County Kerry Groundwater Protection Scheme



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Document Control Sheet

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Executive Summary

The protection of groundwater quality from the impact of human activities is a high priority for land-use planners and water resources managers. There are two main components of a groundwater protection scheme: land surface zoning and groundwater protection responses for potentially polluting activities.

Land surface zoning provides the general framework for a groundwater protection scheme. The outcome is a map, which divides any chosen area into a number of groundwater protection zones according to the degree of protection required.

There are three main hydrogeological elements to land surface zoning. The entire land surface is subdivided according to the vulnerability of the underlying groundwater to contamination. This requires production of a vulnerability map showing four vulnerability categories – extreme, high, moderate and low. Areas contributing to groundwater sources (usually public and group supply sources), termed source protection areas, can also delineated. As well as this, areas are subdivided according to the value of the groundwater resources or aquifer category, and are termed resource protection areas.

The vulnerability maps at 1:50,000 scale are integrated with each of the other two to give maps showing groundwater protection zones. These include source protection zones, where they have been delineated, and resource protection zones.

The location and management of potentially polluting activities in each groundwater protection zone is by means of a groundwater protection response matrix for each activity or group of activities, which describes: (i) the degree of acceptability of each activity; (ii) the conditions to be applied; and, in some instances (iii) the investigations that may be necessary prior to decision-making.

While the two components (the protection zone maps and the groundwater protection responses) are separate, they are incorporated together and closely inter-linked in a protection scheme.

By 2007 the Geological Survey of Ireland had completed Groundwater Protection Schemes on a county-by-county basis for approximately half the land surface of Ireland. The organisation then procured funding as part of the National Development Plan II, which, along with associated funding from relevant Local Authorities, would allow the completion of a countrywide Groundwater Protection Scheme: mapping in detail the remaining areas with little or no data. This project is being completed over a five year period; 2008 to 2012 inclusive.

Work has been completed in Kerry and this report details the Groundwater Protection Scheme concepts and zonings for the county. The report should be used as an explanatory guide to the associated groundwater vulnerability, aquifer and groundwater protection zone shapefile coverages delivered by the GSI to Kerry County Council.

1 Introduction

1.1 Groundwater Protection – A Priority Issue for Local Authorities

The protection of groundwater quality from the impact of human activities is a high priority for land-use planners and water resources managers. This situation has arisen because:

- groundwater is an important source of drinking water supply
- human activities pose increasing risks to groundwater quality: there is widespread disposal of domestic, agricultural and industrial effluents to the ground, and volumes of waste are increasing
- groundwater provides the baseflow to surface water systems, many of which are used for water supply and recreational purposes. In many rivers, more than 50% of the annual flow is derived from groundwater and more significantly, in low flow periods in summer, more than 90% is from groundwater. If groundwater becomes contaminated the rivers can also be affected and so the protection of groundwater resources is an important aspect of sustaining surface water quality
- groundwater generally moves slowly through the ground and so the impact of human activities can last for a relatively long time
- polluted drinking water is a health hazard and once contamination has occurred, drilling of new wells is expensive and in some cases not practical. Consequently 'prevention is better than cure'
- groundwater may be difficult to clean up, even when the source of pollution is removed
- unlike surface water where flow is in defined channels, groundwater is present everywhere
- EU policies and national regulations are requiring that polluting discharges to groundwater must be prevented as part of sustainable groundwater quality management
- Since 2003, the Department of Environment, Heritage and Local Government (DEHLG) has recommended that GWPSs are incorporated into County Development Plans (Circular Letter SP 5/03 Groundwater Protection and the Planning System). In 2010, the DEHLG issued a Circular Letter concerning the implementation of the EPA Code of Practice on Wastewater Treatment and Disposal Systems Serving Single Houses (Circular Letter PSSP 1/10). The Circular Letter recommended that where Local Authorities do not already have a GWPS, they should prepare one as soon as is practicable in order to facilitate implementation of the Code of Practice.

1.2 Groundwater – A Resource at Risk

Groundwater as a resource is under increasing risk from human activities, for the following reasons:

- lack of awareness of the risks of groundwater contamination, because groundwater flow and contaminant transport are generally slow and neither readily observed nor easily measured
- contamination of wells and springs
- widespread application of domestic, agricultural and industrial effluents to the ground
- generation of increasing quantities of domestic, agricultural and industrial wastes
- increased application of inorganic fertilisers to agricultural land, and usage of pesticides
- greater volumes of road traffic and more storage of fuels/chemicals
- manufacture & distribution of chemicals of increasing diversity and often high toxicity, used for a wide range of purposes.

The main threats to groundwater are posed by:

- (a) point contamination sources: farmyard wastes (silage effluent, soiled water), effluent from on-site systems (septic tanks), leakages, spillages, non-agricultural pesticides, landfill leachate, contaminated sinking streams;
- (b) diffuse sources spreading of fertilisers (organic and inorganic) and pesticides.

While point sources have caused most of the contamination problems identified to date, there is increasing evidence that diffuse sources are impacting on groundwater.

1.3 Groundwater Protection through Land-use Planning: A Means of Preventing Contamination

There are a number of ways of preventing groundwater contamination, such as improved well siting, design and construction, and better design and management of potential contamination sources. However, one of the most effective ways is integrating hydrogeological factors into land-use policy and planning by means of Groundwater Protection Schemes.

Land-use planning (including environmental impact assessment), integrated pollution control licensing, waste licensing, water quality management planning, water pollution legislation, etc., are the main methods used in Ireland for balancing the need to protect the environment with the need for development. However, land-use planning is a dynamic process with social, economic and environmental interests and impacts influencing to varying degrees the use of land and water. In a rural area, farming, housing, industry, tourism, conservation, waste disposal, water supply, etc., are potentially interactive and conflicting and may compete for priority. How does groundwater and groundwater pollution prevention fit into this complex and difficult situation, particularly as it is a resource that is underground and for many people is 'out of sight, out of mind'? Groundwater Protection Schemes enable planning and other regulatory authorities to take account of both geological and hydrogeological factors in locating developments; consequently they are an essential means of preventing groundwater pollution.

1.4 'Groundwater Protection Schemes' – A National Methodology for Preventing Groundwater Pollution

The Geological Survey of Ireland (GSI), the Department of Environment and Local Government (DELG) and the Environmental Protection Agency (EPA) have jointly developed a methodology for the preparation of groundwater protection schemes (DELG/EPA/GSI, 1999). The publication **Groundwater Protection Schemes** was launched in May 1999, by Mr. Joe Jacob TD, Minister of State at the Department of Public Enterprise. Five supplementary publications are currently available: **Groundwater Protection Responses for On-Site Systems for Single Houses ('septic tanks')**, **Groundwater Protection Responses for Landfills**, **Groundwater Protection Responses for Earth Lined Slurry Stores** and **Groundwater Protection Responses for Outwintering Pads**. Similar 'responses' publications will be prepared in the future for other potentially polluting activities, such as underground storage tanks and petrol stations.

There are two main components of a groundwater protection scheme:

• Land surface zoning

• Groundwater protection responses for potentially polluting activities

These are shown schematically in Figure 1.1.

Land surface zoning provides the general framework for a groundwater protection scheme. The outcome is a map, which divides any chosen area into a number of groundwater protection zones according to the degree of protection required.



Figure 1-1 Summary of the Main Components of a Groundwater Protection Scheme

There are three main hydrogeological elements to land surface zoning:

• Division of the entire land surface according to the **vulnerability** of the underlying groundwater to contamination. This requires production of a vulnerability map showing four vulnerability categories – extreme, high, moderate and low.

- Delineation of **areas contributing to groundwater sources** (usually public and group supply sources); these are termed source protection areas.
- Delineation of areas according to the value of the groundwater resources or **aquifer category**: these are termed resource protection areas.

The vulnerability maps are integrated with each of the other two to give maps showing **groundwater protection zones**. These include source protection zones and resource protection zones.

The location and management of potentially polluting activities in each groundwater protection zone is by means of a **groundwater protection response matrix** for each activity or group of activities, which describes: (i) the degree of acceptability of each activity; (ii) the conditions to be applied; and, in some instances (iii) the investigations that may be necessary prior to decision-making.

While the two components (the protection zone maps and the groundwater protection responses) are separate, they are incorporated together and closely inter-linked in a protection scheme.

1.5 Objectives of the County Kerry Groundwater Protection Scheme

The overall aim of the groundwater protection scheme is to preserve the quality of groundwater in County Kerry for drinking purposes and other beneficial uses, for the benefit of present and future generations.

The objectives, which are interrelated, are as follows:

- to assist the statutory authorities in meeting their responsibilities for the protection and conservation of groundwater resources;
- to provide geological and hydrogeological information for the planning process, so that potentially polluting developments can be located and controlled in an environmentally acceptable way;
- to integrate the factors associated with groundwater contamination risk, to focus attention on the higher risk areas and activities, and to provide a logical structure within which contamination control measures can be selected.

The scheme is not intended to have any statutory authority now or in the future, but to provide a framework for decision-making and guidelines for the statutory authorities in carrying out their functions. As groundwater protection decisions are often complex, sometimes requiring detailed geological and hydrogeological information, the scheme is not prescriptive and should be qualified by site-specific considerations.

1.6 Scope of County Kerry Groundwater Protection Scheme

The groundwater protection scheme is the result of co-operation between Kerry Council and the Geological Survey of Ireland. The programme of works is majority NDP funded.

