Technical Support Document

State of Colorado

TECHNICAL SUPPORT DOCUMENT
FOR
POINT SOURCE AND OIL & GAS EMISSIONS INVENTORY DEVELOPMENT

Supporting the

Denver Metro/North Front Range
Serious State Implementation Plan
for the 2008 8-Hour Ozone
National Ambient Air Quality Standard

Approved by:
Colorado Air Quality Control Commission
(Anticipated December xx, 2020)

COLORADO
Department of Public Health & Environment

RAQC
Regional Air Quality Council

Point Source and Oil & Gas Sources Emissions Inventory Development

Introduction

OVERVIEW

Per Clean Air Act (CAA), 42 U.S.C. §7511a(a)(1) ("§182(a)(1)"), on July 17, 2014, the Colorado Department of Public Health and Environment (CDPHE) submitted a 2011 Periodic Emissions Inventory for Ozone Precursors for the Denver Metro/North Front Range (DM/NFR) nonattainment area under the 2008 Ozone National Ambient Air Quality Standard (NAAQS). The 9–county nonattainment area consists of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, and portions of Larimer and Weld counties. The 2011 base year inventory was included as part of the Moderate Area State Implementation Plan (SIP) submittal and establishes the baseline from which Reasonable Further Progress (RFP) must be calculated for nonattainment areas classified as Moderate and higher (CAA §182(b)(1)(A)). Additionally, as part of the Moderate Area SIP, a projected 2017 attainment year emissions inventory was developed and submitted to U.S. Environmental Protection Agency (EPA) and was approved by EPA in 2018 (83 FR 31068). Due to EPA's reclassification of the DM/NFR to Serious nonattainment for the 2008 NAAQS, effective January 2020, the CDPHE has prepared an updated 2017 emissions inventory (now referred to as a "milestone" year for purposes of RFP) based on currently available data, in accordance with EPA's revised guidance on emissions inventory development, and is being resubmitted as part of this Serious Area SIP (CAA §182(c)(2)(B)).

2011 BASE YEAR EMISSIONS INVENTORY

An emissions inventory was developed for a typical July day for the year 2011 for the ozone precursors of oxides of nitrogen (NO_X) and volatile organic compounds (VOC) emitted in the DM/NFR area. An inventory of emissions was developed for all major source categories including oil and gas, point, area, non–road, and on–road sources (see Table 1). Residential fuel combustion is excluded because emissions from this category are negligible in the summer. Fire emissions and other "naturally occurring" emissions are not included in the anthropogenic portion of the inventory but are included as "biogenic" sources, which are held constant and are addressed in section 3.3.7 of the Serious Area SIP. The full discussion of the 2011 emissions inventory with detailed information on methodology is available in the Moderate Area SIP. This 2011 emissions inventory is the baseline year inventory for both RFP (Chapter 4) and the Contingency Measures Plan (Chapter 10) of this Serious Area SIP.

2017 MILESTONE YEAR EMISSIONS INVENTORY

The Regional Air Quality Council (RAQC), in conjunction with the Colorado Air Pollution Control Division (APCD or the Division hereafter), developed an updated 2017 "milestone year" emissions inventory for the DM/NFR Serious Nonattainment Area. When initially developed for the Moderate Area SIP, the 2017 inventory was calculated based on projected values. The 2017 inventory approved as part of the Moderate Area SIP has been updated for the purposes of the Serious Area SIP using actual data collected in 2017 and methodologies as presented in the

following sections. This inventory is also being used to meet requirements for the DM/NFR Marginal Nonattainment Area under the 2015 8-hour Ozone NAAQS. This inventory is in tons per summer day (tpd) and represents the most current available data for emissions estimates for an average episode day during the peak summer ozone season of June through September. This includes actual data for the oil and gas sector and stationary sources in addition to newer data from updated regional transportation demand models used by the two Metropolitan Planning Organizations in the DM/NFR.

The development of the 2017 *Milestone Year Emissions Inventory* for the 2015 8-hour Ozone NAAQS is described in the *Denver Metro Area/North Front Range Nonattainment Area 2017 Emission Inventory*, June 18, 2020, and the Technical Support Document for that inventory.

