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APPENDICES

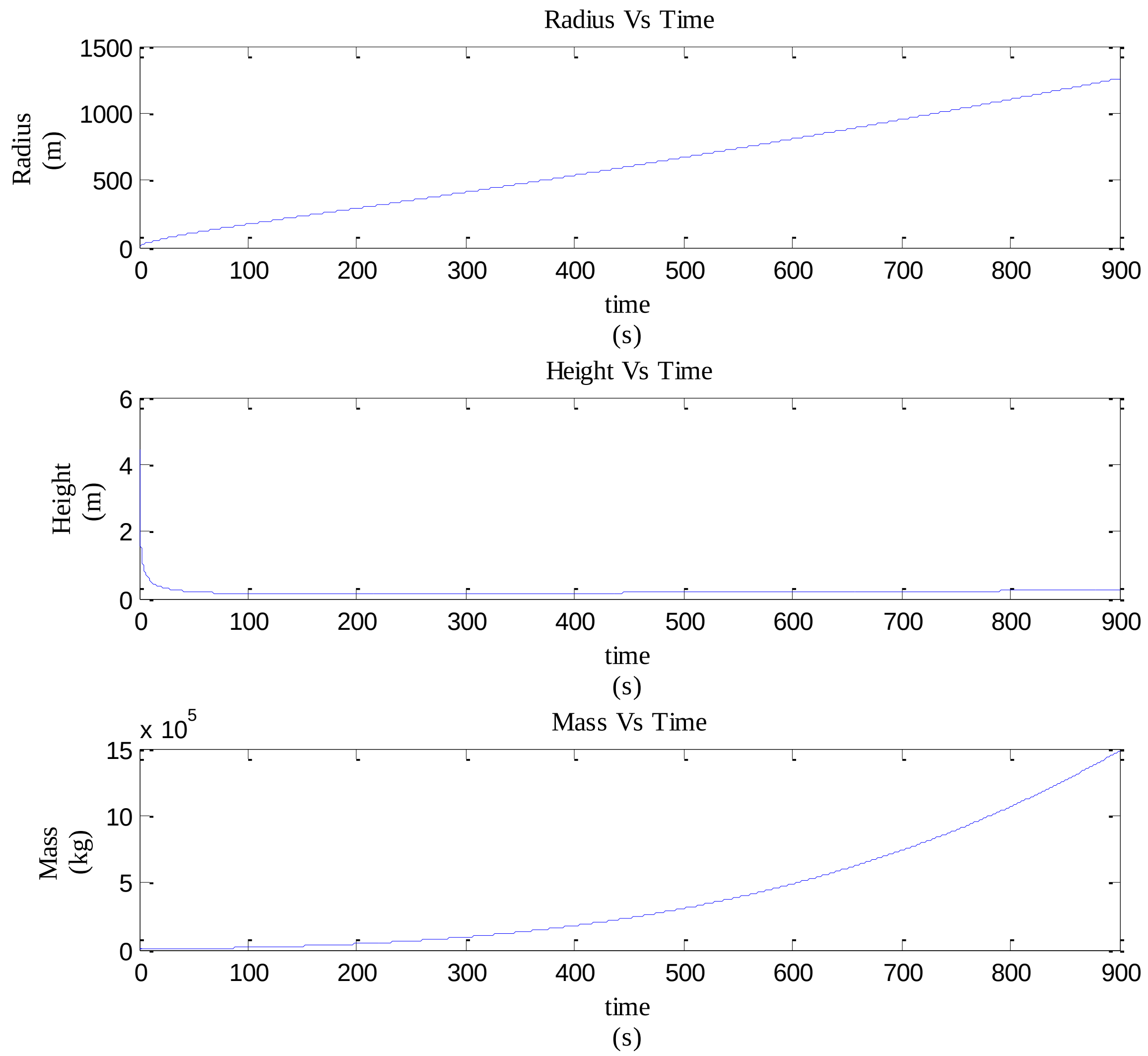
APPENDIX A – Supporting calculation excel for the Matlab m files

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Supporting calculation for the Matlab m files**												
2													
3	Air velocity	u	=	1.5	m/s								
4	Initial toxic mass	Mg	=	900	kg								
5	Constant	C	=	1.3									
6	Gas density	Pg	=	3.214	kg/m3								
7	Air density	Pa	=	1.225	kg/m3								
8	Gravitational constant	g	=	9.81	m/s2								
9													
10													
11	dr/dt = C*(gh(Pg-Pa)/Pa).^0.5												
12													
13		A	=	3.203113378									
14													
15	dr/dt	=	Asqrt(h)										
16													
17	**Gravity slumping phase:**												
18	Assumption:												
19	At t=0 radius and height is equal.												
20													
21	Vo = Mg/Pg												
22		Vo	=	280.0248911	m3								
23													
24	V = pi*r^2*h												
25													
32													
33													
34													
35		U*/u	=	0.1									
36		U*	=	0.15									
37													
38	Entrainment velocity	Ue											
39													
40	Ue=alpa*U1/Ri												
41													
42		alpa	=	0.6									
43		alpha2	=	0.5									
44	Turbulence velocity	U1											
51	Richardson number												
52													
53	Ri=(gls/U1^2)*(Pg-Pa)/Pg												
54		Ri0	=	1271.218613									
55													
56													
57													
58	dMa/dt = Pa(pi*r^2)Ue+2Pa(pi*r*h)*alpha2*(dr/dt)												
59	dMa/dt = Pa(pi*r^2)(alpa*U1/Ri)+2Pa(pi*r*h)*alpha2*(dr/dt)												
60	dMa/dt = Pa(pi*r^2)(alpa*U1^3*Pg/(g*5.88*h^0.48*detlaP)+2Pa(pi*r*h)*alpha2*(dr/dt)												
61													
62		dMa/dt	=	0.000894202	r^2/h^0.48+	3.848451	r*h*dr/dt						
63		dMa/dt	=	0.000894202	r^2/h^0.48+	12.32702	r*h^1.5						
64													
65	dMa/dt = Pa(pi*r^2)dh/dt+2Pa(pi*r*h)*(dr/dt)												
66													
67		dMa/dt	=	3.848451001	*r^2*dh/dt+	7.696902	*r*h*(dr/dt)						
68													
69													
70													
71	3.848451001	*r^2*dh/dt+	7.696902	*r*h*(dr/dt)	=	0.000894	r^2/h^0.48+	3.848451	r*h*dr/dt				
72													
73		3.848451	*r^2*dh/dt		=	0.000894	r^2/h^0.48+	3.848451	r*h*dr/dt -		7.696902	*r*h*(dr/dt)	
74		3.848451	*r^2*dh/dt		=	0.000894	r^2/h^0.48+	-3.84845	r*h*dr/dt				
75													
76				dh/dt	=	0.000232	/h^0.48	-3.20311	h^1.5/r				
77													
78		B =	0.000232										
79		D =	-3.20311										
80		E =	0.000894										
81		F =	12.32702										
82													

APPENDIX B – mfile for entrainment phase

```
%Air entrainment phase R , H and Ma vs time graphs

%define variables for Equation 1 (r'=A*h^0.5)
clear all;
% read excel for variables
filename = 'calculation.xlsx';
sheet = 1;
xlRange = 'D3:D8';
subsetA1 = xlsread(filename,sheet,xlRange);

u = subsetA1(1);
Mg = subsetA1(2);
C   =   1.3;
Pg  =   3.214;
Pa  =   1.225;
g   =   9.81;

A = C*(g*(Pg-Pa)/Pg)^0.5;

xlRange = 'C78:C81';
subsetA2 = xlsread(filename,sheet,xlRange);

%define variables for Equation 2 (h'=B/h^0.48+D*h^1.5/r)

B=subsetA2(1);
D=subsetA2(2);

%define variables for Equation 3 (dMa/dt=E*r^2/h^0.48+F*r*h^1.5)

E=subsetA2(3);
F=subsetA2(4);

xlRange = 'D29';
subsetA3 = xlsread(filename,sheet,xlRange);
```

```
r0 = subsetA3(1);
h0 = subsetA3(1);

%ODE solver
t1=0:0.1:900;
funch   =   @(T,x)   [A*x(2)^0.5;   B*x(2)^(-0.48)+D*(x(2)^1.5)/x(1);
E*x(1)^2/x(2)^0.48+F*x(1)*x(2)^1.5];
[t1,RHM_VAL] = ode45(funch, t1, [r0 h0 0]);



r1 = RHM_VAL(:,1);
h1 = RHM_VAL(:,2);
m1 = RHM_VAL(:,3);

%plot time vs radius
subplot(3,1,1)
plot(t1,RHM_VAL(:,1), 'b-');
xlabel({'time','(s)'});
ylabel({'Radius','(m)'});
title('Radius Vs Time');

%plot time vs height
subplot(3,1,2)
plot(t1,RHM_VAL(:,2), 'b-');
title('Height Vs Time');
xlabel({'time','(s)'});
ylabel({'Height','(m)'});



%plot time vs mass
subplot(3,1,3)
plot(t1,RHM_VAL(:,3), 'b-');
title('Mass Vs Time');
xlabel({'time','(s)'});
ylabel({'Mass','(kg)'});
```



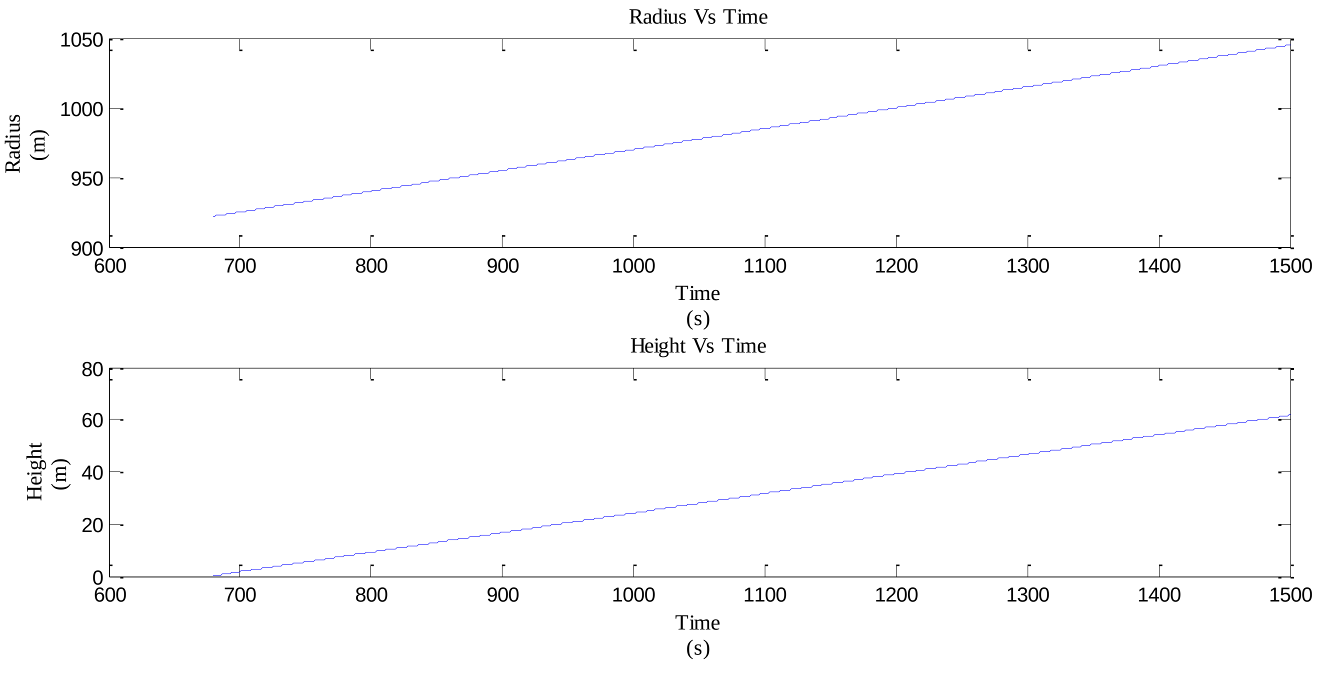
Graphs of (a) Radius vs Time (b) Height vs Time (c) Mass vs Time in entrainment phase

