COLORADO:

Denver Metro/North Front Range Nonattainment Area

Final Area Designations for the
2015 Ozone National Ambient Air Quality Standards
Technical Support Document (TSD)

1.0 Summary

This technical support document (TSD) describes the EPA's final designations for the Denver Metro/North Front Range area in Colorado, as defined in this document, as nonattainment for the 2015 ozone National Ambient Air Quality Standards (NAAQS).

On October 1, 2015, the EPA promulgated revised primary and secondary ozone NAAQS (80 FR 65292; October 26, 2015). The EPA strengthened both standards to a level of 0.070 parts per million (ppm). In accordance with Section 107(d) of the Clean Air Act (CAA), whenever the EPA establishes a new or revised NAAQS, the EPA must promulgate designations for all areas of the country for that NAAQS.

Under section 107(d), states were required to submit area designation recommendations to the EPA for the 2015 ozone NAAQS no later than 1 year following promulgation of the standards, i.e., by October 1, 2016. Tribes were also invited to submit area designation recommendations. On September 23, 2016, Colorado recommended that the counties/partial counties identified in Table 1 be designated as nonattainment for the 2015 ozone NAAQS based on air quality data from 2013-2015.

After considering these recommendations and based on the EPA's technical analysis as described in this TSD, the EPA is designating the area listed in Table 1 as nonattainment for the 2015 ozone NAAQS. The EPA must designate an area nonattainment if it has an air quality monitor that is violating the standard or if it has sources of emissions that are contributing to a violation of the NAAQS in a nearby area. Detailed descriptions of the final nonattainment boundaries for the area are found in the supporting technical analysis in Section 3.

Table 1. Colorado's Recommended Nonattainment Area and the EPA's Final Designated Nonattainment Area for the 2015 Ozone NAAQS

Area	Colorado's Recommended Nonattainment Counties	EPA's Final Nonattainment Counties
Denver Metro/North Front Range, CO	Adams County Arapahoe County Boulder County Broomfield County Denver County Douglas County Jefferson County Larimer County (partial) Weld County (partial)	Adams County Arapahoe County Boulder County Broomfield County Denver County Douglas County Jefferson County Larimer County (partial) Weld County (partial)

On November 6, 2017 (82 FR 54232; November 16, 2017), the EPA signed a final rule designating most of the areas the State did not recommend for designation as nonattainment as attainment/unclassifiable.[1] EPA explains in section 2.0 the approach it is now taking to designate the remaining areas in the State.

2.0 Nonattainment Area Analyses and Final Boundary Determination

The EPA evaluated and determined the boundaries for each nonattainment area on a case-by-case basis, considering the specific facts and circumstances of the area. In accordance with the CAA section 107(d), the EPA is designating as nonattainment the areas with the monitors that are violating the 2015 ozone NAAQS and nearby areas with emissions sources (i.e., stationary, mobile, and/or area sources) that contribute to the violations. As described in the EPA's designations guidance for the 2015 NAAQS (hereafter referred to as the "ozone designations guidance"[2] after identifying each monitor indicating a violation of the ozone NAAQS in an area, the EPA analyzed those nearby areas with emissions potentially contributing to the violating area. In guidance issued in February 2016, the EPA provided that using the Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)[3] as a starting point for

[1] In previous ozone designations and in the designation guidance for the 2015 ozone NAAQS, the EPA used the designation category label Unclassifiable/Attainment to identify both areas that were monitoring attainment and areas that did not have monitors but for which the EPA had reason to believe were likely attainment and were not contributing to a violation in a nearby area. The EPA is now reversing the order of the label to be Attainment/Unclassifiable so that the category is more clearly distinguished from the separate Unclassifiable category.

[2] The EPA issued guidance on February 25, 2016 that identified important factors that the EPA evaluated in determining appropriate area designations and nonattainment boundaries for the 2015 ozone NAAQS. Available at *https://www.epa.gov/ozone-designations/epa-guidance-area-designations-2015-ozone-naaqs*

[3] Lists of CBSAs and CSAs and their geographic components are provided at www.census.gov/population/www/metroareas/metrodef.html. The Office of Management and Budget (OMB) adopts

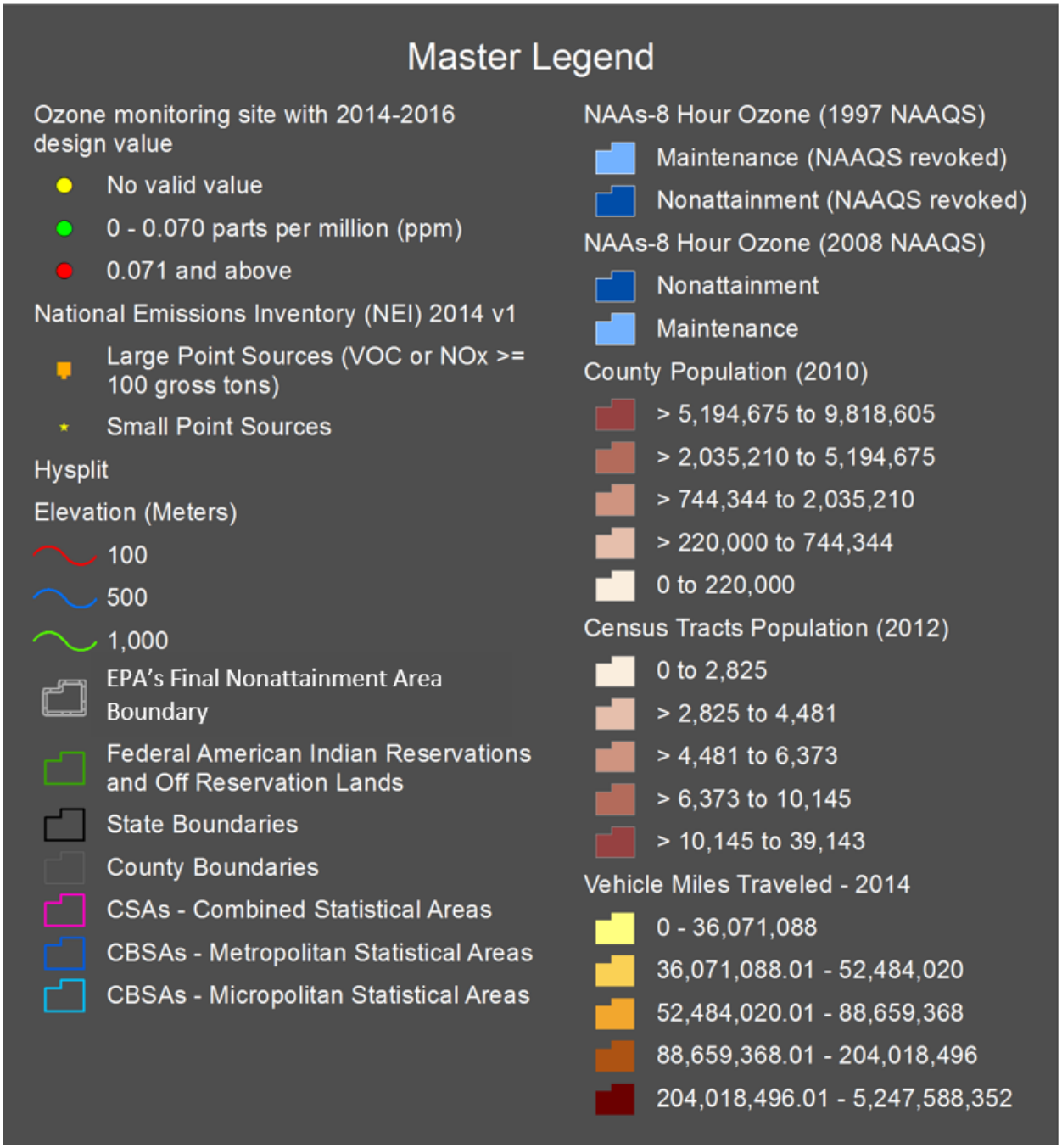
the contribution analysis is a reasonable approach to ensure that the nearby areas most likely to contribute to a violating area are evaluated. The area-specific analyses may support nonattainment boundaries that are smaller or larger than the CBSA or CSA.

On November 6, 2017, the EPA issued attainment/unclassifiable designations for approximately 85% of the United States and one unclassifiable area designation.[4] At that time, consistent with statements in the designations guidance regarding the scope of the area the EPA would analyze in determining nonattainment boundaries, EPA deferred designation for any counties in the larger of a CSA or CBSA where one or more counties in the CSA or CBSA was violating the standard and any counties with a violating monitor not located in a CSA or CBSA. In addition, the EPA deferred designation for any other counties adjacent to a county with a violating monitor. The EPA also deferred designation for any county that had incomplete monitoring data, any county in the larger of the CSA or CBSA where such a county was located, and any county located adjacent to a county with incomplete monitoring data.

The EPA is proceeding to complete the remaining designations consistent with the designations guidance (and EPA's past practice) regarding the scope of the area EPA would analyze in determining nonattainment boundaries for the ozone NAAQS as outlined above. For those deferred areas where one or more counties violating the ozone NAAQS or with incomplete data are located in a CSA or CBSA, in most cases the technical analysis for the nonattainment area includes any counties in the larger of the relevant CSA or CBSA. For counties with a violating monitor not located in a CSA or CBSA, EPA explains in the 3.0 Technical Analysis section, its decision whether to consider in the five-factor analysis for each area any other adjacent counties for which EPA previously deferred action. We are designating all counties not included in five-factor analyses for a specific nonattainment or unclassifiable area analyses, as attainment/unclassifiable. These deferred areas are identified in a separate document entitled "Designations for Deferred Counties and County Equivalents Not Addressed in the Technical Analyses." which is available in the docket.

standards for defining statistical areas. The statistical areas are delineated based on U.S. Census Bureau data. The lists are periodically updated by the OMB. The EPA used the most recent July 2015 update (OMB Bulletin No. 15-01), which is based on application of the 2010 OMB standards to the 2010 Census, 2006-2010 American Community Survey, as well as 2013 Population Estimates Program data.

[4] Air Quality Designations for the 2015 Ozone National Ambient Air Quality Standards published on November 16, 2017(82 FR 54232).



Figures in the remainder of the document refer to the master legend above.

3.0 Technical Analysis for Denver Metro/North Front Range

This technical analysis identifies the areas with monitors that violate the 2015 ozone NAAQS. It also provides EPA's evaluation of these areas and any nearby areas to determine whether those nearby areas have emissions sources that potentially contribute to ambient ozone concentrations at the violating monitors in the area, based on the weight-of-evidence of the five factors recommended in the EPA's ozone designations guidance and any other relevant information. In developing this technical analysis, the

EPA used the latest data and information available to the EPA (and to the states and tribes through the Ozone Designations Mapping Tool and the EPA Ozone Designations Guidance and Data web page).[5] In addition, the EPA considered any additional data or information provided to the EPA by states or tribes.

The Denver-Aurora Combined Statistical Area (CSA) includes the Boulder Core Based Statistical Area (CBSA), Denver-Aurora-Lakewood CBSA, and Greeley CBSA. The Fort Collins CBSA, which is comprised solely of Larimer County, is not a part of the Denver-Aurora CSA. For both the 1997 and the 2008 ozone NAAQS, part of the Larimer County was included as part of the designated Denver nonattainment area. The State has recommended part of Larimer county be included in the Denver nonattainment area for the 2015 ozone NAAQS. Therefore, we have included the Fort Collins CBSA in the area of analysis. The counties included in the Boulder, Denver-Aurora-Lakewood, Greeley, and Fort Collins CBSAs, which comprise the area of analysis, are:

- Boulder
- Denver
- Arapahoe
- Jefferson
- Adams
- Douglas
- Broomfield
- Elbert
- Park
- Clear Creek
- Gilpin
- Weld
- Larimer

The five factors recommended in the EPA's guidance are:

1. Air Quality Data (including the design value calculated for each Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitor);
2. Emissions and Emissions-Related Data (including locations of sources, population, amount of emissions, and urban growth patterns);
3. Meteorology (weather/transport patterns);
4. Geography/Topography (including mountain ranges or other physical features that may influence the fate and transport of emissions and ozone concentrations); and
5. Jurisdictional Boundaries (e.g., counties, air districts, existing nonattainment areas, areas of Indian country, Metropolitan Planning Organizations (MPOs)).

