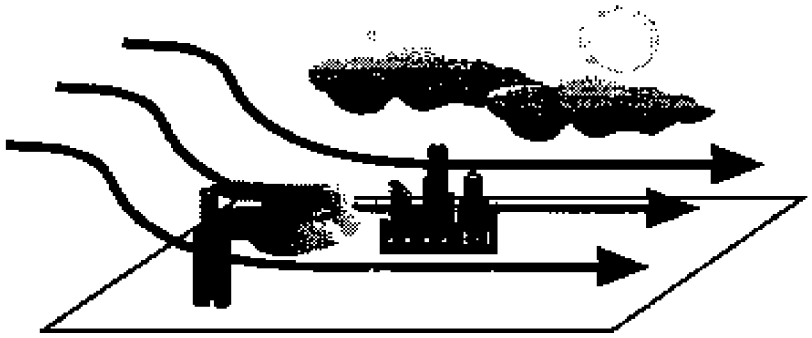
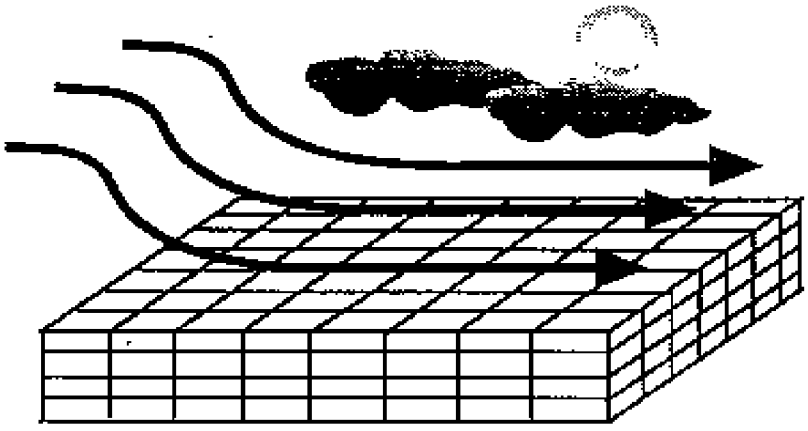
FIGURE 1

Urban Airshed Model Grid Concept



The Area to be Modeled



Specification of the Grid

Source: Urban Airshed Model Hands-On Workshop, March 25-26, 1993
EPA Research Triangle Park, NC

THE UAM MODEL APPLICATION PROCESS

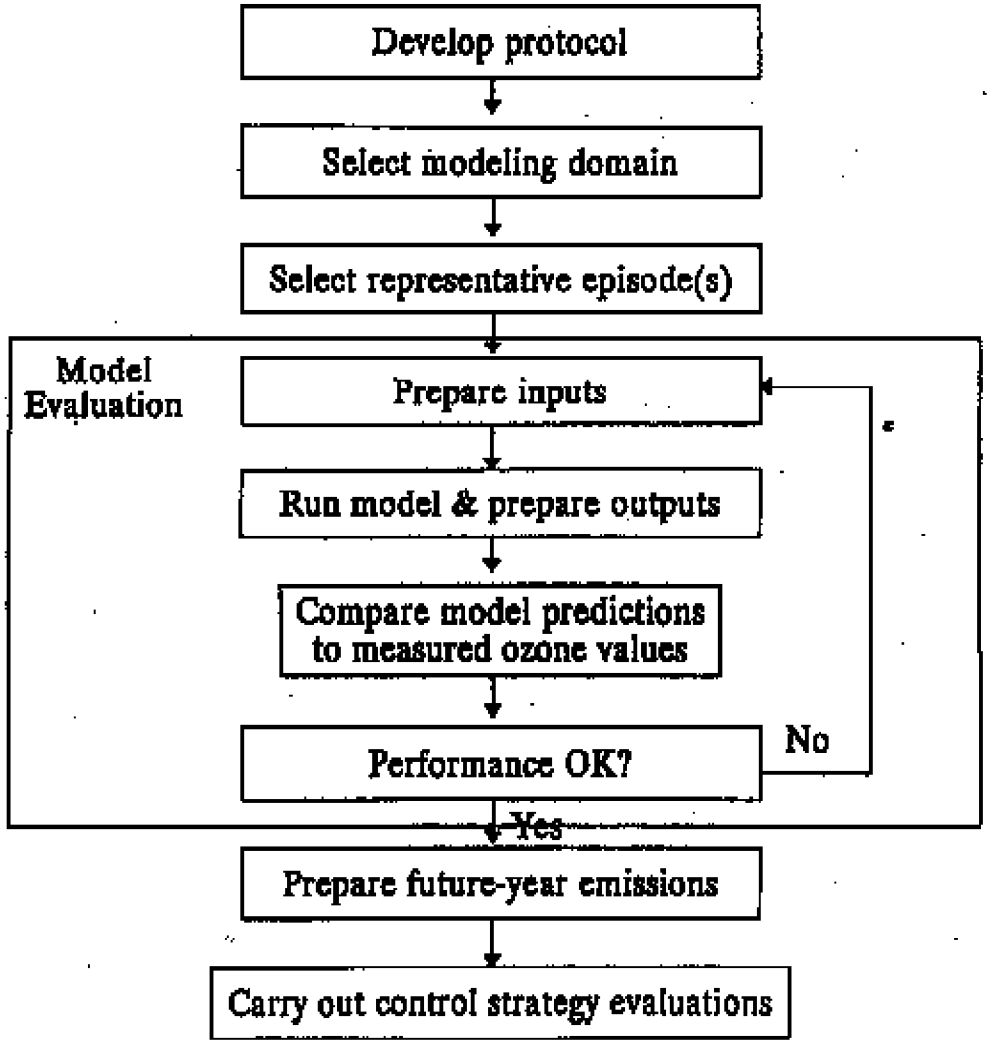


FIGURE 2

Source: TNRCC UAM-V Workshop - Overview of UAM-V Modeling System, Systems Applications International, June 27-29, 1994

FIGURE 3

COAST Project Modeling Domain

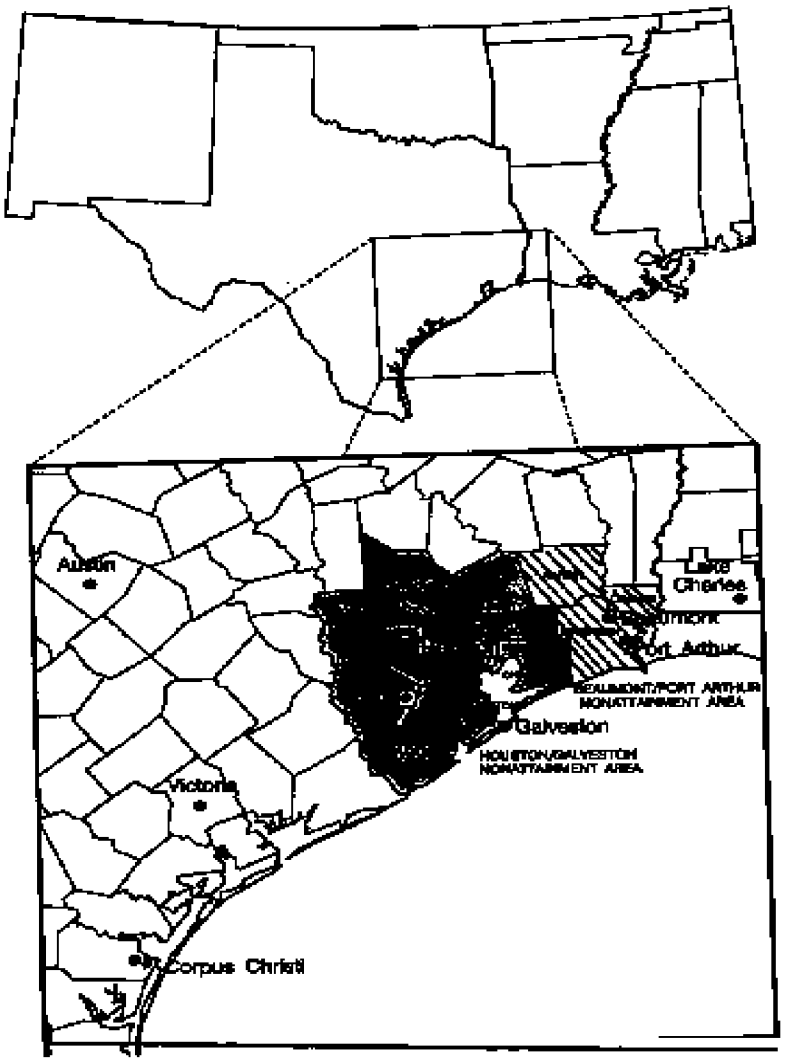
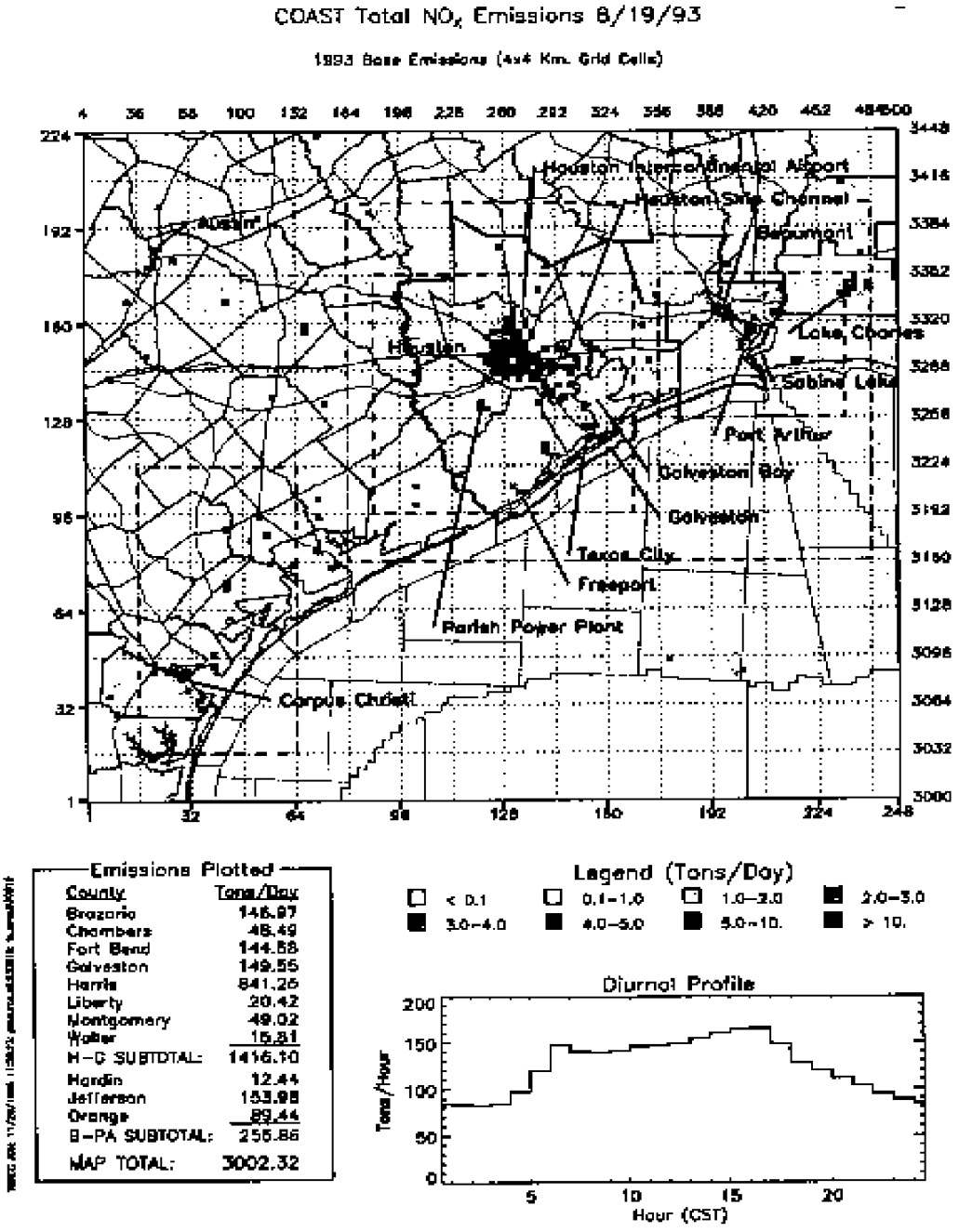


FIGURE 4

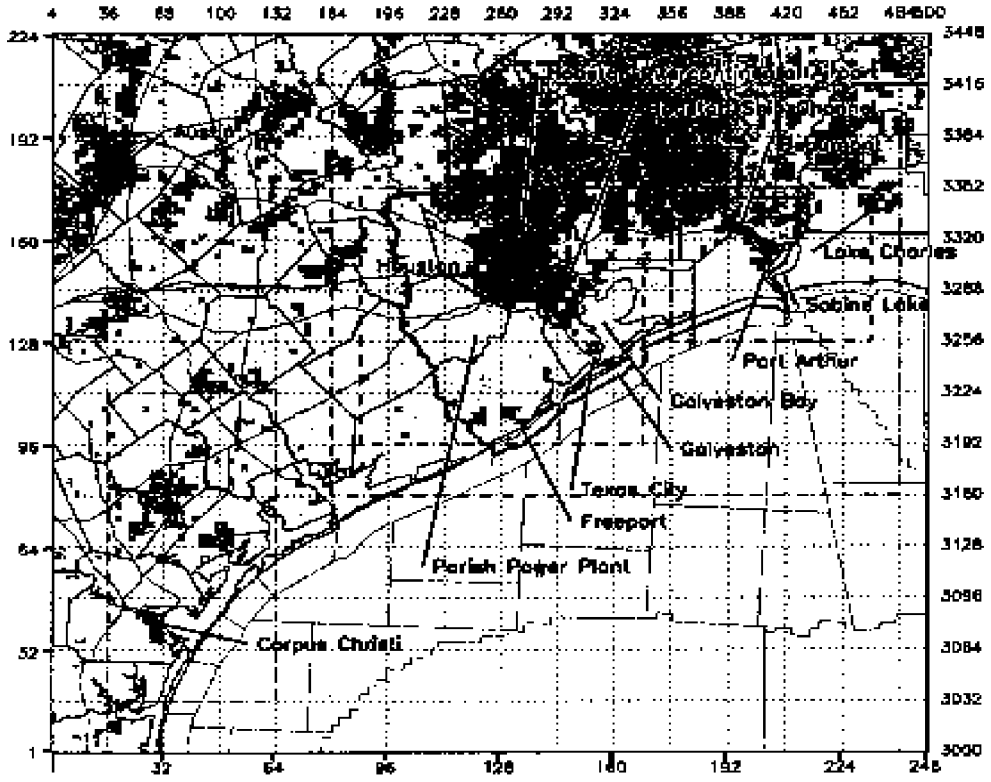


Tileplot of COAST Total NO_x Emissions

FIGURE 5

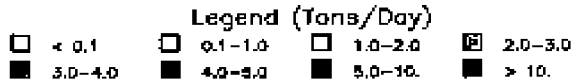
COAST Total CB-IV HC Emissions 8/19/93

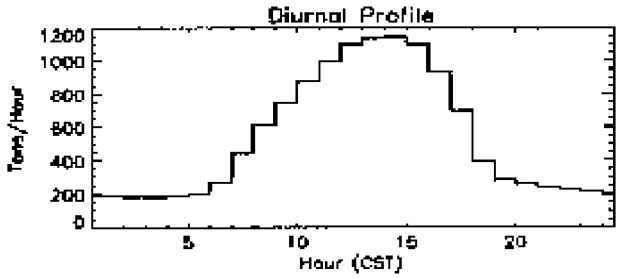
1993 Base Emissions (4x4 Km. Grid Cells)



Emissions Plotted

County	Tons/Day
Brazoria	228.45
Chambers	118.73
Fort Bend	81.75
Galveston	141.03
Harris	1023.00
Liberty	419.10
Montgomery	458.62
Waller	98.09
H-G SUBTOTAL:	2568.78
Hardin	406.34
Jefferson	291.50
Orange	153.73
B-PA SUBTOTAL:	851.57
MAP TOTAL:	12824.90





Tileplot of COAST Total CB-IV HC Emissions

FIGURE 6

UAM-V Input and Output

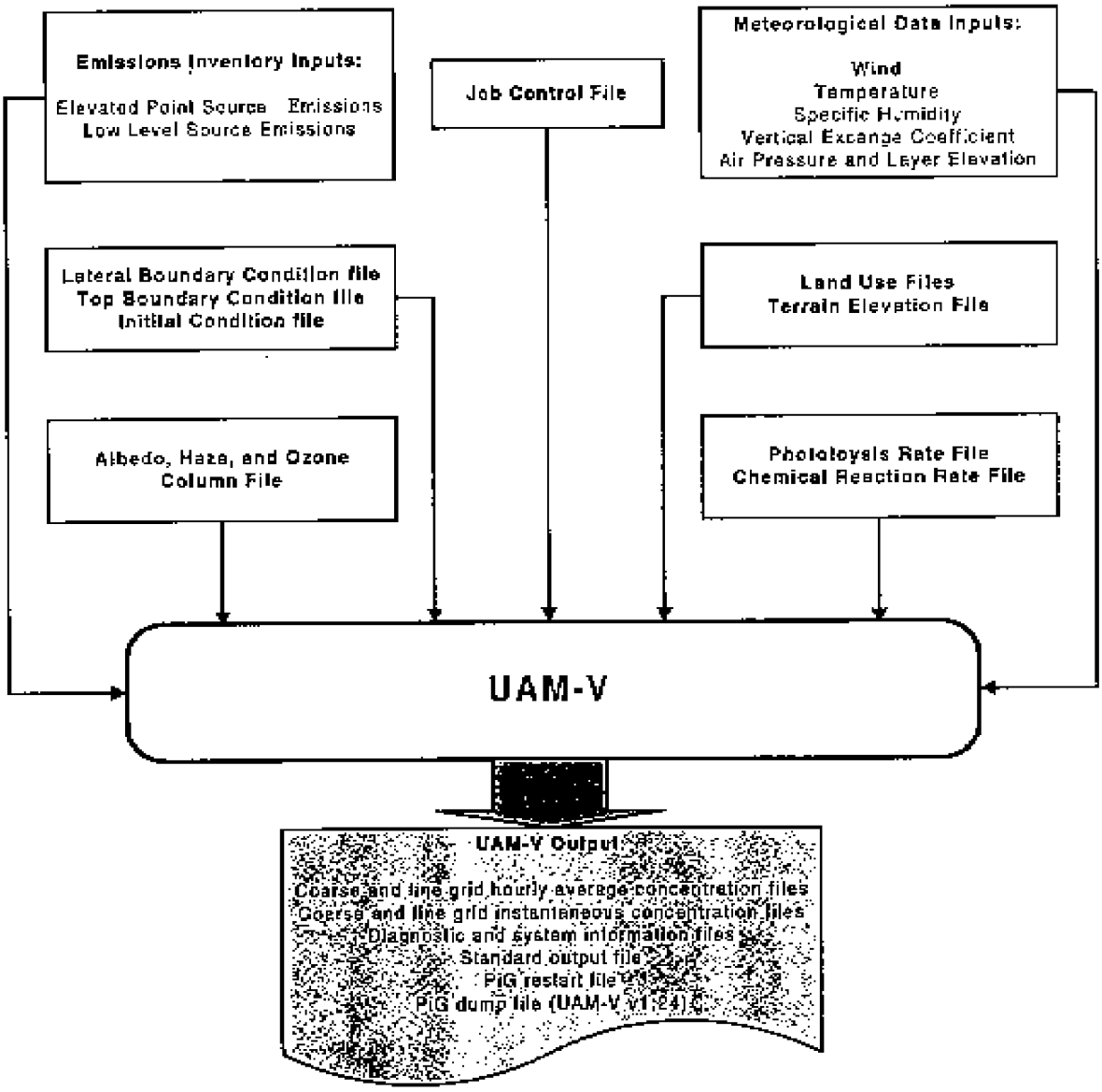


Figure 7 UAM modeling performance statistical calculation areas.

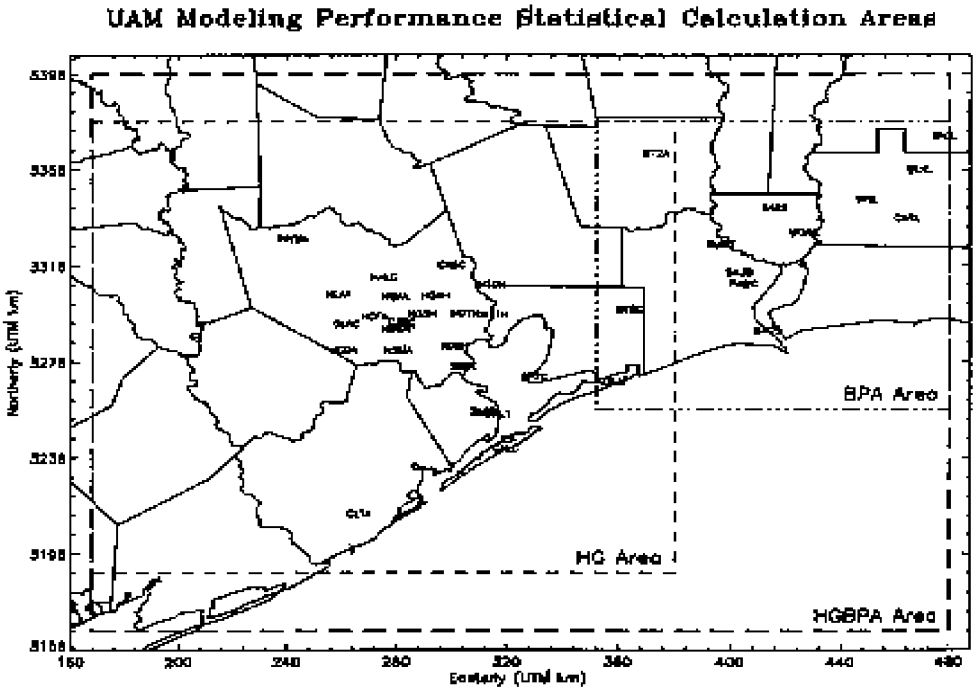


FIGURE 8

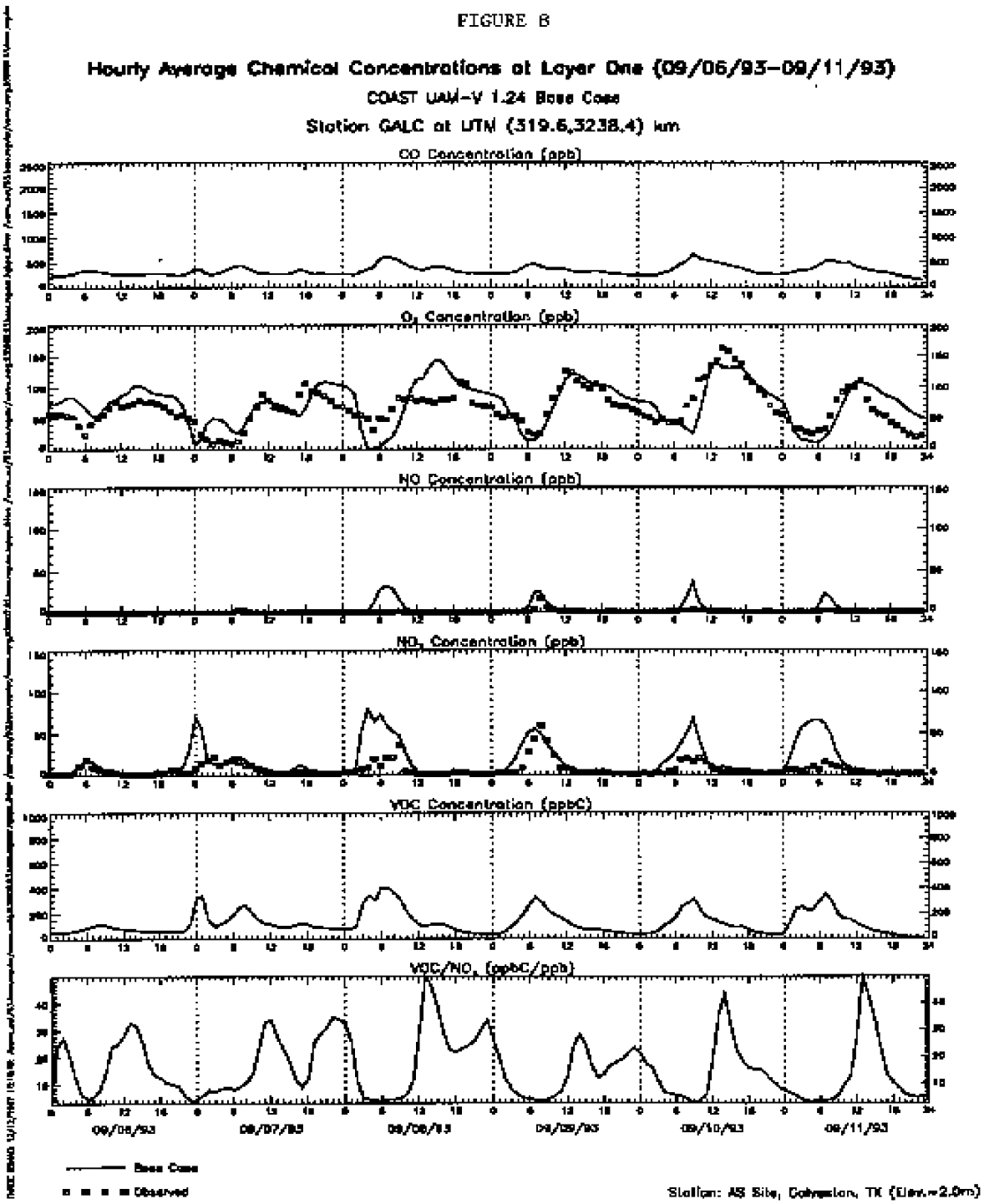

Hourly Average Chemical Concentrations at Layer One (09/06/93–09/11/93)
COAST UAM-V 1.24 Base Case
Station GALC at UTM (319.6,3238.4) km
CO Concentration (ppb)
O3 Concentration (ppb)
NO Concentration (ppb)
NO2 Concentration (ppb)
VOC Concentration (ppbC)
VOC/NOx (ppbC/ppb)
09/06/93
09/07/93
09/08/93
09/09/93
09/10/93
09/11/93
Base Case
Observed
Station: AS Site, Galveston, TX (Elev.=2.0m)

