Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites

VELVETSTOWN
TIER II SITE INVESTIGATION REPORT
And
TIER III QUANTITATIVE RISK ASSESSMENT

Landfill Site: Velvetstown Landfill
Site Reference: 16/W
Division: North Cork
Area Office: Charleville

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May 2010

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Table of Contents

APPENDICES

APPENDIX 1	**-**	**VELVETSTOWN TIER I REPORT**
APPENDIX 2	**-**	**EPA MATRICES FOR VELVETSTOWN**
APPENDIX 3	**-**	**TRIAL PIT & GAS WELL LOGS**
APPENDIX 4	**-**	**FULL LABORATORY REPORTS**
APPENDIX 5	**-**	**SITE SURVEY**
APPENDIX 6	**-**	**GEOPHYSICAL SURVEY**
APPENDIX 7	**-**	**SOIL ANALYSIS**
APPENDIX 8	**-**	**RE-RUN OF SPR LINKAGES**
APPENDIX 9	**-**	**1st DRAFT MITCHELSTOWN GWB DESCRIPTION**
APPENDIX 10	**-**	**PEARMEABILITY TEST**

1.0 SITE SUMMARY

Cork County Councils Environment Directorate completed a Tier I report and risk assessment on Velvetstown Landfill in December 2007. The Tier I assessment was completed in accordance with the EPA CODE OF PRACTICE Environmental Risk Assessment for Unregulated Waste Disposal Sites. The Tier I Report showed Velvetstown Landfill to be a **"Moderate Risk"** site.

A Tier II Exploratory Investigation was organised for this site in March 2010. The purpose of the Exploratory Investigation was to confirm the initial conceptual site model (CSM) prior to the designing of the Main Investigation programme (in accordance with 5.3.2 of the Code of Practice). Following the Exploratory investigation a main investigation was designed and completed in accordance with the EPA Matrix (see Appendix 2) in April 2010.

2.0 SITE INTRODUCTION

Velvetstown landfill is located 2Km north of Buttevant town, (GIS Coordinates E154,650, N111,788) and is situated adjacent to the N20. The site covers an area of approximately 0.40Hectares.

Fig 2.1: Location of Velvetstown Landfill 16/N

2.1 Surrounding Land Use

The site is covered with bare yellow scrub. A large mound of C&D and tarmac waste cover the northern end of the site. There is an area approximately 20m wide next to the main N20 that has been procured by the council for road widening. The landfill is situated within this area. One house is situated 75m to the west of the site. The site is bounded by agricultural land to the west and the N20 to the East.

2.2 Site History

This landfill is on the site of an old quarry. It is estimated that this site was in use from the late 60's (68/69) up until approximately 1979/80.

2.3 Tier I SPR Linkage Score

The table below shows the Tier I linkage scores for Velvetstown.

Calculator	SPR Values	Maximum Score	Linkages	Normalised Score
SPR 1 =	35	300	Leachate => surface water	12%
SPR 2 =	70	300	Leachate => SWDTE	23%
SPR 3 =	70	240	Leachate => human presence	29%
SPR 4 =	70	240	Leachate => GWDTE	29%
SPR 5 =	175	400	Leachate => Aquifer	44%
SPR 6 =	105	560	Leachate => Surface Water	19%
SPR 7 =	35	240	Leachate => SWDTE	15%
SPR 8 =	0	60	Leachate => Surface Water	0%
SPR 9 =	0	60	Leachate => SWDTE	0%
SPR 10 =	30	150	Landfill Gas => Human Presence	20%
SPR 11 =	45	250	Landfill Gas => Human Presence	18%

Table 2.1: Tier I SPR Linkage Scores

The main linkage of concern is SPR 5, leachate to the Aquifer under the landfill site. The Normalised Score for SPR 5 showed up as 44% which categorised Velvetstown Landfill as a "Moderate" Risk Site.

2.4 Tier I Conceptual Site Model

The diagram below shows the Tier I Conceptual Site Model for Velvetstown.

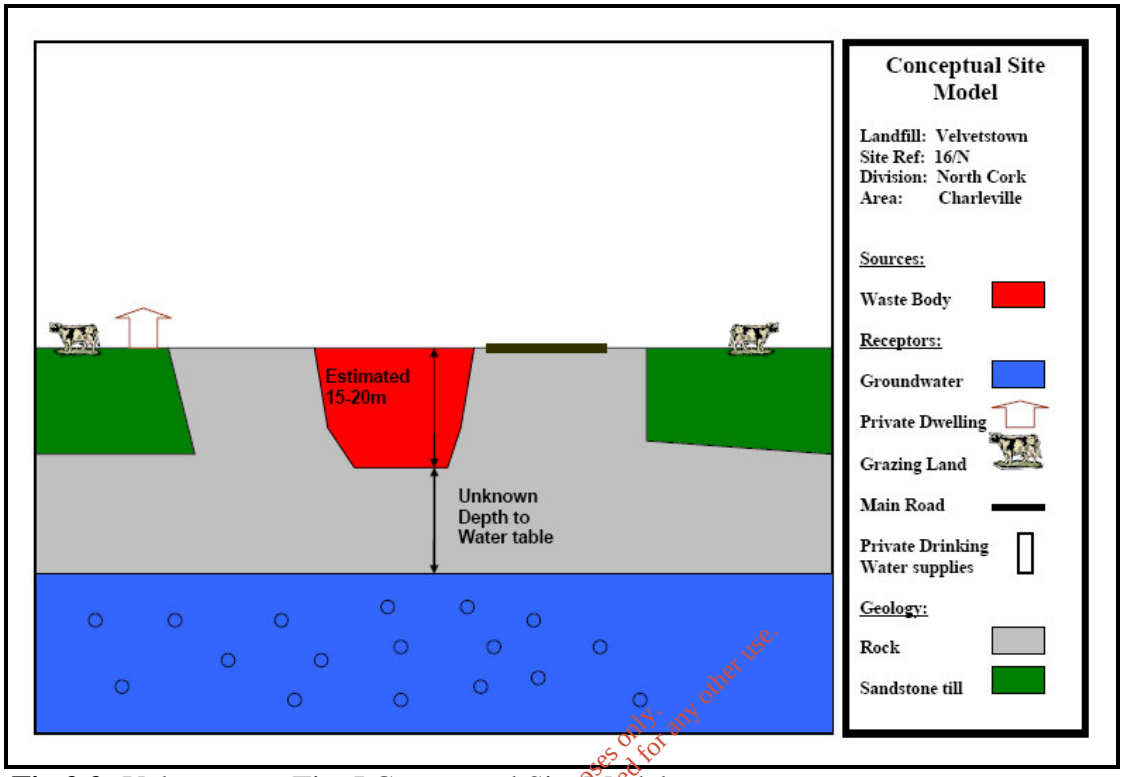


Fig 2.2: Velvetstown Tier I Conceptual Site Model

2.5 Background to Tier II Investigation

The design of the new M20 Motorway between Cork and Limerick is currently underway by the National Roads Authority (NRA). As part of the design process Cork County Council was asked to identify any landfills along the route. The Velvetstown Tier I report was provided to the NRA. Cork County Council and the NRA further cooperated on the completion of the Tier II report. A number of Groundwater Wells are installed along the proposed M20 route. 4No. wells are installed in the region around/near Velvetstown Landfill with a further 2No. down gradient of the landfill. A Geophysical Study of the landfill was also completed by the NRA on the landfill and this report is used as part of the Tier II Investigation.

3.0 TIER II SITE INVESTIGATION

3.1 OBJECTIVES

The main objective of the investigation was to collect sufficient information to confirm the Tier I conceptual site model.

The objectives are summarised as follows:

- Characterise the waste on site
- Delineate the lateral and vertical extent of the waste
- Determine the depth and composition of any capping layer
- Determine the subsoil type, thickness and permeability
- Confirm if the Tier I Conceptual Site Model is valid (and adjust if required)
- Show if there is evidence of the landfill causing any environmental impacts
- Use the information gathered to design the Main Tier II Investigation

3.2 SITE INVESTIGATION METHODOLOGY

The site investigation included the following elements:

- Completion of Geophysical Survey
- Installation of Groundwater Wells
- Excavation of Slit Trenches around the waste mass
- Excavation of Trial Pits throughout the site
- Collection and Analysis of Groundwater Samples
- Collection and Analysis of Leachate Samples
- Collection and Analysis of the Waste Samples
- Completion of a Site Survey

3.3 ON SITE INVESTIGATIONS

3.3.1 Geophysical Investigation

The geophysical survey was completed by Apex Geoservices Ltd. The full Apex report is included in Appendix 6.

The objectives of the survey were to assess the sub-surface conditions and to identify any possible leachate plumes as well as to provide a direction/guidance for the exploratory investigation. The geophysical method employed was 2-D Resistivity Profiles to investigate the lateral and vertical extent of the landfill material.

5No. Resistivity Profiles were taken. The location of the profiles can be seen below (the location of the old quarry is outlined in blue).

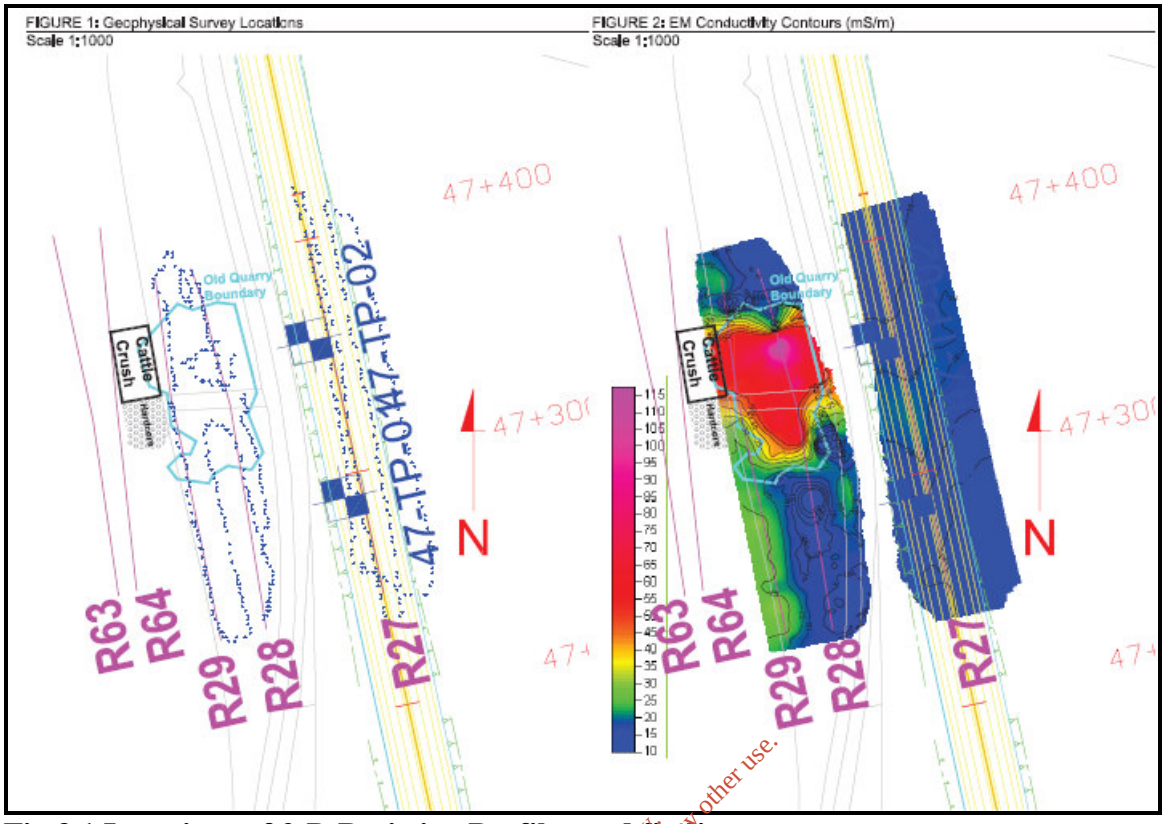


Fig 3.1 Locations of 2-D Resistivy Profiles and findings

The geophysical investigation confirmed the area of the old quarry as being the location of the landfill site.

