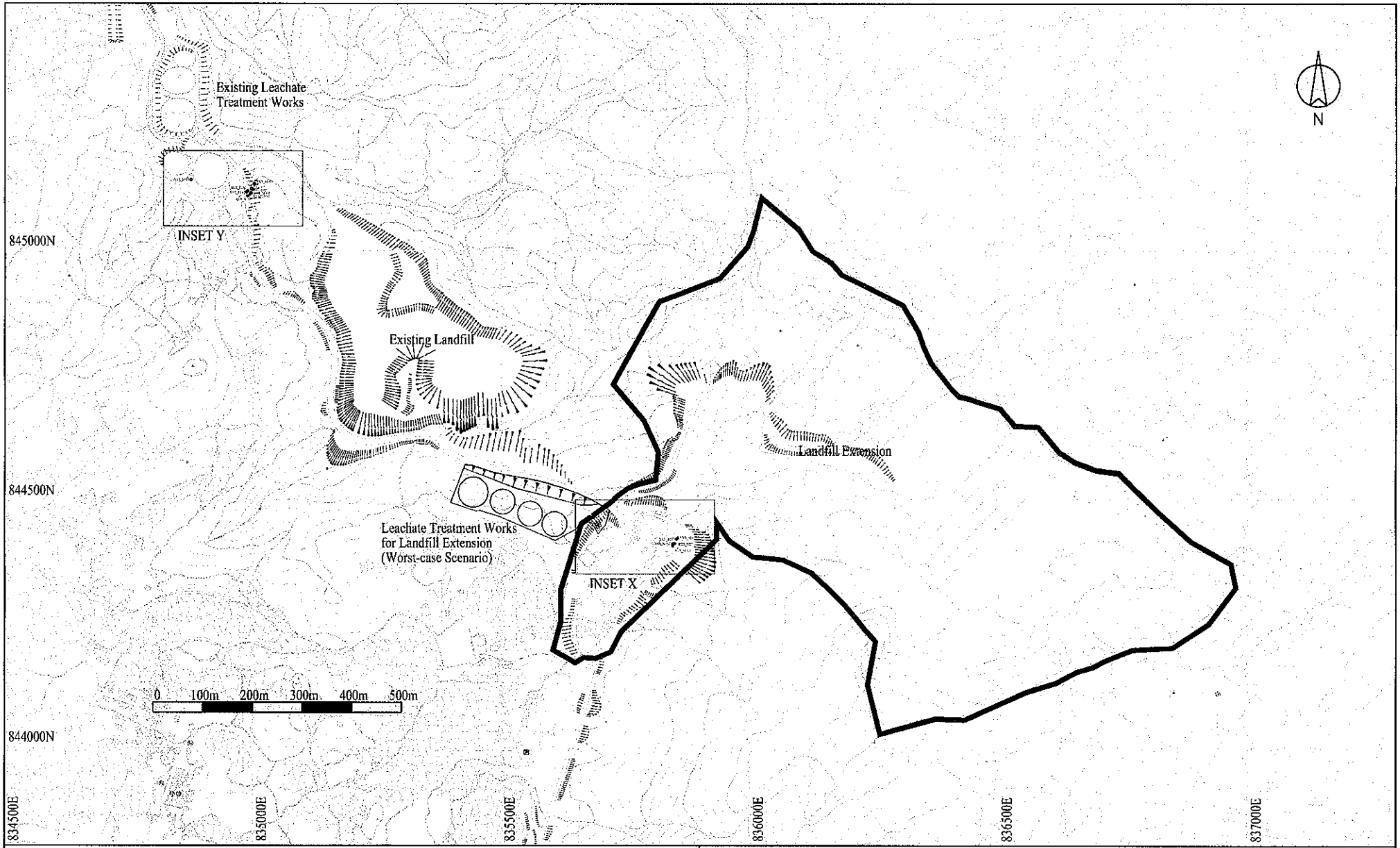