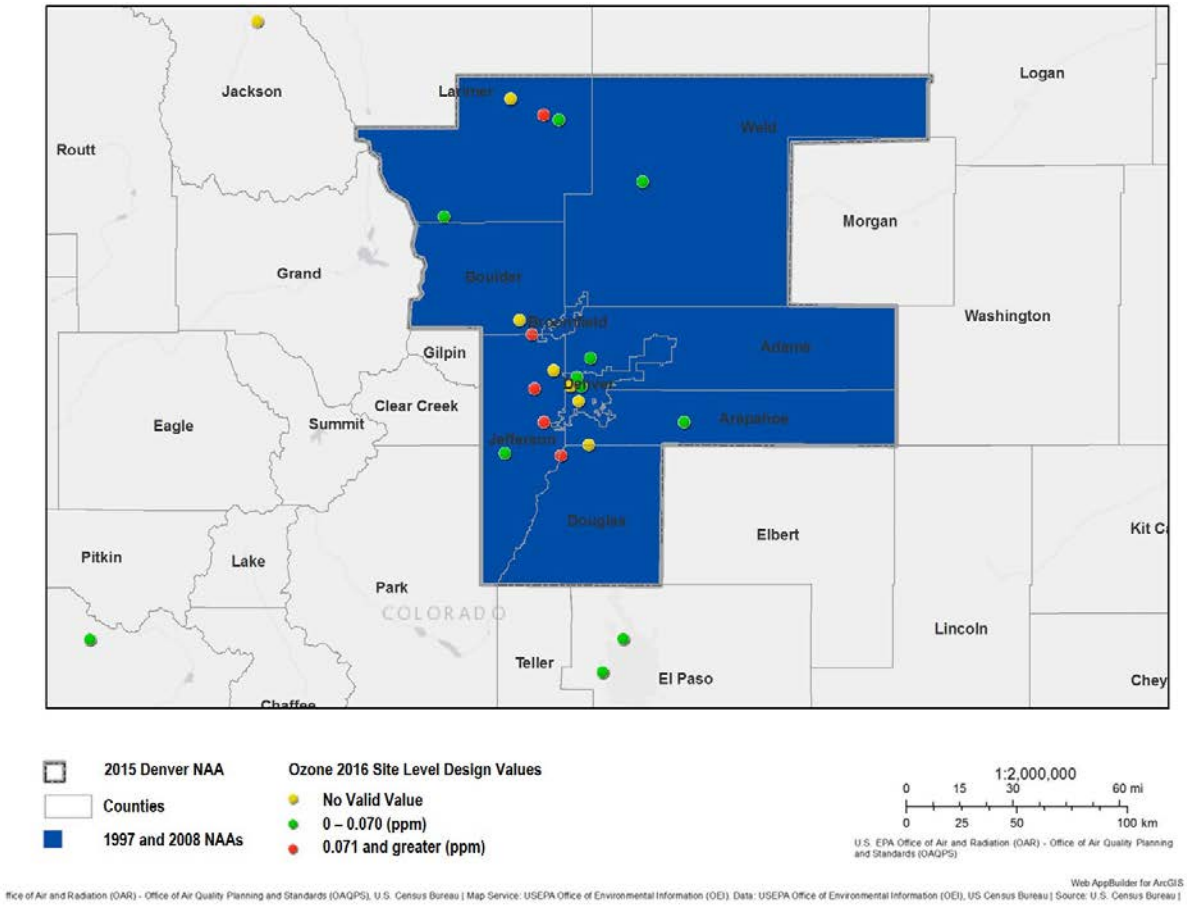
[5] The EPA's Ozone Designations Guidance and Data web page can be found at *https://www.epa.gov/ozone-designations/ozone-designations-guidance-and-data.*

Figure 1 is a map of the EPA's final nonattainment boundary for the Denver Metro/North Front Range. The map shows the location of the ambient air quality monitors, county, and other jurisdictional boundaries including existing 1997 and 2008 ozone NAAQS nonattainment boundaries and design values for violating monitors.

For purposes of the 1997 and 2008 ozone NAAQS, this area was designated nonattainment. The boundary for the nonattainment area for both the 1997 and 2008 ozone NAAQS included the entire Counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson and parts of Larimer and Weld Counties.

The boundary for the 2015 ozone NAAQS is the same as the boundaries for the 1997 ozone NAAQS and the 2008 ozone NAAQS.

Figure 1. EPA's Final Nonattainment Boundaries for the Denver Metro/North Front Range Area.



The EPA must designate as nonattainment any area that violates the NAAQS and any nearby areas that contribute to the violation in the violating area. Douglas, Jefferson, and Larimer Counties have monitors in violation of the 2015 ozone NAAQS, therefore all or portions of Douglas, Jefferson, and Larimer County are included in the final nonattainment area. Based on the five-factor analysis that follows, the EPA determined that all of Douglas and Jefferson County and a portion of Larimer County should be included in the nonattainment area and that the counties of Adams, Arapahoe, Boulder, Broomfield,

Denver and portions of Weld County contribute to the violating area. The following sections describe the five factor analysis. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

Factor Assessment

Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for air quality monitors in the area of analysis based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This is the most recent three-year period with fully-certified air quality data. The design value is the 3-year average of the annual 4th highest daily maximum 8-hour average ozone concentration.[6] The 2015 NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations.[7] The EPA uses FRM/FEM measurement data residing in the EPA's Air Quality System (AQS) database to calculate the ozone design values. Individual exceedances of the 2015 ozone NAAQS that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule[8] are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e. monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitor(s) based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified monitors where the most recent design values violate the NAAQS, and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248).

[6] The specific methodology for calculating the ozone design values, including computational formulas and data completeness requirements, is described in 40 CFR part 50, appendix U.

[7] The QA requirements for ozone monitoring data are specified in 40 CFR part 58, appendix A. The performance test requirements for candidate FEMs are provided in 40 CFR part 53, subpart B.

[8] The EPA finalized the rule on the Treatment of Data Influenced by Exceptional Events (81 FR 68513) and the guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events in September of 2016. For more information, see *https://www.epa.gov/air-quality-analysis/exceptional-events-rule-and-guidance.*

The 2014-2016 design values for counties in the area of analysis are shown in Table 2.

Table 2. Air Quality Data (all values in ppm)

County, State	State Recommended Nonattainment?	AQS Site ID (Site Name)	2014-2016 DV	2014 4th highest daily max value	2015 4th highest daily max value	2016 4th highest daily max value
Adams, CO	Yes	08-001-3001 (Welby)	**0.067**	0.067	0.069	0.066
Arapahoe, CO	Yes	08-005-0002 (Highland Res.)	N/A	N/A	0.062	0.072
		08-005-0006 (Aurora East)	**0.067**	0.067	0.068	0.066
Boulder, CO	Yes	08-013-0011 (S Boulder)	N/A	0.070	0.074	N/A
Broomfield, CO	Yes	No monitor	N/A			
Clear Creek, CO	No	No monitor	N/A			
Denver, CO	Yes	08-031-0002 (CAMP)	0.066	0.061	0.067	0.070
		08-031-0026 (La Casa)	**0.068**	0.066	0.071	0.069
Douglas, CO	Yes	08-035-0004 (Chatfield)	**0.077**	0.074	0.081	0.078
Elbert, CO	No	No monitor	N/A			
Gilpin, CO	No	No monitor	N/A			
Jefferson, CO	Yes	08-059-0005 (Welch)	0.072	0.066	0.075	0.075
		08-059-0006 (Rocky Flats)	0.077	0.077	0.077	0.079
		08-059-0011 (NREL)	**0.080**	0.076	0.081	0.083
		08-059-0013 (Aspen Park)	0.070	0.067	0.070	0.073
Larimer, CO	Yes (partial)	08-069-0007 (RMNP)	0.069	0.069	0.069	0.069
		08-069-0011 (Ft. Collins W.)	**0.075**	0.074	0.075	0.076
		08-069-1004 (Ft. Collins)	0.070	0.072	0.069	0.070
Park, CO	No	No Monitor	N/A			
Weld, CO	Yes (partial)	08-123-0009 (Greeley Twr.)	**0.070**	0.070	0.073	0.067

The highest design value in each county is indicated in bold type.

N/A means that the monitor did not meet the completeness criteria described in 40 CFR, part 50, Appendix U, or no data exists for the county.

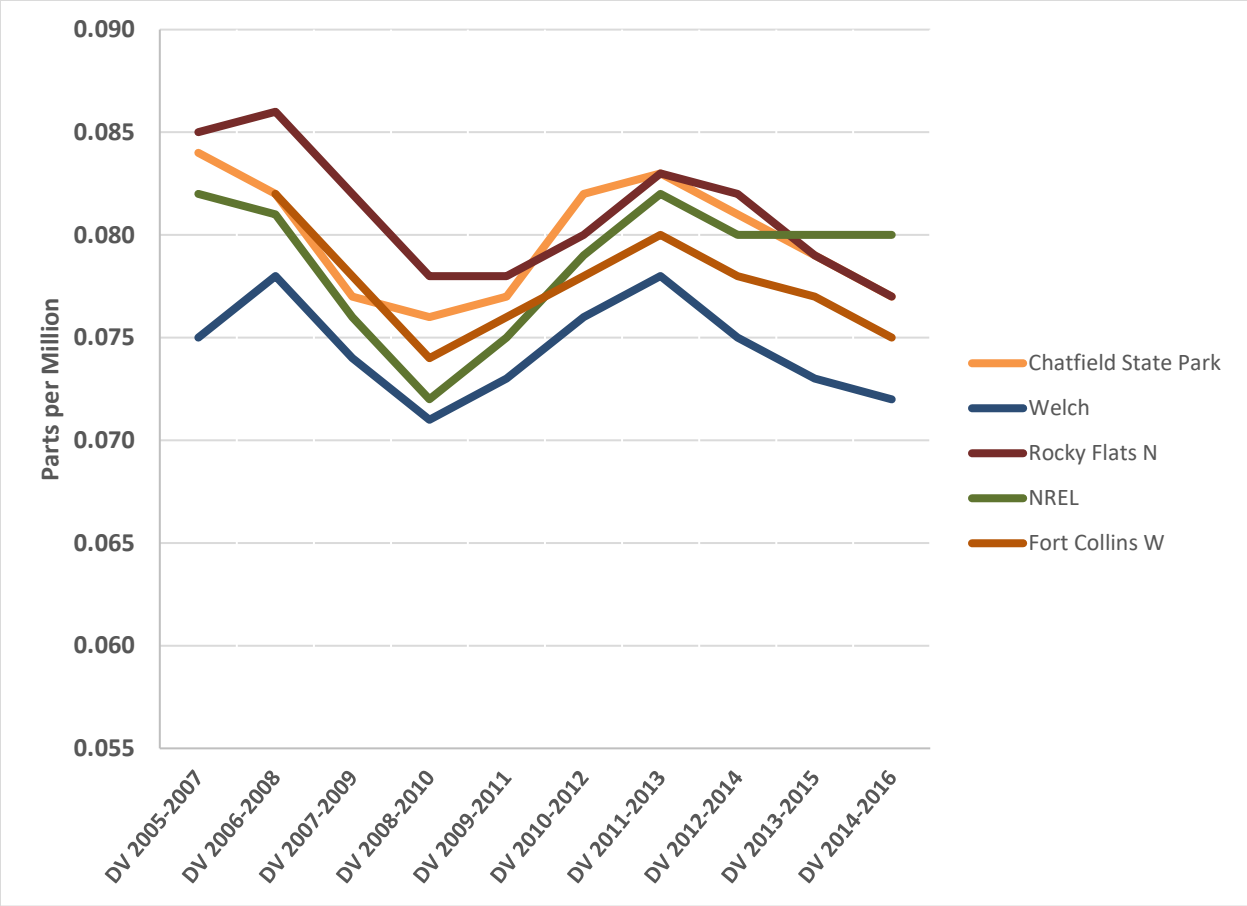
Douglas, Jefferson, and Larimer Counties show a violation of the 2015 ozone NAAQS. A county (or partial county) must also be designated nonattainment if it contributes to a violation in a nearby area.

