APPENDIX 2

Ecology Report

A DESK STUDY INVESTIGATION OF POTENTIAL ECOLOGICAL IMPACTS FROM THE WHITEGATE LANDFILL, COUNTY CLARE, ON THE CONSERVATION STATUS OF SPECIES AND HABITATS IN THE SLIEVE AUGHTY MOUNTAINS SPECIAL PROTECTION AREA

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CONSERVATION SERVICES
&
BIOSPHERE ENVIRONMENTAL SERVICES

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1 INTRODUCTION

A Tier 1 Risk Assessment of Whitegate Landfill County Clare was undertaken by Clare County Council in accordance with the Code of Practice for Environmental Risk Assessment of Unregulated Waste Disposal Sites, EPA, 2007 (EPA CoP, 2007). Based on the SPR9 linkage between the landfill and the adjacent Slieve Aughty Mountains designated Special Protection Area (Site Code 004168), via leachate migration through surface water, Whitegate landfill site was rated as a Class A (high risk) site.

Subsequent to the Tier 1 Risk Assessment, an Exploratory Investigation on Whitegate Landfill was carried out to determine the overall cost requirements for the full Tier 2 investigation (using the methodology recommended in the EPA matrix), and to further develop the conceptual site model (CSM) for Whitegate landfill.

The Exploratory Investigation at Whitegate Landfill concluded that ecological advice was required regarding potential impact of waterborne pollutants on the conservation objectives or conservation status of any species in the special protection area.

The present desk study report assesses the potential for a significant impact from the Whitegate Landfill on the Slieve Aughty Mountains SPA. The report utilises the "Source-Pathway-Receptor (S-P-R)" conceptual model for environmental management recommended by EPA in its Code of Practice - Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA CoP, 2007). The report is presented in the following sections:

1. Source – An assessment of the polluting potential of the Whitegate Landfill

2. Receptor – An assessment of the Slieve Aughty Mountains SPA with particular reference to Annex bird species for which the site has been designated

3. Pathway – An assessment of potential pathways whereby pollutants from Whitegate Landfill might impact on the biota and habitats of the SPA

2 AN ASSESSMENT OF THE POLLUTING POTENTIAL OF WHITEGATE LANDFILL

2.1 COMPOSITION OF LEACHATE IN LANDFILLS

One of the consequences of the disposal of wastes in landfills is the generation of leachate, which is the noxious liquid that is produced as a result of the interactions in the waste as water passes through it.

The concentration of various potentially polluting substances in leachate varies depending on a variety of factors such as water content of the waste, rainfall, design and operation of the site, the age of the waste and the type of waste being disposed.

Many organic compounds which may be found in landfill leachate are of environmental significance in very low concentrations - parts per billion (ppb) or parts per trillion (ppt) quantities. Consequently very small amounts can cause severe pollution (Daly 1991). Of particular concern are compounds which are fat-soluble and biologically stable so that they accumulate in body fats. Such compounds may biomagnify along food chains and in some ecosystems concentration factors from water to top predators may be as high as 10 to the power of 7 (Mason 1996).

Thornton *et al* (1999) after Robinson (1986) list 3 acid organics (e.g. Phenol), 23 volatile organics (e.g. Methylene chloride, Toluene, 1,1-Dichloroethane, Trans-1,2-Dichloroethene, Ethylbenzene, Chloroform), 8 base-neutral organics (e.g. Bis(2-ethylhexyl)Phthalate, Diethylphthalate, Dibutylphthalate), 1 chlorinated pesticide, and 1 PCB in landfill leachate. The Robinson 1986 data suggest that methylene chloride and Trans-1,2-Dichloroethene are the most common synthetic organic chemicals in leachate.

2.1.1 WASTE ELECTRICAL & ELECTRONIC EQUIPMENT (WEEE)

According to the Commission of the European Communities (2000) the most environmentally problematic substances contained in WEEE include heavy metals, such as mercury, lead, cadmium and chromium, halogenated substances, such as chloroflourocarbons (CFCs), polychlorinated biphenols (PCBs), polyvinyl chloride (PVC) and brominated flame retardants as well as asbestos and arsenic.

2.1.2 ENDOCRINE DISRUPTING CHEMICALS (EDCS)

Endocrine disrupters, also known as oestrogen mimicking chemicals, are substances which interfere with the hormonal systems of animals and humans. "*A range of chemical substances, designed for use in industry, agriculture and consumer products, are suspected of interfering with endocrine (hormonal) systems of humans and wildlife*". (European Union Commission Communication COM (2001) 262). Landfill leachate has been identified as a potential source of EDC pollution, in Ireland (Dempsey & Costello 1998) and abroad (Daughton et al 1999).

In October 2000 the European Parliament adopted a resolution on endocrine disrupters emphasising the application of the precautionary principle and calling on the Commission to identify substances for immediate action.

A research team at Cork Institute of Technology has drawn a list of endocrine disruptors most likely to be present in surface and waste waters in the Irish aquatic environment. Included in the list are the following phthalates (Dr H. Tarrant, Cork Institute of Technology, pers. comm.):

Dimethyl Phthalate	Plasticiser
Diethyl Phthalate	Plasticiser
Di-n-butyl Phthalate	Plasticiser
Butyl Benzyl Phthalate	Plasticiser
Bis 2-(ethylhexyl) Phthalate	Plasticiser
Di-n-octyl phthalate	Plasticiser

Phthalates are probably the most important group of endocrine disrupting chemicals which may be present in landfill leachate. Phthalates are a major component in PVC, of which they form up to 60% of the total volume (European Commission 2000). About 50% of the total consumption of phthalates is bis(2-ethylhexyl) phthalate DEHP (Cadogen *et al* 1993 quoted in European Commission 2000). PVC forms approx. 2.5% of landfilled municipal waste in Europe (European Commission 2000).

The Final Report to the European Commission: *The Behaviour of PVC in Landfill* (European Commission 2000) indicates that a significant proportion of phthalates are degraded within landfills and are therefore not released to the environment. However, the report also states: "*Essential information is still lacking for an assessment of quantitative phthalate emission from landfills. … Emissions of phthalates to landfill leachates and to the aquatic environment cannot be excluded, DEHP in particular is considered to be persistent and to accumulate in sediments. …. According to the findings from the literature survey and from our own analysis with regard to emissions resulting from the disposal of PVC in landfills, a contribution to the contamination of leachate … occurs. … As there is evidence that phthalates, DEHP mainly, are not fully eliminated through current leachate treatment .. emission to aquatic ecosystems cannot be excluded. …Technical solutions for leachate treatment are feasible.*" (European Commission 2000).

