Report on the Black Lough Catchment
(Kilsherdany Group Water Scheme)

Norma O'Hea

National Centre for Freshwater Studies, Dundalk Institute of Technology

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NATIONAL CENTRE FOR FRESHWATER STUDIES

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1. Introduction

Source protection is the protection of raw water quality through measures that limit or eliminate the risk of water contamination. It is an increasingly important strategy for the protection and maintenance of drinking water sources, in particular, as the first barrier in a multi-barrier approach to drinking water quality.

In Ireland, a limited number of studies have investigated the potential of source protection to improve water quality. The National Source Protection Pilot Project (NSPPP) at Churchill and Oram group water scheme, Co. Monaghan (2005-2009), was established by the National Rural Water Monitoring Committee and is overseen by the National Centre for Freshwater Studies (NCFS) at Dundalk Institute of Technology. The objectives of the Pilot Project are to assess water quality within the Milltown Lake catchment, identify sources of contamination and implement remediation measures to protect and enhance water quality in the lake. The project represents a model of best practice for the implementation of source protection in Ireland and was designed for replication to other group water schemes around the country.

It is in the interest of privately sourced group water schemes to carry out risk assessments to determine the potential for nutrient enrichment and biological contamination (e.g. *Enterococcus* spp., *Escherichia coli*, *Cryptosporidium* spp.) of their water supplies, and to meet application conditions for a Water Services Licence under the Water Services Act (2007).

The assessment of Black Lough, source for Kilsherdany GWS, has three components. The first is a preliminary characterisation of the lake catchment whereby the underlying geology, hydrogeology, soils and habitats of the catchment are described and their influence on water quality is discussed. Secondly, potential water quality risks in the catchment are identified, including possible point and diffuse sources of pollution within the lake catchment that might threaten water quality in waterbodies[1]. Thirdly, a series of recommended practical measures are proposed that can be implemented by the GWS and the local community to safeguard the long-term quality of Black Lough.

2. Background

Kilsherdany Group Water Scheme was originally founded in 1982-83. In the period between 2001-2003, monitoring of water quality at Black Lough was conducted by T.J. O'Connor and Associates and the National Drinking Water Monitoring Programme to establish baseline conditions for the lake. The DBO contract for operation of the treatment plant was awarded to

[1] Point sources are distinct points (e.g. pipeline, drain) where pollution enters a waterbody at a specific location. Diffuse pollution typically arises when fertiliser, pesticides and slurry run off land into waterbodies via rainfall, soil infiltration and surface run-off.

Veolia Water Ltd. in December 2005. The treatment process at the plant consists of coagulation, flocculation, dissolved air filtration and chlorine treatment. The average daily water volume abstracted is approximately 213 m^3 (2009).

3. Methodology

As part of an information-gathering exercise to collate all existing historical information and water quality data on Black Lough, the NCFS consulted with Kilsherdany GWS committee through GWS manager, Mary O'Reilly. A visual inspection and walkover assessment of Black Lough and its immediate surroundings were conducted on 21st October 2009 to identify the limits of the lake catchment and potential environmental issues relating to waters quality in the lake. Historical water sampling data for Black Lough was provided by:

- T.J. O'Connor and Associates Consultant Engineers
- National Drinking Water Monitoring Programme
- Virginia Laboratories Services Ltd.
- Veolia Water Ltd.
- City Analysts

The Geological Survey of Ireland provided assistance with the interpretation of geological and hydrogeological maps.

4. Physical site description

The physical characteristics of an area encompass its geology, hydrogeology, soils, slope of land and habitats. These characteristics influence the vulnerability of waterbodies in the area to pollution by nutrients, pathogens or pesticides. The following sections describe the physical attributes of the Black Lough catchment and highlight features of the landscape that are vulnerable to pollution.

4.1 Source water supply and associated inflow and outflow watercourses

Black Lough is approximately 6 ha in size and is located in the townland of Drumhurt in northeast Co. Cavan (grid reference H 578 108) (Figure 1). It is a spring-fed lake (76 m a.s.l.), approximately 5.3 m deep and 60 m wide (Plate 1). It has no known inflows or outflows. The Black Lough catchment, including the lake, covers an estimated 1.25 km^2 (125 ha). Black Lough is located in the North Western River Basin District (Hydrometric Area HA36) (designated as part of the implementation of the Water Framework Directive) but its water quality has not been classified as part of the designation process.

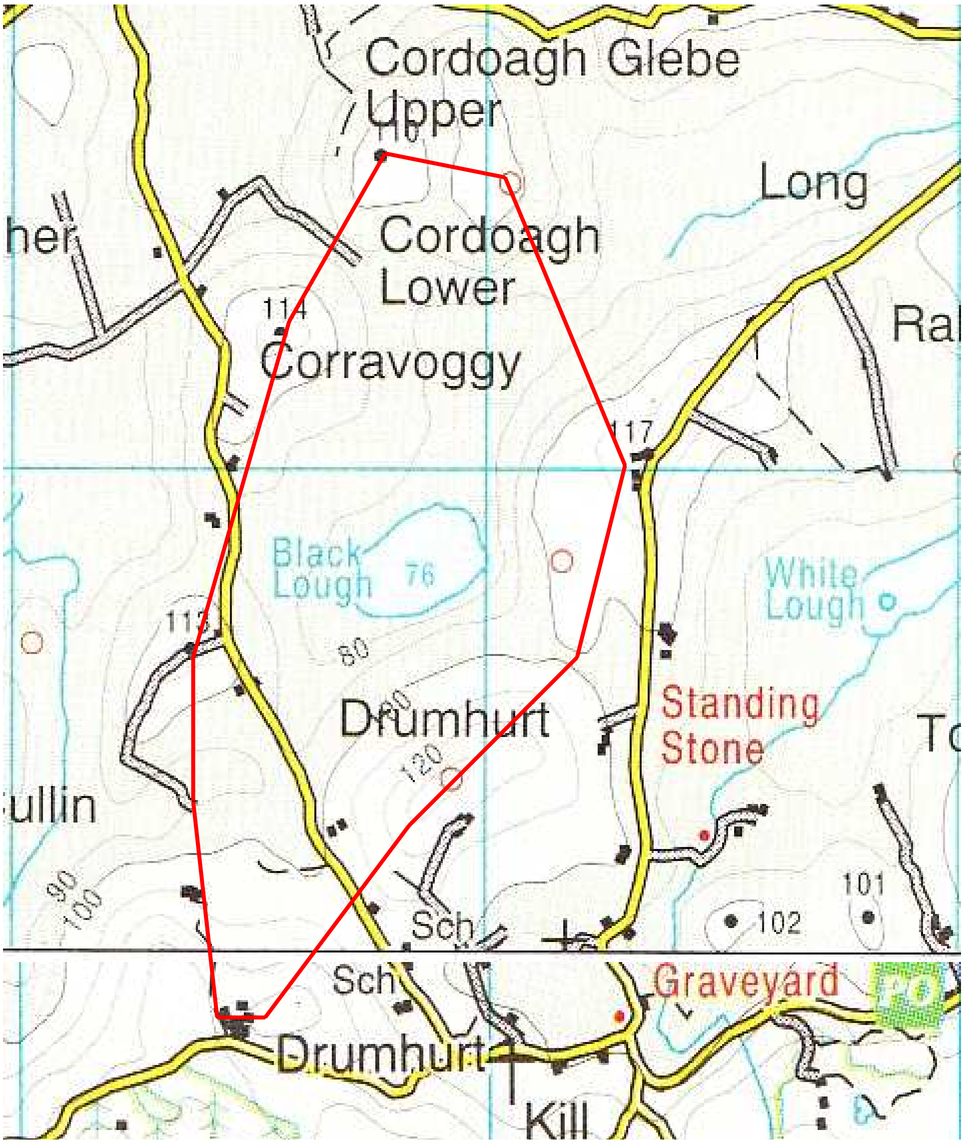


Figure 1 Geographical extent of the Black Lough catchment

Catchment boundary

Although surface water flows into Black Lough via run-off from surrounding land, it is primarily a spring-fed lake and, therefore, protection of the groundwater source in the catchment is of major importance. Delineation of a catchment/source protection zone is critical in order to ensure that raw water is adequately protected (only an estimation of the catchment size could be attempted in this report). The actual extent of the groundwater source and associated protection zones as well as the direction of flow can only be determined by a detailed hydrogeological study.

The GWS should endeavour to determine the extent of the groundwater contribution to the lake. This could be achieved through liaison with Cavan County Council who have some mapping information (as discussed with Colm O'Callaghan, Environment section) and the source protection unit of the Geological Survey of Ireland (Taly Hunter-Williams).

Plate 1 View of Black Lough from southern side

4.2 Bedrock Geology

Bedrock geology describes the rock formations underlying the Earth's surface. Over time, the weathering of bedrock by water, wind and ice contributes to the formation and composition of overlying subsoils and soils. The vulnerability of overlying aquifers to pollution is influenced by bedrock type and the nature and thickness of overlying subsoils. For example, limestone tends to be highly fissured and at risk of dissolution by water, which increases its susceptibility to pollution. The catchment is underlain with Silurian Metasediments and Volcanics (Figure 2). These are a series of layered sandstones, siltstones and shales with minor volcanic rocks, and tend to be non-calcareous in nature (so are not as vulnerable to pollutants seeping through as other bedrock types).

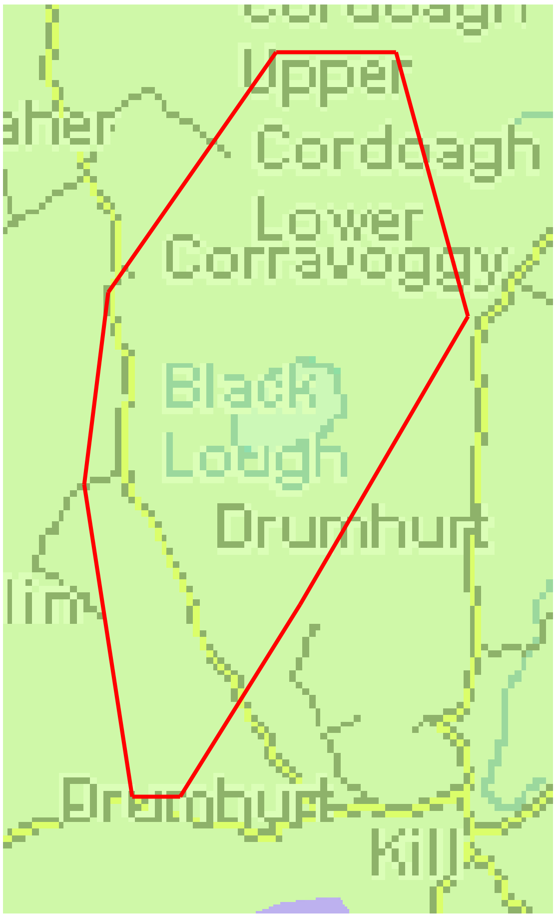


Figure 2 Bedrock geology in the Black Lough catchment

Silurian Metasediments and Volcanics

Catchment boundary

4.3 Groundwater

Groundwater is water occurring below the water table (i.e. saturated gaps in rock (aquifers)) and is typically abstracted from wells and springs. It is at risk of contamination from excessive nutrients and pathogens that may infiltrate via fissures and pores in overlying soils and rocks. Contamination of groundwater takes much longer (months or years) to resolve than that of surface water because it moves more slowly.

The lake catchment is underlain with a poor aquifer that is moderately productive only in local zones (Figure 3). Therefore, the quantity of water in this aquifer is more limited than in, for example, a limestone aquifer. This type of aquifer has few and poorly-connected fractures, fissures and joints, and reduced permeability, storage capacity, recharge capacity, and length of flow path. This suggests that surface water does not easily move to groundwater and that groundwater movement within the aquifer is slow, thus providing a level of protection to groundwater from surface contaminants. Typically, such poor aquifers have an upper few metres of weathered bedrock through which groundwater flows.

The bedrock aquifer is part of a single larger groundwater body, the Cavan groundwater body (GWB) (IE_NW_G_061) (see Appendix 1 for further information on the groundwater body).

