RPS

Donegal County Council

Balbane Landfill Site

Balbane Scoping Report

FINAL

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EXECUTIVE SUMMARY

RPS was commissioned to complete a scoping report for the restoration of Balbane Landfill Site. This report considers what is the optimal restoration solution for this unengineered remote landfill site by assessing options and proposing the scope to the EPA for their preliminary approval to complete a Specified Engineering Works (SEW) for the restoration works.

The site in its present condition appears to be impacting on surface waters immediately downstream from the landfill predominantly via surface water discharges from leachate breakout from the waste body and subsequent overland and shallow groundwater flow. The primary receptor considered at risk from the site is the Balbane River and further downstream of the Lough Aderry River which are located down gradient of the waste body and are connected to the waste body by a series of small unnamed streams.

The VOC survey would indicate that the existing soil cover is providing a sufficient barrier for the gas to prevent surface emissions.

Restoration works to minimise the impacts of the site on local surface water in particular is therefore required. This report has been compiled with a view to determining the most effective and sustainable option which achieves the goal of restoring the site in line with waste licensing requirements and minimising fugitive emissions to the environment.

A qualitative and quantitative assessment has been undertaken of the proposed options using the criteria and simple matrix provided below;

- Capital Cost,
- Annual Running Cost,
- Regulation Requirement, and
- Specific Problems.

The preferred option is Option 4 Reduced Engineered Cap and the Installation of an ICW on the existing site. This is subject to further analysis and ultimately detail design which would incorporate information derived from the commissioning of the ICW which is being utilised to treat leachate on Churchtown Landfill Site.

1 Introduction

1.1 Introduction

This report considers what is the optimal restoration solution for this unengineered remote landfill site by assessing options and proposing the scope to the EPA for their preliminary approval to complete a Specified Engineering Works (SEW) for the restoration works.

The Report considers several licence conditions in terms of the suitability of each option under consideration when compared to the functionality of a fully engineered cap as outlined in the Waste Licence. This will include details from Condition 4 Restoration and Aftercare, to include:

- Condition 4.3 - Profiling
- Condition 4.4 - Capping
- Licence Attachment H - Restoration and Aftercare Plan

1.2 Location

Balbane Landfill Site is located approximately 6.5km north of Killybegs, in the townland of Balbane, Co. Donegal. The landfill site was developed to operate on the dilute and disperse principle where leachate generated by rainfall was allowed to disperse into the surrounding environment.

1.3 Site History

Donegal County Council (DCC) submitted an application to the Environmental Protection Agency for the continued operation of the landfill site, as required by the Waste Management (Licensing) Regulations 1997. On the 13th of November 2001 the Environmental Protection Agency granted the Council a Waste Licence (registration number 90-1) for the facility, in accordance with the Third Schedule of the Waste Management Act, 1996. The site ceased operating in January 2004. The site is uncapped and currently has no leachate collection or treatment infrastructure in place.

The initial Restoration and Aftercare Plan submitted to the EPA in October 2004 envisaged capping the site, passive venting of gas and collection of leachate in a lagoon for removal off site and treatment elsewhere. The estimated capital cost of these works in 2004 was €1.12

million. This was revisited in 2008 for the purposes of a grant application and the cost estimate had increased to €1.71 million. These estimates did not include proposals for leachate treatment.

Developments in environmental law and practice over the years have caused a reconsideration of those earlier proposals. The licensing of discharges from wastewater treatment plants has reduced / eliminated options previously considered available for the off-site treatment of leachate from landfill sites.

The EPA requires DCC to carry out a site remediation scoping study to develop a sustainable proposal for remediation works of Balbane Landfill Site.

2 Desk Top Review

A number of previous reports were reviewed to obtain information on the site as part of this Scoping Report and are summarised below.

2.1 Balbane Annual Environmental Report 2015

Monitoring of surface water, groundwater and leachate has been undertaken on site since 2004 as per the EPA waste license requirements. An outline review of the receptors (groundwater and surface water) currently being impacted by the site is provided below.

2.1.1 Groundwater Quality

Groundwater locally flows in a south-easterly direction as shown in Figure 5 in Appendix A. GW1 reflects baseline conditions up-gradient of the site. GW2 & GW4 are down-gradient but in / adjacent to waste. Details of the monitoring locations are shown on Drawing IBR0859/004. Results for 2015 are provided in Appendix B.

The groundwater results were assessed against the following:

- EPA Interim guideline values1[1] (IGV);
- SI No 278 of 2007 EC (Drinking water) Regulations (DWR); and
- SI No 9 of 2010 European Communities Environmental Objectives (Groundwater) Regulations 2010 as amended (GWR 2010).

The GTV for ammonia is 0.175 mg/l. An elevated concentration of ammonia was recorded up-gradient of the site in GW1 in November (8.60 mg/l N) which reflects the baseline conditions of the groundwater up-gradient of the site. It is important to note that elevated levels of ammonia up gradient trigger an emission incident on the site; however the source of contamination remains unexplained. Ammonia concentrations ranged from >0.04 to 0.07 mg/l N for the remaining sampling dates.

Elevated concentrations of ammonia were also recorded down gradient of the site in boreholes GW2 and GW4 throughout the sampling period. Concentrations ranged from 0.61 to 20.00 mg/l N in GW2 and ranged from 0.83 to 16.20 mg/l N in GW4. Monitoring wells GW2 and GW4 are located adjacent to the waste body.

[1] EPA (2003) Towards setting guideline values for the protection of groundwater in Ireland. Interim Report

Electrical conductivity (EC) levels up-gradient in GW1 were consistently below the GTV of 1000 µS/cm ranging between 314 and 616 µS/cm. EC levels down-gradient within GW2 were below the guideline value ranging between 79 and 129 µS/cm. EC levels within GW4 exceeded the guideline value in 3 of the 4 sampling dates ranging between 668 and 1,130 µS/cm.

Chloride concentrations were consistently below the GTV guideline value of 185.7 mg/l in all boreholes. The highest chloride concentrations are recorded in GW4. However a reducing trend since is evident and the levels continue to reduce with the most recent concentration recorded at 28 mg/l in November 2015.

Potassium concentrations were below the IGV guideline value for Potassium of 5 mg/l in GW1 and GW2. Potassium concentrations within GW4 were recorded at significantly elevated levels in 3 of the 4 sampling dates ranging between 1.8 to 41.2 mg/l.

The GTV guideline value for iron is 200 µg/l. Elevated concentrations of iron were recorded in all boreholes in June and July.

All other parameters measured quarterly are below the GTV and IGV. Analysis for metals and List I / II substances were undertaken in Quarter 2 (June 2014), as agreed with the EPA (to be undertaken every three years) and therefore are not required until 2017.

The landfill site was developed to operate on the dilute and disperse principle and results show that groundwater is being impacted from leachate generated within the landfill. It should be noted that groundwater monitoring boreholes in Balbane are adjacent to /within the unlined waste body and it is expected that concentrations in groundwater have reduced further down gradient of the site. The graphs in appendix B also show the seasonal variation in parameter concentrations at the site.

2.1.2 Surface Water Quality

The surface water results were assessed against the following:

- SI No 294 of 1989 European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations (SWQS); and
- SI No 272 of 2009 European Communities Environmental Objectives (Surface Water) Regulations 2009 (EQS).

Surface water quality is monitored at Balbane Landfill site at 5 locations. S1 is located upstream of the site, whilst S4–S7 inclusive are downstream. S2 and S3 were relocated and relabelled at the request of the EPA. Results from surface water sampling point S4 have been used in this report to assess the impact of the landfill site on surface water as S4 is located immediately downstream of the waste body. Results and graphs are provided in Appendix B.

The EQS 2009 guideline values for ammonia ranges from 0.09 (high) to 0.14 mg/l N (good). Ammonia concentrations downstream from the waste body at surface water sampling point S4 have exceeded the good guideline value of 0.14 mg/l N throughout the sampling periods. There is a generalised reduction in ammonia concentration over time at any fixed point as seen in graphs provided in Appendix B.

The EQS 2009 guideline value for BOD is 2.6 mg/l. BOD concentrations in surface water exceeded the guideline value downstream of the site at S4 throughout 2013. Elevated BOD concentrations were also recorded in 2 of the 4 sampling periods in 2014 and in 1 of the 4 sampling periods in 2015. The concentration of BOD in S4 overtime is displayed in graphs provided in Appendix B.

COD concentrations exceeded the SWQS of 40 mg/l downstream of the site in June 2014 when a concentration of 220 mg/l was recorded in S4. The concentration of COD in S4 overtime is displayed in graphs provided in Appendix B.

No elevated concentrations above the appropriate EQS and/or SWQS values have been recorded for the remaining parameters in S4 downstream of the site.

2.2 Hydrogeological Risk Assessment 2015

A hydrogeological risk assessment was undertaken in 2015 and submitted to the EPA. The report found that;

- The site in its present condition appears to be impacting on surface waters immediately downstream from the landfill predominantly via surface water discharges from leachate breakout from the waste body and subsequent overland and shallow groundwater flow. An impact at the furthest downstream sampling location, S7, is actively recorded and is attributed to either the landfill and/or agricultural/forestry sources in the area.

- Groundwater flow follows the topographical relief of the area and flows in a south-easterly direction across the site and likely contributes to baseflow in the unnamed stream tributaries of the Balbane and Lough Aderry Rivers.

- The area of impact to groundwater from the landfill leachate is considered to be minor relative to the groundwater body catchment area of the Northwest Donegal GWB i.e. < 0.001%.

- The primary receptor considered at risk from the site is the Balbane River and further downstream of the Lough Aderry River which are located down gradient of the waste body and are connected to the waste body by a series of small unnamed streams.

2.3 Balbane Landfill Site Leachate Treatment Proposal 2010

RPS completed a report in 2010 'Balbane Landfill Site Leachate Treatment Proposal' to investigate the potential for the installation of an on-site leachate treatment system at Balbane Landfill Site. Additional sampling was undertaken during this period to determine the source and the contributory factors to surface water contamination at the site which is summarised below.

Two areas of apparent surface water contamination were identified and are highlighted as zones A and B on drawing IBL0126/101 in Appendix A. Leachate was sampled from surface water at surface water monitoring points S2 and S3 which are located downstream from the landfill site in the vicinity of zone A. S2 and S3 were later relocated and relabelled at the request of the EPA.

Zone A, shown in Plate 1 (Appendix A), consists of contaminated surface water stream at the north and east of the site. The stream appears to commence along the northern boundary of the site. It is orange in colour and, due to the overgrowth, it is unclear if it runs through the landfill or merely collects leachate outbreaks along the northern and eastern flanks. While the stream at the north of the site contains a slight flow and a direct point of discharge to the eastern flank of the site, the flow along the eastern boundary is slower as the stream is more disparate and the peat ground saturated. The leachate from Zone A discharges from the site at a number of locations along the eastern boundary.

Zone B, shown in Plate 3 (Appendix A), consists of contaminated surface water stream which appears to emanate from the south east corner of the landfill site. Zone B is difficult to access by foot and is surrounded by steep rock and waste slopes. The ground at Zone B is highly saturated, however, there appears to be a direct point of discharge to a stream at the southern boundary of the site.

Table 2.4 below details the result of sampling undertaken by DCC in the vicinity of zone A.

Table 2.4 Leachate Sampling Results

	February 2003		March 2003		April 2010
	S2	S3	S2	S3	S2
COD (mg/l)	**66**	**162**	**54**	**205**	**65**
BOD (mg/l)	**6.52**	**12.86**	1.2	**15.5**	1.1
Suspended Solids (mg/l)	**97**	**62**	**113**	**57**	**242**
NH_3 (mg/l)	**128**	**175**	**64**	**96**	**65.5**
pH	7.55	7.95	7.7	8.07	7.48
Conductivity (µg/l)	993	**1326**	826	**1021**	**1505**
Chloride (mg/l)	240	320	201	297	170
Temp (°C)	6.6	6.5	8.7	8.7	8.4
Dissolved Oxygen (mg/l)	7.08	2.24	-	-	6.6

2.4 Trial Pits

Twenty eight trial pits were undertaken at the site in March 2013. These indicated that the existing soil cover on the site would appear to be poor and of varying quality with a total of twenty one trial pits having soil cover of less than 0.25 meters.

2.5 Gas Survey

A gas survey to establish if the existing soil covering on the site is adequate for the purpose of managing gas was undertaken at the site. DCC commissioned Odour Monitoring Ireland to perform a landfill gas surface emissions survey of the site. This was carried out in February 2013.

The assessment involved a Volatile Organic Compound (VOC) surface emissions survey of the landfill in order to ascertain the VOC emission points and mark them upon a map for remediation. The survey concluded that no zones of surface emissions were identified within the landfill facility that exceeded recommended trigger levels. The survey would indicate that the existing soil cover is providing a sufficient barrier for the gas to prevent surface emissions.

The detailed report is contained in Appendix C.

2.6 Waste Licence Requirement

The conditions of the waste licence with regards to restoration are as follows:

Condition 3.8 Leachate Management Infrastructure

Within twelve months of date of grant of this licence, unless the licensee can demonstrate to the satisfaction of the Agency that leachate discharges from the facility have no significant impact upon the receiving waters, the licensee shall implement a leachate management programme. This shall consist of the following:

- Installation of a leachate collection toe drain around the perimeter of the facility. This toe drain shall consist of a gravel and perforated pipe drainage system. The leachate collection toe drain shall be keyed into and covered by the capping layer, once the capping layer is installed.
- Provision of an appropriately sized leachate storage tank at the South-Eastern corner of the facility.
- Installation of an appropriate road for access to the leachate storage tank by the leachate tanker vehicle.
- Separation of clean surface water from contaminated surface water/leachate. Contaminated surface water shall be discharged to the leachate collection system. Clean surface water shall be discharged to adjacent watercourses.

The frequency of leachate removal/discharge from the leachate lagoon shall be such that a minimum freeboard of 0.5m shall be maintained in the leachate lagoon at all times.

Leachate stored in the leachate storage lagoon shall be disposed of by tankering off-site in fully enclosed road tankers, to an agreed waste water treatment plant.

Condition 4 Restoration and Aftercare

The final height of the facility shall not exceed 185mOD (Malin Head).

