

Whitegate Public Supply

Groundwater Source Protection Zones

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In collaboration with:

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1. Introduction

The objectives of this report are as follows:

- To delineate source protection zones for the Whitegate Public Water Supply.
- To outline the principle hydrogeological characteristics of the Whitegate area.
- To assist Clare County Council in protecting the water supply from contamination.

2. Location and Site Description

The Whitegate source is situated approximately 1.5 km north-east of Mountshannon village in the townland of Cloonoolia North, County Clare.

A number of springs rise in the Cloonoolia North area; two such springs supply the Whitegate PWS while the others discharge into the nearby streams. The PWS springs are piped into a collecting chamber below ground level before being pumped to the reservoir. When the pumps are not running the chamber overflows into a nearby drain. The chamber which is covered and locked is located next to the pumphouse on a fenced site.

3. Summary of Well Details

GSI no.	1717NW W002
Grid ref. (1:25,000)	17277 18807
Townland	Cloonoolia North
Owner	Clare County Council
Well type	Two springs
Elevation	50 m O.D.
Depth-to-rock	>3 m and < 10 m
Abstraction rate	204 m ³ /d

4. Methodology

The assessment involved three stages; (a) detailed desk study, (b) site visits and fieldwork, and (c) analysis of the data. The desk study was conducted in the Geological Survey where bedrock geology information was compiled from a geology map of the Mountshannon - Whitegate area (AMAX, 1981) and from subsoils were compiled from the GSI Subsoils Map of County Clare (Bloetjes, 1999). Basic public supply well details were obtained from GSI records and County Council personnel; such details include abstraction rate, water quality data.

The second stage comprised site visits and fieldwork in the Whitegate area. This included a walkover survey in order to further investigate the subsoil and bedrock geology, the hydrogeology, the vulnerability to contamination and the current pollutant loading.

Stage three, the assessment stage, utilised analytical equations and hydrogeological mapping to delineate protection zones around the public supply well.

5. Topography, Surface Hydrology and Land use

The Whitegate PWS is located on a minor road to the north of the main Mountshannon–Whitegate road (see Fig 1). The source is located along the 50 m contour. The topography in the Whitegate area slopes from the foothills of the Slieve Aughty mountains southeast toward Lough Derg.

There are a high density of drains in the vicinity of the Whitegate PWS. These drains feed into streams and eventually discharge into Lough Derg. Drainage to the northwest of the Whitegate PWS is very good due to the thick deposits of sandy and gravelly tills.

Agriculture is the principal activity in the area immediately surrounding the source. Most of the land is used for pasture although some areas on higher ground are forested. There are some houses and farms in the general vicinity of the source.

6. Geology

6.1 Bedrock Geology

The bedrock geology of the Whitegate area was dependent on the deposition of sediments during Devonian and Carboniferous times (over 300 million years ago) and on the subsequent faulting of these sediments. The rock units of the area, which are shown in Figure 1, are summarised as follows;

6.1.1 Old Red Sandstone

This unit comprises red, medium grained sandstones with interbedded mudstones, siltstones and conglomerates.

6.1.2 Ballysteen Limestone

The Ballysteen Limestone comprises dark blue fossiliferous limestones with some shalier horizons.

6.1.3 Structure

There is a large northeast-southwest trending fault in the Whitegate area which runs close to the Whitegate PWS. Some geophysical investigations indicate a series of anomalies aligned in an east west direction approx. 200m south of the supply which may represent the main fault or a smaller fault - see Fig. 2 (Hanrahan & Deakin, 1999). There are a series of small anomalies located close to the PWS. It is likely that there are a number of faults along the fault zone which may be 10's of metres in width. The Old Red Sandstone beds occur to the north of this fault and the Ballysteen limestone occurs to the south of this fault.

6.2 Subsoils (Quaternary) Geology

The subsoils in the Whitegate area are shown in Figure 3 and are subdivided into till with gravel, sandstone till and peat.

6.2.1 Till with Gravel

The area to the northwest of the PWS is overlain by sandstone till with gravel deposits. These deposits are derived from Devonian sandstones and sandstone clasts are quite angular in places. These till with gravel deposits are on the whole very well drained.

6.2.2 Sandstone Till

The area surrounding the PWS is overlain by sandstone till deposits. These are also derived from Devonian sandstone but are more compacted and less well drained than the till with gravel deposits. They tend to be quite silty in places and in certain areas drainage is very poor.

6.2.3 Peat

There are small areas of peat scattered throughout the Whitegate area. These are likely to be quite thin and underlain by till with gravel deposits. These peaty areas tend to be poorly drained and vegetated by rushes.