Tarrant *et al* (2005) conclude that "*with the caveat that estrogenic 'hotspots' are more likely in densely populated urban and/or industrialised areas* …. *Irish rivers and lakes do not appear to be at general risk from significant concentrations of environmental estrogens. ….In general, wild fish populations do not appear to be at risk from estrogenic chemicals.*"

2.1.3 RISKS FROM OTHER CHEMICALS AND PRODUCTS WHICH ARE PERMITTED IN THE LANDFILL

All biodegradable organic wastes which enter the landfill such as food waste, garden waste, paper and cardboard products, animal products, and a range of commercial and industrial wastes will ultimately decompose; leachate produced during this decomposition process typically has levels of B.O.D. and ammonia which are potentially lethal (in the absence of adequate treatment) to most aquatic animals and plants. Likewise decomposition of organic material frequently results in the production of phosphorus containing compounds, which if released to the aquatic environment may result in eutrophication of the receiving waters. Non organic phosphorus containing compounds disposed at the landfill may also result in phosphorus in the leachate, which if not removed by leachate treatment could result in eutrophication of receiving waters.

In addition to such well documented pollutants in landfills, a wide range of compounds enter landfill, the environmental effects of which are not known. The number of chemicals now on the market is very large and growing (Royal Commission on Environmental Pollution 2003; EU MEMO 03/213). "*Extensive national, EU and international legislation and agreements prescribe requirements for testing and assessing chemicals for their potential to cause harm in the environment, but only a small proportion of chemicals on the market have been the subject of risk assessment."* (Royal Commission on Environmental Pollution 2003). To redress this situation the European Commission has brought in a new EU regulatory framework for chemicals called REACH (Registration, Evaluation and Authorisation of Chemicals).

2.1.4 RISKS FROM CHEMICALS AND PRODUCTS WHICH ARE PROHIBITED IN THE LANDFILL

Evidence from Britain (Royal Commission on Environmental Pollution Report 2003) indicates that significant quantities of domestic pesticides may still be disposed of illegally to landfill in Britain. Thornton *et al* (1999) also highlight the significant potential for hazardous waste disposed of by small commercial enterprises without contracts with waste disposal companies to make its way to non hazardous waste landfills.

2.1.5 TIMESCALE FOR LEACHATE GENERATION

The sequence of microbiological breakdown processes which occurs in landfills is now well established, in that the landfill progresses through the aerobic, acetogenic, methanogenic and finally semi-aerobic phases. Whilst these phases will ensure that organic matter is eventually completely broken down and the carbon is released in the form of methane and carbon dioxide gases, some of the end products of these degradation processes remain as soluble components of leachate. Thus, waste components which constitute pollutants in the solid phase are gradually transposed into a liquid phase and can only be eliminated from a landfill providing waste encapsulation by the removal and treatment of the leachate. Robinson and Gronow (1993) state that a large, deep, high-density domestic waste landfill, operated in a typical manner as at present in the UK, will continue to produce strong and polluting leachates well in excess of values considered acceptable for discharge to surface or ground water for a large number of decades, and possibly over timescales in excess of a century.

Investigations into potential polluting effects of PVCs in landfills (see section 2.1.1.2 above) are described in "The Final Report to the European Commission: *The Behaviour of PVC in Landfill* - European Commission 2000". This report states that; "*There is no evidence that the release of additives will come to a standstill. Thus it is expected that this process will last for a very long time …Nowadays the technical guarantee for landfill bottom liners and pipes for leachate collection is restricted to 80 years. Emissions resulting from the presence of PVC in landfills are likely to last longer than the guarantee of the technical barrier*."

One of the most difficult components of leachate to eliminate is ammonia, since this is the soluble end product of the anaerobic breakdown of nitrogenous components of wastes. Typically the ammonia content of leachates is 1000 mg/l, and for direct discharge to controlled waters a limit of say perhaps 1 mg/l would be required. Thus a dilution ratio of 1000:1 would be required for all leachate contained within a site. Walker (1993) calculates that if an engineered landfill site were capped over a depth of refuse of 10m with an average drained moisture content of 40%, then the hydraulic retention time (HRT) for the infiltration rate of 50mm per annum is given by: 10m x 0.4 ÷ 0.05m/a = 80 years. Knox (1990) calculates that for a hydraulic retention time of 80 years, the time to reduce the concentration of ammonia from 1000 mg/l to 1 mg/l is 552 years. Krumpelbeck and Ehrig (1999) report that in a study of 50 German landfills, ammonia concentrations did not show a significant decrease thirty years after closure. Thus extremely protracted time scales may be involved for the operation of leachate control measures at fully engineered sites. This conclusion is supported by Freeze and Cherry (1979) who state that "in some cases leachate production may continue for many decades or even hundreds of years". The concept of very protracted time scales for leachate control is discussed in more detail by Belvi and Baccini (1989).

2.2 WHITEGATE LANDFILL – GENERAL INFORMATION

The Exploratory Investigation on Whitegate Landfill by Clare County Council has established the following:

1. The area of waste deposition is 1.19 hectares.

2. The maximum depth of waste deposited, based on trial hole detail is 4.8 m, (including capping)

3. Waste is deposited at and below the level of the water table on the site

4. In general there is some overburden above the bedrock, but the depth of overburden was not clearly established throughout the site.

5. Taking account of the water table level observed on the site, it would appear that the waste volume is in direct contact with groundwater, so that sub-soil investigation (for permeability) is unlikely to be an issue across the site.

6. The more recent area of waste deposition is located at the eastern end of the site, but landfilling at the site appears to have taken place over the entire area of the site between 1994 and 1998.

7. Significant volumes of leachate were encountered in trial holes

8. Groundwater movement in the overburden, (and associated leachate movement) appears to be from a south west to north east direction, based on observation of seeps in each trial hole

9. Based on very preliminary observation of the level of the water table in the trial holes, and the level in the adjacent water course- it is likely that the leachate is in contact with and draining to surface waters

10. The movement of leachate into surface waters is the pathway identified for any potential hazardous substances dissolved in water. The topography of the site, preliminary level observations and observations on movements of water /leachate in the trial holes suggests that the movement of a contaminant plume is likely to be towards surface waters located around the site on the northern and eastern boundaries.