The geological and hydrogeological data for County Kerry are interpreted to enable:

- (i) further delineation of aquifers
- (ii) assessment of the groundwater vulnerability to contamination

(iii) production of a groundwater protection scheme which relates the data to possible land uses in the county and to groundwater protection responses for potentially polluting developments.

By providing information on the geology and groundwater, this report should enable the balancing of interests between development and environmental protection.

This study compiles, for the first time, all readily available geological data for the county and sets in place a database within the Geological Survey of Ireland (GSI), which can be accessed by the local authority and others, and which can be up-dated as new information becomes available.

A suite of environmental geology maps were used as input maps and overlaid and manipulated within a GIS in order to arrive at the final Groundwater Resource Protection Zones GIS coverage. These input maps are as follows:

- (i) Primary Data or Basic Maps
 - bedrock geology map
 - subsoils (Quaternary) geology map
 - subsoils permeability map
 - geomorphic regions map
 - karst features map
 - outcrop and depth to bedrock map
 - hydrogeological data map

(ii) Derived or Interpretative Maps

- aquifer map
- groundwater vulnerability map
- source protection area maps, if delineated

(iii)Land-use Planning Map

• groundwater protection scheme maps: resource protection zones and source protection zones (if delineated).

Of the above, the bedrock and subsoils geology maps, the aquifer map and the source protection area maps were all previously completed by GSI for County Kerry, and have therefore been used by this project as the compiled, current versions of each respective map.

For the subsoils permeability map, geomorphic regions map and depth to bedrock map, no data were available for Kerry at the project's inception. All of these were therefore mapped for the first time at the 1:50,000 scale within this project, and involved a significant time element, with 5 months alone devoted to undertaking fieldwork throughout County Kerry (by a five person team). Work involved completing a total traverse of all of the county's roads, and identifying all subsoil/bedrock exposures, which were logged/recorded in detail. All exposures encountered by the mapping team were examined, for example road cuttings, house cuts, pipe excavations, trial holes for site assessments, gravel pits, quarries, coastal cliffs, deep drainage ditches and stream cuttings. Furthermore, a drilling programme was undertaken to provide depth to bedrock and subsoil permeability data where exposures were limited. The transition has therefore been from a situation with little or no spatially-mapped subsoil permeability, subdivided geomorphic and depth to bedrock information within Kerry, to one where the mapped coverages are to the highest current standard of GSI mapping and modelling.

From this mapping programme, for the karst features and hydrogeological data maps, although some data were previously available for County Kerry in GSI databases, these data were augmented by the fieldwork described above where new information was collected and features noted. The subsequent maps therefore resulted in an improvement of already-existing GSI coverages, which provides a better overall understanding of the county's geology in the third dimension.

The groundwater vulnerability and groundwater protection maps were then compiled using all of the above mapped information, to create new, previously unavailable maps of Kerry to the highest, current GSI standard.

The digital Geographical Information System (GIS) dataset is registered to the standard Ordnance Survey Irish National Grid map base and is designed to be compatible with planning department GIS systems in the Local Authorities. As well as the interpretative maps described above, the GIS incorporates groundwater protection responses for each protection zone, for landfill, EPA-licensable landspreading of organic wastes, on-site wastewater treatment systems for single houses (including 'septic tanks'), outwintering pads and earth-lined slurry stores. It is envisaged that the protection responses will be the feature most of interest to the Local Authorities in that they will be of direct relevance to the planning process.

The GIS and their printed paper map versions can be used not only to assist in groundwater development and protection, but also in decision-making on major construction projects such as pipelines and roadways. However, they are not a substitute for site investigation.

Regional hydrogeological investigations in County Kerry have included work by the GSI (70's, 80's and early 90's) as well as feasibility studies for the development of public supply sources, Environmental Impact Statements and research publications. This report thus provides a good basis for strategic decision-making and for site specific investigations.

1.7 County Kerry Development Plan

It is envisaged that this Groundwater Protection Scheme should be incorporated into the County Development Plan as outlined in Circular Letters SP 5/03 and PSSP 1/10. The Circular Letters recommended that where Local Authorities do not already have a GWPS, they should prepare one as soon as is practicable.

1.8 Structure of Groundwater Protection Scheme and Report

The structure of the Groundwater Protection Scheme is based on the information and mapping requirements for land surface zoning. The Groundwater Protection Scheme structure is illustrated in Figure 1.2. The Groundwater Protection Zone Map is obtained by combining the Aquifer and Groundwater Vulnerability Maps. The Aquifer Map, in turn, is based on the Bedrock Map boundaries and the aquifer categories as derived from an assessment of the available hydrogeological data: this was previously completed by the GSI as part of the Initial Characterisation Process for Irish Aquifers for the EU Water Framework Directive. The Groundwater Vulnerability Map, the delineation of which formed the majority of the work within the current Groundwater Protection Scheme Project, is based on the Subsoils Map, the Depth to Bedrock Map, and an assessment of specifically relevant permeability and karstification information.



Figure 1-2 Conceptual Framework for Production of Groundwater Resource Protection Zones, Indicating Information Needs and Links

Similarly, the Source Protection Zone Map results from combining vulnerability and source protection area maps (if delineated). The source protection areas are based largely on assessments of site specific hydrogeological data. It should be noted that no source protection zone delineation work was carried out in County Kerry as part of this project, but previously-delineated Source Protection Zones have been incorporated into the map or revised based on the newly-available information from the mapping.

This County Kerry Groundwater Protection Scheme report initially discusses the background to Groundwater Protection Schemes (Chapter 1) before providing a brief summary of the subsoils geology of Kerry (Chapter 2) and the general characteristics of subsoil permeability (Chapter 3). Chapter 4 describes the subsoil permeability distribution throughout the county, while Chapter 5 detailing the variation in depth to bedrock across the area. Chapter 6 discusses the spatial distribution of Groundwater Vulnerability across the region. Chapter 7 outlines the aquifer classification scheme for County Kerry and Chapter 8 draws the entire scheme together and summarises the final groundwater protection zones delineated for the county.

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2 Subsoil (Quaternary) Geology

2.1 Introduction

This chapter deals primarily with the geological materials which lie above the bedrock and beneath the topsoil. The subsoils were deposited during the Quaternary period of glacial history. The Quaternary period encompasses the last 1.6 million years and is sub-divided into the Pleistocene (1,600,000-10,000 years ago); and the more recent Holocene (10,000 years ago to the present day). The Pleistocene, more commonly known as the 'Ice Age', was a period of intense glaciation separated by warmer interglacial periods. The Holocene or post-glacial period, saw the onset of a warmer and wetter climate approaching that which we have today.

During the Pleistocene the glaciers and ice sheets laid down a wide range of deposits, which differ in thickness, extent and lithology. Material for the deposits originated from bedrock and was subjected to different processes within, beneath and around the ice. Some were deposited irregularly by ice and so are unsorted and have varying grain sizes, while others were deposited by water in and around the ice sheets and are relatively well sorted and coarse grained. Mapping of subsoils in County Kerry was undertaken by Teagasc in a project funded by the EPA during the period 1998-2006. This mapping formed the foundation of subsequent subsoil permeability assessments (described in Chapter 4). Subsoil distribution is presented in Figure 2.2., with a simplified subsoil map showing the major classes of subsoil material only shown in Figure 3. An overview of evidence for ice flow directions across County Kerry has been provided in Section 2.4.

2.2 Subsoil Types

There are three main subsoil types identified in County Kerry and shown on Figures 2.2 and 2.3:

- ♦ till
- sands and gravels
- ♦ alluvium

Areas where bedrock comes within about 1 m of the surface are shown on the maps as "bedrock outcrop and subcrop".

TILL

Till (often referred to as boulder clay) is the most widespread subsoil in County Kerry as can be seen on Figure 2.3, covering over 80% of the county area. It is a diverse material which is deposited sub-glacially and it has a wide range of characteristics due to the variety of parent materials and different processes of deposition. Much of the till material is dominated by 'silt' and 'sand' texturally, owing to its derivation from underlying Devonian Old Red Sandsotne or Ordovician Volcanics during the last Ice Age. From this, much of the area covered by till in County Kerry is of moderate permeability class, with free draining soils and good infiltration characteristics.

SANDS AND GRAVELS

Deposition of sands and gravels takes place mainly when the glaciers are melting. This gives rise to large volumes of meltwaters with great erosive and transporting power. The subsoils deposited in this environment are primarily well rounded gravels with sand, with the finer fractions of clay and silt washed out. Outwash deposits take the form of fans of stream debris dropped at the glacier front *via* drainage channels. Deltaic deposits are similar but are formed where drainage channels discharge into a standing body of water. Deposits remaining in the drainage channels form eskers, similar to a river drainage system in arrangement, with tributaries converging downstream.

County Kerry has a few sand and gravel deposits distributed throughout western and central Kerry, the most extensive of which is the sand and gravel located between Killorglin and Killarney. These deposits have been quarried historically, where present, throughout the county. The presence of sand and gravel is often reflected in the topography as hummocks and hollows (kames and kettle holes) or in large fan shaped deposits (outwash terraces).

ALLUVIAL DEPOSITS

Alluvial sediments are deposited by rivers and include unconsolidated materials of all grain sizes, from coarse gravels down to finer silts and clays, and they may also contain organic detritus.

2.3 Depth to Bedrock

The depth-to-bedrock (*i.e.* subsoil thickness) is a critical factor in determining groundwater vulnerability. Subsoil thicknesses vary considerably over the county, from very thin (rock at surface) to depths of more than 20 metres. The direction of ice movement has spatially influenced the subsoil thicknesses.