6.3 Depth-to-rock

Accurate depth to bedrock information is based on outcrop information, well records, subsoil sections and drilling. Some mineral exploration drilling was also carried out in this area (AMAX, 1981). Depth to bedrock ranges from 3 to 10 m in the vicinity of the Whitegate source; it is likely that depth to rock at the source itself is closer to 3m. The subsoils to the northwest of the area are >10 m in thickness and in some places subsoils are up to 23 m thick. The depth-to-rock contours are based on relatively few data points, however they can be refined as further depth-to-rock data become available. Outcrop and depth to rock data is given in Map 3.

7. Hydrogeology

7.1 Data availability

Hydrogeological information for this study was obtained from the following sources:

- ◆ County Clare Groundwater Protection Scheme, (Deakin *et al*, 1999).
- ◆ Two rounds of chemical analyses (October 1997, February 1998) were carried out at Whitegate for the GSI by the State Lab. The State Lab analyses comprised all major cations and anions, hardness and trace metals. The County Council carried out raw water bacteriological analyses concurrently.
- ◆ Subsoil mapping for Co. Clare (Bloetjes, 1999).
- ◆ Well survey of the Whitegate/Mountshannon area.
- ◆ “An Investigation into Elevated Lead Concentrations in Groundwater Used for Drinking Water; Mountshannon, Co. Clare (Jones, 1998). Report to Clare County Council.
- ◆ Report on Cloonoolia North Springs, Whitegate, Co. Clare. Report to Clare County Council. (KT Cullen & Co. 1993).

7.2 Meteorology and Recharge

Rainfall data for the area are taken from a contoured rainfall map of Co.Clare, which is based on data from Met Éireann. For 1951 - 1980, the mean annual rainfall (R) for the area was 1055 mm. Evaporation data for the area are taken from the national contoured map produced by Met Éireann. Potential evaporation is estimated as 534 mm/yr. Actual evapotranspiration (A.E) is then calculated by taking 95 % of the potential figure, to allow for soil moisture deficits, so A.E. is estimated as 507 mm/yr. Using these figures, the potential recharge (R - A.E.) is taken to be approximately 548 mm. The high percentage of drains in the area indicates that the subsoils though permeable are poorly drained due to the high water table in this area. Therefore a significant proportion of the effective rainfall runs off into drains. Runoff is taken to be 50 % of available recharge and is estimated to be 274 mm. These calculations are summarised below:

Average annual rainfall	1055 mm
Estimated P.E.	534 mm
Estimated A.E. (90% P.E.)	434 mm
Available recharge	548 mm
Surface Runoff	274 mm
Recharge	274 mm

7.3 Groundwater levels

Water levels vary from 80 m OD at a private supply in the Derrycon area (1 km northeast of the source) to 50m OD at the source itself. There are a large number of rises and springs in the Old red Sandstone to the northeast and east of the Whitegate PWS. The subsoils in this area are moderately to highly permeable indicating that the numerous springs are due to a high water table rather than poorly draining low permeability subsoils. Many of the springs are located close to breaks of slope where the shallow groundwater intercepts the ground surface. Some of these springs are used for private supply and others over flow into drains and rivers and flow southeastward toward Lough Derg. Water levels

in the Ballysteen Limestone are also likely to be close to or at surface particularly close to Lough Derg.

7.4 Groundwater Flow Directions and Gradients

The water table in the Whitegate area is assumed to broadly reflect topography with water flowing toward and discharging as springs or into Lough Derg. The main groundwater flow direction is therefore in a south to southeasterly direction. The natural hydraulic gradient is estimated to be 0.03 in the Old Red Sandstone based on the existing data. The gradient in the Ballysteen Limestone is likely to be flatter.

7.5 Hydrochemistry and Water Quality

- 1) The groundwater at the Whitegate Springs is a moderately hard (169 mg/l CaCO₃) with a pH of 7.08. The groundwater is characterised by relatively low calcium (54.66 mg/l) and magnesium levels (6.425 mg/l). Nitrate levels at Whitegate for the period 1989 to 1995 were very low < 10 mg/l. Chlorides were also relatively low (18.5 mg/l) in 1997, 1998. Faecal coliforms were detected in the untreated spring water on the 12/1/93 (Cullen, 1993) although in October 1997 they were not present.
- 2) As part of an M.Sc thesis a study was carried out on the presence of lead in the groundwater in the Mountshannon/Whitegate area (Jones, 1998). Lead at the Mountshannon spring source has frequently exceeded the EU MAC e.g. 60 µg/l (6/5/97) 70 µg/l (30/3/98). A high lead anomaly in the subsoils was found over much of the area by an exploration company (AMAX, 1981) and is considered to be largely associated with the east-west fault and also disseminated in the sandstone. Lead concentrations at the Whitegate source and surrounding areas are low (<0.02 mg/l) although the springs are located close to the faulted contact between the Ballysteen Limestone and the Old Red Sandstone. The Mountshannon/Whitegate area is an historical mining area and so other types of mineralisation such as zinc (Zn) and barium (Ba) have also been detected in the groundwater. Low concentrations of these parameters were recorded in 1997, 1998. High Iron and Manganese levels have been recorded in private wells in the Whitegate area but concentrations appear to be low at the source.
- 3) The water quality in the Whitegate PWS appears to be good. The low calcium and magnesium indicate that the supply is derived from the sandstone bedrock or from the overlying sandstone till. Sandstone rocks often have a mineral rather than a carbonate cement and so groundwater is generally softer than in the carbonate rocks. Iron and manganese are a common occurrence in groundwater derived from Old red Sandstone and Ballysteen Limestone. This is due to the dissolution of Fe and Mn from the sandstone/shale during reducing conditions.