Figure 1, above, identifies the Denver Metro/North Front Range final nonattainment area and the violating monitors in the area of analysis. Table 2, above, identifies the design values for all monitors in the area of analysis and

Figure **2**, below, shows the historical trend of design values for the violating monitors. As indicated on the map, there are five violating monitors that are located in Chatfield State Park in Douglas County (08-035-0004); near the town of Morrison (Welch, 08-059-0005), City of Golden (National Renewable Energy Laboratory (NREL), 08-059-0011, and Rocky Flats National Wildlife Refuge (08-059-0006) in Jefferson County; and City of Fort Collins in Larimer County (Ft. Collins W., 08-069-0011). There is one monitor east and one southwest of the violating monitor in Larimer County that are attaining. There is also one monitor west of the violating monitors in Jefferson County that is attaining. The remainder of the monitors in Adams, Arapahoe, Boulder, Denver, and Weld Counties are attaining. As shown in

Figure **2**, the monitor at NREL has the highest 2016 DV, followed by monitors at Rocky Flats North, Chatfield State Park, Fort Collins West, and Welch.

Figure 2. Three-Year Design Values for Violating Monitors (2007-2016).


0.090
0.085
0.080
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Parts per Million
DV 2005-2007
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DV 2009-2011
DV 2010-2012
DV 2011-2013
DV 2012-2014
DV 2013-2015
DV 2014-2016
Chatfield State Park
Welch
Rocky Flats N
NREL
Fort Collins W

Factor 2: Emissions and Emissions-Related Data

The EPA evaluated ozone precursor emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOC) and other emissions-related data that provide information on areas contributing to violating monitors.

Emissions Data

The EPA reviewed data from the 2014 National Emissions Inventory (NEI). For each county in the area of analysis, the EPA examined the magnitude of large sources (NO_x or VOC emissions greater than 100 tons per year) and small point sources and the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires. Emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

Table 3 provides a county-level emissions summary of NO_x and VOC (given in tons per year (tpy) emissions for the area of analysis considered for inclusion in the final Denver Metro/North Front Range nonattainment area.

Table 3. Total County-Level NO_x and VOC 2014 Emissions.

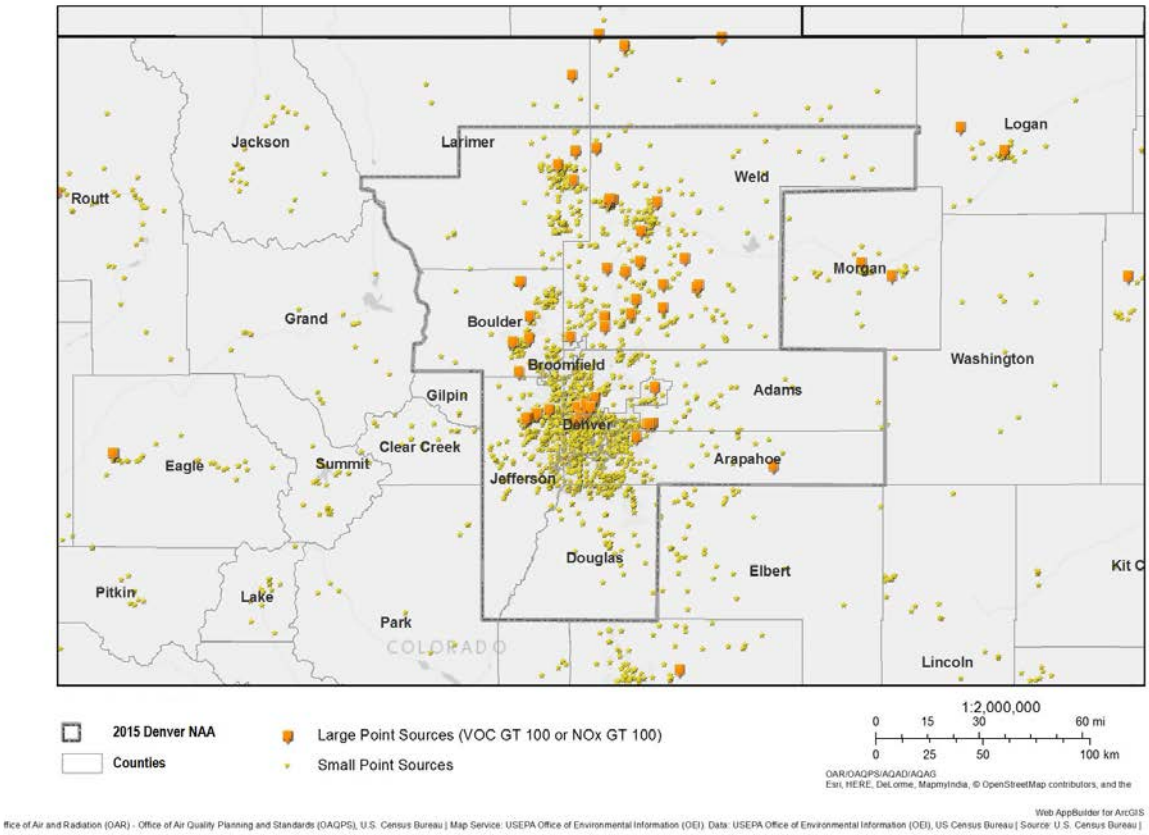
County	State Recommended Nonattainment?	Total NO_x (tpy)	Total VOC (tpy)
Weld	Yes (partial)*	31,318	102,046
Adams	Yes	17,651	12,927
Denver	Yes	15,408	12,746
Jefferson	Yes	10,737	11,445
Arapahoe	Yes	10,191	12,726
Boulder	Yes	8,441	6,484
Larimer	Yes (partial)*	7,938	8,307
Douglas	Yes	6,879	5,755
Clear Creek	No	1,654	550
Broomfield	Yes	1,297	1,326
Elbert	No	989	737
Park	No	577	1,325
Gilpin	No	396	196
	Area wide:	113,475	176,570

* For state recommended partial counties, the emissions shown are for the entire county.

In addition to reviewing county-wide emissions of NO_x and VOC in the area of analysis, the EPA also reviewed emissions from large and small point sources. The location of these sources, together with the other factors, can help inform nonattainment boundaries. The locations of the large point sources are shown in

Figure 3 below. The final nonattainment boundary is also shown.

Figure 3. Large and Small Point Sources in the Area of Analysis.

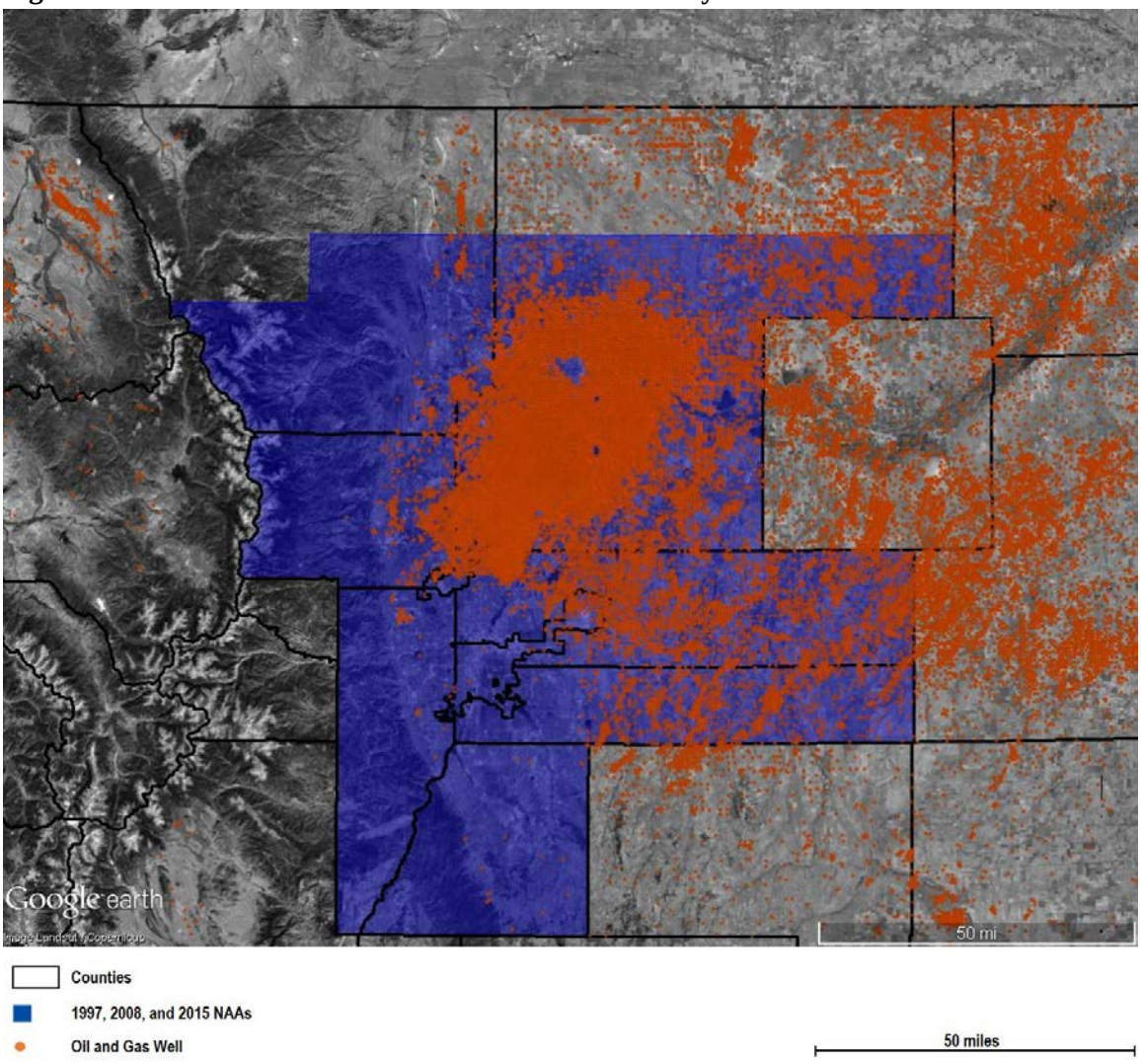


In the area of analysis, Weld County has the highest NO_x emissions, followed by Adams and Denver with approximately 56 and 49 percent, respectively, of the level of emissions in Weld. Jefferson and Arapahoe each have about 33 percent the level of NO_x emissions as Weld County. Boulder, Larimer and Douglas Counties each have in the range of 22 to 27 percent the level of NO_x emissions as Weld County. The remaining five counties each have about 5 percent or less than the NO_x emissions from Weld County. Weld County also has the highest level of VOC emissions. The Counties with the next highest level of emissions, Adams, Denver, Arapahoe and Jefferson each have emissions of approximately 11 to 13 percent of those in Weld. Boulder, Larimer and Douglas Counties have approximately 6 to 8 percent of the VOC emissions as occur in Weld County. The remaining counties all have roughly 1 percent or less emissions of VOC than Weld County. Figure 3 indicates that the majority of large and small point sources are within the EPA final nonattainment area, including Southern Weld County, while figure 4 illustrates gas wells in the EPA final nonattainment area, as well as the area of analysis. The majority of gas wells in Figure 4 indicate the greatest density of wells located in the Southern part of Weld County.

The State did not recommend the northern portions of Weld and Larimer Counties for inclusion in the nonattainment area. Emissions data from 2011 provided by the State of Colorado in the TSD that accompanied their 2016 recommendation, NO_x and VOC emissions for the northern portion of Larimer County, are estimated at 2,879 tpy and 3,076 tpy, respectively and 2011 NO_x and VOC emissions for the

northern portion of Weld County are estimated at 8,042 tpy and 18,610 tpy, respectively. 2011 emissions from the northern portions of Larimer were approximately 36% of NO_x and 37% of VOC total emissions in Larimer County, while 2011 emissions from the northern portions of Weld County were approximately 25% of NO_x and 18% of VOC total emissions in Weld County. Figure 3 indicates that Northern Larimer county has one large point source, while Northern Weld county has 3 large point sources. Figure 4 indicates that oil and gas wells are present within Northern Weld County, and to a lesser extent Northern Larimer County, but that the majority of wells are located within the area the State recommended for inclusion as part of the designated nonattainment area.

Figure 4. Oil and Gas Wells in and Around Area of Analysis.



<u>Population density and degree of urbanization</u>

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. These include emissions of NO_x and VOC from on-road and non-road vehicles and engines, consumer

products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NO_x and VOC emissions that may contribute to violations of the NAAQS. Table 4 shows the population, population density, and population growth information for each county in the area of analysis.

Table 4. Population and Growth.

