

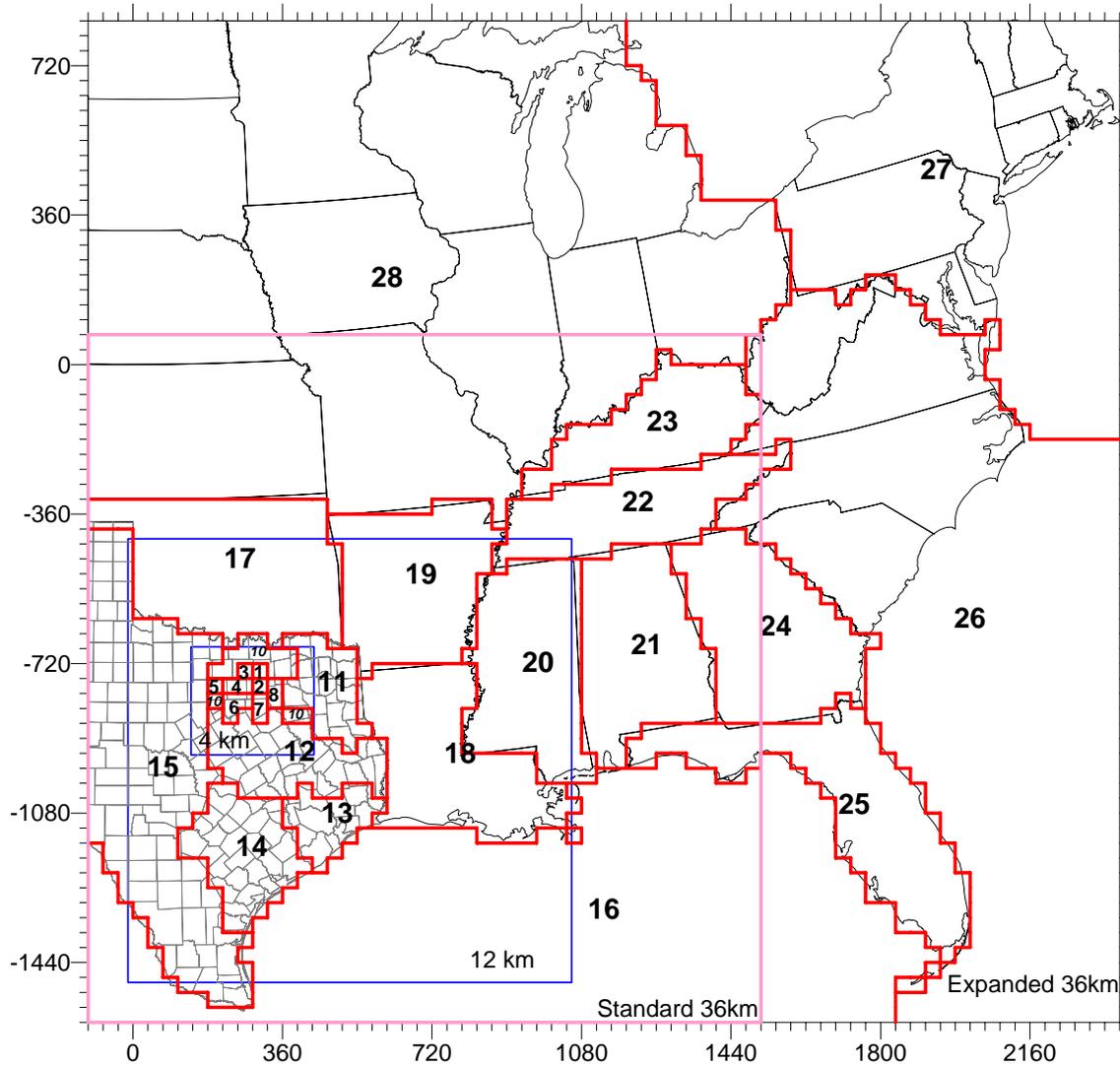
## MEMORANDUM

**To:** Pete Breitenbach  
**From:** Edward Tai and Greg Yarwood  
**Date:** 22 February 2006  
**Subject:** Dallas/Fort Worth 2009 Midlothian Cement Kiln Sensitivity Tests

---

Two cement kiln sensitivity tests were analyzed for 8-hour ozone in the Dallas/Fort Worth August 13-22, 1999 episode for the 2009 future year. The runs were based on the Run 44 baseline configuration, with the modeling domain covering the expanded 36 km domain with 14 km model top. Inputs included meteorology from MM5 Run 6, which was based on the ETA PBL scheme coupled with the Noah land surface model, with the kv100 patch applied to the vertical diffusivity. The boundary conditions assigned moderate conditions in the mixed layer over land, and clean conditions over the Gulf, Atlantic and all areas aloft. A modified version of CAMx 4.03 was used in which several NO<sub>x</sub> recycling reactions were added to the CB4 mechanism (CB4xi).

