REPORT

Biffa Waste Services Ltd

Eye Landfill, Eastern Extension

Landfill Gas Management Plan

Submitted to:

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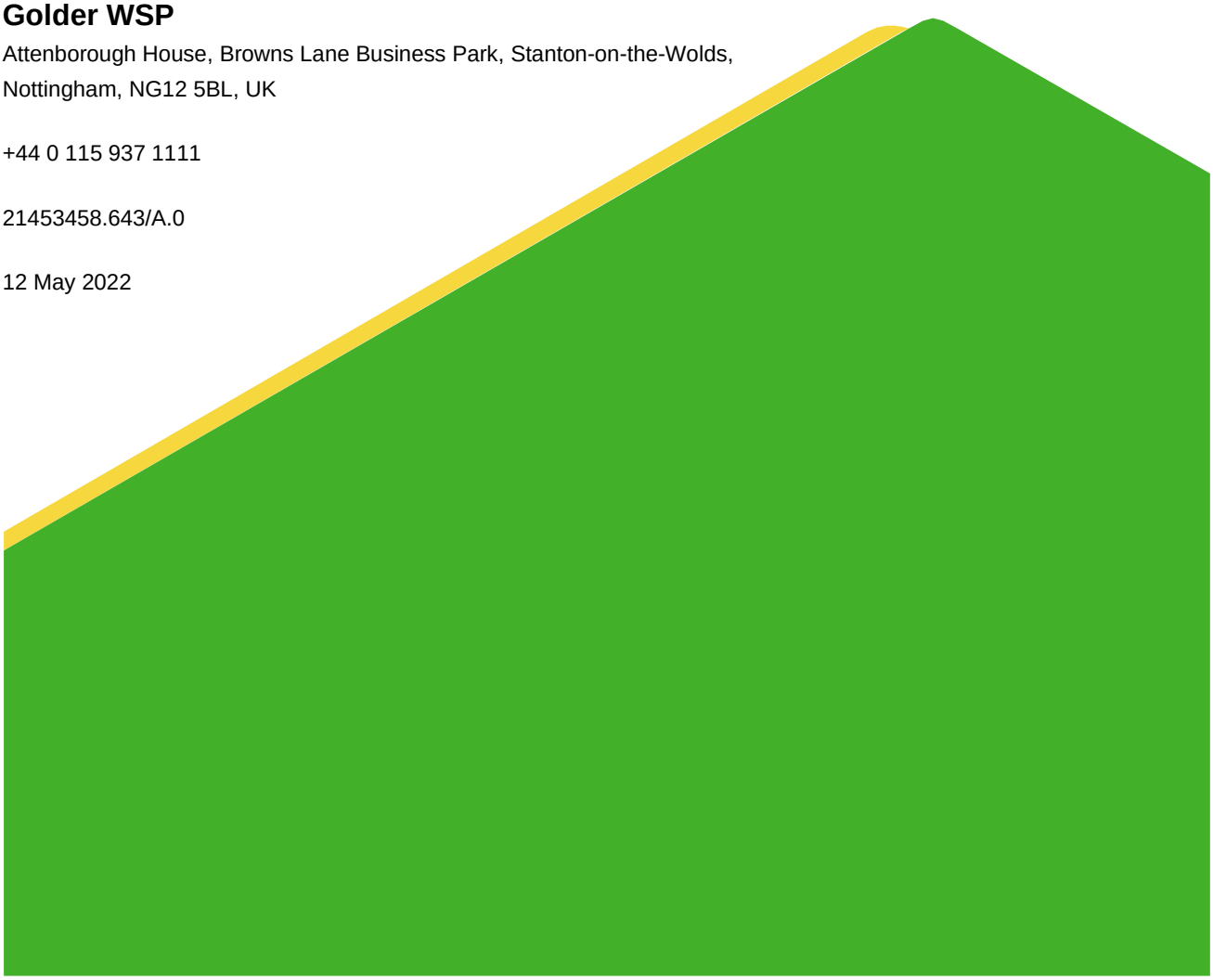
21453458.643/A.0

12 May 2022



Distribution List

Biffa Waste Service - 1 pdf

Environment Agency - 1 pdf

Golder, member of WSP UK Ltd - 1 pdf

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1.0 REPORT CONTEXT

This report has been prepared by Golder, member of WSP in UK (Golder), on behalf of Biffa Waste Services Ltd (Biffa) and presents a Gas Management and Monitoring Plan for the proposed Eastern Extension (Eastern Extension) at Eye Landfill, Eyebury Road, Eye, Peterborough PE6 7TH (the Site).

The Site currently consists of four main areas comprising the Central Area, Northern Extension, North-eastern Extension, and Southern Extension. The North-eastern and Southern Extensions are currently authorised by Environmental Permit (EP) EPR/BP/3537PP. Biffa intends to secure additional void space for non-hazardous waste landfill development at the neighbouring Willow Hall Farm Quarry and Inert Landfill, Willow Hall Lane, Thorney, Peterborough, PE6 0QN, which lies to the east of the Eye Landfill, currently operated by PJ Thory Ltd ('Thory'). Thory currently operate their Quarry and Inert Landfill under EP for inert landfill (EPR/DB3007TZ), which was issued to TAG Industries Ltd in 2016 and transferred to Thory in 2017 (EPR/FB3204MX).

The Gas Management and Monitoring Plan provides a framework for the management of landfill gas (LFG) based on the site characteristics and the nature and extent of the gas control system (LFTGN03). Key elements of the Gas Management and Monitoring Plan include the landfill gas risk assessment, specification of control measures and definition of operational procedures, monitoring plan and action plan.

This report details the Gas Management and Monitoring Plan to be implemented specifically at the proposed Eastern Extension and is therefore not applicable to other areas of the Site. This Plan should be read in conjunction with the Permit variation application for the Eastern Extension, in particular Environmental Setting and Installation Design (ESID; ref. 21453458.632), and the Gas Risk Assessment (GRA; ref. 21453458.635).

The Gas Management and Monitoring Plan draws on Biffa's (2020) Gas Management Plan & Control Specifications which forms part of Biffa's Landfill Gas management procedures and outlines the generic installations, utilisation technologies and operational standards that will be applied by Biffa to its landfill gas management systems.

Biffa (2020) describes Biffa's principles of LFG management, the specification and expected standards for the installation of the gas collection and utilisation systems, as well as the operational practices and checks that will be undertaken to ensure that Biffa meets the regulatory body best practice guidance. It further details Biffa's risk- based management approach to gas control.

Biffa's (2020) Gas Management Plan & Control Specification is a generic document that applies nationally to all Biffa landfill facilities. This document is reviewed and updated regularly as part of Biffa's management practices and all updated versions implemented across all of Biffa's landfill facilities. The Gas Management and Monitoring Plan for the Eastern Extension should be read in conjunction with Biffa's Gas Management Plan & Control Specification which forms **Appendix GMP1**.

2.0 LANDFILL GAS RISK ASSESSMENT

A detailed Gas Risk Assessment (GRA) has been completed for the proposed Eastern Extension. The GRA includes estimated LFG generation at the Eastern Extension over time and a Tier 2 Risk Assessment using GasSim2.5. The GRA covers emissions from the Eastern Extension itself as well as the existing Gas Utilisation Plant (GUP) which the Eastern Extension will share with other parts of Eye Landfill (GRA; ref. 21453458.635).

3.0 LANDFILL GAS MANAGEMENT

Landfill gas management and control will be achieved by:

- **Containment** provided by low permeability liner installed across the base and perimeter slopes and low permeability capping;
- **Collection** via an active gas extraction system;
- **Treatment** within the GUP including engine utilisation and flaring; and
- **Monitoring** of LFG emissions using internal and external gas monitoring systems, surface emissions monitoring and stack emissions monitoring of engines and flare.

4.0 LANDFILL GAS CONTROL MEASURES AND PROCEDURES

Drawing ESID8 – Landfill Gas Management illustrates the planned layout of the landfill gas collection system at the Eastern Extension. The Site features gas wells at 40 m spacing which connect to gas manifolds feeding into a ring main system. The extracted gas will be fed to the existing Eye Landfill GUP which is located to the northwest of the Southern Extension and treated by engine utilisation and flaring. The gas infrastructure specifications, construction details of both temporary and permanent installations, CQA and operational procedures are detailed in **Appendix GMP1**.

5.0 MONITORING PLANS

The monitoring plan allows the performance of the LFG management system to be established. Monitoring data is used to verify compliance with the Gas Management Plan and EP conditions. Monitoring is undertaken in line with Biffa's internal monitoring procedures (**Appendix GMP1**).

5.1 Internal Monitoring

In-waste monitoring is undertaken in line with the requirements in LFTGN03, LFTGN04 and **Appendix GMP1**. The monitoring programme is in accordance with the EP for the Eastern Extension. Table GMP1 sets out provisional monitoring requirements which will be updated once the EP has been determined.

Table GMP1: Internal Monitoring Programme

Monitoring Location	Monitoring Parameter	Monitoring Frequency
In-waste gas monitoring boreholes, sealed leachate wells or sacrificial gas system for phases which have no active gas extraction	Methane Carbon Dioxide Oxygen Carbon Monoxide Differential pressure Atmospheric pressure	Monthly until gas extraction commences
	Hydrogen Sulphide	Quarterly until gas extraction commences

Monitoring Location	Monitoring Parameter	Monitoring Frequency
One in-waste borehole or one leachate well per cell once extraction commences	Methane Carbon Dioxide Oxygen Carbon Monoxide Differential pressure Atmospheric pressure	Monthly
	Hydrogen Sulphide Monthly	Quarterly
Gas collection system at well control valve, manifolds (if applicable) and strategic points on gas system	Methane Carbon Dioxide Oxygen Carbon Monoxide Atmospheric pressure Gas flow rate or suction % Balance Gas	Monthly or at such frequency as agreed in writing with the Environment Agency
Gas collection system at well control valve	Hydrogen Sulphide	Six monthly
Input to GUP	Trace Gas	Annually
Input to GUP	Methane Carbon Dioxide Oxygen Gas flow rate suction % Balance Gas	Weekly

5.2 External Monitoring

The monitoring of external boreholes is essential to demonstrate the efficiency of gas management systems within landfill sites, and to detect any gas migrating from the site. The network of external perimeter monitoring boreholes planned by Biffa at the Eastern Extension is shown on **Drawing HRA3 - Monitoring and Extraction Point Plan**. The external monitoring is undertaken in line with the requirements of **Appendix GMP1**. The monitoring programme is in accordance with the EP for the Eastern Extension. Table GMP2 sets out provisional monitoring requirements which will be updated once action levels and compliance limits have been agreed and the EP has been determined.

Table GMP2: External Monitoring Programme

Monitoring Location	Monitoring Parameter	Action Level & Compliance Limit	Monitoring Frequency
Perimeter Boreholes identified in the Monitoring and Extraction Point Plan (HRA3)	Methane Carbon Dioxide Oxygen Differential pressure Atmospheric pressure	To be determined	Monthly

For the external perimeter monitoring boreholes, background methane and carbon dioxide concentrations need to be established to determine appropriate action levels and compliance limits. These action levels and compliance limits will be completed in line with:

- The Environment Agency Position Statement on Industry Code of Practice of Soil Gas (August 2011); and
- Industry Guidance 'Perimeter soil gas emissions criteria and associated management' (January 2011, Version 1.01, the 'ICoP')

The ICOP states that carbon dioxide should not be used to regulate emissions as there are alternative sources in the sub-surface environment. It takes the position that no compliance (formerly trigger) limits should be set for carbon dioxide in the future emissions performance assessment of a site. However, carbon dioxide data should continue to be collected and assessed against a lower action (formerly control) level because this activity informs the conceptual model and initiates investigatory action by the Operator.

The ICOP presents 'best available' approaches to establishing background methane and carbon dioxide concentrations at site on a well by well or zonal basis using statistical techniques. Background data should include:

- Data obtained 24-12 months prior to any landfill operations commencing – it is essential that new cells have boreholes in place well before the liner or waste is placed. 24 to 30 background data points should be viewed as a minimum before statistics can be reliably applied to the data set.
- Data after the lining system has been placed but prior to placement of waste within specific cells in the landfill.
- Data obtained as early as practically possible prior to the onset of methanogenic conditions within specific cells in the landfill (these data should be cross referenced to on-site monitoring data to show when methanogenic conditions start).
- Note that lining a landfill changes the background conditions because gas generated in the subsurface that has previously diffused to surface unimpeded now has to migrate around the impermeable lining. This may result in soil gas concentrations changing during or following lining construction which may not be related to any emission from the installation. Typically, there is a four-week period between the end of liner construction and waste deposit to allow the regulator to assess the CQA verification report for the lining works. A period of intensive background monitoring is recommended during and after liner Perimeter soil gas emission criteria and management installation to understand such changes if there is evidence to suggest this is an issue at the site.

5.3 Surface Emissions Monitoring

Monitoring of methane emissions through the cap can help to identify any faults in the gas management system and prioritise required remediations. The monitoring is undertaken in line with the requirements in LFTGN07. The monitoring programme is in accordance with the EP for the Eastern Extension. Table GMP3 sets out provisional monitoring requirements which will be updated once the EP has been determined.

Table GMP3: Surface Emissions Monitoring Programme

Monitoring Location	Monitoring Parameter	Monitoring Frequency
Permanently capped zone	Methane Concentration	Every 12 months
Temporarily capped zone	Methane Concentration	Every 12 months
Whole Site	Total Methane Emission	As agreed with the Environment Agency

5.4 Emissions Monitoring from Engines and Flare

Stack emissions monitoring for engines and flares will be undertaken in line with the requirements in LFTGN05, LFTGN08, Technical Guidance Notes M1 and M2 and **Appendix GMP1**. The applicable monitoring programme is stipulated in the EP for the Eye Landfill Southern and North-Eastern Extension (EPR/BP3537PP) and detailed in Table GMP4.

Table GMP4: Engines and Flare Emissions Monitoring Programme

Emission Point	Monitoring Parameter	Limit	Reference Period	Monitoring Frequency
Gas Engines within GUP	Oxides of Nitrogen	500 mg/m^3	Hourly mean	Annually
	Carbon Monoxide	1400 mg/m^3		
	Total VOCs	1000 mg/m^3		
Gas Engines within GUP	Oxides of Nitrogen and Carbon Monoxide	n/a	n/a	Quarterly[1]
Flare within GUP	Oxides of Nitrogen	150 mg/m^3	Hourly mean	Annually
	Carbon Monoxide	100 mg/m^3		
	Total VOCs	10 mg/m^3		
Flare within GUP	Temperature	n/a	n/a	As per LFTGN05 or as agreed in writing with the Environment Agency

Note: [1]Using a portable flue gas analyser. Where measurements indicate exceedance of emission limits, the cause shall be investigated, and appropriate measures taken to reduce emissions.

6.0 MONITORING DATA MANAGEMENT AND REPORTING

Environmental monitoring data relating to routine landfill gas monitoring is entered directly onto Biffa's Electronic Database System. Monitoring data is then stored, processed, and reported on in line with Biffa's procedures as set out in **Appendix GMP1**.

7.0 ACTION PLANS

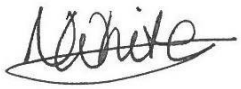
Actions plans are detailed in **Appendix GMP1** including for:

- Surface & Sub-Surface Fires;
- Observed Abnormal Changes in Collected Monitoring Data;
- Operational Problems or Failure of the Gas Control System; and
- Minor Gas Control System Problems.

Actions taken in response to abnormal changes in perimeter borehole monitoring data (e.g. in relation to action levels and compliance limits breaches) are detailed specifically in the 'Landfill Gas Monitoring Protocol & Response Plan – Gas Perimeter Boreholes' which is appended to **Appendix GMP1**.

Signature Page

Golder WSP



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SB/JS/NW/ab

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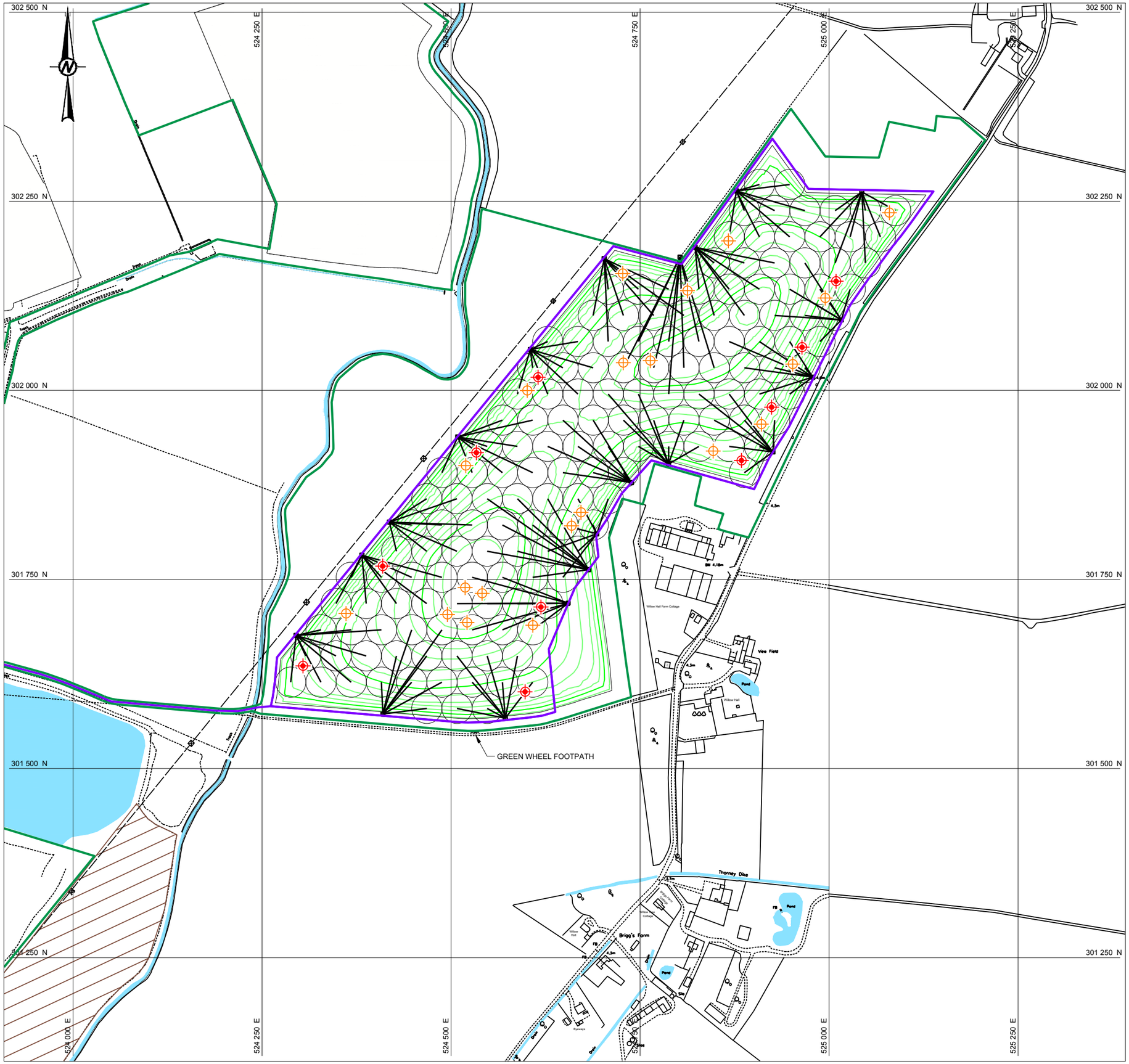
DRAWINGS

Drawing ESID8 - Landfill Gas Management

Drawing HRA3 - Monitoring and Extraction Point Plan



LEGEND

- PROPOSED BIFFA ENVIRONMENTAL PERMIT BOUNDARY EPR/BP3537PP/V011
- GAS EXTRACTION RING MAIN
- GAS WELL (INDICATIVE WITH 20 m RADIUS OF INFLUENCE)
- GAS MANIFOLD AND PIPES FROM GAS WELLS
- LEACHATE EXTRACTION WELL
- LEACHATE MONITORING WELL
- PRE-SETTLEMENT, PRE-RESTORATION CONTOURS

NOTE(S)

1. GAS WELL AND PIPE LOCATIONS ARE INDICATIVE ONLY.

0 100 200
1:5,000 METRES

WSP GOLDER

GOLDER FILE REF	ENGINEER	REVIEWED BY
1403-PA-0012	NW	CMcD

REV.	DATE	DRAWN	DESCRIPTION

Biffa

Biffa Waste Services Ltd
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Nutfield, Redhill
RH1 4ER
Tel. 01737 765042
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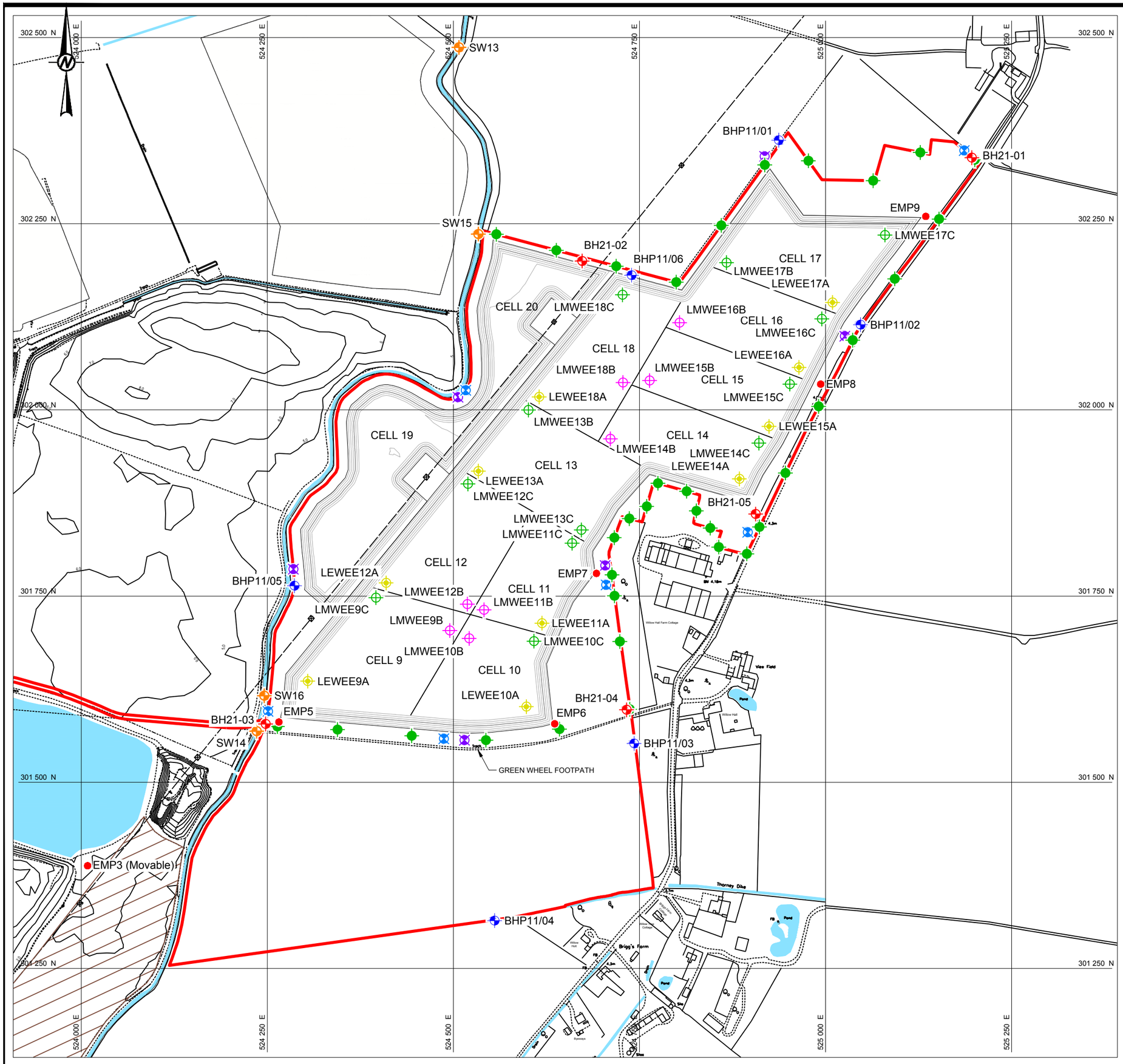
PROJECT	Eye Eastern Extension
LOCATION	Eye Landfill, Peterborough
DRAWING TITLE	Landfill Gas Management
DRAWING No.	ESID8
COMPUTER REF.	E5238800
DRAWN	ECS
DATE	25/02/2022
SCALE(S)	1:5,000



LEGEND

- PLANNING APPLICATION BOUNDARY
- EXISTING GROUNDWATER MONITORING BOREHOLE (SAND AND GRAVEL)
- EXISTING GROUNDWATER MONITORING BOREHOLE (KELLAWAYS SANDS)
- SURFACE WATER MONITORING POINT
- PROPOSED GROUNDWATER MONITORING POINT (RIVER TERRACE DEPOSITS)
- PROPOSED GROUNDWATER MONITORING POINT (KELLAWAYS SAND)
- PROPOSED PERIMETER GAS MONITORING POINT
- LEACHATE EXTRACTION WELL EASTERN EXTENSION (UPSLOPE RISER)
- LEACHATE MONITORING WELL EASTERN EXTENSION (UPSLOPE RISER)
- LEACHATE MONITORING WELL EASTERN EXTENSION (VERTICAL)
- ENVIRONMENTAL MONITORING POINT

NAME	BEDS DESCRIPTION AND CODE
BH21-01	BH46 - 91002460
BHP11/01	BH47 - 91002470
BHP11/06	BH48 - 91002480
BH21-02	BH49 - 91002490
BHP11/05	BH50 - 91002500
BH21-03	BH51 - 91002510
BHP11/04	BH55 - 91002550
BHP11/03	BH56 - 91002560
BH21-04	BH52 - 91002520
BH21-05	BH53 - 91002530
BHP11/02	BH54 - 91002540

NOTE(S)

1. INDICATIVE POSITIONS SHOWN ONLY. EXACT LOCATIONS TO BE CONFIRMED IN CELL SPECIFIC CQA PLAN.

0 100 200
1:5,000 METRES

WSP GOLDER

GOLDER FILE REF	ENGINEER	REVIEWED BY
1005-HR-0005	EMcA	CMcD

REV.	DATE	DRAWN	DESCRIPTION

Biffa
Biffa Waste Services Ltd
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E-mail phil.mumford@biffa.co.uk

PROJECT	Eye Eastern Extension
LOCATION	Eye Landfill, Peterborough
DRAWING TITLE	Monitoring and Extraction Point Plan
DRAWING No.	HRA3
COMPUTER REF.	E5239600
DRAWN	TS
DATE	21/02/2022
SCALE(S)	1:5,000

APPENDIX GMP1

Biffa Landfill Gas Department: Gas Management Plan & Control Specification

Biffa Waste Services Ltd

Biffa Landfill Gas Department

Gas Management Plan & Control Specification

(Generic Specification & Standards)

November 2020 **Edition IX**

Biffa Waste Services Ltd

Landfill Gas Management Plan & Control Specification

Contents **Page No.**

Appendices

6 - Action Plan: Damage to Gas Carrier Main
7 - Action Plan: Gas Booster Failure
8 - Action Plan: Removal of Blockage of a Permanent Gas Line due to a Liquid Build Up
8 - Biffa Complaints Reporting Procedure
9 - Fire and Evacuation Procedure (typical).

