Environmental Protection Agency

Establishment of Groundwater Source Protection Zones

Carrignadoura Group Water Supply Scheme

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PROJECT DESCRIPTION

Since the 1980's, the Geological Survey of Ireland (GSI) has undertaken a considerable amount of work developing Groundwater Protection Schemes throughout the country. Groundwater Source Protection Zones are the surface and subsurface areas surrounding a groundwater source, i.e. a well, wellfield or spring, in which water and contaminants may enter groundwater and move towards the source. Knowledge of where the water is coming from is critical when trying to interpret water quality data at the groundwater source. The Source Protection Zone also provides an area in which to focus further investigation and is an area where protective measures can be introduced to maintain or improve the quality of groundwater.

The project "Establishment of Groundwater Source Protection Zones", led by the Environmental Protection Agency (EPA), represents a continuation of the GSI's work. A CDM/TOBIN/OCM project team has been retained by the EPA to establish Groundwater Source Protection Zones at monitoring points in the EPA's National Groundwater Quality Network.

A suite of maps and digital GIS layers accompany this report and the reports and maps are hosted on the EPA and GSI (www.epa.ie ; www.gsi.ie).

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1 INTRODUCTION

Groundwater Source Protection Zones (SPZ) are delineated for the Carrignadoura source according to the principles and methodologies set out in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999) and in the GSI/EPA/IGI Training course on Groundwater SPZ Delineation.

Carrignadoura is the main source for Carraignadoura Group Water Scheme (GWS).

The objectives of the report are as follows:

- To outline the principal hydro geological characteristics of the Carrignadoura area.
- To delineate source protection zones for the Carrignadoura well.
- To assist EPA and Cork County Council in protecting the water supply from contamination.

Groundwater protection zones are delineated to help prioritise the area around the source in terms of pollution risk to groundwater. This prioritisation is intended as a guide in evaluating the likely suitability of an area for a proposed activity prior to site investigations. The delineation and use of groundwater protection zones is further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The maps produced are based largely on the readily available information in the area, limited fieldwork and on mapping techniques which use inferences and judgements based on experience at other sites. As such, the maps cannot claim to be definitively accurate across the whole area covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

2 LOCATION, SITE DESCRIPTION AND WELL HEAD PROTECTION

The site is located in Carrignadoura Townland (Figure 1), 3 km north to northwest of Ballingeary. It comprises one borehole adjacent to a pump-house. The water is pumped to a reservoir 1.3 km to the north-northeast which is located on the site of a spring that was previously used for the public supply.

In mid 2004, the borehole was drilled which provides a sustainable supply for the group scheme. It replaced the spring supply which was decommissioned because it was unable to meet demand after long dry periods. The upgrade to the group water scheme began at the end of 2004 and was completed early 2006.

Since the end of 2004, the upgrade and extension to the group water scheme has been conducted by BJS Consultants Ltd. These improvements consisted of the laying of approximately 4.5 km of new pipe network and the installation of a new pre-cast concrete reservoir with compound. A new pump house compound was also constructed at the borehole site.

The compound is protected by a palisade fence with access by a padlocked gate. The ground surface in the compound comprises granular fill. The borehole is located in a concrete manhole set 70 m above ground level with a steel manhole cover. There is no information available (e.g. a borehole or well construction log) to establish whether or not the borehole is adequately sealed to prevent shallow subsurface inflow or to determine the precise depths of inflow to the well. The borehole location is shown in Photos 1, 2 and 3.

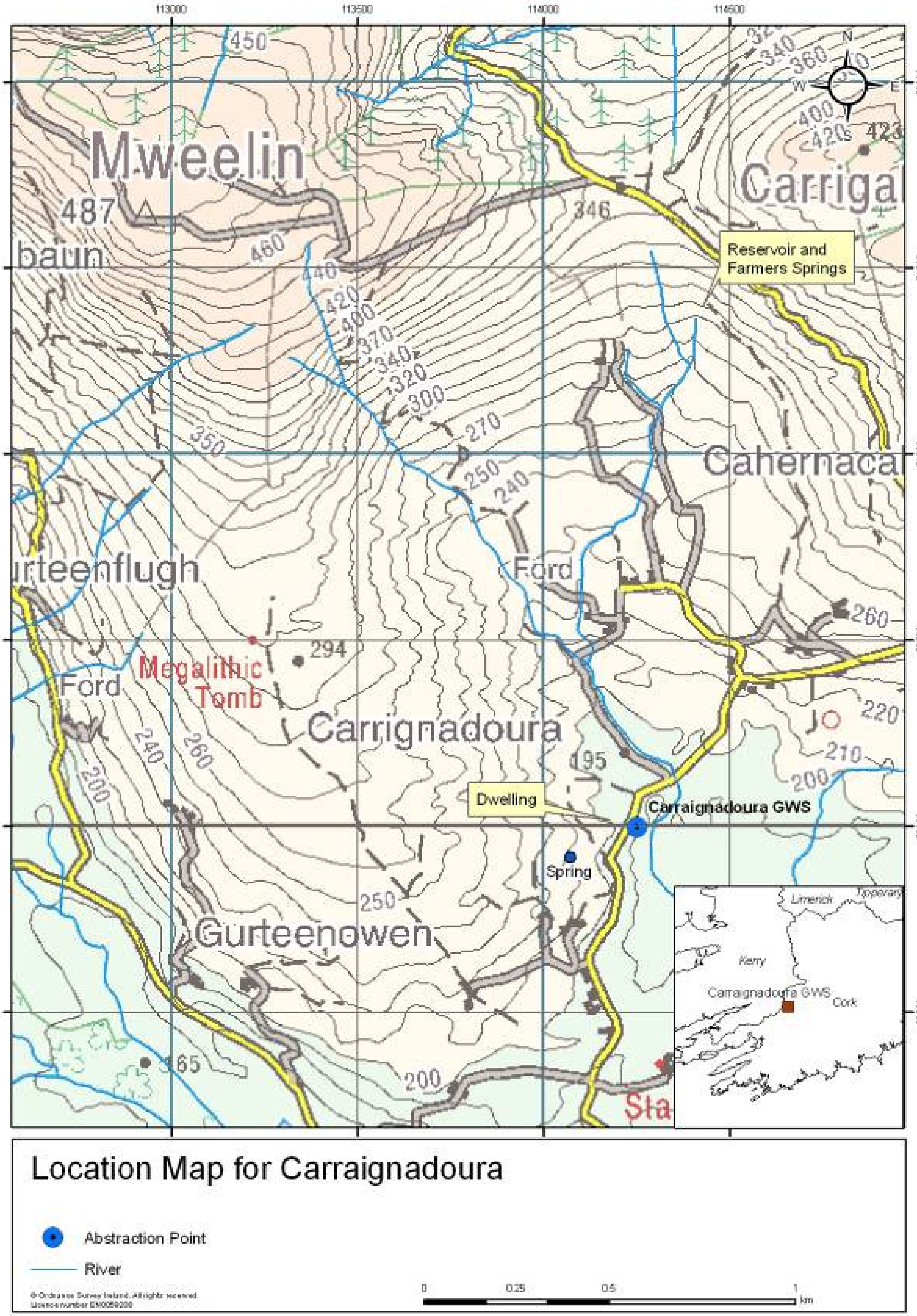

Figure 1 Location map

Photo 1: The borehole and pump house

Photo 2: Concrete manhole

Photo 3: Well head

3 SUMMARY OF WELL DETAILS

During the site inspections the pump in the well was switched off and artesian conditions were observed at the well head. Because of the construction of the borehole in a manhole chamber, measuring the discharge rate from the well proved unreliable.

Groundwater is pumped during the night (night-saver) to the reservoir. The chlorine levels are constantly monitored at the outlet from the reservoir using a residual chlorine analyzer, which relays this information to the control panel at the pump house where the chlorine levels are adjusted accordingly. Sodium hypochlorite provides a chlorine residual in the water between 0.2 ppm and 0.8 ppm.

During the initial stages of pumping the water, it was noticed by the Council that there was very fine clay particles in the water. A water filtration system was incorporated into the rising main to the reservoir. The filter is used to remove fine suspended sediments.

The reservoir has a volume of 257 m^3 (Photo 4) and was designed to allow for existing and future demand. There are currently 121 people served by the scheme. The total demand for 121 people is estimated as 225L\P\day x 121 = 28 m^3/d. Agricultural demands were also taken into account. At the current demand, the reservoir provides 3 days storage.

Error! Reference source not found. provides a summary of the details as currently known.

Photo 4: Reservoir tank

Table 3-1: Well Details

EU Reporting Code	IE_SW_G_005_04_006
Grid ref. (GPS)	114252 69996
Townland	Carrignadoura
Source type	One Borehole
Drilled	2004
Owner	Cork Co Co
Elevation (Ground Level)	~ 190 m OD
Depth	c. 90 m There is no borehole log or well construction detail for the well. Based on the specification recommended by Eugene Daly it is estimated that the well is approximately 90 m deep
Depth of casing	Unknown-
Diameter	200 mm
Depth to rock	unknown
Static water level	Artesian all year
Pumping water level	-
Consumption (Co Co records)	182 m^3/d
Pumping test summary: (i) abstraction rate m3/d	No Test Completed-
(ii) specific capacity	-
(iii) transmissivity	-

4 METHODOLOGY

The methodology consisted of data collection, desk studies, site visits and field mapping. Analysis of the information collected during the studies was used to delineate the SPZ.

The site visit and interview with the caretaker took place on 09/09/2009 and 22/09/09. Field mapping of the study area (including measuring the electrical conductivity and temperature of the source and streams in the area) was carried out.

5 TOPOGRAPHY, SURFACE HYDROLOGY AND LANDUSE

The borehole is located in a low lying part of the catchment of a tributary of the Bunsheeling River. The elevation of this low ground ranges from 190 m to 210 m OD. The borehole and the pump-house are situated approximately 40 m to the west of the stream. The western portion of the catchment consists mainly of steeply sloping ground to the south-east with an elevation ranging from 210 m to 400 m OD

The stream rises to the north-northwest in the high ground and flows south-southeast before discharging into the Bunsheeling River 1.7 km downstream. (Figure 1) A spring discharge was identified during the site walkover adjacent to the closest dwelling, approximately 150 m to the northwest of the well. The spring supplies drinking water for the dwelling and water for animal grazing. The overflow is drained by an old stone drainage system (~200 years old) which goes under fields and the road to discharge into the stream on the north side of the borehole. It was not possible to obtain an accurate calculation of the discharge rate from the spring because of the presence of a lot of vegetation. The landowner, a 70 year old man, informed OCM that the spring has never been dry in his life time.

The springs which previously supplied the group scheme are located on the other side of the Bunsheeling tributary approximately 1.3 km to the north-northeast (close to the reservoir tank), in Cahernacaha. The springs discharge into first order streams which ultimately discharge into the Bunsheeling tributary 500 m to the north and up hydraulic gradient of the public supply well.

The presence of rush, alder and willow between the well and the river suggests that silty sandy gravels are more saturated in comparison to the lands up hydraulic gradient of the well which are better draining.

Land use in the area is dominated by scrub and rock outcrop in the higher ground and by low intensity pasture with some forestry lower in the catchment. There are isolated dwellings and farms throughout the area which are served by individual septic tank systems systemss. The streams in the area are used for animal watering. A public third class road runs from south to north approximately 20 m up hydraulic gradient of the production well.

6 GEOLOGY

6.1 INTRODUCTION

This section briefly describes the relevant characteristics of the geological materials that underlie the site. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections.

Geological information was taken from a desk-based survey of available data, which comprised the following:

- Geology of Kerry-Cork. Bedrock Geology 1: 100,000 Map series, sheet 21, Geological Survey of Ireland (M. Pracht, 1997).
- Forest Inventory and planning system – Integrated Forestry Information System (FIPS-IFS) Soils Parent Material Map, Teagasc (Meehan, 2002).
- Report "Prospect of developing groundwater for Carrignadoura Group Scheme", (Eugene Daly, 2003).

6.2 BEDROCK GEOLOGY

The bedrock geology is illustrated in Figure 2. The bulk of the area is underlain by purple siltstones and fine grained sandstones of the Bird Hill Formation. Fine grained lithologies dominate the formation. The southeastern part of the area is underlain by the Gortanimill Formation which consists of medium to fine grained green sandstones interbedded with green and red/purple silstones and fine sandstones. The Gortanimill Formation overlies the Bird Hill Formation. Both these formations are in a sub vertical position with bedding dipping to the southeast and are also described as part of the Devonian Old Red Sandstone Group for the purposes of the generalised rock unit map prepared for the WFD in characterising and describing the groundwater bodies by the GSI.