Broad, regional-scale variations in depth to bedrock have been interpreted across the county as part of the mapping programme, using extensive GSI drilling data collected as part of this project, as well as information from the GSI databases, from consultants investigations, from field mapping and air photo interpretation. Depth-to-rock data maps show areas where the rock crops out at the surface, and the depth-to-rock data from exposure and borehole records. Generally speaking, the thickest deposits are tills or gravels in lowland plain or valley settings, throughout the county.

2.4 Ice Flow Direction

As ice flows over the terrain, it erodes the underlying bedrock surface and deposits the material it has picked up further down the course of the glacier. This means that it should be possible to reconstruct former ice flow directions using small and large-scale lineaments expressed in the modern topography, as well as looking at the fabric of basal tills and the provenance of their clasts.

County Kerry displays the same types of topographic features as other relict-glaciated area. There are a number of features that allow us to tentatively reconstruct former paths of ice-flow. Prior to the current mapping programme a number of striae were recorded on the nineteenth century GSI bedrock maps. These striae concur with the observations in the current

mapping programme, highlighting a flow of ice from the north to south across the majority of the county, while localised flows occur within the higher mountains ranges associated with valley glaciers (Figure 2.1).

Streamlined crag-and-tail ridges and drumlins throughout County Kerry also indicate ice moving in a north to south direction. Crag and tails have bedrock exposed on the up-ice side and till plastered on the lee side of the slopes, whereas drumlins are streamlined hills comprised of subglacially-deposited till aligned along-ice flow. A full account of the various ice flow directions and phases of ice flow to affect County Kerry during the last glacial episode is given in Greenwood and Clark (2009).



Figure 2-1: Ice streams reconstructed for the Irish Ice Sheet, from Greenwood and Clark, 2009. As can be seen in Stage III-b, County Kerry had its own independent ice cap over the high mountains, while ice invaded from the north and northeast across the rest of the county.



Figure 2-2 Subsoils Map of County Kerry, showing all subsoil types encountered across the county.



Figure 2-3 Simplified subsoil map of County Kerry, showing the major subsoil classes only.

3 Subsoil Permeability

The permeability categories, and related vulnerability categories, are qualitative regional assessments of the subsoil based on how much potential recharge is infiltrating and how quickly potential contaminants can reach groundwater. The permeability of subsoil is largely a function of (a) the grain size distribution, (b) the amount (and sometimes type) of clay size particles present, and (c) how the grains are packed together. It can also be influenced by other factors such as discontinuities (fissures/cracks, plant roots, pores formed by soil fauna, isolated higher permeability beds or lenses, voids created by weathering of limestone clasts) and density/compactness of the deposit.

In poorly sorted sediments such as glacial tills, which are common and widespread in County Kerry, these characteristics describe the engineering behaviour of the materials as detailed in the subsoil description and classification method derived from BS 5930:1999 (Swartz, 1999). This method is used to assess the subsoil permeability at each exposure, and is combined with recharge and drainage observations in the surrounding area for a regional, three-dimensional classification. Each approach used in assessing the permeability is discussed briefly here. Some are described in more detail in the research theses of Lee (1999) and Swartz (1999):

Subsoil Description and Classification Method (derived from BS 5930:1999). Using this method, subsoils described as sandy CLAY or CLAY has been shown to behave as low permeability materials. Subsoils classed as silty SAND and sandy SILT, on the other hand, are found to have a moderate permeability (Swartz, 1999). In general, sands and gravels that are well sorted have a high permeability. Permeability mapping focuses on areas where soil and subsoil are thicker than 3m, since areas with thinner soil/subsoil than this are automatically considered 'Extremely Vulnerable'.

Particle Size Analyses. The particle size distribution of sediments describes the relationships between the different grain sizes present. Well-sorted sediments such as water-lain gravels (high permeability) or lacustrine clays (low permeability) will, on analysis, show a predominance of grain sizes at just one end of the scale. Glacial tills, on the other hand, are more variable and tend to have similar proportions of all grain sizes. Despite their complexity, evaluations of the grain size analyses for a range of tills in Ireland have established the following relationships (Swartz, 1999):

- i. Samples described as 'moderate permeability', based on observations of recharge indicators (vegetation, drainage density); typically have less than 35% fines (silt plus clay).
- ii. These 'moderate permeability' samples also tend to have less than 12% clay.
- iii. Samples described as 'low permeability' frequently have more than 50% fines.
- iv. These 'low permeability' samples also tend to have more than 14% clay.
- v. 'High permeability' sand/gravel deposits tend to be sorted and have less than 7.5% fines (O Suilleabhain, 2000).

Once the general characteristics and variations have been identified, these can be extrapolated to other similar areas where permeability observations may be lacking.

Subsoil Parent Material. The subsoil parent material, which is often the bedrock, plays a critical role in providing the particles that give rise to different subsoil permeabilities. Sandstone, for example, gives rise to a high proportion of sand size grains in the deposit

matrix; pure limestone provides a relatively high proportion of silt, whilst shale, shaly limestone and mudstone break down to the finer clay size particles. A good knowledge of the nature of the bedrock geology is therefore critical. It is also useful to know the direction of movement of the glaciers and the modes of deposition of the sediments as these will dictate where the particles have moved to, how finely they have been broken down, and what the relative grain size make-up and compaction are. Understanding these processes enables more informed extrapolations to be made where observations are lacking.

Recharge Characteristics. Examining the drainage and recharge characteristics in an area gives an overall representative assessment of the permeability. Poor drainage and certain vegetation species can indicate low permeability subsoil providing iron pans, underlying low permeability bedrock, high water-tables, and excessively high rainfall can be ruled out. Well-drained land suggests a moderate or high permeability once artificial drainage is taken into consideration (Lee, 1999). Tables 3.1 and 3.2 indicate the general relationship between permeability categories and natural and artificial drainage density respectively. Rigorous analysis of drainage density was not undertaken in this project, but general abundance or absence of drainage ditches was recorded.

 Table 3-1Broad Permeability Categories for Natural Drainage Density (Lee et al., 1999)

Permeability	Natural Drainage Density	Units
High	<0.6	km/km ²
Moderate	0.6-1	km/km ²
Low	>1	km/km ²

 Table 3-2 Broad Permeability Categories for Artificial Drainage Density (Lee et al., 1999)

Permeability	Artificial Drainage Density	Units
High	<2	km/km ²
Moderate	2-8	km/km ²
Low	>8	km/km ²

Topsoil Map. The soils map can be used to indicate broad drainage characteristics, especially where specific site recharge observations are not available. Poorly drained soils such as surface water gleys are usually related to underlying low permeability subsoil; the more free draining soils such as grey brown podzolics are more typical of the sandy and silty moderate permeability subsoil.

Quantitative Analysis. From a limited number of national field permeability measurements, the boundary between moderate and low permeability is estimated as approximately 10^{-8} - 10^{-9} m/s. While the moderate to high boundary has not yet been examined in detail, one study suggests this boundary may be in the region of 10^{-4} m/s (O'Suilleabhain, 2000). However, permeability measurements are highly scale dependent: laboratory values are often up to two orders of magnitude lower than field measurements, which in turn tend to be lower than regional assessments based on large scale pumping tests. Thus, for regional permeability mapping, qualitative assessments of the recharge characteristics and engineering behaviour of the subsoils are more appropriate than specific permeability measurements.

None of these methods can be used in isolation: a holistic approach is necessary to gain an overall assessment of each site and thereby build up a three dimensional picture of the regional permeability. In any given area, as many factors as possible are considered together

in order to obtain a balanced, defensible permeability decision. In order to extrapolate from point data to area assessments, the county is divided into geomorphic regions, usually on the basis of similar subsoil and/or bedrock characteristics. It is intended that the assessments will allow a broad overview of relative permeability across the county, in order to help focus field investigations for future developments in areas of interest. In mapping an area the size of County Kerry, the process is aimed at providing regional guidance and is not intended to be applied to a site-specific level. Consequently, it is stressed that the permeability assessments are not a substitute for site investigations for specific projects.



Figure 3-1 Distribution of subsoil samples taken and analysed under British Standard (BS 5930) subsoil classification or for particle size analyses, to determine permeability class for this project, across County Kerry.

4 Permeability units in County Kerry

The glacial till subsoil in County Kerry is divided into ten permeability units based on their geomorphology and internal material properties, as shown in Figure 4.1. For the purpose of permeability mapping in this project, areas that have less than 3m depth to bedrock are not included in the permeability maps.

There are four further permeability units that are mapped subsoil types with direct, particular corresponding decisions on their permeability. These are dispersed throughout the permeability regions and are: sand and gravel, moderate permeability alluvium low permeability alluvium and peat.

It should be noted that, owing to this, the Kerry Islands geomorphic region (see Figure 4-1), which are comprised of rocky ground which has less than three metres depth to bedrock and are categorised as extreme vulnerability are therefore not assessed for permeability, or included as a permeability region. The islands include these off Rough Point and Slea Head, the Great Blasket Island, Valentia Island and the islands within the inlet at Kenmare.

Although these subdivisions have been based on all of the available data, it is noted that given the 1:50,000 scale of mapping, these regions are likely to include smaller discrete units of differing permeability. The presence of samples with contradicting data reflect this variability, however these units are delineated wherever possible. This further highlights the need for individual site assessment.

4.1 Low Permeability Units

An equal proportion of the ten major permeability regions within County Kerry constitute low and moderate permeability subsoil material. The low permeability areas consist of glacial till with "*clayey*" matrixes, generally dominated by Namurian Sandstones and Shales that underlie much of this area as bedrock.

