DATASHEET:
Nitrate vulnerable zone (NVZ) designation 2017 - Groundwater
Publication Date: June 2016

NVZ Name: St Bees
NVZ ID: G180
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Introduction

This document provides a summary of the evidence used in proposing an area of land as one which should be, or should continue to be, designated as a Nitrate Vulnerable Zone (NVZ) for the purposes of the Nitrate Pollution Prevention Regulations 2015.

A full description of the methods used in developing the NVZ proposals is set out in the detailed methodology for groundwater NVZs, available via http://apps.environment-agency.gov.uk/wiyby/141443.aspx. These methods were developed under the guidance of a review group convened by the Defra for the last NVZ review (2011-2013), which included representatives from the farming and water industries as well as independent academic experts. Minor refinements to the methods have been made for the current review.

The approach developed for the assessment of groundwater uses a combination of monitored groundwater concentrations, agricultural nitrate loads based on Defra census returns and non-agricultural (urban) loads based on land use and population data for the whole of England. Non-agricultural sources are included in the methodology in order to make sure that agricultural sources make up a significant contribution before establishing a NVZ.

Additional lines of evidence comprising local knowledge of the land and/or hydrogeology are also incorporated into the risk assessment. Examples of additional information include the location of point sources that may unduly influence a particular monitoring point (e.g. industrial or septic discharges), monitoring data from different groundwater bodies and monitoring data from related surface waters which may tell us something about the hydrogeological setting.

A weight of evidence approach is used to combine the national and local lines evidence. In practice this means that each dataset or piece of evidence is given a weight and a score between 0 and 2. The higher the value, the stronger the evidence is indicating that groundwater is affected by agricultural pollution or could be affected by agricultural pollution. All the strands of evidence are combined to give an overall risk score between 0 and 18. An overall score above 8 indicates both the nitrogen loading data and the monitored concentrations agree that nitrate concentrations exceed or were likely to exceed 11.3mg/l, and that agriculture was a significant source of the pollution identified. This is sufficient evidence to propose an area for designation.

Where sufficient evidence exists for designation we consider the most appropriate boundary features to use to demarcate a zone. The following list sets out the types of boundaries that have been used.
- Geological boundaries such as changes in rock type, faults and geological contacts.
- Groundwater abstraction boundaries such as Source Protection Zones (SPZ).
- Surface water catchment boundaries.
- Groundwater level contours.
- High permeability drift outcrops.
- Low permeability drift outcrops.
- Rivers, acting as groundwater catchment divides.
- Coastlines.
- Solution features.

The final NVZ proposals are developed through close working between Area and National Environment Agency teams, with quality assurance through discussions at local workshops.

Please note that any maps shown here have not used detailed field boundaries and therefore represent the indicative 'soft' boundary only. The definitive NVZ area can be seen on the “What's in Your Backyard” (WIYBY) website ([http://apps.environment-agency.gov.uk/wiyby/141443.aspx](http://apps.environment-agency.gov.uk/wiyby/141443.aspx)).
Description of the boundary

Table 1 Summary statistics for NVZ ID G180

<table>
<thead>
<tr>
<th>NVZ ID</th>
<th>G180</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVZ name</td>
<td>St Bees</td>
</tr>
<tr>
<td>Previously designated</td>
<td>Yes. New designated area 2013</td>
</tr>
<tr>
<td>Designation year</td>
<td>2013</td>
</tr>
<tr>
<td>Total area designated in 2017</td>
<td>13.13 km²</td>
</tr>
<tr>
<td>Change in area designated in 2017</td>
<td>0.03 km² (small change due to remapping of field boundaries)</td>
</tr>
</tbody>
</table>

For NVZ ID G180 the boundary is based on the following;
The NVZ boundaries have been delineated for the protection of the St Bees Sandstone Formation not covered by superficial formation.

