Assessing the environmental sensitivity of petrol filling station locations across Europe

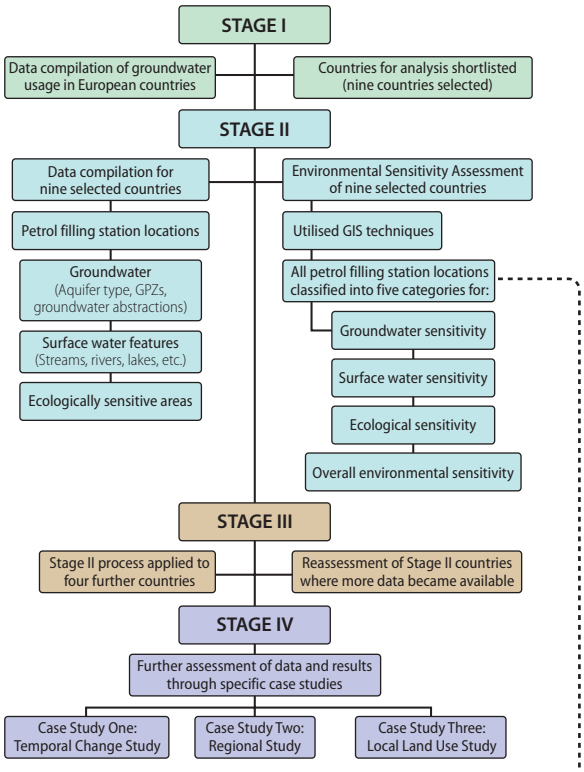
The need for a risk-based approach to implementing the Groundwater Directive

In the context of the Groundwater Directive (2006/118/EC), the CONCAWE Soil & Groundwater Task Force commissioned the consultants, Arcadis Geraghty & Miller (Newmarket, UK) to assist in a study of petroleum facilities across Europe. The first phase of the project specifically assesses the environmental sensitivity of petrol filling station locations with regard to their proximity to groundwater, surface water and ecological receptors. The principal aim is to promote a risk-based approach, as opposed to a prescriptive engineering-based approach, to implementing the Groundwater Directive. Additionally, the methodology developed through this study provides a tool for the oil industry to identify areas of higher environmental sensitivity and thus encourage rational investment in preventative measures where it is most needed. The countries included in this study are listed in Table 1, while an outline of the overall project structure is illustrated in Figure 1. This article illustrates the results to date at a European, National, Regional and Site level.

Table 1 Countries covered by this study

- Austria
- Belgium
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Italy (Emilia Romagna, Lazio, Lombardi, Piedmont and Veneto only)
- The Netherlands
- Norway
- Poland
- Spain
- United Kingdom

Figure 1 Project structure



Background

Across Europe, the consistency of digital data in terms of definitions, scale and quality varies greatly from country to country. So, to try to obtain a meaningful comparison across countries, petrol filling station locations have been classified in this study into five categories of envi-

Table 2 Classification criteria

	Sensitivity Category						
	Category 1	*Category 2*	*Category 3*			*Category 4*	*Category 5*
Groundwater	Within a GPZ1 Class	Within 100 m of a GPZ1 Class GPZ2 **AND** Major Aquifer Class	Other GPZ2 Class	GPZ3 Class	Not in a GPZ but on, or within 100 m of a Major Aquifer Class	Minor Aquifer Class **AND** not in a GPZ	Non-Aquifer Class **AND** not in a GPZ
Surface water	< 25 m	25–50 m **OR** < 250 m from the coast	50–100 m			100–250 m	> 250 m
Ecological	Within	< 50 m	50–100 m			100–250 m	> 250 m
Overall environmental sensitivity	Defined by whichever of the groundwater, surface water and ecological categories are most sensitive						

ronmental sensitivity in relation to groundwater, surface water and ecological receptors.

The classification criteria are provided in Table 2, where Category 1 represents the most sensitive conditions and Category 5 represents the least sensitive conditions.

Aquifer class and Groundwater Protection Zone (GPZ) definitions for each country exhibit the greatest variation. Therefore, wherever possible, the data for each country has been sub-divided to define three classes of aquifer type (Major, Minor and Non-Aquifer) and GPZ (GPZ1, 2 and 3). Generally the GPZ1 class represents the area of highest protection or most stringent legislation, with the GPZ3 class representing the total catchment area for public drinking water supplies.

Methodology

The environmental sensitivity of each petrol filling station location was determined using a Geographical Information System (GIS). Digital data in a GIS format was collected for each country to represent:

- Petrol filling station locations
- Aquifer types/groundwater vulnerability
- Groundwater Protection Zones (GPZs)
- Groundwater abstraction locations
- Surface water features
- Ecologically sensitive areas (e.g. Natura2000 sites).

The petrol filling station locations were overlaid onto the various environmental receptor datasets within the GIS. The proximity of the sites to the environmental receptors were then calculated and recorded as attributes of each petrol filling station. Lastly, each petrol filling station was classified into an environmental sensitivity category according to the criteria in Table 2.

