Appendix F-13

Additional Information on the RRF and the Modeled Attainment Test

TSD-1g

Relative Response Factor (RRF) and "Modeled Attainment Test"

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

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EPA guidance (EPA 2005) and the subsequent document (EPA 2006) require the use of a *modeled attainment test* which is described as a procedure in which an air quality model is used to simulate current and future air quality. If future estimates of ozone concentrations are <= 84 ppb, then this element of the attainment test is satisfied. A *modeled attainment demonstration* that consists of (a) analyses which estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS or progress goals and (b) an identified set of control measures which will result in the required emissions reductions is provided elsewhere.

For this modeled attainment test, model estimates are used in a "relative" rather than "absolute" sense. That is, one calculates the ratio of the model's future to current (baseline) predictions at ozone monitors. These ratios are called *relative response factors (RRF)*. Future ozone concentrations are estimated at existing monitoring sites by multiplying modeled RRF at locations "near" each monitor by the observation-based monitor-specific "baseline" ozone design value. Therefore, the following equation describes approach as applied to a monitoring site i:

$$(DVF)_i = (RRF)_i \times (DVC)_i \qquad \text{(Equation 1)}$$

Where $(DVC)_i$ is the baseline concentration monitored at site i; $(RRF)_i$ is the relative response factor, calculated for site i, and $(DVF)_i$ is the estimated future design value for site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted at a monitor to the baseline 8-hour daily maximum concentration predicted at the monitor location averaged over multiple days determined from the base case.

The following sections describe the calculation of each of the elements in Equation 1 as implemented by NYSDEC through an in-house computer program (fortran). Note, the subscript "i" from equation is dropped in the following description. However, all calculations are still performed on a monitor-by-monitor basis.

1. <u>Calculation of DVC</u>

Design values (DV) at each monitoring site are calculated in accordance with 40 CFR Part 50.10, Appendix I. The DV is calculated as the 3 year average of the fourth highest monitored daily 8-hour maximum value at each monitoring site. For example, the design value for the 2000-2002 is the average of the fourth highest monitored daily 8-hour maximum values in 2000, 2001 and 2002. Design values are labeled with the *last* year of the design value period, i.e. the design value for the 2000 – 2002 is labeled as "2002 design value".

For the "modeled attainment test", the guidance defines the DVC in Equation 1 as the average of the design values, which straddle the baseline inventory year. In our case, the baseline inventory year is 2002. Therefore, DVC is the average of the "2002 design value" (determined from 2000-2002 observations), the "2003 design value" (determined from 2001-2003 observations), and the “2004 design value” (determined from 2002-2004 observations). Consequently, DVC is derived from observations covering a five year period and is a weighted average with 2002 observations “weighted” three times, 2001 and 2003 observations weighted twice, and 2000 and 2004 observations weighted once.

The following criteria concerning missing DV were implemented in the fortran code calculating DVC:

- For monitors with only four years of consecutive data, the guidance allows DVC to be computed as the average of two DV within that period.
- For monitors with only three years of consecutive data, the DVC is equal to the DV calculated for that three year period
- For monitors with less than three years of consecutive data, no DVC can be estimated

2. Calculation of RRF

The guidance requires the calculation of RRF with CMAQ output from grids that are “near” a monitor. Because of the 12km grid spacing used in the CMAQ simulations, model predictions in a 3*3 grid array centered on the monitoring location are considered “near” that monitor. For each day, the maximum base case and control case concentration within that array is selected for RRF calculation as set forth in the guidance document.

Because photochemical models were found to be less responsive to emission reductions on days of lower simulated ozone concentrations, the guidance recommends applying screening criteria to the daily model predictions at individual monitors to determine whether that day’s predictions are to be used to calculate the RRF or not. Only “high ozone days” are to be selected:

RRF = (average control case over high ozone days selected based on base case concentrations) / (average base case over selected high ozone days)

In addition, the guidance recommends that preferably ten or more “high ozone days”, as identified below, be selected for RRF calculation. In no case can the RRF be calculated with fewer than five “high ozone days”.

The following describes the logic with which NYSDEC implemented these screening criteria into its Fortran code for RRF calculation:

a. Selecting concentrations from grid cells surrounding the monitor

i. Determine the grid cell in which the monitor is located and include the surrounding 8 grid cells to form a 3*3 grid cell array

ii. Determine daily maximum 8-hr ozone concentrations for each day for each of the 9 grid cells for both the base case and control case

iii. For each day, pick the highest daily maximum 8-hr ozone value out of all 9 grid cells. This is the daily maximum 8-hr ozone concentration for that monitor for that day to be used in RRF calculations (following the screening criteria below).

iv. This is done for both the base case and the control case. Note that the grid cell selected on any given day for the base case need not be the same as the grid cell selected for the same day in the control case.

b. <u>Selecting modeling days to be used in the RRF computation (again, this is done on a monitor-by-monitor basis)</u>

i. Starting with a ozone threshold (TO_3) of 85 ppb and a minimum required number of days (Dmin) of 10, determine all days for which the simulated base case concentration (as determined in step (a) is at or above the threshold TO_3.

ii. If the number of such days is greater to or equal Dmin, identify these days and proceed to step (c). Otherwise, continue to b(iii), below.

iii. Lower the threshold (TO_3) by 1ppb interval and go back to b(i) to identify the days. If the minimum number of days is not reached then reduce that requirement by 1 but no lower than 5 days and with TO_3 > =70 ppb and go back to b(i). Otherwise proceed to b(iv) below.

iv. Stop. No RRF can be calculated for this monitor because there were less than 5 days with base case daily maximum concentration > =70 ppb.

c. <u>RRF computation:</u> Compute the RRF by averaging the daily maximum 8-hr ozone concentrations for base case and control case determined in step (a) over all of the days determined in step (b). The RRF is the ratio of average control case concentrations over average base case concentrations.