Alluvial deposits are found in narrow strips along streams and rivers throughout the county. The alluvial deposits along the larger rivers often thicker than 3m and therefore determine the permeability in these zones; where clayey they are classified as low permeability alluvial units.

4.1.1 Permeability Unit 1: Stacks-Glanaruddery Mountains

This region, shown on Figure 4.2, covers 834 km² and occupies approximately 18 % of the county. This mountainous area runs much of the length of Kerry's eastern county boundary, starting just south of Tarbert in the north and extending south as far as Ballydesmond. The area extends out westwards ending near to Ardfert in the north and Milltown in the south.

This area is underlain by bedrock of Namurian Sandstones, Shales and various Undifferentiated Namurain Rocks.

The subsoil is derived from Namurian sandstone and shale till, as well as occasional thin strips of alluvium and a thin layer of blanket peat along the mountain summits.

The unit is classed as "Low Permeability" based on the following data:

The subsoil is classed predominantly as "CLAY" or heavy "SILT/CLAY" using BS 5930 in the collected subsoil exposure and borehole samples.



Particle size distributions, in all excepting two samples, have over 15% CLAY and over 50% fines.



- ➤ Till subsoils are derived from Namurian Sandstones and Shales with a resulting matrix which is described as "*clayey*" in texture.
- > The soils are predominantly poorly drained surface water and groundwater gleys.
- The natural drainage density is calculated as high, at 1.2 km/km², suggestive of low permeability subsoil.
- The artificial drainage density is high, with drainage ditches bordering the edges of well managed fields.
- ▶ Wet grassland and bogland are the dominant land covers in this region.



Figure 4-1 Permeability Units (geomorphic regions) of County Kerry, with a hillshaded Digital Elevation Model showing the land surface topography across the county.



Figure 4-2: Permeability Unit 1: The Stacks-Glanruddery Mountains



Figure 4-3 Rushes on slope and exposure of CLAY subsoil (shown in top right) at Knockariddera in the Stacks and Glanaruddery Mountains unit.

4.1.2 Permeability Unit 2: Rathmore-Ballyhar Ridges

This region covers 184km² or approximately 4 % of the county (see Figure 4-4), located in central Kerry, northeast of Killarney. This area extends from Faha in the west to Rathmore in the east, ending at the Cork county boundary.

This unit is principally underlain by Namurian Undifferentiated bedrock with a band of Namurian Sandstones and Shales in the area around Gneevgullia.

The permeability for this subsoil unit, which is dominated by Namurian sandstone and shale till, is deemed as low.

The unit is classed as "Low Permeability" based on the following data:

The subsoil is classed as "CLAY" or heavy "SILT/CLAY" using BS 5930 in the available, analysed borehole subsoil samples.



- > The subsoils are generally described as "*clayey*" in texture.
- Lithosols and regosols occur in the areas of bedrock outcrop and subcrop, with the vast majority of the soils of the area being surface water gleys, occurring extensively across till-covered lowlands.
- The natural drainage density is estimated to be 1.2 km/km², and is therefore high, suggestive of low permeability subsoil. Streams are abundant between the ridges, oriented along the same plane as the ridge crests.
- The artificial drainage density is moderate to high, with ditches along roads and field boundaries.
- > Wet grassland with rushes occurs commonly throughout this area.



Figure 4-4: Permeability Unit 2: Rathmore – Ballyhar Ridges

4.1.3 Permeability Unit 3: Tralee-Castlemaine Lowlands

This lowland region encircles the Dingle Peninsula, beginning just east of Tralee and extending southwards as far as Castlemaine Harbour. The eastern boundary is marked by the change in topography at the Stacks and Glanruddery Mountains just beyond Castleisland. This area covers 170km², or approximately 4% of the total county area (see Figure 4-5).

This region is underlain predominantly by Dinantian Pure Unbedded Limestone, with smaller areas of Upper and Lower Impure Limestones and Namurian Shales.

The area between Castleisland and Tralee is underlain mainly by limestone till, with a strip of Devonian sandstone till. The southern portion, from Castleisland to the coast at Castlemaine Harbour, is dominated by Namurian sandstone and shale till, and including an extensive deposit of alluvium along the River Maine. There are pockets of cut peat throughout the region.



Figure 4-5: Permeability Unit 3: Tralee – Castlemaine Lowlands

The unit is classed as "Low Permeability" based on the following data:

The subsoil is classed as "CLAY" to heavy "SILT/CLAY" using BS 5930 on the available analysed subsoil samples.



➤ The particle size analysis resulted in all samples, excepting one, with 14% or greater clay and all samples having greater than 35% fines.



- > The subsoil is described as "*clayey*" in texture.
- > The areas soils are dominated by surface water and groundwater gleys.
- ➤ The natural drainage density is estimated to be 1.3 km/km², and is therefore high, suggestive of low permeability subsoil.
- > The artificial drainage density is high, with ditches along roads and field boundaries.
- > Wet grassland with profuse rushes occurs commonly in this lowland area.



Figure 4-6: Mottling in CLAY exposure at Cloontarriv to the southeast of Tralee, indicating low permeability subsoil in the Tralee – Castlemaine Lowlands unit.

4.1.4 Permeability Unit 4: Ballybunnion-Tarbert Uplands

This region, shown on Figure 4-7, covers 162 km^2 and occupies 3% of the county. This is an upland area that borders Kerry's northern coastline, extending inland along the Knockanore Mountains and ending at Listowel.

The underlying rock unit is Namurian Undifferentiated rocks, with a narrow band of Namurian Shales and Dinantian Pure Unbedded Limestones between Ballybunnion and Listowel.

Namurian sandstone and shale till dominates the subsoil, with pockets of peat in depressions and flat areas, and wind blown sands along the coast.

The unit is classed as "Low Permeability" based on the following data.

The subsoil is classed as "CLAY" using BS 5930 in the collected subsoil and borehole samples.



- ➤ Till subsoils are derived from Namurian Sandstones and Shales with a resulting matrix which is described as "*clayey*" in texture.
- Surface water and ground water gleys are dominant, with acid brown earths only present in elevated areas.
- > The natural drainage density is calculated as moderate, at 0.6km/km².
- The artificial drainage density is high, with drainage ditches bordering the edges of fields and roads.
- > This area is dominated by wet grassland.



Figure 4-7: Permeability Unit 4: Ballybunnion – Tarbert Uplands

4.1.5 Permeability Unit 5: Newtownsandes-Ballylongford Basin

This is the smallest permeability unit in Kerry, covering just 70 km² or approximately 1% of the county. This basin is situated in north Kerry and is surrounded on all sides by rolling hills. The River Feale defines its southern boundary and Ballylongford bounds it at the north (Figure 4-9).

Namurian Undifferentiated bedrock underlies this area. The till is also derived from Namurian Sandstones and Shales with large areas of cutover peat. A band of alluvium occurs, along the Galey River, through the centre of the region.

The unit is classed as "Low Permeability" based on the following data:

The subsoil in is classified as "CLAY" using BS 5930 in the available, analysed subsoil sample.



The particle size analysis of this sample resulted in 14% clay and 39% fines indicating low permeability subsoil.



The subsoils, probably influenced by Namurian Shales, are described as "clayey" in texture.

- The vast majority of the areas soils are surface water and ground water gleys, occurring extensively across till-covered lowlands. This is an indication of poorly drained subsoil.
- \blacktriangleright The natural drainage density is estimated to be 0.7 km/km², and is therefore moderate.
- > The artificial drainage density is high, with ditches along roads and field boundaries.
- Wet grassland with profuse rushes, and bogland, occurs commonly through out this area.



Figure 4-8: Permeability Unit 5: Newtownsandes – Ballylongford Basin

4.1.6 Permeability Unit 6: Low Permeability Alluvium

As discussed in Section 4.1, strips of alluvium occur throughout County Kerry. Greatly affected by the surrounding subsoil and bedrock, these deposits fall into two permeability categories of low and moderate.

There are strips of alluvium assigned low permeability along the Rivers Feale, Owenalondrig, Maine and Inny. These units of low permeability alluvium occur along flat, lowlying river courses where fine estuarine clays have been deposited close to the coast, or in areas surrounded by low permeability glacial till.

Alluvial materials are generally fine-grained, waterlain deposits found along the banks and floodplains of rivers. The depth-to-bedrock in these areas is assumed to be generally greater than 3m, and the alluvium generally overlies till or sand and gravel deposits.




> The alluvial subsoils are generally described as "*clayey*" in texture

- The alluvial materials host variable soils, dominated by brown earths, lithosols, gleys and regosols.
- The artificial drainage density is high, with ditches along roads and field boundaries, as well as in extensive underground networks through fields.
- > Wet grassland with scattered rushes and meadowsweet occurs in these areas.

Where alluvial areas of a separate, distinct permeability are delineated, the deposits are assumed to be of greater than 2m-3m depth.

4.1.7 Permeability Unit 7: Peat

The majority of peat deposits in Kerry consist of blanket peat and cutover peat. The majority of the peat in Kerry is not thick enough to be taken as an individual permeability unit, but the areas of peat which have been deemed to be of substantial thickness are assessed as low permeability (see Figure 4-10).

The bedrock underlying the peat is variable in its' composition.

The peat unit is classed as "Low Permeability" based on the following data.

- The soils are frequently recorded as cutover peat and blanket peat. This area is also associated with peaty podzols and gleys.
- ➤ The natural drainage density is low to moderate, as the peat can store a great deal of the recharge; frequent streams can be seen throughout this region.
- The artificial drainage density is high, where the peat has been reclaimed, artificial drains and underground drains in fields are frequent.