7.6 Aquifer Parameters

Although there are no pumping test data available for the Old Red Sandstone or the Ballysteen Limestone in East Clare, pumping tests have been carried out in Limerick. Permeability values in the order of 1.3 m/d were calculated for the ORS in Bruree and Mortlestown PWS's (Deakin, 1995). Hydraulic gradients in the range of 0.01–0.04 for these two sources compare relatively well with a hydraulic gradient of 0.03 in Whitegate. Porosity values in the order of 0.015 are likely to be representative of the ORS in Clare. Similarly, pumping tests carried out in the Ballysteen Limestone in Bruff, Hospital, Co. Limerick yielded a permeability value in the range of 0.6–1.87 m/d and a porosity of 0.015 (Deakin, 1995).

7.7 Aquifer Category

The Old Red Sandstone is classed as a Locally important aquifers which are moderately productive only in local zones (**L1**) over much of Clare. Well yields indicate that this unit may be a poor aquifer in some parts of East Clare (Deakin, 1999). The Ballysteen Limestone is also classed as a Locally important aquifer which are moderately productive only in local zones (**L1**). (For more information refer to the Co. Clare Groundwater Protection Scheme, (Deakin *et al*, 1999).)

7.8 Conceptual Model

- ◆ The groundwater divides and the water table in the Whitegate area are assumed to broadly coincide with the topographic divides and the topography. There is a northwest–southeast trending groundwater divide located approx. 6 km northwest of the Whitegate PWS in the Slieve Aughty mountains. Water flows from the Slieve Aughty mountains in a southwesterly direction towards Lough Derg.
- ◆ The Whitegate PWS is located in the Old Red Sandstone and is probably fed in a combination of ways which are outlined below.
 - 1) . Shallow groundwater flow is likely to be the main mechanism of flow in the Whitegate area. Shallow flow is likely to occur in the upper weathered zone of the bedrock, along the intersection between bedrock and subsoils and in the overlying subsoils. This flow discharges as a spring where subsoils are less permeable or where there is a change of slope. There are a large number of springs and rises in the area which discharge into numerous drains and streams before flowing toward Lough Derg.
 - 2) There is a large east–west trending fault located approx. 200 m south of the Whitegate source. This fault may act as a barrier to flow in places causing some groundwater flow to rise to the surface. This upward flow is probably occurring in the vicinity of the Whitegate public supply resulting in poor drainage and discharge at the spring. Other discharge areas along the fault are include the Mountshannon spring source and the artesian borehole.). Elsewhere the fault may act as a zone of enhanced permeability allowing groundwater to circulate along its path. As well as vertical flow along the fault there may be some horizontal flow. Water may flow along the fault plane from discharge areas to recharge areas and local catchment divides may exist along its extent.
- ◆ The Old Red Sandstone is a locally important aquifer which is moderately productive only in local zones. Permeability, though not measured is estimated to be approx. 1.3 m/d in this unit.
- ◆ Flow in the Ballysteen Limestone is unlikely to be contributing to flow at the Whitegate PWS although flow is also probably along the upper weathered zone and along faults/fissures.
- ◆ Gradients in the Old Red Sandstone are approximately 0.03 in the Whitegate area, although these gradients are likely to be steeper in the hillier areas to the northwest. Gradients for the Ballysteen limestone though not measured are likely to be much flatter approaching Lough Derg.
- ◆ The Old Red Sandstone and Ballysteen Limestone are largely overlain by moderately permeable sandstone tills and highly permeable till with gravels. Therefore the groundwater can be considered as unconfined.

7.9 Catchment Delineation

The boundaries of the Zone of Contribution are defined as follows:

Northern Boundary

This boundary represents the catchment divide between the springs to the north and the Whitegate Spring. Shallow groundwater flow to the south of these springs is likely to discharge at the Whitegate PWS. This is the most tentatively defined boundary based on the uncertainty of where the exact source of flow to the Whitegate PWS originates.

Southern Boundary

The southwestern boundary is defined by the fault. Its western extent lies approx. midway between the Whitegate PWS and the Mountshannon artesian supply and is assumed to be a groundwater divide between the two catchments.. Although the overall gradient is southward it is possible that water could travel along the fault toward the Whitegate Supply therefore recharging the spring.

The southeastern boundary is defined by topography. All water south of the line lies at a low elevation to the spring and is unlikely to travel northward to supply the source.

