MONITORING REPORT

Project Title	The Capture and Utilisation of Methane at the GFI Mining South Africa owned Beatrix Mine in South Africa
Version	01
Report ID	Not applicable
Date of Issue	06-06-2012
Project ID	4728 – registered under the CDM
Monitoring Period	01-03-2011 to 30-06-2011
Prepared By	Promethium Carbon (Pty) Ltd
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1 PROJECT DETAILS

1.1 Summary Description of Project

The purpose of the project is to reduce greenhouse gas (GHG) emissions through the capture and destruction of methane.

The Beatrix Mine (referred to as Beatrix from here on) is a gold mine that is owned by GFI Mining South Africa; of which Gold Fields is the holding company. Beatrix is located in the Free State Province of South Africa.

The project activity involves the destruction of methane at Beatrix. The project can be divided into two distinct activities:

The capture and destruction of mine methane:
Mine methane originates in the main Beatrix mine from intersecting geological faults during mining. The mining activity releases underground methane which is highly explosive and a safety hazard. The origin of this methane is unknown. Prior to the implementation of the project activity, the underground mine methane was diluted with ventilation air to below its explosion limits and released into the atmosphere through ventilation shafts. The project activity involves the flaring of the mine methane to reduce the amount of GHGs emitted to the atmosphere.

The capture and destruction of non-mine methane:
Non-mine methane is emitted from boreholes drilled for exploration purposes by the Beatrix mine. Methane is released from numerous exploration boreholes. Since the start of the drilling program in the 1950s, a number of boreholes have intersected methane-carrying geological structures. During the development of this project, 488 holes were identified in the GFI Mining South Africa mining area. However, only five of these boreholes, geographically far apart from each other, are venting methane at rates that justified the implementation of a greenhouse gas reduction project. The project activity involves the flaring of the non-mine methane at these five boreholes to reduce the amount of GHGs emitted to the atmosphere.

1.2 Sectoral Scope and Project Type

Sectoral Scope: 10
The project is not grouped.

1.3 Project Proponent

GFI Mining South Africa (Pty) Ltd
+27 57 733 8526

1.4 Other Entities Involved in the Project

Promethium Carbon (Pty) Ltd
+27 11 706 8185

Mercuria Energy Trading SA
+41 22 595 8030

1.5 Project Start Date

17-06-2010

1.6 Project Crediting Period

01-03-2011 to 30-06-2011

1.7 Project Location

The project is located on Leeuwbult 52, which is a farm in the district of Theunissen near Virginia. Virginia is in the Free State Province of South Africa.

Mine methane:
The plant that destroys the underground mine methane is located at the Beatrix mine close to the Number 1 shaft. The GPS coordinates are: S 28° 15' 44'' E 26° 47' 06''

Non-mine methane:
The project flares non-mine methane from five boreholes. The boreholes are located at the following GPS coordinates:

DBE1	S 28º 11' 066" E 26º 45' 488"
EX1	S 28º 16' 334" E 26º 44' 612"
ST23	S 28º 11' 995" E 26º 44' 312"
1400	S 28º 13' 323" E 26º 44' 607"
2264	S 28º 13' 908" E 26º 47' 078"

1.8 Title and Reference of Methodology

AM0064: Methodology for methane capture and utilization or destruction in underground, hard rock, precious and base metal mines (Version 02).

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The start of operation of the flares, together with the start of monitoring CDM parameters, is shown in the table below.

Flare		Start of operation
Mine methane	Number 1 Shaft	21/05/2011
Non-mine methane	DBE1	08/03/2011
	2264	04/03/2011
	1400	06/03/2011
	EX1	23/03/2011
	ST23	02/03/2011

The registered PDD also provides for the installation of internal combustion engines for the generation of power from the mine methane. This is Phase 2 of the project (Phase 1 being the installation of the flares). Phase 2, however, has not been implemented yet.

For this monitoring period, there were no downtimes of equipment or major overhauls. There were, however, times when the combustion temperatures of the borehole flares were below 500°C. During these times, the flare efficiency was assumed to be 0% (as per version 01 of the 'Tool to determine project emissions from the flaring of gases containing methane'). Furthermore, not all of the flares monitoring systems were fully operational at the start of the monitoring period. No Certified Emission Reductions (CERs) are claimed for these periods, as shown in the table below.

Borehole flare	Period when no CERs were generated
DBE1	Entire monitoring period – 122 days (combustion temperature below 500°C and monitoring system not fully operational at the start of the monitoring period).
2264	Entire monitoring period – 122 days (combustion temperature below 500°C and monitoring system not fully operational at the start of the monitoring period).
1400	104 days (combustion temperature below 500°C and monitoring system not fully operational at the start of the monitoring period).
EX1	68 days (monitoring system not fully operational at the start of the monitoring period).
ST23	1 day (the monitoring system was not fully operational at the start of the monitoring period).

No events or situations occurred during this monitoring period that would impact on the applicability of the methodology. All conditions of AM0064 version 02 were met.

2.2 Deviations from the Monitoring Plan

There have been no deviations from the monitoring plan described in the registered PDD.

2.3 Grouped Project

Not applicable. This is not a grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / Parameter:	GWP_{CH_4}
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential for methane
Source of data:	AM0064 Version 02.
Value applied:	21
Purpose of the data:	Baseline and project emission calculations.
Any comment:	-

Data Unit / Parameter:	$EF_{EL,grid}$
Data unit:	tCO_2/MWh
Description:	Emission factor of the grid.
Source of data:	Eskom and NERSA data.
Value applied:	1.01
Purpose of the data:	Project emission calculations.
Any comment:	-

Data Unit / Parameter:	CEF_{CH_4}
Data unit:	tCO_2e/tCH_4
Description:	Carbon emission factor for combusted methane.
Source of data:	AM0064 Version 02.
Value applied:	2.75
Purpose of the data:	Project emission calculations.
Any comment:	-

The following values were also used in the flaring tool to calculate project emissions:

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_c	kg/kmol (g/mol)	Atomic mass of carbon	12
AM_h	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_o	kg/kmol (g/mol)	Atomic mass of oxygen	16
AM_n	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101 325
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant	8,314.472