FIGURE 9

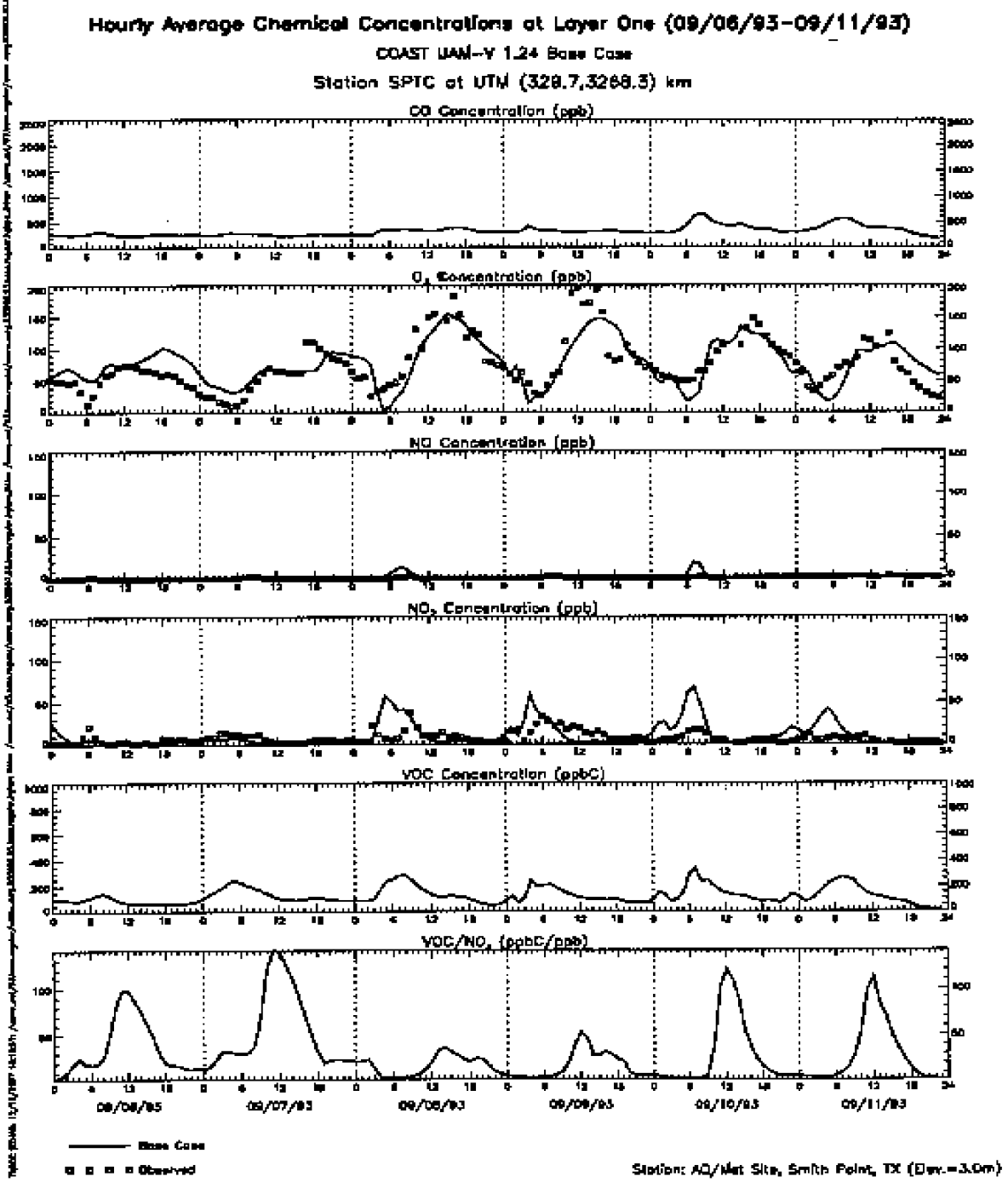

Hourly Average Chemical Concentrations at Layer One (09/06/93-09/11/93)
COAST UAM-V 1.24 Base Case
Station SPTC at UTM (328.7,3268.3) km
CO Concentration (ppb)
O3 Concentration (ppb)
NO Concentration (ppb)
NO2 Concentration (ppb)
VOC Concentration (ppbC)
VOC/NOx (ppbC/ppb)
09/06/93
09/07/93
09/08/93
09/09/93
09/10/93
09/11/93
Base Case
Observed
Station: AQ/Met Site, Smith Point, TX (Elev.=3.0m)

FIGURE 10

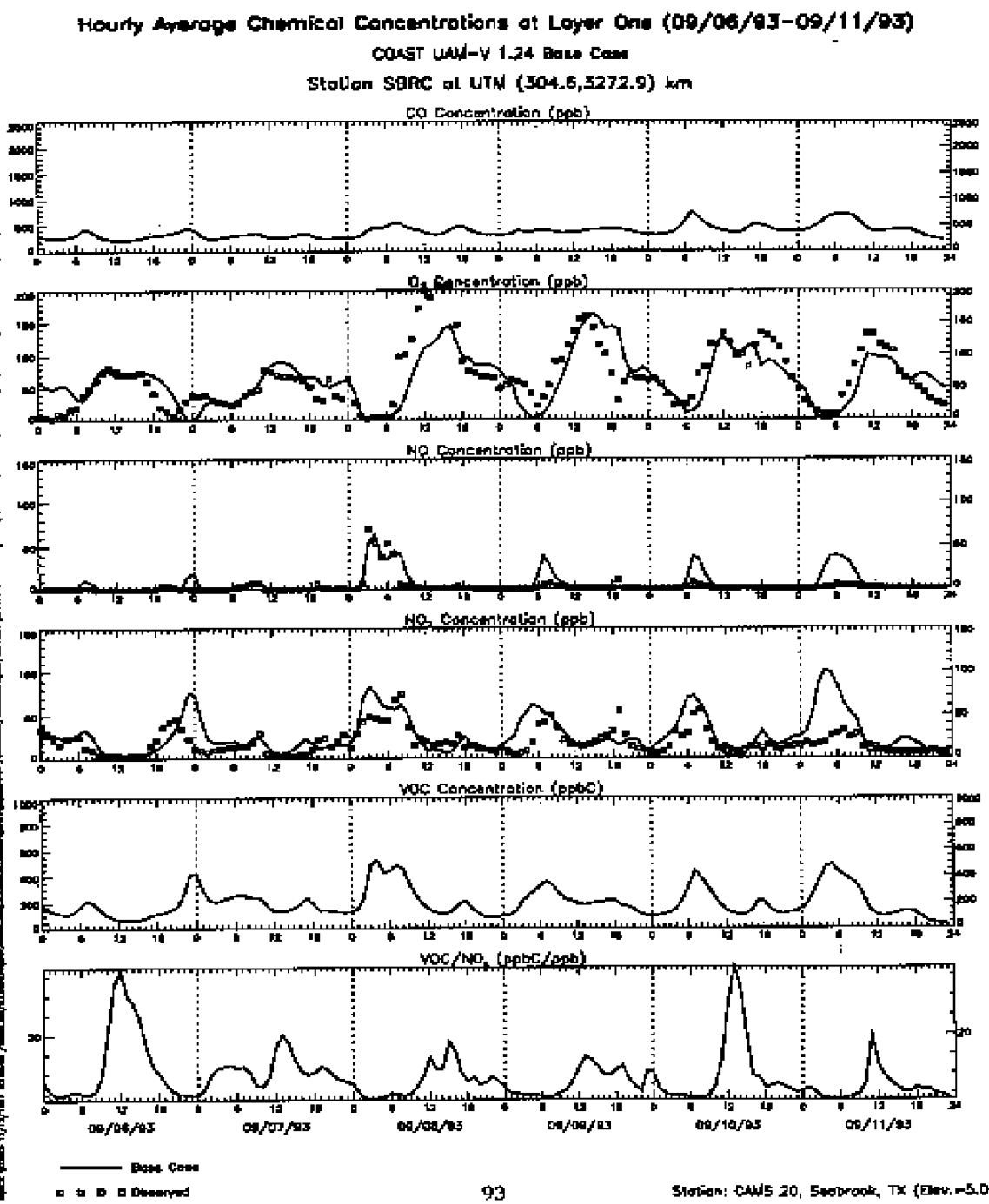

Hourly Average Chemical Concentrations at Layer One (09/06/93-09/11/93)
COAST UAM-V 1.24 Base Case
Station SBRC at UTN (304.6,3272.9) km
CO Concentration (ppb)
O3 Concentration (ppb)
NO Concentration (ppb)
NO2 Concentration (ppb)
VOC Concentration (ppbC)
VOC/NOx (ppbC/ppb)
09/06/93
09/07/93
09/08/93
09/09/93
09/10/93
09/11/93
Base Case
Observed
Station: CAMS 20, Seabrook, TX (Elev.=5.0m)

FIGURE 11

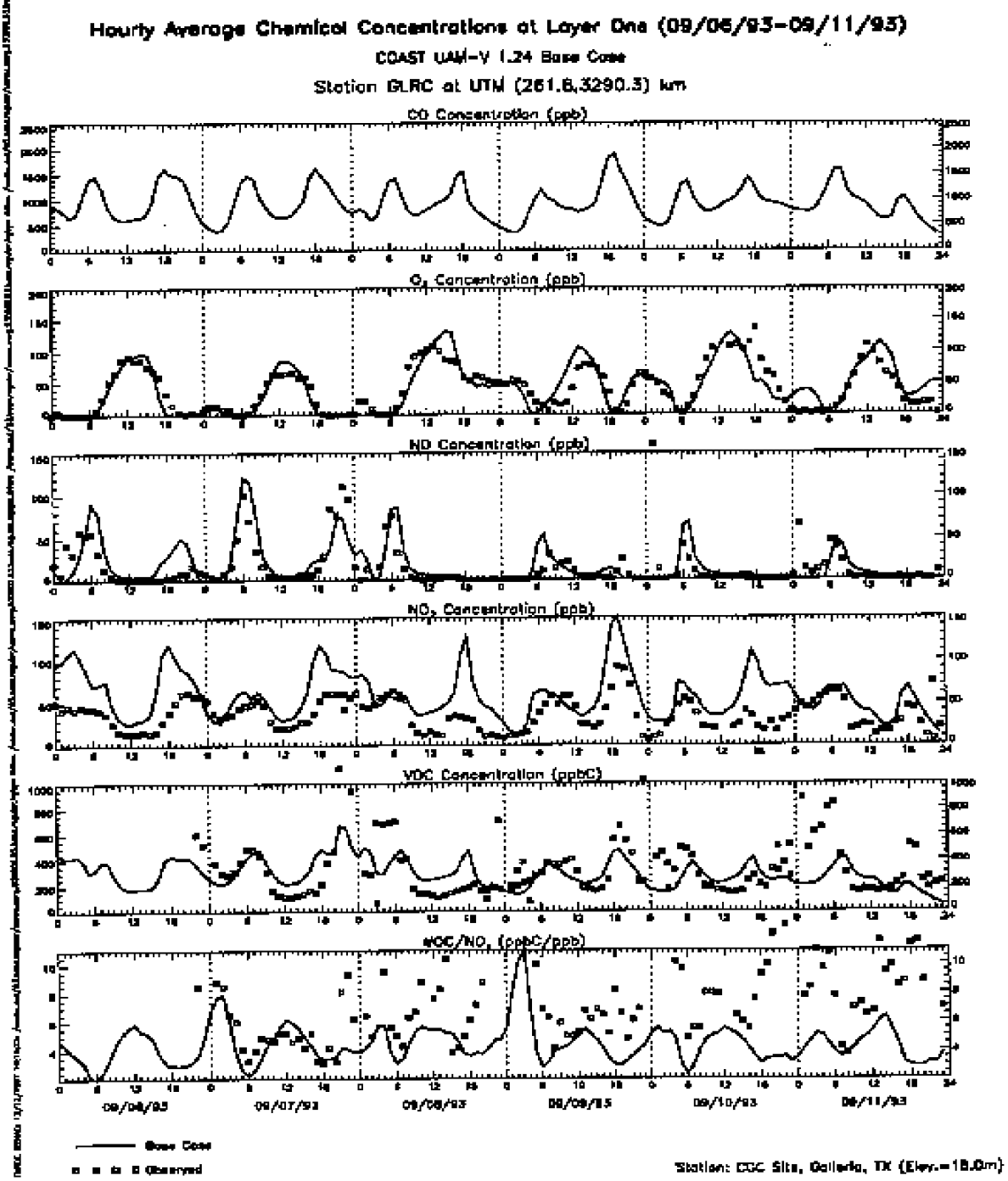

Hourly Average Chemical Concentrations at Layer One (09/06/93-09/11/93)
COAST UAM-V 1.24 Base Case
Station GLRC at UTM (261.6,3290.3) km
CO Concentration (ppb)
O3 Concentration (ppb)
ND Concentration (ppb)
NO2 Concentration (ppb)
VOC Concentration (ppbC)
VOC/NO, (ppbC/ppb)
09/06/93
09/07/93
09/08/93
09/09/93
09/10/93
09/11/93
Base Case
Observed
Station: CGC Site, Galleria, TX (Elev.=18.0m)

FIGURE 12

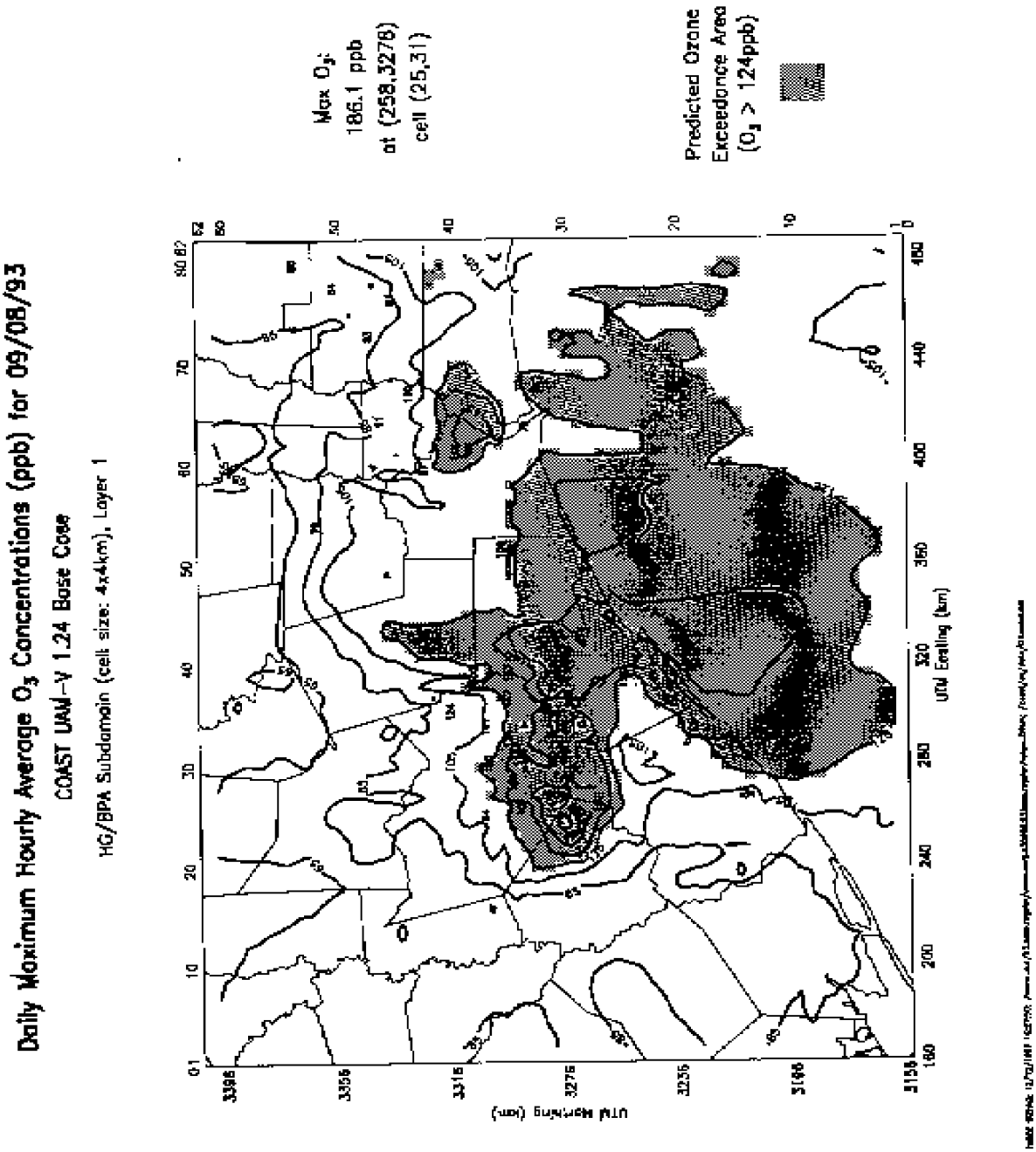

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
CDAST UAM-V 1.24 Base Case
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
186.1 ppb
at (258,3278)
cell (25,31)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

FIGURE 13

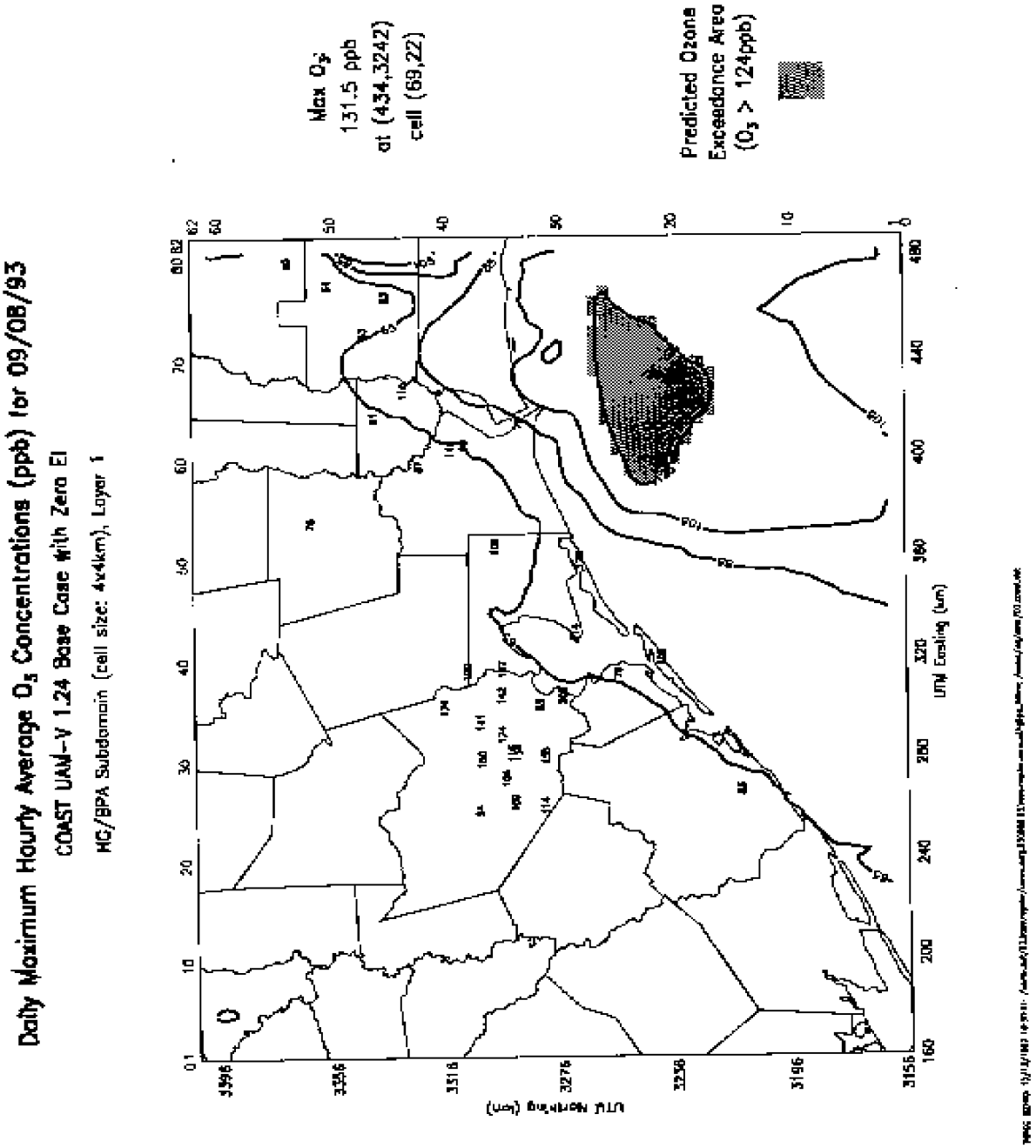

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case With Zero EI
MC/EPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
131.5 ppb
at (434,3242)
cell (69,22)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

FIGURE 14

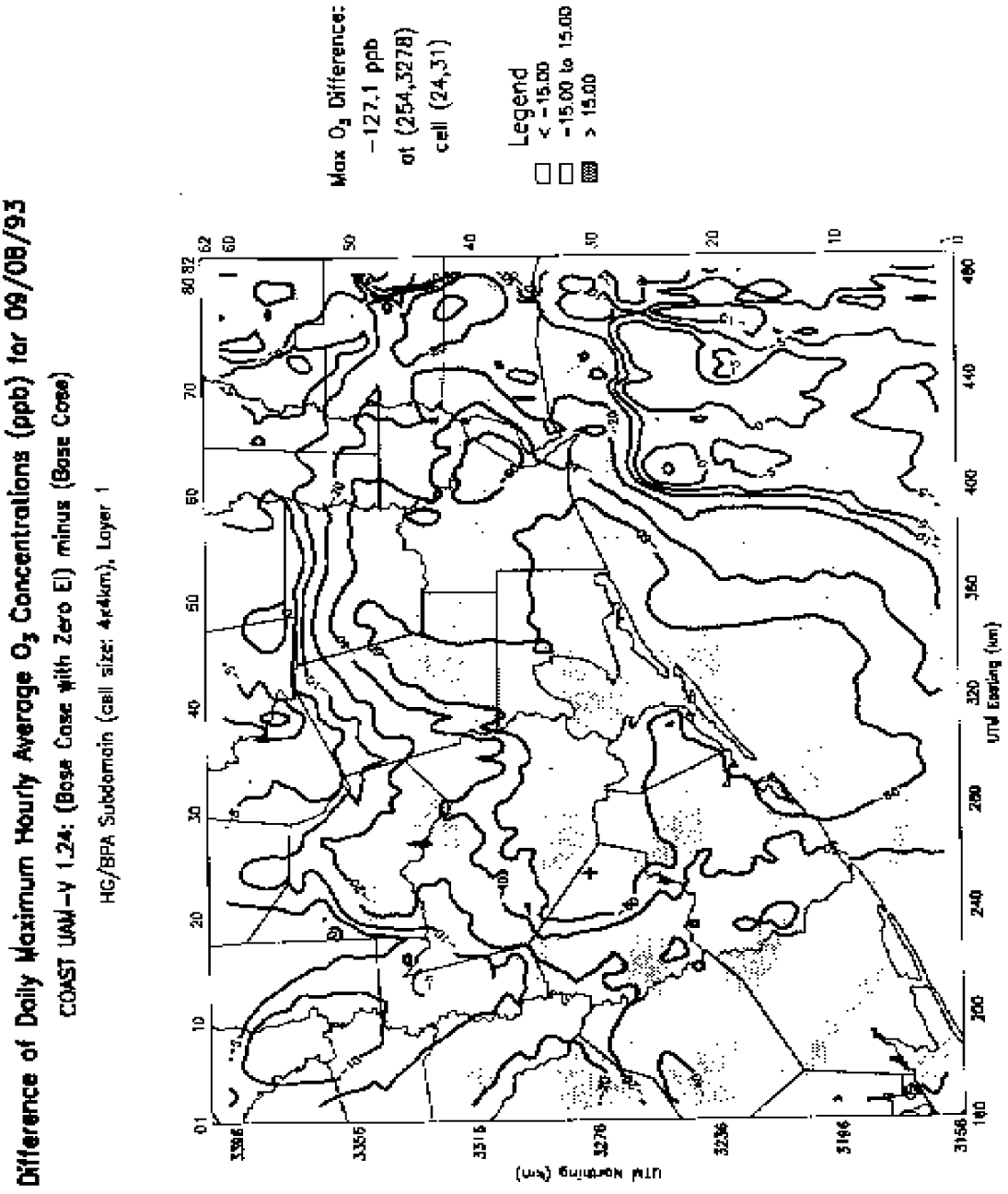

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24: (Base Case with Zero EI) minus (Base Case)
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3 Difference:
-127.1 ppb
at (254,3278)
cell (24,31)
Legend
< -15.00
-15.00 to 15.00
> 15.00
UTM Northing (km)
UTM Easting (km)

FIGURE 15

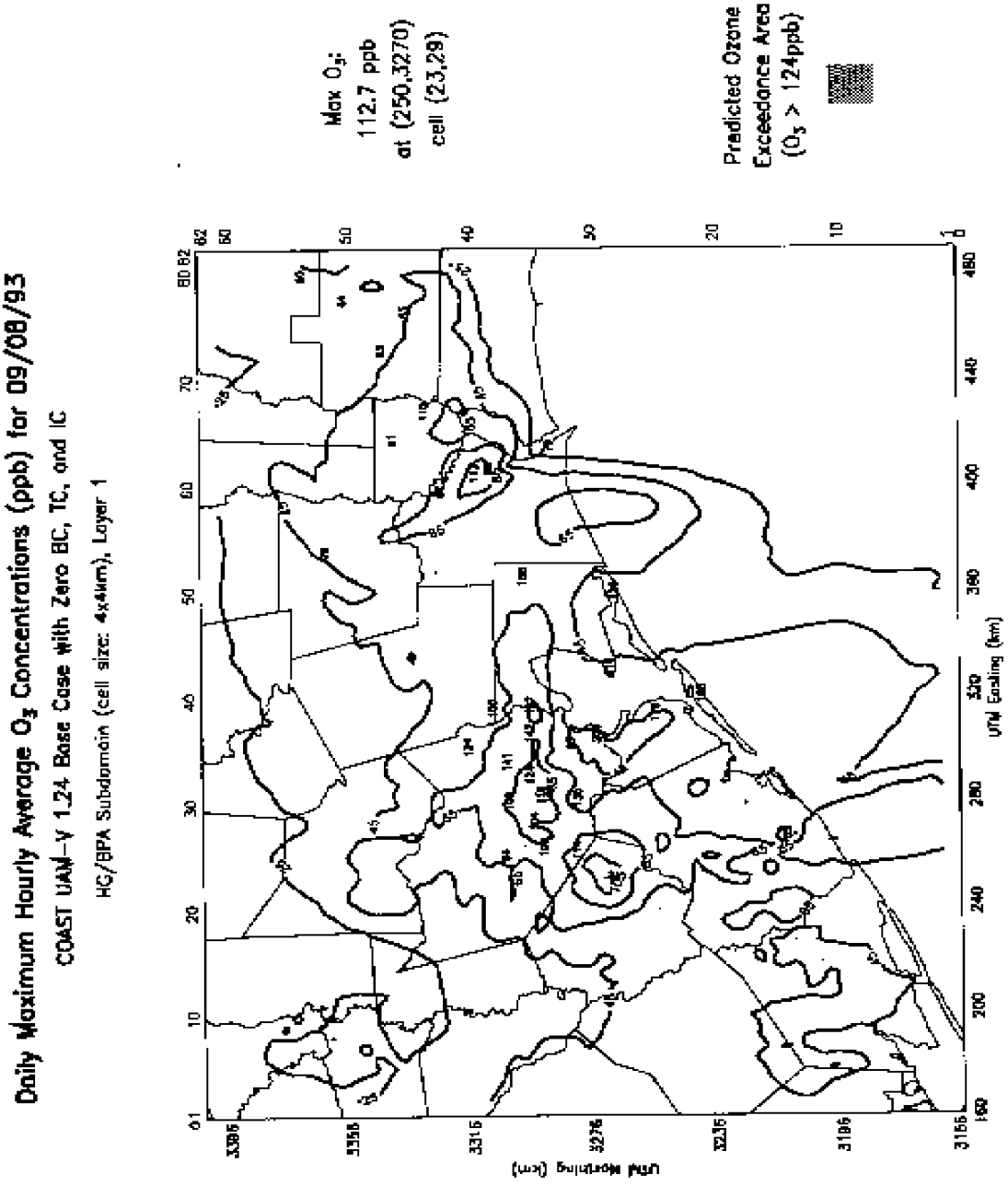

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case with Zero BC, TC, and IC
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3: 112.7 ppb at (250,3270) cell (23,29)
Predicted Ozone Exceedance Area (O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

