Appendix C

Cooling Water Discharge Assessment

EAST RAIL EIA

Impact Assessment of Cooling Water Discharge from the Proposed East Tsim Sha Shui Station

Introduction

KCRC has expressed its preference of using water cooling for the proposed Tsim Sha Shui Interchange Station, part of the East Rail extension scheme. The proposed discharge location for the cooling water effluent is shown in Figure 1. The cooling water effluent will have a higher temperature than the receiving water. As a result, the temperature in the receiving water in the vicinity of the discharge location will rise. The temperature rise needs to be quantified according to the EIA Technical Memorandum of EPD since the cooling water discharge will exceed 6000 m^3/day.

This document describes the details of the proposed cooling water discharge, the methodology of assessing the impact of the cooling water discharge on the receiving water quality and the conclusions of the assessment.

Methodology of the Assessment

Cooling water is normally discharged into the receiving water via a outfall and diffuser structure. The impact of the cooling water discharge on the temperature of the receiving water depends on the following factors:

- discharge quantity and effluent temperature,
- background temperature in the receiving water,
- density and salinity of the receiving water,
- tidal currents and water depths, and
- diffuser structure

On discharge into the receiving water, the effluent mixes with the ambient water mainly via turbulence, buoyancy, entrainment and re-entrainment in the initial dilution stage, and then by advection and diffusion in the far-field process. PLUMES, a model developed by US EPA and widely used in the world for this type of study, has been used for the assessment. The model is capable of simulating both the sub-grid initial dilution process and the advection and diffusion in the far field.

The impact has been assessed for both the wet and the dry seasons in order to identify the most adverse conditions.

The Cooling Water Discharge

There is no design details available yet with regard to the temperature and quantity of the effluent from the proposed water cooling system. For the purpose of this impact assessment, Hyder's past experience in designing the Mei Foo Interchange of West Rail, which has a similar passenger capacity to the Tsim Sha Shui Station, was quoted. The normal range of the temperature difference between the incoming cooling water and the outgoing cooling water (i.e. the effluent) is 5 to 10^0C. A medium value of 7^0C was adopted. That is, the temperature in the effluent was assumed to be 7^0C higher than that in the incoming cooling water. A conservative estimate of the required cooling water volume under the summer peak load is about 240 l/s for a station of this scale.

The Receiving Water Conditions

Mixing takes place in Victoria Harbour between the fresh water from the Pearl River and the saline ocean water. In the summer wet season, the considerable amount of the fresh water leads to the stratification in Victoria Harbour as can be seen from the salinity measurement and prediction for the year 1997 (Figure 2). The salinity in the surface and bottom layer is typically 25 ppt and 30 ppt respectively in the wet season. However, there is no such stratification in the winter dry season due to the relative small input of the fresh water from the Pearl River, with a typical salinity of 34 ppt throughout the water column.

There is also a pronounced difference in temperature between the surface and the bottom layer during the wet season, as shown in Figure 3. The typical surface layer temperature is 27^0C whilst the temperature in the bottom layer is about 25^0C. For some unknown reasons, the highest surface temperature in the year 1997, at about 28^0C, was recorded in September.

In Figures 2 and 3, both modelled and field measured data quoted from a Hyder-CES joint study for EPD [1], are shown. The agreement between the two sets of data is considered to be reasonably good. As the field data is relatively sparse and demonstrates a scattered range, the modelled data has been adopted for the plume modelling study.

As mentioned in the above, tidal currents also influence the extent of the temperature rise in the receiving water resulting from the cooling water discharge. However, the speeds and direction of tidal currents change all the time. According to field measurements, the tidal current speeds in the area range from 0 to 0.5 m/s depending on the tidal states. The latest navigation chart (HK0802) indicates a water depth of about 10m CD at the discharge position, and the MLLW (mean lower low water) of 0.6m CD at Quarry Bay, some 3.5km southeast of the discharge position.

The Diffuser Structure

Two different diffuser structures have been tested:- one diffuser port with a diffuser diameter of 1.0m, and two diffuser ports, each with a diameter of 0.7m. In both cases, the alignment of the diffuser pipe was assumed to be perpendicular to the main stream tidal currents in the area, following the common design practice. The mid level of the diffuser port was assumed to be typically 1.0m above the sea bed.