11. Preliminary results of analysis of surface water samples indicates elevated ammoniacal nitrogen in the northern boundary drain, which suggests a link between leachate in the overburden and the adjacent surface water drain.

12. Non hazardous municipal waste appears to comprise the main volume of deposited material, with significant levels of black plastic (presumably arising from agricultural sources).

13. Some industrial waste was evident in the trial holes. This was identified as probably coming from the Finsa facility as the waste was mainly chipboard, or chipboard products

In summary the results of the investigation indicate a small (1.19ha) landfill with maximum depth of 4.8m, which operated during the 1990s. The main volume of deposited material was non-hazardous municipal waste. The landfill was unlined and leachate is dispersed beyond the site by surface water (rather than groundwater) flow, which is via boundary drains, which connect with an adjacent stream which flows in a north east direction for c.2.5km to 1km long Lough Allewnaghta, which in turn discharges via a c. 0.6km stream to Lough Derg.

2.3 WHITEGATE LANDFILL - POLLUTANTS IN LEACHATE

As part of the Exploratory Investigation on Whitegate Landfill by Clare County Council, leachate samples were taken at four locations at the landfill and analysed for a large suite of organic and inorganic pollutants. Results are presented in Appendix 1. The range of concentrations recorded for a number of important pollutants are presented in Table 1 below alongside typical concentrations found in leachate from recent and aged landfill waste.

Table 1

	Range of concentrations (mg/l) recorded at Whitegate Landfill (untreated leachate)	Typical Composition (mg/l) of untreated leachates from domestic wastes in Britain D.O.E. data reproduced in Daly (1987)		
Parameter		**Untreated Leachate Recent Waste**	**Untreated Leachate Aged Waste**	**Maximum Admissible Concentration in receiving waters**
pH	6.78 – 6.89	6.2	7.5	6.0 - 9.0 (Salmonid Waters Regulations)
C.O.D.	349 – 1333 mg/l	23,800 mg/l	1,160 mg/l	
B.O.D.	15 – 186 mg/l	11,900 mg/l	260 mg/l	<5 (Salmonid Waters Regulations)
Ammon-iacal N	35 – 193 mg/l	790 mg/l	370 mg/l	1.0 mg/l total ammonium subject to complying with standard of 0.02 mg/l for non-ionised ammonia NH_3 (Salmonid Waters Regulations)
Chloride	44 – 222 mg/l	1315 mg/l	2080 mg/l	250 mg/l (Surface Water Regulations)
Magnesium	50 – 95 mg/l	252 mg/l	185 mg/l	50 (Drinking Water Regulations)
Potassium	44 – 272	780	590	12

	Range of concentrations (mg/l) recorded at Whitegate Landfill (untreated leachate)	Typical Composition (mg/l) of untreated leachates from domestic wastes in Britain D.O.E. data reproduced in Daly (1987)		
Parameter		**Untreated Leachate Recent Waste**	**Untreated Leachate Aged Waste**	**Maximum Admissible Concentration in receiving waters**
Manganese	1.7 – 2.2 mg/l	27 mg/l	2.1 mg/l	0.05 mg/l (Surface Waters Regulations)
Iron	1.3 – 22.8 mg/l	540 mg/l	23 mg/l	0.2 mg/l (Surface Waters Regulations)
Nickel	<0.001 mg/l	0.6 mg/l	0.1 mg/l	0.05 mg/l (Drinking Water Regulations)
Chromium (unfiltered)	0.025 – 0.730 µg/l			0.032 µg/l (Environmental Objectives Surface Water Regulations 2009)
Di (2-ethylhexyl)-phthalate (DEHP)	4.64 - 54.6 µg/l			1.3 µg/l max annual average (Environmental Objectives Surface Water Regulations 2009)
Phenol	<1.00 – 14.6 µg/l			46 µg/l (Environmental Objectives Surface Water Regulations 2009)

(Sources for leachate concentrations: Daly (1987), & Leachate monitoring data for Whitegate Landfill provided by Clare County Council)

The analysis establishes that for a range of major indicators of leachate pollutant concentration such as ammonia, BOD, and COD, the concentration recorded in the Whitegate leachate was substantially lower than would be typical of aged landfill waste. For example ammonia concentrations of 35 – 193 mg/l were recorded comparing favourably with typical concentrations of in leachate from aged waste of 370mg/l and in leachate from recent waste of 790 mg/l (Daly 1987). This relatively low concentration of pollutants in the leachate may be due to a combination of:

i. The age of the waste

ii. The shallow depth of the waste

iii. The uncontained nature of the landfill

iv. High rainfall levels

v. Rapid water infiltration rate

vi. Short hydraulic retention time

However, as the assessment was carried out on only one sampling date, further investigation would be required to establish the condition of the landfill leachate with more certainty.

Nevertheless the leachate assessment indicates pollutants at concentrations which would be damaging to aquatic flora and fauna. Pesticides were all below the detection level of the analysis methods used. A range of volatile organic compounds (SVOCs) and volatile organic compounds (VOCs) were detected in the leachate. Notably the phthalate DEHP was detected at over 40 times the maximum allowable annual average concentration acceptable in surface water under the Environmental Objectives Surface Water Regulations 2009.

2.4 WHITEGATE LANDFILL - POLLUTANTS IN DOWNSTREAM SURFACE WATERS

Surface water samples were taken by Clare County Council at seven stream sites adjacent to the landfill on 5th November 2009. Results are tabulated in Appendix 1. At downstream sites the assessment indicated elevated levels of a number of pollutants particularly ammonia. At Site SW3, which is immediately downstream of the confluence with the landfill drains, ammonia concentration of 4.23 mg/l was recorded (the maximum admissible concentration under the Salmonid Waters Regulations is 1.0 mg/l total ammonium, subject to complying with standard of 0.02 mg/l for non-ionised ammonia NH_3).

Results of monitoring carried out by EPA in 2007 & 2008 at Lough Alewnaghta (c. 2.5 km downstream of the landfill) are presented in Appendix 2. The results of the monitoring show no indication of contamination from the landfill, apart from a possible landfill effect indicated by an elevated ammonia level on one of the ten sampling dates. The level of ammonium NH_4 was 1.6 mg/l on 1/10/08 as compared with an average of 0.081 mg/l over the other sampling dates.