APPENDIX C- mfile for post transition period

```
%Post transition phase R and H vs time graphs

%define variables for Equation 1 (r'=A*h^0.5)
clear all;
% read excel for variables
filename = 'calculation.xlsx';
sheet = 1;
xlRange = 'D3:D8';
subsetA1 = xlsread(filename,sheet,xlRange);

u = subsetA1(1);
Mg = subsetA1(2);
C   =   1.3;
Pg  =   3.214;
Pa  =   1.225;
g   =   9.81;
U_fr =  0.1 * u;
alpha2 = 0.5;

A = C*(g*(Pg-Pa)/Pg)^0.5;

xlRange = 'C78:C81';
subsetA2 = xlsread(filename,sheet,xlRange);

%define variables for Equation 2 (h'=B/h^0.48+D*h^1.5/r)

B=subsetA2(1);
D=subsetA2(2);

%define variables for Equation 3 (dMa/dt=E*r^2/h^0.48+F*r*h^1.5)

E=subsetA2(3);
```

```
F=subsetA2(4);

xlRange = 'D29';
subsetA3 = xlsread(filename,sheet,xlRange);

r0 = subsetA3(1);
h0 = subsetA3(1);

%ODE solver
t1=0:1:1200;
funch   =   @(T,x)   [A*x(2)^0.5;   B*x(2)^(-0.48)+D*(x(2)^1.5)/x(1);
E*x(1)^2/x(2)^0.48+F*x(1)*x(2)^1.5];
[t1,RHM_VAL] = ode45(funch, t1, [r0 h0 0]);



r1 = RHM_VAL(:,1);
h1 = RHM_VAL(:,2);
m1 = RHM_VAL(:,3);

M = Mg+m1;
V = Mg/Pg+m1/Pa;



rho = M./V;
 [row,col] = size(rho);

idx = 1;
while idx < row && ((rho(idx)-Pa)>0.001 )
%  print(i);
  idx = idx + 1;
end

t_T = t1(idx);
r_T = r1(idx);
h_T = h1(idx);

t2 = t_T : 1 : 1500;
```

```
r2 = r_T + U_fr * (t2 - t_T);
h2 = h_T + alpha2 * U_fr * (t2 - t_T);


% plot time vs radius
subplot(2,1,1)
plot(t2, r2, 'b-');
xlabel({'time','(s)'});
ylabel({'Radius','(m)'});
title('Radius Vs Time');

%plot time vs height
subplot(2,1,2)
plot(t2, h2, 'b-');
title('Height Vs Time');
xlabel({'time','(s)'});
ylabel({'Height','(m)'});
```



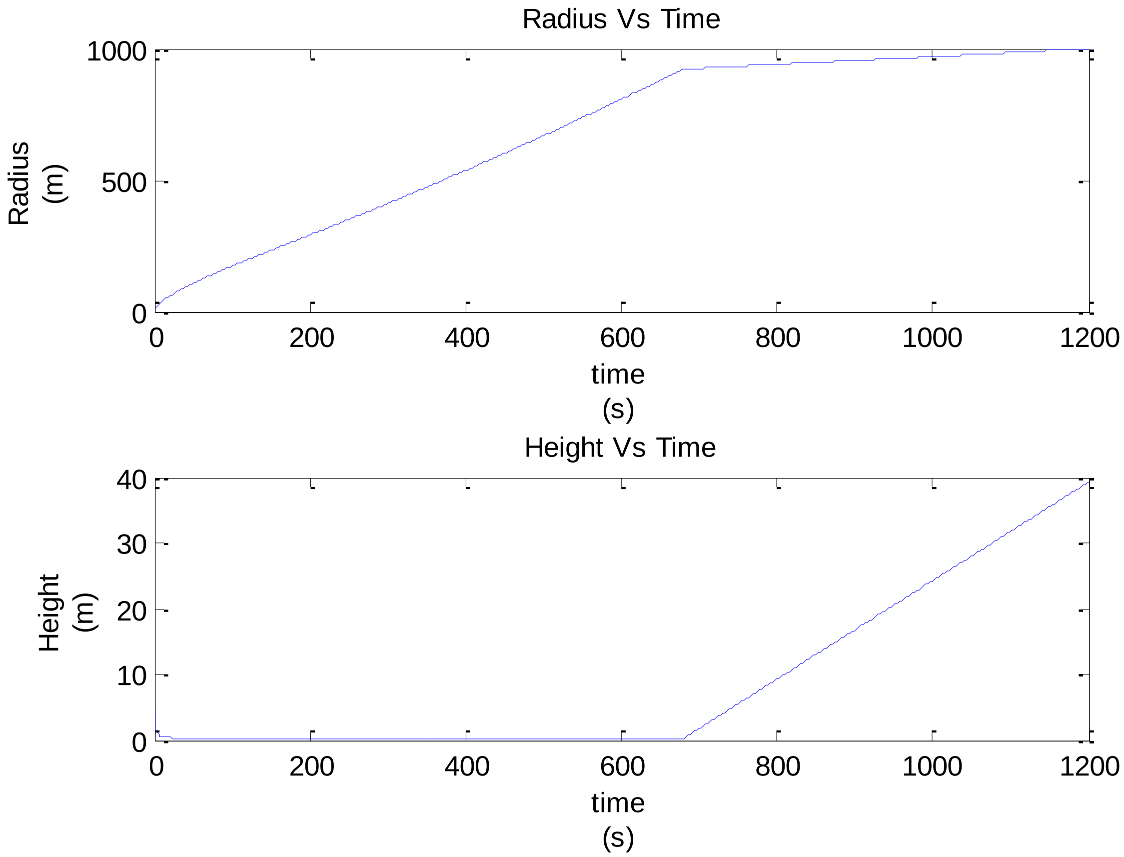
Graphs of (a) Radius vs Time (b) Height vs Time in post transition phase

APPENDIX D - mfile for all three phases

```
%define variables for Equation 1 (r'=A*h^0.5)
clear all;
% read excel for variables
filename = 'calculation.xlsx';
sheet = 1;
xlRange = 'D3:D8';
subsetA1 = xlsread(filename,sheet,xlRange);

u = subsetA1(1);
Mg = subsetA1(2);
C    =    1.3;
Pg   =    3.214;
Pa   =    1.225;
g    =    9.81;
U_fr =   0.1 * u;
alpha2 = 0.5;

A = C*(g*(Pg-Pa)/Pg)^0.5;

xlRange = 'C78:C81';
subsetA2 = xlsread(filename,sheet,xlRange);

%define variables for Equation 2 (h'=B/h^0.48+D*h^1.5/r)

B=subsetA2(1);
D=subsetA2(2);

%define variables for Equation 3 (dMa/dt=E*r^2/h^0.48+F*r*h^1.5)

E=subsetA2(3);
F=subsetA2(4);

xlRange = 'D29';
subsetA3 = xlsread(filename,sheet,xlRange);
```

```
r0 = subsetA3(1);
h0 = subsetA3(1);

%ODE solver
t1=0:1:1200;
funch = @(T,x) [A*x(2)^0.5; B*x(2)^(-0.48)+D*(x(2)^1.5)/x(1);
E*x(1)^2/x(2)^0.48+F*x(1)*x(2)^1.5];
[t1,RHM_VAL] = ode45(funch, t1, [r0 h0 0]);

r1 = RHM_VAL(:,1);
h1 = RHM_VAL(:,2);
m1 = RHM_VAL(:,3);

M = Mg+m1;
V = Mg/Pg+m1/Pa;

rho = M./V;

[row,col] = size(rho);

idx = 1;
while idx < row && ((rho(idx)-Pa)>0.001 )
%  print(i);
  idx = idx + 1;
end

t_T = t1(idx);
r_T = r1(idx);
h_T = h1(idx);

t2 = t_T : 1 : 1200;
r2 = r_T + U_fr * (t2 - t_T);
h2 = h_T + alpha2 * U_fr * (t2 - t_T);

%t_m = [t1';t2(1:idx)]; % combining phase1 and phase2
t_final = [t1(1:idx); t2'];
r_final = [r1(1:idx);r2'];
```

```
h_final = [h1(1:idx);h2'];
m_final = m1(1:idx);

%plot time vs radius
subplot(2,1,1)
plot(t_final, r_final, 'b-');
title('Radius Vs Time');
xlabel({'time','(s)'});
ylabel({'Radius','(m)'});

%plot time vs height
subplot(2,1,2)
plot(t_final, h_final, 'b-');
title('Height Vs Time');
xlabel({'time','(s)'});
ylabel({'Height','(m)'});
```