Eastern Boundary

The eastern boundary is a shallow groundwater catchment divide; all water to the east is likely to flow southward to Lough Derg. All flow to the southwest is likely to supply the Whitegate PWS.

Western Boundary

The western boundary is the shallow water catchment divide; all water to the east is likely to flow southward to Lough Derg. All flow to the southeast is likely to supply the Whitegate PWS.

8. Delineation Of Source Protection Areas

8.1 Introduction

Two source protection areas are delineated:

- ◆ Inner Protection Area (SI), designed to give protection from microbial pollution;
- ◆ Outer Protection Area (SO), encompassing the zone of contribution (ZOC) of the well.

8.2 Outer Protection Area

The Outer Protection Area (SO) includes the complete catchment area to the source, i.e. the zone of contribution (ZOC), and it is delineated as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by a) the pumping rate, b) the groundwater flow direction and gradient, c) the rock permeability and d) the recharge in the area. The ZOC is delineated as follows:

- i) An estimate of the area size is obtained by using the average recharge and the abstraction rate.
- ii) The shape of the area is then derived by hydrogeological mapping techniques.
- iii) To allow for errors in the estimation of groundwater flow direction and to allow for an increase in the ZOC in dry weather, a safety margin is incorporated by assuming a higher abstraction rate than the current rate.

The max abstraction rate at the Whitegate Public Water Supply is estimated to be 460 m³/d. The average yield is increased by 50% to 690 m³/d for the following reasons:

- ◆ The higher yield allows for increased water demand due to expansion in Whitegate.
- ◆ Recharge is averaged out over winter and summer, and so not allow for an increase in the ZOC during dry weather. This is overcome by assuming a higher abstraction rate in the calculations.

Taking the recharge to be 274 mm as indicated in Section 7.2, the area required to supply a pumping rate of 460 m³/d is calculated to be 0.61 km² (61 ha). The outer catchment area defined in Figure 5 is larger than the calculated area. This allows for variation in hydraulic gradient under different flow conditions and a degree of uncertainty in defining the northern and western boundaries to the catchment

8.3 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (TOT) from a point below the water table to the source and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular from microbial contamination. This area is defined using analytical equations, topography and hydrogeological mapping techniques.

9. Vulnerability

Subsoil deposits are > 3m over the catchment area and therefore there are no areas in which groundwater is extremely vulnerable to contamination. The Till with gravel deposits have a well drained, sandy texture and so are classed as highly permeable. Where these deposits are > 3m thick the

so groundwater is considered to be “highly” vulnerable to contamination. The sandy till deposits are classed as moderately permeable on the basis of their silty/sandy texture. Where deposits are 3-10 m thick, for example at the Whitegate PWS groundwater is classed as highly vulnerable to contamination. Where the sandy till deposits are >10m in thickness groundwater is considered to be moderately vulnerable to contamination. Vulnerability of groundwater in the Whitegate area is shown in Figure 5.

10. Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones (see the matrix in the table below). In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SO/H**, which represents an Outer Source Protection area where the groundwater is highly vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present around each local authority source. There are 4 groundwater protection zones present around the Whitegate source (see Figure 6), as shown in the matrix below.

Matrix of Source Protection Zones

VULNERABILITY RATING	SOURCE PROTECTION	
	<i>Inner</i>	<i>Outer</i>
<i>Extreme (E)</i>		
<i>High (H)</i>	SI/H	SO/H
<i>Moderate (M)</i>	SI/M	SO/M
<i>Low (L)</i>		

It is not within the scope of this report to delineate the protection zones in the surrounding area and this is dealt with at the regional resource protection scale.

The accompanying response measures imposing restrictions on developments will follow when discussions have been carried out between the Council, the EPA and the GSI as to the degree of restriction necessary in each protection zone.

11. Potential Pollution Sources

Agriculture is the principal activity in the area. The main hazards within the ZOC are farmyards, septic tank systems, application of fertilisers (organic and inorganic), and possible spillages along the roads. No detailed assessment of hazards was carried out as part of this study.

12. Conclusions and Recommendations

- ◆ The source at Whitegate is an excellent spring, which is located in a locally important important sandstone aquifer.
- ◆ The area around the Whitegate source is considered ‘highly’ to ‘moderately’ vulnerable to contamination.
- ◆ The inner and outer protection zones delineated in the report are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

◆ It is recommended that:

- chemical and bacteriological analyses of raw water rather than treated water should be carried out on a regular basis (every 3 - 6 months).
- a full analysis should be carried out (refer to the Co. Clare Groundwater Protection Scheme, (Deakin *et al*, 1999).)
- care should be taken in allowing any activities or developments which might increase nitrate levels;
- the potential hazards in the ZOC should be located and assessed;
- an interim code of practice for dealing with spillages along the roads in the area should be drawn up.