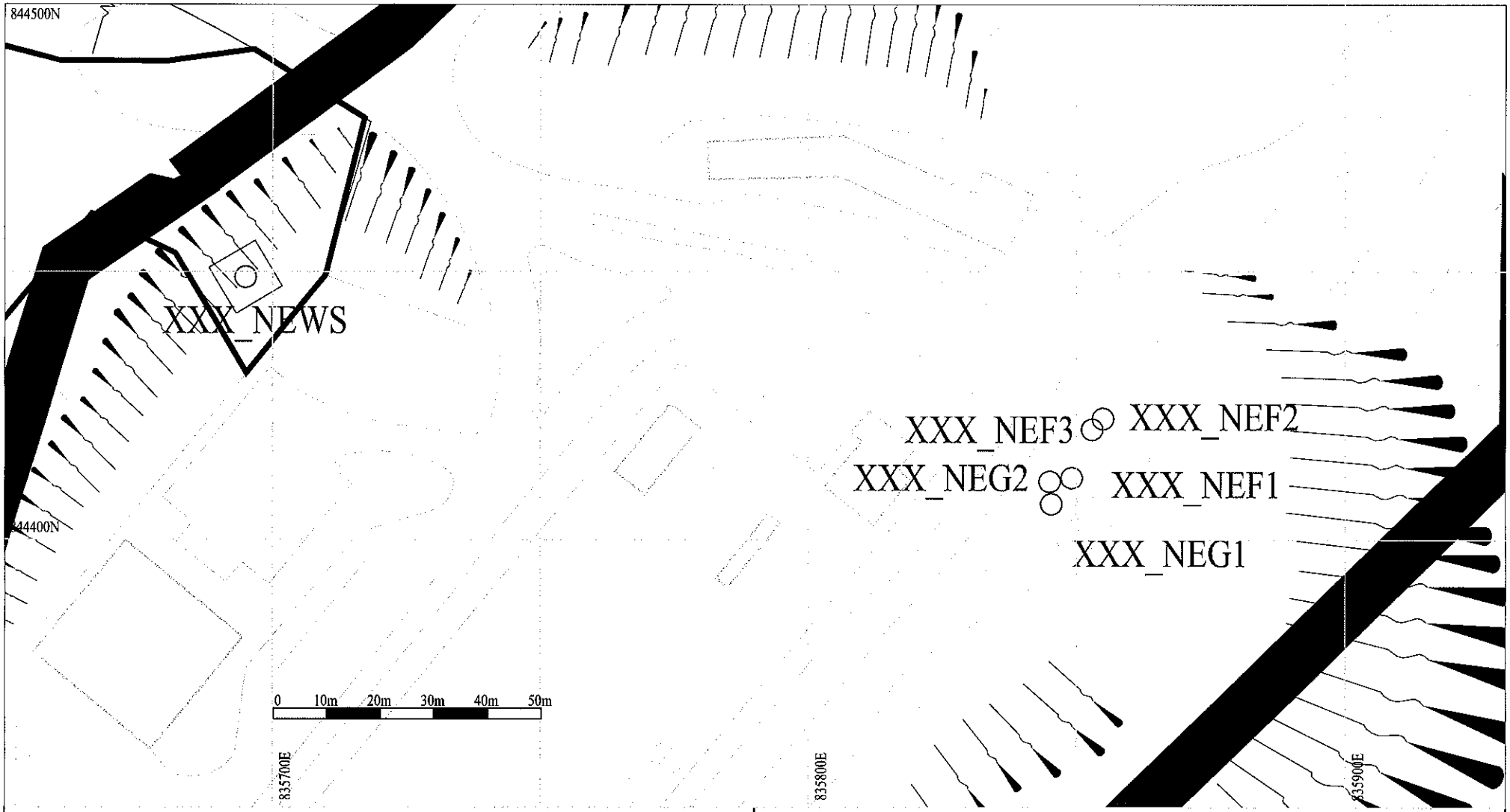
Appendix 3.2