3. Computation of DVF

Compute DVF as the product of DVC from step (1) and RRF from step (2). Note, the following conventions on numerical precision (truncation, rounding) were applied:

a. DV are truncated in accordance with 40 CFR Part 50.10, Appendix I. This applies to the “2002 DV”, the “2003 DV”, and the “2004 DV”

b. DVC (averages of DV over multiple years) are calculated in ppb and carried to 1 significant digit

c. RRF are calculated and carried to three significant digits

d. DVF is calculated by multiplying DVC with RRF, followed by truncation

References

EPA (2005) Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS. EPA-454/R-05-002.

EPA (2006) Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. Draft 3.2-September 2006.

TSD-1h

Projected 8-h ozone air quality over the Ozone Transport Region

Bureau of Air Quality Analysis and Research

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The USEPA guidance (EPA 2005 and EPA 2006) recommends the use of relative reduction factor (RRF) approach for demonstrating the attainment of the 8-hr ozone NAAQS. The OTC Modeling committee implemented this recommended approach in performing attainment assessment of the areas.

Attainment year 2009

As described in TSD-1g (2007), the RRFs were determined for all OTR monitors for the two future year simulations with 2009OTW and 2009BOTW emissions data. The base design value (DVc) for 2002 representing the number of DVs estimated on the basis of 3-yr averages available from 2000 to 2004 are listed in Tables 1 and 2 along with the RRF, the number of days, the level of threshold, and future year projected concentrations for each monitor identified by its AIRS ID, common name and the county. The values in bold represent projected design values that exceed the 8-hr ozone NAAQS.

In general both simulations do not differ much from each other in that they yield similar design values with the 2009BOTW providing concentrations that are about one or two ppb lower than the 2009OTW. However it should be noted that the Guidance provides for a window (82 to 87 ppb) that can be considered as demonstrating attainment provided there is sufficient information to support in the form of weight of evidence (WOE) that suggests that the projected design value would be at or less than the 8-hr ozone NAAQS, taking into consideration the current measured design value and other projected emissions reductions within and outside the modeling domain.

If such a consideration is given then there are only 6 monitors above 87 ppb in the OTR, and without such an option of WOE there would be 21 monitors that have projected design value above 84 ppb. It should be noted that in either case, a majority of them are located in the Baltimore–Philadelphia-New York City-Connecticut portion of inner OTR corridor associated with high emissions region.

These Tables also list monitors for which no future DV (DVF) was calculated, listed as -9 in all columns except for DVC, which is a limitation inherent in the method for calculating the RRF. Often these monitors have DVC less than 84 ppb, with the exception of the monitor at the summit of Whiteface, NY (360310002), that has a DVC of 88.3 ppb while at the base of Whiteface (360311003) the measured DVC is 84.3 ppb. In both instances, there were fewer than 5 days that the model simulation predicted base concentrations in the 9-grid cells surrounding these monitors was below the threshold of 70 ppb, resulting in assigning no RRF and no estimate of DVF for these monitors.

Attainment year 2012

One other option that was considered by the OTC Modeling committee is the simulation of 2012BOTW emissions within the OTR. The details of the development of the 2012BOTW inventory are provided in TSD-1f (2007). The CMAQ simulation was performed with the 2012BOTW emissions in the OTR with the remainder of the modeling domain also at 2012 emissions. The results of the simulation were processed in a manner similar to those of 2009 and the resulting future year design values are listed in Table 3 in a format similar to those in Tables 1 and 2.

The listed future DVs indicate that there are 5 monitors that would have a projected design value above 84 ppb, again located in the inner OTR corridor. However it should be noted that if consideration is given to these monitors along with WOE then these would be within the prescribed range of WOE, thereby demonstrating ***modeled attainment for all monitors in the OTR*** under this scenario.

Non-monitored locations

One of the requirements of the EPA guidance is the need to investigate if there are locations within the modeling domain where the predicted future design values (DVF) are above the level of NAAQS but are not associated with a monitor to provide DVC. While the EPA has recommended the use of modeled attainment test software (MATS) to investigate such occurrences, it was decided by the Modeling committee that such an assessment should be undertaken by the individual areas themselves as part of their SIP analysis.

References

EPA (2005) Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS. EPA-454/R-05-002.

EPA (2006) Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. Draft 3.2-September 2006.

TSD-1f (2007) Future Year Emissions Inventory for 8-h OTC Ozone Modeling

TSD-1g (2007) Relative response factor (RRF) and "Modeled Attainment Test"

Table 1 Projected 8-hr Ozone Design Values over OTR based on 2012BOTW Emissions Inventory

