Appendix 9

Preliminary Risk Assessment Report

BROWNFIELD RESTORATION IRELAND LTD.

REPORT ON

PRELIMINARY RISK ASSESSMENT
SITE AT
WHITESTOWN LOWER, CO. WICKLOW.

Prepared By:
Environment & Resource Management Ltd.
No. 3 Tara Court,
Naas, Co. Kildare.

Tel.: (045) 874411
Fax: (045) 874549
Email: info@erml.biz

March 2004

TABLE OF CONTENTS

LIST OF FIGURES

All Figures are located in Volume II, Appendix 1 of EIS March 2004

LIST OF TABLES

All Tables listed below are found within text of Preliminary Risk Assessment Report (March 2004)

All tables listed below are included at back of Preliminary Risk Assessment Report (March 2004)

BROWNFIELD RESTORATION IRELAND LTD.

REPORT ON
PRELIMINARY RISK ASSESSMENT
OF WASTES AT A SITE
AT WHITESTOWN LOWER, CO. WICKLOW.

MARCH 2004

---

1. INTRODUCTION

1.1 Preamble

Brownfield Restoration Ireland Ltd. (BRI) purchased a ca. 14.6 ha site comprising an existing sand and gravel pit, sheds and a private dwelling in Whitestown Lower, Co. Wicklow in September 2003. An outline of the landholding in the context of the local area is shown on Figure 1.1

The site and lands have been used for processing of sand and gravel for several decades. There is evidence as indicated on historical maps prepared by the Ordnance Survey of Ireland (OSI) that a sand pit has been on this site since at least 1908. It is also understood that wastes from outside sources have been deposited on this site, since the 1970s. It is understood that no such activities have been carried out since November 2001 and certainly not since BRI took control of the site. It is further understood that there was an intensification of waste disposal activities on this site during the period 1997 to 2001.

BRI intends to continue extracting and processing sand and gravel, develop the site as an Integrated Waste Management Facility, carry out necessary works to ensure that previously deposited wastes do not pose a threat to the environment, and restore the site.

A Waste Licence will be required for activities relating to waste management on the site specifically disposal activities as defined in the Third Schedule of the WMA, 1996 as amended and planning permission will be required for development not currently included in the planning permission granted in 1979 for development on the lands.

Environment & Resource Management Ltd. (ERML) has been retained by BRI to address engineering and environmental matters in relation to the remediation and restoration of the site and other proposed development at the Whitestown Lower site.

The first phase of work carried out by ERML comprised investigating areas of suspected waste deposition and assessing the existing and potential future environmental impacts and risks associated with the previously deposited wastes on the site. The focus of this work was assessing risks to the local groundwater and surface water. This report entitled 'Preliminary Risk Assessment' documents the first phase of work by ERML.

1.2 Objectives and Scope of Work

In order to assess the risks associated with the previously deposited wastes, the scope of work carried out by ERML, between December 2003 and February 2004, included the following:

- A comprehensive review of available literature, aerial photos and historical maps relating to the receiving environment, including the groundwater, surface water and ecology of the area,
- A detailed trial pit investigation in order to assess the extent, quantity and nature of previously deposited wastes at the site,
- A detailed laboratory and field testing schedule, which included analysis of groundwater and surface water; analysis of the eluate and total pollutant content of soils/fines within the waste bodies; and assessment of the composition of leachate and gas within the waste bodies, and
- Documentation of the baseline environmental conditions in regard to the overburden and bedrock geology, groundwater, surface water and ecology in the environs of the site.

Based on the findings of the above activities, the existing and future potential environmental impacts and risks associated with the previously deposited wastes in the environs of the Whitestown Lower site were assessed. In particular, the potential effects of the previously deposited wastes on the groundwater/surface water network were briefly examined using a preliminary 'mixing model', as outlined in Section 10 of this report.

2. REVIEW OF EXISTING ENVIRONMENT

2.1 Methodology

The existing geological, hydrogeological and surface water environments were explored by detailed desk studies and on site investigations.

Desk studies were carried out into the general overburden, bedrock geology and hydrogeology of the site and surrounding lands.

Site investigations were carried out between December 2003 and February 2004 by ERML staff and associated sub-contractors. Investigations included trial pitting, soil sample analysis, drilling of borehole/monitoring wells, groundwater sampling/laboratory analysis, and surface water and groundwater flow mapping.

Results of these investigations are included in the following Sections.

2.2 Overburden

The landscape in and surrounding the site derives its present morphology and its rich sand & gravel deposits from the influence of melt water channels (otherwise known as 'Eskers') from the Quaternary glaciation of Ireland.

The Geological Survey of Ireland (GSI) 'Quaternary Deposit Map' has classified the overburden of the area as "Gravel & Sand derived chiefly from Chert" (GCH), with the site in question marked as a "Sand & Gravel Pit in use". It should be noted that there is considerable evidence of sand & gravel extraction activity in the surrounding landscape. Figure 3.7.1 presents a map of the Quaternary deposits in the area based on the information collected by the GSI.

The sand and gravel deposits have been worked from the site since the early 1900s to present. Backfilling of sections of the pit, with imported wastes is understood to have taken place over a number of decades, with an intensification of this activity in the late 1990s until November 2001.

2.3 Bedrock Geology

The site geology was researched using the Geological Survey of Ireland (GSI) Booklet – "Geology of Kildare – Wicklow" and associated Geological Map – 'GSI Sheet No. 16' (Scale map – 1:100,000). A geological map, for the area, based on the information gathered is attached on Figure 3.7.2.

The bedrock beneath the glacial sequence on the site comprises the Lower Palaeozoic (Cambrian) Butter Mountain Formation. This consists of dark blue-grey slates, with thin interbedded grey quartzites in places (which may include beds, which are complexly folded and garnet rich, called "Coticules").

To the extreme southeast of the site, along the site contact with the Carrigower River, the bedrock changes to the Donard Andesite Member, as shown on Figure 3.7.2. This member of the main Butter Mountain Formation comprises fine-grained volcanic andesites.

Twelve (12 no.) groundwater wells have been identified within 2 kilometres of the site following a GSI database 'well search' in the Whitestown Lower area, which was undertaken in December 2003. They have varying depths to bedrock ranging between 0.9m to 27 metres below ground level, and may be explained by the undulating glacial landscape of the area. The five (5 no.) closest GSI borehole locations in the vicinity of the site are indicated in Figure 1.1.

2.4 Site Hydrogeology

2.4.1 Groundwater Classification

Based on desktop reviews, it is understood that three hydrogeological units underlie the site, namely:

- Shallow water table in overburden sand and gravels and upper fractured bedrock
- Deeper bedrock aquifer – Butter Mountain Formation.
- Deeper bedrock aquifer – Donard Andesite Member.

The Geological Survey of Ireland has not classified the water-bearing sand and gravels at this site.

The Butter Mountain Formation, which underlies the majority of the site, is classified by the GSI as '**LI**', which is a Locally Important Aquifer, with bedrock, which is moderately productive, only in Local Zones.

The Donard Andesite Member, which underlies only the southeast boundary of the site, is also classified by the GSI as a Locally Important Aquifer (**LI**), with bedrock, which is moderately productive, only in Local Zones.

2.4.2 Groundwater Vulnerability

The assessment of groundwater vulnerability for the area is based on guidelines issued by the Geological Survey of Ireland (Groundwater Protection Schemes 1999), and Map 7 of the Groundwater Protection Scheme for Co. Wicklow. These guidelines and Protection Maps evaluate the natural protection of an area against contamination through the overburden characteristics of the area.

As defined by the GSI, '*vulnerability is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities*'.

The GSI classify both the Butter Mountain Formation & the Donard Andesite Member as having High Vulnerability ('H'). The two bedrock units are shown on the GSI bedrock geology Figure 3.7.2. It should also be noted that according to the County Wicklow Resource Protection Zones Map No. 7 (prepared in April 2003), the majority of the site has a vulnerability rating of 'High' (**Ll/H**). However, towards the Carrigower River to the east of the site, the vulnerability rating is Extreme 'E' (**Ll/E**).