The final capping shall consist of the following:

a) top soil (150 -300mm);

b) subsoils, such that total thickness of top soil and subsoils is at least 1m;

c) drainage layer of 0.5m thickness having a minimum hydraulic conductivity of 1×10^{-4} m/s;

d) compacted mineral layer of a minimum 0.6m thickness with a permeability of less than 1×10^{-9} m/s or a geosynthetic material (e.g. GCL) or similar that provides equivalent protection; and

e) gas collection layer of natural material (minimum 0.3m) or a geosynthetic layer.

2.7 Conclusions of Desk Top Review

The site in its present condition appears to be impacting on surface waters immediately downstream from the landfill predominantly via surface water discharges from leachate breakout from the waste body and subsequent overland and shallow groundwater flow. The primary receptor considered at risk from the site is the Balbane River and further downstream of the Lough Aderry River which are located down gradient of the waste body and are connected to the waste body by a series of small unnamed streams.

The VOC survey would indicate that the existing soil cover is providing a sufficient barrier for the gas to prevent surface emissions.

Restoration works to minimise the impacts of the site on local surface water in particular is therefore required. Options to achieve this goal in a suitable and sustainable manner are considered further in the remainder of this scoping report.

3 Restoration Options

The site in its present condition appears to be impacting on surface waters immediately downstream from the landfill predominantly via surface water discharges from leachate breakout from the waste body and subsequent overland and shallow groundwater flow.

The stream adjacent to the site appears to commence along the northern boundary of the site. It is unclear if it runs through the landfill or merely collects leachate outbreaks along the northern and eastern flanks. The flow along the eastern boundary appears very slow as the stream is more disparate and the peat ground saturated. The leachate from this area discharges from the site at a number of locations along the eastern boundary.

A second water course appears to emanate from the south east corner of the landfill site. Access by foot to this area is difficult and is surrounded by steep rock and waste slopes. The ground in this area is highly saturated; however, there appears to be a direct point of discharge to a stream at the southern boundary of the site.

The existing soil cover on the site would appear to be poor and of varying quality with a total of twenty one trial pits having soil cover of less than 0.25 meters.

This scoping report considers the suitability of a number of restoration options for the site in addition to an engineered cap as per waste licence requirement. The purpose of the restoration would be to reduce/intercept leachate and to treat/tanker it to minimise contamination of surface water runoff from the site which has been identified as the main receptor being impacted.

Our adopted methodology for the restoration of the site is centred around the following key factors:

- Minimal environmental impact and enabling works taking place during the pre restoration layer installation;
- Provision of a low hydraulic conductivity engineered clay barrier of minimum thickness offering an industry accepted and quality assured solution;
- Provision of the most economically advantageous engineering solution; and.
- Reducing the current impact of the site on surface water and groundwater.

A number of options for the restoration of the site are provided below.

3.1 Option 1 – Engineered Cap, installation of a leachate collection system and tankering leachate off site

Balbane Landfill Site has operated historically on a dilute and disperse principle. In order to minimise future potential environmental risks the restoration of the site would comprise of five main stages:

1. Minimal reprofiling or doming of the site - to increase surface runoff and reduce infiltration into the landfill, therefore reducing the amount of leachate generated.

2. Capping of the site – to prevent infiltration of precipitation into the landfill mass therefore reducing the potential for leachate generation.

3. Passive Venting System – vent landfill gas from the waste to prevent off site migration.

4. Control of leachate levels within the waste mass (leachate toe drain) by pumping the leachate to a leachate lagoon/tank on site prior to treatment/offsite disposal.

5. Environmental Monitoring – to ensure that the restoration measures from the site are effective.

3.1.1 Profiling

In this option the site would be graded, using capping materials, to a high point of 185m AOD and a low point of 161m AOD, as shown on Drawing IBR0859/011. The grading of the site would not only facilitate surface water runoff but would also allow for ongoing settlement of the waste without the risk of undue ponding of water.

From the existing survey it is evident that following reprofiling of the landfill, that the landfill area would lie at a minimum gradient of 1:25 and the side slopes to the south of the site vary between 1:3 and 1:2.

3.1.2 Capping

The capping system is designed to prevent the ingress of rainfall and surface water, reduce leachate production, and to provide a suitable growing medium for restoration planting.

The existing soil cover on the site would appear to be poor and of varying quality as per trial pits previously undertaken. Therefore additional soil would have to be imported to the site for the purposes of the proposed works.

The format of capping and restoration of the facility is outlined in Table 3.1 below.

Table 3.1 Capping and Restoration Plan

Layer	Thickness (mm)	Properties	Purpose
Topsoil	150		To provide a growing medium, to control surface water erosion of the capping layers and provide a satisfactory visual appearance to the site.
Subsoil	850		To provide a layer of protection against damage to the GCL layer. To provide a growing medium for shrub growth.
Drainage Layer (GEONET)		Hydraulic conductivity of equivalent to 500mm deep layer of stone at $k_v \geq 1x10^{-4}$m/s	To remove and transport the surface water to an appropriate discharge point.
Geosynthetic Clay Liner GCL or LLDPE		Permeability of less than $5x10^{-11}$m/s and a minimum bentonite content of 3000g/m^2	To provide a low permeable barrier to prevent infiltration of water into the landfill mass as required in the Licence conditions
Geosynthetic Gas Collection Layer (GEONET)			To control and facilitate the lateral movement of landfill gas which is generated within the Landfill mass to gas vents.
Regulating Layer	<300		To provide a temporary cover of the waste prior to the permanent capping layer being installed.
Waste			

The Site extends to an area of approximately 3.1 ha. The approximate material requirements for the capping system are as follows:

- 4,650 m^3 of topsoil soil,
- 26,350 m^3 of subsoil,
- 31,000 m^2 of geosynthetic surface water drainage layer,
- 31,000 m^2 of GCL/LLDPE),
- 8,500 m^2 of geogrid on slopes.
- 31,000 m^2 of geosynthetic gas drainage layer.

3.1.3 Surface Water System

The 1: 25 gradient would enable surface water run-off to be collected in the watercourse at the eastern corner of the site and discharged as clean water from the site, hence minimising the potential for leachate generation.

The clean water collected from surface run-off would be discharged into the adjacent watercourses. The quality of this water would be monitored at the discharge point.

3.1.4 Passive Venting System

Landfill gas, the principal components of which are methane and carbon dioxide, is generated as a result of the decomposition of the organic faction of waste within the landfill mass. Landfill gas production can continue for significant periods of time, albeit at decreasing rates, after infilling. Therefore gas venting wells would be installed to allow passive venting into the atmosphere and prevent migration off site. A geosynthetic gas collection layer (Geonet) would be installed as part of the capping system. Approximately twelve gas vents would be installed at 50m centres and comprise of a 150 mm diameter slotted High Density Polyethylene (HDPE) pipe with a stone surround which would allow landfill gas to vent vertically, discouraging lateral movement and potential off-site migration.

3.1.5 Leachate Management System

The management of leachate is achieved by two methods:

1. Limiting leachate generation, by the profiling and capping of the landfill; and
2. Control of leachate levels within the waste mass by pumping the leachate to a holding tank/lagoon on site prior to offsite disposal.

Leachate would be controlled by installing a capping layer at a 1 in 25 gradient, this would enable run-off to a toe drain around the perimeter of the site, and alleviate rainwater from percolating into the existing landfill mass, therefore reducing leachate generation at the site and ensuring surface water and leachate are effectively separated. A leachate toe drain shall consist of a gravel and perforated pipe drainage system, keyed into and covered by the capping layer. This would drain by gravity to a leachate collection and pumping chamber which it would be pumped to a leachate holding tank. A service road would also be provided to allow leachate tankers to access the facility. Leachate would be tankered to Letterkenny WWTW for disposal.

3.2 Option 2 – Reduced Engineered Cap (reduced soil layer, no gas collection layer), installation of a leachate collection system and tankering leachate off site.

The site would be restored as per 3.1.1, 3.1.3 and 3.1.5 above. Proposed reductions to the capping system are provided below.

3.2.1 Profiling

As per Option 1.

3.2.2 Capping

The Geosynthetic Clay Liner provides a low permeable barrier to prevent infiltration of water into the landfill mass. Due to the remoteness of the site location there is no proposed afteruse for Balbane landfill site such as amenity, forestry or agriculture. Therefore the proposed depth of the topsoil/subsoil layer has been reduced to reflect this reduced risk to the cap. The site would be sown with grass seed after the completion of the restoration. The site would be managed to ensure that no vegetation will take root that will affect the integrity of the liner. Given the remote location of the site it is also anticipated that a readily available source of suitable restoration soils may not be available to install the cap outlined in Option 1 within an acceptable timeframe.

The format of the reduced capping system is outlined in Table 3.2 below.

Table 3.2 Capping and Restoration Plan

Layer	Thickness (mm)	Properties	Purpose
Topsoil	100		To provide a growing medium, to control surface water erosion of the capping layers and provide a satisfactory visual appearance to the site.
Subsoil	400		To provide a layer of protection against damage to the GCL layer. To provide a growing medium for shrub growth.
Drainage Layer (GEONET)		Hydraulic conductivity of equivalent to 500mm deep layer of stone at $k_v \geq 1x10^{-4}$m/s	To remove and transport the surface water to an appropriate discharge point.
Geosynthetic Clay Liner		Permeability of less than $5x10^{-11}$m/s	To provide a low permeable barrier to prevent infiltration of water into

Layer	Thickness (mm)	Properties	Purpose
GCL/LLDPE or clay cap layer depending on option		and a minimum bentonite content of $3000g/m^2$ Or 0.5m depth of the clay cap has achieved a maximum permeability of $1x10^{-8}$ m/s.	the landfill mass as required in the Licence conditions
Regulating Layer	<300		To provide a temporary cover of the waste prior to the permanent capping layer being installed.
Waste			

The approximate material requirements for the capping system are as follows:

- 3,100 m^3 of topsoil soil,
- 12,400 m^3 of subsoil,
- 31,000 m^2 of geosynthetic surface water drainage layer,
- 31,000 m^2 of GCL/LLDPE or clay cap.
- 8,500 m^2 of geogrid on slopes.

3.2.3 Surface Water System

As per Option 1.

3.2.4 Passive Venting System

The gas survey from 2013 confirmed that there were no zones of surface emissions at the landfill facility which exceeded recommended trigger levels. The gas monitoring piezometers at Balbane are located within the waste body and show relatively low landfill gas concentrations within the waste body.

Table 3.3 Landfill Gas Results 2015

Location	Date	Atmospheric Pressure	Carbon Dioxide %v/v	Methane %v/v	Oxygen %v/v
BH1 (Gas)	Mar-15	989	3.3	0.1	17
BH2 (Gas)	Mar-15	989	0.9	0.3	20.6
BH3 (Gas)	Mar-15	989	13.6	9.3	11.3
BH1 (Gas)	Jun-15	1018	5.5	0	12.9
BH2 (Gas)	Jun-15	1018	0.9	0.4	19.9
BH3 (Gas)	Jun-15	1018	0.7	13.6	17.8
BH1 (Gas)	Jul-15	992	5.1	0	13.3
BH2 (Gas)	Jul-15	992	0.5	0.6	20.1
BH3 (Gas)	Jul-15	992	16.1	14.2	0.9
BH1 (Gas)	Dec-15	989	8.5	19.1	1.7
BH2 (Gas)[2]	Dec-15	NT	NT	NT	NT
BH3 (Gas)[2]	Dec-15	NT	NT	NT	NT

Therefore gas venting wells would be installed to allow passive venting into the atmosphere and prevent migration off site. A geosynthetic gas collection layer (Geonet) would not be installed as part of the capping system. Approximately twelve gas vents would be installed at 50m centres as previously stated in 3.1.4.

3.2.5 Leachate Management System

As per Option 1.

3.3 Option 3 – Reduced Engineered Cap and Installation of a Leachate Treatment System

3.3.1 Profiling

As per Option 2.

3.3.2 Capping

As per Option 2.

[2] BH2 and BH3 were inaccessible in December 2015 due to flooding.

3.3.3 Surface Water System

As per Option 2.

3.3.4 Passive Venting System

As per Option 2.

3.3.5 Leachate Treatment System

The purpose of the proposed treatment system is to contain and treat contaminated surface water on site. This was previously reviewed in 2010 by RPS. Due to the disparate nature of the leachate on site and the various discharges locations, the flow rate was estimated at 17m^3/day. Further investigation was considered to be required to confirm the exact flow however it was considered that a suitable treatment system such as one proposed by Bord na Móna could be installed which would be capable of dealing with variable volumetric loading. Following a review of the historical site data, the following influent parameters were used by Bord na Móna for design purposes;

Table 3.4 Design Influent Parameters

Parameter	Influent
Flow	17m^3/day
BOD	150 mg/l
SS	500 mg/l
NH_3	120 mg/l[3]
COD	500 mg/l

* Bord na Móna noted that a guarantee on effluent could not be provided when the NH_3 exceeds 120 mg/l.

Bord na Móna proposed the installation of an 85 PE Platinum 2000R Wastewater Treatment Plant. This 85 PE Platinum Wastewater Treatment system provides both primary and secondary treatment.

The following table summarises the expected effluent parameters for the proposed systems;

[3] For domestic effluent the COD can be approximately 5 - 7 times the BOD value of the treated effluent, i.e. with BOD of 15 mg/L you would expect to get the COD to 90mg/L, however given that this particular application is not domestic, it would be difficult to determine the COD reduction.

Table 3.5 Anticipated Effluent Parameters

Parameter	Influent	Effluent Parameters (85 PE)
BOD	150 mg/l	25 mg/l
SS	500 mg/l	35 mg/l
NH_3	125 mg/l	35 mg/l
COD*	500 mg/l	150 mg/l

Following a query by Donegal County Council, Bord na Móna also confirmed that proposed treatment system would also provide effective treatment of lower influent parameters, e.g. low BOD.

This system was previously proposed to the EPA in 2010. Approval for the scheme was not granted by the EPA as the Licence requires that leachate shall be exported for treatment unless it can be demonstrated that there is no impact on receiving waters. The Council was not in a position to provide evidence to demonstrate this and as such the scheme did not progress.

An assimilative capacity assessment of the receiving waters would be required for all proposed discharges to surface water. This would be determined at the design stage when setting realistic effluent qualities for the preferred option. No leachate would be tankered off site.

