Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

## Emissions from Existing Heater (EH) in YLSTW

| | | | |
|---|---|---|---|
| Maximum biogas to be utilized in heater | = | 189 | $m^3$/hr |
| No. of exhuast from the heater | = | 1 | |
| US EPA Standard Condition | = | 20 | C° |
| | = | 293 | K |
| Assume Biogas at 20 C° ambient temperature | = | 20 | C° |
| | = | 293 | K |
| Estimated biogas ($CH_4$) to be utilized in CHP | = | 189 | $m^3$/hr at 20 °C |
| | = | 189 | dscm/hr |
| | = | 0.053 | dscm/s |

**Heater Emission**

**RSP/FSP Emission**

| | | | | |
|---|---|---|---|---|
| Emission Factor for Secondary RSP/FSP emission from heater (Boiler) | **=** | 130 | kg/$10^6$ dscm $CH_4$ | *Ref. to Table 2-4.4, USEPA AP42* |
| RSP/FSP Emission Rate | = | 0.0068 | g/s | |
| **Total RSP/FSP Emission Rate at CHP Exhaust** | **=** | **0.0068** | **g/s** | |

## Emission Rates and Parameters for the Emission from Existing Boiler in YLSTW

**Emission Source Listing in AERMOD**

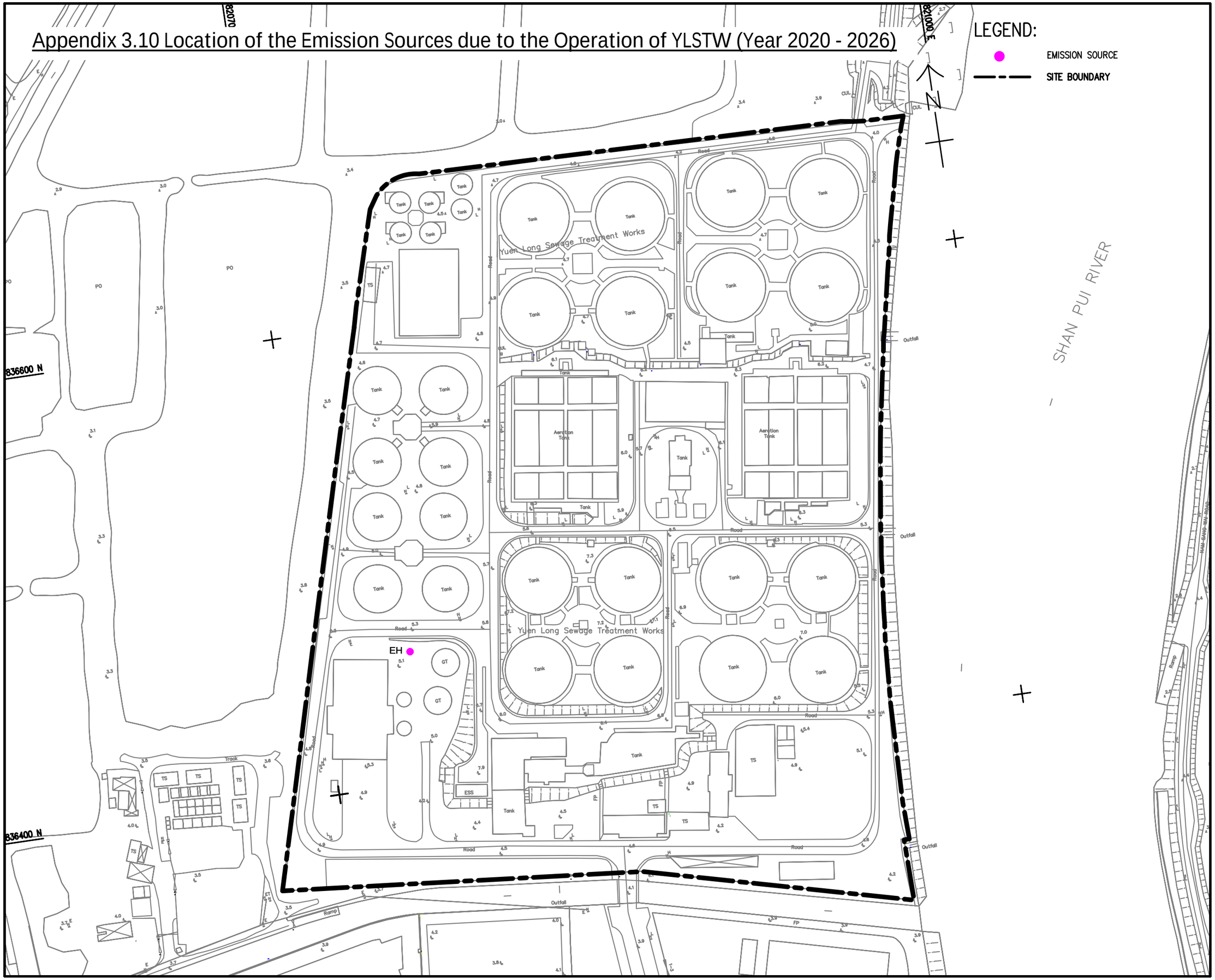
| | | | | | | | | | | | Emission Rate (g/s) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source ID** | **Description** | **Type** | **X** | **Y** | **Flow rate ($m^3/s$)** | **Height (mAG)** | **Exit temp (K)** | **Exit velocity (m/s)** | **Stack Diameter (m)** | **Operation Hours** | **TSP** | **RSP** | **FSP** | **Particle Size Distribution Adpopted** |
| EH | Existing Heater [1][2] | Point | 820739.46 | 836457.05 | 0.38 | 8.7 | 343.00 | 5.403 | 0.30 | 24 | 6.8250E-03 | 6.8250E-03 | 6.8250E-03 | No dry deposition applied |