Carrignadoura is located approximately 0.5 km to the southeast of the Beara Anticline which extends from the Beara Peninsula to the west of Macroom. As is the case across much of this section of Munster, the rocks are broken by a series of faults trending NNW- SSE at approximately right angles to the fold axes. The geological map (Figure2) shows one such NW-SE trending fault along the stream valley located to the east of the well.

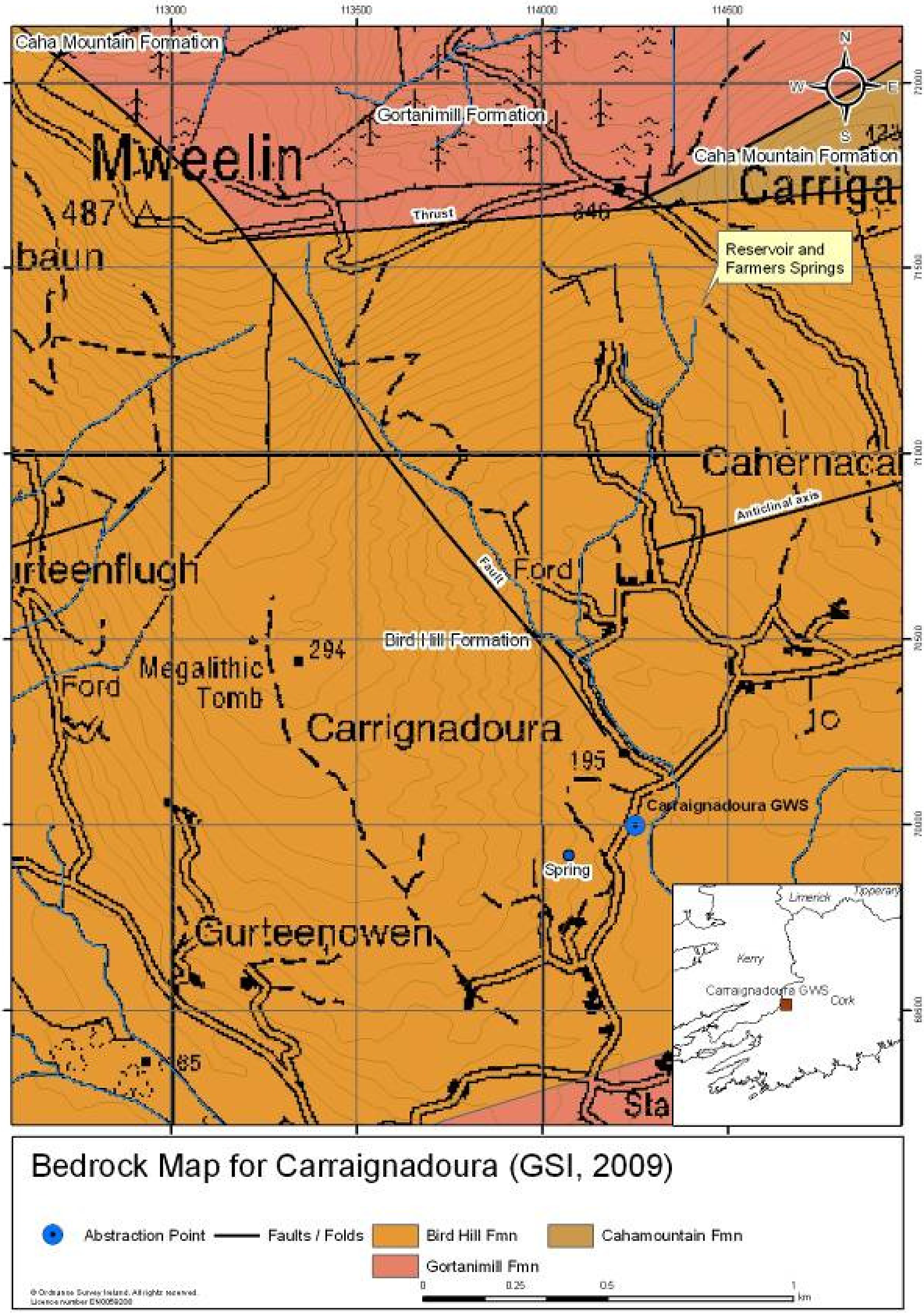

Figure 2: Bedrock/Rock Unit Map

6.3 SUBSOILS GEOLOGY

Bedrock outcrops or is close to the surface over much of catchment. The bedrock is overlain by a relatively thin succession of subsoil close to the borehole.

The subsoil, in the eastern part of the catchment comprises Devonian Sandstone Tills (TDSs). In the western part of the catchment the subsoil is thin and comprises till (TDSs), but much of the area is dominated by outcrop or rock close to the surface (Devonian Old Red Sandstone).

Using BS 5930 (1999), these deposits were classified as silty sandy GRAVEL which are derived from the underlying Devonian rocks (Photo 5). This texture confirms the moderate permeability (Low Confidence in the subsoil permeability map) of the subsoil in this area as shown on Figure3.

Photo 5: Silty sandy GRAVEL subsoil

6.4 DEPTH TO BEDROCK

In the high ground above 210 m OD, the bedrock outcrops or is close to the surface. However, on the lower ground (from ~210 m OD to 190 m OD), the subsoil is thicker (Photo 5) possibly 2-3 m. There is no depth to bedrock data for the borehole drilled to install the water supply well. However observations of subsoil exposures locally indicate a thickness ranging from 2-3 m.

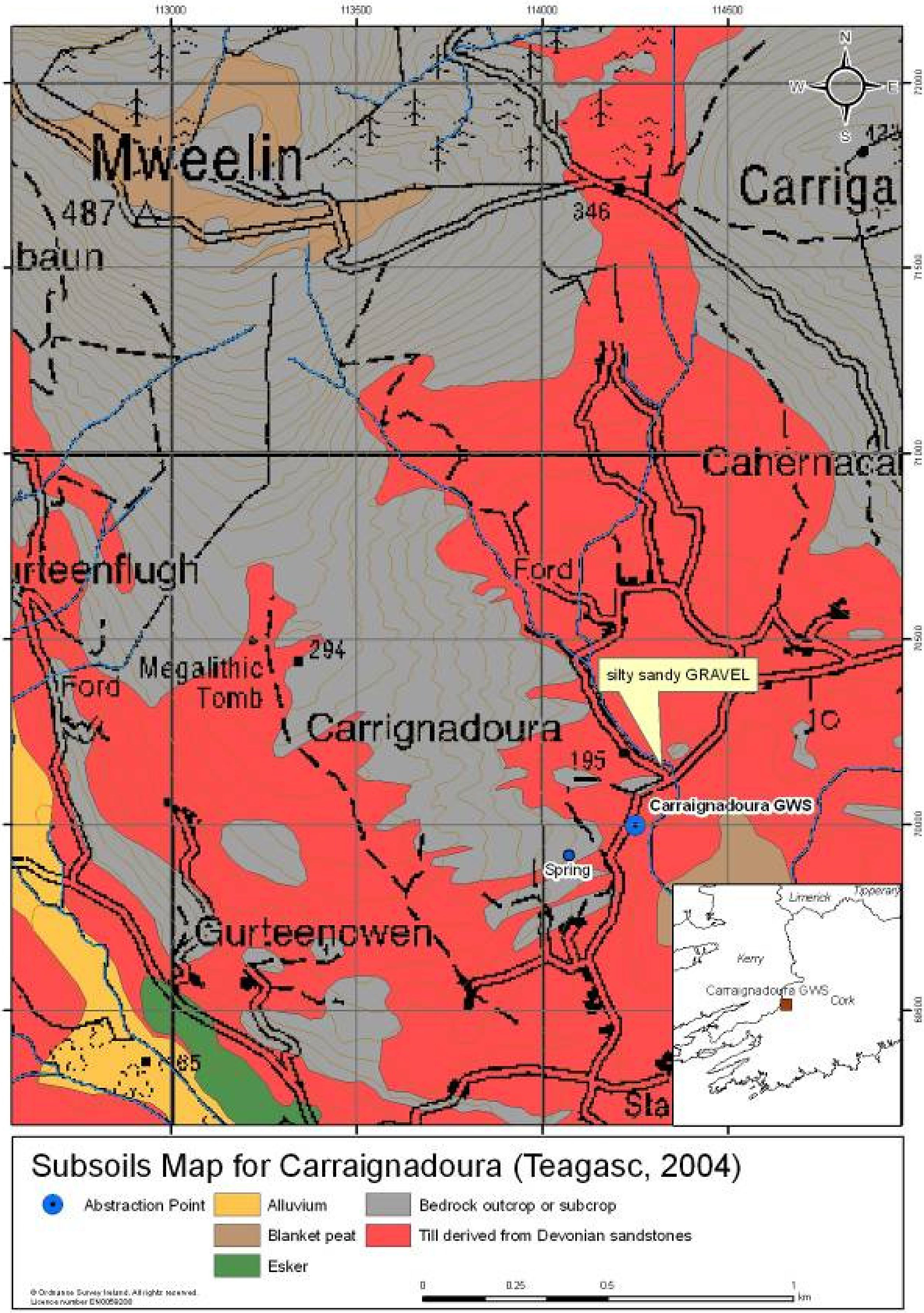

Figure 3: Subsoil Map

6.5 SOILS

In the eastern part of the catchment the subsoil is overlain by a soil classified as Acid Mineral Deep Well Drained (AminDW). Between the well location and the river, the presence of rush, alder and willow indicates the soil in this area are poorly draining in comparison to the lands up hydraulic gradient of the well. (photo6).

In the western part of the catchment much of the area is dominated by outcrop or rock close to the surface (Devonian Old Red Sandstone). The soil is classified as Acid Mineral Deep Well Drained (AminDW) where tills are present to Acid Mineral Shallow Well Drained (AminSW) where the rock is close to surface. Where the Tills are located, there is no evidence of poor drainage (Photo 7).

Photo 6: Borehole Downgradient

Photo 7: Borehole Upgradient

7 GROUNDWATER VULNERABILITY

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. This means that vulnerability relates to the thickness of the unsaturated zone in the aquifer, and the permeability and thickness of the subsoil. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons, 2003).

In terms of subsoil coverage within the catchment of the well, the area can be divided into two zones:

- Over the high ground to the north and northwest of the borehole, which represents the largest portion of the catchment of the borehole (around 70%), the subsoil is very thin or absent and outcrop dominates. Here the vulnerability is classed as Extreme with Rock near the surface.

- In the area of the valley which is situated between approximately 190 m OD and 210 m OD, and up hydraulic gradient of the well, the subsoil is generally less than 3 m and the vulnerability is considered to be "Extreme".

The vulnerability map is shown in Figure 4.