AIRS-ID	County	Monitor	#ofDV	DVC	DVF	RRF	#Days	Threshold
90013007	Fairfield	Stratford	3	98.3	86	0.878	38	85
340290006	Ocean	Colliers Mills	3	106	86	0.819	20	85
361030009	Suffolk	Holtsville	3	97	86	0.889	34	85
420170012	Bucks	Bristol	3	99	84	0.849	25	85
90010017	Fairfield	Greenwich	3	95.7	83	0.874	30	85
90093002	New Haven	Madison	3	98.3	83	0.853	39	85
340070003	Camden	Camden	3	98.3	83	0.852	26	85
340155001	Gloucester	Clarksboro	3	98.3	83	0.853	25	85
340071001	Camden	Ancora St. Hos	3	100.7	82	0.817	27	85
361030002	Suffolk	Babylon	3	93.7	82	0.884	22	85
361192004	Westchester	White Plains	3	91.3	82	0.904	22	85
421010024	Philadelphia	Northeast (Air	3	96.7	82	0.858	23	85
90011123	Fairfield	Danbury	3	95.7	81	0.853	18	85
90019003	Fairfield	Westport	3	94	81	0.868	37	85
90099005	New Haven	Hamden	3	93.3	81	0.874	25	85
340030005	Bergen	Teaneck	3	91.7	81	0.892	18	85
340210005	Mercer	Rider Univ.	3	97	81	0.843	23	85
90070007	Middlesex	Middletown	3	95.7	80	0.839	21	85
240251001	Harford	Edgewood	3	100.3	80	0.804	41	85
340250005	Monmouth	Monmouth Univ.	3	95.7	80	0.836	45	85
360290002	Erie	Amherst	3	95.7	80	0.839	11	78
360850067	Richmond	Susan Wagner	3	93	80	0.868	42	85
510130020	Arlington	Arlington Co.	3	96.7	80	0.832	24	85
250092006	Essex	LYNN	3	90	79	0.88	16	85
250213003	Norfolk	MILTON	1	91	79	0.873	13	85
340230011	Middlesex	Rutgers Univ.	3	96	79	0.826	22	85
340273001	Morris	Chester	3	95.3	79	0.83	13	85
360631006	Niagara	Middleport	3	91.7	79	0.871	15	85
510590018	Fairfax	Fairfax Co. -	3	96.7	79	0.825	20	85
518000004	Suffolk City	Suffolk - TCC	3	87	79	0.91	26	85
240030014	Anne Arundel	Davidsonville	3	98	78	0.797	30	85
240030019	Anne Arundel	Ft. Meade	3	97	78	0.809	30	85
340190001	Hunterdon	Flemington	3	95.3	78	0.825	15	85
421010014	Philadelphia	Northwest (Rox	3	90.7	78	0.868	20	85
516500004	Hampton City	Hampton	3	88.3	78	0.893	36	85
250250041	Suffolk	BOSTON (Long I	3	88.7	77	0.873	21	85
360450002	Jefferson	Perch River	3	91.3	77	0.847	10	81
360790005	Putnam	Mt. Ninham	3	91.3	77	0.845	14	85
420030010	Allegheny	Pittsburgh (Ca	3	90.7	77	0.858	16	85
420290050	Chester	West Chester	1	95	77	0.813	12	85
420450002	Delaware	Chester	3	91.7	77	0.844	23	85
420910013	Montgomery	Norristown	3	92.3	77	0.839	21	85

440090007	Washington	EPA Lab	3	93.3	77	0.828	33	85
510590030	Fairfax	Fairfax Co. -	3	95	77	0.82	21	85
510591005	Fairfax	Fairfax Co. -	1	94	77	0.82	21	85
100031010	New Castle	Brandywine	3	92.7	76	0.83	19	85
110010043	DC	McMillan Reser	3	92.7	76	0.824	22	85
240053001	Baltimore	Essex	3	91.3	76	0.838	48	85
240259001	Harford	Aldino	3	97	76	0.793	35	85
240330002	Prince Georges	Greenbelt	2	94	76	0.812	28	85
240338003	Prince Georges	PG Coun.Eques.	1	94	76	0.809	28	85
360130006	Chautauqua	Dunkirk	3	93	76	0.824	20	85
360270007	Dutchess	Millbrook	3	92	76	0.828	12	80
420030008	Allegheny	Lawrenceville	3	89.3	76	0.858	16	85
90131001	Tolland	Stafford	3	92.3	75	0.814	11	85
230090102	Hancock	ANP Cadillac M	3	91.7	75	0.818	10	82
240150003	Cecil	Fair Hill	3	97.7	75	0.775	18	85
250010002	Barnstable	TRURO	3	92	75	0.825	23	85
250051002	Bristol	FAIRHAVEN	3	91	75	0.833	23	85
250130008	Hampden	CHICOPEE	3	92	75	0.82	10	83
340110007	Cumberland	Millville	3	95.7	75	0.791	16	85
340170006	Hudson	Bayonne	3	84.7	75	0.891	22	85
360050083	Bronx	Botanical Gard	3	83.7	75	0.908	20	85
420030067	Allegheny	South Fayette	3	89.3	75	0.851	13	85
440030002	Kent	Alton Jones	3	93.3	75	0.809	17	85
90110008	New London	Groton	3	90	74	0.831	38	85
100010002	Kent	Killens Pond	3	88.3	74	0.849	25	85
100031007	New Castle	Lums Pond	2	94.5	74	0.789	18	85
100031013	New Castle	Bellefonte	3	90.3	74	0.827	21	85
100051003	Sussex	Lewes	3	87	74	0.853	26	85
240290002	Kent	Millington	3	95.3	74	0.784	17	85
420031005	Allegheny	Harrison Twp	3	91.3	74	0.815	14	85
420770004	Lehigh	Allentown	3	90.7	74	0.816	11	84
510360002	Charles City	Charles City C	3	89.3	74	0.833	14	85
510850003	Hanover	Hanover Co.	2	92	74	0.815	11	85
515100009	Alexandria Cit	Alexandria	3	90	74	0.825	20	85
110010025	DC	Takoma Park	3	88.7	73	0.833	24	85
110010041	DC	River Terrace	3	89	73	0.824	22	85
340010005	Atlantic	Nacote Creek	3	89	73	0.826	27	85
340315001	Passaic	Ramapo	3	86.7	73	0.853	19	85
420070002	Beaver	Hookstown	3	91.3	73	0.802	10	82
420070005	Beaver	Brighton Twp	3	89.7	73	0.814	12	82
420290100	Chester	New Garden (Ai	3	94.7	73	0.777	19	85
420490003	Erie	Erie	3	89	73	0.83	23	85
420850100	Mercer	Farrell	3	91.3	73	0.804	10	82
420950025	Northampton	Freemansburg	3	90	73	0.816	11	85
421290008	Westmoreland	Greensburg	3	88	73	0.831	18	85
440071010	Providence	Francis School	3	89.7	73	0.819	17	85
90031003	Hartford	E. Hartford	3	88	72	0.826	16	85
90050005	Litchfield	Cornwall	1	89	72	0.818	11	84