County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Denver, CO	Yes	600,158	682,545	4461	82,387	14
Arapahoe, CO	Yes	572,003	631,096	791	59,093	10
Jefferson, CO	Yes	534,543	565,524	740	30,981	6
Adams, CO	Yes	441,603	491,337	421	49,734	11
Larimer, CO	Yes (partial)*	299,630	333,577	128	33,947	11
Douglas, CO	Yes	285,465	322,387	384	36,922	13
Boulder, CO	Yes	294,567	319,372	440	24,805	8
Weld, CO	Yes (partial)*	252,825	285,174	72	32,349	13
Broomfield, CO	Yes	55,889	65,065	1970	9,176	16
Elbert, CO	No	23,086	24,735	13	1,649	7
Park, CO	No	16,206	16,510	8	304	2
Clear Creek, CO	No	9,088	9,303	24	215	2

Gilpin, CO	No	5,441	5,828	39	387	7
	Area wide:	3,390,504	3,752,453	240	361,949	11

* For state recommended partial counties, the emissions shown are for the entire county.
Source: U.S. Census Bureau population estimates for 2010 and 2015. www.census.gov/data.html.

Table 4 indicates population and growth in each county in the area of analysis. Denver County has the 2015 greatest population, population density, absolute change in population, and population percent change from 2010-2015. Arapahoe County has the next greatest population (92% of Denver County), followed by Jefferson (82% of Denver County), and Adams (71% of Denver County). Larimer, Douglas, Boulder and Weld all have populations that are approximately 48% - 42% of Denver County and they had population growth ranging from 8 to 13%. Boulder and Douglas are more densely populated than either Larimer or Weld. The remaining five counties all have relatively low populations in the area of analysis – less than 60,000. However, Broomfield County is both densely populated for counties in the area of analysis and had high growth. The other four counties are the least densely populated and had the lowest growth for counties in the area of analysis.

The State provided data regarding the northern portions of Larimer and Weld Counties - which it did not recommend for inclusion in the designated nonattainment area. The data demonstrate that the northern portion of Larimer County has 16,679 people (2% of Denver County), while the northern portion of Weld County has 2852 people (0.42% of Denver County). The State of Colorado also provided

Figure 5 below which shows the population density by census tract and the degree of urbanization for NE Colorado, SE Wyoming and SW Nebraska based on the 2010 US Census. The recommended nonattainment area is highlighted in black and some peripheral counties are labeled. This data shows that the northern portions of Larimer and Weld Counties generally have population densities that are under 5-persons per square mile.

Figure 5. Population Density & Degree of Urbanization of the NE Colorado Region.

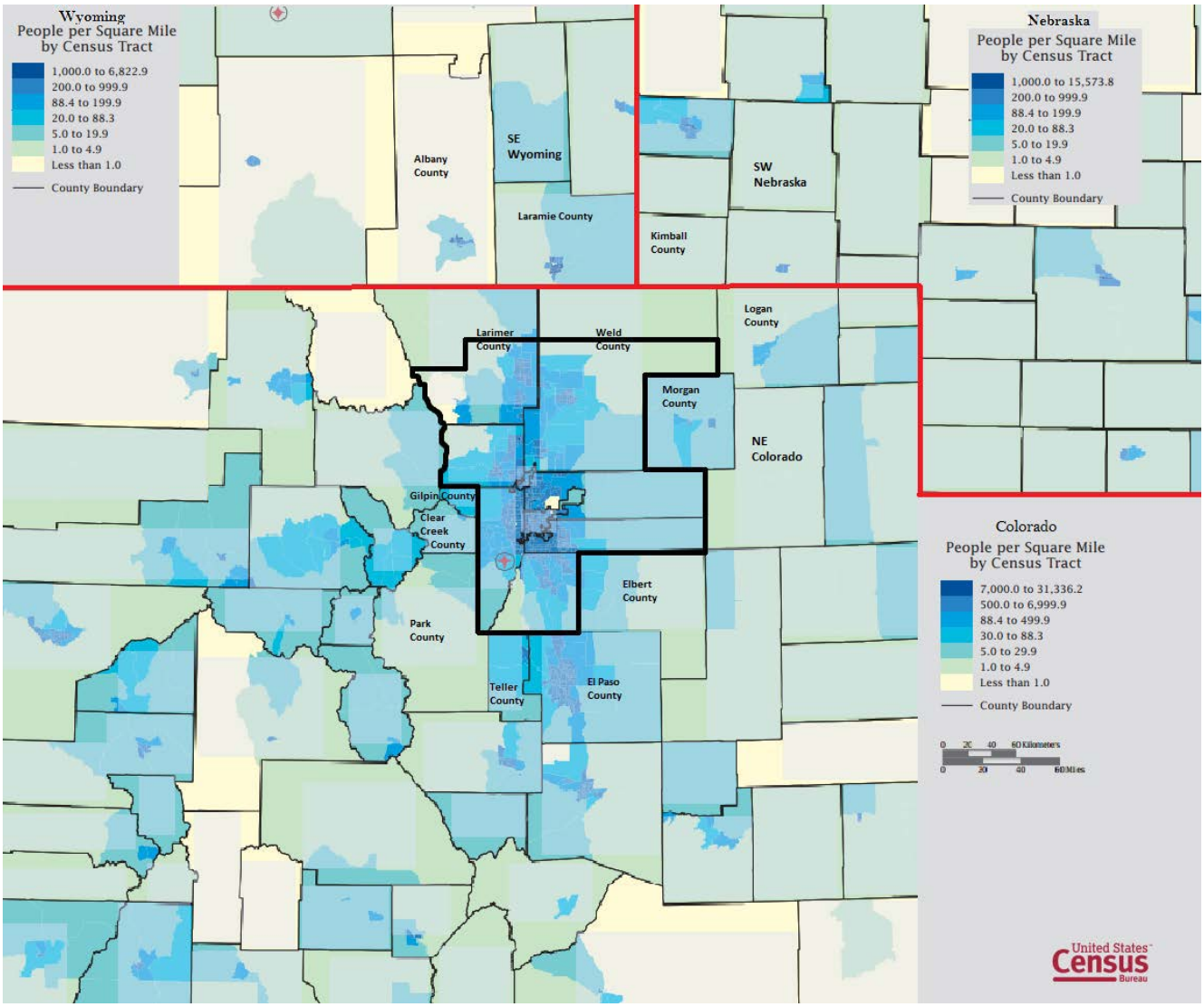


Figure 6. County-Level Population.

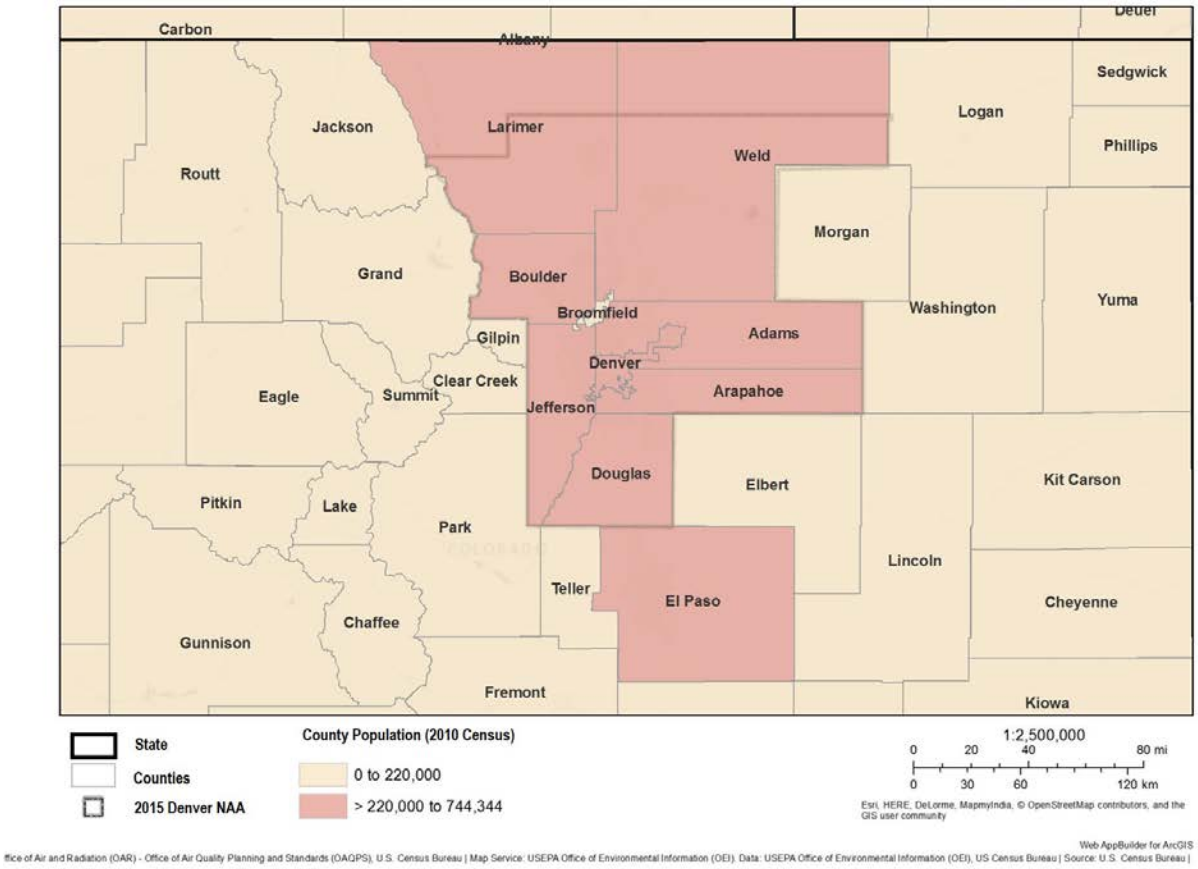


Figure 6 illustrates that urbanization rapidly diminishes beyond the central portion of the recommended nonattainment boundary.

Traffic and Vehicle Miles Travelled (VMT)

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the U.S. Census Bureau[9] for the counties in the area of analysis. Table 5 shows the traffic and commuting pattern data, including total VMT for each county in the area of analysis, number of residents who work in each county, number of residents that work in counties with violating monitor(s), and the percent of

[9] The worker data can be accessed at: http://onthemap.ces.census.gov/.

residents working in counties with violating monitor(s). The values in Table 5 are based on 2014 data. Table 5 indicates that Denver County has the greatest total VMT (5,682 million miles). Denver is the largest metropolitan area in the area of analysis but does not have a monitor that is violating the 2015 ozone NAAQS; thus, although it has the greatest number of county residents who work (299,489 people) the percent that commute to an area with a violating monitor is relatively small (16%). The three counties with the violating monitors – Jefferson, Douglas, and Larimer - have the highest percentage of commuters commuting within or to a county with a violating monitor. Respectively, they rank 2nd, 6th and 7th in number of people who work. Jefferson County also ranks second for total VMT (4,704 million miles), followed closely by Adams and Arapahoe both with over 4,000 million miles. Weld, Douglas, Larimer and Boulder rank 5th through 8th for VMT with between 3,000 and 4,000 million miles. The remaining five counties have much lower VMT - between 61 million miles (Gilpin) and 662 million miles (Broomfield). Figure 7 illustrates that the highest density of VMT is within the urban area of the city of Denver and that there is a corridor of heavier VMT along the I-25 interstate that runs north-south through the area.

Table 5. Traffic and Commuting Patterns.