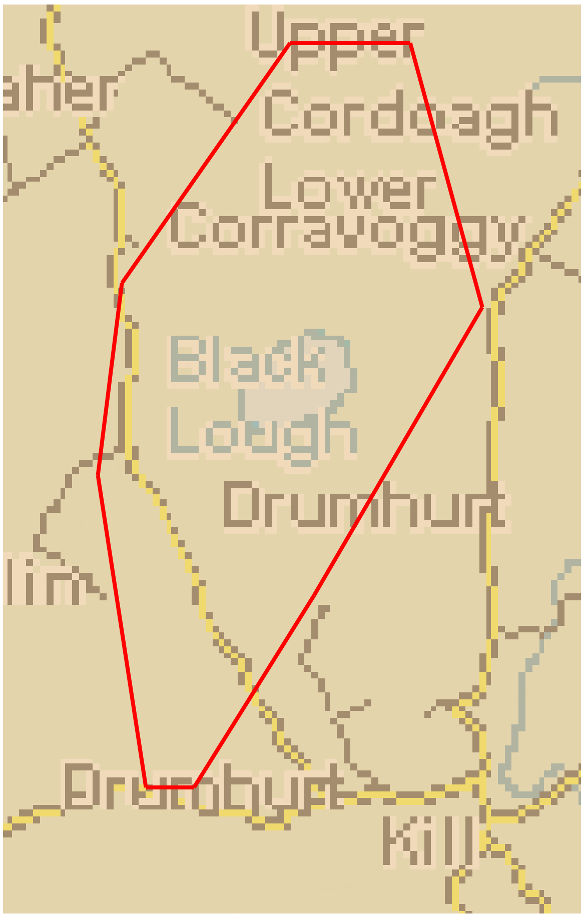


Figure 3 Hydrogeology in the Black Lough catchment

Poor aquifer that is moderately productive only local zones

Catchment boundary

Groundwater vulnerability in the catchment area ranges from high to low (based on an interim study of vulnerability) (Figure 4). Areas of extreme vulnerability occur to the northeast and southwest of the catchment, particularly where rock is exposed at the surface. Based on the characteristics of the GWB and the local aquifer, groundwater in the catchment may not be generally vulnerable to contamination; however, in extremely vulnerable areas (e.g. where bedrock is exposed), contaminants may be able to reach groundwater rapidly.

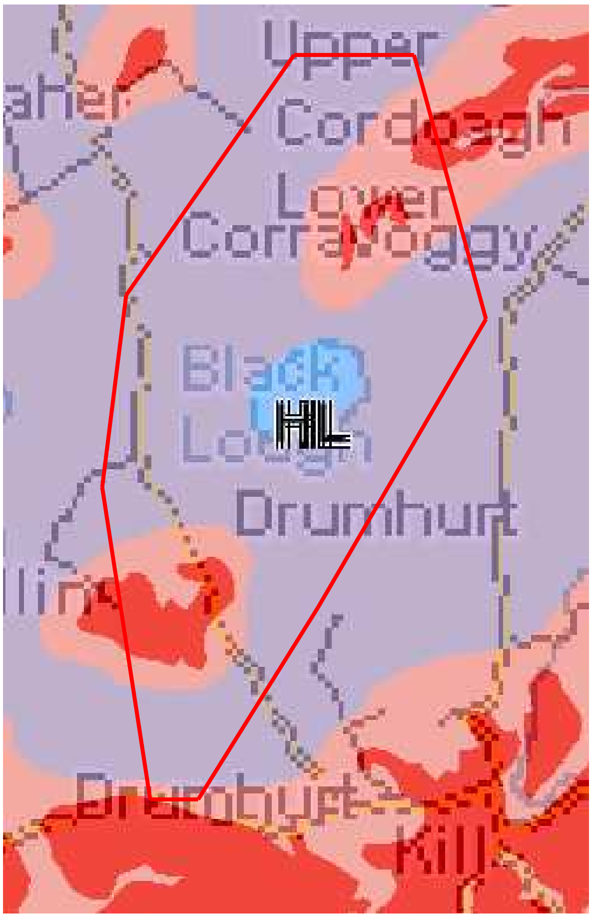


Figure 4 Groundwater vulnerability in the Black Lough catchment

- Extreme - rock near surface or karst
- Extreme
- High to low; based on an interim study
- Catchment boundary

Due to the interconnected nature of groundwater and surface water, contamination at one location can have impacts at another. However, the magnitude of these impacts depends on a number of factors, such as soil permeability, groundwater flow direction and the time-to-travel (the time it takes water to travel from one point to another). In the Cavan GWB, water moves slowly and groundwater flow paths are short, suggesting that groundwater contamination, if it occurs, will tend to have localized impacts and not affect areas that are further away. Groundwater flow is likely to follow local topography, flowing from high to low ground.

4.4 Subsoils and soils

The overlying soil type, structure and depth are other key factors in determining the vulnerability of groundwater to contamination. The ease with which contaminant substances move from the soil surface to groundwater depends on the physical structure and chemical composition of soils and subsoils, and the depth to the rock interface. Soil type also determines the capacity of soil to retain or weaken pathogens, thereby reducing their impact on underlying waterbodies. The risk of pathogen contamination is generally highest in the top 3 m of soil.

Subsoils lie underneath topsoil and above bedrock. The permeability and depth of subsoils determines its infiltration capacity and the vulnerability of groundwater to pollutants transported from the soil surface. Thus, subsoils present the most effective barrier to groundwater contamination. Cutover peat lies around the lake perimeter and to the north of the lake. The remainder of the catchment is underlain with sandstone shale and till. Peat, and sandstone shale and till, have low permeability to water. An area of bedrock at the surface occurs to the north of the lake. Groundwater underlying bedrock here will be vulnerable to infiltration from the surface (Figure 5).

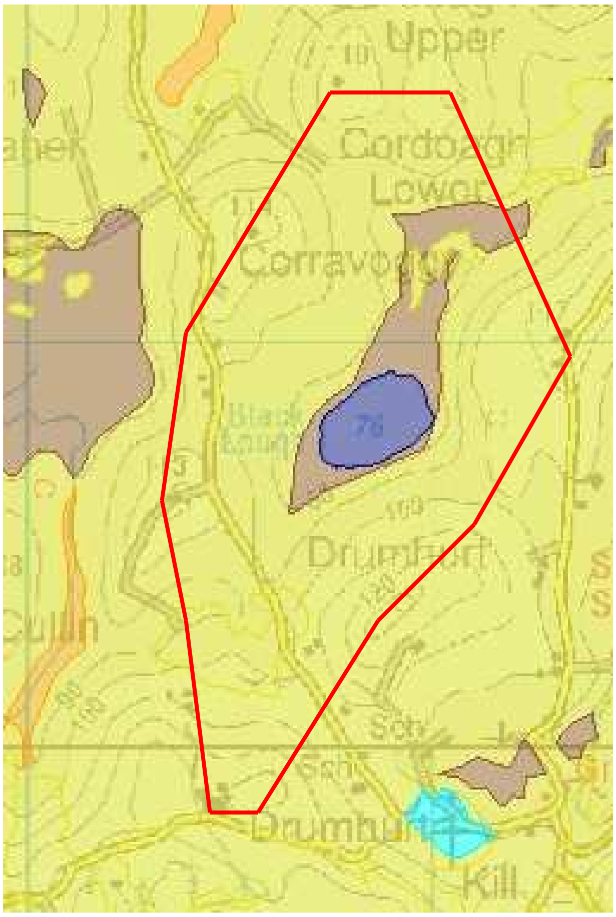


Figure 5 Subsoils in the Black Lough catchment

- Sandstone and shales till (Lower Paleozoic)
- Cutover peat
- Bedrock at surface
- Catchment boundary

Soil type describes the topsoil of an area. The permeability and depth of the soil determines its infiltration capacity and therefore, the volume and rate at which potential pollutants might move from the soil to subsoil and possibly to groundwater. Lithosols/Regasols overlie areas of exposed bedrock; these are skeletal, often stony soils, providing poor cover for underlying subsoil. Cutover peat lies to the north of the lake while the rest of the catchment is dominated by surface water and groundwater gleys (Figure 6). These soil types have low permeability and are saturated in wet weather.

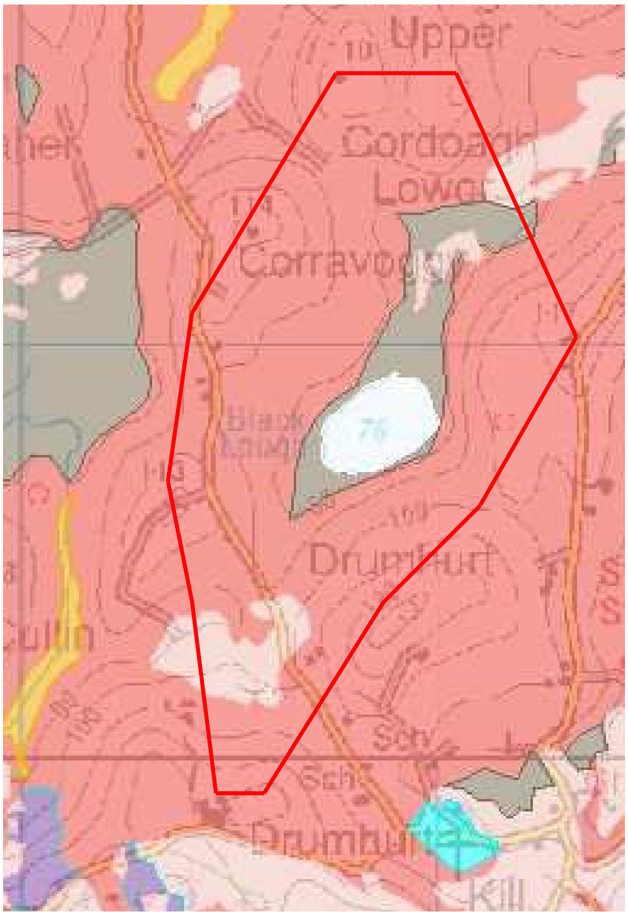


Figure 6 Soils in the Black Lough catchment

- Surface water and Groundwater gleys
- Cutover peat
- Lithosols/Regasols
- Catchment boundary

The combination of subsoils and soils in the catchment probably provide adequate protection for groundwater due to their thickness and low permeability, although the area with bedrock is particularly susceptible to infiltration. A detailed hydrogeological survey would confirm this. However, low permeability soils suggest that ground on the surface can become readily saturated with water and prone to run-off. Therefore, the main potential source of contaminants in the lake is likely to be surface run-off from surrounding land.

4.5 Soil nutrient status

Soil nutrient status provides a measure of soil fertility levels and indicates the presence of excessive or deficient nutrient levels. This ultimately determines the rate, volume and nature of nutrient additions to the lake.

Assessment of the nutrient status of soils within the lake catchment would involve a field survey which was not within the scope of this report but should be prioritised by the GWS on a phased basis as part of a source protection plan and target areas of vulnerability.

4.6 Slope

The slope of lands leading to a waterbody is an important determinant of the rate at which water and pollutants move into the lake by overland and subsurface flows, and will ultimately affect the quantity of nutrients and pathogens entering the lake and, hence, its water quality. Steep slopes are vulnerable to surface run-off.

In general the area immediately surrounding the lake slopes downwards to the lake and has poorly draining soils (Plates 2 and 3). This suggests that any activity on land surrounding the lake that results in nutrient or pathogen release e.g. slurry spreading, grazing, could contribute to nutrient enrichment or biological contamination of the lake, unless appropriate safeguards are in place (e.g. adequate buffer zones).

The degree of slope within the catchment needs to be considered further as part of a source protection plan.

Plate 2 View of southern side of catchment from eastern side of lake

Plate 3 View of western side of catchment from eastern side of lake

4.7 Habitats

The range of habitat types in an area may affect the rate and movement patterns of nutrients into a lake. Nutrients are taken up by vegetation during its growing phase, preventing or delaying the entry of those nutrients into water courses. The presence of vegetation along the length of a stream or at the edge of a lake can also act as a buffer strip by intercepting or preventing the entry of nutrients and pathogens into a waterbody. The flora and fauna adjacent to, or within, a waterbody, act as biological indicators of water quality. For example, the presence of freshwater trout and salmon, or mayfly larvae may be used to indicate water of high quality.