The case studies in Stage IV (see Figure 1) were developed utilising the CORINE land cover data produced by the European Environment Agency.

Study findings—European level

To date, more than 85,000 petrol filling station locations across Europe have been analysed for their environmental sensitivity. Approximately 14% of these sites were found to be located in areas of higher environmental sensitivity (Categories 1 and 2 in Table 2). This average figure conceals a wide variation between countries, ranging from approximately 32% of sites in Poland to 7% of sites in Germany.

Approximately 14% of sites are located in areas of lowest environmental sensitivity (Category 5 in Table 2).

A further breakdown of the higher sensitivity sites across Europe shows that the majority (approximately 8% of sites) are thus categorised because of their proximity to

Table 3 Groundwater protection zone classification in Europe

Country	GPZs defined	Regulation basis	Digital format	Number of GPZ Classifications	Notes
Austria	✓	Regional	✓	5	Two types of GPZ; one protects aquifers (2 Classes) and another abstractions (3 Classes).
Belgium	✓	Regional	✓	3	GPZs in Wallonia are not as established as in Flanders. No data for Brussels.
Czech Republic	✓	National	✓	3	Water protection zones — not GPZs. Additional data on areas of General GW Accumulation (Natural Spring areas).
Denmark	✗	–	✗	–	Groundwater Vulnerability is focused on quality of groundwater for public supply.
Finland	✓	National	✓	4	Not all GPZs have been digitally mapped to date.
France	✓	Local	✗	3	Many GPZs are yet to be designated, very few are digitally mapped. The third class of GPZ is not always defined.
Germany	✓	Regional	✓	3	Water protection zones — not GPZs. Some definitions of classes vary between regions.
Italy (5 regions)	✓✗	Regional	✓✗	2–4	Where designated, definitions of GPZ class vary widely between regions.
The Netherlands	✓	National	✓	3	
Norway	✗	National	✗	–	
Poland	✓	National	✓	2	Spatially, GPZs are wide-ranging throughout Poland.
Spain	✗	–	✗	–	
United Kingdom	✓	Regional	✓	3	GPZs only defined for England and Wales.
	✓= yes, ✗= no		✓= yes, ✗= no		

surface water, with groundwater sensitivity accounting for about 4% of sites, and ecological sensitivity for some 3% of sites.

The study has also identified major inconsistencies in data across, and in some cases within, countries—limiting the potential to accurately compare data and results from the different sources. Groundwater Protection Zones, which are an important concept in protecting public water supplies in any country, have also proved to be by far the most inconsistent data type, as illustrated in Table 3.

Study findings—national level

Germany example

The distribution of environmental sensitivity at petrol filling stations on a national level, as illustrated for Germany in Figure 2, enables the identification of areas where clusters of sites with higher sensitivities occur. For example, the majority of Category 3 and 4 sites are driven by groundwater sensitivity, whereas the proximity to surface water features is the main driver for Category 1 and 2 sites—a higher proportion of which tend to occur to the west and south-west of the country. Likewise, areas of lower sensitivity (Category 5 sites) can be identified, such as the area along the Germany/Czech Republic border.

Figure 2 Overall environmental sensitivity of petrol filling stations in Germany

Thuringia omitted from analysis due to insufficient data availability

Category 1 – 624 (4%)
Category 2 – 477 (3%)
Category 3 – 8510 (84%)
Category 4 – 5241 (33%)
Category 5 – 906 (6%)

Study findings—regional level

Berlin and Stuttgart case study

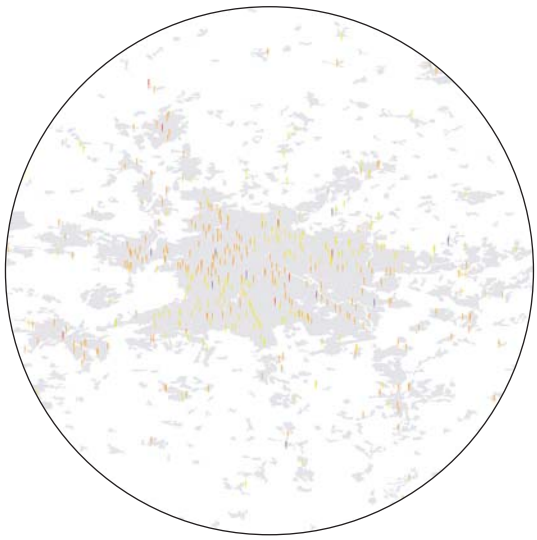
The regions around Berlin and Stuttgart were found to have similar environmental characteristics, however the distribution of environmental sensitivity at petrol filling station locations in these regions differs as seen in Figure 3. In both regions, between 85–90% of sites lie within an urban category of land cover, as defined by the CORINE land cover dataset, however the spatial distribution of these urban areas is very different. As a result, the increased proportion of higher sensitivity sites (Category 1 and 2) that occur in the Stuttgart region, in comparison to the Berlin region, is largely due to the dispersed nature of urban areas around Stuttgart. When combined with the spatial distribution of the environmental factors, urban areas and therefore petrol filling stations in the Stuttgart region are in proximity to more environmental receptors.

