# MINANE BRIDGE WATER SUPPLY

## GROUNDWATER SOURCE PROTECTION ZONES

## Revised 2002

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# 1. Introduction

The objectives of this report are:

- To delineate source protection zones for the Minane Bridge Water Supply Scheme(WSS).
- To outline the principal hydrogeological characteristics of the Minane Bridge area.
- To assist Cork County Council (Southern Division) in protecting the water supply from contamination.

# 2. Location and site description

The Minane Bridge Water Supply is situated in Springhill townland, approximately 180 m north of the bridge at Minane Bridge in South Cork, and just south of Springhill House. The source was developed in 1977, following some exploratory excavations in June-July 1976. The water source comprises an engineered infiltration gallery, about 40 metres long, which underlies a fairly extensive tract of river gravels and alluvium on the northern side of the stream. The site of the infiltration gallery is fenced off and the pump controls and the sump are protected by a hexagonal pumphouse by the roadside. The water is pumped to a service reservoir in Springhill townland, about 275 m northwest of the source.

Figures 1 and 2 show the site locality in some detail.

# 3. Summary of well details

| | |
|---|---|
| **GSI no.** | 1705SW W070 |
| **Grid ref. (1:25,000)** | 17440 05685 |
| **Townland** | Springhill |
| **Owner** | Cork County Council (Southern Division) |
| **Source type** | Infiltration Gallery |
| **Elevation (top of casing)** | 3.17 m O.D. |
| **Depth** | ~ 9 m (shallow sump) |
| **Dimensions** | Sump is c. 2 m diameter. Gallery is c. 40 metres long (E-W). Gallery pipes are 450 mm diameter. |
| **Depth-to-rock** | Unknown |
| **Static water level** | Unknown but assumed less than 3 m |
| **Drawdown** | unknown |
| **Current Abstraction** | ~ 98 $m^3$/d (900 gals/hr) (not continuously) |

# 4. Methodology

## *4.1 Desk Study*

Bedrock geology information was compiled from the published Geological Survey of Ireland 1:100,000 Bedrock Series (Sheet 25), (Sleeman & Pracht, 1994) and subsoil information was compiled from the draft mapping by Teagasc and additional air photo interpretation. Basic source details were obtained from GSI records and County Council personnel.

### *4.2 Site Visits and Field Work*

This included walkover surveys and an investigation into the nature of the alluvial gravel which is being exploited, using trial pitting, to aid in the conceptualisation of the hydrogeology. Vulnerability to contamination and the current pollutant loading in the area were also examined.

### *4.3 Assessment*

This stage utilised field studies and a knowledge of the flow regime in the area to delineate protection zones around the public supply well.

## 5. Topography and surface hydrology

The unnamed stream which flows eastward beneath Minane Bridge into Ringabella Creek has a catchment area of approximately 26 $km^2$ to Minane Bridge. The topography rises quite steeply on both sides of the valley to reach maximum elevations of over 150 metres to the north and over 100 metres to the south. Most of the catchment (c. 75%) lies to the north, where four tributary streams rise; the southern tributaries are much shorter. The south-flowing stream stream which enters the valley at Ahane Bridge (600 m west of Minane Bridge) is deeply incised into the topography.

The bridge surface is at about 5 metres O.D. The alluvial flat has an elevation of approximately 4 metres above O.D. The O.S. map warns of flooding at spring tides close to the stream. Below the bridge the stream channel is confined by raised banks

## 6. Geology

### *6.1 Bedrock geology*

#### 6.1.1 Geological succession

The catchment is underlain by rocks of the 'Cork Group', including the Lispatrick Formation, Courtmacsherry Formation (Ringabella Member and Fountainstown Member), Kinsale Formation (Pigs Cove Member, Narrow Cove Member, Cuskinny Member, and Castle Slate Member), the Old Head Formation, and the Gyleen Formation.

| Formation | Code | Description |
|---|---|---|
| Lispatrick Formation | LP | Pyritic cherty mudstone with dolomite |
| Courtmacsherry Formation | CY | Calcareous mudstone with limestone |
| Kinsale Formation | KN | Grey mudstone with subordinate sandstone |
| Pigs Cove Member | KNpc | Sand-lensed mudstone |
| Narrow Cove Member | KNnc | Flaser-bedded sandstone & mudstone |
| Cuskinny Member | KNcu | Flaser-bedded sandstone & mudstone |
| Castle Slate Member | KNcs | Grey mudstone |
| Old Head Sandstone Formation | OH | Flaser-bedded sandstone & minor mudstone |
| Gyleen Formation, Ballyknock Member | GYbn | Green sandstone, siltstone & mudstone |

#### 6.1.2 Geological Structure

The rock formations are folded into a small syncline (the Powerhead Syncline), which lies between the Church Bay Anticline (to the north) and another to the south. The axis of the folding is approximately WSW-ENE. The rocks are also broken by a strong system of faults running approximately NNW-SSE, or roughly at right angles to the fold axes. The faulting has generally resulted in moving the rocks to the east of each fault a little way to the south (i.e. they are dextral wrench faults). One such fault crosses the valley, just to the west of the Bridge.