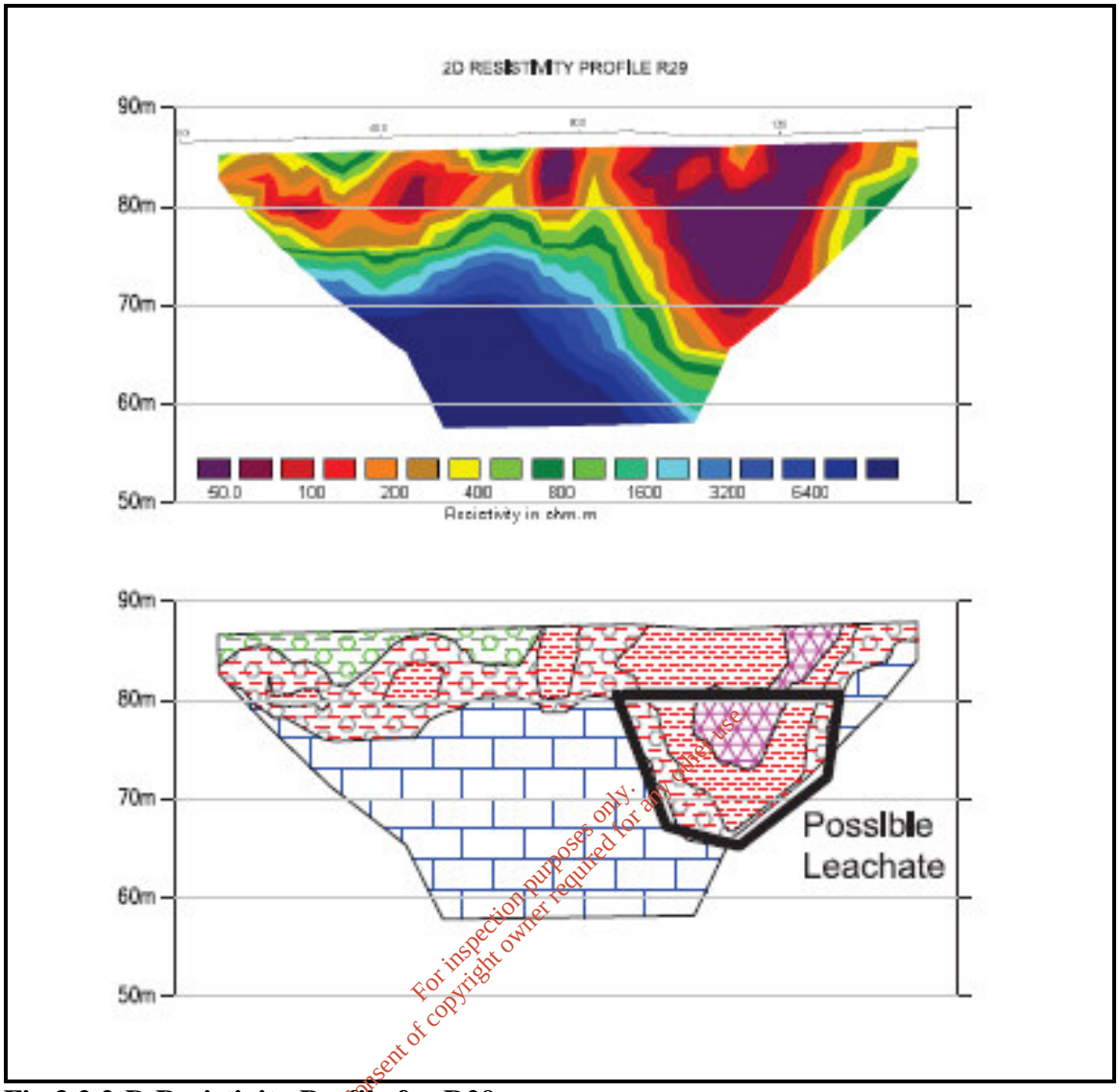


Fig 3.2 2-D Resistivity Profile for R29

The geophysical survey also identified the possibility of a leachate plume or waste to a depth of 13m-16m at the North Western end of the landfill (i.e. along Profile R29).

The information obtained in the geophysical survey was used in the Trial Pit/ exploratory investigation.

3.3.2 Exploratory Investigation

The exploratory investigation comprised the use of 21½ Tonne Tracked Excavator to dig 8No. Slit Trenches and 12No. Trial Pits throughout the site. The excavations commenced on the 22nd March 2010 and were supervised by a competent Cork County Council Engineer. Each Trial Pit was logged in accordance with BS5930. Trial Pit and Slit Trench locations can be seen below.

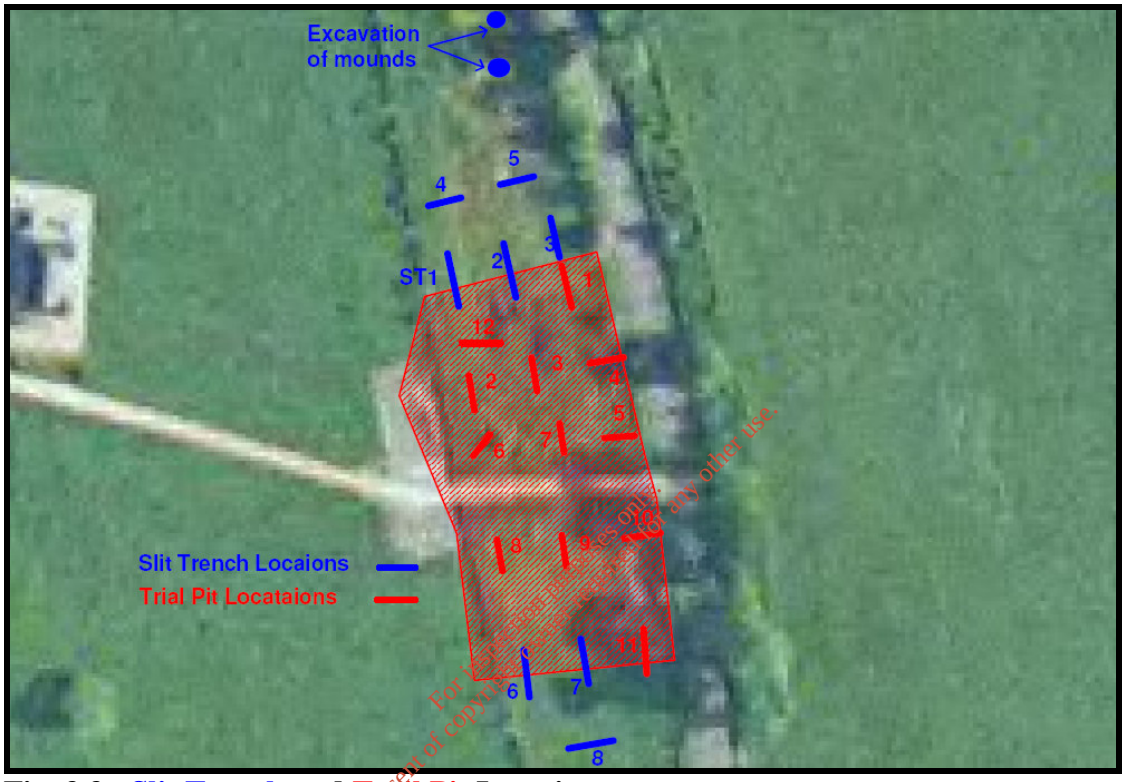


Fig. 3.3 - Slit Trench and Trail Pit Locations

3.4 ON-SITE OBSERVATIONS

3.4.1 Waste Characterisation

Waste was found in all Trial Pits within the Tier I boundary area. The waste was between 1 and 3m deep but was also very shallow in some areas (100-200mm deep on most boundaries). The majority of the waste was comprised of domestic waste including papers, plastics, glass and metal. The waste was supported in most areas by a clay matrix (80 – 90% material). Waste was sampled for VOC's with a hand held Photo Ionisation Detector. No significant VOC readings were recorded (Highest reading of 2ppm in TP-2). The trial pits were also tested for Methane and Carbon Dioxide with a hand held meter. No methane or abnormal CO_2 readings were detected. Water / Leachate was only found in 4No. Trial Pits (at between 3.1m and 4.0m below ground level (See Appendix 3). A brown firm CLAY was found below all Trial Pits. This Clay layer varied in depth between 0.2m to 2.2m.

Photos of Slit Trenches and Trial Pits can be seen below:

Slit Trench 1

Slit Trench 1

Slit Trench 2

Slit Trench 2

Slit Trench No.3

Slit Trench No.3

Trial Pit No.1

Waste / clay from Trial Pit No.1

Trial Pit No.1

Trial Pit No. 2

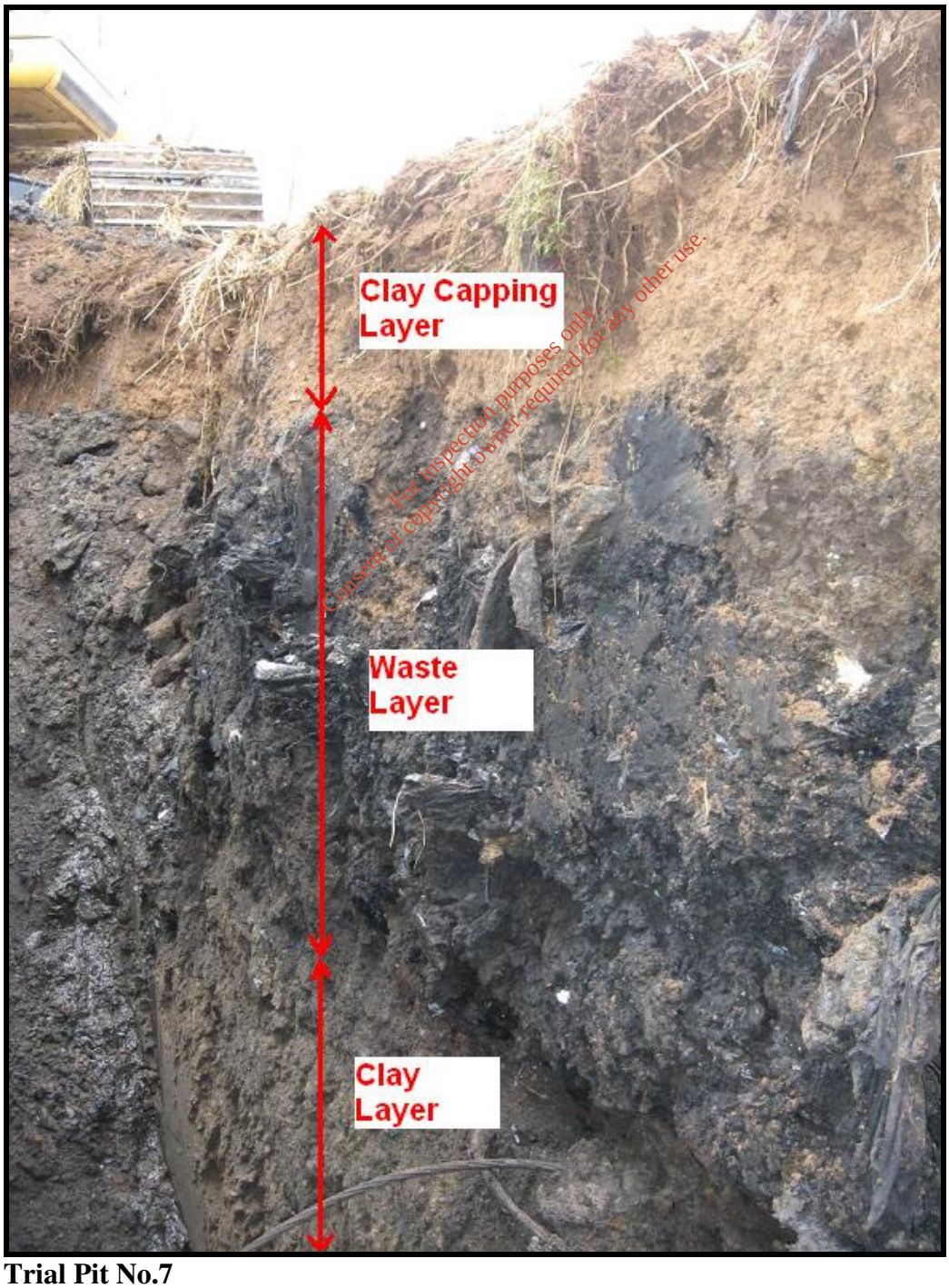
Trial Pit No.2

Panoramic of Landfill Area

Trial Pit No.5

Clay Layer Under TP5

Waste Sample from TP5



Trial Pit No.7

Trial Pit No.11 (showing clay layer under the waste)

3.4.2 Lateral and Vertical Extent of the Waste

Lateral: The slit trenching confirmed that the waste was located up to the Tier I boundary (i.e. Old Quarry boundary on Raster maps) but not outside this boundary. 3No. Slit trenches (No.'s 4, 5 & 8) were excavated outside the waste mass and no waste was found in these trenches. Two trial holes were also excavated in a waste mound to the north of the landfill. These mounds were composed of 95% soil with

small amounts of construction and demolition waste (tarmac, concrete pipes). Trenches that were excavated at the North, East and South of the site confirmed the location of the edge of the landfill. The Northern boundary of the landfill was well defined (i.e. TP1, see photos above). In most other locations the depth of the landfill increased gradually. No slit trenches could be excavated on the western boundary due to the danger of undermining the boundary wall with the neighbouring property. The geophysical investigation confirmed the edge of the waste however.

Vertical: The depth of the waste varied from shallow areas of 0.6m below ground level at the southern boundary up to a maximum of 3.0m below ground level at the northern boundary. A clay cap of generally 0.3m to 0.5m covered the whole site. A clay barrier of between 0.2m (TP1) and 2.2m (TP7) was found below the waste with an average thickness of 0.8m. Limestone Rock was found at the base of all Slit Trenches and Trial Pits. The depth of the rock varied from 0.3m to 4m below ground level. Groundwater was encountered in 4No. trial pits between 3.2m and 4m below ground level. This groundwater was below the waste in the landfill in all cases.

3.5 SAMPLING AND ANALYSIS

3.5.1 Groudwater/Liquid Samples from base of Trial Pits

Samples were taken from the base of 3No. Trial Pits. 1No. of the samples was analysed for parameters as per Table C.2 of the EPA Landfill Monitoring Manual. The other 2No. samples were sampled for indicator parameters as outlined in the EPA. The samples were not leachate samples in the normal sense as the water was only encountered below the waste. Due to the nature of the trial pitting there was some mixing of waste with the groundwater however.

The samples were analysed in accordance with the Guidance Matrix for Exploratory Investigations for all Unregulated Waste Disposal Sites (See Appendix 4). The results are outlined below:

Parameter	Liquid Sample TP6	Liquid Sample TP9	Liquid Sample TP10	Units
pH	7.3	7.3	7.2	pH Units
Conductivity	807	954	735	uscm - 1@25C
Ammonia	0.928	8.5	0.01	mg/L as N
Nitrogen (Total Oxidised)	2.25			mg/L as N
BOD	8	164	< 2	mg/L
COD	81			mg/L
Sulphate	18.1	24.7	<10.0	mg/L as SO4
Chloride	27.7	33.6	33.5	mg/L
Phosphate (Ortho)	0.024			mg/L as P
Cyanide	< 10			ug/L
Fluoride	<0.1			mg/L
Atrazine	<0.01			ug/L
Dichloroethane	< 0.1			ug/L
Simazine	<0.01			ug/L
Toluene	<0.5			ug/L
Xylene (Total)	< 0.5			ug/L
Calcium	200.9			mg/L
Magnesium	24.8			mg/L
Sodium	18.1	45.3	14.6	mg/L
Potassium	16	83.7	6.6	mg/L
Iron (Total)	40.1			mg/L
Manganese	3.17			mg/L
Cadmium	0.007			mg/L
Chromium	0.105			mg/L
Copper	0.184			mg/L
Nickel	0.0459			mg/L
Lead	0.553			mg/L
Zinc	1.048			mg/L
Arsenic	0.0141			mg/L
Boron	0.210			mg/L
Mercury	0.00011			mg/L

Table 3.1 Trial Pit Liquid Sample Results

3.5.2 Interpretation of Liquid Sample Results from Trial Pitting

Ammonia concentrations averaged 3.15mg/L over the 3No. locations tested. Trace Organic substances as outlined in table D2 of the EPA Landfill Monitoring Manual were all under detection limits (See Appendix 4)

When comparing the above results to leachates sampled from other landfills (i.e. Table 7.2 Leachate from a Stage IV Landfill, EPA Landfill Site Design, 2000) the liquid/leachate from this landfill is very dilute. The pH of the liquid/leachate and the fact that no methane gas was detected during the site investigation suggests that the landfill is in Stage V of the degradation process. There was evidence that burning of waste was common at this landfill (both visual and from interviews held). This may also account for the low contamination recorded as well as the fact that the landfill is now over 30 years old.