Typical Arrangement Drawings

Biffa Computer Ref. No.	**Description**
00120303	Typical Impact Well Detail.
00120402	Typical Extraction Wellhead Detail for Temporary or Permanent Installation.
00120502	Compound condensate KOP/Filter Vessel (Plan) sheet 1 of 2.
00120602	Compound condensate KOP/Filter Vessel (Section) sheet 2 of 2.
00120702	Typical in line condensate knock out pot (plan) sheet 1 of 2.
00121102	Gas scavenger systems
00120802	In line condensate knock out pot (section) sheet 2 of 2.
00121002	Proposed Gas Extraction Manifold Design
00121702	Service Corridor (typical detail)
00121902	Conventional well (typical details)

00122302	Typical Well Head and Enclosure
00122501	Gas well sealing when installed thro' Bentomat (typical detail)
00124200	Gas well sealing when installed through existing cap
00124300	Concrete Leachate Chamber Wellhead Detail

A - Record of Amendments

Item No. & Description	Reason for Update	Date of Amendment
Page 37: 3.1.22.14 & 3.1.22.16	Correction of spelling mistake 'gases'	23rd June 2003
Page 45: 3.1.25.4	Turn down ratio changed from 5:1 to 10:1	23rd June 2003
Page 48: 3.1.29.8	Inclusion of statement 'with a vertical discharge'	23rd June 2003
Page 52: section 5	Technical amendment to monitoring requirements	25th July 2003
The following sections have been changed: Sec. 3.0.2.9; Sec. Biffa Gas Management Structure; Sec. 3.1.20.7; sec. 3.1.21.7; sec. 3.1.21.19; sec. 3.1.21.22; sec. 3.1.22.6, sec. 3.1.22.7; sec. 3.1.22.8; sec. 3.1.22.11; sec. 3.1.22.14; sec. 3.1.22.18; sec.3.1.23.2; sec.3.1.24.1; sec. 3.1.25.2; sec. 3.1.25.3; sec. 3.1.25.5; sec. 3.1.25.7; sec. 3.1.25.11; sec. 3.1.25.12; sec. 3.2.1.2; sec. 3.2.2; sec. 3.2.2.2 (del); sec. 3.2.2.4 (now 3.2.2.3); sec. 3.2.2.5 (now 3.2.2.4); Sec. 3.2.3 (new); sec. 3.3.5 (new). Appendices 'Typical Flare Specification (del); Landfill Gas Analysis – updated.	2005 Annual Review	July 2005
Edition IV	2007 Review	October 2007
Edition V	2013 full Review	January 2013
Edition VI	2014 Review	July 2014
Edition VII Typical arrangement drawings 00120302; revised & renumbered 00120303, 00120501; revised & renumbered 00120501, 00120601; revised & renumbered 00120601, 00121101; revised & renumbered 00121101, 00121002; deleted, 00122300; revised & renumbered 00122302, 00122400; deleted, 00122500; revised and renumbered	2016 review	June 2016

00122501, 00124200; new insertion, 00124300; new insertion. Area Classification Drawings; all deleted. Definitions and Abbreviations; new insertion. Sec. 1.1.1; amended Sec. 1.1.2; new insertion Sec. 1.1.3; new insertion Sec.1.1.5; amended Sec. 1.1.7; amended Sec. 1.3.1; amended Sec. 1.3.5; amended Sec. 1.3.8; deleted Sec. 1.3.9; amended Sec. 1.4; amended Sec. 1.6; LFG Management Plan Route Map; amended Sec. 2.1.2; amended Footnote 1; new insertion Sec. 2.4; amended Sec. 2.6; amended Sec. 2.7; deleted Sec. 2.10; amended Sec. 2.12; deleted Sec. 2.13; LFG Protocol; amended Sec. 3.1; amended Sec. 3.2; amended Sec. 3.3; amended Footnote 2; deleted Sec. 3.5; deleted Sec. 3.7; amended Sec. 4.3; amended Sec. 4.4; amended Sec. 4.6; amended Sec. 5.1; amended Sec. 5.2.2; amended Sec. 5.2.3; new insertion Sec. 5.2.4; amended Sec. 5.2.5; amended Sec. 5.2.7; amended Biffa Landfill Gas Structure; amended Sec. 6.1.3; amended Sec. 6.1.4; amended Sec. 6.2.1; amended Sec. 6.3; amended Sec. 6.3.1; amended Sec. 6.3.2; amended Sec. 6.3.4; amended Sec. 6.3.6; amended Sec. 6.4.2; amended Sec. 6.4.3; amended Sec. 6.4.4; amended Sec. 6.4.5; deleted		

Sec. 6.4.6; amended Sec. 6.5.9; deleted Sec. 6.6; amended Sec. 6.6.1; amended Sec. 6.6.2; amended Sec. 6.6.3; amended Sec. 6.7; amended Sec. 6.7.1; amended Sec. 6.7.6; amended Sec. 6.7.9; amended Sec. 6.7.10; amended Sec. 6.7.11; amended Sec. 6.7.13; amended Sec. 6.8.7; amended Sec. 6.9; amended Sec. 6.9.1; amended Sec. 6.9.2; amended Sec. 6.9.5; amended Sec. 6.9.8; amended Sec. 6.10; deleted Sec. 6.14.3; amended Sec. 6.15.1; amended Sec. 6.16.1; amended Sec. 6.16.2; amended Sec. 6.16.7; amended Sec. 6.16.14; amended Sec. 6.18.1; amended Sec. 6.18.2; deleted Sec. 6.18.3; deleted Sec. 6.18.6; deleted Sec. 6.18.8; amended Sec. 6.18.10; amended Sec. 6.18.13; deleted Sec. 6.18.16; deleted Sec. 6.20.5; amended Sec. 6.20.10; amended Sec. 6.22.1; deleted Sec. 6.22.3; amended Sec. 6.22.6; amended Sec. 6.22.10; amended Sec. 6.23.1; amended Sec. 6.23.2; amended Sec. 6.23.7; deleted Sec. 6.23.9; amended Sec. 6.23.14; deleted Sec. 6.23.17; amended Sec. 6.23.22; amended Sec. 7.2.2; amended Sec. 7.2.3; amended Sec. 7.3.2; new insertion Sec. 7.4.2; amended Sec. 7.6.1; amended Sec. 7.7; amended Sec. 7.8; amended Sec. 7.9; deleted Sec. 8.1.1; amended		

Sec. 8.2.5; amended Sec. 8.3; amended Sec. 8.3.1; amended Sec. 8.3.2; amended Sec. 8.4.2; amended Sec. 8.5.1; amended Sec. 8.5.4; amended Sec. 8.7; deleted Sec. 8.8.1; amended Sec. 8.9.2; deleted Sec. 8.10; new insertion Sec. 9.2; amended Sec. 10.1; amended Sec. 10.2; amended Sec. 11.2; amended Sec. 11.4; deleted Sec. 13.1; amended Sec. 14.1; amended Sec. 14.4.2; amended Appendices LFG Analysis suit; amended, LFG Monitoring Protocol….; amended, Action Plan-Perimeter Borehole (Gas in Perimeter borehole); new inclusion, Action Plan (Part 1) Surface and Subsurface fire control; amended, Action Plan (Part 2) Surface and Subsurface fire control ; new insertion Action Plan Electricity Grid Failure; amended Action Plan Damage to Gas Infrastructure; amended Action Plan Gas Booster Failure; amended Action Plan Removal of blockage from a permanent gas line due to liquid build up; amended		
Edition VII.1 Sec. 1.1.2; revised. Emergency Plan: Removed	Name change: “Gas to Energy” to “Landfill Gas Department”. To clarify connection between GMP and other Landfill Gas documentation. Generic Emergency Plan available on OBi.	June 2017
Edition VIII Definitions and Abbreviations: Removal of VAB: Vented Air Burner Sec.1.1.1; revised Sec. 2.12; “gas to energy” replaced with “Landfill Gas” Sec. 3.2; new section on H_2S Sec. 5.2.3; deleted	Review of all document with specific attention on hydrogen sulphide	February 2019

Sec. 5.2.6; revised Sec. 5.2.8; deleted Biffa Landfill Gas Structure: revised Sec.6.3.2; revised Sec. 8.9.5.2; revised Sec. 8.9.5.6; revised Sec. 8.9.6: deleted Sec. 14.6.1; revised Sec. 14.6.2; revised Appendix: Complaints reporting procedure; revised		
Edition IX Sec. 1.1.4 amended Sec 4.3 amended Sec. 6.4.1 amended Sec. 6.9.2 amended – '20-40mm gravel pack' Sec. 6.21.5 Sec. 7.3.6 added, use of bypass lines Action Plans Action Plan: surface & subsurface fire control part 2 – Box line 3 amended Appendices 00124300 Title amended	2020 Review	November 2020

Definitions & Abbreviations

Bentomat: Is a liner (can be installed as part of the capping structure at a landfill), consisting of a layer of bentonite clay encapsulated between 2 textiles which are needle punched together.

Biffa's 5 Pillars: This forms part of Biffa's business strategy, providing clear objectives for the business group and its individual operating divisions. The group business plan sets out agreed KPI's in areas of "Working Together Safely", "First Choice for Customers", "Easy to do Business with", "Building Pride in Biffa" and "Growing Profitably". These all underpin the overall vision, mission, targets and values identified in the plan.

Boosters: Also called "blowers" these are items of plant installed as part of the gas collection / management system and provide a means of moving landfill gas from the body of the waste mass through to the landfill gas engines by imparting a negative pressure on the landfill side of the booster and a positive pressure on the delivery to the engines.

Collection Main: The main gas carrier pipework typically installed around the landfill site.

Condensate: As landfill gas is extracted from the body of the waste through the collection of gas pipe work, it cools. As it cools, the gases ability to retain moisture decreases forming a liquid termed condensate. It is usually grey or dark grey in colour and has a distinct pungent odour.

Construction Quality Assurance (CQA): In order to achieve the high degree of reliability in the gas collection and utilisation system installed at their landfill sites, Biffa has developed a series of installation / construction standards for its gas collection and utilisation plants. The requirements of these standards have been documented in a Construction Quality Assurance manual; the procedures / standards detailed in the CQA manual are reviewed on a regular basis to ensure that Biffa is working at the leading edge of development.

G.C.L: Geosynthetic clay liner.

GasSim: A software based modelling tool, accepted by the UK Environment Agency to simulate the fate of landfill gas arising from managed or unmanaged landfill.

Leachate: Landfill leachate is a liquid, which is formed when liquid seeps through the body of the landfill, extracting substances from the waste containing numerous contaminants depending upon the constituents in the landfill mass. Landfill leachate is usually dark in colour, can have an oily texture and has a pungent odour.

Perched Leachate: This is the term given to the condition where leachate when it seeps back down through the body of the landfill is retained or is prevented from seeping back to the base of the site by an impervious layer of material in the waste.

Permanent Gas Systems: A gas collection system considered to have an infinite design life, generally installed in an area of the landfill site where tipping has been completed.

Regulatory Body: This term is used to include the following bodies, The Environment Agency, Scottish Environment Protection Agency (SEPA), Northern Ireland Environment Agency (NIEA), National Resources Wales (NRW), Local Authorities etc.

Sacrificial Gas Systems: A sacrificial system is one of less than 6 months design life and / or constructed during infilling or as part of a temporary capping or sealing system to scavenge gas for odour control.

Safi: A company specialising in the design, development and sale of industrial valves.

Service Pipe: A gas collection pipe that feeds into the collection main generally through a gas manifold.

Temporary Gas Systems: Generally a temporary system is one, which has a finite design life and is not intended to form part of the final gas collection system. Typically this will include impact well installations.

1.0 Gas Management Plan

1.1 Interaction with other Documentation

1.1.1 This document 'Landfill Gas Management & Control Specification' has been put together to meet in part the requirements of the Environmental Permitting Regulations (England and Wales) 2010 which were introduced on 6 April 2010, replacing the 2007 Regulations and the Landfill Gas Industry Code of Practice (Initial issue) March 2012. Additionally, this edition (VIII) has been revised to include relevant information relating to to elevated levels of hydrogen sulphide being measured within the landfill gas at some sites and the control procedures to be followed.

1.1.2 This Gas Management Plan forms part of Biffa's Landfill Gas management procedures. Additional Landfill Gas procedures and guidance notes, produced to complement this GMP can be found on Biffa's intranet, On Line Business Information system (OBi).

1.1.3 Where a landfill operates under a former Environmental Management License (e.g. Waste Management License) rather than a modern Environmental Permit, the management systems described in this Gas Management Plan will be revised to reflect the results of a site specific risk assessment, potential environmental impact, gas production levels, age and state of the landfill.

1.1.4 This document outlines the 'generic' installations, utilisation technologies and operational standards that will be applied by Biffa Waste Services Limited ("Biffa") to its landfill gas management systems. If this document is being supplied as part of an application for an operating permit for a landfill site, then any variations from these generic conditions will be outlined in any site specific documentation forwarded to the Environment Agency when applying for the permit.

1.1.5 Additional documentation and systems including that of the 'Construction Quality Assurance for Gas Collection Systems, Gas Wells, Pipes and Testing' (for the

purposes of this report this document will be known as the CQA Manual) provide evidence demonstrating Biffa's compliance with the requirements of the permit issued by the Environment Agency (or other regulatory body).

1.1.6 A number of cross-references to various sections within the CQA documentation are made throughout this document. The reader is recommended to have a copy of the CQA manual available for reference.

1.1.7 This particular document describes the specification and expected standards for the installation of the gas collection and utilisation systems, as well as the operational practices and checks that will be undertaken to ensure that Biffa meets the Regulatory Body Best Practice Guidance. The associated CQA documentation describes in detail how the specifications quoted in this document will be checked and managed to ensure compliance.

1.1.8 Provided on page 6 is a 'route map' showing the stages of the landfill gas management plan that will be operated by Biffa. This 'map' shows that Biffa will adopt a risk based management approach to gas control at each of its landfill sites.

1.2 Health & Safety

1.2.1 As a responsible operator, Biffa takes its obligations under the Health & Safety at Work Act very seriously and although it will always strive to satisfy any environmental issues that may arise, if these are in conflict with its health and safety obligations, then precedence will be taken in complying with the latter to protect personnel and or equipment/ plant that may be affected by its actions.

All landfill sites will have their own health and safety controls and systems and in all cases these should be pre-eminent; the advice in any Industry Code of Practice should never overrule site rules, risk assessments and data. Where there is a perceived contradiction or conflict between the site's systems, contractor's own systems or Codes of Practice, the contradiction should be raised with the site's management team prior to undertaking any work.

In all cases, site specific risk assessments should be in place before any activities are undertaken.

Any accidents or incidents should be advised to the site's operational management team as soon as is practicably possible after the accident/incident occurs.

1.3 Dangerous Substances and Explosive Atmosphere Regulations

1.3.1 DSEAR (Dangerous Substances and Explosive Atmospheres Regulations 2002, Regulations amended 1st June 2015) is the way the UK has enacted ATEX directives. These regulations require employers to control the risks from fire and explosions.

1.3.2 Dangerous substances can put people at risk from fire and explosion. DSEAR regulations place a duty on employers and the self-employed to protect people from the risks from fires, explosions and similar events in the workplace. This includes members of the public who may be put at risk by work activity.

1.3.3 Dangerous substances are any substances used, or present at work that could, if not properly controlled, cause harm to people as a result of a fire or explosion. The most relevant dangerous substances for the landfill environment are the gases associated with it such as methane, hydrogen sulphide and hydrogen.

1.3.4 In response to meet the requirements of DSEAR and produce some form of common approach throughout the waste industry, a series of Industry Codes of Practice have been produced, supported by the Environmental Services Association (ESA).

1.3.5 Five codes of practice have been produced, all of which relate to activities carried out by a typical Resource and Recovery facility. At the time of preparing this edition of the Gas Management Plan, some of the ICoP's remain in draft form Biffa are working to the principles described in each of the documents to ensure compliance with the Regulations.

1.3.6 The ICoPs that are in circulation are detailed below:

- ESA ICoP1, Edition 1: Nov. 2005, DSEAR Implementation for the Waste Management Industry.
- ESA ICoP2, Edition 2 (Final Draft Version 4): Nov. 2006, Area Classification for Landfill Gas Extraction, Utilisation and Combustion.
- ESA ICoP3, Edition 1: May 2006, Area Classification for Leachate Extraction, Treatment & Disposal.
- ESA ICoP4, Edition 1 (Final Draft Version 7): October 2006, Drilling into Landfill Waste.
- ESA ICoP5, Edition 1 (Final Draft Version 9): Nov. 2006, Landfill Operations Involving Potentially Explosive Atmospheres.

1.3.7 One of the most important stages in achieving compliance with DSEAR is to undertake an assessment and identification of where potential explosive or flammable atmospheres may be present and Zone them accordingly, (the Zone being dependent on the probability that an explosive or flammable atmosphere could exist), this process is known as Area Classification.

1.3.8 Any person undertaking works of any nature on a Landfill Site must refer to the ICoPs for further information. Biffa have typical area classification drawings of operating equipment that can be supplied as a guide for persons working in the vicinity of such plant and equipment.

1.4 Document Review Process

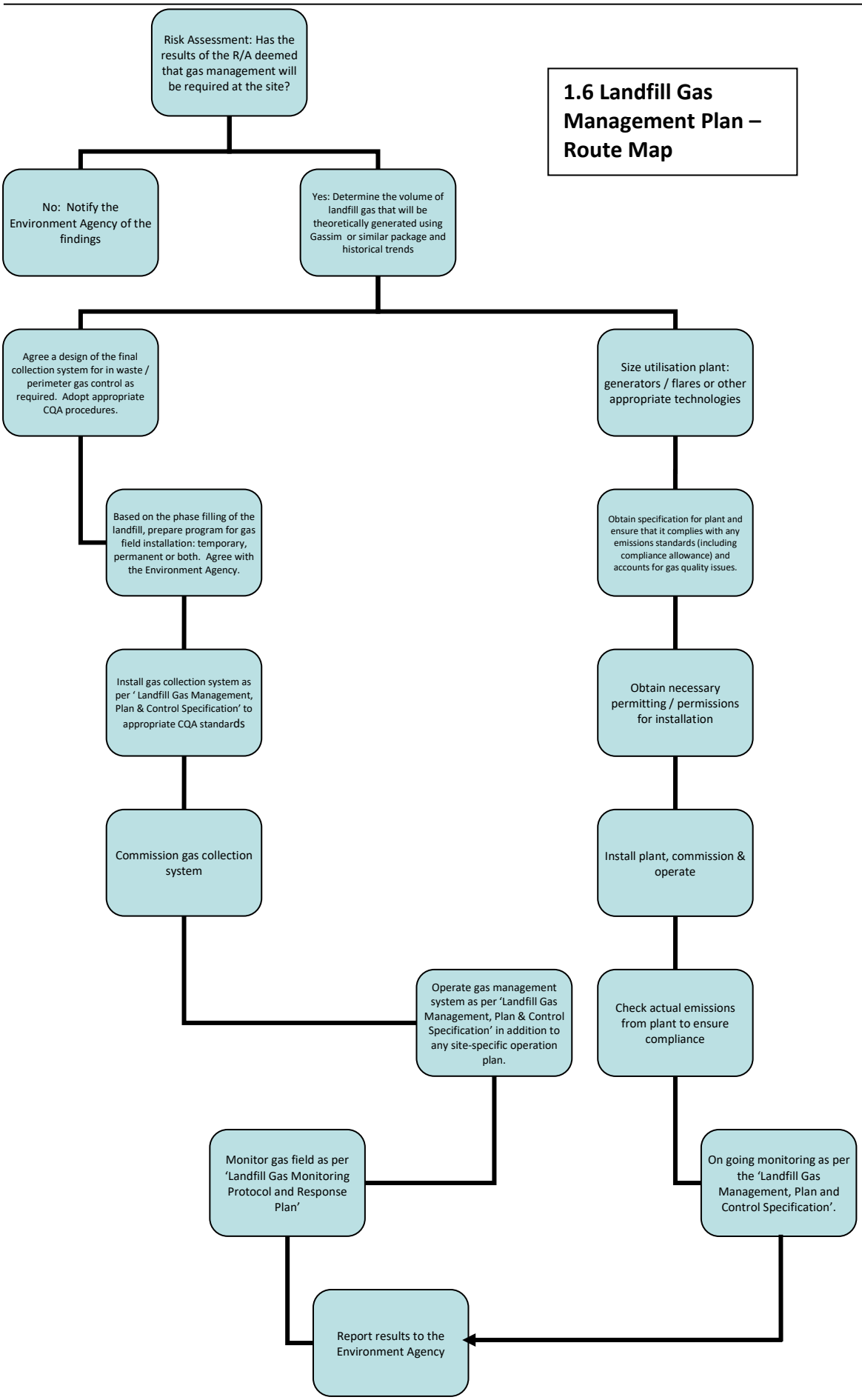
This gas management plan will be subject to a review and will be triggered by any of the following:

- Changes to health and safety legislation affecting the detail as described in the 'Plan',
- Changes in 'Best Practice' impacting on the operations or methodologies described in the 'Plan'.
- Advancements or development of new technologies affecting the management of landfill gas.

1.5 Amendments to the Gas Management Plan

Following a review of the 'Plan', Biffa reserve the right to amend the detail herein contained.

1.6 Landfill Gas Management Plan – Route Map



2 Landfill Gas Management Protocol

2.1 Risk Assessment (Extract from LFTGN 03)

2.1.1 A risk based strategy

The environment Agency's Strategy for the future regulation of landfill gas is based on environmental outcomes. This places great emphasis on emissions monitoring and compliance assessment. The strategy augments, but does not replace, the existing philosophy of best practice regulation of landfill gas infrastructure, which retains a key role.

At a fundamental level, this strategy requires an understanding and quantification of landfill gas through risk assessment and the development of a conceptual model of the site. The conceptual model and proposed level of risk assessment should be the subject of early pre-application discussions with the regulator.

The risk assessment approach involves:

- The assessment of potential impacts on local environment, health and amenity.
- The development of a Gas Management Plan.

The Gas Management Plan includes:

- Management options, procedures and collection efficiency determination;
- Emissions monitoring and assessment from various parts of the landfill gas infrastructure.

The feedback of monitoring and assessment information enables the validation/improvement of both the conceptual model and the Gas Management Plan. This provides opportunities for improvements based on environmental outcomes.

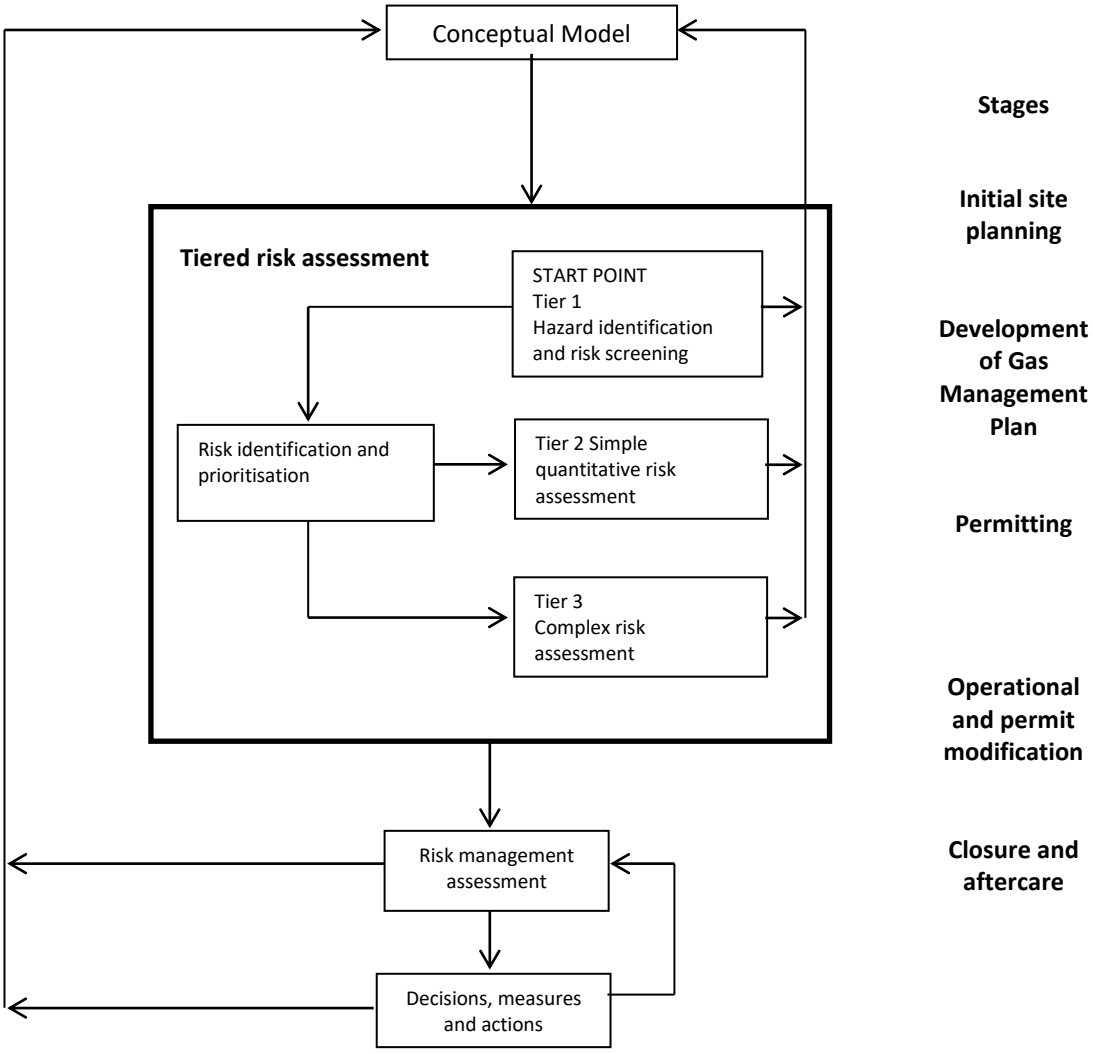
2.1.2 Risk assessment framework

The regulator requires the use of a structured approach to the assessment of the risks posed by a landfill to human health, the environment and local amenity. This is a pre-requisite for the permitting of all landfills under the Environmental permitting Regulations and a fundamental part of preparing a Gas Management Plan. The

ongoing assessment of risk for operational sites is a requirement for the maintenance of an EPR permit.

Risk assessment should be a transparent and practical process that aids decision making. The recommended framework for environmental risk assessment and management is described in *'Guidelines for environmental risk assessment and management' Defra 2011*[1]. This consists of a tiered approach where the level of effort put into assessing each risk is proportionate to its magnitude and complexity.

A conceptual approach to the tiered risk assessment is shown below.



This process emphasises the:

- Importance of developing a robust conceptual site model at the risk screening stage, based on a source-pathway-receptor approach that is continually reviewed and updated as new information is collected;

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[1]Guidelines for environmental risk assessment and management' Defra 2011: Also known as "Green Leaves III"; Revised Departmental Guidance, Prepared by Defra and the Collaborative Centre of Excellence in Understanding and Managing Natural and environmental Risks, Cranfield University.