3.4 Option 4 – Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) on existing site

The site would be restored as per Option 2 above. Depending on the availability of suitable clays the wetland ponds could be constructed from the imported clay material. The base and sides of the ICW ponds would be formed using a low permeability clay material. Topsoil would be placed over the subsoil as a growing medium for the wetland plants. The subsoil material used to form the ICW ponds would be layered and compacted to ensure that there is containment of waters within the system. The capping layer would consist of a 0.5 m compacted clayed layer instead of the GCL.

The estimated land requirement for Integrated Constructed Wetlands (ICW) is 1-1.5ha. The area available on site (10,300 m^2) may not be sufficient and an additional land take might be required to accommodate the ICW. This would be determined at the design stage. No leachate would be tankered off site.

3.4.1 Profiling

As per Option 2.

3.4.2 Capping

As per Option 2, however it is expected that the area beneath the ICW will be formed with compacted clay and this area will therefore not require LLDPE/GCL.

3.4.3 Surface Water System

As per Option 2 however there will be no requirement for a surface water drainage layer beneath the ICW.

3.4.4 Passive Venting System

As per Option 2.

3.4.5 Leachate Treatment System

The use of alternative on-site treatment involving ICW and possibly SRWC plantation was previously considered, prompted by an INTERREG- funded cross-border research project ANSWER. A proposal to develop an SRWC at Balbane was developed in March 2013, to form part of that INTERREG project. It was initially contended that a cap would not be required as there were insignificant gas emissions from the site and a proposal was developed on that basis. A cost estimate of €300,000 was developed for that proposal. However discussions with the EPA confirmed that a cap would be required. The sourcing of sufficient sub soils and topsoil materials for the cap close to Balbane also emerged as a problem. Waterford County Council4 has developed a 5 pond ICW system (of 18,000m2) for the treatment of landfill leachate at Dungarvan Landfill Site. This ICW, which has been in operation since 2010, is located on top of the landfill site. The sizing of the ICW was based on a leachate loading rate of 0.2 l/m2/d. The influent volume to the constructed wetlands is reported to be 26.9m3/d (9,818.5m3/annum). Leachate from the interceptor tank and leachate boreholes is diluted with groundwater and then pumped to the first ICW pond. From here it flows by gravity to each subsequent pond. The treated leachate is then discharged intermittently to the onsite surface water lagoon located in the south east corner of the site.

[4] Dungarvan Landfill Hydrogeological Review http://www.epa.ie/licences/lic_eDMS/090151b2805947cb.pdf

Ammonium values at the ICW outlet in 2015 ranged from 0.01 to 0.58 mg/l, with an average of 0.14 mg/l, and were below the proposed discharge licence limit of 5 mg/l[5].

ICW can have either horizontal or vertical flow. A horizontal flow ICW is a large gravel and sand-filled basin that is planted with wetland vegetation. As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms degrade the organics. The effluent is then discharged to a receiving water body.

Vertical flow ICW works by intermittently dosing the wetland 4 to 10 times a day. The water flows vertically down through the filter matrix to the bottom of the basin where it is collected in a drainage pipe. The water is treated by a combination of biological and physical processes. The filter goes through stages of being saturated and unsaturated, and, therefore phases of aerobic and anaerobic conditions. The filter media acts as a filter for removing solids, a fixed surface upon which bacteria can attach and a base for the vegetation. The top layer is planted and the vegetation which maintains permeability in the filter and provide habitat for microorganisms. Nutrients and organic material are absorbed and degraded by the microbial populations.

Therefore the main difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions due to the intermittent dosing.

In addition vertical filters always need pumps whereas horizontal flow constructed wetlands can be operated without pumps if the site location topography allows.

An ICW could be considered to cleanse water through physical, chemical and biological processes. The main treatment processes include:

- Uptake and transformation of contaminants/nutrients by micro-organisms and plants;
- Breakdown and transformation of contaminants/pollutants by micro-organisms and plants;
- Filtration and chemical precipitation through contact with substrate and plant litter;
- Settling of suspended particular matter;
- Chemical transformation of pollutants;
- Absorption and ion exchange on the surface of plants, sediment, and litter (of particular relevance to the capture and storage of phosphorous); and

[5] Annual Environmental Report 2015 http://www.epa.ie/licences/lic_eDMS/090151b2805ab1e7.pdf

- Predation and natural die-off of pathogens (e.g. E. coli and Cryptosporidium).
- ICW are designed to be as self-maintaining and as self-operable as possible. Some of the main maintenance procedures have been listed below for the ICW:

    1. **Water level management and flow maintenance** – Maintain an operational water level of ~100-200mm. Overtime there would be a build-up of vegetation and sediment in the cells, which would require the outlet pipes to be adjusted to maintain appropriate water depths.

    2. **Vegetation monitoring and maintenance** – The vegetation in the wetland cells should be assessed regularly to ensure it is healthy. Vegetation, especially grassed areas, around the wetland cells should be maintained to provide for easy and safe access for monitoring and maintenance.

    3. **Maintenance of access** – fences, gates and access routes should be maintained to ensure safe and easy access is maintained, while also restricting access for livestock.

    4. **Maintenance of inlet and outlet pipes** – The area around the inlet and outlet pipes should be kept clear so that flows between cells are maintained and that vegetation or sediments do not build up in or around the pipework.

    5. **Sediment/sludge management** – Over time there would be a build-up of sediment in the wetland cells, which would need to be cleaned out to maintain the proper functionality of the ICW. The initial wetland cell would require cleaning out first; however this is not expected for at least 5-10 years.

Treated leachate would be discharged to surface water. The ICW at Churchtown Landfill Sites is currently being commissioned. Insufficient data is available to date on the quality of the discharge from this system. This would be reviewed once available.

Leachate would be extracted from the leachate collection and pumping chamber and distributed around the site via a common 90mm HDPE leachate pumping main. The treatment method is anticipated to be through onsite ICWs. Flow of leachate to ICW's would be controlled on the pumping main with an actuated valve along with flow measurements via flow meter.

The hydrogeology report 2015 states that given the proximity to surface waters to the site and the likely connection between shallow groundwater and these surface waters, no significant groundwater plume is envisaged; although more representative groundwater monitoring wells are required to confirm this. Therefore the diversion of groundwater on site has not been considered in this report.

3.5 Option 5 – Reduced Engineered Cap and Installation of a ICW downstream of the site

The site would be restored as per Option 4 above, however the ICW would be constructed downstream of the site on adjacent lands. The estimated land requirement for ICW is 1-1.5ha. This would be determined at the design stage. The topography of the ground is to be checked to confirm that the proposed wetland can operate under gravity flow. This option would require the purchase of additional lands to the east and south of the site. This area would also require the lining of the ICW ponds.

No leachate would be tankered off site.

3.5.1 Leachate Treatment System

Leachate shall be extracted from the leachate collection and pumping chamber and distributed around the site via a common 90mm HDPE leachate pumping main. The primary treatment method is anticipated to be through an offsite ICWs. Flow of leachate to ICW's would be controlled on the pumping main with an actuated valve along with flow measurements via flow meter or by gravity flow. Treated leachate would be discharged to surface water.

3.6 Summary of Options

A qualitative assessment of the 5 options is presented in Table 3.6 below

Table 3.6 Restoration Options Summary[6]

Options	Description	Pros	Cons
Option 1	Engineered Cap, installation of a leachate collection system and tankering leachate off site	▪ Restoration in accordance with licence requirement. ▪ No onsite treatment of leachate required.	▪ Capital investment cost high ▪ Additional soil would have to be imported to the site for the proposed works. ▪ Operational costs high - Tankering fuel and disposal cost. ▪ Poor road infrastructure to site for tankering
Option 2	Reduced Engineered Cap, installation of a leachate collection system and tankering leachate off site	▪ Reduced cap still provide the same low permeable barrier to prevent infiltration of water into the landfill mass. ▪ No onsite treatment of leachate required.	▪ Capital investment cost reduced. ▪ Additional soil would have to be imported to the site for the purposes of the proposed works although reduced. ▪ Operational costs high – Tankering fuel and disposal cost. ▪ Poor road infrastructure to site for tankering
Option 3	Reduced Engineered Cap, installation of a leachate collection system and treatment onsite	▪ Reduced cap still provide the same low permeable barrier to prevent infiltration of water into the landfill mass. ▪ No tankering required	▪ Capital investment cost reduced. ▪ Additional soil would have to be imported to the site for the purposes of the proposed works although reduced. ▪ Maintenance and running costs high - Conventional wastewater treatment. ▪ High level of automation required SCADA system required to allow plant to be remotely monitored for alarms and optimisation. ▪ Sludge may be required to be removed ▪ Environment – capacity of the system in providing consistent and reliable treatment of a specified leachate to a required standard ▪ Energy use ▪ Assimilative capacity of the receiving waters required

Options	Description	Pros	Cons
Option 4	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) on existing site (assumed 1 hectare).	▪ Reduced cap still provides the same low permeable barrier to prevent infiltration of water into the landfill mass. ▪ Can provide long-term sustainable treatment ▪ Suitable for remote unmanned sites ▪ Low maintenance cost ▪ Low operational cost ▪ Low monitoring requirements - number of simple checks required - pipes, water levels and sediment levels.	▪ Capital investment cost high ▪ Additional soil would have to be imported to the site for the purposes of the proposed works although reduced. ▪ Assimilative capacity of the receiving waters required. ▪ Environment – capacity of the system in providing consistent and reliable treatment of a specified leachate to a required standard
Option 5	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) downstream of site (assumed 1 hectare).	▪ Reduced cap still provides the same low permeable barrier to prevent infiltration of water into the landfill mass. ▪ Can provide long-term sustainable treatment ▪ Suitable for remote unmanned sites ▪ Low maintenance cost ▪ Low operational cost ▪ Low monitoring requirements - number of simple checks required - pipes, water levels and sediment levels.	▪ Capital investment cost high ▪ Additional land required ▪ Additional soil would have to be imported to the site for the purposes of the proposed works although reduced. ▪ Assimilative capacity of the receiving waters required ▪ Environment – capacity of the system in providing consistent and reliable treatment of a specified leachate to a required standard

4 Financial Considerations

RPS have prepared a preliminary cost estimate for the options described above. The cost estimates are for the capital cost of the projects.

Although some consideration has been given to the particularly remote nature of Balbane, the construction cost estimate is based on the cost of similar construction activities on other landfill sites in Ireland.

The cost estimate is also predicated on the assumption that waste has not been filled in the north east corner of the site.

As can be seen in Table 4.1 below the estimated capital costs for the restoration of the site range from €1.2 to €1.62 million.

Table 4.1 Estimated capital Costs

Options	Description	Estimated Cost €	Estimate annual running costs €
Option 1	Engineered Cap, installation of a leachate collection system and tankering leachate off site	1,621,631	55,000[7]
Option 2	Reduced Engineered Cap, installation of a leachate collection system and tankering leachate off site	1,239,446	55,000
Option 3	Reduced Engineered Cap, installation of a leachate collection system and treatment onsite	1,343,746	40,000
Option 4	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) on existing site (assumed 1 hectare).	1,324,318	25,000 - 30,000
Option 5	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) downstream of site (assumed 1 hectare).	1,541,524	25,000 - 30,000

As can be seen from Table 4.1 above, Option 2 is the most cost effective method with regards to capital costs. These options are further assessed in Section 5 below.

[7] Estimated annual leachate removal expected to be approximately 5,000m^3 with leachate exported to Letterkenny WwTW for treatment

5 Options Assessment

A qualitative and quantitative assessment has been undertaken of the proposed options using the criteria and simple matrix provided below;

- Capital Cost (scoring based on costs provided in Table 4.1)
- Annual Running Cost. Energy/fuel use requirements for pumping, treatment and tankering (scoring based on estimated annual costs provided in Table 4.1),
- Regulation. Licence requires that leachate shall be exported for treatment unless it can be demonstrated that there is no impact on receiving waters. An assimilative capacity assessment of the receiving waters will be required to demonstrate that there is no impact on receiving waters. A waste licence review may be required to agreed discharge emission limit values.
- Specific Problems (road access, traffic, land requisition required).

Generally, each option can receive a maximum score of 5, with the option receiving the greater score as the most preferred option and least preferred option receiving score of 1.

No weighting has been applied to the scores. The scores achieved are set out in Table 5.1 below.

Capital and maintenance costs scoring (quantitative) were based on the estimated costs provided in Table 4.1. As can be seen from Table 5.1, Option 2 is the most cost effective option with regards to capital costs and therefore it was allocated 5 marks.

However in relation to annual running costs Option 1 and 2 received the least score due to running costs such as tankering the leachate off site to a waste water treatment works. These costs could be substantial as tankering would be from Balbane to Letterkenny WwTW, a significant distance (approximately 136km round trip per tanker load). The licensing of discharges from wastewater treatment plants has reduced / eliminated options previously considered available for the off-site treatment of leachate. Currently the waste water treatment works is accepting leachate from other landfill sites by DCC and may not be in a position to accept further leachate for treatment. A review of leachate being tankered from other landfill sites is ongoing by DCC in consultation with the EPA. Options 3 to 5 which propose that no leachate would be tankered off site are therefore the most preferred options with regards to the long-term management of Balbane landfill site.

DCC are currently developing more sustainable methods of treating landfill leachate. A trial is currently ongoing at another landfill site in the County where ICW is being utilised to treat leachate. Therefore Options 4 or 5, although being more expensive initially in terms of capital expenditure would in the longer term offer a more sustainable solution at Balbane.

With regards to regulatory requirements an assimilative capacity of the receiving waters would be required for all proposed discharges to surface water. This may require a review of the existing licence and therefore Options 3 to 5 have been scored down accordingly. This would be determined at the design stage when setting realistic effluent qualities for the preferred option. Option 5 would also require a review of the licence boundary if ICW requires the purchase of additional lands.

Furthermore, due to the particularly remote location of Balbane landfill site, there are a number of specific problems in relation to a number of the options. Road access and traffic are an issue in relation to tankering off site and therefore have been scored down for these criteria. Option 5 would require the requisition of land outside the current boundary.

Based on the criteria listed above the most preferred option, as shown in Table 5.1, is Option 4 (Reduced Engineered Cap and the Installation of an ICW on the existing site).