3.5.3 Waste Samples

3No. Waste samples were taken from the trial pits during the Exploratory Investigation. The Waste samples were tested in accordance with the waste acceptance criteria as outlined in "Council Decision of 19th December 2002, establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of the Annex II to Directive 1999/31/EC". The results can be seen below:

Parameter	Unit	TP-2	TP-5	TP-10	Inert Landfill	Non-Hazardous Landfill
Antimony	mg/kg	0.06	0.04	0.05	0.06	0.7
Arsenic	mg/kg	< 0.02	< 0.02	< 0.02	0.5	2
Cadmium	mg/kg	< 0.01	< 0.01	< 0.01	0.04	1
Copper	mg/kg	< 0.3	< 0.3	< 0.3	2	50
Chromium	mg/kg	< 0.1	< 0.1	< 0.1	0.5	10
Lead	mg/kg	< 0.03	< 0.03	0.05	0.5	10
Nickel	mg/kg	< 0.05	< 0.05	< 0.05	0.4	10
Molybdenum	mg/kg	0.3	0.4	0.1	0.5	10
Selenium	mg/kg	< 0.02	< 0.02	< 0.02	0.1	0.5
Zinc	mg/kg	1.3	1.9	1.6	4	50
Mercury	mg/kg	< 0.002	< 0.002	< 0.002	0.01	0.2
Barium	mg/kg	3	3.4	4.2	20	100
Chloride	mg/kg	298	620	< 26	800	15,000
Fluoride	mg/kg	1.28	< 1	5.8	10	150
Sulphate*	mg/kg	657	935	208	1000*	20,000
Dissolved Organic Carbon	mg/kg	37.08	50.47	24.72	500	800
Total Dissolved Solids	mg/kg	2,472	3,862	772	4,000	60,000
Phenols	mg/kg	< 0.05	< 0.05	< 0.05	1	NE
Total Organic Carbon	mg/kg	55,556	46,667	18,889	30000**	NE
Total BTEX	mg/kg	< 0.1	< 0.1	Note 2	6	NE
Benzene	mg/kg	< 0.1	< 0.1	Note 2	6	NE
Toluene	mg/kg	< 0.1	< 0.1	Note 2	6	NE
Ethylbenzene	mg/kg	< 0.1	< 0.1	Note 2	6	NE
Total Xylene	mg/kg	< 0.1	< 0.1	Note 2	6	NE
PCB Total of 7	mg/kg	0.0181	0.004	0.004	1	NE
Naphthalene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Acenaphthylene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Acenaphthene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Fluorene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Phenanthrene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Anthracene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Fluoranthene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Pyrene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Benzo(a)anthracene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Chrysene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Benzo(b)+Benzo(k)fluoranthene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Benzo(a)pyrene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Indeno(123cd)pyrene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Dibenzo(ah)anthracene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Benzo(ghi)perylene	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Total 17 PAH's	mg/kg	< 0.1	< 0.1	Note 2	NE	NE
Mineral Oil	mg/kg	< 10	< 10	Note 2	500	NE

NE - Not Established

* - sulphate level exceeding inert waste limit may be considered as complying if the TDS value does not exceed 6,000mg/kg at L/S = 10l/

**-a higher limit may be accepted provided the DOC values of 500mg/kg is achieved

Table 3.2: Waste Sample Results (Note 2: Insufficient sample volume to test)

3.5.4 Interpretation of Waste Results

Two of the results for Total Organic Carbon are above the limits allowed for an Inert Landfill (i.e. 30,000mg/Kg). The dissolved organic carbon levels are below 500mg/Kg however. This waste can therefore be regarded as being inert in accordance with the EU Council Decision. No hydrocarbon, heavy metal or PCB contamination was detected in this waste. This indicates that the risk from this landfill to the surrounding environment or receptors is low.

3.5.5 Groundwater Sample Results

The Groundwater along the route of the proposed M20 is being monitored on an ongoing basis. 4No. borewells are beside the old landfill. The locations can be seen below:

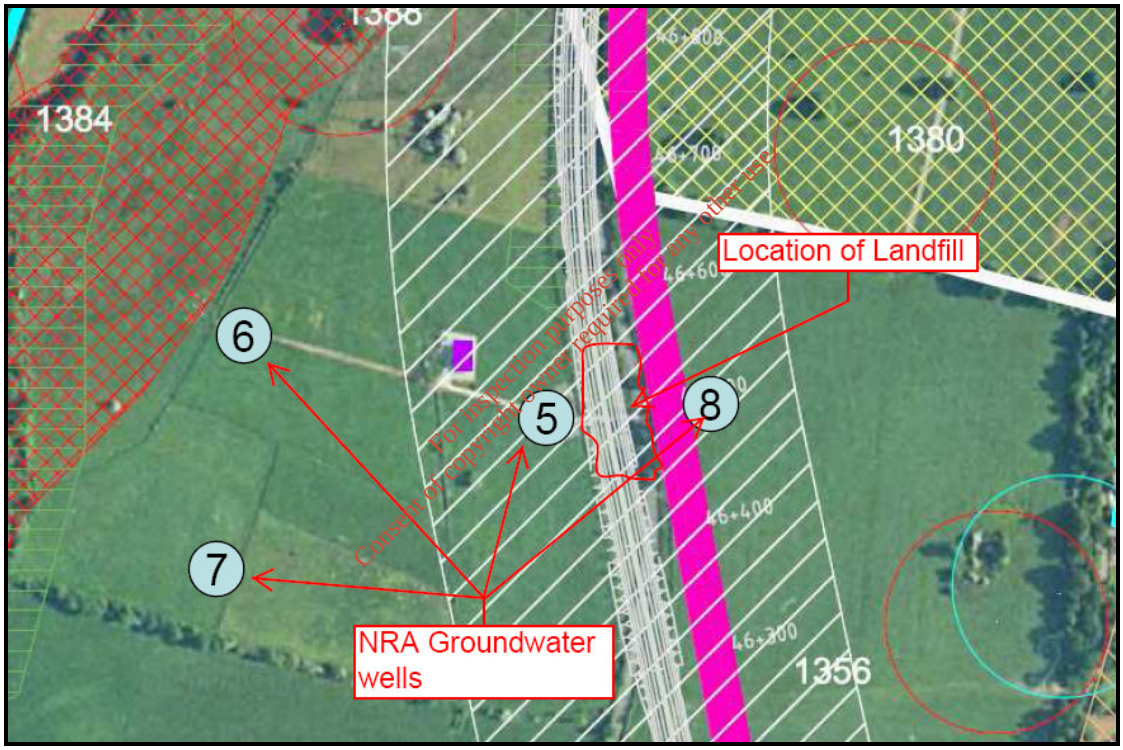


Fig 3.2 Velvetstown Groundwater Well Locations

The above locations were re-named to match up with the other monitoring points along the M20 route. Numbers were re-named as follows:

MW5	-	SP37
MW6	-	SP38
MW7	-	SP39
MW8	-	SP40

The results of Groundwater monitoring can be seen in the Table 3.3 below:

Parameter	SP37	SP38	SP39	SP40	*Interim Guideline Values*	Units
pH	8	7.4	7.2	7.3	**≥6.5 and ≤ 9.5**	**pH Units**
Conductivity	641	636	728	632	**1000**	**uscm - 1@25C**
Ammonia	0.068	0.033	0.04	0.063	**0.15**	**mg/L as N**
Nitrogen (Total Oxidised)	2.46	1.23	2.31	3.47	**No abnormal change**	**mg/L as N**
Total Alkalinity (CaCO3)	320	273	428	293	**200**	**mg/L**
TDS	360	395	440	355	**1000**	**mg/L**
BOD	NT	NT	NT	NT	**~**	**mg/L**
COD	NT	NT	NT	NT	**~**	**mg/L**
Sulphate	30.5	28.6	35.8	16.9	**200**	**mg/L as SO4**
Chloride	28.4	24.7	22.7	9.29	**30**	**mg/L**
Phosphate (Ortho)	0.055	0.009	0.015	0.03	**~**	**mg/L as P**
Cyanide	<10	<10	<10	<10	**10**	**ug/L**
Fluoride	<0.1	<0.1	<0.1	<0.1	**1**	**mg/L**
Atrazine	<0.01	<0.01	<0.01	<0.01	**1**	**ug/L**
Dichloroethane	<0.1	<0.1	<0.1	<0.1	**3**	**ug/L**
Simazine	<0.01	<0.01	<0.01	<0.01	**1**	**ug/L**
Toluene	<0.5	<0.5	<0.5	<0.5	**10**	**ug/L**
Xylene (Total)	<0.5	<0.5	<0.5	<0.5	**10**	**ug/L**
Calcium	143.6	< 1.0	3.8	2	**200**	**mg/L**
Magnesium	13.6	15.9	14.1	7.5	**50**	**mg/L**
Sodium	17	13.6	13.7	7.1	**150**	**mg/L**
Potassium	11.5	3.7	8	4.9	**5**	**mg/L**
Iron (Total)	0.0083	0.0154	0.222	0.0338	**0.2**	**mg/L**
Manganese	0.007	0.0122	0.0266	0.087	**0.05**	**mg/L**
Cadmium	<0.1	<0.1	0.2	<0.1	**5**	**ug/L**
Chromium	3.9	<1.0	<1.0	1.1	**30**	**ug/L**
Copper	0.005	<0.003	0.004	<0.003	**0.03**	**mg/L**
Nickel	2.3	1.8	2.9	1.6	**20**	**ug/L**
Lead	<0.3	<0.3	2.2	<0.2	**10**	**ug/L**
Zinc	34.3	14	21.5	23.6	**100**	**ug/L**
Arsenic	0.9	0.2	0.6	0.6	**10**	**ug/L**
Boron	110	<20	40	<20	**1000**	**ug/L**
Mercury	<0.02	<0.02	<0.02	<0.02	**1**	**ug/L**

Table 3.3: Groundwater Sample Results

3.5.6 Interpretation of Groundwater Results

Apart from high Total Alkalinity (as $CaCO_3$), Potassium and Iron, all readings were below the Interim Guideline Values for Groundwater. The Total Alkalinity values are likely to be due to the limestone rock under the landfill and not due to the landfill. An extract from the *"1st Draft Mitchelstown Grond Water Body Description – 5th March 2004"* below supports this view (see Appendix 9 for full document).

> The groundwater in this body is dominated by calcium and bicarbonate ions. Hardness can range from moderately hard to very hard (200 mg/l to >400 mg/l (as $CaCO_3$). Spring waters tend to be softer as throughput is quicker and there is less time for the dissolution of minerals into the groundwater. Groundwater alkalinity is high, up to 400 mg/l (as $CaCO_3$). These hydrochemical signatures are characteristic of clean limestone. Like hardness and alkalinity, electrical conductivities can vary greatly. Typical limestone water conductivities (EC) are of the order of 500-700 µS/cm Lower values suggest that the residence times of some of the sources are very short.

The higher conductivity values (average value 659µS/cm) also indicate a higher residence time and lower groundwater transmissivity values in this area.

Although Potassium levels exceeded the Interim Guideline Values for Groundwater at two locations, they were still within Drinking Water Standards of 12mg/L for all locations. Iron only slightly exceeded the Interim Guideline Values at one location. No List I or List II substances (In accordance with the EC Groundwater Directive 88/68/EEC) were recorded above guideline values. It is concluded that Velvetstown Landfill is only having an imperceptible impact on the groundwater.

3.6 CONCLUSIONS AND RECOMMENDATIONS FOLLOWING EXPLORATORY INVESTIGATION

Waste throughout the site was consistent in nature and was mainly composed of mixed domestic waste including metal, plastic, glass and string in a sandy clay matrix. The waste footprint of the site remains the same as the Tier I footprint following the Tier II Exploratory Investigation. There is a very definite boundary where the waste disposal starts and ends (as identified during the excavation of slit trenches and trial pits). The waste is covered in a clay cap that varies in depth between 300-500mm. There is a clay layer under all the trial pits that were excavated. The depth of soil varied between 0.2m and 2.2m before the limestone bedrock was encountered. Groundwater was only encountered in 4No. trial pits and below he waste mass in all cases. This layer seemed to be providing an effective barrier between the waste and the groundwater/bedrock. Based on the observations and knowledge obtained in the exploratory investigation it was concluded that the SPR linkages in the Tier I were valid and the focus of the main investigations was on these SPR linkages (i.e. Leachate to the Aquifer).

It is recommended to investigate the reason for the deep profile identified in Resistivity Profile 29 during the Tier II Main Investigation as the Trial Pitting did not show up the reason for this profile.

4.0 TIER II MAIN INVESTIGATION

4.1 Tier II Main Investigation Scope

The following works were carried out as part of the Tier II Main Investigation:

1. Installation of 2No. Groundwater Wells
2. Testing of Soil under the Landfill for Permeability
3. Testing of the Capping Material

4.2 Groundwater Well Installation

2No. further groundwater wells (MW1 & MW2) were installed at Velvetstown on the 12th and 13th of April 2010. The drilling method was rotary openhole. 1No. well was installed just outside the waste mass and a second well was installed inside the waste mass along Resistivity Profile 29. The installation of the wells and the locations of the borewells can be seen below:

Photo showing Installation of GW2

Groundwater Well Locations and Estimated Groundwater flow direction

4.2.1 Installation of Groundwater Wells

Groundwater wells were constructed using high density polyethylene 50mm diameter standpipes. A gravel filter pack was inserted between the borehole and the standpipe. The top 4.5m of the well was sealed with bentonite to prevent any leachate entering the aquifer below the landfill.

