

**Final Report****AIR QUALITY MODELING ANALYSIS FOR THE  
DENVER EARLY ACTION OZONE COMPACT:****2007 Emission Reduction Sensitivity Modeling**

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## 1. INTRODUCTION

This report describes additional future-year (2007) sensitivity modeling carried out as part of the Denver-Northern Front Range 8-hour ozone Early Action Compact Study (Denver EAC Study).

The procedures used in the Denver EAC photochemical modeling are described in detail in the modeling protocol (Tesché et al., 2003a). Meteorological modeling performed to develop meteorological inputs for the Comprehensive Air-quality Model with extensions (CAMx) photochemical grid model and the June-July 2002 modeling period is described by McNally and co-workers (2003). The preparation of the emissions inputs for the Denver EAC modeling is described in Mansell and Dinh (2003a,b,c). The 2002 Base Case modeling and model performance evaluation is described by Morris and co-workers (2003) and the preliminary 2007 modeling analysis performed in December 2003 is described by Morris and co-workers (2004).

## 2. 2007 ADDITIONAL SENSITIVITY ANALYSIS RESULTS

The purpose of the additional 2007 emission reduction sensitivity analysis is to enhance our knowledge on the effectiveness of VOC and/or NO<sub>x</sub> emissions reductions in the seven county Denver Metropolitan Area (DMA) and vicinity for reducing elevated 8-hour ozone concentrations in the region. The December 2003 control strategy and emissions reduction sensitivity tests provided some initial information on 8-hour ozone sensitivity to emission controls (Morris et al., 2004). The work reported here corrected some errors in the 2007 emissions inventories (omission of non-road mobile source emissions in states east of Colorado and on-road mobile sources in California) and examines the effectiveness for reducing elevated 8-hour ozone concentrations in the Denver region of: (1) reducing VOC and/or NO<sub>x</sub> emissions in the DMA; and (2) reducing VOC emissions from mobile sources in the DMA.

### REVISED 2007 BASE CASE AND THREE CONTROL STRATEGY

As part of the emissions quality assurance/quality control (QA/QC) activities, several omissions of emissions were discovered in the 2007 simulations performed in December 2003. Normally the emissions QA/QC activities are performed prior to performing the photochemical modeling. However, the aggressive schedule of the Denver EAC precluded such activities so that the QA/QC found the omissions after the runs had been completed. The following emissions were omitted from all of the 2007 emission scenarios conducted in December 2003 and presented in Morris et al., 2004:

- Non-Road mobile source emissions for states east of Colorado including Texas, Oklahoma, Kansas, Nebraska, and Louisiana; and
- On-Road mobile source emissions for California.

As these emissions are outside of Colorado and are not affected by any of the control strategies, they likely will just affect the amount of background ozone entering the Denver region. Thus, their biggest effect would be to raise the estimated 2007 8-hour ozone Design Values across all scenarios, but not substantially change the incremental reductions due to the control measures.

Corrections were made to the 2007 emission scenarios and revised CAMx simulations were performed to project 8-hour ozone Design Values for the 2007 Base Case and 2007 Three Control (cntl4) emission scenarios. Table 2-1 compares the projected 8-hour ozone Design Values using the older (December 2003) and updated (January 2004) 2007 emissions. The inclusion of the missing emissions raises the 8-hour ozone Design Values by 0.4 to 0.8 ppb for the 2007 Base Case simulation. At the key Rocky Flats monitor, where the highest observed 2001-2003 8-hour ozone Design Value occurred, including the missing emissions increased the projected 8-hour ozone Design Value in the 2007 Base Case by 0.4 ppb, from 86.2 to 86.6 ppb. The 2007 Three Control Strategy (8.1 RVP + Flash + RICE ) emissions scenario (cntrl4) is estimated to reduce the 8-hour ozone Design Values by 0.2 to 0.5 ppb from 2007 Base Case levels.

**Table 2-1.** Current year (2001-2003) observed and 2007 projected 8-hour ozone Design Values (ppb) at the Rocky Flats ozone monitor for the 2007 Base Case and 2007 Three Control strategy (cntl4).