Parameter	SI Unit	Description	Value
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	t_{CO2}/t_{CH4}	Global warming potential of methane	21
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal conditions	22.414

3.2 Data and Parameters Monitored

Mine methane capture and destruction

Data Unit / Parameter:	$MMES_{PR,flare,y}$
Data unit:	tCH_4/month
Description:	Mine methane captured, sent to and destroyed by flare in the project activity.
Source of data:	A flow meter is used to measure the flow rate of the raw gas sent to the flare and a gas analyser is used to measure the methane concentration of the raw gas sent to the flare.
Description of measurement methods and procedures to be applied:	The mine methane sent to the flare is calculated by multiplying the measured raw gas flow rate by the measured methane composition of the raw gas, and converting to mass by multiplying by the density of methane.
Frequency of monitoring/recording:	The methane concentration and the flow rate of the raw gas are measured every minute. The values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 13.7 01 – 30 Jun 2011: 65.4
Monitoring equipment:	<u>Flow meter:</u> *Instrument code:* FIR 71.51 *Type:* Endress and Hauser *Accuracy class:* +/- 1.2% measurement tolerance *Calibration frequency:* Yearly <u>Gas analyser:</u> *Type:* Endress and Hauser *Accuracy class:* +/- 1% full scale measurement tolerance

	Calibration frequency: Weekly
QA/QC procedures to be applied:	The flow meter and gas analyser are calibrated in accordance with manufacturer's specifications.
Calculation method:	The measured pressure and temperature corrected raw gas flow rate (in Nm^3) is multiplied by the measured raw gas methane concentration (volume %), which is then multiplied by the density of methane (0.716 kg/m^3 – as specified by the applied methodology).
Any comment:	-

Data Unit / Parameter:	$EC_{pj,y}$
Data unit:	MWh/month
Description:	The quantity of electricity consumed by the project activity.
Source of data:	Power meter.
Description of measurement methods and procedures to be applied:	Measured in kWh/day and converted to MWh/month.
Frequency of monitoring/recording:	The electricity consumption of the project activity is logged electronically and averaged daily. These values are aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 0.60 01 – 30 Jun 2011: 2.48
Monitoring equipment:	Power meter: *Type:* Endress and Hauser *Accuracy class:* +/- 2% measurement tolerance *Calibration frequency:* Biennial replace
QA/QC procedures to be applied:	The power meter is biennialy replaced.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	TDL_y
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to the project activity.
Source of data:	'Tool to calculate baseline, project and/or leakage

	emissions from electricity consumption' version 01
Description of measurement methods and procedures to be applied:	Default value.
Frequency of monitoring/recording:	Not applicable. The default value is sourced from the applied tool.
Value monitored:	0.03
Monitoring equipment:	Not applicable. The default value is sourced from the applied tool.
QA/QC procedures to be applied:	Not applicable. The default value is sourced from the applied tool.
Calculation method:	Not applicable. The default value is sourced from the applied tool.
Any comment:	-

Data Unit / Parameter:	$FV_{RH,h}$
Data unit:	Nm^3/hour
Description:	Volumetric flow rate of the residual gas in dry basis as normal conditions in hour *h*.
Source of data:	Flow meter.
Description of measurement methods and procedures to be applied:	The volumetric flow rate is measured on a dry basis to ensure that all of the moisture is removed prior to the analysis. The flow rate is measured after the dewatering unit and after the pressure increase of the blower (here there is a significant gas temperature increase). At this time, there is no condensate and the relative humidity is approximately 20-30%. Hence, the gas is dry.
Frequency of monitoring/recording:	The flow rate of the residual gas is measured every minute. The values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 108 01 – 30 Jun 2011: 192
Monitoring equipment:	Flow meter: *Instrument code:* FIR 71.51 *Type:* Endress and Hauser *Accuracy class:* +/- 1.2% measurement tolerance *Calibration frequency:* Yearly
QA/QC procedures to be applied:	The flow meter is calibrated in accordance with

	manufacturer specifications.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	$fv_{i,h}$
Data unit:	-
Description:	Volumetric fraction of methane and nitrogen in the residual gas in the hour *h*.
Source of data:	Gas analyser.
Description of measurement methods and procedures to be applied:	Measured in the project.
Frequency of monitoring/recording:	The methane concentration of the residual gas is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	<table><tr><th>Period</th><th>Methane volumetric fraction</th><th>Nitrogen volumetric fraction</th></tr><tr><td>01 – 31 Mar 2011</td><td>-</td><td>-</td></tr><tr><td>01 – 30 Apr 2011</td><td>-</td><td>-</td></tr><tr><td>01 – 31 May 2011</td><td>0.61</td><td>0.39</td></tr><tr><td>01 – 30 Jun 2011</td><td>0.65</td><td>0.35</td></tr></table> As per the ‘Tool to determine project emissions from flaring gases containing methane’ (version 01), a simplified approach can be taken where project participants only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen.
Monitoring equipment:	<u>Gas analyser:</u> *Type:* Endress and Hauser *Accuracy class:* +/- 1% full scale measurement tolerance *Calibration frequency:* Weekly
QA/QC procedures to be applied:	The gas analyser is calibrated in accordance with manufacturer specifications.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	$fv_{CH_4,FG,h}$
Data unit:	mg/Nm^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*.
Source of data:	Gas analyser.
Description of measurement methods and procedures to be applied:	A flow meter is used to measure the flow rate of the raw gas sent to the flare and a gas analyser is used to measure the volumetric methane concentration in the exhaust gas of the flare. The methane concentration is measured on a dry basis by ensuring that all of the moisture is removed prior to the analysis.
Frequency of monitoring/recording:	The flow rate of the residual gas and the methane concentration of the exhaust gas are measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 265 01 – 30 Jun 2011: 284
Monitoring equipment:	Flow meter: *Instrument code:* FIR 71.51 *Type:* Endress and Hauser *Accuracy class:* +/- 1.2% measurement tolerance *Calibration frequency:* Yearly Gas analyser: *Type:* Endress and Hauser *Accuracy class:* +/- 1% full scale measurement tolerance *Calibration frequency:* Weekly
QA/QC procedures to be applied:	The flow meter and gas analyser are calibrated in accordance with manufacturer's specifications.
Calculation method:	The concentration of methane in the exhaust gas is calculated by dividing the mass of methane in the exhaust gas (mg) by the volume of exhaust gas (Nm^3). The mass of methane in the exhaust gas is obtained by multiplying the volumetric flow by the methane volumetric fraction in the exhaust gas, and then multiplying by the density of methane.