13. References

Bloetjes, O (1999) Subsoils of Soutny Clare. Quaternary section, Geological Survey of Ireland.

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Deakin, J. (1995) Source reports for Bruff, Bruree, Hospital and Mortlestown PWS's, Co. Limerick. Geological Survey of Ireland reports to Limerick County Council.

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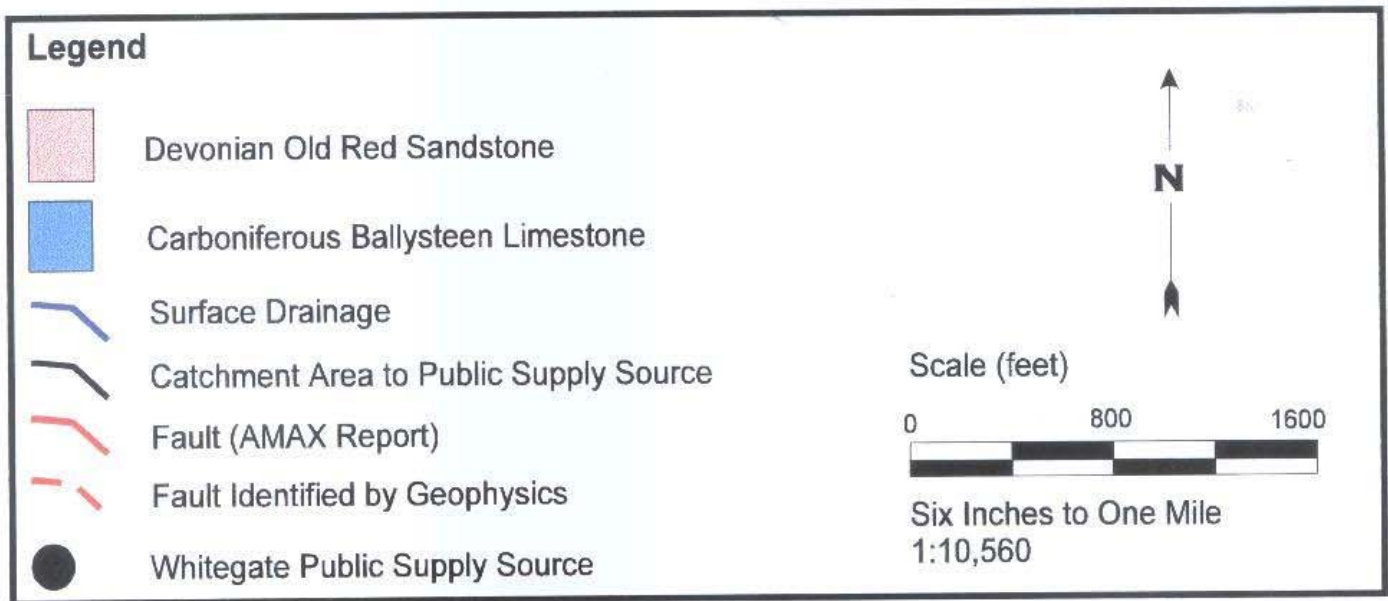
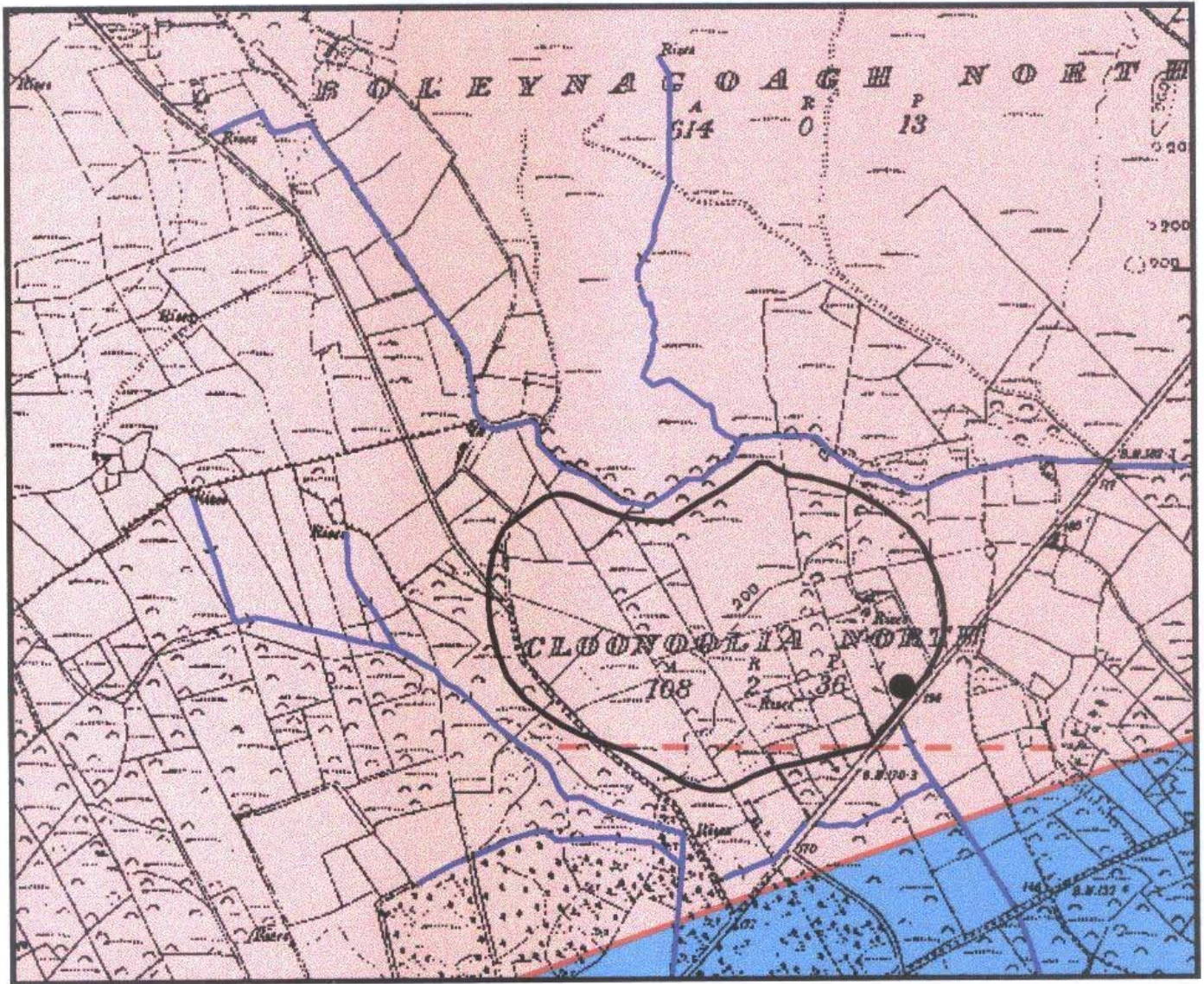


