relating to Environmental Setting and Sensitivity

\*High Risk Areas comprise : Groundwater Source Protection Zones (SPZ) 1 and 2, plus Groundwater Safeguard Zones (SgZ) for bentazone or nitrate.

Category 1 Geology	Category 2 Groundwater	Category 3 Soils	Category 4 High Risk Area
<b>Stewardship Guidance Definition</b>			
Aquifers: Sandstone, limestone or chalk	Shallow groundwater (<1m depth)	Soils < 30-35cm thick present	In SPZ 1 or 2, and/or Groundwater Safeguard Zone (SgZ) for nitrate/bentazone
<b>Availability of information to growers in guidance</b>			
Unavailable	Unavailable	Unavailable	Available - England Unavailable - Wales and Scotland
<b>Availability of free datasets for GB</b>			
Unavailable - data extracted from other relevant datasets	Unavailable - estimated from other datasets	Unavailable - similar dataset used	Available - England and Wales Unavailable - Scotland
<b>Data difficulties</b>			
Some geological strata are heterogeneous. Unclear whether bedrock 'sands' are considered as 'sandstone'. Coarse scale mapping used	Groundwater levels vary seasonally and in some cases in response to rainfall events	Soil thickness varies locally. The term 'soil' can vary in definition. Stony soils difficult to ascertain	Guidance unclear for confined aquifers. Designations not defined in Scotland. Private abstractions have default SPZ 1 but are not shown in published mapping
<b>Solution</b>			
Review of UK-wide geological data to identify permeable chalk/limestone or sandstone. Review of stratigraphical sequence in respect of aquifer connectivity. Inclusion as aquifers where strata coincide with SPZ 1 or 2 or Principal Aquifer. Exclusion of low permeability/effective porosity aquifers due to low productivity.	Groundwater levels estimated by assuming water table surface is commensurate with typical water levels in rivers/streams. Topographical data used to estimate depth.	UK mapping for 'diggable' soils < 50 cm thick utilised. Assumed superficial soils to be more than 30-35 cm thick. Stony soils not considered	Published data for England and Wales used, with confined SPZs excluded. In Scotland all groundwater is within a drinking water protection area (DWPA). The DWPA has been used as a proxy for a SgZ. Private abstractions excluded

Table 2 Stewardship Guidance Categories and Risk Map Methodology



Category	1	2	3	4	Output	Exceptions
N/A	P	N/A	P		Do not use	None
P	A	P	P		Do not use	With exceptions, otherwise avoid use
P	A	A	P		Use - Subject to Restriction	With exceptions, otherwise OK to use in specified season
A	A	N/A	P		Use - Subject to Restriction	With exceptions, otherwise OK to use in specified season
N/A	P	N/A	A		Avoid Use	None
P	A	P	A		Avoid Use	With exceptions, otherwise OK to use
P	A	A	A		Use - Subject to Restriction	In some circumstances, avoid use
A	A	N/A	A		Use - Subject to Restriction	In some circumstances, avoid use

P - present, A - absent, N/A - not applicable

Table 3 - Map Development Method

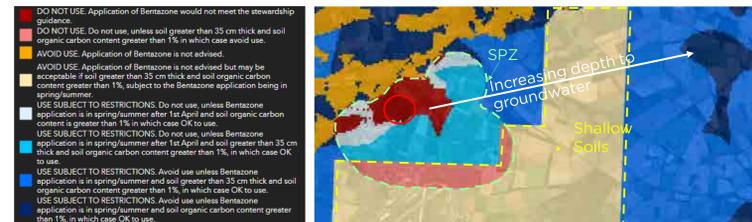


Figure 1 - Map Key

Figure 3 - Example Calibration



Figure 2 - Map Output

- are within Source Protection Zones (SPZ) 1 or 2, such as the Ravenscar Group, or
- are designated principal aquifers.

This screening method allows for low permeability well-cemented sandstones (such as the Devonian Sandstones, and cyclical strata such as the Coal Measures which contain only limited sandstone units) to be excluded from the 'key strata'.

Figure 1 shows the data generated for each of the Categories 1 to 4. These datasets were combined using a 'present' or 'absent' approach described in Table 3 to align with the three use zones established by the stewardship guidance (Use Subject to Restrictions; Avoid Use; Do Not Use). Additional conditions were applied to these zones to draw growers' attention to situations where field-specific information available only to the grower concerned is also needed (e.g. on soil thickness and soil organic matter content) in order for them to conclude on the suitability of a given field for application of Bentazone.

## Map Output

The map is accessed via a webmap journal page, which provides background bentazone stewardship information, map use functionality, risk classification summary, and information on field-scale/weather dependent stewardship guidance that is not specifically covered by the map.

From here, users can access the interactive webmap either via a computer or mobile device in the field. An example view is shown in Figure 2.

## Calibration

The risk map use zones were calibrated on the basis of detailed hydrogeological assessment of five groundwater catchments in which exceedances of regulatory standards for bentazone have been observed in licensed groundwater abstractions for potable supply. The sources of bentazone within these catchments were linked to:

- historical point sources; and/or
- historical field applications (prior to implementation in 2019 of the current stricter label conditions and stewardship guidance for growers); and/or
- the highly vulnerable nature of the catchment relating to rapid hydrogeological pathways for infiltration and/or lateral migration to the abstraction within the aquifer;
- the configuration of the abstraction infrastructure;
- cultivation of very shallow-rooting crops; and/or
- inappropriately defined groundwater SPZs 1 and 2 for some of the individual abstractions.

An example calibration for one of the study areas is shown in Figure 3. The area of greatest risk for bentazone application is commensurate with the expected presence of shallow groundwater and outcrop of the Chalk aquifer below shallow soils, with increasing suitability for bentazone use further up in the catchment, outside the SPZ 2 and where the unsaturated zone is thicker and/or where low permeability superficial deposits are present capping the Chalk. Diffuse bentazone field applications within the demarcated higher risk areas were shown through the study to have potentially given rise to elevated concentrations in the abstraction at times seasonally within a given growing year.

## Constraints

The risk map is intended for use as a screening tool only, with growers checking data at the scale of an individual field. Current limitations include:

- map based on relatively coarse-scale Open Source data;
- groundwater levels are variable, and have been estimated based on surface water elevations;
- the Stewardship Guidance defines shallow soils as <35cm, but published datasets use slightly different thicknesses (e.g. 50cm); and
- geological units shown on the free Open Source BGS geological map (1:625,000 scale) are defined by parent units; subdivisional geology may differ.

## Future Use/Updates

In order for growers to have access to up-to-date information, the risk map is updated annually to reflect changes in available baseline datasets.

Information relating to additional pesticides could be added to the map if desired in the future, allowing growers to holistically assess the suitability of their fields for application of various plant protection products.

The map allows growers to forward plan with regards to field suitability for bentazone application, identifying where best to consider bentazone target crop cultivation.

The map enables the most vulnerable areas of Great Britain to be considered in the context of where the greatest use of bentazone occurs and thus helps grower outreach educational programmes to be targeted, in particular with regards to encouraging the use of drip trays to help prevent spills/point sources which the hydrogeological studies associated with the map development have shown to be a major, if not dominant, contributor to bentazone exceedances of potable standards in groundwater in supply abstractions.

The map and underlying GIS model can be used by plant protection product manufacturers to strategically evaluate the effect of potential changes in stewardship guidance and how much land and where in Great Britain would be implicated in such changes.