Plume Modelling

In order to assess the impact under the most adverse conditions, zero speed was first tested, which should produce the minimum dilution achieved. The temperature rise under an ambient current speed of 0.1 m/s has also been evaluated to investigate the sensitivity of the impact to the ambient tidal currents. The scenarios tested are summarised in Table 1, and the plume model outputs are shown in Figures 4 to 9. The temperature in the receiving water was modelled and expressed as a "concentration". The model results are discussed in the following.

Case 1 - Wet Season, 0 Ambient Velocity, 1 Diffuser Port, Figure 4

As there is only one port, the UM module of the PLUMES was used. Initial dilution was calculated. The model cannot perform the calculation of far-field dilution if the ambient tidal current velocity is zero. According to the modelling, the thermal plume will be trapped at about 4.7m below the water surface due to the density stratification. At this point, the dilution at the centre of the plume is about 4.6 with a temperature of 27.12^{0}C (dilution and temperature presented in this document always refer to the centre of the plume where dilution is smallest and the temperature is highest, giving the most conservative estimate). The background temperature is 27^{0}C and 25^{0}C in the surface and bottom layer respectively. Assuming a linear temperature profile, the background temperature at the trapping level should be 26.01^{0}C. As such, the temperature rise resulting from the cooling water effluent discharge is 27.12-26.01=1.11^{0}C at about 3m from the discharge point.

Case 2 - Dry Season, 0 Ambient Velocity, 1 Diffuser Port, Figure 5

Both the temperature and salinity are uniform throughout the water column, there is no stratification and the thermal plume can reach the water surface. The initial dilution is predicted to be about 8 at 6.5m from the discharge point, and the temperature in the receiving water at this position is predicted to be 20.86^{0}C, a 0.86^{0}C rise compared to the background temperature.

It should be noted that the cooling water intake was assumed to be placed in the bottom layer. The temperature rise in Case 2 is smaller than in Case 1. This is because there is more water available for mixing with the discharged effluent (thus larger initial dilution) in Case 2 than in Case 1.

Cases 1 and 2 represent the worst-case scenarios in terms of the dilution condition.

Case 3 - Wet Season, 0.1m/s Ambient Velocity, 1 Diffuser Port, Figure 6

By imposing a conservative ambient current velocity of 0.1m/s, the improvement in dilution achieved can be easily seen. At the trap level, a dilution of 6.9 is predicted with the corresponding temperature in the receiving water to be 26.58^{0}C, 0.74^{0}C higher than the background temperature.

The introduction of an ambient current velocity enables the calculation of the far-field temperature and dilution. The plume width is estimated to be 6.305m only. At 100m from the discharge point, the temperature in the receiving water is predicted to be 26.22^{0}C based on the 4/3 Power Law, a 0.38^{0}C rise as compared to the background temperature.

Case 4 - Dry Season, 0.1m/s Ambient Velocity, 1 Diffuser Port, Figure 7

The initial dilution is increased to 20.64 on reaching the surface. The temperature rise is predicted to be 0.34^0C. At 100m from the discharge point, the dilution and temperature rise are estimated to be 30.1 and 0.23^0C respectively. The plume width in the far field is just under 7m.

Case 5 - Wet Season, 0 Ambient Velocity, 2 Diffuser Ports, Figure 8

Cases 5 and 6 are designed to test the sensitivity of the plume dispersion to the number of diffuser ports.

At the trap level, the dilution has been marginally increased from 4.576 to 5.44, and the predicted temperature rise at the trap level is 0.93^0C as compared to 1.11^0C in Case 1.

Case 6 - Dry Season, 0 Ambient Velocity, 2 Diffuser Ports, Figure 9

On reaching the surface, the dilution and temperature rise at the centre of the plume are predicted to be 11.45 and 0.61^0C respectively, as compared to 8.097 and 0.86^0C in Case 2.

An overview of the plume modelling results is given in Table 2.