- Need to screen and prioritise all actual and potential risks before quantification;
- Need to match effort and resources in evaluating potential risks to the magnitude of environmental damage that could result from each hazard;
- Need for an appropriate level of measures to manage the risks;
- Iterative nature of the process, with annual reviews being an integral part

2.1.3 The assessment of risk from landfill and gaseous emissions must be developed in conjunction with the risk assessment for aqueous emissions. The guidance below focuses on the assessment of gaseous risks.

Stage 1: Hazard identification and risk screening

The initial development of the conceptual model and provides the basis for pre-application discussions for planning applications or for existing sites seeking a permit or a permit modification.

Stage 2: Simple quantitative risk assessment

Submitted in support of the planning application and forming part of the Environmental Impact Assessment for the site or in support of a permit application

Stage 3: Complex quantitative risk assessment

Submitted in support of a permit application for sites where a stage 2 approach is insufficient due to either the significance of the risks posed by landfill gas at the site or the complexity of the issues associated with landfill gas. The Gas Management Plan should be developed from the risk assessment. Continuous review of site investigations and monitoring data produced as part of the Gas Management Plan will indicate whether:

- The data validates the conceptual model
- There is need to modify/update the conceptual model and the Gas Management Plan

Stage 4: Completion

A thorough review of the conceptual model and monitoring data will be undertaken to determine whether the site meets the surrender test and to confirm that it no longer poses any pollution risk.

2.2 The flow diagram, sec. 2.13 on page 12, shows the process of the landfill gas management protocol that will be operated by Biffa.

2.3 If the results of the risk assessment carried out finds that a gas management system is required, then from the design to the installation of any gas collection system an appropriate level of CQA will be applied.

2.4 A proposed collection system design for the site will be developed by Biffa which will address the issues identified in the assessment where a significant risk has been identified.

2.5 As part of the design criteria used for the system, gas network analysis for the proposed gas collection system will be undertaken to determine the pressure losses through the gas collection system. The results from this analysis will then be used to ensure that the correct sized pipe work and gas booster system is installed.

2.6 When a conceptual design has been formulated this will be reviewed by various bodies within Biffa including, where appropriate Operations division (for the landfill site in question), Biffa Landfill Gas and where appropriate Biffa Safety, Health and Environmental (SHEQ) divisions or the Environment Agency. Failure at this point to accept the design at this stage will result in the Biffa gas management team producing an alternative conceptual design. This procedure has been incorporated into the CQA (Construction Quality Assurance) system; the final design being signed off by Biffa Landfill Gas.

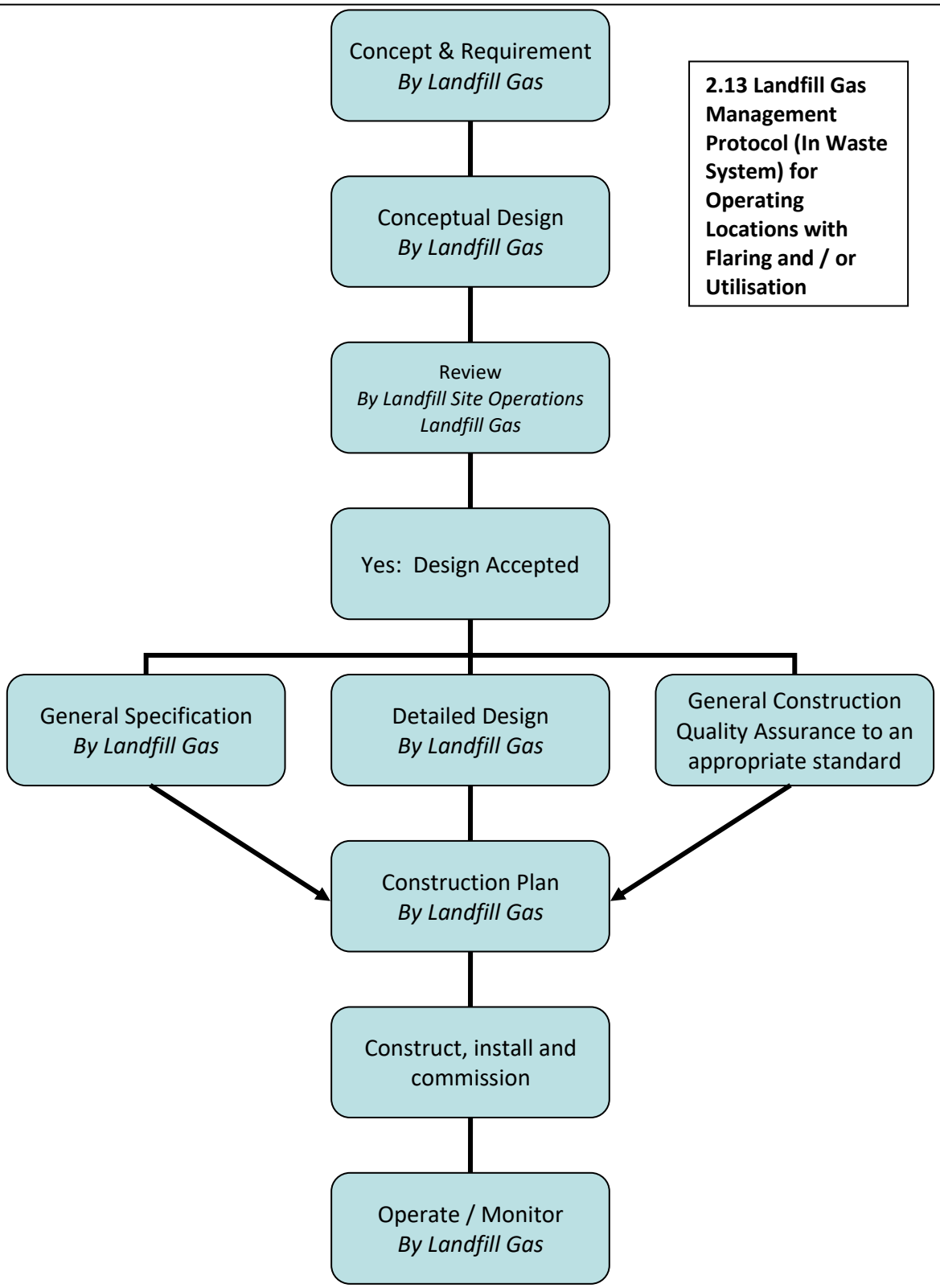
2.8 The construction of the permanent gas collection system will be subject to the CQA protocols. The construction of temporary and sacrificial systems will be subject to an appropriate level of CQA; reference should be made to the current version of the CQA manual for further details.

2.9 For the avoidance of doubt the following definitions shall apply for temporary and sacrificial systems:

2.10 Temporary Systems: Generally a temporary system is one, which has a finite design life and is not intended to form part of the final gas collection system. Typically this will include impact well installations

2.11 Sacrificial Systems: A sacrificial system is one of less than 6 months design life and / or constructed during infilling or as part of a temporary capping or sealing system to scavenge gas for odour control.

2.12 After installation and commissioning each section of the gas collection system will be handed over to the Landfill Gas operations team, who will operate and monitor as per the specifications provided later in this document.


Concept & Requirement
By Landfill Gas
Conceptual Design
By Landfill Gas
Review
By Landfill Site Operations
Landfill Gas
Yes: Design Accepted
General Specification
By Landfill Gas
Detailed Design
By Landfill Gas
General Construction Quality Assurance to an appropriate standard
Construction Plan
By Landfill Gas
Construct, install and commission
Operate / Monitor
By Landfill Gas
2.13 Landfill Gas Management Protocol (In Waste System) for Operating Locations with Flaring and / or Utilisation

3.0 Managing Landfill Gas

3.1 Landfill gas (LFG) is defined in the Landfill Gas Management ICOP (September 2011) as *"the end product of the decomposition of biodegradable waste. Methane (CH_4), a core component of LFG is a highly potent greenhouse gas having at least 20 times greater global warming potential effect than that of carbon dioxide (CO_2)"*. The gas produced is typically a mixture of approximately 60% methane and 40% carbon dioxide, plus a small quantity of air and trace gases. Methane is flammable at concentrations between 4.4 – 16.5% by volume in air. The production of landfill gas is a by-product of the land filling of waste containing biodegradable matter, this type of material being present as part of the domestic and commercial/industrial waste streams that can be accepted by a typical landfill site. The quantity of biodegradable material has reduced with the gradual implementation of the EU Landfill Directive.

3.2 Hydrogen sulphide present within the landfill gas has become an issue at some sites; work undertaken by the Health and Safety Laboratory and published by the Health and Safety Executive[2] has been taken into account in determining safe working practice when working with landfill gas. Further details relating to the management of hydrogen sulphide and landfill gas can be found in the Biffa Landfill Gas guidance note GN/G/036. The measures in place to control landfill gas (methane) will also mitigate the issues relating to hydrogen sulphide.

3.3 Without control and management, the migration of gas from a landfill can give rise to the risk of fire or explosion and can cause nuisance as a result of the odorous trace components of the gas. The lining system that will be used to contain the waste at the site will minimise the risks of sub surface gas migration from the site, and will act as a containment barrier, improving the collection efficiency of any control system.

3.4 A number of options exist for the control and management of landfill gas at a site. In summary these are as follows:

a). Disposal of the gas by pumping and controlled combustion (flaring),
b). Gas utilisation for generation of heat or power,
c). Other technologies are being developed, such as ceramic flares, will be considered by Biffa.

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[2] Good control practices for workers' exposure to gases in landfill; Sampling and Measurement Report; Research Report, HSE 2011.

3.5 Options a) and b) are considered by the Company to be the most practical options for the control of landfill gas at a landfill site. Utilisation of the gas is considered to be the best option, providing that it is commercially and technically viable.

3.6 The actual quantity, and rate of production, of LFG produced at a landfill site would be dependent on several factors including, but not limited to:

- Carbon content of the waste
- The nature of the carbon and the degree of recalcitrance
- The moisture content and distribution of the waste
- Temperature within the waste mass
- Boundary layer formation and existence within the waste matrix
- European Legislation limiting the proportion of biodegradable material contained in waste

3.7 Each of these criteria will be considered during the modelling process to determine the likely gas yield from a site, and their impact will be considered in the design of any control system, with the adverse effects of waste conditions being mitigated (i.e. increase well density or amend well design etc.). For determining the potential volumes of landfill gas generated by a landfill over its life, a modelling package, Gassim (or similar) will be used by Biffa. Historical data will be used, where appropriate, to calibrate any results obtained from the modelling exercise. The actual design process and methodology adopted by Biffa is detailed in the CQA documentation.

4. Gas Extraction

4.1 LFG will travel from areas of high pressure to areas of lower pressure to reduce its potential energy, and it is this principle (The Second Law of Thermodynamics) that is used to capture and recover gas generated within landfill sites. Vacuum relative to atmospheric pressure is applied to the waste through a network of pipes connected to vertical or horizontal wells installed at appropriate centres throughout the waste mass. This creates artificial areas of low pressure to which gas will be encouraged to flow.

4.2 The exact flow pattern through the waste matrix is difficult to predict as it is affected by boundary layer conditions. Vertical travel is often restricted by cover soils and/or perched leachate, often causing local pressurisation. Lateral movement is again governed by soils and bund/ engineering structures. Well centres are generally determined based on waste types, depth, moisture content and density, and how these factors impact on the radius of influence of the well, with wells typically installed at a maximum of 40 metre centres.

4.3 As the gas travels into the well and through the pipe system, expansion occurs and the associated cooling produces condensate. This condensate is generally acidic, resulting from Volatile Fatty Acid (VFA) accumulation, with elevated Chemical Oxygen Demand (COD) loading. Condensate must be intercepted, controlled and removed to prevent pipe blockages. Management of condensate will normally be done by returning the liquid to the waste mass or disposal to an on-site treatment facility. Condensate management is described in section 6.20 of this document.

4.4 The control of LFG would normally be undertaken during two stages of a sites operation - prior to final cap installation, and after the installation of the capping and restoration soils systems. Generally the installation of control systems during active filling or prior to cap placement is temporary or sacrificial in nature, with permanent system construction only taking place after cap placement. Similarly condensate control systems are designed and constructed to account for the nature of the installation (i.e. temporary or permanent).

4.5 The permanently installed system will be designed such that when land filling activities on the site cease, it will be adequate, reliable and suitable to be operated on an unmanned basis, requiring only periodic checks at the site. This protocol will be subject to a regular review.

4.6 The basic philosophy of constructing the permanent perimeter collection network in advance or associated with the development of the engineering of the waste cells shall be followed throughout the development of the site, with temporary systems being used for early gas recovery. The temporary pipe system shall be installed as per the methodology provided in the Biffa Landfill Gas Construction Quality Assurance Manual.

5. Management Options

5.1 The structure for the Biffa Landfill Gas department is given in the organogram later in this section.

5.2 The responsibilities of the personnel within the team are outlined below:

5.2.1 Site Manager: Shall hold the records and ensure that they are complete and, where possible, compliant with permit requirements. Shall undertake a periodic review (minimum quarterly) with the gas operations team.

5.2.2 Regional Controller (Gas): Shall ensure that sufficient resources are made available to safely complete monitoring tasks, shall ensure that a review of monitoring data is undertaken and that the results and trends are compliant with permit requirements. Shall ensure that monitoring and maintenance is completed in a safe and timely manner.

5.2.3 Operations Manager (Gas): Shall ensure that the Regional Controllers are adequately trained and resourced, shall arrange a periodic review (minimum quarterly) of monitoring results with the gas operations team, and if appropriate, the Site Manager.

5.2.4 Environmental Control Advisor (ECA): Shall collate data from the Landfill Gas operations team, for submission to the regulator by the site manager or other members of the landfill team.

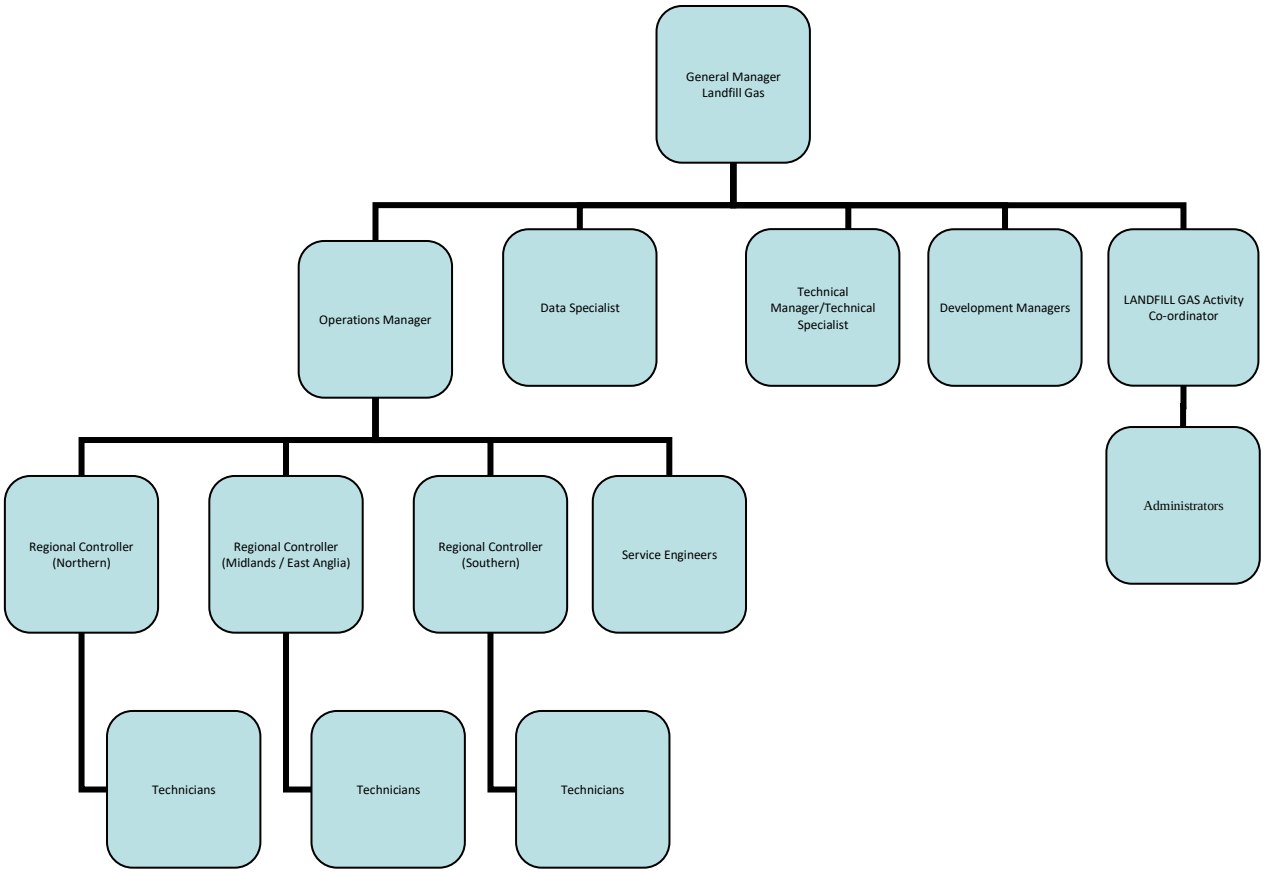
5.2.5 Technician (Gas): Shall be responsible for sampling and analysis of gas fields and systems in accordance with the requirements of the permit, shall undertake basic and routine system maintenance and adjustment.

5.2.6 Technical Manager/Technical Specialist/Data Specialist or General Manager (Gas): Shall arrange a periodic review of the data (minimum frequency annually) to ensure that the site is being operated to plan. Shall assess recovery efficiencies against theoretical models, and shall advise how/where efficiency can be improved. Shall revise operating protocols as appropriate, with the agreement of the Site Manager and the Regulator, to ensure that data capture and interpretation is optimised.

5.2.7 Service Engineer: Shall optimise the performance and maintenance of electrical/mechanical plant and equipment used to extract and deliver landfill gas for utilisation and disposal. Shall ensure that the plant and equipment used is suitable for purpose, and is installed, maintained and operated compliantly with current guidance and legislation.

5.2.8 Flare, Generator and Booster Maintenance: Shall be undertaken by competent persons and generally in accordance with manufacturers' requirements. Persons employed to undertake such works may be either sub-contract or directly employed by the company. All employees used to complete maintenance works shall be inducted in site safety rules and advised of specific operating requirements prior to commencing works.

Biffa Landfill Gas Structure



6. Control Measures

6.1 Gas Infrastructure Construction (for permanent and temporary installations)

6.1.1 A number of methods for installing wells are available and in general use. The most rapid method of installing a large number of wells on uncapped or shallow areas of waste is to use impact wells. This technique is most appropriate for the elimination of odours or to augment gas utilisation schemes, however, this system can be used effectively as part of an overall gas control scheme, and can be replaced or reinforced quickly if required.

6.1.2 Where appropriate all parts of the gas collection network unless otherwise stated will be manufactured from medium density polyethylene (MDPE) or high density polyethylene (HDPE) in accordance with DIN 8074 and DIN 8075 standards.

6.1.3 Other manufacturing standards (or similar) that will apply to the materials used in the installations are:

BS7336 (1990) (Gas Specification): 20^{o}C Hydrostatic Test (10,000 hours).

BS EN 1555/3: 2010 + A1: 2012, ISO 4437-3 (2014): Plastics Piping Systems for the Supply of Gaseous Fuels – Polyethylene (PE) – Part 3: Fittings

The supplier shall provide a certificate of conformance to the above standards.

6.1.4 The specifications BS7336, BS EN1555/3 and ISO 4437/3 also cover standards for joint strength (adhesion and crush), dimensional stability, material tests, tensile locking for sockets <75mm, Tapping Tee impact, pressure loss across Tapping Tee and Branch Saddle pull off.

6.1.5 WIS 4-24-01 (1998) Water Industry Specification for mechanical fittings and joints including flanges for polyethylene pipes for conveyance of cold potable water for the size range 90 to 1000mm inclusive made of metal or plastics or a combination of both.

6.1.6 BS EN 12201; Parts 1 - 5 (2011) Specification for blue polyethylene (PE) pressure pipe for cold potable water (nominal sizes 90 – 1000mm for underground or protected use).

6.1.7 WIS 4-32-08 (2002) Water Industry Specification for site fusion of PE80 ad PE 100 pipe and fittings.

6.1.8 WIS 4-32-17 (2000) Water Industry Specification for black polyethylene pressure pipes for potable water above ground or sewage (nominal sizes 90 – 1000mm).

6.1.9 BS EN 12201: Part 3 (2011) Specification for PE80 and PE100 Electro fusion fittings for nominal sizes up to and including 630mm.

6.1.10 WIS 4-32-15 (1995) Water Industry Specification for PE80 and PE100 spigot fittings and drawn bends for nominal sizes up to and including 1000mm.

6.1.11 DIN16963 – Part 1 – 1980 High-density polyethylene (HDPE) fittings dimensions, type 2.

6.2 Impact Wells

6.2.1 Impact wells are installed by using an excavator mounted vibrator (EMV) and a metal probe, a thermoplastic or metal liner, typically 32 - 90 mm in diameter and suitably perforated, complete with a gravel pack. The well is then sealed with a bentonite seal. Impact wells are installed at appropriate centres, depending on the nature of the emplaced waste and the nature of the waste surface. Impact well systems are usually operated at low wellhead pressures relative to atmospheric pressure to reduce air ingress.

6.3 Impact Gas Well Installation

6.3.1 Prior to works commencing the contractor is required to confirm safe access into the site (other than in circumstances where access issues have been previously documented) and to the working area and to complete the necessary risk assessments.

6.3.2 Prior to mobilisation the contractor is to provide detailed method statements and risk assessments for the construction and a Safety Plan created; these are to be

reviewed in all cases by a member of Landfill Gas. The procedures as laid out in the Biffa Contractor Control Protocol are to be followed.

6.3.3 An area is to be set out, and the depth to liner established prior to commencement.

6.3.4 CQA Supervision for temporary installations will not be required. For those incorporating impact wells into the permanent works, CQA supervision is required. CQA supervision will be undertaken by personnel who are competent, experienced and suitably qualified; and could be by employees of Biffa or external bodies.

6.3.5 Well centres will depend on the effectiveness of surface sealing in the location of the pin wells but in general should be @15 metres but could be in the range 10 to 25 metres. The installation of the wells should establish a pattern where the rows are staggered to encourage improved falls.

6.3.6 For all impact well installations, a final inspection should be undertaken by a Landfill Gas representative.

6.4 Impact Well Packing & Sealing

6.4.1 The basic specification for construction is detailed as per the Biffa drawing no.00120303 Revision B 'Typical Impact Well Details' (see Typical Arrangement Drawings).

6.4.2 Bentonite seals are to be fully hydrated (where possible the use of granular grade bentonite should be adopted).

6.4.3 The minimum depth of bentonite seal should be 1 metre and could be deeper depending upon site-specific conditions. Identification of any site-specific issues affecting the ability to form a seal around the wells should be agreed with the site manager prior to commencing installation.

6.4.4 No impact well holes will be left incomplete or unsealed at the end of the working day. The contractor is not to install unless all the necessary plant and materials are on site.

6.4.5 All impact wells are to be fitted with a LDPE push fit bottom end cap and a flexi end cap and are in all circumstances to be secured using Jubilee clips, or equivalent devices.

6.5 Impact Well – Connection

6.5.1 An elbow is to be fitted to the top of the impact well, with a minimum of 1 metre of pipe connected to the same. A tee connection is only to be used where a well is to act as a dewatering point.

6.5.2 The service pipe connecting groups of wells is to be laid to fall.

6.5.3 The minimum diameters of service pipes will be for:

A maximum of 6 wells on 63mm (min 6 bar SDR 17)
A maximum of 12 wells on 90mm (min 6 bar SDR17)
A maximum of 24 wells on 125mm (min 6 bar SDR 17)

6.5.4 Sample taps or blanking plugs (1/4" BSP tapered thread or similar) will be installed on the point of connection at the control valve location.

6.5.5 Typically one control valve to be installed based on the pipe diameters shown in section 6.5.3, unless operational circumstances dictate otherwise.

6.5.6 Ball valves (Plasson compression fit or similar) to be used to regulate the flow from each well cluster.

6.5.7 Electro fusion tees to be used for all 63mm connections to service pipe work.

6.5.8 90 x 63 or 125 x 63mm reduced branch tees are to be used for connections onto larger service pipes.

6.6 Permanent Drilled Gas Wells

6.6.1 The most common and preferred well installation technique uses rotary drilling methods, with the drilling operation terminating typically at 15m below ground level, and/or at 80% of the depth of waste or a minimum of 3.0m above the waste cell lining system, assessed by site specific risk assessment. The wells are drilled to create a hole diameter of 350 - 450 mm, with drill returns logged in accordance with BS 5930: 2015; Code of Practice for site investigations, modified to take particular account of the degree of saturation of the waste encountered. Logging of the returns allows for assessment of the boundary conditions that occur within the site. Details of the logging procedure and record sheets are contained within the CQA documentation.

6.6.2 Invasive drilling of this nature is undertaken in accordance with the requirements of the UK Institution of Civil Engineers Guidance for the Drilling of Contaminated Land Sites and the ESA[3]; Waste Management Industry Code of Practice, Drilling into Landfill Waste; ESA ICoP4 & the British Drilling Association (BDA) Publication 'Guidance for the Safe Intrusive Activities on Contaminated or Potentially Contaminated Land: 2008, and BDA Publication, Health & Safety Manual for Land Drilling 2015; A Code of Safe Drilling Practice. The drilling contractor employed to install using rotary techniques shall be obliged under the terms of any contract to conform to these guidance and any other Health & Safety regulations prevalent at the time.

6.6.3 Upon completion of the formation of the hole a well liner shall be installed, of thermoplastic (or similar) construction, typically using either:

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[3] Environmental Services Association

Nominally 125, diameter MDPE minimum PN10 SDR 11 (Check with drilling companies) or other compatible diameter of liner as agreed with Biffa Landfill Gas.

6.6.4 The liner shall be perforated for its lower portion to produce sufficient transfer of vacuum into the waste matrix. The pipe may be either holed or slot perforated as appropriate, but shall not allow the passage of the gravel pack into the well body - perforation size shall be selected to achieve this aim.

6.6.5 A gravel pack and bentonite seal shall be installed to complete the permanent well, with a compatible wellhead unit, including a sample tap and control valve, fitted to the well liner to allow for flow adjustment. The permanent and completed installation will include for a secure head works enclosure.

6.7 Permanent Drilled Well Construction

6.7.1 The installation / construction of permanent gas wells will be subject to the Biffa Landfill Gas CQA process.

6.7.2 A typical design detail drawing, 00121902 for a gas well construction is contained in the drawings section of this manual.

6.7.3 Prior to mobilisation the contractor is required to inspect his access to site (other than in circumstances where access issues have been previously documented in any pre-tender H&S plan) and to complete the necessary risk assessments.

6.7.4 Prior to mobilisation the contractor is to provide detailed method statements and risk assessments for the construction; these are to be reviewed in all cases. Any Safe System of Work should comply with the requirements of the waste industry DSEAR Code of Practice ICoP4.