	2001-2003	2007 Base Case		2007 Three Control (cntl4)	
	Observed	Dec '03	Jan '04	Dec '03	Jan '04
Weld County Tower	81	79.0	79.8	78.5	79.4
Rocky Mtn. NP	81	79.3	79.7	78.9	79.2
Fort Collins	71	70.1	70.7	69.7	70.3
USAF Academy	73	70.9	71.4	70.6	71.1
Welch	70	68.8	69.1	68.5	68.9
Rocky Flats North	87	86.2	86.6	85.9	86.2
NREL	85	84.2	84.6	83.9	84.4
Arvada	76	75.4	75.9	75.2	75.6
Welby	66	66.1	66.5	65.8	66.0
S. Boulder Creek	77	76.3	76.7	76.0	76.3
Carriage	76	74.6	75.2	74.4	75.0
Highland	81	79.6	80.0	79.3	79.8
Chatfield Res.	85	83.2	83.7	82.9	83.4

The January 2004 Revised 2007 Base Case and Three Control Strategy emission updates were used for the 2007 emission reduction sensitivity simulations discussed below.

**DEFINITION OF ADDITIONAL SENSITIVITY AND CONTROL SCENARIOS**

The first two simulations performed under this additional (January 2004) modeling analysis was to revise the 2007 Base Case (07Base) and 2007 Three Control Strategy (Cntrl4) emissions scenarios to account for the omitted emissions:

- 2007 Base Case: Growth and controls (on-the-books) with on-road mobile sources using a 9.0 psi RVP gasoline with a 40% ethanol market penetration (07base); and
- 2007 Three Control Strategy: Implementation of Flash, RICE, and 8.1 psi RVP with 40% ethanol market penetration controls on top of 2007 Base (cntl4).

Emissions for the 2007 Base Case and all control factors were provided by the Colorado Department of Health and Environment (CDPHE).

The following additional VOC/NOx emission reduction sensitivity scenarios:

- 10% Reduction in Anthropogenic VOC in DMA+Weld on top of 2007 Base Case (cntl8);
- 10% Reduction in Anthropogenic NOx in DMA+Weld on top of 2007 Base Case (cntl9);
- 10% Reduction in Anthropogenic VOC and NOx in DMA+Weld on top of 2007 Base Case (cntl10);

- 10% Reduction in Anthropogenic VOC in DMA+Weld on top of 2007 Three Control Scenario (cntl11);
- 10% Reduction in Anthropogenic NO<sub>x</sub> in DMA+Weld on top of 2007 Three Control (cntl12);
- 10% Reduction in Anthropogenic VOC and NO<sub>x</sub> in DMA+Weld on top of 2007 Three Control (cntl13);
- 10% Reduction in on-road mobile source VOC emissions in the core DMA from 2007 Base Case (cntl14);
- 20% Reduction in on-road mobile source VOC emissions in the core DMA from 2007 Base Case (cntl15);
- 10% Reduction in off-road mobile source VOC emissions in the core DMA from 2007 Base Case (cntl16); and
- 20% Reduction in off-road mobile source VOC emissions in the core DMA from 2007 Base Case (cntl17).

## **2007 SENSITIVITY AND CONTROL STRATEGY MODELING RESULTS**

The CDPHE provided the control factors for adjusting the DMA on-road mobile source emissions for the 8.1 RVP with 40% ethanol penetration Three Control Strategy emissions scenario. It should be pointed out that the control factors for the RVP control measure were later found to be in error and were corrected in subsequent modeling. Thus we focus on the directional and magnitude changes in ozone due to the emission reduction sensitivity tests.

### **Projected 8-Hour Ozone Design Values at Rocky Flats**

Table 2-2 displays the projected 8-hour ozone Design Values at the Rocky Flats monitor for the additional emission reduction sensitivity scenarios. Details on the data used to project the 2007 8-hour ozone Design Values for each scenario and all ozone monitors are provided in Appendix A. As seen in Table 2-1 and Appendix A, in 2007 8-hour ozone attainment is demonstrated for all monitors but the Rocky Flats monitor northwest of Denver. The emission reduction sensitivity results suggest that:

- As seen in the previous (December 2003) modeling, the modeled ozone concentrations exhibit a stiff response to changes in emissions in the DMA (Morris et al., 2004).
- VOC control in the DMA is more effective than NO<sub>x</sub> control for reducing 8-hour ozone concentrations near the Rocky Flats monitor, as well as all the other monitors except Rocky Mountain National Park (Appendix A).

