FEDAMORE PUBLIC SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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1. SUMMARY OF WELL DETAILS

GSI no.	: 1413NE W140	
Grid ref.	: 15929 14453	
Owner	: Limerick Co. Co.	
Well type	: Borehole	
Elevation (top of casing)	: 72.88 m OD to Poolbeg	
Depth	: 80.7 m	
Depth of casing	: 10.2 m	
Diameter	: 254 mm (10"); also an outer 8.4 m @ 304 mm	
Depth-to-rock	: 10.2 m	
Static water level	: 13.62 m on 19/8/1993 (9.46 m on 6/7/1993)	
Drawdown	: 9.6 m (after 10 hours continuous pumping)	
Abstraction rate	: $333 \text{ m}^3/\text{d}$ (3050 gal/hr over approx. 9 hrs)	
Normal consumption	: $123 \text{ m}^3/\text{d}$ (27,000 gal/d)	
Specific capacity	: $20 \text{ m}^3/\text{d/m} (1 \text{ week})$	
Pumping test summary:		
	(i) abstraction rate : $191 \text{ m}^3/\text{d}$	
	(ii) specific capacity $: 20 \text{ m}^3/\text{d/m}$	
	(iii) transmissivity $: 34 \text{ m}^2/\text{d} [23-41 \text{ m}^2/\text{d}]$	

2. METHODOLOGY

There were three stages involved in assessing the area, a detailed desk study, site visits and fieldwork, and analysis of the data. The desk study was conducted in the Geological Survey where the subsoil and bedrock geologies were compiled from the original 6" field sheets. Basic public supply well details were recorded by County Council personnel in the form of a questionnaire which included a precise location and any relevant borehole, chemistry and pumping test data available.

The second stage comprised site visits and fieldwork in the surrounding area. A pumping test with recovery was carried out to examine the aquifer characteristics. The area enclosed by a circle of 1 km radius around the borehole was mapped with regard to subsoil and bedrock geology, hydrogeology and vulnerability to contamination. Finally, two raw water samples were taken in September 1993 and April 1994, for full suites of chemical and bacterial analyses.

Stage three, the assessment stage, utilised analytical equations and computer modelling (FLOWPATH) to take a detailed assessment at the hydrogeology and to delineate protection zones.

3. WELL LOCATION AND SITE DESCRIPTION

The public supply well in Fedamore is located north of the village on the western side of the main Limerick road. The wellhead is sealed and is outside the pumphouse in a concrete chamber which is not locked. The site is fenced off. Eight other council wells in the vicinity of the village are now abandoned as the yields were too small to sustain the required output. In addition there are a number of private wells in the area, including one approximately 50 m to the southeast, which was used as an observation well during the pumping test.

4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

Fedamore village is located on the southern side of a small hill (summit at 118.5 m OD). This hill lies on a regional northeast-southwest trending ridge which is bounded by the 61 m (200 ft.) contour. A particularly flat area is evident to the southeast below the 61 m (200 ft) contour. The well lies at the base of the hill at approximately 72 m OD.

Drainage ditches and spring fed streams are abundant in the flatter parts of the area to the east and southeast and flow direction is away from the village. To the north, a slightly bigger spring-fed stream flows to the west and northwest. There is a marked absence of surface water on the ridge in general, except for a wet hollow area to the northeast of the source.

The land is used primarily for grazing for cattle and horses. There is a local stud farm and a number of dairy farms.

5. GEOLOGY

5.1 Bedrock geology

The bedrock geology of the area comprises the massive, blue grey limestones of the Waulsortian Bank Formation. A significant fold with a southwest-northeast axis trends through the village. It is likely that this folding is repeated throughout the area. The rock is also jointed in a north-south direction and there is evidence of dolomitisation.

5.2 Subsoils

Subsoils in the immediate vicinity of the well comprise mainly gravels with associated tills, which are classed overall as till-with-gravel (Fig. 1). A number of ridges radiate away from the hill and these are suspected to contain more gravel than the lower lying areas. Till becomes dominant to the west of the source. The hill is bedrock cored with a thin covering of stoney till and head deposits. The wetter area to the southeast is underlain by heavy, light brown clays with a thin (0.5 m) peaty top.

5.3 Soils

Soils of the area are primarily derived from a parent material of glacial drift origin, mainly limestone with some shale, sandstone and volcanics and include members of two series, the Elton grey brown podzolics, which cover most of the area, and the Howardstown gleys. Soils of a third series, the alluvium derived Camoge gleys, are found overlying the wetter areas to the north and southeast of the area. The soils are shown on the published soils map of Co. Limerick (Finch and Ryan, 1966) and so are not reproduced here.

