Appendix 4.4c **Detailed Calculations of In-Tunnel Air Quality along Tuen Mun Road Town Centre Section in front of Tuen Mun Town Plaza Block 1 & 2**

Two-way Enclosure - Normal Condition

Tunnel Parameter

Tunnel length (m), L	=	73	
Tunnel height (m), H	=	6	
Tunnel width (m), W	=	34.5	(Averaged width)
Tunnel size (m2), At	=	H * W	
		207	
Equivalent diameter (m), dt	=	(4*At/π)^0.5	
		16.23456	
Effective length of the tunnel (m), Le	=	L + 2*3*dt	
		170.4073	

Emission Data

		Traffic Breakdown (%)															
Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
108	390	0.01	0.30	0.17	0.00	0.06	0.00	0.00	0.02	0.02	0.09	0.08	0.13	0.01	0.01	0.04	0.06
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
110	3485	0.01	0.42	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.07	0.05	0.36	0.02	0.00	0.01	0.01
149	903	0.01	0.30	0.22	0.00	0.03	0.00	0.00	0.01	0.01	0.07	0.05	0.05	0.01	0.01	0.09	0.14
Total	7606	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.06	0.05	0.31	0.02	0.002	0.02	0.03
NOx Emission Factor (g/mile)		1.14	0.28	0.28	0.00	7.07	0.00	0.00	0.82	1.07	0.59	3.76	7.89	10.01	5.44	5.81	0.77

Weighted NOX E.F. (g/km/veh)	=	2.0513	
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow	
	=	5.42E-04	
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN B2 + IN E2)	(Note: For the amounts of IN B2 and IN E2 in normal condition, please refer to Appendix 4.4)
	=	5.21E-02	
Length of Enclosure E1 (m)	=	73	
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	7.14E-04	
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2	
	=	1.26E-03	

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Petrol PC &LGV	1.7	1.5	4.6
Taxi	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Single Deck Franchised Buses	2.5	3.5	12

Appendix 4.4c **Detailed Calculations of In-Tunnel Air Quality along Tuen Mun Road Town Centre Section in front of Tuen Mun Town Plaza Block 1 & 2**

Two-way Enclosure - Normal Condition

Double Deck Franchised Buses	2.5	4.6	12
Public Light Buses	2	3	6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-sectional area (m2)	=	(1.7*1.5*0.01)+(1.7*1.5*0.38)+(1.7*1.5*0.07)+(2.5*3.5*0.02)+(2*3*0.01)+(2.1*1.6*0.01)+(2.1*1.6*0.06)+(2.1*1.6*0.05)+(2.5*4.6*0.31)+(2.5*4.6*0.02)+(2.5*3.5*0.002)+(2.5*4.6*0.02)+(2*3*0.03)	
	=	6.04396	
Number of lanes per direction, nl	=	4	
Equivalent cross-sectional area for each direction (m2), Av		=	24.17584
Equivalent diameter of vehicle (m), dv	=	(4*Av/π)^0.5	
	=	5.548122	
Traffic density (traffic flow /s), N	=	2.112778	
Average vehicle speed (m/s), v	=	50 km/hr	
	=	13.88889	
Head to head distance on a lane (m), l	=	2*nl*v/N	
	=	52.59006	

Diffusion Parameters

Reynolds number, Re	=	(v*dv)/σ	where σ = 15.6*10^-6
	=	4939568	
According to Figure 16 (Ohashi and Koso)			
Since l / dt	=	3.23939	
D / (N * dt^2 * Re^0.13)	=	0.33	
Longitudinal			
diffusion coefficient (m2/s) , D	=	0.33 * (N * dt^2 * Re^0.13)	
	=	1362.788	

Maximum Concentration of NO2

Cmax (µg/m3)	=	w * Le^2 / (8 * D * At)
(without background)	=	16

Appendix 4.4c **Detailed Calculations of In-Tunnel Air Quality along Tuen Mun Road Town Centre Section in front of Tuen Mun Town Plaza Block 1 & 2**

Two-way Enclosure - Worse Condition

Tunnel Parameter

Tunnel length (m), L	=	73	
Tunnel height (m), H	=	6	
Tunnel width (m), W	=	34.5	(Averaged width)
Tunnel size (m2), At	=	H * W	
		207	
Equivalent diameter (m), dt	=	(4*At/π)^0.5	
		16.23456	
Effective length of the tunnel (m), Le	=	L + 2*3*dt	
		170.4073	

Emission Data

Traffic Breakdown (%)

Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
108	390	0.01	0.30	0.17	0.00	0.06	0.00	0.00	0.02	0.02	0.09	0.08	0.13	0.01	0.01	0.04	0.06
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
110	3485	0.01	0.42	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.07	0.05	0.36	0.02	0.00	0.01	0.01
149	903	0.01	0.30	0.22	0.00	0.03	0.00	0.00	0.01	0.01	0.07	0.05	0.05	0.01	0.01	0.09	0.14
Total	7606	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.06	0.05	0.31	0.02	0.002	0.02	0.03
NOx Emission Factor (g/mile)		1.02	0.38	0.38	0.00	10.41	0.00	0.00	1.21	1.55	0.86	5.57	11.82	15.06	9.45	10.26	1.14

Weighted NOX E.F. (g/km/veh)	=	3.0747		
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow		
	=	8.12E-04		
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN B2 + IN E2)	(Note: For the amounts of IN B2 and IN E2 in worse condition, please refer to Appendix 4.4)	
	=	8.35E-02		
Length of Enclosure E1 (m)	=	73		
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	1.14E-03		
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2		
	=	1.96E-03		

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Petrol PC &LGV	1.7	1.5	4.6
Taxi	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Single Deck Franchised Buses	2.5	3.5	12

Appendix 4.4c **Detailed Calculations of In-Tunnel Air Quality along Tuen Mun Road Town Centre Section in front of Tuen Mun Town Plaza Block 1 & 2**

Two-way Enclosure - Worse Condition

Double Deck Franchised Buses	2.5	4.6	12
Public Light Buses	2	3	6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-sectional area (m2) = (1.7*1.5*0.01)+(1.7*1.5*0.38)+(1.7*1.5*0.07)+(2.5*3.5*0.02)+(2*3*0.01)+(2.1*1.6*0.01)+(2.1*1.6*0.06)+(2.1*1.6*0.05)+(2.5*4.6*0.31)+(2.5*4.6*0.02)+(2.5*3.5*0.002)+(2.5*4.6*0.02)+(2*3*0.03)
= 6.04396
Number of lanes per direction, nl = 4
Equivalent cross-sectional area for each direction (m2), Av = 24.17584
Equivalent diameter of vehicle (m), dv = (4*Av/π)^0.5
= 5.548122

Equivalent length of each vehicle (m) = (4.6*0.01)+(4.6*0.38)+(4.6*0.07)+(12*0.02)+(6.5*0.006)+(5.2*0.011)+(5.2*0.06)+(5.2*0.05)+(16*0.31)+(16*0.02)+(12*0.002)+(12*0.02)+(6.5*0.03)
= 8.809598
Distance between vehicle (m) = 1 (worst case)
Head to head distance on a lane (m), l = 9.809598
Traffic density (traffic flow /s), N = 2.112778
Average vehicle speed (m/s), v = l*N/(2*nl)
= 2.590688

Diffusion Parameters
Reynolds number, Re = (v*dv)/σ where σ = 15.6*10^-6
= 921375.1
According to Figure 16 (Ohashi and Koso)
Since l / dt = 0.604242
D / (N * dt^2 * Re^0.13) = 0.14
Longitudinal
diffusion coefficient (m2/s) , D = 0.14 * (N * dt^2 * Re^0.13)
= 464.7714

Maximum Concentration of NO2
Cmax (µg/m3) = w * Le^2 / (8 * D * At)
(without background) = 74

Appendix 4.4c Detailed Calculations of In-Tunnel Air Quality along Tuen Mun Road Town Centre Section in front of Tuen Mun Town Plaza Block 1 & 2

Overall Concentrations

Six assessment points (ASRs E21-E26) at the boundary of the enclosure are chosen.
Using CALINE4 and ISCST3 model, the air pollutants concentrations at the 6 assessment points at different levels are calculated.
The highest concentration among the six assessment points is assumed to be the background concentration inside the proposed enclosure section.

Elevation	NO2 Concentrations (ug/m3) at Various Levels	
	(mAG)	NO_2
E21	0.0	282
	3.0	271
	6.0	252
E22	0.0	316
	3.0	298
	6.0	255
E23	0.0	361
	3.0	295
	6.0	238
E24	0.0	281
	3.0	271
	6.0	265
E25	0.0	249
	3.0	244
	6.0	241
E26	0.0	276
	3.0	254
	6.0	221

Therefore, the NO2 background concentration inside the enclosure is 361 ug/m^3

Total Maximum NO2 concentration inside enclosure of Tuen Mun Road in front of Tuen Mun Town Plaza Block 1 & 2 (Normal Speed) **= 16 + 361**
= 378 ug/m3

Total Maximum NO2 concentration inside enclosure of Tuen Mun Road in front of Tuen Mun Town Plaza Block 1 & 2 (Worse Case) **= 74 + 361**
= 435 ug/m3