Any comment:	-

Data Unit / Parameter:	$t_{O_2,h}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour *h*.
Source of data:	Gas analyser.
Description of measurement methods and procedures to be applied:	Measured in the project activity.
Frequency of monitoring/recording:	The volumetric fraction of the oxygen in the exhaust gas is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 0.16 01 – 30 Jun 2011: 0.14
Monitoring equipment:	Gas analyser: *Type:* Endress and Hauser *Accuracy class:* +/- 1% full scale measurement tolerance *Calibration frequency:* Weekly
QA/QC procedures to be applied:	The gas analyser is calibrated in accordance with manufacturer specifications.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	PC_{CH_4}
Data unit:	%
Description:	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
Source of data:	Gas analyser.
Description of measurement methods and procedures to be applied:	Calculated value.
Frequency of monitoring/recording:	The methane concentration of the residual gas is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	

	01 – 31 Mar 2011: 51 01 – 30 Apr 2011: 54 01 – 31 May 2011: 0.0037 01 – 30 Jun 2011: 0.0040
Monitoring equipment:	Gas analyser: *Type:* Endress and Hauser *Accuracy class:* +/- 1% full scale measurement tolerance *Calibration frequency:* Weekly
QA/QC procedures to be applied:	The gas analyser is calibrated in accordance with manufacturer specifications
Calculation method:	A gas analyser is used to measure the volumetric fraction of methane. This value is converted to a mass fraction by multiplying it by the density of methane at normal conditions (0.716 kg/m^3) and dividing it by the density of the residual gas.
Any comment:	-

Data Unit / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare.
Source of data:	Thermocouple
Description of measurement methods and procedures to be applied:	Measured in the project activity.
Frequency of monitoring/recording:	The temperature in the exhaust gas of the flare is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	01 – 31 Mar 2011: - 01 – 30 Apr 2011: - 01 – 31 May 2011: 551 01 – 30 Jun 2011: 320
Monitoring equipment:	Thermocouple: *Instrument code:* TIR 71.53 *Type:* Endress and Hauser Type N *Accuracy class:* +/- 2.5°C *Calibration frequency:* Yearly replace *Date of last calibration:* Not applicable

	Validity: Not applicable
QA/QC procedures to be applied:	Thermocouple is replaced yearly.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Non-mine methane capture and destruction

<table>
<tr><td>Data Unit / Parameter:</td><td>$FV_{RH,h}$</td></tr>
<tr><td>Data unit:</td><td>Nm^3/hour</td></tr>
<tr><td>Description:</td><td>Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h.</td></tr>
<tr><td>Source of data:</td><td>Flow meter.</td></tr>
<tr><td>Description of measurement methods and procedures to be applied:</td><td>Measured in the project activity.</td></tr>
<tr><td>Frequency of monitoring/recording:</td><td>The flow rate of the residual gas is measured every minute. The values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.</td></tr>
<tr><td>Value monitored:</td><td>
<table>
<tr><th>Period</th><th>DBE1</th><th>2264</th><th>1400</th><th>EX1</th><th>ST23</th></tr>
<tr><td>01 – 31 Mar 2011</td><td>-</td><td>-</td><td>-</td><td>-</td><td>207</td></tr>
<tr><td>01 – 30 Apr 2011</td><td>-</td><td>-</td><td>-</td><td>-</td><td>203</td></tr>
<tr><td>01 – 31 May 2011</td><td>-</td><td>-</td><td>-</td><td>122</td><td>210</td></tr>
<tr><td>01 – 30 Jun 2011</td><td>-</td><td>-</td><td>-</td><td>121</td><td>223</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment:</td><td>
<u>Flow meter:</u>
<table>
<tr><th></th><th>DBE1</th><th>2264</th><th>1400</th><th>EX1</th><th>ST23</th></tr>
<tr><td>Type</td><td colspan="5">Endress and Hauser</td></tr>
<tr><td>Accuracy class</td><td colspan="5">+/- 1.2% measurement tolerance</td></tr>
<tr><td>Calibration frequency</td><td colspan="5">Yearly</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures to be applied:</td><td>The flow meter is calibrated in accordance with</td></tr>
</table>

	manufacturer specifications.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	$fv_{i,h}$
Data unit:	-
Description:	Volumetric fraction of methane and nitrogen in the residual gas in the hour *h*.
Source of data:	Gas analyser.
Description of measurement methods and procedures to be applied:	Measured in the project activity.
Frequency of monitoring/recording:	The methane concentration of the residual gas is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	

Methane volumetric fraction					
Period	DBE1	2264	1400	EX1	ST23
01 – 31 Mar 2011	-	-	-	-	0.97
01 – 30 Apr 2011	-	-	-	-	0.98
01 – 31 May 2011	-	-	-	0.99	0.95
01 – 30 Jun 2011	-	-	-	0.91	0.77

Nitrogen volumetric fraction					
Period	DBE1	2264	1400	EX1	ST23
01 – 31 Mar 2011	-	-	-	-	0.03
01 – 30 Apr 2011	-	-	-	-	0.02
01 – 31 May 2011	-	-	-	0.01	0.05
01 – 30 Jun 2011	-	-	-	0.09	0.23

As per the 'Tool to determine project emissions from flaring gases containing methane' (version 01), a simplified approach can be taken where project participants only measure the volumetric fraction of methane and consider the difference to

	100% as being nitrogen.
Monitoring equipment:	Gas analyser: | | DBE1 | 2264 | 1400 | EX1 | ST23 | | Type | Endress and Hauser | | Accuracy class | +/- 1% full scale measurement tolerance | | Calibration frequency | Weekly |
QA/QC procedures to be applied:	The gas analyser is calibrated in accordance with manufacturer specifications.
Calculation method:	Not applicable. No calculation method is used.
Any comment:	-