6.7.5 The default depth of drilling for a gas well or other except in exceptional circumstances (site specific and risk based) is to be 15 metres.

6.7.6 Minimum drilled hole diameter to be 350mm.

6.7.7 Favoured drilling method to be rotary core barrel.

6.7.8 Wells to be set out by a surveyor or other competent person who will be responsible for checking the depth to the landfill liner and marking out accurately the location of the gas well.

6.7.9 Minimum drill clearance from the liner to be either 20% of the well depth or 3 metres (whichever is the greater).

6.7.10 Well liners to be PN10 SDR11 (minimum) welded. Only under exceptional circumstances shall wells using screwed sections of liner be allowed. ;

6.7.11 Perforation of gas wells to be either holed or slotted, to a design as agreed with Biffa Landfill Gas. Holes to be drilled to typically 10mm diameter, ideally drilled to create a total perforated area between 2A and 3A where A is the cross sectional area of the well liner, unless inappropriate to do so.

6.7.12 Wells are to be installed with end caps to their base to reduce initial fouling.

6.7.13 The minimum liner diameter shall be 125mm, the maximum diameter 200mm

6.7.14 The minimum length of plain casing to the site surface to be 3 metres.

6.7.15 The completed well liner is to be finished off at 1metre above ground level where practicable.

6.8 Contingency Plan for Accidental Penetration of the Engineered Base.

6.8.1 Biffa has developed a contingency plan that will be invoked in the unlikely event of an accidental penetration of the engineered base of the landfill site. This particular action plan has been developed on the assumption that the drilling technique used is that of a barrel auger design. Where other forms of drilling technique are to be employed at a site, a contingency plan will be developed with the drilling company prior to commencement of drilling operations on the site.

6.8.2 With the barrel auger removed from the drill hole, approximately 50kg of bentonite clay, fully hydrated, will be poured down the drill hole.

6.8.3 The barrel auger will then be inserted into the drill hole and used to compact the bentonite into the penetration of the base.

6.8.4 The addition and compression of hydrated bentonite into the hole will be progressed until the bentonite level is equal to that of the surface if drilling in an operational area with no cap installed, or to approximately 1m below the surface on a capped or restored area. The final metre then being filled and compacted with the appropriate capping or restoration material.

6.8.5 The drill location will be abandoned and an alternative location identified.

6.8.6 The site manager will be notified of the event.

6.8.7 The Environment Agency will be notified via a Schedule notification.

6.8.8 Biffa will carry out an investigation to determine how the event occurred.

6.9 Permanent Wells - Packing & Sealing – prior to capping

6.9.1 The packing and sealing of permanent gas wells will be subject to the Biffa Landfill Gas CQA process.

6.9.2 Drawing no's 00121902, 00122501 and 00124200 provides details of the typical packing and sealing arrangements when sealing through an existing cap or when gas wells are installed through bentomat.

6.9.3 The gravel pack is to comprise clean washed rounded gravel (20 - 40mm) or similar inert stone with less than 5% calcareous material present.

6.9.4 The gravel pack is to extend from the base of the drilled hole to the interface with the underside of the bentonite seal.

6.9.5 A fully hydrated bentonite seal (the installation of which should be supervised and subject to a written procedure) is to be installed from 2 metres below the cap/waste interface. Site-specific conditions may require that a deeper bentonite seal, GCL or boot detail be installed - a site specific Risk Assessment will be undertaken to assess these requirements.

6.9.6 All wells not completed with well heads and bentonite seals are to be temporarily capped and sealed to the following specification: Open hole – ply wood sheet (or similar) to be installed, minimum 20mm thick, to overlap the drilled hole by a minimum of 400mm on all radii. The sheet is to be bedded on a ring of bentonite or wet clay to affect a seal. Either the drill head or a large heavy object to be placed on the sheet to hold it in position.

6.9.7 The drilling contractor is to specify and maintain on site all necessary equipment to seal a well during construction should a break down occur. This is to include circumstances when the drill head is stuck in the hole. The contractor is not to drill unless all the necessary plant and materials are on site. The contractor is required to supply a method statement prior to the works commencing.

6.9.8 All permanent drilled wells are to be fitted with a LDPE push fit bottom end cap and a flexi end cap are in all circumstances to be secured using Jubilee clips, or equivalent devices.

6.10 Permanent Well – Wellheads

6.10.1 All permanent wellheads where possible to be interference fitted using male: female connection method.

6.10.2 All permanent wellheads to be secured to the well liner using Fernco / Flex Seal or similar.

6.10.3 For well diameters of up to 160mm diameter the wellhead shall where possible, be standardised at 90mm unless the well is fitted with a pump or similar device.

6.10.4 For well diameters of 160mm and greater, the well head unit will be specifically designed and constructed to suit the purpose but will as a minimum include a male: female locator.

6.10.5 Drawing no 00120402 provides details of a typical arrangement for the construction of a wellhead with an adjustable sliding seal.

6.11 Permanent Wells – Flow Control

6.11.1 For a standard 90mm wellhead, 80mm NB valves with chemical duty bodies and seals (nylon coated cast iron disc, EPDM body, stainless steel shaft) or similar are to be used.

6.11.2 The preferred valve operation is to be of a butterfly type but others will be considered.

6.12 Extension of Existing Wells

6.12.1 Where possible, gas wells are to be extended in solid casing and maintained operational.

6.12.2 In all other circumstances, a site-specific assessment is to be completed to include detailed Safe Systems of Work that not only provide a safe methodology for carrying out the task but also for the prevention of odour release. These method statements are to be prepared and reviewed prior to the works commencing. Further guidance on producing Safe Systems of Work involving landfill gas can be found in Waste Industry DSEAR Guidance, Industry Code of Practice, ESA ICoP 5.

6.13 Well Connections

6.13.1 Permanent connection to the well to be constructed as per the Biffa well head detail. This assumes that condensate is to be drained away from the well in all cases.

6.13.2 Where flow and drainage cannot be encouraged away from the well, a site-specific design shall be developed. This shall include revisions to the standard wellhead detail if necessary.

6.13.3 Temporary connections to the wells are to be established to fall and drain away from the well. They shall incorporate a length of flexible pipe to accommodate expansion and contraction of the pipe. Double Jubilee clips or similar devices are to be used to connect the wellhead to the flexible pipe and onto the service pipe.

6.13.4 If the temporary connection is to be in place for more than 12 months then permanent construction methodology and CQA is to be applied.

6.14 Pipeline Installation

6.14.1 The design of the permanent gas collection system or any part thereof will be subject to the Biffa Landfill Gas CQA process. In general and where possible the gas collection pipe work will be designed such that it comprises a large diameter gas collection main laid around the site perimeter. Connection of the collection main to the service pipe work will be established at various intervals using valved manifolds, allowing connection of three or more of the service pipes to be housed in the same enclosure. This method allows for adjustments to, analysis of and maintenance to the system to be done more easily.

6.14.2 All pipelines, both service pipe work and the gas collection main, are to be constructed using polyethylene or similar material, with pipe sizes chosen to ensure that the most effective and efficient distribution of pressure flow occurs. Pipe network design is undertaken using Mears flow calculators (or similar methodology), with design pressure losses calculated to maintain typically 10-mbar suction at the wellhead.

6.14.3 Permanent pipes will be jointed by butt fusion techniques, or intermediate sections, jointed by electro fusion techniques. In certain cases it may be necessary to use joints that allow for settlement; these are usually of a push-fit or mechanical type. Pipes will be laid to falls, where possible in the direction of gas flow, to encourage condensate to drain to dewatering points. Where drainage of condensate is in the opposite direction to the gas flow, the pipe falls are to be increased. Where pipes are installed in stable ground conditions and settlement is likely to be limited, the gradients for larger pipes can be reduced.

6.14.4 Temporary over land pipe work, used over disturbed areas, areas yet to be capped, or where disturbance of the installation is likely to occur, shall be installed to achieve maximum practicable falls, however, these pipes may rely on manual dewatering and regular (weekly) inspection.

6.14.5 Manual dewatering of temporary systems is, where practical, undertaken by "walking the pipe" and causing the condensate to drain into the permanent pipe work - where this cannot be achieved the condensate is drained down well structures. Both the permanent and temporary systems will connect to the same gas main manifolds.

6.15 Pipe Line Installation – Permanent

6.15.1 The installation of the permanent pipelines is subject to the Biffa Landfill Gas CQA process.

6.15.2 The perimeter ring main shall be designed to accommodate the predicted future peak flow of gas from the site incorporating a factor for safety of 30%.

6.15.3 The design shall include the ability to transfer a minimum of 30mbar vacuum to the furthest manifold on the network and 10mbar to the furthest gas well (this needs to be calculated taking account of the gas booster specification).

6.15.4 The minimum pipe specification to be used is PN6 SDR 17 unless site-specific requirements dictate otherwise.

6.15.5 The installation shall include in line knock out pots (KOP) designed and installed as detailed in the relevant section of this document. These KOP's will be located at system low points (either natural or man made).

6.15.6 At the locations where substantial fabrications such as tees etc. are installed the CQA supervisor will make a photographic record, incorporating the unique serial number, of the installation.

6.15.7 All perimeter gas collector design shall be approved and signed off by the General Manager.

6.15.8 Full time supervision shall be used on all permanent perimeter collection system installations.

6.15.9 Drain legs or non-sealed condensate traps are not to be used under any circumstances as part of the perimeter collection system.

6.15.10 Pipe work shall be buried a maximum of 1.5 metres to the pipe crown other than in exceptional circumstances. The pipe trench shall be used to carry all perimeter services where possible, but as a minimum the gas carrier, condensate disposal pipes and necessary power transport for the gas system operation.

6.15.11 The pipe trench shall be aligned to take account of anchoring systems for the site containment system, including cap, monitoring boreholes and any other service or installations forming part of the site. Consideration should be given at the design stage to the avoidance where possible of any hazardous zones that may be formed during this process as detailed in the DSEAR regulations.

6.15.12 All trenching shall be bottomed up as necessary.

6.15.13 Where possible the perimeter collector shall be laid to falls in the direction of the gas flow. The minimum pipe fall shall be 1:D/2, where D is the external diameter of the pipe in mm. Where condensate drainage is counter the direction of gas flow, the fall on the pipe may be increased to accommodate drainage of liquid to KO vessels.

6.15.14 Pressure testing of the installed system will be carried out prior to back filling (see method statement no.3 – 'Gas Collection System – Pressure Testing of installed Landfill Gas Collection System' within the Biffa Landfill Gas CQA Document 'Construction Quality Assurance Plan for Gas Collection Systems, Gas Wells, Pipes and Testing').

6.16 Back Filling Trench Work

6.16.1 All excavation and back filling operations will be subject to site-specific risk assessment and method statements.

6.16.2 Back filling may be undertaken using selected excavated materials or imported suitable fill depending on the quality of on-site materials. The back fill shall ensure that the pipe haunches below the pipe centre line are fully supported with the material being tamped into position as required.

6.16.3 Material to be used for back filling should not contain large hard objects that would be capable of damaging the pipes or cables.

6.16.4 Back fill above the pipe centre line should be carefully placed and graded over the services. This back fill shall be compacted using suitable means agreed by the site manager or CQA supervisor. Ground conditions and the nature of the material used to backfill will be taken into account.

6.16.5 Completed filling shall be compacted at the surface and finished to form a slight crown over the trench.

6.17 Manifolds

6.17.1 The details of a typical manifold arrangement are shown in the 'drawings' (00121002) section of this document.

6.17.2 All manifolds to be constructed using MDPE (or similar) and incorporating only extruded tees and fittings. Unless warranties are offered, fabricated tees and fittings shall not be used.

6.17.3 Only quality assured fabricated tees or extruded tees shall be used to effect main line connections.

6.17.4 The CQA supervisor (or other appointed person) should make a photographic record of the installation showing the unique serial number.

6.17.5 The purpose built enclosure should be fitted with a suitable locking mechanism to prevent unauthorised access.

6.17.6 Each incoming and outgoing pipe shall be regulated by a butterfly valve or similar control device.

6.17.7 Each incoming and outgoing pipe shall be fitted with:

- Flow monitoring point (1/2" BSP or similar) where appropriate and where conditions allow.
- Sample tap.
- Sampling tubes extended to 6" just below the lid of the enclosure .
- 6.18.11 All manifolds shall be standardised (where possible) to include 3 nr 160mm diameter inlets from the gas field and a single 250mm diameter exit pipe.

6.17.8 The manifolds should also include:

- 25mm (or similar) drain valve to invert
- Small cross fall to drain valves
- Cross fall to be created towards the connecting tee.

6.17.9 The manifold enclosures shall be designed to take account of manual handling requirements, the potential to produce sparks and the risk of the lid impact on personnel.

6.17.10 Valve operation shall where possible be accessed using smaller individual hinged lid units to avoid lifting the main cover, and / or using a valve key.

6.18 Service Pipe Work

6.18.1 This includes all permanent pipe work between the manifolds and the gas well fields. The documented Biffa Landfill Gas Division CQA process will cover the design of the service pipe work.

6.18.2 Service pipe work shall be designed to accommodate the peak projected flow from the gas wells including a factor for safety of 30%.

6.18.3 The minimum diameter of service pipes shall be 90mm diameter. The minimum pipe standard shall be PN6 SDR17 (or similar).

6.18.4 The service pipe excavation design shall be subject to a site-specific assessment, accounting for cover depths and type of cap.

6.18.5 All permanent pipe work shall be fusion welded using butt or electro fusion techniques (see minimum standards no's 1 & 2 of the CQA document – 'Construction Quality Assurance Plan for Gas Collection Systems, Gas Wells, Pipes and Testing'.).

6.18.6 Where possible service pipes shall be installed perpendicular to the contour of the land and / to maximise the falls in the direction of the gas flow.

6.18.7 The service pipe work shall be designed, where possible, to avoid the need for intermediate dewatering using drain legs or traps.

6.18.8 Service pipe work should where possible be installed in an excavated trench system with the depth of excavation adjusted to accommodate the sites restoration specification.

6.19 Road Crossing Installation

6.19.1 At locations where gas lines interface with transport routes an adequate crossing will be built.

6.19.2 Site-specific assessment required in order to determine the volume of traffic that will traverse the crossing.

6.19.3 Based on the assessment of traffic loading a design will be produced for a suitable and sufficient crossing.

6.19.4 The crossing shall be constructed as a pipe within a pipe assembly, unless only very light loading is anticipated.

6.19.5 The outer support pipe shall be either manufactured from HDPE SDR 17, twin walled, or similar at a size of 2D to 3D where D is the diameter of the gas service pipe (to a maximum support pipe size of 400mm). In all other instances the support pipe to be manufactured in steel or concrete where the ratio in size compared to the gas pipe can be reduced.

6.19.6 The support pipe and gas pipe shall be laid to a fall through the road crossing.

6.19.7 Where possible the support pipe is to be bedded in the ground to a depth of no greater than 1.5m.

6.19.8 Support pipe shall be bedded in on suitable material (site specific assessment required to determine quality of any material that may be used to haunch).

6.19.9 Where the risk assessment indicates it is beneficial for protection of the installation, consideration should be given to installation of concrete pad (or similar) over the top of the support pipe work.

6.19.10 Suitable sample facilities to be installed into the gas pipe either side of the road crossing where possible.

6.20 Condensate Management

6.20.1 LFG is extracted in saturated form. As it travels through the distribution pipe work system, expansion and cooling occur causing moisture to condense and collect, forming “condensate”. This condensate can, unless drained and managed properly, create pipe blockages.

6.20.2 To deal with this condensate, dewatering points are constructed at the low points of the system, with the falls of the pipe work established to allow the drainage of condensate to these dewatering points. Dewatering points may either be in the form of drainage outlets where condensate is released back into the waste (generally used for temporary pipe systems), or collection vessels constructed as part of the permanent installation.

6.20.3 Condensate collection vessels are manufactured using suitable corrosion resistant materials, and are sized to accommodate the predicted gas flows from the corresponding area of the site, without introducing significant pressure loss.

6.20.4 An automatic pumping system, controlled by float switches or other suitable level sensing devices, is installed in each of the knock out pots, pumping the condensate along dedicated pumping mains to a suitable disposal point. The specification of the automatic system will be complaint with the requirements of DSEAR.

6.21 Condensate Pots

6.21.1 The main chamber depth should not exceed 3 metres below ground level where possible.

6.21.2 Prior to back filling, a photographic record of the installation, showing the fabrication will be made by the CQA supervisor.

6.21.3 The condensate pot will be installed outside of the containment system (other than in site specific circumstances).

6.21.4 The main chamber diameter size is to be selected taking into account the incoming, exiting pipe work and the diameter of the pump sleeve to be used.

6.21.5 The condensate pump is to be selected to achieve the following (or as many of the criteria as possible):

- Pump solids of 3mm in size.
- Use a 3-phase power supply, or compressed air as standard.
- The pump will be specifically designed to deliver the required head and distance. Rated as per the results of a Zoning Assessment carried out under the requirements of the DSEAR[4] Regulations.
- Minimum 12-month warranty pumping leachate/condensate mixture (where possible).
- At 10 metre head to pump $0.5LS^{-1}$ (litres per second) unless site specific conditions dictate otherwise.

6.21.6 The vessel is to comprise a main chamber with an insert protruding through the lid unit to receive the pump.

6.21.7 Level sensing is to be carried out using probes (or other suitable technology) ideally installed into the outer chamber.

6.21.8 The pump controller is to be rated as per the results of the Area Classification Zoning assessment as required by DSEAR.

6.21.9 Site-specific circumstances may necessitate a variation to the above. In the event of this occurring the design and installation should be determined on a stand-alone basis with the final design being approved by the Biffa Landfill Gas Division Technical Manager or General Manager.

6.22 Condensate Knock Out Pots / Filter Vessel (Compound).

6.22.1 Where possible a side chamber system is to be used for all applications. The size of the main pot will be flow dependent as will the inlet and outlet pipe diameters. Each unit is to be manufactured with staggered inlet / outlet with a facility to balance the gas pressure. Access to the filters for cleaning or replacement via the lid unit is to be built into the design. Typical designs are included in the drawings 00120502 and 00120602.

6.22.2 On duplex pots the condensate drainage connection between the pots is to be typically 75mm NB.

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[4] DSEAR – Dangerous Substances and Explosive Atmospheres Regulations 2002

6.22.3 The upper connection between to balance the gas pressures to be typically 80 or 90mm NB.

6.22.4 A 2" flange (or similar sized) to be fitted to the side chamber to facilitate the installation of a sight glass.

6.22.5 Bosses (1/2" BSP or similar) to be fitted above and below the filter / demister pad. To be installed with downwards facing elbows and ¼" stainless steel ball valves (or similar), or sample barbs and a clear plastic sight tube.

6.22.6 Galvanised steel construction (schedule 20, or similar chemical resistant material) is to be used in all cases.

6.22.7 Standard stainless steel "Knit mesh" or similar approved shall be installed to the main vessel. The design is to make allowance for ease of removal for cleaning or replacement. A support frame shall be incorporated to allow for correct positioning.

6.22.8 Any new equipment will incorporate a high condensate level beacon fitted local to the vessel.

6.22.9 Probes (or other suitable technology) shall be used to sense the level in the secondary chamber. Probes to be top mounted, entering the chamber via a 6" (or similar sized) blank flange. Probes shall be suitably specified for operation in the DSEAR zone within which they are to be installed.

6.22.10 The probes installed are to sense and switch for:

- Stop, start, high alarm and ground
- Probes, in particular the high level, shall include connection capacity (volt free changeover or similar) to activate a dial out should this be necessary.

6.22.11 Pipe work connections are to include low-level entry for incoming gas coupled with high-level exit. Simple flanged connections to be used for pipe connection, matched to predicted flow.

6.22.12 Entry gas to be introduced through a 'dispersion bar' where the incoming pipe crosses the chamber and has its base cut away to create an aperture $\geq$ 1.5 times the cross sectional area of the incoming pipe.

6.22.13 The invert of incoming gas mains shall be established at 1m above the base plate or floor level where practicable, allowing standardisation of secondary chamber connections.

6.22.14 The knock out vessel is to be constructed to a total height of typically 3m. The upper lid is to be removed by Hiab, davit or similar and is to incorporate a number of jacking points to free it prior to removal.

6.22.15 The outlet pipe is to be flanged and the crown located at a suitable distance below the top plate.

6.22.16 The top flange and incoming and outgoing gas flanges are to be holed to a standard pattern.

6.22.17 Pumps are to be selected and installed suitable for the zone in which they are to be installed and are to have a maximum weight of 20Kg (where possible). The pump selection is to be specified and based on the results of the Zoning assessment carried out as per the requirements of the DSEAR Regulations.

6.22.18 Pumps to be used shall be 3-phase or compressed air operation.

6.22.19 The design allows for a side mounted blank flange on the side of the chamber to enable inspection and cleaning out to be carried out.

6.22.20 The lid should be constructed such that its weight is as low as possible. A Minimum of 300mm diameter (dependent upon the size of the actual vessel). The lid unit is to be lifted using the purpose lifting mechanism. A facility to secure and restrain the open lid mounted on the main knock out pot body is to be installed in all cases.

7.0 Collection Systems

7.1 Gas Extraction Systems

7.1.1 Every landfill site's gas system will display some unique properties in the way it responds to changes in atmospheric and geological conditions, changes brought about when new or additional parts of the a gas field are brought on line, manual changes to the gas field etc. It is therefore difficult to be concise when describing how a gas system should be controlled.

7.1.2 There are however certain ground rules, the following provides typical generic details for gas management of systems relating to 'in waste' and 'perimeter' systems.

7.2 In waste

7.2.1 Effective gas control from landfill gas collection systems (conventional gas wells, impact wells, scavengers, leachate collection features etc.) require operating parameters adapted to the site specific circumstances and construction features. This is to ensure that the distribution mechanics are adequate, and the design and review process can be planned.

7.2.2 As the systems may contain ineffective seals between the waste mass / engineering features and atmosphere, the extraction of gas may contain high concentrations of oxygen, which unless managed can give rise to unsafe operating conditions. If consistent over extraction occurs there is a risk of sending the waste aerobic, with associated heat production, and the risk of creating oxidation in the waste mass. This is generally found with the presence of elevated concentrations of carbon monoxide (CO) and heat.

7.2.3 Under normal circumstances extracted gas could contain methane in the range 35% to 60% by volume and oxygen from 0% to 5% by volume, (dependent upon the age of the tipped waste from which the gas is being extracted) with any combination of the gasses in between. Successful extraction will therefore generally be determined

by mass yield (i.e. volume times methane concentration) and comparison to models used to predict the gas quantity being produced by the site (Gassim or similar).

7.2.4 The operation of the wells will generally be controlled based on applied force (vacuum pressure) or flow, depending on the conditions encountered and in particular the porosity and transmissivity of the waste through which gas is being recovered, whilst targeting maintaining methane, carbon monoxide and oxygen in the range 35 – 60%, < 100 ppmV and < 5% respectively.

7.3 Well Connections

7.3.1 Conventional permanent deep wells are generally to be connected to the extraction system using dedicated head works complete with sampling facilities, dipping points, and flow regulation valves. The connection is to be effected using flexible pipe work or mechanical couplings to accommodate movement and settlement. Conventional wells are generally grouped as units of 3 – 6 individual wells connected onto a single service pipe, fitted with a control valve, routed directly back to a manifold on the main collector system.

7.3.2 Extraction of gas from a leachate well; where possible and as required, landfill gas will be extracted from leachate extraction wells. A gas extraction point, typically a 63mm diameter elbow off the top of the leachate well on to which an appropriately sized MDPE SDR 17.6 pipe will be welded. A control valve (Safi, Butterfly or similar design) will be installed into the pipework to provide a means of gas extraction control.

7.3.3 Impact wells, generally, are installed to operating areas of the site, and are typically grouped in clusters of 6 – 24 wells. Each cluster is sampled and regulated at its point of connection to the gas service pipe work. Individual wells can be taken out of circuit by severing the connecting pipe and blanking both the well and the connecting pipe.

7.3.4 A cluster of 6 – 24 impact wells should be treated as a single unit, based on pipe diameters shown in section 6.5.3.

7.3.5 Scavengers are generally connected to service pipes at the top of engineered slopes avoiding liner penetration to the lower slope, and generally use a "boot" seal with the capping layer to prevent air ingress when placed under extraction. Scavengers can be connected individually to service pipes, or using a manifold where typically 2 – 6 scavengers are routed onto the gas extraction system. The individual connection should be treated as a single well unit. A drawing (00121102) showing a typical scavenger unit is included in the drawings section of this document.

7.3.6 To prevent over extraction, whilst maintaining vacuum on gas infrastructure for odour or migration control, 8mm (or larger) bypass lines connecting sample taps either side of the control valve may be used. This control system must only be used where it is deemed that conventional control valves do not offer enough fine control to prevent over extraction (low flow conditions).

7.4 Perimeter Systems

7.4.1 Effective gas control from perimeter collection systems (gas drainage, attenuation zone extraction, features of the gas containment system) require their own unique set of operating parameters which need to be adapted to the site specific circumstances and construction features.

7.4.2 As the systems may be in continuity with flow paths that outcrop to atmosphere, or have ineffective seals between the waste mass or engineering / geological features, the extraction of residual gases may contain high concentrations of oxygen, and necessitate either interface with the main gas control system, or use a dedicated infrastructure.

7.4.3 Under these circumstances extracted gas could contain a wide range of methane concentrations and oxygen from 0% to 21% by volume. Extraction on the perimeter systems will be measured therefore by impact on gas monitoring boreholes, or

demonstrated impact on adjacent perimeter wells (i.e. an extracted well that has a pressure influence on the adjacent isolated well). The operation of the wells will generally be controlled based on applied force (vacuum pressure) or flow, depending on the conditions encountered and in particular the porosity and transmissivity of the media through which gas is being recovered.

7.5 Well Connections (Perimeter Systems)

7.5.1 Where well yield is low (i.e. the flow from the perimeter well is less than 20 m^3 per hour) and / or the total flow from the perimeter system is less than 5% of the total gas volume extracted from a site, it is likely that gases from the perimeter system can be safely blended with gas from the waste and transported in parallel to the site compound for disposal.

7.5.2 Where the flow from the perimeter system exceeds 5% of the total volumetric flow rate (unless the methane concentration is high and oxygen low) this is likely to need an independent carrier system to transport gas for disposal. In conditions approaching the limits above, a site and circumstance specific assessment should be completed to determine the most appropriate way to proceed.

7.5.3 Where perimeter wells are to be connected to the main “in waste” gas collection system the point of connection shall be fitted with a non-return valve to avoid conditions where gas from the site is passed out to the perimeter system or vented to atmosphere.

7.5.4 An individual site-specific assessment is to be completed for either of the above cases.

7.6 Control Protocols

7.6.1 Typical landfill gas monitoring schedules adopted by Biffa are provided in the following tables. The details given are for monitoring of the gas extraction system within the waste but also for perimeter gas extraction outside the waste mass.