Remarks:

[1] The existing heater will not be operating during Phase 1 Operation.PM has been identified to be the major air pollutant during construction phase. The emission from the existing heater is operating during "Year 2020-2026".

[2] TSP emission rate and FSP emission rate are assumed to be the same as that for RSP, as best estimation.

# Appendix 3.10 Location of the Emission Sources due to the Operation of YLSTW (Year 2020 - 2026)



# Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

## Emissions from CHP in YLEPP

| | |
|---|---|
| Oa: | Oxygen concentration of flue gas, dry gas |
| Os: | Standard oxygen concentration, dry gas |
| Ca, dry, Oa: | Actual flue gas concentration, dry gas, Oa |
| Ca, dry, Os: | Actual flue gas concentration, dry gas, Os |
| Ca, wet, Oa: | Actual flue gas concentration, wet gas, Oa |
| Cs: | Flue gas concentration at standard conditions |
| Va, dry: | Volume of flue gas at emission point, dry gas |
| Va, wet: | Volume of flue gas at emission point, wet gas |
| Vs: | Volume of flue gas under standard condition, dry gas |
| M: | Mass of pollutant in flue gas |
| %H2O: | % of moisture in flue gas |
| Pa: | Pressure of flue gas at emission point |
| Ps: | Standard pressure |
| Ta: | Temperature of flue gas at emission point |
| Ts: | Standard temperature |

In accordance with Annex VI of EU Directive 200/76/EC,

| | | |
|---|---|---|
| Ca, dry, Oa | = Ca, dry, Os x (20.9 - Oa) / (20.9 - Os) | (eqn. 1) |
| Ca, dry, Oa | = M / Va, dry | (eqn. 2) |
| | = M / [Va, wet x (1 - %H2O)] | (eqn. 3) |
| Ca, wet, Oa | = M / Va, wet | |
| | = Ca, dry, Oa x (1 - %H2O) | (from eqn. 3) |
| | = Ca, dry, Os x (1 - %H2O) x (20.9 – Oa) / (20.9 – Os) | (from eqn. 1) |
| | | (eqn. 4) |
| Cs | = M / Vs | (eqn. 5) |

By standard gas law,

Pa x Va, dry / Ta = Ps x Vs / Ts

Since Pa = Ps,
Therefore, Va, dry / Ta = Vs / Ts

From eqn. 2 and eqn. 5,
(M / Ca, dry, Oa) / Ta = (M / Cs) / Ts

Therefore,
Ca, dry, Oa = Cs x Ts / Ta

From eqn. 4,
Ca, wet, Oa = Cs x (Ts / Ta) x (1 - %H2O) x (20.9 – Oa) / (20.9 – Os)