Data Unit / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare.
Source of data:	Thermocouple
Description of measurement methods and procedures to be applied:	Measured in the project activity.
Frequency of monitoring/recording:	The temperature in the exhaust gas of the flares is measured every minute. These values are averaged daily, and then aggregated monthly for the purposes of calculating the emission reductions.
Value monitored:	(see table below)
Monitoring equipment:	Thermocouple: | | DBE1 | 2264 | 1400 | EX1 | ST23 |

Value monitored:

Period	T_{flare} (°C)				
	DBE1	2264	1400	EX1	ST23
01 – 31 Mar 2011	-	-	-	-	883
01 – 30 Apr 2011	-	-	-	-	804
01 – 31 May 2011	-	-	-	899	812
01 – 30 Jun 2011	-	-	-	899	818

<table>
<tr><td></td><td><table>
<tr><td>Type</td><td>Endress and Hauser</td></tr>
<tr><td>Accuracy class</td><td>+/- 2.5°C</td></tr>
<tr><td>Calibration frequency</td><td>Yearly replace</td></tr>
<tr><td>Date of last calibration</td><td>Not applicable</td></tr>
</table></td></tr>
<tr><td>QA/QC procedures to be applied:</td><td>The thermocouples are replaced yearly in accordance with manufacturer specifications.</td></tr>
<tr><td>Calculation method:</td><td>Not applicable. No calculation method is used.</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

3.3 Description of the Monitoring Plan

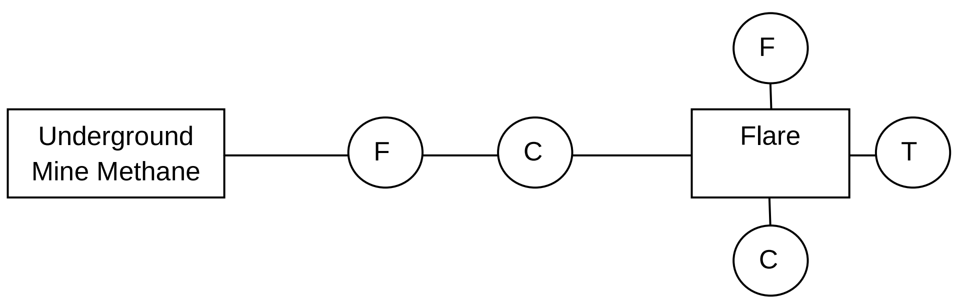
Beatrix's monitoring system ensures that the project activity's emission reductions are accurately monitored, recorded and reported.

1. Line diagrams showing relevant monitoring points

The monitoring system is divided into two sections – mine methane and non-min methane monitoring.

Mine methane monitoring:

An enclosed flare is installed at the Beatrix Number 1 shaft. The mine methane monitoring equipment of this flare (and the placing of the equipment) is shown in the diagram below.



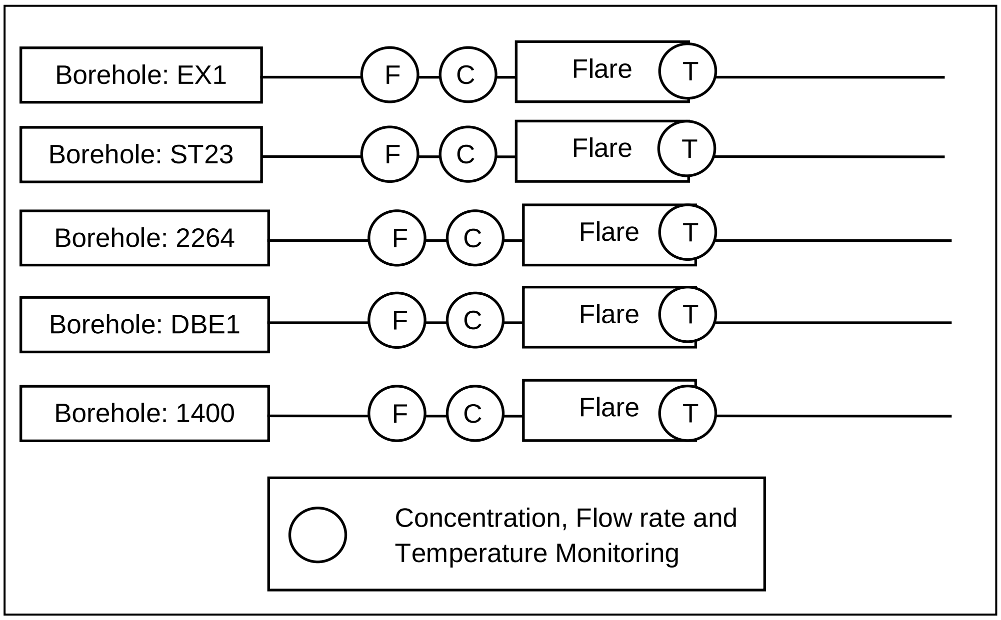
A description of the symbols is provided in the table below.

Symbol	Description	Instrument Code	Function
F	Gas flow meter	FIR 71.51	Measures gas flow rate
C	Concentration meter	CIR 71.52	Measures methane and oxygen concentration of gas
T	Thermocouple	TIR 71.53	Measures temperature of flare to ensure correct operation

Non-mine methane monitoring:

Enclosed flares are installed at five boreholes. These flares are fitted with thermocouples to monitor the combustion temperature. A default flare efficiency of 90% is used when the flares are operating at temperatures above 500°C for more than 40 minutes in every hour. This is in accordance with version 01 of the ‘Tool to determine project emissions from the flaring of gases containing methane’.

The non-mine methane monitoring equipment of the borehole flares (and the placing of the equipment) is shown in the diagram below.



A description of the symbols is provided in the table below.

Symbol	Description	Function
F	Gas flow meter	Measures gas flow rate
C	Concentration meter	Measures methane concentration of gas
T	Thermocouple	Measures temperature of flare to ensure correct operation

2. Data collection procedure

Each flare is fitted with a data logger where the monitored data (from the start of flare operation) is stored. A 4MB USB stick is installed in the data logger. This USB stick can be inserted into a computer when the monitored data needs to be extracted. The data is viewed in the software programme ‘ReadWin 2000’.