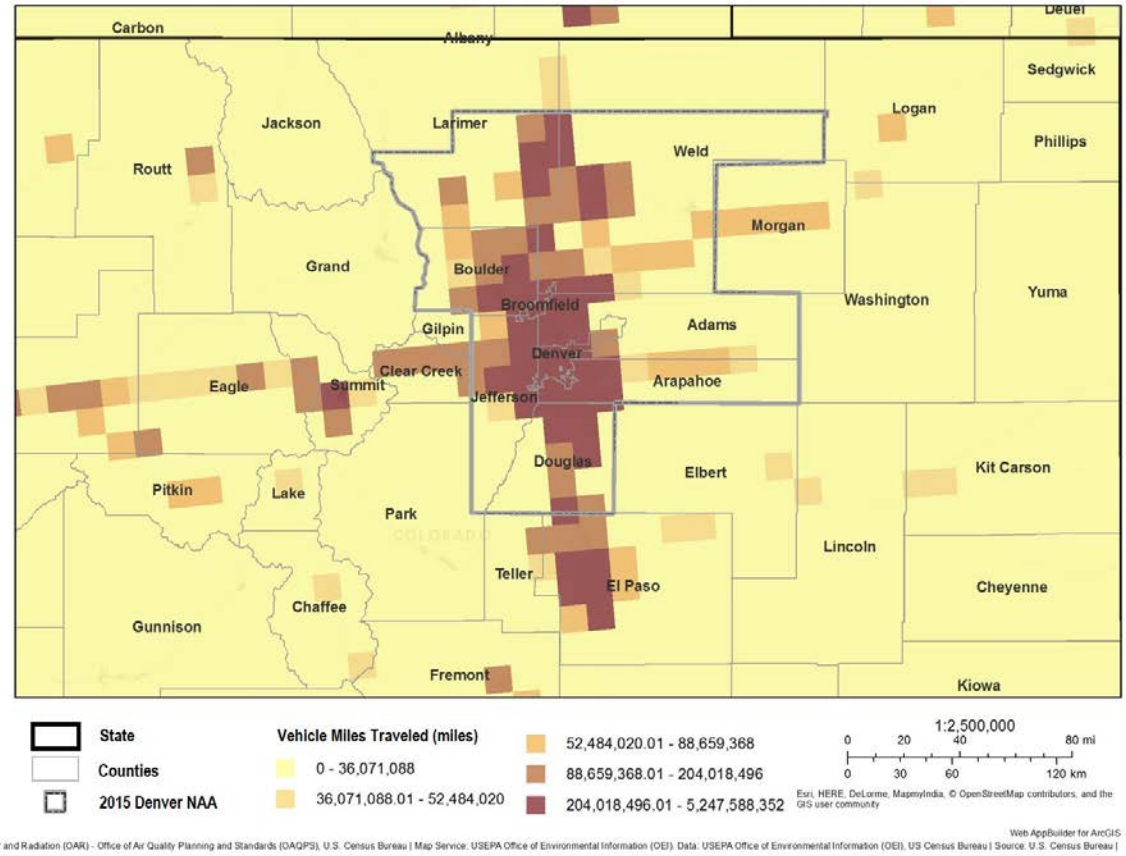
County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
Denver, CO	Yes	5,682	299489	46991	16%
Jefferson, CO	**Yes**	**4,704**	281748	107071	**38%**
Adams, CO	Yes	4,480	215675	34433	16%
Arapahoe, CO	Yes	4,344	287328	47507	17%
Weld, CO	Yes (partial)*	2,991	133199	27638	21%
Douglas, CO	**Yes**	**2,959**	152852	53487	**35%**
Larimer, CO	**Yes (partial)***	**2,721**	140317	91342	**65%**
Boulder, CO	Yes	2,266	134407	13689	10%
Broomfield, CO	Yes	662	30775	4862	16%
Clear Creek, CO	No	503	4459	1187	27%

Elbert, CO	No	270	12866	3184	25%
Park, CO	No	223	6735	1644	24%
Gilpin, CO	No	61	2432	465	19%
	Total:	31,866	1,702,282	433,500	25%

* For state recommended partial counties, the data provided are for the entire county.
Counties with a monitor(s) violating the NAAQS are indicated in bold.

To show traffic and commuting patterns, Figure 7 overlays twelve-kilometer gridded VMT from the 2014 NEI with a map of the transportation arteries.

Figure 7. Twelve Kilometer Gridded VMT (Miles) Overlaid with Transportation Arteries.



Factor 3: Meteorology

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations. Results of meteorological data analysis may inform the determination of nonattainment area boundaries. In order to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources

in the area., the EPA evaluated 2014-2016 HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) trajectories at 100, 500, and 1000 meters above ground level (AGL) that illustrate the three-dimensional paths traveled by air parcels to a violating monitor.

Figure 8 through Figure 12 show the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8 hour values that exceed the 2015 ozone NAAQS) for the violating monitors.

Figure 8. HYSPLIT Back Trajectories for Rocky Flats (Violating Monitor).

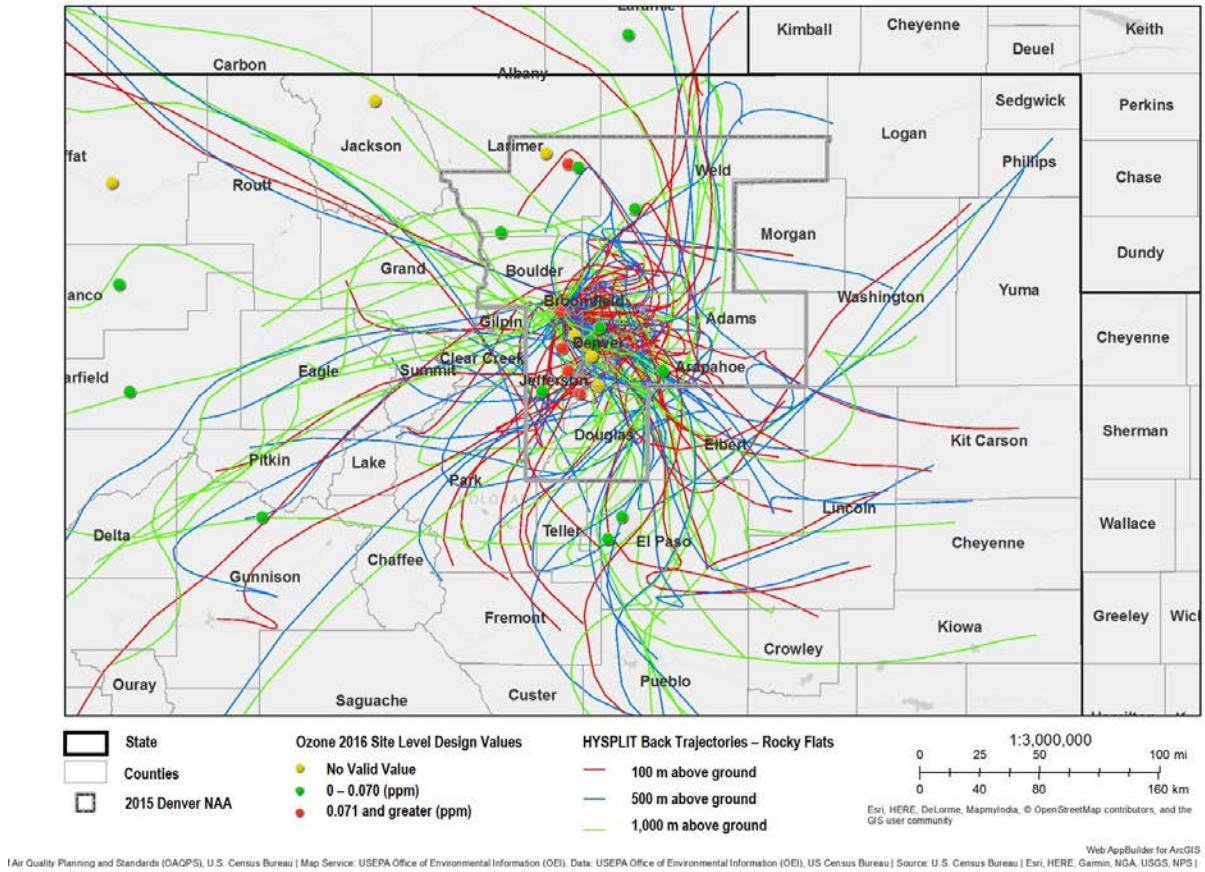


Figure 9. HYSPLIT Back Trajectories for NREL (Violating Monitor).

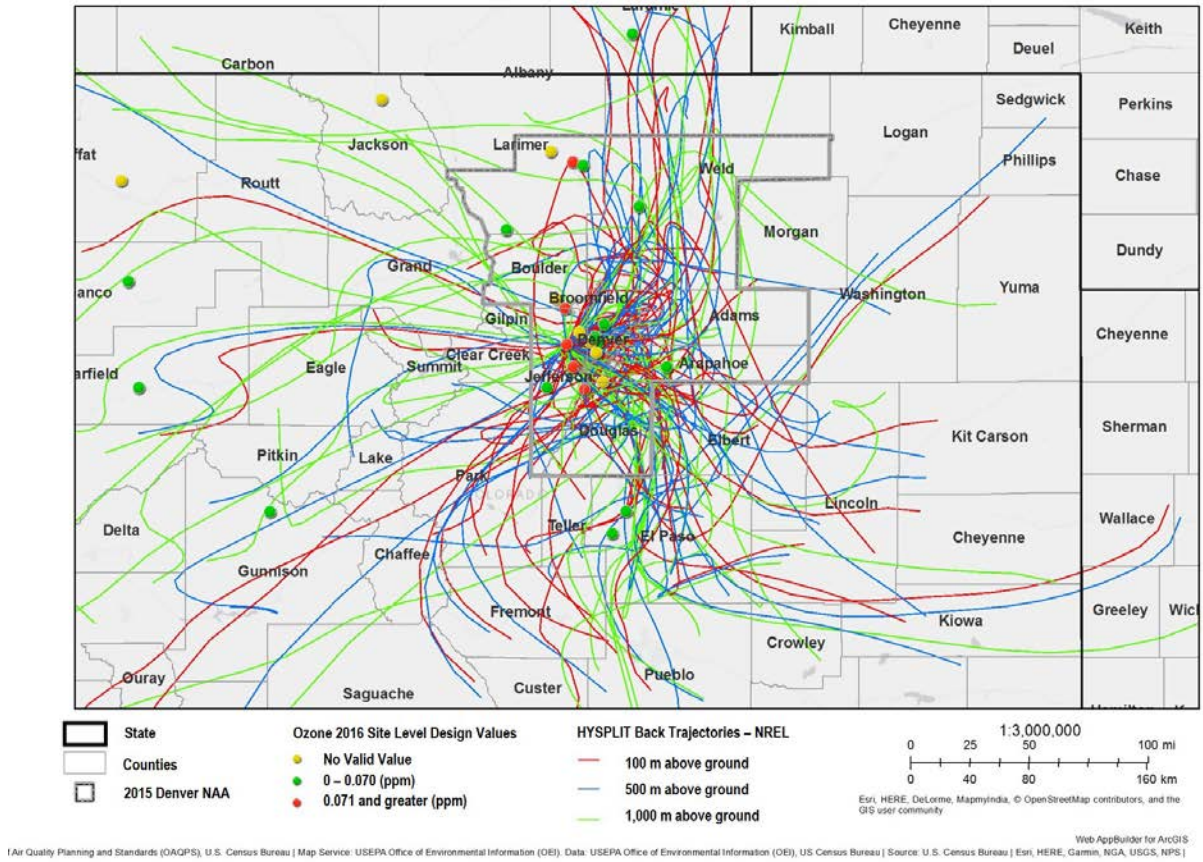


Figure 10. HYSPLIT Back Trajectories for Welch (Violating Monitor).