It is assumed that where the overburden cover is less than 3.0 metres, the vulnerability changes from 'High' to 'Extreme'. This would conform with the overburden geology depicted in Figure 3.7.1 and site observations which indicates that overburden near the Carrigower River is less than 1.0 metre in thickness.

2.4.3 Groundwater Usage

Two public water supplies are located within 4km of the site (Freynestown & Eadestown), both of which are supplied by springs.

Site walkover surveys and discussions with the Local Authority indicate that there is no groundwater users between the site proposed for development and the Carrigower River (hydraulic divide) located ca. 120 metres south east of the site.

It is understood that the two residences located immediately south of the site (see Figure 3.5.1) are supplied by the Eadestown Public Water Supply. This mains water infrastructure runs from Eadestown, which lies ca. 4km south of the site, and south of the Rivers Slaney and Carrigower. A small domestic pipe runs north from the crossroads to supply these two residences. This information is based on discussions with the Local Authority.

The two surface water features described above (Carrigower and Slaney) are understood to act as groundwater divides, thus reducing the potential of impact on groundwater users south of these river features. It is noted that there are no known groundwater users immediately downgradient of the site and north of the Carrigower River.

2.5 Surface Water

2.5.1 Regional Drainage

The site is located along the western margin of the River Carrigower, as depicted in Figure 3.10.2 (Local Surface Water Drainage). The Carrigower is a lowland spate river, rises in Hollywood Glen and is a first order tributary of the River Slaney.

The Carrigower River flows in a south to southwest direction past the site and joins the River Slaney ca. 2.0 km southwest of the site boundary.

The Carrigower River catchment area upstream of the southeast corner of the site is estimated as 49 km^2, as depicted in Figure 3.10.1.

2.5.2 Local Drainage

Beyond the northeastern section of the Whitestown Lower site, the ground slopes steeply down to the flood plain of the river, which has been described as a wet grassland area. The southeastern section of the site encompasses a section of the river's flood plain, where the site boundary is the river itself, as shown on Figure 3.10.2

This wet grassland floodplain is part of the Carrigower River Candidate Special Area of Conservation (cSAC), which in turn is part of the River Slaney cSAC. The cSAC is discussed further in Section 8.3 of this report.

Five arterial drainage channels drain from the wet grassland area between the site and the River Carrigower. These drainage channels are shown on Figure 3.10.1. The most northern channel (DC-1) is shallow (<0.3m in depth) and runs from the northeastern corner of the site, in a southerly direction, to join with the Carrigower River. During all site visits, throughout December 2003 & January 2004, this channel was dry.

Drainage channels DC-2 and DC-3 (ca. 0.3 deep, 0.5m wide) run either side of the site boundary and drain towards the Carrigower River in a southeastern direction. During the January 2004 site visits, water was observed in both channels, however flow was slight to absent.

Drainage channels DC-4 and DC-5 run along the southern boundary of the site, again draining in a southeasterly direction. During the January 2004 site visits, water was observed in both channels, however flow was slight to absent.

The five channels described are believed to be man-made, developed in order to drain the low-lying wet grassland area.

2.5.3 Surface Water Flows

The total surface water catchment for the Carrigower River lying above the site is estimated to be 49 km^2 in area. An outline of the Carrigower catchment is depicted in Figure 3.10.1 of this report.

Flows in the River Carrigower at the downstream corner of the site may be estimated by reference to two gauged stations.

Table 2.5.1: Flows at Nearby Gauged Stations

Hydrometric Station No.	River	Catchment Area	Average Runoff (m^3/sec)	95% Flow (m^3/sec)	Dry Weather Flow
12013	Slaney	18,500	4.39	1.540	0.640
12028	Carrigower	5,300	0.98*	0.350	0.140

*** Based on pro-rata calculation from existing data**

The estimated flows in the Carrigower River at the downstream corner of the site are as summarised in Table 2.5.2.

Table 2.5.2: Estimated Flows for River Carrigower

Flow	(m^3/sec)	(m^3/sec)	mm/year *
Average Runoff	0.905	78,192	582
95 Percentile Flow	0.320	27,648	206
Dry Weather Flow	0.129	11,146	83

*** Based on 4,900 hectare catchment area.**

3. TRIAL PIT ASSESSMENT

3.1 Objectives and Summary of Findings

As part of the overall site investigations at the Whitestown Lower site, a trial pitting exercise was undertaken by ERML on behalf of BRI in areas suspected of containing wastes, which had been previously deposited at this site. This exercise was undertaken between 15 to 19 December 2003.

Based on discussions with BRI and its consultants it is understood that site investigations were undertaken previously at the site. This investigation is understood to have included groundwater and surface water sampling, and trial pit investigations. On the basis of discussions with BRI and its consultants it was decided that the target area for the December 2003 investigation would be east of the overhead power lines that cross the site from north to south. The main objective of this trial pit investigation was to establish the nature and extent of waste previously deposited at the site east of the power lines.

Findings by ERML indicated that there are three primary zones east of the power lines that contain imported wastes mixed with soils that may be from the site or may also be imported construction and demolition wastes. These zones have been denoted as Zones A to C on Figure 3.7.3.

It is noted that wastes from sand and gravel processing on site have been deposited in areas west of the target area of the December 2003 investigation. It is also noted that the possibility of other imported wastes being present west of the power line cannot be ruled out.

Further details on the trial pit investigation are provided in the sections that follow.

3.2 Field Activities

A 32-tonne excavator was used to dig the trial pits, which could achieve depths of ca. 7.0 metres below ground level.

Trial pitting was undertaken in areas where wastes had been previously deposited with a view to establishing the extent and nature of the waste body. A number of trial pits were dug in areas beyond the suspected waste zones to confirm that the absence of waste in these areas.

A total of 67 trial pits were excavated within the site. Locations of these trial pits are depicted on Figure 3.7.3 attached. During the trial pitting exercise, the following information was collected:

- Depth of trial pit
- Materials encountered, including a percentage breakdown of material types on a volumetric basis

- Representative leachate samples for indicator parameters
- Representative soil samples for eluate and total pollutant content testing
- Digital photographs

A comprehensive and detailed topographic survey of the site was carried out in conjunction with the trial pit exercise in December 2003. This survey was required to estimate the volume of wastes at the site, determine levels of trial pits and boreholes and assist with the planning and engineering of future work on the site.

3.3 Excavation of Trial Pits

A summary of trial pits excavated in each of the three suspected waste zones is noted on Table 3.1 below.

Table 3.1: Number of Trial Pits Dug in each of the Three Suspected Waste Zones.

Zone	Trial Pits
A	19
B	8
C	18
Total	51

As described previously, trial pits were excavated to determine the nature and extent of imported waste deposition. The remaining 16 no. trial pits not listed above were beyond the zones containing imported waste. They are therefore not considered in the determination of an estimate of imported waste quantities.

Field notes were completed and transcribed onto field logs. These trial pit logs are appended.

A summary description of each of the three suspected waste zones (see Figure 3.7.3 based on the findings of the trial pitting exercise undertaken by ERML in December 2003, is presented in each of the following sections.

3.4 Detailed Description of Wastes in Zone A

Zone A typically contained wood, metals, plastics & paper/cardboard, in a soils/fines matrix. This waste body contained very bulky C&D wastes and is likely to be the most recently deposited material based on visual observations and extent of biodegradation. Newspapers from 2000 were identified at some locations. Wastes were found from what appeared to be commercial and industrial sources, including a Dublin Airport source. Much of this waste was packaging waste (paper/cardboard/plastics).

These soils/fines may have been sourced from the site or may be imported C&D wastes.