The monitored data from each flare is extracted at the end of each cost month, and burnt to a disk which is stored at the Beatrix mine offices. This data is also sent to the CDM consultant

(Promethium Carbon (Pty) Ltd) who is responsible for calculating the emission reductions and writing the monitoring report.

3. Roles and responsibilities of personnel

The Beatrix operations manager is responsible for ensuring that the data is monitored and recorded and that all of the instruments are in working order. The operations manager will also extract the monitored data from the data logger at each flare at the end of each cost month.

Promethium Carbon (Pty) Ltd is responsible for calculating the emission reductions and writing the monitoring report.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

This section provides the baseline emission calculations for mine and non-mine methane capture and destruction.

Mine methane capture and destruction

The baseline emissions for mine methane capture and destruction are calculated using equation 1 of the applied methodology.

$$BE_y = BE_{MD,y} + BE_{MR,y} + BE_{USe,y}$$ (AM0064 equation 1)

Where,

BE_y	Baseline emissions in year *y* (tCO_2e/yr)
$BE_{MD,y}$	Baseline emissions from the destruction of methane in the baseline scenario in year *y* (tCO_2e/yr)
$BE_{MR,y}$	Baseline emissions from the release of methane into the atmosphere in year *y* that is avoided by the project activity (tCO_2e/yr)
$BE_{Use,y}$	Baseline emissions from the production of power and/or heat displaced by the project activity in year *y* (tCO_2e/yr)

But, $BE_{MD,y} = BE_{Use,y} = 0$ as no electricity is generated in the project activity (gas engines have not yet been installed) and no methane was destructed in the baseline. Therefore equation 1 simplifies to:

$$BE_y = BE_{MR,y}$$

The table below shows the monthly values used in the calculation of BE_y.

Month	BE_y	$BE_{MR,y}$
	tCO_2e	tCO_2e
Mar-11	-	-
Apr-11	-	-
May-11	287	287
Jun-11	1,373	1,373

The baseline emissions from the venting of methane are calculated using equation 6 of the applied methodology.

$$BE_{MR,y} = GWP_{CH_4} \times \sum_i \left[\left(MM_{PR,i,y} - MM_{BL,i,y} \right) + \left(VAM_{PR,i,y} - VAM_{BL,i,y} \right) \right]$$

(AM0064 equation 6)

Where,

$BE_{MR,y}$	Baseline emissions from the release of methane into the atmosphere in year y that is avoided by the project activity (tCO_2e/yr)
GWP_{CH_4}	Global Warming Potential of methane
$MM_{PR,i,y}$	Mine methane captured, sent to and destroyed by use *i* in the project activity in year *y* (tCH_4/yr)
$MM_{BL,i,y}$	Mine methane that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4/yr)
$VAM_{PR,i,y}$	VAM captured, sent to and destroyed by use *i* in the project activity in year *y* (tCH_4)
$VAM_{BL,i,y}$	VAM that would have been captured, sent to and destroyed by use *i* in the baseline scenario in year *y* (tCH_4)

No ventilation air methane (VAM) is used in the baseline (BL) or in the project case (PR). The result is that $VAM_{PR,i,y} = VAM_{BL,i,y} = 0$. Furthermore, no mine methane (MM) is captured and used in the baseline (BL). The result is that $MM_{BL,i,y} = 0$.

The flaring of excess methane will take place in the project case (PR). Therefore, equation 6 simplifies to:

$$BE_{MR,y} = GWP_{CH_4} \times MM_{PR,flare,y}$$

Where:

$MM_{PR,flare,y}$	Mine methane captured, sent to and destroyed by flare in the project activity in year *y* (tCO_2e/yr)

The table below shows the monthly values used in the calculation of $BE_{MR,y}$.

Month	$BE_{MR,y}$	GWP_{CH4}	$MM_{PR,flare,y}$
	tCO_2e	tCO_2e/tCH_4	tCH_4
Mar-11	-	21	-
Apr-11	-	21	-
May-11	287	21	14
Jun-11	1,373	21	65

<u>Non-mine methane capture and destruction</u>

The baseline emissions for non-mine methane capture and destruction are calculated using equation 12 of the applied methodology.

$$BE_y = \sum_{h=1}^{8760} TM_{RG,h} \times \frac{GWP_{CH_4}}{1000}$$ (AM0064 equation 12)

Where,

BE_y	Baseline emissions in year y (tCO_2e)
GWP_{CH_4}	Global warming potential for methane (value of 21)
$TM_{RG,h}$	Mass flow rate of methane in the residual gas (in the “Tool to determine project emissions from flaring gases containing methane” it is defined as the gas stream flowing to the flare) in the hour *h* (kg/h)
$1/1000$	Factor to convert kg/year to ton/year

Borehole flare DBE1

The table below shows the monthly values used in the calculation of BE_y in borehole flare DBE1.

Month	BE_y	$TM_{RG,h}$	GWP_{CH4}
	tCO_2e	kg/h	tCO_2e/tCH_4
Mar-11	-	-	N/A
Apr-11	-	-	N/A
May-11	-	-	N/A
Jun-11	-	-	21

Borehole flare 2264

The table below shows the monthly values used in the calculation of BE_y in borehole flare 2264.

Month	BE_y	$TM_{RG,h}$	GWP_{CH4}
	tCO_2e	kg/h	tCO_2e/tCH_4
Mar-11	-	-	N/A
Apr-11	-	-	N/A
May-11	-	-	N/A
Jun-11	-	-	N/A

Borehole flare 1400

The table below shows the monthly values used in the calculation of BE_y in borehole flare 1400.

Month	BE_y	$TM_{RG,h}$	GWP_{CH4}
	tCO_2e	kg/h	tCO_2e/tCH_4
Mar-11	-	-	21
Apr-11	-	-	21
May-11	77	25.5	21
Jun-11	145	24.0	21

Borehole flare EX1

The table below shows the monthly values used in the calculation of BE_y in borehole flare EX1.

Month	BE_y	$TM_{RG,h}$	GWP_{CH4}
	tCO_2e	kg/h	tCO_2e/tCH_4
Mar-11	-	-	21
Apr-11	-	-	21
May-11	1,043	86.2	21
Jun-11	1,193	78.9	21

Borehole flare ST23

The table below shows the monthly values used in the calculation of BE_y in borehole flare ST23.