Groundwater levels were taken on 4th June 2010. These can be seen in the table below:

Well No.	Groundwater Level
MW 2	83.56
SP40	83.53
SP37	83.44
MW 1	83.33

The sample results from the groundwater wells can be seen below:

Parameter	MW1	MW2	*Interim Guideline Values*	Units
pH	7.2	7.3	**≥6.5 and ≤ 9.5**	**pH Units**
Conductivity	684	879	**1000**	**uscm - 1@25C**
Ammonia	0.038	0.036	**0.15**	**mg/L as N**
Nitrogen (Total Oxidised)	2.63	1.87	**No abnormal change**	**mg/L as N**
Total Alkalinity (CaCO3)	309	356	**200**	**mg/L**
TDS	480	565	**1000**	**mg/L**
Sulphate	12.5	90	**200**	**mg/L as SO4**
Chloride	27.8	33.7	**30**	**mg/L**
Phosphate (Ortho)	0.045	0.061	**~**	**mg/L as P**
Cyanide	<10	<10	**10**	**ug/L**
Fluoride	<0.1	<0.1	**1**	**mg/L**
Atrazine	<0.01	<0.05	**1**	**ug/L**
Dichloroethane	<0.1	<0.1	**3**	**ug/L**
Simazine	<0.01	<0.05	**1**	**ug/L**
Toluene	<0.5	<0.5	**10**	**ug/L**
Xylene (Total)	<0.5	<0.5	**10**	**ug/L**
Calcium	126.3	147	**200**	**mg/L**
Magnesium	7.064	19.4	**50**	**mg/L**
Sodium	14.98	19.2	**150**	**mg/L**
Potassium	6.15	11.94	**5**	**mg/L**
Iron (Total)	<0.005	<0.005	**0.2**	**mg/L**
Manganese	0.0018	0.105	**0.05**	**mg/L**
Cadmium	0.1	0.3	**5**	**ug/L**
Chromium	1.5	8.5	**30**	**ug/L**
Copper	<0.003	0.004	**0.03**	**mg/L**
Nickel	0.8	4.1	**20**	**ug/L**
Lead	<0.3	<0.3	**10**	**ug/L**
Zinc	3.9	81	**100**	**ug/L**
Arsenic	0.6	1.2	**10**	**ug/L**
Boron	<20	150	**1000**	**ug/L**
Mercury	<0.02	<0.02	**1**	**ug/L**

Table 4.1: Groundwater Sample Results

4.2.2 Interpretation of Groundwater Results

The groundwater results MW1 & 2 are similar to results obtained for SP37 – SP40. Readings exceeded the Interim Guideline Values for Chloride and Manganese (the latter at MW2 only). The chloride levels were within drinking water standards however (of 250mg/L).

No List I or List II substances (In accordance with the EC Groundwater Directive 88/68/EEC) were recorded above guideline values. Based on the results obtained it is concluded that Velvetstown Landfill is having an imperceptible impact on the groundwater.

There was no finding of leachate in MW2 despite the indications from the Resistivity Survey. During the drilling rock was encountered at 3.7m. The likely reasons for the resistivity profile is the semi saturated soil/waste combined with the relatively high conductivity readings for the groundwater. The rock under other areas of the site surveyed are likely to be more massive resulting in a reduced resistivity profile.

4.3 Analysis of Clay Under the Waste Mass and Cover Material

4.3.1 Permeability test of Clay Layer Under the Landfill

Samples of the clay layer under the landfill was sent to a Geotechnical Testing Laboratory for permeability testing.

Permeability testing was conducted in accordance with Clause 6 of *BS 1377-6:1990 Methods of test for soils for civil engineering purposes—Part 6: Consolidation and permeability tests in hydraulic cells and with pore pressure measurement.*

The remoulded test specimen was prepared by amalgamating the supplied samples using compaction in accordance with Clause 3.3 of *BS 1377-4: 1990 Methods of test for soils for civil engineering purposes—Part 4: Compaction-related tests*

The results of the test showed the layer under the waste to have a permeability of $6x10^{-6}$ m/s (K value). The test documents can be viewed in Appendix 7.

4.3.2 Testing of Capping Layer

The clay capping layer over the landfill categorised in accordance with BS5930:1999.

Photo of Thread of Clay Capping

The capping layer was confirmed to be a "Sandy Gravely CLAY" in accordance with the BS5930:1999 categorising procedures.

The Permeability for this type of soil is estimated to be 1 x 10^{-5} to 1 x 10^{-7} (Ref: C.W. Fetter).

A P Test was conducted on a 300mm x 300mm x 200mm deep Hole. The water dropped 32mm in 1 Hour. The resultant Permeability value is 2.4 x 10^{-6} m/s.

4.2.3 Interpretation of Soil Test Results

The Clay layer under the landfill is providing a significant barrier under the waste. This layer is limiting the infiltration of leachate into the aquifer below.

The Clay capping layer is also providing a barrier preventing the infiltration of rainwater through the waste mass.

5.0 RE-ASSESSMENT OF TIER I CSM

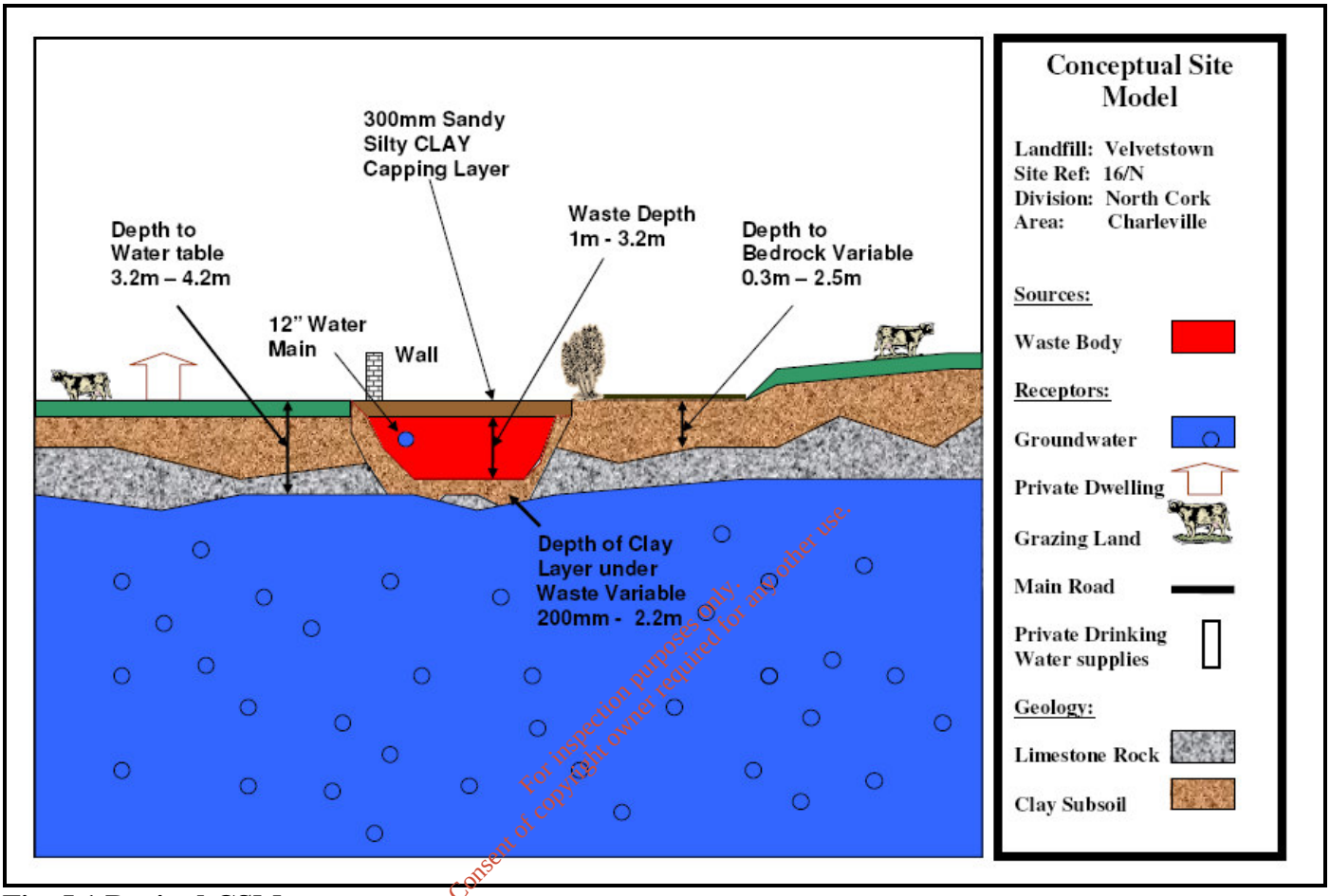


Fig. 5.1 Revised CSM

The CSM was revised following the Tier II Exploratory and Main Investigations. The trial pits showed a low permeability clay layer under the landfill. This layer varied in depth from 200mm to 2.2m. The groundwater levels varied throughout the site also, varying between 3.2 and 4.2m below ground level. There is a silty sandy CLAY capping layer over the whole site with a depth of about 300mm. The Limestone Rock was encountred at varying depths throughout the investigation. The depth varied from 300mm below the surface up to 2.5m below ground level.

6.0 QUANTITATIVE RISK ASSESSMENT

Risk assessment is a scientific mechanism that allows the various hazards, pathways and receptors present at a site to be evaluated. It uses a systematic and progressive approach to identify the risks with the aim of establishing a pollutant linkage from a source (S) via a pathway (P) to a receptor (R). If a pathway does not exist there is no risk.

The CSM completed in the Tier 1 Assessment identified leachate migration to the underlying bedrock aquifer as a potential source; groundwater, soil as potential pathways; and the bedrock aquifer and humans as the potential receptors. The highest potential linkage score was for SPR 5-Leachate to Aquifer (44%), all other linkage scores were less than 30 i.e. Low Risk. The overall site classification was 'Moderate Risk'.

The objective of the Tier II assessment was to establish if the SPR linkages identified in the Tier I actually existed. The Tier II assessment identified that the only SPR of concern was SPR 8-Leachate to the bedrock aquifer.

6.1 Potential Sources

6.1.1 Waste Body

The Tier II site investigations identified waste, with an average thickness of 2.2m extending over 0.4Ha, which equates to approximately 8,800 tonnes. A brown firm CLAY was found beneath the waste, which appears to form an effective barrier between the waste and the underlying aquifer.

The waste is consistent in nature and mainly composed of mixed domestic waste including metal, plastic, glass and string in a sandy clay matrix. No layers or pockets of significantly contaminated material were encountered. Based on the field observations and in-situ screening the waste can be categorised as non-hazardous municipal solid waste.

6.1.2 Subsoils

The site investigations identified a naturally occurring low permeability clay layer beneath the waste. Groundwater was not encountered in the waste but is present in the subsoils beneath the waste. Water levels in the monitoring wells installed adjacent to

and within the landfill indicate the water table is approximately 1.5 – 2m below the clay layer.

Rock outcrop is recorded outside the landfill footprint. It is likely therefore that the bedrock aquifer is not confined. However the subsoil layer, which is continuous beneath the waste, does inhibit the migration of water percolating through the waste to the bedrock.

6.1.3 Leachate

While no leachate was encountered in the waste, groundwater was encountered at the base of four trial pits (TP2, TP-6, TP-9 and TP-10). Samples were collected and analysed for the parameters specified in Table C2 of the EPA Landfill Monitoring Manual 2003 as recommended in the EPA 2009 Matrix Guidance which is included in Appendix 2. The results are consistent with a very weak leachate indicating the site is in late Stage V of the biodegradation process.

6.1.4 Landfill Gas

Landfill gas monitoring in the open trial pits did not identify the presence of methane or carbon dioxide. This is consistent with the age of the waste, which is estimated to be at least 30 years old.

6.1.5 Groundwater

Groundwater monitoring was undertaken at the four monitoring wells (MW-5, 6, 7 and 8) installed as part of an NRA monitoring programme for the M-20 Motorway Construction project and two wells installed in the Tier 2 Investigations (MW-1 and MW-2).

The NRA wells are located close to but outside the landfill footprint. Based on groundwater level monitoring results MW-8 is considered to be up hydraulic gradient, MW-5 appears to be side gradient while MW-6 and MW-7 are down hydraulic gradient.

MW-1 is down hydraulic gradient of the landfill and MW-2 is within the waste body, at a point where the preliminary geophysical survey had indicated the possible presence of a leachate plume.

While the monitoring results indicate the presence of a slightly hard groundwater, they do not indicate any significant impact on groundwater quality associated with leachate (water quality results are contained in Table 3.3).

7.2 Potential Pathways

To establish the pollutant linkage, a pathway or pathways to the receptor must be identified. This is the route by which a hazard can move toward the receptor. The pathways may allow the passage of a hazard in any of its three basic phases or in a combination, i.e. as a liquid as a solid or as a gas. Potential pathways at the site are shown in Table 7.1.

Potential Pathway	Route
Surface Water	Leachate migration from the landfill discharging to a surface water stream or river.
Groundwater	Leachate migration to the water table through the base of the landfill into the subsoil and underlying limestone bedrock.
Air/Soil	Landfill gas migration to buildings along subsurface or surface pathways.

Table 7.1 Potential Pathways

7.3 Potential Receptors

Potential receptors are identified in Table 72.

Potential Receptor	Type
Surface Water	Closest stream is 500m to the south. This stream discharges to the Awbeg River approximately 3km from the site.
Groundwater	Regionally Important Diffuse Flow, Limestone, Karst Aquifer
Human	Not Present, there are no public supply wells within 1km of the site.