According to the National Parks and Wildlife Service (NPWS), there are no protected areas (Natural Heritage Areas (NHAs), Special Protection Areas (SPAs) or Special Areas of Conservation (SACs)) in the Black Lough catchment.

The catchment is predominantly agricultural. The area immediately surrounding the lake comprises mainly of improved grassland which slopes downwards to the lake. A buffer strip of *Typha* (reed mace) surrounds the lake on all sides. Trees and shrubs are also present (e.g. Willow, Alder). There is a large area of vegetation at the north-eastern side of the lake, which consists of reed mace and several tree and shrub species. Such natural buffer zones can intercept and reduce run-off from surrounding land into the lake (Plates 4 and 5). These buffer zones should be maintained and extended.

Plate 4 Buffer strip at eastern and southern sides of lake

Plate 5 Buffer strip at north-eastern side of lake

4.8 Drainage

Land drainage can lead to increased sedimentation due to disturbance of banks and beds and increased nutrient loads. Drainage of land will increase the rate of flow of water and can impact on river habitat and water quality by increasing the movement of sediments into a waterbody.

An assessment needs to be carried out on drainage so that intercepting piping or a ditch can be positioned to divert run-off away from the lake (e.g. into a wetland or buffered area) if necessary.

5. Activities within the catchment

5.1 Agriculture

Cattle rearing is the main agricultural enterprise in the catchment. Grazing cattle do not have direct access to the lake. Slurry and fertiliser spreading takes place on the fields surrounding the lake but farmers stay back from the lake edge when spreading. However, it is possible that faecal material enters the lake due to the sloping nature of land in the lake catchment. This can give rise to *E. coli* and other coliforms in the lake water which, if present in sufficient numbers, could cause outbreaks of illness. In addition, nutrients such as nitrogen and phosphorus may either leach into soil and eventually to the lake, or enter the lake via run-off from surrounding land. Fertiliser inputs to water can lead to over-enrichment (eutrophication) of the lake over time, resulting in algal blooms and deterioration of water quality.

The GWS should ensure that local farmers adhere to the Code of Good Agricultural Practice (see Appendix 3). Any slurry pits in the catchment should be assessed to determine if they are in good working condition or present a threat to water quality. Grazing and slurry/fertiliser spreading should not take place near areas of exposed bedrock. The GWS might approach landowners to discuss the possibility of controlling grazing in lands immediately adjacent to the lake, or leasing/purchasing land that would act as a buffer strip.

5.2 Domestic properties

There are a number of households in the lake catchment, each having its own wastewater treatment system. Damaged or leaking septic tanks will become sources of phosphates and pathogens for source water. Cavan County Council adopted the Water Pollution (Wastewater Treatment Systems for Single Houses) Bye-Laws, 2004, to control the design, maintenance and operation of wastewater treatment systems, such as septic tanks. These Bye-Laws require the owners of such systems to have an approved and fully functioning system, and to maintain it to certain standards.

In cooperation with householders, the GWS should ask the County Council to assess the potential risk posed by wastewater treatment systems in the catchment. This should determine if they are adequately maintained and/or adhere to the conditions of the Bye-Laws.

6. Water quality data

Raw water sampling has been carried out in Black Lough since 2000. T.J. O'Connor and Associates (Consulting Engineers) conducted raw water sampling in 2002-2003 prior to construction of the treatment plant. The National Water Monitoring Committee monitored raw water quality in the lake during 2000-2001. Veolia Water Ireland Ltd. has sampled raw water in the lake on a weekly basis since 2005. External laboratory analyses are carried out by City Analysts Ltd. on a periodic basis since 2007. All sampling results are presented in Appendix 2.

The following pages provide a summary and interpretation of water quality data collated for Black Lough. The possible sources and significance of water quality parameter values are discussed. The parameter values are compared to the maximum values (+ 20%) recorded during the baseline survey of 2001-2003. They are also compared to mandatory limits in the Drinking Water Regulations (2007) [European Communities (Drinking Water) Regulations 2007 (S.I. No. 106/2007)].

6.1 Iron

Iron is present in rocks and soils in an insoluble form but can become soluble when water passes through ground formations. Large amounts of iron in water do not normally have harmful effects for users but can be aesthetically unpleasing by causing colour changes or turbidity (due to oxidation of soluble ferrous to insoluble ferric). This can lead to staining of laundry, discolouration of vegetables following cooking, and taste problems. Under the Drinking Water Regulations (2007) the recommended concentration of iron is 0.2 mg/L. The contracted maximum allowable limit is 0.214 mg/L. The raw water in Black Lough exceeded both limits from October 2006-June 2007 but limits have not been exceeded since then and iron does not appear to be a problematic issue for Kilsherdany GWS at present.

6.2 Manganese

Manganese is found in soils and groundwater. It is generally not considered to be harmful to humans but can cause more severe staining problems than iron and adversely affect taste. Under the Drinking Water Regulations (2007) the recommended value for manganese is 0.05 mg/L. The contracted maximum limit is 0.341 mg/L. The contracted limit has been exceeded on a number of occasions but not recently. The presence of manganese in raw water cannot be manipulated at source due to its natural origin but it does not appear to be a major issue of concern for the GWS at present.

6.3 Conductivity

Conductivity quantifies the ability of water to conduct an electrical current and is an indicator of the mineral salt content of water. The Drinking Water Regulations (1989) specify a limit of 2500 µS/cm at 20 ℃. The contracted maximum limit is 442.8 µS/cm. Conductivity has not exceeded either limit in Black Lough to date.

6.4 pH

The pH value of water is generally only of concern if it is extremely low or high, indicating extreme acidity or alkalinity, respectively, which in turn may have consequences for odour or taste, lead to corrosion in distribution systems, or affect fish survival. Water generally lies in the range of 6.5-8.0. The Drinking Water Regulations (2007) recommend a range of 5.5-8.5 for Class A1 waters. The contracted maximum allowable limit is 10.44. The pH of water in Black Lough is within or below this range on all dates since monitoring commenced.

6.5 Colour

Natural colour reflects the presence of organic molecules originating from humic matter such as peat, leaves and branches. A coloured water supply does not pose high health risks in itself but can react with chlorine in the treatment plant to create trihalomethanes. For this reason high levels of colour should be avoided. Two forms of colour are generally measured: apparent colour records the colour of an unfiltered sample while true colour is the colour of a filtered sample; thus apparent colour is the most accurate measure of raw water colour.

Colour is a parameter that varies greatly depending on quantities of precipitation and run-off leading to spikes in results. In Black Lough, the maximum value recorded for colour during the baseline survey was 157.2 PtCo. This limit has only been exceeded twice since Veolia began operations on the lake. Only one measurement of true colour was taken during the survey so it is not possible to provide a representative limit for true colour. Reasons for high readings or exceedances are likely to be due to large amounts of rainfall, marking the entry of large quantities of decaying vegetative material into the lake. Decaying algal matter may also cause seasonal changes in lake water colour.

6.6 Turbidity

Turbidity in water consists of very finely divided particles. Their origin may include clay particles, silt, sewage solids and organic or biological sludges. In the open water zone of lakes, turbidity is affected mainly by phytoplankton (aquatic microscopic plants). High levels of turbidity in the raw water supply can interfere with the ability of the treatment plant to provide safe drinking water. The following units are often used to present Turbidity; JTU (Jackson Turbidity Units), FTU (Formazin Turbidity Units) and NTU (Nephalometric Turbidly Units). These three units can be interpreted to mean the same thing.

The maximum allowable limit is 27.6 NTU. The Drinking Water Regulations (2007) specify a limit of 1 NTU while the EPA recommends that turbidity should not exceed 0.2 NTUs. The turbidity of raw water has remained below the maximum limit but has exceeded regulatory limits. Turbidity is an important parameter to monitor as it can act as an indicator of potential *Cryptosporidium* contamination. The *Cryptosporidium* Risk Assessment carried out for Black Lough in 2008 recommended alarming and linking the existing raw water turbidity meter to the telemetry (see section 6.10 for details).

6.7 Total and Faecal Coliforms

Faecal coliforms (e.g *E. coli*) originate in either human or animal wastes. Total coliforms include faecal and soil-borne coliforms. Coliforms are used as an indicator of pathogenic organisms within a water body. Both faecal and total coliforms should be included as part of the monthly water sampling programme for the lake. Currently coliforms are only measured by City Analysts.

Faecal Coliforms (e.g. E. coli)

Under the Drinking Water Regulations (2007) there should be no coliform units per 100 ml of sample. The maximum limit measured during the baseline survey was 36 coliform units per 100 ml and 80.4 units per 100 ml for *E. coli*. Although the baseline limits have not been exceeded to date, *E. coli* and other faecal coliforms have been detected in raw water (according to City Analysts data). This indicates that faecal material or slurry is entering the lake, probably via run-off from surrounding sloping lands.

The scheme needs to ensure that current levels of faecal contamination are contained and reduced. This will require on-going monitoring as well as assessment of the sources of such contamination.

Total Coliforms

The maximum limit measured during the baseline survey was 156 units per 100 ml. Total coliform counts have not exceeded this limit to date. While total coliforms will never be totally eliminated, steps should be taken to reduce the potential for organic run-off into the lake. This might include establishment of buffer strips around the lake perimeter and reduced stock numbers on steep slopes where soil may be vulnerable to erosion.

6.8 Phosphorus

Phosphorus occurs widely in nature but is also added to the environment by human activities e.g. use of phosphorus as a fertilizer in agriculture and as a constituent in cleaning products. Phosphorus and Nitrate are the main nutrients that stimulate eutrophication. This process leads to an increase in algal mass and a decrease in raw water quality. Phosphorus results for lakes are usually presented as mg/L Total Phosphorus. This makes for easy comparison with standards.

The baseline assessment in 2000-2003 established a maximum allowable limit of 0.509 mg/L P for total phosphorus and 0.047 mg/L P for orthophosphate. Orthophosphate is measured as part of the external laboratory analysis by City Analysts. While this is not directly comparable with total phosphorus it does form part of total phosphorus and is useful for interpretation. Orthophosphate is also the form of phosphorus most easily used by algae and therefore can lead to the development of algal blooms. Since 2007, orthophosphate has only been measured in the lake four times. Since absolute values have not been provided (Table 6, Appendix 2), it is not possible to know whether orthophosphate levels have increased since the baseline survey. Parameter values, such as orthophosphate, can vary greatly over time since many environmental factors affect water quality and pollution events may be missed by infrequent sampling. Orthophosphate needs to be measured on a much more regular basis to gain a better understanding of P variability. There has been no measurement of total phosphorus in the lake since the baseline survey.

The main sources of P within the catchment are likely to be agricultural (e.g. slurry, cattle livestock manure, chemical fertiliser) and human (waste from septic tanks). Human or animal wastes are loaded with nutrients, such as phosphorus, and if not properly applied to the land or treated, are susceptible to loss to the aquatic environment. Household detergents are also sources of phosphorus.

The Code of Good Agricultural Practice (see Appendix 3) should be complied with when organic manure and chemical fertiliser are being spread. The GWS should encourage homeowners to reduce their use of phosphate washing powders and detergents, or replace these with phosphate-free alternatives.

6.9 Nitrogen

Nitrogen exists in many forms in the natural environment. The most important and widely measured are ammonia, nitrate and nitrite.

<u>Ammonia</u> is present in natural waters but if it is found in excess of 0.1mg/L N, it is seen as an indication of human waste or industrial contamination. Due to the potential link between high ammonia concentrations and human waste, it is an important parameter to monitor at a drinking water source. The Drinking Water Regulations (2007) specify a limit of 0.30 mg/L for ammonium. The maximum limit set during the baseline survey was 0.612 mg/L N. Neither limit has been exceeded to date.

Nitrogen in the form of nitrite is uncommon in waterways as nitrogen is more likely to be found as Ammonia or Nitrate. Ammonia is transformed into nitrite before being transformed into nitrate. As human and animal waste is the most likely source of ammonia, it is also probably the original source of nitrate and a high nitrite concentration should be of concern as it is probably an indication of human or animal waste material entering the water.