Figure 1 Geology Map of Whitegate Public Supply Source

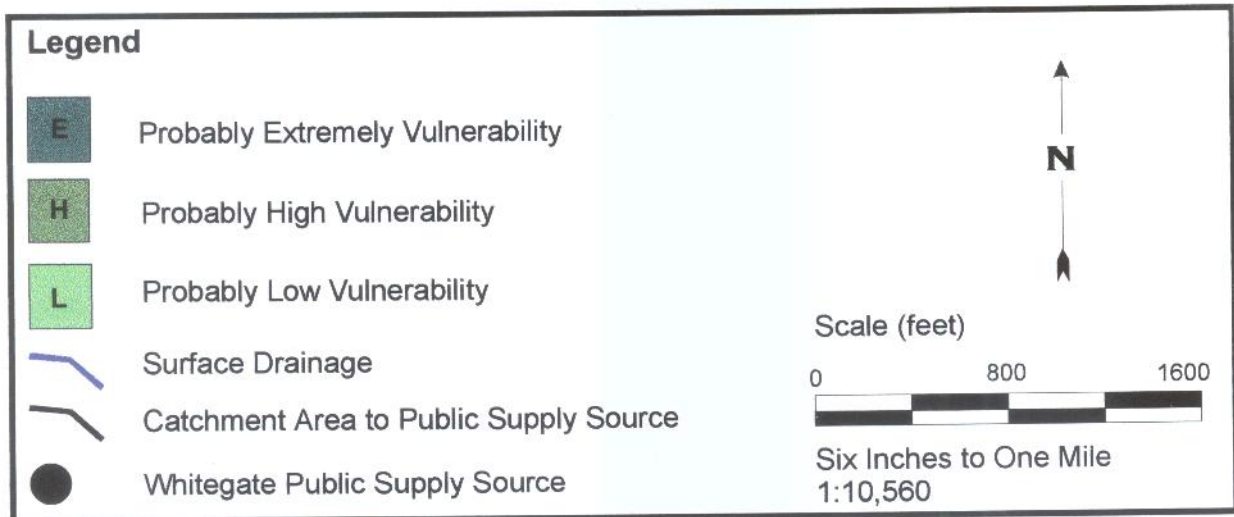
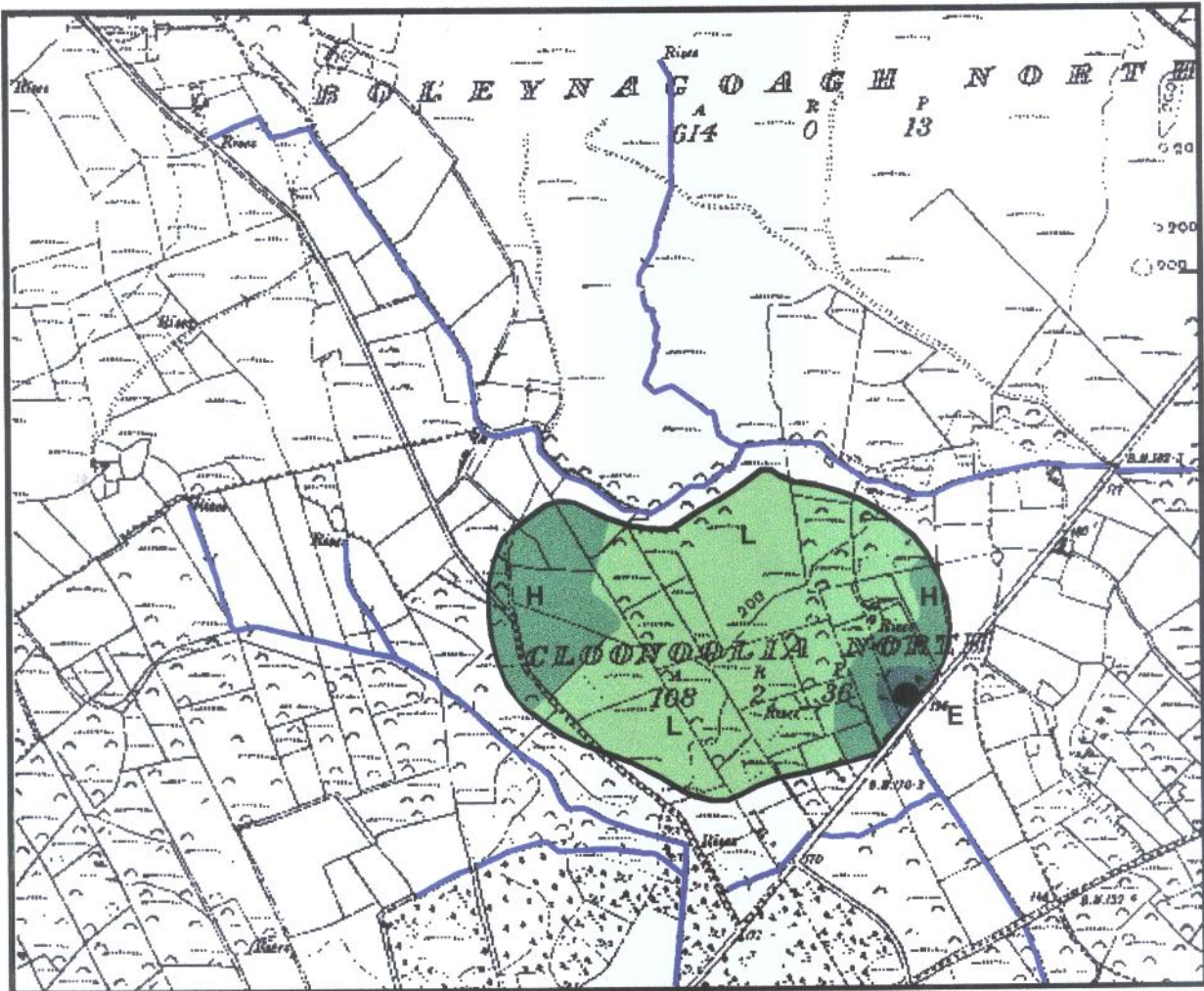