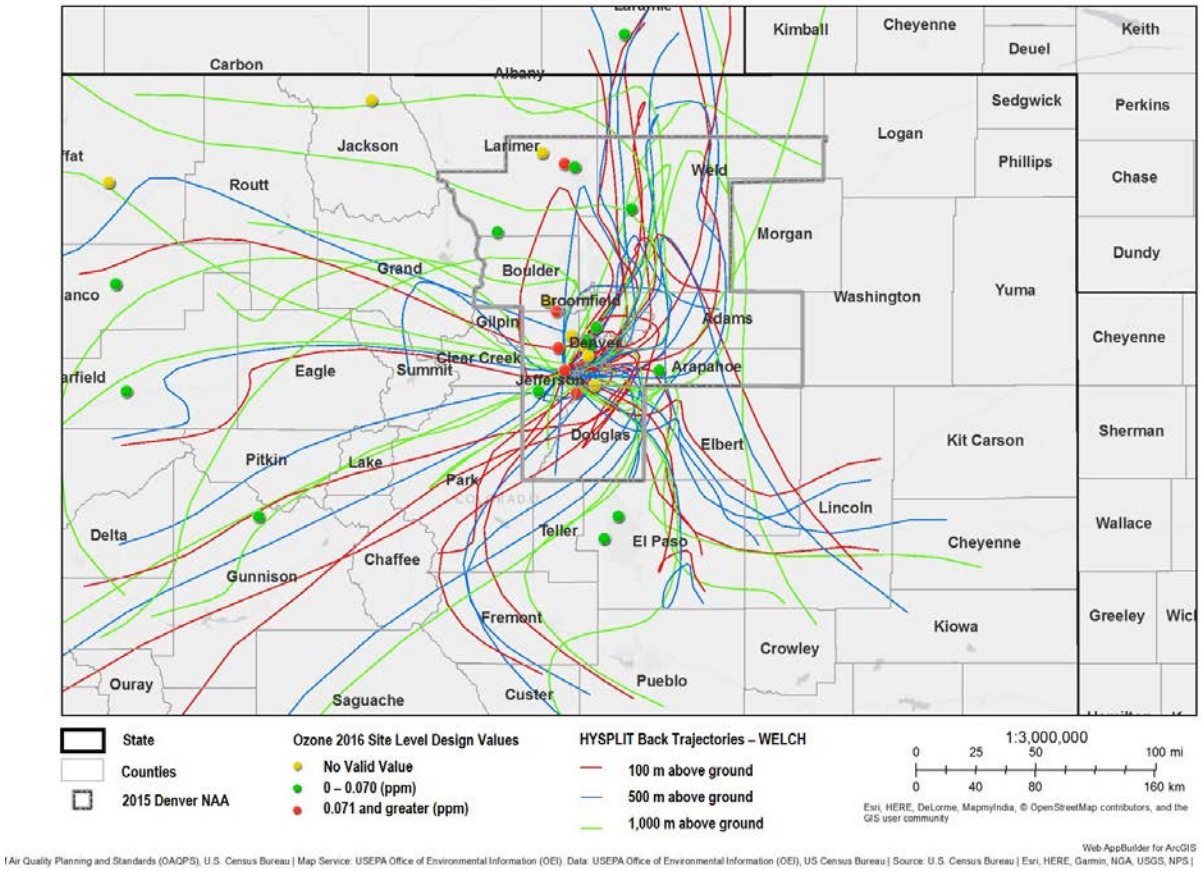


Figure 11. HYSPLIT Back Trajectories for Chatfield (Violating Monitor).

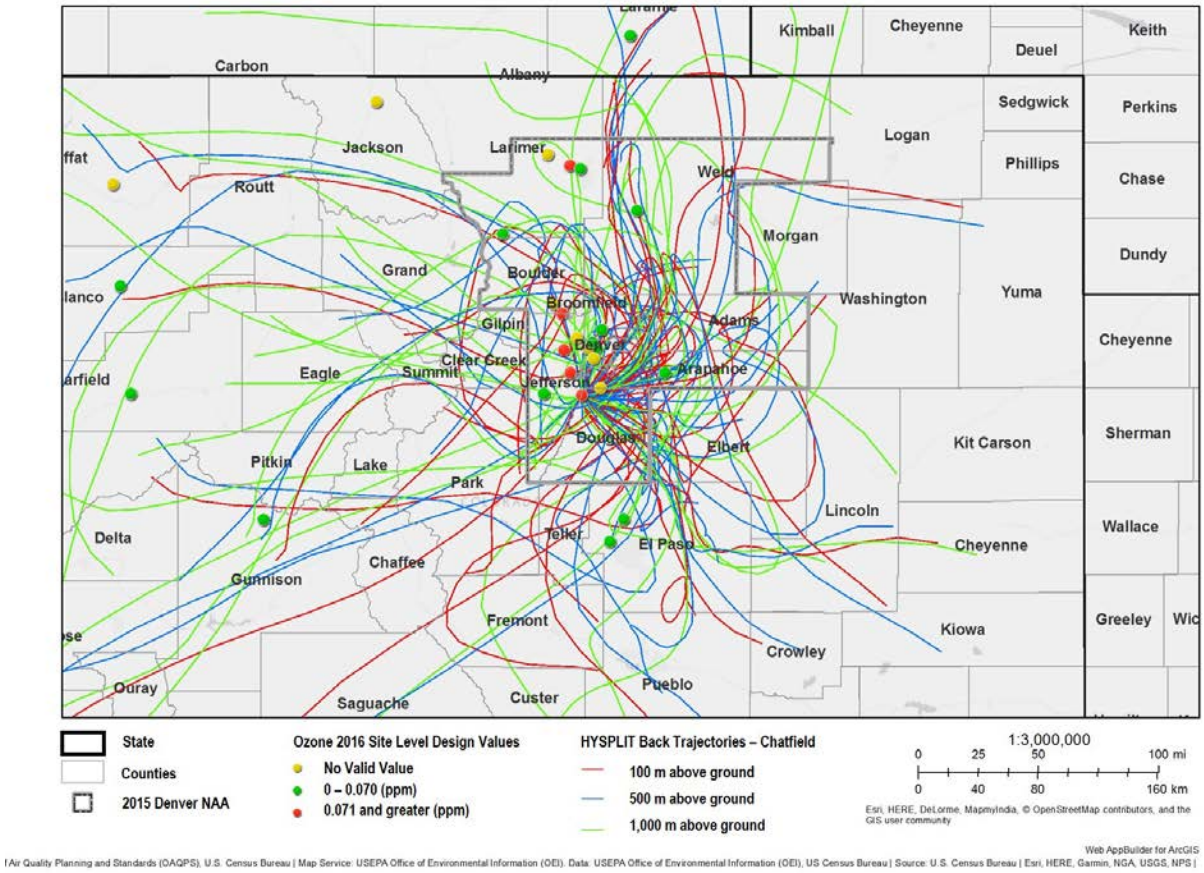
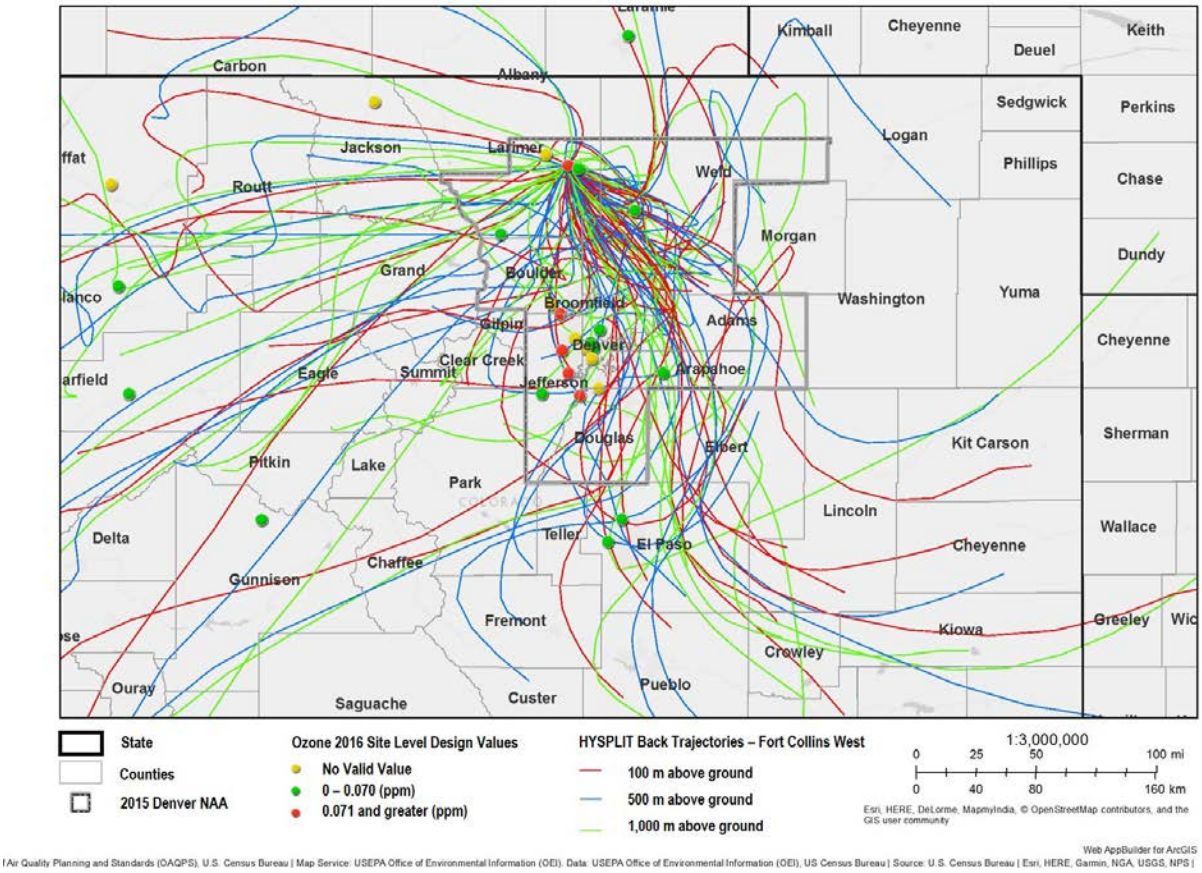


Figure 12. HYSPLIT Back Trajectories for Fort Collins West (Violating Monitor).



The analysis in the State of Colorado Technical Support Document for Recommended 8-Hour Ozone Designations (Colorado TSD) adopted by the Air Quality Control Commission on September 15, 2016, provides a thorough description of the unique meteorological conditions resulting in elevated ozone in the Denver Metro/Northern Front Range (DM/NFR) area[10].

> … the South Platte Valley and surrounding plains, the east-west Cheyenne Ridge along Colorado's border with Wyoming to the north of the South Platte Valley, the east-west Palmer Divide to the south of the Denver metro area, and the Continental Divide to the west of the South Platte Valley create local circulations that tend to magnify and constrain the influence of local emissions on air quality[11]

[10] Colorado TSD p. 33-35.
[11] Colorado TSD p. 33.

Colorado identifies the three key circulations affecting summer air quality within the airshed as:

- Nighttime and early-morning down-valley drainage flow[12].
- Thermally-driven upslope flow which is a component of a mountain-valley circulation[13].
- Mountain-plains solenoid circulation[14].

The three key circulation patterns (drainage flow, upslope flow, and mountain-plains solenoid circulation), in conjunction with the surface topography, in the area serve to trap emissions and produce ozone in the basin formed by the surrounding higher elevation features. Further, these circulation patterns serve to recirculate prior day emissions into the Denver area population centers as the mountain-plains solenoid flow lifts the polluted atmosphere up the mountain slopes of the Rocky Mountains to the west in warm afternoons, and then returns the polluted air to the surface as the lofted air circulates back to the east and subsides overnight. The thermally-driven upslope flow, flowing upstream along the South Platte River valley in the afternoon from northeast to southwest and along the Cache la Poudre valley from southeast to northwest, serves to close off the three sided basin formed by the elevated terrain to the south, west and north. These topographic features are discussed further in Factor 4.

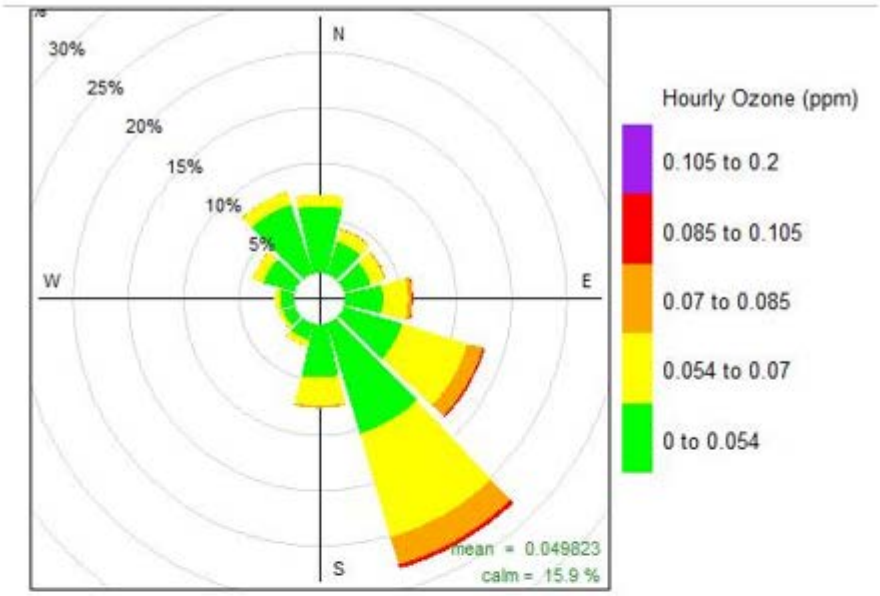
The EPA identified one more circulation pattern that can be a contributing pattern within the nonattainment area. The Denver Convergence Vorticity Zone[15], or "Denver Cyclone", is a cyclonic (counterclockwise) atmospheric motion that is an orographically-driven low pressure event. The Denver Cyclone is driven by topographic forcing and orographics; where downsloping wind primarily forced from the Palmer Divide and the Continental Divide, create a low pressure circulation which can have an impact on localized pollution transport due to mesoscale winds. The event is not a static feature however, and its motion is fluid in the atmosphere. The Denver Cyclone does not predict localized wind but during these low pressure events, the system that forms does have cyclonic motion. For example, Fort Collins, in the northwest portion of the nonattainment area, will often have a wind component of north or northeast, while an area in the southeastern portion of the nonattainment area will have a south or southwesterly wind direction. Minor shifts in the mesoscale and synoptic patterns will affect the oscillation of the low pressure center throughout the nonattainment area. Surface winds are important for ozone and precursor transport, and may be strongly influenced by local terrain leading to wind directions different from the flow further aloft.