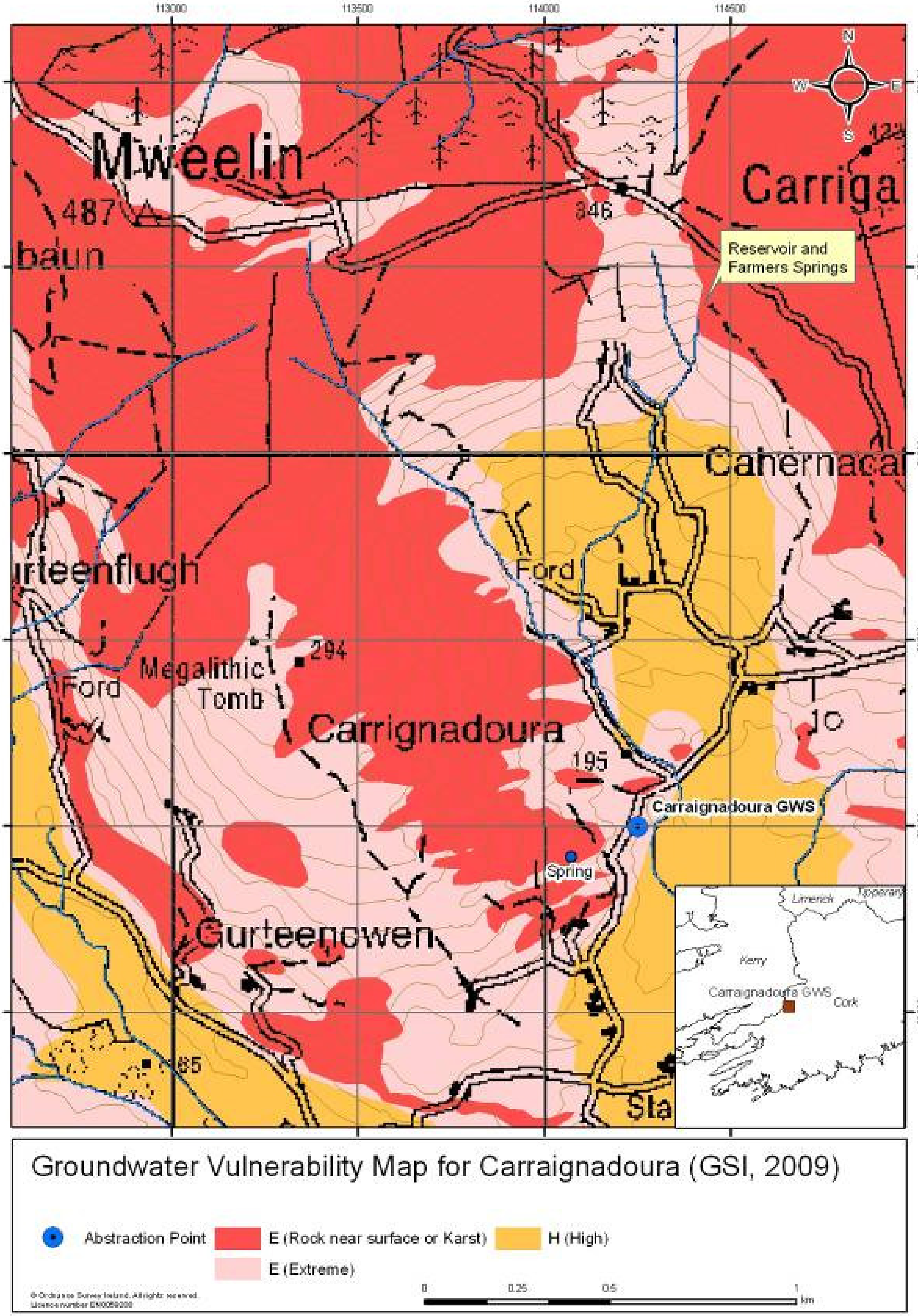

Figure 4: Vulnerability Map

8 HYDROGEOLOGY

This section describes the current understanding of the hydrogeology in the vicinity of the source. Hydrogeological and hydrochemical information was obtained from the following sources:

- GSI Website and Database
- County Council Staff
- EPA website and Groundwater Monitoring database
- Local Authority Drinking Water returns
- Report "Prospect of developing groundwater for Carrignadoura Group Scheme", (Eugene Daly, 2003).

8.1 GROUNDWATER BODY AND STATUS

The Carrignadoura borehole is located within Ballinhassig_2 Groundwater Body (identified as IE_SW_G_005) which has been classified as being of Good Status. The groundwater body descriptions are available from the GSI website: www.gsi.ie and the 'status' is obtained from the Water Framework Directive website: www.wfdireland.ie/maps.html.

8.2 METEOROLOGY

Establishing groundwater source protection zones requires an understanding of general meteorological patterns across the area of interest. Meteorological information was obtained for this study from Met Eireann.

Annual rainfall: 2160 mm. The annual rainfall is estimated from a contoured rainfall map of Ireland (Met Éireann website, data averaged from 1961–1990) which shows that the source is located between the 2200 mm and 2000 mm average annual rainfall contours.

Annual evapotranspiration losses: 460 mm. Potential evapotranspiration (P.E.) is estimated to be 485 mm/yr (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95% of P.E., to allow for seasonal soil moisture deficits.

Annual Effective Rainfall: 1700 mm. The annual effective rainfall is calculated by subtracting actual evapotranspiration from rainfall.

8.3 GROUNDWATER LEVELS, FLOW DIRECTIONS AND GRADIENTS

Based on observations of groundwater level at the well, which overflows with the pump switched off, the well is artesian. Apart from this and the discharge at the springs, there are no other groundwater level data for the area. Based on the topography and surface water drainage, groundwater infiltrating the bedrock in the high ground to the north northwest of the borehole, where the subsoils are thin or absent, flows to the south-east, towards the stream.

The Birds Hill Formation is not very permeable, it is anticipated that the groundwater gradient is likely to reflect the valley topography. Thus a relatively steep value of 0.1 has been assumed.

8.4 HYDROCHEMISTRY AND WATER QUALITY

The well has been included in the EPA operational chemical network since 2007 and there were 9 raw water sample analyses available for review during the preparation of this report. The data are summarized graphically in Figure 5 to 7 below. The following key points have been identified from these data:

- Analysis of hardness indicates a hard calcium bicarbonate hydrochemical signature (average 130.5 mg/l $CaCO_3$). The average conductivity is 274 µS/cm and pH is around 7, indicative of siliceous bedrock material.

- There is only two reported incidents of Faecal Coliforms in the analyses, (1 and 5 No/100 ml on respectively the 15/08/2007 and the 31/07/08), which would be considered to be very low. It is inferred from the available data that the Faecal Coliform results are isolated and do not indicate contamination or specifically highlight on-going problems. The values are summarized graphically in Figure 5.

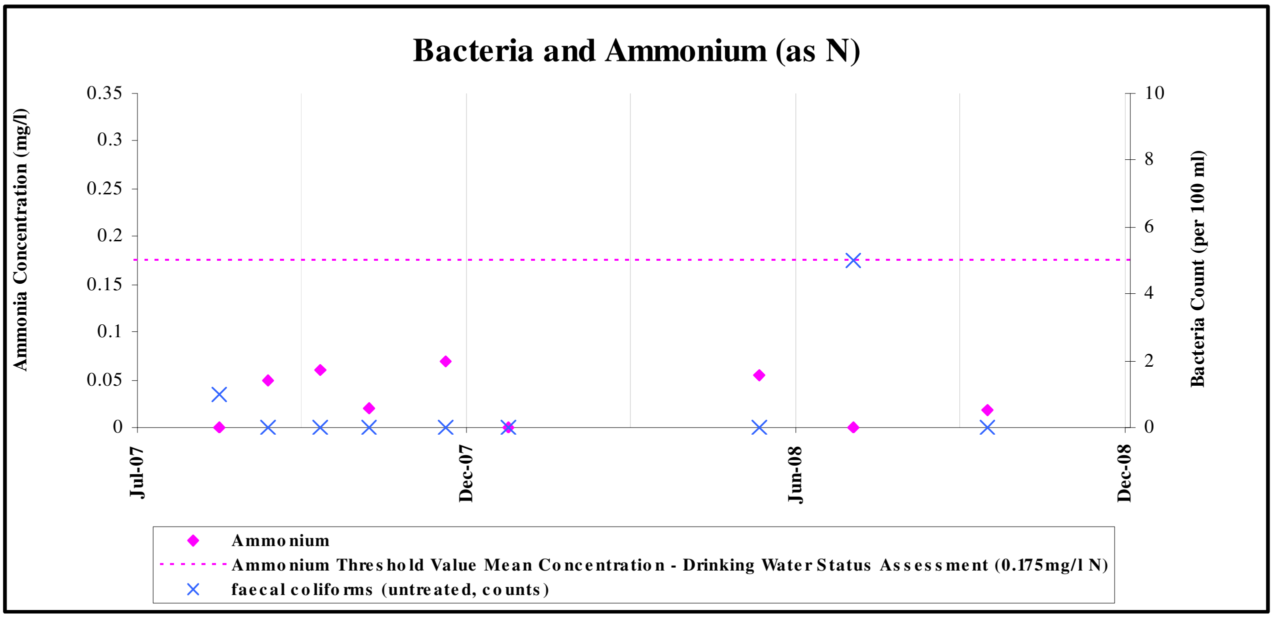

Figure 5:Key Indicators of Agricultural and Domestic Contamination : Bacteria and Ammonium

- The nitrate level is very low (average of 5mg/l) and therefore below its respective threshold value (37.5 mg/l) and the Admissible Concentrations (MAC) as outlined in the Drinking Water Regulations S.I. 278, 2007 which is 50 mg/l.

- Chloride, nitrite, and ammonia levels are below their respective MAC limit or threshold value.

The values are summarized graphically in Figure 6.

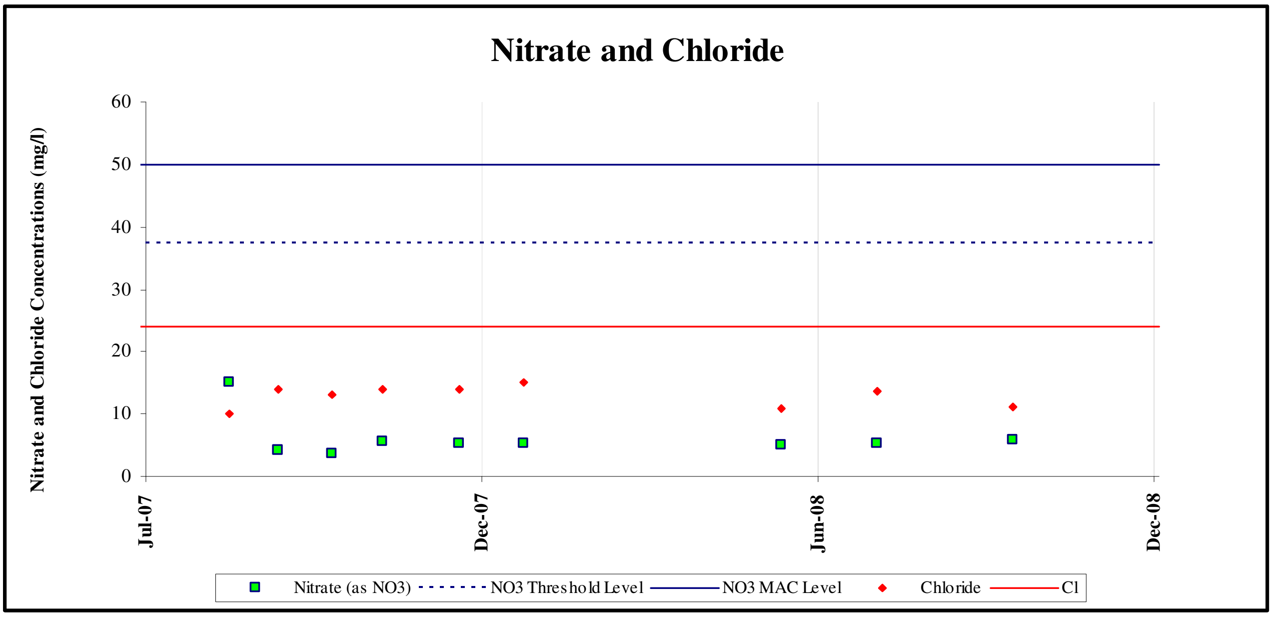

Figure 6: Key Indicators of Agricultural and Domestic Contamination : Nitrate and Chloride

- The concentration of sulphate, potassium, sodium, manganese, magnesium and calcium are within normal ranges. The potassium: sodium (K:Na) ratio is low (average of 0.053 mg/l), consistently less than 0.15, never exceeding the GSI threshold of 0.35. These data suggest no organic waste sources. The values are summarized graphically in Figure 7.

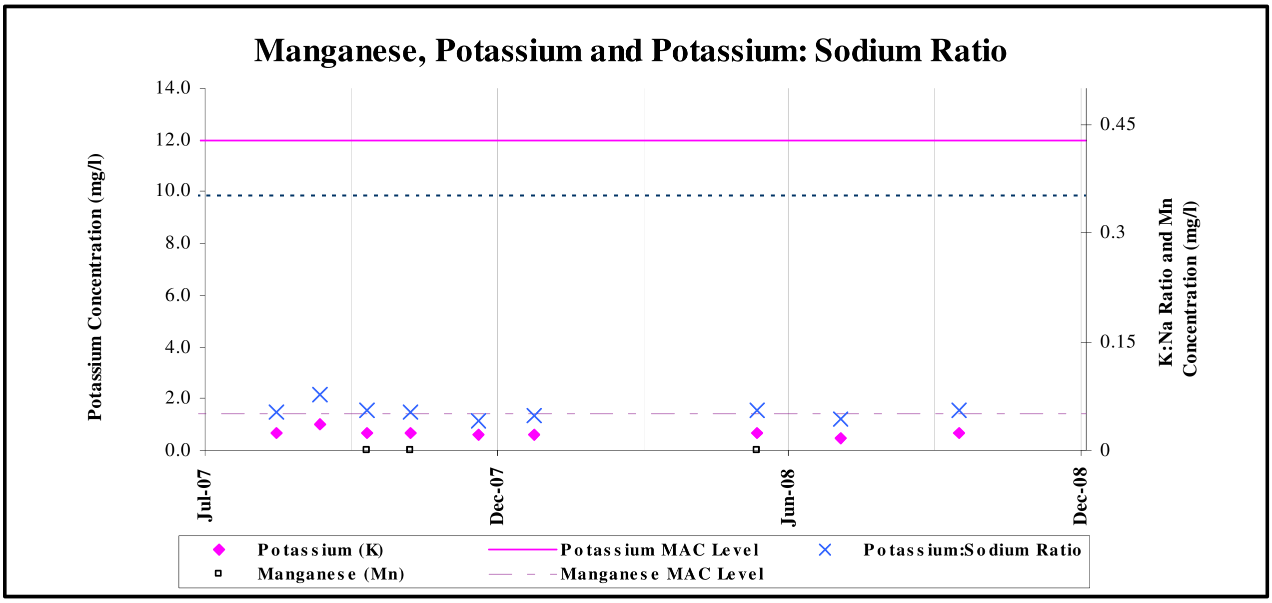

Figure 7: Key Indicators of Agricultural and Domestic Contamination : Manganese, Potassium and K/Na ratio

- The turbidity is frequently above the MAC limit with a maximum on the 31/07/08 of 3.1 NTU. This is likely due to the presence of very fine clay particles within the water which are removed from the drinking water supply through filtration. The turbidity of the water may indicate that the well was not fully developed before being used or that some of the water gets to the well along quicker pathways than would usually be expected in this type of bedrock e.g. along the fault.