## *6.2 Subsoil geology*

### 6.2.1 Subsoil types

Two subsoil types were identified in the area: Till and Alluvium.

#### *6.2.1.1 Till*

Till, described on the 1902 mapping as 'stony clay', occurs over much of the upland areas. Recent draft maps by Teagasc (1999) distinguish between 'Limestone Till' (largely derived from Carboniferous limestones) and 'Sandstone Till' (largely derived from the sandstones and mudstones of the Cork Group). The sandstone till generally lies north of the valley, and limestone till to the south, plus some small occurrences on the north side, immediately around Minane Bridge itself.

#### *6.2.1.2 Alluvium*

The alluvial deposits comprise a thin upper layer, mainly silty clay and peat, about 1-2 metres thick, overlying an alluvial gravel of uncertain depth. Evidence for this comes from notes taken at the time of the original exploration for the infiltration gallery in 1976, the construction of the gallery in 1977, and a trial pit excavated nearby in 1999 for this project.

### 6.2.2 Depth to bedrock

Mapping by GSI (19$^{th}$ Century) and Teagasc (2000) show a number of rock outcrops: along the incised valley north of Ahane Bridge, and along the road to the east and west of Ahane Bridge. There is also an isolated outcrop in the hillside 400 m east of Springhill House. Areas of less than 3 m subsoil cover are quite extensive, particularly to the north of the valley, along the incised valley and along the hillslopes.

# 7. Rainfall, Evapotranspiration and Recharge

## *7.1 Rainfall*

Long term average annual rainfall (P) is estimated at 1210 mm (Met Eireann).

## *7.2 Evapotranspiration*

Long term average annual actual evapotranspiration (AE) is estimated at 486 mm (EPA).

## *7.3 Recharge*

Long term average annual potential recharge is (1210 - 486) 724 mm. Actual recharge is arbitrarily taken as about 50% of this, say, 360 mm/yr.

# 8. Water Quality

## *8.1 Nitrate*

Nitrate levels in water from the Minane Bridge source have been a cause of concern for about ten years. Figure A1.1 (Appendix1) presents the available data since 1991. Nitrate levels have ranged as high as 106 mg/l and have been consistently above 40 mg/l (with one recorded exception) throughout the 1990s, and have commonly exceeded the Maximum Acceptable Concentration (MAC) of 50 mg/l. However, there has been some reduction in average levels since 1994, and the two measurements by GSI/State Laboratory in 1999 were both below 50 mg/l. The reduction in nitrate may be due to action taken on foot of warnings to two local landowners in 1991. Further frequent monitoring of the nitrate levels at this source are needed to confirm this downward trend.

High nitrate values have typically been recorded in winter, which may imply an association with polluted runoff from farmyards or fields. However, even though levels are lower in the summer months, they still average out at about 40-45 mg/l.

### *8.2 Bacteria*

Historical records from Cork County Council appear to show that water from this source has quite good bacteriological quality. However, it is thought that most of these samples were treated and the characteristics of the raw water would not show through. Sampling of this source by the G.S.I. in September 1999 found 3 total coliforms per 100 ml. Samples from October 1993 (3 total per 100 ml) and January 1996 (41 total per 100 ml) also showed bacteriological contamination.

### *8.3 Other parameters*

Potassium/Sodium ratios for this source also seem to indicate some form of organic contamination. The background ratio in most groundwaters is usually less than 0.4. Soiled water and wastes from plant organic matter will have a ratio considerably greater than 0.4. Sampling in April and September noted ratios of 0.83 and 0.67 respectively.

Although this source is quite close to the sea, chloride levels are not in themselves a cause for concern. They are however, slightly elevated at 61.9 mg/l in April 1999 and 55.5 mg/l in September as would be expected for a source close to tidal waters.

Groundwater hardness values from this source are moderately hard at around 220 mg/l $CaCO_3$.