Graphs of (a) Radius vs Time (b) Height vs Time in all three phases

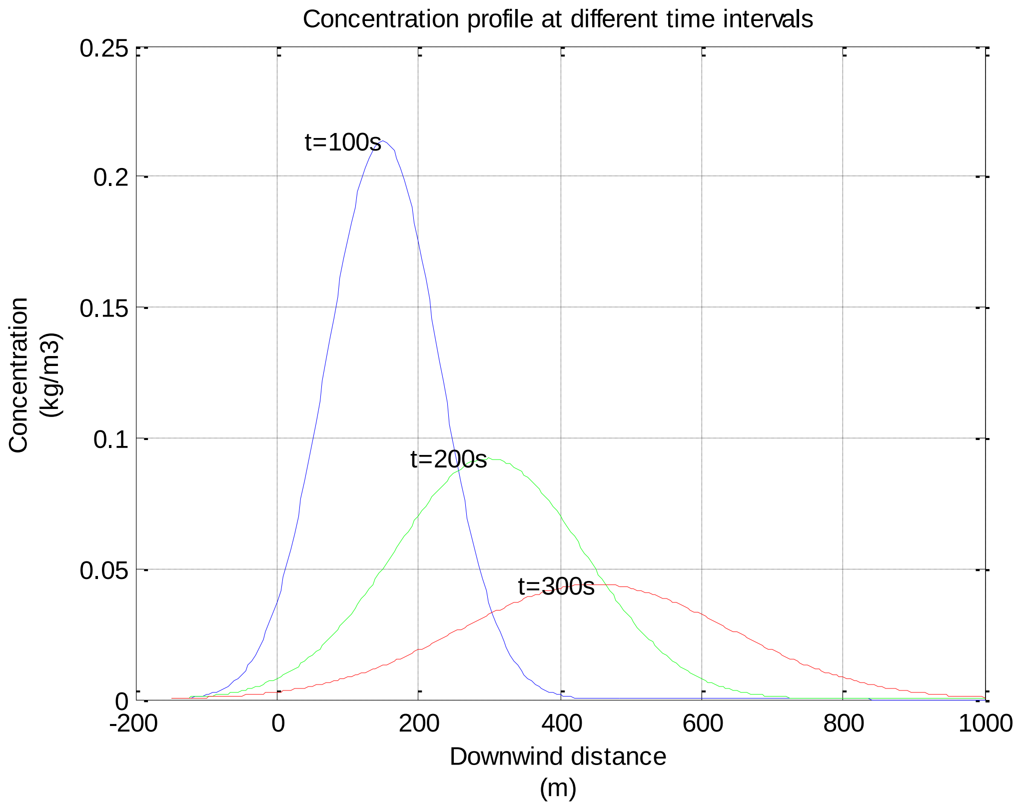
APPENDIX E – mfile for concentration profile

```
%define variables for Equation 1 (r'=A*h^0.5)
clear all;

% read excel for variables
filename = 'calculation.xlsx';
sheet = 1;
xlRange = 'D3:D8';
subsetA1 = xlsread(filename,sheet,xlRange);

u = subsetA1(1);
Mg = subsetA1(2);
C   =   1.3;
Pg  =   3.214;
Pa  =   1.225;
g   =   9.81;
U_fr =  0.1 * u;
alpha2 = 0.5;

A = C*(g*(Pg-Pa)/Pg)^0.5;

xlRange = 'C78:C81';
subsetA2 = xlsread(filename,sheet,xlRange);

%define variables for Equation 2 (h'=B/h^0.48+D*h^1.5/r)

B=subsetA2(1);
D=subsetA2(2);

%define variables for Equation 3 (dMa/dt=E*r^2/h^0.48+F*r*h^1.5)

E=subsetA2(3);
F=subsetA2(4);
```

```
xlRange = 'D29';
subsetA3 = xlsread(filename,sheet,xlRange);

r0 = subsetA3(1);
h0 = subsetA3(1);

%ODE solver
t1=0:0.1:1000;
funch = @(T,x) [A*x(2)^0.5; B*x(2)^(-0.48)+D*(x(2)^1.5)/x(1);
E*x(1)^2/x(2)^0.48+F*x(1)*x(2)^1.5];
[t1,RHM_VAL] = ode45(funch, t1, [r0 h0 0]);



r1 = RHM_VAL(:,1);
h1 = RHM_VAL(:,2);
m1 = RHM_VAL(:,3);

M = Mg+m1;
V = Mg/Pg+m1/Pa;

rho = M./V;
 [row,col] = size(rho);

idx = 1;
while idx < row && ((rho(idx)-Pa)>0.001 )
%  print(i);
  idx = idx + 1;
end

t_T = t1(idx);
r_T = r1(idx);
h_T = h1(idx);

t2 = t_T : 1 : 1500;
r2 = r_T + U_fr * (t2 - t_T);
h2 = h_T + alpha2 * U_fr * (t2 - t_T);
```

```
t_final = [t1(1:idx); t2'];
r_final = [r1(1:idx);r2'];
h_final = [h1(1:idx);h2'];
m_final = m1(1:idx);

sigmay = r_final / 2.14;
sigmaz = h_final / 2.14;

colors = {'-b' '-g' '-r' '-c' '-m'};
legendInfo =  {};
plots = {};
for n = 1:3

    t_index = (n)*1000;
    t = t_final(t_index);

[x,y,z] = meshgrid(-150:5:1000,-50:5:500,0:0.1:3);
G = exp (-(((y.^2) + ((x-(u*t)).^2))/(2*(sigmay(t_index)^2))) -
((z.^2)/(2*(sigmaz(t_index)^2))));
C = Mg*G/(sqrt(2)*(pi^1.5)*(sigmay(t_index)^2)*sigmaz(t_index));
Z = C(:,:,1);
[rw,col] = size(Z);

%X = ones(rw,col);
[Xa,Y] = meshgrid(-150:5:1000,-50:5:500);
Y = Z(1,:);
X = Xa(1,:);
plot(X,Y , colors{n});
indexmax = find(max(Y) == Y);
xmax = X(indexmax);
ymax = Y(indexmax);

strmax = strcat('t=' , num2str(round(t)),'s');
text(xmax,ymax,strmax,'HorizontalAlignment','right');
```

```
title('Concentration profile at different time intervals');
xlabel({'Downwind distance','(m)'});
ylabel({'Concentration','(kg/m3)'});

hold on;
 end

grid on
```



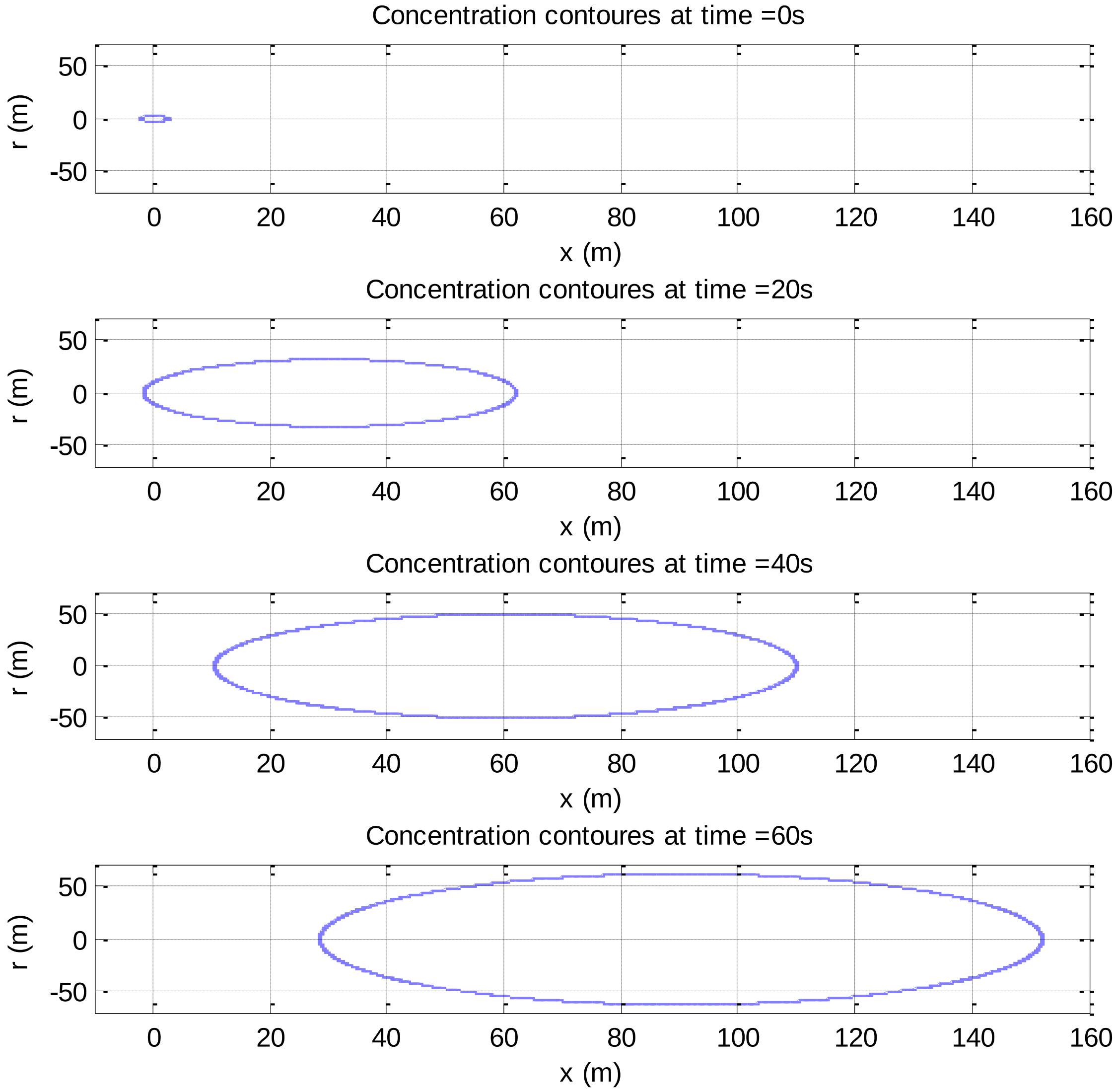
Concentration profile at different times after the release

APPENDIX F - m file for contour curves

```
%define variables for Equation 1 (r'=A*h^0.5)
clear all;
% read excel for variables
filename = 'calculation.xlsx';
sheet = 1;
xlRange = 'D3:D8';
subsetA1 = xlsread(filename,sheet,xlRange);

u = subsetA1(1);
Mg = subsetA1(2);
C   =   1.3;
Pg  =   3.214;
Pa  =   1.225;
g   =   9.81;
U_fr =  0.1 * u;
alpha2 = 0.5;

A = C*(g*(Pg-Pa)/Pg)^0.5;

xlRange = 'C78:C81';
subsetA2 = xlsread(filename,sheet,xlRange);

%define variables for Equation 2 (h'=B/h^0.48+D*h^1.5/r)

B=subsetA2(1);
D=subsetA2(2);

%define variables for Equation 3 (dMa/dt=E*r^2/h^0.48+F*r*h^1.5)

E=subsetA2(3);
F=subsetA2(4);

xlRange = 'D29';
subsetA3 = xlsread(filename,sheet,xlRange);

r0 = subsetA3(1);
h0 = subsetA3(1);

%ODE solver
t1=0:0.1:1000;
funch = @(T,x) [A*x(2)^0.5; B*x(2)^(-0.48)+D*(x(2)^1.5)/x(1);
E*x(1)^2/x(2)^0.48+F*x(1)*x(2)^1.5];
[t1,RHM_VAL] = ode45(funch, t1, [r0 h0 0]);


r1 = RHM_VAL(:,1);
h1 = RHM_VAL(:,2);
m1 = RHM_VAL(:,3);
%======================== end of
phase1===================================
```

```
M = Mg+m1;
V = Mg/Pg+m1/Pa;


rho = M./V;


[row,col] = size(rho);

%for idx = 1:1:row
%     if(rho(idx)<1.2251 && rho(idx)>1.2250)
        % t_post = t(idx);
         %disp( t(idx));
 %        break
 %    end
%end
idx = 1;
while idx < row && ((rho(idx)-Pa)>0.001 )
%  print(i);
  idx = idx + 1;
end

t_T = t1(idx);
r_T = r1(idx);
h_T = h1(idx);

t2 = t_T : 1 : 1500;
r2 = r_T + U_fr * (t2 - t_T);
h2 = h_T + alpha2 * U_fr * (t2 - t_T);



t_final = [t1(1:idx); t2'];
r_final = [r1(1:idx);r2'];
h_final = [h1(1:idx);h2'];
m_final = m1(1:idx);

sigmay = r_final / 2.14;
sigmaz = h_final / 2.14;

for n = 1:2:8
    %n = 2;
    %t_index = (n-1)*2+1;
    t_index =(n-1)*100+1;
    t = t_final(t_index);
    disp(t);
[x,y,z] = meshgrid(-10:0.5:160,-70:0.5:70,0:0.1:3);
G = exp (-(((y.^2) + ((x-(u*t)).^2))/(2*(sigmay(t_index)^2))) -
((z.^2)/(2*(sigmaz(t_index)^2))));
C = Mg*G/(sqrt(2)*(pi^1.5)*(sigmay(t_index)^2)*sigmaz(t_index));
Z = C(:,:,1);
[rw,col] = size(Z);
colormap cool;
```

```
inx = (n+1)/2;
subplot(4,1,inx);
[X,Y] = meshgrid(-10:.5:160,-70:.5:70);
[c,h] = contour(X,Y,Z,1);
str = strcat('Concentration contoures at time = ' , num2str(t),
's');

title(str);
xlabel({'x (m)'});
ylabel({'r (m)'});
hold on;
grid on;


end
```