Month	BE_y	$TM_{RG,h}$	GWP_{CH4}
	tCO_2e	kg/h	tCO_2e/tCH_4
Mar-11	2,176	144	21
Apr-11	2,156	143	21
May-11	2,224	142	21
Jun-11	1,495	124	21

4.2 Project Emissions

This section provides the project emission calculations for mine and non-mine methane capture and destruction.

Mine methane capture and destruction

The project emissions for mine methane capture and destruction are calculated using equation 13 of the applied methodology.

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \qquad \text{(AM0064 equation 13)}$$

Where,

PE_y Project emissions in year y (tCO_2e/yr)

$PE_{ME,y}$ Project emissions from energy use to capture and use methane in year y (tCO_2e/yr)

$PE_{MD,y}$ Project emissions from methane destroyed in year y (tCO_2e/yr)

$PE_{UM,y}$ Project emissions from un-combusted methane in year *y* (tCO_2e/yr)

The table below shows the monthly values used in the calculation of PE_y.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	41.5	0.62	37.1	3.77
Jun-11	195	2.58	178	14.7

The project emissions for mine methane capture and destruction are calculated using equation 14 of the applied methodology.

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y}$$ (AM0064 equation 14)

Where,

$PE_{ELEC,y}$ Project emissions from the use of electricity for capture, transportation, compression and utilisation or destruction of MM/VAM in y (tCO_2e/yr)

$PE_{FF,y}$ Project emissions from the combustion of fossil fuels for capture, transportation, compression, and utilisation or destruction of MM/VAM in year y (tCO_2e/yr)

No fossil fuel will be used for the capture, transportation, compression, utilisation or destruction of MM/VAM in the project activity so $PE_{FF,y} = 0$.

The table below shows the monthly values used in the calculation of $PE_{ME,y}$.

Month	$PE_{ME,y}$	$PE_{ELEC,y}$	$PE_{FF,y}$
	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	0
Apr-11	-	-	0
May-11	0.62	0.62	0
Jun-11	2.58	2.58	0

According to AM0064 Version 02, $PE_{ELEC,y}$ is calculated using the 'Tool to calculate baseline, project and/or leakage emissions from electricity consumption' (Version 01). The project emissions from the consumption of electricity in the project activity are calculated using equation 1 of the applied tool.

$$PE_{EC,y} = EC_{PJ,grid,y} \times EF_{EL,grid,y} \times \left(1 + TDL_{grid,y}\right)$$ (Tool equation 1)

Where,

$PE_{EC,y}$ Project emissions from electricity consumption in year *y* ($tCO_2/year$)

$EC_{PJ,grid,y}$ Quantity of electricity consumed by the project from the grid in year *y* (MWh/yr)

$EF_{EL,grid,y}$ Emission factor of the grid (tCO_2/MWh)

$TDL_{grid,y}$ Average technical transmission and distribution losses for providing electricity in year *y*

The table below shows the monthly values used in the calculation of $PE_{EC,y}$.

Month	$PE_{EC,y}$	$EC_{PJ,j,y}$	$EF_{EL,j,y}$	$TDL_{j,y}$
	tCO_2e	MWh	tCO_2e/MWh	-
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	0.62	0.60	1.01	0.03
Jun-11	2.58	1.53	2.48	0.03

The project emissions from methane destroyed in the project activity are calculated using equation 15 of the applied methodology.

$$PE_{MD,y} = \left(MD_{FL,y} + MD_{OX,y} + MD_{ELEC,y} + MD_{heat,y} + MD_{GAS,y}\right) \times \left(CEF_{CH_4} + r \times CEF_{NMHC}\right)$$

(AM0064 equation 15)

Where,

$PE_{MD,y}$	Project emissions from MM/VAM destroyed in year *y* (tCO_2e/yr)
$MD_{FL,y}$	Amount of methane destroyed through flaring in year *y* (tCH_4/yr)
$MD_{OX,y}$	Amount of methane destroyed through catalytic oxidation in year *y* (tCH_4/yr)
$MD_{ELEC,y}$	Amount of methane destroyed through power generation in year *y* (tCO_2e/yr)
$MD_{heat,y}$	Amount of methane destroyed through heat generation in year *y* (tCO_2e/yr)
$MD_{GAS,y}$	Amount of methane destroyed after being supplied to gas grid or for vehicle use in year *y* (tCH_4)
CEF_{CH_4}	Carbon emission factor for combusted methane (2.75 tCO_2/ tCH_4)
CEF_{NMHC}	Carbon emission factor for combusted non methane hydrocarbons (the concentration varies and, therefore, to be obtained through periodical analysis of captured methane) ($tCO_2/tNMHC$)
r	Relative proportion of NMHC compared to methane $r = \frac{PC_{NMCH}}{PC_{CH4}}$
PC_{CH4}	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
PC_{NMHC}	NMHC concentration (in mass) in extracted gas (%)

However, no mine methane will be destroyed through catalytic oxidation, supplied to a gas grid or used as vehicle fuel, or destroyed through heat generation. In addition, no electricity is generated in the project activity. Therefore, $MD_{OX,y} = MD_{ELEC,y} = MD_{GAS,y} = MD_{heat,y} = 0$.

Furthermore, gas analysis indicated that non-methane hydrocarbons (NMHCs) accounts for less than 1% of the residual gas composition, and are therefore not included in the emission reduction calculations (NMHCs can be assumed to negligible). Therefore, equation 15 simplifies to:

$$PE_{MD,y} = MD_{FL,y} \times CEF_{CH_4}$$

The table below shows the monthly values used in the calculation of $PE_{MD,y}$.

Month	$PE_{MD,y}$	$MD_{FL,y}$	CEF_{CH4}
	tCO_2e	tCH_4	tCO_2e/tCH_4
Mar-11	-	-	2.75
Apr-11	-	-	2.75
May-11	37.1	13.5	2.75
Jun-11	178	64.7	2.75

The amount of methane destroyed through flaring is calculated using equation (16) of the applied methodology.

$$MD_{FL,y} = MMES_{FL,y} - \left(PE_{flare,y}/GWP_{CH_4}\right)$$ (AM0064 equation 16)

Where,

$MMES_{FL,y}$ Amount of methane measured sent to flare in year *y* (tCH_4)

$PE_{flare,y}$ Project emissions of non-combusted CH_4, expressed in terms of tCO_2e, from flaring of the residual gas stream in year *y* (tCO_2e)

GWP_{CH_4} Global warming potential of methane

The table below shows the monthly values used in the calculation of $MD_{FL,y}$.