FIGURE 16

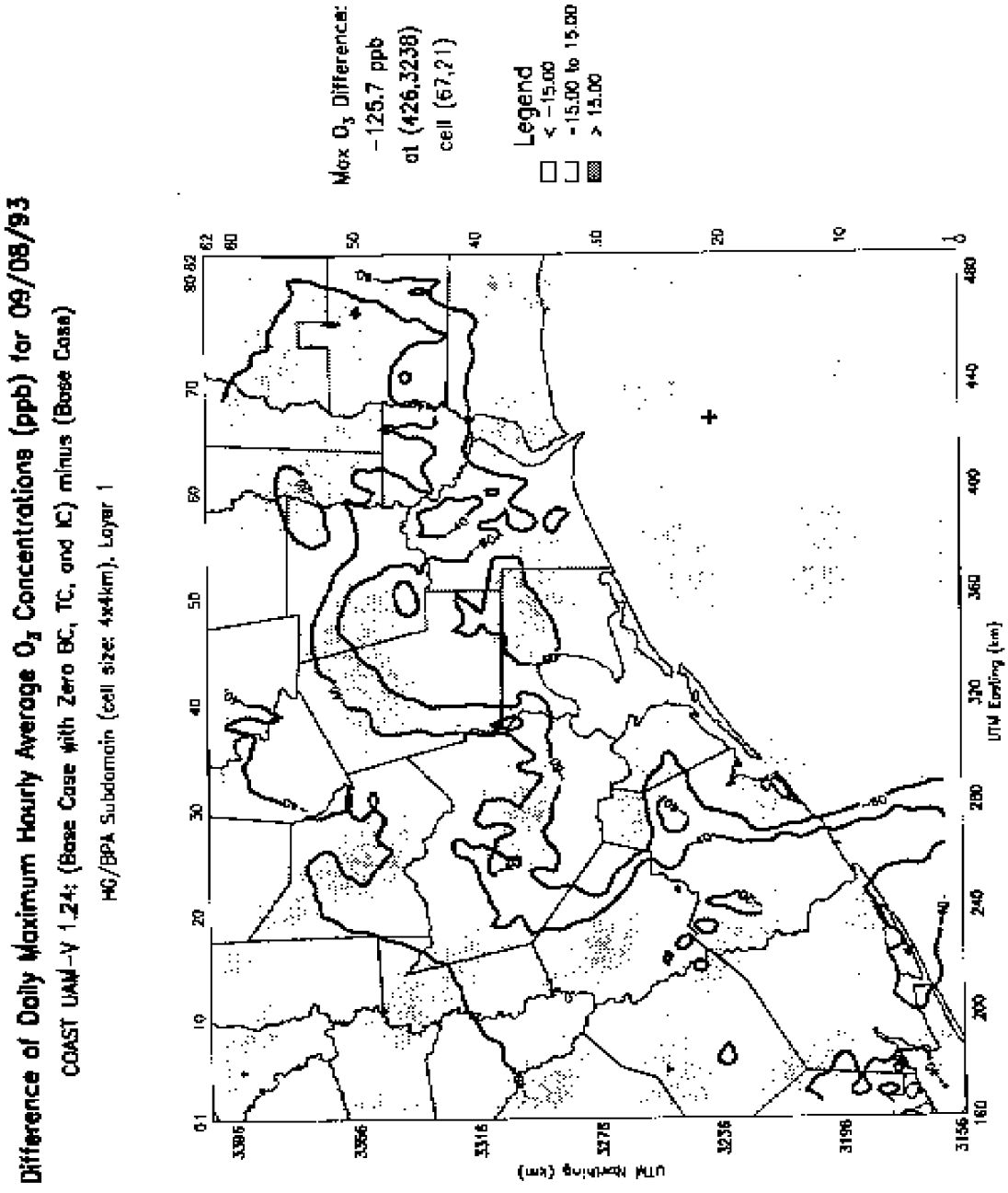

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24; (Base Case with Zero BC, TC, and IC) minus (Base Case)
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3 Difference:
-125.7 ppb
at (426,3238)
cell (67,21)
Legend
< -15.00
-15.00 to 15.00
> 15.00
UTM Northing (km)
UTM Easting (km)

FIGURE 17

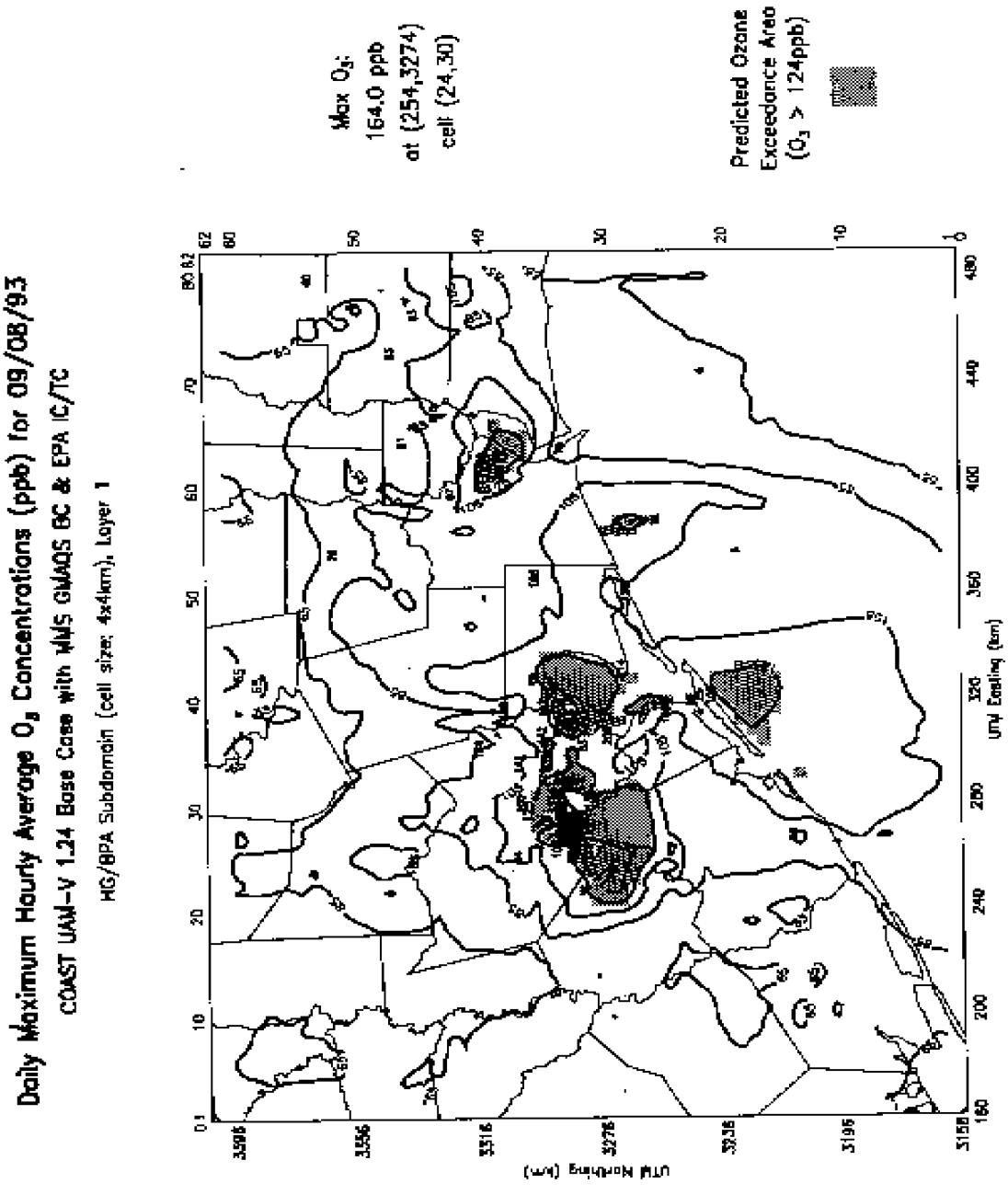

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case with WMS GMAQS BC & EPA IC/TC
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
164.0 ppb
at (254,3274)
cell (24,30)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

FIGURE 15

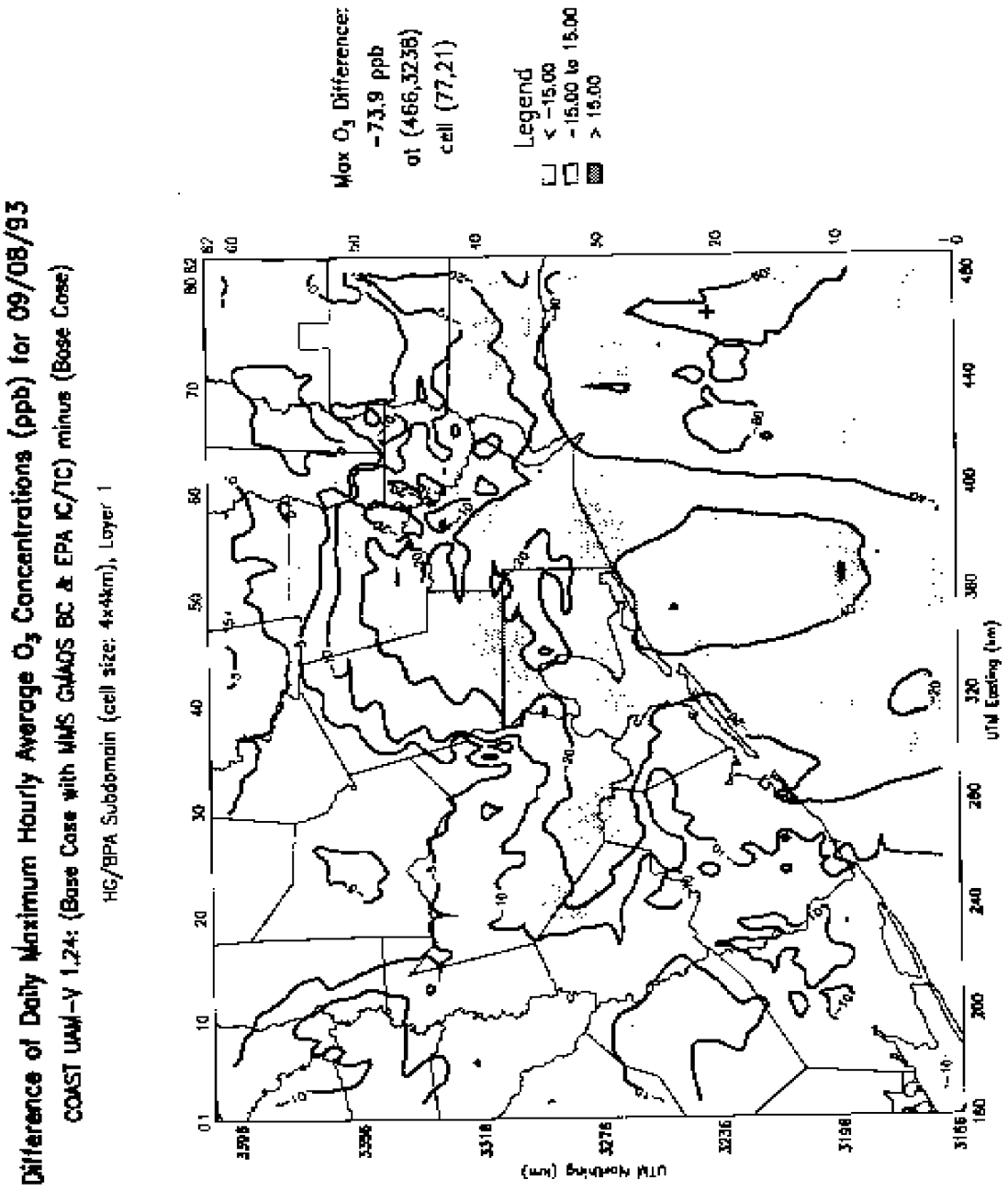
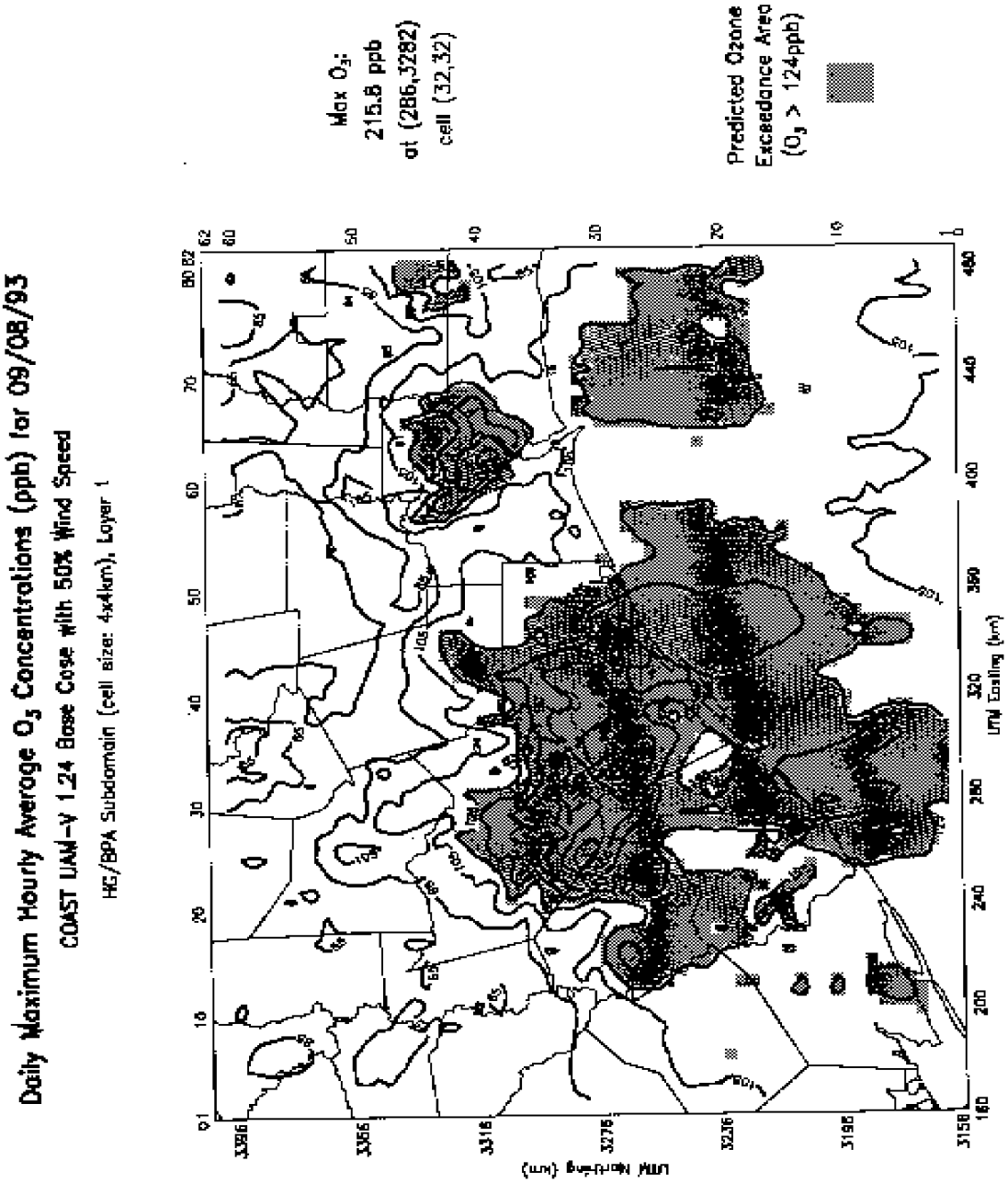

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24: (Base Case with MMS GMAQS BC & EPA IC/TC) minus (Base Case)
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3 Difference:
-73.9 ppb
at (466,3236)
cell (77,21)
Legend
< -15.00
-15.00 to 15.00
> 15.00
UTM Northing (km)
UTM Easting (km)

FIGURE 19


Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case with 50% Wind Speed
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
215.8 ppb
at (286,3282)
cell (32,32)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93

COAST UAM-V 1.24: (Base Case with 50% Wind Speed) minus (Base Case)

HG/BPA Subdomain (cell size: 4x4km), Layer 1

FIGURE 20

FIGURE 21

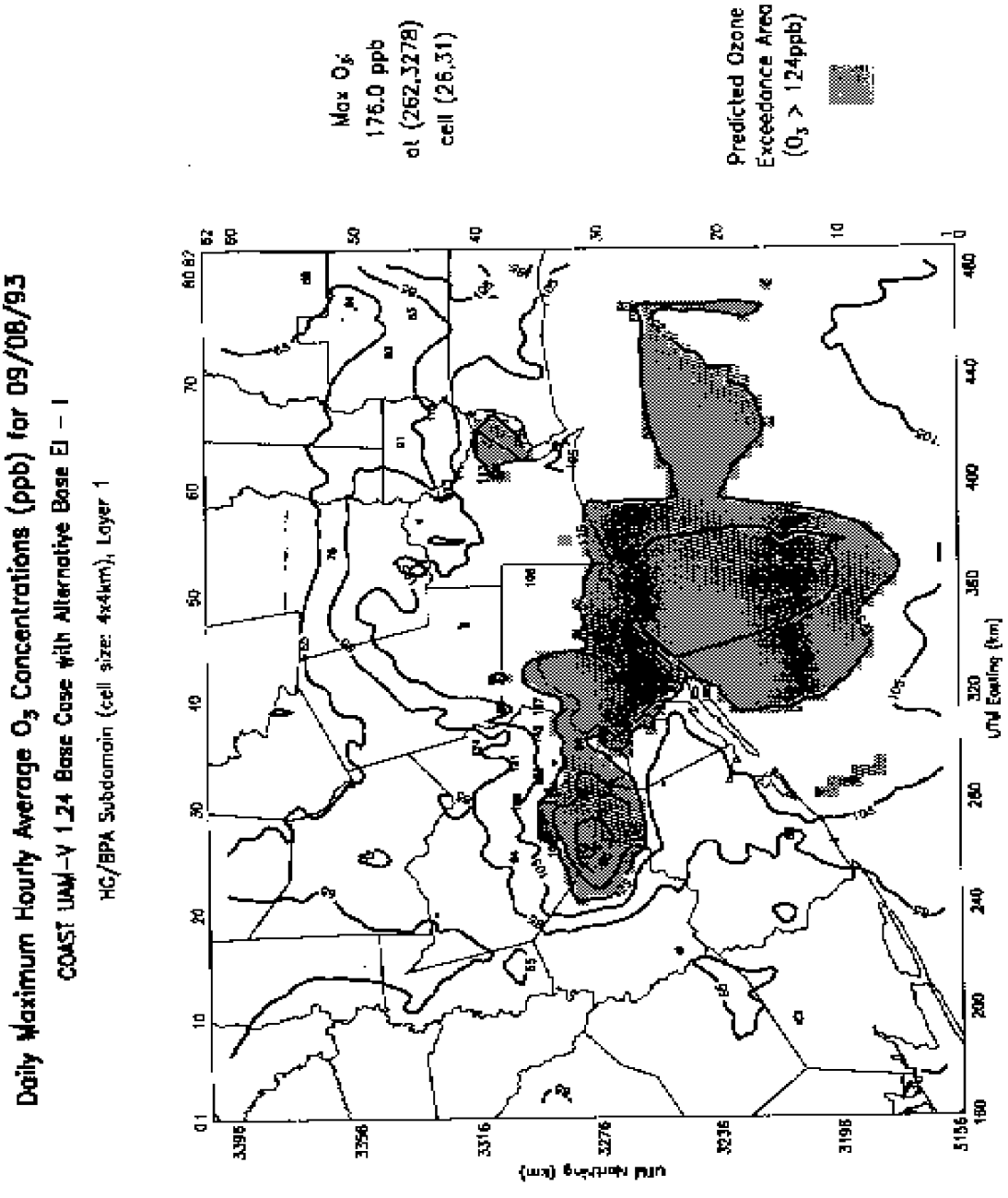

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case with Alternative Base EI - I
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
176.0 ppb
at (262,3278)
cell (26,31)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Easting (km)
UTM Northing (km)

FIGURE 22

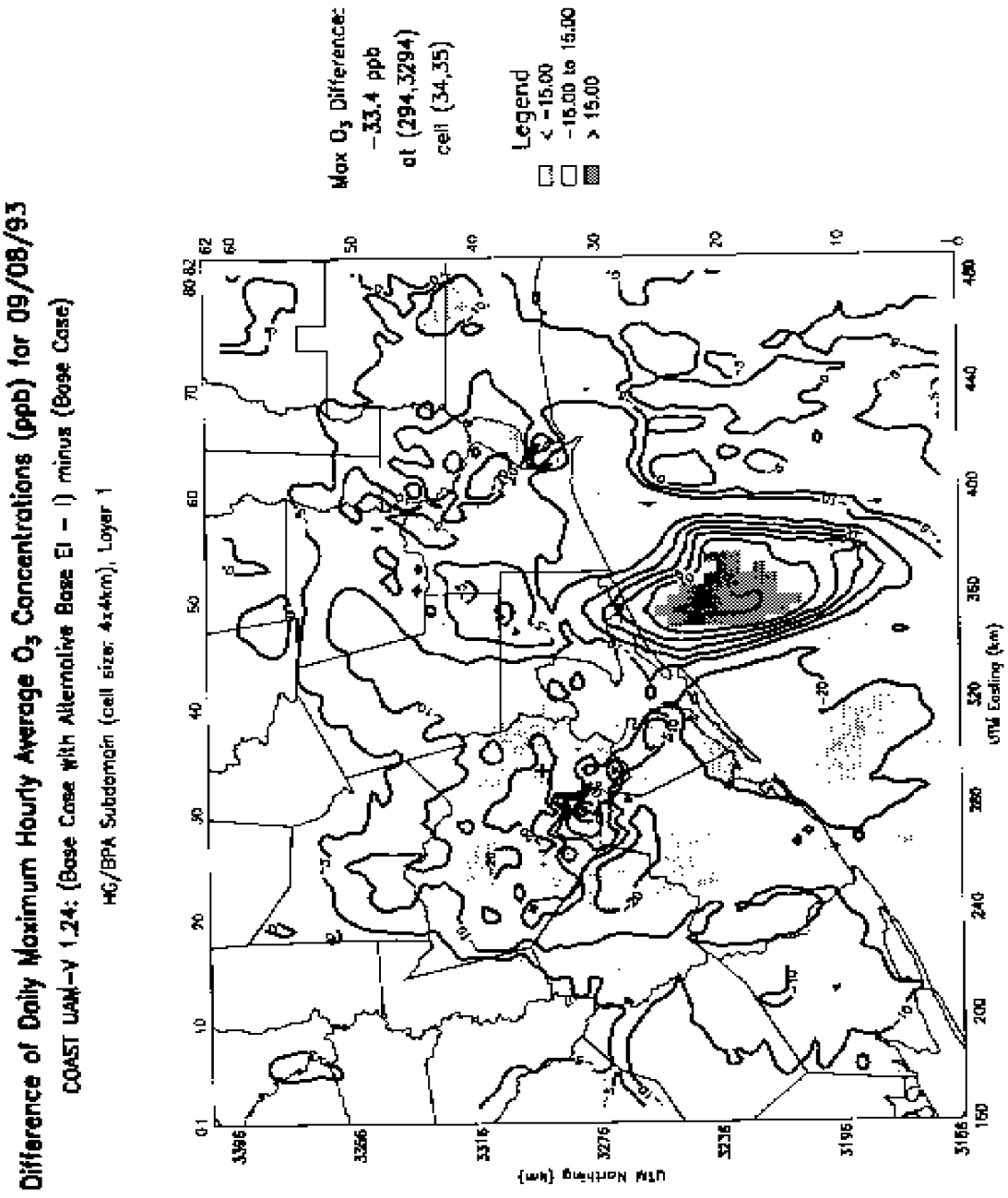

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24: (Base Case with Alternative Base EI - EI) minus (Base Case)
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3 Difference:
-33.4 ppb
at (294,3294)
cell (34,35)
Legend
< -15.00
-15.00 to 15.00
> 15.00
UTM Northing (km)
UTM Easting (km)

FIGURE 23

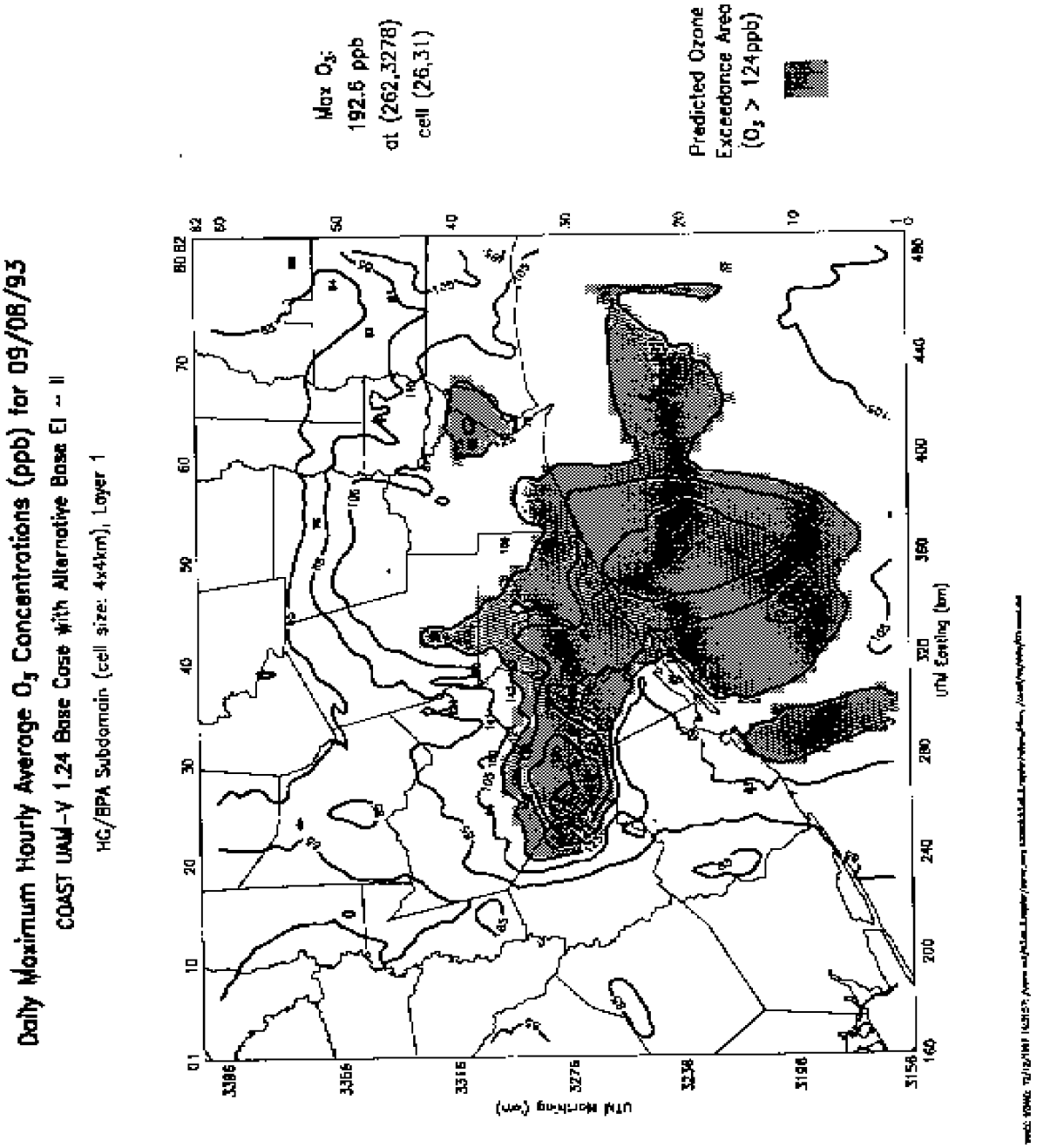

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
COAST UAM-V 1.24 Base Case with Alternative Base EI -- II
HG/BPA Subdomain (cell size: 4x4km); Layer 1
Max O_3:
192.8 ppb
at (262,3278)
cell (26,31)
Predicted Ozone
Exceedance Area
(O_3 > 124ppb)
UTM Northing (km)
UTM Easting (km)