Nitrate is the most common form of nitrogen in rivers and lakes. It usually originates from human or animal wastes or from the application of artificial fertilizers to agricultural lands. Nitrate is an important nutrient for plant growth and excess of this nutrient can play a significant role in eutrophication. The nitrate limit specified under the Drinking Water Regulations (2007) is 50 mg/L N and the maximum limit measured in the baseline survey was is 1.56 mg/L N. Nitrate levels in Black Lough, as measured by City Analysts on four occasions have ranged from <0.063 to <2 mg/L N (no absolute values are provided so it is not possible to know if nitrate levels have increased over time).

Nitrogen does not appear to be a problematic nutrient in Black Lough at present but it can accumulate over time in lakes so it is important to monitor levels.

6.10 Cryptosporidium

Cryptosporidium spores may be present in faeces of infected animals and are highly pathogenic, causing cryptosporidiosis in the gastrointestinal tract of humans. Humans are mainly infected by *C. parvum* (present in livestock waste) and *C. hominis* (present in human waste). It is very resistant to treatment processes such as disinfection. T.J. O'Connor and Associates carried out a *Cryptosporidium* Risk Assessment for the East Cavan DBO Bundle in 2008, including Kilsherdany GWS, in accordance with EPA guidelines (Drinking Water Regulations Guidance Booklet No. 4: Risk Screening Methodology for *Cryptosporidium*). Kilsherdany GWS was classified as Low Risk based on an assessment of catchment factors (e.g. animal densities, farming activities, livestock access to the source) and treatment plant factors (e.g. presence/absence of turbidity alarms and monitors). The report made a number of recommendations including:

- alarming and linking of the existing raw water turbidity meter to the telemetry
- monthly catchment inspections with a defined monitoring procedure
- official procedures for notification of stakeholders e.g. landowners, County Council Environment section, Department of Agriculture officials, etc., in the event of emergencies in the catchment
- installation of fencing to prevent access to source and feeder streams

However, the fact that faecal coliforms have been detected in raw water indicates that faecal material, either from grazing animals or slurry, is entering Black Lough. This in turn increases the potential risk of *Cryptosporidium* entering the raw water supply.

Cattle access to the lake should be immediately prevented by fencing off the perimeter of the lake. Alternatively, the GWS should consult with local landowners to determine what can be done to minimise the impact of grazing cattle on sloping lands bordering the lake.

There may also be a risk associated with septic tanks in the catchment if these are not adequately maintained or discharging into the lake.

The GWS should ensure that septic tanks are properly sited and maintained, in accordance with the Bye-Law on Wastewater Treatment Systems.

Clostridium perfringens is typically found in faecal matter and its presence is often used as an early warning of the potential for *Cryptosporidium* contamination.

The GWS should include *Clostridium perfringens* in its monthly sampling programme as it is often used as an indicator of potential *Cryptosporidium* contamination.

7. Sampling protocols

7.1 Raw water sampling protocols

Maximum allowable limits for raw water parameters were determined following sampling by T.J. O'Connor and Associates, Cavan County Council and the National Drinking Water Monitoring Committee in 2001-2003 as part of the tender process for the DBO contract. Tables 1-4 (Appendix 2) present these limits. Deviations of + 20% in these limits are permitted under the current DBO contract but exceedances are the responsibility of the GWS. The raw water parameters measured by Veolia Water Ltd. (e.g. iron, manganese, turbidity and colour) provide valuable information but are not widely used as indicators of water quality and tend only to become important when there are aesthetic concerns about water e.g. appearance, taste.

A programme of monthly raw water sampling of relevant parameters should be conducted by the GWS over a 12 month period at the lake. Parameters should include faecal and total coliforms, *Clostridium*, pH, chlorophyll-a, conductivity, colour, dissolved oxygen, *E. coli*, pH, turbidity, transparency, ammonia, nitrite, nitrate, total nitrogen, orthophosphate, total phosphorus, iron, manganese and suspended solids.

Operational staff should be properly trained in sampling techniques by collaborating with an accredited laboratory.

Apart from weekly sampling of raw water by Veolia, additional sampling of the lake takes place infrequently. The absence of a continuous monitoring programme may miss important events that could impact on water quality e.g. heavy rainfall events when large amounts of P and faecal matter could potentially enter the lake. In addition, lake dynamics change with season; stratification generally occurs in summer while mixing of water occurs under cooler temperatures in winter. Such seasonality can influence water quality parameters.

Lake sampling needs to be conducted on a more frequent basis to gain a real understanding of lake chemistry and to avoid missing pollution events. It is recommended, in addition to monthly monitoring and sampling, that the GWS takes lake samples following specific events e.g. storms, forestry removal, land-spreading, in the area.

8. Recommendations

8.1 Preliminary source protection measures - recap

1. The GWS should endeavour to determine the extent of the groundwater contribution to the lake. This could be achieved through liaison with Cavan County Council who have some mapping information (as discussed with Colm O'Callaghan, Environment section) and the source protection unit of the Geological Survey of Ireland (Taly Hunter-Williams).
2. Assessment of the nutrient status of soils within the lake catchment would involve a field survey which was not within the scope of this report but should be prioritised by the GWS on a phased basis as part of a source protection plan and target areas of vulnerability.
3. The degree of slope within the catchment needs to be considered further as part of a source protection plan.
4. An assessment needs to be carried out on drainage so that intercepting piping or a ditch can be positioned to divert run-off away from the lake (e.g. into a wetland or buffered area) if necessary.
5. The GWS should ensure that local farmers adhere to the Code of Good Agricultural Practice (see Appendix 3). Any slurry pits in the catchment should be assessed to determine if they are in good working condition or present a threat to water quality. Grazing and slurry/fertiliser spreading should not take place near areas of exposed bedrock. The GWS might approach landowners to discuss the possibility of controlling grazing in lands immediately adjacent to the lake, or leasing/purchasing land that would act as a buffer strip.

6. In cooperation with householders, the GWS should ask the County Council to assess the potential risk posed by wastewater treatment systems in the catchment. This should determine if they are adequately maintained and/or adhere to the conditions of the Bye-Laws.

7. The scheme needs to ensure that current levels of faecal contamination are contained and reduced. This will require on-going monitoring as well as assessment of the sources of such contamination.

8. The Code of Good Agricultural Practice (see Appendix 3) should be complied with when organic manure and chemical fertiliser are being spread. The GWS should encourage homeowners to reduce their use of phosphate washing powders and detergents, or replace these with phosphate-free alternatives.

9. Cattle access to the lake should be immediately prevented by fencing off the perimeter of the lake. Alternatively, the GWS should consult with local landowners to determine what can be done to minimise the impact of grazing cattle on sloping lands bordering the lake.

10. The GWS should ensure that septic tanks are properly sited and maintained, in accordance with the Bye-Law on Wastewater Treatment Systems.

11. The GWS should include *Clostridium perfringens* in its monthly sampling programme as it is often used as an indicator of potential *Cryptosporidium* contamination.

12. A programme of monthly raw water sampling of relevant parameters should be conducted by the GWS over a 12 month period at the lake. Parameters should include faecal and total coliforms, *Clostridium*, pH, chlorophyll-a, conductivity, colour, dissolved oxygen, *E. coli*, pH, turbidity, transparency, ammonia, nitrite, nitrate, total nitrogen, orthophosphate, total phosphorus, iron, manganese and suspended solids.

13. Operational staff should be properly trained in sampling techniques by collaborating with an accredited laboratory.

14. Lake sampling needs to be conducted on a more frequent basis to gain a real understanding of lake chemistry and to avoid missing pollution events. It is recommended, in addition to monthly monitoring and sampling, that the GWS takes lake samples following specific events e.g. storms, forestry removal, land-spreading, in the area.

15. The GWS should erect signage around Black Lough to indicate that the lake is a drinking water source and should be respected as such. Signs should state that motor-powered vehicles (e.g. boats, jet-skis) are not permitted on the lake. Signs should also state that boats be thoroughly cleaned before entering the lake to avoid the introduction of invasive species to the lake e.g. *Lagarosiphon major* (Curly-leaved waterweed).

8.2 Agriculture

Guidelines and recommendations on environmental mitigation of agricultural practices are outlined in Appendix 3.

8.3 Cryptosporidium *Risk Assessment*

The recommendations of the Risk Assessment by Jennings O'Donovan should be implemented in conjunction with those outlined above. The report should be consulted for a full list of recommendations.

Appendices

Appendix 1: Groundwater body description

Cavan Groundwater Body: Summary of Initial Characterisation

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km2)
Hydrometric Area 36 Cavan Co. Co. Monaghan Co. Co. Longford Co. Co. Leitrim Co. Co.	***Rivers:*** Annalee, Bunnoe, Cavan, Cullies, Dromore, Finn, Knappagh, Erne, Stradone, Laragh, Magheramey. ***Streams:*** Aghnacliffe, Avaghon Lake Stream, Laheen, Legga, Madabawn, 1100 unnamed. ***Lakes:*** see list below *	Lough Oughter and associated lakes (O'Riain, 2004)	1410

Topography

This large, SW-NE aligned GWB is bounded to the south, east and west by the topographic divide (Hydrometric Area 36). The northern boundary comprises more productive aquifers. The entire GWB is characterised by drumlin topography. Inter-drumlin elevations generally range from 5 mAOD around Lough Oughter (Killashandra GWB), to c.250 mAOD in the southeast. The drumlin peaks are generally an additional 40-60 m. There are also three higher areas in western and central region of the GWB, the highest of which rises to c.300 mAOD. Surface water generally feeds from the periphery of the GWB towards Lough Oughter, which then flows northwards towards Lough Erne.

Geology and Aquifers	
	Aquifer type(s) The vast majority of the GWB (c.98%) comprises **Pl:** Poor aquifer, generally unproductive except for local zones. In the southwest, there is a small area of **Ll:** Locally important aquifer, moderately productive only in local zones, and there is also a small outlier of **Lm:** Locally important aquifer, generally moderately productive, in the centre of the GWB.
	Main aquifer lithologies Essentially split by a SW-NE line across this GWB, the northern area is dominated by Ordovician Metasediments (54.22% of GWB) and the south by Silurian Metasediments and Volcanics (41.97%). Other rocks of note are two areas of Granites & other Igneous Intrusive Rocks (1.34%) and thin bands of Ordovician Volcanics (<0.5%) in the southern area. There are also Dinantian age rocks (2.17%) in the southwest and as the central outlier. Refer to Table 1 for details.
	Key structures. Being part of the Longford-Down Inlier, the rocks in this part of the country have been significantly deformed, resulting in a large number of approximately SW-NE faults with associated perpendicular faults e.g. Carrickateane, Orlock Bridge, Kehernagilly and Laragh Faults. Dips in the rock succession are variable but overall, appear to be to the SE by up to 80°.
	Key properties Yields in this GWB are available for 65 wells and range from 4.4-1091 m^3/d, averaging 143 m3/d. Of these, 3 have 'excellent' yields – 2 of which are located on a mapped fault – and 39 have 'good' yields, approximately half of which are in faulted zones. Only 3 specific capacity values are available for the higher yields, all of which are quite low: 6, 7 and 12 m^3/d/m. These low specific capacities result in low productivity values for these wells (III; IV and IV). For the remaining poorer yielding wells, specific capacity values range from 0.1-19.9 m^3/d/m, averaging 4.3 m^3/d/m over are 23 values. Only one transmissivity value is available for this GWB: 0.23 m^2/d for a low yielding well. The national transmissivity data for these rocks are also low (<20 m^2/d in most rocks) or possibly moderate in the Silurian rocks (20-80 m^2/d). However, higher values may be achieved in faulted zones, especially in the coarser-grained rocks, which may be exemplified by the 'excellent' and 'good' yields. The available specific dry weather flows are low, ranging from 0.01-0.55 l/s/km^2 (6 stations), suggesting that