The kiln controls were applied to the 2009 “a1” baseline emissions, which incorporated 2005 acid rain data for the Texas EGUs. The 2009 base case NO<sub>x</sub> emissions from the Midlothian cement kilns was 28 tpd. The high control scenario (run44.fy2009.a1.kiln1) reduced the kiln emissions by 20 tpd NO<sub>x</sub>. The low control scenario (run44.fy2009.a1.kiln2) reduced Midlothian kiln NO<sub>x</sub> by 10 tpd. Table 1 shows the August 17 biogenic and weekday anthropogenic NO<sub>x</sub> emissions by source region as defined in Figure 1 for the two control scenarios. Differences from the baseline, all coming from elevated point sources, are also shown. Weekday VOC emissions are summarized in Table 2, which show no change from the baseline in either control.



**DFW Source Regions. 36 km Expanded Domain**

- |                   |                             |
|-------------------|-----------------------------|
| 1. Collin Co.     | 15. West Texas              |
| 2. Dallas Co.     | 16. Gulf of Mexico + Mexico |
| 3. Denton Co.     | 17. Oklahoma                |
| 4. Tarrant Co.    | 18. Louisiana               |
| 5. Parker Co.     | 19. Arkansas                |
| 6. Johnson Co.    | 20. Mississippi             |
| 7. Ellis Co.      | 21. Alabama                 |
| 8. Kaufman Co.    | 22. Tennessee               |
| 9. Rockwall Co.   | 23. Kentucky                |
| 10. DFW 16-County | 24. Georgia                 |
| 11. NE Texas      | 25. Florida                 |
| 12. Central Texas | 26. Mid Atlantic States     |
| 13. Houston       | 27. Northeast US            |
| 14. South Texas   | 28. Northern Plains         |

**Figure 1.** Map of source regions in the 36 km expanded domain.



Golden Gate Plaza • 101 Rowland Way • Novato, California 94945-5010 USA  
 Tel: (415) 899-0700 • Fax: (415) 899-0707 • www.environcorp.com

**Table 1.** Weekday NOx emissions in 2009 for the two cement kiln control runs.

NOx [tpd]	Biogenics	High Midlothian Cement Kiln Control		Low Midlothian Cement Kiln Control	
		Anthro	Change from 2009 Baseline	Anthro	Change from 2009 Baseline
Collin Co	10	26	0	26	0
Dallas Co	4	149	0	149	0
Denton co	8	40	0	40	0
Tarrant Co	3	89	0	89	0
Parker Co	1	10	0	10	0
Johnson Co	5	16	0	16	0
Ellis Co	15	31	-20	41	-10
Kaufman Co	5	13	0	13	0
Rockwall Co	2	5	0	5	0
<b>DFW 9-County</b>	<b>52</b>	<b>376</b>	<b>-20</b>	<b>386</b>	<b>-10</b>
<b>DFW 16 County</b>	<b>83</b>	<b>472</b>	<b>-20</b>	<b>482</b>	<b>-10</b>
NE Texas	16	397	0	397	0
Central TX	113	353	0	353	0
Houston	21	585	0	585	0
South TX	229	653	0	653	0
West TX	524	653	0	653	0
<b>Texas</b>	<b>986</b>	<b>3112</b>	<b>-20</b>	<b>3123</b>	<b>-10</b>
Gulf + Mexico	79	892	0	892	0
Oklahoma	227	924	0	924	0
Louisiana	106	1905	0	1905	0
Arkansas	125	692	0	692	0
Mississippi	121	808	0	808	0
Alabama	75	932	0	932	0
Tennessee	118	906	0	906	0
Kentucky	145	1060	0	1060	0
Georgia	110	1230	0	1230	0
Florida	56	1573	0	1573	0
Mid Atlantic (SC, NC, VA, WV)	293	3310	0	3310	0
NE US	314	7051	0	7051	0
Northern Plains	5238	11892	0	11892	0
<b>Total</b>	<b>7992</b>	<b>36288</b>	<b>-20</b>	<b>36298</b>	<b>-10</b>

**Table 2.** Weekday VOC emissions in 2009 for the two cement kiln control runs.

Golden Gate Plaza • 101 Rowland Way • Novato, California 94945-5010 USA  
 Tel: (415) 899-0700 • Fax: (415) 899-0707 • www.vironcorp.com

VOC [tpd]	High Midlothian Cement Kiln Control			Low Midlothian Cement Kiln Control	
	Biogenics	Anthro	Change from 2009 Baseline	Anthro	Change from 2009 Baseline
Collin Co	27	23	0	23	0
Dallas Co	50	141	0	141	0
Denton co	65	28	0	28	0
Tarrant Co	64	94	0	94	0
Parker Co	121	9	0	9	0
Johnson Co	111	9	0	9	0
Ellis Co	89	15	0	15	0
Kaufman Co	112	11	0	11	0
Rockwall Co	3	4	0	4	0
<b>DFW 9-County</b>	<b>642</b>	<b>333</b>	<b>0</b>	<b>333</b>	<b>0</b>
<b>DFW 16 County</b>	<b>1538</b>	<b>413</b>	<b>0</b>	<b>413</b>	<b>0</b>
NE Texas	4917	181	0	181	0
Central TX	6098	180	0	180	0
Houston	1683	675	0	675	0
South TX	2069	408	0	408	0
West TX	6198	367	0	367	0
<b>Texas</b>	<b>22503</b>	<b>2223</b>	<b>0</b>	<b>2223</b>	<b>0</b>
Gulf + Mexico	658	378	0	378	0
Oklahoma	7940	490	0	490	0
Louisiana	9941	601	0	601	0
Arkansas	13925	466	0	466	0
Mississippi	14818	583	0	583	0
Alabama	13954	695	0	695	0
Tennessee	8678	961	0	961	0
Kentucky	3753	656	0	656	0
Georgia	12198	922	0	922	0
Florida	9793	1636	0	1636	0
Mid Atlantic (SC, NC, VA, WV)	31294	2903	0	2903	0
NE US	20472	5655	0	5655	0
Northern Plains	40144	8450	0	8450	0
<b>Total</b>	<b>210073</b>	<b>26618</b>	<b>0</b>	<b>26618</b>	<b>0</b>