**For the CHP, for RSP and $SO_2$,**

Oa = 5%
Os = 6%
%H2O = 20.4%
Ta = 453K
Ts = 273K

Therefore, for RSP and $SO_2$,

Ca, wet, Oa = Cs x (273 / 453K) x (1 – 0.204) x (20.9 – 5) / (20.9 – 6)
=0.5119Cs

# Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

**For the CHP, for NOx,**

Oa = 5%
Os = 5%
%H2O = 20.4%
Ta = 453K
Ts = 273K

Therefore, for NOx,

Ca, wet, Oa = Cs x (273 / 453K) x (1 – 0.204) x (20.9 – 5) / (20.9 – 5)
=0.4767Cs

---

**For the CHP, for $NH_3$,**

Oa = 5%
Os = 15%
%H2O = 20.4%
Ta = 453K
Ts = 273K

Therefore, for $NH_3$,

Ca, wet, Oa = Cs x (273 / 453K) x (1 – 0.204) x (20.9 – 5) / (20.9 – 15)
=1.293Cs

---

Peak Flow rate of CHP = 3,523 m3/hr at 453K

| Air Pollutant | Emission Level ($mg/Nm^3$) | *Remarks* | Emission Rate (g/s) |
|---|---|---|---|
| **RSP** | 15 | *[1] [4]* | **0.0075** |
| **NOx (as $NO_2$)** | 30 | *[2] [5]* | **0.0141** |
| **SO2** | 50 | *[1] [4]* | **0.0250** |
| **$NH_3$** | 8 | *[3] [6]* | **0.0101** |

Remarks:
[1] The emission level is taken as reference from the approved EIA for Organic Waste Treatment Facilities Phase I (AEIAR-149/2010) and the associated VEP (i.e. Application No. VEP-488/2015).
[2] The emission level is estimated by Engineer.
[3] The emission level is referenced to "A Guidance Note on the Best Practiable Means for Electricity Works (Coal-fired Plant, Gas-fired Gas Turbine, and Oil-fired Gas Turbine (Peak Lopping Plant)) BPM 7/1 (2018)"
[4] The emission level refers to an oxygen content of 6% and dry basis.
[5] The emission level refers to an oxygen content of 5% and dry basis.
[6] The emission level refers to an oxygen content of 15% and dry basis.

# Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

## Emission from Boiler (BO) in YLEPP

Diesel (Distillate oil) will be used as fuel for boiler in YLEPP.
The highest emission rates with reference to Table 1.3-1 and Table 1.3-6, AP-42, USEPA are adopted disregard of the size of boiler.

| | | | |
|---|---|---|---|
| Emission Rate of SO2 (g/s) | = | F x 0.12 x 142S /3600 | |
| Emission Rate of PM (g/s) | = | F x 0.12 x Ef / 3600 | |
| Emission Rate of NOx (g/s) | = | F x 0.12 x 20 / 3600 | |
| | | | |
| $NO_2$ Removal Efficiency of SCR | = | 70.0% | *Reference to Air Pollutant Control Technology Fact Sheet (EPA-452/F-03-032), USEPA.* |
| | | | |
| Fuel Consumption, F (L/hr) | = | 400 | *Advised by Engineer* |
| Weight % of sulphur in fuel oil, S (%) | = | 0.005 | *As stipulated in to the Air Pollution Control (Fuel Restriction) (Amendment) Regulation (the "Amendment Regulation")* |
| Emission factor of TSP, Ef | = | 2 | *Reference to Table 1.3-6, AP-42, USEPA.* |
| Emission factor of RSP, Ef | = | 1 | *Reference to Table 1.3-6, AP-42, USEPA.* |
| Emission factor of FSP, Ef | = | 0.25 | *Reference to Table 1.3-6, AP-42, USEPA.* |
| | | | |
| **Emission Rate of $SO_2$ (g/s)** | = | **9.47E-03** | |
| **Emission Rate of TSP (g/s)** | = | **2.67E-02** | |
| **Emission Rate of RSP (g/s)** | = | **1.33E-02** | |
| **Emission Rate of FSP (g/s)** | = | **3.33E-03** | |
| **Emission Rate of NOx (as $NO_2$) (g/s)** | = | **8.00E-02** | |
| | | | |
| Emission Level of NH3 ($mg/m^3$) | = | **8.00** | *Reference to "A Guidance Note on the Best Practiable Means for Electricity Works (Coal-fired Plant, Gas-fired Gas Turbine, and Oil-fired Gas Turbine (Peak Lopping Plant)) BPM 7/1 (2018)"* |
| Flow Rate at Boiler ($m^3/s$) | = | 2.94 | |
| **Emission Rate of $NH_3$ (g/s)** | = | **2.35E-02** | |

Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

## Emissions from Ammonia Stripping Unit (ASP) in YLEPP

| | |
|---|---|
| Oa: | Oxygen concentration of flue gas, dry gas |
| Os: | Standard oxygen concentration, dry gas |
| Ca, dry, Oa: | Actual flue gas concentration, dry gas, Oa |
| Ca, dry, Os: | Actual flue gas concentration, dry gas, Os |
| Ca, wet, Oa: | Actual flue gas concentration, wet gas, Oa |
| Cs: | Flue gas concentration at standard conditions |
| Va, dry: | Volume of flue gas at emission point, dry gas |
| Va, wet: | Volume of flue gas at emission point, wet gas |
| Vs: | Volume of flue gas under standard condition, dry gas |
| M: | Mass of pollutant in flue gas |
| %H2O: | % of moisture in flue gas |
| Pa: | Pressure of flue gas at emission point |
| Ps: | Standard pressure |
| Ta: | Temperature of flue gas at emission point |
| Ts: | Standard temperature |

In accordance with Annex VI of EU Directive 200/76/EC,

| | | |
|---|---|---|
| Ca, dry, Oa | = Ca, dry, Os x (20.9 - Oa) / (20.9 - Os) | (eqn. 1) |
| Ca, dry, Oa | = M / Va, dry | (eqn. 2) |
| | = M / [Va, wet x (1 - %H2O)] | (eqn. 3) |
| Ca, wet, Oa | = M / Va, wet | |
| | = Ca, dry, Oa x (1 - %H2O) | (from eqn. 3) |
| | = Ca, dry, Os x (1 - %H2O) x (20.9 – Oa) / (20.9 – Os) | (from eqn. 1) |
| | | (eqn. 4) |
| Cs | = M / Vs | (eqn. 5) |

By standard gas law,

Pa x Va, dry / Ta = Ps x Vs / Ts

Since Pa = Ps,
Therefore, Va, dry / Ta = Vs / Ts

From eqn. 2 and eqn. 5,
(M / Ca, dry, Oa) / Ta = (M / Cs) / Ts

Therefore,
Ca, dry, Oa = Cs x Ts / Ta

From eqn. 4,
Ca, wet, Oa = Cs x (Ts / Ta) x (1 - %H2O) x (20.9 – Oa) / (20.9 – Os)

For the ASP, for any pollutant,

Oa = 5%
Os = 11%
%H2O = 20.4%
Ta = 413K
Ts = 273K

Therefore,

Ca, wet, Oa = Cs x (273 / 413K) x (1 – 0.204) x (20.9 – 5) / (20.9 – 11)
=0.8410Cs

Peak Flow rate= 7.8 m3/s at 413K

| Air Pollutant | Emission Level[2] ($mg/Nm^3$) | *Remarks* | Emission Rate (g/s) |
|---|---|---|---|
| **RSP** | **5** | *[1]* | **0.0330** |
| **NOx (as $NO_2$)** | 200 | *[1]* | |
| *- $NO_2$ Removal Efficiency of SCR of 70% [4]* | **60** | *[3]* | **0.3955** |
| **$SO_2$** | **50** | *[1]* | **0.3296** |
| **$NH_3$** | 35 | *[1]* | |
| *- $NH_3$ Removal Efficiency of carbon filter of 70%* | **10.5** | *[3]* | **0.0692** |

Remarks:
[1] The emission level is taken as reference from the approved EIA for Organic Waste Treatment Facilities Phase I (AEIAR-149/2010) and the associated VEP (i.e. Application No. VEP-488/2015).
[2] The emission level refers to an oxygen content of 11% and dry basis.
[3] The emission level is provided by Engineer for YLEPP.
[4] Reference to Air Pollutant Control Technology Fact Sheet (EPA-452/F-03-032), USEPA.