- The concentration of iron and manganese is also within normal ranges, which also suggests an absence of any influence of effluent from organic wastes.

- Normal levels of trace metals were identified or levels are below the detection limit of the laboratory, and the water is safe for drinking. The concentration of all organic compounds and herbicides is below the detection limit of the laboratory.

In summary, given the low levels of the key indicators of domestic and agricultural contamination, the water quality at the source is generally very good, which is likely to be a function of the lack of pressures in the zone of contribution to the well.

The low electrical conductivity and pH values in this spring compared to the well suggest that the well water may be more mineralised indicating a longer residence time in the aquifer and therefore an origin at greater depth (Table 8-1). The variation in field chemistry between the borehole and the stream indicates that there is limited hydraulic connection between the stream and the borehole water supply well though it is possible that water from the river may reach the boreholes via the fault.

Table 8-1: Water quality data

	Former Carrignadoura Springs	Stream	Spring located in the dwelling field	Borehole
pH	6.6	8	5.8	7.1
Conductivity (µS/cm)	43-48	91	65	274

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8.5 AQUIFER CHARACTERISTICS

The Carrignadoura borehole appears to abstract water from the Birds Hill sandstone/siltsone Formation which forms part of the Ballinhassig_2 Groundwater body. The aquifer is classified on the GSI bedrock aquifer map as a *Poorly productive aquifer except for Local Zones (Pl)* (Figure 8).

Well yields in these strata are generally less than 50 m^3/d, although at favourable locations, yields in excess of 100 m^3/d can be obtained, for example along more fractured or faulted zones or along the weathered top of bedrock

The transmissivity (T) range for Pl aquifers in this groundwater body is 2-20 m^2/d with median values towards the lower end of the range. Thus, because the aquifer is classified as poor, the bulk transmissivity range in this location is likely to range from 2-11 m^2/d, with transmissivities in the fault zone towards the upper end.

Bedrock permeability for a Pl aquifer is expected to be relatively low. The permeability is calculated by dividing the transmissivity by the saturated thickness of the aquifer, which is estimated in this case as the depth of the well, c.90 m. Therefore the bulk permeability (k) is estimated as follows in table 8-2:

Table 8-2: Permeability Range

	Local Minimum Assumption	Local Maximum Assumption
Transmissivity (m2/d)	2	11
Permeability (m/d)	0.02	0.12

The velocity of water moving through this aquifer to the borehole can then be estimated from Darcy's Law:

$$v = (k \times i) / n$$

Where v = velocity; k = permeability; i = gradient and n = porosity

The gradient estimated from the topography of the catchment area is 0.10. The typical effective porosity (n) for a Poor fractured sandstone aquifer is estimated to be no more than 0.5 - 1%. A value of 0.5% would probably be representative of groundwater flow deeper in the aquifer where as 1% is considered to be more representative of shallower flow in the upper weathered zone. However, because there is no information available in relation to the construction detail of the borehole it is assumed that flow to the well comprises shallow and deep components and an effective porosity of 0.75% was considered to be conservative. Values for transmissivity and effective porosity will be reassessed if /when a pumping test can be undertaken in the borehole.

Table 8-3: Velocity Range

Velocity (m/d)	Local Minimum k Assumption (0.02 m/d)	Local Maximum k Assumption (0.12 m/d)
Local Effective Porosity (0.75%)	0.30	1.6

The aquifer parameters are summarized in Table 8-4 below.

Table 8-4: Indicative Parameters for the Birds Hill sandstone/siltsone Formation Aquifer in Carrignadoura

Parameters	Source of Data	Local Minimum Assumption	Local Maximum Assumption
Transmissivity (m2/d)	Assumed	2	11
Permeability (m/d)	Assumed	0.02	0.12
Porosity	Assumed	0.75%	0.75%
Groundwater gradient	Assumed	0.1	0.1
Velocity (m/d)	Assumed	0.30	1.60

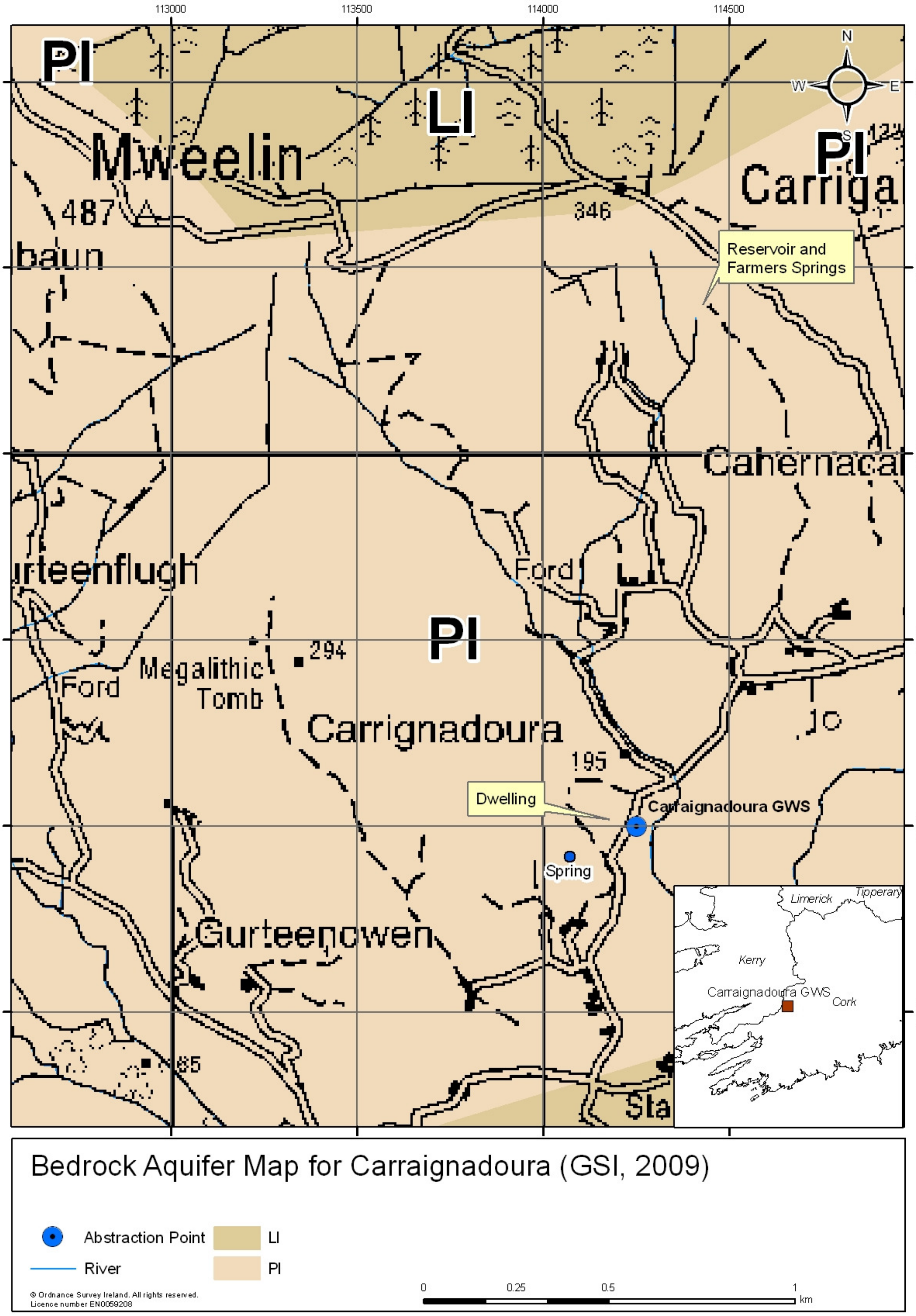

Figure 8: Aquifer Map

8.6 RECHARGE

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and assumed to consist of input (*i.e*. annual rainfall) less water loss prior to entry into the groundwater system (*i.e*. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as it will dictate the size of the zone of contribution to the source (*i.e*. the outer Source Protection Area).

At Carrignadoura therefore, the main parameters involved in recharge rate estimation are: annual rainfall; annual evapotranspiration; and a recharge coefficient. The recharge is estimated as follows.

The ***Potential recharge*** is equivalent to 1700 mm/year i.e. (Annual Effective Rainfall as outlined in Section 8.2.)

The ***Recharge Cap*** is 100 mm/yr The Bird Hill formation is classified as a Poorly Productive aquifer (Pl). Applying the aquifer cap to poorly productive aquifers (GWG 2008), the recharge is estimated to be 100 mm/yr. This is assumed to be the case in this area. The presence of shallow springs in the catchment indicates that much of the potential recharge is rejected and that a cap of 100 mm is reasonable.

The *B**ulk recharge coefficient*** for the area is therefore estimated to be 6%.

Runoff losses **are** 1600 mm. Runoff losses are assumed to be 94% of potential recharge. This value is based on the recharge cap on poorly productive aquifers.

These calculations are summarised as follows:

Average annual rainfall (R)	2160 mm
estimated P.E.	485 mm
estimated A.E. (95% of P.E.)	460 mm
effective rainfall	1700 mm
potential recharge	1700 mm
run off losses	1600 mm
runoff losses	94%
bulk recharge coefficient	6%
Actual Assumed Recharge	**100 mm**

8.7 CONCEPTUAL MODEL

The conceptual model has been has been compiled based on the available information for the borehole. The model could be improved by completing a pumping test to provide site specific assessment of the aquifer transmissivity in the vicinity of the borehole.

- The Carrignadoura Group Water Scheme (CGWS) consists of 1 borehole, which abstracts on average at a rate of 182 m^3/d from the Birds Hill sandstone/siltsone Formation. The aquifer is classified as poorly productive aquifer except for Local Zones (Pl).

- The Carrignadoura well is artesian with a yield that is higher than the more typical range of groundwater yields found in (Pl) aquifers (50–100 m^3/d).

- Some of the higher yield may be related to increased flow from extension fractures along the Beara Anticline but is primarily expected to be associated with flow along the NW–SE trending fault mapped along the stream close to the well. Surfaec water inflow to the fault and hence to the well may also occur in this area.

- As well as flow along the fault, diffuse flow reaches the well from the recharge area on the higher ground where the subsoil is thin or absent and where the rock is exposed and weathered. The shallow groundwater flow in this area is unconfined.

- As the shallow groundwater moves down-gradient it may percolate downwards along the steep southeasterly dipping bedding planes and become at least partially confined in places by the more competent beds or layers.

- There is a spring discharge approximately 150 m up hydraulic gradient of the well close to the break in slope where the subsoil increases in thickness. Measurement of electrical conductivity and pH, which differ hydrochemically from the water abstracted from the borehole, suggest that this spring is derived from shallow groundwater moving through the weathered top of rock which discharges on encountering the till.

- Measurement of electrical conductivity and pH are higher in the borehole than those from spring discharges. The higher electrical conductivity values may be indicative of more mineralised groundwater coming from deeper in the aquifer.

- The hydraulic gradient in the bedrock is unknown, but likely to be steep, of the order of 0.1 based on the topography of the borehole catchment.

