Title of the project activity:
EnviroServ Chloorkop Landfill Gas Recovery Project. Revision to Monitoring Plan 08 December 2010

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:	
(Copy this table for each data and parameter)	
Data / Parameter:	**Q**
Data unit:	Nm^3
Description:	Total amount of landfill gas collected at Normal Temperature and Pressure.
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Expected emission reductions were calculated with the assumption that 75% of the theoretical landfill gas generation could be recovered from the mass of domestic waste in place with active gas extraction in a particular year. (Non-domestic waste was subtracted from the total waste mass before theoretical gas production modelling.) The recovered gas was assumed to contain 40% CH_4 (v/v). Then 50% of the estimated theoretical CH4 was used to provide a conservative estimation of potential CERs. The 75% recovery figure is conservative based on field determination of the landfill CH_4 mass balance at field scale for 9 landfill cells at 3 sites in France, which was published in 2006 in the peer-reviewed journal, Waste Management *[see Spokas K., J. Bogner, J. Chanton, M Morcet, C Aran, C. Graff, Y. Moreau-le-Govan, N.Bureau, and I. Hebe, 2006: Methane mass balance at three landfill sites: what is the efficiency of capture by gas collection systems? Waste Management(Elsevier), 26, 516-525.]* Through a combination of intensive field measurements using multiple methods for emissions measurements and supporting laboratory studies, high rates of CH_4 recovery were documented at sites with final soil cover. For example, it was shown that only about 1-2 % of the CH_4 production was being emitted and about 97% was being recovered with an active gas extraction system at Montreuil-sur-Barse in eastern France (near Troyes). At Lapouyade (near Bordeaux in southwestern France), a minimum of 94% of the CH production was being recovered at two cells with engineered gas recovery, but for a cell without recovery, 92% of the CH_4 production was being emitted. Based on this study, the default capture rate currently being using by ADEME (the French environment agency) for sites with

	final soil cover is 85%. This study quantified the following mass balance for each of 9 full-scale field cells at 3 sites with different design and management practices, applying the following mass balance equation to each cell: CH_4 Production = CH_4 Recovered + CH_4 Emitted + Lateral CH_4 Migration + CH_4 Oxidized + ΔCH_4 Storage (all units = mass t^{-1}, from Bogner and Spokas, 1993) *[See Bogner, J., Spokas, K., 1993. Landfill CH4: rates, fates, and role in global carbon cycle, Chemosphere 26, 366-386.]* The Chloorkop landfill has controlled placement of waste in engineered cells with daily, intermediate, and final cover. Gas collection will be initiated in cells at final grade using vertical wells and then extended with horizontal collectors in areas still undergoing active filling. Gas collection can only be initiated from horizontals after they are covered by approx. 10m. waste, consistent with best international practice. Thus, given the well-engineered site, 75% can be considered realistic and conservative.
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer. Data will be aggregated monthly and yearly
QA/QC procedures to be applied:	Flowmeters will be calibrated every 3 years to ensure accuracy. The flowmeters will be calibrated according to the ISO/IEC 17025:2005 standards. The typical accuracy of the thermal mass flowmeters is ± 1.5% of reading + 0.5 % of full scale
Any comment:	The flowmeter will express gas flow in normalized cubic meters, therefore no separate monitoring of pressure (P) and temperature (T) of the LFG is necessary.

Data / Parameter:	**W_{CH4}**
Data unit:	%
Description:	Methane fraction in landfill gas
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	40% (v/v) Landfill gas which is undiluted with air typically contains 50-60% (v/v) CH4; therefore an assumption of 40% of theoretical LFG being recovered is conservative
Description of measurement methods and procedures to be applied:	Measured by semi- continuous gas quality analyser.