Table 5.1 Qualitative and Quantitative Assessment

Options	Description	Capital Cost	Annual Running Cost	Regulation	Specific Problems	Overall Ranking
Option 1	Engineered Cap, installation of a leachate collection system and tankering leachate off site	1	1	5	1	8
Option 2	Reduced Engineered Cap, installation of a leachate collection system and tankering leachate off site	5	1	5	1	12
Option 3	Reduced Engineered Cap, installation of a leachate collection system and treatment onsite	3	3	1	5	12
Option 4	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) on existing site (assumed 1 hectare).	4	5	1	5	15
Option 5	Reduced Engineered Cap and Installation of an Integrated Constructed Wetlands (ICW) downstream of site (assumed 1 hectare).	2	5	1	2	10

6 Conclusions

Balbane Landfill has been operated by Donegal County Council since 1976. Donegal County Council submitted an application to the EPA for the continued operation of the landfill site and a licence was issued on the 13th of November 2001. The site subsequently closed in January 2004.

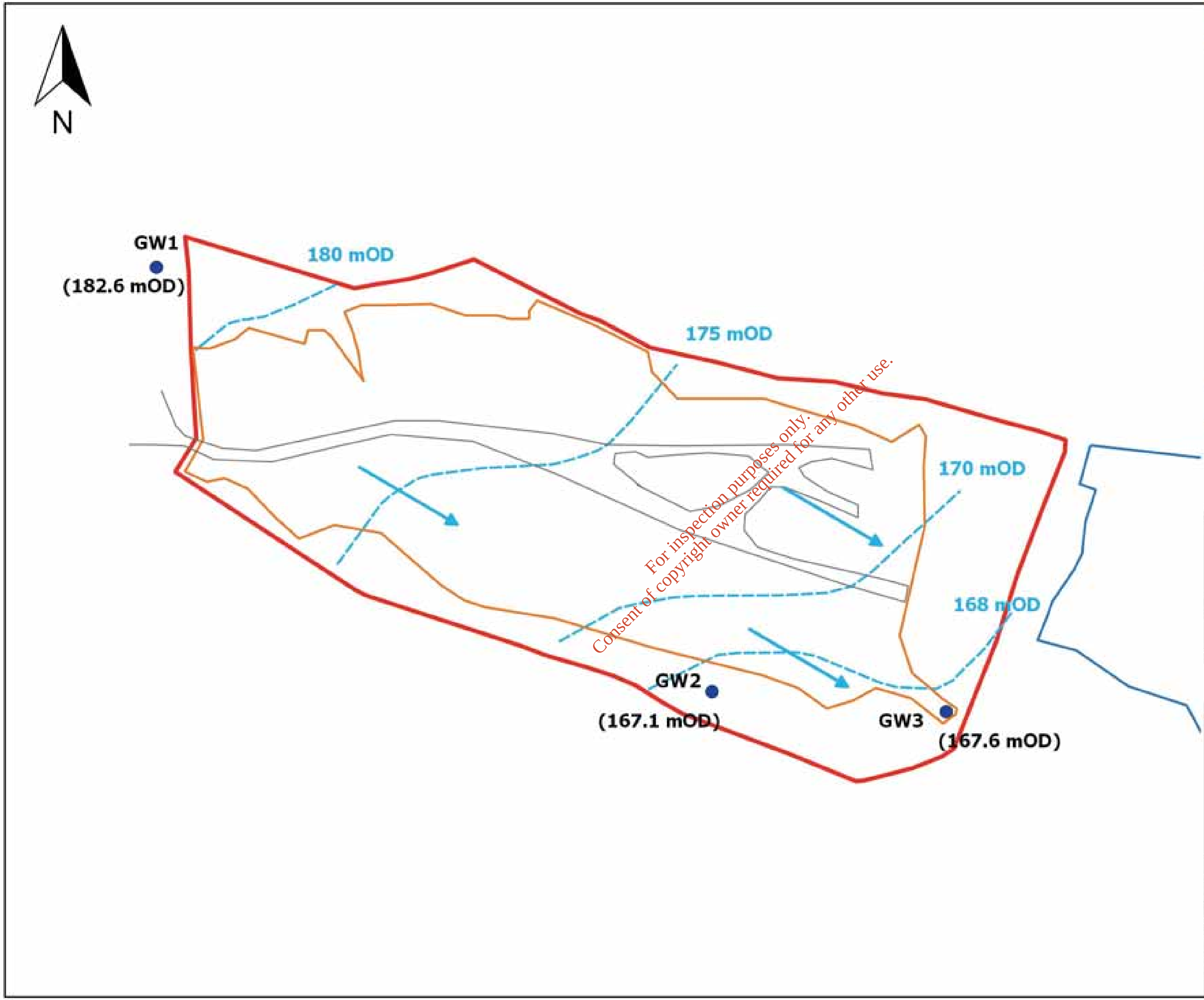
This site remediation scoping study to assess proposals for remediation works at Balbane landfill site has been compiled with a view to determining the most effective and sustainable option which achieves the goal of restoring the site in line with waste licensing requirements and minimising fugitive emissions to the environment.

The most preferred option, as shown in Table 5.1, is Option 4 Reduced Engineered Cap and the Installation of an ICW on the existing site. This is subject to detail design which would incorporate information derived from the commissioning of the ICW which is being utilised to treat leachate on Churchtown Landfill Site and it can be demonstrated that there would be no impact on receiving waters.

Therefore Option 4 although being more expensive initially in terms of capital output would in the longer term offer a more sustainable solution at Balbane.

Appendix A

Drawings



Legend

- Road
- Waste Boundary
- Groundwater Contours
- Stream
- Wells
- Site Boundary
- Groundwater Flow Direction

Project

Balbane Landfill Hydrogeological Risk Assessment

Client
Donegal County Council

Drawing
Figure 5

Title
Groundwater Contours September 2014

BlueRock Environmental
The Hydrogeological and Contaminated Land Consultancy

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File Ref : BRE14021
Drawing Ref : BRE14021DG05
Revision : V01
Date : 09/09/2015
Drawn by: SB
Copyright: OSI EN0075112

NOTES

1. Verifying Dimensions.
   The contractor shall verify dimensions against such other drawings or site conditions as pertain to this part of the work.

2. Existing Services.
   Any information concerning the location of existing services indicated on this drawing is intended for general guidance only. It shall be the responsibility of the contractor to determine and verify the exact horizontal and vertical alignment of all cables, pipes, etc. (both underground and overhead) before work commences.

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4. DATUM:

5. Keys
   - Site Boundary
   - 1.0m Contours
   - Site Fence
   - Top of Bank
   - Bottom of the Bank
   - Gate
   - Zone A
   - Zone B

rev	amendments	drawn date	checked date

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Client

Donegal County Council

Project

Balbane Landfill Site

Title

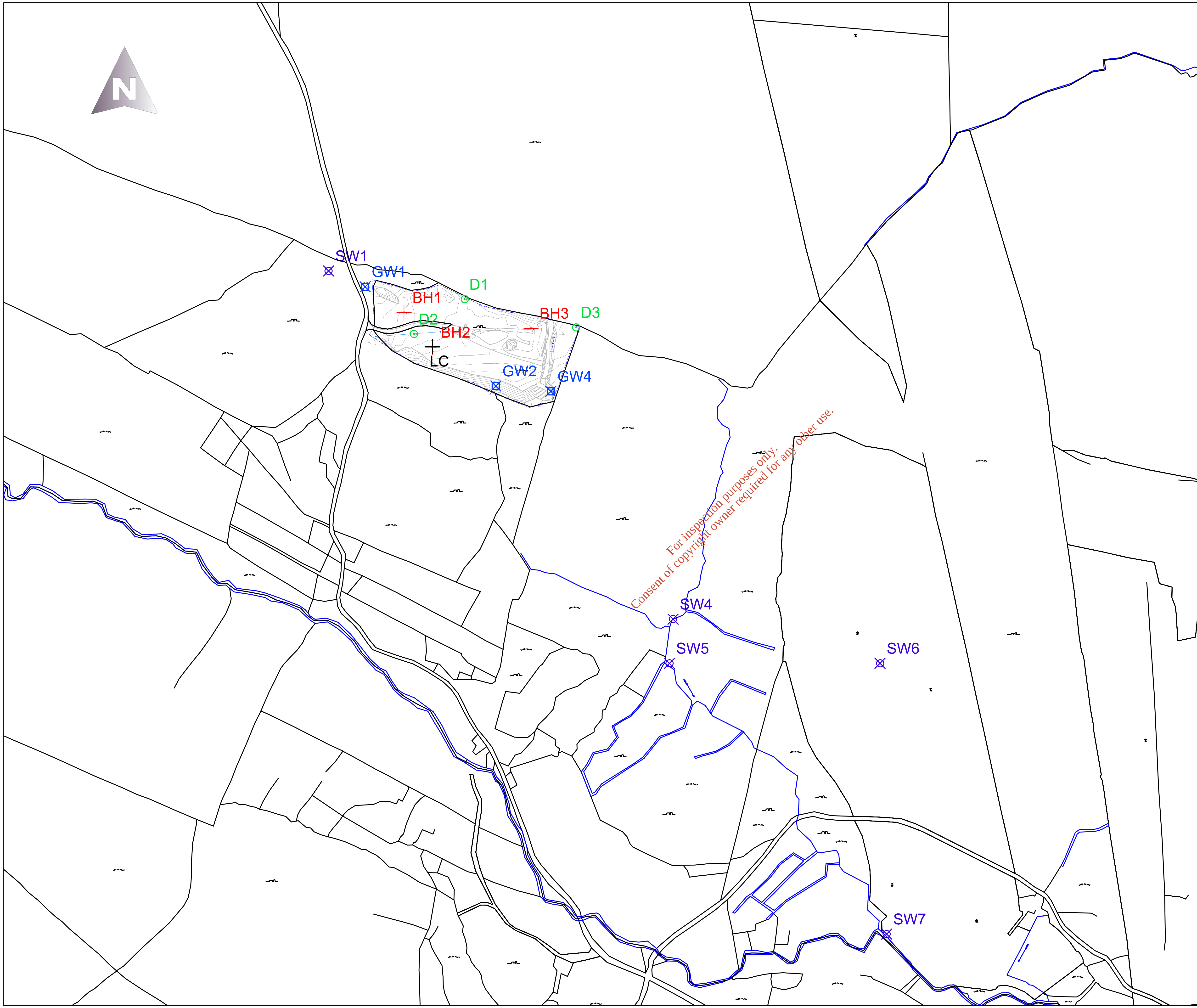
Areas of Surface Water Contamination

Architect

Drawing Status	Sheet Size	Drawing Scale
Prelim	A3	1:1000

Drawing Number	Rev
IBR0126/101	0

Drawn By / Date		Checked By / Date		Approved By / Date	
AMB	MAY '10	NR	MAY '10	DD	MAY '10



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4. Keys:
   - BH Landfill Gas Monitoring Boreholes
   - D1 Dust Monitoring Point
   - GW Groundwater monitoring Locations
   - LC Leachate Monitoring Locations
   - SW Surface Water Monitoring Locations

rev	amendments	drawn	date

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Client
Donegal County Council

Project
Donegal Landfill Site Reporting 2015

Title
Balbane LFS - Monitoring Points

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:5000

Drawing Number	Rev
IBR0859 /004	0

Project Leader	Drawn By	Date	Initial Review
DD	AMB	Apr '15	AMcG

NOTES

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4. Datum:

5. Keys

- Site Boundary
- Proposed Restoration Contours
- Proposed Lechate Toe Drain
- Proposed 3.0m wide Access Track

rev	amendments	drawn	date

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Client

Donegal County Council

Project

Balbane Landfill Site

Title

Proposed Restoration Contours - Option 1

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:1000

Drawing Number	Rev
IBR0859 /011	

Project Leader	Drawn By	Date	Initial Review
DD	AMB	Apr '16	AMcG

NOTES

1. Verifying Dimensions.
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4. Datum:

5. Keys
   - Site Boundary
   - Proposed Restoration Contours
   - Proposed Lechate Toe Drain
   - Proposed 3.0m wide Access Track

rev	amendments	drawn	date

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Project
Balbane Landfill Site

Title
Proposed Restoration Contours - Option 2 Reduced Cap

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:1000

Drawing Number	Rev
IBR0859 /012	

Project Leader	Drawn By	Date	Initial Review
DD	AMB	Apr '16	AMcG

NOTES

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4. Datum:

5. Keys

- Site Boundary
- Proposed Restoration Contours
- Proposed Lechate Toe Drain
- Proposed 3.0m wide Access Road

rev	amendments	drawn	date

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Project
Balbane Landfill Site