Table 1 East Rail Tsim Sha Tsui Station Cooling Water Discharge - Thermal Plume Modelling Scenarios

Case	Flowrate (m/s)	No of Ports	Port Dia (m)	Effl Temp (^{0}C)	Effl Sal (ppt)	A Temp Surf (^{0}C)	A Temp Bot (^{0}C)	A Sal Surf (ppt)	A Sal Bot (ppt)	Amb Vel (m/s)	Port Depth (m)	Seabed Level (m CD)	Tidal Level (m CD)	General Description
1	0.24	1	1.0	33	25	27	25	25	30	0	9.6	10	0.6	Wet season, 0 velocity, 1 port
2	0.24	1	1.0	27	34	20	20	34	34	0	9.6	10	0.6	Dry season, 0 velocity, 1 port
3	0.24	1	1.0	33	25	27	25	25	30	0.1	9.6	10	0.6	Wet season, 0.1m/s velocity, 1 port
4	0.24	1	1.0	27	34	20	20	34	34	0.1	9.6	10	0.6	Dry season, 0.1m/s velocity, 1 port
5	0.24	2	1.0	33	25	27	25	25	30	0	9.6	10	0.6	Wet season, 0 velocity, 2 ports
6	0.24	2	1.0	27	34	20	20	34	34	0	9.6	10	0.6	Dry season, 0 velocity, 2 ports

Table 2 East Rail Tsim Sha Tsui Station Cooling Water Discharge - Overview of Thermal Plume Modelling Results

Case	Dilution at Trap Level or on Reaching the Surface	Temperature Rise at Trap Level or on Reaching the Surface (^{0}C)	Dilution at 100m from the Discharge Point (4/3 Power Law)	Temperature Rise at 100m from the Discharge Point (^{0}C, 4/3 Power Law)
1	4.58	1.11	N/A	N/A
2	8.10	0.86	N/A	N/A
3	6.89	0.74	23.30	0.38
4	11.50	0.34	30.10	0.23
5	5.44	0.93	N/A	N/A
6	11.45	0.61	N/A	N/A

Conclusions

Dilution and temperature rise resulting from the cooling water effluent discharge have been assessed. Under the worst-case scenarios (0 current velocity), the temperature rise at the centre of the plume some 6m from the discharge point is 1.11^{0}C or 4.3%, occurring in the wet season.

The introduction of a modest ambient tidal current velocity of 0.1m/s is still regarded as being very conservative for the proposed discharge area. Under the ambient tidal current condition, the temperature rise in the near field during the wet season is 0.74^{0}C, or 2.9%. This is reduced to 0.34^{0}C, or 1.3% at 100m and 0.26^{0}C or 1% at 500m from the discharge point. The maximum plume width out of all the scenarios tested is just under 7m, occurring in the dry season with the ambient tidal current velocity of 0.1m/s.

In the wet season, the peak load duration will normally be no greater than 3 hours per day, and the tidal currents will generally be greater than 0.1m/s. Consequently, the temperature rise in the real life operation will be less than the predicted ones most of time. As the cooling demand (thus the discharge flow rate of the cooling effluent) in the dry season will be much smaller than the summer peak load, therefore in reality, the temperature rise in the dry season resulting from the cooling effluent discharge will also be much smaller than that predicted in this study.

Although the discharge location is within the Victoria Water Control Zone, the effluent plume is remote from any other environmentally sensitive areas. The temperature rise in the receiving water, therefore the environmental impact resulting from the cooling water effluent discharge, is negligible.

Sensitivity analysis shows that increasing the number of diffuser ports can increase the dilution. However, this is not regarded as necessary because of the negligible environmental impact under one diffuser port. By adopting the minimum number of diffuser ports, the impact of the outfall structure on marine traffic can be minimised.

References

1. Hyder-Maunsell Joint Venture, Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool, Calibration and Verification of the Water Quality Model, Draft Report, August 1999