The content of the soils/fines within each of the zones varies. At Zone A & C, it is estimated that the soils/fines content may make up 60-70% of the total mass of the waste body. At Zone B, it is estimated that the soils/fines make up to or greater than 90% of the total mass of the waste body.

Each of Zones A, B, and C consist of a surface layer of cover material (made-ground) consisting mainly of soft brown clayey silts with some sands and gravels, ranging from 0.2 to 1.8 metres, and typically greater than 0.4 metres in thickness. The surface cover material is underlain with varying percentages of waste material. During the trial pit assessment, where possible the percentage breakdown of wastes was described based on visual estimates only on a volumetric basis. These details are included in the trial pit logs that are appended.

Of the 45 trial pits excavated within the three zones containing imported waste (Zone A, B and C), only 12 of the excavations reached the natural subsoil (mainly a loose light brown fine silty SAND with gravels), below the madeground/waste material. The depth to the natural subsoil varied from 1.1m - 6m below the waste layer.

It should be noted that no obvious hazardous waste materials were identified at any of the trial pit locations on the site.

The remainder of the site consisted of previously worked out sand and gravel deposits, surrounded by higher ground (also composed of native glacial deposits of silt, sand and gravel). Across the site there are scattered mounds of soft light brown clayey sandy SILTS, which appear to be deposits from the sand and gravel washing process, once carried out on the site.

4. WASTE TYPES AND QUANTITIES

Table 4.1 below depicts the estimated surface area of each of the three Zones, which contain waste.

Table 4.1: Estimate of Surface Area in each Waste Zone

Zone	Surface Area (m^2)
Zone A	10,300
Zone B	8,550
Zone C	11,300
Total	30,150

Table 4.2 below depicts the volume of each of the three waste Zones.

Table 4.2: Rounded Estimates of Volume in each Waste Zone

Zone	Volume (m^3)
Zone A	67,000
Zone B	38,000
Zone C	74,000
Total	179,000

An estimate of waste types and quantities was made using the following broad headings for the different wastes identified at the site, including:

- Apparently Inert wastes (i.e. soils, fines, concrete, bricks, etc.)
- Non-Inert Wastes (not readily biodegradable) (i.e. plastics, rubber, metals, etc.)
- Non-Inert Wastes (readily biodegradable) (i.e. wood, paper)

Based on these broad headings, estimated waste quantities for each of the zones were calculated using appropriate density conversion ratios.

Table 4.3: Rounded Estimates of Waste Volumes and Tonnages

Waste Type	Inert Wastes	Non-readily Biodegradable Wastes	Readily Biodegradable Wastes	Total Volume (tonnes)
Typical Density t/m^3	(1.7)	(1.0)	(0.4)	
Zone A	70,000	15,000	5,000	90,000
Zone B	49,000	3,000	3,000	55,000
Zone C	75,000	15,000	5,000	95,000
Totals of Waste in Zones A, B and C	194,000	33,000	13,000	240,000

The foregoing estimates suggest an average density of 1.34 tonnes/m^3 for the wastes. This value accords with previous experience. It is possible due to the limitations of the investigation that the volumes of wastes are underestimated. If one allows for a 10% underestimate, the total is ca. 266,000 tonnes of waste.

5. SOIL/FINES ASSESSMENT WITHIN WASTE ZONES

5.1 Methodology

During the December 2003 ERML site investigations, soil samples were taken from the following locations:

- Within waste body (including Zones A, B & C)
- Beneath the waste body (including Zones A, B & C)
- Raised grassland area (considered background sample)

Composite samples were prepared from samples taken to provide spacial representation of the soil quality in both the waste zones and beneath them. Table 5.1 below is a summary of sampling details

Table 5.1: Soil/Fines Samples Collected for Eluate/Total Pollutant Content Analysis

Sample Location	Details of Sampling
Within Waste Body	Composite sample from TP 1, 2, 7, 13 & 39A Sample from TP 62 Composite sample from TP16, 19A, 22, 24 & 52
Beneath Waste Body	Sample from TP 19B Sample from 39B Sample from TP 59B
Raised Grassland Area	Sample from TP-33

5.2 Soils/Fines Eluate Results Within Waste Body

A summary of the soils/fines eluate and total pollutant content results are presented in Table 5.2. The analyses are compared to the Council Decision 2003/33/EC on Limits for Eluate & Total Pollutant Content.

Analytical results from samples taken from within the waste body show concentrations for Total Dissolved Solids (TDS), Dissolved Organic Carbon, Total Phenols, Inorganics - chloride & fluoride, Metals, Mineral Oils, BTEX & PCB's all below the Council Decision limit for inert waste, with most below the laboratory detection limit.

A composite sample from Zone C shows a slightly elevated DRO concentration. A slightly elevated PAH concentration was also identified in sample from Zone A (2.1 mg/kg). The generally accepted PAH threshold for Ireland is 2.0 mg/kg.

The analysis of inorganic parameters from samples taken within the waste body indicated elevated concentrations for Sulphate, in particular from

Zones A & C (2,399 mg/kg and 1,317 mg/kg respectively), both of which were above the Council Decision limit for inert waste.

5.3 Soils/Fines Results Beneath Waste Body

Samples were also taken in natural ground beneath the waste zones including TP-19B (Zone C), TP-39B (Zone A) & TP-59B (Zone B). These were sampled and analysed in order to investigate if previously deposited wastes had an affect on the natural ground below.

A low concentration for DRO was recorded at TP-19B, but was below detection limits in the other two samples.

An elevated result for Sulphate was also identified at TP-19B, however this was below the Council Decision threshold for inert waste.

In summary, these results indicate that in general, the natural sub-soil below the waste body has not been adversely affected by previously deposited wastes to date. However, TP-19B showed slightly elevated concentrations for Sulphate & DRO's, which indicate a possible downward migration of contaminants from the upper waste layers within Zone C.

5.4 Soils/Fines Eluate Results From Raised Grassland Area (Background Sample)

One sample was also collected from the raised grassland area located to the south of the buildings on site. The sample collected from TP-33 may be used as a representative background sample, used for comparison purposes, as no waste was identified within this area. The analysis results from this sample show no elevated readings for all eluate and total pollutant content parameters.

5.5 Summary of Findings of Soils/Fines Assessment

Eluate and Total Pollutant Content analysis on soils within Zones A and C indicate some impact on the soils/fines faction from the wastes has occurred. Slightly elevated concentrations, in particular for Sulphate and Diesel Range Organics confirm that decomposition of the waste has resulted in these elevated concentrations in the soils/fines matrix.

6. LEACHATE ASSESSMENT WITHIN WASTE ZONES

6.1 Methodology

As indicated previously, 67 trial pits were excavated in the December 2003 ERML site investigation. In total, only 2 trial pits within the waste body contained sufficient water entry for leachate sampling. Two leachate samples were subsequently collected from TP-63 (Zone B) TP-24 (Zone C) and sent for detailed laboratory analysis.

Table 6.1 Leachate Samples Collected During Site Investigations

Zone	Trial Pit
A	No leachate found
B	TP-63.
C	TP-24.
Background	No leachate found

Analytical results for all parameters analysed for are presented in Table 6.2. In general, results from the leachate analysis indicated the presence of elevated concentrations for many parameters.

6.2 Indicator Parameters from Leachate Analysis

Leachate is defined as any liquid, including precipitation and ingress groundwater, percolating through deposited wastes and emitted from or contained within deposited wastes. As it percolates through the waste, it picks up suspended and soluble materials that originate from, or are products of, the degradation of the waste.

For the purposes of this report, the following parameters have been selected as indicator or signature parameters, as they may typically be elevated where leachate is present, and include:

- Conductivity
- Ammoniacal Nitrogen
- Chloride
- Potassium
- Sulphate
- Boron
- Chromium

Results of the indicator parameters are summarized in Table 6.3.

The quality of the leachate from the two samples taken indicates elevated concentrations for the indicator parameters, which include Ammoniacal Nitrogen, Chloride, Potassium, Sulphate, Boron, Chromium and Toluene.