Month	$MD_{FL,y}$	$MMES_{FL,y}$	$PE_{flare,y}$	GWP_{CH4}
	tCH_4	tCH_4	tCO_2e	tCO_2e/tCH_4
Mar-11	-	-	-	21
Apr-11	-	-	-	21
May-11	13.5	13.7	3.77	21
Jun-11	64.7	65.4	14.7	21

The project emissions of non-combusted CH_4 (expressed in terms of CO_2e) from the flaring of the residual gas stream ($PE_{flare,y}$) were calculated following the procedures described in version 01 of the ‘Tool to determine project emissions from flaring gases containing methane’. The calculations of the project emissions of non-combusted CH_4 can be found in the attached spreadsheet.

The project emissions from un-combusted methane are calculated using equation (23) of the applied methodology.

$$PE_{UM,y} = \left[GWP_{CH_4} \times \sum_i MMES_{i,j} \times (1 - Eff_i)\right] + PE_{flare,y} + PE_{OX,y} + GWP_{CH_4}$$

(AM0064 equation 23)

Where,

$PE_{UM,y}$	Project emissions from un-combusted methane in year *y* (tCO_2e)
GWP_{CH_4}	Global warming potential of methane
$MMES_{i,j}$	Methane measured sent to use *i* in year *y* (tCH_4)
Eff_i	Efficiency of methane destruction in use *i* (%)
$PE_{flare,y}$	Project emissions of non-combusted CH_4, expressed in terms of tCO_2e, from the residual gas stream (tCO_2e)
$PE_{OX,y}$	Project emissions of non oxidized CH_4 from catalytic oxidation of the VAM stream in year *y* (tCH_4)

As applied to this project, equation (23) becomes:

$$PE_{UM,y} = PE_{flare,y}$$

The table below shows the monthly values used in the calculation of $PE_{UM,y}$.

Month	$PE_{UM,y}$	$PE_{flare,y}$
	tCO_2e	tCO_2e
Mar-11	-	-
Apr-11	-	-
May-11	3.77	3.77
Jun-11	14.7	14.7

As mentioned above, the project emissions of non-combusted CH_4 (expressed in terms of CO_2e) from the flaring of the residual gas stream ($PE_{flare,y}$) were calculated following the procedures described in version 01 of the 'Tool to determine project emissions from flaring gases containing methane'. The calculations of the project emissions of non-combusted CH_4 can be found in the attached spreadsheet.

<u>Non-mine methane capture and destruction</u>

The project emissions for mine methane capture and destruction were calculated using equation (24) of the applied methodology.

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \quad \text{(AM0064 equation 24)}$$

Where,

PE_y	Project emissions in year y (tCO_2e/yr)
$PE_{ME,y}$	Project emissions from energy use to capture and use methane in year y (tCO_2e/yr)
$PE_{MD,y}$	Project emissions from methane destroyed in year y (tCO_2e/yr)
$PE_{UM,y}$	Project emissions from un-combusted methane in year y (tCO_2e/yr)

There is no electricity used for the operation of the borehole flares and instrumentation. Each of the flares is equipped with a solar panel. There is no fossil fuel consumption for the operation of the non-mine methane facilities. Hence, $PE_{ME,y} = 0$.

Borehole flare DBE1

The table below shows the monthly values used in the calculation of PE_y in borehole flare DBE1.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	-	-	-	-
Jun-11	-	-	-	-

Borehole flare 2264

The table below shows the monthly values used in the calculation of PE_y in borehole flare 2264.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	-	-	-	-
Jun-11	-	-	-	-

Borehole flare 1400

The table below shows the monthly values used in the calculation of PE_y in borehole flare 1400.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	16.8	-	9.1	7.7
Jun-11	31.6	-	17.1	14.5

Borehole flare EX1

The table below shows the monthly values used in the calculation of PE_y in borehole flare EX1.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	-	-	-	-
Apr-11	-	-	-	-
May-11	227	-	123	104
Jun-11	260	-	141	119

Borehole flare ST23

The table below shows the monthly values used in the calculation of PE_y in borehole flare ST23.

Month	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Mar-11	474	-	256	218
Apr-11	470	-	254	216
May-11	485	-	262	222
Jun-11	326	-	176	150

The project emissions from methane destroyed (combusted methane) in year *y* were calculated using equation (26) of the applied methodology.

$$PE_{MD,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \eta_{flare,h} \times \frac{CEF_{CH4}}{1000} \qquad \text{(AM0064 equation 26)}$$

Where,

$TM_{RG,h}$ Mass flow rate of methane in the residual gas (in the Tool it is defined as the gas stream flowing to the flare) in the hour h (kg/h)

$\eta_{flare,h}$ Flare efficiency in hour *h*, according to the 'Tool to determine project emissions from flaring gases containing methane'

CEF_{CH4} Carbon emission factor for combusted methane (tCO_2/tCH_4)

A default flare efficiency of 90% was used for all borehole flares (provided that the temperature in the exhaust gas of the flare was above 500°C for more than 40 minutes during the hour *h*), in accordance with version 01 of the 'Tool to determine project emissions from flaring gases containing methane'.

Borehole flare DBE1

The table below shows the monthly values used in the calculation of $PE_{MD,y}$ in borehole flare DBE1.

Month	$PE_{MD,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	-	-	-	N/A
Jun-11	-	-	-	N/A

Borehole flare 2264

The table below shows the monthly values used in the calculation of $PE_{MD,y}$ in borehole flare 2264.

Month	$PE_{MD,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	-	-	-	N/A
Jun-11	-	-	-	N/A

Borehole flare 1400

The table below shows the monthly values used in the calculation of $PE_{MD,y}$ in borehole flare 1400.

Month	$PE_{MD,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	9.1	25.5	0.9	2.75
Jun-11	17.1	24.0	0.9	2.75

Borehole flare EX1

The table below shows the monthly values used in the calculation of $PE_{MD,y}$ in borehole flare EX1.