3 AN ASSESSMENT OF THE SLIEVE AUGHTY MOUNTAINS SPA

3.1 SPA SELECTION CRITERIA

The Slieve Aughty Mountains SPA is designated under the EU Birds Directive (Council Directive 79/409/EEC). The site qualifies for designation under Article 4.1 of the Directive by supporting a population of European importance of **Hen Harrier** *Circus cyaneus*, a species listed on Annex I of the Directive. In 2005, 27 breeding pairs (24 confirmed, 3 possible) were recorded, representing 17.6% of the estimated breeding population in the Republic of Ireland.

Site also supports a population of the Annex I species **Merlin** *Falco columbarius*, that is likely to exceed with ease the threshold for national importance - probably 5 pairs but further survey required.

3.2 SITE DESCRIPITON

The Slieve Aughty Mountains SPA is a very large site (61,127 ha) that extends from just south of Lough Rea (Co. Galway) in the north to as far south as Scariff in Co. Clare (and close to the village to Whitegate in the south-east). The peaks are not notably high or indeed pronounced, with a maximum of 378 m near Cappaghabaun Mountain. The site includes many small and medium sized lakes, notably Lough Graney and Lough Atorick. Important rivers which rise in the site include the Owendalulleegh and Graney. Lough Derg occurs immediately to the south-east of the site. The Slieve Aughty hills are predominantly comprised of Old Red Sandstone. Outliers of Lower Palaeozoic provide occasional outcrops capping the hills.

The site consists of a variety of upland habitats, though approximately half is afforested. The coniferous forests include first and second rotation plantations, with both pre-thicket and post-thicket stands present. Substantial areas of clearfell are also present at any one time. The principal trees are sitka spruce and lodgepole pine. Almost one-third of the site is unplanted blanket bog and heath, with both wet and dry heath present. Well developed blanket bog occurs at several locations, notably Sonnagh, Loughatorick South and Glendree. The vegetation is characterised by such species as ling heather, bilberry, common cottongrass, hare's-tail cottongrass, deergrass and especially purple moor grass. Bog mosses (*Sphagnum* spp.) are well represented. The remainder of the site is largely rough grassland that is used for hill farming. This varies in composition, with some wet areas with rushes (*Juncus* spp.) and some areas with scrub encroachment.

The main threat to the long-term survival of Hen Harriers within this site is further afforestation which would reduce the amount of foraging habitat, with a possible reduction in breeding density and productivity.

Overall this site provides excellent nesting and foraging habitat for breeding Hen Harriers and is considered among the top two sites in the country for the species.

3.3 HEN HARRIER – BACKGROUND INFORMATION

The principal interest of the SPA is the population of nesting Hen Harriers, supporting the second largest concentration in the country. The mix of forestry and open areas provides optimum habitat conditions for this rare bird. The early stages of new and second-rotation conifer plantations are the most frequently used nesting sites, though some pairs may still nest in tall heather of unplanted bogs and heath.

Hen Harriers will forage up to c. 5 km from the nest site, utilising open bog and moorland, young conifer plantations and hill farmland that is not too rank. Birds will often forage in openings and gaps within forests. In Ireland, small birds and small mammals appear to be the most frequently taken prey. Meadow pipits and bank voles are considered the principal avian and mammalian prey items but harriers will take a wide range of small birds, including warblers, finches, thrushes and even larger prey such as snipe and grouse (an extensive list of prey items is given in Watson 1977).

In its most usual type of hunting flight, the Hen Harrier flies low, flapping and gliding at an average of less than 3 metres above the ground. The technique of low-level flight, varied pace and use of local topography enables a harrier to exploit its long legs to maximum effect in striking at prey on, or close to, the ground. Harriers will also patrol over low scrub or along the margins of forests, using the element of surprise to pick off small birds.

Hen Harriers return to the breeding grounds during March and are usually present until July or August. After that, adults and juveniles disperse widely, mostly to low-lying areas where the winter climate is less harsh. Research on Irish Hen Harriers by Mr Barry O'Donoghue has recorded a young female wing tagged in Co. Clare on an island in Wales, which proves that some birds travel abroad. Some harriers may visit the uplands during winter or at least linger on into early winter.

3.4 MERLIN - BACKGROUND INFORMATION

Little is known about the Slieve Aughty breeding population of Merlin, a further Annex I listed species. Merlin is a difficult species to census but is typically found in mosaics of forestry and open bog. The birds nest mostly in trees, utilising the old nests of crows.

The merlin is a small falcon and uses its speed and agility to chase down prey items, mainly small birds and small mammals but also larger insects.

Like the hen harrier, the merlin population largely vacates the uplands in winter and spends the winter in more hospitable lowland areas often along coastal strips.

3.5 SPA CONSERVATION PLAN

A Conservation Plan for the Slieve Aughty Mountains SPA has not yet been prepared by the Department of the Environment, Heritage & Local Government. However, it is understood that the principal nature conservation objectives for the site are to maintain the population of the species (hen harrier & merlin) for which the site is selected, and to maintain and, where possible, enhance, the habitats on which the harriers are dependant.

4 AN ASSESSMENT OF POTENTIAL PATHWAYS WHEREBY POLLUTANTS FROM WHITEGATE LANDFILL MIGHT IMPACT ON THE BIOTA AND HABITATS OF THE SLIEVE AUGHTY MOUNTAINS SPA

Three potential pathways for leachate pollutants to impact on the Slieve Aughty Mountains SPA are considered (1) Groundwater movement, (2) Surface water movement, (3) Contamination of birds and other biota in the SPA via food chains based on contaminated flora/fauna downstream of the landfill.

4.1 GROUNDWATER

The Clare County Council report on the Exploratory Investigation on Whitegate Landfill (2009) states:

i. "*Groundwater movement in the overburden, (and associated leachate movement) appears to be from a south west to north east direction, based on observation of seeps in each trial hole*."

ii. "*The movement of leachate into surface waters …is the pathway identified for any potential hazardous substances dissolved in water. The topography of the site, preliminary level observations and observations on movements of water /leachate in the trial holes suggests that the movement of a contaminant plume is likely to be towards surface waters located around the site on the northern and eastern boundaries. Preliminary results of analysis of surface water samples indicates elevated ammoniacal nitrogen in the northern boundary drain … which suggests a link between leachate in the overburden and the adjacent surface water drain*."