5.4 Depth-to-rock

On the hill west of the well, bedrock is close to the surface above a height of approx. 75 m O.D (Fig.1). Rock crops out in quarries to the south and west of this hill. Below 75 m O.D., the subsoils become thicker moving away in all other directions. Borehole records for the area show the subsoils to be generally between 5-12 m thick, although they are slightly thicker to the southeast of the village. Bedrock lies at a depth of 10.2 m at the public supply borehole.

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the Fedamore area are better than at most of the sources in Co. Limerick; the following data sources were used in considering the conceptual model:

• A 10 hour pumping test with more than four hours recovery which was carried out as part of the study in August 1993. A nearby private well was both suitable and accessible for use as an observation hole during the test.

- A survey carried out by Geoex (a hydrogeological consulting firm) to assess the groundwater resources in the region. As part of this survey, well data from the many private wells were collected and a water table map was constructed.
- The GSI well database.

6.2 Groundwater levels

The static water level recorded in the public supply well on 6/7/93, following overnight recovery, was 63.42 m OD (9.46 m below the top of the casing). A second reading taken on 19/8/93, again following overnight recovery, was 59.26 m OD (13.62 m below the top of the casing).

Springs and levels from private wells present towards the edges of the ridge imply that groundwater is at, or near the surface in these areas. Towards the centre of the ridge, water levels are deeper, reaching at least 16 m below ground level.

6.3 Groundwater flow directions and gradients

It is considered that the NE-SW trending ridge acts as a groundwater divide and that groundwater flows in a northwesterly direction towards the source. In addition, it is assumed that there is a low groundwater mound beneath the small hill, which will focus groundwater in a northeasterly direction towards the source.

Using the available water level data, the natural gradient from the groundwater divide on the ridge, towards the low lying area to the northwest, is estimated to be approximately 0.008.

6.4 Meteorology

Rainfall data for the area are taken from the nearest, most representative weather station which in this case is Ballyneety. Mean annual rainfall for the years 1951–1980 is taken to be 972 mm. Potential evapotranspiration (P.E.) is estimated from a regional Meteorological Service contoured map, and a ranking scheme with all the other sources, as 490 mm per annum. Actual evapotranspiration (A.E.) is then calculated by taking 93% of the potential figure, to allow for soil moisture deficits during part of the year. Using these figures, the average annual effective rainfall (E.R.) is taken to be approximately 515 mm per annum.

There are relatively few drainage ditches or streams in the suspected catchment area but the subsoils contain a significant proportion of tills and the effective rainfall infiltrating to the water table is estimated (with the aid of the numerical model) to be of the order of 75%, i.e. ~385 mm per annum.

These calculations are summarised below:

Average annual rainfall	972 mm
Estimated P.E.	490 mm
Estimated A.E. (93% P.E.)	456 mm
Effective rainfall	~515 mm
Recharge (75% E.R.)	~385 mm

6.5 Hydrochemistry and water quality

The hydrochemical properties of the groundwater at Fedamore are typical of a limestone aquifer in which carbonate dissolution is the dominant chemical process. The analyses show a **very hard** (430 mg/l; CaCO₃), calcium bicarbonate type water with high alkalinity (370–380 mg/l; CaCO₃), although these values may be influenced by contamination (see below). The magnesium-calcium ratios are relatively high and may either be indicative of dolomitisation, or may be a consequence of contamination.

The water quality in the Fedamore suggests that slight contamination may be occurring at times, although none of the indicator parameters exceeded the EC limits. Chloride levels were usually greater than 30 mg/l; a concentration of almost 40 mg/l was recorded in the C3 analysis sample taken in November, 1993. Nitrate was also often slightly elevated, averaging at 22 mg/l, while electrical conductivities were also somewhat high at times, reaching more than 800 μ S/cm.

6.6 Aquifer coefficients

Analysis of the pumping test data, from both the pumped well and the observation well, gave a range of transmissivity values from 23–41 m²/d with the best estimate taken as $34 \text{ m}^2/\text{d}$. The graphs showed no major recharge or barrier boundaries. The specific capacity was calculated as $20 \text{ m}^3/\text{d/m}$ after 10 hours pumping.

6.7 Conceptual model

The aquifer providing the groundwater is the Waulsortian Bank limestone. Permeabilities in the limestones are likely to be increased by the network of joints and fractures and the dolomitisation.

The influence of the hill, to the west of the well, on groundwater flow directions is not known with certainty. However, it is unlikely that the rock permeability is high enough for it to have no impact; consequently, a low groundwater mound is assumed to be present beneath the hill.

6.8 Aquifer category

Considering the Waulsortian Bank Limestones in terms of well yields, specific capacities, lithology and structure over the county, they are classed as a **regionally important aquifer** which is dominated by **fissure flow**.