FIGURE 24

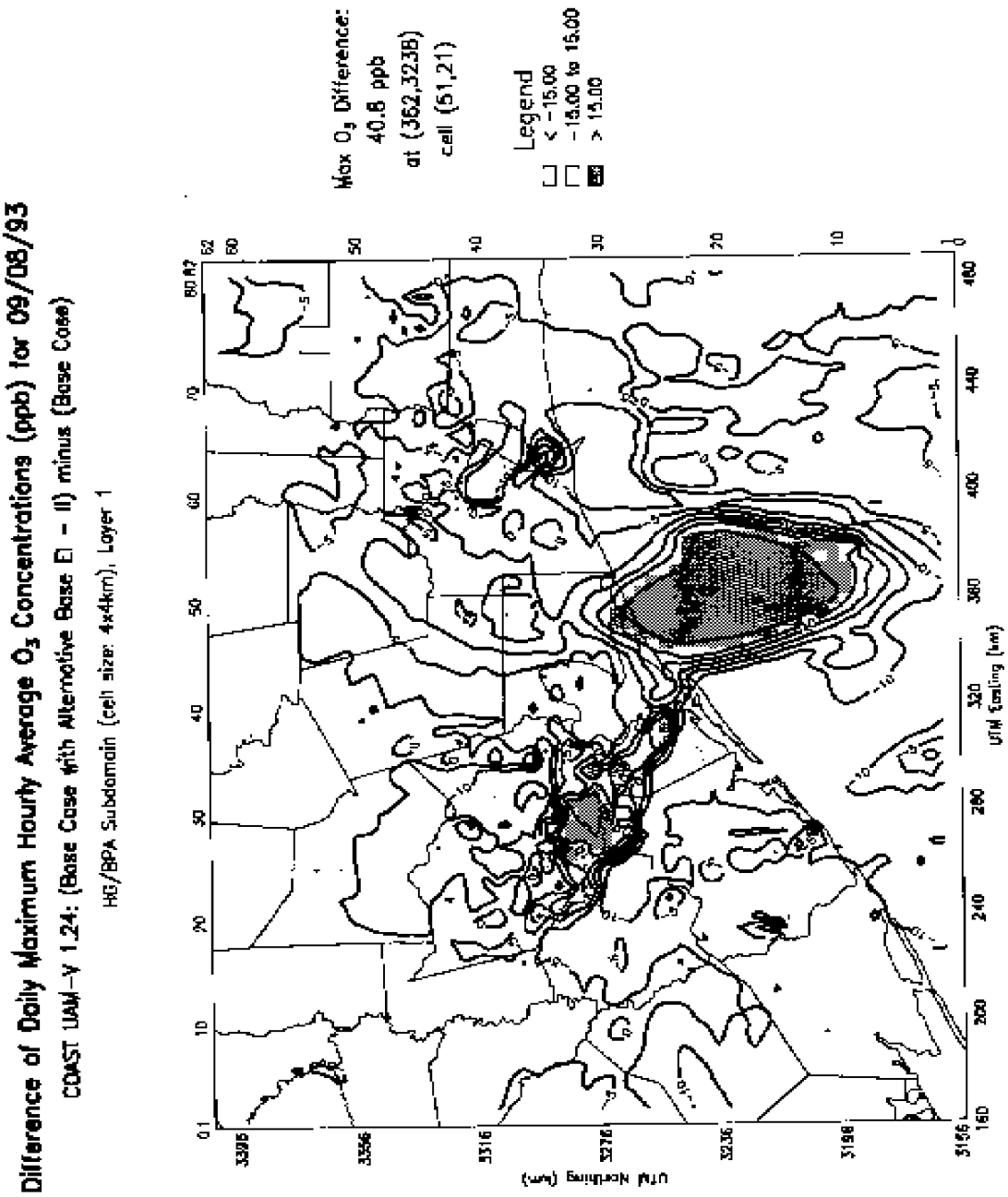
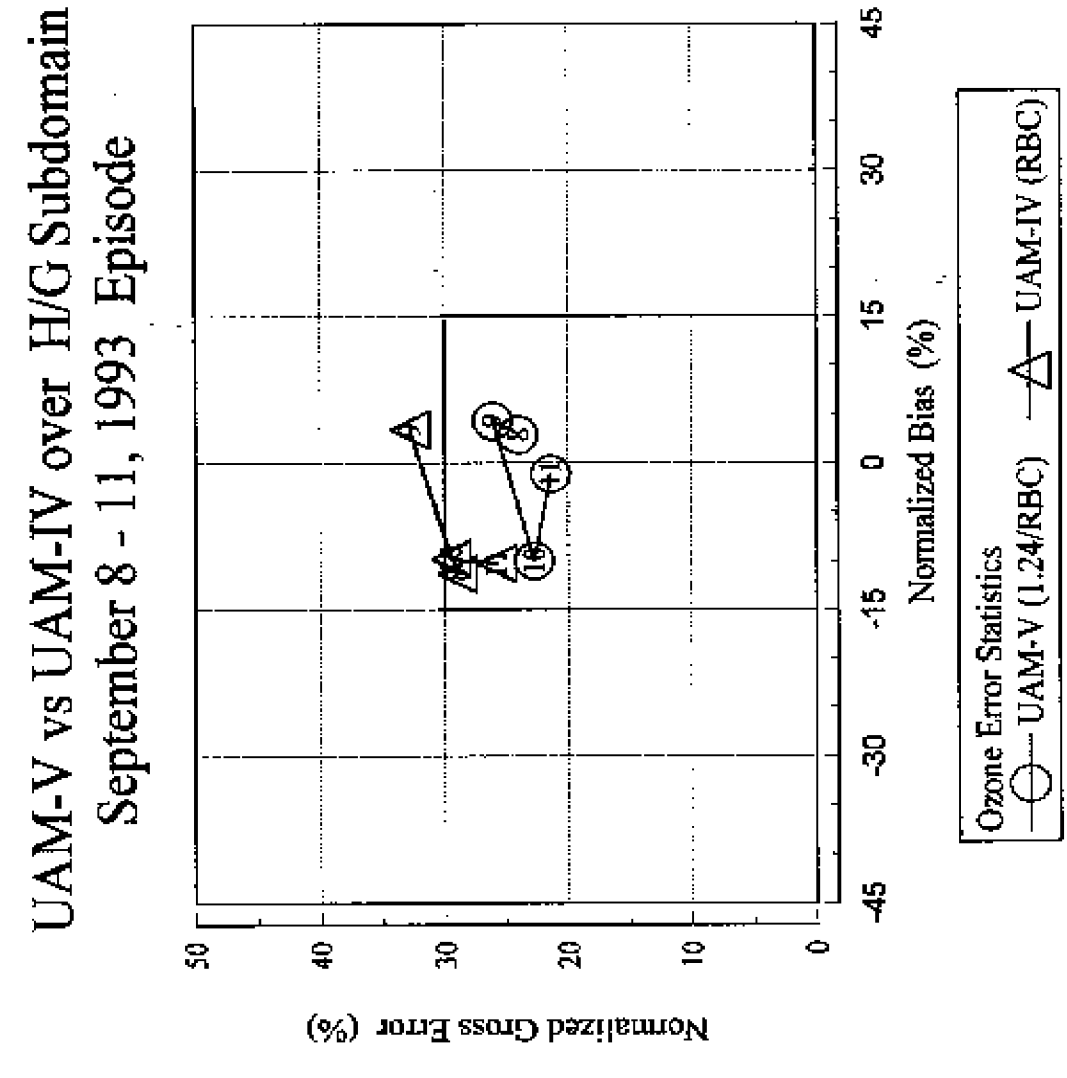

Difference of Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93
CDAST UAM-V 1.24: (Base Case with Alternative Base D - II) minus (Base Case)
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3 Difference:
40.8 ppb
at (362,3236)
cell (51,21)
Legend
< -15.00
-15.00 to 15.00
> 15.00
UTM Northing (km)
UTM Easting (km)

FIGURE 25


UAM-V vs UAM-IV over H/G Subdomain
September 8 - 11, 1993 Episode
Normalized Gross Error (%)
0
10
20
30
40
50
-45
-30
-15
0
15
30
45
Normalized Bias (%)
Ozone Error Statistics
UAM-V (1.24/RBC)
UAM-IV (RBC)
TNRCC/Breitenbach IV-V9008L.scx

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/08/93

COAST UAM-V 1.24 Year 2007 Emission Control: No Reductions in HG

HG/BPA Subdomain (cell size: 4x4km), Layer 1

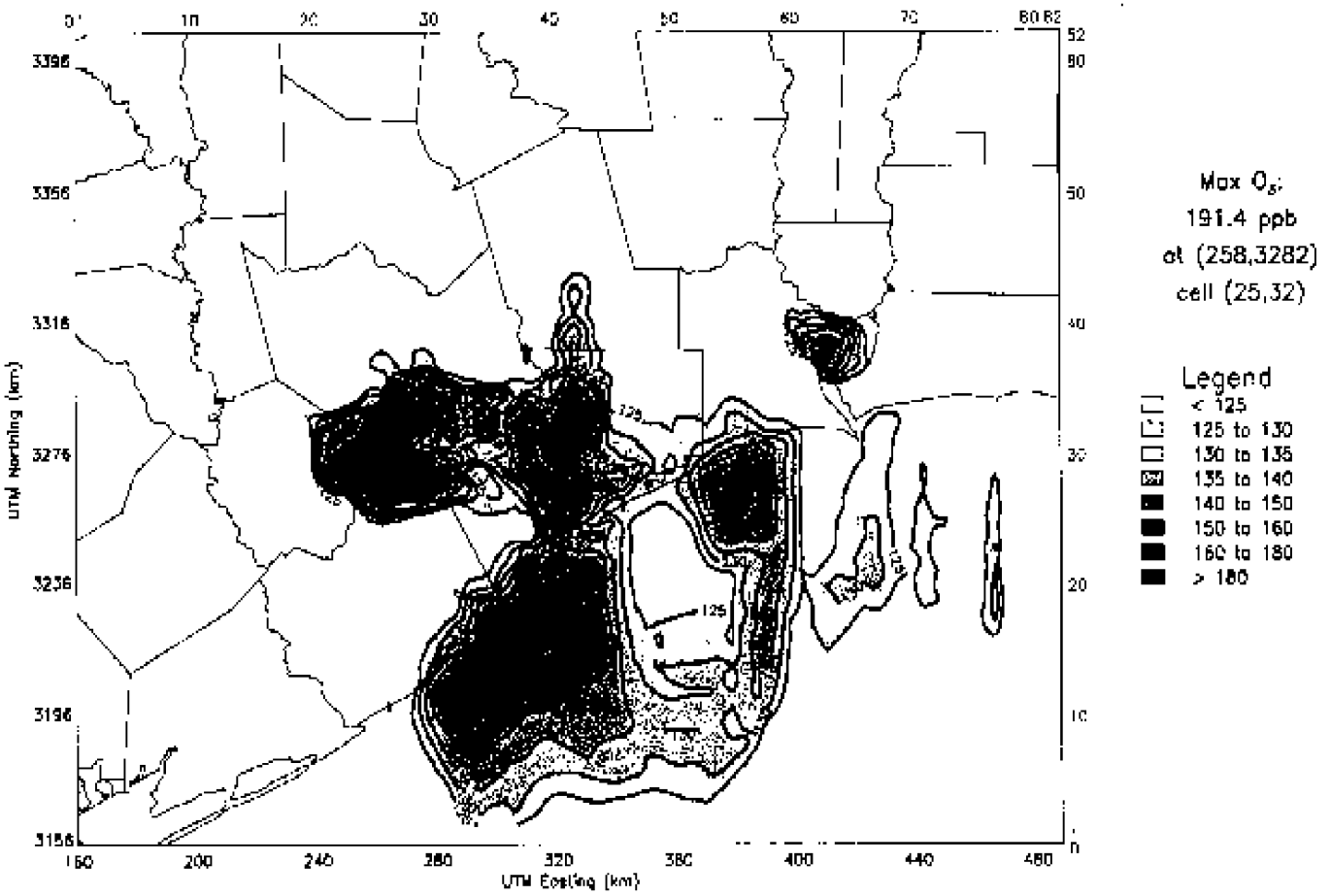


FIGURE 26

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/09/93

COAST UAM-V 1.24 Year 2007 Emission Control: No Reductions in HG

HG/BPA Subdomain (cell size: 4x4km), Layer 1

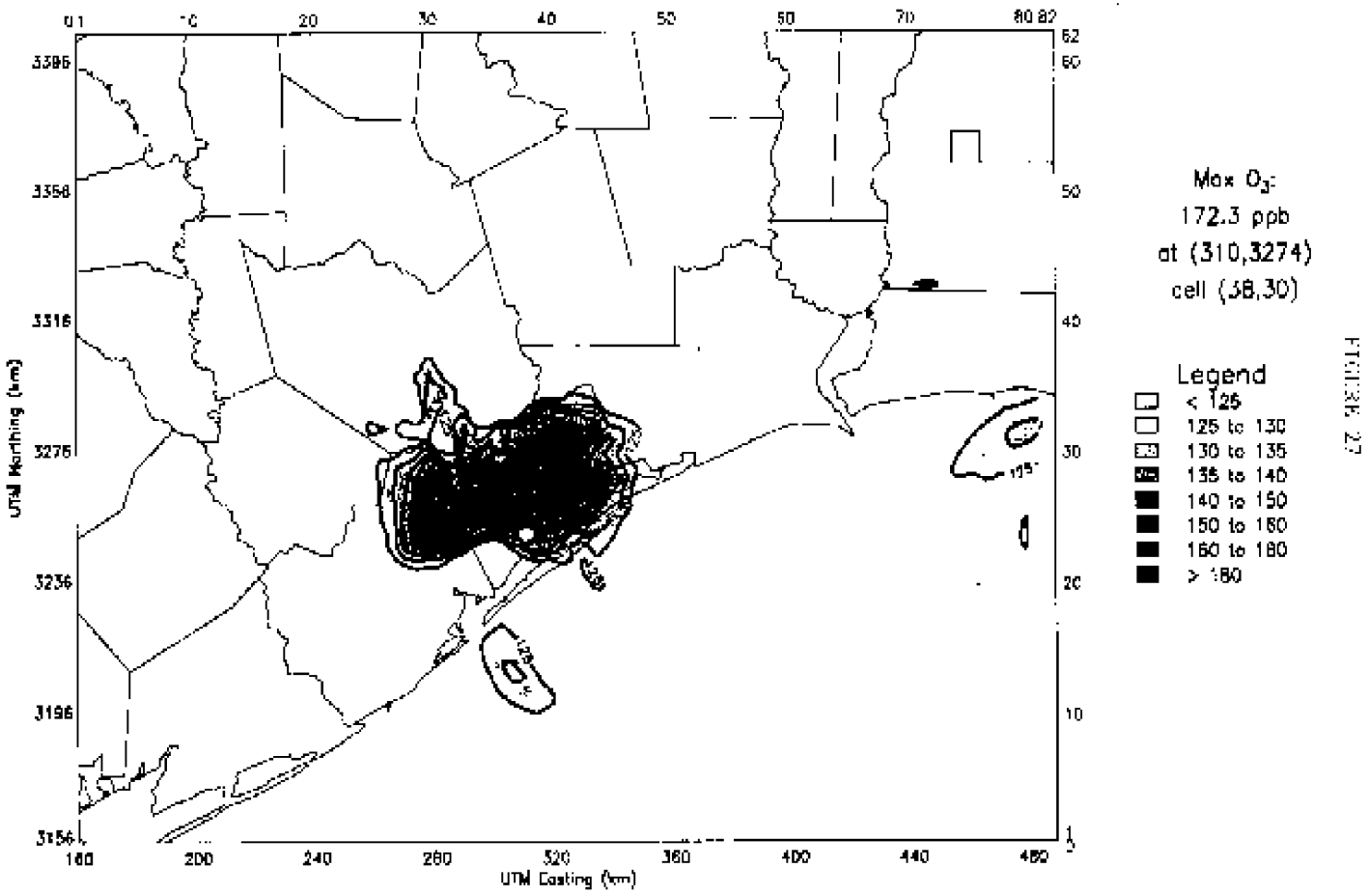


FIGURE 28

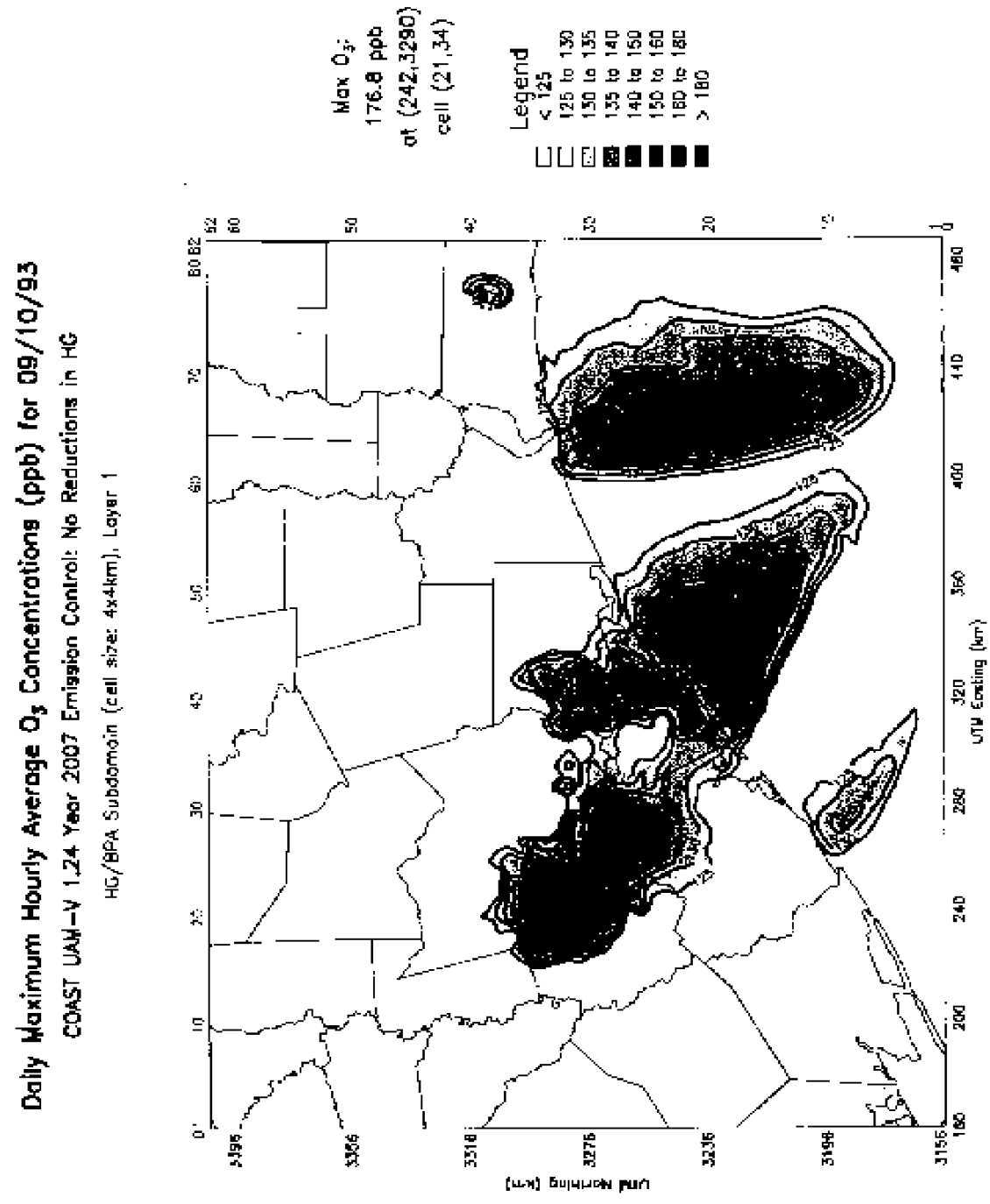

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/10/93
COAST UAM-V 1.24 Year 2007 Emission Control: No Reductions in HG
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
176.8 ppb
at (242,3290)
cell (21,34)
Legend
< 125
125 to 130
130 to 135
135 to 140
140 to 150
150 to 160
160 to 180
> 180
UTM Northing (km)
UTM Easting (km)

FIGURE 29

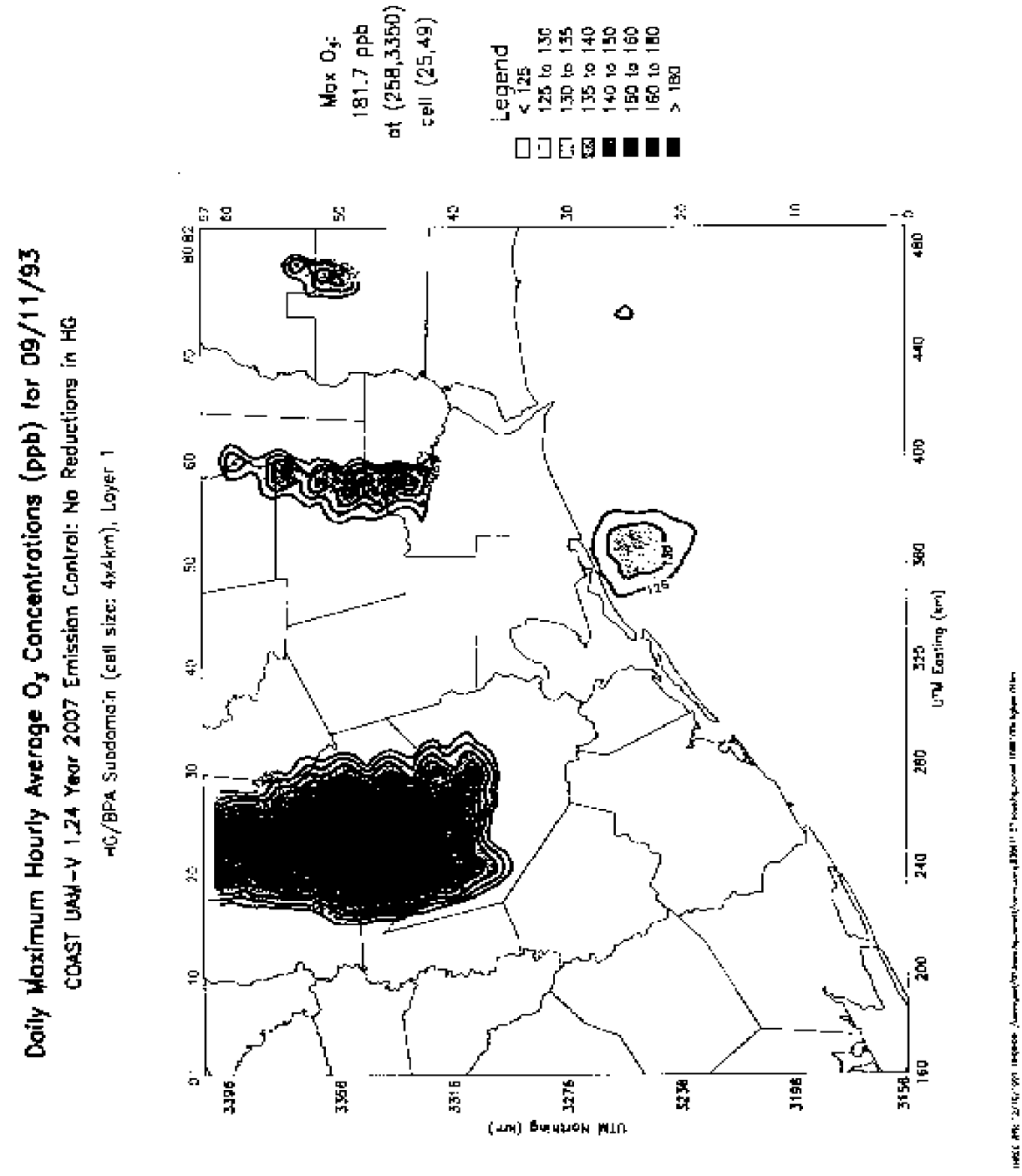
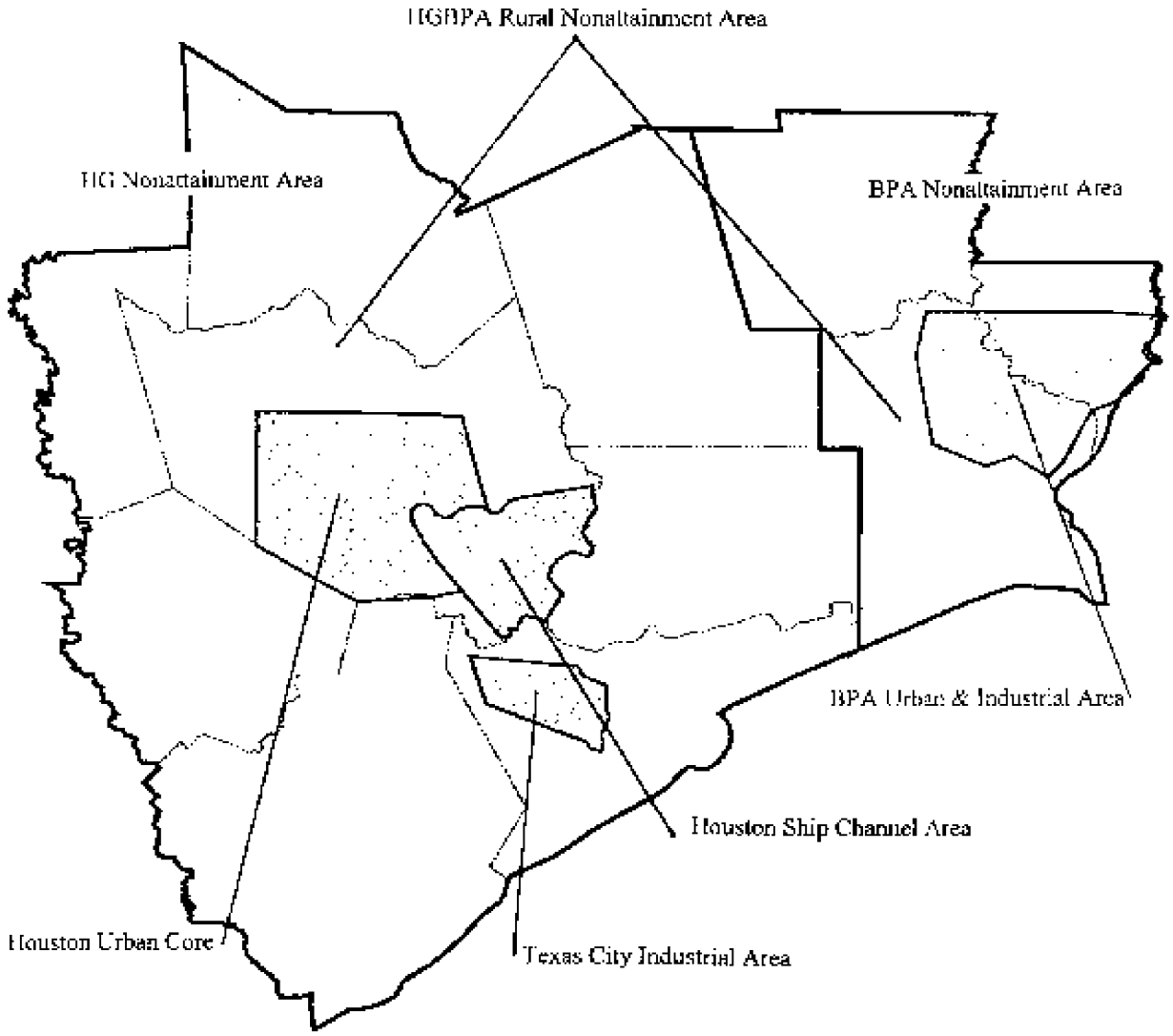

Daily Maximum Hourly Average O_3 Concentrations (ppb) for 09/11/93
COAST UAM-V 1.24 Year 2007 Emission Control: No Reductions in HG
HG/BPA Subdomain (cell size: 4x4km), Layer 1
Max O_3:
181.7 ppb
at (258,3360)
cell (25,49)
Legend
< 125
125 to 130
130 to 135
135 to 140
140 to 150
150 to 160
160 to 180
> 180
UTM Northing (km)
UTM Easting (km)