Title
Proposed Restoration - Option 3
Reduced Cap

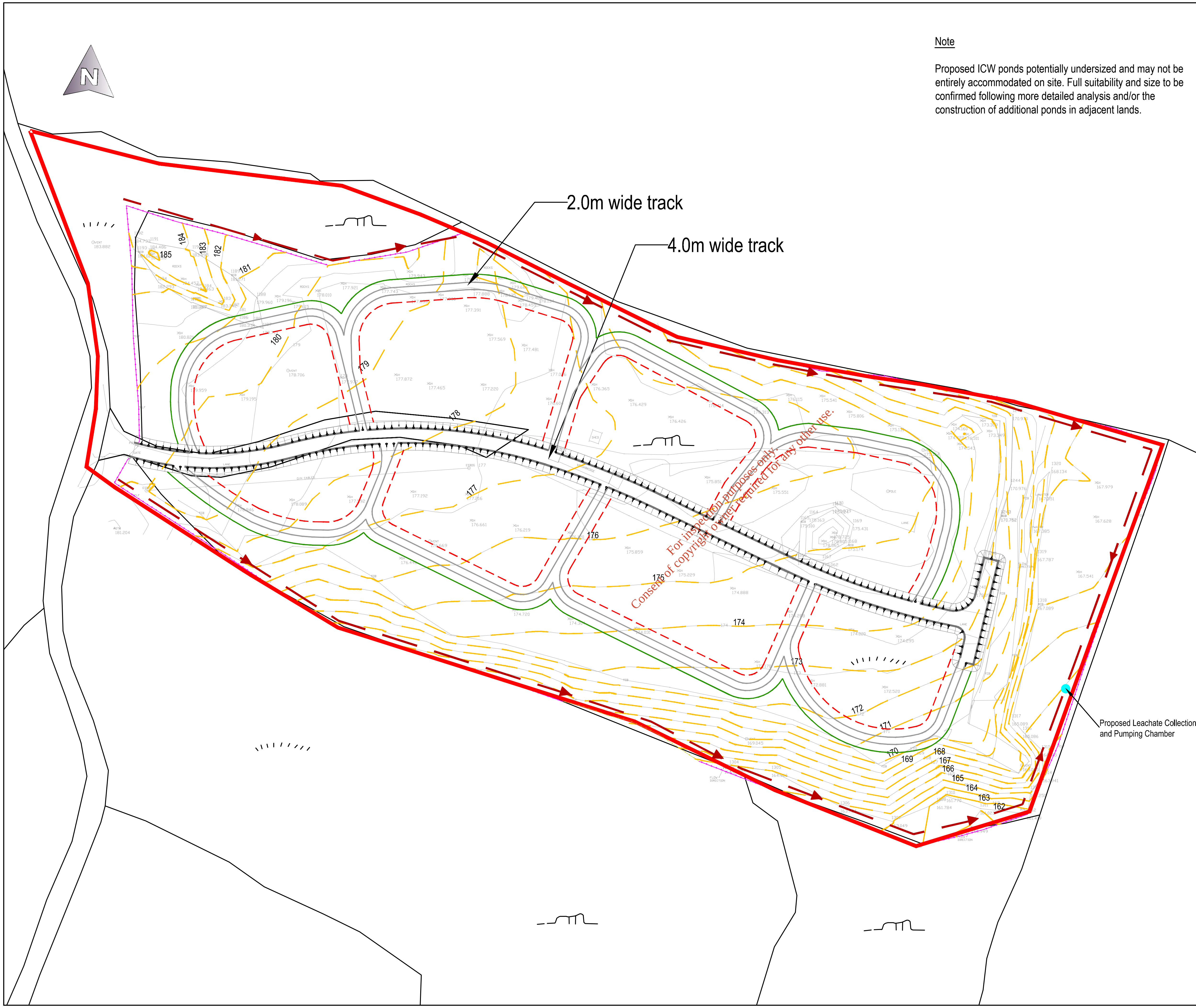
Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:1000

Drawing Number	Rev
IBR0859 /013	

Project Leader	Drawn By	Date	Initial Review
DD	AMB	May '16	AMcG

Note

Proposed ICW ponds potentially undersized and may not be entirely accommodated on site. Full suitability and size to be confirmed following more detailed analysis and/or the construction of additional ponds in adjacent lands.



NOTES

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4. Datum:

5. Keys

- Site Boundary
- Proposed Restoration Contours
- Proposed Leachate Toe Drain
- 1:2 Pond Slope
- Proposed Access Road
- Proposed Pond Floor

rev	amendments	drawn	date

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Project

Balbane Landfill Site

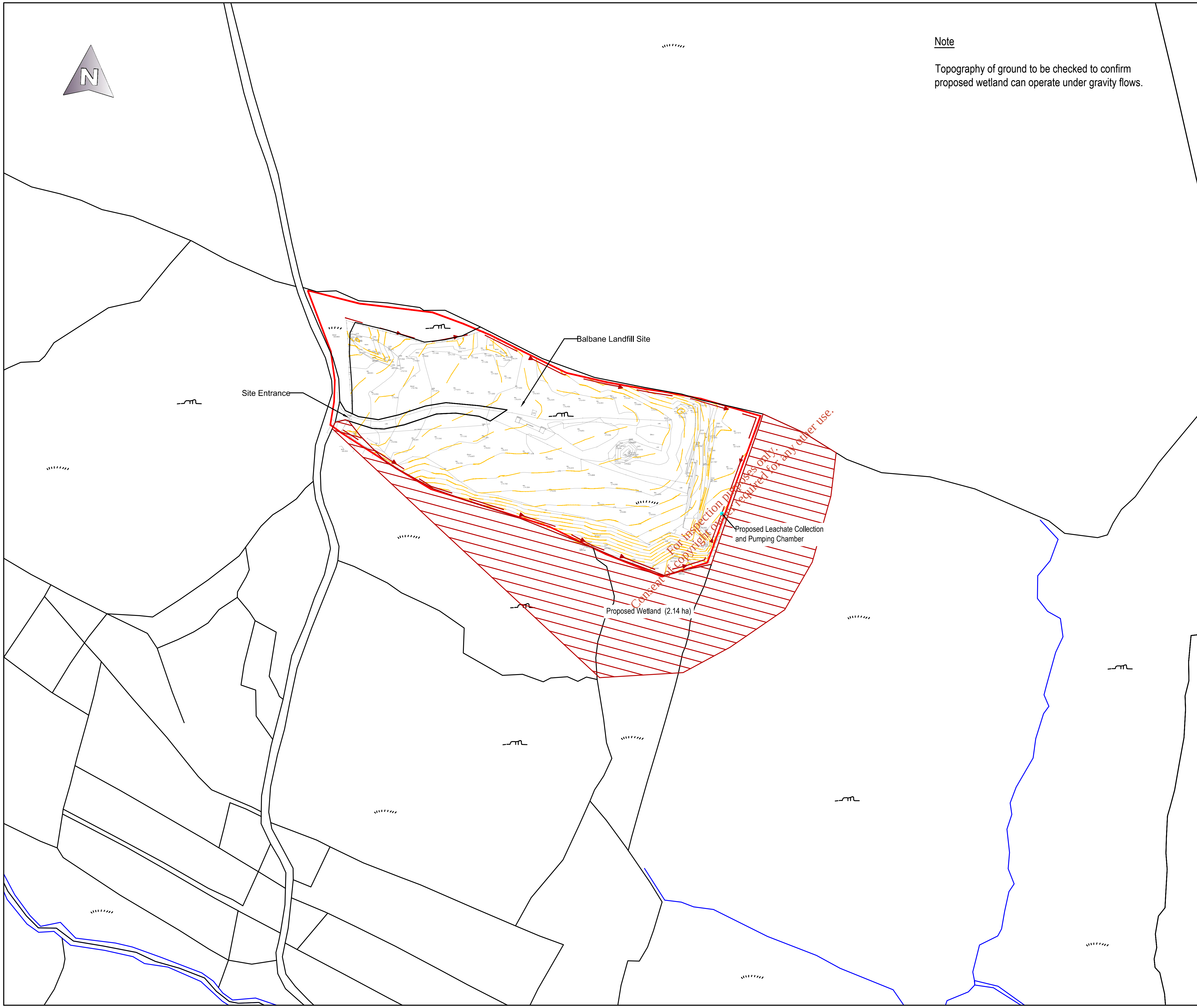
Title

Proposed Restoration ICW - Option 4

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:1000

Drawing Number	Rev
IBR0859 /014	

Project Leader	Drawn By	Date	Initial Review
DD	AMB	May '16	AMcG



NOTES

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Any information concerning the location of existing services indicated on this drawing is intended for general guidance only. It shall be the responsibility of the contractor to determine and verify the exact horizontal and vertical alignment of all cables, pipes, etc. (both underground and overhead) before work commences.

3. Issue of Drawings.
Hard copies, dwf and pdf will form a controlled issue of the drawing. All other formats (dwg, dxf etc.) are deemed to be an uncontrolled issue and any work carried out based on these files is at the recipients own risk. RPS will not accept any responsibility for any errors arising from the use of these files, either by human error by the recipient, listing of un-dimensioned measurements, compatibility issues with the recipient's software, and any errors arising when these files are used to aid the recipients drawing production, or setting out on site.

4. Datum:

5. Keys

Site Boundary

Proposed Wetland Area (2.142 ha approx)

rev	amendments	drawn	date

RPS Consulting Engineers
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Ballyraine
Letterkenny
Co. Donegal

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E ireland@rpsgroup.com

Client
Donegal County Council

Project
Balbane Landfill Site

Title
Proposed Restoration
ICW Offsite - Option 5

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:2500

Drawing Number	Rev
IBR0859 /015	

Project Leader	Drawn By	Date	Initial Review
DD	AMB	May '16	AMcG

Appendix B

Monitoring Results and Graphs

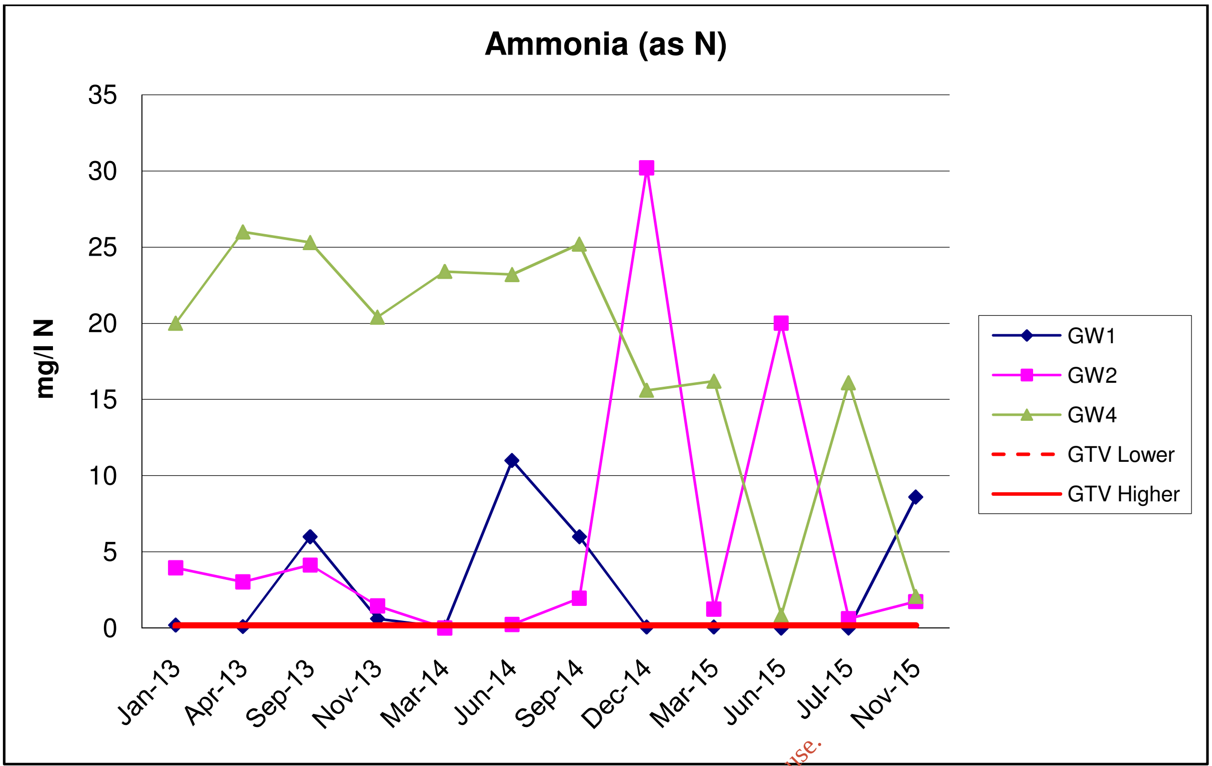
Groundwater Concentrations 2015

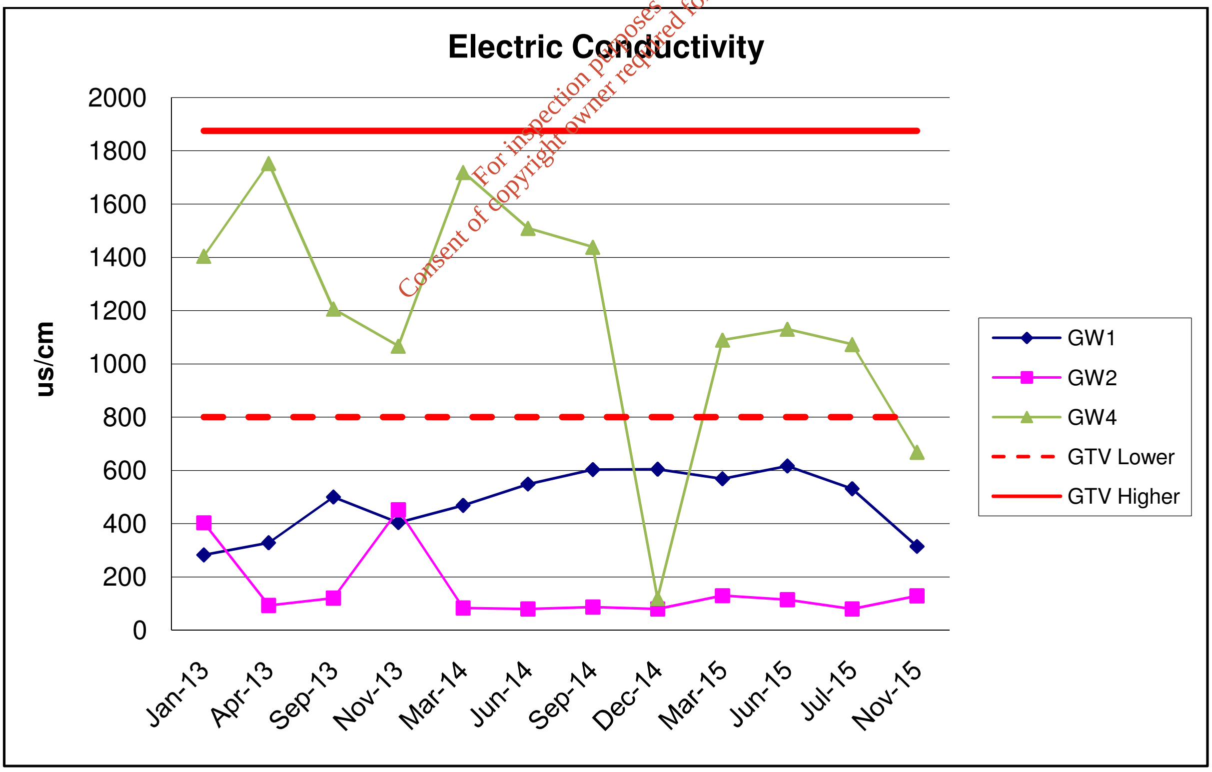
	Date	Ammonia (as N)	Chloride	Conductivity @ 20℃	Depth	DO (Meas't)	Iron	pH	Phenols	Potassium	Sodium	Temp	TOC	TON
GW 1	Mar-15	0.07	16.87	568	1	9.7	<20	7.25	<0.15	2.8	42.2	8.7	8.53	<0.11
GW 2	Mar-15	**1.25**	21.84	129	2.2	12	<20	6.57	<0.15	1.9	15	8.9	1.84	<0.11
GW 4	Mar-15	**16.2**	143.93	1089	3	12.1	<20	7.28	<0.15	**32.1**	90.1	8.8	9.04	<0.11
GW 1	Jun-15	<0.04	17.87	616	0.5	5.06	**2.16**	6.74	<0.15	2.3	40.2	15.2	10.66	<0.1
GW 2	Jun-15	**20**	29.78	113.6	4.3	5.21	**0.48**	6.14	<0.15	1.1	13	13	1.43	0.1
GW 4	Jun-15	**0.83**	152.86	**1130**	4.1	5.19	**2.93**	7.14	<0.15	**29.9**	94.8	14.4	10.09	<0.1
GW 1	Jul-15	<0.04	10.92	616	0.9	4.96	**1.334**	6.75	0.1	2.3	34.9	14.6	6.73	0.054
GW 2	Jul-15	**0.614**	12.9	113.6	3.9	5.74	**0.407**	6.07	<0.1	1	9.6	14.7	0.98	0.272
GW 4	Jul-15	**16.1**	134.99	**1130**	3.6	3.88	**4.245**	7.21	<0.1	1.8	112.8	15	6.67	0.093
GW 1	Nov-15	**8.6**	30.77	314	0.6	6.67	210	6.78	<0.1	1.3	17.8	9.5	3.27	<0.11
GW 2	Nov-15	**1.74**	26.8	128.4	4.2	5.97	<20	6.12	<0.1	0.8	6.3	9.6	1.31	0.226
GW 4	Nov-15	**2.06**	27.79	668	3.3	6.32	37	8.93	<0.1	**41.2**	88.4	9.5	5.29	1.4