LIST OF FIGURES

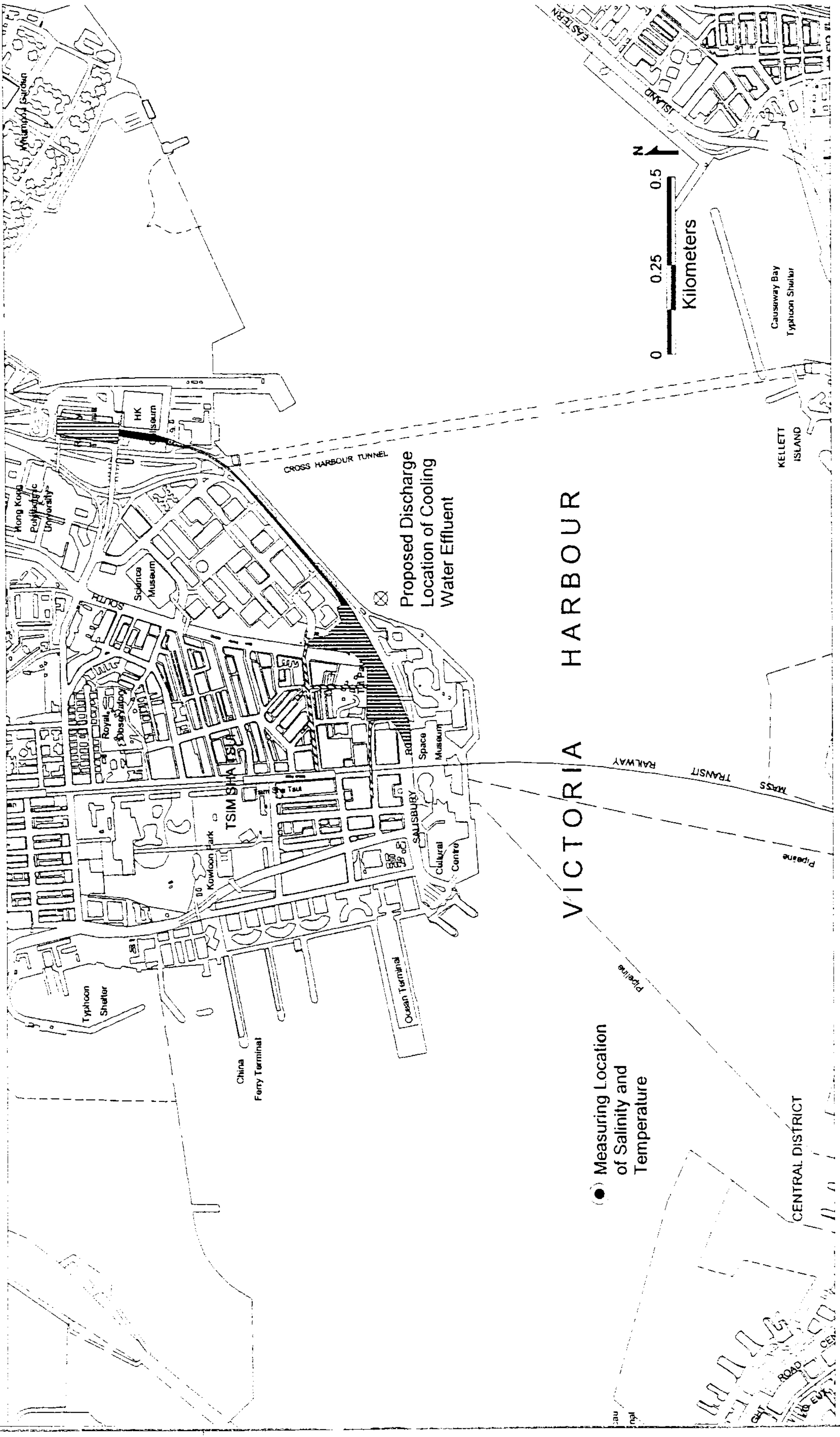

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Figure 1 **Locations of Proposed Cooling Water Discharge and Salinity and Temperature Measurement in 1997**

