

Groundwater Response Matrix for one off housing wastewater

Background

The primary responsibility for groundwater protection rests with any person who is carrying on an activity that poses a threat to groundwater. Groundwater in Ireland is protected under European Community and national legislation. Local authorities and the Environmental Protection Agency (EPA) have responsibility for enforcing this legislation. The Geological Survey of Ireland (GSI), in conjunction with the Department of Environment and Local Government (DELG) and the EPA, have issued guidelines on the preparation of groundwater protection schemes to assist the statutory authorities and others to meet their responsibility to protect groundwater (DELG/EPA/GSI, 1999). A groundwater protection scheme incorporates land surface zoning and groundwater protection responses.

This document is concerned with groundwater protection responses for the siting of on-site wastewater treatment systems for a dwelling house of up to 10 people with facilities for toilet usage, living, sleeping, bathing, cooking and eating. These responses should be used in conjunction with the EPA guidance document Wastewater Treatment Manual: Treatment Systems for Single Houses (EPA, 2000). The groundwater protection responses outline acceptable on-site wastewater treatment systems in each groundwater protection zone (as described in Groundwater Protection Schemes DELG/EPA/GSI, 1999) and recommend conditions and/or investigations depending on the groundwater vulnerability, the value of the groundwater resource and the contaminant loading. It will be noted that these responses relate to discharges to groundwater. Less stringent responses may be appropriate for discharges to surface waters.

In Ireland, wastewater from approximately 400,000 dwellings is treated by on site systems. On-site systems can be subdivided into two broad categories: septic tank systems and mechanical aeration systems.

A conventional septic tank system consists of a septic tank followed by a soil percolation area. As an alternative to a conventional percolation area the effluent from a septic tank can be treated by filter systems such as:

- a soil percolation system in the form of a mound;
- an intermittent sand filter followed by a polishing filter;
- an intermittent peat filter followed by a polishing filter;
- an intermittent plastic or other media filter followed by a polishing filter; or
- a constructed wetland or reed bed, followed by a polishing filter.

Mechanical aeration systems include: biofilm aerated (BAF) systems; rotating biological contactor (RBC) systems; and sequencing batch reactor (SBR) systems. The effluent from a mechanical aeration system should be treated by a polishing filter to reduce micro-organisms, phosphorus and nitrate nitrogen.

On-site systems are the primary method used for the treatment and disposal of domestic wastewater in rural areas. These systems are also used in urban areas, which are not connected to public sewer systems. On-site systems are often located close to private or public wells.

When choosing the location and type of on-site system, developers should have regard to any nearby groundwater source, the groundwater as a resource and the vulnerability of the underlying groundwater. The groundwater protection responses in this guidance combine these factors to produce a response matrix.

The objectives of these groundwater protection responses are:

- to reduce the risk of pollutants reaching drinking water supplies;
- to reduce the risk of pollution of aquifers;
- to minimise pollution of domestic wells; and
- to provide advice where it is proposed to locate domestic wells in the vicinity of existing wastewater treatment systems and vice versa.

The risk from on-site wastewater treatment systems is mainly influenced by:

- its proximity to a groundwater source;
- the groundwater vulnerability;
- the value of the groundwater resource;
- the height of the water table;
- the groundwater flow direction; and
- the type of on-site system and the quality of the final effluent.

The use of these groundwater protection responses allows decisions to be made on the acceptability or otherwise of on-site wastewater treatment systems from a hydrogeological point of view.

These groundwater protection responses should be read in conjunction with *Groundwater Protection Schemes* (DELG/EPA/GSI, 1999). Other published responses in this series are *Groundwater Protection Responses for Landfills* and *Groundwater Protection Response to the Landspreading of Organic Wastes*.

Effluent from On-site Wastewater Treatment Systems for Single Houses: a Potential Hazard for Groundwater

The characteristics of domestic wastewater are outlined in Table 1.