Gaseous Emission Assessment



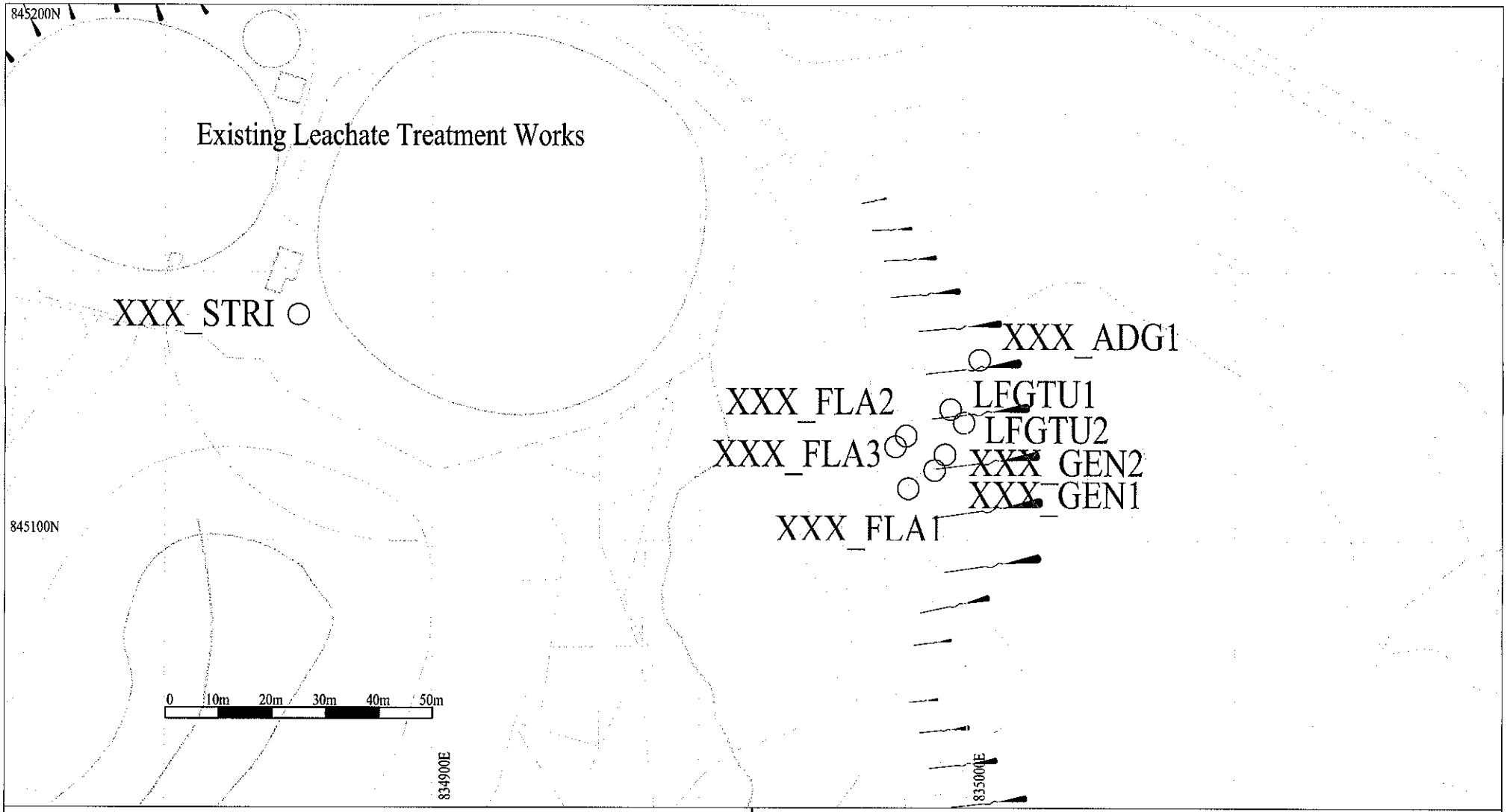
Appendix 3.2
Gaseous Emission Assessment
Location of Gaseous Emission Sources



NOTES :
XXX = pollutant name
XXX_NEWS - New NENT Extension ASP Thermal Destructor
XXX_NEF1 - NENT Extension Gas Flare 1
XXX_NEF2 - NENT Extension Gas Flare 2
XXX_NEF3 - NENT Extension Gas Flare 3 (Operate at later stage)
XXX_NEG1 - NENT Extension LFG Power Generator 1
XXX_NEG2 - NENT Extension LFG Power Generator 2 (Stand-by)