BASE AND FUTURE YEAR EMISSIONS PHOTOCHEMICAL MODELING INVENTORIES

The 2016 base year emissions data for the 36/12-km domains were initially based on the EPA/MJO 2016 Beta emissions (2016ff) and then updated to the 2016v1 emission estimates (2016fh). For the 4-km Colorado domain, the EPA 2016fh emissions with Division updates for Colorado oil and gas and on-road mobile sources were used. New emissions were generated for natural emission sources, including biogenic and lightning NO_X (LNO_X) for all three domains. The previous EPA 2016ff platform did not include LNO_X emissions and used the Biogenic Emission Inventory System (BEIS) biogenic emission model whose emissions were replaced by MEGAN biogenic emissions in all three domains for 2016fh. Future year emissions for 2020 were based on an interpolation between EPA's 2023 and 2016 emissions with some updates to Colorado provided by the Division.

Specifically, the Division supplied oil & gas area and point source inventories for both the 2016 and 2020 modeling years using methodology described below in the Oil & Gas section.

2020 ATTAINMENT YEAR EMISSIONS INVENTORY

The 2020 emissions inventory was developed for a typical high ozone day for the ozone precursors NOx and VOC emitted in the ozone nonattainment area. The 2020 inventory is a projection of the latest data available when the inventory was being developed in 2019.

This section presents the 2020 emissions inventory used in the modeling scenarios for the Serious area SIP for the DM/NFR. This inventory is in tpd and represents emissions estimates for an average episode day during the peak summer ozone season (June through September). The 2020 inventory for VOC and NOx accounts for emissions growth associated with projected changes in population, fuel use, and economic activity as well as emissions reductions associated with on–the–books controls. The EPA has provided guidance on developing emission projections to be used with models and other analyses for demonstrating attainment of air quality goals for ozone. This guidance and other information[1] available from EPA was followed and used in developing the future year emission projections.

[1] U.S. Environmental Protection Agency's (EPA) final *2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements*, 80 Fed. Reg. 12,264 (Mar. 6, 2015).

Table 1 includes an overall summary of anthropogenic daily ozone precursor emissions in the Denver/North Front Range (DM/NFR) ozone nonattainment area.

Table 1 – 2020 Nonattainment Area Emissions Inventory (tpd)

Description	VOC	NOx
Area	**54.6**	**-**
Architectural and Industrial Maintenance	25.1	-
Consumer Products	15.7	-
Other	13.9	-
Non-Road	**44.3**	**39.1**
Agriculture	0.2	1.8
Aviation	1.9	6.9
Commercial Equipment	6.5	14.1
Lawn and Garden	33.0	7.6
Railroad	0.4	8.2
Recreation	2.2	0.5
Oil and Gas	**119.0**	**48.2**
Area	54.5	34.4
Condensate/Oil Tanks	50.2	0.6
Point	14.3	13.1
On-Road	**49.4**	**54.7**
Light-Duty Vehicles	47.6	41.4
Medium/Heavy-Duty Vehicles	1.8	13.3
Point	**25.0**	**21.7**
Electric Generating Units (EGU)	0.4	4.6
Non-EGU	24.6	17.1
Grand Total	**292.3**	**163.7**

Oil and Gas Sources

The emissions inventory for the oil and gas sector in Colorado includes three segments: point sources, condensate/oil tanks, and area sources. In consideration of the technological advancements and emission controls taking place in the oil and gas sector, and building upon efforts beginning during the Moderate area SIP development process, the Regional Air Quality Council (RAQC) and APCD sought assistance from industry in developing the future year emissions inventory. Beginning in late 2018, the APCD held a series of meetings with representatives from the major oil and gas producers in the Denver–Julesburg (DJ) basin, which resulted in detailed information and future projections being provided to the APCD for 2020 inventory development.