Table 1: Characteristics of Domestic Wastewater

Parameter	Typical concentration mg/l unless otherwise stated
COD (as O ₂)	400
BOD ₅ (as O ₂)	300
Total solids	200
Total Nitrogen (as N)	50
Total Phosphorus (as P)	10
Total coliforms (MPN/ 100 ml)*	10 ⁷ - 10 ⁸

* Most probable number (MPN/100 ml).

Particular contaminants of concern are pathogenic organisms and nitrates.

Pathogenic organisms

Pathogenic organisms can cause gastro-enteritis, polio, hepatitis, meningitis and eye infections.

Organisms such as *E. coli*, streptococci and faecal coliforms, with the same enteric origin as pathogens, indicate whether pathogens may be present or not in wastewater.

Nitrates

Nitrate in excess concentrations in water may constitute a risk to human health and the environment. Nitrogen enters on-site wastewater treatment systems mainly as organic nitrogen, which means the nitrogen is part of a large biological molecule such as a protein. Bacteria and other microbes oxidise or mineralise the organic nitrogen to ammonia, which is further oxidised to nitrites and nitrates.

Groundwater Protection Response Matrix for Single House Systems

The reader is referred to the full text in *Groundwater Protection Schemes* (DELG/EPA/GSI, 1999) for an explanation of the role of groundwater protection responses in a groundwater protection scheme.

A risk assessment approach is taken in the development of this response matrix. A precautionary approach is taken because of the variability of Irish subsoils, bedrock and the possibility that the treatment system may not function properly at all times. Where there is a high density of dwellings in the vicinity of public, group scheme or industrial water supply sources, more restrictive conditions may be required or the development may need to be refused. The density of dwellings and associated treatment systems may impact on the groundwater because of the cumulative loading, particularly of nitrate. This should be taken into account especially where the vulnerability of the groundwater is high or extreme.

The potential suitability of a site for the development of an on-site system is assessed using the methodology outlined in *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000). This methodology includes a desk study and on-site assessment (visual, trial hole test and percolation tests). The groundwater protection responses set out in Table 2 below should be used during the desk study assessment of a site to give an early indication of the suitability of a site for an on-site system. Information from the on-site assessment should be used to confirm or modify the response. In some situations site improvement works may allow a system to be developed. In such situations, site improvement works followed by reassessment of the groundwater responses, may allow a system to be developed. Site improvements are dealt with in Section 3.2.2 of the *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000).

Where groundwater protection zones have not yet been delineated for an area, the responses below should be used in the following circumstances:

- where on-site systems are proposed in the vicinity of domestic wells;
- where on-site systems are proposed in the vicinity of sources of water with an abstraction rate above 10m³/d (e.g. public, group scheme and industrial supply wells and springs);
- where groundwater is extremely vulnerable (based on the visual assessment and trial hole test); and
- where there are karst features such as swallow holes, caves etc.

The appropriate response to the risk of groundwater contamination from an on-site wastewater treatment system is given by the assigned response category (**R**) appropriate to each protection zone.

Table 2: Response Matrix for On-site Treatment Systems

VULNERABILITY RATING	SOURCE PROTECTION AREA *		RESOURCE PROTECTION Aquifer Category					
			Regionally Important		Locally Important		Poor Aquifers	
	Inner (SI)	Outer (SO)	Rk	Rf/Rg	Lm/Lg	L1	Pl	Pu
Extreme (E)	R3 ²	R3 ¹	R2 ²	R2 ²	R2 ¹	R2 ¹	R2 ¹	R2 ¹
High (H)	R2 ⁴	R2 ³	R2 ¹	R1	R1	R1	R1	R1
Moderate (M)	R2 ⁴	R2 ³	R1	R1	R1	R1	R1	R1
Low (L)	R2 ⁴	R1	R1	R1	R1	R1	R1	R1

* For public, group scheme or industrial water supply sources where protection zones have not been delineated, the arbitrary distances given in DELG/EPA/GSI (1999) of 300 m for the Inner Protection Area (SI) and 1000 m for the Outer Protection Area (SO) should be used as a guide up-gradient of the source.