Appendix 3.2
Gaseous Emission Assessment

Location of Gaseous Emission Sources -- INSET X



NOTES :
XXX = pollutant name
XXX_STRI - ASP Thermal Destructor for existing NENT
XXX_GEN1 - LFG Power Generator 1 for existing NENT
XXX_GEN2 - LFG Power Generator 2 for existing NENT (Standby only)
XXX_ADG1 - Additional LFG Power generator 1 for existing NENT
XXX_FLA1 - Gas Flare 1 for existing NENT
XXX_FLA2 - Gas Flare 2 for existing NENT
XXX_FLA3 - Gas Flare 3 for existing NENT (Operate at later stage)
LFGTU1 - LFG Treatment Unit (Compressor engine) 1 from TGES (Existing NENT)
LFGTU2 - LFG Treatment Unit (Compressor engine) 2 from TGES (Existing NENT)

Appendix 3.2
Gaseous Emission Assessment

Location of Gaseous Emission Sources -- INSET Y

Appendix 3.2

Table A: Modes of operation for various LFG facilities

	Plants	Modes of operation (e)		
		Case 1 – ASP On	Case 2 – ASP Off	Case 3 [d] – LFGES Off
Existing NENT [a]	Thermal Destructor in Ammonia Stripping Plant	✓ [STRI On]	× [STRI Off]	✓ [STRI On]
	Two Existing Landfill Gas Flare (one on duty and one standby)	× [FLA 1 Off, FLA2 Off]	× [FLA 1 Off, FLA2 Off]	✓ [FLA 1 On, FLA2 Off]
	Existing LFG Power Generator (Electricity Generation –one on duty and one standby) [b]	✓ [GEN1 On, GEN2 Off]	✓ [GEN1 On, GEN2 Off]	✓ [GEN1 On, GEN2 Off]
	New Landfill Gas Flare at later stage [b]	× [FLA 3 Off]	× [FLA 3 Off]	✓ [FLA 3 On]
New LFGES Facilities [a]	Future LFG Power Generator (Only One Electricity Generator)	✓ [ADG1 On]	✓ [ADG1 On]	✓ [ADG1 On]
	New LFG Treatment Unit (LGFTU) from LFGES (2 compressor engines for two parallel processing streams of the LFG TU – purifying methane in LFG)	✓ [LFGTU1 On, LFGTU2 On]	✓ [LFGTU1 On, LFGTU2 On]	× [LFGTU1 Off, LFGTU2 Off]
NENT Extension	Thermal Destructor in Ammonia Stripping Plant	✓ [NEWS On]	× [NEWS Off]	✓ [NEWS On]
	Two small Landfill Gas Flare at start - one on duty and one standby [b]	× [NEF1 Off, NEF2 Off]	✓ [NEF1 On, NEF2 Off]	✓ [NEF1 On, NEF2 Off]
	New Landfill Gas Flare at later stage [b] [c]	× [NEF3 Off]	✓ [NEF3 On]	✓ [NEF3 On]
	LFG Power Generator (Electricity Generation – one on duty and one standby)	✓ [NEG1 On, NEG2 Off]	✓ [NEG1 On, NEG2 Off]	✓ [NEG1 On, NEG2 Off]

Notes:

(a) The LFG Export Scheme aims to utilise all available gas collected from NENT. LFG will not be flared under normal condition. It is anticipated that maintenance of the LFG Export Scheme will occur only a few times in a year and each will last for a few days.

(b) Based on the long-term monitoring data, the flares system was not in operation all the time during the year (utilization rate is not high).

(c) The flare should be a smaller rating than that in the existing NENT Landfill in view of the smaller waste capacity of the landfill extension.

(d) In fact, the peak gaseous emission for existing landfill and the landfill extension will not overlap, due to the different time frame of the project implementation. The assessment is thus on conservative side.

(e) The plant ID and status of operation is shown in [ ]. The nearest plant to ASR is assumed to be ON, while the more distance plant is assumed to be on standby mode.

Table B: Pollutants emission rates from plants in Existing NENT Landfill (Information provided by existing NENT operator)