The conclusion of the County Council report is that leachate movement within the landfill is in a south west to north east direction i.e. away from the adjacent SPA, and furthermore that leachate contamination enters surface waters adjacent to the landfill. This conclusion is however qualified as the Council also states in the report:

i. "*To evaluate the SPR9 linkage an investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity*."

ii. "*A hydrogeological investigation to establish groundwater quality (upgradient, within and downgradient of the landfill) and flow direction associated with the landfill site should be included in the full Tier 2 assessment*."

If the conclusion of the Exploratory Investigation on Whitegate Landfill that "*movement of leachate into surface waters …is the pathway identified for any potential hazardous substances dissolved in water"* is borne out by the further investigations proposed, then a significant direct impact on the SPA via groundwater can be ruled out.

4.2 SURFACE WATER

The Exploratory Investigation on Whitegate Landfill (2009) states that:

- *"The protected site is located to the west of the site, upstream of the direction of surface water flow."*

- *"Crooked Lough (wetland) lies approximately 250m to the southwest of the site (upstream of the landfill site)."*

- *"Cregg Lough lies 750m southwest and upgradient of the site. According to the river water body delineation made by the Shannon River Basin District Project there is no connection from this lough to the landfill site area."*

- *"Lough Allewnaghta is approximately 1km to the northeast of the landfill. The surface water drains from the landfill boundary flow to Lough Allewnaghta via a first order stream."*

- *"The northern boundary drain, which appears to be very slow moving, with max depth of 1 metre and maximum width 1.5m. The water in the drain was orange, and appeared to be impacted by leachate. This drain flows in a west to east direction along the line of the landfill site. This drain appears to be the main surface water connected with the water table and leachate in the main waste body."*

- *"The eastern boundary drain, which probably receives flow from the water ponds on the southern boundary of the landfill (based on forestry drain connections and local topography). This drain is also fed from forestry drainage ditches. At the eastern edge of the landfill site the forestry drains showed some evidence of leachate impact."*

On this basis a significant direct impact on the SPA via surface water can be ruled out.

4.3 FOOD CHAIN

The assessment carried out by Clare County Council establishes that there is a significant level of leachate contamination of surface watercourses evident in the immediate vicinity of the landfill (albeit at a considerably lower level than might be expected). The concentration of ammonia (a reliable indicator of leachate contamination) in Lough Allewnaghta (c. 2.5 km downstream of the landfill) was unsatisfactory on one sampling date out of ten over a two year period. Rigorously applying the precautionary principle, one could conclude that Lough Allewnaghta and the 2.5km of stream between it and the landfill could be exposed to significant landfill contamination, taking into account the fact that some pollutants that may be in landfill leachate can bio-accumulate and bio-magnify as they pass along ecological food chains.

The main components of the stream and lake ecosystems are aquatic plants, invertebrate animals (insects, molluscs, worms etc), fish, birds which feed largely on the aquatic food chain e.g. dipper, grey wagtail, duck, swans etc., and mammals which feed largely on the aquatic food chain such as otter and mink.

The two species for which the SPA is selected, hen harrier and merlin, are at the top of the food chain and are therefore theoretically susceptible to bio-accumulation of chemicals contained in substances such as leachate. The drastic effect on the Peregrine population during the 1960s due to accumulation of organochlorine pesticides and other synthetic chemicals is well documented (see Ratcliffe 1980). The effects not only included death of adult birds but also poor reproduction with high losses of eggs and hatched chicks.

As already noted, hen harriers are adapted for hunting over open country and during the nesting season hunt almost entirely over open bog/heath, rough grassland and in pre-thicket forests. In winter, they often forage over open wetland habitats such as reed-beds and marshes but will also forage over agricultural lands. Hen harriers are not adapted for feeding along rivers or streams on riparian species such as dippers or kingfishers (and it is not known if such species even occur on the streams below the landfill) and there appears to be no instances in the literature where there is evidence of hen harriers taking these bird species. Lough Allewnaghta may support wetland birds such as wildfowl, moorhen, coot and possible waders such as lapwing and curlew. Whilst there are records of hen harriers taking wildfowl and waders (lapwing, young curlew, snipe etc.) these are very occasional and would be taken mainly outside the nesting season (Watson 1977).

It is concluded that there is no real risk to the hen harrier population from preying upon birds and/or mammals that may have been contaminated from leachate originating from the landfill for the following reasons:

(i) It is highly improbable that hen harriers from the Slieve Aughty Mountains SPA would predate riparian birds along the streams below the landfill

(ii) It is also improbable that hen harriers from the Slieve Aughty Mountains SPA would predate wetland birds at Lough Allewnaghta as such seldom feature in their diet (and especially during the nesting season)

Merlin is also generally a species associated with hunting over open countryside and is not normally associated with hunting along riparian habitats. However, Tyler & Ormerod (1994) note that kestrels, merlins and peregrines occasionally take Dippers. They observe that it is likely that the close proximity of breeding merlins to dippers in some upland valleys result in dippers being taken as prey. On the other hand, they note that Colin Bibby analysed bird remains at 66 merlin sites in Wales and of over 1,600 individual bird prey items, none were dippers.

As with hen harriers, it is considered that it is highly improbable that merlins from the Slieve Aughty Mountains SPA (with a population of perhaps less than 10 pairs) would predate riparian birds along the streams below the landfill. Even if a merlin was to take riparian prey, this would likely be an opportunistic event. Similarly, merlins would not be expected to predate wildfowl or waders such as lapwing (due to their size) which may occur on Lough Allewnaghta. It is concluded that there is no risk to the merlin population by preying upon birds and/or mammals that have been contaminated from leachate originating from the landfill.

5 CONCLUSIONS

Preliminary investigations by Clare County Council indicate that the leachate of Whitegate landfill contains pollutants with the potential to cause significant ecological impacts. The concentration of pollutants recorded are however lower than might be expected in aged landfill wastes. It is conjectured that this may be due to the relatively shallow depth of refuse, the age of the landfill and short hydraulic retention time, resulting in a declining concentration of pollutants in the leachate. However, as the assessment was carried out on only one sampling date, further investigation would be required to establish the condition of the landfill leachate with more certainty.