230312002	York	Kennebunkport	3	88.3	72	0.824	19	85
240051007	Baltimore	Padonia	3	88.7	72	0.816	26	85
360130011	Chautauqua	Westfield	3	87	72	0.829	12	85
360551004	Monroe	Rochester	3	83.7	72	0.861	18	85
420050001	Armstrong	Kittanning	3	90.7	72	0.799	11	84
420710007	Lancaster	Lancaster	3	90.7	72	0.795	17	85
421250005	Washington	Charleroi	3	86.3	72	0.838	15	85
510870014	Henrico	Henrico Co.	3	88.3	72	0.824	15	85
240313001	Montgomery	Rockville	3	86.7	71	0.822	26	85
250094004	Essex	NEWBURY	3	86	71	0.834	27	85
360810124	Queens	Queens College	2	83	71	0.861	26	85
361173001	Wayne	Williamson	3	84	71	0.848	18	85
420110009	Berks	Reading	3	88.7	71	0.806	10	85
420550001	Franklin	Methodist Hill	3	90.7	71	0.788	11	77
420958000	Northampton	Easton	3	88	71	0.816	12	85
421010136	Philadelphia	Southwest (Elm	3	83	71	0.861	23	85
421330008	York	York	3	89	71	0.807	17	85
510595001	Fairfax	Fairfax Co. -	3	88	71	0.818	21	85
511071005	Loudon	Loudoun Co.	3	90	71	0.798	15	85
100051002	Sussex	Seaford	3	90	70	0.787	10	80
240170010	Charles	S Maryland	3	93	70	0.753	17	85
250154002	Hampshire	WARE	3	86.3	70	0.82	10	81
250171102	Middlesex	STOW	3	85.7	70	0.819	10	80
330111010	Hillsborough	Nashua	2	86	70	0.816	10	75
360010012	Albany	Loudonville	3	83	70	0.853	8	70
360671015	Onondoga	East Syracuse	3	82.3	70	0.854	8	70
361030004	Suffolk	Riverhead	3	83	70	0.845	36	85
420590002	Greene	Holbrook	3	87.7	70	0.804	10	85
230052003	Cumberland	Cape Elizabeth	3	84.3	69	0.822	18	85
230313002	York	Kittery	3	85.3	69	0.819	16	85
240130001	Carroll	South Carroll	3	88.7	69	0.782	12	85
330115001	Hillsborough	Peterborough	1	84	69	0.822	10	73
360910004	Saratoga	Stillwater	3	84.7	69	0.824	6	70
421290006	Wetsmoreland	Murrysville	3	82	69	0.848	20	85
510410004	Chesterfield	Chesterfield C	3	84.7	69	0.816	10	85
230090103	Hancock	ANP McFarland	3	83.7	68	0.82	10	82
230130004	Knox	Port Clyde	3	83.7	68	0.82	13	85
240210037	Frederick	Frederick Airp	3	87.3	68	0.779	11	85
250034002	Berkshire	ADAMS	3	83.3	68	0.828	9	70
250130003	Hampden	AGAWAM	1	83	68	0.823	10	83
330150012	Rockingham	Rye	2	83.5	68	0.819	16	85
360715001	Orange	Valley Central	3	84.7	68	0.812	10	76
420070014	Beaver	Beaver Falls	3	85	68	0.81	10	83
420431100	Dauphin	Hershey	3	86.7	68	0.792	16	85
421174000	Tioga	Tioga County (	3	85	68	0.805	5	70
421250200	Washington	Washington	3	85.3	68	0.803	11	85
510590005	Fairfax	Fairfax Co. -	3	87	68	0.789	18	85
510690010	Frederick	Frederick Co.	3	82.7	68	0.825	11	81

511130003	Madison	Madison Co. -	3	84.7	68	0.806	11	71
511530009	Prince William	Prince William	3	85	68	0.804	12	83
511611004	Roanoke	Roanoke Co.	3	83.7	68	0.823	11	76
511790001	Stafford	Stafford Co.	3	86	68	0.798	36	85
240430009	Washington	Hagerstown	3	85.3	67	0.791	10	84
250270015	Worcester	WORCESTER	3	84	67	0.809	10	79
420010002	Adams	Biglerville (P	3	85	67	0.791	10	80
420110001	Berks	Kutztown	2	84.5	67	0.802	10	85
420210011	Cambria	Johnstown	3	85	67	0.798	10	85
420274000	Centre	Penn Nursery (	3	84.7	67	0.798	11	74
420334000	Clearfield	Moshannon (PSU	3	87.3	67	0.775	11	76
421255001	Washington	Florence	3	85.7	67	0.787	10	83
360650004	Oneida	Camden	3	79.7	66	0.84	10	70
420130801	Blair	Altoona	3	83.3	66	0.794	10	80
420270100	Centre	State College	3	84.3	66	0.787	10	76
420430401	Dauphin	Harrisburg	3	85	66	0.786	15	85
420690101	Lacakawana	Peckville	3	83.3	66	0.796	10	75
500030004	Bennington	Bennington	3	79.7	66	0.837	8	70
518000005	Suffolk City	Suffolk - Holl	3	82.3	66	0.808	10	76
420692006	Lacakawana	Scranton	3	82	65	0.796	10	75
420791101	Luzerene	Wilkes-Barre	3	83.7	65	0.786	10	76
420810100	Lycoming	Montoursville	1	82	65	0.798	11	75
420990301	Perry	Perry County	3	83.3	65	0.792	10	77
330150013	Rockingham	999	1	80	64	0.802	10	73
420791100	Luzerene	Nanticoke	3	81.7	64	0.788	10	76
510330001	Caroline	Caroline Co.	3	82.3	64	0.78	10	84
230112005	Kennebec	Gardiner Pray	3	78	63	0.818	10	71
250250042	Suffolk	BOSTON (Harris	3	73	63	0.87	16	85
330173002	Strafford	Rochester	2	78.5	63	0.807	11	71
360430005	Herkimer	Nick's Lake	3	74	63	0.853	6	70
511390004	Page	Page Co.	3	79.7	63	0.799	12	72
230090301	Hancock	Castine	1	75	62	0.827	10	79
510610002	Fauqier	Fauquier Co.	3	79.3	62	0.788	11	73
250150103	Hampshire	AMHERST	3	74.7	61	0.825	10	76
420730015	Lawrence	New Castle	3	78.3	61	0.79	10	83
420814000	Lycoming	Tiadaghton (PS	3	78.7	61	0.785	10	72
421010004	Philadelphia	Frankford (Lab	3	71.3	61	0.86	25	85
511630003	Rockbridge	Rockbridge Co.	3	76.7	61	0.797	8	70
230310038	York	West Buxton	1	75	60	0.806	9	70
330050007	Cheshire	Keene	3	74.3	60	0.813	10	72
250090005	Essex	LAWRENCE	1	70	58	0.829	10	82
330150015	Rockingham	Portsmouth	1	68	55	0.819	16	85
CC0040002	999	Roosevelt-Camp	3	58.3	49	0.849	10	75
230038001	Aroostook	Ashland135	3	64	-9	-9	-9	-999
230173001	Oxford	North Lovell	3	60.7	-9	-9	-9	-999
230194007	Penobscot	Howland	3	66.7	-9	-9	-9	-999
230194008	Penobscot	Holden Rider B	2	79	-9	-9	-9	-999
330012004	Belknap	Laconia	2	76.5	-9	-9	-9	-999