## 9. Hydrogeology

The bedrock in the Minane Bridge area (Cork Group – Kinsale, Courtmacsherry and Lispatrick formations) is classified as a **Locally Important Aquifer, moderately permeable only in local zones (Ll).**

The aquifer feeding the Infiltration Gallery is the alluvial gravel, which is classified as a **Locally Important Gravel Aquifer (Lg)**. The thickness of the gravel is not known, but by comparison with other local gravel aquifers (e.g. in the Bandon Valley) is unlikely to be much above 10 metres.

Relevant data for the gravel aquifer, such as thickness, permeability, transmissivity, porosity, water levels or gradients, are lacking. In their absence, some values typical of such aquifers (by reference to similar deposits elsewhere in Cork) have been used in the aquifer conceptualisation and estimation of the source protection areas.

## 10. Groundwater Vulnerability

The gravel aquifer is protected by only a thin layer of alluvial sity clay and peat, which appears to be less than 3 metres thick. Hence, the groundwater vulnerability category around the gallery and on the alluvial flat is ‘extreme’ *(E).*

Away from the alluvial flat, the vulnerability depends mainly on the subsoil thickness or depth to bedrock. Where this is less than 3 m, the vulnerability is ‘extreme’; where it is greater than 3 m, the vulnerability is classed as ‘high (possibly moderate in places)’.

The extreme vulnerability areas cover the hill slopes bordering the alluvium, except for a couple of small areas to the northeast and east of Minane Bridge (Map 2).

## 11. Conceptual Model

The aquifer is an alluvial gravel deposit which is covered by a thin layer (c. 1.2m) of finer grained alluvial material, including peat and silty clay. The aquifer is fed by surface and subsurface water

draining from the surrounding hillsides, by direct recharge of rainfall over the surface of the alluvium, and (possibly) by lateral percolation of water in streams flowing though the alluvium.

Groundwater entering the gallery itself can be envisaged as travelling along three routes:

- Water drawn in from the stream, which lies just over 100 metres south of the gallery. Given the small hydraulic head which the gallery develops, this is probably a negligible source of water to the gallery. This seems to be confirmed by the hydrochemistry of the water.
- Subsurface flow within the gravel aquifer. This is expected to be flowing parallel to the stream, i.e. eastwards. Since the gallery is orientated in the same direction as this groundwater flow (i.e. roughly east-west), it is not well positioned to intercept this flow. Consequently, this source probably provides only a minor proportion of the pumpage from the gallery.
- Subsurface flow from the hillside to the north of the gallery, plus shallow subsurface flow ('interflow') and surface runoff which infiltrates into the ground at the foot of the slope. Since the gallery is orientated at right angles to the direction of this flow, it is optimally placed to intercept it. Hence it is expected that this source contributes most of the flow into the gallery, and therefore also contributes most to the problems of water quality.

The groundwater catchments are assumed to coincide with the relevant surface water catchments.

# 12. Source Protection Areas

## *12.1 Introduction*

This section describes the delineation of the areas around the gallery that are believed to contribute groundwater to the public water supply at Minane Bridge, and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern, as described above. Given the limited amount of calibration data available, a full groundwater numerical model is not believed to add significant useful information to the conceptualisation.

Two source protection areas are delineated:

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

## *12.2 Outer Source Protection Area (SO)*

In theory, stream water could reach the gallery through the gravel aquifer. Hence, the entire stream catchment could be regarded as the Zone of Contribution to the gallery. However, as outlined above (Section 11), infiltration from the stream to the gallery is probably negligible.

The Zone of Contribution to the gallery is therefore envisaged as comprising:

- The alluvial flat extending to the south of the gallery as far as the stream, to the west as far as the Bridge, and to the east as far as the calculated down-gradient 'null point', i.e. 100 metres;
- The surface catchment draining to the gallery and to those parts of the alluvial flat outlined above. This catchment extends northwards and westwards, within the townlands of Minane and Springhill. Its maximum extent is about 600 m to the west and 700 m to the north.

The total extent of this area is approximately 0.2 $km^2$ (20 ha) and is shown on the maps.

Another approach is to calculate the area required to supply the current abstraction rate of about 98 $m^3$/day. In practice, GSI normally increases the current abstraction rate by 50% or so, to allow for possible future increases in demand. In this case, a designated abstraction rate of 150 $m^3$/d is assumed.

If annual recharge is about 360 mm (Section 7), then the area required to provide 150 $m^3$/d all year round is 0.15 $km^2$, or 15 hectares. This compares reasonably well with the above figure.