Figure 2 Groundwater Vulnerability Map for Whitegate Public Supply Source

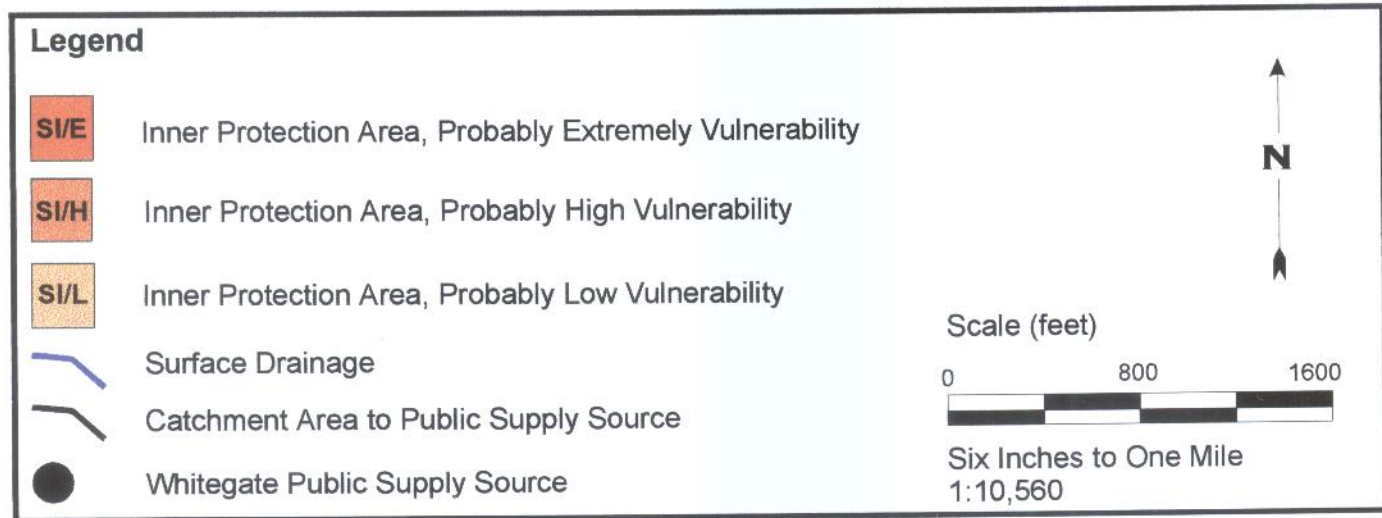
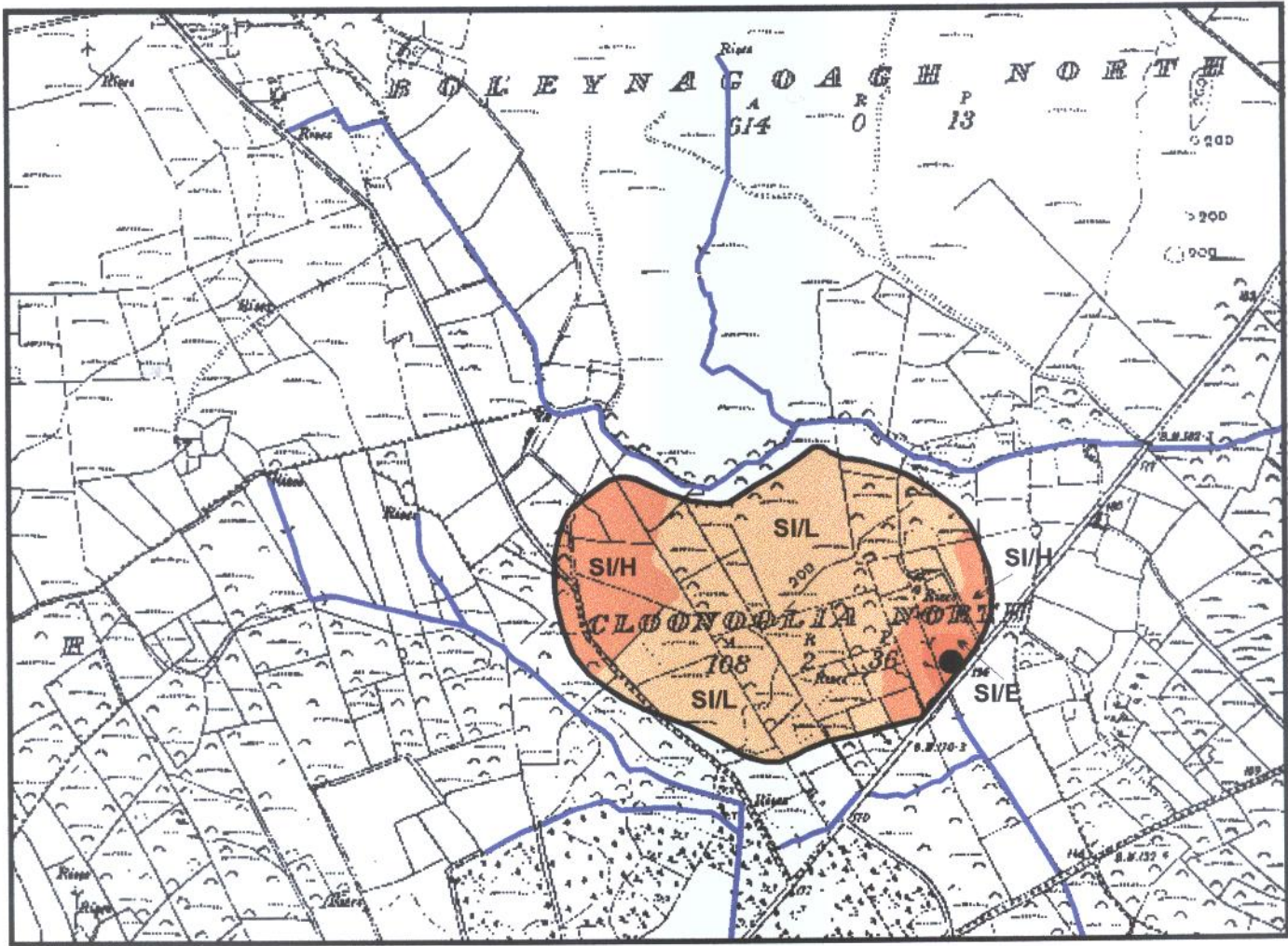


Figure 3 Source Protection Zones for Whitegate Public Supply Source