Three potential pathways whereby leachate contamination might significantly impact on the adjacent SPA are considered:

1. Direct movement via groundwater

2. Direct movement via surface water

3. Contamination of birds and other biota in the SPA via food chains based on contaminated flora/fauna downstream of the landfill

Initial investigations by Clare County Council indicate that leachate movement within the landfill is in a south west to north east direction i.e. away from the adjacent SPA, and furthermore that leachate contamination moves into surface waters adjacent to the landfill. The Council however qualifies this conclusion by highlighting the need for further more detailed investigations.

The SPA is located to the west of the landfill site, upstream of the direction of surface water flow. Preliminary investigations by Clare County Council of surface water adjacent to the landfill indicated elevated levels of a number of pollutants, particularly ammonia, immediately downstream of the landfill. Results of monitoring carried out by EPA in 2007 & 2008 at Lough Alewnaghta (c. 2.5 km downstream of the landfill) show no indication of contamination from the landfill apart from a possible landfill effect indicated by an elevated ammonia level on one of the ten sampling dates.

On the basis of the groundwater and surface water investigations carried out by Clare County Council and subject to the requirement for more detailed investigations, it is concluded that direct significant impact on the SPA via groundwater or surface water is not a significant likelihood.

Based on the findings of the County Council and EPA investigations, and rigorously applying the precautionary principle, one could conclude that Lough Allewnaghta and the 2.5km of stream between it and the landfill could be exposed to significant landfill contamination, taking into account the fact that some pollutants that may be in landfill leachate can bio-accumulate and bio-magnify as they pass along ecological food chains. However, hen harrier and merlin are the two species for which the Slieve Aughty Mountains SPA was selected. A detailed consideration of the feeding habits of Merlins and Hen Harriers presented in this reports indicates that the proportion of the diet of these birds derived from aquatic/riparian food chains is insignificant, thereby ruling out any significant likelihood of a food chain impact on these species (or indeed any other element of the Slieve Aughty Mountains SPA biota) from the landfill.

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APPENDIX 1

LEACHATE AND SURFACE WATER MONITORING DATA

(Data provided by Clare County Council)

		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	**-**	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
		(u/s location)	***U/s location***	***May be run off from landfill***	***D/S of landfill Ds of Sw6***	***D/S of landfill-boundary drain. D/s of SW5)***	***Boundary drain-mid drain***	***(D/S of landfill***				
Temperature	**°C**	9.2	9.8	9.4	9.4	9.2	9.5	9.4	9.2	9.3	9.2	9.2
Dissolved oxygen	**mg/l**	5.54	5.51	7.2	7.72	7.65	6.11	6.94				
Dissolved oxygen	**%**	49.3	49.6	64.1	68.9	68	54.6	61.9				
Ph	**-**	5.19	4.13	5.63	6.07	6.05	6.72	6.89	6.89	6.78	6.88	6.86
Conductivity	**μS/cm**	89	189	102	115	122	400	447	2400	2600	4000	2200
Total Suspended solids	**mg/l**	<2	<2	9	5	4	3	15	14,108	2,840	8,812	41,736
Ammonia	**mg/l**	0.120	0.339	0.044	0.288	0.349	2.725	4.233	34.8	98.36	193.35	81.27
TON	**mg/l**	<0.001	0.301	<0.001	<0.001	<0.001	<0.001	0.068	<0.001	<0.001	<0.001	<0.001
Nitrate	**mg/l**	<0.001	0.317	<0.001	<0.001	<0.001	<0.001	0.074	<0.001	<0.001	<0.001	<0.001
Nitrite	**mg/l**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
BOD	**mg/l**	<2	<2	<2	2	<2	<2	4	15	80	186	36
COD	**mg/l**	115	104	105	103	102	16	26	349	831	1333	659
Sulphate	**mg/l**	<0.5	15.303	<0.5	<0.5	<0.5	13.652	10.086	61.38	8.302	109.522	7.157
Chloride	**mg/l**	17.73	31.25	17.901	18.88	20.78	22.48	25.93	72.89	222.40	70.81	43.96

		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
Ortho-phosphate	**mg/l**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01
Fluoride	**mg/l**	0.016	0.037	0.023	0.017	0.017	0.049	0.043	0.030	0.027	0.50	0.025
Total Alkalinity	**mg/l**								1210	2320	4300	1440
Arsenic[1]	**µg/l**	**18.1**	**17.0**	**13.3**	**10.6**	**12.6**	5.45	8.95	4.46	6.31	**16.8**	6.46
Arsenic[3]	**µg/l**	-		-	-	-	-	-	-	-	-	-
Boron[1]	**µg/l**	<18	<18.0	<18	<18	<18	74.1	132	**1090**	939	776	618
Boron[1]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Cadmium[1]	**µg/l**	<0.220	<0.220	<0.220	<0.220	<0.220	<0.220	<0.220	<0.22	<0.22	<0.22	<0.22
Cadmium[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Chromium[3]	**µg/l**	<0.700	2.86	<0.770	<0.7	<0.7	<0.7	<0.700	8.90	22.3	**38.5**	11.1
Copper[1]	**µg/l**	<1.60	<1.60	<1.60	14.2	17.2	8.71	<1.60	2.27	<1.6	<1.6	<1.6
Copper[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Lead[1]	**µg/l**	3.21	2.05	2.85	2.50	2.47	1.83	2.14	2.35	2.10	1.64	1.88
Lead[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Manganese[1]	**µg/l**	**396**	**734**	**237**	**197**	**284**	**458**	**470**	**1730**	**1380**	**2130**	**2230**
Nickel[1]	**µg/l**	<1.50	2.08	<1.50	1.65	2.15	2.56	2.62	<1	<1	<1	<1
Selenium[1]	**µg/l**	<1.00	<1.00	<1.00	1.17	1.07	<1.00	<1.00	<1	<1	<1	<1
Selenium[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Zinc[1]	**µg/l**	**12.7**	**11.9**	**12.2**	**9.18**	**17.7**	**20.6**	**15.8**	<0.01	<0.01	<0.01	<0.01

