APPENDIX L

Modeling to Confirm the VOC/NOx Directional Guidance Established for the Houston-Galveston Area

HOUSTON/GALVESTON ATTAINMENT DEMONSTRATION - PART II

OCTOBER 1999 REVISION

June 15, 1999

Modeling to Confirm the VOC/NO_x Directional Guidance Established for the Houston-Galveston Area

Prepared for:

the Texas Natural Resource Conservation Commission
Dr. Jim Smith, Project Manager
Under Work Order No. 9800693000-05

Prepared by:

Neil Wheeler
Saravanan Arunachalam
Pat Dolwick
Jeff Vukovich

Environmental Programs
MCNC–North Carolina Supercomputing Center
P.O. Box 12889
Research Triangle Park, NC 27709-2889

Table of Contents

1. INTRODUCTION

In the 1998 State Implementation Plan (SIP) revision for the Houston/Galveston (H/G) ozone nonattainment area, the Texas Natural Resource Conservation Commission (TNRCC) reported modeling which showed that the area would need to implement significant reductions of NO_X in order to reach attainment. Also, the SIP revision concluded that concurrent volatile organic compound (VOC) reductions would be useful in diminishing any potential ozone increases resulting from reduced ozone titration due to local NO_X control (TNRCC, 1998). These conclusions were based on the results of a series of Urban Airshed Modeling runs using an existing 2007 projected emissions inventory. This inventory has since been updated to reflect improvements in both biogenic and on-road mobile source emissions (MCNC, 1999).

The purpose of this analysis is to determine the type and general level of emission reductions that may be needed in the eight-county Houston-Galveston nonattainment area to demonstrate attainment of the ozone standard. A series of 12 modeling runs were completed using the Comprehensive Air Quality Model with Extensions (CAM_X) (Environ, 1998) to simulate the September 6^{th} - 11^{th} Coastal Oxidant Assessment for Southeast Texas (COAST) episode. Table 1 summarizes the modeling simulations preformed, which reduced *anthropogenic* NO_X and VOC in the H/G nonattainment counties by varying factors. An "X" in the cell indicates that a particular combination of VOC/NO_X reductions was modeled. Ozone peaks over the 13 simulations will be compared to determine which path (VOC only, NO_X only, or combined VOC and NO_X) is most effective in bringing the area into attainment.

Anthropogenic VOC Reduction (%)

Anthropogenic NOX Reduction (%)	0	25	50	75	100
0	X	X	X	X	X
25	X	X			
50	X		X		
75	X			X	
100	X				X

Table 1. Summary of Anthropogenic VOC and NOX reductions modeled for the 6-11 September 1993 COAST episode. All reductions are based off the 2007 projected base case.

2. EMISSIONS PREPARATION

The emissions reductions were applied to the current 2007 projection emissions inventory over the 8-county H/G nonattainment area. This area consists of the counties of: Harris, Galveston, Liberty, Fort Bend, Montgomery, Brazoria, Waller, and Chambers. An MCNC utility, *geocuts.f*, was used to ensure that reductions were only instituted in those grid cells which exist partially or completely in the nonattainment area. Figure 1 shows a sample emissions difference field, after the application of the reductions.