R1	Acceptable subject to normal good practice (i.e. system selection, construction, operation and maintenance in accordance with EPA (2000)).
R2¹	Acceptable subject to normal good practice. Where domestic water supplies are located nearby, particular attention should be given to the depth of subsoil over bedrock such that the minimum depths required (EPA, 2000) are met and that the likelihood of microbial pollution is minimised.
R2²	Acceptable subject to normal good practice and the following additional condition: 1) There is a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench of a conventional septic tank system; OR 1) A treatment system other than a conventional septic tank system as described in EPA (2000) is installed, with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values 1 from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2 m in total for a soil polishing filter).
R2³	Acceptable subject to normal good practice, condition 1 above and the following additional condition: 2) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.
R24	Acceptable subject to normal good practice, conditions 1 and 2 above and the following additional condition: 3) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.
R3¹	Not generally acceptable, unless: A conventional septic tank system is installed with a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench (i.e. an increase of 0.8 m from the EPA manual); OR A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2m in total for a soil polishing filter); AND subject to the following conditions: 1)The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate

	and/or microbiological contamination is unlikely. 2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source. 3) A management and maintenance agreement is completed with the systems supplier.
R3²	Not generally acceptable unless: A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 1.2 m unsaturated soil/subsoil with P/T values from 1 to 50, (in addition to the polishing filter which should be a minimum depth of 0.6 m) beneath the invert of the polishing filter (i.e. 1.8m in total for a soil polishing filter); AND subject to the following conditions: 1) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely. 2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source. 3) A management and maintenance agreement is completed with the systems supplier.

¹ The T value (expressed as min/25mm) is the time taken for the water level to drop a specified distance in a percolation test hole. For shallow subsoils the test hole requirements are different and hence the test results are called P values. For further advice see page 25 of the EPA Manual (2000).

The responses above assume that there is no significant groundwater contamination in the area. Should contamination by pathogenic organisms or nitrate (or other contaminants) be a problem in any particular area, then more restrictive responses may be necessary. Where nitrate levels are known to be high or nitrate loading analysis indicates a potential problem, consideration should be given to the use of treatment systems which include a de-nitrification unit. Monitoring carried out by the Local Authority will assist in determining whether or not a variation in any of these responses is required.

Ponding may occur in areas of low permeability subsoils ($T > 50$) and thus safeguards for surface waters should be put in place.

Additional Requirements for the Location of On-site Treatment Systems Adjacent to Receptors at Risk, such as Wells and Karst Features

Table 2 above outlines responses for different hydrogeological situations, which may restrict the type of on-site treatment system, and must be satisfied in the first instance. Once a response has been determined for a site, the next step is to manage the risk posed to the features identified during the desk study and on-site assessment. These features include water supply wells and springs (public and domestic), and karst features that enable the soils and subsoil to be bypassed (e.g. swallow holes, collapse features).

Table 3 below provides recommended distances between receptors (see also Figure 1) and percolation area or polishing filters, in order to protect groundwater. These distances depend on the thickness and permeability of subsoil. The depths and distances given in this table are based on the concepts of 'risk assessment' and 'risk management', and take account, as far as practicable, of the uncertainties associated with hydrogeological conditions in Ireland. Use of the depths and distances in this table does not guarantee that pollution will not be caused; rather, it will reduce the risk of significant pollution occurring.

Where an on-site system is in the zone of contribution of a well, the likelihood of contamination and the threat to human health depend largely on five factors:

- the thickness and permeability of subsoil beneath the invert of the percolation trench;
- the permeability of the bedrock, where the well is tapping the bedrock;
- the distance between the well or spring and the on-site system;
- the groundwater flow direction; and
- the level of treatment of effluent.