Apart from the less compacted upper layers, peat has a relatively low permeability. Data is sparse but it seems likely that the overall depth to bedrock over much of the peat areas is 5-10m. Extensive cutting and draining effects the depth and permeability of the material, and only areas that have peat depths well over 2m appear on the permeability map as separate low permeability units, which in Kerry are mainly found in north Kerry, the area surrounding Listowel, in central Kerry near to Glenbeigh and west of Killarney, and in the south, scattered throughout the south Kerry mountain ranges.



Figure 4-9 Exposure of Peat along the coast south of Cahersiveen, at Oghermong



Figure 4-10 Permeability Unit 7: Peat of sufficient thickness to constitute a permeability unit across County Kerry

4.2 Moderate Permeability Units

In Kerry the greater proportion of the south and eastern parts of the county (shown in Figure 4-1) are deemed to be of moderate permeability. This is probably due to the Devonian Sandstones and Dinantian Limestones which underlie much of the moderate permeability areas and result in overlying subsoil matrixes dominated by "*silt*" or "*sand*".

4.2.1 Permeability Unit 8: South Kerry Mountains

This is the largest geomorphic region in Kerry, shown in Figure 4-11 and covering 1,971 km^2 , or 42% of the county. It consists of the mountainous area between Glenbeigh in the west and Headford in the east, also encompassing the rest of Kerry as far as the county boundary with Cork in the south.



Figure 4-11: Permeability Unit 8: South Kerry Mountains

Devonian Old Red Sandstone bedrock underlies the majority of the area, with a band of Dinantian Limestones at Kenmare and small pockets of granite and other associated intrusive igneous rocks along the summits of Mangerton and Stoompa Mountains. There is an isolated band of Dinantian Mudstones and Sandstones at Tahilla and Tuosist.

A large portion of this region, across the summits and shoulders of the mountains, has less then 3m depth to bedrock, which is therefore not assessed for permeability. The permeability for the remaining subsoil, which is dominated by sandstone till, is classified as being moderate. The unit is classed as "Moderate Permeability" based on the following data:

The subsoil is predominantly classed as "SILT" and "SAND" using BS 5930 on the collected subsoil and borehole samples.



Particle size analysis done for this region confirmed the overall trend which resulted in low clay percentages indicating moderate permeability subsoil (see Figure 4-12).



- At 1.6km/km² the natural drainage density is described as being high. However, this maybe due to the steep topography, the abundance of outcrops and the high rainfall rather than an indication of subsoil permeability in the region.
- > The artificial drainage density is also high; also interpreted as the result of the topography and high rainfall levels.
- The topsoil is variable with blanket peat along the mountain tops and a mixture of acid brown earths and peaty gleys through the valleys.
- > The majority of this area is used for grazing. There are small areas of forest and scrub.



Figure 4-12 This exposure of silty SAND at Ballycarbery, near Doulus Head, has 4% Clay and 29% fines, confirming that the subsoil of this South Kerry Mountains region is of moderate permeability.

4.2.2 Permeability Unit 9: Killarney Rolling Lowlands

The Killarney Rolling Lowlands is an area between the Stacks-Glanaruddery Mts in the north and Mangerton and the Macgillycuddy Reek Mountains in the south. The area extends from Glenbeigh, at the coast, inland to include Killorglin and Killarney, and pinches out eastwards, ending at the Cork county boundary. At 294km² this unit covers 6% of the total county area (see Figure 4-13).

This area is predominantly underlain by bedrock of Dinantian Pure Unbedded Limestones. There is a band of Namurian Undifferentiated rocks and Namurian Sandstones running the length of the areas' northern boundary, and small strips of Dinantian Limestones, Shales and Sandstones and Devonian Old Red Sandstones along the boundary with the "Kerry Mountain" unit to the south.

Devonian sandstone till is dominant with substantial glaciofluvial sand and gravel deposits around Killorglin and Killarney. There is a small pocket of Namurian sandstone till north of Killarney, as well as pockets of peat throughout the region.



Figure 4-13: Permeability Unit 9: Killarney Rolling Lowlands

This unit is classed as "Moderate Permeability" based on the following data:

The subsoil is predominantly classed as "SILT" and "SAND" using BS 5930 on the collected subsoil and borehole samples (see Figure 4-14)



Particle size analysis for the area resulted in all samples with less than 10% clay and 27% fines, which is conclusively moderate permeability.



- Well drained brown podzolics are the dominant soil throughout, with small areas of surface water and groundwater gleys in depressions and valleys
- The artificial drainage density in this area is described as being low, which would suggest free draining subsoils.
- The natural drainage density is 0.9km/km². This indicates a moderate natural drainage density and moderate permeability subsoil.
- > The area contains much dry grassland with some arable crops.

4.2.3 Permeability Unit 10: Dingle Peninsula

The Dingle Peninsula is situated north of Castlemaine Harbour and west of Tralee. The peninsula is an upland area dominated by the Slieve Mish Mountains, and extends inland ending at the change in topography to lowlying flat limestone plains, just beyond the N22. The total surface area covers 640 km², which is 14% of the total county area (see Figure 4-15).

This area is mostly underlain by bedrock of Devonian Old Red Sandstone, with smaller areas of Silurian and Ordovician Metasediments around Clogher Head and Anascaul.

This area is underlain by Devonian sandstone till with smaller zones of Lower Palaeozoic sandstone and shale till at Ballyferriter, as well as dissecting the Slieve Mish Mountains at Anascaul. Blanket peat covers much of the rocky upland areas.



Figure 4-14: Exposure of moderate permeability sandy GRAVEL at Reennanallagane, close to Caragh Creek in the Killarney Rolling Lowlands unit.



Figure 4-15 Permeability unit 10: The Dingle Peninsula

This unit is classed as "Moderate Permeability" based on the following data.

The subsoil descriptions derived from BS 5930 completed on both field exposures and augured boreholes suggest a dominance of "SILT" and "SAND" subsoil.



Particle size distribution resulted in all samples with less than 42% fines and less than 14% clay, which confirm this as a unit of moderate permeability.



- Surface water and ground water gleys are present in upland areas, with brown earths dominating in the valleys with deeper till deposits.
- There occurs low artificial drainage density, with the exception of alluvial or peaty areas.
- The natural drainage density is high at 1.4 km/km²; this is likely a function of the upland topography receiving high levels of rainfall, rather than an indication of subsoil permeability.
- Dry grassland mixed with rough bogland and heathland dominates throughout this area.



Figure 4-16 Exposure of moderate permeability silty SAND at the base of the Slieve Mish Mountains close to Blennerville



Figure 4-17 Areas where depth to bedrock is less than 3m are not assigned a permeability ranking, as at Beenbane on the Dingle Peninsula

4.2.4 Permeability Unit 11: Listowel-Castlegregory Lowlands

This area extends in a semi-circular arc from the coast at Ballyheigh Bay, along the flat limestone plains and continuing south along the lowlying Kerry coastline, ending at Castlegregory on the Dingle Peninsula. This area includes Ballincloher, Listowel and Tralee, covering 295km² or 4% of the total county area (Figure 4-18).

This area is underlain by bedrock of Dinantian Pure Unbedded Limestone with lesser areas of Dinantian Upper and Lower Impure Limestones and Namurian Undifferentiated rocks.

The subsoil is derived from Namurian Sandstone and Shale in the area from Ballyheigh Bay to Banna Strand. Devonian sandstone till dominates along the Dingle Peninsula, and there occur two areas of limestone till around Fenit and Tralee.



Figure 4-18: Permeability Unit 11: Listowel – Castlegregory Lowlands

The unit is classed as "Moderate Permeability" based on the following data.

The subsoil is classed predominantly as "SILT", "SAND" or "SILT/CLAY" using BS 5930 in the collected exposure and borehole samples.



> The particle size analysis resulted in all samples with 14% or less clay and all but one sample with less than 50% fines.



- > The matrix is mainly described as "*silty*" or "*sandy*" in texture.
- Due to this being a flat and lowlying area, surface water gleys are common; but this seems to be a function of the topography rather than a permeability indicator. There occur well drained brown earths along the Dingle Peninsula, around Tralee and Fenit, and inland from Banna.
- The natural drainage density is calculated as moderate, at 0.9km/km²; this is an indication of moderate permeability subsoil
- > The artificial drainage density is moderate, and only high in peaty areas.
- > This area is dominated by dry grassland and interspersed bogland.

4.2.5 Permeability Unit 12: Ballyheige Hills

The Ballyheige Hills are located along Kerry's northwestern coastline. This upland area extends from Ballyduff to Kerry Head and covers 112km^2 , or 2% of the county. The region is bounded by water to the north and west and Ballyheige town and the Cashen River inland (see Figure 4-19).

The majority of this region consists of bedrock of Devonian Old Red Sandstones, with some Dinantian (early) Sandstones, Shales and Limestones along the periphery of this upland area.

The subsoil is till derived from Devonian Sandstones, with thin strips of alluvium also occurring. There are small pockets of peat in upland areas and in flat zones.

The unit is classed as "Moderate Permeability" based on the following data.

The subsoil is classed as "SILT" to "SAND" using BS 5930 on the available exposure and borehole samples (see Figure 4-20).



Particle size analysis was carried out and resulted in all samples with less than 11% clay and 40% fines, which indicates moderate permeability subsoil.