Beings/Animals	There are no private wells within 1km of the site. All dwellings on mains water supply.

Table 7.2 Potential Receptors

7.4 Pollution Linkages

Potential hazards, pathways, and receptors have been identified at the site. For a risk to pose a significant threat to a receptor a linkage via a pathway must be established.

6.4.1 Surface Water

There are no surface water drains, streams or rivers within 500m of the site and the closest stream is 500m to the south. Given the dilute nature of the leachate and no measurable impact on the groundwater the risk of an impact on this stream is considered to be insignificant.

6.4.2 Groundwater

The bedrock aquifer is characterised by the GSI as a Regionally Important Bedrock Aquifer with Diffuse Flow. This means groundwater flow paths are generally long 100s to 1000s of metres. There are no public or private groundwater abstraction wells within 1km of the landfill site.

There is a continuous clay layer beneath the waste. Permeability testing indicates this low permeability, in the range of 10^{-6}m/s The water table is located at least 1.5m below the base of the waste. While the quality of the water encountered in the trial pits is consistent with a weak leachate, there is no significant impact on groundwater quality in the underlying bedrock aquifer.

6.4.3 Landfill Gas

No landfill gas was detected during the Tier 1 Investigation. The landfill ceased operation c30years ago and given the age of the waste, it is unlikely that significant landfill gas generation is occurring.

6.3 QRA Conclusions

The only potential source-pathway-receptor risk that may be present at the site is that for leachate discharge to the bedrock aquifer. However, groundwater monitoring indicates that there has been no significant impact on groundwater quality and the associated risk is considered to be imperceptible. The presence of the clay layer

beneath the waste and the groundwater monitoring results indicate that this pathway is incomplete.

There is an imperceptible/insignificant risk posed by the presence of the landfill to existing receptors or to future users of the Motorway access tracks.

6.4 QRA Recommendations

The Risk Ranking for this site should be revised to Low Risk. To minimise the infiltration of rainfall through the waste mass, it is recommended that the existing clay layer on top of the waste be re-worked to enhance the compaction and thereby reduce the permeability of this layer. The resultant surface water should be diverted away from the waste.

While landfill gas generation is unlikely to be significant, it is recommended that gas monitoring be undertaken to confirm the absence of landfill gas. Should methane be detected at significant levels, ventilation measures may be required to minimise the risk of landfill gas entering Motorway Service ducts.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Landfill Gas – There is no landfill gas risk to the local residents from this site.

Groundwater – The risk to the groundwater is considered to be imperceptible following analysis of the waste and groundwater. No List I or II substances were detected above Interim Guideline Value levels throughout the site. Some protection is also being provided to the groundwater by the low permeability layer under the landfill.

SAC - The local protected area is approximately 300m from the landfill site. The risk to this SAC is considered very low (as per SPR risk rating).

Surface Water - The surface water is approximately 400m from the landfill. The impact on this receptor is imperceptible. Ground water wells close to the river (SP38 & 39) show minor contamination.

Tier I Speculation on Landfill Depth: During the Tier I investigation some interviewees had suggested that the old quarry could be up to 15m deep. There was no indication during the Tier II investigations that this was a possibility (apart from the R29 Resistivity Profile). The Trial Pitting and open core drilling showed that the maximum depth to rock was 4m.

7.2 Recommendations

To prevent the infiltration of rain water into the waste mass and the resultant generation of leachate it is recommend that an engineered capping system should be placed over the landfill as outlined in the QRA. The design of any cap will form part of a remediation plan that should be agreed with the EPA.

As the SAC is within 1Km of the landfill site a screening for an Appropriate Assessment in accordance with Article 6(3) of the Habitats Directive (92/43/EEC) should be completed on this site.

An application for a Certificate of Authorisation should be made to the EPA for Velvetstown Landfill.

Appendix 1

Velvetstown Tier I Risk Assessment

Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites

Tier 1 Study

Conceptual Site Model, Risk Screening & Prioritisation

For

Landfill Site: **Velvetstown**
Site Reference: **16/N**
Division: **North Cork**
Area Office: **Charleville**

TIER 1 RISK RATING	MODERATE

Report by: Kieran Coffey
Environment Directorate
Cork County Council
December 2007

Contents

Site Summary

Velvetstown landfill is located 2Km north of Buttevant town, (GIS Coordinates E154,650, N111,788) and is situated adjacent to the N20. The site covers an area of approximately 0.40Hectares.

Location of Velvetstown Landfill Site (16/N)

This landfill is on the site of an old quarry. It is estimated that this site was in use from the late 60's (68/69) up until approximately 1979/80. It was quite a deep quarry and possibly 15 – 20 m deep. The North Cork Refuse truck operated in the area for two days a week from 1969. It is estimated that 5 loads of municipal waste per week were disposed of by this service at the time. Locals were also known to dispose of waste at this site.

Walkover Survey:
The site is now covered with bare yellow scrub (discolouration possibly as a result of the landfill). A large mound of C&D and tarmac waste cover the northern end of the site. There is an area approximately 20m wide next to the main N20 that has been procured by the council for road widening in the future. The landfill is situated within this area. There was some evidence of surface waste on the site. One house is situated to the west of the site. The site is bounded by agricultural land to the west and the N20 to the East. There was no evidence of leachate or gas during the walkover survey. There is a major water supply borehole for Charleville 3km to the north north west of this site.

Geology:

This landfill is situated in a *"Sandstone Till"* region. There is an *Alluvium area* within 50m. As this was a quarry it is assumed that there is rock close to the surface although this is not apparent from the subsoil maps. This landfill is situated over a "*Regionally Important Karstified Aquifer"* which is dominated by diffuse flow. It is also situated in a High/Low groundwater vulnerability area. This site has been identified as having a 44% risk rating for leachate migration to the regionally important aquifer.

Risk Rating: MODERATE

Recommendations:

Proceed to Tier 2 – site investigation and testing. Confirm if there remains a risk of leachate migration to the Regionally Important Aquifer.

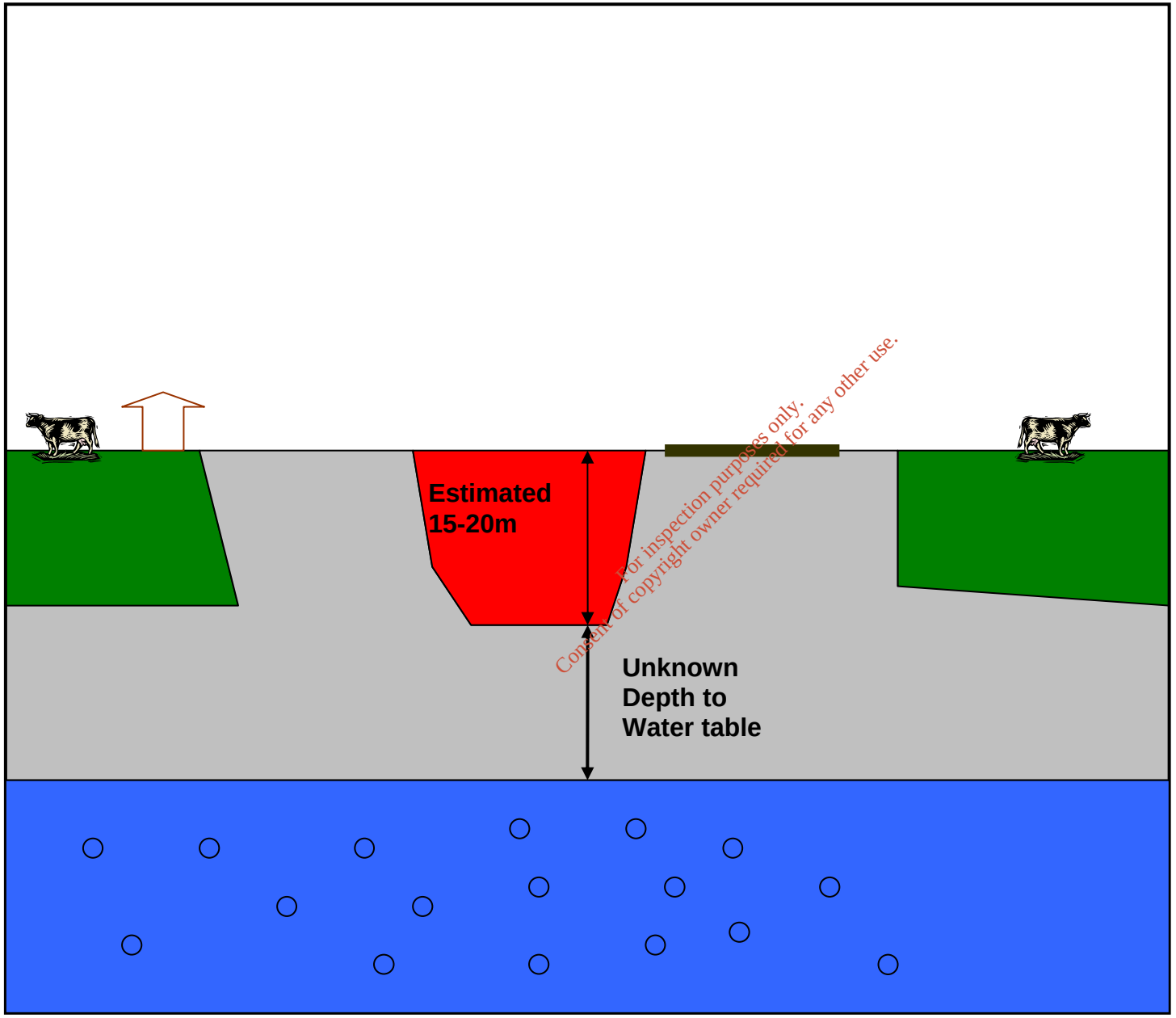
Site Photos

Locations from which photos were taken

1. View of site facing South

2. Photo of site facing west

3.



Conceptual Site Model

Landfill: Velvetstown
Site Ref: 16/N
Division: North Cork
Area: Charleville

Sources:

Waste Body

Receptors:

Groundwater

Private Dwelling

Grazing Land

Main Road

Private Drinking Water supplies

Geology:

Rock

Sandstone till

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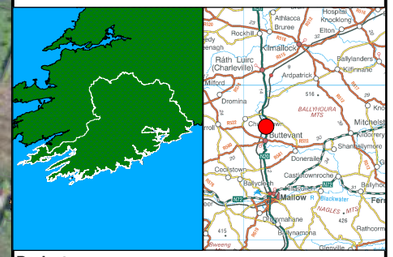

Project

Environmental Risk Assessment for Unregulated Waste disposal Sites

Tier 1 Investigation

Drawing Description

CSM Plan

Landfill Name & Ref No:

Velvetstown - 16/N

Division:

North Cork

Area Office:

Charleville

Legend

- Roads
- Buildings
- Landfill Area

Issue Details

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Checked:	-		
Approved:			
Scale:		**Drawing No.**	**Rev.**
Date:	11th Dec 07	**16/N_CSM**	**0**

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4. Risk Screening & Prioritisation Calculations

Risk Screening/ Prioritisation

Table 1a LEACHATE: SOURC/HAZARD SCORING MATRIX			
	Waste FOOTPRINT (ha)		
WASTE TYPE	≤ 1ha	> 1 ≤ 5 ha	> 5ha
C&D	0.5	1	1.5
Municipal	5	7	10
Industrial	5	7	10
Pre 1977 sites	1	2	3

1a =	5

Table 1b LANDFILL GAS: SOURC/HAZARD SCORING MATRIX			
	Waste FOOTPRINT (ha)		
WASTE TYPE	≤ 1ha	> 1 ≤ 5 ha	> 5ha
C&D	0.5	0.75	1
Municipal	5	7	10
Industrial	3	5	7
Pre 1977 sites	0.5	0.75	1

1b =	5

Table 2a : LEACHATE MIGRATION: PATHWAYS	
GROUNDWATER VULNERABILITY (Vertical Pathway)	Points
Extreme Vulnerability	3
High Vulnerability	2
Moderate Vulnerability	1
Low Vulnerability	0.5
High - Low Vulnerability (use where vulnerability not on GIS)	2

2a =	2

Table 2b : LEACHATE MIGRATION: PATHWAYS	
GROUNDWATER FLOW REGIME (Horizontal Pathway)	Points
Karstified Groundwater Bodies (Rk)	5
Productive Fissured Bedrock Groundwater Bodies (Rf & Lm)	3
Gravel Groundwater Bodies (Rg and Lg)	2
Poorly Productive Bedrock Groundwater Bodies (Ll, Pl, Pu)	1

2b =	5

Risk Screening/ Prioritisation

Table 2c : LEACHATE MIGRATION: PATHWAYS	
SURFACE WATER DRAINAGE (Surface water pathway)	**Points**
Is there a direct connection between drainage ditches associated with the waste body and adjacent surface water body? Yes	2
If no direct connection	0

2c =	**0**

Table 2d : LANDFILL GAS: PATHWAY	
LANDFILL GAS LATERAL MIGRATION POTENTIAL	**Points**
Sand and Gravel, Made ground, urban, karst	3
Bedrock	2
All other Tills (including limestone, sandstone etc - moderate permabi	1.5
All Namurian or Irish Sea Tills (low permability)	1
Clay, Alluvium, Peat	1

2d =	**2**

Table 2e : LANDFILL GAS: PATHWAY (assuming receptor located above source)	
LANDFILL GAS LATERAL MIGRATION POTENTIAL	**Points**
Sand and Gravel, Made ground, urban, karst	5
Bedrock	3
All other Tills (including limestone, standstone etc - moderate permab	2
All Namurian or Irish Sea Tills (low permability)	1
Clay, Alluvium, Peat	1

2e =	**3**

Table 3a : LEACHAGE MIGRATION: *RECEPTORS*	
HUMAN PRESENCE (presence of a house indicaates potential private wells)	**Points**
On or within 50m of the waste body	3
Greater than 50m but less than 250m	2
Greater than 250m but less than 1km from waste body	1
Greater than 1km of the waste body	0