The two key factors, which are currently affecting the strength of leachate, within the previously deposited wastes, include:

- present cover material which reduces infiltration, as observed by the relative dryness of the wastes within each zone
- relative age of the wastes

6.3 Present Cover Material

Following the ERML site investigation in December 2003, a review of the thickness and type of material currently covering the waste zones was undertaken. The cover material and thickness across the waste zones are summarized in Table 6.4 below:

Table 6.4: Thickness of Surface Cover on Waste Zones investigated by ERML December 2003

Waste Zone	Cover Material	Cover Thickness
Zone A	Consists predominantly of silty CLAYS with gravels	ca. 0.2 – 1.2 metres
Zone B	Consists predominantly of clayey sandy SILTS	ca. 0.4 metres
Zone C	Consists predominantly clayey silts to very fine SANDS with gravels	ca. 0.2 – 1.8 metres

6.4 Age of Wastes

The age of the wastes is difficult to determine. Based on field observations, information available to BRI and also a review of enlarged aerial photographs taken between 1973 and 2000. It appears the wastes in Zones A and C were deposited sometime after 1995 and up to November 2001. The age of the wastes in Zone B are more difficult to determine as they mainly comprise soils with only small pockets of obviously imported non inert wastes. It is likely therefore that the wastes in Zones A and C have not reached their full leachate producing potential.

6.5 Significance of Constituents in Leachate

As discussed previously in this report, a number of indicator parameters have been selected for the purposes of this risk assessment. The significance of a number of these constituents of leachate is summarised below, and is referenced from the EPA Landfill Site Design Manual, 2000.

It should be noted that the degradation process is divided into five successive stages, namely:

- Aerobic
- Hydrolysis and fermentation
- Acetogenesis
- Methanogenesis
- Anaerobic

6.5.1 Ammoniacal Nitrogen

Over extended timescales, Ammoniacal Nitrogen is the contaminant with the greatest potential over an extended time scale to adversely impact upon surface waters and groundwater in the vicinity of landfills. According to the EPA Manual, it can be several decades before concentrations of ammoniacal nitrogen will fall to values where direct release to a watercourse becomes a viable option.

6.5.2 Chloride

Leachate contains the final soluble degradation products of waste, which are in the main simple ions. The major contributor to this ionic strength is chloride and this can cause a problem to fish life and can be prejudicial to other water users.

6.5.3 Sulphate

Methanogenic leachate generally contains low concentrations (median of 35 mg/l) whereas on average acetogenic leachate contains up to 10 fold higher sulphate concentrations. Sulphates if present are likely to cause a problem due to reduction to hydrogen sulphide which gives rise to odour problems at low odour thresholds.

6.5.4 Other Compounds

It is important that the List I and List II substances referred to in the EU Directives on Dangerous Substances (76/464/EEC) and Groundwater (80/68/EC) and amendments are prevented from being discharged or limited so that surface water or groundwater pollution is prevented.

6.6 Typical Composition of Leachate

For the purposes of this report, Table 6.5 provides a summary of indicator parameter concentration values from different leachate sources. These sources include:

- Acetogenic leachate (relatively dry high waste input)
- Methanogenic leachate (relatively dry high waste input)
- Recent waste (domestic)
- Bioreactive waste (domestic)

- EPA licenced commercial & industrial waste landfill (Licence No. 81-2)
- Landfills in U.K accepting commercial/industrial and construction/demolition wastes

6.7 Summary of Findings From Leachate Assessment

Leachate results have also indicated the presence of contaminants in the liquid fraction, within the waste body, in particular Ammoniacal Nitrogen, Potassium, Chromium, Diesel Range Organics and Toluene. However it should be noted that as a silt/ clay cap exists over the waste zones, the generation of leachate has been restricted.

7. GROUNDWATER ASSESSMENT

7.1 Groundwater Sampling & Analysis

Seventeen groundwater monitoring wells were installed on and surrounding the Whitestown Lower site (8 off-site & 9 on-site) during previous ownership of the site. These well locations are shown on Figure 3.7.4. Their geographic location, whether onsite or offsite, and whether up gradient or down gradient to groundwater flow & waste bodies, are summarised on Table 7.1 below.

Table 7.1: Description of Locations of Previously Drilled Boreholes

Borehole Name	Borehole Location	On-site / Off-site	* Up-gradient / Down-gradient of Waste Zones	Presumed Location of Well Screen
MW-1	Northwest	Off-site	Upgradient	Overburden
MW-2	West	Off-site	Up gradient	Bedrock
MW-3	Southwest	Off-site	Up gradient	Bedrock
MW-4	Northeast	Off-site	Up gradient	Overburden
MW-5	Northeast	Off-site	Up gradient	Overburden
MW-6	West	Off-site	Down gradient	Overburden
MW-7	West	Off-site	Down gradient	Overburden
MW-8	West	On-site	Down gradient	Overburden
MW-9	Southeast	On-site	Down gradient	Overburden
MW-10	South	Off-site	Down gradient	Overburden
MW-11	West	On-site	Down gradient	Bedrock
MW-12	North	On-site	Up gradient	Bedrock
MW03-1	Northeast	On-site	Down gradient	Overburden
MW03-2	South	On-site	Down gradient	Bedrock
MW03-3	Northeast	On-site	Down gradient	Overburden
MW03-4	South	On-site	Upgradient	Bedrock
MW03-5	North	On-site	Up gradient	Bedrock

*** Upgradient or Downgradient of waste zones in relation to groundwater flow.**

As part of the site investigation by ERML, these wells were monitored for groundwater table level in terms of metres Ordnance Datum (mOD), then purged and sampled the following day. The groundwater sampling logs, including a record of all field parameters measured, are appended.

MW03-1 was dry on the date of sampling (12 December 2003). All groundwater samples collected were sent to *Alcontrol Geochem (Dublin)* for independent laboratory analysis. An additional groundwater monitoring event was undertaken on 25 February 2004 at the ERML monitoring well boreholes (MW04-1 to MW04-5) inclusive. At the time of issuing this report, only Ammoniacal Nitrogen data was available.

A summary of the groundwater laboratory results is presented on Table 7.2. In the absence of appropriate standards, the analysis is compared to the European Communities (Drinking Water) Regulations 2000 (S.I. No. 439 of 2000).

7.2 General Groundwater Quality

In general, the majority of parameters measured were below background concentrations for this type of environmental setting. However, some parameters were elevated above background, in particular those parameters which may be associated with leachate contamination.

7.3 Indicator Parameters

As described earlier, the following parameters have been selected as indicator or signature parameters, as they may typically be elevated where leachate is present, and include:

- Conductivity
- Ammoniacal Nitrogen
- Chloride
- Potassium
- Sulphate
- Boron
- Chromium

The groundwater analytical results below are discussed in terms of upgradient and downgradient of the waste zones. Five monitoring wells upgradient and five downgradient of the waste zones have been selected for comparative purposes.

It is understood that all 17 groundwater wells previously installed are screened both in bedrock and/or the overburden strata. In the absence of data describing the location of the screen for each monitoring well, the groundwater quality is discussed in general terms.

It should be noted that the groundwater encountered is likely to be from the saturated zone above the slate bedrock, in particular towards the east of the site, where there is a greater thickness of overburden. Strata within the saturated zone are likely to include sand and gravel and weathered bedrock.

7.3.1 Indicator Parameters in Groundwater External to Site

Indicator analytical results from monitoring wells located externally to the site (upgradient), in terms of groundwater quality, are included in Table 7.3. The general groundwater quality is good, and typically reflects this type of agricultural setting.

7.3.2 Indicator Parameters in Groundwater Downgradient of Waste Zones

Indicator analytical results from monitoring wells located immediately downgradient of the waste zones, in terms of groundwater flow, are included in Table 7.4. The groundwater is typically poorer in quality than the upgradient wells, with elevated concentrations for the leachate indicator parameters including Conductivity, Ammoniacal Nitrogen, Potassium and Chromium.