### *12.3 Inner Source Protection Area (SI)*

This area was estimated by first calculating the 100-day time-of-travel distance to the gallery, based on the estimated aquifer characteristics, as follows:

- Aquifer permeability (k) 20 m/d
- Hydraulic gradient 0.005
- Aquifer porosity 0.2

Using these parameters, the groundwater velocity is estimated as 0.5 m/d, hence the 100-day time-of-travel distance is 50 metres. Hence the Inner Protection Area extends 50 metres in all directions from the gallery.

However, to the north of the gallery a 50 metre zone extends beyond the alluvial flat and up the hillside. It is clear that shallow subsurface flow (interflow) and surface runoff down the hillside would infiltrate the gravel at the foot of the slope, well within the 50 metre area. Therefore, to provide adequate protection to the gallery, the SI area must be extended up-gradient to include all the surface catchment which can drain directly into the 50-metre area. (Map 3).

## 13. Groundwater Source 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. **SI/H**, which represents an Inner Protection area where the groundwater is highly vulnerable to contamination. Four groundwater protection zones are delineated around the gallery at Minane Bridge (Map 3), as shown in the matrix below.

**Matrix of Source Protection Zones**

| **VULNERABILITY RATING** | **SOURCE PROTECTION** | |
|---|---|---|
| | ***Inner*** | ***Outer*** |
| ***Extreme (E)*** | SI/E | SO/E |
| ***High (H)*** | SI/H | SO/H |
| ***Moderate (M)*** | *SI/M (absent)* | *SO/M (absent)* |
| ***Low (L)*** | *SI/L (absent)* | *SO/L (absent)* |

The response measures imposing restrictions on certain developments and activities within these zones are included in "Groundwater Protection Schemes", published by DELG, EPA and GSI in 1999. These measures indicate the degree of restriction recommended in each protection zone.

## 14. Land Use and Potential Pollution Sources

There are some domestic dwellings within the ZOC of the source. A farm with pasture and cattle lies north of the source and directly up-gradient of the gallery, within its Zone of Contribution.

Water quality at the Minane Bridge source is poor although there is a lack of full analyses. Nitrate levels (discussed in Section 8) are unacceptably high and have often exceeded MAC levels.

No detailed assessment of hazards was carried out as part of this study.

The main hazard within the Zone of Contribution is considered to be pollution from farmyards.

## 15. Conclusions and Recommendations

- The public water supply at Minane Bridge consists of an engineered infiltration gallery, about 40 metres long, which underlies a fairly extensive tract of river gravels and alluvium on the northern side of the stream. It is located in Springhill townland just north of the village.
- The bedrock in this area is the Courtmacsherry Formation and is classified as a Locally Important Aquifer, moderately permeable only in local zones (**Ll**). However the aquifer that the infiltration gallery is abstracting from is the overlying alluvial gravels, which are classified as a Locally Important Gravel Aquifer (**Lg**). The thickness of the gravel is not known, but trial pitting in 1999 and the reported depth of the gallery itself, suggest that it could be between 5 and 10 m thick (Kelly & Wright, 2000). The groundwater in a large proportion of the catchment for this infiltration gallery is either extremely or highly vulnerable to pollution.
- Water quality from the gallery is unsatisfactory in a number of respects. The main concern is the nitrate concentration, but other parameters have breached the MAC from time to time, namely E. *coli*, nitrite, and manganese.
- 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.
- A new gallery further away from the hillside, and orientated to maximise interception of the throughflow in the alluvial gravel aquifer, would probably produce water of better quality.
- It is recommended that:

  Chemical and bacteriological analyses of raw water should be carried out on a regular basis (every 6 months). A treatment system should be installed for the village supply. The chemical analyses should include all major ions - calcium magnesium sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and especially nitrate.

  Particular care should be taken in allowing any activities or developments which might significantly increase nitrate levels or cause further contamination in the gallery.

  The potential hazards in the ZOC should be located and assessed.

  Interim guidelines should be drawn up for dealing with underground petroleum storage/transfer, and spillages along the roads in the area.