Propagation of contours in downwind direction

APPENDIX G- Probit calculation Excel sheet

Percentage Fatalities from a Fixed Concentration-Time Relationship Example:

Input Data:

Concentration:	30	Ppm
Exposure Time:	260	minutes
Probit Equation:		
k1:	-17.1	
k2:	1.69	
Exponent:	2.75	

Equation for Fatality:

$$Y = -17.1 + 1.69\ln(\Sigma C^{2.75} t)$$

Calculated Results:

Probit Value (Y):	8.10	
Percent:	99.90	%

Concentration @ 20 ppm	
Time (min)	Percentage of Death (%)
10	0
20	0
30	0.76
40	2.6
50	5.87
60	10.42
70	15.93
80	22.01
90	28.34
100	34.66
110	40.77

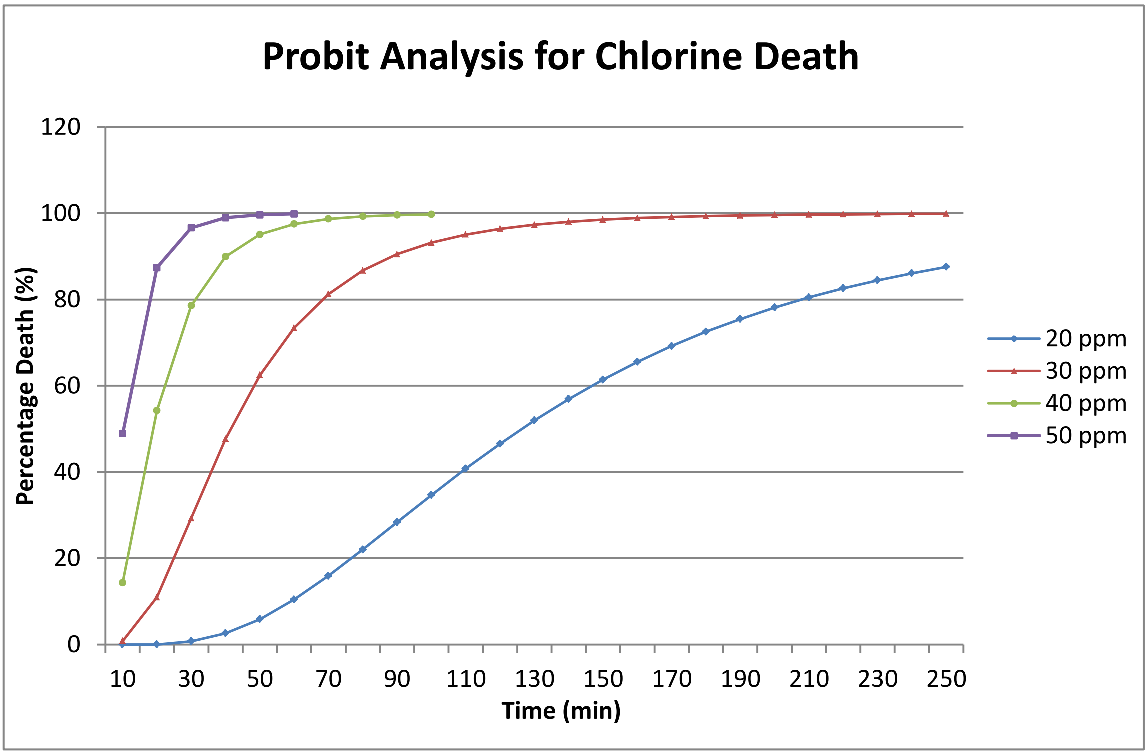
Concentration @ 30 ppm	
Time (min)	Percentage of Death (%)
10	0.82
20	10.93
30	29.29
40	47.66
50	62.49
60	73.45
70	81.25
80	86.71
90	90.52
100	93.19
110	95.06

Concentration @ 40 ppm	
Time (min)	Percentage of Death (%)
10	14.35
20	54.25
30	78.58
40	89.94
50	95.11
60	97.52
70	98.69
80	99.29
90	99.6
100	99.76

Concentration @ 50 ppm	
Time (min)	Percentage of Death (%)
10	48.9
20	87.37
30	96.63
40	98.97
50	99.65
60	99.87

120	46.55
130	51.95
140	56.91
150	61.43
160	65.53
170	69.22
180	72.53
190	75.49
200	78.14
210	80.49
220	82.59
230	84.45
240	86.1
250	87.57

120	96.39
130	97.34
140	98.02
150	98.52
160	98.88
170	99.15
180	99.35
190	99.5
200	99.61
210	99.7
220	99.76
230	99.81
240	99.85
250	99.88
260	99.9

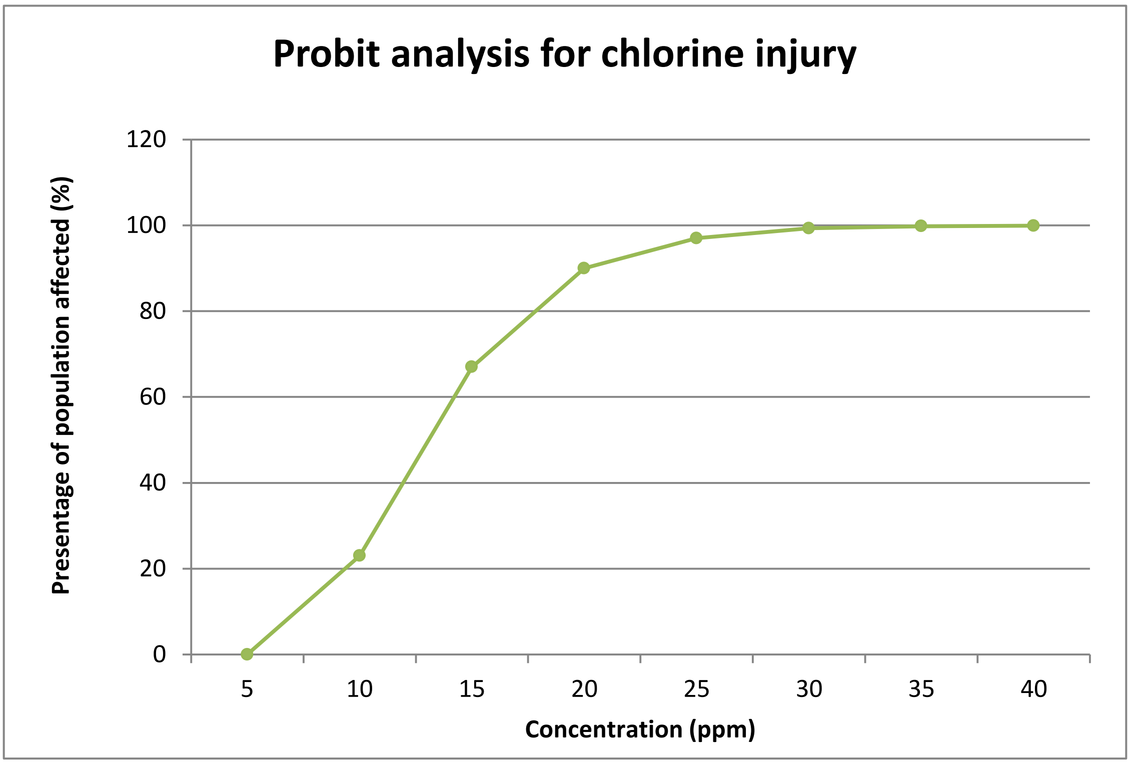


Probit analysis for chlorine injury

Probit equation for non-lethal injury:

$$Y = -2.40 + 2.90\ln(C)$$

C	Y	%
5	2.26736995	0
10	4.27749677	23
15	5.45334558	67
20	6.28762359	90
25	6.93473989	97
30	7.46347241	99.3
35	7.91050938	99.8
40	8.29775042	99.9



Probit analysis for chlorine injury

APPENDIX H – Model validation and sensitivity analysis of parameters

Parameters C, α*, α, U*/U are varied to obtain the optimum validation results. Best values were obtained from test 8.

Table: Values varied in sensitivity analysis

	C	α*	α	U*/U
test1	1.00	0.50	0.20	0.10
test2	1.00	0.50	0.45	0.10
test3	1.00	0.50	0.50	0.10
test4	1.00	0.50	0.60	0.10
test5	1.30	0.50	0.50	0.10
test6	1.30	0.50	0.50	0.20
test7	1.30	0.50	0.60	0.10
test8	***1.30***	***0.60***	***0.50***	***0.10***
test9	1.30	0.70	0.50	0.10

The obtained results (error %) is shown in below table:

Test 1:

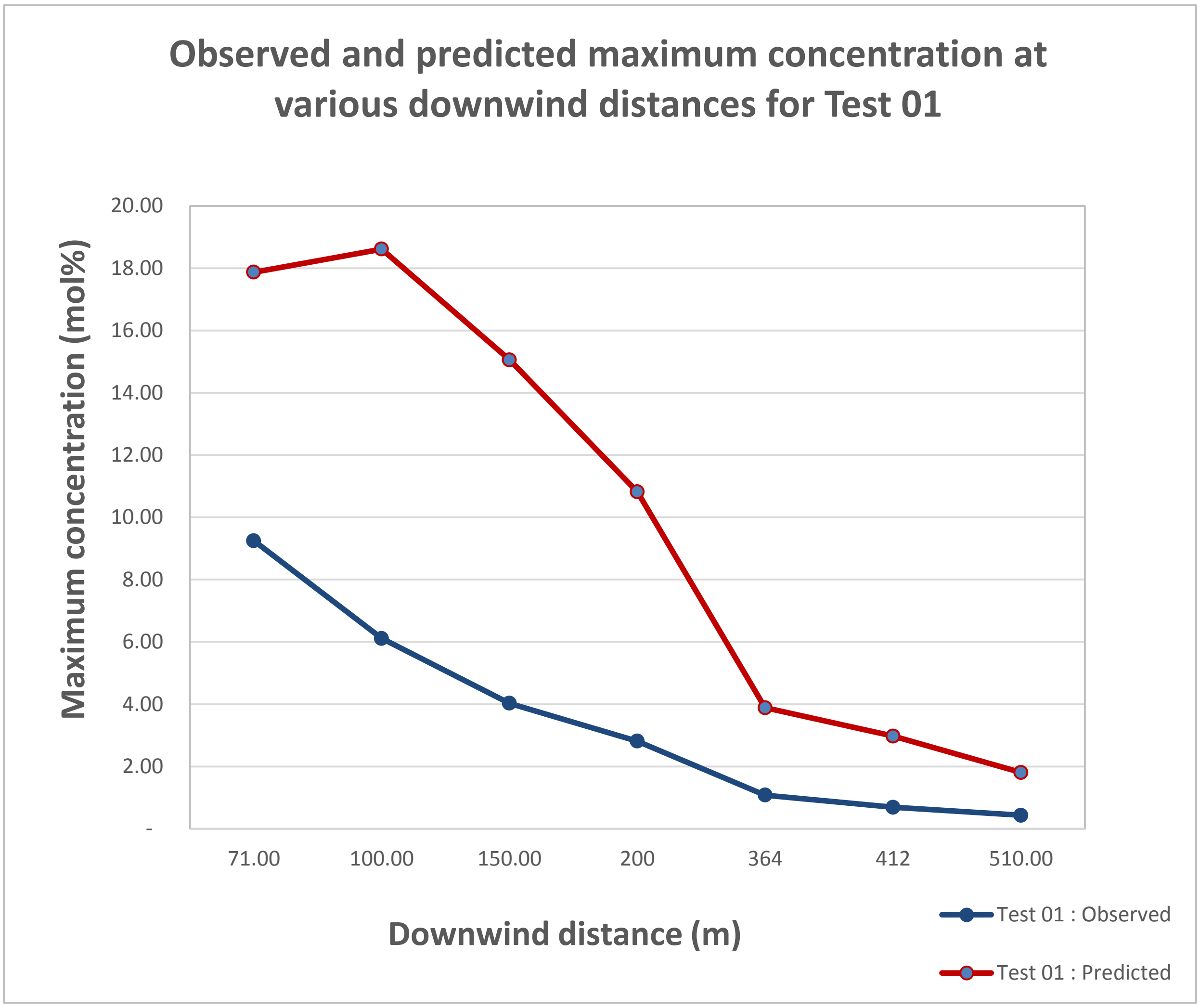
C = 1.00

α* = 0.50

α = 0.20

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol%	observed mol %	error %
71	29.9	300	0.71090	120	0.005924	65.19	0.4258	4,489	5,684.83	0.7896	29	0.0272	17.87	9.25	48.23
100	41.7	418	0.84270	120	0.007023	79.90	0.3765	6,725	7,551.07	0.8906	29	0.0307	18.61	6.11	67.17
150	61.9	620	0.74800	120	0.006233	103.50	0.3639	12,490	12,246.52	1.0199	29	0.0352	15.06	4.03	73.23
200	83.9	840	0.55190	120	0.004599	129.60	0.3819	22,160	20,151.60	1.0997	29	0.0379	10.82	2.81	74.02
364	151.9	1,520	0.19880	120	0.001657	216.00	0.4745	82,630	69,549.43	1.1881	29	0.0410	3.89	1.08	72.21
412	171.9	1,720	0.15180	120	0.001265	243.30	0.5027	111,900	93,485.22	1.1970	29	0.0413	2.97	0.69	76.80
510	212.9	2,130	0.09199	120	0.000767	302.90	0.5603	195,100	161,498.70	1.2081	29	0.0417	1.81	0.43	76.20



Observed and predicted maximum concentration at various downwind distances for Test 01
Maximum concentration (mol%)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 01 : Observed
Test 01 : Predicted

Test 2:

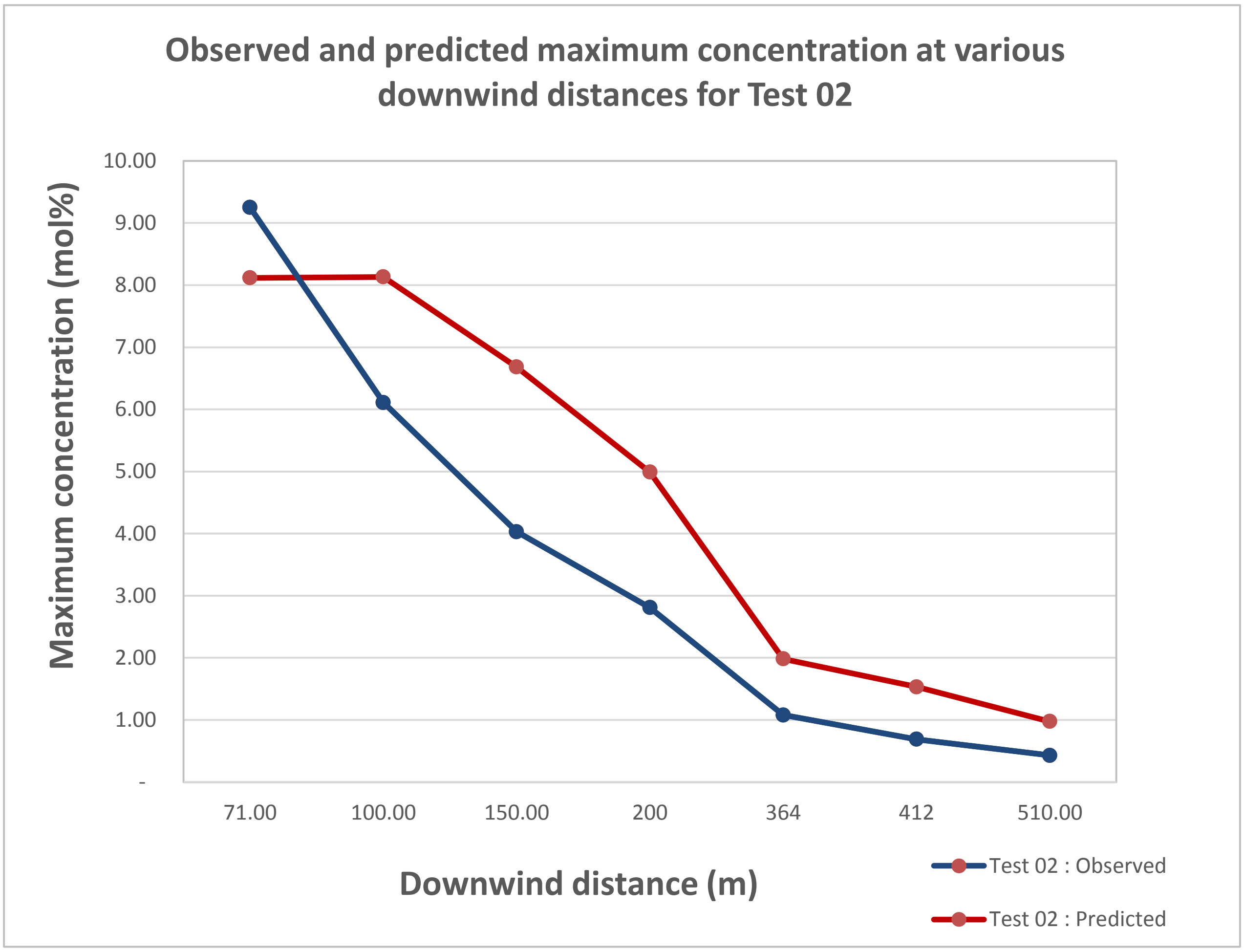
C = 1.00

α* = 0.50

α = 0.45

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol%	error %
71	29.9	300	0.39360	120	0.003280	80.94	0.80360	17,810	16,539.26	1.0768	29	0.03713	8.12	9.25	(13.97)
100	41.7	418	0.40710	120	0.003393	100.70	0.68480	24,250	21,815.87	1.1116	29	0.03833	8.13	6.11	24.86
150	61.9	620	0.34080	120	0.002840	132.00	0.60230	37,930	32,969.37	1.1505	29	0.03967	6.68	4.03	39.68
200	83.9	840	0.25520	120	0.002127	164.90	0.58040	58,220	49,581.38	1.1742	29	0.04049	4.99	2.81	43.69
364	151.9	1,520	0.10110	120	0.000843	267.40	0.63470	172,200	142,574.28	1.2078	29	0.04165	1.98	1.08	45.53
412	171.9	1,720	0.07800	120	0.000650	298.80	0.66130	224,700	185,485.34	1.2114	29	0.04177	1.53	0.69	54.97
510	212.9	2,130	0.04966	120	0.000414	365.10	0.71930	366,500	301,219.86	1.2167	29	0.04196	0.98	0.43	55.98


Observed and predicted maximum concentration at various downwind distances for Test 02
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 02 : Observed
Test 02 : Predicted

Test 3:

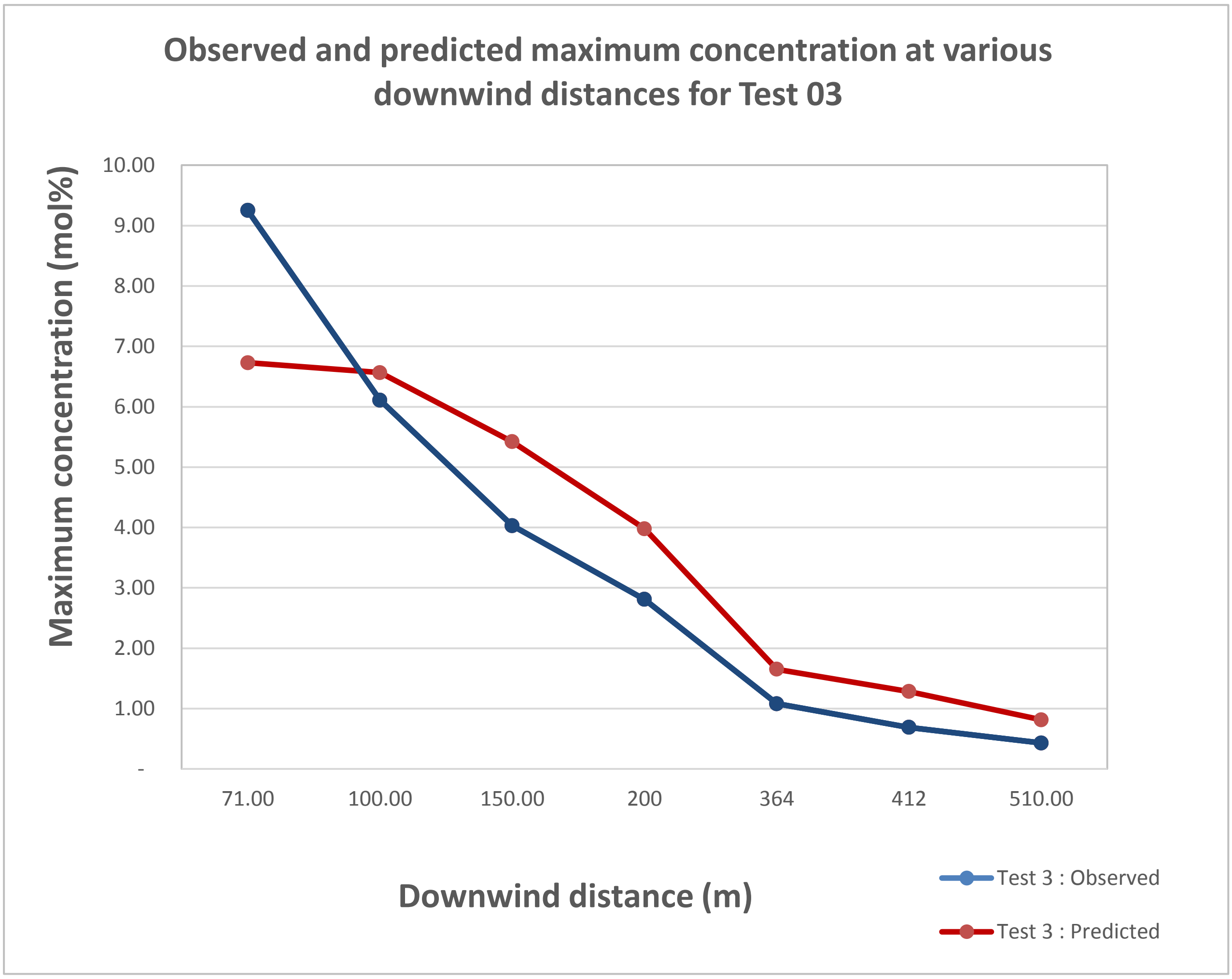
C = 1.00

α* = 0.50

α = 0.50

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol%	error %
71	29.9	300	0.33140	120	0.002762	85.24	0.93800	23,770	21,411.13	1.1102	29	0.03828	6.73	9.25	(37.47)
100	41.7	418	0.33070	120	0.002756	106.60	0.79950	32,470	28,541.89	1.1376	29	0.03923	6.56	6.11	6.92
150	61.9	620	0.27120	120	0.002260	140.40	0.69540	49,260	43,064.44	1.1439	29	0.03944	5.42	4.03	25.63
200	83.9	840	0.20340	120	0.001695	175.50	0.65890	75,620	63,756.38	1.1861	29	0.04090	3.98	2.81	29.39
364	151.9	1,520	0.08295	120	0.000691	283.60	0.69370	209,400	175,280.67	1.1947	29	0.04120	1.65	1.08	34.56
412	171.9	1,720	0.06532	120	0.000544	316.30	0.71800	274,000	225,669.41	1.2142	29	0.04187	1.28	0.69	46.24
510	212.9	2,130	0.04165	120	0.000347	385.20	0.77000	439,400	358,932.81	1.2242	29	0.04221	0.82	0.43	47.27



Observed and predicted maximum concentration at various downwind distances for Test 03
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 3 : Observed
Test 3 : Predicted

Test 4:

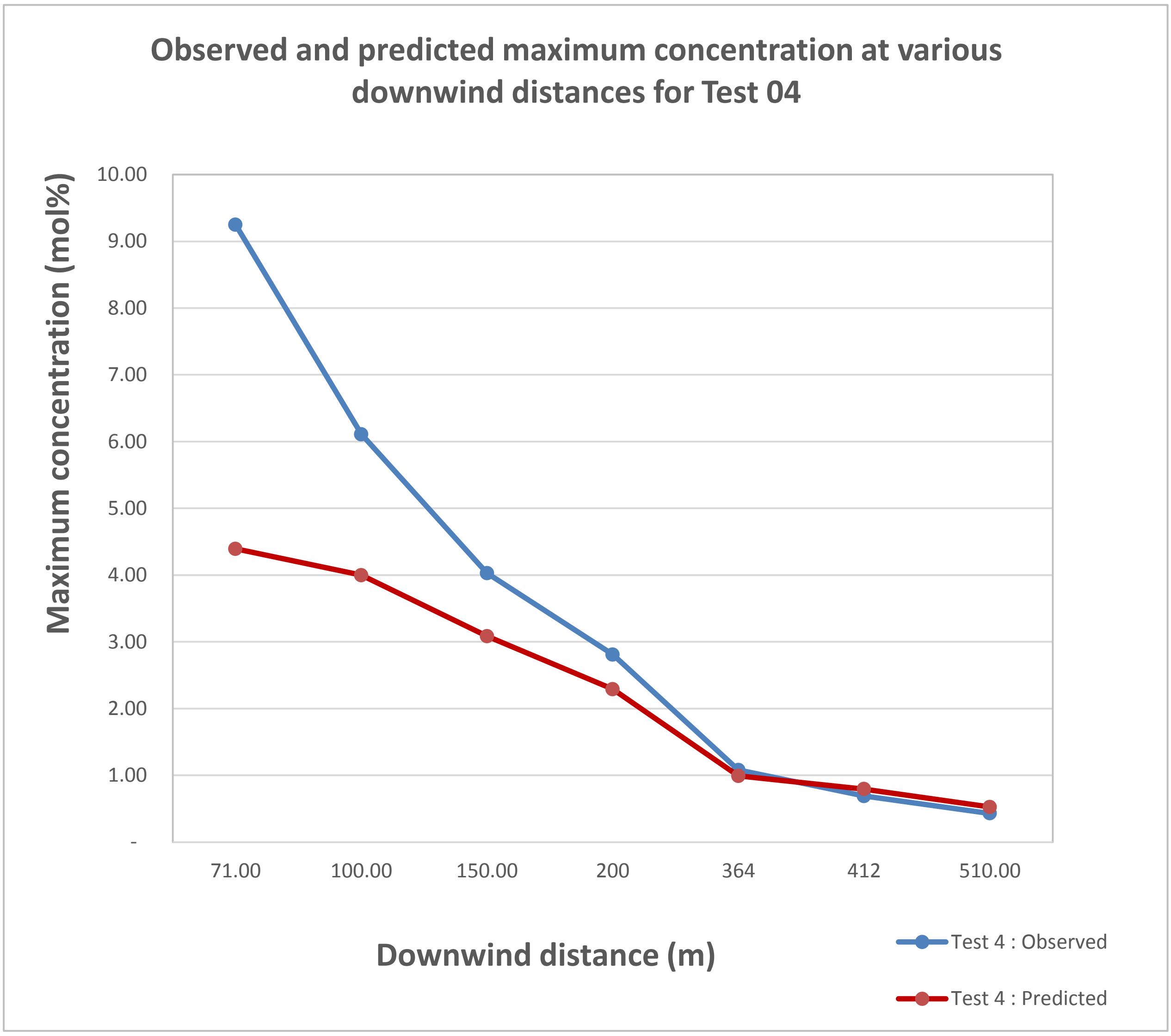
C = 1.00

α* = 0.50

α = 0.60

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol%	error %
71	29.9	300	0.22060	120	0.001838	95.43	1.31800	43,750	37,708.14	1.16	29	0.04001	4.39	9.25	(110.56)
100	41.7	418	0.20290	120	0.001691	120.80	1.13400	61,210	51,987.24	1.18	29	0.04060	4.00	6.11	(52.82)
150	61.9	620	0.15720	120	0.001310	161.00	0.97770	95,050	79,617.26	1.19	29	0.04117	3.08	4.03	(30.67)
200	83.9	840	0.11680	120	0.000973	202.40	0.90340	140,000	116,265.53	1.20	29	0.04152	2.29	2.81	(22.68)
364	151.9	1,520	0.05032	120	0.000419	326.40	0.87870	357,700	294,097.14	1.22	29	0.04194	0.99	1.08	(9.10)
412	171.9	1,720	0.04031	120	0.000336	363.00	0.89410	451,000	370,125.68	1.22	29	0.04202	0.79	0.69	13.00
510	212.9	2,130	0.02665	120	0.000222	439.40	0.94	694,300	568,766.35	1.22	29	0.04209	0.52	0.43	18.07


Observed and predicted maximum concentration at various downwind distances for Test 04
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 4 : Observed
Test 4 : Predicted

Test 5:

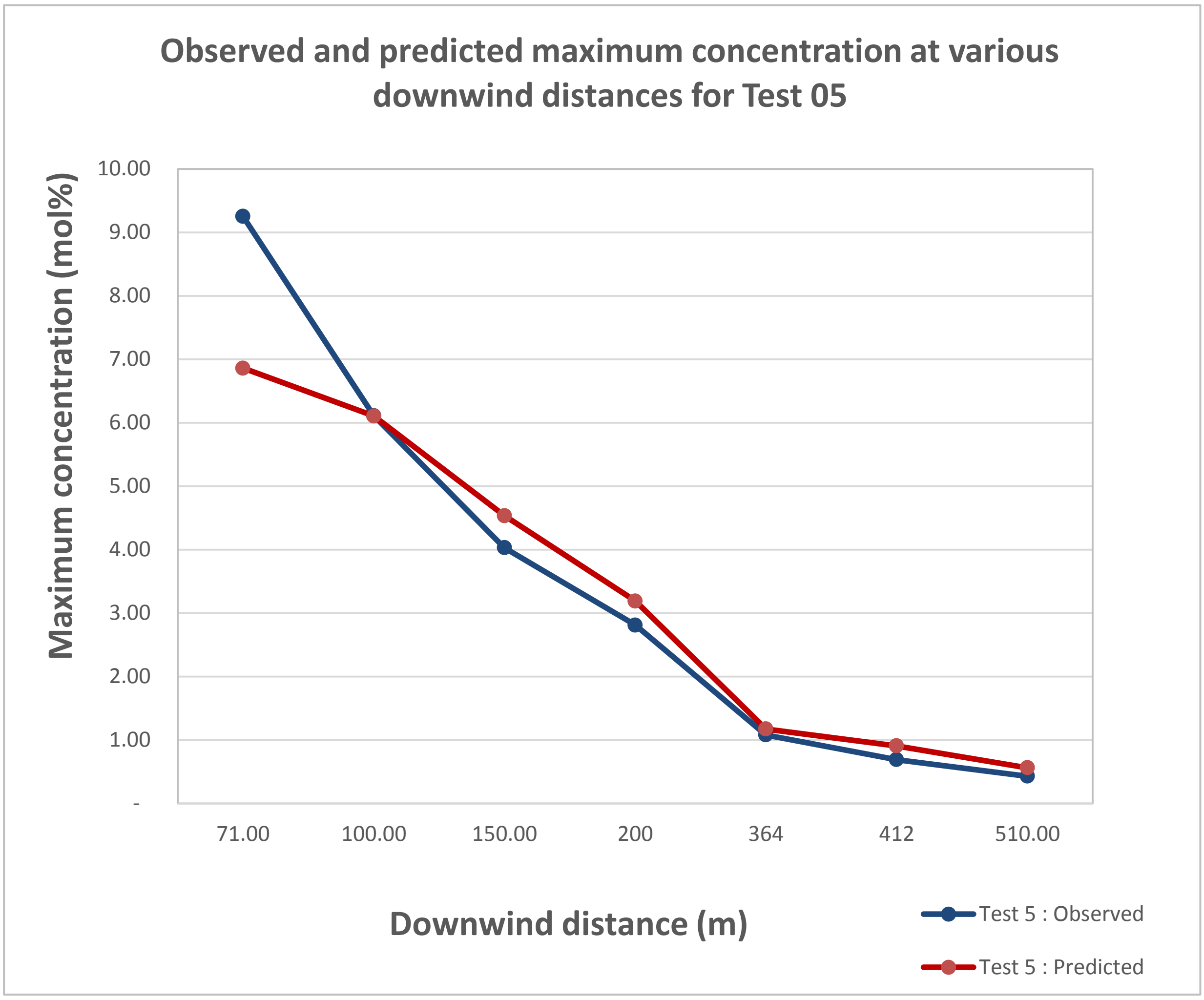
C = 1.30

α* = 0.50

α = 0.50

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol%	observed mol%	error %
71	29.9	300	0.34420	120	0.002868	101.30	0.80560	29,330	25,970.97	1.13	29	0.03894	6.86	9.25	(34.84)
100	41.7	418	0.31090	120	0.002591	127.00	0.69480	40,680	35,206.04	1.16	29	0.03984	6.11	6.11	(0.08)
150	61.9	620	0.23200	120	0.001933	168.20	0.61840	64,880	54,963.11	1.18	29	0.04070	4.53	4.03	11.12
200	83.9	840	0.16300	120	0.001358	211.60	0.59950	100,800	84,327.73	1.20	29	0.04122	3.19	2.81	11.92
364	151.9	1,520	0.05966	120	0.000497	347.30	0.65870	303,200	249,601.45	1.21	29	0.04189	1.17	1.08	7.93
412	171.9	1,720	0.04611	120	0.000384	388.80	0.68650	396,800	326,019.01	1.22	29	0.04197	0.91	0.69	23.95
510	212.9	2,130	0.02856	120	0.000238	476.60	0.74700	650,500	533,063.01	1.22	29	0.04208	0.56	0.43	23.54