3a =	**2**

Risk Screening/ Prioritisation

Table 3b : LEACHAGE MIGRATION: RECEPTORS PROTECTED AREAS (SWDTE or GWDTE)	Points
Within 50m of waste body	3
Greater than 50m but less than 250m of the waste body	2
Greater than 250m but less than 1km from waste body	1
Greater than 1km of the waste body	0
Undesignated sites within 50m of waste body	1
Undesignated sites greater than 50m but less than 250m	0.5
Undesignated sites greater than 250m of the waste body	0

3b =	2

Table 3c : LEACHAGE MIGRATION: *RECEPTORS*	
AQUIFER CATEGORY (resource potential)	Points
Regionally Important Aquifers (Rk, Rf, Rg)	5
Locally Important Aquifers (LI, Lm, Lg)	3
Poor Aquifers (Pl, Pu)	1

3c =	5

Table 3d : LEACHAGE MIGRATION: *RECEPTORS*	
PUBLIC WATER SUPPLIES (Other than private wells)	Points
Within 100m of site boundary	7
Greater than 100m but less than 300m or with in Inner SPA for GW supplies	5
Greater than 300m but less than 1km or within Outer SPA (SO) for GW supplies	3
Greater than 1km (karst aquifer)	3
Greater than 1km (no karst aquifer)	0

3d =	3

Table 3e : LEACHAGE MIGRATION: *RECEPTORS*	
SURFACE WATER BODIES	Points
Within 50m of site boundary	3
Greater than 50m but less than 250m	2
Greater than 250m but less than 1km	1
Greater than 1km	0

3e =	1

Landfill SiteName: Velvetstown
Landfill Ref. No. :16/N

Tier 1 Study

Risk Screening/ Prioritisation

Table 3f : LEACHAGE MIGRATION: *RECEPTORS*	
HUMAN PRESENCE	**Points**
On site or within 50m of site boundary	5
Greater than 50m but less than 150m	3
Greater than 150m but less than 250m	1
Greater than 250m	0.5

3f =	**3**

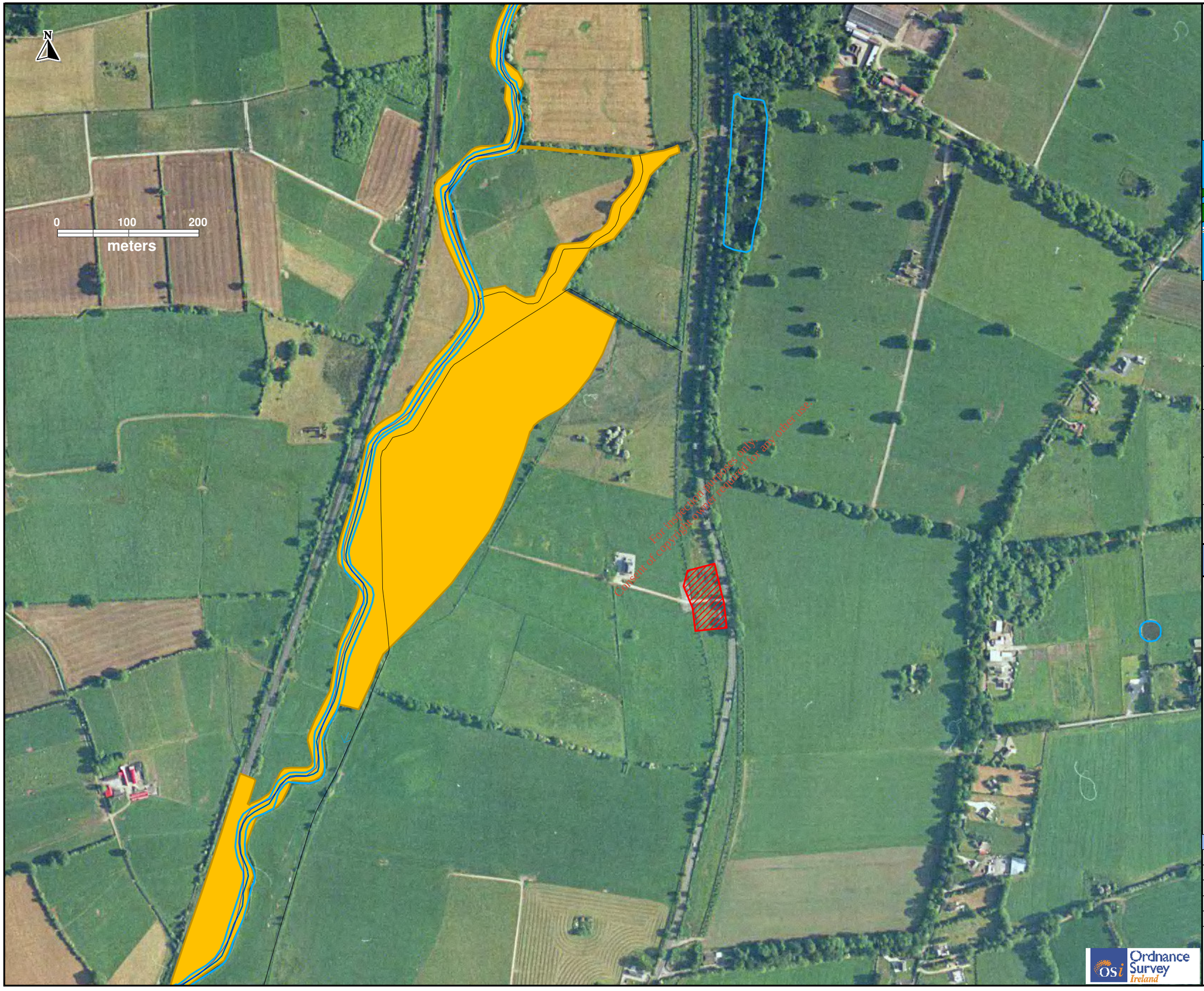
Note: The table below represents the Tier 1 risk rating for this site. SPR 1 to 9 represent the leachate risk scores. SPR 10 & 11 represent Landfill Gas risks. The migration pathways are colour coded as follows:

Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical

Calculator	SPR Values	Maximum Score	Linkages	Normalised Score
SPR 1 =	35	300	Leachate => surface water	**12%**
SPR 2 =	70	300	Leachate => SWDTE	**23%**
SPR 3 =	70	240	Leachate => human presence	**29%**
SPR 4 =	70	240	Leachate => GWDTE	**29%**
SPR 5 =	175	400	Leachate => Aquifer	**44%**
SPR 6 =	105	560	Leachate => Surface Water	**19%**
SPR 7 =	35	240	Leachate => SWDTE	**15%**
SPR 8 =	0	60	Leachate => Surface Water	**0%**
SPR 9 =	0	60	Leachate => SWDTE	**0%**
SPR 10 =	30	150	Landfill Gas => Human Presence	**20%**
SPR 11 =	45	250	Landfill Gas => Human Presence	**18%**

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	**Greater than or equal to 70% for any individual SPR lingage**
Moderate Risk (Class B)	**Between 40-70% for any individual SPR linkage**
Lowest Risk (Class C)	**Less than or equal to 40% for any individual SPR linkage**

OVERALL RISK RATING	**MODERATE**



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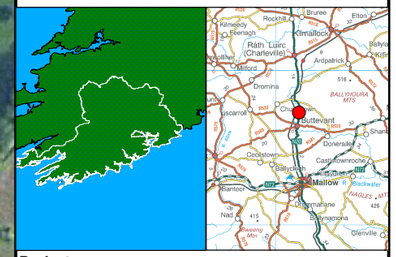

Project

Environmental Risk Assessment for Unregulated Waste disposal Sites

Tier 1 Investigation

Drawing Description

Protected Areas Map

Landfill Name & Ref No:

Velvetstown - 16/N

Division:

North Cork

Area Office:

Charleville

Legend

- Landfill Area
- SAC
- NHA
- SPA
- National Park
- Nature Reserve
- Rivers

Issue Details

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Date:	12th Dec 2007	**16/N_PA1**	

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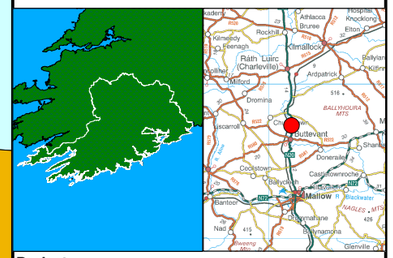

Project

Environmental Risk Assessment for Unregulated Waste disposal Sites

Tier 1 Investigation

Drawing Description:

Aquifer Map

Landfill Name & Reference No:

Velvetstown - 16/N

Division:

North Cork

Area Office:

Charleville

Legend

Landfill Area

AQUIFER CATEGORY

- Ll - Locally Important
- Pending Classification
- Pl - Poor Bedrock Aquifers
- Pu - Poor Bedrock Aquifers
- Rf - Regionally Important Aquifer
- Rkd - Regionally Important Karstified Aquifer

Rivers

0 100 200
meters

Issue Details

Drawn: KC		**File Ref.**	
Checked: -		**16/N**	
Approved:			
Scale:		**Drawing No.** 16N_AC_0	**Rev. 0**
Date: 12th Dec 2007			

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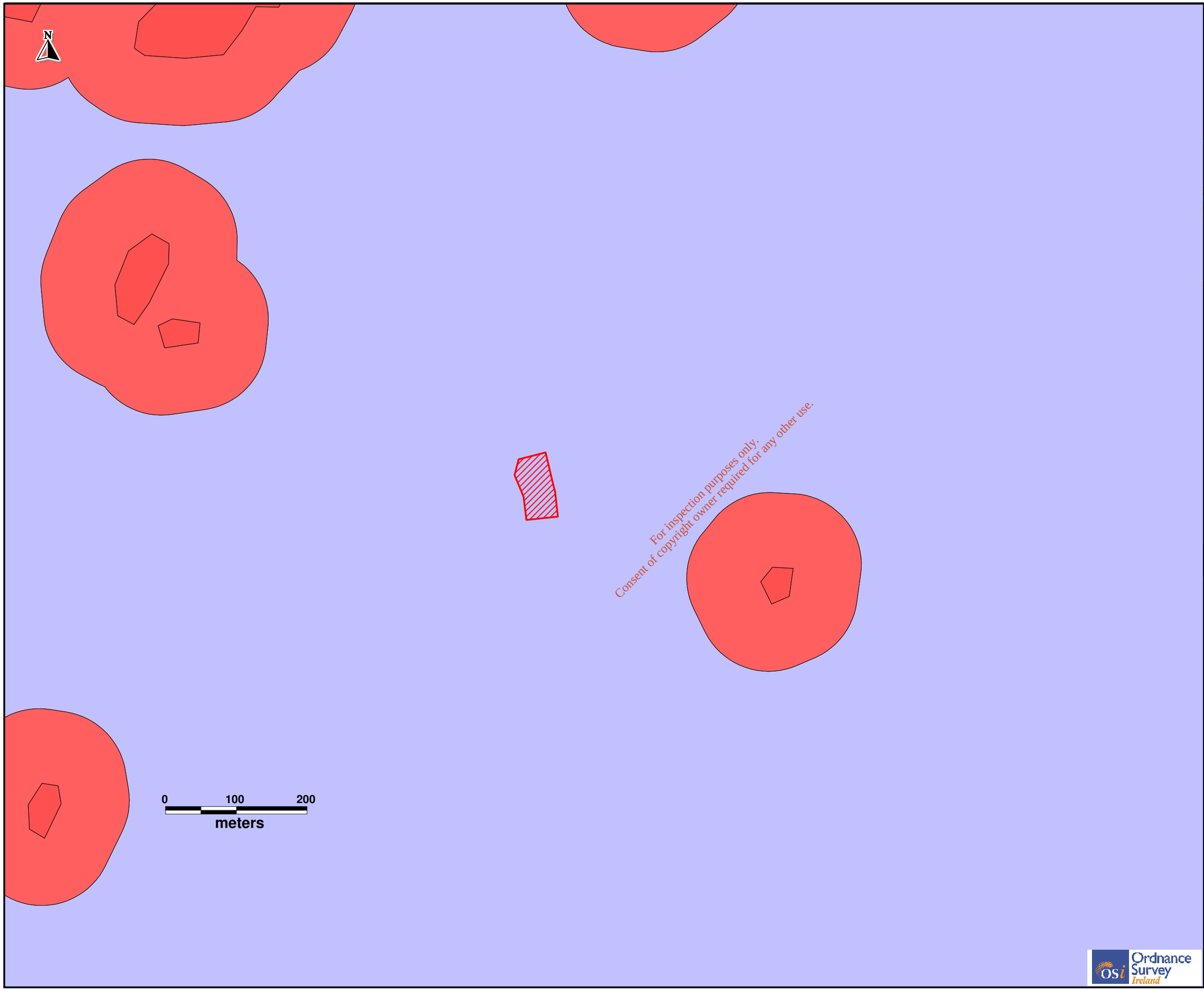

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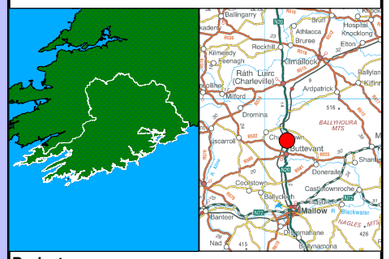

Project

Environmental Risk Assessment for Unregulated Waste disposal Sites

Tier 1 Investigation

Drawing Description:

Groundwater Vulnerability Map

Landfill Name & Ref No:

Velvetstown - 16/N

Division:

North Cork

Area Office:

Charleville

Legend

Landfill Area

SWRBD_Groundwater Vulnerability

- E (Rock near Surface or Karst)
- E - Extreme
- H - High
- HL - High/Low
- M - Moderate
- L - Low
- Water