Job No. EA00561

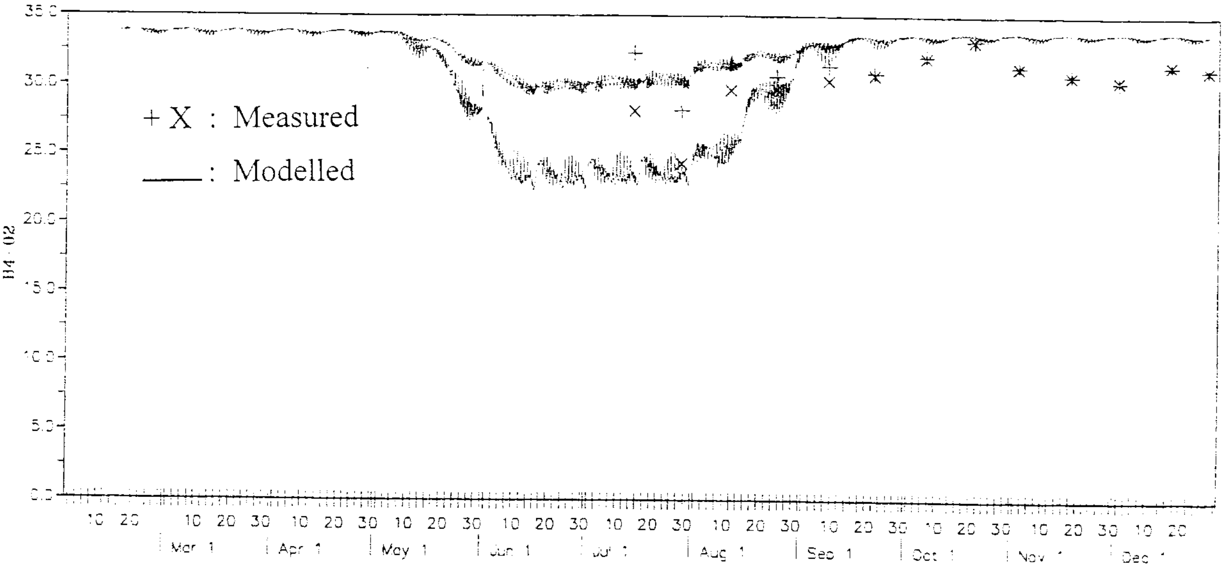

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Figure 2 **Salinity (ppt) in Victoria Harbour, 1997 (Black: Surface Layer, Red: Bottom Layer)**

Job No. EA00561

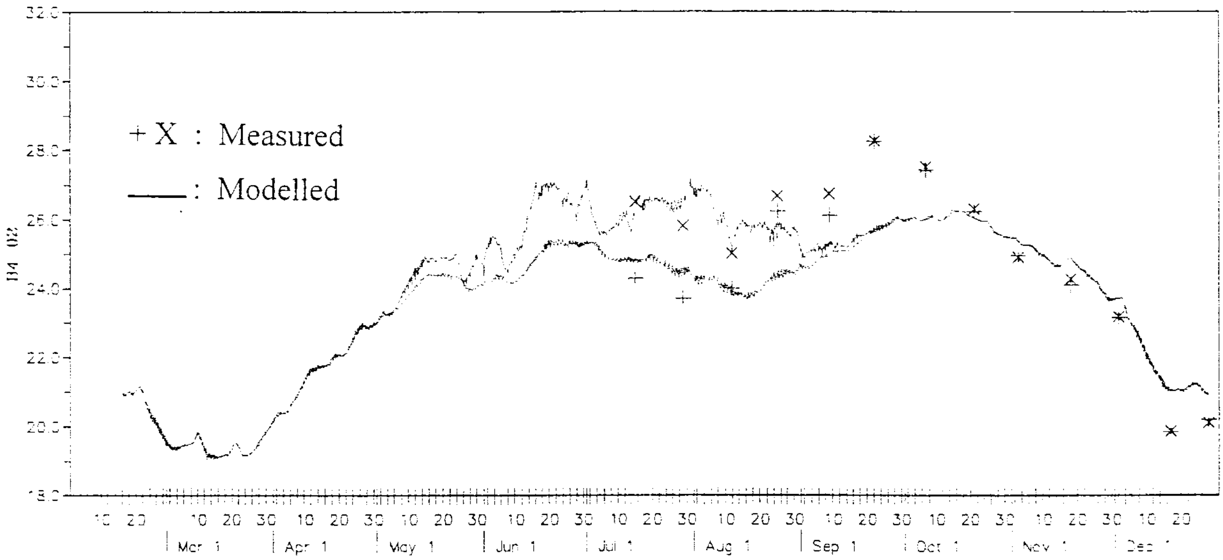

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Figure 3 **Temperature (^{0}C) in Victoria Harbour, 1997 (Black: Surface Layer, Red: Bottom Layer)**

Job No. EA00561

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Oct 21, 1999,  15:49:29  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   1 of   6
Title   Wet Season, 0 Velocity, 1 Port                                nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
     0.24         1    0.2400        10        25        33       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6         1     1.000    0.3056    0.3056     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay   Froude # Roberts F
        1       0.0       1.0   13.2492        33         0     3.059 4.176E-12
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
       90    10.000     14.28      1e-5    0.0003         0     30560  -0.09775
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0      1e-5   15.2473        25        27        27  -0.03121  0.009977
      9.6      1e-5   19.6001        30        25        25 buoy flux puff-ther
                                                            0.0002394     60.79
                                                            jet-plume jet-cross
                                                                2.880     27080
                                                            plu-cross jet-strat
                                                            2.394E+12     2.946
                                                            plu-strat
                                                                2.979
                                                              hor dis>=