	these aquifers do not make a significant baseflow contribution to streamflow. Storativity is also expected to be low. Of the c.320 available groundwater levels, 60% are 0-3 m below ground level and just over 12% area greater than 10 m bgl, indicating that flow is predominantly shallow. Groundwater gradients have not been calculated by are expected to be relatively steep. *(Ordovician Aquifer Chapter; Silurian Aquifer Chapter*)
	Thickness Most groundwater flux will be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3 m thick, as indicated by the predominantly shallow water levels, a zone of interconnected fissuring around 10 m thick, and a zone of isolated poorly connected fissuring typically less than 150 m. Water strikes of between 30-40 m bgl are noted 5 boreholes and an additional borehole ('good' yield) has strikes recorded at 43 and 82 m bgl. This suggests some deeper flow component, although it is likely to be very limited.
Overlying Strata	**Lithologies** The GWB is predominantly covered by till subsoil (71%), with a smaller proportion of peat (9%). Approximately 10% of the body is mapped as rock outcrop/shallow subsoil. There are no data for the western end of the GWB (c.4% of the area).
	Thickness Across the GWB, outcrop and borehole data suggest that the drumlins appear to represent a thicker deposit, frequently >10 m thick, with rock nearer the surface of the inter-drumlin areas. Generally, the southern half of the GWB has shallower subsoil.
	% area aquifer near surface *[Information will be added at a later date]*
	Vulnerability From the Monaghan GWPS, the vulnerability is predominantly classed as Extreme in the southeast of the GWB, and Low in the northeast, where deposits are less permeable and thicker. No data are available for Cavan or Leitrim however, the similar topography and outcrop distribution may suggest a similar pattern of vulnerability.
Recharge	**Main recharge mechanisms** Diffuse recharge occurs via rainfall percolating through the thinner/more permeable subsoil and via outcrops. Due to the low permeability of some of the subsoil (thicker till and peat) and the aquifers in the GWB, a high proportion of the available recharge will discharge to the streams in the GWB. In addition, the steep drumlin slopes will promote surface runoff. The high stream density is likely to be influenced by the lower permeability rocks as well as the subsoil.
	Est. recharge rates *[Information will be added at a later date]*
Discharge	**Important springs and high yielding wells** ***Sources:*** None identified. ***Springs:*** None identified. ***Excellent Wells:*** Cooltrimegish (1091 m^3/d), Sallaghan (523 m^3/d), Corrachulter (436 m^3/d). ***Good Wells:*** Drumloo (327 m^3/d), Milltown (273 m^3/d), Dromod (262 m^3/d), Tirquin (259 m^3/d), Poles (245 m^3/d), Corglass (218 m^3/d), Dernaroy (218 m^3/d, 196 m^3/d), Drumaveale (218 m^3/d), Drumgola (218 m^3/d), Garrybane (218 m^3/d), Drumauna (218 m^3/d), Ardlougher (196 m^3/d), Drollagh (190 m^3/d), Fastry (173 m^3/d), Killycannan (153 m^3/d), Killgary (153 m^3/d), Tullyvin (149 m3/d, 120 m^3/d), Annagelliff (131 m^3/d), Bruse (131 m^3/d), Brusky (131 m^3/d), Carrickboy (131 m^3/d), Cootehill (131 m^3/d), Lismagratty (131 m^3/d), Tievenanass (131 m^3/d), Tullnahinnera (131 m3/d, 118 m^3/d), Unshinagh (131 m^3/d), Corduff (126 m^3/d), Turfad (120 m^3/d), Ardvarny (112 m^3/d), Clonoose (109 m^3/d), Derrycassan (109 m^3/d), Lisnacark (109 m3/d), Moyne (109 m^3/d), Mullaghoran (109 m^3/d), Tullnanegish (109 m^3/d), Carrickallen (103 m^3/d).

	Main discharge mechanisms The main groundwater discharges are to the lakes and rivers and streams crossing the GWB, reflecting short groundwater flow paths. Small springs (of which a number are recorded) and seeps are likely to issue at the stream heads and along their course. Groundwater may also flow into the adjacent, higher permeability (Lm) GWB.
	Hydrochemical Signature ***National classification:*** Ordovician/Silurian Metasediments Non-calcareous. Ca-Mg-HCO_3 signature. However, Cavan and Monaghan also have Ca-Mg-SO_4 recorded. Alkalinity (mg/l as $CaCO_3$): range of 9-470; mean of 172 (445 'non limestone subsoils' data points) Total Hardness (mg/l): range of 5-481; mean of 222 (389 'non limestone subsoils' data points) Conductivity (μS/cm): range of 80-477; mean of 490 (477 'non limestone subsoils' data points) *(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)*

Groundwater Flow Paths

In the absence of inter-granular permeability, groundwater flow is expected to be concentrated in fractured and weathered zones and in the vicinity of fault zones. Available groundwater levels are mainly 0-10 m below ground level (60% <3 mbgl). Flow paths are likely to be short (30-300 m) with groundwater discharging rapidly to nearby lakes, streams and small springs. There are observed deeper water strikes, indicating that there is a component of deep groundwater flow, however shallow groundwater flow is thought to dominant. Groundwater flow directions are expected to follow topography – overall in a northerly direction.

Groundwater & surface water interactions

Groundwater will discharge locally to streams and rivers crossing the aquifer and also to small springs and seeps. Owing to the poor productivity of the aquifers in this body it is unlikely that any major groundwater - surface water interactions occur. Baseflow to rivers and streams is relatively low.

Conceptual model

This large, SW-NE aligned GWB is bounded to the south, east and west by the topographic divides (Hydrometric Area 36). The northern boundary comprises more productive aquifers. The entire GWB is characterised by drumlin topography. Inter-drumlin elevations generally range from 5 mAOD to c.250 mAOD. There are also three higher areas in western and central region of the GWB, the highest of which rises to c.300 mAOD.

The GWB is composed primarily of low transmissivity rocks. Most of the groundwater flux is in the uppermost part of the aquifer: comprising a broken and weathered zone typically less than 3m thick; a zone of interconnected fissuring typically less than 10m; and a zone of isolated fissuring typically less than 150m.

Recharge occurs diffusely through the thin/permeable subsoil and via outcrops, although is limited by ay thicker low permeability subsoil and the low permeability bedrock itself. Therefore, most of the effective rainfall is not expected to recharge the aquifer.

Flow paths are likely to be short (30-300 m) with groundwater discharging rapidly to the lakes and streams crossing the aquifer, and to small springs and seeps. Overall, the flow direction is expected to be to the north and east, as determined by the topography.

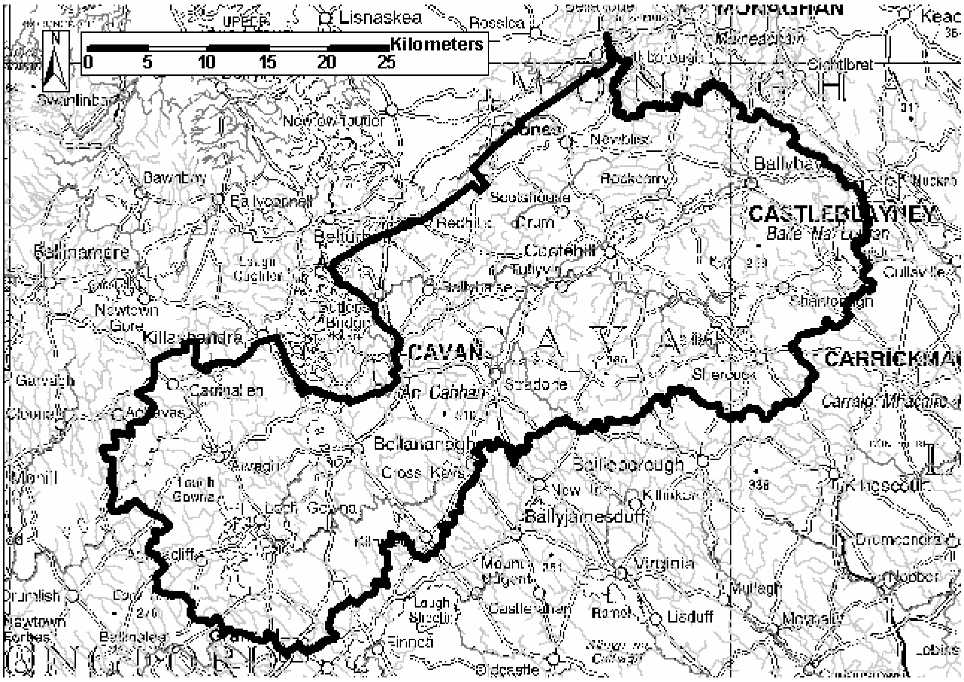
Instrumentation

Stream gauges: 36010*, 36011*, 36012 *, 36015* (Present but not representative of flow in this GWB), 36016*, 36017*, 36018*, 36024, 36030, 36031, 36037, 36038, 36039, 36044, 36070, 36072, 36074, 36075, 36076, 36077, 36078, 36079, 36080, 36081, 36082, 36085, 36120, 36121, 36122, 36123, 36124, 36125, 36126, 36127, 36130, 36135, 36136, 36137, 36138, 36139, 36141, 36143, 36145, 36146, 36147, 36149, 36150, 36151, 36152, 36153, 36155, 36157, 36172, 36173, 36174, 36182, 36183, 36184, 36190, 36192, 36193, 36194, 36195, 36196, 36197, 36198.

*Adjusted dry water flow data available for these

EPA Water Level Monitoring boreholes: CAV141 (on boundary with Killashandra GWB), CAV161

EPA Representative Monitoring points: CAV26, LEI67, MON14, MON17, MON18, MON19, MON23, MON28, MON29, MON31, MON44, MON46, MON53, MON55.



Location and boundaries of Cavan GWB

Appendix 2: Raw water sampling results

Raw water sampling data for Black Lough have been recorded by T.J. O'Connor and Associates, National Drinking Water Monitoring Programme, Cavan County Council (Environment Section), Veolia Water Ireland Ltd. and City Analysts.

Baseline data

Baseline parameter values for raw water in Black Lough were provided by T.J. O'Connor and Associates and the National Drinking Water Monitoring Programme, and are presented in Tables 1-3.

Table 1 Raw water results (T.J. O'Connor and Associates)

Parameter	Units	09/10/2002	05/11/2002	04/12/2002	27/01/2003	25/02/2003	12/03/2003	09/04/2003	22/05/2003	18/06/2003	17/07/2003	MAX
Alkalinity (bicarbonate)	**mg/l HCO_3**								<5			**6**
Alkalinity (total)	**mg/L $CaCO_3$**	132	71	72	74	68	61	65	53			**158.4**
Aluminium	**µg/L**			<0.02			0.057		<6.6			**667.2**
Aluminium (dissolved)	**µg/L**								<6.6			**7.92**
Ammonia	**mg/L as N**	0.14	0.38	0.06	0.09	0.12	0.08	0.03	0.29	0.1	0.16	**0.612**
Antimony	**µg/L**								<1.4			**1.68**
Arsenic	**µg/L**	<0.005	<0.005	0.3	0.3	2.3	1	0.4	0.4			**2.76**
Barium	**mg/L**	<0.03	0.038	17.4	22.9	0.32	0.026	0.021				**27.48**
Boron	**µg/L**								4.1			**4.92**
Bromide	**mg/L**	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5			**0.6**
Cadmium	**µg/L**	<0.003	<0.003	<0.1	<0.1	<0.1	0.5	<0.1	<0.4			**0.6**
Calcium	**mg/L**								23.05			**27.66**
Carbon dioxide	**mg/L**								40			**48**
Chloride	**mg/L**								13			**15.6**
Chlorophyll	**mg/m^3**	150	18.7	20.1	10.8	17.2	18.7	5.3	<3.0	16.2	26.2	**180**
Chromium	**µg/L**	129	<0.02	0.08	<0.001	0.001	0.001	<0.001	<2.0			**154.8**
Clostridia	**no/ml**								6			**45.6**
Coliforms (total)	**no/ml**	0	42	22	13	0	4	0	69	0	8	**156**
Coliforms (faecal)	**no/ml**	0	1	6	9	0	0	0		0	0	**36**
Colour (apparent)	**PtCo**	30	46	41	32	33	27	35	23	40	43	**157.2**
Colour (true)	**PtCo**								21			**25.2**
Conductivity	**$\mu S/cm^{-1}$ @ 25°C**	183	156	154	159	165	173	159	166			**442.8**
Copper	**µg/L**								<2.8			**3.36**
Cryptosporidium	**no/ml**	0	0	0	0	0	0	0	0			**0**
Cyanide	**µg/L**								<3			**3.6**
DOC	**mg/L**								7			**8.4**
DO	**mg/L**	7.7	9.4	9.6	9.8	9.8	11.6	10.8	10.1			**13.92**
E coli	**no/100ml**								67			**80.4**
Fluoride	**mg/L**								0.08			**0.096**
Hardness (bicarbonate)	**mg/L $CaCO_3$**	<5	<5	<5	<5	<5	5	<5				**6**
Hardness (total)	**mg/L $CaCO_3$**	75	55	51	68	71	66	62	64			**90**
Iron (dissolved)	**mg/L**								<0.002			**0.0024**
Iron (total)	**mg/L**	0.35	0.24	0.307	0.177	0.545	0.243	0.01	<0.002	0.119	0.032	**0.654**
Lead	**µg/L**								<0.6			**0.72**
Magnesium	**mg/L**								3.78		0.013	**4.536**
Manganese	**mg/L**	0.284	0.125	0.067	0.042	0.093	0.054	0.007	<0.0002	0.183		**0.3408**
Manganese (dissolved)	**mg/L**								<0.004			**0.0048**
Mercury	**µg/L**	<0.0005	<0.0005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.4			**0.48**
Nickel	**µg/L**								<9.9			**11.88**
Nitrite	**mg/L as N**	0.028	0.1	<0.005	0.019	0.016	0.018	<0.005	0.027			**0.12**