- The direction of local groundwater flow is likely to be from north-west to south-east in direction of the tributary of the Bunsheeling Stream. The variation in field chemistry between the borehole and the stream indicates that there is limited hydraulic connection between the stream and the borehole water supply well.

- The ZOC covers an area of 0.12 km^2. Diffuse recharge occurs across the entire ZOC. Higher recharge is expected in the more elevated portion of the ZOC where the subsoils are thin or absent with lower recharge occurring where the subsoils thicken in the vicinity of the borehole. Because data is limited and given the location of the fault mapped between the borehole and the river the ZOC has been extended beyond the river to allow for some inflow of water from the river via the fault.

- The water is of high quality which is likely to be a function of the low pressures from farming due to low density of farm activity in the catchment of the well.

- The conceptual model is outlined by a schematic cross-section (Figure9).

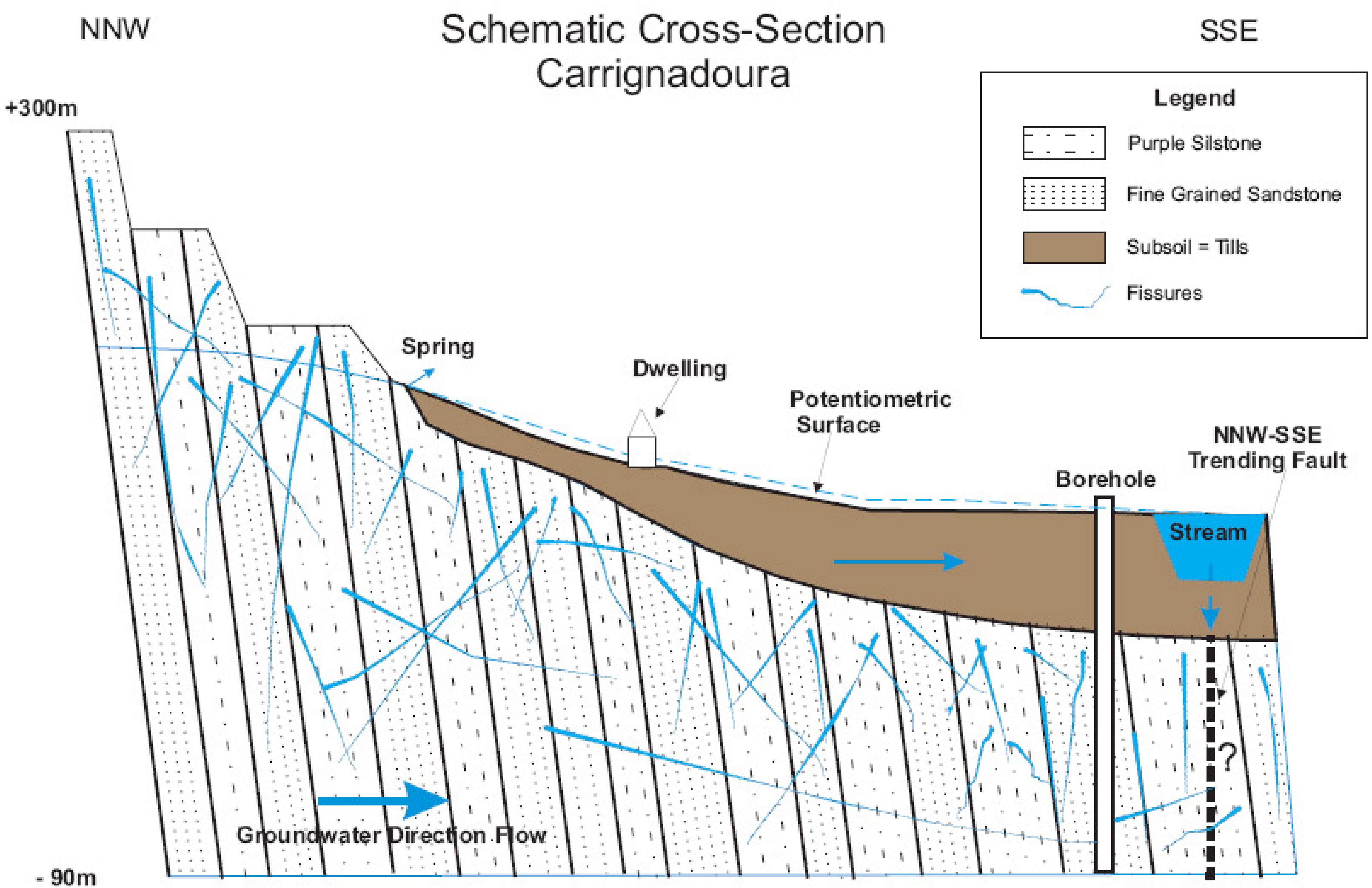

Figure 9: Schematic cross-section

9 DELINEATION OF SOURCE PROTECTION AREAS

This section describes the delineation of the areas around the source that are believed to contribute groundwater to it, and that therefore require protection. The areas are delineated based on the conceptualisation of the groundwater flow, as described in Section 8.7 Conceptual Model and presented in Figure 6.

Two source areas are delineated:

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

9.1 OUTER PROTECTION AREA

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. **the zone of contribution (ZOC)**, which is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by (a) the total discharge, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. The shape and boundaries of the ZOC were determined using hydrogeological mapping, water balance estimations, and conceptual understanding of groundwater flow. The boundaries (Figure 6) are described below along with associated uncertainties and limitations.

The Western and Northern boundary are defined by conceptualised groundwater flow-lines, which are themselves defined by the topography of the area.

The Eastern boundary is constrained by a NW-SE trending fault between the borehole and the stream. It is likely that the fault contributes a significant portion of the flow to the well. Comparison of field chemistry (pH, temperature and electrical conductivity) between the stream and the water from the supply well indicates that the two are different and that water is not reaching the well from the river along the fault. Therefore, the boundary is parallel to the fault and does not encompass the river.

The Southeastern boundary – the Downgradient boundary is the maximum downgradient distance that the borehole can pump water from and is based on the uniform flow equation (Todd, 1980).

$x_L = Q / (2\pi * T * i)$ where

Q is the daily pumping rate +/- X%

T is Transmissivity (taken from aquifer characteristics)

i is background non pumping gradient.

Where the pumping rate is 182 m^3/d, the transmissivity range is 2–11 m^2/d and the hydraulic gradient is 0.1. This gives respectively an approximate down-gradient extent ranging from 26–145 depending on the transmissivity.

Because the borehole is not considered to by hydraulically connected to the stream (described in section 8.5), the down gradient boundary is considered be located to be north-west side of the stream.

To allow for daily variations in abstraction and to allow for expansion of ZOC during dry weather periods the GSI usually increase the abstraction rate for a source by a factor of safety of 50%. However, increasing the pumping rate in this case would most likely result in surface water inflow from the river rather than groundwater in flow from a larger ZOC. Given that the ZOC already encompasses the entire hydrologic catchment and incorporates flow along the fault zone and the low potential recharge from the aquifer also mitigate against increasing the pumping rate by 50%.

Water balance The water balance calculations indicate that at a recharge of 100 mm/yr, an average discharge of 182 m^3/day would require a recharge area of 0.66 km^2. The higher than expected yields from the borehole for this formation suggests that the well is being provided mainly with water from a nearby north-south trending fault which runs between the well and the tributary. Therefore, given the topography boundaries and the location of the fault, the ZOC is estimated at 0.12km^2.

9.2 INNER PROTECTION AREA

According to “Groundwater Protection Schemes” (DELG/EPA/GSI 1999), delineation of the Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100-day time of travel (ToT) to the supply.

Based on the indicative aquifer parameters outlined in section 8.5, the distance groundwater will travel to the well in 100 days is estimated as being in the region of 30 – 160 m meters based on an effective porosity of 0.75%. Taking a conservative approach and assuming that there is flow to the well along the fault, a 100 day ToT of 160 m is considered to be more appropriate than the 30 m zone, from a microbial and viral contamination risk perspective.

The Inner Protection Zone is illustrated in Figure 10.

10 GROUNDWATER PROTECTION ZONES

Groundwater protection zones are shown in Figure 8 and are based on an overlay of the source protection areas on the groundwater vulnerability. Therefore the groundwater protection zones are SI/E, SI/H and SI/M. The majority of the area is designated SI/E.

Table 10-1 Source Protection Zones (%area, km^2)

Source Protection Zone	% of total area (0.12km^2)
SI/Extreme	23.2% (0.0287 km^2)
SI/X	0.2% (0.0002 km^2)
SO/Extreme	72.1% (0.0892 km^2)
SO/X	4% (0.0049 km^2)
SI/High	0.5% (0.0006km^2)

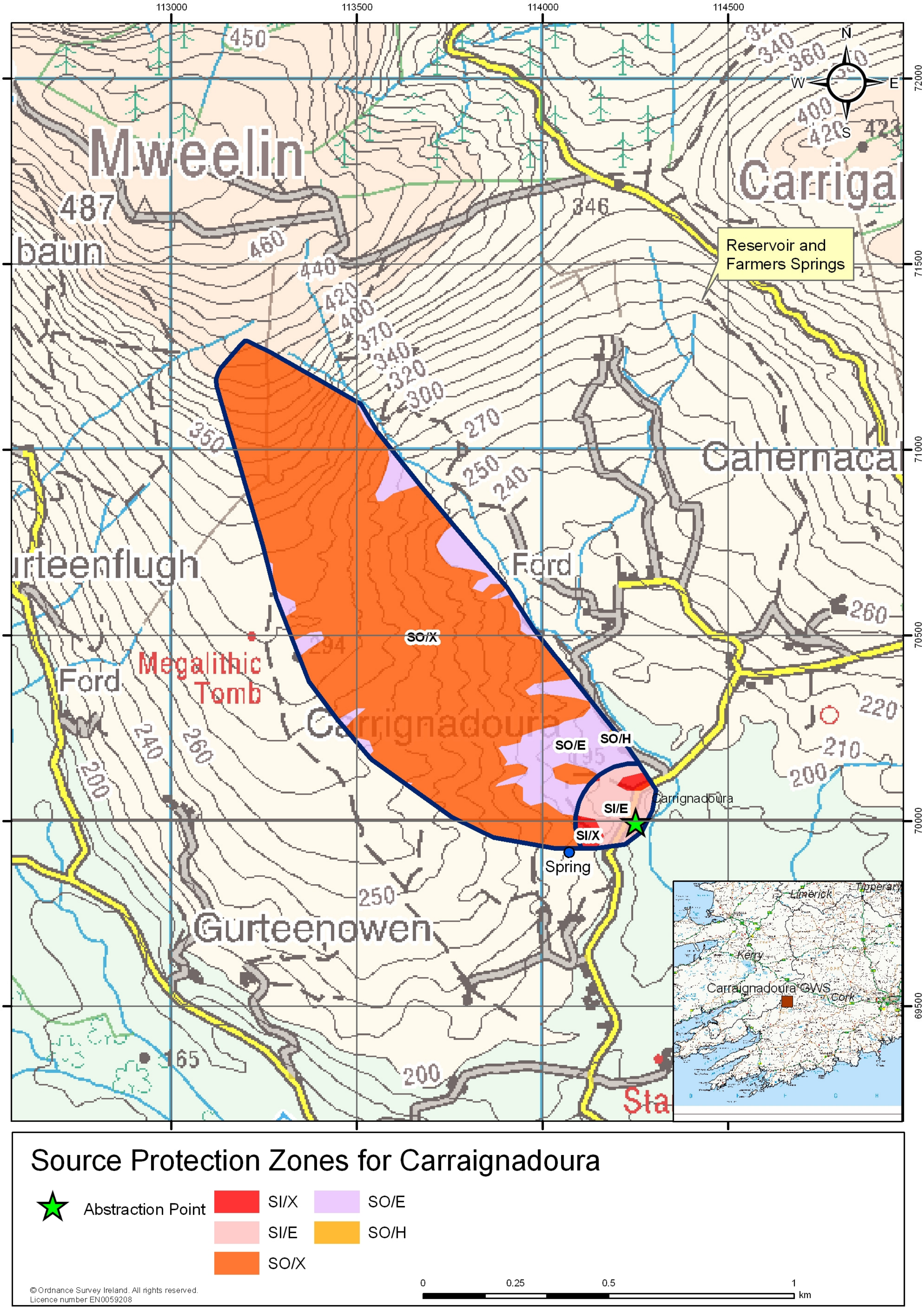

Figure 10: Groundwater protection zones

11 POTENTIAL POLLUTION SOURCES

The land within the inner zone is primarily pastureland for grazing animals (that may be used for land spreading) with some forestry and scrub land. The zone is bounded in the south-east by the stream.