330031002	Carroll	Conway	1	67	-9	-9	-9	-999
330090008	Grafton	Haverhill	3	70.3	-9	-9	-9	-999
330130007	Merrimack	Concord	3	74.7	-9	-9	-9	-999
330190003	Sullivan	Claremont	3	74.3	-9	-9	-9	-999
360150003	Chemung	Elmira	3	80.3	-9	-9	-9	-999
360310002	Essex	Whiteface Summ	3	88.3	-9	-9	-9	-999
360310003	Essex	Whiteface Base	3	84.3	-9	-9	-9	-999
360410005	Hamilton	Piseco Lake	3	78.7	-9	-9	-9	-999
360530006	Madison	Camp Georgetow	3	79.7	-9	-9	-9	-999
361111005	Ulster	Belleayre	3	81.3	-9	-9	-9	-999
500070007	Chittenden	Underhill	3	77	-9	-9	-9	-999
511970002	Wythe	Wythe Co.	3	79.7	-9	-9	-9	-999

Appendix F-14

Future Year Modeling Emissions and Controls

TSD-1f

Future Year Emissions Inventory for

8-h OTC Ozone Modeling

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

February 22, 2007

Following the designation of an area as non-attainment for the criteria pollutant Ozone, the Clean Air Act requires submission of an implementation plan, commonly referred to as State Implementation Plan (SIP), demonstrating as to how that area will be meeting the NAAQS in the time period established by the Act. Several areas of the OTR were designated as being in nonattainment for 8-hr ozone (see http://www.epa.gov/ozonedesignations/) with a maximum attainment date of June 2009 and June 2010. However, given that ozone precursors also contribute to $PM_{2.5}$ and other logistics, it was recommended and agreed by the member states that the future year for demonstrating attainment would be 2009. Therefore the OTR states initiated the development of emissions inventories reflecting growth and control from 2002 to 2009 as well as for 2012 and 2018. The 2018 inventory was in response to the need for submission of regional haze SIP, and the 2012 as a next step in the event that attainment for ozone was not feasible in 2009.

Future year emissions inventories within the OTR

The OTR states through MANE-VU contracted MACTEC Federal Programs (called Contractor) develop the 2009, 2012 and 2018 inventories based upon 2002 inventories that the states had previously developed for use in the base year model work. The Contractor in consultation with the states developed the necessary growth and control factors and applied to the 2002 inventory. It should be noted that emissions for mobile sources and the electric energy generating units (EGUs) was not part of the Contractor's effort. The states provided VADEQ and NESCAUM appropriate MOBILE 6 input files along with the projected VMTs, which coupled with the hourly gridded temperature information was used to generate mobile source emissions. As for the emissions from the EGU sector, the inter-RPO work group utilized the Integrated Planning Model (IPM) to develop the state and unit-level emissions. Details on these topics can be found in MACTEC (2007) for non-EGU sectors and in ICF (2005a, 2005b) for the EGU sector. These inventories are identified as 2009 on the way (2009OTW), since they reflect all emission control measures that were promulgated or would become effective on or before 2009.

In addition to these OTW inventories, states have also requested the development of what is termed as beyond on the way (BOTW) inventories for 2009, 2012, and 2018. These inventories are to be based on additional OTC model rules, which would result in reduction in emissions from specific source categories. Details on the development of these controls and the corresponding inventories can be found in MACTEC (2007).

Future year emission inventories outside the OTR

MANE-VU obtained inventories for 2009OTW and 2018OTW as part of the inter-RPO workgroup. However, only MRPO provided emissions for 2012OTW. For the VISTAS region, 2012 emissions were obtained by interpolating area, nonroad, and non-EGU emissions between 2009 and 2018. For mobile sources, VMT were interpolated between

2009 and 2018 and the 2012 emissions were calculated with MOBILE6 using these interpolated VMT and 2012 emission factors. For the CENRAP region, no 2012 emissions were generated, and therefore the 2009 emissions were used in the 2012 CMAQ simulation.

Canadian Emissions

In the case of Canadian emissions, 2010 and 2020 area, non-road, and mobile source emissions were obtained from USEPA (ftp://ftp.epa.gov/EmisInventory/canada_2000inventory/).
Primary $PM_{2.5}$ and PM_{10} emissions for the SCCs listed in http://www.epa.gov/ttn/chief/emch/invent/tf_scc_list2002nei_v2.xls were divided by a factor of 4 to account for the fugitive dust transport fraction correction. EGU point source emissions for 2010 and 2020 were obtained from Environment Canada (Bloomer, 2006), while non-EGU point source emissions were assumed to be the same as those developed for 2002 and described elsewhere (see TSD-1c). The 2010 inventories were used in preparing CMAQ input files for the 2009OTW, 2009BOTW, and 2012BOTW scenarios.