Source	Operating Conditions [a]	Pollutant	Estimated Emission ($\mu g/m^3$) [e,f]	Emission Rates in atmosphere (g/s)
Thermal Destructor in Ammonia Stripping Plant (existing NENT)	1123K (dry condition), stack height= 19.5m, internal chimney diameter =3.5m, flow rate=223,000 m^3/hr, gas exit velocity = 223000/[(3.5/2)^2x3.14]/3600 = 6.44m/s	Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	5.067x 1E-3 (81.8µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	3.97x 1E-3 (64.1 µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		TNMOC as C	13,1926.4 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	8.172 (13,1926.4 µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		NO_x from Thermal Destructor	200,000	12.389 (200,000 µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		NO_2 from Thermal Destructor	60,000[b]	3.7167 (60,000 µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		SO_2 from Thermal Destructor [d, e]	64,000	3.964 (64,000 µg/m^3 x 223,000m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
Two Existing Landfill Gas Flares – one duty and one standby(only operated during maintenance period of the LFG export scheme and zero emission under normal operation)	Existing (each): 1473K (dry condition), flow rate 138,491m^3/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	0.003146823 (81.8µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	0.002465909 (64.1µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		TNMOC as C	13,1926 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	5.075156574 (13,1926 µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		NOx from Landfill Gas Flare	80,000	3.0776 (80,000µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		NO_2 from Landfill Gas Flare	24,000[b]	0.9233 (24,000µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		SO_2 from Landfill Gas Flare	64,000 [d, e]	2.462 (64,000 µg/m^3 x 138,491m^3/hr x 1/10g^6/µg x 1/3600hr/s)
New Landfill Gas Flare (only operated during maintenance period of LFG export scheme and zero emission under normal operation)	One new stack: 1473K (dry condition), flow rate 387,774 m^3/hr, stack height= 17m, internal chimney diameter =3.25m, gas exit velocity = 12.983m/s	Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	0.008811087 (81.8µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600 hr/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	0.006904532 (64.1 µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		TNMOC as C	13,1926 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	14.21040909 (13,1926 µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		NOx from Landfill Gas Flare	80,000	8.6172 (80,000µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		NO_2 from Landfill Gas Flare	24,000[b]	2.5852 (24,000µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600hr/s)
		SO_2 from Landfill Gas Flare	64,000 [d, e]	6.894 (64,000 µg/m^3 x 387,774m^3/hr x 1/10g^6/µg x 1/3600hr/s)
Existing LFG Power Generator (Electricity Generation – one duty and one standby)	853K (dry condition), flow rate 10,839 m^3/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	2.46 x 1E-4 (81.8µg/m^3 x 10,839m^3/hr x 1/10g^6/µg x 1/3600 hr/s)

Source	Operating Conditions [a]	Pollutant	Estimated Emission ($\mu g/m^3$) [e,f]	Emission Rates in atmosphere (g/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	1.93 x 1E-4 (64.1 $\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		TNMOC as C	13,1926.4 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	0.3972 (13,1926.4$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		NO_x from LFG power generator	500,000	1.5054 (500,000$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		NO_2 from LFG power generator	150,000[b]	0.4516 (150,000$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		SO_2 from LFG power generator	64,000 [d, e]	0.1927 (64,000 $\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
Future LFG Power Generator (Only One Electricity Generator)	853K (dry condition), flow rate 10,839 m^3/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	2.46 x 1E-4 (81.8$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	1.93 x 1E-4 (64.1 $\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		TNMOC as C	13,1926.4 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	0.3972 (13,1926.4$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		NO_x from LFG power generator	500,000	1.5054 (500,000$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		NO_2 from LFG power generator	150,000[b]	0.4516 (150,000$\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		SO_2 from LFG power generator	64,000 [d, e]	0.1927 (64,000 $\mu g/m^3$ x 10,839m^3/hr x 1/10g^6/μg x 1/3600hr/s)
New LFGTU from Towngas (2 compressor engines for two parallel processing streams of the LFG TU) – Will not be operated during maintenance period of LFG export scheme	723K (dry condition), flow rate 10,896 m^3/hr each, stack height= 6m, internal chimney diameter =0.5m, gas exit velocity = 15.415m/s [h]	NO_x from LFG power generator	500,000	1.5133 (500,000$\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		NO_2 from LFG power generator	150,000[b]	0.454 (150,000$\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		SO_2 from LFG power generator	64,000 [d, e]	0.1937 (64,000 $\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600hr/s)
		Vinyl Chloride [c]	81.8 [1.6ppmv at inlet / 0.02445 * 62.5 at inlet * (1-0.98)]	2.47 x 1E-4 (81.8$\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		Benzene [c]	64.1 [1ppmv at inlet / 0.02445 * 78.4 * (1-0.98)]	1.94 x 1E-4 (64.1 $\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600 hr/s)
		TNMOC as C	13,1926.4 [4,800ppmv at inlet / 0.02445 * 12 * (1-0.944)]	0.3993 (13,1926.4$\mu g/m^3$ x 10,896m^3/hr x 1/10g^6/μg x 1/3600 hr/s)