CORMIX1 flow category algorithm is turned off.
 27                                                           0.0 to any  range
Help: F1.  Quit: <esc>.  Configuration:ATNO0.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     9.600     1.000     33.00     1.000     0.000

     9.280     1.274     30.66     1.412    0.9213
     8.402     1.483     29.05     1.994     1.714
     7.158     1.788     27.97     2.818     2.368
     5.530     2.278     27.30     3.984     2.989
     4.736     2.580     27.12     4.576     3.259 -> trap level
     3.304     3.410     26.94     5.634     3.769
     2.543     4.527     26.89     6.166     4.160 -> begin overlap
```


Figure 4 Plume Model Output, Case 1 - Wet Season, 0 Velocity, 1 Port

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Oct 21, 1999,  16:10:24  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   2 of   6
Title   Dry Season, 0 Velocity, 1 Port                                 nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
     0.24         1    0.2400        10        34        27       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6         1     1.000    0.3056    0.3056     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
        1       0.0       1.0   21.9900        27         0    -1.123-5.632E-13
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
       90    10.000     14.28      1e-5    0.0003         0     30560    0.1316
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0      1e-5   24.0230        34        20        20  -0.09906  -0.07399
      9.6      1e-5   24.0230        34        20        20 buoy flux puff-ther
                                                            -0.001776     31.17
                                                            jet-plume jet-cross
                                                                1.058     27080
                                                            plu-cross jet-strat
                                                            1.776E+13     1.653
                                                            plu-strat
                                                                2.067
                                                              hor dis>=

CORMIX1 flow category algorithm is turned off.
 0.0003 m2/3/s                              0.0001 to 0.0005 m2/3/s range
Help: F1.  Quit: <esc>.  Configuration:ATNO0.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     9.600     1.000     27.00     1.000     0.000

     9.476     1.388     24.95     1.413     1.015
     8.900     1.816     23.50     1.998     2.271
     7.669     2.222     22.47     2.825     3.526
     5.890     2.673     21.75     3.994     4.635
     3.533     3.230     21.24     5.647     5.605
    0.5632     3.929     20.88     7.986     6.471
    0.4303     3.961     20.86     8.097     6.504 -> surface hit
```


Figure 5 Plume Model Output, Case 2 - Dry Season. 0 Velocity, 1 Port

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Oct 21, 1999,  15:49:43  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   3 of   6
Title   Wet Season, 0.1m/s Velocity, 1 Port                         nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
     0.24         1    0.2400        10        25        33       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6         1     1.000    0.3056    0.3056     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
        1       0.0       1.0   13.2492        33         0     3.059 4.176E-12
hor angle red space p amb den p current   far dif  far vel K:vel/cur Stratif #
       90    10.000     14.28      1e-5    0.0003       0.1     30560  -0.09775
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0       0.1   15.2473        25        27        27  -0.03121  0.009977
      9.6       0.1   19.6001        30        25        25 buoy flux puff-ther
                                                             0.0002394     60.79
                                                             jet-plume jet-cross
                                                                 2.880     27080
                                                             plu-cross jet-strat
                                                             2.394E-12     2.946
                                                             plu-strat
                                                                 2.979
                                                              hor dis>=

CORMIX1 flow category algorithm is turned off.
 27                                                            0.0 to any  range
Help: F1.  Quit: <esc>.  Configuration:ATN00.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     9.600     1.000     33.00     1.000     0.000