A pollution rose which combines the hourly ozone concentration data and local hourly wind direction at the Fort Collins West site exemplifies the influence of local terrain and resulting upslope flow on high ozone transport (Figure 13). This site is located in the northwest portion of the NAA, and is the closest violating monitor to the northern NAA boundary. The local topography is dominated by the foothills a

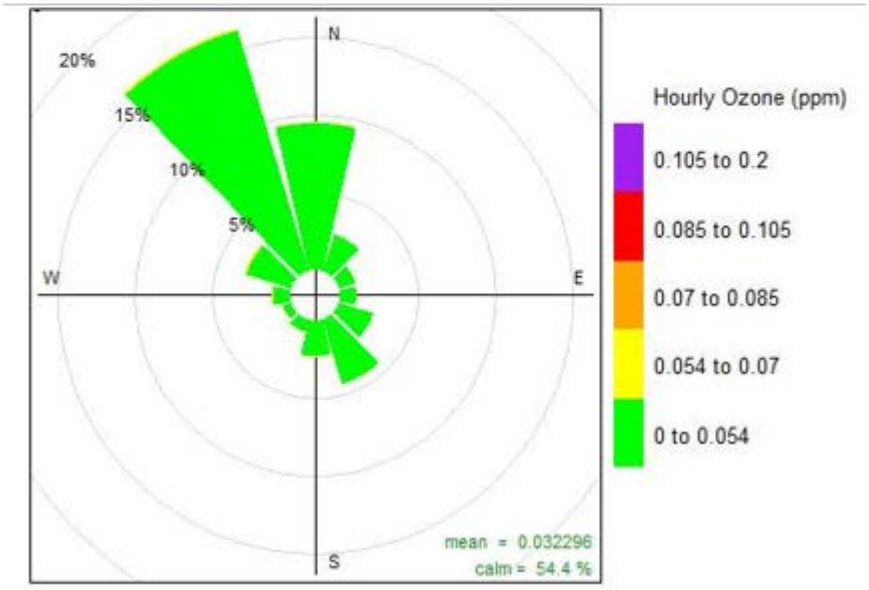
[12] Colorado TSD p. 34, *see* Figure 1-20.
[13] Colorado TSD p. 34, *see* Figure 1-21.
[14] Colorado TSD p. 35.
[15] "Denver Convergence-Vorticity Zone." *American Meteorological Society*, glossary.ametsoc.org/wiki/Denver_convergence-vorticity_zone.

few miles to the west and the Cache la Poudre watershed which drains to the southeast. The Cache la Poudre is less than two miles from the monitor site, and during upslope flow conditions, one would expect southeasterly flow up this watershed. As illustrated in the figure, virtually all of the hourly ozone values exceeding 0.070 ppm are transported from the south-southeast to east directions between the hours of 7:00 am and 9:00 pm MST. In contrast, between 10:00 pm and 6:00 am, ozone greater than 54 ppb is rarely observed, and dominant winds are northwesterly, down the Cache la Poudre drainage.

Figure 13. Fort Collins West pollution rose of hourly ozone during daylight hours (7:00 am to 9:00 pm MST top), and nighttime hours (10:00 pm to 6:00 am, bottom) during the ozone season (May – September) from 2013 through 2016.



Top: 7:00 am to 9:00 pm, MST



Bottom: 10:00 pm to 6:00 am, MST

Colorado states that:

> Upslope flow from the lower elevation regions through the urbanized and industrialized regions of the airshed dominates on high ozone days[16].

Furthermore, the upslope flows are consistent with HYSPLIT back trajectories shown above in Figures 8 through Figure 12. Figures 8 through 12 all show areas of highest density, where the largest number of trajectories transect, to the east of the violating monitors. For Chatfield, at the south end of the Denver metro area in Figure 11, the heaviest concentration of trajectories is to the northeast; for Fort Collins West, at the north end of the recommended nonattainment area in Figure 12, the greatest concentration of trajectories lies to the southeast.

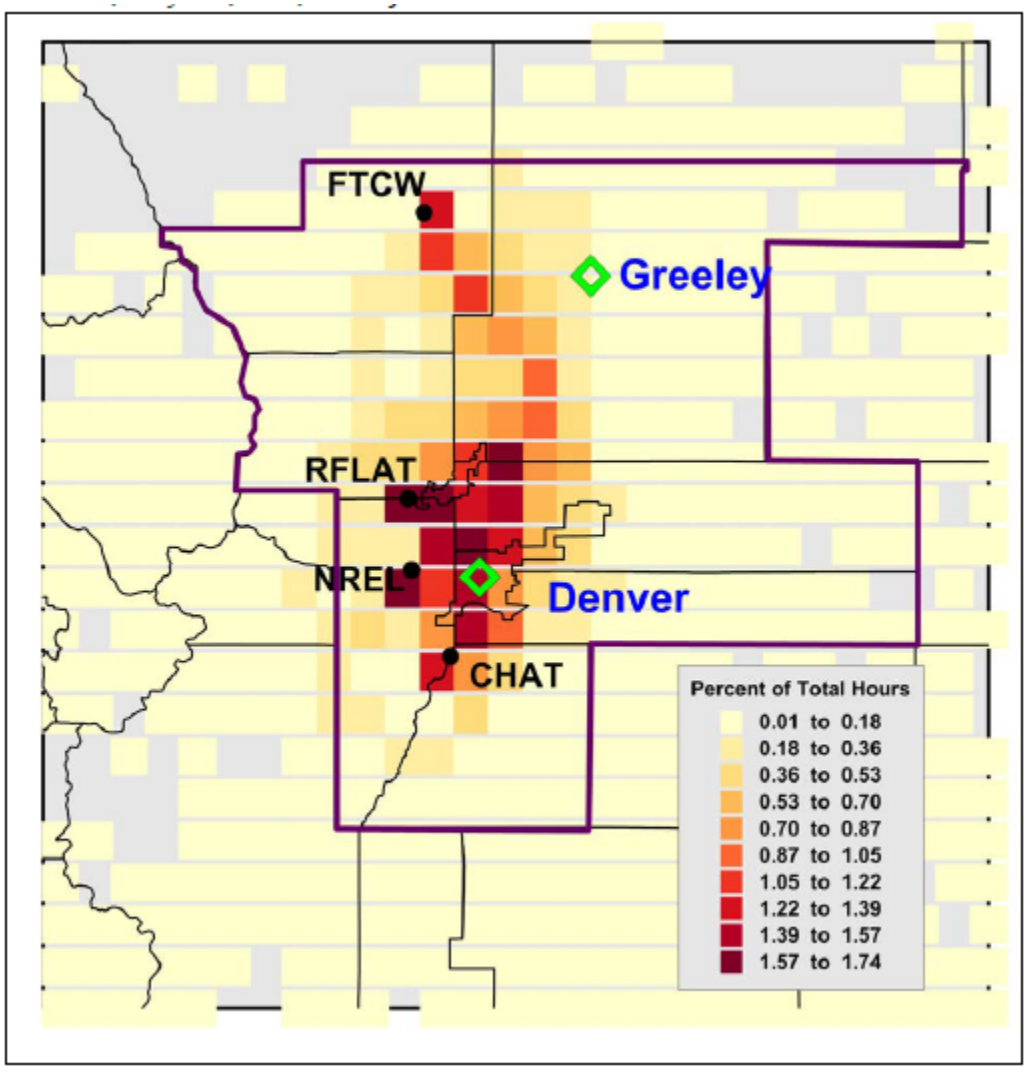
Colorado independently evaluated HYSPLIT back trajectories for its recommendation. The Colorado methodology included numeric evaluations of trajectory locations, allowing more focused interpretation and depiction of the HYSPLIT trajectory data.[17] Where the EPA utilized 24-hour back trajectories for every exceedance day in 2014-16, Colorado focused on the four highest exceedance days in the years 2013-15. Even though the total number of trajectories in the Colorado evaluation is less than the total number of trajectories in Figure 8 through Figure 12, the Colorado methodology shows the same geographic distribution of trajectory hours as shown in Figure 8 through Figure 12.[18]

To illustrate this distribution, Colorado combined methodology results for each of the four monitors analyzed into a single map in the Colorado TSD. The map shows that, for the most part, grid cells outside the recommended nonattainment boundary included fewer than 5 trajectory hours.[19]

Figure 14 shows the percentage of total hours, aggregated by grid cell and representing 24 hours of back trajectories for each of the eight hours that compose the 4 highest values for each year and for each monitor, in which a back trajectory is crossing a given grid cell.[20] The figure shows a general background level of very low back trajectory presence (less than 0.18% of total hours) in grid cells in all directions outside the area recommended by the State to be included in the designated nonattainment area. Areas with a more significant occurrence of back trajectories are shown in the darker colors on the map.

[16] Colorado TSD p. 44.
[17] Colorado TSD p. 35-43.
[18] Colorado TSD p. 36, *see* Figures 1-23 through 1-26.
[19] Colorado TSD p. 41, *see* Figure 1-27.
[20] Colorado TSD, p. 43; there are a total of 9,216 hourly trajectory points in the 48 analyzed 24-hour back trajectories from the violating monitors.

Figure 14. HYSPLIT Back Trajectories for the Four Highest Days in 2013-2015 for Each Violating Monitor; Percent of Total Hours Crossing Each Grid Cell.



Factor 4: Geography/topography

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

The EPA used geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The geographic and topographic features (Figure 15) in the area of analysis include:

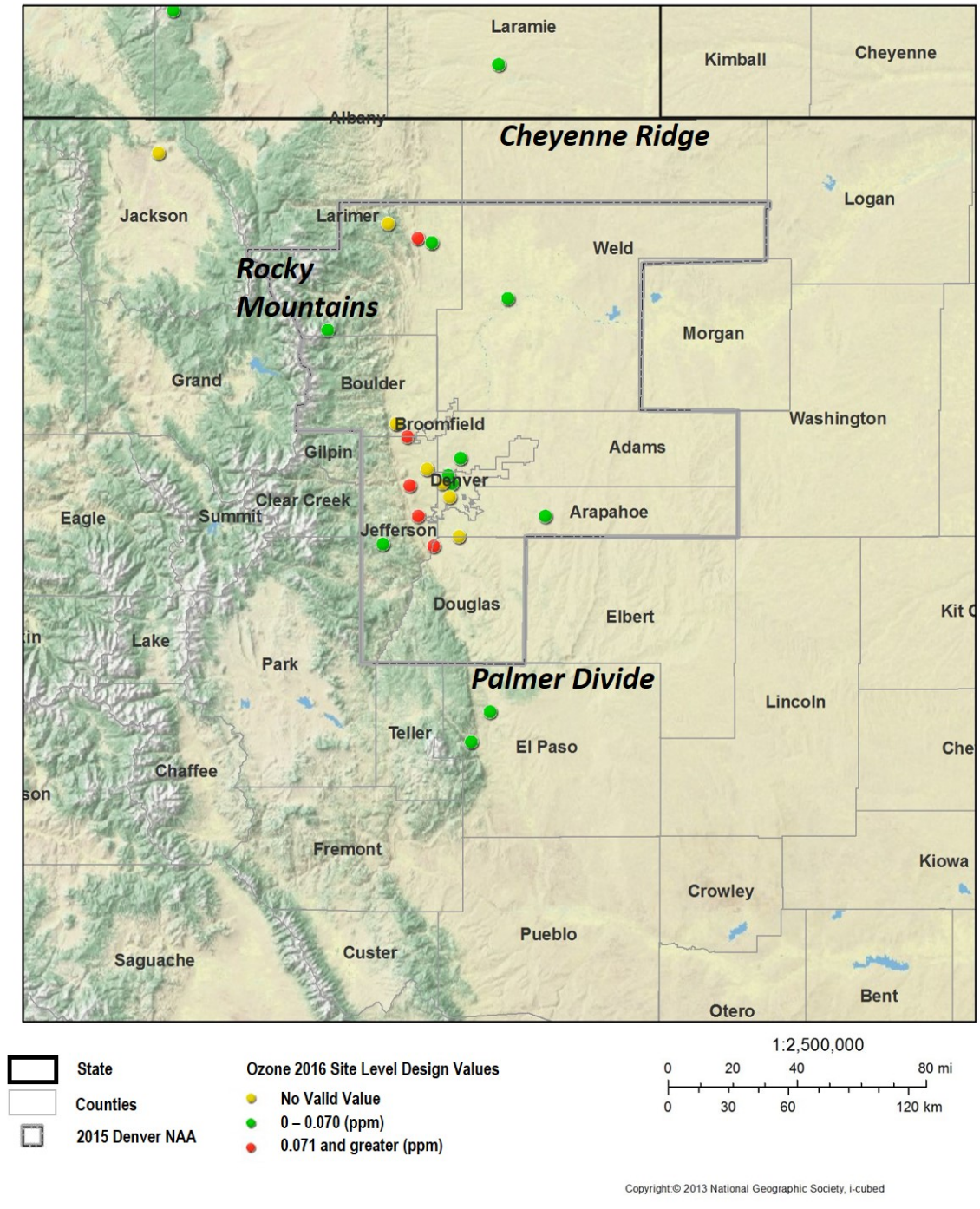
- the Rocky Mountains to the west;
- the Palmer Divide to the south;
- the Cheyenne Ridge to the north;
- and following the S. Platte River valley to the northwest.