- > The subsoil results in a predominantly "*silty*" or "*sandy*" matrix.
- Acid brown earth soils cover the majority of this region.
- The natural drainage density is calculated as moderate, at 0.7km/km², this is an indication of moderate permeability subsoil.

- ➤ The artificial drainage density is low.
- > This area is dominated by dry grassland with occasional peaty areas confined to depressions.



Figure 4-19: Permeability Unit 12: Ballyheige Hills



Figure 4-20: Sandy SILT classed as moderate permeability at an exposure at Kilmore. near to Ballyduff in the Ballyheige Hills unit.

4.2.6 Permeability Unit 13: Moderate Permeability Alluvium

Strips of moderate permeability alluvium occur throughout County Kerry, with notably wide belts along the Rivers Brick, Flesk and Sheen (Figure 4-22).

Alluvial materials are generally fine-grained, water-lain deposits found along the banks and floodplains of rivers. The depth-to-bedrock in these areas is assumed to be generally greater than 3m, and the alluvium generally overlies till or sand and gravel deposits. Localised strips of bedrock-floored channel do occur, however.

These alluvial deposits are classed as "**Moderate Permeability**" due to the strong influence of the surrounding glaciofluvial sand and gravels deposits and moderate permeability glacial tills with "*silty*" and "*sandy*" matrixes.



Figure 4-21: Permeability Unit 13: Moderate Permeability Alluvium of the Brick, Flesk, Sheen and Bohy Rivers, as well as along some unnamed streams

The subsoil is classed as "SAND & GRAVEL" or "SILT" using BS 5930 Methodology on the two collected subsoil samples.



Particle size analysis results confirmed the analysed sample as moderate permeability with less than 12% clay and 35% fines.



- These alluvial materials host variable soils, dominated by brown earths, lithosols, gleys and regosols.
- The artificial drainage density is often high but this reflects the proximity of the water table to the surface.
- Immediately next to the rivers the land is commonly rushy and waterlogged, again due to the high water table. Where alluvium is extensive there may be grassland or tillage cover.

4.3 High Permeability Units

In Kerry, the deposits which have high permeability are well-sorted sand and gravel deposits and their occurrence is shown in Figure 4-22.

4.3.1 Permeability Unit 14: Sand and Gravels

Sands and gravels areas are distributed throughout western and central Kerry, with the most extensive sand and gravel area located between Killorglin and Killarney. Large expanses of windblown sand deposits are also present along the coast, at Inch, Brandon Bay and Rossbehy Creek (see Figures 4-23 and 4-24). The sands and gravels are underlain primarily by Dinantian Limestones.

These units are classed as "High Permeability" based on the following data:

- > Due to their depositional processes, the materials are sorted and bedded.
- This region is dominated by acid brown earth soils, with some brown podzolics, rendzinas and regosols.
- The natural drainage density is low. Sometimes streams occur when they are located in low lying discharge areas.
- > The artificial drainage density is very low.



> Land use is dominated by grazing across dry grassland.

Figure 4-22: Permeability Unit 14: Sands and Gravels in County Kerry



Figure 4-23: High permeability beach sand, at Inch.



Figure 4-24: Subsoil permeability map of County Kerry. Areas of less than 3m depth to bedrock have no permeability assigned.

5 Depth to bedrock in County Kerry

5.1 Depth to Bedrock

Along with permeability, the subsoil thickness (depth to bedrock) is a critical factor in determining groundwater vulnerability to contamination. A brief description of subsoil thicknesses around County Kerry is given in Chapter 2.

Subsoil thicknesses vary considerably over the county, from very thin (rock at surface) to depths of more than 20 metres. The direction of ice movement has spatially influenced the subsoil thicknesses.

Broad, regional-scale variations in depth to bedrock have been interpreted across the county as part of the mapping programme, using extensive GSI drilling data collected as part of this project, as well as information from the GSI databases, from consultants investigations, from field mapping and air photo interpretation. Depth-to-bedrock data maps show areas where the rock crops out at the surface, and the depth-to-rock data from exposure and borehole records. Generally speaking, the thickest deposits are tills or gravels in lowland plain or valley settings, throughout the county.

The depth to bedrock is contoured at 1m (equivalent to outcrop or subcrop), 3m, 5m and 10m intervals. A detailed portion of the depth to bedrock map follows, and the countywide map is shown on the following page.



Figure 5-1: Depth to bedrock map of the area between the Stacks and Glanaruddery Mountains. See how the valleys have depths to bedrock of over 10m.



Figure 5-2 Depth to bedrock map of County Kerry

6 Groundwater Vulnerability in County Kerry

6.1 Introduction

The term 'vulnerability' is used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities (DELG *et al.*, 1999). The vulnerability of groundwater depends on:

- the time of travel of infiltrating water (and contaminants)
- the relative quantity of contaminants that can reach the groundwater
- the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate.

All groundwater is hydrologically connected to the land surface; the effectiveness of this connection determines the relative vulnerability to contamination. Groundwater that readily and quickly receives water (and contaminants) from the land surface is more vulnerable than groundwater that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of any area:

- the type and permeability of the subsoils that overlie the groundwater
- the thickness of the unsaturated zone through which the contaminant moves
- the recharge type whether point or diffuse.

In other words, vulnerability is based on evaluating the relevant hydrogeological characteristics of the protecting geological layers along the pathway, and the possibility of bypassing these layers. In summary, the entire land surface is divided into four vulnerability categories: Extreme, High, Moderate and Low, based on the geological and hydrogeological characteristics. Further details of the hydrogeological basis for vulnerability assessment can be found in 'Groundwater Protection Schemes' (DELG et al., 1999).

The Groundwater Vulnerability Map shows the vulnerability of the first groundwater encountered, in either sand/gravel or bedrock aquifers, by contaminants released at depths of 1-2 m below the ground surface. Where the water-table in bedrock aquifers is below the top of the bedrock, the target needing protection is the water-table. However, where the aquifer is fully saturated, the target is the top of the bedrock. The vulnerability map aims to be a guide to the likelihood of groundwater contamination, if a pollution event were to occur. It does not replace the need for site investigation. Note also that the characteristics of individual contaminants are not considered.

Except where point recharge occurs (e.g. at swallow holes), the groundwater vulnerability depends on the type, permeability and thickness of the subsoil.

The groundwater vulnerability map is derived by combining the permeability and depth to bedrock maps, using the three subsoil permeability categories: high, moderate and low; and four depths to rock categories: <3m, 3-5m, 5-10m and >10m. The resulting vulnerability classifications are shown in Table 6.1.

6.2 Sources of Vulnerability Data

Specific vulnerability field mapping and assessment of previously collected data were carried out as part of this project. Fieldwork focused on assessing the permeability of the different subsoil deposit types (Figure 2.2), so that they could be subdivided into the three permeability categories. This involved:

- Describing selected exposures/sections according to the British Standard Institute *Code of Practice for Site Investigations* (BS 5930:1999).
- Collection of subsoil samples for laboratory particle size analyses
- Assessing the recharge characteristics of selected sites using natural and artificial drainage, vegetation and other recharge indicators.

The following additional sources of data were used to assess the vulnerability and produce the map:

- Subsoils Map of County Kerry (Figure 2.2) (EPA/Teagasc Subsoil Map, 2006), which is the basis for the main permeability boundaries. Some tills are low permeability in Kerry. 'Clean' sands and gravels are usually high permeability. Alluvium deposits and the majority of tills across the county are moderate permeability.
- Depth to bedrock map, compiled by the mapping team for the current project in the Geological Survey of Ireland, using data compiled from GSI, consultant and county council reports, along with purpose-drilled auger holes
- Geological Survey of Ireland Bedrock Geology Map
- Geological Survey of Ireland well and karst database, which supplied information on well yields and depth to bedrock, as well as areas of point recharge.
- General Soils Map of Ireland (Gardiner and Radford, 1980). This gives additional, indirect information on subsoil permeability in the areas mapped by Teagasc as 'till'.

6.3 Thickness of the Unsaturated Zone

The thickness of the unsaturated zone, or the depth of ground free of intermittent or permanent saturation, is only relevant in vulnerability mapping over unconfined sand and gravel aquifers. As described in Table 6.1, the critical unsaturated zone thickness is 3m; unconfined gravels with unsaturated zones thicker than 3m are classed as having a 'high' vulnerability, while those with unsaturated zones thinner than 3m are classed as having an 'extreme' vulnerability. Four sand and gravel aquifers occur in County Kerry; all are locally important and are the Ballycolane Gravels, Duagh Alluvial Gravels, Ardfert Gravels and Killorglin-Killarney Gravels.

In unconfined gravels, the water table is considered to be generally more than 3 m deep. Thinner unsaturated zones are expected very close to major rivers, but gravels in these areas are generally overlain by alluvium. This alluvium will increase the travel time of percolating groundwaters and will partially compensate for the reduced protection afforded by the thinner unsaturated zone in the gravels. Therefore, the thinner unsaturated zone generally found close to the major rivers is not considered to significantly influence the overall vulnerability in Kerry.

The exception to this general rule is Ardfert where the depth to the water table has been estimated as part of the Groundwater Source Report being prepared (Kelly, 2012 *in prep*). This is included on the Vulnerability map.