Parameter	Units	09/10/2002	05/11/2002	04/12/2002	27/01/2003	25/02/2003	12/03/2003	09/04/2003	22/05/2003	18/06/2003	17/07/2003	MAX
Nitrate	**mg/L as N**	0.09	0.29	0.13	0.05	0.77	0.03	<0.02	<0.04			**1.56**
Pesticides (organochlorine)	**µg/L**	<0.1							<0.1			**0.12**
Pesticides (organophosphorus)	**µg/L**								<0.1			**0.12**
pH		8.7	7.3	7.1	7.4	7.4	7.5	7.3	7.3	7.1	7.7	**10.44**
Orthophosphate	**mg/L as P**		0.026	0.039	0.016	0.01	0.009	0.006	<0.002			**0.0468**
Phosphate (total)	**mg/L as P**	0.062	0.05	0.07	0.043	0.054	0.106	0.052	0.424			**0.5088**
PAH	**µg/L**								<1			**1.2**
Potassium	**mg/L**								2.75			**3.3**
Pseudomonas	**no/100ml**								0			**0**
Selenium	**µg/L**								<4.6			**5.52**
Semivolatile organic compounds	**µg/L**								<1			**1.2**
Silica	**mg/L as Si**			5.9					3.2			**7.08**
Sodium	**mg/L**								7.79			**9.348**
Solids (total dissolved)	**mg/L**	124	142	86	95	122	122	86	110			**170.4**
Sulphate	**mg/L as SO_4**			<5					<5			**6**
Temperature		14.3	8.6	6.8	8.4	6.4	7.8	11.9	12.4			**17.16**
TOC	**mg/L**	9	7	10	9	36	7	11	8	10.3	<1.0	**43.2**
Turbidity	**NTU**	4.36	7.23	4.59	3.88	2	3.71	9.3	4.65	6.92	4.98	**27.6**
UV abs	**Abs**	0.238	0.27	0.268	0.2255	0.1886	0.192	0.2104	0.2181	0.268	0.245	**0.324**
Volatile organic compounds	**µg/L**								<1			**1.2**
Zinc	**mg/L**								<0.007			**0.0084**

MAX = Maximum values (+20%) recorded during baseline monitoring (by T.J. O'Connor and Associates, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant

National Water Monitoring Committee

The National Water Monitoring Committee conducted raw water sampling over a year from 2000-2001. Results of analyses are presented in Table 2.

Table 2 Raw water results (National Water Monitoring Committee)

Parameter	Units	Nov-00	Dec-00	Jan-01	Feb-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	MAX
Colour	**Ha**	63	72	25	37	63	31	131	40	40	72	125	**157.2**
Turbidity	**NTU**	14	16	4	11	13	4	23	5	9	12	19	**27.6**
Conductivity	**µs/cm^{-1}**	228	160	185	149	170	165	185	369	178	202	169	**442.8**
pH		7	7.3	6.8	6.7	7.2	7.3	7	8	8.4	7.4	7.4	**10.44**
Ammonia	**mg/L N**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.51	0.1	<0.1	<0.1	<0.1	**0.612**
Nitrate	**mg/L N**	1.3	<0.5	<0.5	<0.5	<0.45	<0.45	<0.45	<0.5	<0.5	<0.5	<0.5	**1.56**
Nitrite	**mg/L N**	0.017	0.011	0.007	<0.006	0.015	<0.012	0.01	<0.01	0.017	<0.01	0.013	**0.12**
Aluminium	**µg/L**	17	<0.7	<0.7	<0.7	5	556	<0.7	<0.7	<0.7	<0.7	27	**667.2**
Iron	**mg/L**	0.048	0.065	0.015	0.102	0.175	0.271	0.087	<0.00009	0.236	<0.00009	0.011	**0.654**
Manganese	**mg/L**	0.014	<0.00003	<0.00003	0.004	0.149	0.229	0	0	0.137	0.001	0	**0.3408**
Total Coliforms	**0/100ml**	130	0	0	0	0	19	0	0	8	42	3	**156**
Faecal Coliforms	**0/100ml**	30	0	0	0	0	7	0	0	0	29	1	**36**

MAX = Maximum values (+20%) recorded during baseline monitoring (by T.J. O'Connor and Associates, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant

National Drinking Water Monitoring Programme

The National Drinking Water Monitoring Programme carried out water sampling on Black Lough on 15th November 2002. Results are presented in Table 3.

Table 3 National Drinking Water Monitoring Programme

Parameter	Units	15/11/2002	MAX
Total coliforms	no per 100 ml	38	**156**
Clostridia perfringens	no per 100 ml	38	**45.6**
E coli	no per 100 ml	14	**80.4**
Colour	PtCo	56	**157.2**
Turbidity	NTU	6.03	**27.6**
pH		7.5	**10.44**
Conductivity	$\mu S/cm^{-1}$	127	**442.8**
Aluminium	mg/L	<20	**667.2**
Iron	mg/L	0.31	**0.654**
Manganese	mg/L	0.247	**0.3408**
Nitrite	mg/L N	0.005	**1.56**
Nitrate	mg/L N	0.289	**0.12**
Ammonia	mg/L N	0.023	**0.612**

MAX = Maximum values (+20%) recorded during baseline monitoring (by T.J. O'Connor, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant

Virginia Laboratories Services Ltd.

Virginia Laboratories carried out sampling on Black Lough on one occasion in October 2001. Results are presented in Table 4.

Table 4 Raw water results (Virginia Laboratories)

Parameter	Units	28/10/2001	MAX
Odour		Peaty	
Taste		Boggy	
Turbidity	FTU	20.7	**27.6**
Temperature	℃	4	
Conductivity	µS/cm	140	**442.8**
pH		7.32	**10.44**
Nitrates	mg/L	0	**1.56**
Ammonia	mg/L	0	**0.612**
Colour		Slight brown	
Iron	mg/L	0	**0.654**
Manganese	mg/L	0.02	**0.3408**
Phosphate	mg/L as P	0	**0.508**
Total hardness	mg/L as $CaCO_3$	65.3	
Total coliforms	no./ml	20	**156**
Faecal coliforms	no./ml	23	**36**

MAX = Maximum values (+20%) recorded during baseline monitoring (by T.J. O'Connor, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant

Veolia Water Ireland Ltd.

Raw water sampling is currently carried out by Veolia at the treatment plant. One sample is taken weekly. The weekly analysis is carried out in an internal laboratory and results are available from 2006 onwards (Table 5). Parameters analysed include iron, manganese, colour, pH, alkalinity and turbidity. Exceedances in these are generally of aesthetic concern rather than important indicators of water quality *per se*. Alkalinity is a measure of the buffering capacity of water, i.e. its ability to neutralise the effects of acids e.g. acid rain.

External sample analysis is undertaken by City Analysts in Dublin (Table 6). Parameters such as nutrient concentrations and bacterial counts were analysed. Nitrates (NO_3) and phosphates (PO_4) indicate the organic matter loading in surface water. Faecal coliforms indicate the presence of human or animal faecal matter in water, while total coliforms are a measure of the presence of both faecal coliforms and coliforms of other origin (e.g. soil).

Table 5 Raw water results (Veolia)

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	**m^3**	**m^3/day**	**m^3/hr**	**PtCo**	**PtCo**	**NTU**	**mg/L**	**mg/L**	**mg/L**		**mg/L**
Limits†					**20**		**0.2**	**0.05**		**5.5-8.5**	
Limits§				**157.2**	**25.2**	**27.6**	**0.654**	**0.341**	**0.612**	**10.44**	**158.4**
Date											
04/01/2006	11643.8	301.00	19.9	30	14	3.4	0.143	0.079		6.88	69.6
10/01/2006	13437.3	298.00	19.906	95	27	3.8	0.146	0.051		7.67	89.6
17/01/2006	15268.8	320.00	20.11	38	14	3.5	0.103	0.042		7.57	82.8
24/01/2006	16714.5	311.00	20.064	40	17	3.5	0.255	0.180		7.58	94.6
30/01/2006	18133.8	237.00	20.1	51	18	4.2	0.255	0.270		n/a	86.6
07/02/2006	19694.3	195.06	20.402	74	22	4.5	0.248	0.220		7.58	85.3
14/02/2006	21562.6	266.90	22.821	97	22	3.4	0.059	0.062		7.97	86
22/02/2006	23632.4	258.73	20.159	72	15	5.9	0.085	0.030		8.37	85.4
01/03/2006	25036.2	200.54	20.162	141	26	4.6	0.137	0.049		8.4	94.8
06/03/2006	26194	231.56	20.119	50	19	4.2	0.527	0.050		7.04	93
13/03/2006	28278.5	297.79	25	45	22	3.04	0.071	0.073		7.89	67
20/03/2006	30596	331.07	25.1	55	15	3.56	0.060	0.066		8.18	64
27/03/2006	32108	216.00	26	41	5	2.74	0.054	0.053		8.16	64
03/04/2006	33563	207.86	24.8	51	40	3.51	0.063	0.108		8.02	65.3
11/04/2006	35090	190.88	24.6	36	18	2.36	0.049	0.082		7.58	74
19/04/2006	36498	176.00	23.277	58	23	3.88	0.058	0.111		8.03	73.6
25/04/2006	37666	194.67	24.1	71	22	3.16	0.078	0.131		7.49	65.6
02/05/2006	38970	186.29	24.5	60	30	2.53	0.088	0.066		7.25	69.6
09/05/2006	39966	142.29	25.1	43	17	3.17	0.094	0.073		7.76	81
15/05/2006	41006	173.33	24.4	37	16	2.47	0.085	0.078		7.89	74
22/05/2006	42025	145.57	24.4	43	19	3.89	0.027	0.112		7.35	76
06/06/2006	44977	208.38	24.47	61	39	2.5	0.032	0.067		7.65	71.2
12/06/2006	46334.6	226.27	24.908	74	35	4.62	0.091	0.130		7.43	72.8
20/06/2006	47850	189.43	24.36	91	45	4.03	0.087	0.175		7.73	79.2
27/06/2006	49252	200.29	24.7	94	44	4.25	0.106	0.161		7.7	77.6
04/07/2006	50707	207.86	25.1	118	38	5.59	0.075	0.344		7.21	82.8
12/07/2006	52865	269.75	25.1	157	65	5.36	0.167	0.198		7.69	78.4
18/07/2006	54299	239.00	25.1	68	51	3.25	0.048	0.068		7.5	80.4
24/07/2006	55926	271.17	24.9	71	48	3.7	0.126	0.188		7.34	83.2
01/08/2006	57765	207.86	25.1	99	46	18.2	0.264	0.061		7.46	80.8
09/08/2006	59451	269.75	25.1	81	39	22.7	0.191	0.384		8.51	80.4
15/08/2006	60572	239.00	25.1	148	43	14.2	0.097	0.072		7.73	83
21/08/2006	61895	271.17	24.9	71	12	5.37	0.145	0.281		7.33	90
29/08/2006	63102			87	41	10.2	0.381	0.381		7.66	85.2
04/09/2006	64126	170.00	25.1	53	27	7.98	0.088	0.249		7.33	79.6
11/09/2006	65466	191.00	25.1	49	21	7.19	0.117	0.136		7.52	63.2
18/09/2006	66939	210.00	25.1	54	8	7.36	0.260	0.387		7.46	80.8
26/09/2006	68713	222.00	25.4	53	13	4.92	0.070	0.078		7.38	92.6
05/10/2006	70221	167.56	25.4	25.4	37	4.74	4.740	0.065		7.8	92.6
12/10/2006	71292	153.00	25	25	53	6.68	6.680	0.248		7.62	76.4
17/10/2006	72144	170.40	25.9	25.9	81	4.7	4.700	0.263		7.24	69.2
24/10/2006	73230	155.14	25.45	25.45	84	4.8	4.800	0.339		7.2	77.6
01/11/2006	74346	139.50	24.534	99	26	4.7	4.700	0.197		7.47	83.2
06/11/2006	75331	197.00	25.1	82	24	3.8	3.800	0.180		7.21	83
13/11/2006	76530	171.29	25.7	64	13	4.6	4.600	0.154		7.27	83.2
21/11/2006	78027	187.13	25.6	120	16	9.8	9.800	0.100		6.2	61.2
05/12/2006	80551	178.88	25.5	40	11	1.8	1.800	0.200		7.67	72
12/12/2006	81816	180.71	26.2	229	70	4.3	4.300	0.105		7.52	136.4
19/12/2006	83097	183.00	26	244	111	3.2	3.200	0.100		7.75	76
02/01/2007	85735	188.43	26	69	51	5.7	5.700	0.148		7.65	67.2
09/01/2007	87012	182.43	25.27	58	47	5.9	5.900	0.047		7.52	106.4
16/01/2007	88203	170.14	24.8	66	34	3.9	3.900	0.148		7.62	68
21/01/2007	89288	217.00	24.78	50	27	3.72	3.720	0.131		7.57	74
06/02/2007	92769	245.43	25.3	56	20	3.3	3.300	0.105		7.9	73.2
13/02/2007	94917	306.86	24.7	66	41	3	3.000	0.092		7.81	71
19/02/2007	96824	317.83	24.8	67	40	2.5	2.500	0.120		7.64	76.2
26/02/2007	98526	243.14	25.2	55	49	2.62	2.620	0.082		7.52	78.4
05/03/2007	100387	265.86	25	65	45	2.76	2.760	0.081		7.74	119.2
12/03/2007	102308	274.43	25	60	47	2.93	2.930	0.126		7.76	86