- NOx control in the DMA appears to be counterproductive at the levels of control examined (10%) increasing ozone over the base case conditions.
- A 10% anthropogenic VOC emissions reduction in the DMA results in a 0.3 to 0.4 ppb reduction in the projected 8-hour ozone Design Value at Rocky Flats.
- A 10% anthropogenic NOx emissions reduction in the DMA results in a 0.4 ppb increase in the projected 8-hour ozone Design Value at Rocky Flats.
- A combined 10% VOC and NOx anthropogenic emissions reductions in the DMA reduces the projected 8-hour ozone Design Value at Rocky Flats by 0.2 to 0.3 ppb.

**Table 2-2.** Projected 2007 8-hour ozone Design Values at the Rocky Flats monitor for the emission reduction sensitivity simulations.

Scenario	Base	DV	) O <sub>3</sub>
2001-2003 Observed		87	
2007 Base		86.6	
8.1RVP/40%EtOH, Flash/RICE (cntl4)*	07Base	86.2	-0.4
10% VOC (cntl8)	07Base	86.1	-0.5
10% NOx (cntl9)	07Base	87.0	+0.4
10% VOC+NOx (cntl10)	07Base	86.3	-0.3
Cntl4 plus 10% VOC (cntl11)	Cntl4	85.9	-0.3
Cntl4 plus 10% NOx (cntl12)	Cntl4	86.6	+0.4
Cntl4 plus 10% VOC+NOx (cntl13)	Cntl4	86.0	-0.2
10% On-Road VOC (cntl14)	07Base	86.5	-0.1
20% On-Road VOC (cntl15)	07Base	86.3	-0.3
10% Off-Road VOC (cntl16)	07Base	86.5	-0.1
20% Off-Road VOC (cntl17)	07Base	86.5	-0.1

\* Emission factors provided for 8.1RVP/40%EtOH scenario were in error.

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## **Appendix A**

### **Details on the 8-Hour Ozone Design Value Scaling for the 2007 Emission Reduction Sensitivity Simulations**

2007 Base Case

- 2007 Three Control Strategy (cntl 4)
  - 2007 10% VOC (Cntl 8)
  - 2007 10% NO<sub>x</sub> (cntl 9)
  - 2007 10% VOC and NO<sub>x</sub> (cntl 10)
- 2007 Three Control Plus 10% VOC (cntl 11)
- 2007 Three Control Plus 10% NO<sub>x</sub> (cntl 12)
- 2007 Three Control Plus 10% VOC and NO<sub>x</sub> (cntl 13)
  - 2007 10% On-Road VOC (cntl 14)
  - 2007 20% On-Road VOC (cntl 15)
  - 2007 1-% Off-Road VOC (cntl 16)
  - 2007 20% Off-Road VOC (cntl 17)

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 Base Case -- Future Year: 07run11a.a0**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.6	57	65	60.1	68.9	66.3	69.9	0.9857	79.8
Rocky Mtn. NP	81	62.7	63.8	66.3	61.4	70.5	75.1	77.5	0.9845	79.7
Fort Collins	71	62.7	62.2	68.8	58.6	64.8	71.5	72	0.9952	70.7
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.3	69	0.978	71.4
Welch	70	58.9	67.2	69.5	70.5	65.1	72.6	85.8	0.9873	69.1
Rocky Flats Nor	87	63	62.2	70.9	61.8	69.8	74.2	83.6	0.9958	86.6
NREL	85	60.5	65.7	70.9	65.6	62.7	74.2	85.8	0.9957	84.6
Arvada	76	60.1	61.1	70.9	62.6	68.5	71.7	84.7	0.9982	75.9
Welby	66	56.1	54.8	64.6	65.5	69.6	68.4	74.1	1.0073	66.5
S. Boulder Cree	77	63.1	62.3	70.9	62.5	70.5	74.2	83.6	0.9959	76.7
Carriage	76	59.1	64.3	69.7	68.6	66.3	71.2	82.8	0.9894	75.2
Highland	81	57.2	67	63.4	71.3	67.6	71.1	81.4	0.9882	80
Chatfield Res.	85	58	67	61.8	71.3	67.6	71.2	84.7	0.9841	83.7