These meetings were focused on discussion of actual site–specific emissions data from 2017, including technology and production as well as projected 2020 emissions and production. Discussions also took place with the Colorado Oil & Gas Association (COGA) to estimate future production and technology use among the rest of the producers in the DJ basin. Estimates for this segment assumed that production would increase approximately 27% per year from 2017 to 2020, consistent with historic production increases from 2014 to 2018 based on data reported to the Colorado Oil and Gas Conservation Commission (COGCC). It is also assumed that there would be a decline in vertical well production and increase in horizontal well production, with new production utilizing multiple stages of separation.

OIL AND GAS POINT SOURCES

Table 2 shows oil and gas point sources which include external combustion boilers, industrial processes, internal combustion sources, and petroleum/solvent evaporation. This portion of the inventory is based upon the Colorado Air Pollution Emission Notice (APEN) database and is provided in (i.e., the 2018 APEN database). Emissions from well pad production facilities were excluded from the point source inventory.

For the 2020 emissions inventory, the Division used APEN-reported data based on the most recently available data at the time (i.e., the 2018 APEN database). In order to avoid double counting of emissions, oil and gas well pad production facilities were excluded from the below point source inventory.

Table 2 – 2020 Oil and Gas Point Source Emissions Inventory (tpd)

Description	VOC	NOx
Point		
External Combustion Boilers	0.1	0.3
Industrial Processes	4.3	0.9
Internal Combustion Engines	5.6	11.8
Petroleum and Solvent Evaporation	4.3	0.1
Oil and Gas Point Total	**14.3**	**13.1**

OIL AND GAS CONDENSATE/OIL TANKS

In 2020, VOCs from condensate/oil tanks are projected to only slightly outpace those of on-road mobile sources in the emissions inventory. As described in section 3.3.2 of the Serious area SIP (2017 Oil & Gas Emissions Inventory), Colorado experienced a large production uptick around 2012 owing to advancements in technology that caused the majority of new wells to be drilled directionally or horizontally versus the prior method of vertical extraction. Such new drilling techniques caused profitable increases in production for industry, but brought with it a large increase in the amount of condensate storage tanks, pipeline development, venting/flaring episodes, truck traffic, and tank loadout, to name a few. Over the past several years, efforts have been made as a result of 2014 regulations on storage tanks and 2014 regulations initiating Leak Detection and Repair (LDAR) inspections to implement more stages of separation or (even in some instances) tankless production, alongside the LDAR program established by the EPA to reduce fugitive VOC emissions from components. Strategies such as these allow for more capture of gas, while simultaneously reducing the flashing or leaking of such gases to the atmosphere.

All future growth in oil and gas development is assumed to involve horizontal wells in combination with either tankless facilities or 2 and 3 stages of separation. Vertical well production is declining, as are single stage separation facilities. Tankless facilities have zero tank emissions at the well pad since there is no storage on site with all liquid production being piped to midstream centralized processing facilities such as Occidental Petroleum's centralized oil stabilization facility. Such centralized facilities use pressurized vessels to stabilize liquids and thereby eliminate upstream flashing of gases from atmospheric storage tanks. Pressure vessels have no thief hatches or pressure relief valves, thus resulting in very low emissions. Such

technology allows Occidental Petroleum's centralized facility to be classified a true minor source.

Projections to 2020 for Colorado were based on reported oil production for the 5-year timeframe 2014 to 2018 (the approach taken by the Inventory Collaborative workgroup through the Western Regional Air Partnership (WRAP) and the Western State Air Resources Council (WESTAR). This method involved a simple linear approximation of change in production from DM/NFR counties only (note that production projections include the portions of Weld and Larimer that lie outside the DM/NFR). It is worth noting that regardless of year, over 95% of all oil production in the 9 counties occurs in Weld County alone.