7.7 Monitoring Schedule – Gas Extraction within the Waste Mass

Commissioning	• Connect wells to active extraction system having followed the relevant design for construction. • Walk system and set all valves up to 25% open. Visually inspect all mechanical connections, and look for signs of disturbance. • Commence extraction and monitor extraction pressure (P, methane (CH4), carbon dioxide (CO2), carbon monoxide (CO) and oxygen (O2) at the connection point. • Allow to stabilise for @ least 1 hour. Check each point of connection into the system (either individual wells or groups) for pressure, methane, carbon dioxide, carbon monoxide and oxygen. • Adjust valves to initially balance out pressure and flow across the system. • Upon completion record final settings and results. • If gas quality of the extracted gas is out of specification, the system will be rebalanced. If the gas quality remains out of specification, isolate the affected infrastructure. Undertake a design review.
After 24 hours	• Undertake complete monitoring exercise prior to any adjustment of wells measuring Pressure, CH4, CO2, CO, O2 at each well, and these parameters plus flow at the point of connection to the main extraction system. • Record results. Review relationship between vacuum and flow across the system. • Adjust wells to account for gas quality experienced – reduce flow or isolate if O2 > 5% or CO > 100 ppmV or if CH4 has declined by more than 10% since previous result, or is less than 35%.
Weekly thereafter	• Undertake complete monitoring exercise prior to any adjustment of wells measuring Pressure, CH4, CO2, CO, O2 at each well, and these parameters plus flow (where possible) at the point of connection to the extraction system. • Record results. Review relationship between vacuum and flow across the system. • Adjust wells to account for gas quality experienced – reduce flow or isolate if O2 > 5% or CO > 100 ppmV or if CH4 has declined by more than 10% since previous result, or is less than 35%. • If steady state conditions are established, and migration to atmosphere is being contained by the control system, the frequency of system monitoring and balancing may be reduced using the weekly monitoring regime.

7.8 Monitoring Schedule – Perimeter Gas Extraction – Outside the Waste Mass

Commissioning (Perimeter system outside of waste mass)	• Connect wells to active extraction system having followed the relevant design for construction. • Monitor perimeter boreholes and record conditions prior to commencing extraction. • Walk system and set all valves upto 25% open. Visually inspect all mechanical connections, and look for signs of disturbance. • Commence extraction and monitor extraction pressure , methane (CH4), carbon dioxide (CO2), carbon monoxide (CO) and oxygen (O2) at the extraction plant. • Allow to stabilise for @ least 1 hour. Check each point of connection into the system (either individual wells or groups) for pressure, methane, carbon dioxide, carbon monoxide and oxygen. • Adjust valves to initially balance out pressure across the system. • Upon completion record final settings and results. • If gas quality of the extracted gas is inappropriate to the means of disposal isolate the system and undertake a design review.
After 24 hours (Perimeter system outside of waste mass)	• Undertake complete monitoring exercise prior to any adjustment of wells measuring Pressure, CH4, CO2, CO, O2 at each well, and these parameters plus flow at the point of connection to the extraction system. • Monitor target boreholes adjacent to the perimeter extraction system. • Record results. Review relationship between vacuum and flow across the system. • If gas in monitoring boreholes has declined continue to operate system and monitor. If gas in boreholes remains elevated rebalance system by adjusting valves to increase extraction rate in perimeter wells adjacent to target boreholes.
Weekly thereafter (Perimeter system outside of waste mass)	• Undertake complete monitoring exercise prior to any adjustment of wells measuring Pressure, CH4, CO2, CO, O2 at each well, and these parameters plus flow where possible, at the point of connection to the extraction system. • Monitor target boreholes adjacent to the perimeter extraction system. • Record results. Review relationship between vacuum and flow across the system. • If gas in monitoring boreholes has declined continue to operate system and monitor. If gas in boreholes remains elevated rebalance system by adjusting valves to increase extraction rate in perimeter wells adjacent to target boreholes. • If steady state conditions are established, and migration

	is being contained by the control system, the frequency of system monitoring and balancing may be reduced to monthly, but using the weekly monitoring regime.
Monthly thereafter in addition to the weekly sequence. (Perimeter system outside of waste mass)	• If gas in monitoring boreholes has declined, continue to operate system and to monitor. If gas in boreholes remains elevated rebalance system by adjusting valves to increase extraction rate in perimeter wells adjacent to target boreholes. • Undertake data review and assessment of operating conditions, well yields and impact on monitoring system.
Monitoring boreholes experience rising trend (Perimeter system outside of waste mass)	• Monitor operating condition and performance of the adjacent extraction system and wells. If outflow can be increased then increase rate of extraction. If vacuum is high and flow is low, measure depth to water or blockage – review construction records to diagnose likely mode of well failure. Remedy by reducing restriction if appropriate, or increase well density in the area by retrofitting if this is considered to be beneficial. • Undertake design review using operating data. Refine design as appropriate, accounting source and pathway relationships. Implement findings of the review process.

8. Utilisation Technologies

8.1 Technology Selection

8.1.1 Biffa will employ differing technologies for the utilisation or disposal of the landfill gas dependent upon the quantity of methane within the landfill gas. The details of the technologies that will be applied are given in the table below:

Methane Concentration v/v	Technology
>25%	Dedicated high temperature flare and/or generator set.
10%* to 25%**	Landfill gas will be blended if possible with landfill gas of a higher methane concentration and combusted in either a high temperature flare or generator set. Where this is not practicable, consideration will be given to the use of a specialist low CV flare.
<10%**	Landfill gas will be diluted with air or consideration will be given to the use of a bio-filter to the extent that the emissions meet the prevalent flare emissions standards. Alternatively, consideration will be given to using low calorific value flare systems. If further technologies become available for the processing of landfill gas with a low methane concentration then Biffa will with agreement with the Environment Agency explore the suitability for use at the site. Alternatively the 'weak' gas mixture may be used as combustion air for the gensets or the flares, or vented under safe conditions.

*Based on 150% of the Lower Explosive Limit (LEL) for methane in air and on the lowest combustion capacity of a low CV Flare

** Selection by BAT assessment.

8.1.2 The above technology selection will be applied to both landfill gas generated by the waste within the containment system and that extracted from any perimeter gas system (or similar) that may have been installed at the landfill site.

8.2 Flares and flaring (general specification)

8.2.1 For the initial phase of gas extraction at the site, flare(s) will be installed, sized to handle gas generated by the site during the early years of land filling. The units installed will be selected so that a minimum combustion temperature of 1000^0C

(High Temperature) and a gas residence time within the combustion chamber of >0.3s is achieved.

8.2.2 The flare(s) installed will be designed to meet the Environment Agency Guidance on Landfill Gas Flaring Version 2.1 November 2002**.** A typical summary flare specification is provided below.

8.2.3 The flare will have a turn down ratio of 5:1 or greater with emissions remaining in compliance throughout the whole operating turn down range.

8.2.4 An approved automatic control system will be installed to control the temperature of the combustion at a pre-determined set point.

8.2.5 Sample points (to a design detailed in Environment Agency Technical Guidance Note LFTGN 05 version 2.0 2010) will be installed at locations above the combustion zone at positions around the circumference of the flare stack. The monitoring method employed[5] for measurement of the combustion components will be to Environment Agency Guidance LFTGN 05 (2010), Technical Guidance Note M2 – Monitoring of Stack Emissions to Air (2015), Technical Guidance Note M1 – Sampling Requirements for Stack Emission Monitoring (2016) or subsequent revisions to these guidance notes, or other techniques as agreed with the Agency. Sampling of the emissions will only be undertaken when a flare is used for more than 10% of annual hours per annum. A suitable method of recording run time will be installed as per Environment Agency guidance.

8.2.6 The flare, where possible will be skid mounted to enable easy relocation to another area or site.

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[5] There are currently no test methods approved for monitoring at the elevated temperatures seen in a flare stack that would produce definitive results (any results obtained from monitoring could only be used as a guide and for establishing trends).

8.2.7 Where a flare is the primary form of gas disposal on the site, an auto dial out facility can be fitted to the flare system. The necessity to activate the system shall be determined by risk assessment.

8.3 Boosters (for Flare / Generator Installations)

8.3.1 One or more belt driven centrifugal boosters (or similar), will be used to create sufficient lift to provide adequate delivery pressure to the flare/generator and a minimum 10mb vacuum to all wells connected to the gas extraction system. The blower will be connected to the incoming gas mains through a separation vessel and manifold.

8.3.2 The flare plant shall be fitted with a number of protection features. An automatically dewatering condensate collection vessel shall be placed between the incoming pipe work and the blower to ensure that water does not reach the fan mechanism. The flare plant will be fitted with sensors to detect condensate or excessive suction pressure. A non-return and isolation valve will be fitted into the gas lines at an appropriate location.

8.4 Flare Stack Operation

8.4.1 The flaring and boosting systems shall be designed to operate on a continuous basis, with operation of the flare stack and all adjustments to the system made in accordance with the manufacturer's manuals. During periods when the flare is not burning, it shall be maintained in standby mode, with this type of operation generally coinciding with active gas utilisation.

8.4.2 Records for flaring and utilisation systems will include gas flow and quality, vacuum and delivery pressures, flare temperature, run hours thereby ensuring that the flame temperature is kept sufficiently high, and that generation equipment is efficiently operated.

8.4.3 Any flares installed will be maintained as per the manufacturers' service schedule or as the suppliers' recommendations.

8.5 Generators

8.5.1 Any generation installation project will be developed to follow the gas production pattern at the site, maximising the energy recovered from the gas produced by the deposited waste. The landfill gas extracted will typically be used to power a number of spark ignition engines/generator sets and as gas production rises, the number of generator sets on site will be increased. In order to maximise the utilisation of the gas it may be necessary to use smaller modules. Such units will generally comply with the requirements of the Regulatory Body Best Practice Guidance. As gas production at the site starts to decline the number of sets will be reduced, over a number of years, until there is insufficient gas produced to continue the utilisation scheme; at this point the site will return to continuous flaring to control the gas produced.

8.5.2 It is proposed that based on current technical and operational capabilities of the landfill gas combustion engines available on the market that, any new landfill gas engines installed would be to a standard, meeting current EA guidance (LFTGN 08 Version 2, 2010 – Guidance for the Monitoring of Landfill Gas Engine Emissions) where achievable.

8.5.3 Generation equipment installed and operated at the landfill site shall be maintained in accordance with the manufacturers' recommendations or agents acting on their behalf.

8.5.4 All new installations will in general conform to the emissions standards and requirements of the relevant Regulatory Body Best Practice Guidance. All new generator installations will be fitted with combustion control systems that will monitor and control the combustion parameters of the engine to achieve the desired emissions standards.

8.5.5 Where possible all existing installations will be operated to conform to the emissions standards and requirements of the relevant Environment Agency Best Practice Guidance (LFTGN 08 Version 2, 2010 – Guidance for the Monitoring of Landfill Gas Engine Emissions).

8.6 Generation Specification (for new installations)

8.6.1 The engine will operate on the principles of spark ignition.

8.6.2 The generator(s) will be sized primarily on the landfill gas availability, accounting for local air quality or electrical system limitations.

8.6.3 It will be designed primarily to run on landfill gas as the fuel but will have the capability to accept a secondary gaseous fuel source as required.

8.6.4 The engines combustion characteristics will be managed by a combustion control system.

8.6.5 The engine will be attached to a self-excited regulated three-phase alternator.

8.6.6 The engine will typically be water-cooled.

8.6.7 The engine will be fitted with an automatic lube oil replenishing system.

8.6.8 The engine will be fitted with an approved design silencer with a vertical discharge with provision for sampling of emissions as described by the Environment Agency Technical Guidance Note LFTGN 08 version 2 2010 or to an alternative design as agreed with the Environment Agency.

8.6.9 The generator will be housed in a weatherproof enclosure, which will be acoustically engineered to meet the requirements of any local planning or other environmental legislative requirements.

8.6.10 Where applicable, within the generator housing, smoke and gas sensors will be installed.

8.6.11 The generator will be fitted with an auto dialler facility.

8.6.12 Where possible the generator will be fitted with a telemetry system to allow for interrogation of various operating parameters and conditions from a remote location. The system should enable trained personnel to make certain changes to the operational parameters of the engine without having to visit the site.

8.6.13 Each generator will be fitted with an automatic grid synchronising unit and monitoring device that will provide agreed and specified protection to the grid system and the generator in the event of abnormal conditions arising with either.

8.7 Generator Operation

8.7.1 The generator and gas booster systems shall be designed to operate on a continuous basis with the exception of down time associated with maintenance and other operational requirements. Operation of the generator(s) and all adjustments to the system will be made in accordance with the manufacturers' manuals or as per the recommendations of the agents of the generator manufacturer. Records of the operation of the generator(s) will be kept electronically.

8.8 Technologies for Managing Low Methane Quality Gas

8.8.1 Where landfill gas with methane levels <10% are present then alternative technologies to that of flaring and combusting in engines will be explored. Any technology considered will have the capability to meet the equivalent emissions

standards for flaring as prevalent at the time. This process will be subject to a BAT assessment.

8.9 Pre-Treatment Systems

8.9.1 Operational experience gained by Biffa Landfill Gas at some of its landfill power generation locations has identified the need to install gas clean up systems to remove contaminants in the gas prior to being utilised as a fuel in the gas engines.

8.9.2 Contaminants in the gas, namely volatile methyl siloxanes, hydrogen sulphide and other non-methane volatile organic compounds (NMVOC's) have been identified as having a detrimental impact on the life and operation of the engines, and ultimately the environment.

8.9.3 Volatile methyl siloxanes (VMS) are a group of chemicals used in personal care products such as tooth pastes, deodorants and in other products such as industrial cutting fluids. The presence of this group of chemicals (siloxanes) in the landfill gas results, on combustion, of solid silicon dioxide deposits on the combustion surfaces of the engine components, in particular the cylinder heads. The presence of these unwanted deposits result in pre-detonation of the gas within the combustion chamber – resulting in the engine having to be de-rated to ensure compliance with the emission standards, failure of the cylinder head valves – potentially resulting in unburnt gas passing through the combustion chamber into the exhaust system and out to atmosphere.
Biffa has operated a number of gas contamination removal systems at its sites, the details of which are described below.

8.9.4 As appropriate, Biffa Landfill Gas will consider the installation of pre-utilisation gas clean up plant on a site specific basis.

8.9.5 Activated Carbon Systems

8.9.5.1 This system is a gas filtration system and primarily consists of a chiller and a number of vessels containing activated carbon and graphite media. The chiller unit performs the action of drying the gas as it passes through.

8.9.5.2 The active media held in the adsorption vessels is extremely porous, having a stated surface area in excess of 500m^2 per gram of media. As the gas passes through the media, Van Der Vaals forces physically bind the siloxanes (also hydrogen sulphide and other NMVOC's) to the media.

8.9.5.3 Results from test work have shown this filtration system removes over 99% of the siloxanes.

8.9.5.4 The adsorption vessels are operated in series and as such as the first unit holding the active media becomes saturated, it is replaced with a new vessel containing fresh

media. Saturated media is sent for either disposal at an approved licenced site or is re-activated at a specialist treatment company.

8.9.5.5 In the event of a failure of the system, the activated carbon plant can be by-passed allowing the landfill gas to pass directly for combustion in the gas utilisation plant.

8.9.5.6 Where required, as part of the management of the gas clean up plant, in-line gas monitoring for siloxanes and H_2S is carried out after the media holding vessels to check that the concentrations exiting the gas clean up plant remain within specification.

9. Monitoring Schedule

Presented in the table below are the typical details of the monitoring schedule that will be adopted by Biffa.

Monitoring Schedule

Location	Description	Minimum Frequency	Parameters
1.	**Extraction/Booster Station** • At the booster station	Weekly	CH_4 CO_2 O_2 Pressure, flow, hours run H_2S
		Annual	Detailed GCMS of Gas for combustion to prescribed standard in LFTGN04.
	• Outlet to Disposal	Weekly	Pressure,
	• Pressure differential or loss across filters, vessels or flame arrestors	Weekly	Pressure.
		Weekly	Observations.
	Visual inspection • Plant service	Weekly	Observations
		Quarterly	Work completed and observations.
2.	**Flare or Flares** • Combustion chamber	Continuous display where appropriate	Temperature
		Annual (Where the flare is used as a standby to a generation facility and operates for less than 10% in any year, there will be no monitoring of emissions undertaken).	CO ,VOC & NOx
		Weekly	hours run.
	• Flare service	Quarterly	Work completed and observations. Record of adjustment.

Location	Description	Minimum Frequency	Parameters
3.	**Generators** • Control panel	Weekly	Hours run Gross KWh generated Fault log/starts
	• Exhaust	Quarterly from 2013 (as appropriate – see LFTGN08 V2 2010)	CO, NOx, using portable instruments
		Annually	NO_x, CO, VOC, (and other parameters that may be required on a site specific basis, defined within the Permit) using methods described in LFTGN 08 V 2
	• Generator service	As per manufacturers recommendation	Service and overhauling to be maintained. Record of adjustment kept by O&M provider.
4.	**Main Gas Collectors** • Individual collectors at point of connection to gas booster station	Weekly	CH_4 CO_2 O_2 CO pressure, flow H_2S
5.	**Manifolds / Service line Junctions** • At each manifold or the point of connection of a service pipe carrying more than one well to the main gas collector / or a service pipe connecting to an influent line to a manifold. •	Weekly Monthly	CH_4 CO_2 O_2 CO, pressure, valve position, H_2S Flow (where possible)
6.	**Condensate Vessels** • Operational check and inspection of each KO pot	Weekly	Hours run Status Physical condition

Location	Description	Minimum Frequency	Parameters
7.	**Extraction wells (permanent and post drilled)**		
	• Where wells are not connected to manifolds and where more than 6 wells are connected to a service pipe which interfaces with the main gas collector	Monthly	CH_4 CO_2 O_2 CO,H_2S, pressure, valve position (recording any change)
	• Where wells are connected to a service pipe which runs to a manifold directly and there are 6 or less wells carried by the service pipe	Quarterly	CH_4 CO_2 O_2 CO, H_2S, pressure, valve position (recording any changes)
	• Visual inspection of well, housing and connection (if visible).	Monthly	Observations
	Note: If manifold conditions or changes in gas quality measured at the manifold, indicate that operating conditions may be creating issues within the waste mass, then assessment and sampling from individual wells connected to the corresponding service pipe shall be undertaken within 24 hours of the anomalous result being found.		
	Anomalies at manifolds requiring assessment of individual wells shall be: - CO greater than 100ppmV - O_2 greater than 5% V/V - Change in O_2 concentration of 2% V/V or more since last reading - CH_4 concentration < 35% V/V - Change in CH_4 since last reading of 5% V/V or more - Balance gas to oxygen ratio exceeds 20:1 (Balance gas = 100% - CH_4%-CO_2%-0_2%)		

10 Landfill Gas Sampling

10.1 Gas sampling will be undertaken as per the requirements of the Environment Agency guidance LFTGN04 .

10.2 Measurements of landfill gas qualities etc. taken 'in the field' will be carried out using portable instruments.

10.3 To establish minor (trace) components of the landfill gas generated by the site sampling will be carried out as per the protocol provided in the Environment Agency guidance LFTGN04 Version 3 (2010). Details of the typical suite of components that will be analysed for in this analysis are included in the appendices.

10.4 Where possible this analysis will be undertaken by an MCERTS and UKAS accredited or approved scientific establishment.

11 Engine & Flare Exhaust Emissions Monitoring

11.1 Emissions monitoring from flare stacks and/ or generators will be carried out as per the Environment Agency technical guidance notes (LFTGN05 – flares, LFTGN 08 – engines and the 'M' technical series of publications).

11.2 Unless otherwise agreed with the Regulatory Body, monitoring techniques will be carried out as per the requirements of Environment Agency Monitoring Guidance Notes M1 and M2 .

11.3 Where possible this testing will be undertaken by an MCERTS and UKAS accredited or approved Test House using certified staff. The testing procedure will be supervised by a MCERTS Level 2 accredited Team Leader with the appropriate Technical Endorsements. Technicians assisting the Team Leader will be either MCERTS Level 1 accredited or an MCERTS registered Trainee.

12 Data Storage

12.1 All environmental monitoring data relating to routine landfill gas monitoring is to be entered directly onto an Electronic Database System that is described in more detail below.

12.2 The system consists of a database that manages and reports environmental data for landfill sites operated by Biffa Waste Services Limited. The system will hold details of all routine site landfill gas monitoring results, pressure measurements, any flow measurements, valve positions (where appropriate) and comments relating to the operational condition of the extraction points. In addition the system holds up to date monitoring requirements and internally set trigger points which if exceeded are highlighted on the system.

12.3 As soon as possible, routine landfill data is down loaded onto the system at the time of measurement via a site computer link.

13. Reporting of Data

13.1 At a frequency required by the permit, the data will be submitted to the regulatory body and this will highlight any breaches of trigger or action levels and any changes that have been made to the extraction system e.g. significant valve position changes.

13.2 The results of the landfill gas monitoring will be reviewed annually with consideration given to:

- The monitoring undertaken
- Analytical results
- Plots of data
- Comparison of analytical data with trigger values.
- Recommendations for any additional monitoring locations or changes to the monitoring frequency or analytical suites and amending the monitoring plan as appropriate.

13.3 Should the review process highlight variances to the predicted environmental outcomes, the monitoring plans and programmes shall be amended to reflect the findings, and mitigation employed.

14. Action Plans

14.1 Criteria for Determining the Severity of an Event

The following sections include details relating to event management and the action plans associated with each occurrence.

Two overriding criteria will be used for determining the severity of an event, the likely effect on the health of persons (working at the site and the public in general) and the potential impact on the environment, both local and in a wider sphere.

14.2 Surface and Sub-Surface Fires

Reference should be made to the publication "The Management and Prevention of Subsurface Fires; 2008" in addition to the detail provided in this section when a surface or subsurface fire is suspected as being present on a landfill site.

In the event of the identification of a subsurface fire, Biffa will manage the fire based on removal/elimination of air from the affected area of the landfill by turning off the gas extraction system from the affected area, allowing the gas pressure to become balanced to slightly positive (<5mbar), in addition to the capping and sealing of all possible pathways of air into the body of waste in the affected area.

A generic action plan identifying the steps required in the management of a surface or subsurface fire is included in the appendices.

The following actions should be carried out on identifying the fire (surface or subsurface):

- Evacuate all personnel from the immediate vicinity of the fire,
- Inform site management,
- Secure the area to prevent unauthorised access, and
- If there are flames present on the surface of the landfill summon the fire brigade, unless it is possible to safely extinguish the fire (usually only if it is a small, locally contained surface fire) using locally available fire-fighting equipment.

Where a site specific Fire Management Plan has not been developed for a landfill site, the following considerations should be made and can be used in producing a guide as to how to manage the fire;

- The proximity to residential property and the potential for any uncontrolled gas and odour emissions impact.
- The proximity to any major aquifer and the potential impact on increased liquid levels within the waste mass. If liquid is used to assist in controlling any subsurface fire for an extended period of time, there may be an impact on the hydrogeology impact that would need to be considered.
- Any pathways (streams etc.) locally that may feed directly into the major aquifer.
- Is the fire close to the side wall construction? Could the fire damage the side wall engineering? Could the side wall liner system allow air to ingress into the body of the waste?
- Sources of liquid close by that could be used a source of liquid for controlling the fire.
- Means of transporting liquid to the source of the fire.
- Vehicle access to the area of the source of the fire.
- If the site operates a leachate treatment facility, does it have spare capacity to deal with the additional liquid volumes that could be used to control the fire?
- Are there any special chemical wastes tipped in the site?
- Availability of gas monitoring equipment.

14.3 Observed Abnormal Changes in Collected Monitoring Data.

14.3.1 Actions that will be undertaken when abnormal changes are observed in the monitoring data for 'in waste' systems are covered in section 9.0 of this document.

14.3.2 Where abnormal changes in monitoring data related to perimeter boreholes are observed, the flow chart, 'Landfill Gas Monitoring Protocol & Response Plan – Gas Perimeter Boreholes' (see appendices) provides the necessary details of the actions that will be taken.

14.4 Operational Problems or Failure of the Gas Control System.

14.4.1 Contained in the appendices are flow charts showing the actions and responses that will be adopted when various events occur.

14.4.2 Flow charts have been included for the following events:

- Surface and Sub-Surface Fire.
- Electricity Grid Failure
- Damage to a Gas Infrastructure
- Gas Booster Failure
- Blockage of a Permanent Gas Line due to Liquid Build Up.

14.5 Actions for Minor Gas Control System Problems.

14.5.1 Biffa Waste Services Ltd. operates a system of undertaking regular checks of the gas collection system. Any minor defects identified in the system such as:

- Leaks in any temporary overland gas pipe
- Leaks at flange connections
- Liquid build up in temporary overland pipe
- Loose connections in the pipe work
- Blocked in-line gas filters etc. would be where possible repaired or rectified as the technician / operator was carrying out the checks.

In the event that a permanent repair cannot be carried out immediately then a temporary fix should be carried out straight away, with, where possible, a permanent fix being under taken within 24 hours.

14.6 Procedure for Dealing with a Reported Event.

14.6.1 Biffa has a standard procedure for managing complaints received in relation to landfill operations. This procedure includes for the management of complaints relating to gas odours, which in such an event, the site will be managed in line with the odour management plan.

14.6.2 The reporting procedure is available on the OBi system and hence enables access to be gained by all relevant Biffa personnel.

14.7 Emergency Procedures and Protocols

14.7.1 All landfill sites on which there is generation or other means of gas utilisation have emergency procedures in place. These procedures cover scenarios such as the outbreak of a fire (within the utilisation compound), fire within the waste where landfill gas extraction is taking place and, where the methane lower explosive limits are exceeded inside any buildings located within the generation compound.

14.7.2 A typical emergency procedure is included in the appendices of this document.

14.8 Remedial Actions

14.8.1 Biffa Landfill Gas Division will undertake to carry out reviews on a regular basis, following particular events / incidents, advances in gas management technologies etc. The results of these reviews may require changes to be made to monitoring routines etc. these changes will be agreed, where applicable, with the Environment Agency prior to implementation. The results of such review processes will be recorded in future revisions to this Gas Management Plan as part of a programme of continuous improvement.

14.9 Notification of Abnormal Emissions.

14.9.1 Biffa Waste Services Ltd will notify the Environment Agency or other regulatory body as required of any abnormal emissions that occur in relation to the management of landfill gas at a particular facility.

14.9.2 Abnormal emissions may include but are not limited to the following: -

- Flare emissions out of compliance (when allowing for approved tolerances).
- Engine emissions out of compliance (when allowing for approved tolerances).
- Total disconnection or failure of a live carrier gas main greater than 200mm diameter in size.

- Where power generation exists on a site, a grid failure leading to an outage of the gas utilisation /flaring equipment (where no back up power supply automatically cuts in) and causes significant impact on the environment
- Failure of a live gas delivery pipe from the gas booster(s) outlet (pressure side) to the engines/flares.
- Flare flame outage with venting of gas continuing to take place due to the failure of the automatic shutdown / isolation system.
- Failure to fit an end cap or connect up gas collection pipe work to newly installed gas extraction points where gas is emitted to atmosphere.
- The failure of a knock out pot pump that results in a significant reduction in extraction levels of gas from a phase or the whole landfill site.
- Failure of a gas booster where no back up unit exists on the site and a significant reduction in gas extraction volume occurs.

Appendices

LANDFILL GAS ANALYSIS

Typical Analytical Suite

Reference should be made to the current version of the Environment Agency guidance LFTGN04 for details of the trace components that should be monitored for.