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 Three Control Strategy -- Future Year: 07run11a.a0-cnt14**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60	56.5	64.5	59.6	67.6	66	69.5	0.98	79.4
Rocky Mtn. NP	81	62.9	63	66.1	61.2	69.8	74.7	77.1	0.9783	79.2
Fort Collins	71	62.4	61.6	68.3	58.4	64	70.8	71.8	0.9897	70.3
USAF Academy	73	56.4	62.7	56.1	64.8	59.7	68.1	68.7	0.9736	71.1
Welch	70	58.9	67	69.3	70.3	64.9	72.4	85.6	0.9842	68.9
Rocky Flats Nor	87	63.2	61.9	70.7	61.4	69.3	73.9	83.2	0.9913	86.2
NREL	85	60.4	65.6	70.7	65.5	62.4	73.9	85.6	0.9925	84.4
Arvada	76	60.1	61	70.7	62.4	67.8	71.4	84.4	0.9948	75.6
Welby	66	56	54.8	64.4	65.3	68.8	68.2	73.9	0.9998	66
S. Boulder Cree	77	63.4	62.1	70.7	62.2	69.8	73.9	83.2	0.9905	76.3
Carriage	76	59.1	64.2	69.5	68.4	65.7	70.9	82.5	0.9862	75
Highland	81	57.1	66.8	63.3	71.1	67.4	70.9	81.1	0.985	79.8
Chatfield Res.	85	58	66.8	61.7	71.1	67.4	70.9	84.4	0.9811	83.4

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 10% VOC Control in DMA+Weld -- Future Year: 07run11a.a0-ctrl8**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.4	56.8	64.4	60	68.7	66.2	69.7	0.9824	79.6
Rocky Mtn. NP	81	62.3	63.5	66.1	61.3	70.3	74.8	77.4	0.9819	79.5
Fort Collins	71	62.5	62	68.3	58.5	64.7	71.4	71.9	0.9943	70.6
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.2	69	0.9776	71.4
Welch	70	58.6	66.6	69.2	70.2	64.9	72.2	85.4	0.9821	68.7
Rocky Flats Nor	87	62.3	61.9	70.5	61.5	69.5	73.7	83	0.99	86.1
NREL	85	60.1	65	70.5	65.3	62.4	73.7	85.4	0.99	84.1
Arvada	76	59.8	60.4	70.5	62.2	68.1	71.3	84.2	0.9922	75.4
Welby	66	56	54.6	64.2	65.3	69.2	67.9	73.4	0.9995	66
S. Boulder Cree	77	62.5	62.1	70.5	62.4	70.2	73.7	83	0.9901	76.2
Carriage	76	58.7	63.6	69.3	68.3	65.9	70.9	82.3	0.9845	74.8
Highland	81	57	66.3	63.3	71	67.6	70.9	80.9	0.9839	79.7
Chatfield Res.	85	57.8	66.4	61.7	71	67.6	70.9	84.2	0.9795	83.3

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 10% NOx Control in DMA+Weld -- Future Year: 07run11a.a0-ctrl9**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.3	56.8	65.5	59.7	68.2	66.1	69.8	0.9838	79.7
Rocky Mtn. NP	81	63.5	63.3	66	61.2	69.9	74.9	76.5	0.977	79.1
Fort Collins	71	62.7	62	68.9	58.4	64.4	70.9	71.9	0.9902	70.3
USAF Academy	73	56.4	62.7	56	64.3	59.5	68	68.3	0.9681	70.7
Welch	70	59.4	67.8	69.6	70.1	64.9	73	86	0.9879	69.2
Rocky Flats Nor	87	64.4	62.4	71.2	61.8	69.7	74.7	84	0.9996	87
NREL	85	61.1	66.7	71.2	66.1	63.6	74.7	86	0.9997	85
Arvada	76	60.9	62.6	71.2	63.5	69	72.1	84.8	1.0016	76.1
Welby	66	56.7	56.8	65.7	65.7	69.7	69.5	75.8	1.0194	67.3
S. Boulder Cree	77	64.4	63.1	71.2	62.3	70.2	74.7	84	0.999	76.9
Carriage	76	60	65.6	70.2	68.8	66.8	71.2	82.8	0.9901	75.2
Highland	81	57.5	67.8	63.5	70.5	66.7	71.2	81.5	0.9858	79.8
Chatfield Res.	85	58.3	67.8	61.5	70.5	66.7	71.2	84.8	0.9816	83.4