     9.238     1.210     30.67     1.412     1.045
     8.597     1.445     29.05     1.994     1.786
     7.843     1.777     27.95     2.818     2.447
     6.991     2.234     27.22     3.983     3.129
     6.080     2.876     26.76     5.632     3.880
     5.567     3.371     26.58     6.885     4.356 -> trap level
     5.227     3.800     26.48     7.964     4.716
     4.594     5.070     26.34     11.26     5.619
     4.250     6.305     26.27     14.97     6.703 -> begin overlap
FARFIELD CALCULATION (based on Brooks, 1960, see guide)
Farfield dispersion based on wastefield width of      6.305m
   --4/3 Power Law--   -Const Eddy Diff-
     conc  dilution       conc  dilution  distance         Time
                                                 m       sec   hrs
    26.22      23.3      26.24      19.1     100.0     933.0   0.3
    26.17      39.3      26.21      24.6     200.0      1933   0.5
    26.15      58.1      26.20      29.1     300.0      2933   0.8
    26.14      79.2      26.19      33.1     400.0      3933   1.1
    26.14     102.3      26.18      36.6     500.0      4933   1.4
    26.13     127.4      26.17      39.9     600.0      5933   1.6
    26.13     154.2      26.17      42.8     700.0      6933   1.9
    26.13     182.7      26.17      45.6     800.0      7933   2.2
    26.12     212.7      26.16      48.3     900.0      8933   2.5
    26.12     244.3      26.16      50.8      1000      9933   2.8
    26.12     277.4      26.16      53.2      1100     10930   3.0
    26.12     311.8      26.16      55.4      1200     11930   3.3
    26.12     347.4      26.16      57.6      1300     12930   3.6
    26.12     384.3      26.15      59.7      1400     13930   3.9
    26.12     422.5      26.15      61.8      1500     14930   4.1
    26.12     461.8      26.15      63.7      1600     15930   4.4
    26.12     502.3      26.15      65.6      1700     16930   4.7
    26.12     543.9      26.15      67.5      1800     17930   5.0
    26.12     586.6      26.15      69.3      1900     18930   5.3
    26.12     630.4      26.15      71.1      2000     19930   5.5
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Figure 6 Plume Model Output, Case 3 - Wet Season, 0.1m/s Velocity, 1 Port

Job No. EA00561

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Oct 21, 1999,  16:10:32  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   4 of   6
Title    Dry Season, 0.1m/s Velocity, 1 Port                          nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
     0.24         1    0.2400        10        34        27       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6         1     1.000    0.3056    0.3056     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
        1       0.0       1.0   21.9900        27         0   -1.123-5.632E-13
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
       90    10.000     14.28      1e-5    0.0003       0.1     30560    0.1316
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0       0.1   24.0230        34        20        20  -0.09906  -0.07399
      9.6       0.1   24.0230        34        20        20 buoy flux puff-ther
                                                            -0.001776     31.17
                                                            jet-plume jet-cross
                                                                1.058     27080
                                                            plu-cross jet-strat
                                                            1.776E+13     1.653
                                                            plu-strat
                                                                2.067
                                                              hor dis>=

CORMIX1 flow category algorithm is turned off.
 0.0003 m2/3/s                                   0.0001 to 0.0005 m2/3/s range
Help: F1.  Quit: <esc>.  Configuration:ATN00.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     9.600     1.000     27.00     1.000     0.000

     9.465     1.307     24.95     1.413     1.134
     9.048     1.656     23.50     1.998     2.338
     8.469     2.071     22.47     2.825     3.437
     7.772     2.579     21.75     3.994     4.520
     6.969     3.202     21.24     5.647     5.659
     6.060     3.963     20.88     7.986     6.914
     5.038     4.887     20.62     11.29     8.348
     3.888     6.001     20.44     15.97     10.03
     2.944     6.965     20.34     20.64     11.50 -> surface hit
FARFIELD CALCULATION (based on Brooks, 1960, see guide)
Farfield dispersion based on wastefield width of      6.965m
   --4/3 Power Law--   -Const Eddy Diff-
     conc  dilution       conc  dilution  distance          Time
                                                 m        sec    hrs
     20.23      30.1     20.27      25.5     100.0      885.0    0.2
     20.14      50.1     20.21      32.7     200.0       1885    0.5
     20.09      73.7     20.18      38.8     300.0       2885    0.8
     20.07     100.2     20.16      44.1     400.0       3885    1.1
     20.05     129.2     20.14      48.8     500.0       4885    1.4
     20.04     160.6     20.13      53.1     600.0       5885    1.6
     20.04     194.2     20.12      57.1     700.0       6885    1.9
     20.03     229.8     20.12      60.8     800.0       7885    2.2
     20.03     267.4     20.11      64.3     900.0       8885    2.5
     20.02     306.9     20.10      67.7      1000       9885    2.7
     20.02     348.1     20.10      70.9      1100      10890    3.0
     20.02     391.2     20.09      73.9      1200      11890    3.3
     20.02     435.8     20.09      76.8      1300      12890    3.6
     20.01     482.0     20.09      79.6      1400      13890    3.9
     20.01     529.7     20.08      82.3      1500      14890    4.1
     20.01     578.8     20.08      85.0      1600      15890    4.4
     20.01     629.4     20.08      87.5      1700      16890    4.7
     20.01     681.4     20.08      90.0      1800      17890    5.0
     20.01     734.7     20.08      92.4      1900      18890    5.2
     20.01     789.4     20.07      94.8      2000      19890    5.5
```