FIGURE 30

HGBPA Nonattainment Area



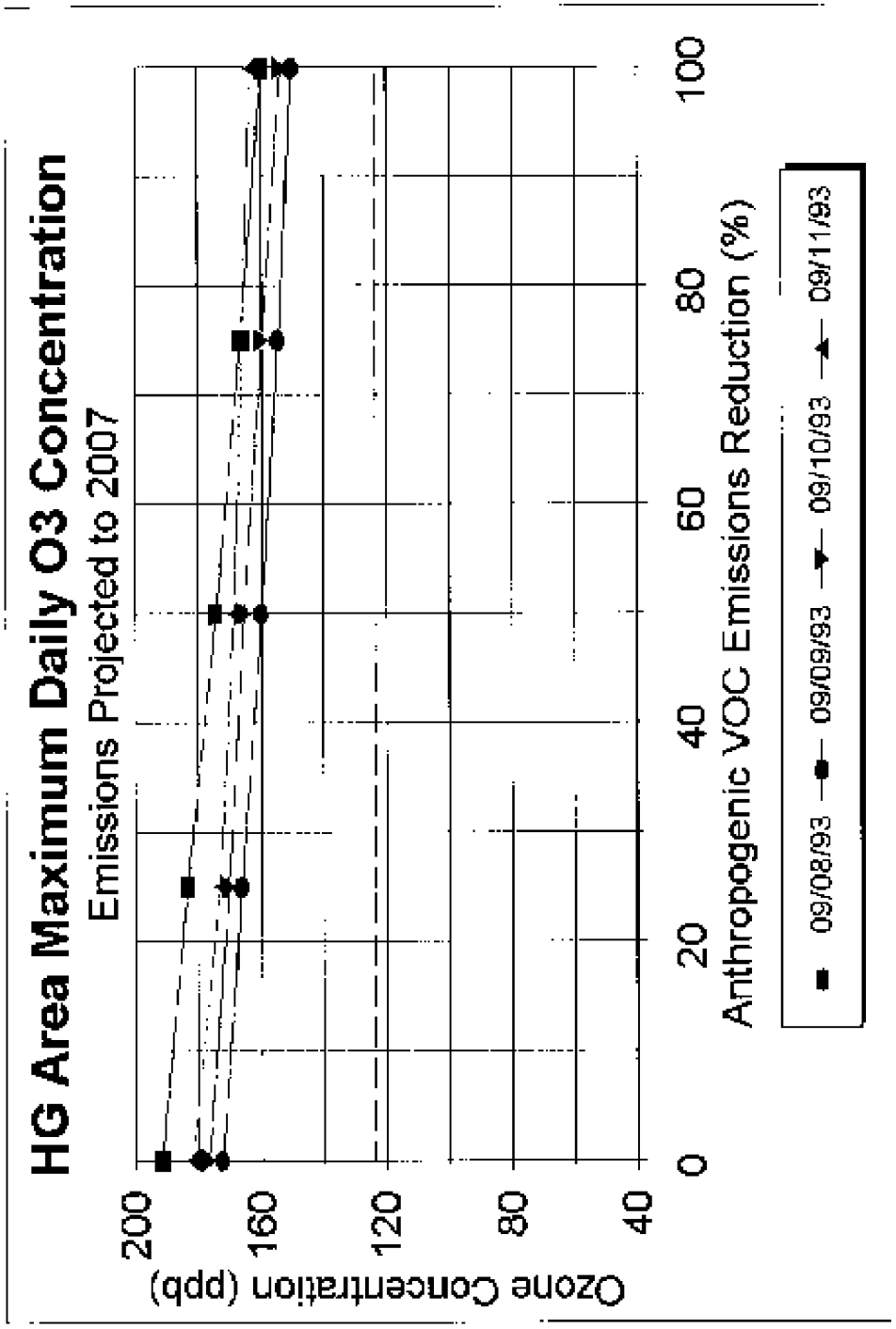


Figure 31 Daily Peak Ozone Response to VOC Reductions in the H G Area

FIGURE 32

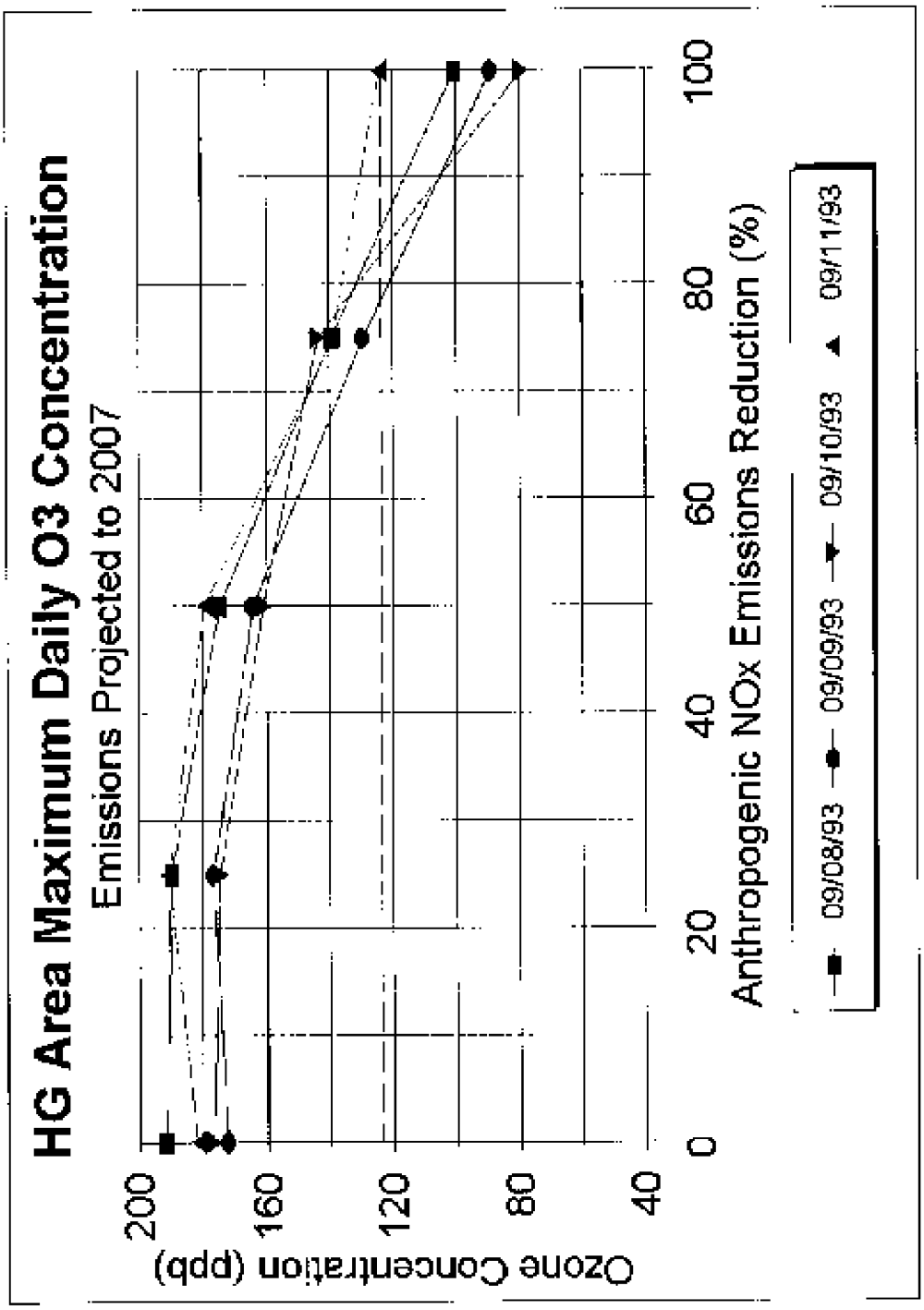


Figure 32 Daily Peak Ozone Response to NO_x Reductions in the H G Area

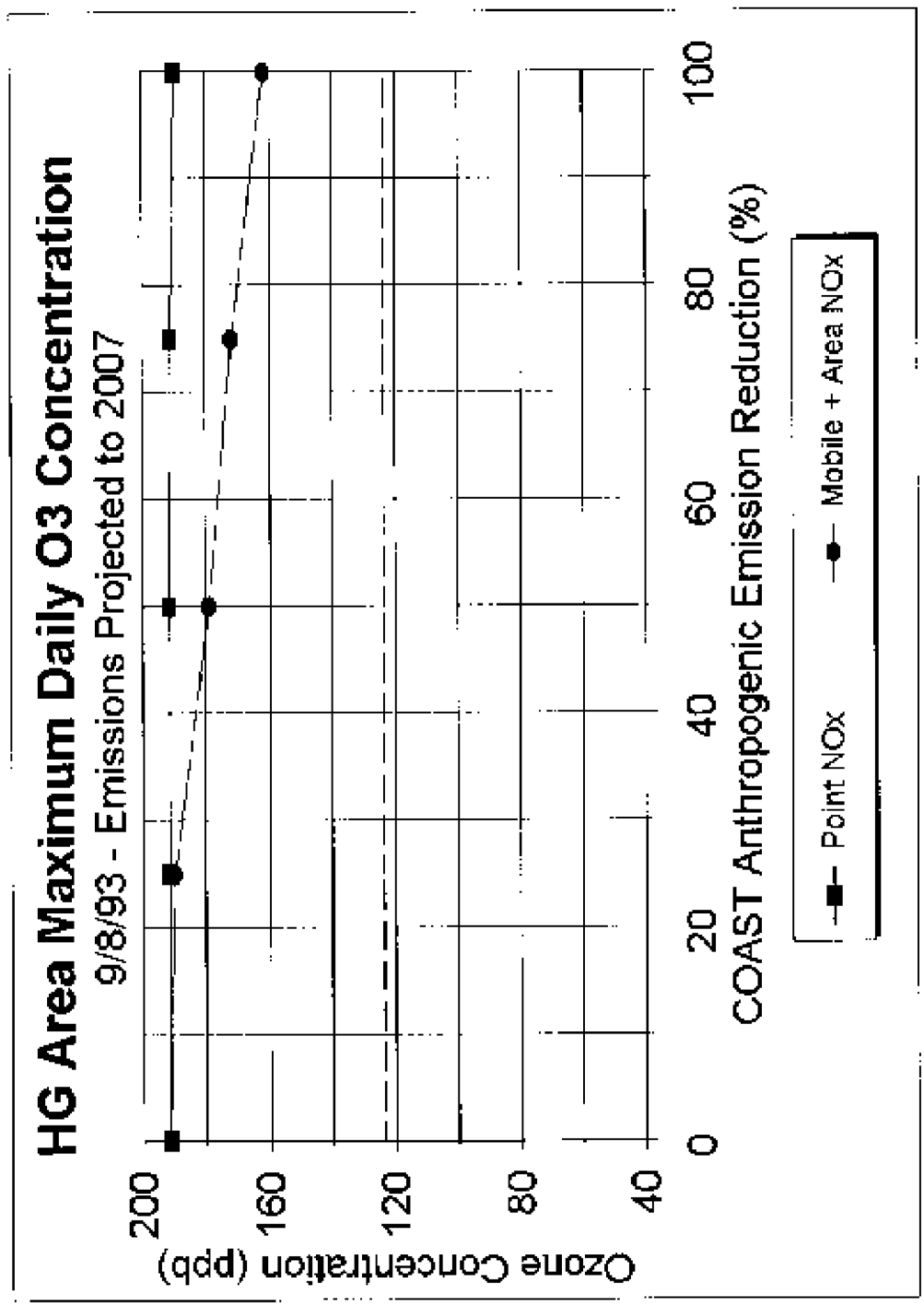


Figure 33 Peak Ozone Response to Point and non-Point NO_x Reductions in the Coast Domain, 9/8/93.

FIGURE 34

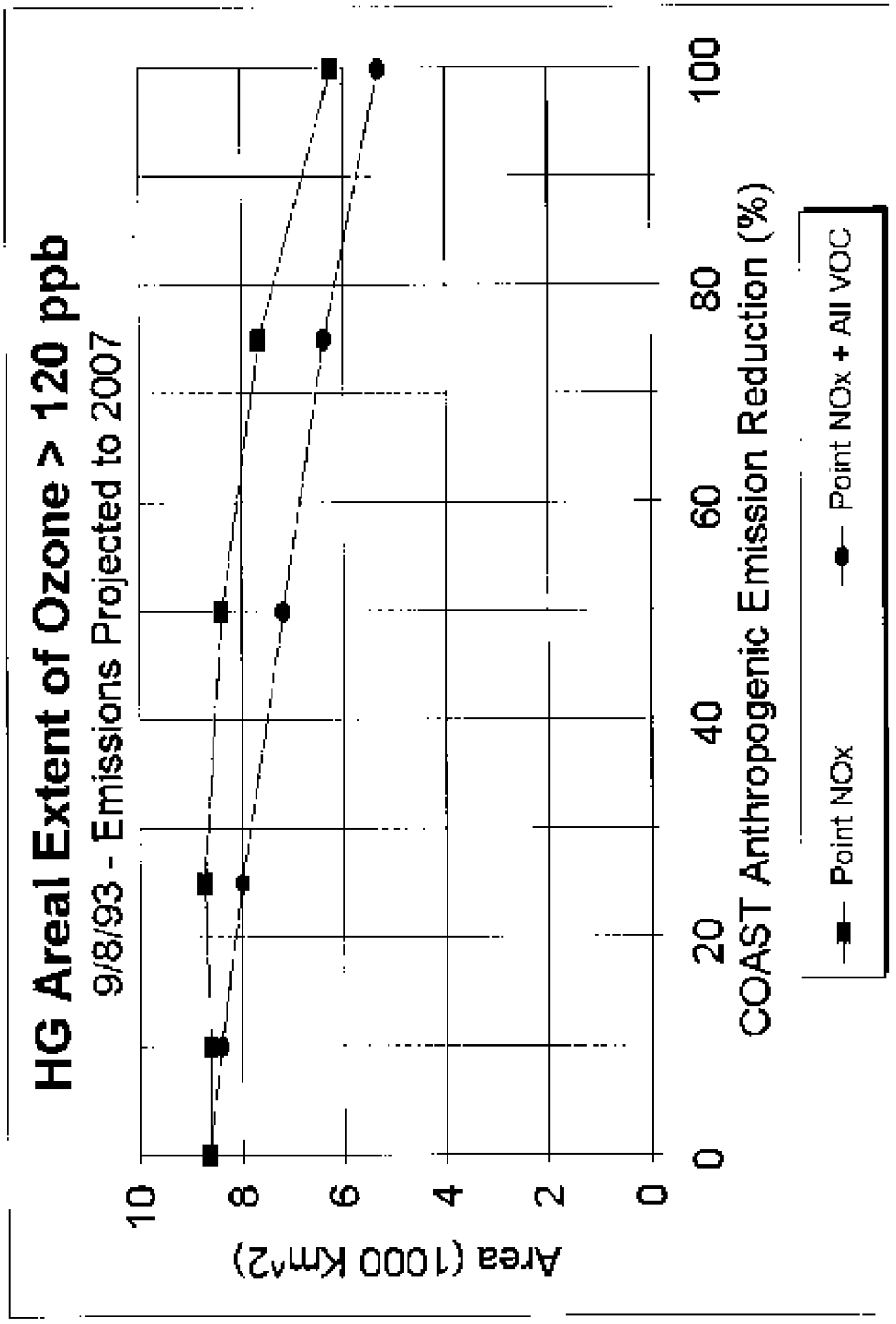


Figure 34 Peak Ozone Response to Point Source NO_x Reductions in the COAST Domain, 9/8/93

FIGURE 35

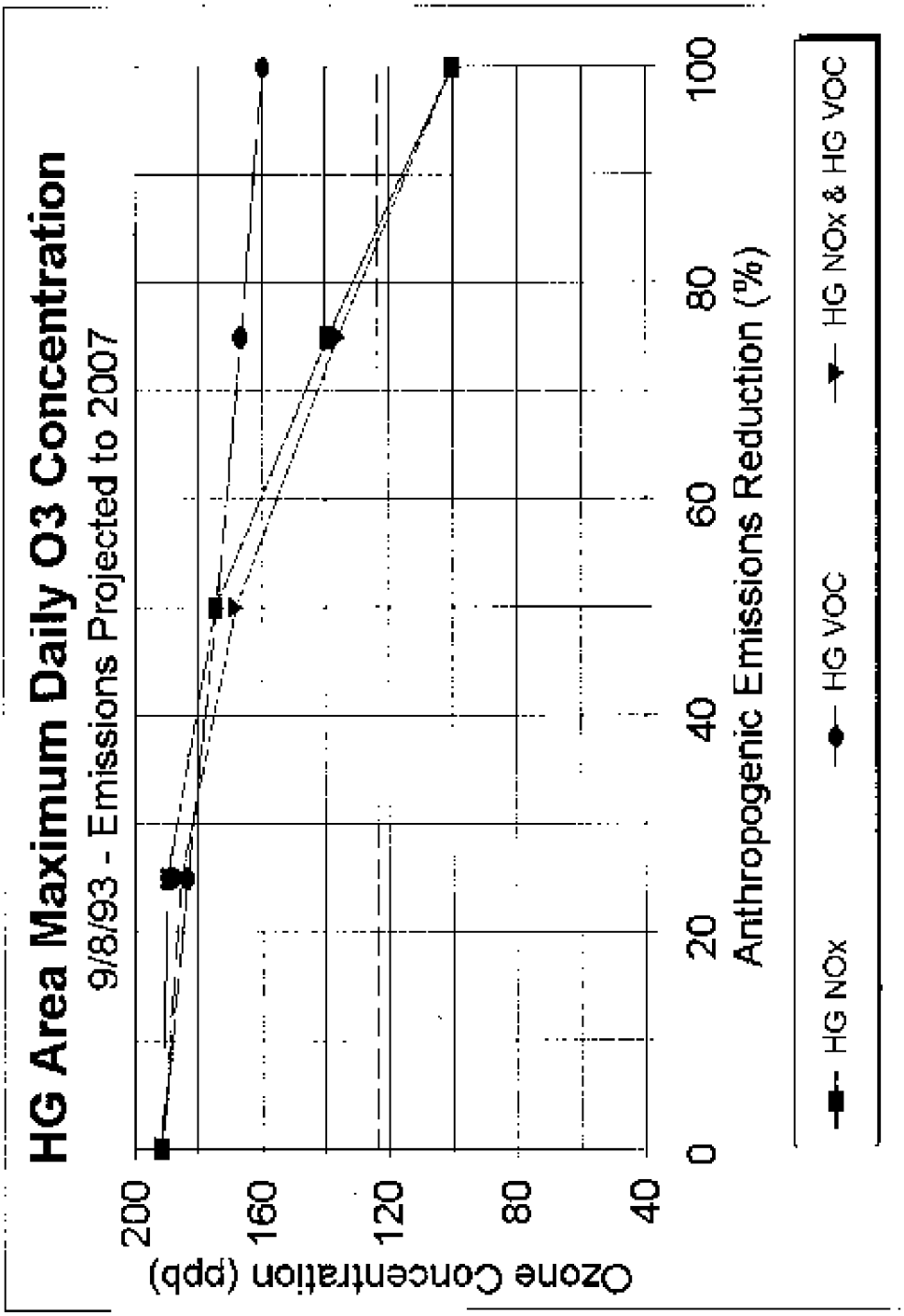


Figure 35 Peak Ozone Response to NO_x and VOC Reductions in the H-G Area, 9/8/93

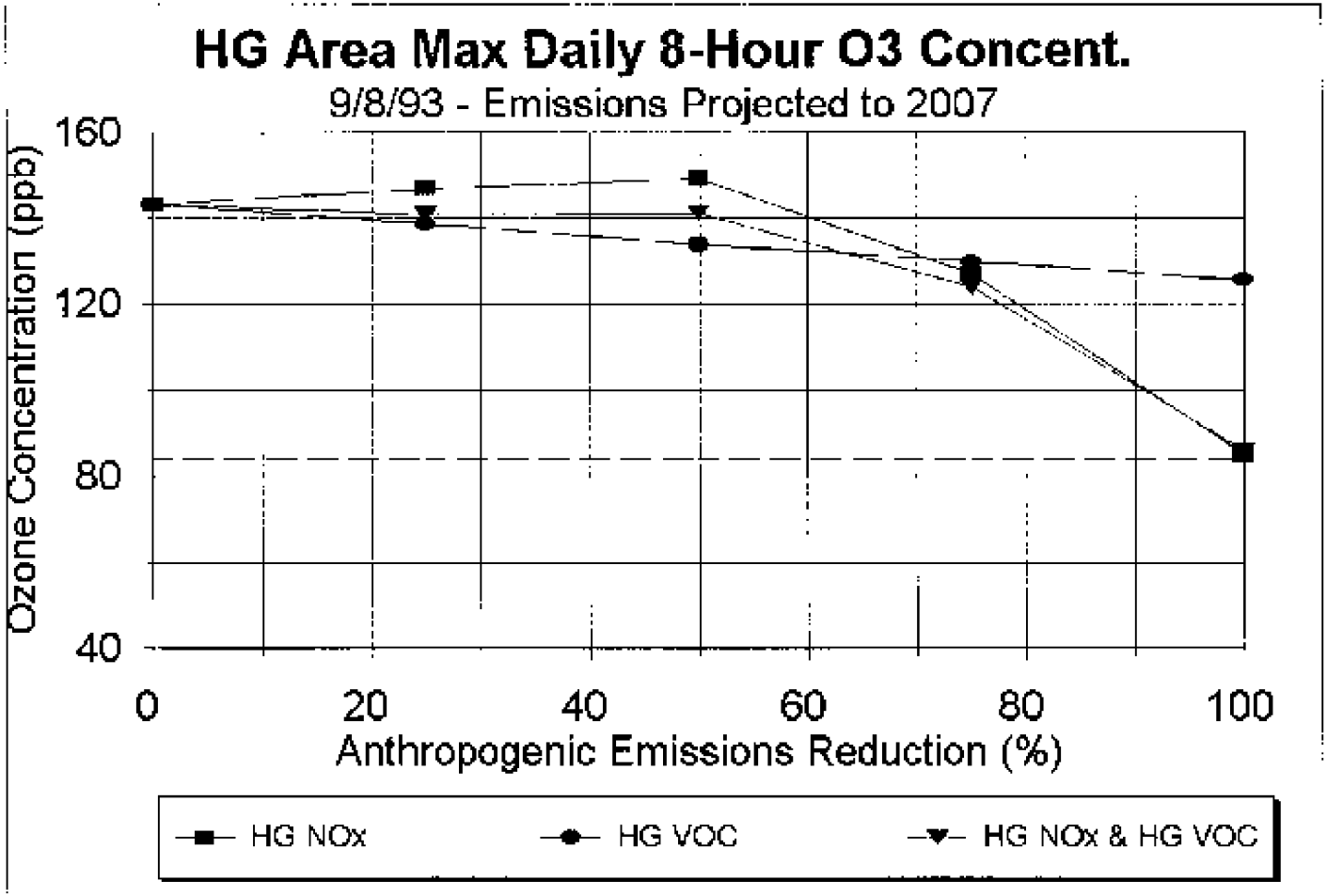


Figure 38 Peak 8-hour Ozone Response to NO_x and VOC Reductions in the H-G Area, 9/8/93

FIGURE 37

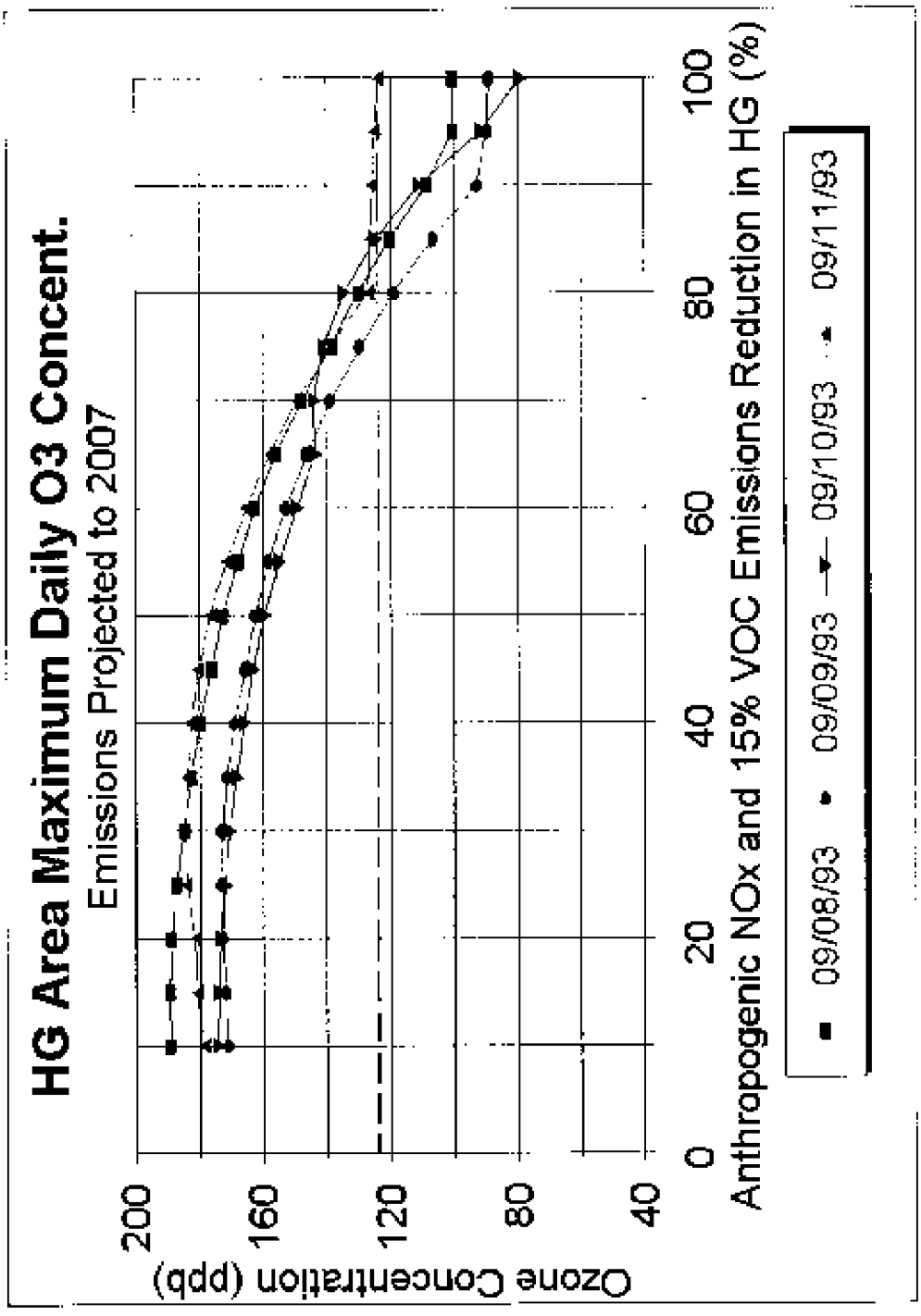


Figure 37 Daily Peak Ozone Response to NO_x Reductions with 15% VOC Reduction in the H-G Area

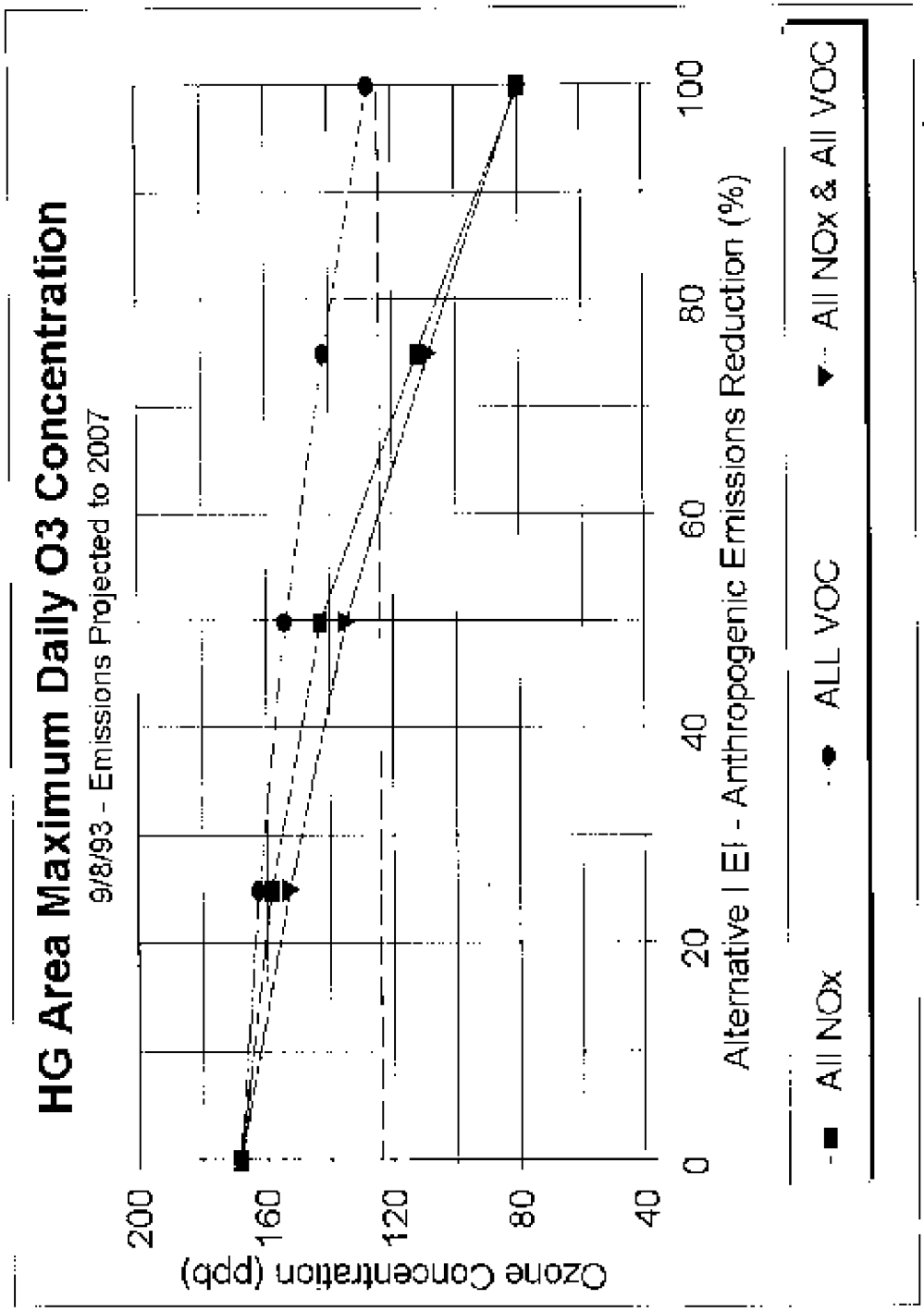


Figure 38 . Peak Ozone Response to COAST NO_x and VOC Reductions in H G Area. Alternative Emissions Inventory 1.