## 16. References


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# Appendix 1

# Water Quality Data

Water Quality Data, Minane Bridge WSS
(Data from Inniscarra Laboratory)

Greater than Guide levels
Greater than MAC levels

| | Date | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | $SO_4$ | Cl | TDS | Alk. | TH | Fe | Mn | Nitrite | Nitrate | $NH_4$ | Al | Bacteria E. coli | Bacteria TC | pH Lab | Temp Lab | EC Lab | F | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Units* | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | $CaCO_3$ | mg/l | mg/l | $NO_2$ | $NO_3$ | mg/l | mg/l | no/100ml | | | °C | uS/cm | mg/l | mg/l |
| *MAC* | | 200 | 50 | 150 | 12 | | | 250 | 250 | | | | 0.2 | 0.05 | 0.1 | 50 | 0.23 | 0.2 | 0 | 0 | | | 1500 | 1 | 1 |
| | 15/01/1991 | | | | | | | | | | | | | | 0.003 | 87.71 | 0.032 | | 0 | 0 | 6.6 | 6 | 680 | | |
| | 26/08/1991 | | | | | | | | | | | | | | 0.043 | 44.01 | 0.014 | | 0 | 0 | 6.5 | 16 | 490 | | |
| | 30/09/1991 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 596 | | |
| | 13/01/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | 8 | 516 | | |
| | 27/01/1992 | | | | | | | | | | | | | | 0.004 | 106.2 | 0.028 | | 0 | 0 | 6.6 | 8 | 648 | | |
| | 03/02/1992 | | | | | | | | | | | | | | 0.003 | 51.09 | 0.029 | | 0 | 0 | 6.5 | 9.5 | 551 | | |
| | 18/02/1992 | | | | | | | | | | | | | | | | | | 0 | 1 | | 17.5 | 675 | | |
| | 06/04/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | 10 | 662 | | |
| | 27/04/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | 12 | 660 | | |
| | 11/05/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 783 | | |
| | 11/06/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 741 | | |
| | 06/07/1992 | | | | | | | | | | | | | | 0 | 25.76 | 0.013 | 0 | 0 | 0 | 6.6 | 19.5 | 726 | | |
| | 07/09/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | 16 | 539 | | |
| | 28/09/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 631 | | |
| | 05/10/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 855 | | |
| | 11/11/1992 | | | | | | | | | | | | | | 0.001 | 52.62 | 0.015 | | 0 | 0 | 6.7 | 11 | 604 | | |
| | 16/11/1992 | | | | | | | | | | | | | | 0 | 57.89 | 0.013 | | 0 | 0 | 6.5 | 9 | 623 | | |
| | 30/11/1992 | | | | | | | | | | | | | | | | | | 0 | 0 | | 10 | 634 | | |
| | 19/01/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 757 | | |
| | 08/02/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 626 | | |
| | 15/02/1993 | | | | | | | | | | | | | | | 82.52 | | | | | | | 581 | | |
| | 18/02/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 9.7 | | | |
| | 22/02/1993 | | | | | | | | | | | | | | 0.512 | 74.56 | | | 0 | 0 | | 8.5 | 689 | | |
| | 08/03/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 453 | | |
| | 15/03/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 10 | 469 | | |
| | 23/03/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 9 | 484 | | |
| | 29/03/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 9.5 | 522 | | |
| | 05/04/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 9.5 | 575 | | |
| | 13/04/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 558 | | |
| | 19/04/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 592 | | |
| | 22/04/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 297 | | |

# Water Quality Data, Minane Bridge WSS
(Data from Inniscarra Laboratory)

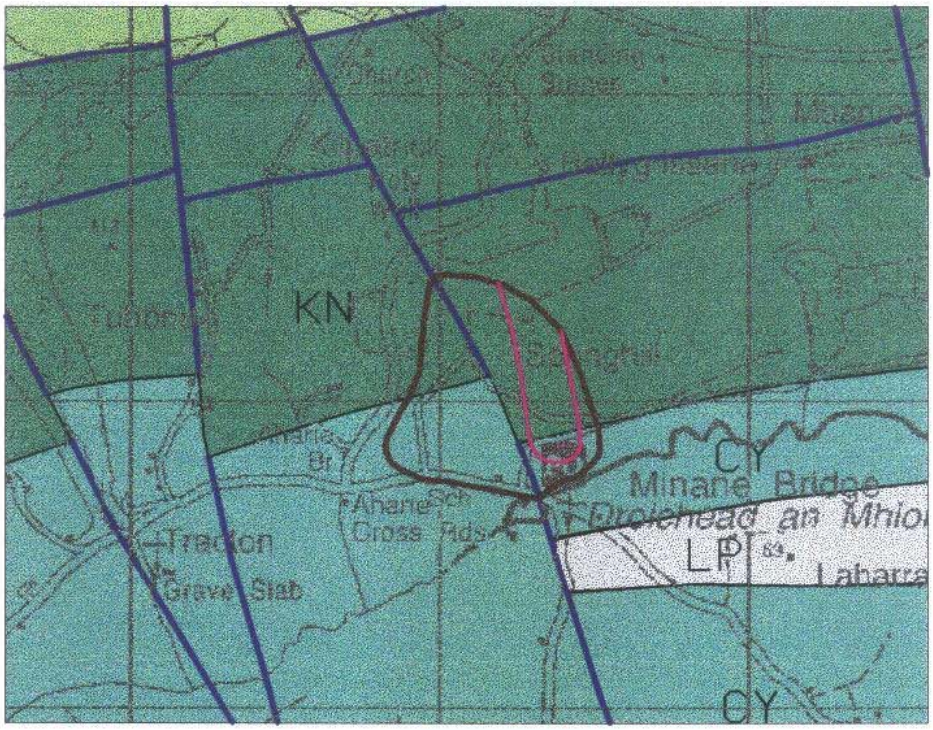
Greater than Guide levels
Greater than MAC levels