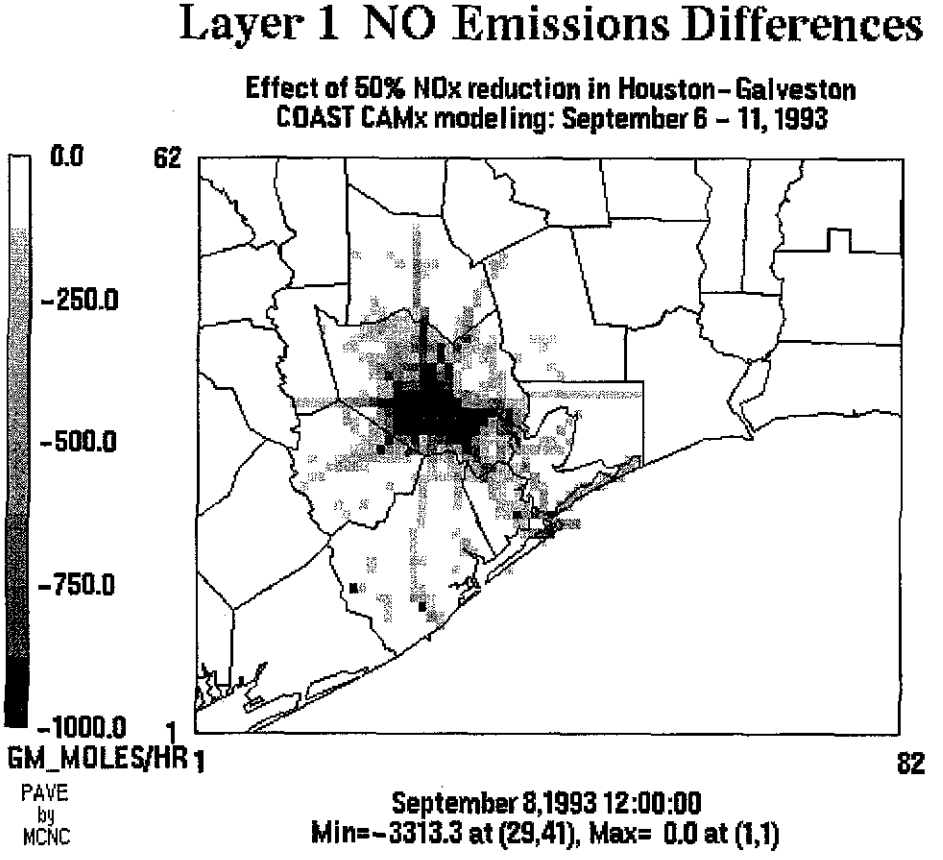

Figure 1. Differences in the NO emissions at 1200 CST between the 2007 projection inventory and the 50% H-G NO_X reduction simulation.

The geographic precursor reductions were applied to the area, mobile, low, and elevated point source files. Table 2 lists the component emissions files that were used in this analysis. The low-level files (2km) were then combined and aggregated to CAM_X-ready 4- and 16-km files.

- Area source emissions files:

  agtsc.allar.19930906.07basA.bin

  agtsc.allar.19930907.07basA.bin

  agtsc.allar.19930908.07basA.bin

  agtsc.allar.19930909.07basA.bin

  agtsc.allar.19930910.07basA.bin

  agtsc.allar.19930911.07basA.bin

- Biogenic emissions files:

  fresh_bio.090693

  fresh_bio.090793

  fresh_bio.090893

  fresh_bio.090993

  fresh_bio.091093

  fresh_bio.091193

- Mobile source emissions files:

  lo_ems.mobile.COAST.fy07.930906.07basA

  lo_ems.mobile.COAST.fy07.930907.07basA

  lo_ems.mobile.COAST.fy07.930908.07basA

  lo_ems.mobile.COAST.fy07.930909.07basA

  lo_ems.mobile.COAST.fy07.930910.07basA

  lo_ems.mobile.COAST.fy07.930911.07basA

- Low point source emissions files:

  lowpgts.allpts.19930906.07basA.bin

  lowpgts.allpts.19930907.07basA.bin

  lowpgts.allpts.19930908.07basA.bin

  lowpgts.allpts.19930909.07basA.bin

  lowpgts.allpts.19930910.07basA.bin

  lowpgts.allpts.19930911.07basA.bin

Table 2. List of the component emissions files used in the 2007 projection base.

3. CAM_X EMISSION REDUCTION SIMULATIONS

Several different metrics should be investigated to determine the impact of a particular set of VOC and/or NO_X controls. Comparisons of episodic peak 1-hour model ozone concentrations are relevant in an determination of the most effective means of reaching the one-hour ozone standard. The peak model ozone value within the eight-county H/G nonattainment area is shown in Table 3.

		Anthropogenic VOC Reduction (%)				
Anthropogenic NOX Reduction (%)	0	0	25	50	75	100
	0	171	166	161	156	152
	25	171	166			
	50	161		155		
	75	132			129	
	100	114				113

Table 3. Episodic peak one-hour model ozone in the Houston/Galveston nonattainment area for a matrix of VOC and NO_X percentage emissions reductions applied within the Houston/Galveston nonattainment area over the 6-11 September 1993 COAST episode.

As can be seen in Table 3, VOC reductions alone are not sufficient to attain the ozone standard. NO_X reductions can yield attainment in the modeling if very large emissions cuts are simulated (> 75%). The H/G NO_X reductions are initially not very effective in reducing the ozone. It is not until at least 50% of the 2007 (manmade) projected inventory is removed that a marked drop in CAM_X ozone occurs.