FIGURE 39

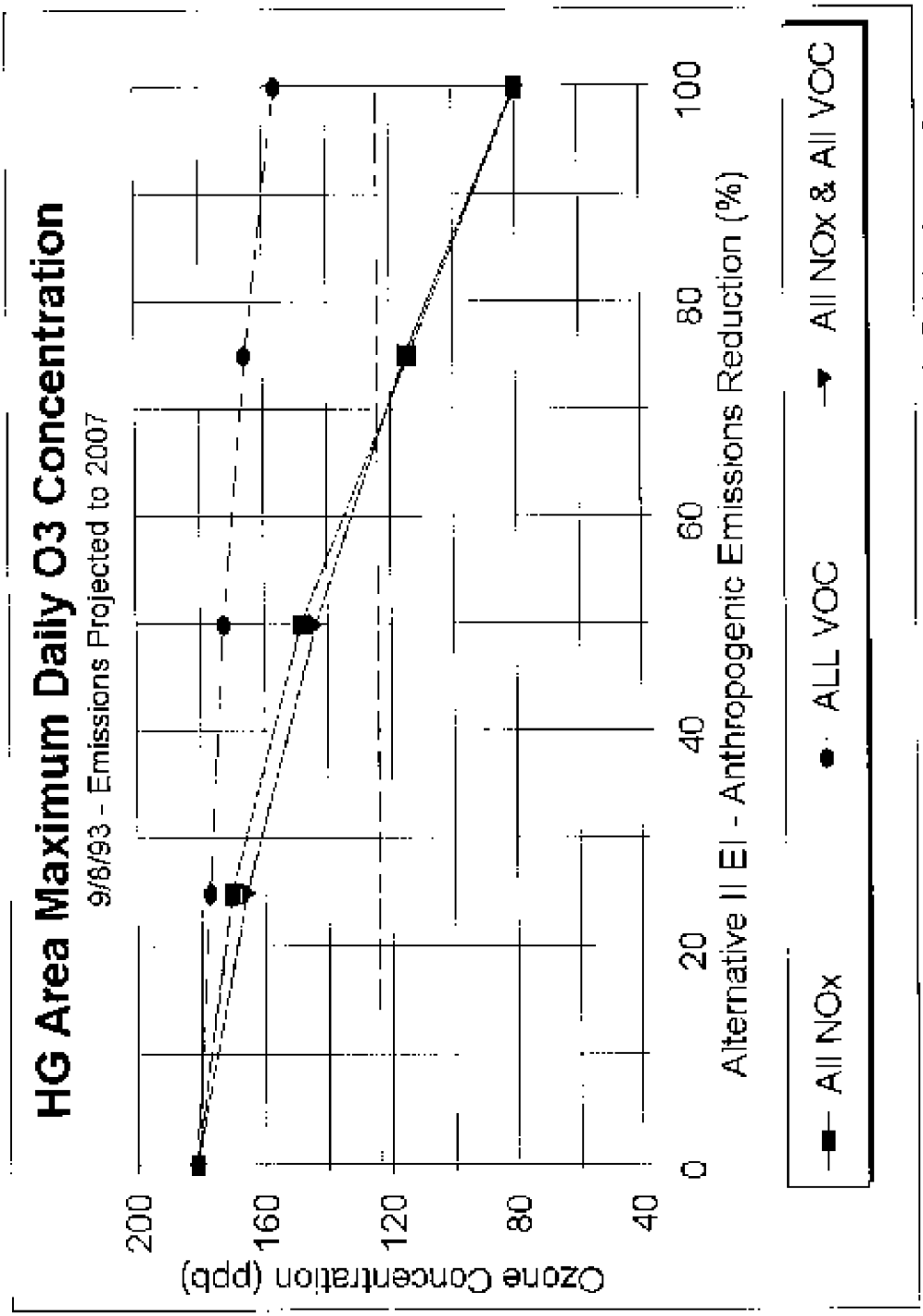


Figure 39 : Peak Ozone Response to COAST NO_x and VOC Reductions in H-G Area, Alternative Emissions Inventory 2.

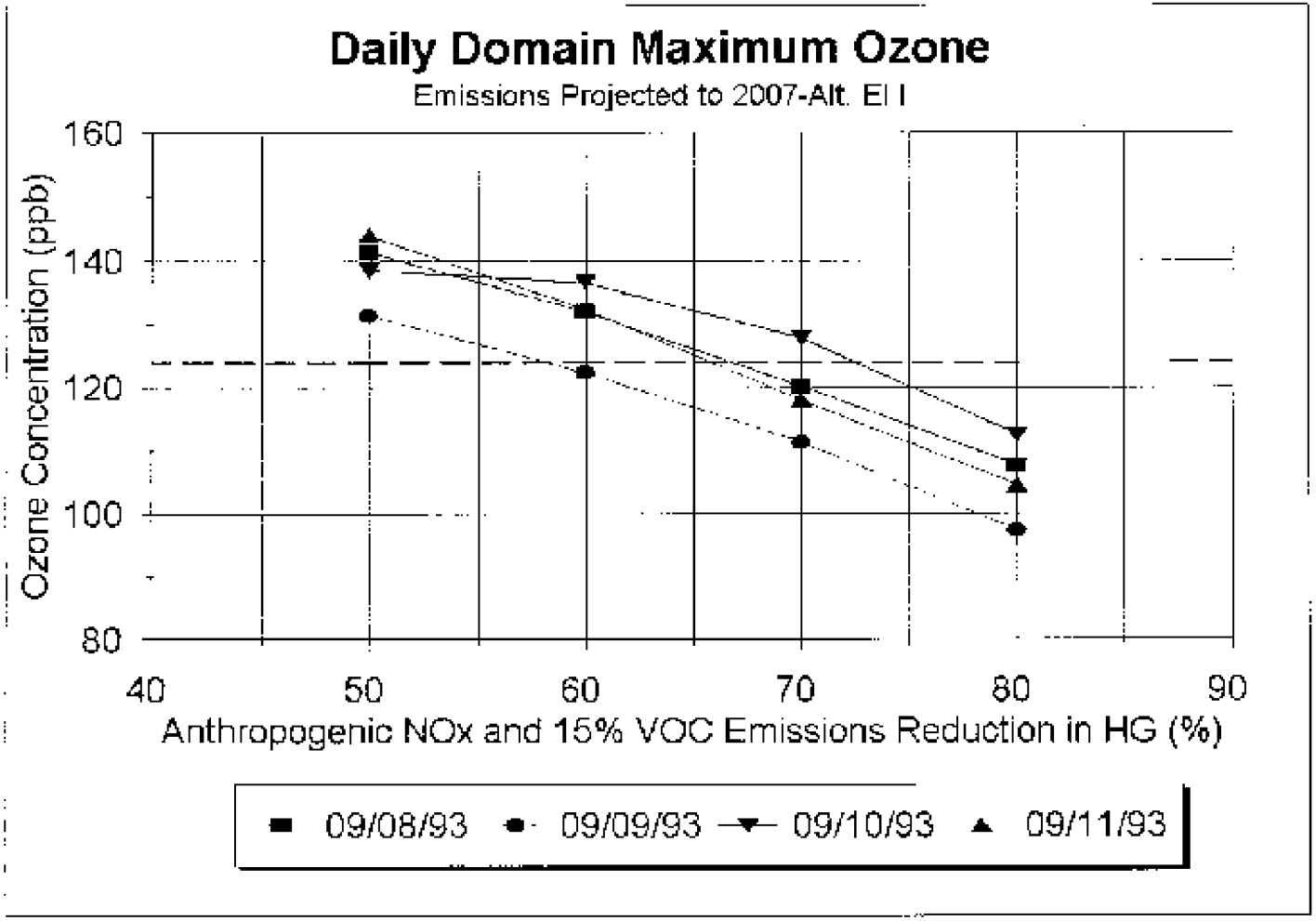


Figure 40 : Peak Ozone Response to H-G NO_x Reductions in H-G Area, Alternative Emissions Inventory

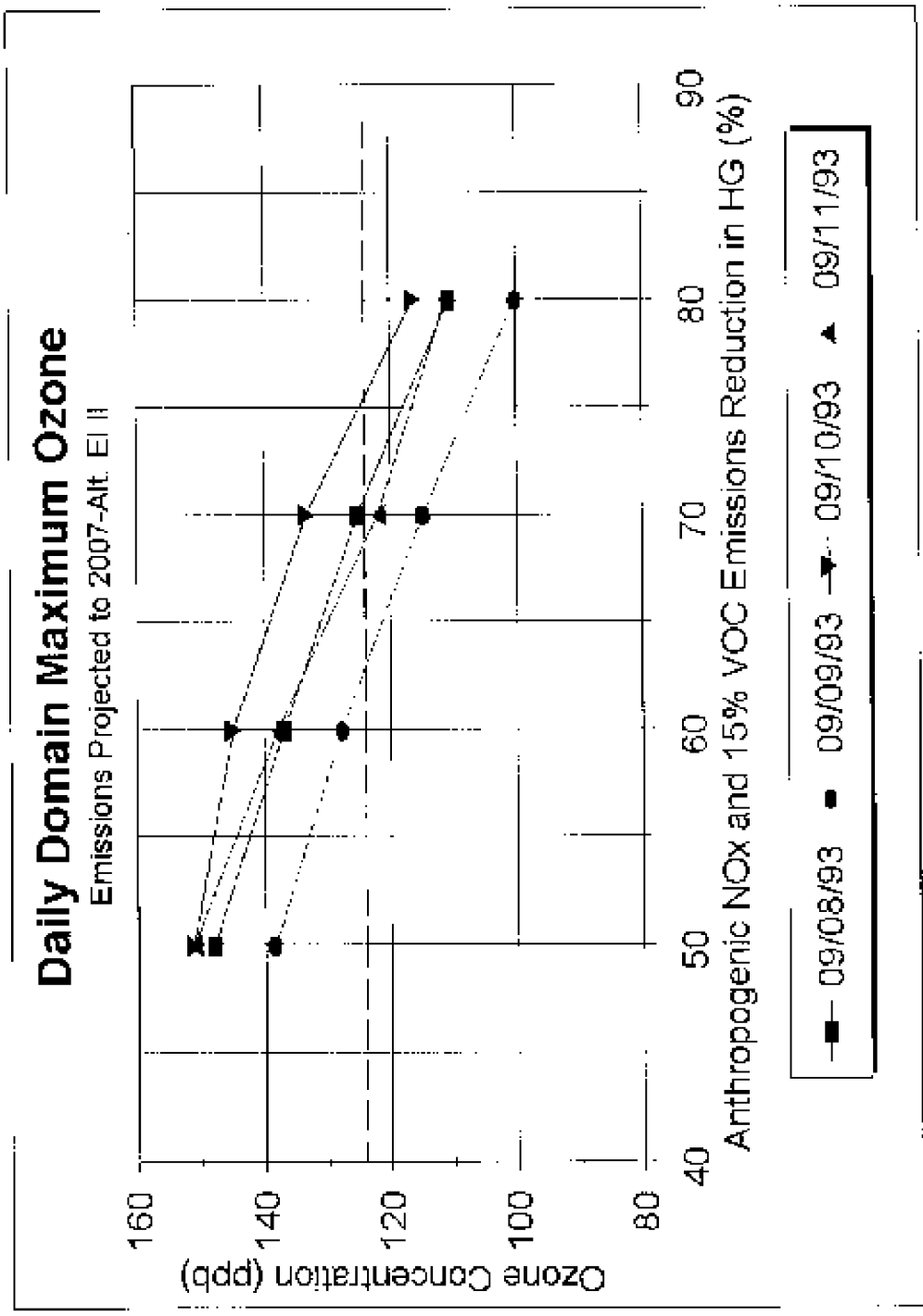


Figure 41 Peak Ozone Response to H-G NO_x Reductions in H-G Area, Alternative Emissions Inventory 2.

FIGURE 42

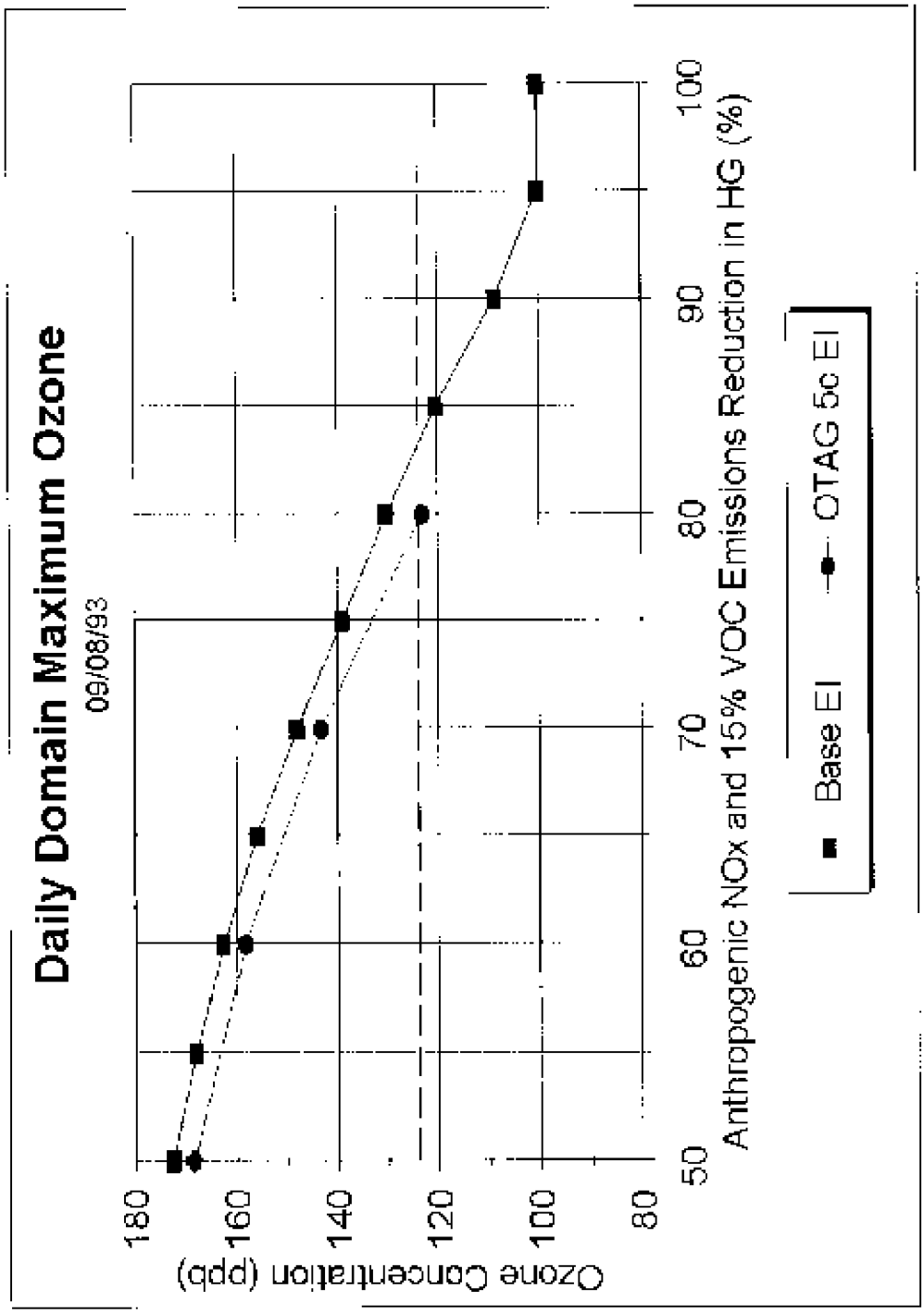


Figure 42 Peak Ozone Response to II-G NO_y Reductions in II-G Area, With & Without Regional Reductions, Sept. 8

FIGURE 43

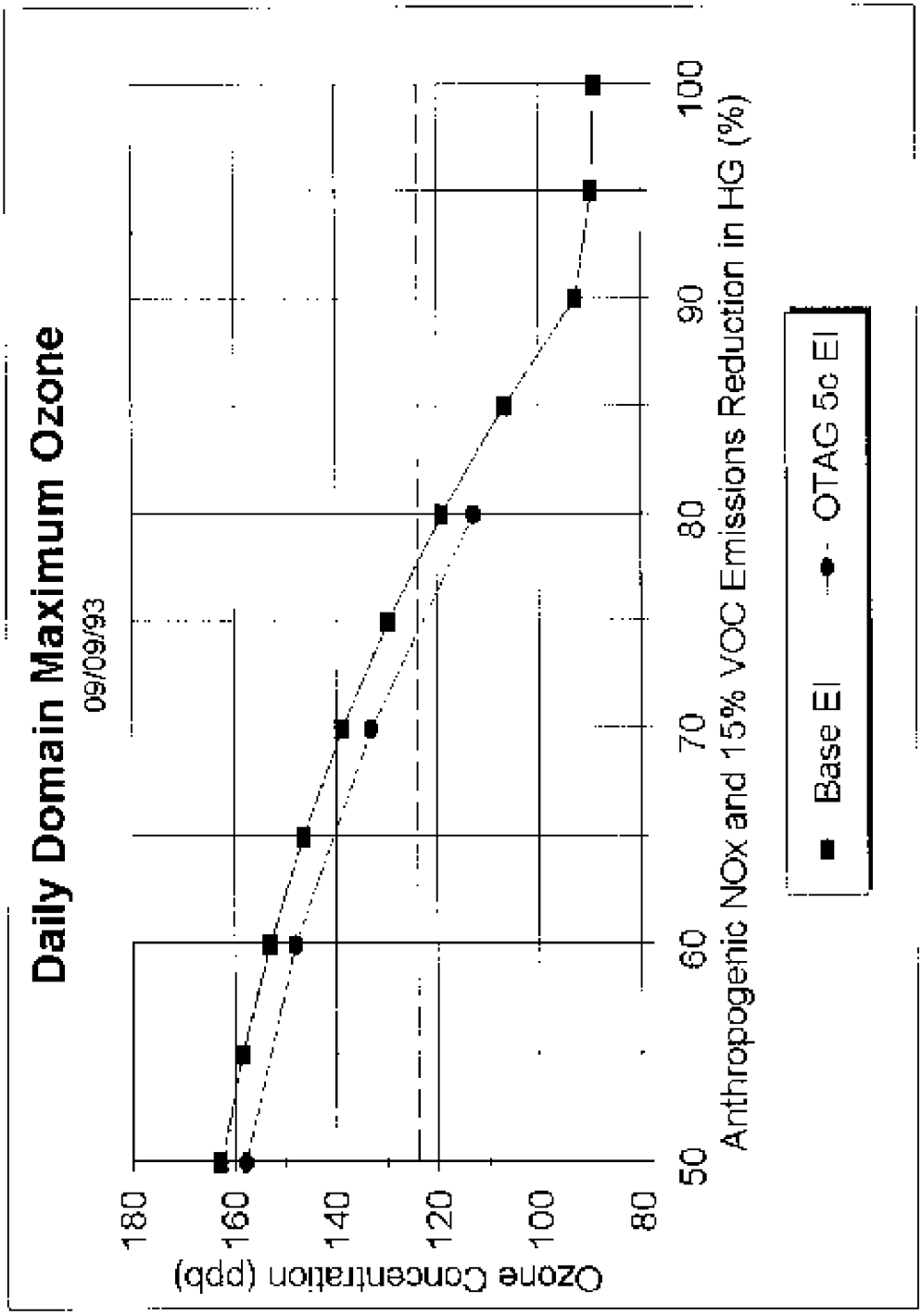


Figure 42 Peak Ozone Response to H-G NO_x Reductions in H-G Area, With & Without Regional Reductions, Sept. 9

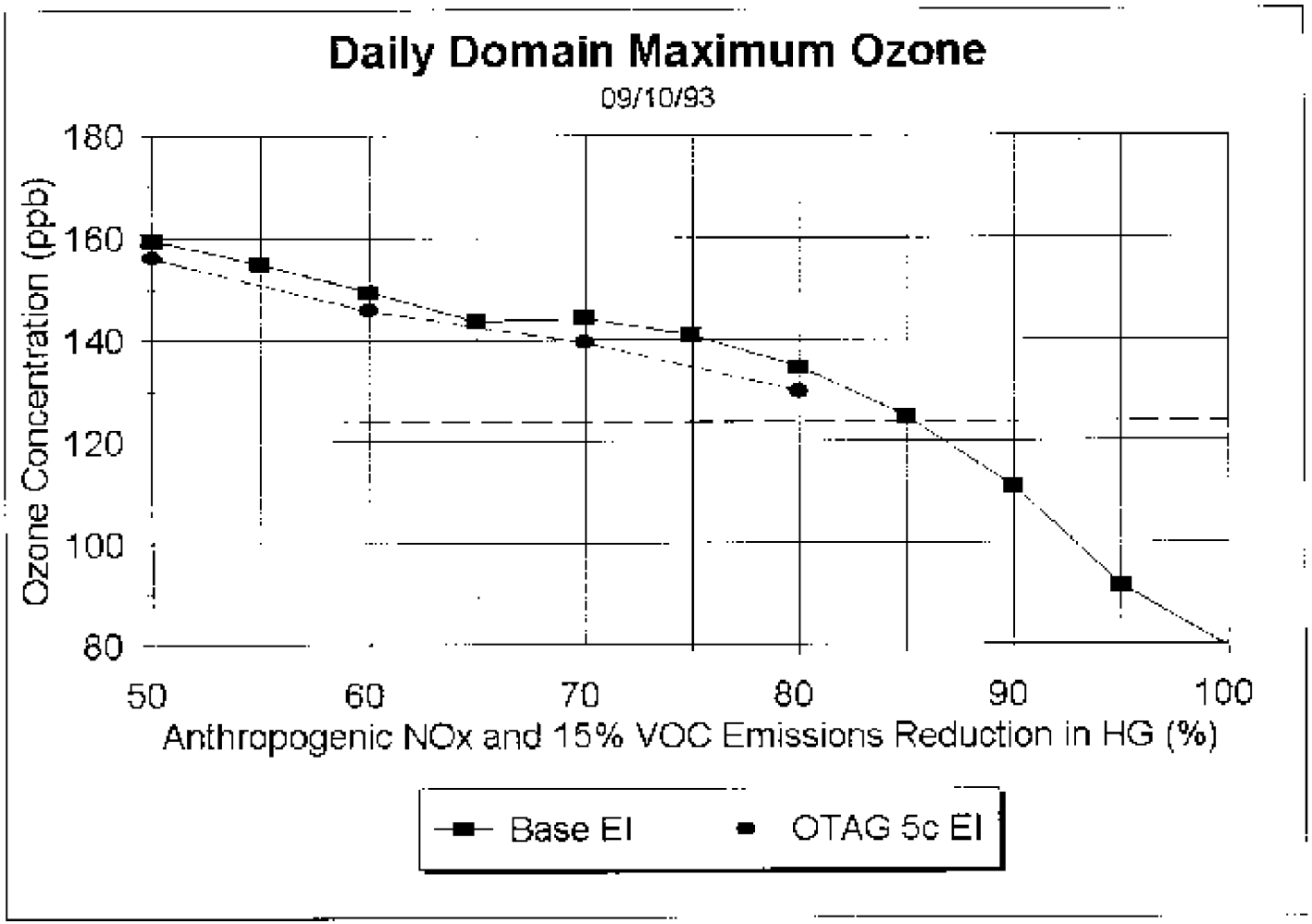


Figure 4A : Peak Ozone Response to H G NO_x Reductions in H-G Area, With & Without Regional Reductions, Sept. 10