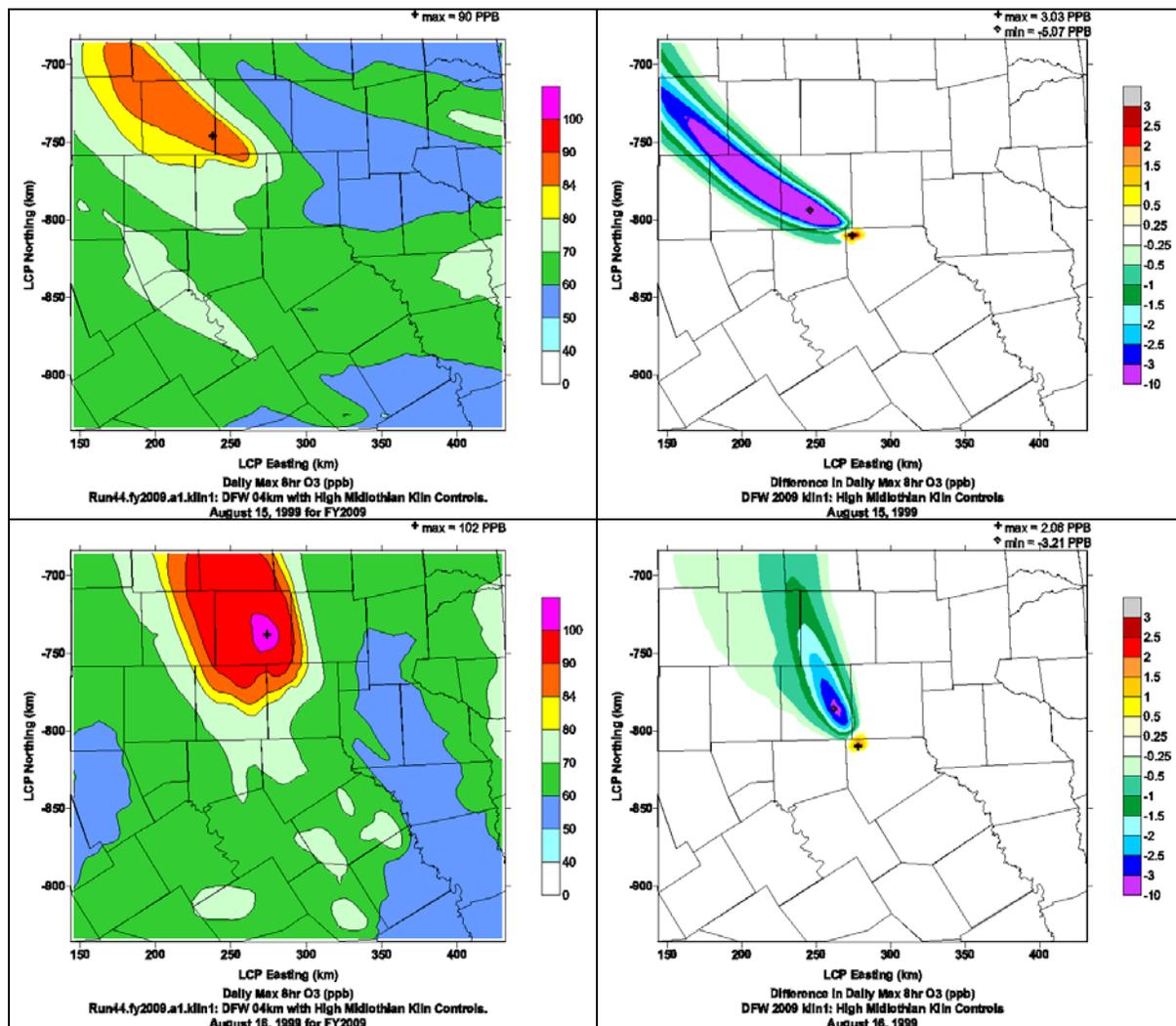
Spatial plots of the daily maximum 8-hour ozone when applying the high cement kiln controls