Plate 6-1 Drilling boreholes for subsoil permeability assessment

	Hydrogeological Requirements for Vulnerability Categories					
Thickness of Overlying		Diffuse Rechar	Point Recharge	Unsaturated Zone		
Subsoils	Subs	soil permeability				
	high permeability (<i>sand/gravel</i>)	moderate permeability (sandy subsoil)	low permeability (clayey subsoil, clay, peat)	(swallow holes, losing streams)	(sand & gravel aquifers <u>only</u>)	
0–3 m	Extreme	Extreme	Extreme	Extreme (30 m radius)	Extreme	
3–5 m	High	High	High	N/A	High	
5–10 m	High	High	Moderate	N/A	High	
>10 m	High	Moderate	Low	N/A	High	

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Table 0-1	vumerabilit	y mapping	guidennes	(adapted fro	m DELG et al	, 1999)

Notes: (i) N/A = not applicable.

(ii) Release point of contaminants is assumed to be 1-2 m below ground surface.

(iii) Permeability classifications relate to the engineering behaviour as described by BS5930.

(iv) Outcrop and shallow subsoil (i.e. generally <1.0 m) areas are shown as a sub-category of extreme vulnerability

(amended from Deakin and Daly (1999) and DELG/EPA/GSIa (1999))



Figure 6-1: Groundwater Vulnerability Map of County Kerry

6.4 Groundwater Vulnerability Distribution

Figure 6.1 shows the groundwater vulnerability across County Kerry. The vulnerability maps are derived by combining the contoured depth to bedrock data with the inferred subsoil permeabilities. Areas are assigned vulnerability classes of low, moderate, high or extreme.

It is emphasised that the boundaries on the vulnerability map are based on the available data and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments, and will frequently require site investigations in order to assess the risk to groundwater.

Approximately two-thirds of the county is classed as having either extreme or high vulnerability. The 3 m contour, which influences the extreme and high vulnerability categories, is based on outcrop information, Quaternary and subsoil mapping and borehole data. The presence or absence of 5 m and 10 m contours, which influence the moderate and low categories, is reliant primarily on borehole data as well as an understanding of the erosion and depositional processes that created the landforms. These contours cannot be drawn without data from boreholes, which are limited in some areas, therefore as more borehole data becomes available, the maps should be up-dated.

The large areas of extreme vulnerability where rock is generally at or close to the surface, include upland areas which have little existing development or potential for development, for example the high mountains of south Kerry. When these are excluded, the proportion of the county's groundwater that is extremely vulnerable is significantly reduced. Similarly, many small pockets of deeper subsoil are likely to exist even within areas where rock outcrop is common. This is particularly likely over karst limestone areas, such as around Castleisland and Tralee.

The areas of low vulnerability have been mapped where the subsoils (tills) have a low permeability and the depth to bedrock information indicates thicknesses of over 10 metres. However, such thick deposits may not be a uniform till but may have interbedded sands and gravels in places; further confirmation by site investigation is essential to verify the vulnerability for specific developments.

7 Hydrogeology and Aquifer Classification

7.1 Introduction

This chapter summarises the relevant aquifer categories in County Kerry, based on the GSI aquifer classification scheme. The spatial distribution of the aquifers is shown on the aquifer map of the county (Figure 7.1).

The delineation of an aquifer classification for bedrock and sands and gravel deposits across the entire island of Ireland was completed by the GSI in 2003-2005 as part of the Initial Characterisation phase for the EU Water Framework Directive. At this time all available drilling, abstraction and pumping test data from Geological Survey, County Council, and consultants' files, as well as from available wells and spring information, were compiled and entered into a computer database at the Geological Survey. For the delineation of aquifers in County Kerry the following data and reports were consulted:

- Groundwater abstraction rates for local authority sources, group scheme sources, and for a limited number of other high yielding private wells and springs.
- Specific capacity and discharge data for several hundred wells in Fingal and the surrounding counties. (Specific capacity is the rate of abstraction per unit drawdown; the unit used is $m^3/d/m$.)
- More detailed pumping tests carried out by consultants on public supplies.
- Information on large springs.
- Reports by engineering and hydrogeological consultants.

As well as this, the general hydrogeological experience of the GSI, including that gained while working on Groundwater Protection Schemes in adjacent counties Limerick and Cork, was called upon.

7.2 Background to Aquifer Classification

7.2.1 Introduction

This section provides an outline of the factors used in aquifer classification. According to the aquifer classification used by the GSI (DELG/EPA/GSI, 1999), there are three main aquifer categories, with each category sub-divided into two or three classes:

Regionally Important (R) Aquifers

- (i) Karstified Bedrock Aquifers (**Rk**)
- (ii) Fissured Bedrock Aquifers (Rf)
- (iii) Extensive Sand/Gravel Aquifers (Rg)

Locally Important (L) Aquifers

- (i) Sand/Gravel Aquifers (Lg)
- (ii) Karstified Bedrock Aquifer (Lk)
- (iii) Bedrock which is Generally Moderately Productive (Lm)
- (iv) Bedrock which is Moderately Productive only in Local Zones (Ll)

Poor (**P**) Aquifers

- (i) Bedrock which is Generally Unproductive except for Local Zones (Pl)
- (ii) Bedrock which is Generally Unproductive (Pu)



Figure 7-1: Aquifer Map of County Kerry

7.2.2 Bedrock Aquifers

Irish bedrock aquifers are not generally thought to have significant pore-space permeability. Consequently, flow is thought to depend on the development of a network of secondary permeability within fractures. As a result, bedrock aquifer categories have been designed to take account of the following factors:

- the overall potential for groundwater development in each rock unit;
- the localised nature of higher permeability zones (*e.g.* fractures) in many of the bedrock units;
- the highly karstic nature of some of the limestones;
- all bedrock types usually give enough water for domestic supplies and therefore all are called 'aquifers'.

Karstification and dolomitisation are two processes which strongly influence the development of secondary permeability and aquifer potential in Irish bedrock units. Each are explained briefly below.

Karstification

Karstification is the process whereby limestones are slowly dissolved away by acidic waters moving through them. This most often occurs in the upper bedrock layers and along some of the pre-existing fissures and fractures in the rocks which become slowly enlarged. This results in the progressive development of distinctive karst landforms such as collapses, caves, swallow holes, sinking streams, turloughs and dry valleys, and a distinctive groundwater flow regime where drainage is largely underground in solutionally enlarged fissures and conduits. The degree of solution is influenced by factors such as: the type and solubility of the limestone; the degree of jointing, faulting and bedding; the chemical and physical character of the groundwater; the rate of water circulation; the geomorphic history (upland/lowland, sea level changes, etc.); and the subsoil cover. One of the consequences of karstification is the development of an uneven distribution of permeability which results from the enlargement of certain fissures at the expense of others and the concentration of water flow into these high permeability zones.

There are gradations in the degree of karstification in Ireland from slight to intensive. In order to assist in the understanding and development of regionally important (**R**) limestone aquifers, the GSI has compartmentalised the broad range of karst regimes into four categories. Where karstification is slight, the limestones are similar to fissured rocks and are classed as **Rf**, although some karst features may occur. Aquifers in which karst features are more significant are classed as **Rk**. Within the range represented by **Rk**, two sub-types are distinguished, termed **Rk**^c and **Rk**^d. Locally important karstified aquifers (**Lk**) are also delineated.

 \mathbf{Rk}^{c} are those aquifers in which the degree of karstification limits the potential to develop groundwater. They have a high 'flashy' groundwater throughput, but a large proportion of flow is concentrated in conduits, numerical modelling using conventional programs is not usually applicable, well yields are variable with a high proportion having low or minimal yields, large springs are present, storage is low, locating areas of high permeability is difficult and therefore groundwater development using bored wells can be problematical.

 \mathbf{Rk}^{d} aquifers are those in which flow is more diffuse, storage is higher, there are many high yielding wells, and development of bored wells is less difficult. These areas also have caves and large springs, but the springs have a more regular flow. In general, these aquifers can be modelled (at an appropriate scale) using conventional programs.

Dolomitisation

Dolomitisation is a weathering process where calcium ions are replaced by magnesium ions in the crystal lattice of dolomite (Ca Mg (CO₃)₂). Hydrogeologically, the most important consequence of dolomitisation is that it results in an increase in the porosity and permeability of the carbonate rock. Dolomitised rocks are a highly weathered, yellow/orange/brown colour and are usually evident in boreholes as loose yellow-brown sand with significant void space and poor core recovery. Dolomitisation often occurs along fault zones, can cross bedrock lithology boundaries and results in unpredictable very high permeability zones. In general, the cleaner the original limestone, the greater the degree of dolomitisation, and the greater the resultant increase in bulk permeability will be.

7.2.3 Sand/Gravel Aquifers

Sand/gravel deposits have a dual role in groundwater development and supply. Firstly, in some cases they can supply significant quantities of water for supply and are therefore classed as aquifers, and secondly, they provide storage for underlying bedrock aquifers.

A sand/gravel deposit is classed as an aquifer if the deposit is highly permeable, more than 10 m thick and greater than one square kilometre in areal extent. The thickness of the deposit is often used rather than the more relevant saturated zone thickness as the information on the latter is rarely available. In many instances it may be assumed that a deposit with a thickness of 10 m will have a saturated zone of at least 5 m. This is not the case where deposits have a high relief (for example eskers or deposits in high topographic areas) as these gravels are often dry.

	Regionally important	Locally important
Aerial extent	$> 10 \text{ km}^2$	$1-10 \text{ km}^2$
Saturated thickness	> 5 m	> 5 m
Permeability	High	High

Table 7.1Sand/gravel Aquifer Classification

Sand/gravel aquifers are therefore classified according to the permeability, areal extent, and the thickness of the unsaturated zone (see Table 7.1). In the absence of permeability test data, gravels with a fines content of less than approximately 8% are generally considered to have sufficient permeability for aquifer development (O'Suilleabhain, 2000).