Table 3: Recommended Minimum Distance between a Receptor and a Percolation Area or Polishing Filter

T or P Value ¹	Type of soil/subsoil *	Depth of soil/subsoil (m) above bedrock (see note 1,2,3,6)	Minimum distance (m) from receptor to percolation area or polishing filter ****				
			Public Water Supply	Karst feature	down-gradient domestic well or flow direction is unknown (see note 5)	Domestic well alongside (no gradient)	up-gradient domestic well
>30	CLAY; silty, sandy CLAY (e.g. dayey till); CLAY/SILT.	1.2 >3.0	60	15	40 30	25	15
10-30	Sandy SILT; clayey, silty SAND; clayey, silty GRAVEL (e.g. sandy till).	1.2 >8.0	60	15	45 30	25	15
<10	SAND; GRAVEL; silty SAND	2.0** 2.0*** >8.0****	60	15	60 40 30	25	15

* BS5930 descriptions

** water table 1.2-2.0m

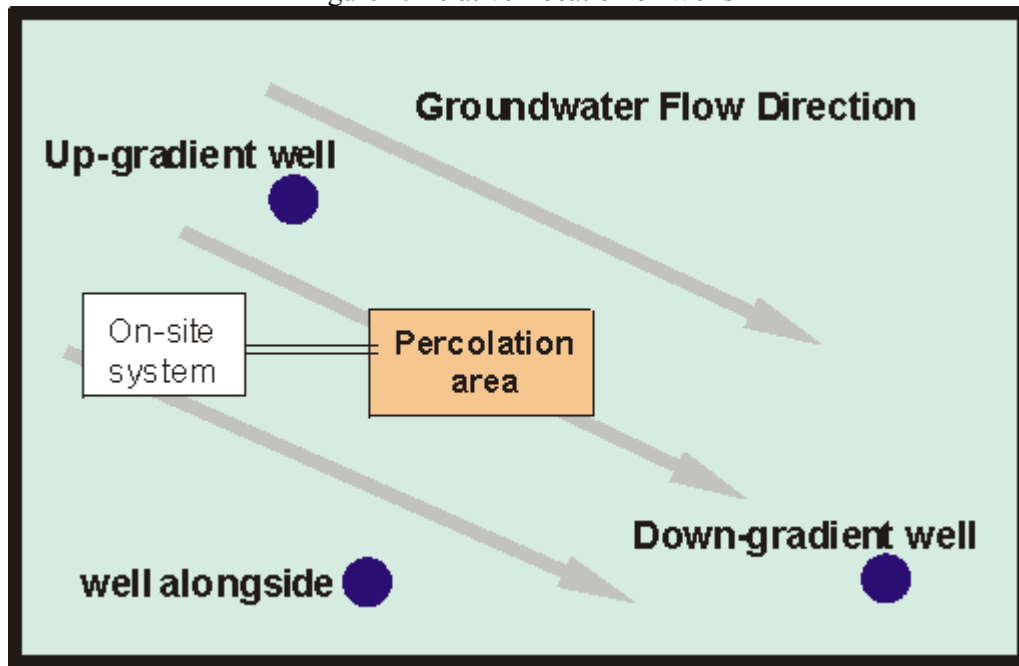
*** water table >2.0m

**** The distance from the percolation area or polishing filter means the distance from the periphery of the percolation area or polishing filter and not the centre.

Notes :

1. Depths are measured from the invert level of the percolation trench.
2. Depths and distances can be related by interpolation: e.g. where the thickness of silty, sandy CLAY is 1.2 m, the minimum recommended distance from the well to percolation area is 40 m; where the thickness is 3.0 m, the distance is 30 m; distances for intermediate depths can be approximated by interpolation.
3. Where bedrock is shallow (<2 m below invert of the trench), greater distances may be necessary where there is evidence of the presence of preferential flow paths (e.g. cracks, roots) in the subsoil.
4. Where the minimum subsoil thicknesses are less than those given above, site improvements and systems other than conventional systems, as described in EPA (2000), may be used to reduce the likelihood of contamination.
5. If effluent and bacteria enter bedrock rapidly (within 1-2 days), the distances given may not be adequate where the percolation area is in the zone of contribution of a well. Further site specific evaluation is necessary.
6. Where bedrock is known to be karstified or highly fractured, greater depths of subsoil may be advisable to minimise the likelihood of contamination.

Figure 1: Relative Location of Wells



References

DELG/EPA/GSI, 1999. Groundwater Protection Schemes. Department of Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland.

EPA, 2000. Wastewater Treatment Manuals: Treatment Systems for Single Houses, Environmental Protection Agency.