In terms of potable water supply it is interesting to note that in the Stuttgart region the public water supply is generally sourced from Lake Constance, whilst in the Berlin region public water supply is sourced from artificially recharged aquifers around the city. However the Stuttgart region contains a larger coverage of GPZs, many of which are designated to protect natural groundwater springs and spa waters, and as a result groundwater sensitivity there is higher in comparison to Berlin.

Figure 3: Urban areas and overall environmental sensitivity of petrol filling stations in Berlin and Stuttgart

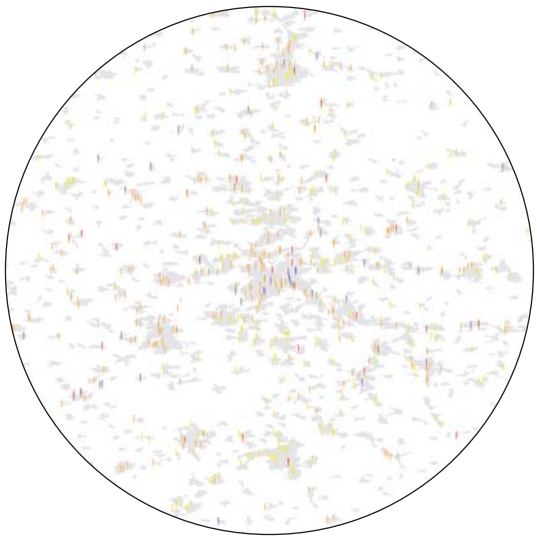
Urban areas as represented by the CORINE Land Cover database produced by the European Environment Agency

Berlin



- Category 1 – 9 (2%)
- Category 2 – 7 (1.6%)
- Category 3 – 231 (52%)
- Category 4 – 196 (44%)
- Category 5 – 3 (0.7%)

Stuttgart



- Category 1 – 43 (7.2%)
- Category 2 – 22 (3.7%)
- Category 3 – 278 (46%)
- Category 4 – 246 (41%)
- Category 5 – 11 (1.8%)

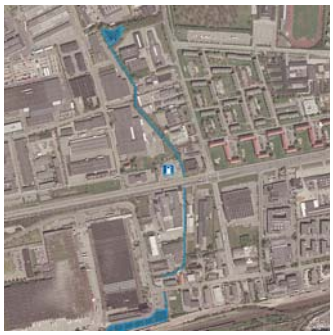
Site level

The principal aim of this study is to provide indications of patterns and trends in environmental sensitivity at a regional and national level. To identify individual sites where the environmental sensitivity is highest, additional data would be required. The 'footprint' of a petrol filling station varies widely from site to site, in terms of the potential for adverse environmental impact, when compared to surrounding land covers and the proximity of environmental receptors. Figure 4 provides an example of the conditions surrounding a site in an urban setting. This highlights the need to consider each site in relation to other potential point sources and to the nature of the environmental receptors at risk. Ultimately this study has demonstrated how each site is subject to different surroundings and environmental circumstances, and thus promotes a risk-based approach on a site-specific basis for dealing with potential environmental impacts.

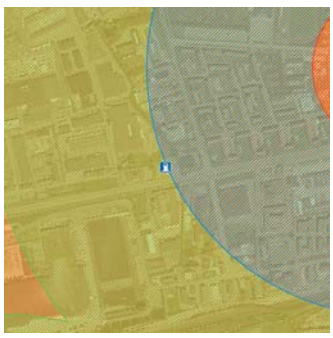
Figure 4: Assessment of environmental sensitivity at a site-specific level

Surrounding land use

Surface water receptors



Groundwater receptors



Minor aquifer class

Proximity to groundwater abstraction:

- <250 m
- <750 m
- <1250 m

Conclusions

This project defined and assessed the environmental sensitivity of more than 85,000 petrol filling stations across Europe and has identified variations in the distribution of environmental sensitivity for sites.

The outcome of the research shows that:

- Patterns in environmental sensitivity at petrol filling station locations can vary at a national, regional and local level.
- The availability, data definitions, quality and scale of environmental data across Europe is not consistent, limiting the potential to compare data and results accurately across national borders.
- Environmental sensitivity of petrol filling station locations is not only a result of the distribution of environmental receptors, but is also influenced by external factors such as land cover patterns, and in the case of groundwater sensitivity, differences in the regulation of groundwater for drinking water supply at both a national and regional scale.
- At a practical level the study has also provided a potential screening tool for identifying sites of higher sensitivity for further investigation at a site specific level, enabling resources and investment to be applied rationally.

This study has shown that each site is subject to different surroundings and environmental circumstances, which clearly justifies adopting a risk-based approach on a site-specific basis when implementing the requirements of the EU Groundwater Daughter Directive.