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 10% VOC+NOx Control in DMA+Weld -- Future Year: 07run11a.a0-ctrl10**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.1	56.6	64.9	59.6	67.9	66	69.5	0.9794	79.3
Rocky Mtn. NP	81	63	63.1	65.7	61	69.7	74.5	76.4	0.9736	78.9
Fort Collins	71	62.5	61.8	68.4	58.3	64.2	70.8	71.8	0.9892	70.2
USAF Academy	73	56.4	62.7	56	64.3	59.5	67.9	68.3	0.9678	70.6
Welch	70	59	67.1	69.2	69.7	64.7	72.6	85.3	0.9812	68.7
Rocky Flats Nor	87	63.7	61.9	70.6	61.5	69.2	74.2	83.3	0.9921	86.3
NREL	85	60.7	65.9	70.6	65.6	63.2	74.2	85.3	0.9921	84.3
Arvada	76	60.4	61.8	70.6	63	68.5	71.7	84.2	0.9946	75.6
Welby	66	56.4	56	65.1	65.2	69.3	69	74.9	1.0104	66.7
S. Boulder Cree	77	63.7	62.5	70.6	62.1	69.9	74.2	83.3	0.9919	76.4
Carriage	76	59.5	64.8	69.7	68.3	66.3	70.9	82.3	0.9843	74.8
Highland	81	57.3	67	63.3	70.2	66.6	70.9	80.9	0.9805	79.4
Chatfield Res.	85	58	67	61.4	70.2	66.6	70.9	84.2	0.9761	83

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 Three Controls plus 10% VOC Control in DMA+Weld -- Future Year: 07run11a.a0-ctrl11**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	59.9	56.3	63.9	59.5	67.8	65.9	69.3	0.977	79.1
Rocky Mtn. NP	81	62.5	62.8	65.9	61	70	74.4	77	0.9773	79.2
Fort Collins	71	62.2	61.4	67.9	58.2	64.1	70.8	71.8	0.9889	70.2
USAF Academy	73	56.4	62.7	56.1	64.8	59.8	68	68.7	0.9733	71
Welch	70	58.6	66.5	69	70	64.8	72	85.1	0.9792	68.5
Rocky Flats Nor	87	62.6	61.6	70.3	61.2	69.3	73.5	82.7	0.987	85.9
NREL	85	60.1	64.9	70.3	65.1	62.3	73.5	85.1	0.987	83.9
Arvada	76	59.7	60.4	70.3	62.1	67.8	71.1	83.9	0.9892	75.2
Welby	66	55.8	54.6	64	65	68.8	67.7	73.2	0.995	65.7
S. Boulder Cree	77	62.9	61.7	70.3	62.1	69.9	73.5	82.7	0.9864	76
Carriage	76	58.7	63.6	69.1	68.1	65.6	70.7	82.1	0.9815	74.6
Highland	81	57	66.2	63.2	70.9	67.5	70.7	80.7	0.981	79.5
Chatfield Res.	85	57.8	66.3	61.7	70.9	67.5	70.7	83.9	0.9767	83



Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 Three Controls plus 10% NOx Control in DMA+Weld -- Future Year: 07run11a.a0-ctrl12**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	59.7	56.3	65	59.2	67.3	66	69.4	0.9784	79.2
Rocky Mtn. NP	81	63.5	62.6	65.8	60.9	69.6	74.6	76.1	0.9723	78.8
Fort Collins	71	62.4	61.5	68.4	58.2	63.9	70.3	71.7	0.985	69.9
USAF Academy	73	56.3	62.7	56	64.2	59.4	67.8	68.2	0.9659	70.5
Welch	70	59.4	67.6	69.4	69.9	64.8	72.8	85.7	0.9845	68.9
Rocky Flats Nor	87	64.7	62.1	70.9	61.4	69.4	74.4	83.6	0.9957	86.6
NREL	85	61.1	66.6	70.9	65.9	63.5	74.4	85.7	0.9962	84.7
Arvada	76	60.8	62.5	70.9	63.2	68.6	71.9	84.5	0.9983	75.9
Welby	66	56.7	56.7	65.5	65.4	69.2	69.2	75.5	1.0138	66.9
S. Boulder Cree	77	64.7	62.8	70.9	62	69.9	74.4	83.6	0.9949	76.6
Carriage	76	60	65.5	70	68.5	66.5	71	82.5	0.9867	75
Highland	81	57.5	67.6	63.4	70.3	66.6	71	81.2	0.9827	79.6
Chatfield Res.	85	58.2	67.6	61.4	70.3	66.6	71	84.5	0.9784	83.2