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	m^3	m^3/day	m^3/hr	PtCo	PtCo	NTU	mg/L	mg/L	mg/L		mg/L
21/03/2007	104708	266.67	25	62	40	3.08	3.080	0.100		7.9	85.6
27/03/2007	106344	272.67	25	65	51	2.87	2.870	0.092		7.94	74.2
02/04/2007	107727	230.50	27.2	46	32	2.4	2.400	0.099		7.54	103.2
12/04/2007	110561	283.40	25	44	38	2.18	2.180	0.069		7.73	88.4
18/04/2007	112014	242.17	25	10	5	2.14	2.140	0.070		7.56	100
23/04/2007	113480	293.20	25.8	43	31	1.98	1.980	0.045		7.59	96
01/05/2007	115619	267.38	24	25	25	1	1.000	0.028		7.01	99
09/05/2007	117827	276.00	25	16	10	2.7	2.700	0.075		7.51	97.4
14/05/2007	118923	219.20	24.6	29	17	4.16	4.160	0.044		7.61	80.8
21/05/2007	120462	24.60	26.4	24	13	3	3.000	0.040		7.45	77.4
07/06/2007	124561	244.33	25	67	41	n/r	n/r	0.146		n/r	79
12/06/2007	125997	287.20	25	21	9	3.62	3.620	0.035		8.37	75
21/06/2007	128065	229.78	26	29	11	4.58	4.580	0.158		n/a	73
25/06/2007	129004	234.75	25	50	32	5.77	5.770	0.075		7.64	84
10/07/2007				70	60	7.48	0.034	0.125		7.84	77
18/07/2007				107	7.74	0.058	0.090	0.025		7.69	56.08
24/07/2007				36	5.55	0.179	0.378	0.133		7.34	79.2
09/08/2007	139158	223.00	24	55	36	5.58	0.222	0.281	0	7.39	76.7
15/08/2007	140405	207.83	24.9	100	20	5.68	0.385	0.358	0	7.49	84.8
20/08/2007	141312	181.40	24.9	118	20	5.12	0.249	0.477	0.19	7.38	88
28/08/2007	143362	256.25	25.04	73	41	3.86	0.218	0.184	0.12	7.45	87
03/09/2007	144955	265.50	24.9	57	0	4.39	0.237	0.245	0	0	88
10/09/2007	146877	274.57	24.9	75	33	3.6	0.167	0.171	0	7.52	85
19/09/2007	149191	257.11	25	32	19	4.33	0.133	0.123	n/r	7.86	90
24/09/2007	150375	236.80	24.9	63	23	3.8	0.087	0.088	n/r	7.41	88
01/10/2007	152288	273.29	24.9	70	27	6.55	0.109	0.182	0.021	7.44	96.4
09/10/2007	154139	231.38	24.9	52	34	3.48	0.085	0.127	0.005	7.36	88
15/10/2007	155675	256.00	25.17	77	52	4.3	0.104	0.111	0.098	7.59	92
22/10/2007	157321	235.14	25.4	41	13	4.49	0.091	0.064	0.017	7.42	94
05/11/2007	160572	239.67	24.7	22	10	4.31	0.051	0.060	0.08	7.98	73.6
12/11/2007	161881	187.00	25.3	58	10	4.32	0.118	0.053	0.06	8.09	81.4
21/11/2007	164093	245.78	25	72	21	4.24	0.130	0.140	0.03	7.7	85
03/12/2007	167053	250.86	25	74	10	n/r	0.099	0.064	0		82
10/12/2007	168678	232.14	24.8	78	31	4.99	0.107	0.057	0	7.64	86.7
19/12/2007	170574	210.67	24.8	86	66	3.53	0.158	0.054	n/r	7.75	60
07/01/2008	174213	191.53	24.6	44	27	4.61	0.044	0.048	n/r		78.4
15/01/2008	175740	190.88	24.7	61	49	6.54	0.093	0.071	n/r	7.59	76
21/01/2008	176881	190.17	25	101	53	6.15	0.170	0.093	n/r	7.84	71
04/02/2008	179633	199.17	25.3	76	27	5.14	0.098	0.042	n/r	7.17	68
11/02/2008	181039	200.86	25	78	53	3.24	0.132	0.015	0.02	7.64	77.2
18/02/2008	182556	216.71	24.8	34	20	2.45	0.057	0.033	n/r	7.49	80.1
25/02/2008	184206	235.71	25	29	7	3.66	0.131	0.053	n/r	7.93	84
04/03/2008	185988	222.75	24.6	72	41	2.98	0.100	0.058	n/r	7.56	74.2
11/03/2008	187597	229.86	24.8	70	35	2.71	0.009	0.048	0	7.98	74
18/03/2008	189097	214.29	25	36	16	1.85	0.133		0.16	7.73	80
31/03/2008	192159	235.54	25	42	26	2.2	0.100	0.068		7.82	76.3
08/04/2008	193866	213.38	24.4	33	21	2.89	0.142	0.065		7.96	76.4
14/04/2008	195182	219.33	24.6	43	28	3.7	0.105	0.056		7.73	82
21/04/2008	196795	230.43	24.8	46	18	3.43	0.073	0.024		7.7	78.4
29/04/2008	198583	223.50	24.6	48	22	1.15	0.112	0.088		7.36	77
06/05/2008	200126	220.43	25	40	20	3.53	0.090	0.045	0.04	7.82	76.4
13/05/2008	202069	277.57	25.4	47	28	4.22	0.011	0.036		7.74	76.8
20/05/2008	203839	252.86	24.6	73	31	8.58	0.108	0.258		7.28	78.8
26/05/2008	205395	259.33	25	65	27	8.81	0.089	0.203			84.8
04/06/2008	207675	253.33	24.8	72	26	4.89	0.072	0.187		7.46	88.8
09/06/2008	208920	249.00	25	44	18	6.54	0.042	0.107		7.03	84.8
19/06/2008	210946	202.60	24.4	33	20	4.25	0.084	0.052		7.32	85.6
24/06/2008	212980	406.80	24.8	35	29	4.89	0.153	0.306	0.1	7.45	87.6
07/07/2008	216535	240.43	26	33	16	3.67	0.365	0.261	0.05	7.77	81.6
14/07/2008	218175	234.29	24.6	40	21	3.27	0.323	0.222	0.07	7.57	84
21/07/2008	220025	264.29	25.1	43	21	5.52	0.410	0.179	0.09	7.63	82.4
28/07/2008	221925	271.43	24.8	77	13	9.63	0.340	0.153		7.67	83.2
05/08/2008	223672	218.38	24.7	39	26	4.18	0.159	0.080		7.68	80.4
12/08/2008	225161	212.71	24.9	70	22	4.35	0.151	0.177		7.62	82
19/08/2008	226732	224.43	24.6	144	56	5.07	0.166	0.452		7.27	80
25/08/2008	228200	244.67	25.3	68	34	3.89	0.150	0.114		7.42	81.4