The geology of this NVZ can be seen using the British Geological Society’s free Geology of Britain viewer available at: [http://mapapps.bgs.ac.uk/geologyofbritain/home.html](http://mapapps.bgs.ac.uk/geologyofbritain/home.html). This shows the bedrock and superficial geology at the 1:625,000 scale for the whole of Britain.
Map of the designated area

Designated area (NVZ ID G180) outlined in yellow

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This NVZ
Other NVZ

Figure 1  Map showing the boundary of the designated area for NVZ ID G180
Nitrate loading data

Nitrate loading data is derived from agricultural practices and from urban (i.e. non-agricultural) sources. Both urban and agricultural loads were considered in the assessment in order to identify if agriculture provides a significant contribution of nitrate to the groundwater.

The agricultural nitrogen loading figures are derived from the Defra agricultural census returns and farm scale research undertaken for Defra and are extrapolated based on farming land-use data for the land area covered by this report. The data was obtained under contract from ADAS. Figure 2 indicates those areas within the catchment with higher or lower levels of agricultural nitrate leaching to the groundwater.

The urban sources maps are derived based on the work of Lerner (2000) using information on land use and population data. The map of urban loading score is shown in Figure 3. Results are shown on a 1km grid square for each.

Both maps categorise average annual leached nitrate concentrations into 3 categories which are assigned a score between 0 and 2 and a weight for inclusion in the final risk assessment score. Tables 2 and 3 show the scores and weights for agricultural and urban sources respectively. The weight for urban sources is negative since a high urban load means that the relative contribution of agriculture is less.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Agricultural pressure scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Pressure</td>
<td>Concentration (mg/l as Nitrogen)</td>
</tr>
<tr>
<td>Category</td>
<td>&lt; 5.65</td>
</tr>
<tr>
<td>Score</td>
<td>0</td>
</tr>
</tbody>
</table>

The map of urban loading score is shown in Figure 3. Results are shown on a 1km grid square for each.
Figure 2  Map showing the nitrate loading score from agricultural sources per 1 kilometre square in a grid over the designated area

Table 3  Urban pressure scoring

<table>
<thead>
<tr>
<th>Urban Pressure</th>
<th>Concentration (mg/l as Nitrogen)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>&lt; 5.65</td>
<td>5.65 – 11.3</td>
</tr>
<tr>
<td>Score</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-2</td>
</tr>
</tbody>
</table>
Figure 3   Map showing the nitrate loading score from urban sources per 1 kilometre square in a grid over the designated area
Nitrate monitoring data

For the 2017 designations nitrate monitoring data was analysed for the period 1st January 1980 to 31st December 2014 and current concentrations calculated using the appropriate statistical method for the data. This involves determination of the 95th percentile value, that is, the concentration which we would expect to be exceeded by 5% of monitoring results. Where sufficient data were available results were also projected to give a predicted future concentration in 2027.

Table 4 below provides the current and future nitrate concentrations of all the monitoring points within 1500 meters of this NVZ. It also contains summary information about the monitoring data and statistical methods applied.

The nitrate concentration data is presented as milligrams of Nitrogen per litre. Please note the limit of 50 mg per litre of Nitrate (NO3) from the Directive is equivalent to 11.3 mg per litre as Nitrogen (N).

Monitoring data from groundwater monitoring points only gives groundwater nitrate concentrations at specific discrete locations within aquifers. In order to estimate nitrate concentrations across the country and use the methodology at a 1km² resolution, a statistical interpolation technique (kriging) was then used to help us to understand spatial patterns in the groundwater dataset and predict nitrate concentrations at unmonitored locations. See the Groundwater Methodology report for more details.

The results of the analysis were then compared to the standard of a value of 11.3 mg N/l. See the Groundwater Methodology report for more details (http://apps.environment-agency.gov.uk/wiyby/141443.aspx).
### Table 4  Summary information for groundwater monitoring data

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Start Year</th>
<th>End Year</th>
<th>Number of Samples</th>
<th>Statistical method</th>
<th>Current concentration (mg/l as Nitrogen)</th>
<th>Future concentration (mg/l as Nitrogen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>88020031NW</td>
<td>2002</td>
<td>2014</td>
<td>25</td>
<td>AntB</td>
<td>20.2</td>
<td>17.1</td>
</tr>
</tbody>
</table>
Table 5  Current groundwater concentration scoring