Emissions processing – Application of SMOKE

The 2009OTW, 2009BOTW, and 2012 BOTW inventories were processed by VADEQ and NYSDEC using a template similar to that was used for processing 2002 base year emissions (see TSD-1d, TSD-1j) for the 12 km domain. In particular, all gridding and speciation profiles and cross-reference files as well as all temporal allocation profiles and cross-reference files used in the 2002 processing were also used for future year processing. For each day, the following files were prepared:

2009OTW:

- MANE-VU
  - 2009 OTW V3 area source (VADEQ)
  - 2009 V3 nonroad source (VADEQ)
  - 2009 mobile source (NYSDEC)
  - 2009 OTW V3 non-EGU point source (VADEQ)
  - 2009 IPM2.1.9. EGU point source (VADEQ)
  - 2009 EGU point source, IPM2.1.9. non-fossil fuel units (VADEQ)
- VISTAS
  - 2009 BaseG area source (VADEQ)
  - 2009 BaseG nonroad source (VADEQ)
  - 2009 BaseG non-EGU point source (VADEQ)
  - 2009 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (VADEQ)
  - 2009 BaseG low-level fires (VADEQ)
  - 2009 BaseG elevated source fires (VADEQ)
- MRPO
  - 2009 BaseK area source (NYSDEC)
  - 2009 BaseK area source NH3/dust (NYSDEC)

  - 2009 BaseK nonroad source (NYSDEC)
  - 2009 non-EGU point source (VADEQ)
  - 2009 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (VADEQ)
- CENRAP
  - 2009 BaseB area source (VADEQ)
  - 2009 BaseB nonroad source (VADEQ)
  - 2009 non-EGU point source (VADEQ)
  - 2009 IPM2.1.9. EGU point source (VADEQ)
- VISTAS/MRPO/CENRAP ("non-MANE-VU RPOs")
  - 2009 mobile sources for all non-MANE-VU RPOs as implemented in VISTAS 2009 BaseG processing (VADEQ)
- Canada
  - 2010 area sources (NYSDEC)
  - 2010 nonroad sources (NYSDEC)
  - 2010 mobile sources (NYSDEC)
  - point sources (2002 non-EGU point sources; 2010 EGU point sources from IPM) (NYSDEC)
- Biogenics
  - Same as for 2002 base case, calculated with hourly MM5 meteorological fields for 2002 (NYSDEC)

2009 BOTW:

As above for 2009 OTW, with the following two exceptions:

- MANE-VU
  - 2009 BOTW V3 area source (NYSDEC)
  - 2009 BOTW V3 non-EGU point source (NYSDEC)

2012 BOTW:

- MANE-VU
  - 2012 OTW V3 area source (NYSDEC)
  - 2012 V3 nonroad source (NYSDEC)
  - 2012 mobile source (NYSDEC)
  - 2012 OTW V3 non-EGU point source (NYSDEC)
  - 2012 IPM2.1.9. EGU point source (NYSDEC)
  - 2009 EGU point source, IPM2.1.9. non-fossil fuel units (VADEQ)
- VISTAS
  - 2012 BaseG area source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
  - 2012 BaseG nonroad source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
  - 2012 BaseG mobile source (interpolated VMT between 2009 BaseG and 2018 BaseG) (NYSDEC)

    - 2012 BaseG non-EGU point source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
    - 2012 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (NYSDEC)
    - 2009 BaseG low-level fires (VADEQ)
    - 2009 BaseG elevated source fires (VADEQ)
- MRPO
    - 2012 BaseK area source (NYSDEC)
    - 2012 BaseK area source NH3/dust (NYSDEC)
    - 2012 BaseK nonroad source (NYSDEC)
    - 2012 BaseK nonroad source (NYSDEC)
    - 2012 non-EGU point source (NYSDEC)
    - 2012 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (NYSDEC)
- CENRAP
    - 2009 BaseB area source (VADEQ)
    - 2009 BaseB nonroad source (VADEQ)
    - 2009 mobile source (based on VISTAS 2009 BaseG processing) (NYSDEC)
    - 2009 non-EGU point source (VADEQ)
    - 2009 IPM2.1.9. EGU point source (VADEQ)
- Canada
    - 2010 area sources (NYSDEC)
    - 2010 nonroad sources (NYSDEC)
    - 2010 mobile sources (NYSDEC)
    - point sources (2002 non-EGU point sources; 2010 EGU point sources from IPM) (NYSDEC)
- Biogenics
    - Same as for 2002 base case, calculated with hourly MM5 meteorological fields for 2002

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TSD-1c (2006) Emissions Processing for 2002 OTC Regional and Urban 12km Base year simulation

TSD-1d (2006) 8-h Ozone Modeling using the SMOKE/CMAQ system

TSD-1j (2007) Emission processing for OTC 2009 OTW/OB 12km CMAQ Simulations

TSD-1j

Emission Processing for OTC 2009 OTW/OTB 12km CMAQ Simulations

Office of Air Data Analysis
Air Division
Virginia Department of Environmental Quality
Richmond, VA

February 19, 2007

Overview

The OTC 2009 OTW/OTB emission modeling was conducted at the Virginia Department of Environmental Quality (DEQ). The modeling followed and retained the framework of the previous (original) OTC 2002/2009 emission modeling done by the New York State Department of Environmental Conservation (NYSDEC). Several changes and corrections had been made throughout the entire modeling period. Virginia DEQ was in close contact with NYSDEC which provided many premerged netCDF files for inclusion in the merging process to obtain final SMOKE outputs for CMAQ simulations.