Issue Details

Drawn: KC		**File Ref.**	
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Scale:		**Drawing No.** 16/N_GV_0	**Rev. 0**
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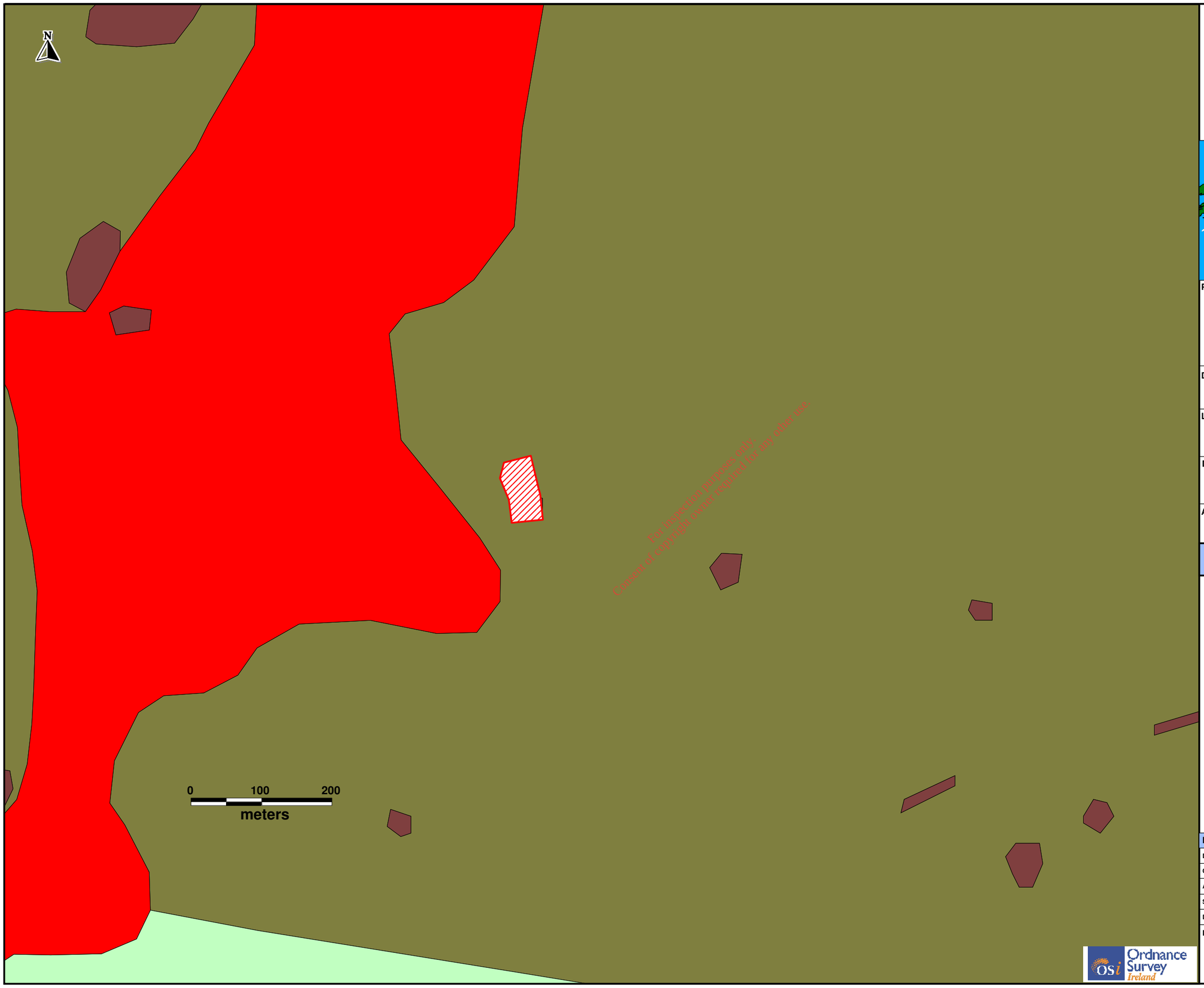

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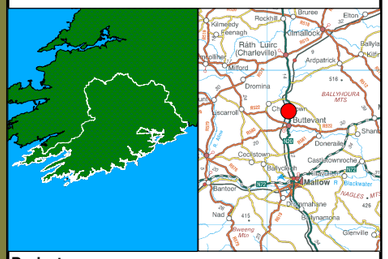

Project

Environmental Risk Assessment for Unregulated Waste disposal Sites

Tier 1 Investigation

Drawing Description:

Subsoils Map

Landfill Name & Ref No:

Velvetstown - 16/N

Division:

North Cork

Area Office:

Charleville

Legend

- Landfill Area
- Soil type

Alluvium	MGs
BktPt	Msi
GDSs	ROCK *
GLs	Scree
GNSSs	TDCSsS
IrSTDSs	TdlMr
KaRck	TDSs*
L	TLPSsS
Made	TLs
Marsh	TNSSs
Mbs	Water
Mesc	Ws

Issue Details

Drawn: KC		**File Ref.**	
Checked: -		**16-N Subsoil Type**	
Approved:			
Scale:		**Drawing No.**	**Rev. 0**
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Appendix 2

EPA Matrices for Velvetstown

EPA COP MINIMUM REQUIRED PRELIMINARY & EXPLORATORY INVESTIGATIONS FOR ALL UNREGULATED WASTE DISPOSAL SITES

IMPORTANT NOTE: THIS IS THE INITIAL PHASE OF WORK IS CONSIDERED MANDATORY FOR ALL SITES IDENTIFIED AND SHOULD AIM TO COMPLETE A COMPREHENSIVE TIER 1 THE FINDING OF WHICH WILL BE CONFIRMED BY THE INITIAL TIER 2 WORKS. EACH PHASE OF ASSESSMENT WILL DEVELOP THE CONCEPTUAL SITE MODEL (CSM) AND SHOULD GUIDE THE DESIGN OF THE NEXT PHASE OF SI . THE APPLICATION OF THE SI PROCESS AND METHODOLOGIES SHOULD BE COMPLETED IN ACCORDANCE WITH THE RELEVANT STANDARDS/EPA GUIDANCE DOCUMENTS AND UNDERTAKEN BY EXPERIENCED PRACTITIONERS.

				TIER 1: PRELIMINARY INVESTIGATION				TIER 2: EXPLORATORY INVESTIGATION & SAMPLING						
				DESK STUDY	**WALKOVER SURVEY**	**CONCEPTUAL SITE MODEL (CSM)**		**TRIAL PITS & TRENCHES**	**WASTE TYPE**	**WASTE SAMPLING**	**LEACHATE TESTING**	**SOIL SAMPLING**	**Surface or Groundwater Sampling**	**TOPOGRAPHIC & GPS SURVEY**
SPR LINKAGE	**SOURCE**	**PATHWAY**	**RECEPTOR**	Critical mandatory element of the SI process - includes gathering baseline site and local area data, history of landfill, waste types, volumes, age, presence and distance to potential receptors, etc	Very important element of the SI process. Confirms physical conditions on site, desk study findings and examines access issues, visual assessment of pathways/receptors allows initial SPR linkage potential to be considered.	The development of the CSM is a critical aspect of the risk assessment and defining SPR linkages and therefore SI requirements		JCB or tracked excavator - waste type assessment & classification - leachate/gas potential, limited depth, good bulk samples & visual assessment. Allows for sampling and possibly temporary standpipes (not best practice). Accurate logs and photographs important.	Assessment of waste type in terms of content and determining composition of C&D, Municipal, Industrial, Pre 1977 sites. Should confirm reported waste types deposited as identified in Tier 1.	Waste Sampling is primarily to enable leachability testing if risk of leachate emanating from waste exists.	List 1 & List 2 substances contamination - Parameters to be considered as per Table C.2 of EPA Landfill Monitoring Manual 2003.	Principle purpose of soil sampling at this stage is to assess permeability potential of surrounding materials (pathway assessment), composition of any cap and potential for local material to be used for remediation/capping. In some cases contamination assessment may be required.	Any obvious receptors should be considered for initial indicator parameter screening. Surface waters and/or existing boreholes can be sampled at this stage. Gas monitoring with hand held equipment can be completed. Parameters to be considered as per Table C.2 of EPA Landfill Monitoring Manual 2003.	Topographic modelling will enable waste extent & volume calculations, location of sampling points, surface drains/features. Topographic data & Well datum for flow direction mapping. GPS system will determine grid ref for SI works. Can be important for remediation/capping design.
SPR 1	LEACHATE	Vertical & Horizontal Groundwater to Surface Water Drainage/Runoff	Surface Water Body	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 2	LEACHATE	Vertical & Horizontal Groundwater to Surface Water Drainage/Runoff	Surface Water Body Protected Area (SWDTE)	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 3	LEACHATE	Vertical & Horizontal Groundwater Migration	Human Presence (Private Well)	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 4	LEACHATE	Vertical & Horizontal Groundwater Migration	Groundwater Protected area (GWDTE)	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 5	LEACHATE	Vertical & Horizontal Groundwater Migration	Aquifer Category	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 6	LEACHATE	Vertical & Horizontal Groundwater Migration	Public Supply (Well) (includes Group Water Schemes)	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 7	LEACHATE	Vertical & Horizontal Groundwater Migration	Surface Water Body	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 8	LEACHATE	Surface Water Drainage/Runoff	Surface Water Body	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 9	LEACHATE	Surface Water Drainage/Runoff	Surface Water Body Protected Area (SWDTE)	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 10	LANDFILL GAS	Lateral Migration (Subsoil)	Human Presence	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
SPR 11	LANDFILL GAS	Vertical Migration (Subsoil)	Human Presence	**M**	**M**	**M**		**M**	**M**	**R**	**R**	**R**	**R/S**	**R/S**
Source & Pathway & Receptor Parameters Targeted for CSM & Risk Screening				Research of all available published site information - Site history, waste type, extent and volumes, possible historic sources, local receptors, infrastructure etc. Interviews with previous site staff should be considered.	Walkover should confirm desk study data and investigate Source Pathway Receptor regimes being considered.	The CSM should graphically represent the relationship's) and receptor's) developed on the basis of hazard identification and refined during subsequent phases of assessment.		Waste type/composition, footprint, volume, depth & groundwater vulnerability, leachate & gas source & migration potential. Should assess nature and depth of any cap or undersoils, if encountered.	waste type, general composition and extent within the landfill area, leachate and gas source & migration potential.	waste type, leachate potential	waste type, leachate potential	ground vulnerability, horizontal or vertical pathway assessment & material use in remediation of site.	surface water or groundwater receptor and potential horizontal pathway information.	waste area & volume, site topography, layout/setting, access roads, surface features, accurate SI points, levels for groundwater flow direction, etc
General comments & COP Section Reference - Note: the development of the CSM and design of the site investigation should involve an experienced SI practitioner.				Critical first step in site and waste characterisation, all potential data sources should be considered. Note Section 3.2 of COP	allows visual assessment of site and local environs, important that walkover confirms findings of desk study and allows accurate CSM to be developed. Note Section 3.4 of COP	This is a fundamental part of the Risk Assessment exercise - the CSM information should be clearly documented and accessible in the form of text, figures and tables. Note section 3 of COP and reporting requirements in Chapter 8.		Trial pits and trenching is a very important phase of work to enable the potential sources and types of leachate & gas to be determined. Detailed logs and photographic records important. Note Section 5.5.2 of COP.	characterises waste type and contamination potential. Note Section 4.3.1 of COP & Table 1a & Table 1b of Scoring Matrix.	characterises waste type and contamination potential. Note Section 4.3.1 of COP & Table 1a & Table 1b of Scoring Matrix.	characterises waste type and contamination potential, samples can be acquired during trial pitting or from existing borehole infrastructure, if present.	Characterises geology type and material strength, permeability	should be completed as per best practice and relevant guidelines. Refer to COP 5.3.2 and EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Sections 4 and 5.	topographic surveys give base map for site layout, investigation points, sample and water level depths, groundwater flow direction etc. recommended.
Provisional Guidance on Extent of Testing/Sampling - This will ultimately depend on the type of risk identified, size of site, extent & volume of waste, ground conditions, variability of the waste material, etc..				Office based assessment using all available existing site data that is vital in assessing the initial risk level and conceptual model for the site. Sites may have GIS data available.	Locations and access issues for sampling and site suitability should be assessed at this stage.	A good conceptual site model will facilitate an initial risk classification for the site and guide future works.		Typically 7 to 10 trial pits are completed to 3 to 5m per day. Initial two days of trial pitting should be undertaken on and around the waste body to confirm extent and composition. Initial gas monitoring can be by hand held gas and volatile monitors & based on physical observations. Further Trial Pits & Trenching can be completed as part of the Main SI if required.	Each trial pit should be logged as per BS 5930:1999 and nature of waste and composition recorded. Photographic records important. Potential to cause source of contamination to be assessed.	Leachability testing of waste should be completed once is not C&D type - minimum of two samples should be acquired for the NRA Leachability test and comparison to the relevant guidelines such as, EPA groundwater Interim Guideline Values (IGVs).	Will depend on nature and composition of the waste and number of investigation points. Initially one to three samples should be taken with one full screen as per Table C.2 of EPA Landfill Monitoring Manual 2003, and at other locations to do indicator parameters such as ph Conductivity, temp, BOD, Ammonia, Chloride, sulphate, sodium and potassium.	Will depend on nature and variability of soil material around waste body and number of investigation points. Initially three disturbed samples should be taken and tested for soil type, particle size, permeability and strength, refer to BS 5930 standard.	Nearest or local downgradient locations should be considered for exploratory sampling. Basic indicator parameters such as ph Conductivity, temp, BOD, Ammonia, Chloride, sulphate, sodium and potassium should be completed as a minimum.	A topographical survey should be considered for the site area and immediate environs of low risk sites and is recommended for all moderate and high risk sites. GPS survey locations as required.

AFTER TIER 1 INVESTIGATION, DEVELOP CONCEPTUAL SITE MODEL, DETERMINE RISK CLASSIFICATION & SCOPE EXPLORATORY INVESTIGATION

AFTER TIER 2 EXPLORATORY INVESTIGATION, REFINE CONCEPTUAL SITE MODEL, CONFIRM RISK CLASSIFICATION & SCOPE MAIN SITE INVESTIGATION AS REQUIRED

M = Mandatory and should be completed as thoroughly as possible for each site.

R = Recommended technique assuming site conditions allow.

S = Should be considered but is dependent on site suitability for that methodology.