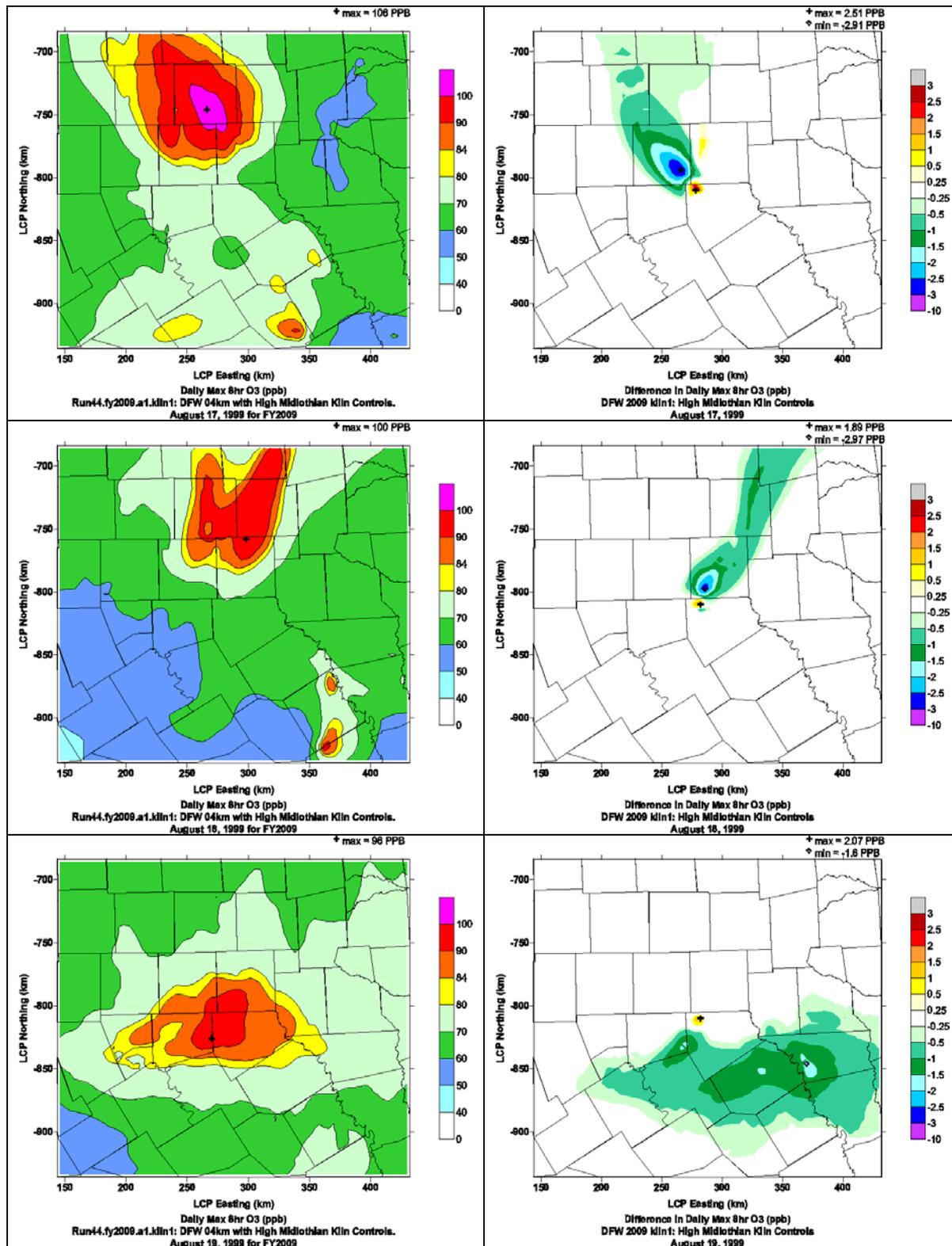
Golden Gate Plaza • 101 Rowland Way • Novato, California 94945-5010 USA  
Tel: (415) 899-0700 • Fax: (415) 899-0707 • www.vironcorp.com

and differences from the 2009 baseline are shown in Figure 2 for each date. Similar plots for the low cement kiln control scenario are shown in Figure 3. Ozone reduction was always greater under the high control scenario. The plume of ozone reduction was strongest over Tarrant County on all dates except from August 18 to 20.

The difference plume approached Denton on August 16 and 17, but was weaker on the latter date, and missed Denton on the other dates. Frisco never took a direct hit from the kiln controls. Local ozone increases near the Midlothian kilns were observed on all dates as less NOx became available to scavenge the ozone. A small increase in 8-hour ozone was also detected in western Dallas County on August 17.