7.4 Drilling of Subsequent Monitoring Boreholes

In order to investigate the depth to bedrock on the site itself, five subsequent boreholes were drilled on the site over a three-day period, between 23 to 27 January 2004. These borehole locations (MW04-1, MW04-2, MW04-3, MW04-4 & MW04-5) are also shown in Figure 3.7.4.

All five borehole locations were completed as bedrock monitoring wells, as indicated on the borehole logs appended. Table 7.5 below summarises the location, depth to bedrock, and depth to water table etc. from these boreholes.

Table 7.5: Summary of Details on Boreholes Drilled during January 2004

Borehole Name	Borehole Location	Depth to Bedrock	Depth to Groundwater Strikes	Comment
MW04-1	Southwest	0.4m	7.2m	Drilled from floor of pit
MW04-2	West	1.5m	5m / 5.5m / 7m	Drilled from floor of pit
MW04-3	Northwest	0.6m	5.5m / 7m	Drilled from floor of pit
MW04-4	East-Northeast	8m	5.5m / 5.8m	Drilled in raised grassland area
MW04-5	East	8.2m	5.5m / 7.8m	Drilled in raised grassland area

In each of the boreholes located to west of the site (MW04-1, MW04-2 & MW04-3), groundwater was recorded within the bedrock, with water strikes ranging between 5.0 to 7.2 metres below ground level. As this bedrock type is considered to be locally important aquifer, which is moderately productive, only in Local Zones it is expected that the groundwater encountered is found in fissures, disturbed bedding planes, weathered zones etc. within the bedrock.

As summarised in Table 7.5, the three boreholes to the front/west of the site (MW04-1, MW04-2 & MW04-3), which were drilled on the quarry floor, showed a very shallow depth to bedrock of 0.4m, 1.5m & 0.6m respectively, with sand & gravel overburden.

The two deeper boreholes located to the east of the site (MW04-4 & MW04-5), were drilled through ca. 8.0 to 8.2 metres of sand & gravel / coarse gravels prior to reaching bedrock. Groundwater was encountered within the gravel layers, at depths ranging from 5.5 to 7.8 metres below ground level.

The bedrock encountered in the five boreholes was typically a weathered upper layer of light brown slates of varying thickness (see borehole logs as appended) underlain by very consolidated dark grey - blue slates.

As outlined in Table 7.5, water strikes were typically observed in the weathered slate bedrock. However, other water strikes were observed in sand and gravel lenses above the weathered fraction of the bedrock. At one borehole location, a water strike was also observed in the bedrock proper.

7.5 Groundwater Flow Direction and Gradient

Groundwater levels in the 17 monitoring wells (previously installed) were recorded in December 2003. Following the installation of five additional groundwater monitoring wells in January 2004, the groundwater flow direction was also determined using these additional well locations. It is noted that the well construction details for the previously drilled boreholes have not been available to ERML so the groundwater flow directions and gradient are considered to be approximate and indicative of the hydrogeologic conditions in the overburden and upper bedrock.

The groundwater flow, on both occasions, indicated a northwest/southeast direction. The average lateral hydraulic gradient was also calculated to be between 0.020 and 0.300 across the site. During each monitoring event, the surface water level was also recorded and all levels were expressed as metres ordnance datum Malin Head (mOD).

Details of groundwater flow direction and hydraulic gradient for the site are depicted in Figure 3.7.4.

7.6 Hydraulic Conductivity of the Upper Saturated Zone

In February 2004, ERML carried out tests to determine the hydraulic conductivity of the glacial overburden/weathered and fractured bedrock beneath the site. The tests included assessing the gradation of samples of the native soils that were recovered in the trial pits, and by rising head tests in monitoring wells across the site. Table 7.6 includes details of the following tests

- Particle Size Distribution Analysis on trial pit samples in overburden
- Rising head tests on MW03-1 to MW03-5 monitoring well series
- Rising head tests on MW-1 to MW-12 monitoring well series
- Rising head tests on MW04-1 to MW04-5 monitoring well series

In summary, the hydraulic conductivity of the overburden material/fractured bedrock beneath the site is estimated to be in the range of **$4.41x10^{-4}$** to **$3.24x10^{-6}$** m/sec. A representative range of **$1x10^{-4}$** to **$1x10^{-5}$** m/sec is assumed.

8. SURFACE WATER ASSESSMENT

8.1 Methodology

Surface water samples (grab samples) were taken at four monitoring locations (SW1 to SW4 inclusive) on 12 December 2003. These samples were forwarded to Alcontrol Geochem Ireland Ltd. for detailed analysis. A summary table of all analysis for each monitoring location is included in Table 8.1. Results for Ammoniacal Nitrogen are also included in this table for the 25 February 2004 sampling event, which includes an additional sampling location SW-5.

With the exception of some bacteriological parameters, the surface water quality both upstream and downstream of the site, is generally of good quality. Detected concentrations for Faecal Coliforms and Faecal Streptococci were elevated above background, and typically reflect an agricultural setting.

8.2 Leachate Indicator Parameters in Surface Water

As described previously, indicator parameters were selected for comparative purposes, where leachate may have influenced the water quality. Table 8.2 includes the detected concentrations for these parameters at all surface water monitoring locations.

The indicator parameters are not elevated at any of the surface water monitoring locations, thus indicating the absence of leachate in the River Carrigower during the December 2003 sampling event.

8.3 Ecological Surveys

A river water quality investigation at Whitestown Bridge, undertaken by the Environmental Protection Agency in 1998, indicated that the Carrigower River was unpolluted (Q value of 4-5).

A baseline ecological survey was undertaken by Natural Environmental Consultants in January/February 2004. A copy of this report is appended. As part of this survey, an ecological evaluation of the Carrigower River was undertaken. Biological sampling was undertaken at three locations to determine the current water quality status of the river.

In terms of water quality, a Q rating of 3-4 was assigned to the Carrigower River, both immediately upstream and downstream of the Whitestown Lower site, indicating a slightly polluted status (Natura February 2004 Report). (See Figure 3.10.2 for biological sampling locations).

8.4 Ecological Designations

As depicted in Figure 3.4.1, the Whitestown Lower site extends towards the southeast where it meets the Carrigower River. The Carrigower River and its adjacent floodplain are now included within the River Slaney candidate Special Area of Conservation (cSAC)(site code no.000781). It is understood that the River Slaney cSAC was extended in May 2003 to include the Carrigower River on account of its importance as a spawning tributary.

Following a detailed ecological baseline study, which was undertaken in January/February 2004, the study found that the Carrigower River and adjacent floodplain are part of the River Slaney cSAC and are thus of international importance (under EU Habitats Directive – 92/43/EEC). The presence of abundant salmonid spawning habitat in the river along with extensive signs of otter activity adds to the value and importance of this site.

8.5 Historical & Current Quality of River Carrigower

The EPA has undertaken river quality assessments between 1995 to 1997 and 1998 to 2000 in the River Carrigower ("Water Quality in Ireland" 1998 and 2002 references). For both EPA monitoring events, the river quality in the Carrigower was unpolluted for 5 km (Class A) and slightly polluted for 3 km (Class B). It is understood from these sampling events, that the unpolluted 5 km stretch of the Carrigower in the 1995 to 1997 and 1998 to 2000 assessments includes the river stretch adjoining the Whitestown Lower site.

A Q rating of 3-4 (slightly polluted status) in the February 2004 Natura Report, has subsequently been given to the Carrigower River, both upstream, adjacent and downstream of the site.

From the historical EPA results and the more recent Natura sampling event (10 February 2004), it is observed that the Carrigower river quality adjoining the site, which includes upstream and downstream, has deteriorated over the last ca. 10 years.