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 Three Control plus 10% VOC+NOx in DMA+Weld -- Future Year: 07run11a.a0-ctrl13**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	59.5	56.2	64.4	59.1	67.1	65.9	69.1	0.9744	78.9
Rocky Mtn. NP	81	63.1	62.4	65.5	60.8	69.3	74.2	76	0.9692	78.5
Fort Collins	71	62.2	61.2	67.9	58	63.7	70.2	71.6	0.9841	69.9
USAF Academy	73	56.3	62.7	56	64.2	59.4	67.7	68.1	0.9656	70.5
Welch	70	59	66.9	69	69.5	64.6	72.3	85	0.9781	68.5
Rocky Flats Nor	87	63.9	61.6	70.4	61.1	69.1	73.9	82.9	0.9888	86
NREL	85	60.7	65.8	70.4	65.4	63.1	73.9	85	0.9889	84.1
Arvada	76	60.4	61.7	70.4	62.7	68.1	71.5	83.9	0.9915	75.4
Welby	66	56.4	55.9	64.9	65	68.8	68.7	74.6	1.0052	66.3
S. Boulder Cree	77	64	62.3	70.4	61.8	69.5	73.9	82.9	0.9881	76.1
Carriage	76	59.5	64.7	69.5	68.1	66	70.7	82	0.9811	74.6
Highland	81	57.2	66.8	63.2	70.1	66.5	70.7	80.6	0.9774	79.2
Chatfield Res.	85	58	66.8	61.3	70.1	66.5	70.7	83.9	0.9732	82.7

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 10% On-Road VOC Control in DMA Core -- Future Year: 07run11a.a0-cnt114**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.6	57	64.9	60.1	68.9	66.3	69.9	0.9857	79.8
Rocky Mtn. NP	81	62.6	63.8	66.3	61.4	70.4	75	77.5	0.9839	79.7
Fort Collins	71	62.7	62.2	68.7	58.6	64.8	71.4	72	0.9952	70.7
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.3	69	0.9779	71.4
Welch	70	58.8	67	69.3	70.4	65	72.5	85.7	0.9855	69
Rocky Flats Nor	87	62.8	62.2	70.7	61.7	69.7	74	83.4	0.9938	86.5
NREL	85	60.3	65.5	70.7	65.5	62.6	74	85.7	0.9936	84.5
Arvada	76	60	60.9	70.7	62.5	68.4	71.6	84.5	0.9959	75.7
Welby	66	56	54.7	64.4	65.5	69.5	68.3	73.9	1.0047	66.3
S. Boulder Cree	77	62.9	62.3	70.7	62.5	70.4	74	83.4	0.9939	76.5
Carriage	76	58.9	64.1	69.5	68.5	66.2	71.1	82.6	0.9877	75.1
Highland	81	57.1	66.7	63.4	71.2	67.6	71	81.2	0.9867	79.9
Chatfield Res.	85	58	66.8	61.8	71.2	67.6	71.1	84.5	0.9825	83.5

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 20% On-Road VOC in DMA Core -- Future Year: 07run11a.a0-cntl15**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.6	57	64.8	60.1	68.9	66.3	69.9	0.9857	79.8
Rocky Mtn. NP	81	62.6	63.7	66.2	61.4	70.4	74.9	77.5	0.9833	79.6
Fort Collins	71	62.7	62.2	68.7	58.6	64.8	71.4	72	0.9951	70.7
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.3	69	0.9778	71.4
Welch	70	58.7	66.8	69.2	70.3	65	72.4	85.5	0.9838	68.9
Rocky Flats Nor	87	62.6	62.1	70.5	61.7	69.6	73.9	83.2	0.9918	86.3
NREL	85	60.2	65.3	70.5	65.4	62.5	73.9	85.5	0.9914	84.3
Arvada	76	59.8	60.7	70.5	62.4	68.3	71.5	84.3	0.9938	75.5
Welby	66	56	54.7	64.2	65.4	69.4	68.1	73.6	1.0021	66.1
S. Boulder Cree	77	62.7	62.3	70.5	62.5	70.3	73.9	83.2	0.9919	76.4
Carriage	76	58.8	63.9	69.3	68.4	66.1	71	82.4	0.986	74.9
Highland	81	57	66.5	63.3	71.1	67.6	71	81	0.9852	79.8
Chatfield Res.	85	57.9	66.6	61.7	71.1	67.6	71	84.3	0.9809	83.4