Observed and predicted maximum concentration at various downwind distances for Test 05
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 5 : Observed
Test 5 : Predicted

Test 6:

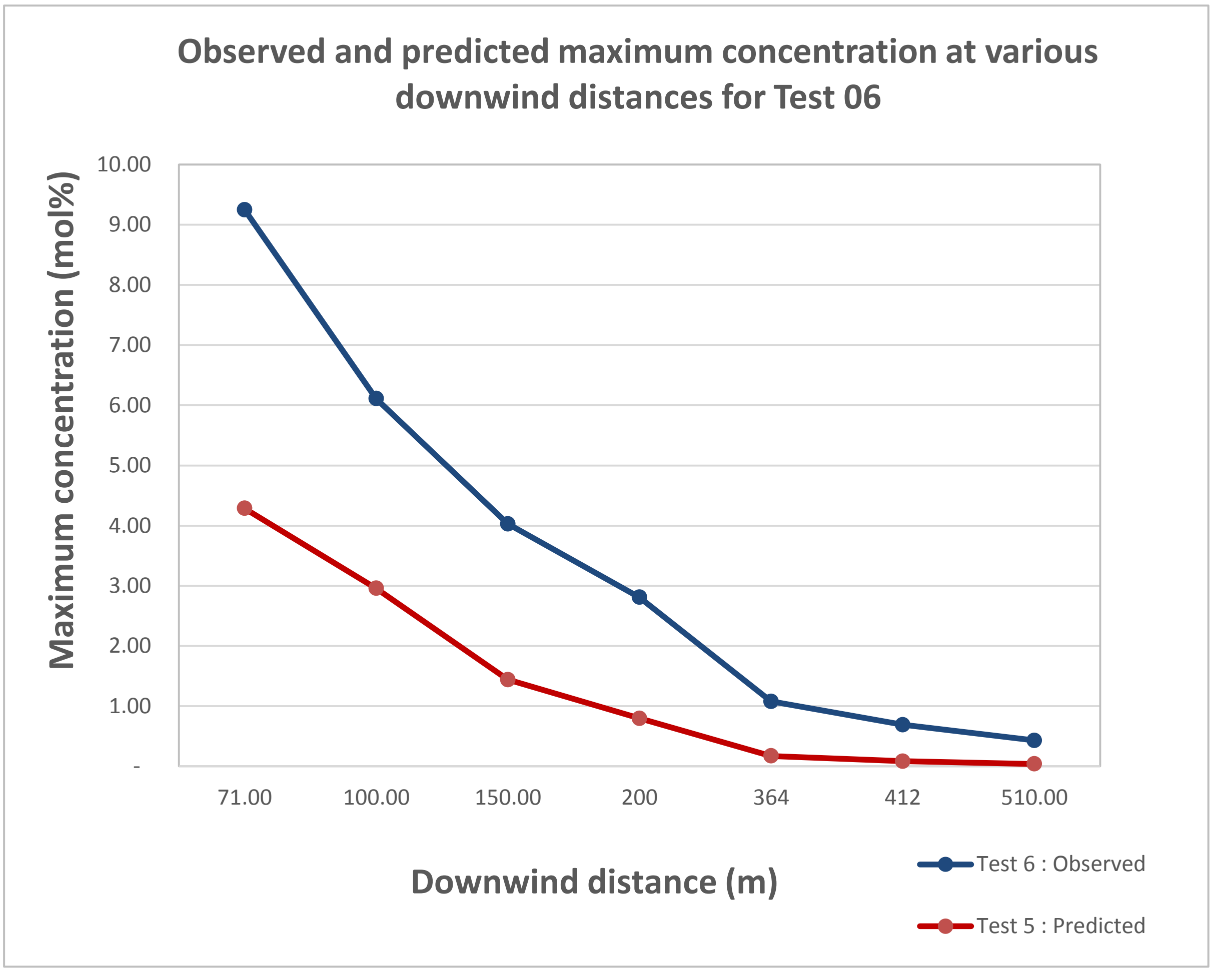
C = 1.30

α* = 0.50

α = 0.50

U*/U = 0.20

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol%	error %
71	29.9	300	0.21670	120	0.001806	107.90	1.20400	51,480	44,037.15	1.169013	29	0.04031	4.29	9.25	(115.73)
100	41.7	418	0.15050	120	0.001254	140.90	1.24700	92,760	77,774.69	1.192676	29	0.04113	2.96	6.11	(106.47)
150	61.9	620	0.07440	120	0.000620	199.60	1.39600	215,000	174,725.53	1.230501	29	0.04243	1.44	4.03	(179.83)
200	83.9	840	0.04047	120	0.000337	267.50	1.58400	433,800	356,084.13	1.218251	29	0.04201	0.80	2.81	(252.83)
364	151.9	1,520	0.00883	120	0.000074	502.70	2.14900	2,088,000	1,706,098.33	1.223845	29	0.04220	0.17	1.08	(520.62)
412	171.9	1,720	0.00428	120	0.000036	578.30	2.30500	2,963,000	2,421,738.17	1.223501	29	0.04219	0.08	0.69	(716.12)
510	212.9	2,130	0.00205	120	0.000017	741.00	2.60900	5,510,000	4,500,495.87	1.224310	29	0.04222	0.04	0.43	(963.60)



Observed and predicted maximum concentration at various downwind distances for Test 06
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 6 : Observed
Test 5 : Predicted

Test 7:

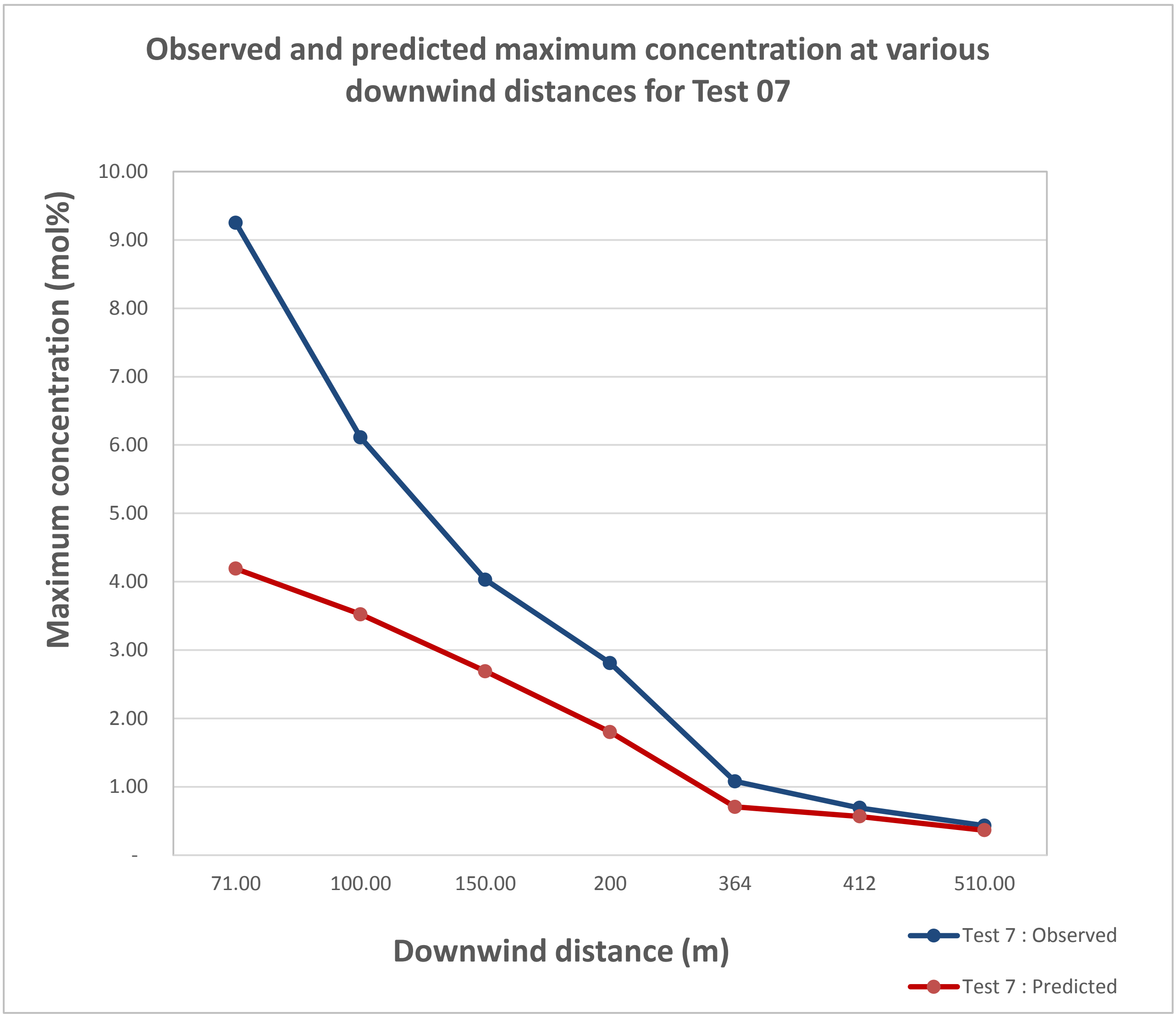
C = 1.30

α* = 0.50

α = 0.60

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol%	error %
71	29.9	300	0.21240	120	0.001770	114.60	1.15100	55,740	47,489.15	1.173742	29	0.04047	4.19	9.25	(120.77)
100	41.7	418	0.17990	120	0.001499	145.40	0.99460	78,660	66,058.26	1.190767	29	0.04106	3.52	6.11	(73.46)
150	61.9	620	0.13740	120	0.001145	194.60	0.87040	124,400	103,551.03	1.201340	29	0.04143	2.69	4.03	(49.83)
200	83.9	840	0.09177	120	0.000765	245.60	0.81660	187,100	154,744.77	1.209088	29	0.04169	1.80	2.81	(56.01)
364	151.9	1,520	0.03589	120	0.000299	400.30	0.82370	505,500	414,658.07	1.219077	29	0.04204	0.71	1.08	(52.88)
412	171.9	1,720	0.02868	120	0.000239	446.60	0.84440	645,500	529,097.29	1.220002	29	0.04207	0.56	0.69	(22.14)
510	213.9	2,130	0.01843	120	0.000154	543.30	0.89600	1,015,000	830,878.06	1.221599	29	0.04212	0.36	0.43	(18.37)