9. LANDFILL GAS ASSESSMENT

9.1 Methodology and Results

Following a literature review in the public offices of the EPA, gas sampling results were found from an EPA sampling event, which was carried out on 2 September 2003 at the Whitestown Lower site. Results from the EPA survey are included in Table 9.1. These results indicate the absence of landfill gases (e.g. CH_4,) in all monitoring well locations that were monitored with the exception of MW-12 (confirmed by GPS coordinate), which indicated a Methane value of 4.7%.

During the EPA landfill gas survey (2/9/03), samples were also taken in each of the waste Zones A, B and C using a 1.0 metre searcher bar, which was driven into the waste body. The results of this 'spike survey' are also included in Table 9.1, and indicated readings for CH_4 ranging from 17.3% to 27.2%, thus showing the presence of landfill gases.

During the ERML December 2003 site investigations, appropriate gas monitoring caps were applied to the existing boreholes at the Whitestown Lower site and its environs. These monitoring boreholes included MW-1 to MW-11 inclusive, and BH03-1 to BH03-5 inclusive.

Gas readings were taken at all monitoring boreholes on 19 December 2003, and the results of this survey are also included in Table 9.1. There were no elevated readings for landfill gas parameters during this sampling event at any of the monitoring well locations.

ERML undertook an additional landfill gas survey on 20 February 2004. This survey included the existing boreholes on site and a spike survey. Results of this survey are also included in Table 9.1. Elevated readings for Methane were observed in monitoring well locations MW03-1 and MW03-3 (10.9% and 11.5% respectively).

One spike reading taken ca. 1.0 metre below ground level was also obtained at Zone A, indicating a Methane level of 28.5%.

An additional landfill gas spike survey was undertaken on 23 February 2004. Due to the thickness and type of cover material, samples were only possible ca. 0.5 metres below ground level. Methane concentrations were detected up to 7.0% during this spike survey.

10. SURFACE WATER/GROUNDWATER IMPACT ASSESSMENT

10.1 Conceptual Model

The surface water and groundwater receiving environments are described in other sections of this report. On the basis of the data already provided in this report and consideration of all other available data, a conceptual model of the groundwater flow regime and its interaction with surface water has been developed by ERML.

The following parameters are the basis of this conceptual model:

- Hydrostratographic Units – Saturated thickness of overburden, depth to bedrock surface thickness of active groundwater
- Groundwater catchment recharge (both upgradient of site and on-site)
- Hydrogeological Parameters - Hydraulic conductivity of the overburden/upper bedrock lying beneath the site, lateral hydraulic gradients, groundwater flow and travel times
- Carrigower River catchment (inferred flow rates)

10.1.1 Hydrostratigraphic Units

Conceptualised geological sections (A to C inclusive) were prepared using trial pit data, available borehole log data and a comprehensive ground survey as shown on Figure 3.7.5. The sections illustrate the nature of the ground conditions across the site and the shallow depth to the groundwater table beneath large parts of the existing Whitestown Lower sand and gravel pit. The base of the previously deposited waste relative to the water table is also shown on the sections.

The principal hydrostratigaphic unit of interest beneath the site is the saturated glacial sand deposit and upper zone of fractured bedrock. The thickness of the active zone of groundwater in these materials beneath the site is inferred to be in the range of 2 to 4 metres. This active zone of groundwater is considered to be hydraulically connected to the river.

It is noted that the thickness of overburden may be quite limited east of the site (i.e. less than 1.0 metres in places), in the river floodplain. The physical characteristics of the alluvial soils that have been mapped in the floodplain are different than the materials that underlie the floor of the pit. Samples of native soils taken along the eastern side of the site were anaylsed for gradation, in particular TP65.

These analyses indicated the presence of finer materials in the subsurface alluvial material including firm grey SILT with organics and high organic peat material (See cross sections Figure No. 3.7.5). As a result, it is expected that the alluvial material where present would have a hydraulic conductivity several orders of magnitude lower than the coarser grain sediments that underlie the pit floor as described earlier. Hydraulic conductivity values may range in the **10^{-8} to 10^{-10}** m/sec range.

10.1.2 Groundwater Catchment Recharge

The inferred groundwater catchment of the site is outlined in Figure 3.7.6. The area of the groundwater catchment excluding the site is ca. 534,000m^2. The groundwater catchment within the site is estimated at ca. 146,000m^2, including the surface area of the waste zones, which is ca. 30,000 m^2 (see Table 10.1).

In terms of assumed recharge within the groundwater catchment different recharge rates values have been assumed based on the overburden or soil cover material overlying the uppermost groundwater zone beneath the site.

A general recharge rate has been computed for the catchment on the basis of inference from the 95 percentile surface water flows in gauged river catchments. In this regard the base flow of a river is considered to be the groundwater flow and the 95 percentile flow is assumed to be a lower bound estimate of the base flow. A groundwater recharge rate of 260 mm per annum has been inferred for the Carrigower River catchment. This compares to the total average runoff value that is expected to be in the range of 800 mm in this catchment.

Within the site (excluding the wastes) there is little to no vegetative cover and a very low potential for direct surface water runoff off the site so a relatively high recharge rate of 800 mm/year has been assumed.

As discussed above, the wastes have a surface cover of soil that restricts the amount of infiltration/recharge through these zones. A recharge rate equal to 400 mm/year, which is approximately half of the average runoff value, has been assumed in the model.

On the basis of the above recharge rates the groundwater flux is estimated to be in the order of 700 m^3/day.

10.1.3 Estimated Hydrogelogical Parameters

- The hydraulic conductivity of the overburden material/fractured bedrock beneath the site is estimated to be in the range of **4.41×10^{-4}** to **3.24×10^{-6}** m/sec. A representative range of **1×10^{-4}** to **1×10^{-5}** is assumed.
- The estimated hydraulic gradient across the site is in the range of 0.020 and 0.030 with a representative value of 0.025.
- The thickness of the active groundwater flow beneath the site is assumed to be in the range of 2 to 4 metres.
- The width of the groundwater flow path heading towards the river is estimated to be 450 to 480 metres.

- On the basis of the above but not taking into account the likelihood of lower permeability deposits between the site and the river, the groundwater flux is estimated to be in the range of 0.1 to 1.0 m^3/day.
- As groundwater velocity and travel time may be computed by assuming an average porosity for the deposits in which flow is occurring. For the purpose of computation a porosity of 0.2 is assumed to be representative of the overburden as flow in bedrock will be via fracture flow.
- On the basis of the foregoing, a groundwater velocity of 0.1 to 1.0 m/day is computed. In this case contaminants in the groundwater emanating from the existing waste body may travel to the river in 100 to 1,000 days assuming plug flow, no dispersion and no attenuation in the alluvial silt/clay along the flow path to the River Carrigower.
- It is noted that travel time may be longer due to the presence of alluvial deposits between the edge of the site and the River Carrigower.

10.1.4 Carrigower River Catchment Flows

Based on the EPA river monitoring station no. 12028 (Whitestown), the average flow rate (pro-rata estimate), 95 percentile flow and dry water flow rates for the Carrigower River in the Whitestown townland are as follows:

- 0.98 m^3/sec (average flow rate - estimated)
- 0.35 m^3/sec (95 percentile)
- 0.14 m^3/sec (dry water flow)

All of the above information has been incorporated or considered in the development of a spread sheet mass flux model of the interaction between the groundwater discharge downgradient of the site and the surface water flow in the Carrigower River immediately downstream of the site. The overall surface water/groundwater conceptual model is demonstrated in Table 10.1 of this report.

Further input parameters to this model in relation to groundwater catchment recharge are described in Table 10.2 below.