A public third class road runs from south to north approximately 20 m upgradient of the production well. The road is at a higher elevation than the supply well compound by approximately 1 m. There is the potential that a diesel or petrol spill from the road could discharge into the soils and subsoils and contaminate the well. However, the low traffic density locally indicates that the risk of such an incident is low.

Landuse in the Inner zone is illustrated on Photos 6 and 7 above in Section 6.3.

The land use in the outer protection zone is dominated by scrub land with some pasture (cattle and sheep) and forestry.

There is just one (1 No.) dwelling up hydraulic gradient direction approximately 100 m to the north-north-west of the compound. The house is serviced by a septic tank systems which discharges to a percolation area.

12 CONCLUSIONS

The public water supply at Carrignadoura comprises one borehole, drilled in 2004, which is located in Carrignadoura Townland, 3km north to northwest of Ballingeary, in the valley of a tributary of the southeasterly flowing Bunsheelin River.

The well is artesian and is currently abstracting about 182 m^3/day from purple silstones and fine grained sandstoneswhich comprise a *Poorly Productive Aquifer except for Local Zones (Pl).*

The higher than expected yields from the borehole for this formation suggests that the well is being provided with water from a nearby north-south trending fault which runs between the well and the tributary. Groundwater also flows along the weathered surface of the bedrock and discharges in the lower valley area where the till deposits increase in thickness. This is supported by the hydrochemistry data. Water quality at the source is generally very good, which is likely to be a function of the lack of pressures in the zone of contribution to the well.

The Zone of Contribution is estimated as 0.12km^2. The inner and outer source protection zones delineated in the report are based on our current understanding of the groundwater conditions and the available data. Additional data obtained in the future from pumping tests may indicate that amendments to the boundaries are necessary. The environmental pressures in the two zones suggest a low risk of contamination.

13 RECOMMENDATIONS

A pumping test should be carried out to determine the sustainable yield of the well and provide better data on the aquifer characteristics (Transmissivity, Specific Yield), which would in turn allow the protection areas to be refined.

The ZOC of the borehole is located in an area of Extreme Vulnerability. If landspreading is likely to take place within the ZOC it is recommended that an adequate barrier to Cryptosporidium be installed as part of the water treatment system for the supply. For further information on setback distances, see the Addendum on landspreading below.

Weed growth was noted in the borehole compound during the site visit. In order to minimise the risk of localised groundwater contamination it is strongly recommended that weedkiller not be applied to remove weed growth in or around the compound.

14 REFERENCES

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APPENDIX 1

Site selection report Eugene Daly Associates in 2003
and BJS consultants' Group Water Scheme Report 2006

Title [prospects of developping GW for the Carrin-group Scheme - Eug. Daly report 2003

Introduction

The Carrignadoura Group Water Scheme (CGWS) provides the water supply for a sizeable upland area north of Ballingeary in West Cork. Two springs currently provide the source for the Group Scheme. The existing sources are unable to meet the demand after a long dry period. It is anticipated that the demand will increase in the future.

BJS Consultants Ltd. were commissioned by CGWS to examine the existing system and make recommendations for any necessary upgrading to conform with the Group Water Scheme Programme proposed by the Department of the Environment and Local Government. Eugene Daly Associates (EDA) were asked to examine the prospects of augmenting the supply with a new borehole source.

This report contains a brief review and compilation of the readily available and relevant geological and hydrogeological information for the general area. A number of potential well drilling sites within the distribution area were examined with a view to developing a groundwater source. Specifications for Trial and Production Wells are included.

A field visit was made to the area on 29/I/2003.

The Group Scheme

The CGWS was set up in 1982 and now supplies 34 houses of which 18 are farms. The current demand is estimated to be about 100m^3/d (22,000 gallons per day) of water at peak demand. The distribution system is supplied by gravity.

The Group Scheme covers an area of elevated ground to the west of a NE-SW trending county road (Figure 1). The distribution system extends to houses located along and off a rectangular area bounded by minor roads and the county (Figure 1).

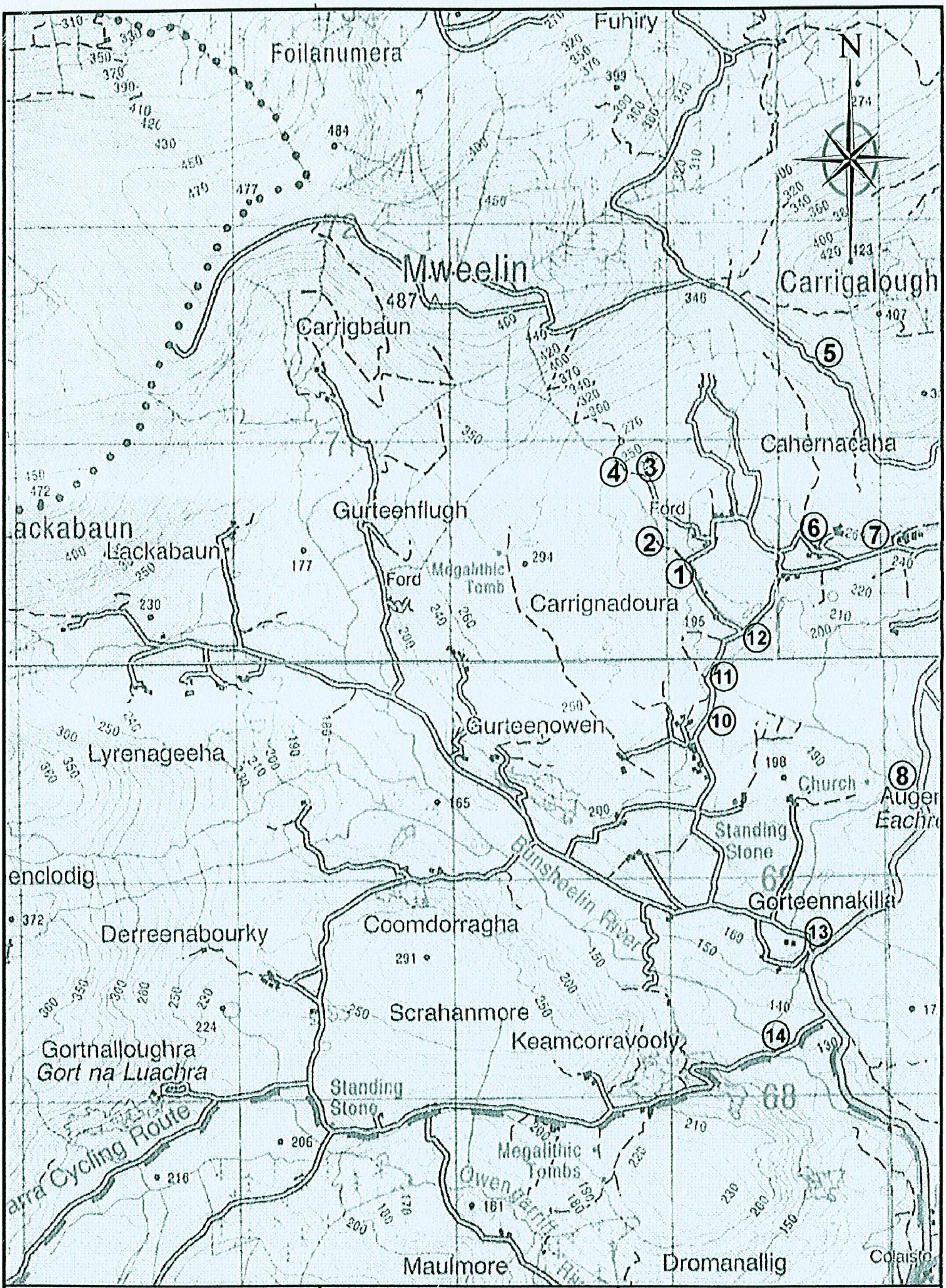
The water supply for the Group Scheme come from two high level springs wells. The two springs are piped to a storage tank. They are unable to meet the demand during long periods of dry weather.

A borehole was drilled at the storage tank in 2002. It went to a depth of 155m but only gave a supply estimated to be less than 10m^3/d.

A new borehole source giving a supply of about 100m^3/d is required.

Topography, Soils and Land Use

The distribution system covers two types of ground. The eastern area of relatively low undulating ground drained by a tributary of the southeasterly flowing Bunsheelin River. The elevation of most of this ground is around 150m to 200m above G.L. The western part of the distribution area consists mainly of steeply sloping land with an elevation of 200m to 300m above G.L.



EDA
Eugene Daly Associates
Groundwater, Hydrological and Environmental Consultants
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Figure 1 - Location Map showing potential drilling sites for the Carrignadoura Group Scheme, Ballingeary, County Cork.

Ref No. E02/28A | Date: 02/04/03

Legend:

① Potential Drilling Site Location and Number

The soils in the area are classified as Mountain and Hill, Association 1 soils (Gardiner and Radford, 1980). The dominant soil in this association is a moderate to poorly drained, peaty soil. An ironpan is common at depth in this type of ground. The range of uses of these soils is quite limited.

Land use in the area is dominated by agriculture, low intensity pasture with some forestry. There are isolated dwellings and farms throughout the area. Water supply is provided by the Group Scheme. The streams in the area are used for animal watering. There is one private well located to the southwest of the distribution area. Foul waste is discharged to septic tanks/percolation areas.

General Geology, Hydrology and Hydrogeology

Geology

The bulk of the area is underlain by the purple siltstones and fine grained sandstones of the Bird Hill Formation which is Devonian in age. Fine grained lithologies dominate the formation. The southeastern part of the area is underlain by the Gortanimill Formation which consists of medium to fine grained green sandstones interbedded with green and red/purple siltstones and fine sandstones. The Gortanimill Formation overlies the Birds Hill Formation. The most recent geological map of the area (GSI 1997) shows a NW-SE trending fault along the stream valley that passes through the area. There appears to be some copper mineralisation associated with the fault.

Bedrock crops out or is close to the surface at numerous locations in the area. Bedrock beneath the area is overlain by a relatively thin succession of Quaternary (subsoil) deposits on the higher ground. There are a number clearly visible glacial type features (moraines) on the lower ground where the deposits are likely to be thicker. These deposits consist mainly of till (boulder clay) derived from the underlying Devonian rocks.

Hydrology

Mean annual rainfall over this area is about 1,750mm/a. Actual evapotranspiration in this area is estimated to be of the order of 400mm/a. Hence potential recharge is about 1,350mm/a. Most of the potential recharge would runoff to surface drainage channels in the top 10m of geological strata.

Hydrogeology

The rocks of the neither the Birds Hill nor Gortanimill Formations are very productive and have limited groundwater potential. The Gortanimill Formation may be slightly more productive than the Birds Hill Formation. Most of the groundwater flow, in these strata, is restricted to the weathered zone, sandstone units at depth or along fault/fracture zones. Well yields in these strata are generally less than $50m^3/d$ although at favourable locations yields in excess of $100m^3/d$ can be obtained.

The deep borehole drilled in the high ground at the reservoir confirms the generally unproductive nature of these strata. There is one borehole in the Bunsheelin River valley southwest of the Group Scheme area where a successful borehole was completed recently for a dwelling.

The water levels in these strata are generally less than 5m below ground level.

In the higher ground the shallow groundwaters in the bedrock can be considered to be unconfined and therefore open to the surface. In the lower ground where the subsoil deposits tend to be thicker the groundwater is likely to be at least semi-confined. In the sandstone units at depth the groundwaters will be confined by the siltstone units.

The thin Quaternary deposits only provide a low level of protection to the shallow groundwaters in the elevated ground. In areas where the subsoil deposits are thicker the shallow groundwaters are better protected.

The siltone units in the bedrock will provide a greater level of protection to deeper groundwaters.

Groundwater Chemistry

The analyses of two water samples from the Group Scheme source are provided in Tables 1 as an indication of the likely chemical quality of groundwaters in the area.

The analyses show the waters to be soft waters. The occasional presence of Faecal coliforms is typical of a shallow surface source.

Groundwaters from the upland Devonian strata in this area will generally have a Total Hardness of less than 100mg/l as $CaCO_3$. Owing to the low level of development in the area the waters should have satisfactory quality although significant iron and/or manganese levels are a possibility.