Figure 2 shows the area with peak one-hour model ozone greater than 120 ppb in the base case, the 25 percent NO_X reduction run, the 50 percent NO_X reduction run, and the 75 percent NO_X reduction run. (The 100 percent H/G NOX reduction lowers ozone below the standard for all grid cells and hours.) At a 25 percent reduction level, the areal extent of ozone greater than 120 ppb is diminished only slightly. The domainwide peak increases slightly from 171.1 to 171.9 and the location of this peak is displaced two cells eastward. The areal extent of model ozone greater than 140 ppb is reduced out over the Gulf with this level of NO_X reductions.

When H/G NO_X emissions are reduced by 50 percent, most of the model "exceedances" are contained to the Galveston Bay region and the area bordering southern Harris and northern Fort Bend and Brazoria counties (ignoring the Beaumont/Port Arthur area where emissions reductions were not implemented in these analyses). The domainwide peak is reduced by 10 ppb to 161.9 ppb. As the eight-county nonattainment area NOx is reduced by 75 percent, there remains a persistent area in southern Harris County which remains above the standard.

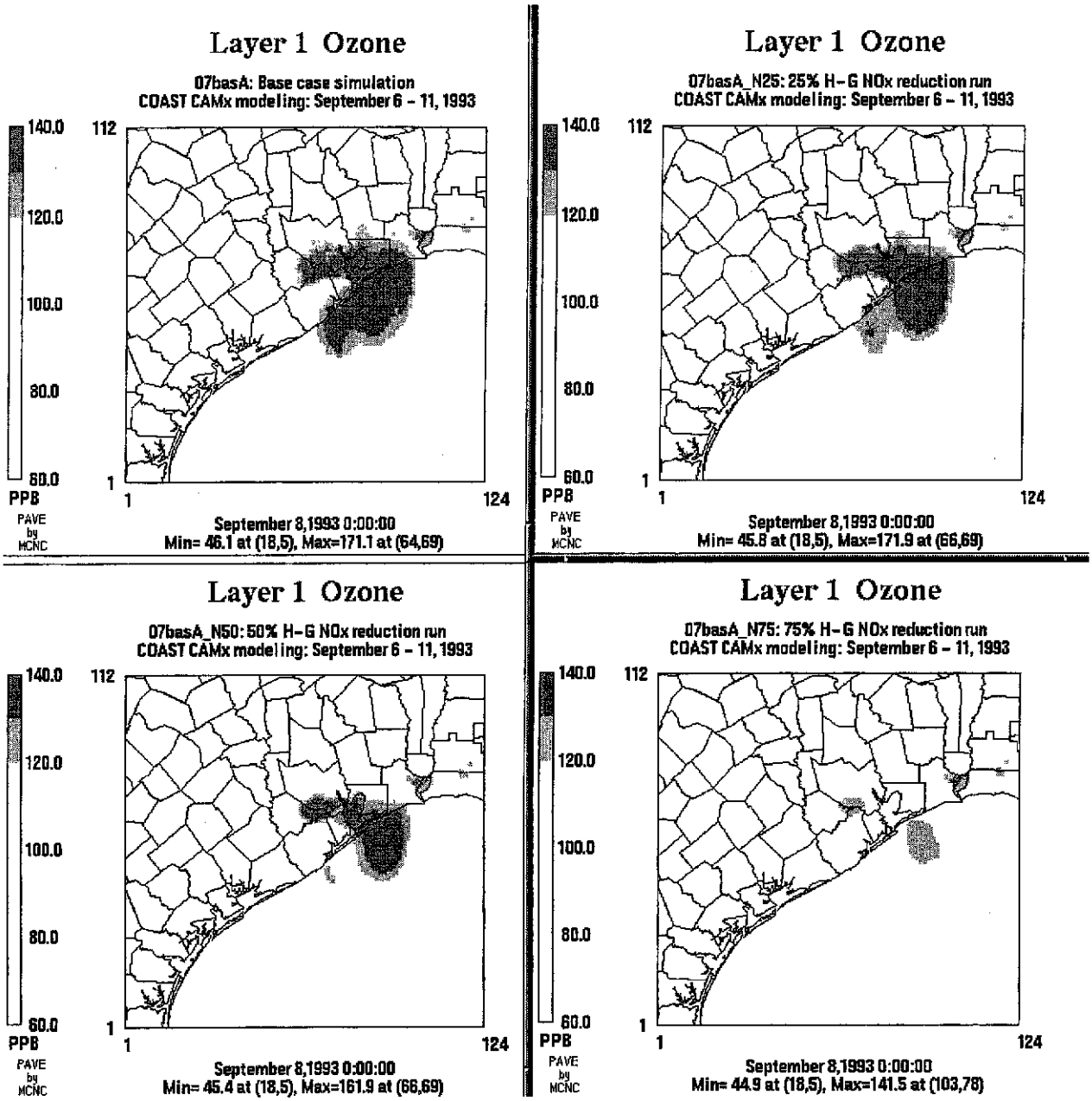

Figure 2. Daily peak model ozone on 8 September 1993 for four simulations: upper left is the 2007 base case, upper right is a 25 percent NOx reduction in the eight-county Houston/Galveston area, lower left is a 50 percent NOx reduction in the eight-county Houston/Galveston area, and lower right is a 75 percent NOx reduction in the eight-county Houston/Galveston area.