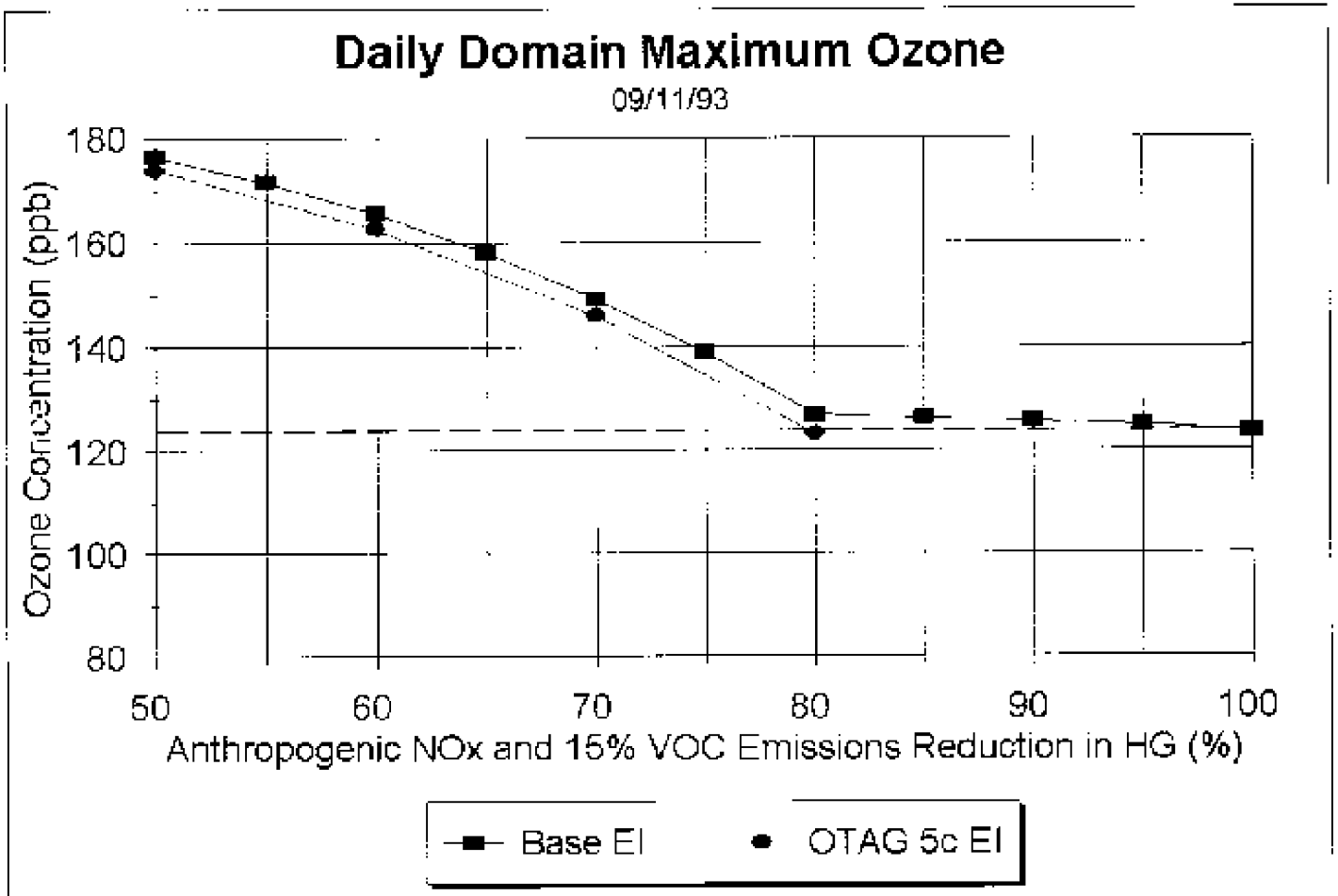
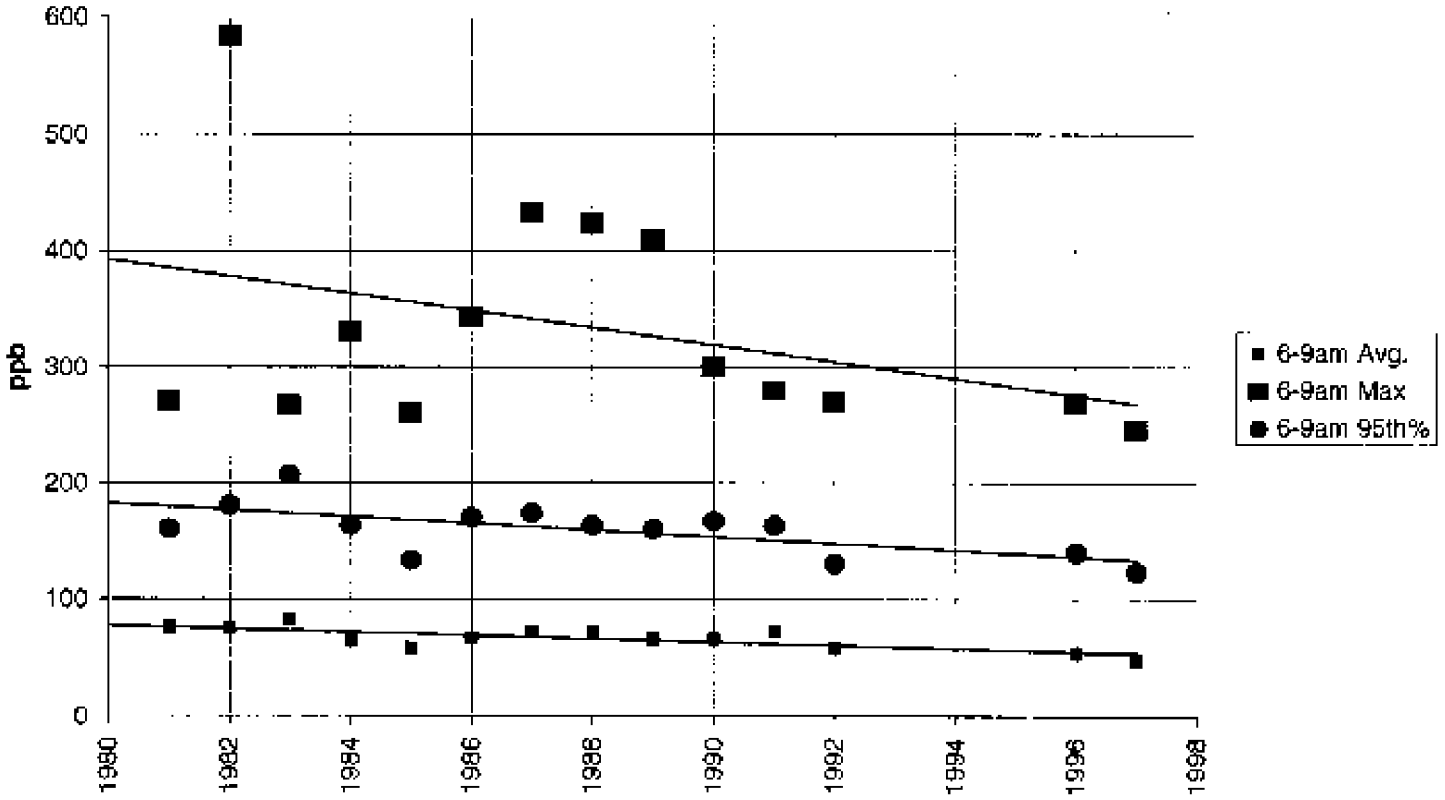


Figure 43 Peak Ozone Response to H-G NO_x Reductions in H-G Area, With & Without Regional Reductions, Sept. 11

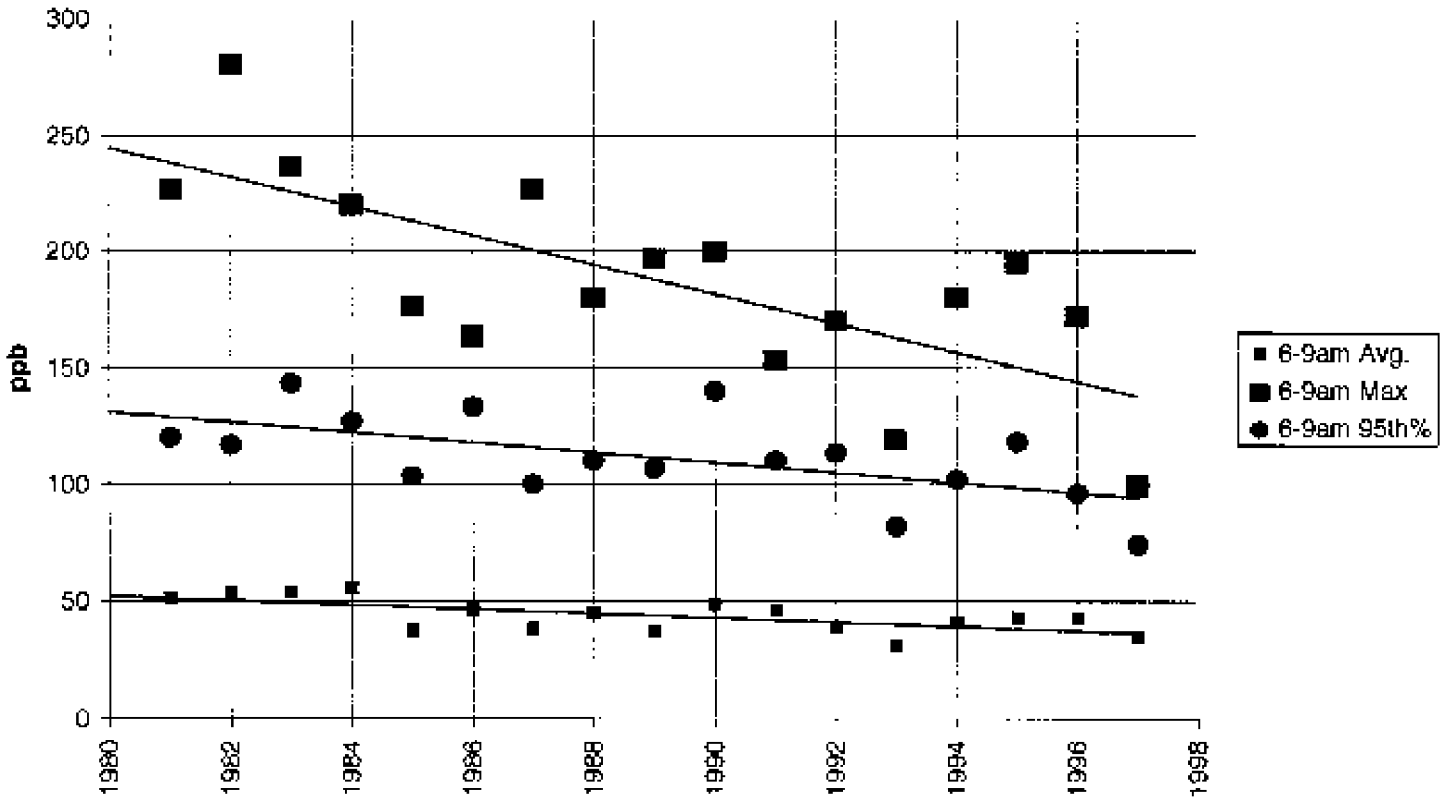
FIGURE 43

Figure 46 Houston East NOx Indicators



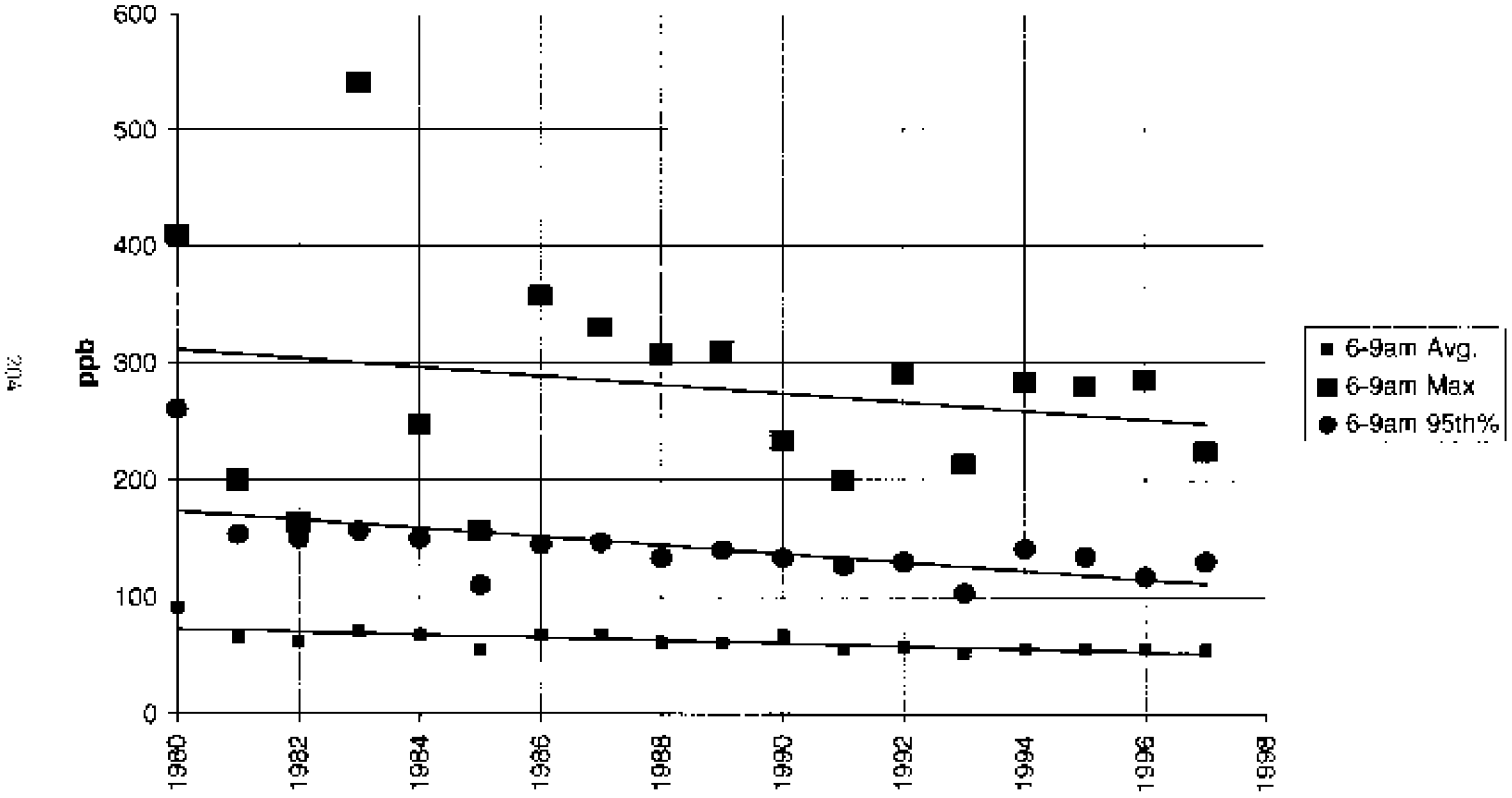
c:\1_dsul\o3ana\woe\noxuni.xls

Figure 47 Aldine NOx Indicators



c:\1_dsull\1o3anal\woe\noxuni.xls

Figure 43 Clinton Dr. NOx Indicators



c:\1_dsull\1o3anal\woe\noxuni.xls

Figure 19 Houston Clinton Dr. VOCs Summer 6-9 a.m. Averages

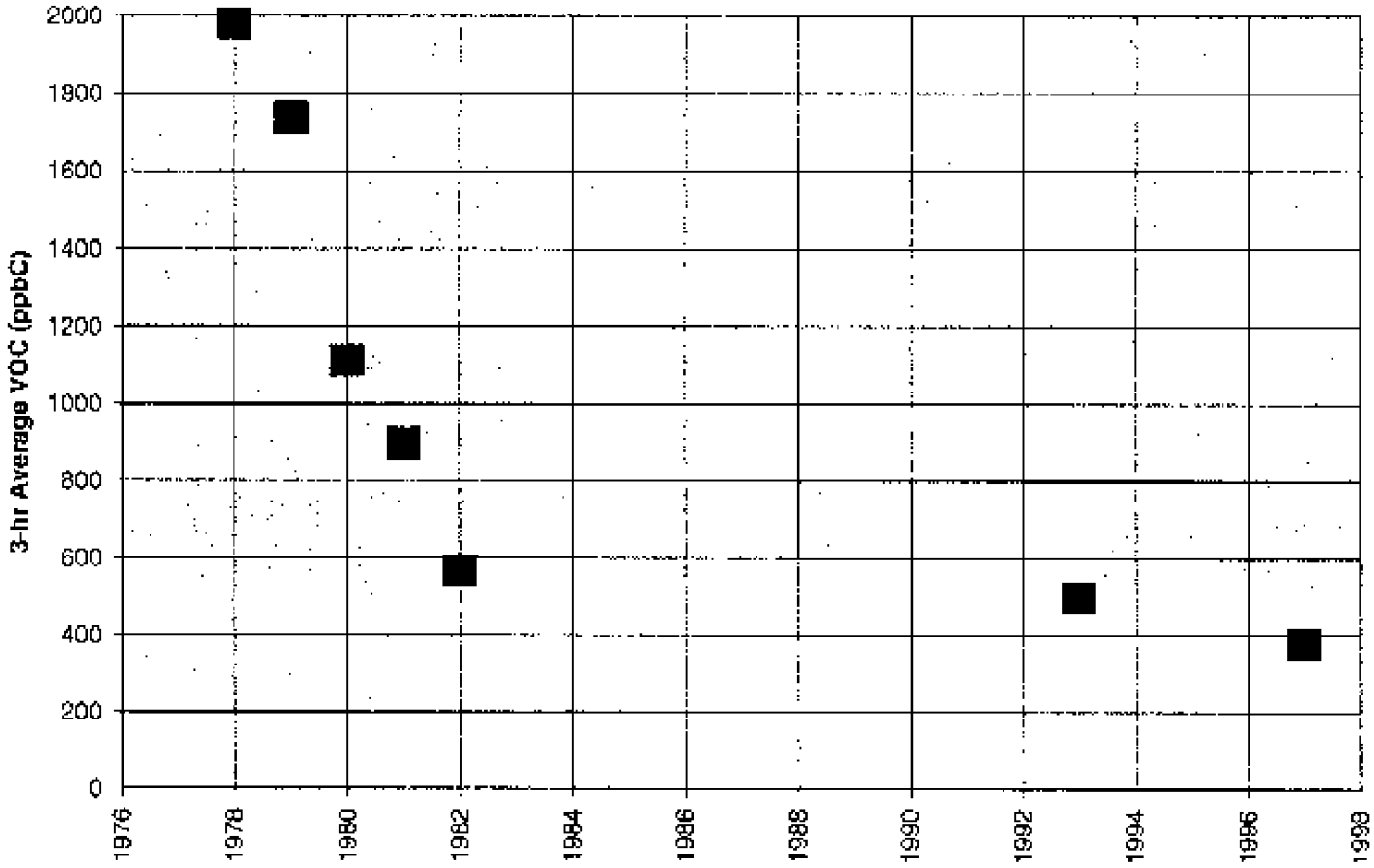


Figure 50 All HRM Sites: Sum of all VOCs

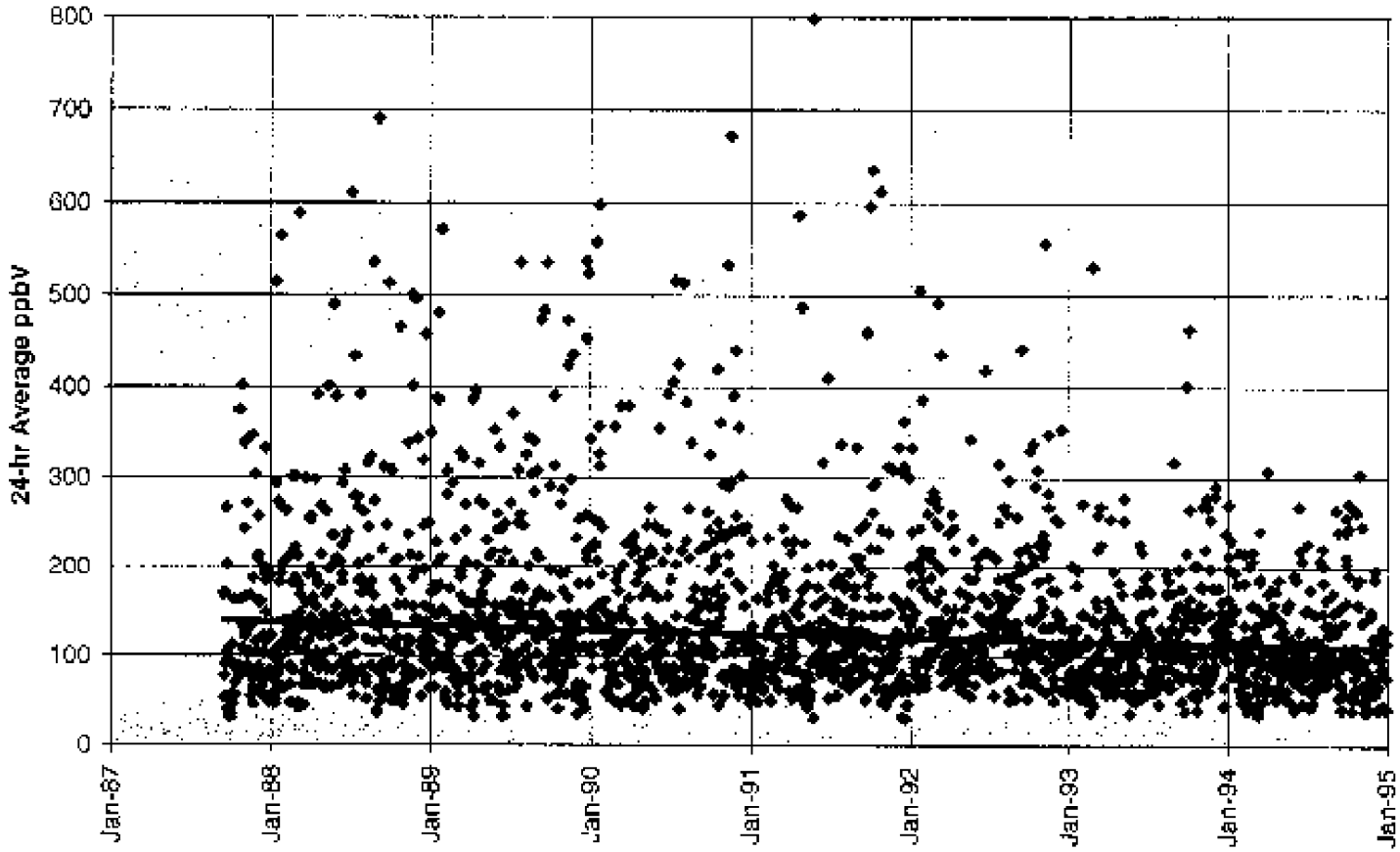


Figure 3) Houston Regional Monitoring Network Sites and the TNRCC/City of Houston Clinton Drive Site in Industrial Areas around Houston

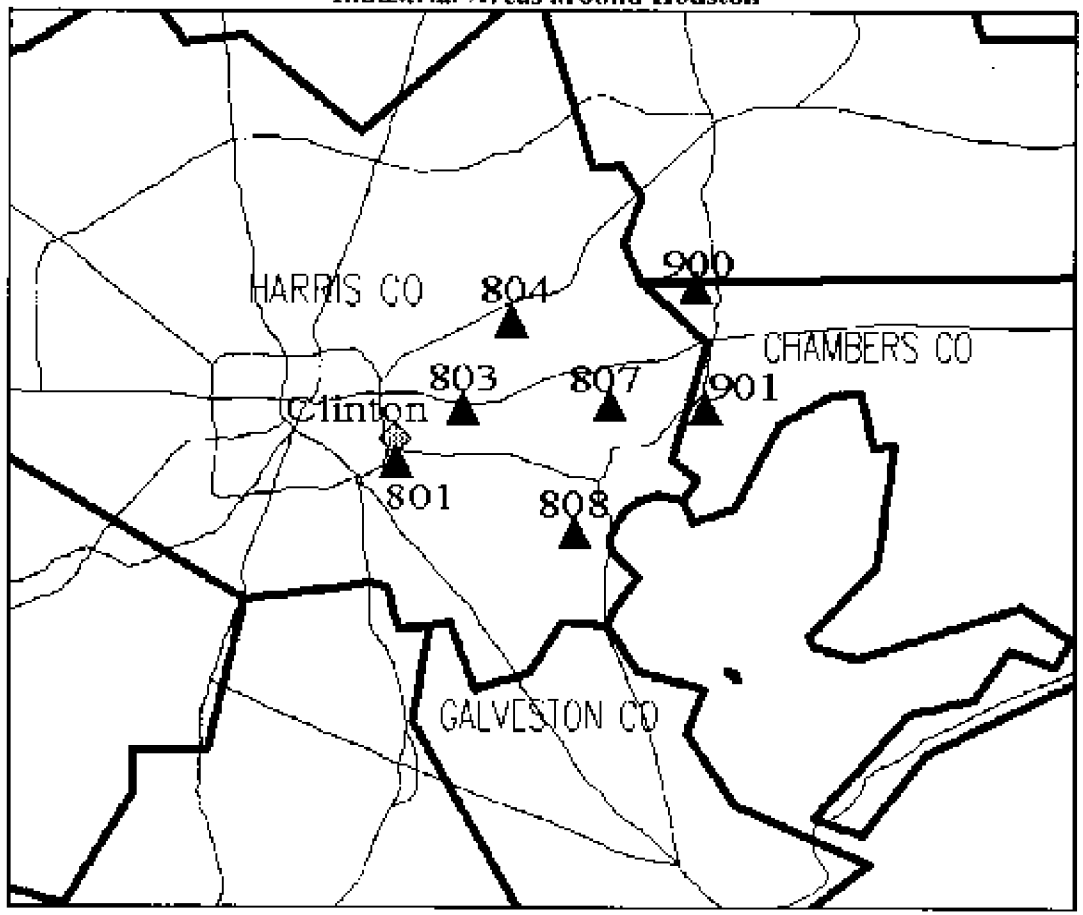


Figure 52. Ozone Design Values (DV)-Year Relation for the Houston-Galveston-Brazoria Nonattainment Area