| | | | | | | | | | | | | | | | | | | Bacteria | | pH | Temp | EC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | $SO_4$ | Cl | TDS | Alk. | TH | Fe | Mn | Nitrite | Nitrate | $NH_4$ | Al | E. coli | TC | Lab | Lab | Lab | F | Zn |
| Units | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | $CaCO_3$ | mg/l | mg/l | $NO_2$ | $NO_3$ | mg/l | mg/l | no/100ml | | | °C | uS/cm | mg/l | mg/l |
| MAC | | 200 | 50 | 150 | 12 | | | 250 | 250 | | | | 0.2 | 0.05 | 0.1 | 50 | 0.23 | 0.2 | 0 | 0 | | | 1500 | 1 | 1 |
| | 03/05/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 10 | 638 | | |
| | 10/05/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 634 | | |
| | 02/06/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 709 | | |
| | 14/06/1993 | | | | | | | | | | | | | | 0.033 | 56.44 | 0.02 | | 0 | 0 | 6.5 | 11 | 580 | | |
| | 26/06/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 622 | | |
| | 28/06/1993 | | | | | | | | | | | | | | 0.007 | 73.93 | 0.01 | | 0 | 0 | 6.3 | 11 | 625 | | |
| | 05/07/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 567 | | |
| | 12/07/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 17 | | | |
| | 20/07/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 17.5 | 699 | | |
| | 26/07/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 596 | | |
| | 03/08/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 579 | | |
| | 17/08/1993 | | | | | | | | | | | | | | | 61.39 | | | 0 | 0 | | | 545 | | |
| | 24/08/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 17 | 544 | | |
| | 31/08/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 17 | 524 | | |
| | 06/09/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 183 | | |
| | 13/09/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | | | |
| | 20/09/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 610 | | |
| | 05/10/1993 | | | | | | | | | | | | | | | | | | 0 | 3 | | | 768 | | |
| | 04/11/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | 11.5 | 569 | | |
| | 29/11/1993 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 600 | | |
| | 10/01/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 612 | | |
| | 24/01/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 654 | | |
| | 01/02/1994 | | | | | | | | | | 90 | 174 | 0.19 | 0.08 | 0.02 | 73.73 | | 0.067 | 0 | 0 | 6.5 | 8.5 | 713 | | |
| | 07/03/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 494 | | |
| | 29/03/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 610 | | |
| | 16/05/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 539 | | |
| | 07/06/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 547 | | |
| | 21/07/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 617 | | |
| | 26/09/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 594 | | |
| | 10/10/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 470 | | |
| | 25/10/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 495 | | |