Emissions for all source categories were processed by SMOKE2.1. The SMOKE programs downloaded from Community Modeling and Analysis System (CMAS) website have been compiled for LINUX system and ready for usage. If existing compiled codes returned errors, such as in the case of large MCIP files, compiled versions provided by NYSDEC and available at Ozone Research Center's (ORC) ftp sites were used instead.

Data Sources

The majority of raw input data files were provided to DEQ by Greg Stella of AlpineGeophysics through its ftp site at alpinegeophysics.com. Different versions of 2009 SMOKE emission modeling have been conducted over the years by AlpineGeophysics. The version of input data files used for OTC 2009 OTW/OTB emission modeling was labeled as BaseG of the AlpineGeophysics.

In some source categories, primarily in MANEVU and Canada regions, several changes and corrections in emissions were made at various stage of SMOKE modeling, causing the outputs using AlpineGeophysics files to be discarded. SMOKE modeling of those categories (described below) was performed by NYSDEC which made netCDF outputs available at Ozone Research Center's ftp site at ozoneresearch.org. In such cases, DEQ used the premerged netCDF files directly for final merging.

SMOKE Processing

The OTC 12km regional and urban scale modeling domain encompasses four RPOs: VISTAS, MANEVU, CENRAP, and MRPO. Part of Canada also falls in the modeling domain.

The OTC 2009 OTW/OTB emissions were processed roughly on a month-by-month and RPO-by-RPO basis. SMOKE modeling was conducted for each month for each of the four individual RPOs as well as for Canada (completed by NYSDEC), except for mobile source category, which was done by two sub-RPOs: one for MANEVU and the other for the combination of VISTAS, CENRAP, and MRPO. A separate SMOKE ASSIGNS file was created for each RPO and/or source category. The episode length in the ASSIGNS files varies from one month to the entire year.

Five major emission source categories (listed below) were included in the OTC 2009 OTW/OTB SMOKE modeling. Sub-categories were lumped into the major categories here for presentation purpose but were treated as separate categories in processing. For example, low-level wildfire was treated as area source, whereas high-level wildfire was modeled as point source. In addition, point source category was further divided into EGU and non-EGU. Minor sources such as non-fossil fuels and marine vessel were processed as well. Table~1 summarizes input files and other relevant information for each of the RPOs and Canada.

(1) Area (including low-level wildfire and NH3);
(2) Nonroad (including marine vessel);
(3) Point (including EGU, Non-EGU, non-fossil fuels and wildfires);
(4) Mobile;
(5) Biogenic.

For VISTAS region (only), AlpineGeophysics has developed annual, daily, or hourly emissions data for EGU and high-level wildfire source categories. SMOKE run script parameters of DAY_SPECIFIC_YN and/or HOUR_SPECIFIC_YN were turned on (to Y) and month-specific temporal profiles of BaseG were applied to make sure those more detailed inventory files were used to override annual emissions.

Mobile source emissions were divided into two groups for processing. The original input file (mbinv_vistas_09g_vmt_12jun06.txt) provided by AlpineGeophysics contains VMT data for all four RPOs. The MANEVU portion was first removed from the original file and the revised file (otherRPOs.mb.vmt.emis) which contains VMT data for the remaining three RPOs (VISTAS, CENRAP, MRPO) was then used as the input inventory for processing. The MANEVU portion removed from the original file was processed separately on its own as another group.

MOBILE6 Processing

As described above, mobile source emissions for three RPOs --- VISTAS, CENRAP, and MRPO --- were grouped and processed together. To estimate vehicle emission factors in MOBILE6, temperature averaging of space and time were specified in input file of mvref_vistas_2009g_26aug06.txt as follows:

(1) Spatial averaging: temperatures were averaged over all counties that share a common reference county;

(2) Temporal averaging: temperatures were averaged over the duration of the episode, which in present case is one month.

The averaging described above is consistent with the original OTC 2002/2009 emission processing done by NYSDEC. DEQ also processed MANEVU portion of mobile source. However, due to the inconsistency of temporal profile and cross-reference file used between DEQ's run and the original 2002/2009 run by NYSDEC, those outputs were discarded. NYSDEC re-processed the MANEVU portion and provided netCDF files to

DEQ for final merging. The re-processed MANEVU run by NYSDEC reflects updated mobile source information in New Jersey and Connecticut.

Speciations, Temporal and Spatial Allocations

For consistency, the OTC 2009 OTW/OTB input profiles for speciations, temporal, and spatial allocations remained the same as the original OTC 2002/2009 emission modeling done by NYSDEC, even though more up-to-date profiles (such as those marked with BaseG or later) were available at the AlpineGeophysics. No attempt was made to examine the effects of different versions of profiles on daily emissions.

Fugitive Dust Corrections

Fugitive dust emissions were corrected in SMOKE by two-step process.   First, SMKINVEN and CNTLMAT were executed with two separate input files: (1) the original inventory file, and (2) a controlled matrix file of 2009 dust projection factors. A new inventory file containing adjusted emissions was created in SMKINVEN/CNTLMAT run. The new file was then used as the inventory input for regular SMOKE processing of SMKINVEN, SPCMAT, GRDMAT, TEMPORAL, LAYPOINT (for point source), and SMKMERGE. The source categories which went through this two-step process included non-EGU for VISTAS, MANEVU, CENRAP, and MRPO, and area sources for MANEVU and CENRAP.

Canadian and Biogenic Emissions

Canadian emissions of all four source categories (area, nonroad, point, mobile) and domain-wide biogenic emissions were processed by NYSDEC. Details on how emission modeling of these categories was conducted have been documented in ``Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations" by NYSDEC. DEQ obtained premerged netCDF files for these source categories from ORC ftp site and used them directly for final merging.