Parameter	Units	**Carrignadoura Spring**		**National Limit Value**
Sampling Date		Nov. 2000	Jan. 2001	
PH	pH units	6.6	6.6	>6.0 <9.0
Elec. Cond.	µS/cm	48	43.1	1,500
Ammonia	mg/l	<0.01	<0.01	0.23
Nitrate	mg/l N	0.5	1	11.3
Iron	µg/l		22.7	200
Manganese	µg/l		2.6	50
Aluminium	µg/l		89.4	200
Total coliforms	No./100ml	84	3	Nil
Faecal coliforms	No./100ml	5	Nil	Nil

Analysed at by Cork County Council

Table 1 Chemical and Microbiological analyses of samples from the Carrignadoura spring source, Ballingeary, County Cork.

Potential Drilling Site

A number of potential well drilling sites throughout the distribution area were inspected during the field visit in January 2003. The 13 sites were evaluated using a number of criteria which are set out in Table 2.

Site No.	Elevation & Topographic Setting	Geology	Potential Pollution Sources	Access for Drilling Rig	Comment
1 & 2	>200m. Small valley	BHF. Bedrock, mainly siltstone, close & steeply dipping. Fault along stream	Old sheepdip near (1). Surface water running along track at (2). Few houses.	Difficult. Steep slopes and very wet.	Bowl shaped mountain upgradient.
3 & 4	250m. Small valley	BHF. Bedrock , close & steeply dipping. Fault along stream	Old copper workings in area.	Possible but not in flood	Too high.
5	330m. On side of hill.	BHF. Bedrock close.	Nothing apparent.	Accessible.	Too high.
6 & 7	260m. On side of hill.	BHF.	A couple of houses.	Accessible.	Too high.
8	180m-200m. More open valley.	GF	Nothing apparent.	Steep slopes, poor access	The lower ground is very wet.
10 & 11	190m –200m. On the edge of open valley	BHF.	A house	Possible	Ground is wet.
12	185m. At head of flat area beside stream.	BHF. Fault along stream	Nothing apparent. River may flood onto land.	Good.	On balance the most suitable site
13	160m. Tight stream valley.	GF. Possible fault to the southeast.	Nothing apparent. River may flood onto land.	Difficult.	Gorteen-nakilla Br.
14	130m. Tight stream valley.	GF. Possible thrust zone to the southeast	Nothing apparent. River may flood onto land.	Accessible. Wet ground.	Keamcorra-vooly Br.

BHF = Bird Hill Formation, GF = Gortanimill Formation

Table 2 Details of potential well drilling sites at Carrignadoura, Ballingeary, County Cork.

Many of the sites inspected were either at too high an elevation where fracturing in the bedrock is not expected or would be difficult to get a large drilling rig to. The most suitable site for the proposed well is considered to be Site 12 (Figure 1). Geologically sites 13 and 14 possibly have a little more potential. However, they are located a considerable distance from the distribution pipeline.

Site 12 covers an area of flat ground on either side of the tributary of the Bunsheelin River (Figure 1). The site is underlain by the Bird Hill Formation with an unknown thickness, probably at least 3m, of Quaternary (subsoil) deposits overlying the bedrock. The most recent geological map (GSI, 1997) of the area shows a fault along the line of the stream. The water table is likely to be within 3m of the ground surface at this site.

The prospects of encountering a fault zone and the possibility of associated fractured rock together with the low ground in the area make this site the most suitable for the development of groundwater supplies. The ground upgradient of the proposed borehole site, the likely capture zone, is used for low level intensity agriculture. There are no houses and farmyards for some distance. As a result land use in this area is unlikely to be a significant factor in the quality of water from the proposed borehole. Access for a drilling rig is also good.

The proposed well should be located at least 25m from the stream channel and the adjoining road. A location should be chosen where the ground is slightly elevated to avoid possible flooding.

Well Design

In developing a new source for a group water scheme it is normal to drill a Trial Well to gather information on the underground conditions, the likely yield and water quality. Trial Wells are drilled to a less rigid specification than Production Wells and are therefore cheaper to complete. They can also be used as standby wells if they prove successful.

The proposed wells are intended to pump up to 100m^3/d (>900g/h). A specification and estimate of cost for both types of well are given below and in Appendix I. The principal details of the proposed Production Well are outlined below.

The well should be drilled at a diameter of at least 300mm (12") to at least 10m or 3m into bedrock. Steel casing (200mm) should then be installed and either grouted in before continuing or fitting a temporary seal with a view to grouting up on completion. The installation of well casing a considerable distance into bedrock and grouting up the annular space between the casing and the borehole walls, is necessary to shut out shallow groundwater (or stream water) which is susceptible to contamination.

Drilling should continue at 200mm in diameter, until the required yield is obtained or a depth of 90m is reached. On reaching the final depth the well should be surged and cleaned out.

A string of uPVC casing/screen should then be installed to the final depth to protect the pump. The casing/screen string should be at least 127mm (5") in diameter. In selecting the appropriate size of casing/screen string, care should be taken to ensure that there will be adequate room for the proposed pump and to allow efficient entry of water to the pump screen. If the bedrock is found to be very solid the uPVC casing/screen may be omitted.

After the well has been completed a well test should be undertaken to confirm the yield and provide water samples for analysis. The well test should consist of at least a 5 hour step drawdown test followed by overnight recovery. This test should be followed by at least a 50 hour constant rate test and recovery. Analysis of the drilling and well test data allows a prediction of the long term well yield to be made.

Water samples should be taken for chemical analysis at the end of the step drawdown test and for chemical and microbiological analysis at the end of the constant rate test.

Likely Cost of Drilling Programme

This section of the report gives an indication of the likely cost of the various aspects of the work required to construct a Production Well at the proposed site.

Approximate costs for the different types of work required are as follows;

	euro
Trial Well (150mm x 70m)	6,000
Production Well (200mm x 90m)	15,000
Well Tests (3 day)	2,000
Water Samples (2)	350

A mobilisation charge (1,500 €) has been included in the price of both types of well to allow a comparison to be made. The cost of the production well includes a string of uPVC casing/screen at 4,500€ which may not be necessary.

The above is exclusive of VAT and does not include the professional fees for supervisory work and the subsequent data analysis.

Groundwater Protection

In the event of the wells being successful it will be necessary to take certain measures in the area around the wells to ensure long term groundwater quality.

Conclusions and Recommendations

The rocks of the Bird Hill Formation have limited potential for the development of groundwater sources. They are likely to be most productive along fault/fracture zones.

The most suitable site (i.e., Site 12) for groundwater development in the distribution area is located in low ground beside a small stream. The geological maps show a fault along this stream.

In view of the uncertainty that the required supply will be obtained it is suggested that initially a well be drilled at the site to Trial Well specifications.

Water quality at this site is likely to be satisfactory.

References and Sources of Information

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Completion Report
Carrignadoora group water scheme, Ballingeary, Co. Cork
By BJS Consultants Ltd
Sept 2006.

1. EXECUTIVE SUMMARY.

The upgrade and extension to the existing group water scheme in Carrigndoura, Ballingeary, Co. Cork consisted of the laying of approximately 4.5km of new pipe network and the installation of a new pre-cast concrete reservoir with a volume of 257m3. A new water source was also located and a new pump house compound was constructed.

An upgrade to the existing scheme was required due to the existing water source being prone to contamination. The previous reservoir consisted of a underground concrete block reservoir, which was prone to leakage. During times of peak demand, during summer months the water system was put under considerable pressure and several houses at high points on the scheme would find themselves without adequate water supply.

Following the upgrade and extension work to the group water scheme no water shortages or leakage has been experienced. The scheme supplies 121 people with water that passes all relevant European Union Requirements.

The main construction work for the scheme began at the end of 2004 with Cro-Bar Construction contracted to do the Civil work and Response Engineering contracted to do the Mechanical and Electrical side of the project. All major work for the scheme was completed early 2006.

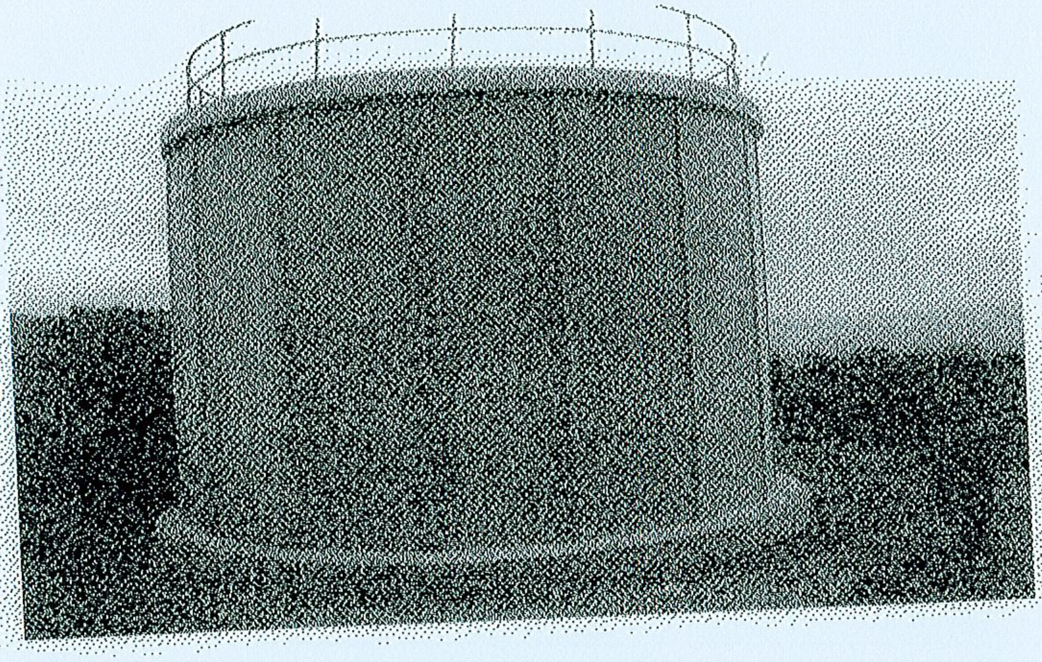
A number of problems arose during the construction process, the main ones being the quality of the water from the new source and problems relating to the weather.

There are no environmental or economic impacts from the upgrade and extension to Carrignadoura Group Water Scheme.

No jobs will be created from this project.

2. GENERAL

The works for Carrignadoura Group Water Scheme consisted of the construction of a new pre-cast reservoir and reservoir compound in Cahernacaha. The reservoir has a volume of 257m^3 and was supplied by Mr. Shay Murtagh Ltd. A new pumphouse/kiosk was constructed approximately 1.3km away as well as a new compound.



Picture 01 – New 257m3 Reservoir

A total of 4500m of new pipeline was laid, which on completion was connected to the existing pipe network.

The treatment of the scheme consisted of a sodium hypochlorite, which was installed in the kiosk/pumphouse. The sodium hypochlorite provides a chlorine residual in the water between 0.2ppm and 0.8ppm as recommended by the Department of health. From the pumphouse the water is pumped up to the reservoir.

2.1 HISTORY OF THE PROJECT

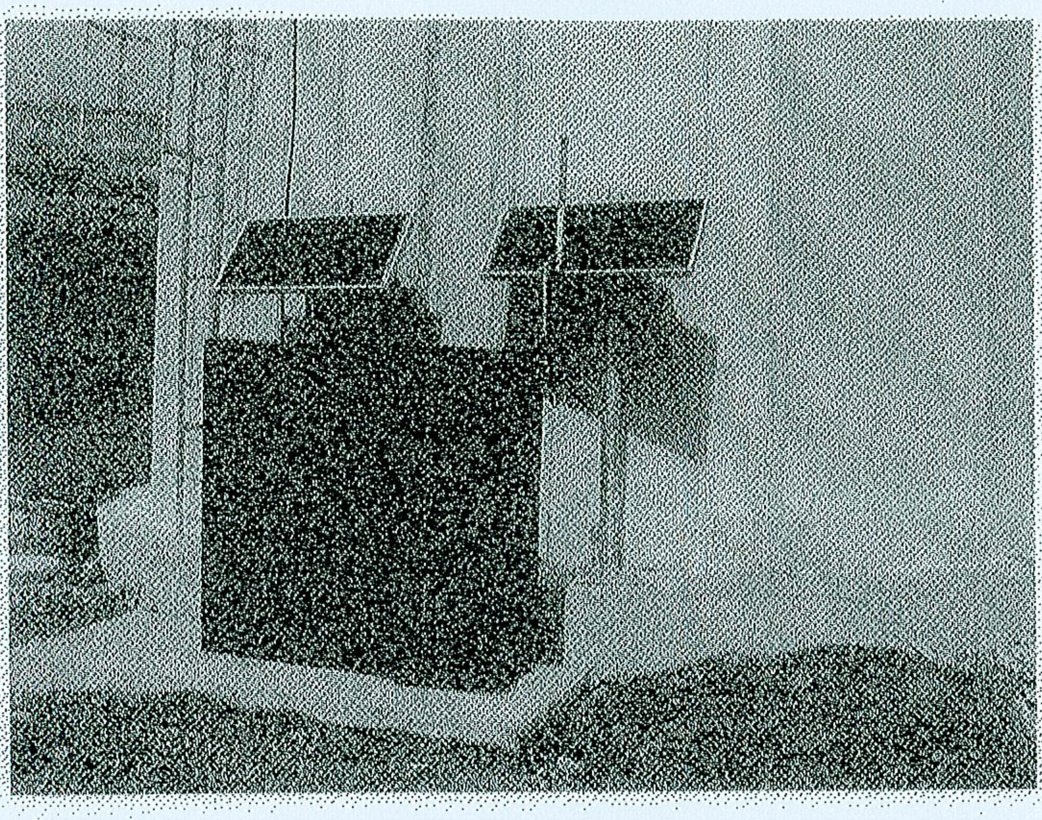
BJS Consultants Ltd. Civil and Structural Engineers prepared the planning package for the Group Water Scheme and submitted the package on 11/05/2004. Full planning permission was received on 10/08/04 with no conditions. (Ref No. 04/3231)

The location for both the reservoir and the pumphouse were based purely on geographical reasons. The reservoir was located at a high point that ensures that minimum pressure requirements were met i.e. minimum pressure at a house is to be 1.5 bar (15m head). The location of the boreholes was based on a recommendation from Mr. Eugene Daly of Eugene Daly Associates, Groundwater, Hydrological and Environmental Consultants. The borehole was located 1.3km downhill from the reservoir location.