A regionally important gravel aquifer should have an aerial extent of *at least* 10 km^2 . This is to ensure that, assuming typical Irish recharge rates, there will be enough recharge to provide a supply of one million cubic metres per year from the whole aquifer.

Four sand and gravel aquifers are mapped in County Kerry; all are locally important :

- Ballycolane Gravels
- Duagh Alluvial Gravels
- Ardfert Gravels
- Killorglin-Killarney Gravels.

7.2.4 Aquifer Classification Criteria

As yield is one of the main concerns in aquifer development projects, yields from existing wells were conceptually linked with the main aquifer categories outlined in Section 7.2.1 as part of the work completed by GSI on aquifers for the EU Water Framework Directive.

- Regionally important (**R**) aquifers should have (or be capable of having) a large number of 'excellent' yields: in excess of approximately $400 \text{ m}^3/\text{d}$ (4000 gph).
- Locally important (L) aquifers are capable of 'good' well yields 100-400 m³/d (1000-4000 gph).
- Poor (**P**) aquifers would generally have 'moderate' or 'low' well yields less than $100 \text{ m}^3/\text{d}$.

However, in practice, existing well yield information is often difficult to use because reliable, long term yield test data are quite rare (particularly for the less productive aquifers). In practice, then, the following criteria are used in aquifer classification:

- Permeability and transmissivity data from formal pumping tests, where discharge and water levels readings have been taken over a period of many hours or days.
- Productivity data from wells where either formal pumping tests have been undertaken or where at least one combined reading of discharge and drawdown data are available. The GSI has developed the concept of 'productivity' as a semi-quantitative method of utilising limited well test data (Wright, 2000). A 'productivity index' is assigned to a well from one of five classes: I (highest), II, III, IV, and V, using a graphical comparison of well discharge with specific capacity (discharge divided by drawdown).
- Occurrence of springs with 'high' flows (greater than $2160 \text{ m}^3/\text{day}$ total flow).
- Occurrence of wells with 'excellent' yields (greater than $400 \text{ m}^3/\text{day}$ discharge).
- Hydrological information such as drainage density where overlying strata are thin, and baseflows or flows in rivers (better aquifers will support higher baseflows and summer flows).
- Lithological and/or structural characteristics of geological formations which indicate an ability to store and transmit water. Clean and sorted sands and gravels for example, are generally more permeable than poorly sorted glacial tills. Pure (clean) limestones are also generally more permeable than impure (muddy) limestones. Areas where folding and faulting has produced extensive joint systems tend to have higher bulk permeabilities than areas where this has not occurred.
- Aquifer assessments from Groundwater Protection Schemes in neighbouring counties and from existing reports.

All seven factors are considered together; productivity and permeability data are only given 'precedence' over lithological and structural inferences where sufficient data are available. Data from neighbouring counties in similar geological environments are included.

Some bedrock units have been grouped if they are of similar geological age and have similar lithological/structural characteristics. In considering the classifications provided, it is important to note that:

• The bedrock aquifer classifications are based on the bedrock units depicted on the bedrock map.

- Irish hydrogeology is unusually complex and variable. As a consequence, there will often be exceptionally low or high yields which do not conform with the aquifer category given.
- The top few metres of all bedrock types are likely to be relatively permeable, even in the poor aquifers.
- There may be localised areas where recharge is restricted. This could occur, for example, where the vulnerability is low, or where a small portion of the rock unit has been faulted away from the main body of the unit. In these situations, the development potential even of regionally important aquifers may be limited. In considering major groundwater development schemes at particular sites, it will be important to consider the long term balance between recharge and abstraction, as well as the aquifer potential.

8 Groundwater Protection Zones and Responses

8.1 Introduction

The general groundwater protection scheme guidelines were outlined in Chapter 1, and in particular, the sub-division of the scheme into two components – land surface zoning and codes of practice for potentially polluting activities – was described. Subsequent chapters described the different geological and hydrogeological land surface zoning elements as applied to County Kerry. This chapter draws these together to give the ultimate elements of land surface zoning – the groundwater protection scheme map and the source protection maps. It is emphasised that these maps are not intended as 'stand alone' elements, but must be considered and used in conjunction with the groundwater protection responses for potentially polluting activities. Five supplementary publications are currently available: Groundwater Protection Responses for Landfills, Groundwater Protection Responses for Landfills, Groundwater Protection Responses for Earth-Lined Slurry Stores and Groundwater Protection Responses for Outwintering Pads. Similar 'responses' publications will be prepared in the future for other potentially polluting activities, such as underground storage tanks and petrol stations.

8.2 Groundwater Protection Maps

The groundwater protection map was produced by combining the vulnerability map with the aquifer map. Each protection zone on the map is defined by a code which represents both the vulnerability of the groundwater to contamination and the value of the groundwater resource (aquifer category). About half of the possible hydrogeological settings are present in County Kerry; those which are present are given in Table 8.1.

	RESOURCE PROTECTION ZONES						
VULNERABILITY RATING	Regionally Important Aquifers (R)		Locally Important Aquifers (L)			Poor Aquifers (P)	
	Rk	Rf/Rg	Lm/Lg	Lk	Ll	Pl	Pu
Extreme (E)	Rk ^d /E	Not present	Lg/E	Not present	Ll/E	Pl/E	Not present
High (H)	Rk ^d /H	Not present	Lg/H	Not present	Ll/H	Pl/H	Not present
Moderate (M)	Rk ^d /M	Not present	Not present	Not present	Ll/M	P1/M	Not present
Low (L)	Rk ^d /L	Not present	Not present	Not present	Ll/L	Pl/L	Not present

Table 8-1 Matrix of Groundwater Resource Protection Zones in County Kerry

8.3 Integration of Groundwater Protection Zones and Responses

The integration of the groundwater protection zones and the groundwater protection responses is the final stage in the production of a groundwater protection scheme. The level of response depends on the different elements of risk: the vulnerability, the value of the groundwater (with sources being more valuable than resources and regionally important aquifers more valuable than locally important and so on) and the contaminant loading. By consulting a **Response** **Matrix**, it can be seen: (a) whether such a development is likely to be acceptable on that site; (b) what kind of further investigations may be necessary to reach a final decision; and (c) what planning or licensing conditions may be necessary for that development. The groundwater protection responses are a means of ensuring that good environmental practices are followed.

As the appropriate level of response takes aquifer category, proximity to public supply sources and vulnerability into account, concentration on the vulnerability map alone may result in the false impression that the acceptability of certain activities is quite limited. Table 8.2 provides a broad indication of the acceptability of certain activities in Kerry with respect to groundwater contamination.

Activity*	Percentage of Kerry Occurring within Each Response Level				
	Least restrictive response level ('R1')	Intermediate response levels: ('R2' and 'R3')	Most restrictive response level ('R4')		
	Risk to groundwater can be managed using normal good practice guidelines.	Higher risk to groundwater. In order to manage the risk, additional requirements over and above normal good practice are recommended. Requirements can relate to site-specific ground conditions, construction, operation, and the number of existing developments in the area. If the required site-specific ground conditions do not occur at a	Additional requirements will not reduce the risk to groundwater to acceptable levels.		
		particular site, or if the density of existing developments is too high, the activity would be regarded as 'unacceptable'.			
Landfill	10%	82%	9%		
IPC Landspreading**	49%	51%	-		
On-site Treatment Systems	47%	53%	-		
Outwintering Pads**	39%	61%	0.01		
Earth-Lined Slurry Stores	38.8%	60.9%	0.28		

Table 8-2 Response Levels in County Kerry

* Details on the precise response requirement for each activity can be found in (DOELG/EPA/GSI, 1999). Response levels for additional activities will be devised in the near future.

** Intensive farming, sewage sludges, poultry litter, industrial wastewater treatment plant sludges.

8.4 Conclusions

This groundwater protection scheme will be a valuable tool for Kerry County Council in helping to achieve sustainable water quality management as required by national and EU policies. It will enable the County Council to take account of: (i) the potential risks to groundwater resources and sources; and (ii) geological and hydrogeological factors, when considering the location of potentially polluting developments. Consequently, it will be an important means of preventing groundwater contamination.

In considering the Groundwater Protection Scheme, it is important to remember that: (a) a scheme is intended to provide guidelines to assist decision-making in County Kerry on the location and nature of developments and activities with a view to ensuring the protection of

groundwater; and (b) delineation of the groundwater protection zones is dependent on the available data. Kerry County Council will apply the scheme in decision-making on the basis that the best available data are being used. The maps have limitations because they generalise (according to availability of data) variable and complex geological and hydrogeological conditions. The scheme is therefore not prescriptive and needs to be qualified by site-specific considerations and investigations in certain instances. The investigation requirements depend mainly on the degree of hazard provided by the contaminant loading and, to a lesser extent, on the availability of hydrogeological data. The onus is on a developer to provide new information which would enable the zonation to be altered and improved and, in certain circumstances, the planning or regulatory response to be changed.

The scheme has the following uses for Kerry County Council:

- it provides a hierarchy of levels of risk and, in the process, assists in setting priorities for technical resources and investigations
- it contributes to the search for a balance of interests between groundwater protection issues and other social and economic factors
- it acts as a guide and provides a 'first-off' warning system before site visits and investigations are made
- it shows generally suitable and unsuitable areas for potentially hazardous developments such as landfill sites and piggeries
- it can be adapted to include risk to surface water
- it will assist in the control of developments and enable the location of certain potentially hazardous activities in lower risk areas
- it helps ensure that the pollution acts are not contravened.

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