The Palmer Divide, Rocky Mountains and Cheyenne Ridge provide topographic features enclosing the Denver metropolitan area on the south, west and north. These three features create an enclosed three-sided basin. Through the enclosed three-sided basin, the South Platte River flows from the southwest to the northeast. As was described under Factor 3, nighttime and early morning drainage flow, thermally driven afternoon and evening upslope flow, and mountain-plains solenoid circulation combine with the topographic features to effectively close off the basin on the east side during summer ozone stagnation episodes. The Palmer Divide, the continental divide of the Rocky Mountains, and the Cheyenne Ridge roughly coincide with the south, west and north boundaries of the nonattainment area or the 1997 and 2008 ozone NAAQS and the boundary recommended by the State for the 2015 ozone NAAQS. The combination of the topographic features and the airflows during ozone episodes serve to enhance contributions from sources in the basin. Moreover, these topographic features and airflows restrict contributions from sources on the upper reaches of and beyond the features, including the northern parts of Weld and Larimer Counties.

This information is supplemented in the State's description in their TSD[21] provided with their boundary recommendation, which includes a thorough examination of these geographic and topographic features.

[21] Colorado TSD p. 46-48.

Figure 15. Topographic Illustration of the Physical Features.



Factor 5: Jurisdictional boundaries

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the final Denver Metro/North Front Range nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country, metropolitan planning organizations, and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the final designated areas.

The area of analysis encompasses the Boulder, Denver-Aurora-Lakewood, Greeley, and Fort Collins CBSAs. The Denver area has previously established nonattainment boundaries associated with the 1997 and 2008 ozone NAAQS. The State has recommended the same boundary for the 2015 ozone NAAQS. This boundary excludes the northern portions of Larimer and Weld Counties roughly corresponding with the location of the Cheyenne Ridge.

Conclusion for Denver Metro/North Front Range Area

Based on the assessment of factors described above, the EPA is not modifying the State's recommendation to designate the following counties or partial counties as the Denver nonattainment area for the 2015 ozone NAAQS: Adams County, Arapahoe County, Boulder County, Broomfield County, Denver County, Douglas County, Jefferson County, Larimer County (partial), and Weld County (partial). These are the same counties that are included in the Denver nonattainment area for the 1997 and 2008 ozone NAAQS. The air quality monitors in Douglas, Jefferson, and Larimer Counties have monitors in violation of the 2015 ozone NAAQS, therefore all or portions of Douglas, Jefferson, and Larimer County are included in the final nonattainment area. Adams, Arapaho, Boulder, Broomfield, Denver, and portions of Weld County are nearby counties that do not have violating monitors, but the EPA has concluded that these areas contribute to the ozone concentrations in violation of the 2015 ozone NAAQS through emissions from point sources and other non-point sources and from commuters into the counties with violating monitors.

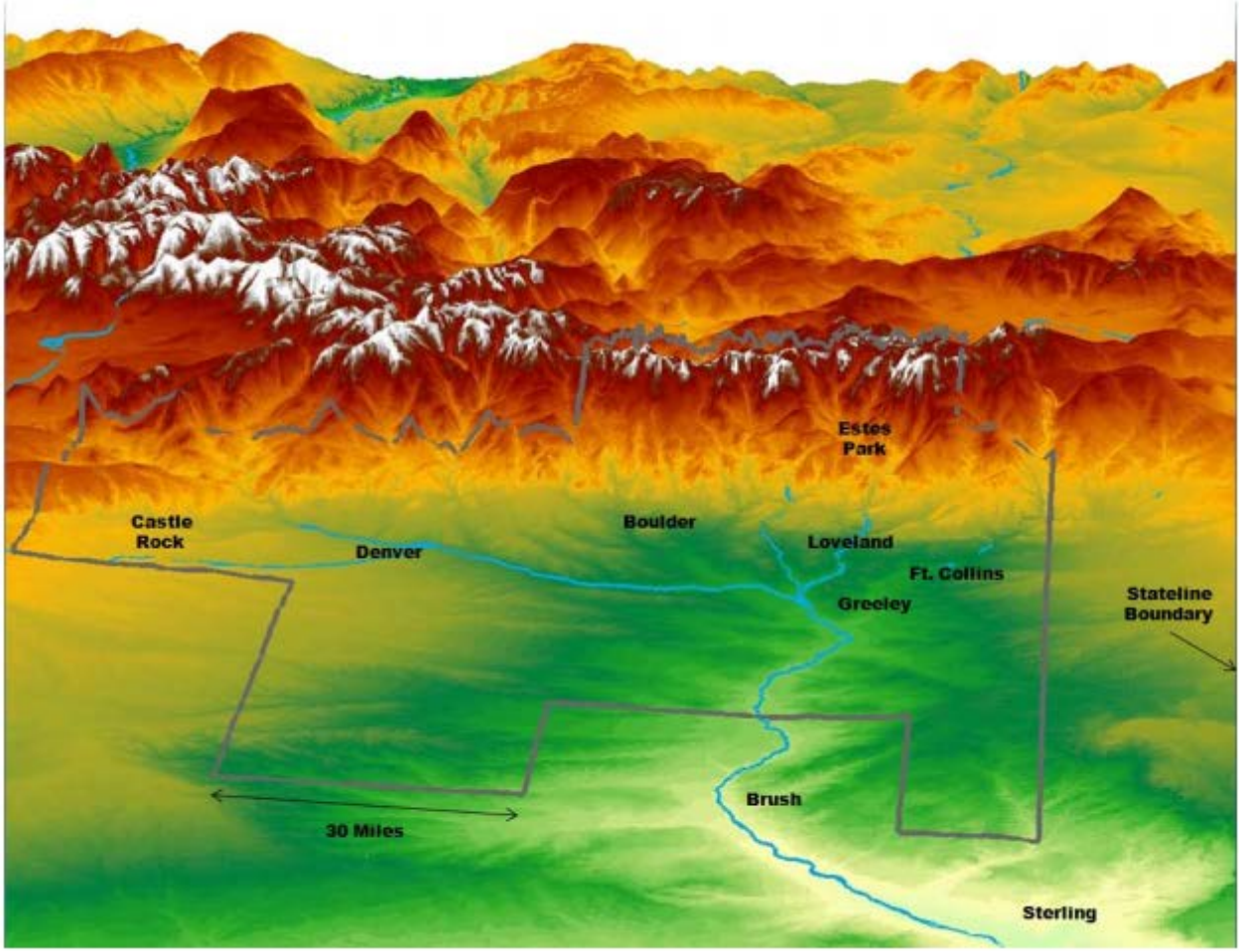
The State recommended that all or a portion of Weld, Adams, Denver, Jefferson, Arapahoe, Boulder, Larimer, and Douglas Counties be included in the nonattainment area. The county-level emissions and the geographic location of large point sources show the greatest levels of the precursor emissions of NO_x and VOC in the area of analysis from these counties which rank 1-7 in terms of total NO_x and VOC emissions. These counties also rank high as compared with other counties in the area of analysis in terms of total population, population density, and population growth. In addition, these counties in full or in part, are within the Denver Basin as described in the topographic discussion of factor 4. The State recommended that the entirety of Adams, Arapahoe, Boulder, Denver, Douglas and Jefferson Counties be

included in the nonattainment area and the EPA is not modifying the State's recommendation for these counties.

The State recommended that only portions of Larimer and Weld County be included in the nonattainment area. The predominant source of NO_x and VOC emissions in Weld County is from oil and gas drilling and exploration activities. While some of these activities are occurring in the northern portion of the county, which the State has not recommended for inclusion in the nonattainment area, the bulk of emissions from these activities are occurring in the remaining portion of the county (*see* Figure 4). The 2011 emissions data provided by the State indicates that emissions from the northern portions of Larimer were approximately 36% of NO_x and 37% of VOC total emissions in Larimer County, while 2011 emissions from the northern portions of Weld County were approximately 25% of NO_x and 18% of VOC total emissions in Weld County. Population data from Larimer and Weld Counties includes the whole county and does not apportion persons residing in the nonattainment area portion of these counties. According to Colorado, the 2015 population of the northern portion of Larimer County (outside the nonattainment area) is estimated to be 16,679 persons (5% of the county total). The 2015 population for the northern portion of Weld County (outside the nonattainment area) is estimated to be 2,852 persons (~1% of the county total).

The northern sections of Weld and Larimer Counties include in the elevated terrain which forms the norther boundary of the Denver Basin, as shown in Figure 16; the southern aspect Cheyenne Ridge is the elevated terrain along the right (north) edge of that figure. The Denver Basin, including the South Platte River drainage from southwest of Denver to Sterling and the Cache la Poudre drainage from Fort Collins through Greeley to the South Platte, is characterized by unique meteorological conditions and topographic features described in Factor 3 and Factor 4 which indicate that emissions in Northern Weld and Northern Larimer Counties are not likely to contribute to violating monitors. The topographic features for the Denver basin (the Rocky Mountains to the west, the Cheyenne Ridge to the north and the Palmer Divide to the south) in conjunction with afternoon up-valley winds from the northeast to the southwest along the Platte River valley serve to confine locally produced ozone to the basin. The EPA is not modifying the State's recommendation to include the southern portions of Weld and Larimer counties in the nonattainment area and to designate the northern portions of those counties as attainment/unclassifiable.

Figure 16. Terrain of the Denver Basin and the Nonattainment Area Boundary (gray line).



The State also recommended that Broomfield County be included as part of the designated nonattainment area. Broomfield County has relatively low emissions for the counties in the area of analysis – ranking 10 out of 14. It has the second highest population density and one of the highest percentage population changes for the area. In addition, Broomfield is only 1.2 miles from the violating monitoring site in Jefferson County and is surrounded by other counties the State recommended for inclusion in the nonattainment area. The EPA is not modifying the State's recommendation to include Broomfield County in the Denver nonattainment area for the 2015 ozone NAAQS.

The State did not recommend Clear Creek, Elbert, Gilpin, and Park Counties for inclusion in the nonattainment area. These counties all ranked among the lowest for emissions, population-related information, and traffic and commuting. Topography (the Rocky Mountains) separates Clear Creek, Gilpin, and Clark from the core of the metropolitan area and the violating monitors. The EPA is not modifying the State's recommendation for these counties. Based on the assessment of factors described above, the EPA has concluded that the following counties meet the CAA criteria for inclusion in the Denver Metro/North Front Range nonattainment area: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer (partial) and Weld (partial). These are the same counties that are included in the Denver Metro/North Front Range nonattainment area for the 1997 and 2008 ozone NAAQS.