The Mechanical and Electrical aspects of the project consisted of the following:

1. New 6"Ø borehole pump with low water cut off.
2. Dial out unit
3. Chlorine dosing unit & pumps (2 No.)
4. Control Panel for Ultrasonic level controller
5. Telemetry System (Radio)
6. Ultrasonic level controller
7. Residual Chlorine Analyzer
8. Telemetry System
9. Solar Panels and Battery back up
10. Control Panel

The reason for using a radio telemetry system was based on cost reasons. As it would not be feasible to lay signal ducts\wires to the reservoir from the pump house. Solar panels were installed in the reservoir as the nearest ESB pole would be 500m away.



Picture 02 – Solar Panels

The sizing of the reservoir was based on a known number of people on the existing scheme, plus an allowance for the future expansion etc. The number of people on the scheme is 121. Total demand for 121 people is 225L\H\day x 121 = 28m³\day.

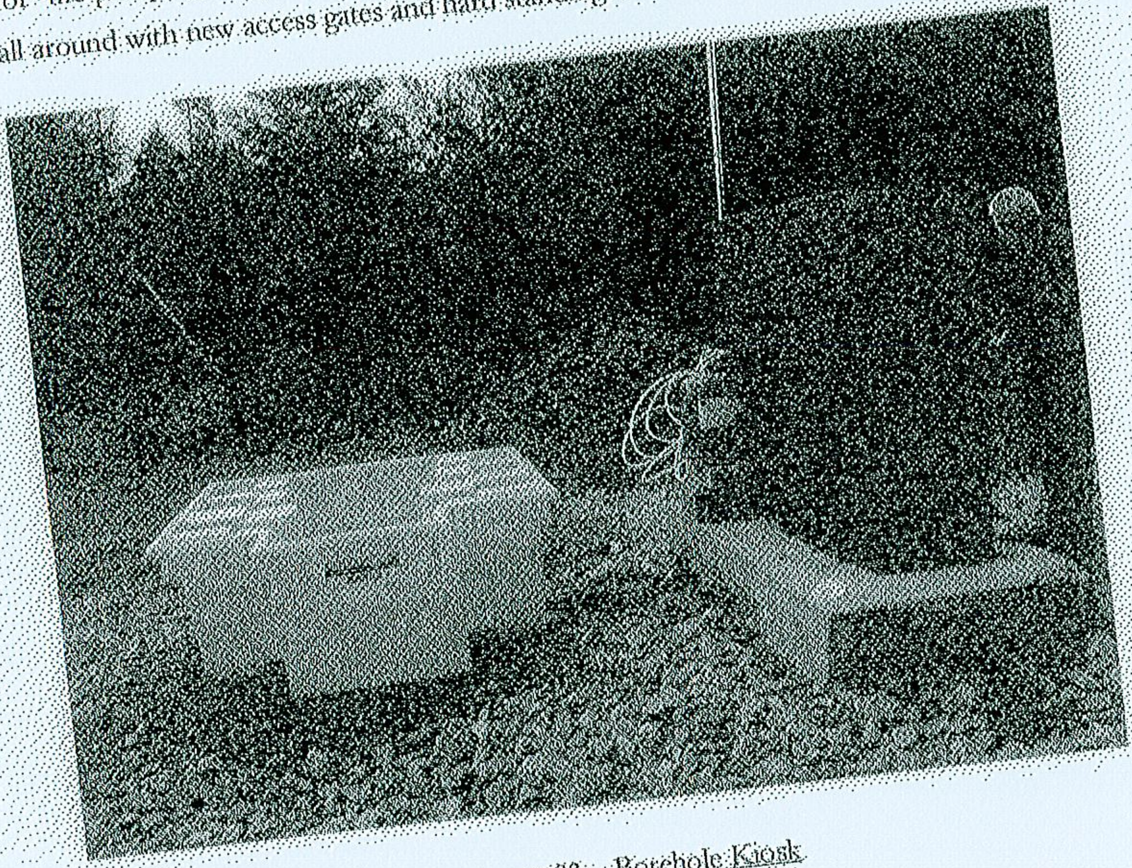
Agricultural demands were also taken into account when sizing the reservoir. The reservoir will provide a minimum of 1.5 days storage; however the actual demand is 85.3m³\day. Therefore the reservoir provides 3.0 days storage.

3.0 CONSTRUCTION

Construction commenced end of 2004, with Cro-Bar Construction laying 4.5km of new pipeline and preparation of the reservoir compound area for the new pre-cast concrete reservoir, which would arrive in early 2005. During 2005 and 2006, the pipelines were completed, sterilized and pressure tested.

The pressure tests were carried out by Crobar Construction and supervised by BJS Consultants Ltd. The pipes were tested to 1.5 times actual static head. No leakage was discovered during the pressure tests.

2 new compounds were constructed one for the pre-cast concrete reservoir and one for the pump house\kiosk and borehole. The compounds consisted of a palisade fence all around with new access gates and hard standing areas.

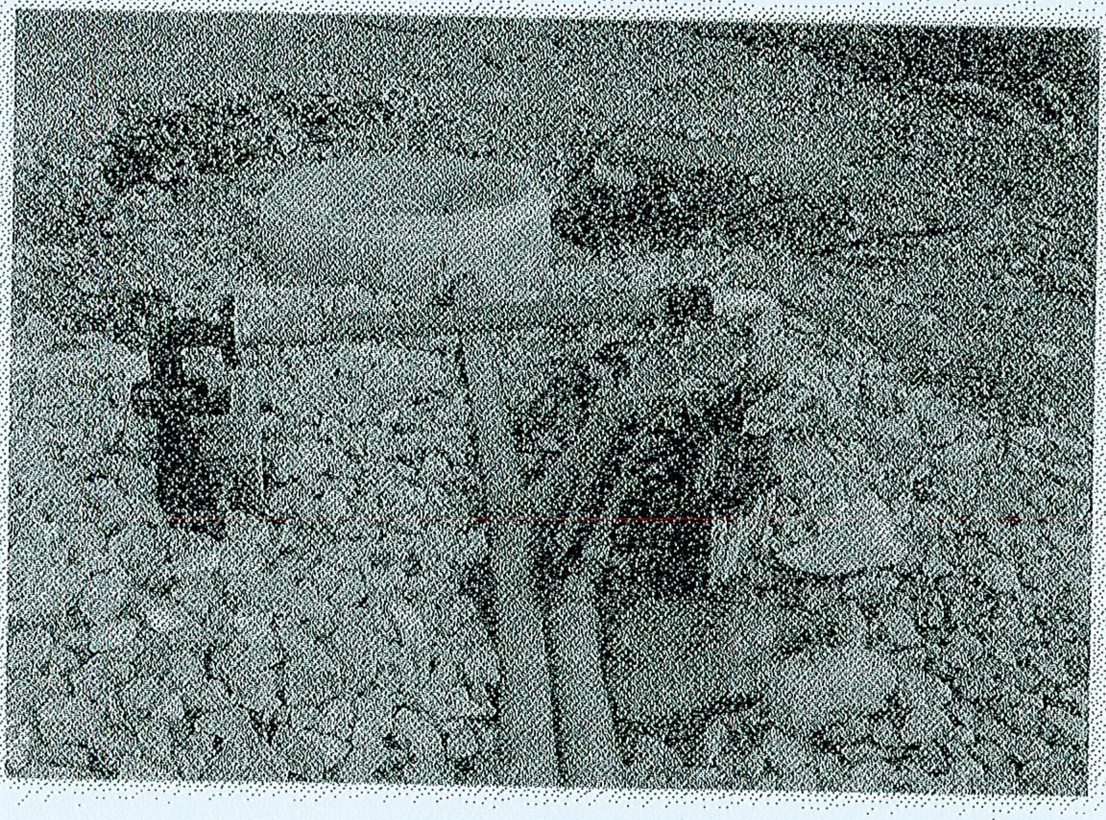


Picture 03 – Borehole Kiosk

The new pipe network would also be fitted with sluice valves, hydrants, air valves and pressure valves.

The Mechanical and Electrical side of the scheme commenced mid 2005, with the installation of a new 6" Ø borehole pump by Response Engineering Ltd. The new pump would also boost the water up to the reservoir location 1.3km away. The new kiosks and control panels along with the dial out unit and telemetry. The chlorine levels are constantly monitored on the outlet from the reservoir using a residual chlorine analyzer, which relays this information to the control panel at the pump house, which adjusts the chlorine levels accordingly.

During the initial stages of pumping the water, it was noticed that there was very fine particles within the water. Upon further investigation it was discovered that it was clay particles, which were being sucked into the pump. The borehole pump was lowered a further 100ft in the borehole and the water was retested. However the same problem appeared 1 week later. Finally in order to remove these very fine particles, we are placing a water filtration system on the rising main to the reservoir.



Picture 04 – Borehole

A number of modifications occurred during the construction of the pipe network. A request from the Area Engineer that a second pipe be laid in the rising trench. A modification was also made to the 6" Ø borehole pump to suit site conditions. The total cost of variations was €66,573.75 (ex VAT)

4. OBJECTIVES

The main objectives of the upgrade and extension to Carrignadoura Group Water Scheme, was to supply the existing water scheme with clean drinking water as the previous source of water was prone to contamination. The previous concrete block reservoir (underground) due to its construction was also prone to leakage.

During the summer months the previous source and reservoir could not cater for the increased demand, residents at high locations on the scheme would be without drinking water. The new borehole (source) is more than capable of supplying water during the peak demand months and the new reservoir gives the added advantage of having 3 days storage.

The new scheme is in compliance with the following standards:

1) European Communities – Quality of Water intended for Human Consumption 1998 and amended 2000 (S.I. No 81 of 1988 and S.I. No 177 of 2000)

2) European Communities – Drinking Water Regulations 2000 (S.I. No 438 of 2000)

There are no environmental or economic impacts from the upgrade and extension to Carrignadoura Group Water Scheme. The main Civil Contract has taken approximately 1.5 years to complete, however work was not always ongoing during this time period due to problems with weather etc. BJS Consultants Ltd. Made periodic inspections to supervise the ongoing work and were always in direct contract with the main site foreman from Cro-Bar Construction.

All work was done in accordance with the Health & Safety (Construction) Regulations. No accidents or incidents were recorded during the works.

5. OUTPUTS

The main construction work for the project took approximately 1.5 years to complete. However work was not always ongoing during this time period due to several reasons. It has taken 3 years in Consultancy/Supervision to complete the project.

6. OPERATION OF THE WORKS

On completion of the project the water quality was re-tested and was found to be safe to drink. All bacteria and coliform quantities were less than the European Union Guidelines.

The annual maintenance costs vary between €3,750 and €10,900 (ex VAT) depending on the frequency of the visits; however maintenance contracts have not been signed yet. When the maintenance contract is awarded the Contractor will issue reports on the components with the Group Water Scheme.

No additional revenue will be gained from the upgrade and extension of the Group Water Scheme.

No jobs will be created from the project.