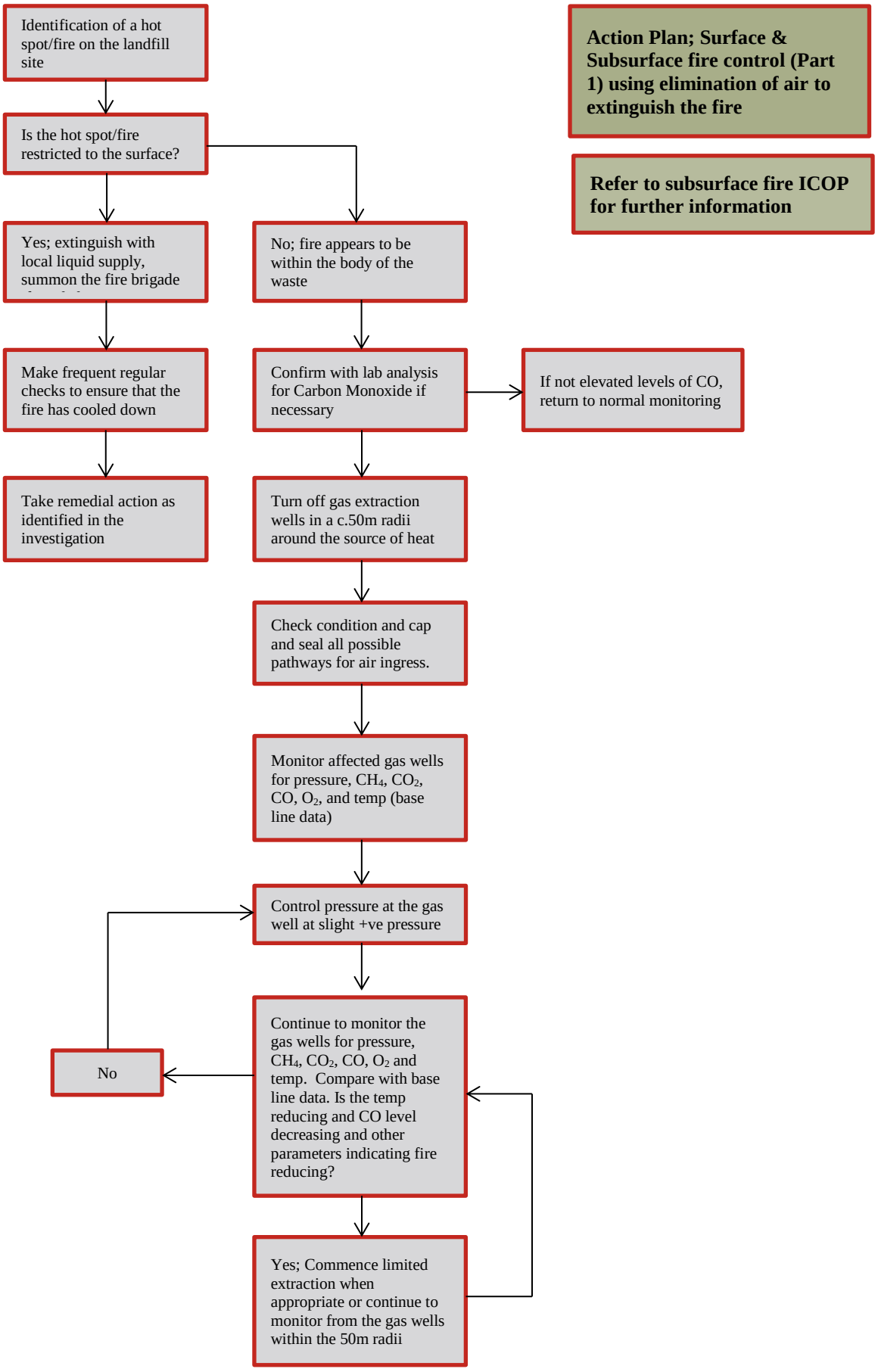
LANDFILL GAS MONITORING PROTOCOL & RESPONSE PLAN – GAS PERIMETER BORE HOLES

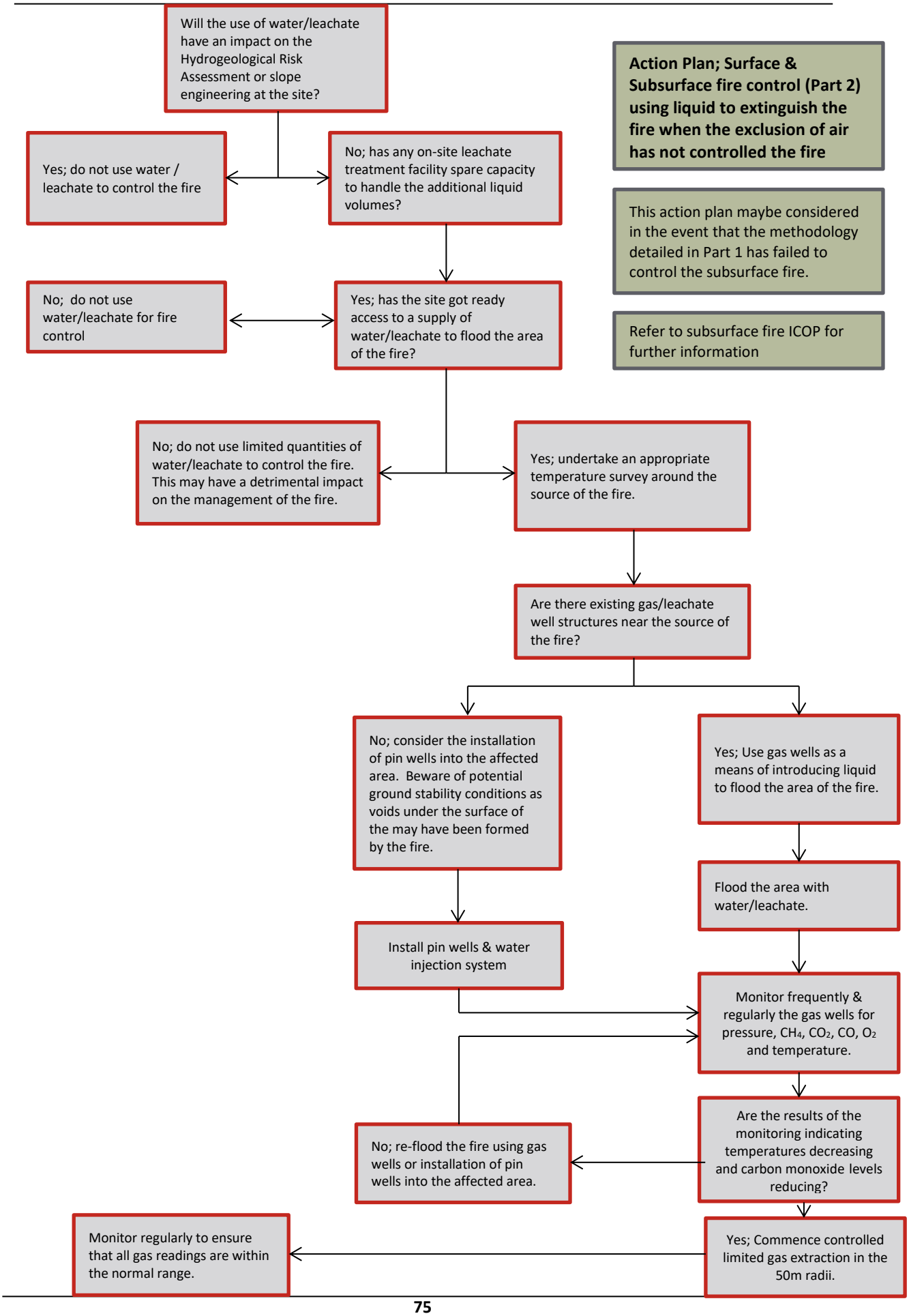
Action Plan - Perimeter Borehole (Gas in Perimeter Borehole)

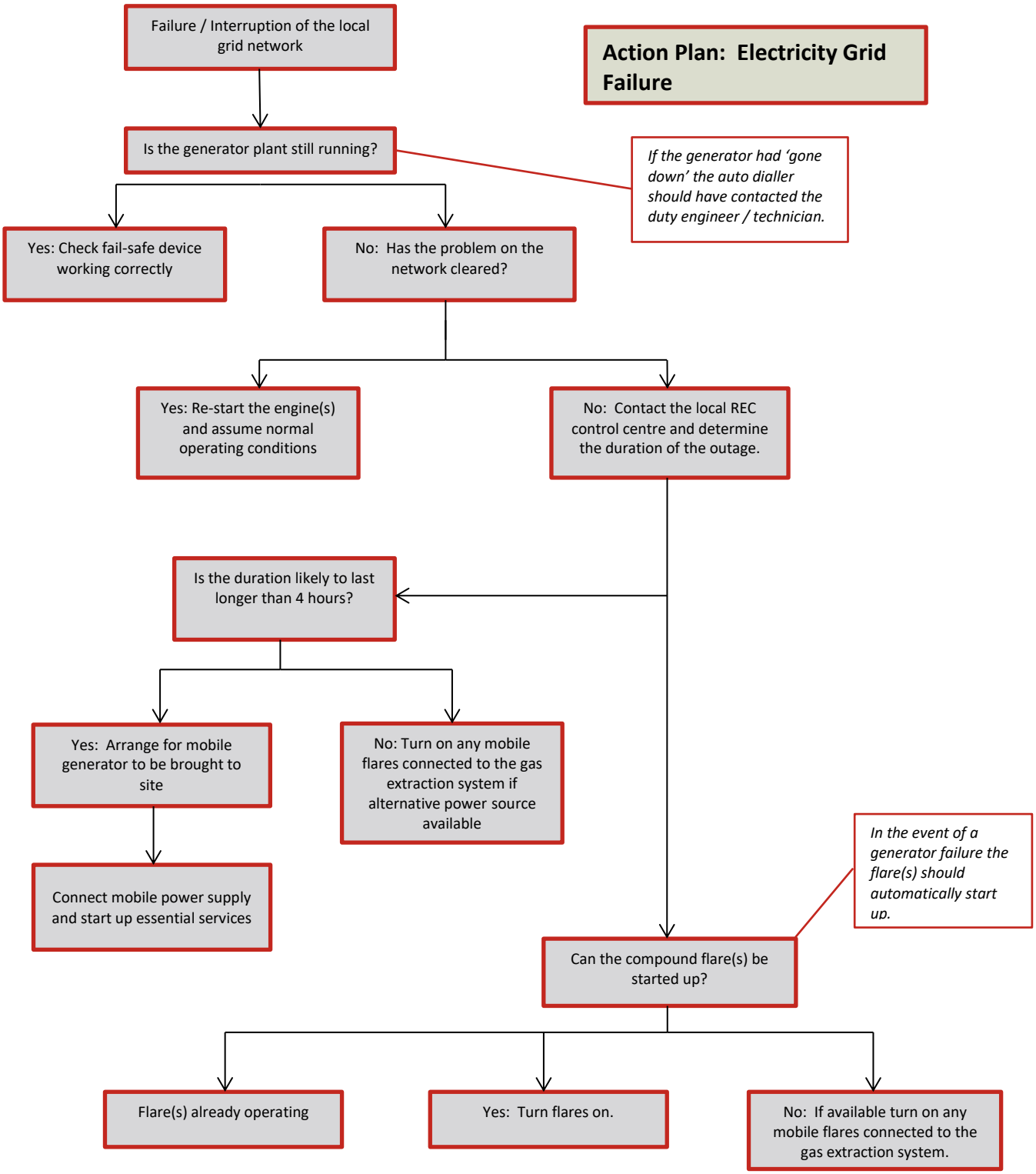
In the event that the level of gas measured in a perimeter borehole is in exceedance of the permitted level, the following list of actions may be carried out as applicable to manage the event and return the gas level to a compliant level (where possible).

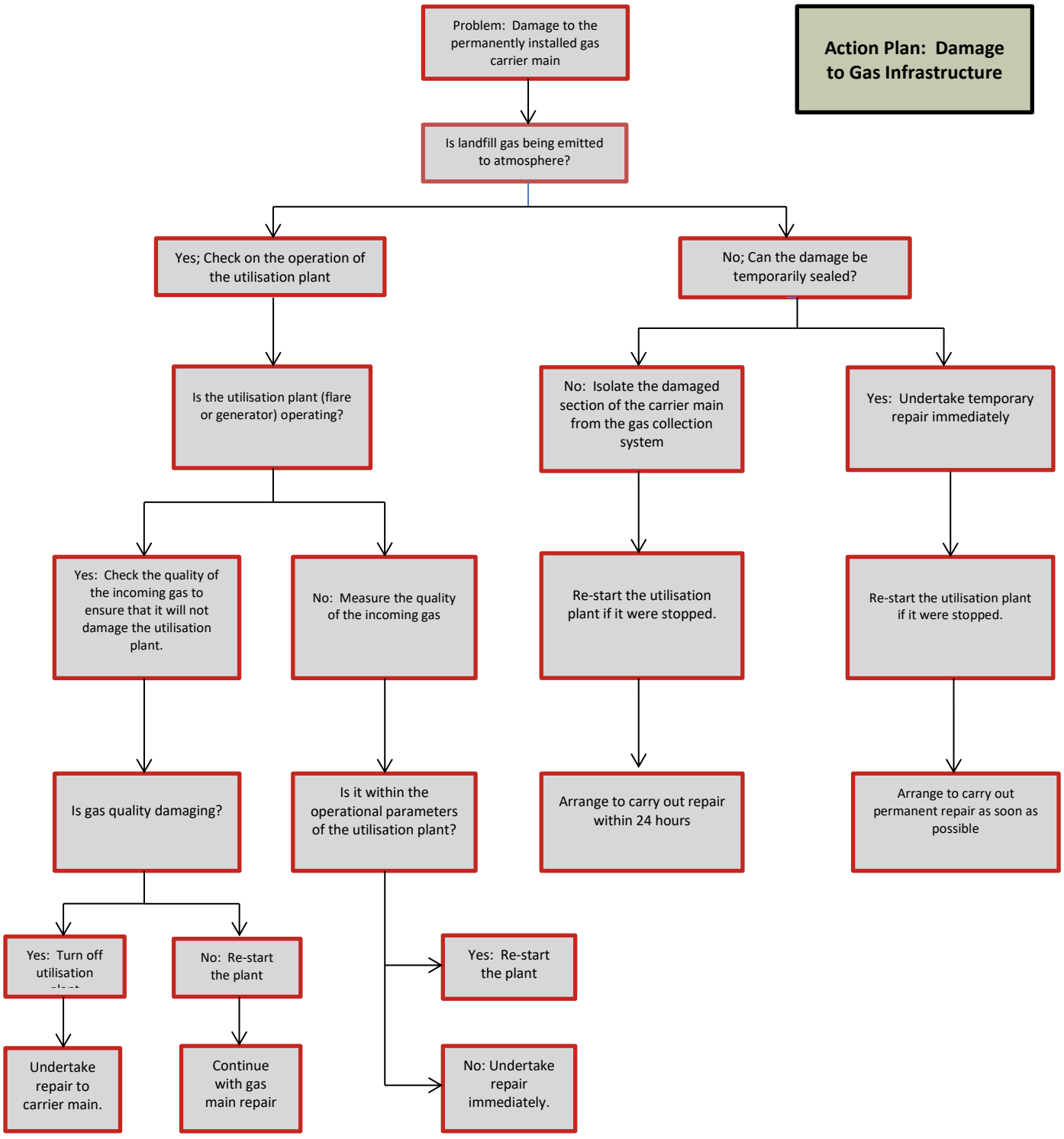
- Check to confirm that the gas is above permitted levels.
- Inform the EA of exceedance of permitted levels
- Increase monitoring frequency of the perimeter borehole
- Measure passive flows at the perimeter borehole (no flow, no risk)
- Assess gas monitoring data trends
- Re-balance the gas extraction system
- Investigate other potential sources of gas
- Carry out trace gas analysis within the landfill and perimeter boreholes to confirm source of gas in perimeter borehole
- Carry out radioactive carbon dating of the gas
- Identify nearest receptors
- Check for signs of vegetation stress.
- Carry out “spike” gas survey (the results from this can be used to assess the risk)
- Risk assess; review if evacuation of property is required
- Review potential to install gas detectors in any occupied buildings
- Undertake flow/pressure monitoring whilst actively extracting on the perimeter boreholes (this would only be done on a temporary basis)
- Review potential to install additional perimeter boreholes
- Review the gas infrastructure (to include FID survey as appropriate)
- Re-inforce gas infrastructure as necessary
- Identify defects in the cell engineering
- Remediate defects found in the cell engineering (where possible)
- Undertake analysis of ground water for dissolved methane
- Introduce a nitrogen purge to determine the depth the gas is entering the borehole (this may assist in identifying the cause and remediation required)
- Produce a report on the findings; submit to the EA.
- Where gas migration cannot be prevented, produce a management plan.
- Review historical data to amend or remove compliance limits where appropriate

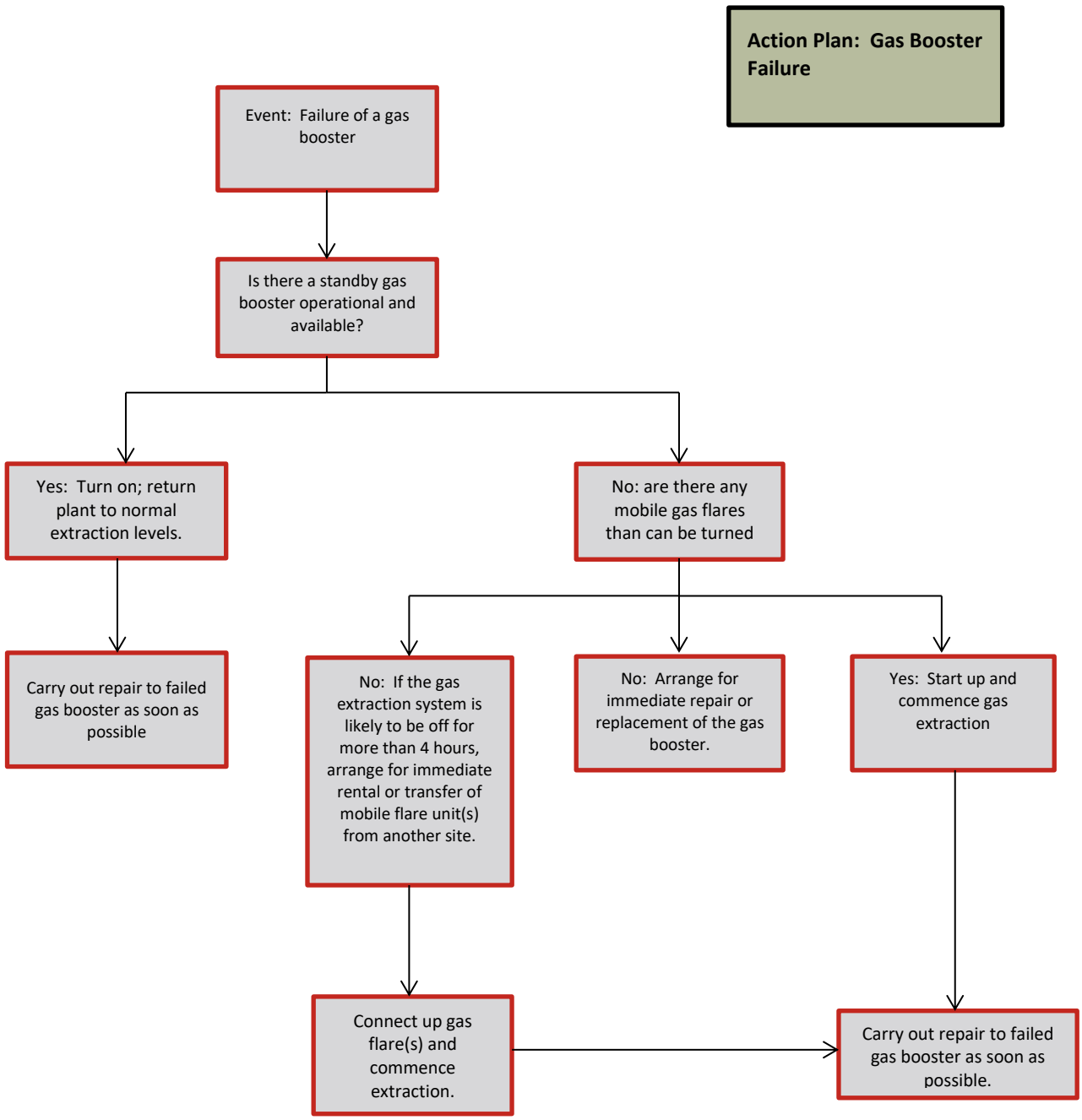
ACTION PLANS


Identification of a hot spot/fire on the landfill site
Is the hot spot/fire restricted to the surface?
Yes; extinguish with local liquid supply, summon the fire brigade
Make frequent regular checks to ensure that the fire has cooled down
Take remedial action as identified in the investigation
No; fire appears to be within the body of the waste
Confirm with lab analysis for Carbon Monoxide if necessary
If not elevated levels of CO, return to normal monitoring
Turn off gas extraction wells in a c.50m radii around the source of heat
Check condition and cap and seal all possible pathways for air ingress.
Monitor affected gas wells for pressure, CH_4, CO_2, CO, O_2, and temp (base line data)
Control pressure at the gas well at slight +ve pressure
Continue to monitor the gas wells for pressure, CH_4, CO_2, CO, O_2 and temp. Compare with base line data. Is the temp reducing and CO level decreasing and other parameters indicating fire reducing?
No
Yes; Commence limited extraction when appropriate or continue to monitor from the gas wells within the 50m radii
Action Plan; Surface & Subsurface fire control (Part 1) using elimination of air to extinguish the fire
Refer to subsurface fire ICOP for further information

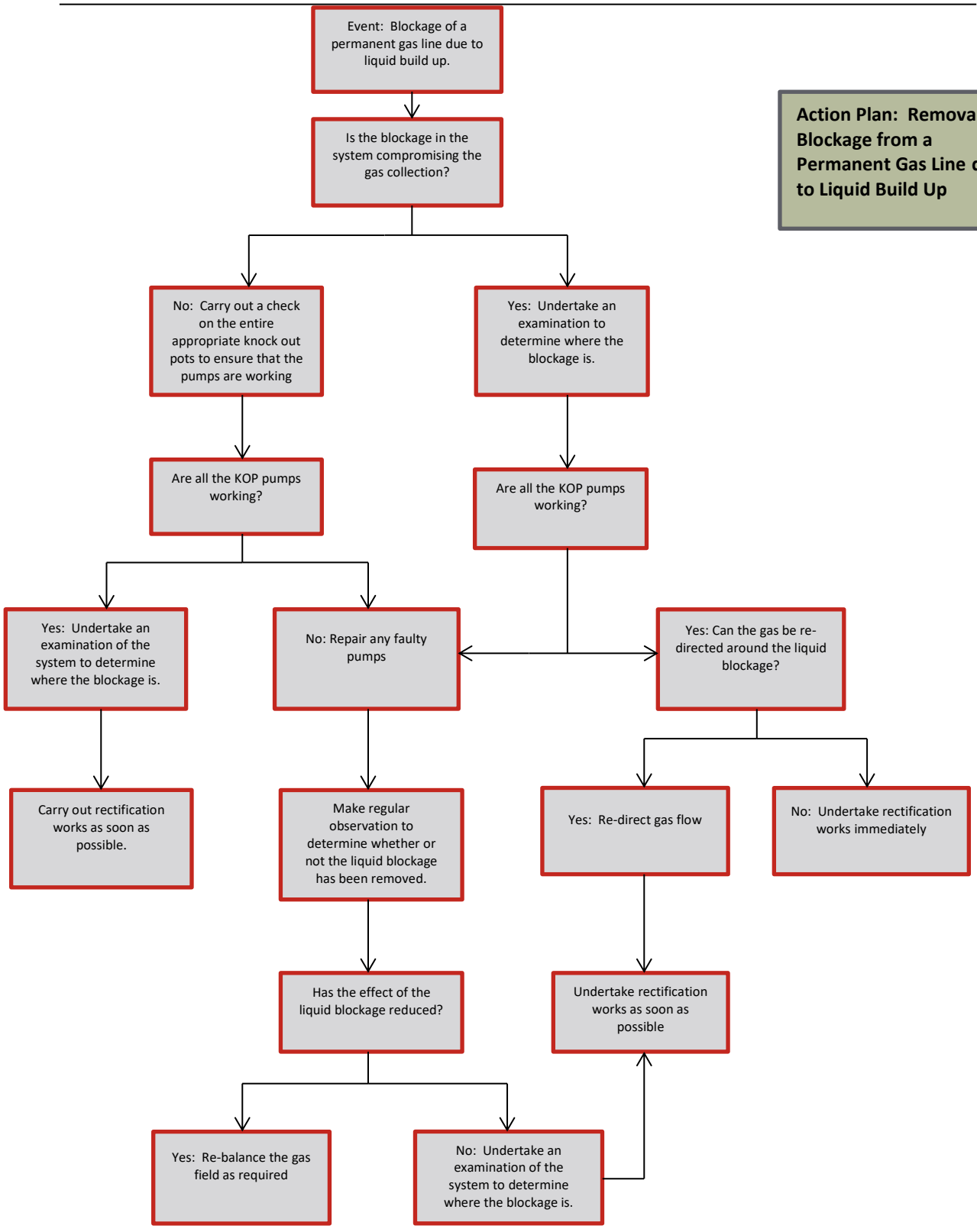

Will the use of water/leachate have an impact on the Hydrogeological Risk Assessment or slope engineering at the site?
Yes; do not use water / leachate to control the fire
No; has any on-site leachate treatment facility spare capacity to handle the additional liquid volumes?
No; do not use water/leachate for fire control
Yes; has the site got ready access to a supply of water/leachate to flood the area of the fire?
No; do not use limited quantities of water/leachate to control the fire. This may have a detrimental impact on the management of the fire.
Yes; undertake an appropriate temperature survey around the source of the fire.
Are there existing gas/leachate well structures near the source of the fire?
No; consider the installation of pin wells into the affected area. Beware of potential ground stability conditions as voids under the surface of the may have been formed by the fire.
Install pin wells & water injection system
Yes; Use gas wells as a means of introducing liquid to flood the area of the fire.
Flood the area with water/leachate.
Monitor frequently & regularly the gas wells for pressure, CH4, CO2, CO, O2 and temperature.
Are the results of the monitoring indicating temperatures decreasing and carbon monoxide levels reducing?
No; re-flood the fire using gas wells or installation of pin wells into the affected area.
Yes; Commence controlled limited gas extraction in the 50m radii.
Monitor regularly to ensure that all gas readings are within the normal range.
Action Plan; Surface & Subsurface fire control (Part 2) using liquid to extinguish the fire when the exclusion of air has not controlled the fire
This action plan maybe considered in the event that the methodology detailed in Part 1 has failed to control the subsurface fire.
Refer to subsurface fire ICOP for further information


Action Plan: Electricity Grid Failure
Failure / Interruption of the local grid network
Is the generator plant still running?
If the generator had 'gone down' the auto dialler should have contacted the duty engineer / technician.
Yes: Check fail-safe device working correctly
No: Has the problem on the network cleared?
Yes: Re-start the engine(s) and assume normal operating conditions
No: Contact the local REC control centre and determine the duration of the outage.
Is the duration likely to last longer than 4 hours?
Yes: Arrange for mobile generator to be brought to site
No: Turn on any mobile flares connected to the gas extraction system if alternative power source available
Connect mobile power supply and start up essential services
In the event of a generator failure the flare(s) should automatically start up.
Can the compound flare(s) be started up?
Flare(s) already operating
Yes: Turn flares on.
No: If available turn on any mobile flares connected to the gas extraction system.