## Emission Rates and Parameters for the Emission from YLEPP

**Emission Source Listing in AERMOD**

| | | | | | | | | | | | | Emission Rate (g/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source ID** | **Description** | **Type** | **X** | **Y** | **Flow rate ($m^3$/s)** | **Oxygen Concentration (%)** | **Height (mAG)** | **Exit temp (K)** | **Exit velocity (m/s)** | **Stack Diameter (m)** | **Operation Hours** | **$NO_2$** | **SO2** | **NH3** | **TSP** | **RSP** | **FSP** | **Particle Size Distribution Adpopted** |
| CHP01 | CHP Stack [1] | Point | 820815.31 | 836480.11 | 0.98 | 5.00 | 12 | 453.00 | 13.845 | 0.30 | 24 | 1.4083E-02 | 2.5048E-02 | 1.0121E-02 | 7.5143E-03 | 7.5143E-03 | 7.5143E-03 | No dry deposition applied |
| CHP02 | CHP Stack [1] | Point | 820819.58 | 836479.79 | 0.98 | 5.00 | 12 | 453.00 | 13.845 | 0.30 | 24 | 1.4083E-02 | 2.5048E-02 | 1.0121E-02 | 7.5143E-03 | 7.5143E-03 | 7.5143E-03 | No dry deposition applied |
| BO | Boiler Stack | Point | 820819.19 | 836475.87 | 2.94 | 5.00 | 12 | 453.00 | 14.973 | 0.50 | 24 | 8.0000E-02 | 9.4667E-03 | 2.3520E-02 | 2.6667E-02 | 1.3333E-02 | 3.3333E-03 | Table 1.3-6, USEPA AP-42 |
| CHP03 | CHP Stack [1] | Point | 820747.37 | 836440.85 | 0.98 | 5.00 | 12 | 453.00 | 13.845 | 0.30 | 24 | 1.4083E-02 | 2.5048E-02 | 1.0121E-02 | 7.5143E-03 | 7.5143E-03 | 7.5143E-03 | No dry deposition applied |
| CHP04 | CHP Stack [1] | Point | 820751.96 | 836440.03 | 0.98 | 5.00 | 12 | 453.00 | 13.845 | 0.30 | 24 | 1.4083E-02 | 2.5048E-02 | 1.0121E-02 | 7.5143E-03 | 7.5143E-03 | 7.5143E-03 | No dry deposition applied |
| ASP | Ammonia Stripping Stack | Point | 820751.00 | 836451.62 | 7.80 | 5.00 | 12 | 413.00 | 9.931 | 1.00 | 24 | 3.9549E-01 | 3.2957E-01 | 6.9210E-02 | 3.2957E-02 | 3.2957E-02 | 3.2957E-02 | No dry deposition applied |

Remarks:

[1] TSP emission rate and FSP emission rate are assumed to be the same as that for RSP, as best estimation.