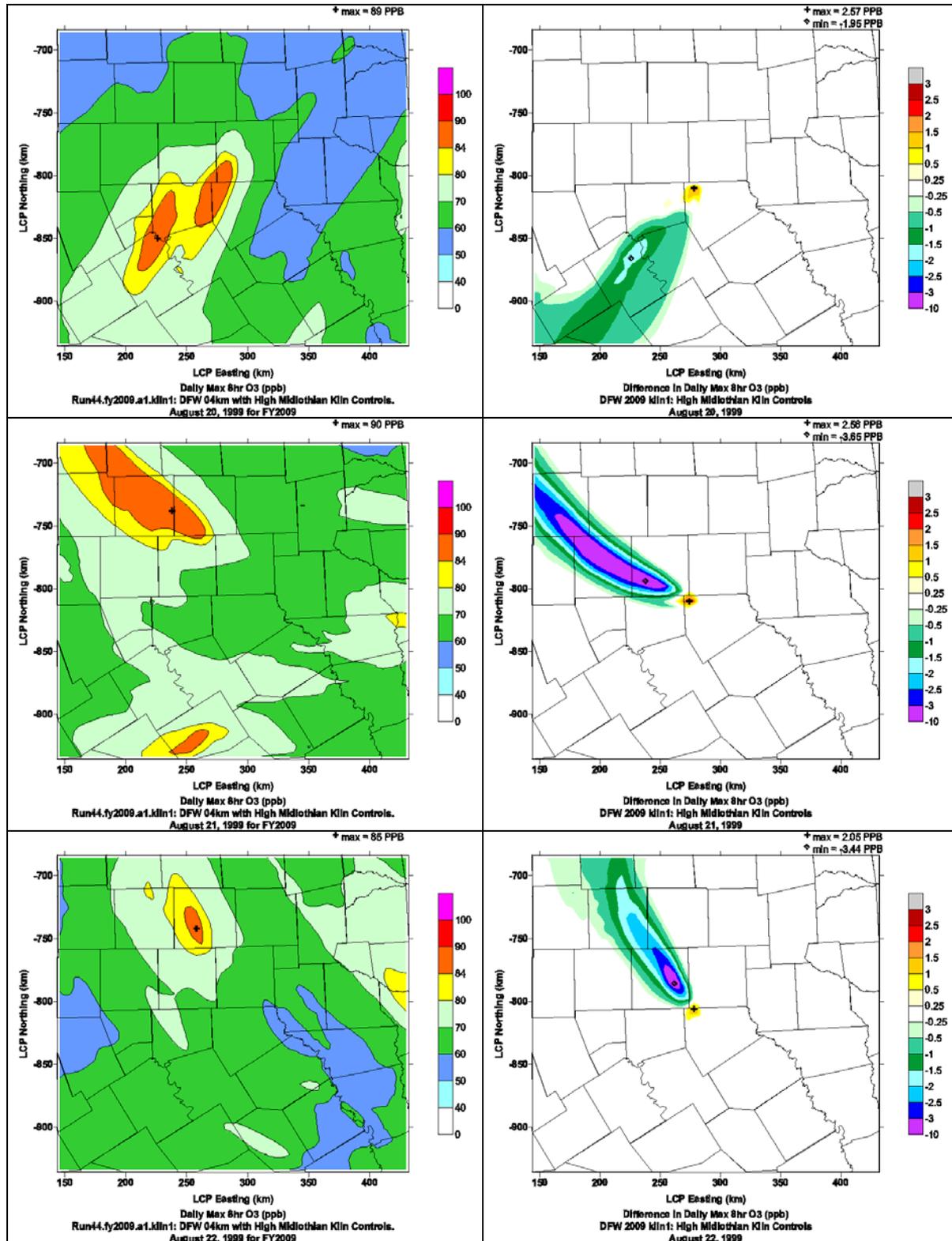


**Figure 2.** Spatial plots of the daily maximum 8-hour ozone with the high cement kiln controls (left) and difference from the 2009 baseline (right).



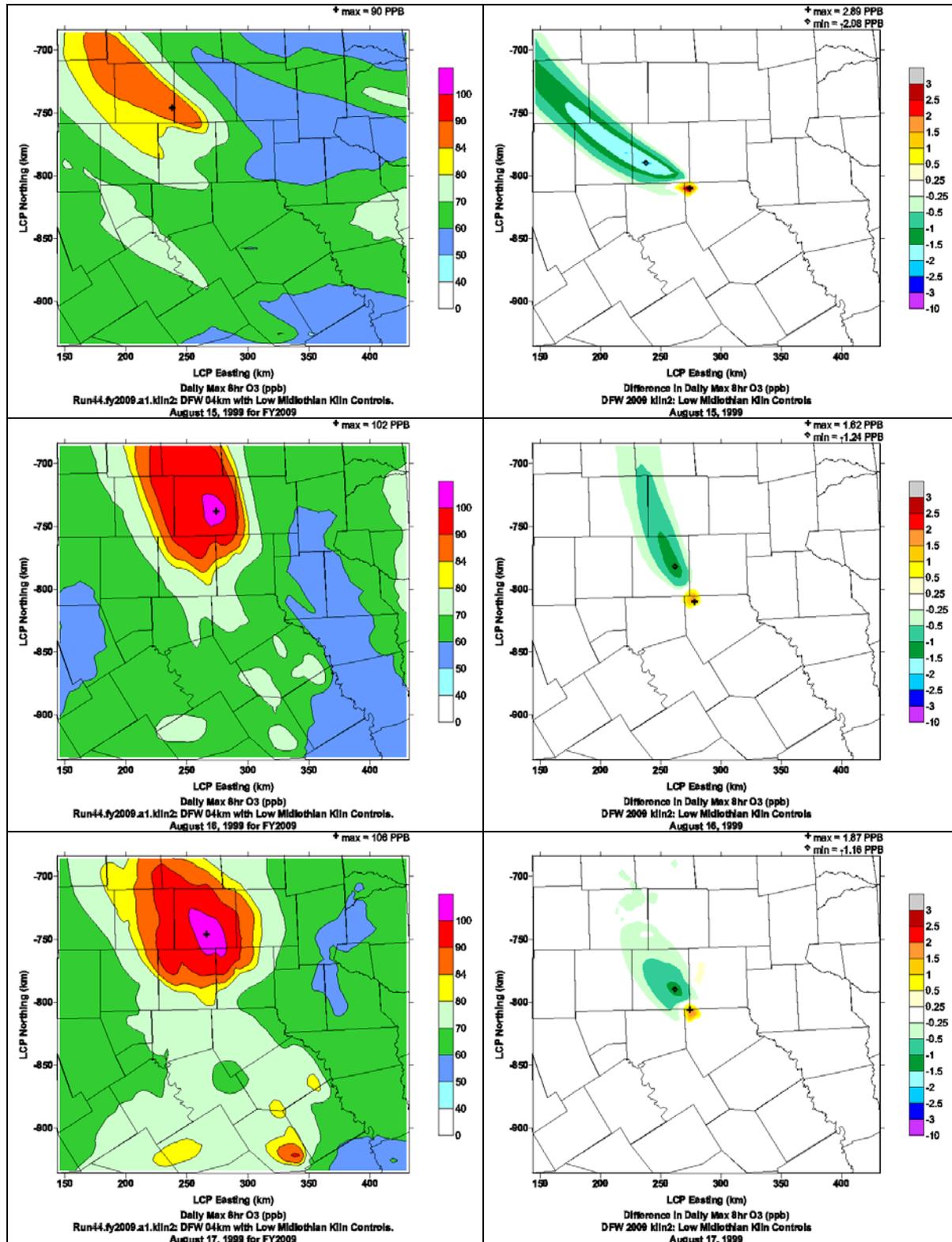
**Figure 2.** (continued). Spatial plots of the daily maximum 8-hour ozone with the high cement kiln controls (left) and difference from the 2009 baseline (right).