7. VULNERABILITY

Using the GSI vulnerability mapping guidelines, the till-with-gravel deposits in the vicinity of the borehole are classed as **probably high** vulnerability. (This is confirmed by the elevated levels of the contaminant indicators nitrate and chloride, and the high conductivity.) The area in the region of the hill is mapped as **probably extreme** vulnerability as the subsoil cover is relatively thin. To the south of the source, the subsoils are thicker and the presence of the 10 m depth-to-bedrock contour lowers the vulnerability classification to **probably moderate** vulnerability. The peat is not classed as low vulnerability in this area as it is likely to be thin, and is probably present as a consequence of a high water table in the underlying permeable deposits; it is consequently classed as **probably moderate** vulnerability. The vulnerability zones are shown in Figure 2.

8. DELINEATION OF SOURCE PROTECTION ZONES

Source Protection Areas are delineated for a 50% higher output than the current abstraction (i.e. $185 \text{ m}^3/\text{d}$) to facilitate an increase in demand and to allow for expansion of the zone of contribution in dry weather

8.1 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 groundwater recharge.

The zone of contribution (ZOC) to the well is considered to be within an arcuate area south and west of the well (Fig. 3). The south-eastern and south-western boundaries are delimited by the groundwater divide, whereas the north-eastern and north-western boundaries are more difficult to delineate. They are based on the assumption that groundwater flow direction is perpendicular to the topographic contours. However, as this assumption is unlikely to apply completely, due to the high permeability of the limestone and the effects of pumping, some deviation from this is allowed for.

Using the Recharge Equation, the area required to collect enough recharge to sustain the increased discharge at the source, on an annual basis, is in the region of 0.18 km^2 (175390 m²), equivalent to a circular area of approximate radius 235 m. The area delineated is significantly larger than this and will therefore incorporate an additional safety margin, which takes account of the uncertainty in the groundwater flow directions, particularly beneath the hill west of the source. FLOWPATH, a modelling package (see section 8.2) and the Uniform Flow Equation were also used to help in delineating the ZOC.

The down-gradient distance to the boundary of the ZOC is calculated as 100 m, based on the Uniform Flow Equation.

8.2 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100-day time of travel from any 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 pollution.

The abstraction rate at the Fedamore source is relatively low and consequently the 100-day travel time distance is small. A number of different methods were used to delineate the area including the Time of Travel Equation, the Volumetric Flow Equation and the numerical model FLOWPATH. The values obtained from each of the methods varied between 60 and 120 m. The latter value is taken as the most realistic. It was calculated using the time of travel equation and taking the following parameters: permeability 0.5 m/d; hydraulic gradient (pumping) 0.06; and porosity 0.025.

8.3 Source Site

In addition to the Inner and Outer Areas there is a third protection area, the Source Site (SS), which is delineated as the area in the immediate vicinity of the source (minimum 10 m radius), and is designed to maintain good wellhead sanitary protection. The fenced off enclosure around the source at Fedamore, which is owned by the County Council, is designated the Source Site Area, although it is currently too small.

9. GROUNDWATER PROTECTION SCHEME

Combining the Source Protection Areas, as described above, with the vulnerability ratings, delineates a total of four groundwater source protection zones for the Ballyagran source. These are listed here and are shown in Figure 4 (with the exception of the Source Site):

- Source Site / High SS H
- Inner Protection Area / High SI H
- Outer Protection Area / Extreme SO E
- Outer Protection Area / High SO H

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 code of practice imposing restrictions on developments will follow when discussions as to the degree of restriction necessary in each protection zone have been carried out between the Council and the EPA, with assistance from the GSI.

10. POTENTIAL POLLUTION SOURCES

The area enclosed within the 100-day travel time radius incorporates the main road and the entrance to Fedamore House. Spillages along the road, with subsequent runoff to the well is probably the most significant threat to the water quality in the well. Excessive land spreading could also be a threat. The remainder of the zone of contribution incorporates a large house and adjoining farm. Farmyard waste is likely to be providing the increased background levels of chloride and nitrate.

11. CONCLUSIONS AND RECOMMENDATIONS

The source at Fedamore is currently pumped at a relatively low rate but it taps a large resource and will facilitate an increase in demand. It is however, highly vulnerable to contamination and the water quality indicates that there is a low level of contamination occurring at times. The sources of this contamination are likely to be of farmyard origin, possibly the nearby farm. The County Council should conduct their own, more detailed pollution surveys in the given protection zones to investigate the source(s) of contamination and to minimise groundwater deterioration.

It is recommended that, as a general policy, a comprehensive suite of hydrochemical and water quality analyses, including all the major anions and cations, should be carried out on a more regular basis (at least twice a year) to monitor changes in groundwater quality and to forecast any further deterioration. Good aquifer management in the zone of contribution will be crucial as a means of preventing further contamination.