QA/QC procedures to be applied:	Gas analyzer will be subject to regular maintenance and calibration to ensure accuracy. The gas analyzer will be calibrated once per month using a supply of span gas which has been calibrated according to ISO/IEC 17025 standards. The typical accuracy of the analyzer is 2% full scale per month.
Any comment:	

Data / Parameter:	**$LFG_{leachate,y}$**
Data unit:	Nm^3
Description:	Total amount of landfill gas used for leachate evaporation
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	This parameter becomes relevant only after implementation of destruction methods other than flaring.

Data / Parameter:	**$LFG_{electricity,\ y}$**
Data unit:	Nm^3
Description:	Total amount of landfill gas used for electricity generation
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be measured continuously with a flow meter by the project developer. Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flowmeters will be calibrated every 3 years to ensure accuracy. The flowmeters will be calibrated according to the ISO/IEC 17025:2005 standards. The typical accuracy of the thermal mass flowmeters is ± 1.5% of reading + 0.5 % of full scale
Any comment:	The flow meter will express gas flow in normalized cubic meters, therefore no

	separate monitoring of pressure (P) and temperature (T) of LFG is necessary. This parameter shall only be measured if and when the project generates electricity.

Data / Parameter:	**$LFG_{flared,y}$**
Data unit:	Nm^3
Description:	Total amount of landfill gas flared
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100% The destruction efficiency of enclosed flared at 1000 deg. C or greater which are combusting CH_4 is typically > 99%. Therefore, 100% was assumed.
Description of measurement methods and procedures to be applied:	Data will be measured continuously with a flow meter by the project developer. The flow meter will be maintained and calibrated regularly in line with the manufacturers recommendations. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flowmeters will be calibrated every 3 years to ensure accuracy. The flowmeters will be calibrated according to the ISO/IEC 17025:2005 standards. The typical accuracy of the thermal mass flowmeters is ± 1.5% of reading + 0.5 % of full scale
Any comment:	The flow meter will express gas flow in normalized cubic meters, therefore no separate monitoring of pressure (P) and temperature (T) of LFG is necessary.

Data / Parameter:	**FE**
Data unit:	%
Description:	Flare efficiency (combustion efficiency)
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100% The destruction efficiency of enclosed flares at 1000 deg.C or greater which are combusting CH4 is typically > 99%. Therefore, 100% was assumed.
Description of measurement methods and procedures to be applied:	The efficiency of the enclosed flare (% of methane completely oxidized by combustion in the flare) will be determined on a quarterly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare shall be applicable for the period up to the next measurement. In case the quarterly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used. Efficiency will be quantified using a

	source test for unburned hydrocarbons at the enclosed flare under steady state conditions. Procedures will conform to South African and international best practice, but the specific test procedures will be developed in conjunction with sampling ports and other flare-specific considerations
QA/QC procedures to be applied:	Regular maintenance will ensure optimal operation of flares. Flare efficiency will be determined quarterly. If there is significant deviation from the previous reading, the test will be repeated and conditions corrected as needed. If this testing is not performed, the default value of 90% will be assumed.
Any comment:	The specific and type and manufacturer of the enclosed flare will be determined through a tender process yet to be completed. It should be noted that enclosed flares are highly efficient for destruction of hydrocarbons and typically give >99% destruction efficiency for CH_4.

Data / Parameter:	**Flare hours**
Data unit:	hours
Description:	Flare working hours
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Continuous (24 hours/day)
Description of measurement methods and procedures to be applied:	Data will be monitored continuously by the project developer using a clock. Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Clock will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	

Data / Parameter:	**Flare temperature**
Data unit:	°C
Description:	Temperature of flare
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods	Data will be monitored continuously by the project developer using a thermometer. Data will be aggregated monthly and yearly.

and procedures to be applied:	
QA/QC procedures to be applied:	Flare thermometer will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	

Data / Parameter:	**EL**
Data unit:	kWh
Description:	Electricity generated
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a kWh meter
QA/QC procedures to be applied:	Meter will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	Only applicable if there is any electricity generation in future

Data / Parameter:	**EL_{IMP}**
Data unit:	kWh
Description:	Electricity consumed by project (blowers)
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Measure operating time of blower. Multiply by blower capacity. Multiply by SA grid combined margin to calculate electricity consumed.
QA/QC procedures to be applied:	
Any comment:	Not required in terms of AM0011. Will however be monitored to assess the significance of emissions

B.7.2 Description of the monitoring plan:

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The amount of methane will be determined by monitoring the amount of landfill gas and the percentage methane in the landfill gas.