```
Oct 21, 1999,  15:49:56  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   5 of   6
Title   Wet Season, 0 Velocity, 2 Ports                                nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
     0.24         2    0.1200        10        25        33       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6       0.7    0.7000    0.3118    0.3118     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
        1       0.0       1.0   13.2492        33         0     3.731 8.353E-12
hor angle red space p amb den p current   far dif  far vel K:vel/cur Stratif #
       90    10.000     14.28      1e-5    0.0003         0     31180  -0.06843
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0      1e-5   15.2473        25        27        27  -0.03121  0.009977
      9.6      1e-5   19.6001        30        25        25 buoy flux puff-ther
                                                            0.0001197     48.90
                                                            jet-plume jet-cross
                                                                2.459     19340
                                                            plu-cross jet-strat
                                                            1.197E+12     2.489
                                                            plu-strat
                                                                2.505
                                                             hor dis>=

CORMIX1 flow category algorithm is turned off.
 27                                                          0.0 to any  range
Help: F1.  Quit: <esc>.  Configuration:ATNO0.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     9.600    0.7000     33.00     1.000     0.000

     9.432    0.9324     30.66     1.412    0.6785
     8.863     1.122     29.03     1.994     1.354
     7.973     1.346     27.92     2.817     1.931
     6.785     1.677     27.20     3.983     2.457
     5.391     2.169     26.81     5.440     2.955 -> trap level
     5.211     2.248     26.78     5.632     3.017
     3.553     3.833     26.61     7.330     3.733 -> begin overlap
```

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East Rail - Hung Hom to Tsim Sha Tsui Extension EIA

Figure 8 Plume Model Output, Case 5 - Wet Season, 0 Velocity, 2 Port

Job No. EA00561

```
Oct 21, 1999,  16:10:50  ERL-N PROGRAM PLUMES, Ed 3, 3/11/94  Case:   6 of   6
                                                                   nonlinear
Title    Dry Season, 0 Velocity, 2 Ports
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
    0.24          2    0.1200        10        34        27       100      2000
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
      9.6       0.7    0.7000    0.3118    0.3118     0.000      0.10        50
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
        1       0.0       1.0   21.9900        27         0     2.668 4.272E-12
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
       90    10.000   24.0230      1e-5    0.0003         0     31180 3.889E-07
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
        0      1e-5   24.0230        34        20        20 0.0001040   0.01951
      9.6      1e-5   24.0230        34        20        20 buoy flux puff-ther
                1e-5                                        0.0002341     39.11
                                                            jet-plume jet-cross
                                                                1.758     19340
                                                            plu-cross jet-strat
                                                            2.341E+12     43.13
                                                            plu-strat
                                                                213.6
                                                             hor dis>=

CORMIX1 flow category algorithm is turned off.
 0.0003 m2/3/s                                0.0001 to 0.0005 m2/3/s range
Help: F1.  Quit: <esc>.  Configuration:ATN00.  FILE: eastr-1.var;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
```

plume dep m	plume dia m	poll conc	dilution	hor dis m	
9.600	0.7000	27.00	1.000	0.000	
9.541	0.9795	24.95	1.413	0.7162	
9.238	1.326	23.50	1.998	1.661	
8.485	1.679	22.47	2.825	2.718	
7.225	2.041	21.75	3.994	3.715	
5.490	2.466	21.24	5.647	4.598	
3.265	2.994	20.88	7.986	5.382	
0.4815	3.653	20.62	11.29	6.089	
0.3571	3.683	20.61	11.45	6.116	-> surface hit

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Figure 9 Plume Model Output, Case 6 - Dry Season, 0 Velocity, 2 Port

Job No. EA00561