ISSUED WORKING DRAFT

DATE:17th September 2009

COMPILED BY WYG

EPA COP MAIN SITE INVESTIGATION REQUIREMENTS FOR MODERATE RISK (CLASS B 40% TO 69%) AND HIGH RISK (CLASS A > 70%) FOR UNREGULATED WASTE DISPOSAL SITES.

IMPORTANT NOTE: THIS IS A GENERAL GUIDE TO INDENTIFY SUITABLE SITE INVESTIGATION (SI) METHODS FOR MODERATE & HIGH RISK WASTE SITES, AS IDENTIFIED BY THE EPA COP RISK CLASSIFICATION FROM THE COMPLETED TIER 1 & INITIAL TIER 2 EXPLORATORY INVESTIGATIONS. EACH PHASE OF INVESTIGATION WILL DEVELOP THE CONCEPTUAL SITE MODEL (CSM) AND SHOULD GUIDE THE DESIGN OF THE NEXT PHASE OF INVESTIGATION & ULTIMATELY THE REMEDIATION . THE APPLICATION OF THE INVESTIGATION PROCESS AND METHODOLOGIES SHOULD BE COMPLETED IN ACCORDANCE WITH THE RELEVANT GUIDANCE DOCUMENTS AND STANDARDS AND BE UNDERTAKEN BY EXPERIENCED PRACTITIONERS.

				TIER 2: MAIN INVESTIGATION					TIER 2 PROBE AND/OR BOREHOLE SAMPLING						TIER 2 SPECIALIST SURVEYS			AFTER TIER 2 MAIN INVESTIGATION, REFINE CONCEPTUAL SITE MODEL, CONFIRM RISK CLASSIFICATION & PROGRESS TO QRA & REMEDIATION PHASE
				The selection of site investigation techniques should be focused on what SPR Linkage is being examined & the site/ground conditions - in some cases a combination of techniques may be required and/or additional trial pitting considered necessary													
				SHALLOW PROBES/HAND AUGERS	GEOPHYSICS/ INFRA RED SURVEYS	WINDOW SAMPLING	CABLE PERCUSSION BORING	AIR ROTARY OPEN OR CORED HOLE	GAS SAMPLING	LEACHATE SAMPLING	SOIL SAMPLING	SURFACE WATER SAMPLING	GROUNDWATER SAMPLING	PUMPING TEST	ECOLOGICAL SURVEYS	SURFACE WATER SURVEYS	ODOUR/DUST or ASBESTOS SURVEYS	
SPR LINKAGE	SOURCE	PATHWAY	RECEPTOR	Manual or mechanical instillation of temporary probes for gas monitoring to typically 2mBGL & use of landfill gas analyser and/or PID to determine concentrations - may give limited soil profile and strength information.	Range of techniques for waste extent, depth, plumes & anomalies; can be influenced by power cables, unsuitable ground conditions, poor interpretation. Needs ground proofing.	Competitor/terrier rig shallow soil sampling, permeability testing & standpipe installation for GW monitoring & gas taps: Ground conditions can limit depth.	Also called Shell & Auger (S&A) drilling - deeper soil sampling, permeability testing & standpipe installation for GW monitoring & gas taps. Can be limited by boulders/ obstructions. No bedrock penetration.	Bedrock drilling, chip sampling & standpipe installation for GW monitoring permeability testing & gas taps. Very limited subsoil or waste sampling. Coring used for geotech logging, rock quality/fracture logging.	Gas Sampling using bags, Gresham Tubes etc.	Sampling from boreholes in waste area giving data on List 1 & List 2 substances contamination - Parameters to be considered as per Table C.2 of EPA Landfill Monitoring Manual 2003.	Soil sampling to assess permeability potential of surrounding materials (leachate or gas pathway assessment). Soil contamination assessment may be required and assessment potential for local material to be used for remediation/capping. Detailed borehole logs should be completed.	List 1 & List 2 substances contamination assessment in SW & seepage locations. Sampling applied for surface water abstractions from shallow dug wells and surface water sources, (SPR 6). Parameters to be considered as per Table C.2 of EPA Landfill Monitoring Manual 2003.	List 1 & List 2 substances contamination assessment GW flow direction. Parameters to be considered as per Table C.2 of EPA Landfill Monitoring Manual 2003.	Enables GW sampling for List 1 & List 2 substances contamination assessment, relevant water standards & GW flow regime & direction	habitat assessment, surface water Q quality rating, ecological significance - surveys should be risk specific.	water levels, flow rates, assimilative capacity, hydrology studies	Only required if odours, dust and asbestos are identified as potential problem during Tier 1 and Tier 2 works	
SPR 1	LEACHATE	Vertical & Horizontal Groundwater to Surface Water Drainage/Runoff	Surface Water Body	N	S	R/S	R/S	R/S	N	R	R	R	R/S	S	S	R	N	
SPR 2	LEACHATE	Vertical & Horizontal Groundwater to Surface Water Drainage/Runoff	Surface Water Body Protected Area (SWDTE)	N	S	R/S	R/S	R/S	N	R	R	R	R/S	S	R/S	R	N	
SPR 3	LEACHATE	Vertical & Horizontal Groundwater Migration	Human Presence (Private Well)	N	S	N	S	R	N	S	S	N	R	S	N	N	N	
SPR 4	LEACHATE	Vertical & Horizontal Groundwater Migration	Groundwater Protected area (GWDTE)	N	S	N	S	R	N	S	S	S	R	S	R	N	N	
SPR 5	LEACHATE	Vertical & Horizontal Groundwater Migration	Aquifer Category	N	S	N	S	R	N	R	R	N	R	R/S	N	N	N	
SPR 6	LEACHATE	Vertical & Horizontal Groundwater Migration	Public Supply (Well) (includes Group Water Schemes)	N	S	N	S	R	N	R	R	S	R	R/S	N	S	N	
SPR 7	LEACHATE	Vertical & Horizontal Groundwater Migration	Surface Water Body	N	S	S	S	R	N	R	R	R	R	S	S	R	N	
SPR 8	LEACHATE	Surface Water Drainage/Runoff	Surface Water Body	N	S	R/S	R/S	N	N	R	R	R	N	N	S	R	N	
SPR 9	LEACHATE	Surface Water Drainage/Runoff	Surface Water Body Protected Area (SWDTE)	N	S	R/S	R/S	N	N	R	R	R	N	N	R	R	N	
SPR 10	LANDFILL GAS	Lateral Migration (Subsoil)	Human Presence	R	S	S	S	S	R/S	N	N	N	N	N	N	N	S	
SPR 11	LANDFILL GAS	Vertical Migration (Subsoil)	Human Presence	R	S	S	S	S	R/S	N	N	N	N	N	N	N	S	
Source & Pathway & Receptor Parameters Targeted for CSM & Risk Screening & Remediation.				waste type, footprint, soil type, thickness, strength. Suitable for gas monitoring and gas migration potential.	waste type/volume, waste footprint, depth to bedrock, groundwater vulnerability, horizontal pathway - plume migration.	waste type, groundwater vulnerability/level, gas migration potential,	waste type, groundwater vulnerability/level, flow direction & resource potential, horizontal pathway, gas migration potential.	groundwater vulnerability/level & flow direction & resource potential, horizontal pathway, gas migration potential.	waste type, gas migration potential	waste type, leachate potential and gas migration potential.	soil type, permeability, leachate & gas migration potential, ground vulnerability, horizontal pathway. May also assist in assessing re-use of material for remediation.	surface water receptor and pathway information.	groundwater receptor and horizontal pathway information.	groundwater resource potential, flow direction, horizontal pathway	surface water pathway, groundwater vulnerability, horizontal pathway,	surface water pathway	Air Pathway	
General comments regarding techniques & COP Section Reference - Note: the development of the CSM and design of the site investigation should involve an experienced SI practitioner.				Gas monitoring should be considered if trial pit phase identifies gas potential, thin/no capping and human presence exists. Section 5.5.2 of COP.	Geophysics should be considered for areas where extent of waste is unclear and where shallow plumes may be impacting on surface waters. Advantage of covering large areas and is not intrusive. Needs ground proofing. Section 5.5.1.2 of COP.	Window sampling option should be considered for shallow boreholes in ground without obstructions (as identified from Trial Pit Survey). Use boreholes for sampling, water/leachate & gas monitoring.	S&A drilling can be completed after or instead of window sampling phase especially if deeper depth required. Use boreholes for sampling, water/leachate & gas monitoring. Section 5.5.2 of COP.	Aquifer category work based on GSI well survey data & rotary drilling. Recommend minimum of three GW level locations are available for flow direction calculation - use of data loggers to confirm levels and/or possible linkage. Core drilling rarely used unless RQD needed. Design and proper grouting of wells is important. Use boreholes for sampling, water/leachate & gas monitoring. Section 5.5.2 of COP.	Should be considered once landfill gas identified as risk to receptors. Compete as per best practice and relevant guidelines. Refer to EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Section 7.	characterises waste type and leachate source/contamination potential. Compete as per best practice and relevant guidelines. Section 5.5.3 of COP. Refer to EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Section 6.	Characterises soil type and if contamination present, characterises geology and permeability. Refer to relevant guidelines and Standards. Section 5.5.3 of COP.	should be completed as per best practice and relevant guidelines. Refer to EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Section 4.	should be completed as per best practice and relevant guidelines. Refer to EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Section 5.	generally step test should be followed by longer CRT test to determine aquifer characteristics and potential linkages. Level loggers should be used.	should be considered for SACs/SPA, wetlands and surface waters - if surface water body is part of salmonoid (Q Index) or marine catchment then ecology survey's should be considered. Consultation with NPWS may be required. Where applicable use existing data from EPA/OPW or local authority sources. Refer to Section 5.5.1.3 and Appendix 4 of COP.	catchment surveys, V-Notch weirs, flow studies should all be considered Consultation with fisheries may be beneficial.	Standard dust jars or specific odour surveys should be considered. Compete as per best practice and relevant guidelines. Refer to EPA Landfill Monitoring Guidelines, 2nd Edition 2003, especially Sections 8 and 10.	
Provisional Guidance on Minimum Extent of Testing/Sampling - (sampling totals will depend on the type of risk identified, size of site, extent & volume of waste, ground conditions, variability of the waste material, etc..)				Number of probes will depend on extent of survey and depth of probe. I	Will depend on the nature and extent of the waste and type of survey being undertaken. Needs to be site specific assessment scoped and completed by experienced and qualified contractors.	Number of probes will depend on survey area, ground conditions and depth of completion. If suitable ground exists typically three five metre boreholes are possible per day.	Number of boreholes will depend on survey area, ground conditions and depth of completion. Rough average 10m of drilling typically completed per day.	Number of boreholes will depend on extent of waste and location of receptors. Completion rate will be impacted by instillations and grouting. Approximately 75m of drilling and casing can be completed per day.	Will depend on extent and nature of gases and receptors. Should be decided on a site specific basis.	Will depend on nature and composition of the waste and number of investigation points. Full screen testing as per Table C.2 of EPA Landfill Monitoring Manual 2003, indicator parameters include ph, Conductivity, Temp, BOD, Ammonia, Chloride, sulphate, sodium and potassium.	Will depend on the variability of site and geology. Ground variability will require more sampling. In-situ permeability and strength (SPT) tests and soil assessment for remediation use should be considered.	Sample upstream and down stream locations as per Table C.2 of EPA Landfill Monitoring Manual 2003. Basic indicator parameters include ph, Conductivity, Temp, BOD, Ammonia, Chloride, sulphate, sodium and potassium.	Sample at all borehole locations. Full screen as per Table C.2 of EPA Landfill Monitoring Manual 2003. Basic indicator parameters include ph, Conductivity, Temp, BOD, Ammonia, Chloride, sulphate, sodium and potassium.	Pumping tests are important for assessing pathways and confirming linkages and should be completed if possible.	Quantified on a site specific basis. For high risk sites functional values for the habitat may need to be assessed.	Quantified on a site specific basis.	Quantified on a site specific basis.	
MODERATE RISK SITES				initial one day probe survey should be considered for moderate gas risk sites.	Less coverage and survey densities would be expected for moderate risk sites when compared to high risk sites.	Minimum of one days should be considered.	Minimum three to five locations should be considered.	Minimum of one down gradient borehole required for moderate risk sites.	Less gas monitoring locations would be expected to be monitored for moderate risk sites when compared to high risk sites.	One full suite and indicator parameters at a minimum of three locations.	Number of samples should be determined by the site specific requirements.	Full suite on down stream locations and indicator parameters at up stream locations.	Full suite on nearest down gradient borehole and indicator parameters at all other relevant groundwater locations.	Step test and minimum of 72 hour test should be initially considered.	Surveys should be determined by the site specific requirements. In general moderate risk sites would be expected to require a less extensive scope of works to be completed.	Quantified on a site specific basis. In general moderate risk sites would be expected to require a less extensive scope of works to be completed.	Quantified on a site specific basis. In general moderate risk sites would be expected to require a less extensive scope of works to be completed.	
HIGH RISK SITES				initial two day probe survey should be considered for moderate gas risk sites.		Minimum of two days should be considered.	Minimum three to five locations should be considered.	Minimum of three boreholes are required for high risk sites.		Minimum of two full suite and indicator parameters at all other suitable locations.		Full suite on up and down stream locations and indicator parameters at any other relevant surface locations.	Full suite on up gradient and down gradient boreholes and indicator parameters at all other relevant groundwater locations.	Step test and five to seven day test should be initially be completed.				

R = Recommended technique assuming site conditions allow.

S = Should be considered but is dependent on site suitability for that methodology.

N = Not recommended, but may occasionally be suitable.

RQD = Rock Quality Designation
CSM = Conceptual Site Model
NPWS = National Parks and Wildlife Service
BGL = Below Ground Level
SI = Site Investigation
GW - Groundwater
GSI = Geological Survey Of Ireland
CRT = Constant Rate Test
QRA = Quantitative Risk Assessment

ISSUED WORKING DRAFT
DATE:17 Sept 09
COMPILED BY WYG

Appendix 3

Trial Pit and Groundwater Well Logs