Action Plan: Damage to Gas Infrastructure
Problem: Damage to the permanently installed gas carrier main
Is landfill gas being emitted to atmosphere?
Yes; Check on the operation of the utilisation plant
No; Can the damage be temporarily sealed?
Is the utilisation plant (flare or generator) operating?
No: Isolate the damaged section of the carrier main from the gas collection system
Yes: Undertake temporary repair immediately
Yes: Check the quality of the incoming gas to ensure that it will not damage the utilisation plant.
No: Measure the quality of the incoming gas
Re-start the utilisation plant if it were stopped.
Re-start the utilisation plant if it were stopped.
Is gas quality damaging?
Is it within the operational parameters of the utilisation plant?
Arrange to carry out repair within 24 hours
Arrange to carry out permanent repair as soon as possible
Yes: Turn off utilisation
No: Re-start the plant
Yes: Re-start the plant
Undertake repair to carrier main.
Continue with gas main repair
No: Undertake repair immediately.


Action Plan: Gas Booster Failure
Event: Failure of a gas booster
Is there a standby gas booster operational and available?
Yes: Turn on; return plant to normal extraction levels.
Carry out repair to failed gas booster as soon as possible
No: are there any mobile gas flares than can be turned
No: If the gas extraction system is likely to be off for more than 4 hours, arrange for immediate rental or transfer of mobile flare unit(s) from another site.
Connect up gas flare(s) and commence extraction.
No: Arrange for immediate repair or replacement of the gas booster.
Yes: Start up and commence gas extraction
Carry out repair to failed gas booster as soon as possible.

Action Plan: Removal of Blockage from a Permanent Gas Line due to Liquid Build Up



BIFFA COMPLAINTS REPORTING PROCEDURE

COMPLAINTS FORMS

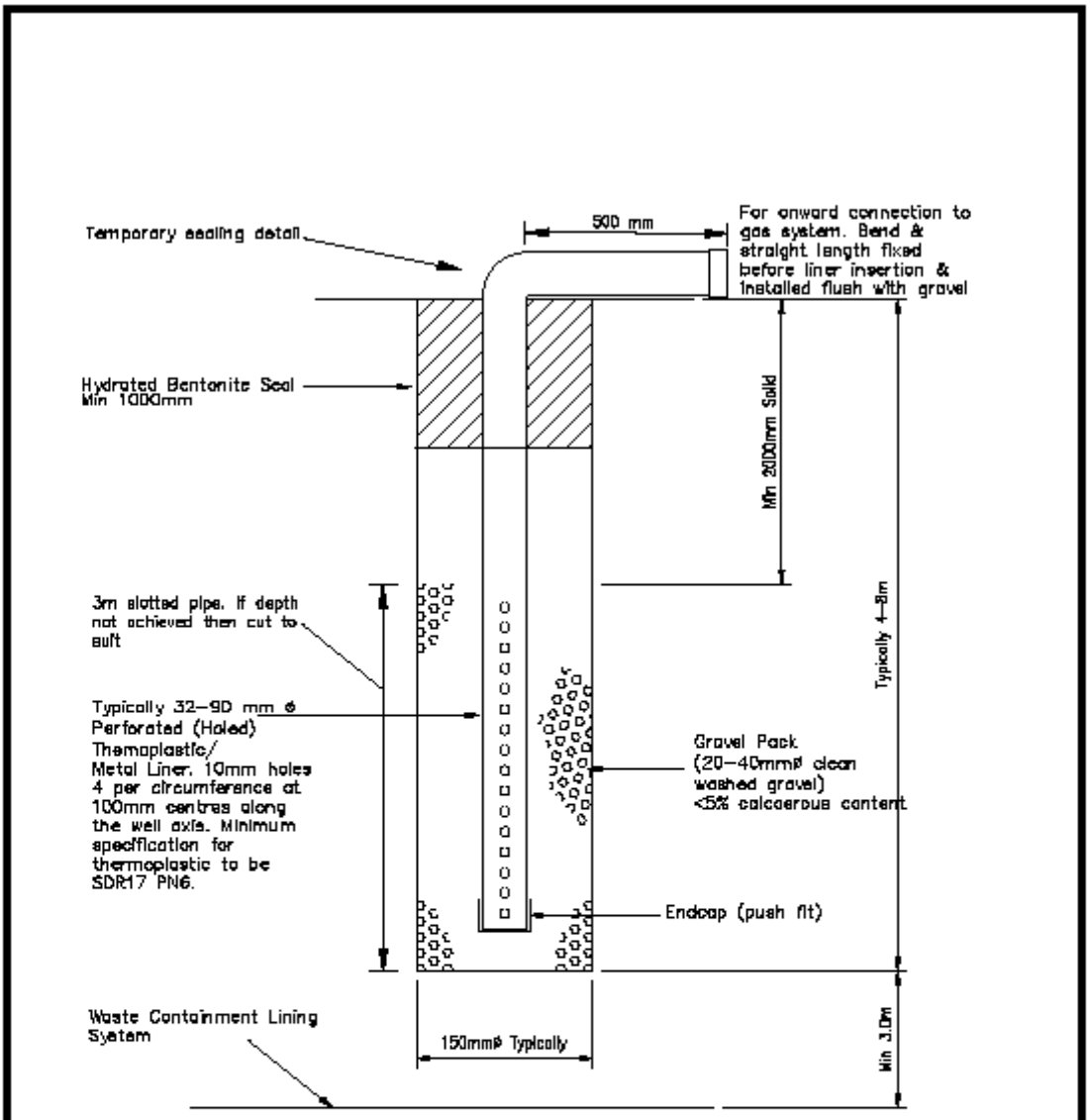
Refer to most recent procedure on OBi (Biffa's intranet system).

FIRE AND EVACUATION PROCEDURE

(Typical)

A copy of a generic Emergency Plan can be found on OBi at Energy/Health & Safety/Forms/Blank Generic Emergency Plan.

Typical Arrangement Drawings



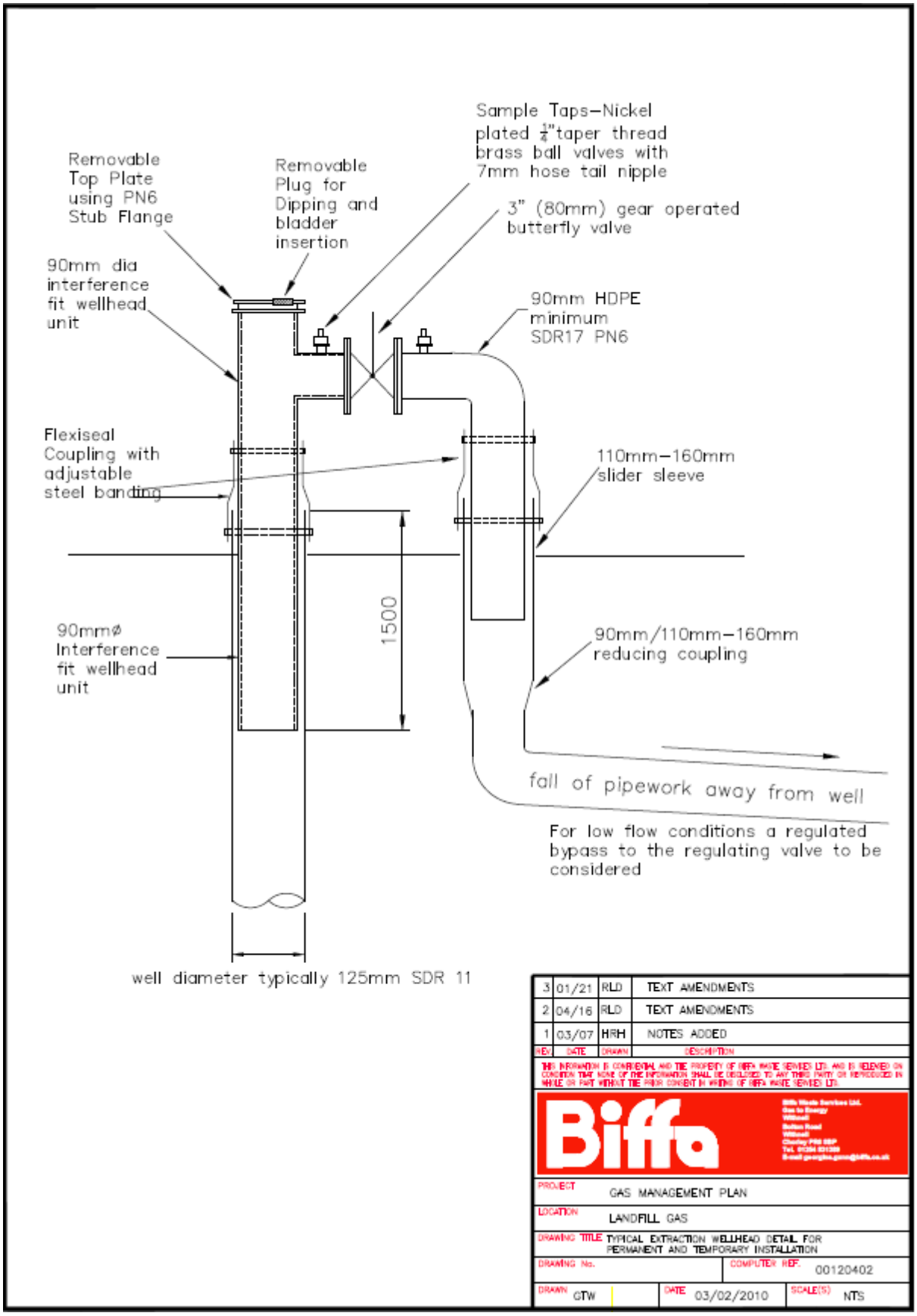
SUMMARY OF INSTALLATION INSTRUCTIONS

* All materials to be available prior to commencement.
* Create aperture.
* Insert liner.
* Install gravel and Bentonite.
* No more than 30 pinwells to be installed before connection to the collection system, unless site specific circumstances dictate.
* Aborted pinwells to be sealed immediately.
* 63mm ball valves, 90mm & 125mm to be butterfly valves.

REF.	DATE	DRAWN	DESCRIPTION
3	03/15	RLD	MINOR AMENDMENTS.
2	02/10	CTM	NOTES ADDED, MINOR AMENDMENTS.
1	03/07	HRH	NOTES ADDED

Biffa

PROJECT	GAS MANAGEMENT PLAN
LOCATION	LANDFILL GAS
DRAWING TITLE	TYPICAL IMPACT WELL DETAIL
DRAWING No.	COMPUTER REF. 0012D303
DRAWN MC	DATE 02/04/03 SCALE(S) NTS


Sample Taps–Nickel plated ¼"taper thread brass ball valves with 7mm hose tail nipple
Removable Top Plate using PN6 Stub Flange
Removable Plug for Dipping and bladder insertion
3" (80mm) gear operated butterfly valve
90mm dia interference fit wellhead unit
90mm HDPE minimum SDR17 PN6
Flexiseal Coupling with adjustable steel banding
110mm–160mm slider sleeve
1500
90mmø Interference fit wellhead unit
90mm/110mm–160mm reducing coupling
fall of pipework away from well
For low flow conditions a regulated bypass to the regulating valve to be considered
well diameter typically 125mm SDR 11
3 01/21 RLD TEXT AMENDMENTS
2 04/16 RLD TEXT AMENDMENTS
1 03/07 HRH NOTES ADDED
REV. DATE DRAWN DESCRIPTION
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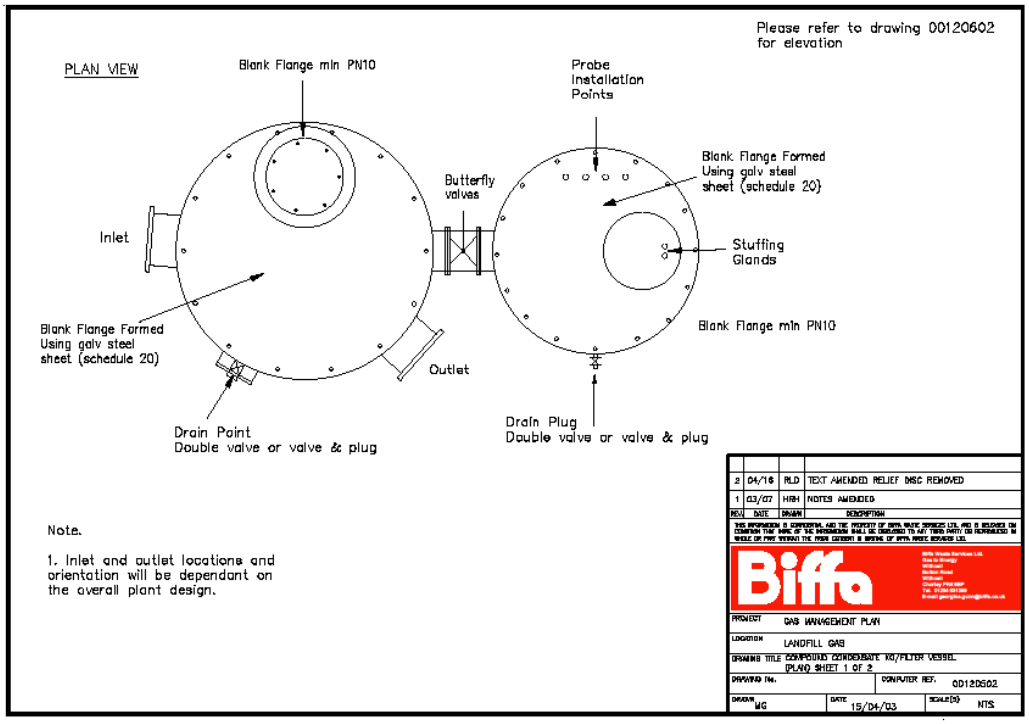
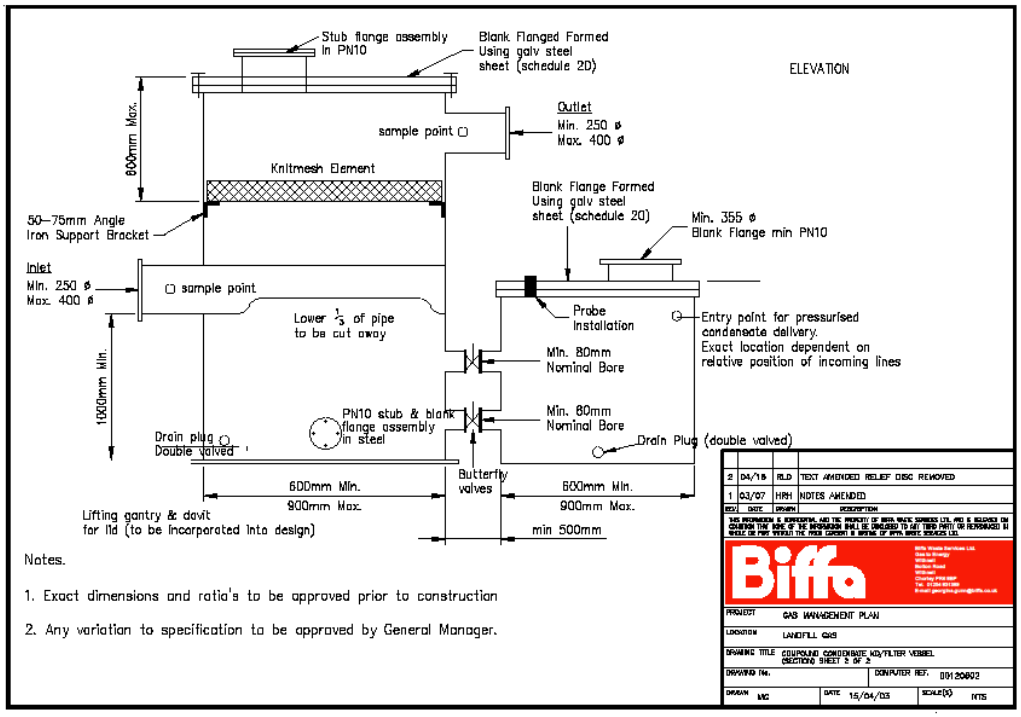
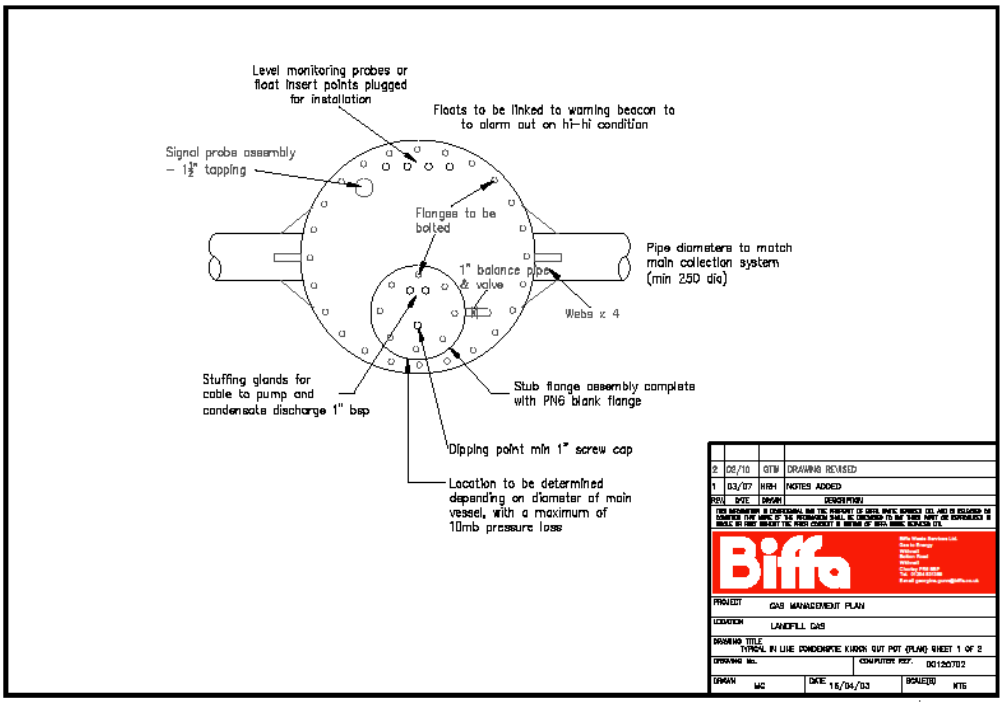
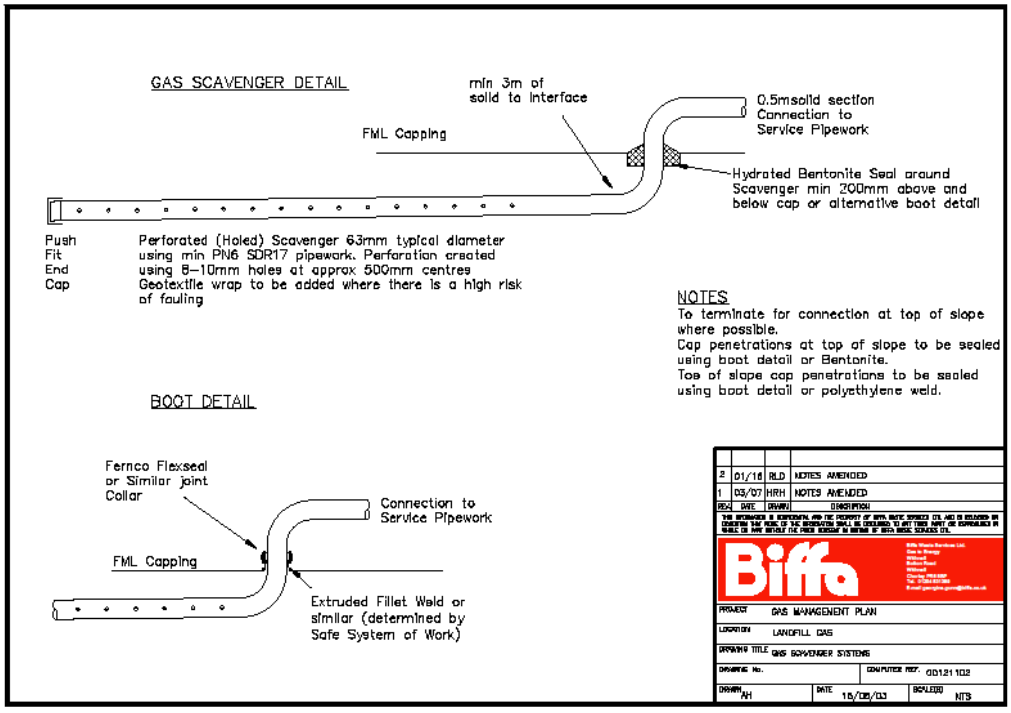
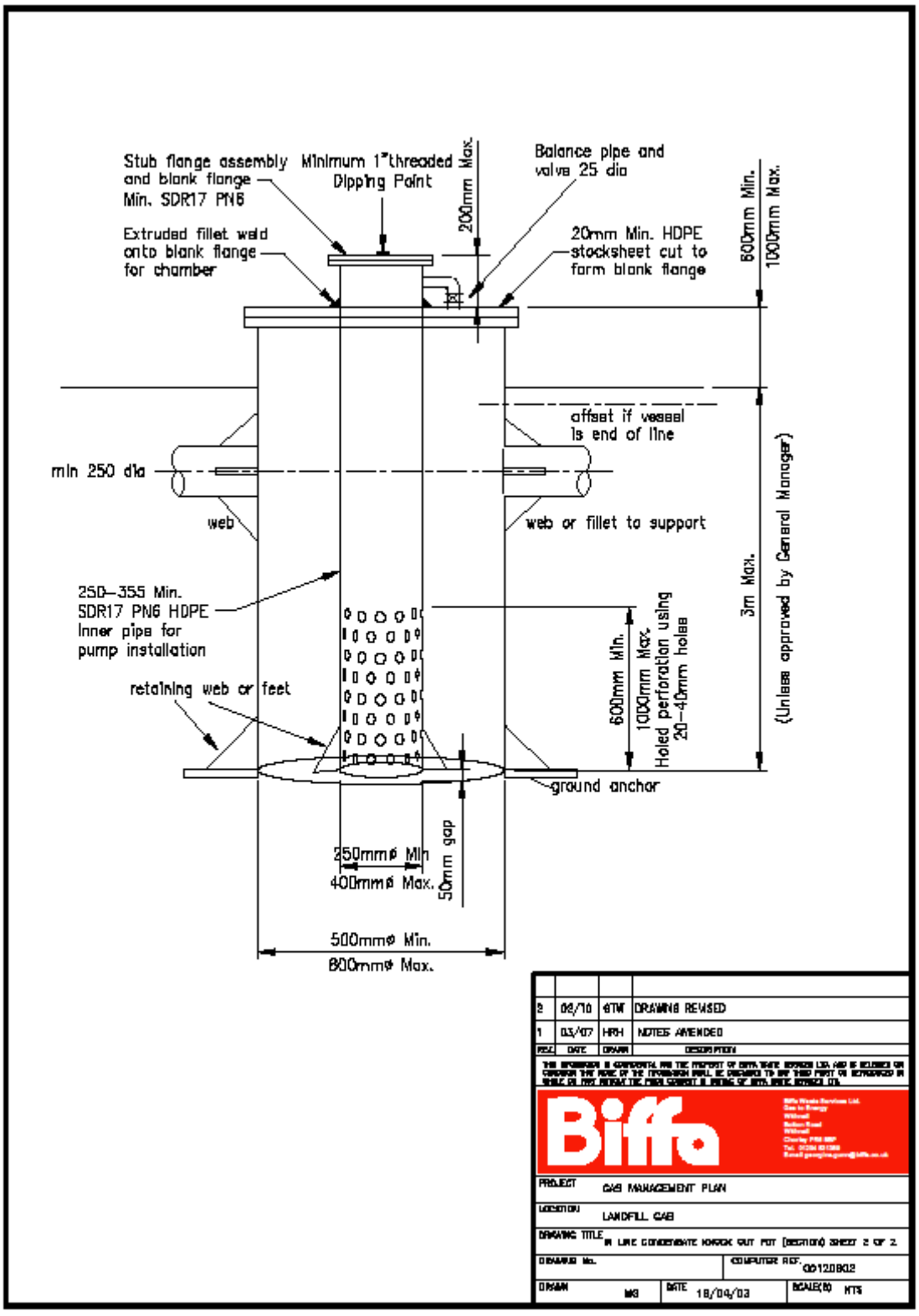
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE TYPICAL EXTRACTION WELLHEAD DETAIL FOR PERMANENT AND TEMPORARY INSTALLATION
DRAWING No.
COMPUTER REF. 00120402
DRAWN GTW
DATE 03/02/2010
SCALE(S) NTS

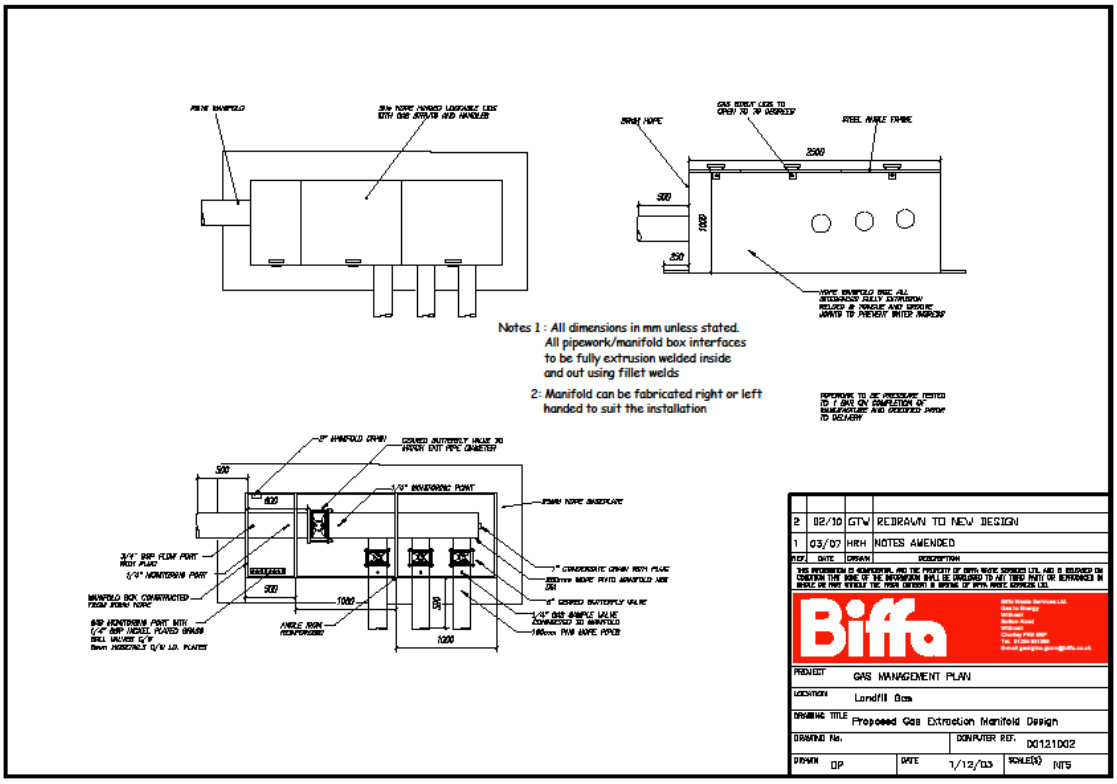

Please refer to drawing 00120602 for elevation
PLAN VIEW
Blank Flange min PN10
Probe Installation Points
Butterfly valves
Blank Flange Formed Using galv steel sheet (schedule 20)
Inlet
Stuffing Glands
Blank Flange Formed Using galv steel sheet (schedule 20)
Blank Flange min PN10
Outlet
Drain Point Double valve or valve & plug
Drain Plug Double valve or valve & plug
Note.
1. Inlet and outlet locations and orientation will be dependant on the overall plant design.
2 04/16 RLD TEXT AMENDED RELIEF DISC REMOVED
1 03/07 HRH NOTES AMENDED
REV DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE COMPOUND CONDENSATE KO/FILTER VESSEL (PLAN) SHEET 1 OF 2
DRAWING No. COMPUTER REF. 00120602
DRAWN MG DATE 15/04/03 SCALE(S) NTS