Figure 3 focuses on this area of persistent ozone over land on 8 September 1993. It appears from these directional guidance runs that the southern Harris/ northern Brazoria County region will be the hardest to demonstrate attainment for in the modeling. This area of the modeling domain experiences ozone increases in response to NO_X controls. This is typically

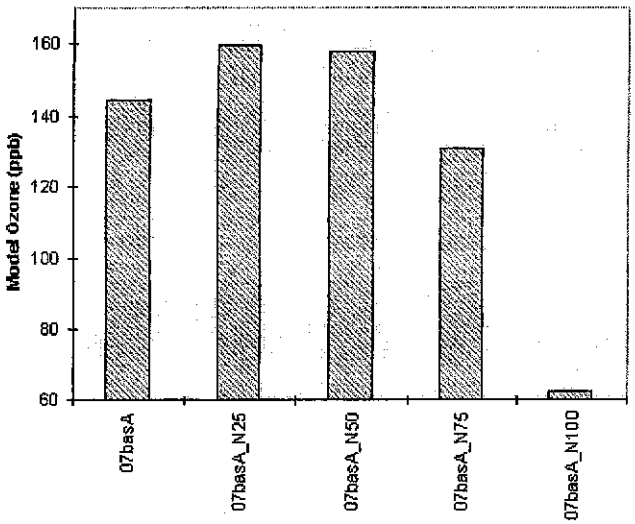

Figure 3. Daily peak model ozone on 8 September 1993 for a grid cell in southern Harris County for five simulations: 2007 base, 25% NOx reduction, 50% NOx reduction, 75% NOx reduction, and 100% NOx reduction.

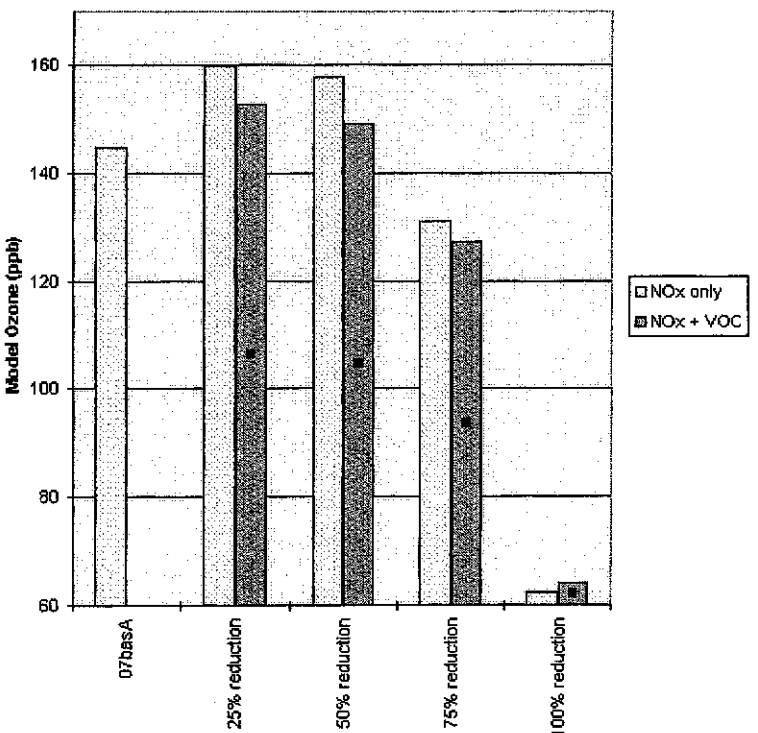

Figure 4. Daily peak model ozone on 8 September 1993 for a grid cell in southern Harris County for nine simulations: 2007 base, 25% NOx, 25% NOx and VOC, 50% NOx, 50% NOx and VOC, 75% NOx, 75% NOx and VOC, 100% NOx, and 100% NOx and VOC reductions. Darker shaded bars include equal NOx and VOC emission reductions.