The regulatory framework will be monitored on an annual basis. In case upcoming regulations in South Africa mandate methane capture and destruction during the crediting period, the baseline scenario and emissions shall be adapted accordingly.

Monitoring as required in terms of the EIA authorisation will also be conducted.

To assure correct monitoring, staff training will involve the following:
To assure correct monitoring, at least two persons will be trained regarding:

- General knowledge of equipment used in the landfill and for landfill gas extraction and monitoring;
- Specialized training with reading and recording data;
- Specialized training regarding calibration of equipment;
- Environmental safety and health, including emergency situations.

Chosen trainees will have a good understanding of the processes and installation technology of the landfill gas extraction.
Verification and training will be initiated in parallel with the first well installations.
An operations and maintenance manual will be developed for the EnviroServ Chloorkop Landfill Recovery Gas Project which is inclusive of environmental safety and health. This manual will include:

- Detailed information on operations
- As-built drawings
- Maintenance procedures
- Equipment drawings and specifications
- Methodologies for monitoring, maintenance of monitoring equipment, and equipment calibration
- Environmental safety and health guidelines and procedures.

Parameters that will be monitored and the frequency of monitoring are described in section B7.1.

Annex 4

MONITORING INFORMATION

The amount of methane will be determined by monitoring the amount of landfill gas and the percentage methane in the landfill gas.

The regulatory framework will be monitored on an annual basis. Other monitoring as required in terms of the EIA authorisation will also be conducted.

Parameters that will be monitored and the frequency of monitoring are indicated below:

Parameter	Unit	Monitoring frequency	Comment
Total amount of landfill gas collected	Nm^3	continuous	Measured by a flow meter. The flow meter will express gas flow in normalized cubic meters, therefore no separate monitoring of pressure and temperature of LFG is necessary. Data will be aggregated monthly and yearly
Methane fraction in the landfill gas	%	continuous	Measured by continuous gas quality analyser.
Amount of landfill gas flared	Nm^3	continuous	Measured by a flow meter. Data will be aggregated monthly and yearly
Combustion efficiency	%	annual	Methane content of flare exhaust gas: The efficiency of the enclosed flare (% of methane completely oxidized by combustion in the flare) will be determined on a yearly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare shall be applicable for the period up to the next measurement. In case the yearly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used.
Combustion efficiency	%	semi-annual, monthly if unstable	Methane content of boiler/engine exhaust gas. Data will be aggregated monthly and yearly
Amount of landfill gas used for electricity generation	Nm^3	continuous	Data will be monitored continuously with a flow meter by the project developer. Data will be aggregated monthly and yearly. Flowmeters will be calibrated every 3 years to ensure accuracy. The flowmeters will be calibrated according to the ISO/IEC 17025:2005 standards. The typical accuracy of the thermal mass flowmeters is ± 1.5% of reading + 0.5 % of full scale
Amount of electricity generated	kWh	continuous	Data will be continuously monitored by a kWh meter. Only applicable if there is any electricity generation in future

Amount of landfill gas used for leachate evaporation	Nm^3	continuous	Data will be monitored continuously with a flow meter by the project developer. Data will be aggregated monthly and yearly. This parameter becomes relevant only after implementation of destruction methods other than flaring.
Flare working hours	h	continuous	Clock. Data will be aggregated monthly and yearly
Flare temperature	°C	continuous	Thermometer. Data will be aggregated monthly and yearly.

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