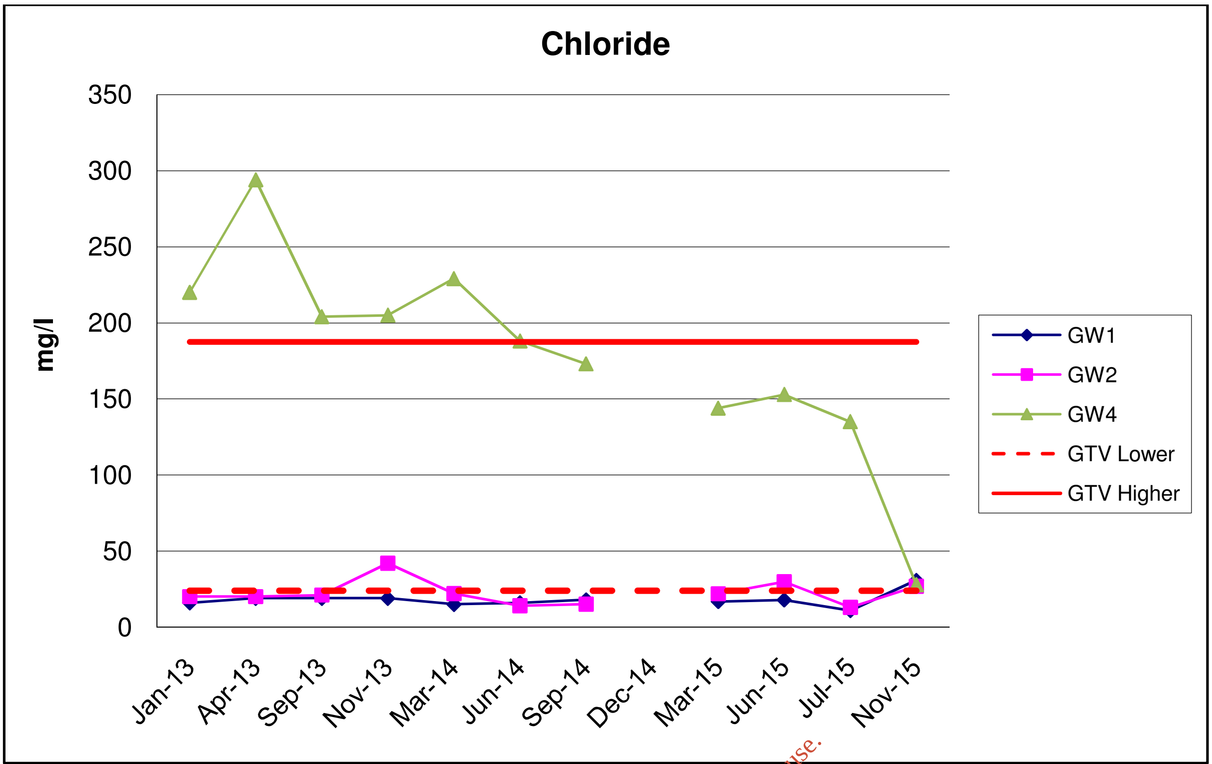
Surface Water Quality

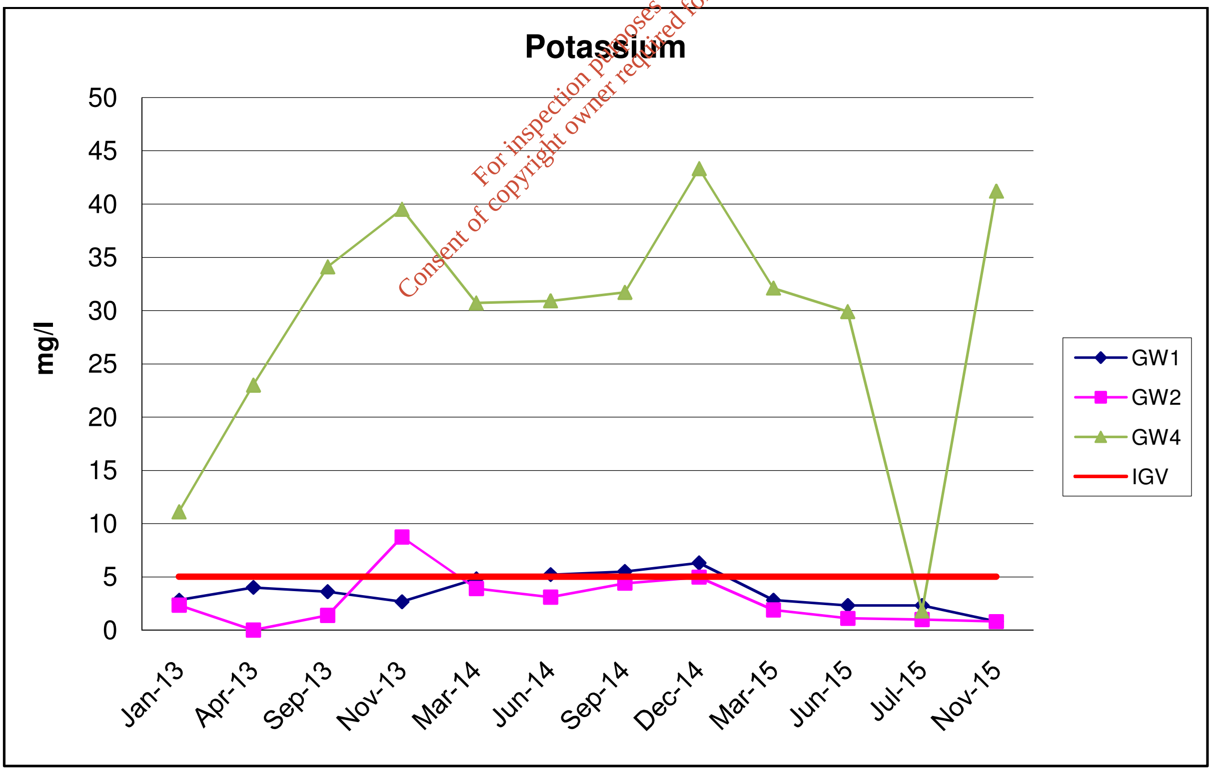
Sampling Results from Surface Water sampling point S4

	2013		2014		2015		February 2016
	Min	Max	Min	Max	Min	Max	
COD (mg/l)	0.47	1.1	12	**220**	10	30	<20
BOD (mg/l)	**10.51**	**12.38**	2.24	**6.61**	1.21	**14.32**	1
Ammonia (mg/l N)	**15**	**23**	**0.34**	**31.6**	**0.36**	**4.07**	**1.72**
pH	6.59	7.68	7.6	8.03	7.18	8	7.2
Conductivity (µg/l)	113	194	210	671	73.3	346	258
Chloride (mg/l)	31	51	22	26	9.93	41.69	31.8
Temp (^{o}C)	6.8	13.8	12	19.3	8.6	15.1	5.8
Dissolved Oxygen (mg/l)	1	4.2	8.75	11.08	9.06	12	10.34


Ammonia (as N)
mg/l N
35
30
25
20
15
10
5
0
Jan-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
GW1
GW2
GW4
GTV Lower
GTV Higher


Electric Conductivity
us/cm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
GW1
GW2
GW4
GTV Lower
GTV Higher


Chloride
350
300
250
200
150
100
50
0
mg/l
Jan-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
GW1
GW2
GW4
GTV Lower
GTV Higher


Potassium
50
45
40
35
30
25
20
15
10
5
0
mg/l
Jan-13
Apr-13
Sep-13
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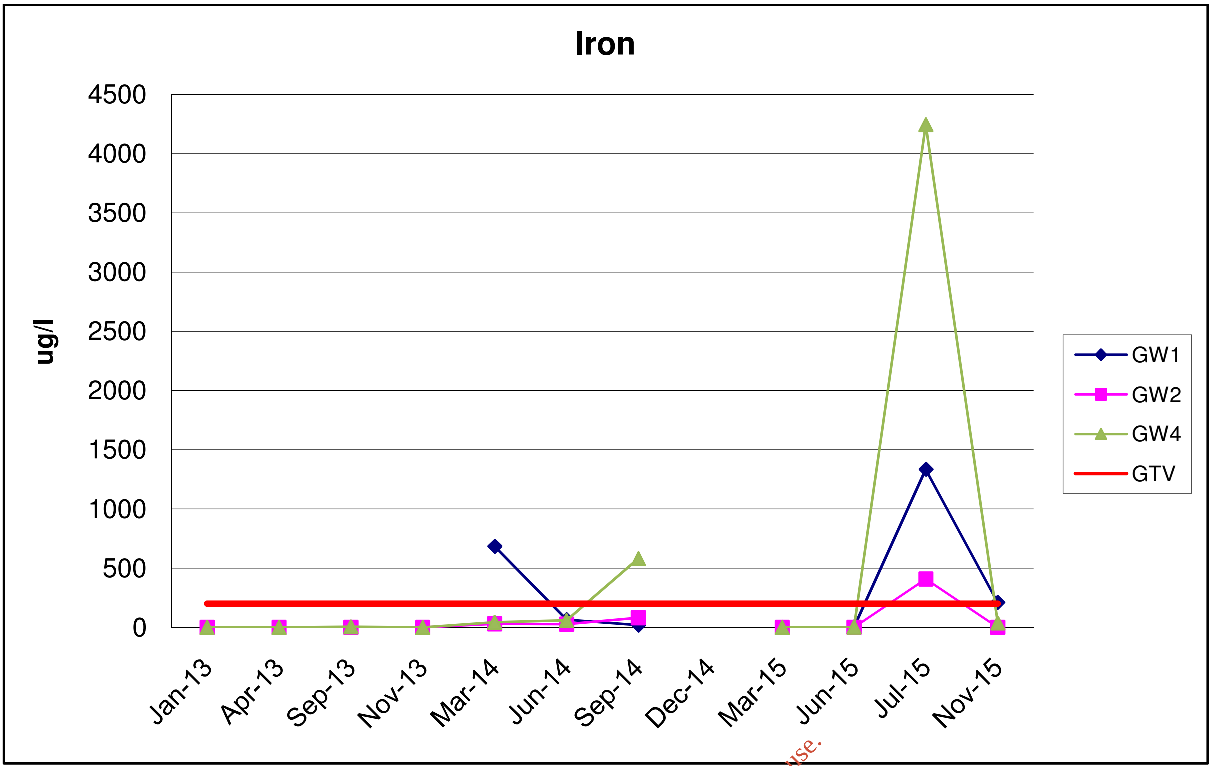
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
GW1
GW2
GW4
IGV