Notes:

(a) Information on NENT Landfill thermal destructor, LFG flare and LFG power generator data in Jan 2007

(b) Assuming NOx to NO_2 conversion factor is 30%

(c) Vinyl Chloride and Benzene are major toxic pollutants from leachate (reacted in Thermal Destructor)

(d) Corresponding to monitoring result of 32 mg/m^3 for H_2S (i.e. 64mg/m^3 SO_2)

(e) Owing to the lack of monitoring data, assume zero SO_2 removal efficiency under the worst-case scenario.

(f) Real monitoring data for NENT Landfill thermal destructor, LFG flare and LFG power generator is adopted for the model which has taken into account the actual oxygen content, pressure, etc. Modelling has taken a conservative assumption on conversion on molecular volume under high temperature. It is also assumed oxygen content is sufficient for oxidation/combustion. The effect on the minor change in operating condition will be insignificant due to large margin in results before reaching criteria.

Table C: Estimated pollutants emission rates from plants in NENT Landfill Extension (Assume no export scheme) – Information confirmed by the Project Proponent

Source	Operating Conditions	Pollutant	Estimated Emission ($\mu g/m^3$) [e,f]	Emission Rates in atmosphere (g/s)
Thermal Destructor in Ammonia Stripping Plant (NENT Extension)	1123K (dry condition), stack height= 19.5m, internal chimney diameter =3.5m, flow rate=223,000 m^3/hr, gas exit velocity = 223000/[(3.5/2)^2x3.14]/3600= 6.44m/s	Vinyl Chloride [c]	81.8	5.067x 1E-3
		Benzene [c]	64.1	3.97x 1E-3
		TNMOC as C	13,1926.4	8.172
		NO_2 from Thermal Destructor	60,000[b]	3.7167
		SO_2 from Thermal Destructor [d, e]	64,000	3.964
Two Landfill Gas Flare – one standby and one duty (NENT Extension)	Each: 1473K (dry condition), flow rate 138,491m^3/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride [c]	81.8	0.003146823
		Benzene [c]	64.1	0.002465909
		TNMOC as C	13,1926.4	5.075156574
		NOx from Landfill Gas Flare	80,000	3.0776
		NO_2 from Landfill Gas Flare	24,000[b]	0.9233
		SO_2 from Landfill Gas Flare [d, e]	64,000	2.462
One more Landfill Gas Flare at later stage (The size of flare is the same as the original flare due to a smaller capacity of about 20Ha in NENT extension)	1473K (dry condition), flow rate 138,491m^3/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride [c]	81.8	0.003146823
		Benzene [c]	64.1	0.002465909
		TNMOC as C	13,1926.4	5.075156574
		NO_2 from Landfill Gas Flare	24,000[b]	0.9233
		SO_2 from Landfill Gas Flare [d, e]	64,000	2.462
LFG Power Generator (Electricity Generation – one standby and one duty)	853K (dry condition), flow rate 10,839 m^3/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride [c]	81.8	2.46 x 1E-4
		Benzene [c]	64.1	1.93 x 1E-4
		TNMOC as C	13,1926.4	0.3972
		NO_2 from LFG power generator	150,000[b]	0.4516
		SO_2 from LFG power generator [d, e]	64,000	0.1927

Notes:

(a) LFG flare, LFG power generator and ASP are assumed to be the same as that in existing NENT

(b) Assuming NOx to NO_2 conversion factor is 30%

(c) Vinyl Chloride and Benzene are major toxic pollutants from leachate (reacted in Thermal Destructor)

(d) Corresponding to monitoring result of 32 mg/m^3 for H_2S (i.e. 64mg/m^3 SO_2)

(e) Owing to the lack of monitoring data, assume zero SO_2 removal efficiency under the worst-case scenario.

(f) Modelling has taken a conservative assumption on conversion on molecular volume under high temperature. It is also assumed oxygen content is sufficient for oxidation/combustion. The effect on the minor change in operating condition will be insignificant due to large margin in results before reaching criteria.