Table 10.2: Summary of Groundwater Catchment Recharge Data

Groundwater Recharge Zone	Area (m^2)	Cover material/Use	Assumed Recharge (m/year)	Groundwater Discharge Q (m^3/day)
Catchment External to Site	749,000	Pasture and some hardstands	0.206	310
Site Area Excluding Wastes	116,000	Sand & Gravel Deposits	0.800	254
Waste Zones A,B,C Combined	30,000	Silt/Clay Cover Material	0.400	33
Combined Groundwater Catchment Recharge Q (m^3/day)				588 m^3/day

10.2 Presumed Concentrations of Leachate Indicator Parameters in Groundwater

As indicated previously, a number of leachate indicator parameters have been selected for this report. In order to calculate the concentration of these parameters in the groundwater upgradient of the site, the baseline water quality results from the ERML December 2003 survey were used (Table 7.2).

These values were inserted into the conceptual model as indicated in Table 10.1.

10.3 Mass Flux Calculations in Groundwater External to Site

Based on the groundwater concentrations upgradient of the site, the mass flux concentration for each of these parameters were calculated. It is assumed that these are the mass flux concentrations for the indicator parameters in groundwater entering beneath the site (Table 10.1). This calculation takes into account the site area excluding the three waste zones.

10.4 Mass Flux Concentrations Beneath Waste Zones

The process is repeated for the groundwater immediately beneath the waste zones. However, the concentrations for the indicator parameters have been selected to reflect a 'worse case scenario' of leachate being produced from the previously deposited wastes.

Based on Table 6.5 (Summary of Composition of Leachate from Different Sources), an assumed concentration for each of the indicator parameters is selected.

Based on these 'worse-case scenario' concentrations, the mass flux concentrations for groundwater emanating from the waste zones is then calculated (Table 10.1).

10.5 Mass Flux in River Carrigower

Based on the above calculations, the Mass Flux concentrations for each of the indicator parameters entering into the River Carrigower downgradient of the site is calculated. These values combine all mass flux concentrations from the upgradient catchment and total site area including the waste zones.

10.6 Impact on River Carrigower

Based on the above conceptual model, the percentage increase (in terms of mass flux concentration) over baseline conditions on the River Carrigower is calculated.

There are slight increases over baseline for many of the indicator parameters. However, the computed concentration of Ammoniacal Nitrogen indicates a percentage increase over baseline at ca. 213%.

To date, this level of impact does not appear to be observed in the river. This is due to a number of factors:

- a worse-case concentration for the various contaminants of concern has been used in the surface water/ groundwater impact assessment model. The concentration of Ammoniacal Nitrogen and other parameters in the groundwater beneath the waste zones are likely much less than this;
- the flows in the River Carrigower may be underestimated, and the groundwater discharge from the site may be overestimated;
- travel time may be longer due to the presence of alluvial deposits between the edge of the site and the River Carrigower;
- natural attenuation processes are occurring along the flow path;
- the surface cover on the wastes is greatly reducing the infiltration of rainwater into the waste thus leachate discharges are lower than indicated above;

11. RISK ASSESSMENT

11.1 Framework

Risk may be defined as the combination of the probability or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence on a receptor. A key consideration in this regard is the pathway between the identified hazard and the receptors. If there is no connection or pathway between the hazard and receptor, then there can be no risk.

A framework for assessment of risk at the Whitestown site is as follows:

- Source/hazard identification and qualitative assessment of risk
- Pathway description
- Receptor identification
- Qualitative assessment of risk

To determine if hazard at the site poses a risk to the immediate environment or other receptors a connection between a possible contaminant *SOURCE* to a *RECEPTOR* via a *PATHWAY* is discussed in the sections that follow.

11.2 Brief Site History

As indicated in the introduction to this report, it is understood that wastes were deposited at the Whitestown site between ca. 1998 to 2001. Following the detailed trial pit investigation in December 2003 by ERML, it was estimated that ca. 240,000 tonnes of Commercial & Industrial (C&I)/ Construction & Demolition (C&D) Wastes were deposited at the site.

During the December 2003 site investigations, the extent of the previously deposited waste was divided into three waste zones, namely Zone A, B and C. A summary of the nature and volume of wastes within each of the waste zones is detailed in Sections 3 and 4 of this Preliminary Risk Assessment Report.

11.3 Source Identification

The site is associated with several sources of possible contamination (or environmental hazard):

- Upgradient sources i.e. National Secondary Road N81, block plant, former and existing sand and gravel pits, and agricultural activities (Figure 1.1 – Site Setting)
- Historically deposited waste on the site. The wastes are mainly C&I and C&D.
- Former sand and gravel processing activities on site

- Incidental spills during equipment/plant refueling or maintenance operations during former occupancy of the site

The principal source of concern is the Historically Deposited Wastes. As identified previously in this report, the surface area of existing waste is estimated at ca. 30,000 m^2. Based on an assumed recharge of 0.4 metres/year (allowing for precipitation and runoff), it is estimated that ca. 33 m^3/day of leachate could be generated for the wastes currently on site (Q).

A summary of values used for the Groundwater/Surface Water Impact Assessment Model is included in Table 10.1.

11.4 Hazard Identification

The most significant potential hazards associated with the Whitestown site in its current status include:

- leachate from previously deposited wastes
- waste biodegradation 'landfill' gas

11.4.1 Hazards Associated with Leachate

As indicated in the leachate section of this Risk Assessment Report, elevated concentrations for a number of contaminants, in particular the leachate indicator contaminants, were identified in the leachate samples taken from Zones B and C.

ERML undertook a review of leachate composition typically found in different types of waste management facilities in March 2004 . Concentrations for the leachate indicator parameters selected for this Risk Assessment Report are listed in Table 6.5. Some of these concentrations will be used to model the 'worst case scenario' for leachate potentially produced from the Whitestown waste zones.

11.4.2 Hazards Associated with Landfill Gas

Elevated Methane concentrations have been identified at the Whitestown site. Concentrations ranging between 17.3% and 27.2% have been identified by both the EPA and ERML between September 2003 and February 2004.

As landfill gas has been identified at the Whitestown Lower site, other organic gases and vapours, some of which may be malodorous and potential harmful to health, may also be present in gases emanating from the waste zones.

11.5 Pathways

11.5.1 Flow Direction and Gradient

The main potential pathway for leachate contaminants is the uppermost groundwater zone, which has been reported to have a northwest to southeast flow direction beneath the site, and flows directly towards the Carrigower River located ca. 120 metres from the nearest Waste Zone B.

Based on a detailed literature review, on-site drilling and groundwater flow monitoring, it is understood that groundwater beneath the site typically moves through the saturated zones found in the sands/gravels and weathered slates beneath this overburden layer. The hydraulic gradient is steep, at 2.0 to 3.0%. On the basis of plug flow of groundwater contaminant travel times are in the order of 100 to 1,000 days.

11.6 Receptors

11.6.1 Groundwater Receptor

Groundwater beneath the site and downgradient (east) of the site is a potential receptor of contaminants and a pathway for contaminant transport.

In terms of groundwater usage, it is understood that there are no groundwater water users immediately downgradient of the waste zones, between the site and the Carrigower River. Water is provided by a mains group water supply. Coupled with this, the bedrock aquifer has been classified by the GSI as a Locally Important Aquifer (LI), which is moderately productive, only in Local Zones.

11.6.2 Surface Water Receptor

As outlined previously in this Report, the adjoining River Carrigower is considered a very sensitive receptor due to its designation as a candidate Special Area of Conservation. The presence of abundant salmonids spawning habitat in the river, along with extensive signs of otter activity, adds to the value and importance of this surface water body.

It is also noted that the River Slaney, of which the Carrigower River is a first order tributary, is also a designated 'salmonid water' under the First Schedule of the European Communities (Quality of Salmonid Waters) Regulations (S.I. No. 293 of 1988). It is noted that the compliance standard for Ammoniacal Nitrogen according to the Salmonid Regulations is 0.016 mg/l.