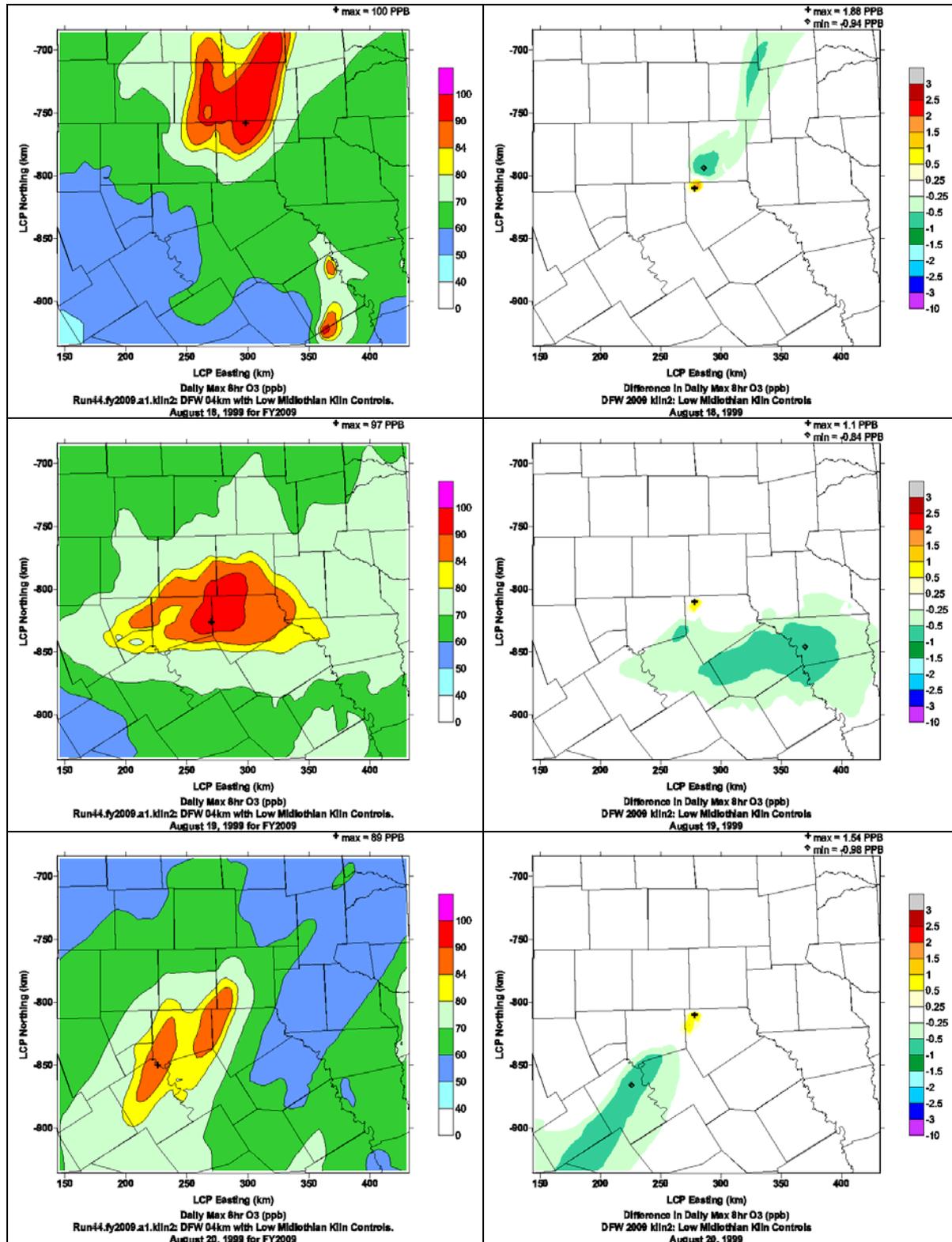
**Figure 2.** (concluded). Spatial plots of the daily maximum 8-hour ozone with the high cement kiln controls (left) and difference from the 2009 baseline (right).