Month	$PE_{MD,y\ y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	123	86.2	0.9	2.75
Jun-11	141	78.9	0.9	2.75

Borehole flare ST23

The table below shows the monthly values used in the calculation of $PE_{MD,y}$ in borehole flare ST23.

Month	$PE_{MD,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	256	144	0.9	2.75
Apr-11	254	143	0.9	2.75
May-11	262	142	0.9	2.75
Jun-11	176	124	0.9	2.75

The project emissions from un-combusted methane in year *y* were calculated using equation (27) of the applied methodology.

$$PE_{UM,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH_4}}{1000} \qquad \text{(AM0064 equation 27)}$$

Where,

$TM_{RG,h}$ Mass flow rate of methane in the residual gas in the hour *h* (kg/h)

$\eta_{flare,h}$ Flare efficiency in hour *h*

GWP_{CH_4} Global warming potential of methane (tCO_2e/tCH_4)

$\frac{1}{1000}$ Factor to convert kg/y to tonne/y

A default flare efficiency of 90% was used for all borehole flares (provided that the temperature in the exhaust gas of the flare was above 500°C for more than 40 minutes during the hour *h*), in accordance with version 01 of the 'Tool to determine project emissions from flaring gases containing methane'.

Borehole flare DBE1

The table below shows the monthly values used in the calculation of $PE_{UM,y}$ in borehole flare DBE1.

Month	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	-	-	-	N/A
Jun-11	-	-	-	N/A

Borehole flare 2264

The table below shows the monthly values used in the calculation of $PE_{UM,y}$ in borehole flare 2264.

Month	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	-	-	-	N/A
Jun-11	-	-	-	N/A

Borehole flare 1400

The table below shows the monthly values used in the calculation of $PE_{UM,y}$ in borehole flare 1400.

Month	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	7.7	25.5	0.9	21
Jun-11	14.5	24.0	0.9	21

Borehole flare EX1

The table below shows the monthly values used in the calculation of $PE_{UM,y}$ in borehole flare EX1.

Month	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	-	-	-	N/A
Apr-11	-	-	-	N/A
May-11	104	86.2	0.9	21
Jun-11	119	78.9	0.9	21

Borehole flare ST23

The table below shows the monthly values used in the calculation of $PE_{UM,y}$ in borehole flare ST23.

Month	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2e	kg/h	-	tCO_2e/tCH_4
Mar-11	218	144	0.9	21
Apr-11	216	143	0.9	21
May-11	222	142	0.9	21
Jun-11	150	124	0.9	21

The mass flow rate in the residual gas on a dry basis ($TM_{RG,h}$) was calculated using equation (13) of the 'Tool to determine project emissions from the flaring of gases containing methane' Version 01.

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n} \qquad \text{(Tool equation 13)}$$

Where,

$FV_{RG,h}$ Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h* (m^3/h)

$fv_{CH4,RG,h}$ Volumetric fraction of methane in the residual gas on dry basis in hour *h*

$\rho_{CH4,n}$ Density of methane at normal conditions (kg/m^3)

Borehole flare DBE1

The table below shows the monthly values used in the calculation of $TM_{RG,h}$ in borehole flare DBE1.

Month	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg/h	m^3/h	-	kg/m^3
Mar-11	-	-	-	0.716
Apr-11	-	-	-	0.716
May-11	-	-	-	0.716
Jun-11	-	-	-	0.716

Borehole flare 2264

The table below shows the monthly values used in the calculation of $TM_{RG,h}$ in borehole flare 2264.

Month	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg/h	m^3/h	-	kg/m^3
Mar-11	-	-	-	0.716
Apr-11	-	-	-	0.716
May-11	-	-	-	0.716
Jun-11	-	-	-	0.716

Borehole flare 1400

The table below shows the monthly values used in the calculation of $TM_{RG,h}$ in borehole flare 1400.

Month	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg/h	m^3/h	-	kg/m^3
Mar-11	-	-	-	0.716
Apr-11	-	-	-	0.716
May-11	25.5	36.0	0.99	0.716
Jun-11	24.0	34.0	0.99	0.716

Borehole flare EX1

The table below shows the monthly values used in the calculation of $TM_{RG,h}$ in borehole flare EX1.

Month	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg/h	m^3/h	-	kg/m^3
Mar-11	-	-	-	0.716
Apr-11	-	-	-	0.716
May-11	86.2	122	0.99	0.716
Jun-11	78.9	121	0.91	0.716

Borehole flare ST23

The table below shows the monthly values used in the calculation of $TM_{RG,h}$ in borehole flare ST23.

Month	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg/h	m^3/h	-	kg/m^3
Mar-11	144	207	0.97	0.716
Apr-11	143	203	0.98	0.716
May-11	142	210	0.95	0.716
Jun-11	124	223	0.77	0.716

4.3 Leakage

No leakage is considered, in accordance with AM0064 version 02.

4.4 Summary of GHG Emission Reductions and Removals

Baseline emissions or baseline net GHG removals by sinks (tCO_2e)	**Project emissions or actual net GHG removals by sinks (tCO_{2e})**	**Leakage (tCO_2e)**	**Emission reductions or net anthropogenic GHG removals by sinks (tCO_2e)**
12,169	2,526	0	9,643

5 ADDITIONAL INFORMATION

The actual emission reductions are smaller than the values applied in the ex-ante calculation in the registered PDD. This is due to three reasons:

1. Lesser than expected flow rates of gas from the boreholes, as shown in the table below:

Borehole flare	Gas Flow rate (l/s)	
	Ex-ante (modelled)	Ex-post (measured)
DBE1	13.2	5.96
2264	11.5	1.26
1400	25.7	9.83
EX1	70.1	34.2
ST23	97.3	70.3

2. There were times during the monitoring period when the combustion temperatures of the borehole flares were below 500°C (this eventuality was not taken into account in the ex-ante emission calculations in the registered PDD). During these times, the flare efficiency was assumed to be 0% (as per version 01 of the 'Tool to determine project emissions from the flaring of gases containing methane'). No CERs have been claimed for these periods, as shown in section B.1 of this document.

3. No electricity was generated by internal combustions engines during this monitoring period.