# Water Quality Data, Minane Bridge WSS
(Data from Inniscarra Laboratory)

Greater than Guide levels
Greater than MAC levels

| | | | | | | | | | | | | | | | | | | Bacteria | | pH | Temp | EC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | $SO_4$ | Cl | TDS | Alk. | TH | Fe | Mn | Nitrite | Nitrate | $NH_4$ | Al | E. coli | TC | Lab | Lab | Lab | F | Zn |
| *Units* | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | $CaCO_3$ | mg/l | mg/l | $NO_2$ | $NO_3$ | mg/l | mg/l | no/100ml | | | °C | uS/cm | mg/l | mg/l |
| *MAC* | | 200 | 50 | 150 | 12 | | | 250 | 250 | | | | 0.2 | 0.05 | 0.1 | 50 | 0.23 | 0.2 | 0 | 0 | | | 1500 | 1 | 1 |
| | 05/12/1994 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 490 | | |
| | 09/01/1995 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 490 | | |
| | 13/02/1995 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 408 | | |
| | 20/02/1995 | | | | | | | | | | | | | | | | | 0.03 | 0 | 0 | | | 413 | | |
| | 07/03/1995 | | | | | | | 24 | 55 | | 57 | 161 | 0.1 | 0.025 | 0.006 | 53.29 | 0.01 | 0.03 | 0 | 0 | 6.5 | 6.5 | 408 | | 0.05 |
| | 19/04/1995 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 435 | | |
| | 24/04/1995 | | | | | | | | | | | | | | | | | 0.03 | 0 | 0 | | | 432 | 0.5 | |
| | 22/05/1995 | | | | | | | | | | | | | | 0.007 | 47.43 | 0.01 | 0.03 | 0 | 0 | 6.4 | 12 | 411 | | |
| | 24/07/1995 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 392 | | |
| | 19/09/1995 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 444 | | |
| | 03/01/1996 | | | | | | | | | | | | | | | | | | 0 | 41 | | | 444 | | |
| | 01/02/1996 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 524 | | |
| | 05/02/1996 | | | | | | | | | | | | 0 | 0 | 0.01 | 58.58 | 0.01 | | 0 | 0 | 6.4 | 7 | 526 | | |
| | 25/03/1996 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 470 | | |
| | 09/04/1996 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 441 | | |
| | 25/06/1996 | | | | | | | | | | | | | | 0.016 | 43 | 0.013 | | 0 | 0 | 6.3 | 17.5 | 409 | | |
| | 07/10/1996 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 433 | | |
| | 05/11/1996 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 441 | | |
| | 14/01/1997 | | | | | | | | | | | | | | | 56 | | | 0 | 0 | | | 495 | | |
| | 29/01/1997 | | | | | | | | | | | | | | | | | | 0 | 0 | | | 469 | | |
| | 11/02/1997 | | | | | | | | | | | | | | 0.016 | 42.44 | 0.013 | | 0 | 0 | 6.7 | 8.5 | 498 | | |
| | 19/02/1997 | | | | | | | | | | | | | | | 58 | | | 0 | 0 | | | 465 | | |
| | 19/03/1997 | | | | | | | | | | | | | | | 70 | | | | | | | | | |
| | 08/04/1997 | | | | | | | | | | | | | | | 51 | | | 0 | 0 | | | 452 | | |
| | 11/06/1997 | | | | | | | | | | | | | | | 41 | | | | | | | | | |
| | 17/11/1997 | | | | | | | | | | | | | | | 51 | | | | | | | | | |
| | 10/12/1997 | | | | | | | | | | | | | | | 57 | | | | | | | | | |
| | 07/01/1998 | | | | | | | | | | | | | | | 45 | | | | | | | | | |
| | 17/02/1998 | | | | | | | | | | | | | | | 56 | | | | | | | | | |
| | 24/03/1998 | | | | | | | | | | | | | | | 55 | | | | | | | | | |