Iron
ug/l
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-13
Apr-13
Sep-13
Nov-13
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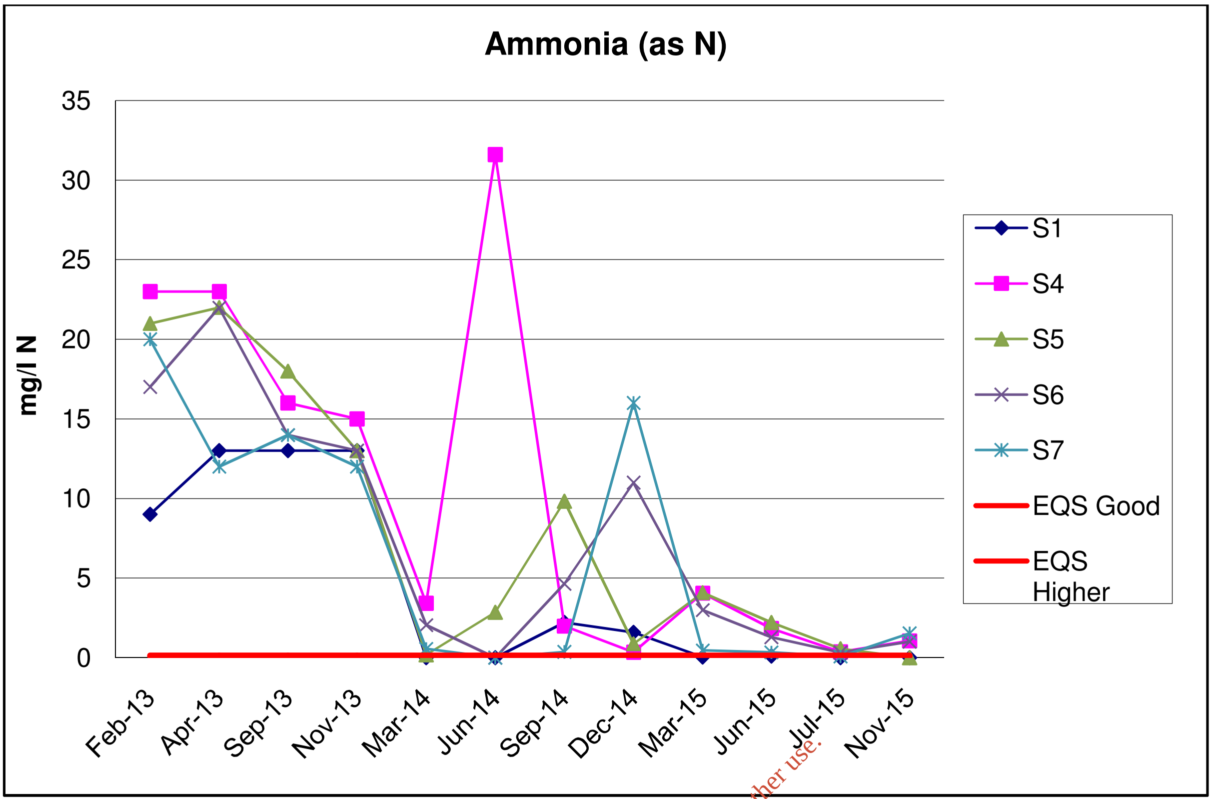
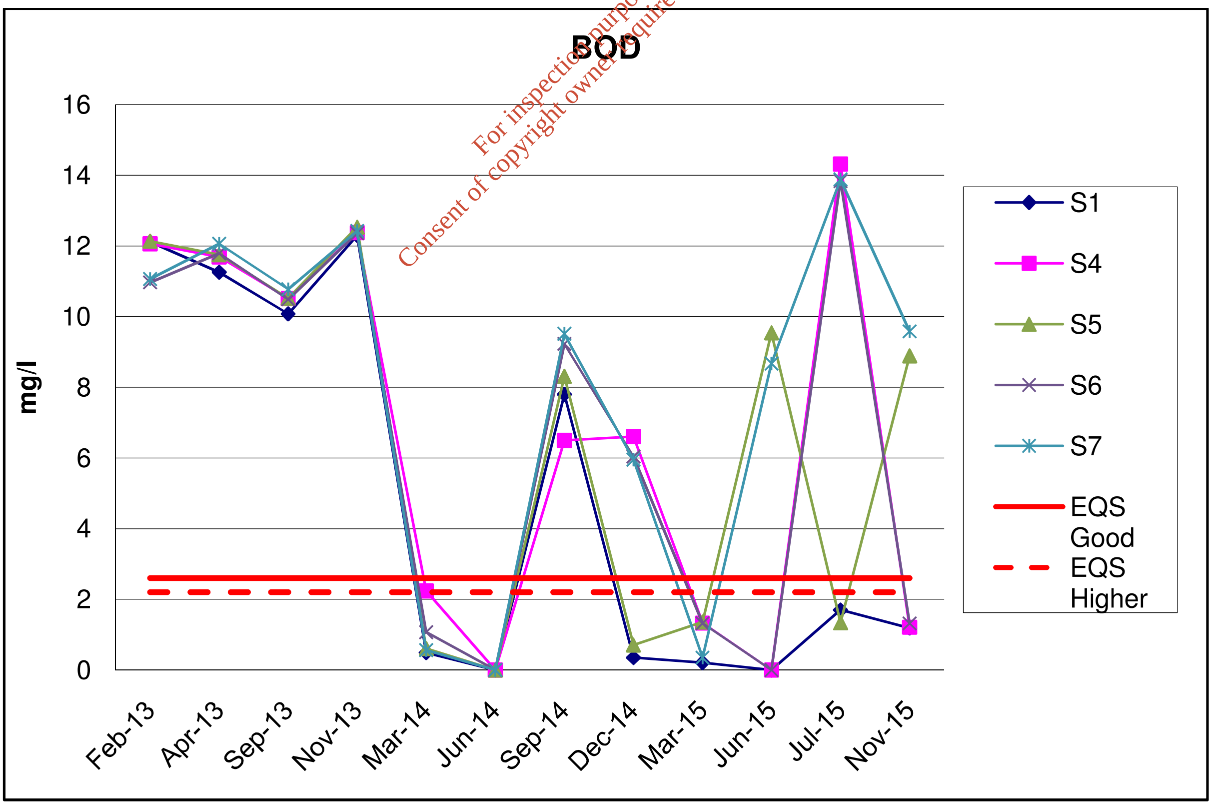
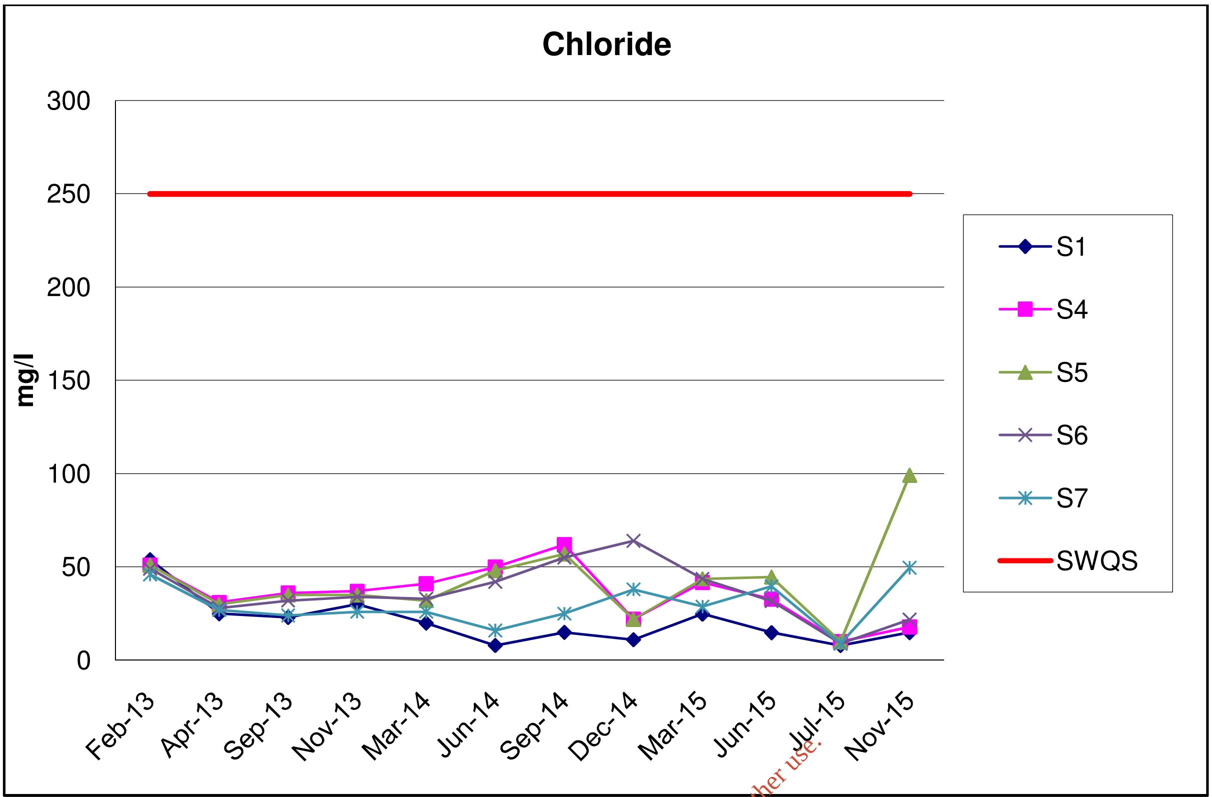
Mar-15
Jun-15
Jul-15
Nov-15
GW1
GW2
GW4
GTV


Ammonia (as N)
mg/l N
35
30
25
20
15
10
5
0
Feb-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
S1
S4
S5
S6
S7
EQS Good
EQS Higher


BOD
mg/l
16
14
12
10
8
6
4
2
0
Feb-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
S1
S4
S5
S6
S7
EQS Good
EQS Higher


Chloride
300
250
200
150
100
50
0
mg/l
Feb-13
Apr-13
Sep-13
Nov-13
Mar-14
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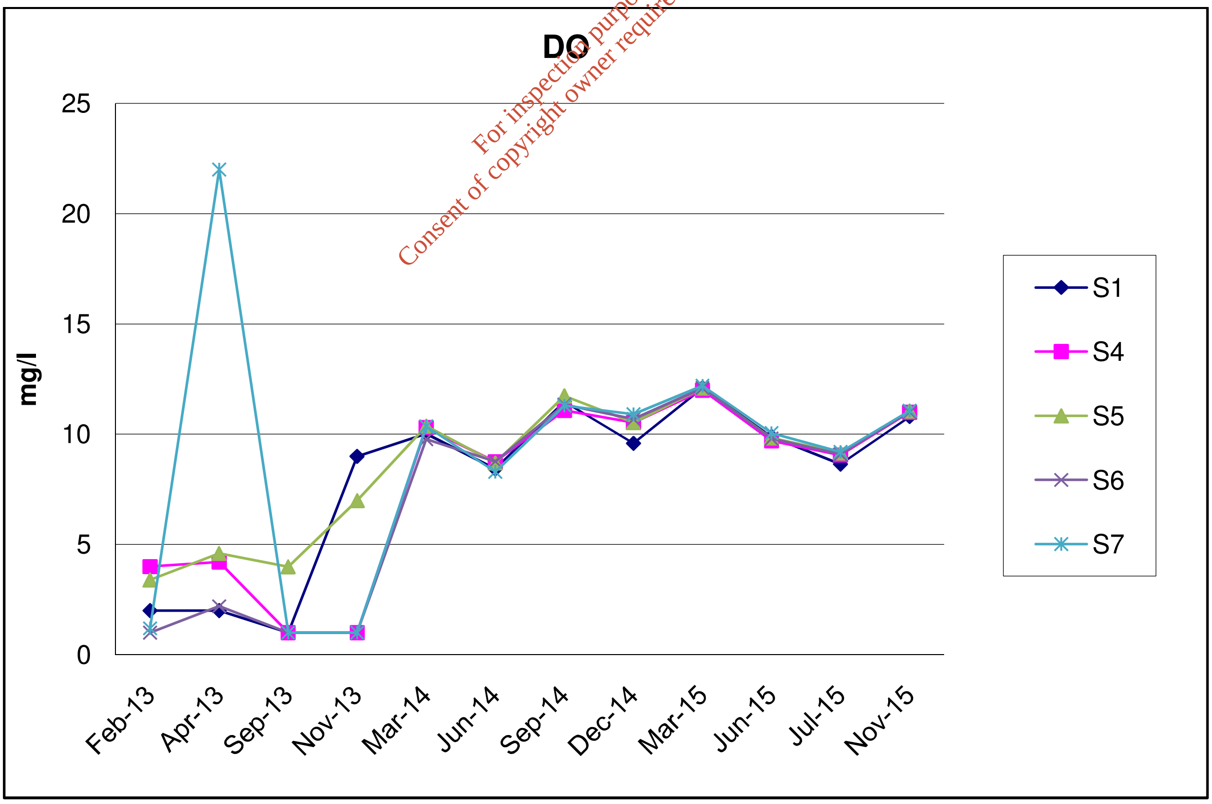
S1
S4
S5
S6
S7
SWQS


DO
25
20
15
10
5
0
mg/l
Feb-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
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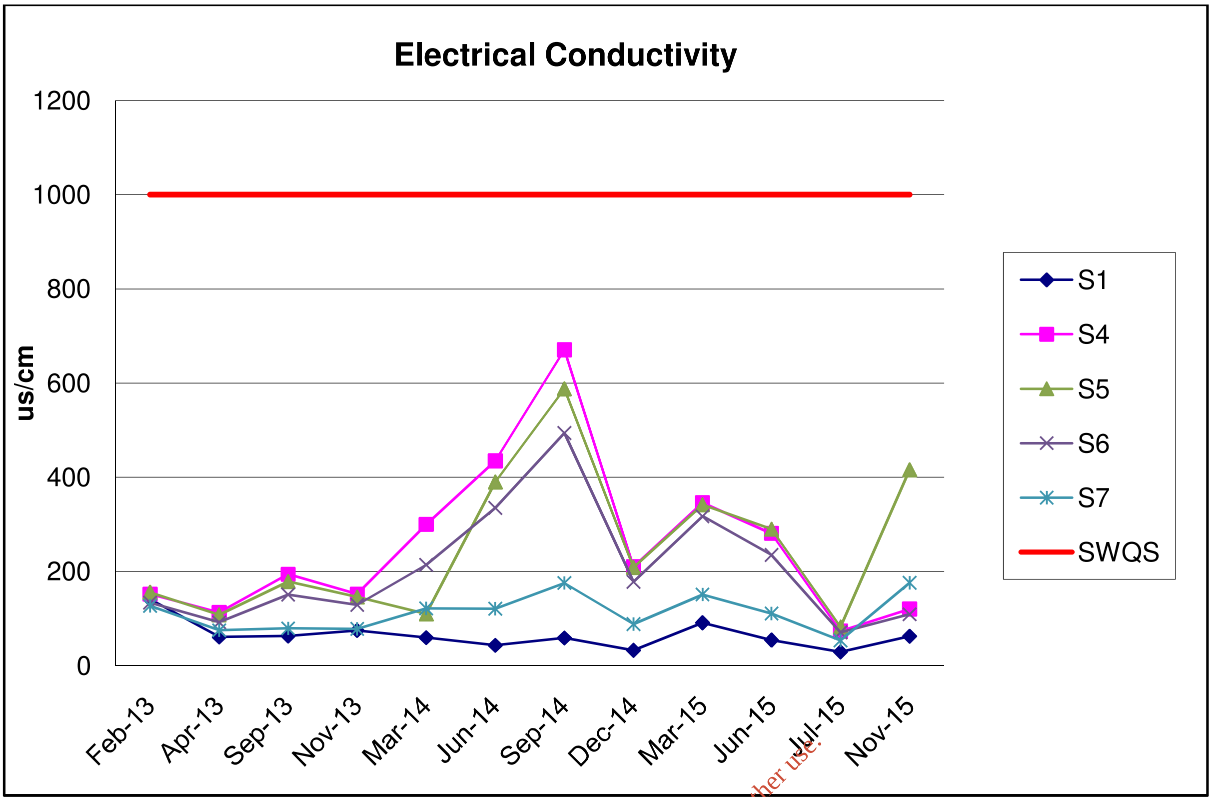
S1
S4
S5
S6
S7