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	m^3	m^3/day	m^3/hr	PtCo	PtCo	NTU	mg/L	mg/L	mg/L		mg/L
04/09/2008	230383	218.30	24	78	20	4.42		0.233		7.73	80
08/09/2008	231598	303.75	25	132	43	8		0.286			82.4
16/09/2008	233331	216.63	25.6	124	28	4.4		0.406		7.42	87.6
23/09/2008	234924	227.57	25	97	34	4.2		0.196	0.02	7.65	85.2
06/10/2008	237606	214.86	24.8	70	20	3.61	0.164	0.128		7.73	83.2
14/10/2008	239055	181.13	25.2	82	30	3.39	0.166	0.100		7.72	82
20/10/2008	240145	181.67	25.1	71	20	3.41	0.100	0.059	0.06	7.59	86.4
28/10/2008	241645	187.50	25.7	57	24	3.62	0.145	0.072		7.41	81.6
03/11/2008	242955	218.33	25	90	38	3.85	0.238	0.082		7.53	80.8
11/11/2008	244532	197.13	25	82	30	2.97	0.210	0.051		7.6	89.4
17/11/2008	245772	206.67	24.9	87	36	2.77	0.128	0.050	0.02	7.52	82.8
21/11/2008	247397	406.25	25.7	50	28	2.51	0.149	0.073		7.81	83.6
03/12/2008	249207	150.83	25	47	26	2.32	0.120	0.050		7.73	86.6
10/12/2008	251121	273.43	24.9	56	22	2.4	0.200	0.096		7.73	84.2
17/12/2008	252961	262.86	24.8	53	29	2.48	0.124	0.100		7.67	79.8
29/12/2008	256211	270.83	24.6	50	26	2.44	0.130	0.095		7.74	83.6
06/01/2009	257866	206.88	25	51	29	3.04	0.121	0.154		7.29	81.6
12/01/2009	259385	253.17	24.7	48	25	2.41	0.120	0.080		7.73	91.6
19/01/2009	261278	270.43	24.9	51	27	4.15	0.097	0.065		7.82	79.8
26/01/2009	263196	274.00	24.8	47	25	2.63	0.099	0.060	0.15	7.89	76.4
02/02/2009	264490	184.86	24.9	44	20	3.68	0.087	0.050		7.64	78
10/02/2009	266241	218.88	24.8	49	27	3.65	0.094	0.049		7.59	108
16/02/2009	267671	238.33	24.2	51	41	2.52	0.093	0.042		7.53	76
23/02/2009	269113	206.00	24.9	44	21	2.26	0.028	0.070		7.39	72.8
02/03/2009	270540	203.86	24.9	32	24	2.19	0.015	0.044		7.84	72.8
11/03/2009	272402	206.89	24.5	41	20	3.39	0.076	0.038		7.76	69.2
16/03/2009	273252	170.00	25	28	20	1.8	0.070	0.037		8.06	76.8
23/03/2009	274700	206.86	25	30	20	1.56	0.120	0.035	0.06	8.15	83.8
06/04/2009	277444	204.67	24.5	28	25	1.39	0.021	0.024		8.15	72.8
15/04/2009	279300	206.22	25	33	27	1.19	0.042	0.036		8.14	73.6
20/04/2009	280422	224.40	24.8	31	27	1.38	0.061	0.032		8.3	78.8
27/04/2009	281886	209.14	25	30	25	2.07	0.051	0.040		7.9	90.3
05/05/2009	283612	215.75	24.8	27	18	1.58	0.029	0.058		7.95	81.6
11/05/2009	284798	197.67	25	39	26	1.82	0.038	0.036	0.03	8.02	86.4
18/05/2009	286334	219.43	24.9	40	22	2.04	0.026	0.009		7.86	84.3
25/05/2009	287756	203.14	24.9	29	20	1.97	0.002	0.028	0.05	8.09	79.6
02/06/2009	289468	214.00	25.1	25	18	1.52	0.059	0.036		8.21	86
09/06/2009	291432	280.57	25.1	37	26	2.65	0.153	0.087		7.94	83.6
15/06/2009	292826	232.33	24.8	17	10	1.93	0.011	0.056		7.93	78.8
22/06/2009	294248	203.14	25	52	24	3.45	0.170	0.110	0.04	7.47	81.6
06/07/2009	297624	249	25.5	47	10	4.46	0.20	0.101		7.69	79.20
13/07/2009	298995	196	25	53	21	4.06	0.20	0.078		7.69	79.00
21/07/2009	300607	202	24.7	59	26	2.59	0.38	0.152		7.80	84.00
27/07/2009	301787	197	26.1	65	23	3.39	0.40	0.150		7.90	82.40
04/08/2009	303519	217	24.7	37	26	2.5	0.18	0.024		7.99	81.60
11/08/2009	304942	203	25	37	24	2.45	0.03	0.084		7.88	83.00
18/08/2009	306353	202	24	56	17	4.75	0.23	0.117		7.52	80.00
24/08/2009	307416	177	24.8	48	26	4.92	0.18	0.078		7.45	82.70
02/09/2009	309109	188	24.8	50	27	3.94	0.16	0.054		7.63	82
07/09/2009	310188	216	24.6	55	15	3.61	0.16	0.058	0.06	7.58	80
14/09/2009	311687	214	25.06	68	26	3.04	0.172	0.099		7.49	84
21/09/2009	313145	208	24.9	50	12	2.72	0.049	0.043	0.03	7.57	89.2

†Drinking Water limits (according to the European Communities (Drinking Water) Regulations (S.I. No. 106 of 2007)
§Maximum values + 20% recorded during baseline monitoring (by T.J. O'Connor, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant
Values highlighted in red are exceedances in the maximum values recorded in 2002-2003
*****Apparent colour is the colour of an unfiltered sample containing suspended and dissolved solids
*True colour is the colour of a filtered sample with the suspended solids removed

External laboratory analysis

Analysis of raw water samples has been carried out periodically since July 2007 by City Analysts. Results are presented in Table 6.

Table 6 Raw water results (City Analysts)

Parameter	Unit	13/07/2007	07/03/2008	14/10/2008	09/04/2009	MAX
Nitrate	**mg/L as N**	<2	<0.063	<2	<2	**1.56**
Orthophosphate	**mg/L as P**	<0.163	0.001	<0.49	<0.163	**0.047**
Ammonia	**mg/L as N**	0.163	0.030	0.101	0.271	**0.612**
Conductivity	**µS/cm at 20°C**	213	205	232	178	**442.8**
Turbidity	**NTU**	2.2	2.5	3.7	1.84	**27.6**
pH	**pH units**	7.57	7.79	7.83	8.02	**10.44**
Colour (apparent)	**Hazen**	41			11*	**157.2**
Colour (true)	**Hazen**	14			6*	**25.2**
Total coliforms	**MPN/100mL**	61.6	21.8	38.8	41	**156**
Faecal coliforms	**cfu/100mL**	0	7	8	8	**36**
E Coli	**MPN/100mL**				12.5	**80.4**
TOC	**mg/L**	7.82	4.75	8.55	5.44	**43.2**
DOC	**mg/L**	7.71		8.49	5.33	**8.4**
Total Mn	**mg/L**	0.011			n/a	**0.341**
Dissolved Mn	**mg/L**	0.014			n/a	**0.0048**
Total Fe	**mg/L**	0.051				**0.654**
Dissolved Fe	**mg/L**	<0.02				**0.0024**

MAX = Maximum values (+ 20%) recorded during baseline monitoring (by T.J. O'Connor and Associates, National Water Monitoring Committee and National Drinking Water Monitoring Programme) prior to establishment of treatment plant

*According to Veolia, the colour test was measured more than one month after sampling and results may not, therefore, be accurate. Veolia measured apparent colour as 30-35 Ha and true colour as 25 on this date.

Appendix 3: Environmental guidelines for Agriculture

The following section is based on the National Action Programme that was put into law under the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 which has since been amended by the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006. Important sections relating to fertiliser and manure storage and application are presented. The information presented below forms only part of the National Action Programme and should only be interpreted in relation to this source protection study. Many of the measures outlined below help to protect drinking water sources as well as achieving compliance with the Nitrates Directive.

Introduction

The Nitrates Directive (91/676/EEC) – *Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources* – has the objective of reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution, with the primary emphasis being on the management of livestock manures and other fertilisers.

Zones

For the purposes of this programme the national territory has been sub-divided into three zones (groups of counties) by reference mainly to soil type, rainfall and length of growing season.

Storage Capacity

Storage capacity on holdings in all zones shall be sufficient for the full housing period and should provide an adequate level of storage for difficult years. Livestock holdings shall have the following minimum storage capacity for bovine livestock manure:

Zones and Minimum Periods of Storage Capacity for Livestock Manure		
Zone A	**Zone B**	**Zone C**
16 weeks	**18 weeks**	**20* or 22 weeks weeks**
Carlow	Clare	Cavan
Cork	Galway	Donegal*
Dublin	Kerry	Leitrim*
Kildare	Limerick	Monaghan
Kilkenny	Longford	
Laois	Louth	
Offaly	Mayo	
Tipperary	Meath	
Waterford	Roscommon	
Wexford	Sligo	
Wicklow	Westmeath	

Periods when land application of fertilisers is prohibited

The periods during which the application to land of certain types of fertiliser will be prohibited (both dates inclusive) are as follows:

Zones	Chemical Fertiliser	Organic Fertiliser	
		All Organic Fertilisers excluding Farmyard Manure	Farmyard Manure
	Grassland and Other Land	All Land	
A	15 Sept. to 12 Jan.	15 Oct. to 12 Jan.	1 Nov. to 12 Jan.
B	15 Sept. to 15 Jan.	15 Oct. to 15 Jan.	1 Nov. to 15 Jan.
C	15 Sept. to 31Jan.	15 Oct. to 31 Jan.	1 Nov. to 31 Jan.

Distances from a water body and other issues

1. Chemical fertiliser shall not be applied to land within 1.5 m of a surface water body.

2. Organic fertilisers or soiled water shall not be applied to land within:

- 200 m of the abstraction point of any surface watercourse, borehole, spring or well used for the abstraction water for human consumption in a water schemes supplying more than 100 m^3 per day or serving more than 500 persons
- 100 m of the abstraction point of any surface watercourse, borehole, spring or well used for the abstraction water for human consumption in a water schemes supplying more than 10 m^3 per day or serving more than 50 persons
- 25 m of a borehole, spring or well used as a drinking water source
- 20 m of a lake shoreline
- 15 m of exposed cavernous (karstified) limestone or karst limestone features such as swallow holes and collapse features
- 5 m of a surface watercourse, other than those mentioned above

3. Farmyard manure shall not be stockpiled on land within:

- 250 m of any surface water body or borehole, spring or well used for the abstraction of water for human consumption in a scheme supplying more than 10m^3 per day or serving more than 50 persons
- 50 m of a borehole, spring or well used for the abstraction of water for human consumption other than a borehole, spring or well

- 50 m of exposed cavernous (karstified) limestone features such as swallow holes and collapse features
- 20 m of a lake shoreline
- 10 m of a surface watercourse

Requirements as to the manner of application of fertilisers, soiled water etc.

1. Fertiliser shall be applied to land in as accurate and uniform a manner as is practically possible.
2. Fertiliser shall not be applied to land where
3. Fertilisers shall not be applied to land when:

- the land is waterlogged
- the land is flooded or likely to flood
- the land is frozen or snow-covered
- heavy rain is forecast within 48 hours
- the ground slopes steeply and where, taking into account factors such as proximity to bodies of waters, soil condition, ground cover and rainfall there is significant risk of causing water pollution.

4. Soiled water shall not be applied to land at any one time in quantities which exceed in any period of 42 days:

- a total quantity of 50,000 litres per hectare
- a total quantity of 25,000 litres per hectare in areas identified by the Geological Survey of Ireland as "Extreme Vulnerability Areas on Karst Limestone Aquifers, unless the land has a consistent minimum thickness of 1 m of soil and subsoil combined.

Rural Environmental Protection Scheme (REPS)

The Rural Environmental Protection Scheme (REPS) rewards farmers for farming in an environmentally friendly manner. There are a number of measures in the REPS scheme that can be valuable tools in the protection of water resources. Standard Measure 1 (REPS 4) relating to Nutrient Managing Planning sets out buffer zones relating to spreading and storage of nutrients on the farm. Standard Measure 3 (REPS 4) relating to the protection and maintenance of watercourses, waterbodies and wells also contains valuable information relating to the protection of the water resource on the farm.

While farmers operating outside of the REPS scheme are not obliged to follow any of the measures outlined in the scheme the implementation of these or similar measures could be beneficial to water quality in the area.

Below are some of the relevant sections from REPS 4. These details should be interpreted in conjunction with a full copy of the REPS handbook and a REPS planner where appropriate.

Standard Measure 1

Buffer Zones Applicable when Farm Yard Manure (FYM) is stored in a Field (Farmers Handbook for REPS 4)

- The extraction point of any water supply source providing $10m^3$ or more of water per day, or serving 50 or more people (250 m)
- The extraction point for any other water supply for human consumption (50 m)
- Exposed cavernous or karstified limestone features (such as swallow holes or collapse features) (50 m)
- Any surface watercourse where the slope to the watercourse exceeds 10% (10 m)
- Any other watercourse (10 m)
- Any open drain (10 m)

Buffer Zones for spreading Organic Fertilisers (Farmers Handbook for REPS 4)

- The extraction point of any water supply source providing $100m^3$ or more of water per day, or serving 500 or more people (200 m)
- The extraction point of any water supply source providing $10m^3$ or more of water per day, or serving 50 or more people (100 m)
- The extraction point for any other water supply for human consumption and all wells (25 m)
- Lake Shores (20 m)

- Exposed cavernous or karstified limestone features (such as swallow holes or collapse features) (15m)
- Any surface watercourse where the slope to the watercourse exceeds 10% (10 m)
- Any other watercourse (5 m)
- Any open drain (5 m)

Precautions for chemical fertilisers

- Never apply fertilizer within 1.5 m of any watercourse or waterbody.

Other information

- Do not store or open baled silage within 20 m of watercourses and water bodies or within 50 m of wells.

Standard Measure 3

- Do not allow cattle to get within 1.5 m of watercourses. Fences must be at least 1.5m from the top of the bank of the watercourse.
- Where it is not feasible to provide a piped water supply for animals, access to drinking points can be provided. These points must be fenced so that the animals cannot move upstream or downstream or stand in the water.
- Herbicides, pesticides or chemical fertilisers must not be applied within 1.5 m of watercourses or waterbodies.
- Under Measure 3 there are also measures which facilitate the widening of watercourse margins and the establishment of planted buffer strips.