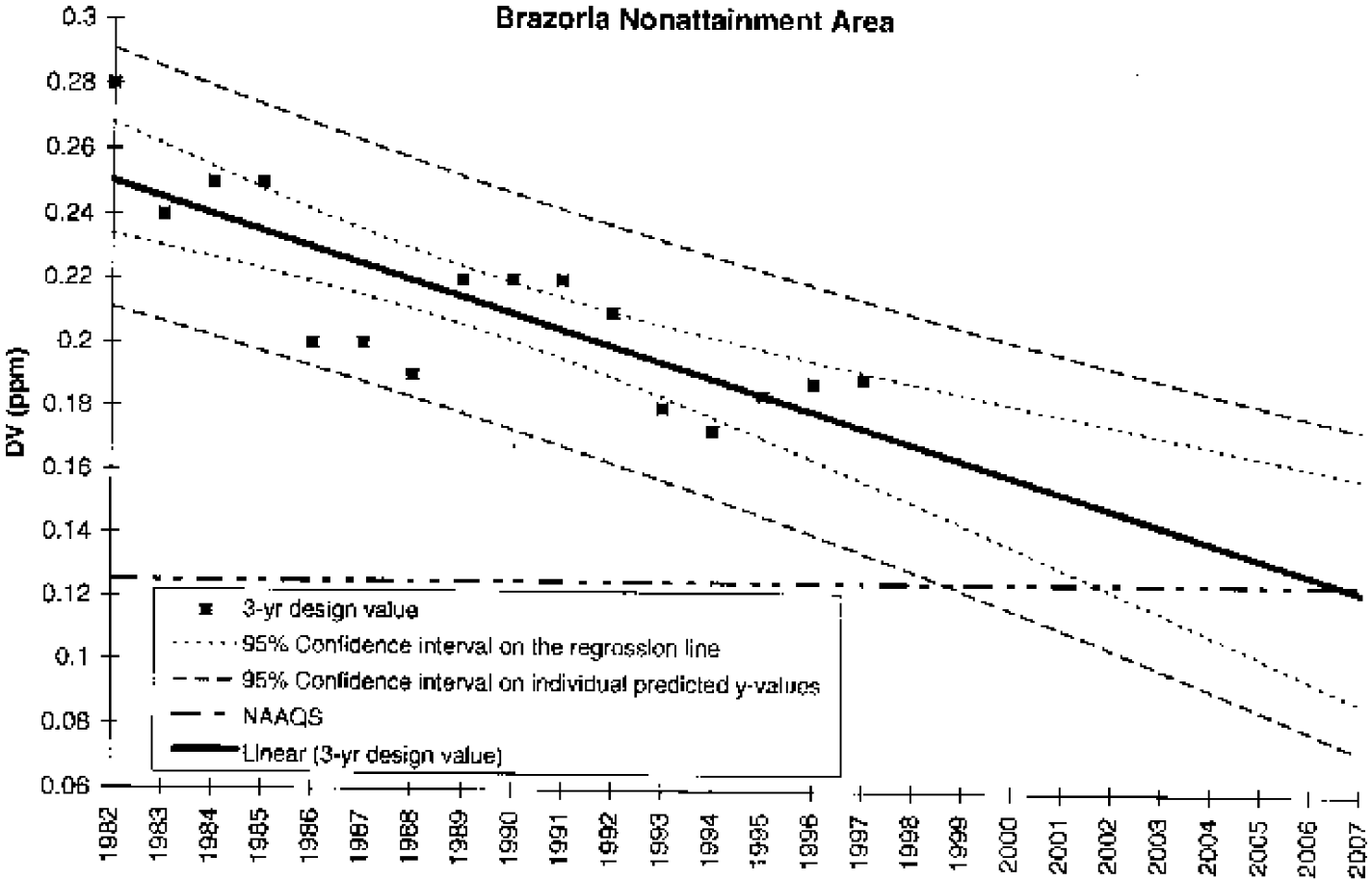
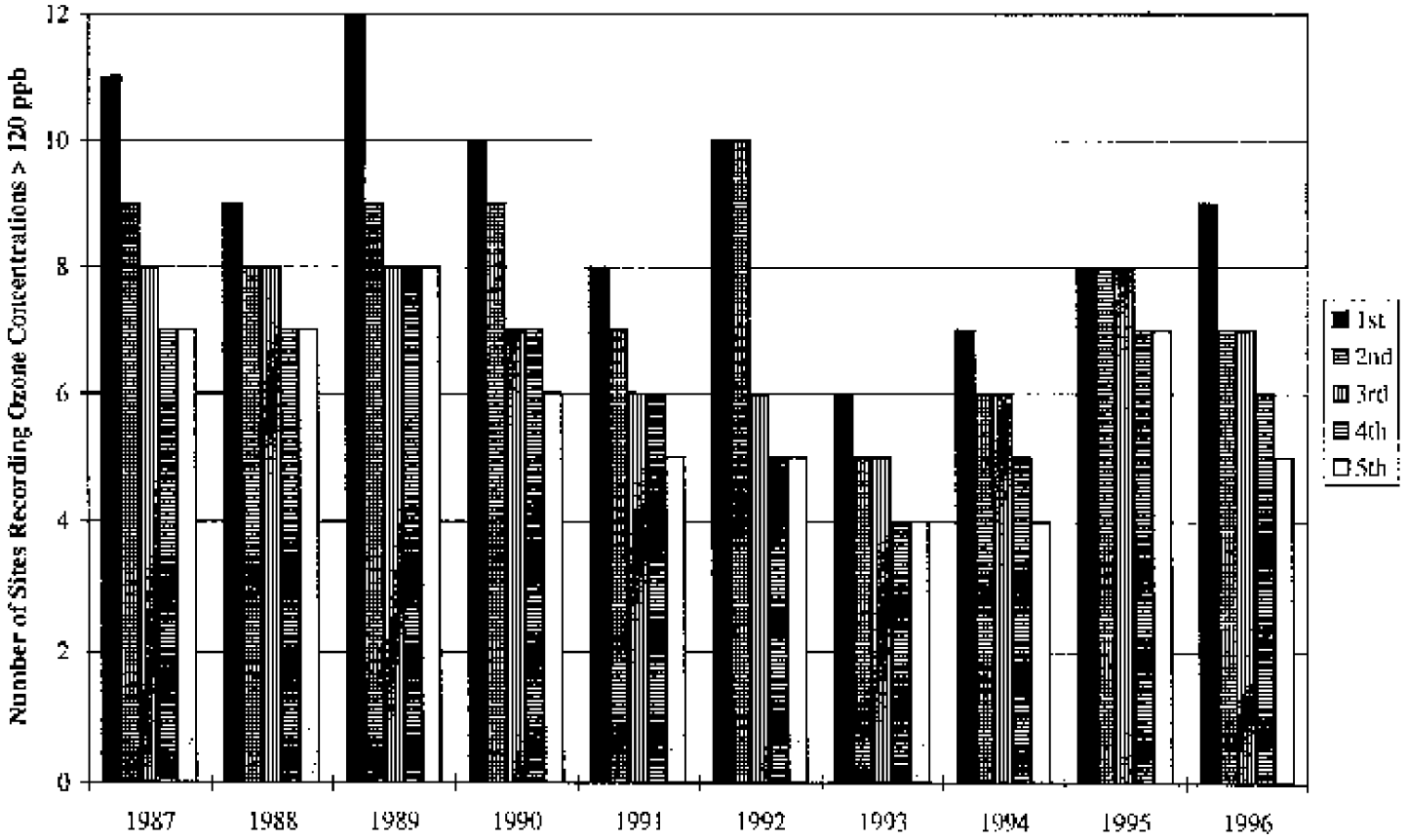
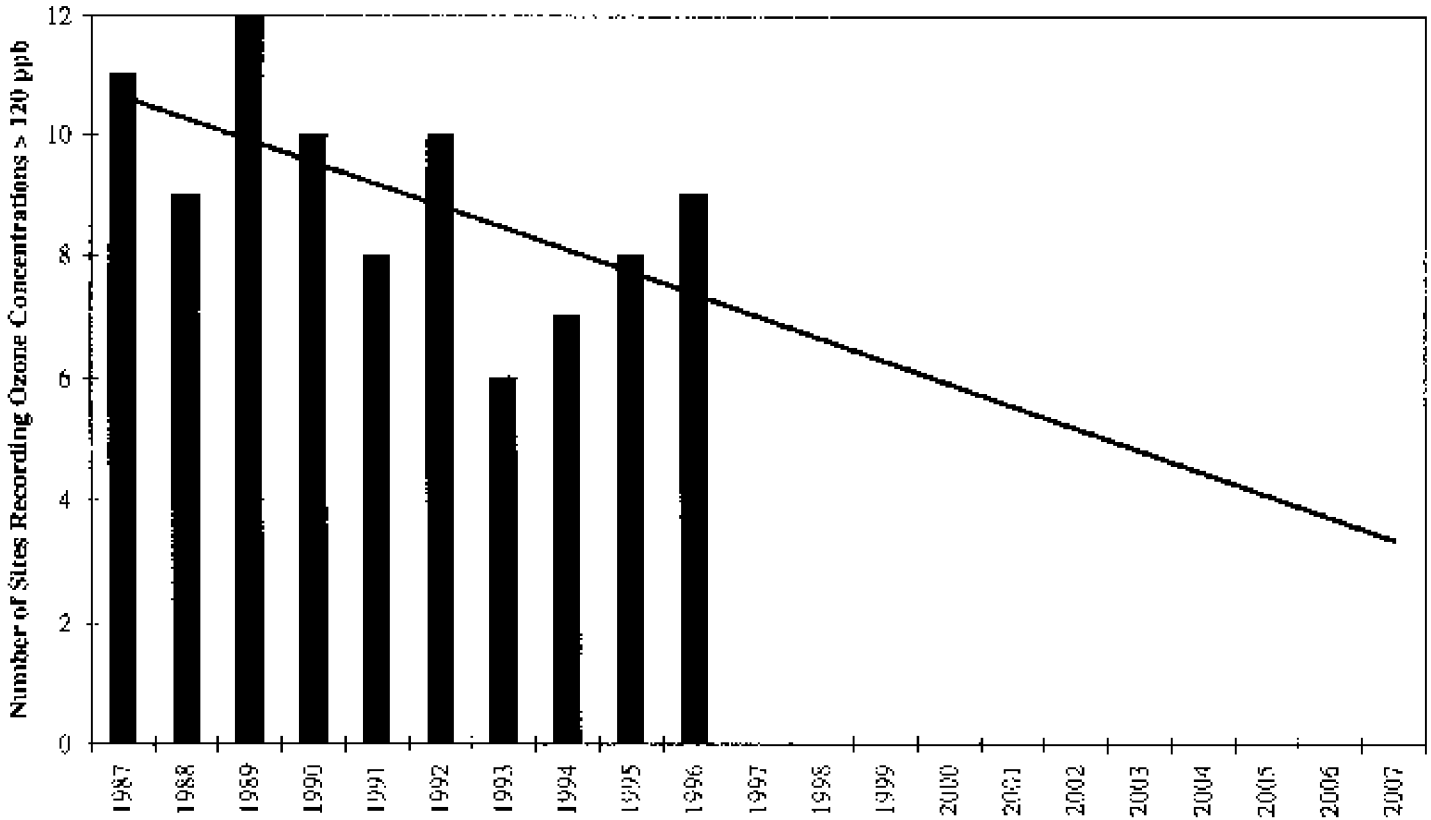


Figure 53 Ozone Areal Exposure in the Houston Area 1987-1996
Five Highest Days Per Year



KD d:\requests\oztrends\hgb\ozarea.xls

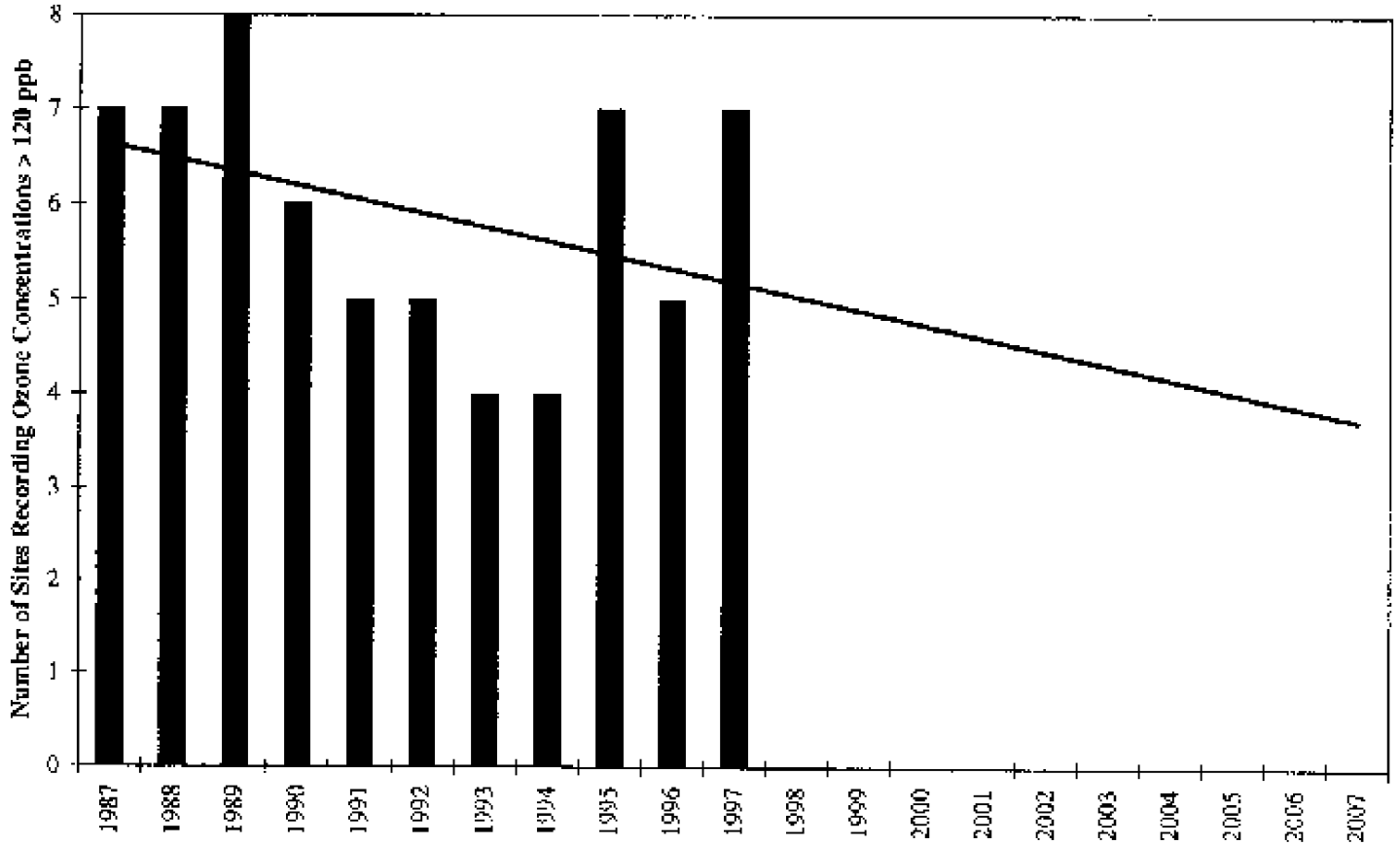
Figure 5: Ozone Areal Exposure in the Houston Area 1987-1996
Highest Day Per Year at 13 Core monitors



Kirk Dean, 12/17/97
d:\requests\oztrends\hgb\ozarea.xls

Figure 11

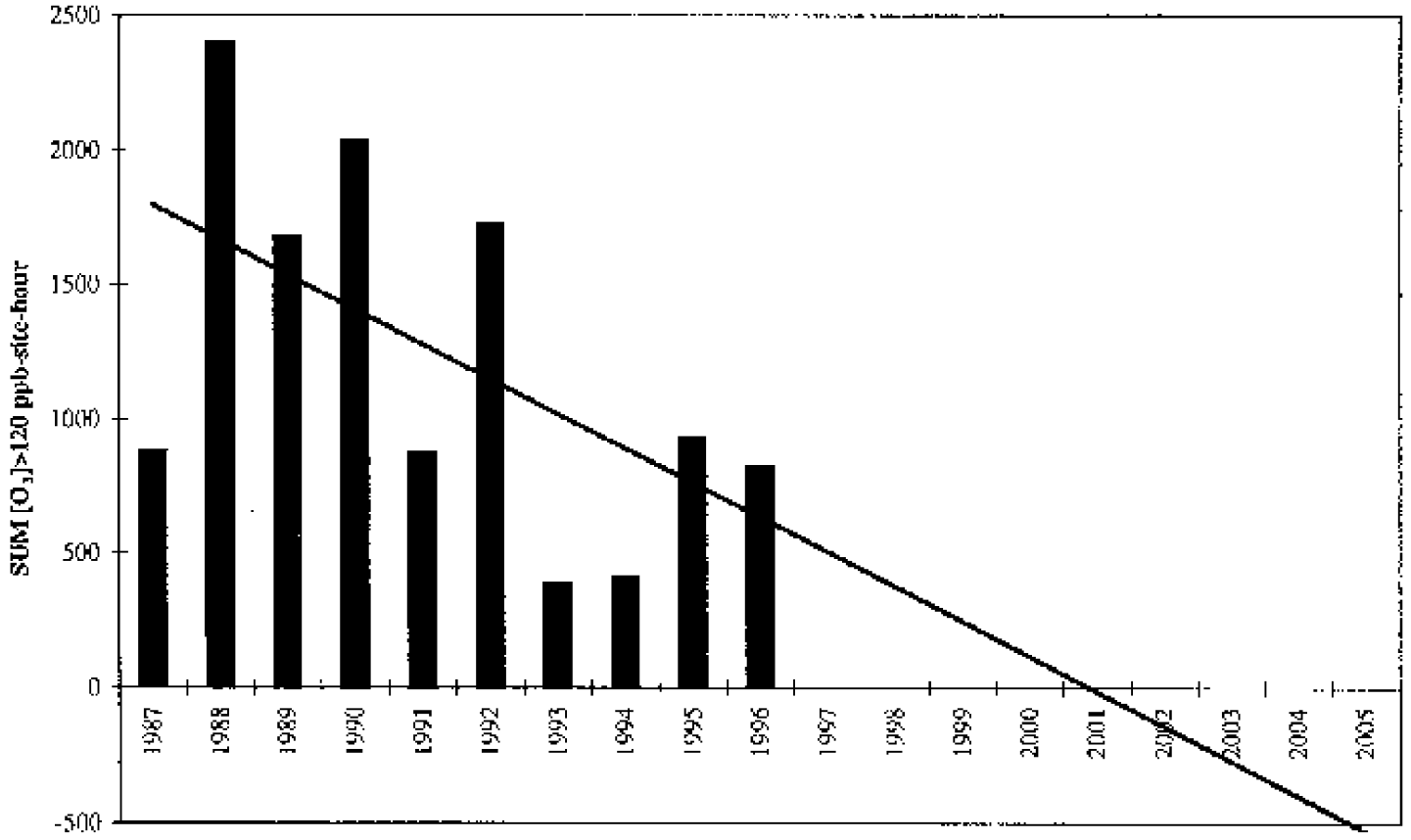
Figure 35 Ozone Areal Exposure in the Houston Area 1987-1997
Fifth Highest Day Per Year at 13 Core monitors



Kirk Dean, 12/17/97
d:\requests\oztrends\hgb\ozarea.xls

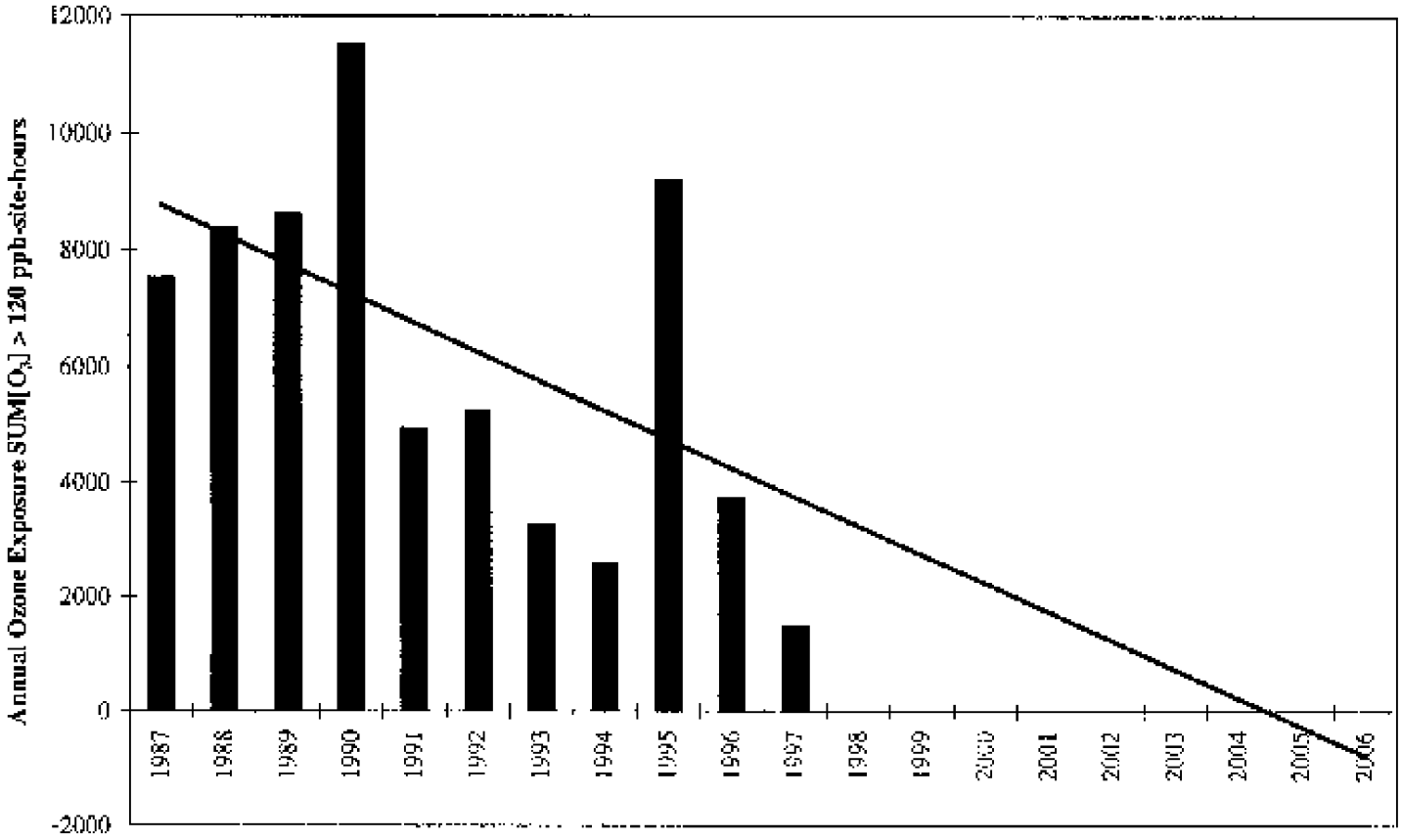
Figure 12

Figure 56. Highest Annual 24-hour Monitored Ozone Exposure Index Trends in the Houston Ozone Non-attainment Area



Kirk Dean, 12/01/1997
d:\requests\oztrends\hgb\sum120.xls

Figure 57 Trends in Measured Total Ozone Exposure > 120 ppb
13 Core Monitors in the Houston Area



Kirk Dean, 12/01/1997
D:\REQUESTS\OZTRENDS\HGB\SUM120.XLS

ANNUAL Figure 14

TABLE 1

1999 ROP Required VOC Emissions Target Calculations
Houston Ozone Nonattainment Area
Ozone Season VOC Tons Per Day
May 6, 1998

Step	Emissions Basis	Stationary		Mobile		Tota
		Point	Area	On-road	Non-road	
1	1990 ROP Nonattainment Area Base Year EI	483.28	200.07	251.52	129.98	1064.85
2	Adjusted Base Year EI Relative to 1996	483.28	200.07	163.59	129.98	976.72
3	Adjusted Base Year EI Relative to 1999	483.28	198.71	153.01	129.98	964.98
4	3% of Adjusted Base Year EI Relative to 1999					28.95
5	RVP and Fleet turnover correction [steps (2-3)]		1.36	10.58		11.74
6	1996 Target Leve					812.77
7	1999 Target Level [steps(6-5+4)]					772.08
8	1999 Emissions Forecast (Grown)	518.56	213.91	192.54	151.75	1076.76
9	Total Reductions Required by 1999 with growth [steps (8-7)]					304.68
10	Creditable Reductions to date	141.1*	41.15	40.77	13.77	236.80
11	*Shortfall*					67.88

Notes for On-Road Mobile

1. Base year on-road mobile emissions calculated with MOBILE5 for an ozone season weekday
2. Adjusted base year on road mobile emissions and 1999 forecast on-road mobile emissions calculated with MOBILE5A for an ozone season weekda

Notes for Point Source

1990 base year emissions of 481.95 tpd are adjusted by addition of 1.33 tpd from pulp and paper mills table in Appendix 11c-K

TABLE 2

1999 ROP Required NOx Emissions Target Calculations
Houston Ozone Nonattainment Area
Ozone Season NOx Tons Per Day
May 6, 1998

Step	Emissions Basis	Stationary		Mobile		Total
		Point	Area	On-road	Non-road	
1	1990 ROP Nonattainment Area Base Year EI (NOx)	754.85	14.37	337.03	198.08	1344.33
2	Adjusted Base Year EI Relative to 1999 (NOx)	754.85	14.37	260.23	198.08	1269.53
3	6% of Adjusted Base Year EI Relative to 1999					76.17
4	Fleet turnover correction [steps(1-2)]			76.39		76.39
5	1999 Target Level [steps(1-3-4)]					1191.77
6	1999 Emissions Forecast (Grown)	712.27	14.65	319.50	259.78	1306.21
7	Total Reductions Required by 1999 with growth [steps (6-5)]					114.44
8	Creditable Reductions to Date					0.00
9	*Shortfall*					114.44

Notes for On Road Mobile

1. Base year on-road mobile emissions calculated with MOBILE5 for an ozone season weekday
2. Adjusted base year on road mobile emissions and 1999 forecast on-road mobile emissions calculated with MOBILE5A for an ozone season weekda

Notes for Point Source

1. Base Year emissions adjustment is explained in footnote 1 of NOx RACT Reductions table in Appendix 11c-K
2. Growth calculations are in Appendix 11c-J

06-May-98 08:55 AM NOX99NEW WB2

TABLE 4 – May 6, 1998

VOC ESTIMATES TOWARDS 9% ROP SIP - HOUSTON/GALVESTON

Emissions Inventory	1990	Percent	Growth	1999	Percent
Area Sources	200.07	20.7%	6.9%	213.91	19.9%
Point Sources	483.28	50.0%	7.3%	518.56	48.2%
On-road Mobile Sources	153.01	15.8%	25.8%	192.54	17.9%
Off-road Mobile Sources	129.98	13.5%	16.7%	151.75	14.1%
TOTALS	**966.34**		11.4%	**1076.76**	

ESTIMATED VOC REDUCTIONS

Control Strategy	1999 Projected Tons Per Day		Reduction Tons Per Day	Percent of Requirement
HON	0.53		0.47	0.69%
Aircraft Engines	2.43		0.97	1.43%
Pulp & Paper	8.90		2.20	3.24%
Recreational Marine	27.30		0.06	0.09%
TCM's	192.54		0.50	0.74%
Utility engine 1997-1999	65.67		6.31	9.30%
UST Remediation	2.05		2.05	3.02%
Tier I. I/M, RFG	192.54		18.59	27.39%
MSW Landfills NSPS & EG	7.40		4.06	5.99%
RFG - Tanks	N/A		2.45	3.61%
RFG - Loading Racks	N/A		3.76	5.54%
*RE Floating Tanks	70.96		26.86	39.57%
		Subtotal	**68.29**	**100.60%**
Contingency Strategy				
Rec. Marine Vess. 2000	27.30		0.31	1.60%
Offset Printing	5.32		2.34	12.11%
I/M, Tier I. RFG Phase II	192.54		15.07	77.97%
Naphtha Dry Cleaners	3.88		1.97	10.17%
Utility Engine 2000	65.67		1.51	7.82%
		Subtotal	**21.20**	**109.68%**
	Required Target		**67.88**	100.00%
	Creditable Reductions		**68.29**	100.60%
	Excess (Shortfall)		**0.41**	0.6%
	Required Contingency		**19.33**	100.0%
	Req'd Targ + Conting		**87.21**	100.0%
	Total Reductions		**89.48**	102.6%
	Excess (Shortfall)		**2.28**	2.6%

*RE credits claimed from this category under "RE Improvements" are subtracted out to avoid double counting.

**VOC reductions will comprise two-thirds of the required contingency measure amount of 3% of the adjusted base year EI. The remaining 1% of the baseline EI is included in NOx contingency measures.

TABLE 3 - May 6, 1998

NOx ESTIMATES TOWARDS 9% ROP SIP - HOUSTON/GALVESTON

Emissions Inventory	1990	Percent	Growth	1999	Percent
Area Sources	14.37	1.1%	2.0%	14.66	1.1%
Point Sources	794.85	62.6%	-10.4%	712.27	54.5%
On-road Mobile Sources	262.23	20.7%	21.8%	319.50	24.5%
Off-road Mobile Sources	198.08	15.6%	31.1%	259.78	19.9%
TOTALS	**1269.53**		2.9%	**1306.21**	

ESTIMATED NOx REDUCTIONS

Control Strategy	1999 Projected Tons Per Day	Reduction Tons Per Day	Percent of Requirement
NOx RACT	712.27	95.00	
RFG, I/M, FMVCP Tier I	319.50	36.49	
Contingency Measures			
I/M, Tier I, RFG Phase II	319.50	7.42	
Required Target		**114.44**	100.00%
Creditable Reductions		**131.49**	114.90%
Excess (Shortfall)		**17.05**	14.9%
Required Contingency*		**12.70**	100.0%
Req'd Targ+Couting		**127.14**	100.0%
Total Reductions		**138.91**	109.3%
Excess (Shortfall)		**11.77**	

*NOx reductions will comprise one-third of the required contingency measure amount of 3% of the adjusted base year EI. The remaining 2% of the baseline EI is included in VOC contingency measures.

Mobile Source reductions due to FMVCP Tier I, Vehicle I/M and Reformulated Gasoline occurred between 1990 and 1999 and are included in the calculation of the target level.