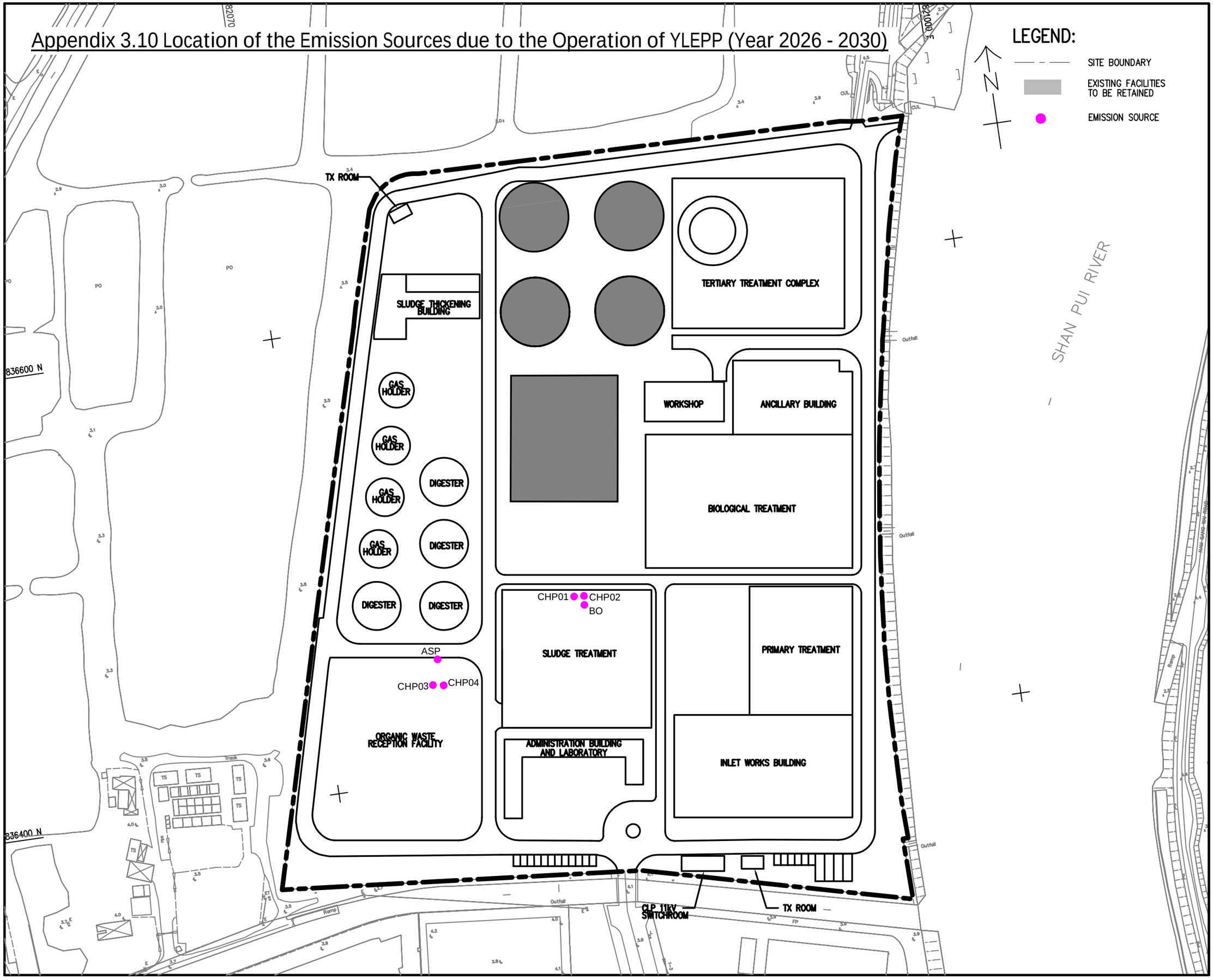
# Appendix 3.10 Calculation of Emission Rate of the Stacks of YLSTW and YLEPP

**Particle Size Distribution for Boiler in YLEPP**
*Reference: Table 1.3-6, USEPA AP-42*

| Particle Diameter (μm) | Average Particle Diameter (μm) | Cumulative Mass % of Stated Size |
|---|---|---|
| 0.625 | 0.3125 | 2% |
| 1 | 0.8125 | 8% |
| 1.25 | 1.125 | 9% |
| 2.5 | 1.875 | 12% |
| 6 | 4.25 | 30% |
| 10 | 8 | 50% |
| 15 | 12.5 | 68% |

Remarks:
Particle size distribution of boiler are extracted and presented as above, thus Method 1 of particle dry deposition is applied in AERMOD for the above source.

Appendix 3.10 Location of the Emission Sources due to the Operation of YLEPP (Year 2026 - 2030)



# Appendix 3.10 Location of the Emission Sources due to the Operation of YLEPP (Ultimate)