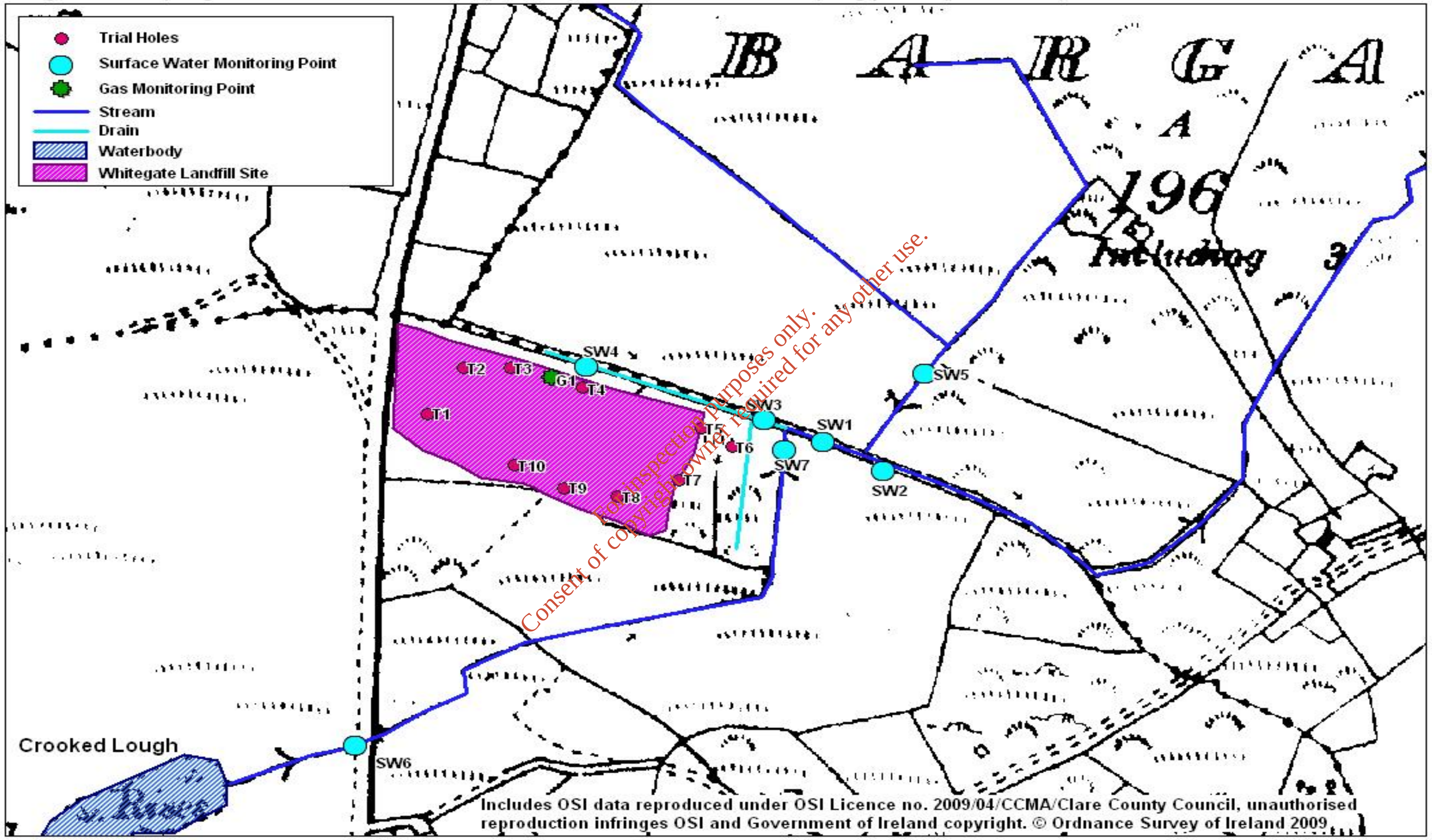
		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
Zinc[3]	**µg/l**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Mercury[1]	**µg/l**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Sulphate	**mg/l**	-	-	-	-	-	-	-	118	19.5	166	55.4
Chloride	**mg/l**	-	-	-	-	-	-	-	**75.3**	**72.4**	**213**	**43.0**
Orthophosphate	**mg/l**	-	-	-	-	-		-	<0.08	<0.08	<0.08	<0.08
Chromium	**µg/l**	<3.00	<3.00	<3.00	SW1	<3.00	<3.00	<3.00	25.7	**223**	**730**	**48.4**
Phosphorus[3]	**mg/l**	30.1	21.5	30.7	<3.00	54.8	35.3	58.6	1710	5720	11600	3640
Total Cyanide	**mg/l**	-	-	-	-	-	-	-	<0.05	<0.05	<0.05	<0.05
Calcium[1]	**mg/l**	7.34	7.92	8.48	11.1	11.1	51.4	16.4	**236**	195	**271**	**206**
Calcium[3]	**mg/l**	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**
Sodium[1]	**mg/l**	11.1	17.7	10.4	11.2	11.1	13.4	12.5	60.8	76.9	133	37.0
Sodium[3]	**mg/l**	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**
Magnesium[1]	**mg/l**	1.62	1.83	1.49	2.16	2.11	10.6	11.8	**94.9**	**77.9**	**74.7**	49.6
Magnesium[3]	**mg/l**	-	-	-	-	-	-	-				
Potassium[1]	**mg/l**	<2.34	<2.34	<2.34	<2.34	<2.34	**9.15**	**7.76**	**109**	**119**	**272**	**44.0**
Potassium[3]	**mg/l**	-	-	-	-	-	-	-				
Iron[1]	**mg/l**	**2.23**	**3.49**	**1.69**	**1.63**	**1.96**	**3.26**		**1.25**	**11.4**	**22.8**	**14.2**
Iron[3]	**mg/l**	-	-	-	-	-	-	-				

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	**-**		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
Pesticides/Herbicides	**Atrazine**	**µg/l**	-	-	-	-	-	-	-	<1	<1	<1	<1
	Simazine	**µg/l**	-	-	-	-	-	-	-	<1	<1	<1	<1
	Remainder	**µg/l**	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01
SVOC's	**4-Methyl phenol**	**µg/l**	-	-	-	-	-	-	-	<1.00	46.5	159	2.62
	Bis (2-ethylhexyl) phthalate	**µg/l**	-	-	-	-	-	-	-	21.1	7.03	54.6	4.64
	Di-n-butyl phthalate	**µg/l**	-	-	-	-	-	-	-	<1.00	1.77	**6.42**	<1.00
	Fluorene	**µg/l**	-	-	-	-	-	-	-	1.11	<1	<1	<1
	Phenol	**µg/l**	-	-	-	-	-	-	-	<1.00	**9.89**	**14.6**	<1.00
	Naphthalene	**µg/l**	-	-	-	-	-	-	-	1.17	<1	1.12	<1.00