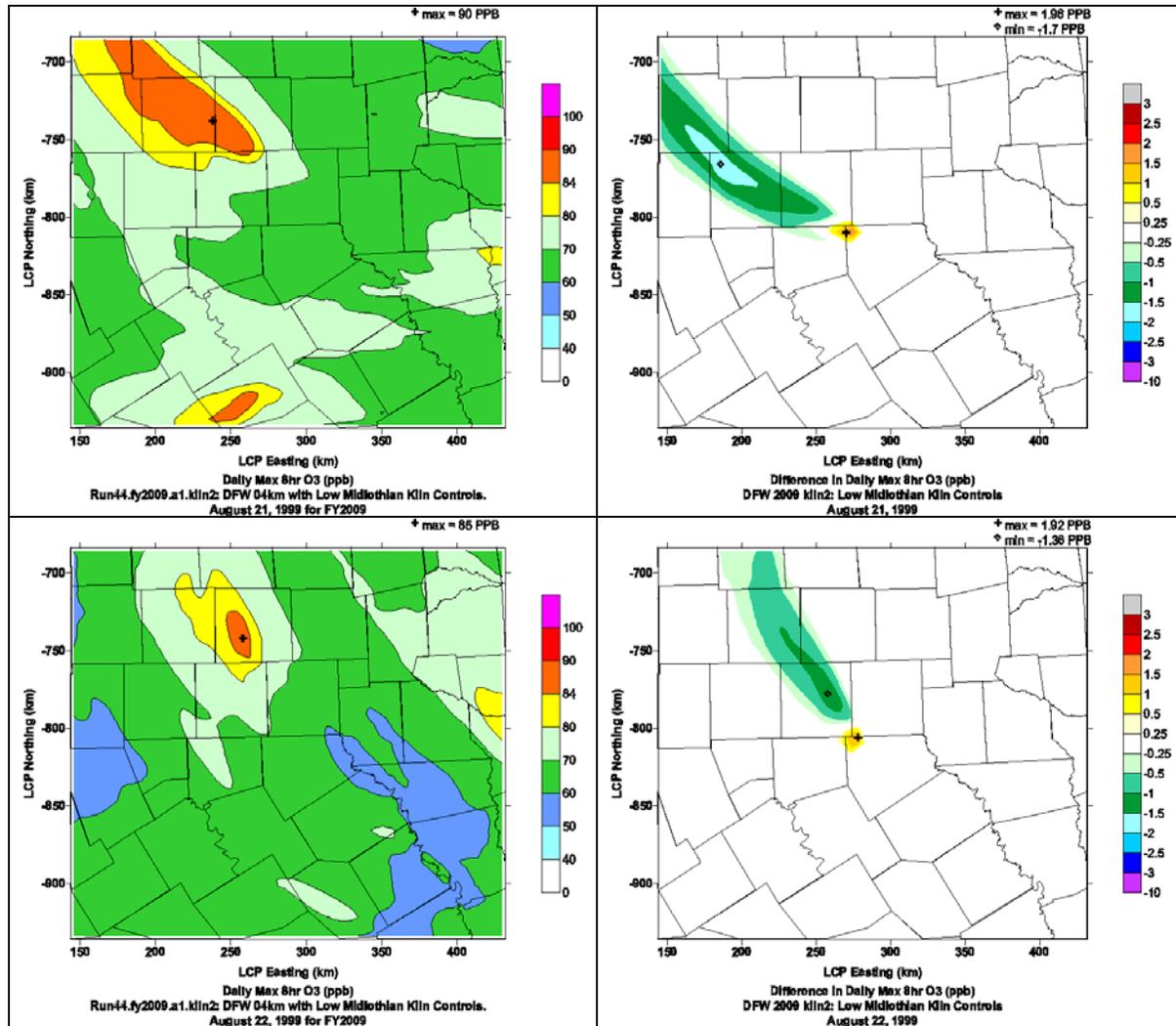
**Figure 3.** Spatial plots of the daily maximum 8-hour ozone with the low cement kiln controls (left) and difference from the 2009 baseline (right).





**Figure 3.** (continued). Spatial plots of the daily maximum 8-hour ozone with the low cement kiln controls (left) and difference from the 2009 baseline (right).





**Figure 3.** (concluded). Spatial plots of the daily maximum 8-hour ozone with the low cement kiln controls (left) and difference from the 2009 baseline (right).

The 2009 future design values scaled to the 1999 baseline design values for 8-hour ozone at all available DFW monitoring sites is shown in Table 3 for the 2009 base case and two cement kiln control scenarios. The bottom of Table 3 shows the differences from the base case.

The future 8-hour ozone design values were lower at all monitoring stations when applying the high cement kiln control. Two of the three monitoring sites in Tarrant County -- Arlington and Fort Worth (CAMS13) -- showed the greatest reduction at  $-1.0$  and  $-0.9$  ppb, respectively, when applying the higher control scenario; the lower control scenario reduced 8-hour ozone by about half as much. At the three Dallas monitoring sites and the two northern stations -- Frisco and Denton, both kiln controls reduced most future design values less than a tenth of a ppb. At the Midlothian monitor, its proximity to the cement kilns led to a  $0.4$  ppb increase in its design value when applying the smaller kiln controls, but a  $0.3$  ppb decrease when using larger cement kiln

controls.