Premerged netCDF Files

In December 2006, NYSDEC made further adjustments to ammonia and dust emissions of MRPO region and ran through SMOKE with the adjusted emissions. Three of MRPO's source categories were affected: area, nonroad, and NH3. As a result, outputs generated by DEQ for the three affected MRPO's categories were discarded. Canadian emissions of all four source categories (area, nonroad, point and mobile) were also re-processed by NYSDEC with updated information.   Seven newer versions, three for MRPO and four for Canada, of premerged netCDF files reflecting the adjustments were made available at ORC ftp site. The updated premerged netCDF files were used to replace earlier versions in the final merging process.

SMOKE Merging

A total of twenty-seven netCDF files were merged together to produce daily total emissions for use as inputs to CMAQ:

(1) Six for VISTAS (excluding mobile);
(2) Five for MANEVU (excluding mobile);
(3) Four for CENRAP (excluding mobile);
(4) Five for MRPO (excluding mobile);
(5) Two for mobile source emissions;
(6) Four for Canadian emissions;
(7) One for domain-wide biogenic emissions.

Table~1 lists the categories (indicated by sequential numbers) which were combined in the merging process.

BOTW Emissions

The differences between 2009 BOTW and 2009 OTW/OTB emissions lie in the area and non-EGU sources of MANEVU region where more controlled emissions are in effect for BOTW than for OTW/OTB. NYSDEC generated premerged netCDF files for BOTW run. To obtain 2009 OTC BOTW emissions, the two affected MANEVU source categories for OTW/OTB run were substituted and replaced by the new BOTW premerged files in the final merging process.

Table 1. 2009 OTW/OTB Emissions Processing Summary			
Category	**Files**	**Files Source**	**Notes**
VISTAS			
(1) Area	arinv_vistas_2009g 2453922 w pmfac.txt	Alpine Geophysics	
(2) Non-Road	nrinv_vistas_2009g 2453908.txt	Alpine Geophysics	
	marinv_vistas_2009g 2453972.txt	Alpine Geophysics	marine vessel emissions
(3) Non-EGU	negu_ptinv_vistas_2009_baseg_2453957.txt	Alpine Geophysics	
(4) EGU	egu_ptinv_vistas_2009_baseg_2453990.txt	Alpine Geophysics	annual emissions
	pthour_2009_baseg_mon_2453990.ems	Alpine Geophysics	hourly emissions, mon=may,jun,...
(5) Low Fire	area_level_res_vistas2002_baseg.ida	Alpine Geophysics	treated as area sources
(6) High Fire	ptinv.plume.vistasbaseg09.num.ida	Alpine Geophysics	treated as point sources; annual data
	ptday.plume.vistasbaseg09.num.ida	Alpine Geophysics	daily data; num=1,2,...
	pthour.plume.vistasbaseg09.num.ida	Alpine Geophysics	hourly data; num=1,2,...
(7) Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	contains VISTAS/CENRAP/MRPO
MANE-VU			
(8) Area	MANEVU2009OTBAreaV3_1_woodburn.incl.IDA.txt	Alpine Geophysics	if BOTW, premerged netCDF for merging
(9) Non-Road	2009MANEVUNRNIFV3_0_NonRoad_IDA.NJ_x.txt	Alpine Geophysics	
(10) Non-EGU	manevu2009noneguv3_0_point_ida.txt	Alpine Geophysics	if BOTW, premerged netCDF for merging
(11) EGU	ptinv_egu_2009_manevu_10aug2006.txt	Alpine Geophysics	annual emissions
(12) Non-Fossil EGU	manevu_nonfossil_2009_19sept2006.txt	Alpine Geophysics	non-fossil fuel emissions
(13) Mobile	netCDF file	Alpine Geophysics	netCDF used for merging
CENRAP			
(14) Area	cenrap_area_burning_smoke_2009_input_ann_tx_neli_071905_2453959.txt	Alpine Geophysics	
	cenrap_area_misc_2009_smoke_input_ann_state_071905_2453959.txt	Alpine Geophysics	
	cenrap_area_misc_2009_smoke_output_nh3_annual_072805 rev_2453959.txt	Alpine Geophysics	
	arinv.cenrap_2009_09_xfact.ida.txt	Alpine Geophysics	
	cenrap_area_smoke_2009_output_nh3_annual_071905_rev_2453959.txt	Alpine Geophysics	
(15) Non-Road	cenrap_nonroad_smoke_2009_output_annual_071305_rev.txt	Alpine Geophysics	
(16) Non-EGU	ptinv_negu_cenrap2009_25aug2006.ida	Alpine Geophysics	
(17) EGU	ptinv_egu_2009_cenrap_10aug2006.txt	Alpine Geophysics	annual emissions
Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	VISTAS/CENRAP/MRPO
MRPO			
(18) Area	arinv_other_mrpok_2009_10aug2006.txt	Alpine Geophysics	dust correction; premerged netCDF
	dustinv_mrpo_basef4_2009_10nov05.ida	Alpine Geophysics	
(19) NH3	nh3inv_2009_mrpok_ann_10aug2006.txt	Alpine Geophysics	dust correction; premerged netCDF
(20) Non-Road	nrinv_mrpo_g_09_2453958 adj.txt	Alpine Geophysics	dust correction; premerged netCDF
	arinv_mar_mrpok_2009_7aug2006.txt	Alpine Geophysics	
(21) Non-EGU	ptinv_negu_2009_mrpok_10aug2006.txt	Alpine Geophysics	
(22) EGU	ptinv_egu_2009_mrpok_10aug2006.txt	Alpine Geophysics	annual emissions
Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	VISTAS/CENRAP/MRPO

Table 1. 2009 OTW/OTB Emissions Processing Summary			
Category	**Files**	**Files Source**	**Notes**
CANADA			
(23) Area	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(24) Non-Road	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(25) Point	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(26) Mobile	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
BIOGENIC			
(27) Biogenic	netCDF file	NYSDEC; downloaded from OTC ftp site	domain-wide emissions; premerged netCDF for merging