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 10% Off-Road VOC in DMA Core -- Future Year: 07run11a.a0-ctrl16**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.6	57	64.9	60.1	68.9	66.3	69.9	0.9857	79.8
Rocky Mtn. NP	81	62.6	63.8	66.3	61.4	70.4	75	77.5	0.9841	79.7
Fort Collins	71	62.7	62.2	68.7	58.6	64.8	71.4	72	0.9952	70.7
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.3	69	0.9779	71.4
Welch	70	58.8	67.1	69.4	70.5	65.1	72.5	85.8	0.9862	69
Rocky Flats Nor	87	62.8	62.2	70.8	61.7	69.7	74.1	83.5	0.9948	86.5
NREL	85	60.4	65.5	70.8	65.6	62.7	74.1	85.8	0.9946	84.5
Arvada	76	60	61	70.8	62.6	68.5	71.6	84.6	0.997	75.8
Welby	66	56.1	54.7	64.5	65.5	69.5	68.3	74	1.0058	66.4
S. Boulder Cree	77	62.9	62.3	70.8	62.5	70.5	74.1	83.5	0.9948	76.6
Carriage	76	59	64.2	69.6	68.6	66.2	71.1	82.7	0.9884	75.1
Highland	81	57.1	66.8	63.4	71.2	67.6	71.1	81.3	0.9873	80
Chatfield Res.	85	58	66.8	61.8	71.2	67.6	71.1	84.6	0.9832	83.6

Base Case: run11a

Site	DV	2176	2177	2178	2179	2180	2181	2182	#Days>70
Weld County Tow	81	61	57.2	65.2	60.6	69.4	66.9	70.9	1
Rocky Mtn. NP	81	63.1	64.3	67.4	62	71.4	76	79.1	3
Fort Collins	71	63.2	62.6	69.5	59	65.4	70.7	73.5	2
USAF Academy	73	56.6	63.5	56.6	66.6	61	69.4	70.6	1
Welch	70	58.9	66.5	69.8	71.7	65.7	73	87.2	3
Rocky Flats Nor	87	62.8	62.7	70.9	62.1	70.5	73.8	84.5	4
NREL	85	60.4	64.6	70.9	64.9	63.1	73.8	87.2	3
Arvada	76	59.8	60	70.8	63.1	69.1	71.8	85.1	3
Welby	66	56.6	55.2	62.6	66.5	70	66.2	72.7	2
S. Boulder Cree	77	63	62.8	70.9	63	70.9	74.1	84.5	4
Carriage	76	58.4	62.3	68.8	67.9	66.6	71.9	83.8	2
Highland	81	57.4	66.3	62.7	73	69.7	71.9	81.6	3
Chatfield Res.	85	57.9	66.5	63.4	73	69.7	71.9	85.9	3

**2007 20% Off-Road VOC in DMA Core -- Future Year: 07run11a.a0-ctrl17**

Site	DV	2176	2177	2178	2179	2180	2181	2182	RRF DV	Scaled
Weld County Tow	81	60.6	57	64.8	60.1	68.9	66.3	69.9	0.9857	79.8
Rocky Mtn. NP	81	62.5	63.7	66.2	61.4	70.4	74.9	77.5	0.9837	79.7
Fort Collins	71	62.7	62.2	68.6	58.6	64.8	71.4	72	0.9951	70.7
USAF Academy	73	56.4	62.8	56.1	64.9	59.8	68.2	69	0.9778	71.4
Welch	70	58.8	66.9	69.4	70.4	65	72.4	85.7	0.9851	69
Rocky Flats Nor	87	62.7	62.2	70.7	61.7	69.7	74	83.4	0.9937	86.5
NREL	85	60.3	65.4	70.7	65.5	62.6	74	85.7	0.9934	84.4
Arvada	76	60	60.8	70.7	62.5	68.4	71.5	84.5	0.9958	75.7
Welby	66	56	54.7	64.5	65.4	69.5	68.2	73.9	1.0043	66.3
S. Boulder Cree	77	62.8	62.3	70.7	62.5	70.4	74	83.4	0.9938	76.5
Carriage	76	58.9	64	69.6	68.5	66.1	71	82.6	0.9874	75
Highland	81	57.1	66.7	63.4	71.2	67.6	71	81.2	0.9864	79.9
Chatfield Res.	85	57.9	66.7	61.8	71.2	67.6	71	84.5	0.9822	83.5