To estimate future emissions, the 2017 data reported by industry (used for the 2017 Milestone Year Emissions Inventory) was analyzed for several specific metrics. Assuming activities reported by industry in 2017 were representative of future modeling years (i.e., 2020), the following parameters were able to be determined:

- ratio of production from new versus existing facilities in 2017
- ratio of new facilities with and without tankless production
- emissions from new production
- emissions from existing production

For existing production, Colorado production and well completion data (found online through the COGCC database) were used to determine the decline factor. The decline in existing production between 2012 and 2015 (as a negative percentage of 83.6%) was used as a proxy for estimating the existing production decrease over the 3-year period from 2017 to 2020. The Division used the years 2012 and 2015 to determine the decline in production from all existing wells in 2012 to the production from the same wells in 2015. This approach was used to determine the decline in emissions from 2017 to 2020 from existing wells. The Division could have used more recent data (2015 and 2018), but that would have made the percentage decline higher, since horizontal wells decline in production faster than vertical wells. This approach may not consistently estimate the decline in emissions since the newer horizontal wells are better controlled than the older vertical wells, but using 2012 and 2015 are more conservative and probably better represent the emission decline.

Emissions from new production were determined from a summary (by source category) of a subset of sources with emissions less than one pound per barrel of oil of uncontrolled emissions. The emissions from these sources were grown by the ratio of the total of the new oil production to the oil production from these sources. The assumption is that new production will be well controlled to minimize leaks and avoid non-compliance with Colorado regulations. Total emissions in 2020 were determined by summing the emissions associated with new production and the emissions associated with existing production. Emissions of NO_X and VOC associated with condensate/oil tanks in the 2020 emissions inventory are provided in Table 3.

Table 3 - 2020 Oil and Gas Condensate/Oil Tank Emissions Inventory (tpd)

Description	VOC	NOx
Condensate/Oil Tanks	**50.2**	**0.6**

OIL AND GAS AREA SOURCES

Oil and gas area sources include a wide variety of categories such as engines, truck loading, pneumatic devices, fugitives, hydraulic fracturing completions, and blowdowns. The 2020 emission projections provided by nine of the highest producing operators in the DM/NFR, which were based on 2017 data and took into account well count and technology advancements as a result of state and federal rules.

Emissions from new production were determined from a summary (by source category) of a subset of sources with emissions less than one pound per barrel of oil of uncontrolled emissions. The emissions from these subsets were grown by the ratio of the total of the new oil production to the oil production from the subset of sources. The assumption is that new production will be well controlled to minimize leaks and avoid non-compliance with Colorado regulations.

Emissions from existing tanks, separators, loadout, and wellsite engines were assumed to decline by the decline in existing production (83.6%). Emissions from existing pneumatic devices, pneumatic pumps, heater/treaters (burners), well unloading, and fugitives were assumed to be unchanged from 2017. A breakout of emissions by categories is provided in Table 4.

Emissions from spuds (new wells, sometimes referred to as pre-production emissions, i.e., completion flaring, drilling, and hydraulic fracturing) were calculated from operator reported 2017 spud emissions to develop a per spud emission rate. Total 2017 emissions were calculated by multiplying the per spud emission rate by the number of spuds in 2017. These emissions were then multiplied by the ratio of the five year average number of spuds per year to the number of spuds in 2017 to get the 2020 total spud related emissions.

Table 4 – 2020 Oil and Gas Area Source Emissions Inventory (tpd)

Description	VOC	NOx
Area		
Drilling	0.7	7.4
Hydraulic fracturing	2.0	9.2
Fugitives	9.5	0.0
Heaters	0.2	3.3
Internal Combustion Engines	6.8	14.3
Pneumatic devices	19.4	0.0
Pneumatic pumps	0.1	0.0
Separator control	3.4	0.0
Truck loading of condensate liquid	3.9	0.0
Venting - blowdowns	4.2	0.0
Venting - initial completions and recompletions	2.5	0.1
Water tank losses	2.0	0.1
Oil and Gas Area Subtotal	**54.5**	**34.4**

POINT SOURCES

The 2020 emissions inventory for power plants, or electric generating units (EGUs), was developed based upon Colorado APEN reported data for 2018 and is specified in Table 5.