Electrical Conductivity
1200
1000
800
600
400
200
0
us/cm
Feb-13
Apr-13
Sep-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Jul-15
Nov-15
S1
S4
S5
S6
S7
SWQS

Appendix C

VOC Gas Survey

ODOUR & ENVIRONMENTAL CONSULTANTS

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Website: www.odourireland.com

W0090-01-VOC/SURFACEEMISSIONS/2013/1 LANDFILL GAS SURFACE EMISSIONS SURVEY AT BALBANE LANDFILL SITE, BALBANE, KILLYBEGS, CO. DONEGAL

PERFORMED BY ODOUR MONITORING IRELAND ON BEHALF OF DONEGAL COUNTY COUNCIL

PREPARED BY:	Dr. John Casey
ATTENTION:	Ms. Julie McMahon
LICENCE NUMBER:	WL090-1
LICENCE HOLDER:	Donegal County Council
FACILITY NAME:	Balbane Landfill Facility
DATE OF MONITORING VISIT:	07th Feb. 2013
NAME AND ADDRESS OF CLIENT ORGANISATION:	Balbane Landfill Facility, Balbane, Killybegs, Co Donegal, Donegal.
NAME AND ADDRESS OF MONITORING ORGANISATION:	Odour Monitoring Ireland, Unit 32 DeGranville Court, Dublin Road, Trim, Co. Meath
DATE OF REPORTING:	18th Feb. 2013
NAME AND THE FUNCTION OF THE PERSON APPROVING THE REPORT:	Dr. Brian Sheridan, Managing Partner, Odour Monitoring Ireland
REPORT NUMBER:	2013632(1)
REVIEWERS:	

TABLE OF CONTENTS

DOCUMENT AMENDMENT RECORD

Client: ***Donegal County Council***

Title: W0090-01-VOC/SurfaceEmissions/2013/1 Landfill Gas Surface emissions Survey at Balbane Landfill Facility, Balbane, Killybegs, Co. Donegal.

Project Number: 2013632			**Document Reference:** W0090-01-VOC/SurfaceEmissions/2013/1		
2013632(1)	Document for review	JWC	BAS	JWC	18/02/2013
Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

Executive Summary

Donegal County Council commissioned Odour Monitoring Ireland to perform a landfill gas surface emissions survey of Balbane landfill facility (i.e. Waste licence number 90-01) in order to ascertain any likely sources of landfill gas surface emissions from the operating landfill. Landfill gas surface emissions are the predominant source of odour emissions from landfills in Ireland. The survey was carried out on the 07th Feb. 2013.

During the surface emissions survey, the following tasks were performed on site:

1. Identification the key mechanisms that lead to the release of landfill gas surface emissions from the site.
2. Identify geographically on a site map, the locations of landfill gas surface emissions in order to perform remediation of the identified surface emissions areas.

The following conclusions were drawn from survey:

- No zones of surface emissions were identified within the landfill facility that exceeded recommended trigger levels.
- A map of the survey area is contained in *Appendix I* of this report.

1. Introduction

1.1. Background to work

Odour Monitoring Ireland was commissioned by Donegal County Council to perform a specified independent Volatile organic compound surface emissions survey at Balbane landfill facility. The assessment involved a Volatile organic compound (VOC) surface emissions survey of the landfill facility in order to ascertain the VOC emission points and mark them upon a map for remediation. This report presents a summary of the findings of a VOC surface emissions survey at Balbane Landfill Facility, Balbane, Killybegs, Co. Donegal. The report is based on scientific measurements and observations made during a site visit conducted on the 07th Feb. 2013.

1.2. Scope of work

The main aims of the survey included:

- Surface emissions monitoring in accordance with AG6 requirements.
- Discussion meeting with landfill manager once survey was complete in order to communicate main surface emissions areas for immediate remediation, where necessary.

2. Techniques used

This section describes the techniques used throughout the study. The surface emissions surveying and reporting was performed by Dr. John Casey, Odour Monitoring Ireland. Dr. John Casey has preformed surface emissions monitoring survey's on behalf of Odour Monitoring Ireland for regulatory bodies in Ireland and Northern Ireland, local authorities in Ireland, private waste operators in Ireland and borough councils in Northern Ireland. A full documented list of previous survey's is available upon request.

2.1. "Odour hog" monitoring within the landfill

The "Odour hog" (i.e. Version 2, 4 years old with less than 3.5 second response time for the FID) VOC analyser is a portable, intrinsically safe, survey VOC dual monitor, which provides fast and accurate readings of organic and inorganic vapours. A Photo ionisation detector (PID) uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionised. A PID does not respond to methane. A FID is similar to a flame thermocouple detector, but measures the ions from the flame instead of the heat generated. The FID detects the methane fraction, which provides greater sensitivity in terms of methane surface emissions detection but not necessarily odour hence why the PID data is also interpreted. The FID/PID analyser was calibrated with certified reference material isobutylene and methane before commencement of the survey, see calibration certificates for gases used in Appendix II. The calibration readings were rechecked in accordance with AG6 requirements.

Using the continuous kinematic "Odour hog" with integrated GPS (i.e Magellan Professional with sub centimetre accuracy post processed), the capping of the landfill was surveyed for potential surface emissions areas. Those areas identified were geo-referenced and highlighted for remediation. This technique is useful for comparison in surface emissions area within the same landfill facility on different survey's. The surface emissions maps generated for the particular facility can be used to assess the effectiveness of implemented mitigation techniques and to qualitatively assess the nature of surface emissions from the facility. All surface emissions surveying was carried out in accordance with *"Surface VOC Emissions Monitoring on Landfill Facilities (AG6)"*.

Efforts should be made to attain surface emissions <100 ppm from open surfaces and <500 ppm around features such as vertical wells, leachate collection sumps, leachate slope risers and other projections out of the waste body (Casey et al., 2008). These are minimum standards, which should lead to greater landfill collection efficiencies thus reducing the impact on the general environment.

2.2. Meteorological conditions

Table 2.1 illustrates the predominant wind direction during the monitoring exercise. The meteorological conditions were characterised for the day of monitoring and were as follows:

Table 2.1. Meteorological conditions during Balbane facility TVOC survey.

07thFeb. 2013	
Average wind speed 5 m s^{-1}	Wind direction northerly
Temperature 8^{0}C	1003 mbar
Dry weather	Capping moisture content high

During the TVOC and gas field survey, wind deviated from a northerly direction. Capping moisture content was high.

2.3 Current landfill gas collection infrastructure on the facility

There no operational landfill gas flare on the facility. There appeared to be no installed landfill gas infrastructure on the facility. Figure 6.1 illustrates the extent of the survey area. The site is permanently capped (*see Figure 6.1*).

3. Results

3.1. Volatile organic compound surface emissions locations identified within Balbane landfill facility

Figure 6.2 and Table 3.1 illustrates the results obtained for the capping surface emissions survey. There were no surface emissions zones located within the survey area.

Table 3.1. Capping VOC surface emissions locations results with source identities correlating with *Figure 6.2 (see Appendix I)*.

Location ID	Easting (m)	Northing (m)	Max VOC conc. (ppm)	Identification and Mitigation	Recommended trigger levels
None	None	None	None	None	--

4. Conclusions

The following conclusions were drawn from the survey of Balbane Landfill facility:

- The surface emissions contour map generated from the kinematic Volatile organic compound (VOC) survey illustrated no surface areas of landfill gas surface emissions.
- There were no surface emissions zones located within the survey area.

5. References

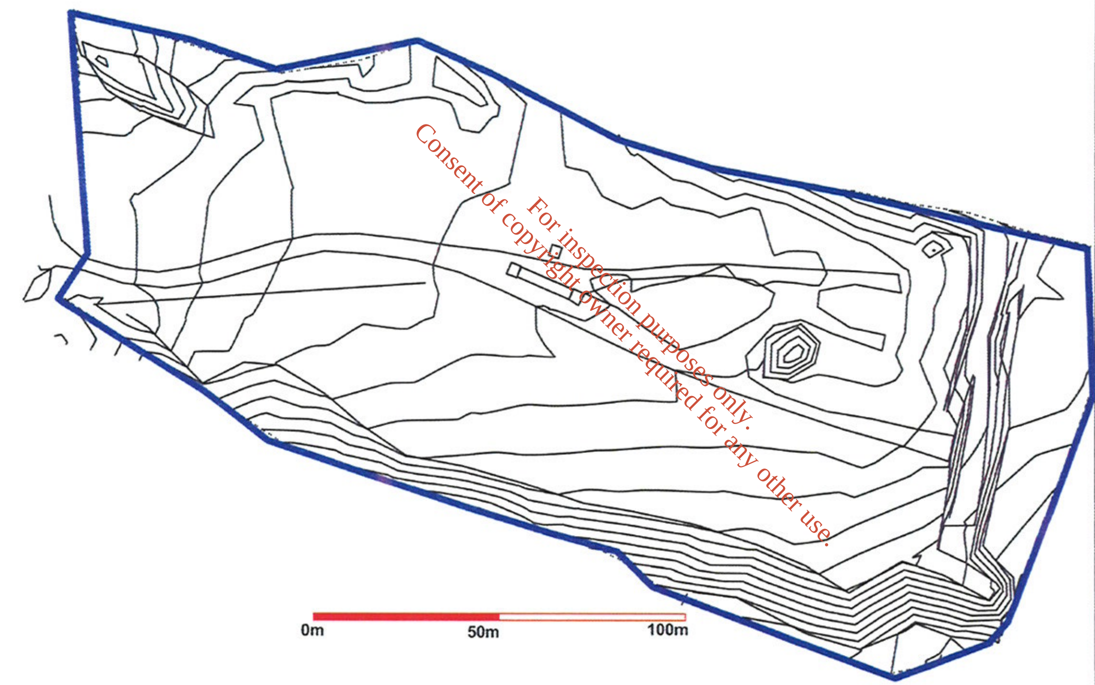
- Casey, J.W., Sheridan, B.A., Henry, M., Reynolds, K., (2008). Effective tools for managing odours from landfill facilities. International Conference on Environmental Odour Monitoring and Control, Rome, Italy, July 6-8, 2008.

6. *Appendix I*- Volatile organic compound surface emissions contour map & Cell capping outline & LFG infrastructure map

Figure 6.1. Cell capping outline & LFG infrastructure on the facility.


Permanent Cap and Survey Area
0m
50m
100m
CLIENT
RPS
PROJECT
BALBANE LANDFILL FACILITY
TITLE
OUTLINE MAP
ODOUR monitoring IRELAND
REVISION NO 1
DRAWN BY JC
DATE Feb 2013
NOT TO SCALE-IF IN DOUBT ASK
APPROVED BY BS
Feb. 2013

Figure 6.2. Landfill gas surface emissions monitoring within the operating landfill facility (colour scale area indicating TVOC gas colour scale).



CLIENT
RPS

PROJECT
BALBANE LANDFILL FACILITY

TITLE
LEAKAGE SURVEY MONITORING MAP

ODOUR monitoring IRELAND

Odour Monitoring Ireland, Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath, Ph 0469437922

REVISION NO 1	DRAWN BY JC DATE Feb 2013
NOT TO SCALE-IF IN DOUBT ASK	APPROVED BY BS Feb. 2013

7. *Appendix II*-Calibration certificates and procedures.

7.1 Span & Calibration procedure

Necessary Calibration gases: Zero gas (0ppm), 100ppm and 500ppm methane (Calibration certificates below).

Calibration is carried out in accordance with manufacturers guidelines.

Location: Zero span instrument onsite.

Frequency: Before, midway through, and after the surface emissions survey, typically therefore at 3-4 hour intervals. If the survey only last 2 to 3 hours the instrument is checked before and after the event.

Instrument settling: The FID is switched on and left to settle for a period of 30 minutes minimum.

Span Procedure: The zero and span gases shall be introduced under the same flow and pressure conditions using the sample probe at the end of the sample line. The adjustment procedure shall be as follows:

a) Feed the zero gas (0ppm) into the FID and set the zero;

b) Feed the span gas (100ppm) and adjust the instrument accordingly;

c) Feed the zero gas into the FID once more and check that the reading returns to zero; if not repeat steps a) to c).

d) repeat procedure A to C to verify

Equipment is maintained and operated as specified by the manufacturer.

Scientific & Technical
Gases Ltd

Certificate of Composition 29485-6-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I

Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt

(Kg) 0.12 Gross Wt (Kg) 1.2

Component Requested Value Certified Value

METHANE 500PPM 500PPM AIR (ZERO GRADE) BALANCE BALANCE

Pressure 1000PSI Volume 112LTR Valid Until *February 2013*

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1956 Date 10/02/2010

Document No. 2013632(ver.1)
Visit No: 01
Year: 2013

WL090-01
Donegal County Council.
Balbane Landfill Facility

Scientific & Technical Gases Ltd

Certificate of Composition 29485-1-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt (Kg) 0.12 Gross Wt (Kg) 1.2

Component Requested Value Certified Value

AIR ZERO GRADE ZERO GRADE

Pressure 1000PSI Volume 1000PSI Valid Until *February 2013*

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1002 Date 10/02/2010

Document No. 2013632(ver.1)
Visit No: 01
Year: 2013

WL090-01
Donegal County Council.
Balbane Landfill Facility

Scientific & Technical Gases Ltd

Certificate of Composition 29485-5-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I

Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt

(Kg) 0.12 Gross Wt (Kg) 1.2

Component Requested Value Certified Value

METHANE 100PPM 100PPM AIR (ZERO GRADE) BALANCE BALANCE

Pressure 1000PSI Volume 112LTR Valid Until *February 2013*

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1956 Date 10/02/2010