<table>
<thead>
<tr>
<th>Monitored concentration</th>
<th>Nitrate mg/l</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>&lt; 5.65</td>
<td>5.65 – 11.3</td>
</tr>
<tr>
<td>Score</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4  Map showing the score for predicted current concentration of nitrate in groundwater per 1 kilometre square in a grid over the designated area
### Table 6  Predicted future groundwater concentration scoring

<table>
<thead>
<tr>
<th>Monitored concentration</th>
<th>Nitrate mg/l</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>&lt; 5.65</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.65 – 11.3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&gt;11.3</td>
<td>2</td>
</tr>
<tr>
<td>Score</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

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**Figure 5**  Map showing the score for predicted future concentration of nitrate in groundwater per 1 kilometre square in a grid over the designated area
Overall risk score

A weight of evidence approach was used to integrate the loading and monitoring datasets and to incorporate any additional factors such as evidence of denitrification or unrepresentative monitoring. Details of specific additional evidence relevant to this proposed NVZ are provided in the following chapter ‘Additional lines of evidence’.

Final scores were calculated for each 1 km square across England based on the weights and values from each section and one of three levels of risk was assigned to each:

- **High risk** – both the loading data and the monitored concentrations agree that nitrate concentrations exceed or were likely to exceed 11.3mg/l, and that agriculture was a significant source of the pollution identified.

- **Medium risk** – either the loading data or the monitored concentrations show that nitrate concentrations exceed, or were likely to exceed, 11.3mg/l.

- **Low risk** – both the loading data and the monitored concentrations agree that nitrate concentrations were not likely to exceed 11.3mg/l.

The table below presents the overall risk scores associated with High, Medium and Low risk.

<table>
<thead>
<tr>
<th>Category</th>
<th>High - Designate</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>&gt;8</td>
<td>3-8</td>
<td>&lt;3</td>
</tr>
</tbody>
</table>

**Table 7** Summary of categories for final risk score

What is the risk that groundwater nitrate is >11.3 mg/l or will be in future and agriculture is the main source?
Figure 6  Map showing the overall risk score per 1 kilometre square in a grid over the designated area
Additional lines of evidence

Advice was sought from local Environment Agency staff to identify any additional information that could be used to improve the decision making process for a particular area. This local knowledge of the land and/or hydrogeology are incorporated into the risk assessment, for example through:

- Identification of point source pollution affecting a monitoring point
- Behaviour of nitrogen in the environment e.g. processes of de-nitrification or mixing
- Hydrogeological setting of the monitoring borehole e.g. age of groundwater being sampled
- Availability of surface water monitoring in areas with infrequent groundwater monitoring

The additional evidence is incorporated into the risk assessment using the scores and weights corresponding to the type of evidence being considered. Tables 8 to 11 in Appendix 1 show the scores and weights for all possible lines of additional evidence. A full description of all possible additional lines of evidence is provided in the groundwater methodology available via http://apps.environment-agency.gov.uk/wiyby/141443.aspx.

For this area, no lines of evidence have been modified from local Environment Agency staff.
References


Appendix 1  Scores and weights for additional lines of evidence

The scores and weights shown in Table 8 to 11 enable local EA staff to modify the final risk score by incorporating additional local knowledge. Broadly, these cover circumstances where confounding factors such as the presence of a nearby non-agricultural point source of nitrate exists or conversely where the monitoring data may not yet reflect known pollution due to the time lag inherent in groundwater monitoring at depth. In making these scores EA staff must demonstrate that there is some evidence for their choice and likely evidence items are shown below.

Table 8  Point source pollution scoring

<table>
<thead>
<tr>
<th>Point source risk</th>
<th>Groundwater concentration is unduly influenced by point source pollution</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Yes, good evidence</td>
<td>Maybe some evidence</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Identifiable point source of nitrate AND groundwater concentrations significantly higher than soil leaching concentrations.

Identifiable point source of nitrate OR groundwater concentrations significantly higher than soil leaching concentrations.