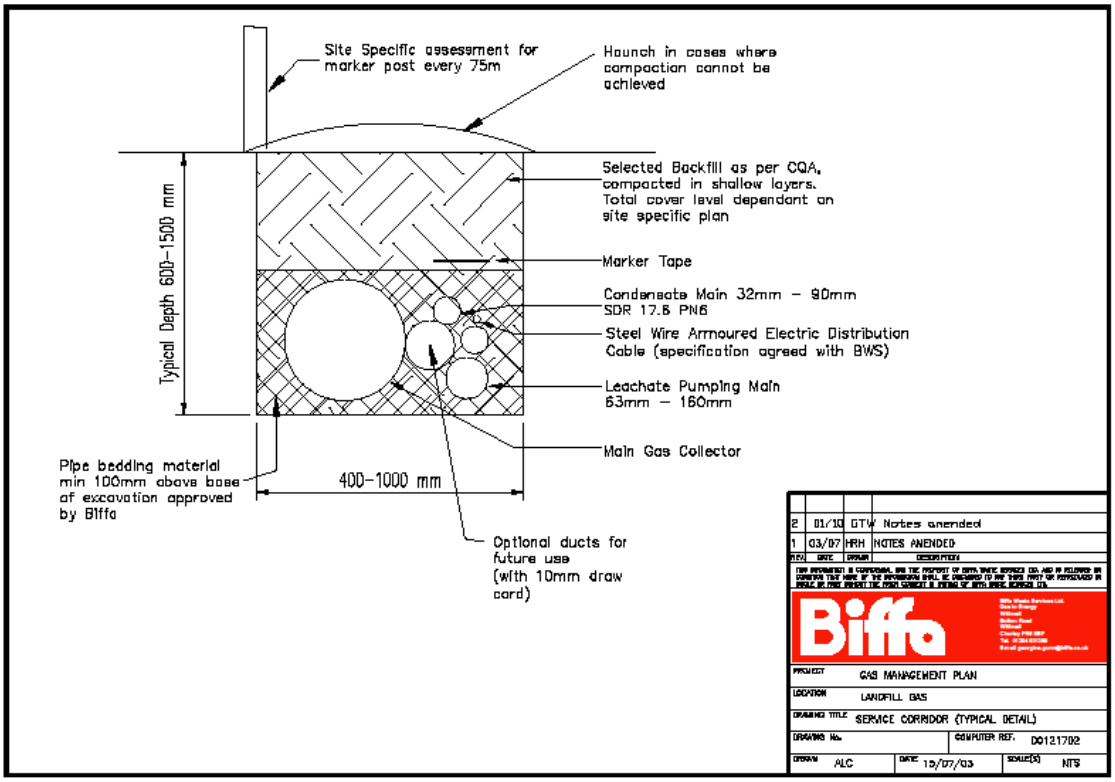

Stub flange assembly in PN10
Blank Flanged Formed Using galv steel sheet (schedule 20)
ELEVATION
800mm Max.
Outlet
Min. 250 ø
Max. 400 ø
sample point
Knitmesh Element
Blank Flange Formed Using galv steel sheet (schedule 20)
Min. 355 ø
Blank Flange min PN10
50–75mm Angle Iron Support Bracket
Inlet
Min. 250 ø
Max. 400 ø
sample point
Lower 1/3 of pipe to be cut away
Probe Installation
Entry point for pressurised condensate delivery. Exact location dependent on relative position of incoming lines
1000mm Min.
Min. 80mm Nominal Bore
PN10 stub & blank flange assembly in steel
Min. 80mm Nominal Bore
Drain plug Double valved
Drain Plug (double valved)
Butterfly valves
600mm Min.
900mm Max.
600mm Min.
900mm Max.
Lifting gantry & davit for lid (to be incorporated into design)
min 500mm
Notes.
1. Exact dimensions and ratio's to be approved prior to construction
2. Any variation to specification to be approved by General Manager.
2 04/16 RLD TEXT AMENDED RELIEF DISC REMOVED
1 03/07 HRH NOTES AMENDED
REV DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE COMPOUND CONDENSATE KO/FILTER VESSEL SECTIONS SHEET 2 OF 2
DRAWING No. COMPUTER REF. 00120602
DRAWN MG DATE 15/04/03 SCALE(S) NTS

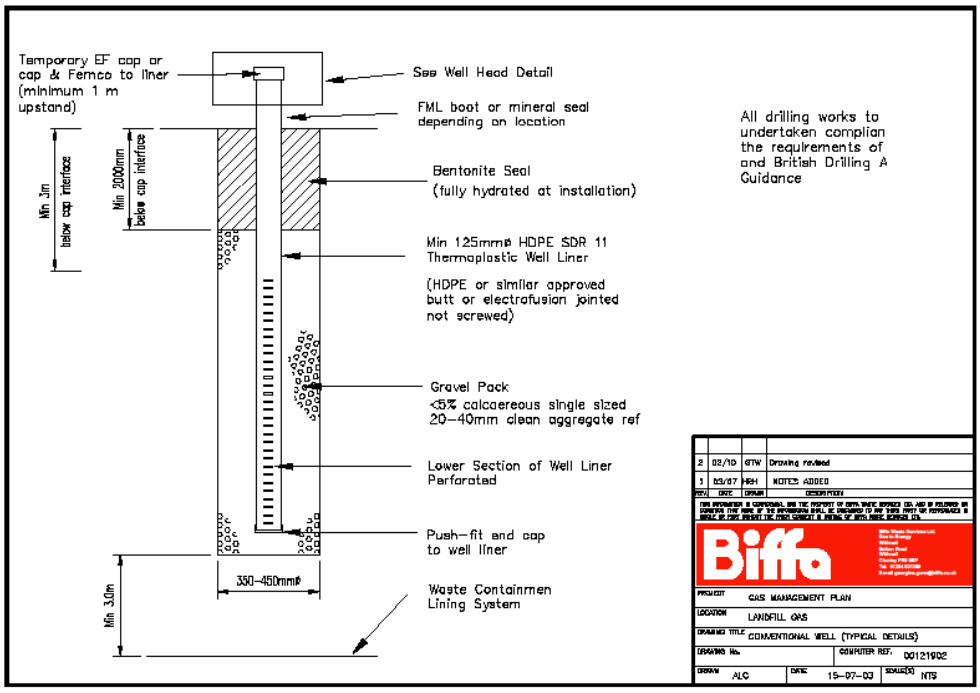

Level monitoring probes or float insert points plugged for installation
Floats to be linked to warning beacon to to alarm out on hi-hi condition
Signal probe assembly – 1½" tapping
Flanges to be bolted
Pipe diameters to match main collection system (min 250 dia)
1" balance pipe & valve
Webs x 4
Stuffing glands for cable to pump and condensate discharge 1" bsp
Stub flange assembly complete with PN6 blank flange
Dipping point min 1" screw cap
Location to be determined depending on diameter of main vessel, with a maximum of 10mb pressure loss
2 02/10 GTW DRAWING REVISED
1 03/07 HRH NOTES ADDED
REV DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE TYPICAL IN LINE CONDENSATE KNOCK OUT POT (PLAN) SHEET 1 OF 2
DRAWING No. COMPUTER REF. 001250702
DRAWN MC DATE 15/04/03 SCALE(S) NTS

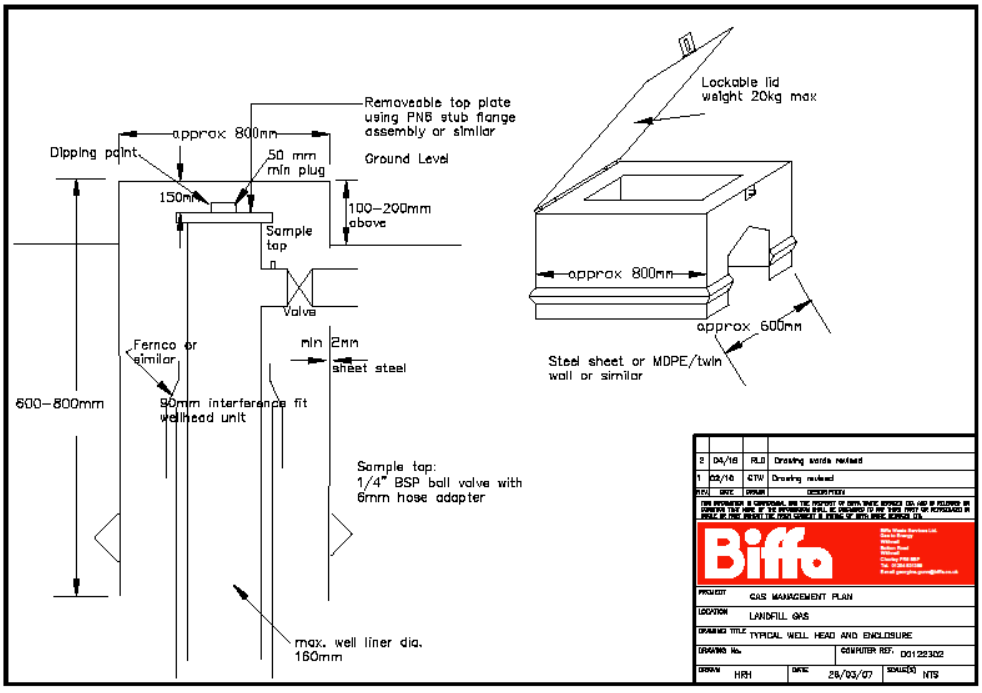

GAS SCAVENGER DETAIL
min 3m of solid to interface
FML Capping
0.5msolid section Connection to Service Pipework
Hydrated Bentonite Seal around Scavenger min 200mm above and below cap or alternative boot detail
Push Fit End Cap
Perforated (Holed) Scavenger 63mm typical diameter using min PN6 SDR17 pipework. Perforation created using 8–10mm holes at approx 500mm centres Geotextile wrap to be added where there is a high risk of fouling
NOTES
To terminate for connection at top of slope where possible.
Cap penetrations at top of slope to be sealed using boot detail or Bentonite.
Toe of slope cap penetrations to be sealed using boot detail or polyethylene weld.
BOOT DETAIL
Fernco Flexseal or Similar joint Collar
Connection to Service Pipework
FML Capping
Extruded Fillet Weld or similar (determined by Safe System of Work)
2 01/16 RLD NOTES AMENDED
1 03/07 HRH NOTES AMENDED
REV DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE GAS SCAVENGER SYSTEMS
DRAWING No. COMPUTER REF. 001211102
DRAWN AH DATE 15/08/03 SCALE(S) NTS

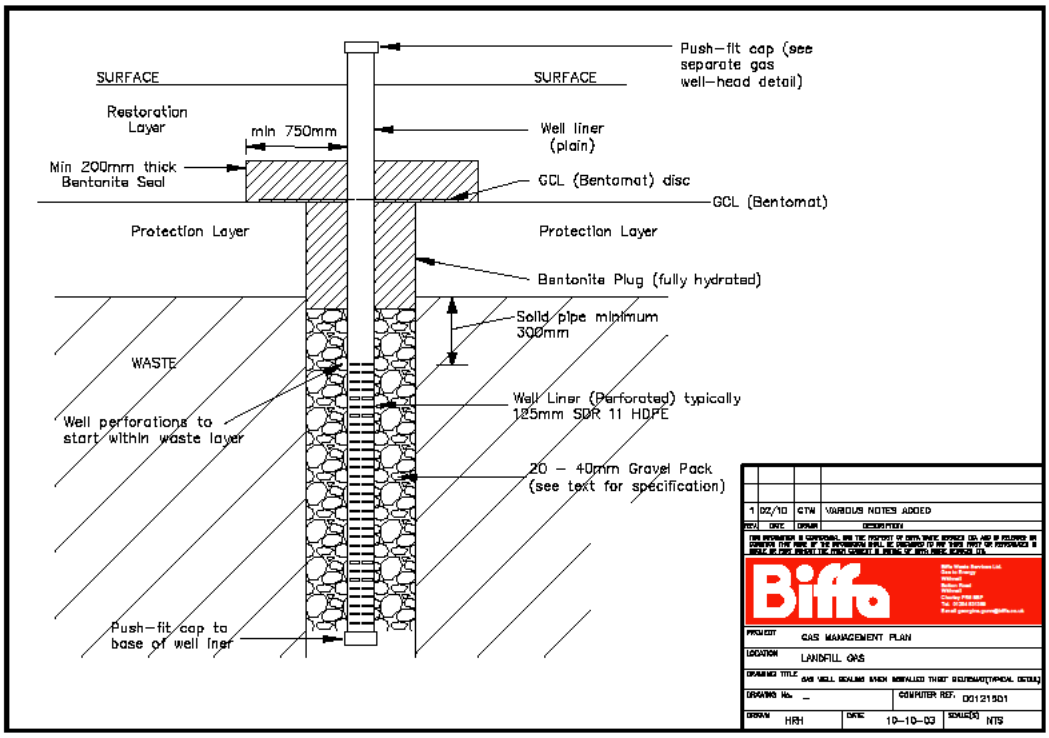

Stub flange assembly and blank flange Min. SDR17 PN6
Minimum 1"threaded Dipping Point
200mm Max.
Balance pipe and valve 25 dia
Extruded fillet weld onto blank flange for chamber
20mm Min. HDPE stocksheet cut to form blank flange
600mm Min.
1000mm Max.
offset if vessel is end of line
min 250 dia
web
web or fillet to support
250-355 Min. SDR17 PN6 HDPE Inner pipe for pump installation
retaining web or feet
600mm Min.
1000mm Max.
Holed perforation using 20-40mm holes
3m Max.
(Unless approved by General Manager)
ground anchor
250mmø Min
400mmø Max.
50mm gap
500mmø Min.
800mmø Max.
2 08/10 GTW DRAWING REVISED
1 03/07 HRH NOTES AMENDED
REV. DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE IN LINE CONDENSATE KNOCK OUT POT (SECTION) SHEET 2 OF 2.
DRAWING No.
COMPUTER REF. 001208G2
DRAWN MG
DATE 18/04/03
SCALE(@) NTS

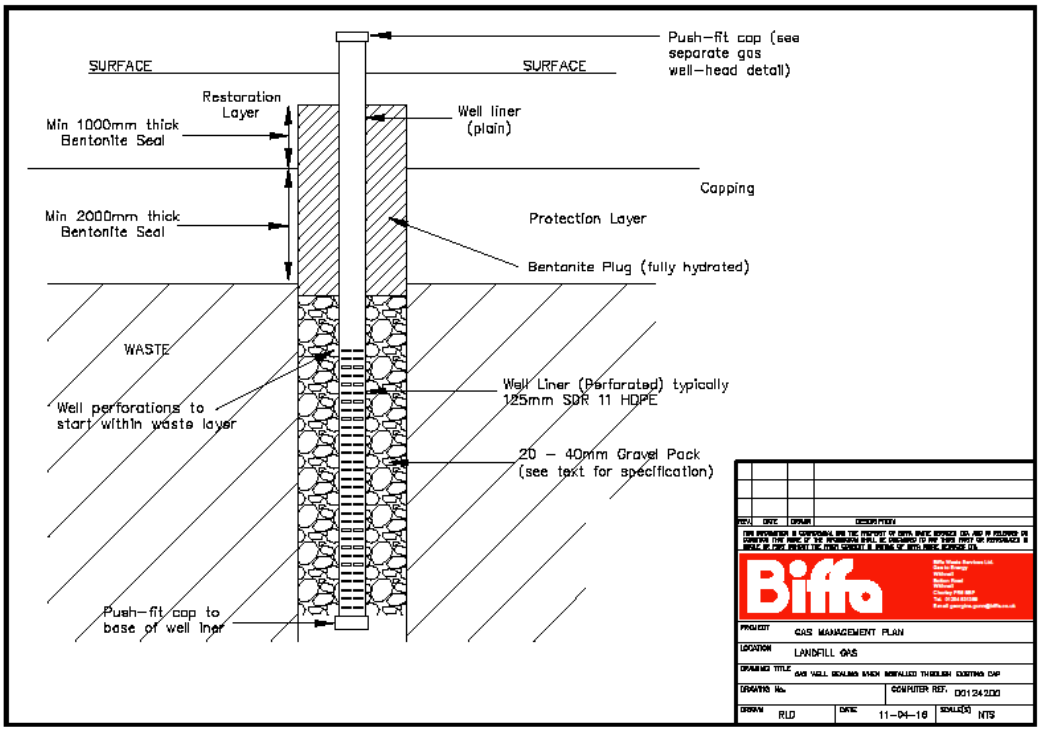

Notes 1 : All dimensions in mm unless stated.
All pipework/manifold box interfaces to be fully extrusion welded inside and out using fillet welds
2: Manifold can be fabricated right or left handed to suit the installation
2 02/10 GTW REDRAWN TO NEW DESIGN
1 03/07 HRH NOTES AMENDED
REF. DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION Landfill Gas
DRAWING TITLE Proposed Gas Extraction Manifold Design
DRAWING No. COMPUTER REF. D0121002
DRAWN DP DATE 1/12/03 SCALE(S) NTS

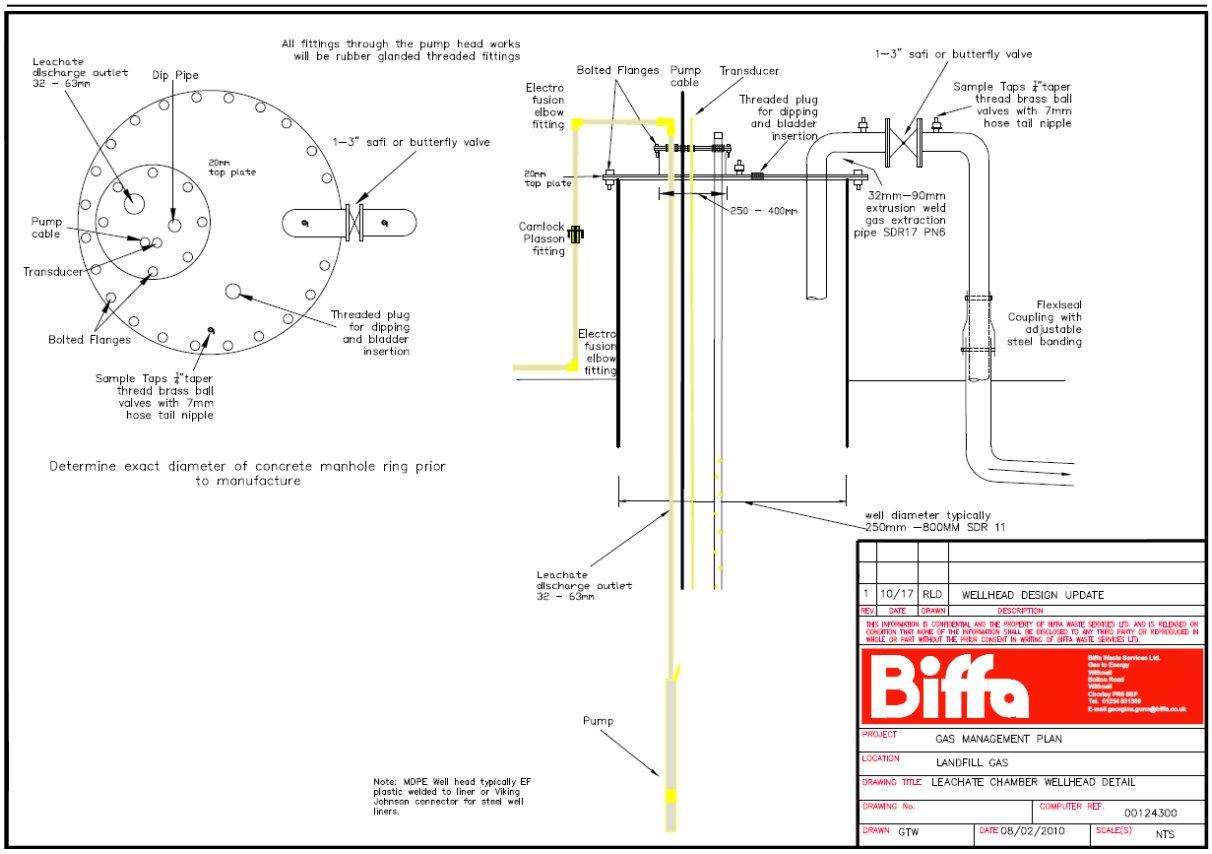

Site Specific assessment for marker post every 75m
Haunch in cases where compaction cannot be achieved
Selected Backfill as per CQA, compacted in shallow layers. Total cover level dependant on site specific plan
Marker Tape
Condensate Main 32mm – 90mm SDR 17.6 PN6
Steel Wire Armoured Electric Distribution Cable (specification agreed with BWS)
Leachate Pumping Main 63mm – 160mm
Main Gas Collector
Optional ducts for future use (with 10mm draw cord)
Typical Depth 600–1500 mm
400–1000 mm
Pipe bedding material min 100mm above base of excavation approved by Biffa
2 01/10 GTW Notes amended
1 03/07 HRH NOTES AMENDED
REF. DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE SERVICE CORRIDOR (TYPICAL DETAIL)
DRAWING No. COMPUTER REF. D0121702
DRAWN ALC DATE 15/07/03 SCALE(S) NTS


Temporary EF cap or cap & Ferrco to liner (minimum 1 m upstand)
See Well Head Detail
FML boot or mineral seal depending on location
All drilling works to undertaken complian the requirements of and British Drilling A Guidance
Min 3m below cap interface
Min 2000mm below cap interface
Bentonite Seal (fully hydrated at installation)
Min 125mmø HDPE SDR 11 Thermoplastic Well Liner
(HDPE or similar approved butt or electrofusion jointed not screwed)
Gravel Pack <5% calcareous single sized 20–40mm clean aggregate ref
Lower Section of Well Liner Perforated
Push–fit end cap to well liner
350–450mmø
Min 3.0m
Waste Containmen Lining System
2 02/10 GTW Drawing revised
1 03/07 HRH NOTES ADDED
REV. DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE CONVENTIONAL WELL (TYPICAL DETAILS)
DRAWING No. COMPUTER REF. 00121902
DRAWN ALC DATE 15–07–03 SCALE(S) NTS


Removeable top plate using PN6 stub flange assembly or similar
approx 800mm
Dipping point
50 mm min plug
Ground Level
150mm
100–200mm above
Sample tap
Valve
Fernco or similar
min 2mm sheet steel
600–800mm
90mm interference fit wellhead unit
Sample tap: 1/4" BSP ball valve with 6mm hose adapter
max. well liner dia. 160mm
Lockable lid weight 20kg max
approx 800mm
approx 600mm
Steel sheet or MDPE/twin wall or similar
2 04/18 RLD Drawing words revised
1 02/18 GTW Drawing revised
REV. DATE DRAWN DESCRIPTION
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE TYPICAL WELL HEAD AND ENCLOSURE
DRAWING No. COMPUTER REF. 00122302
DRAWN HRH DATE 28/03/07 SCALE(S) NTS


Push–fit cap (see separate gas well–head detail)
SURFACE
SURFACE
Restoration Layer
min 750mm
Well liner (plain)
Min 200mm thick Bentonite Seal
GCL (Bentomat) disc
GCL (Bentomat)
Protection Layer
Protection Layer
Bentonite Plug (fully hydrated)
Solid pipe minimum 300mm
WASTE
Well Liner (Perforated) typically 125mm SDR 11 HDPE
Well perforations to start within waste layer
20 – 40mm Gravel Pack (see text for specification)
Push–fit cap to base of well liner
1 02/10 CTW VARIOUS NOTES ADDED
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE GAS WELL SEALING EACH INSTALLED THICK BENTONITE(TYPICAL DETAIL)
DRAWING No. –
COMPUTER REF. 00121501
DRAWN HRH
DATE 19–10–09
SCALE(S) NTS


Push–fit cap (see separate gas well–head detail)
SURFACE
SURFACE
Restoration Layer
Well liner (plain)
Min 1000mm thick Bentonite Seal
Capping
Min 2000mm thick Bentonite Seal
Protection Layer
Bentonite Plug (fully hydrated)
WASTE
Well Liner (Perforated) typically 125mm SDR 11 HDPE
Well perforations to start within waste layer
20 – 40mm Gravel Pack (see text for specification)
Push–fit cap to base of well liner
Biffa
PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE GAS WELL SEALING EACH INSTALLED THROUGH EXISTING CAP
DRAWING No.
COMPUTER REF. 00124200
DRAWN RLD
DATE 11–04–16
SCALE(S) NTS


All fittings through the pump head works will be rubber glanded threaded fittings
Leachate discharge outlet 32 – 63mm
Dip Pipe
20mm top plate
1–3" safi or butterfly valve
Pump cable
Transducer
Bolted Flanges
Threaded plug for dipping and bladder insertion
Sample Taps ¼"taper thread brass ball valves with 7mm hose tail nipple
Determine exact diameter of concrete manhole ring prior to manufacture
Bolted Flanges
Pump cable
Transducer
Electro fusion elbow fitting
Threaded plug for dipping and bladder insertion
1–3" safi or butterfly valve
Sample Taps ¼"taper thread brass ball valves with 7mm hose tail nipple
20mm top plate
250 – 400mm
32mm–90mm extrusion weld gas extraction pipe SDR17 PN6
Camlock Plasson fitting
Flexiseal Coupling with adjustable steel banding
Electro fusion elbow fitting
well diameter typically 250mm –800MM SDR 11
Leachate discharge outlet 32 – 63mm
Pump
Note: MDPE Well head typically EF plastic welded to liner or Viking Johnson connector for steel well liners.
1 10/17 RLD WELLHEAD DESIGN UPDATE
REV. DATE DRAWN DESCRIPTION
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PROJECT GAS MANAGEMENT PLAN
LOCATION LANDFILL GAS
DRAWING TITLE LEACHATE CHAMBER WELLHEAD DETAIL
DRAWING No.
COMPUTER REF. 00124300
DRAWN GTW
DATE 08/02/2010
SCALE(S) NTS

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