The Colorado Clean Air Clean Jobs Act of 2010 was instrumental in spurring NO_X emission reductions from the EGU sector. From 2011 to 2020, NO_X emissions are estimated to be cut by nearly three-quarters because of the mandates in this bill, which called for the closure of multiple units and the switching to natural gas for others. In the DM/NFR, the following plant conversions or shutdowns are factored into the 2020 inventory:

- Cherokee Unit 4 – switch from coal to natural gas
- Valmont Unit 5 – shutdown
- Zuni – shutdown

Table 5 – 2020 EGU NO_X Emissions (tpd)

Description	2020 Summertime Avg. NOx Emission Projections
Arapahoe Combustion Turbine Facility	0.1
Blue Spruce Energy Center	0.2
Cherokee	2.1
Fort St. Vrain	1.0
Frank Knutson Station	0.0
J M Shafer	0.8
Rocky Mountain Energy Center	0.3
Spindle Hill Energy Center	0.1
EGU Subtotal	**4.6**

Other point sources beyond EGUs include external combustion boilers, industrial processes, internal combustion sources, MACT source categories, petroleum/solvent evaporation, and waste disposal that are not associated with the oil and gas industry. The future year inventory is based upon 2018 APEN data. The inventory is provided below in Table 6.

Table 6 – 2020 Point Source (Non–Oil and Gas) Sources Emissions Inventory (tpd)

Description	VOC	NOx
External Combustion Boilers	0.5	5.7
Industrial Processes	7.7	4.9
Internal Combustion Engines	1.1	5.8
MACT Source Categories	0.0	0.0
Petroleum and Solvent Evaporation	11.9	0.4
Waste Disposal	3.4	0.2
Non-EGU Point Sources Subtotal	**25.0**	**21.8**

Evaluation of Platteville Monitoring Data

Trend Analysis of Platteville 6AM to 9AM VOC Precursor data

The APCD has been collecting VOC precursor data at a site in Platteville, Colorado since 2012. The sampling and analysis of the VOC precursors uses standard procedures and that the sampling

location is ideal to reflect overall oil and gas emissions in the ozone nonattainment area. VOC sampling follows the quality assurance and quality control guidelines set forth in the EPA's Technical Assistance Document for the National Air Toxics Trends Stations (NATTS) network. This includes periodic flow verifications and calibrations, instrument cleaning and certifications, as well as the use of duplicate samples to aid in the determination of possible sampling or data quality issues. CDPHE's laboratory uses EPA approved, and well vetted analytical methods for the determination of pollutant concentrations. The same methods are used at labs across the country for data comparability purposes. The Platteville data is presented in Table 7 with the percent change in concentration for every year since 2012. The emissions data is presented in Table 8 with the oil production in Weld County in the first row. The 2011 emissions are from the Denver Metro/North Front Range 2017 8-Hour Ozone State Implementation Plan. The 2012 and 2013 emissions are grown by oil production with point source emissions held constant. The 2014 emissions are from the NEI, and 2016 emissions are from the EPA modeling platform. The 2015 emissions are interpolated. The 2017 emissions are from the 2017 Base Year Inventory and 2020 emissions are from the Serious State Implementation Plan for the Denver Metro and North Front Range Ozone Nonattainment Area. The emissions for 2018 and 2019 are interpolated.

Table 7 – Platteville Monitoring Data

Ambient VOC 6-9 AM precursor Monitoring (ug/m3)								
	2012	2013	2014	2015	2016	2017	2018	2019
Platteville	443.41	575.35	423.28	318.96	270.46	305.51	178.48	163.21
Platteville %	0.0%	29.8%	-4.5%	-28.1%	-39.0%	-31.1%	-59.7%	-63.2%

Table 8 – COGCC Weld County Oil Production and DM/NFR Oil and Gas Emission Data

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Weld County Oil Production (barrels)	**26,891,298**	**36,797,346**	**53,829,299**	**81,692,980**	**109,654,069**	**105,417,921**	**121,909,989**	**150,723,271**	**168,736,164**	
Point Sources Subtotal (tpd)	14.8	14.8	14.8	14.8	14.5	14.14	12	14.3	14.3	14.3
Area Sources Subtotal (tpd)	48.9	67	67	38	38.3	38.29	44	47	51	54.5
Condensate Tanks Subtotal (tpd)	216	296	432	331	241.2	151.8	108	90	71	53.3
Total Emissions (tpd)	279.7	377	514	384	294	204	163	151	137	122
% change from 2012		0.0%	36.3%	1.7%	-22.1%	-45.9%	-56.7%	-60.0%	-63.8%	-67.6%
					yellow indicates interpolation					

Table 9 compares the percentage change in the annual average VOC concertation from 2012 to the percentage change in the Oil and Gas Nonattainment Inventory from 2012 through 2019.