Table 9  Summary of categories for de-nitrification or mixing (Area)

<table>
<thead>
<tr>
<th>De-nitrification or mixing</th>
<th>NO₃ is either de-nitrified or diluted by mixing</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Yes, good evidence</td>
<td>Maybe some evidence</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table: 8

<table>
<thead>
<tr>
<th>Point source risk</th>
<th>Groundwater concentration is unduly influenced by point source pollution</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Yes, good evidence</td>
<td>Maybe some evidence</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Identifiable point source of nitrate AND groundwater concentrations significantly higher than soil leaching concentrations.

Identifiable point source of nitrate OR groundwater concentrations significantly higher than soil leaching concentrations.

Table: 9

<table>
<thead>
<tr>
<th>De-nitrification or mixing</th>
<th>NO₃ is either de-nitrified or diluted by mixing</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Yes, good evidence</td>
<td>Maybe some evidence</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

NVZ Name: St Bees
NVZ ID: G180
**De-nitrification or mixing**  
NO$_3$ is either de-nitrified or diluted by mixing  
Quantifiable source of dilution e.g. forested recharge area. Drift > 10m thick and clay rich.  
Baseline report indicating de-nitrification or mixing.  
Lack of impacted groundwater monitoring sites. Local report, indicating as above.

<table>
<thead>
<tr>
<th>Monitoring not fully representative</th>
<th>Monitored nitrate concentrations not fully representative</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong>&lt;br&gt;Yes, good evidence&lt;br&gt;Yes, some evidence&lt;br&gt;No evidence&lt;br&gt;No, maybe some evidence&lt;br&gt;No, good evidence</td>
<td><strong>Score</strong>&lt;br&gt;2&lt;br&gt;1&lt;br&gt;0&lt;br&gt;-1&lt;br&gt;-2&lt;br&gt;3</td>
<td><strong>Additional data from WFD assessments</strong>&lt;br&gt;Large uncertainty in trend analysis&lt;br&gt;Expert view is that kriging is not sufficient in this setting&lt;br&gt;Expert view is that kriging is not sufficient in this setting&lt;br&gt;Significant drift &gt; 10 m delaying nitrate measurement&lt;br&gt;OR&lt;br&gt;Water company has abandoned a source nearby due to high NO$_3$</td>
</tr>
</tbody>
</table>
Monitoring not fully representative

Unsaturated zone > 30 m delaying nitrate measurement

OR

Aquifer is layered or the sampling is at depth

---

Table 11 Use of surface water monitoring data

<table>
<thead>
<tr>
<th>Surface water monitoring</th>
<th>Surface water quality is representative of groundwater quality</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Yes, good evidence</td>
<td>No evidence</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Confident fail and >2 point source discharges in surface water.

OR

Marginal fail and <2 point source discharges in surface water.

Face value fail and <2 point source discharges in surface water.

OR

Face value pass and <2 point source discharges in surface water.
Appendix 2  Trend analysis graphs

The following figures show the monitored nitrogen concentration in groundwater and the associated trend analysis undertaken for the groundwater NVZ methodology. Graphs are provided for all monitoring points used to predict current and future nitrate trends that are within 1.5km of this NVZ.

The groundwater method uses comparison against the threshold of 11.3 mg/l as Nitrogen (or 50 mg/l as Nitrate) with the Lower 90% Confidence Limit (LCL) around the 95th percentile of the monitored nitrate sample distribution, which equates to a threshold of 9.7 mg/l as Nitrogen (or 43 mg/l as Nitrate). These are included in the following graphs for comparison as a green and blue dashed lines respectively.

Full details of the development of the 43 mg/l threshold can be found in the paper by Davison and Davey (2016). Further explanation of the statistical trend analysis of the data can be found in Bewes et al. (2015).

Please be aware that because data is included for a monitoring site it does not mean this data is representative of the groundwater that is proposed for designation, for example some sites may be sampling groundwater from a different groundwater unit, or be sampling groundwater that is up gradient of the source of groundwater pollution. This is due to the complex 3-dimensional nature of groundwater bodies and the direction of flow of that groundwater.
Figure A1: Site ID 88020031
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