Results of the 1995 to 1997 and 1998 to 2000 river quality assessments by the EPA indicate that the Carrigower river adjoining the site was unpolluted (Q value of 4-5) in historical terms. However, the Natura 2004 investigation has indicated that the Carrigower River both upstream and downstream of the Whitestown Lower site has declined in quality, with a current Q-rating of 3-4, suggesting that the river has a slightly polluted status in February 2004.

11.6.3 Other Possible Potential Receptors

Other potential receptors of contaminants migrating from the site are:

- Humans – there are a number of residents within the vicinity of the Whitestown site. It has been reported that residences immediately downgradient of the Whitestown site are connected to the mains water. Humans do not represent a potential receptor at this point in time. However, residents using groundwater in the future cannot be ruled out. It should also be noted that should landfill gases continue to be produced from the previously deposited wastes, this may lead to a nuisance. The site in its current status could also be considered visually intrusive.
- Livestock – It is possible that livestock drink from the Carrigower River downstream of the site. The surface water quality currently indicates no threat to the health of livestock, however this should not be ruled out.
- Agricultural Land and Crops – if groundwater is abstracted for irrigation purposes and the wastes deposited at the site have contaminated the groundwater, then agricultural land would be a potential receptor of contaminants from the previously deposited wastes.

12. SUMMARY COMMENTS ON POTENTIAL IMPACTS AND RISKS

A conceptual quantitative model has been developed to predict the impact of leachate from the previously deposited wastes. This model suggests that there is a potential for impact on the sensitive water course if the concentrations of critical contaminants in the leachate reach the high levels that have been found in leachate at full scale C&I or MSW landfill sites. No such impacts have been observed to date. It is noted that the quality of the Carrigower River has deteriorated since the 1995 to 1997 and 1998 to 2000 assessments; however, this is the case both upstream and downstream of the site.

The investigations to date have revealed a waste body that is largely made of inert or apparently inert C&D wastes or soils from the site mixed with non-inert wastes that have arisen from commercial or industrial sources. There is a portion of the waste body, estimated to be less than 10%, which would be considered to be non-inert material.

The non-inert fraction of the previously deposited wastes will generate leachate, which would be a concern and would pose a threat to the sensitive adjoining surface water course. This is the most important issue on this site in regard to environmental protection.

As groundwater is not in use immediately downgradient of the site, the risk to human health, as a result of consumption of groundwater is not an immediate concern.

Waste biodegradation gases have been detected at the site. These gases can travel in unsaturated overburden towards open holes or subsurface structures. The conditions at the site are such that there is not an imminent threat to humans or property due to the migration of landfill gases from the previously deposited wastes off-site. The gases will migrate through the surface cover soils and disperse into the atmosphere. The gases may be malodorous and represent a nuisance depending on the climatological conditions on the day.

There are a number of options that could be considered to address the situation at the site and ensure there is no threat to the adjoining groundwater and surface water:

1. Do nothing – This means leave the site as it is.

On the basis of the precautionary principal this would not appear to be an acceptable strategy to follow.

2. Provide an engineered low permeability capping layer and several metres of soil over the wastes to minimise infiltration and leachate generation.

If this system fails in the future the hazard remains as there is no lining system beneath the waste body and if the wastes have been encapsulated to be dry, there will be a potential for future biodegradation of the waste and generation of leachate. This would not appear to be a sustainable strategy.

3. Excavate the wastes and treat them at a facility on-site.

If the treatment is on site, the residual wastes remaining after treatment could be placed in lined areas with leachate collection/evacuation systems that would be operated and monitored over time until the leachate is not a concern.

4. Excavate the wastes and treat them at a facility off-site.

Removal of the wastes from the site for treatment at another facility, with sufficient capacity, transfers the problem to another locality. This would not appear to adhere to the proximity principal for the management of wastes

Fines within the waste body were moderately stained from interaction with the wastes. No leachate was noted at any of the trial pit locations within this zone. A mild to moderate decomposition odour was observed in many of the trial pits within this zone. Trial pits located towards the west of this zone determined the base of this waste body. Photoview 1 depicts wastes in Trial Pit 6, which is representative of this zone.

Photoview 1. Trial Pit 6 containing previously deposited wastes

3.5 Detailed Description of Wastes in Zone B

The zone had a very high percentage of soils/fines (commonly in excess of 90% or higher). The soils/fines were predominantly clean, with sparse waste intermixed. Where waste is present in this zone, the waste layer was identified in excess of 3.0m in thickness. Soils/fines within these waste layers are slightly stained by interaction with the waste body. Photoview 2 depicts wastes in Trial Pit 62, which is representative of Zone B. No leachate was identified in Zone B, and only mild to no odours were observed.

Photoview 2. Trial Pit 62 containing fines/soils

3.6 Detailed Description of Wastes in Zone C

Waste in this zone appears to date back to 1998 (based on a newspaper and correspondence identified from 1998), and is the most decomposed. Some of the wastes in this zone appear to have been passed through a shredding process. The fines are heavily stained from interaction with the decomposing wastes within this zone. Leachate was identified within this zone, and moderate to strong decomposition odours were identified. Photoview 3 depicts wastes in Trial Pit 27, which is representative of Zone C.

Photoview 3: Trial Pit No. 27 containing previously deposited wastes

3.7 Raised Grassland Area South of Buildings

This zone does not contain any waste (i.e. materials identified in other zones on site). The lands appear to be natural ground, with some levelling with native overburden from the site likely to have been undertaken in the past. This zone was not considered during the estimation of waste imported waste quantities on the site. Photoview 4. depicts soils in Trial Pit 32, which is representative of the raised grassland pasture located south of existing site buildings.

Photoview 4. Trial Pit 32 containing clean soils (no imported wastes apparent)

3.8 Detailed Findings of Trial Pit Assessment

The ERML (December 2003) trial pit investigation identified three waste zones (A, B and C), which contain varying amounts of imported waste materials.

The waste body at Zones A and C was found to be in excess of 5-metres in thickness and is underlain by natural ground consisting of clayey silty fine sands and gravels. Subsequent air rotary drilling in January 2004 has indicated that this natural sandy layer beneath the waste body is shallow, and may be less than 1.0 metre in places.

Zone B has a very high percentage of soils/fines (commonly in excess of 90% or higher). The soils/fines are predominantly clean, with sparse waste intermixed. Where waste is present in this zone, the waste layer was identified in excess of 3.0m in thickness. Soils/fines within these waste layers are slightly stained by interaction with the waste body.

The wastes, in particular at Zones A and C, are intermixed with soils/fines, which may have originated during the application of cover material.

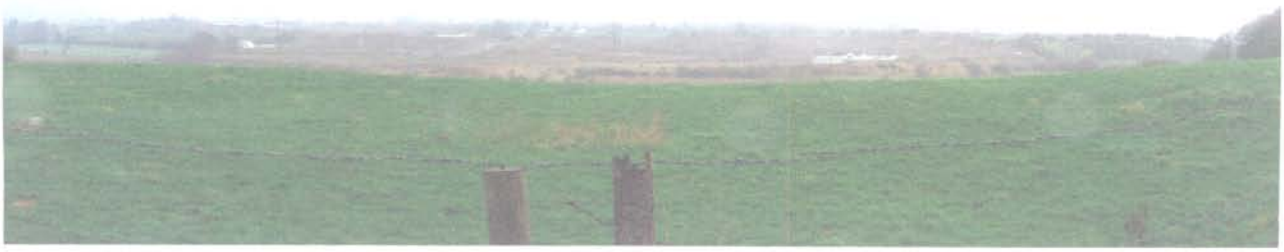
View No. 1- Panorama from east looking west towards site

View No. 2- Panorama from east on higher ground looking northwest towards site

View No 3- View above Chrysalis looking west towards site

View No 4- View from east looking directly west towards site

View No. 5- View from south of Chrysalis



View No. 6- Panorama from southeast of site looking northwest

View No. 7- View from west looking east towards existing site entrance

View No. 8- Panorama from west looking northeast towards site

View No. 9- View from west looking northeast towards site