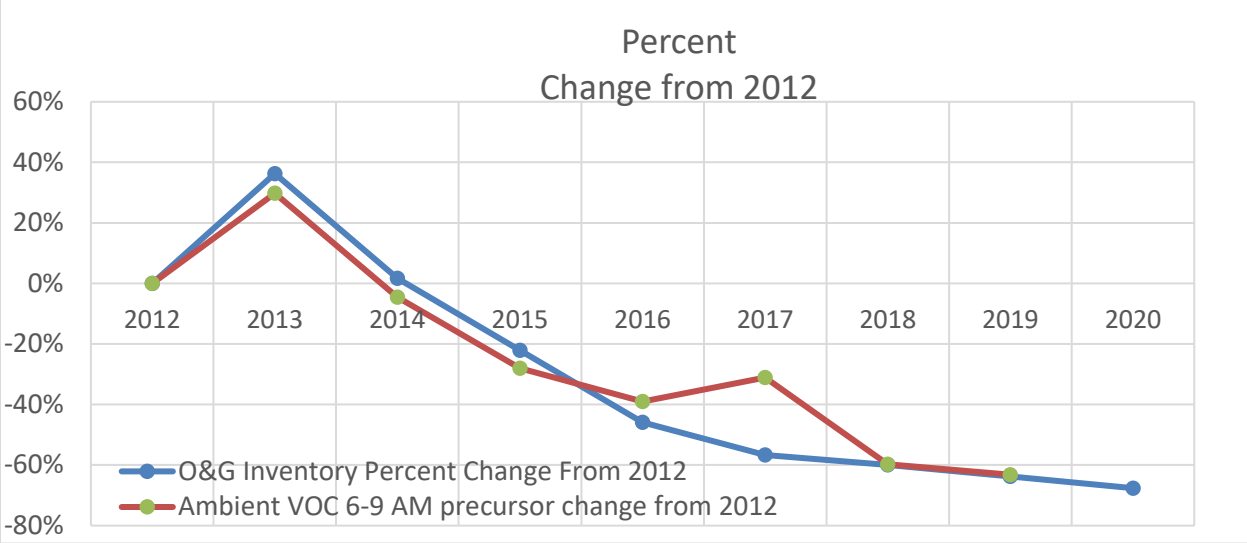
These data are good indicators of the primary VOC species emitted by local sources in these two areas since a) mixing is limited at those early hours and b) the sun angle and temperatures are low so little photochemical reaction is occurring. An analysis of this data set is a robust way to determine the accuracy of the VOC inventory.

Table 9 – Platteville Monitoring and Emissions Change

	2012	2013	2014	2015	2016	2017	2018	2019	2020
O&G Inventory Percent Change From 2012	0%	36.3%	1.7%	-22.1%	-45.9%	-56.7%	-60.0%	-63.8%	-67.6%
Ambient VOC 6-9 AM precursor change from 2012	0%	30%	-5%	-28%	-39%	-31%	-59.7%	-63.2%	

The O&G inventory percent change from 2012 is compared to the percent ambient VOC 6-9 AM precursor change from 2012 in Figure 1.

Figure 1 Percentage Change From 2012 of O&G Emissions an VOC Precursor Concentrations



As can be seen, the percentage reduction in emissions and precursor concentrations form 2012 track each other well. The exception is in 2017, when gathering line pressures were so high that a significant amount of gas production had to be flared and more flash gas was routed to storage tanks resulting in increased emissions from leaks. Therefore, the Division has greater confidence in the 2020 oil and gas VOC emission estimates, since the recent trend in actual precursor concentration data closely tracks with oil and gas emission estimates.