**Table 3.** 2009 future design values and differences resulting from the two cement kiln controls.

Site	Run44.fy2009.a1	Run44.fy2009.a1.kiln1	Run44.fy2009.a1.kiln2
	2009 base case	High kiln controls	Low kiln controls
<b>Future Design Values [ppb]</b>			
Frisco	91.2	91.2	91.2
Dallas C60	87.6	87.5	87.5
Dallas C63	87.0	87.0	87.0
Dallas C402	79.7	79.5	79.6
Denton	89.6	89.6	89.6
Midlothian	84.5	84.2	84.9
Arlington	87.2	86.2	86.8
Fort Worth C13	87.6	86.7	87.1
Fort Worth C17	86.0	85.7	85.9
<b>Change from 2009 base [ppb]</b>			
Frisco		-0.01	0.01
Dallas C60		-0.06	-0.02
Dallas C63		-0.02	0.00
Dallas C402		-0.16	-0.04
Denton		-0.07	-0.03
Midlothian		-0.35	0.41
Arlington		-1.02	-0.46
Fort Worth C13		-0.91	-0.50
Fort Worth C17		-0.23	-0.10

Tables 4 to 6 analyze the area extent of the daily maximum 8-hour ozone exceeding 85 ppb in the DFW 9-county NAA. Table 4 counts the number of unique grid cells in DFW in 4 km resolution when 8-hour ozone exceeds 85 ppb for each date. Values are shown for the 2009 base case and both cement kiln control runs. Table 5 shows the percent change in exceedance area resulting from each control. Table 6 counts the number of exceedance cells that are reduced at least 1 ppb when applying the controls.

The high cement kiln control strategy reduced the number of exceedance grid cells in the DFW NAA by 4 % through the episode. Among the 2009 baseline exceedance cells, 14 % (166 out of 1199) were reduced at least 1 ppb. The controls appeared most effective on August 16, when 38 % (84 out of 223) exceedance grid cells were reduced at least 1 ppb, accounting for half the episode total; the exceedance area was lower by 5 %.

The low cement kiln control scenario reduced the total number of exceedance cells by 2 %. This control reduced 8-hour ozone by at least 1 ppb in only 2 % of the exceedance cells, in contrast to the 14 % from the high control scenario; the majority of cells reduced at least 1 ppb also took place on August 16.

**Table 4.** Daily count of unique grid cells exceeding 85 ppb in the DFW 9-county NAA.

Scenario Run	2009 Future Base run44.fy2009.a1	High Cement Kiln Control run44.fy2009.a1.kiln1	Low Cement Kiln Control run44.fy2009.a1.kiln2
990815	19	19	19
990816	223	211	219
990817	296	288	291
990818	253	243	249
990819	304	291	301
990820	70	65	68
990821	29	29	29
990822	5	1	4
Total	1199	1147	1180

**Table 5.** Change in exceedance area due to the cement kiln controls.

Scenario Run	2009 Future Base run44.fy2009.a1	High Cement Kiln Control run44.fy2009.a1.kiln1	Low Cement Kiln Control run44.fy2009.a1.kiln2
990815	---	0%	0%
990816	---	-5%	-2%
990817	---	-3%	-2%
990818	---	-4%	-2%
990819	---	-4%	-1%
990820	---	-7%	-3%
990821	---	0%	0%
990822	---	-80%	-20%
Total	---	-4%	-2%



**Table 6.** Number of exceedance<sup>1</sup> grid cells that reduce the daily maximum 8-hour ozone by at least 1 ppb in DFW.

Scenario Run	2009 Future Base run44.fy2009.a1	High Cement Kiln Control run44.fy2009.a1.kiln1	Low Cement Kiln Control run44.fy2009.a1.kiln2
990815	---	0	0
990816	---	84	21
990817	---	48	2
990818	---	14	0
990819	---	18	0
990820	---	2	0
990821	---	0	0
990822	---	0	0
Totals	---	166	23

<sup>1</sup> Exceedance cells are 2009 baseline grid cells exceeding 85 ppb

## Summary

Two control scenarios were applied to the Midlothian cement kilns. The high control scenario lowered NOx emissions by 20 tpd; the low control scenario lowered NOx by 10 tpd. Their greatest impacts to 8-hour ozone reduction were in Tarrant County, where the 2009 8-hour ozone design value was reduced nearly 1.0 ppb and 0.5 ppb when applying the high and low levels of the kiln controls, respectively. The high cement kiln control reduced the future design value at least 0.1 ppb at 5 of the 9 monitoring sites; the remaining sites were all located further to the north. The low cement kiln controls reduced the 2009 design value by 0.1 ppb at 3 of the 9 sites. The plume of ozone reduction never made a direct hit on Frisco or Dallas CAMS 63 on any date in the episode.

The high and low cement kiln controls reduced the episode exceedance area by 4 % and 2 %, respectively. The controls were particularly important on August 16, when the plume headed slightly west of Denton, helping lower 38 % and 9% of all exceedance grid cells by at least 1 ppb from the high and low kiln controls, respectively.