Observed and predicted maximum concentration at various downwind distances for Test 07
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 7 : Observed
Test 7 : Predicted

Test 8:

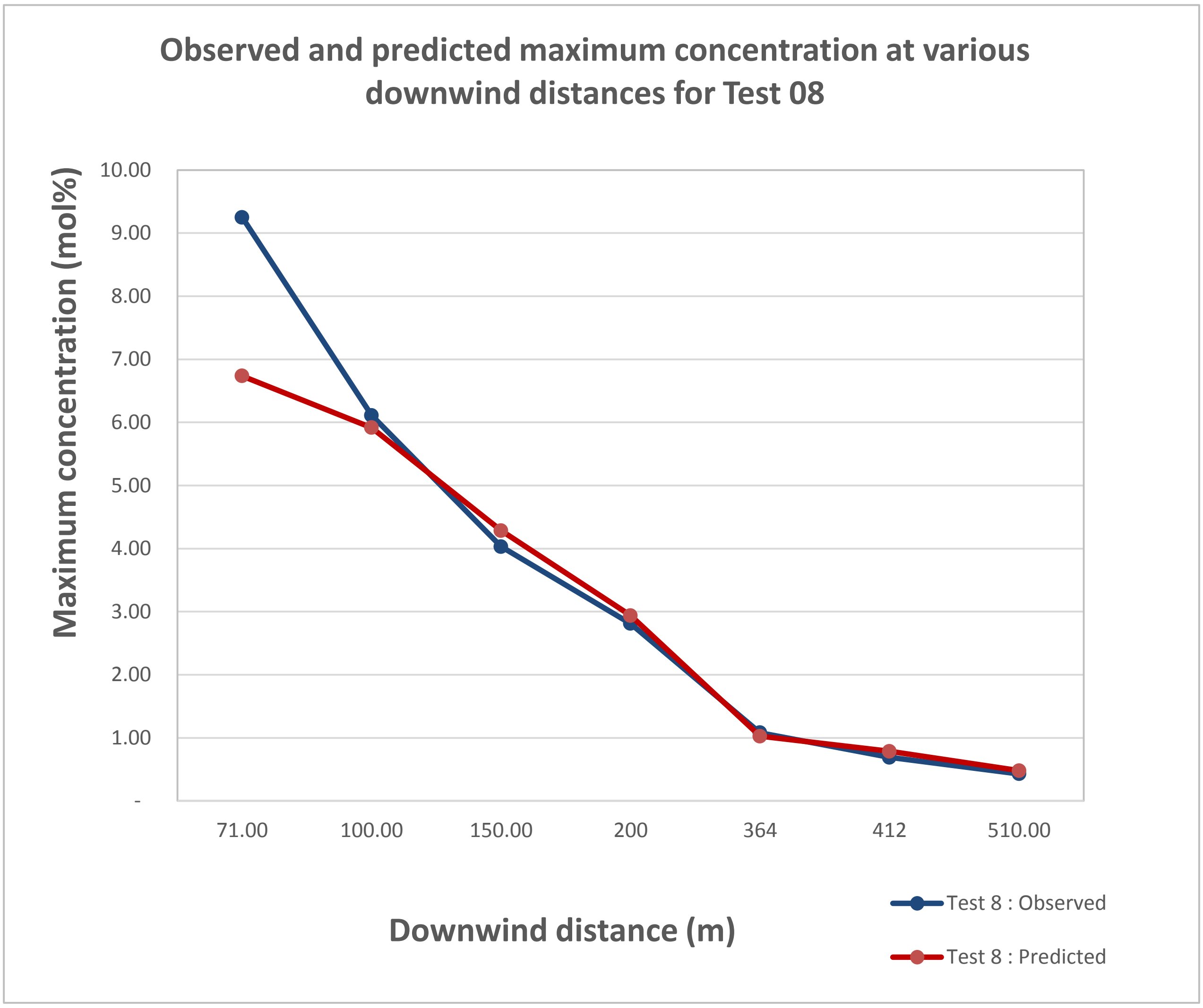
C = 1.00

α* = 0.60

α = 0.50

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol %	observed mol %	error %
71	29.9	300	0.33820	120	0.002818	101.50	0.81850	29,980	26,491.14	1.131699	29	0.03902	6.74	9.25	(37.33)
100	41.7	418	0.30120	120	0.002510	127.50	0.71380	42,200	36,454.13	1.157619	29	0.03992	5.92	6.11	(3.28)
150	61.9	620	0.21900	120	0.001825	169.50	0.64740	69,080	58,433.51	1.182198	29	0.04077	4.28	4.03	5.95
200	83.9	840	0.15000	120	0.001250	214.00	0.63840	110,000	91,848.13	1.197629	29	0.04130	2.94	2.81	4.35
364	151.9	1,520	0.05215	120	0.000435	355.20	0.72180	348,000	286,096.58	1.216372	29	0.04194	1.03	1.08	(5.32)
412	171.9	1,720	0.03992	120	0.000333	398.70	0.75550	459,700	377,291.32	1.218422	29	0.04201	0.79	0.69	12.17
510	212.9	2,130	0.02434	120	0.000203	491.00	0.83	764,900	626,351.85	1.22	29	0.04211	0.48	0.43	10.30


Observed and predicted maximum concentration at various downwind distances for Test 08
Maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71.00
100.00
150.00
200
364
412
510.00
Downwind distance (m)
Test 8 : Observed
Test 8 : Predicted

Test 9:

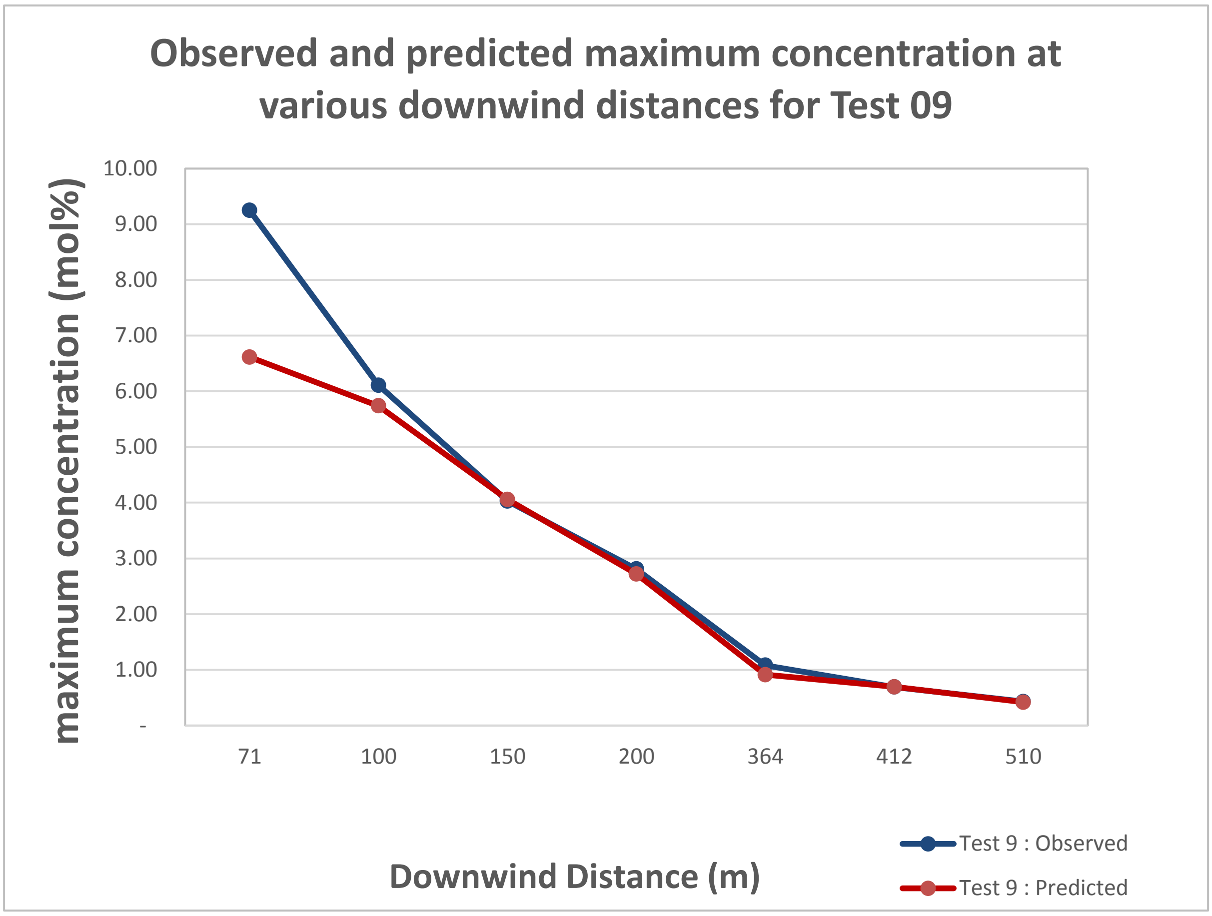
C = 1.3

α* = 0.70

α = 0.50

U*/U = 0.10

X(m)	T(s)	t_index	gas conc.	gas M (kg/mol)	gas conc mol	r	h	ma	v	rho air	air M (kg/mol)	air conc.	mol%	observed mol%	error %
71	29.9	300	0.3323	120	0.002769	101.70	0.83120	30,620	27,008.30	1.133725	29	0.03909	6.61	9.25	(39.84)
100	41.7	418	0.2921	120	0.002434	128.00	0.73240	43,710	37,697.99	1.159478	29	0.03998	5.74	6.11	(6.47)
150	61.9	620	0.2074	120	0.001728	170.70	0.67570	73,280	61,854.43	1.184717	29	0.04085	4.06	4.03	0.71
200	83.9	840	0.1390	120	0.001158	216.30	0.67590	119,300	99,344.85	1.200867	29	0.04141	2.72	2.81	(3.26)
364	151.9	1,520	0.0463	120	0.000386	362.60	0.78180	393,200	322,924.61	1.217622	29	0.04199	0.91	1.08	(18.66)
412	171.9	1,720	0.0351	120	0.000293	408.00	0.82100	523,300	429,351.87	1.218814	29	0.04203	0.69	0.69	0.28
510	212.9	2,130	0.0212	120	0.000176	504.30	0.90280	881,100	721,305.69	1.221535	29	0.04212	0.42	0.43	(3.15)



Observed and predicted maximum concentration at various downwind distances for Test 09
maximum concentration (mol%)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
71
100
150
200
364
412
510
Downwind Distance (m)
Test 9 : Observed
Test 9 : Predicted