## Minane Bridge Water Supply Scheme

0 500m 1 km

## Map 1. Geology

LP Old Head Sandstone Formation

CY Courtmacsherry Formation

KN Kinsale Formation

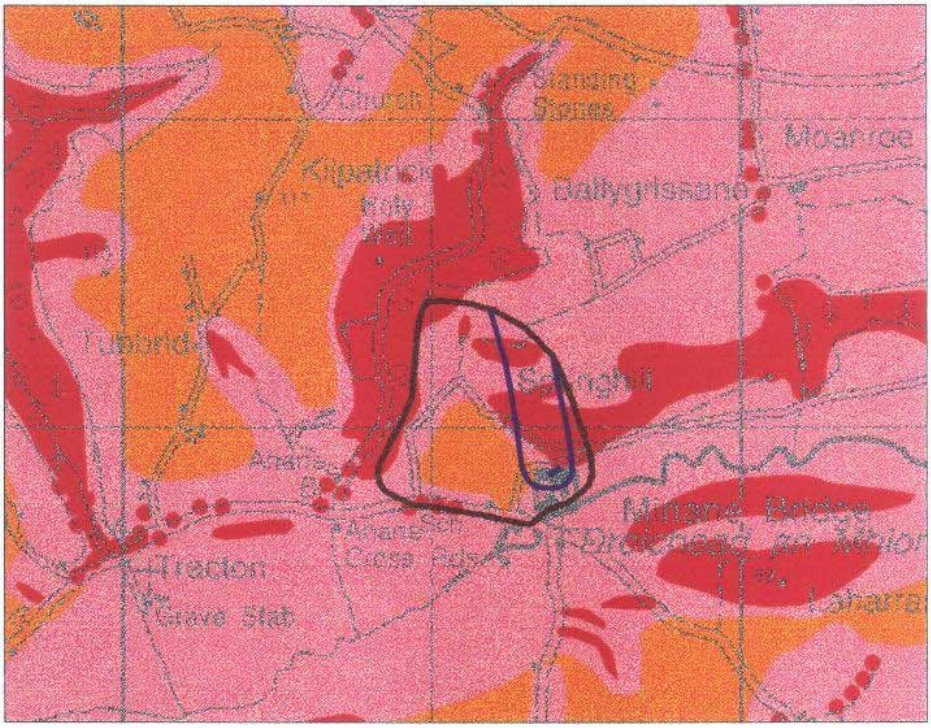
Fault

Infiltration Gallery

Inner Protection Zone

Zone of Contribution

This Bedrock Map is designed for general information and stragegic planning usage. The boundaries are based on the available evidence 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.




## Minane Bridge Water Supply Scheme

0 500m 1km

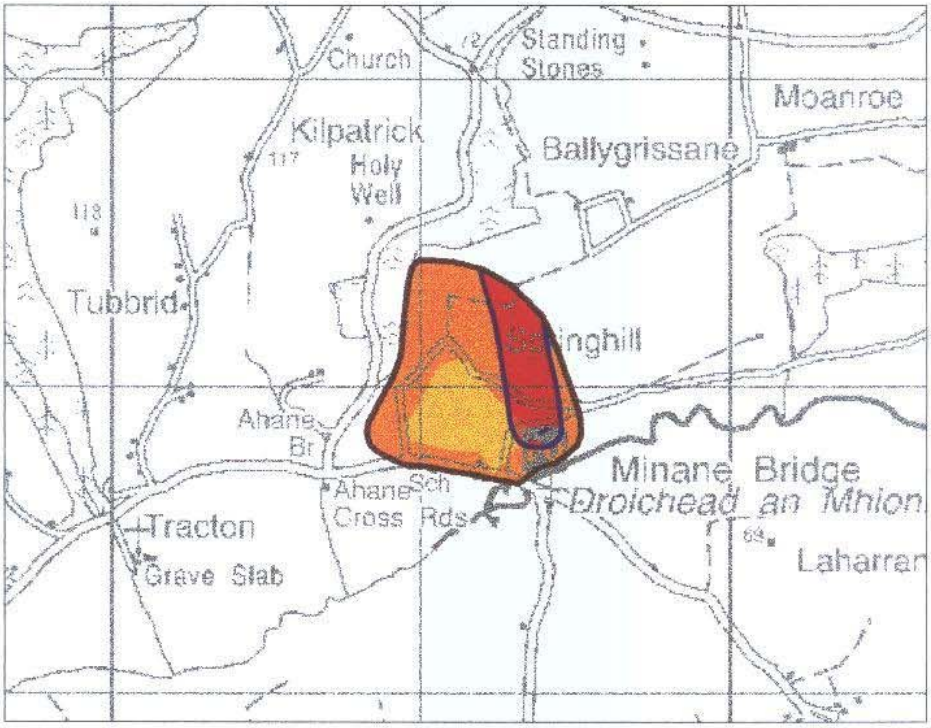
## Map 2. Groundwater Vulnerability

- Extreme (E)
- Outcrop/Shallow rock (E)
- High (H)
- Moderate (M)
- Low (L)
- Infiltration Gallery
- Zone of Contribution
- Inner Protection Zone

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the vulnerability of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This vulnerability map is designed for general information and strategic planning usage.The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements, and will frequently require site investigations to determine the risk to groundwater.




0 500m 1km

## Minane Bridge Water Supply Scheme

## Map 3. Source Protection Zones

| VULNERABILITY RATING | SOURCE PROTECTION ZONES | |
|---|---|---|
| | Inner (SI) | Outer (SO) |
| Extreme (E) | SI/E | SO/E |
| High (H) | SI/H | SO/H |
| Moderate (M) | SI/M | SO/M |
| Low (L) | SI/L | SO/L |

Infiltration Gallery

Inner Protection Zone

Zone of Contribution

This **Source Protection Map** is designed for general information and stragegic planning usage. The boundaries are based on the available evidence 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.
The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.