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	**-**		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
	Diethyl phthalate	**µg/l**	-	-	-	-	-	-	-	1.48	<1.00	<1.00	<1.00
	DI-n-Octyl phthalate	**µg/l**	-	-	-	-	-	-	-	<5	<5	<5	<5
	Remainder of SVOC's	**µg/l**	-	-	-	-	-	-	-	<1.00	<1.00	<1.00	<1.00
VOC's	**Benzene**	**µg/l**	-	-	-	-	-	-	-	<1.30	<1.30	**1.82**	<1.30
	Chlorobenzene	**µg/l**	-	-	-	-	-	-	-	**<3.50**	**<3.50**	**24.7**	**<3.50**
	P/m-Xylene	**µg/l**	-	-	-	-	-	-	-	<2.50	4.76	**19.0**	24.5
	o-xylene	**µg/l**	-	-	-	-	-	-	-	<1.70	<1.70	2.99	<1.70
	1,3,5-Trimethyl-benzene	**µg/l**	-	-	-	-	-	-	-	<1.80	<1.80	4.78	<1.80

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	**-**		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
	1,2,4-Trimethyl-benzene	**µg/l**	-	-	-	-	-	-	-	<1.70	4.51	18.5	5.25
	4-Isopropyltoluene	**µg/l**	-	-	-	-	-	-	-	<2.60	<2.60	14.1	<2.60
	Remainder of VOC's[2]	**µg/l**	-	-	-	-	-	-	-	<LOD[2]	<LOD[2]	<LOD[2]	<LOD[2]

Figure 4 Sampling site locations: Trial Holes (T1 - T10) and Surface Water sampling points (SW1 - SW8).



APPENDIX 2

LOUGH ALLEWNAGHTA MONITORING DATA

(Data provided by Clare County Council derived from EPA Surveillance Monitoring Programme and Clare County Council)

Waterbody	**Sampling date**	**Alkalinity mg/l CaCO3**	**Ammonium mg/l NH4**	**Calcium mg/l CaCO3**	**Chloride mg/l**	**Chlorophyll mg/l**	**Conductivity uS/cm @ 20°C**	**Dissolved Oxygen Surface mg/l O2**	**Dissolved Oxygen Surface %Sat**	**Magne sium**
Alewnaghta	30/04/2007	100.0	0.100	31.4	23.00	5.84	210.9	10.00	105.0	2.78
Alewnaghta	18/06/2007	90.0	0.100			17.53	203.6	9.10	92.0	
Alewnaghta	13/08/2007	80.0	0.100			16.42	158.8	10.10	103.0	
Alewnaghta	28/08/2007	102.0	0.021		15.34		150.0	12.10	131.0	
Alewnaghta	21/09/2007	172.0	0.084		14.92		159.7	8.70	86.0	
Alewnaghta	23/10/2007	110.0	0.260			7.42	186.2	7.30	71.0	
Alewnaghta	04/04/2008	51.0	0.034		20.10	3.10		10.80	99.0	
Alewnaghta	04/04/2008					3.10				
Alewnaghta	20/06/2008	45.0	0.005		19.51	4.00	237.0	9.84	101.0	
Alewnaghta	20/06/2008					4.00				
Alewnaghta	01/10/2008	62.0	1.600	23.7	15.20	0.90	191.0	10.10	97.0	2.47
Alewnaghta	25/08/2008	60.0	0.026	21.0	14.80	5.20	168.0	8.60	88.2	2.22

Waterbody	Sampling date	pH 2	Potassium	Secchi m	Silica mg/l SiO2	Sodium mg/l	Sulphate mg/l	Temp surface ºC	Total Oxidised Nitrogen mg/l N	Total Phosphorus mg/l P	True Colour
Alewnaghta	30/04/2007	7.6		2.80		11.0	9.00	14.20	0.300	0.025	22
Alewnaghta	18/06/2007	7.7		1.86				16.50	0.150	0.025	25
Alewnaghta	13/08/2007	7.4		1.70				16.30	0.150	0.025	64
Alewnaghta	28/08/2007	7.5			0.3490		10.64	19.20	0.050	0.041	83
Alewnaghta	21/09/2007	7.5			1.7400		7.65	14.90	0.050	0.047	35
Alewnaghta	23/10/2007	7.2		2.00				13.90	0.150	0.005	77
Alewnaghta	04/04/2008	7.6			2.06		7.66	11.00	0.390	0.038	16
Alewnaghta	04/04/2008										
Alewnaghta	20/06/2008	7.7			0.72		8.08	16.50	0.050	0.012	15
Alewnaghta	20/06/2008										
Alewnaghta	01/10/2008	7.8	1.34			9.90	5.00	17.60	0.210	0.017	
Alewnaghta	25/08/2008	7.6	1.38			9.45	5.61	16.40	0.120	0.027	

Appendix D

Photographs from Tier 2 Exploratory Investigation

APPENDIX D

Photographs of Surface Water Sampling Locations – Refer to Figure 4 for mapped locations.

1. Upstream of Landfill and downstream from Crooked Lough: SW6

2. D/S on Crooked Lough Stream, down-gradient of Landfill site: SW7

3. Drain on Northern Boundary: SW4

4. Approx 100m downstream of SW4, down-gradient of landfill site and downstream of where land drain (along south boundary) joins stream: SW3

5. Downstream along stream travelling in eastern direction: SW1

6. Stream from northern direction: SW5

7. Furthest downstream: SW2

Trial Holes

8. Trial Hole 1

9. Trial Hole 2

10.Trial Hole 3

11. Trial Hole 4

Vegetative matter evident, similar to surrounding Gorse.

12. Trial Hole 5

13. Trial Hole 6

Clean Trial Hole

14. Trial Hole 7

Clean Trial Hole

15. Trial Hole 8

16. Trial Hole 9

17. Trial Hole 10

Others

Ponding on site, at eastern side

Windblown waste at the eastern part of site

Peat soils evident