seen in areas with large amounts of NOx emissions like Houston, but it is somewhat uncommon for these NOx disbenefits to be associated with relatively high concentrations of model ozone, i.e., greater than 120 ppb. Ozone that was 145 ppb in the base case increases to 160 ppb in the 25 percent control case and to 158 ppb in the 50 percent control case. It is not until NO_X is reduced by 75 percent that these ozone increases are no longer experienced; the peak is near 130 ppb in that scenario. Figure 4 shows the simulation results for the scenario in which matching VOC reductions are taken with the NOx control. The commensurate VOC reductions help alleviate the ozone increases, but the change in model ozone is still positive.

Table 4 lists the total number of grid cells exceeding 124 ppb in the model for each of the 12 reduction scenarios and the 2007 base case. Determinations about most effective control path do not change upon looking at this areal exposure metric. NO_X controls appear *more preferential* (as opposed to VOC) in reducing the spatial extent of ozone than was the case for peak ozone. As an example, when considering one-hour peak ozone, 100 percent VOC control yielded a peak of 152 ppb whereas 50 percent NO_X control yielded a peak of 162 ppb. With this metric, the 50 percent NO_X-only scenario lowers more cells below the standard than the 100 percent VOC case.

Table 5 shows the maximum eight-hour model ozone concentrations within the entire eight-county H/G nonattainment area for the matrix of emissions reductions performed in this analysis. As concluded in TNRCC (1998), the eight-hour value appears more rigorous than the one-hour. It should be noted that the peak 8-hour ozone concentration of 108 ppb that is modeled even when all anthropogenic emissions are removed is the result of transport from outside the H/G nonattainment area. The peak value is modeled over the Gulf of Mexico, just off the Galveston shoreline.

		Anthropogenic VOC Reduction (%)				
Anthropogenic NOX Reduction (%)	0	25	50	75	100
0	1659	1500	1358	1141	884
25	1298	1186			
50	868		681		
75	34			21	
100	0				0

Table 4. Number of grid cells whose ozone exceeds 124 ppb in the Houston/Galveston nonattainment area for a matrix of VOC and NO_X percentage emissions reductions applied within the H/G nonattainment area over the 6-11 September 1993 COAST episode.

Anthropogenic NOX Reduction (%)	Anthropogenic VOC Reduction (%)					
		0	25	50	75	100
	0	146	142	138	135	132
	25	149	145			
	50	141		137		
	75	118			116	
	100	108				108

Table 5. Episodic peak eight-hour model ozone in the Houston/Galveston nonattainment area for a matrix of VOC and NO_X percentage emissions reductions applied within the Houston/Galveston nonattainment area over the 6-11 September 1993 COAST episode.

4. CONCLUSIONS

The conclusions generated as part of the original directional guidance modeling were generally reaffirmed with these set of CAM_X results. At the reduction levels required to bring peak ozone levels down to the National Ambient Air Quality Standard, NO_X reductions are clearly more effective at reducing ozone than are VOC reductions. Additional observations regarding the directional guidance runs are listed below.

1) VOC reductions alone will reduce maximum ozone concentrations, but will not be sufficient for attainment.
2) Total NO_X reductions alone can achieve attainment in the Houston-Galveston nonattainment area, but only with overall reductions of greater than 75 percent from point, mobile, and area sources. Decreases in peak ozone concentrations are relatively small until overall NO_X reductions reach 50 percent and greater.
3) Ozone increases are associated with NO_X emission reductions in some parts of the domain. In particular, the southern portion of Harris County and northern portions of Fort Bend and Brazoria counties experience 10-20 ppb increases when NO_X is reduced from 25 to 50 percent. Base case ozone is already high in this region, on the order of 140-150 ppb. It appears that this region will be the controlling one in terms of demonstrating attainment.
4) Combining VOC reductions with NO_X reductions in the H/G area can reduce the ozone increases that are simulated just south of Houston with NO_X reductions alone.

5. REFERENCES

ENVIRON International Corporation, 1997: *User's Guide to the Comprehensive Air Quality Model with Extensions (CAMx).* Novato, CA.

MCNC, 1999: *Effects of Revised Biogenic and Future-Year Mobile Emissions Estimates on Ozone in the Houston/Galveston Region.* Research Triangle Park, NC.

Texas Natural Resource Conservation Commission, 1998: *Revisions to the State Implementation Plan for the Control of Ozone Air Pollution.* Rule Log No. 97184-SIP-AI. Austin, TX.