AUTOMOBILE INSPECTION AND READJUSTMENT PROGRAM

Department of Public Health and Environment

Performance Evaluation

Prepared For:
The Colorado Office of the State Auditor

Prepared By:
Trinity Consultants, Inc. and subcontractors:
dKC – De la Torre Klausmeier Consulting Company
Oak Leaf Environmental
P Heirigs Consulting LLC

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Trinity Consultants
1661 E Camelback Rd, Ste 290, Phoenix, AZ 85016 / P 602.274.2900 / F 480.222.4561 / **trinityconsultants.com**

November 22, 2022

Members of the Legislative Audit Committee:

This report contains the results of a performance evaluation of the Automobile Inspection and Readjustment Program (AIR Program). The evaluation was conducted pursuant to Section 42-4-316, C.R.S., which requires the State Auditor to conduct a performance evaluation of the AIR Program every 5 years. The Office of the State Auditor contracted with Trinity Consultants to conduct the evaluation. This report presents our findings, conclusions, and recommendations, and the responses of the Department of Public Health and Environment.

Sincerely,

TRINITY CONSULTANTS

Jim Lyons
Principal Consultant
Mobile Source and Fuels Business Line

HEADQUARTERS
12700 Park Central Dr, Ste 2100, Dallas, TX 75251 / P 800.229.6655 / P 972.661.8100 / F 972.385.9203

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REPORT HIGHLIGHTS

Key Conclusions

- The Automobile Inspection and Readjustment Program (AIR Program) decreases ozone precursor emissions by about 13%, or 10 tons per day, thereby providing a significant portion of the controllable ozone precursor emission reductions needed to assist with attainment of the National Ambient Air Quality Standards for ozone.

- The AIR Program reduces the emission of ozone precursors at a cost of about $16,750 per ton, indicating that the Program is a cost-effective pollution control measure.

- The AIR Program's emissions reduction benefits are primarily derived from vehicles that fail the Air Program inspection that are subsequently repaired and pass a retest, repaired in anticipation of the inspection, or retired from the vehicle fleet instead of being repaired.

Air Quality Background

- Ozone is a common pollutant that, in high concentrations, can cause health problems, especially in sensitive populations. Ozone is formed in the atmosphere through photochemical reactions involving ozone precursors (nitrogen oxides, hydrocarbons, and carbon monoxide). The largest source of ground-level ozone precursors comes from human activities, including fossil fuel combustion (e.g., motor vehicle emissions) and solvent usage. Naturally occurring sources of ozone precursor emissions include plants, soil, wildfires, and lightning.

- The federal government has established health-based National Ambient Air Quality Standards that define acceptable ozone concentrations. Areas that are designated as being in non-compliance with these standards have to satisfy specific requirements related to reducing emissions and come into compliance within a given amount of time. Failure to come into compliance results in re-designation, which imposes more stringent requirements to reduce emissions and establishes a new compliance deadline.

- At present, the U.S. Environmental Protection Agency (EPA) classifies the Denver Metro/Northern Front Range (DM/NFR) area as being in serious non-attainment of the 75 parts per billion (ppb) federal ozone standard established in 2008 and in marginal non-attainment of the 70 ppb federal ozone standard set in 2015. The applicable attainment deadlines of July 20, 2021, and August 3, 2021, for the 2008 and 2015 standards, respectively, were not met. Therefore, the DM/NFR area is in the process of being re-designated as being in "severe" and "moderate" non-attainment for the 2008 and 2015 standards and will face new deadlines of 2026, and 2023, respectively.

- Given that the DM/NFR area is in non-compliance with the two federal ozone air quality standards, state and local environmental planning agencies will have to implement a new air quality plan that sets forth new emission reduction measures. That planning process is underway.

Air Program Background

- The AIR Program is part of the State's overall strategy for ensuring compliance with federal air quality standards.

- The Colorado Department of Public Health and Environment (Department) is responsible for overseeing and administering the technical aspects of the AIR Program, including maintaining and analyzing emissions inspection data, reporting emissions data to the Colorado Air Quality Control Commission, and administering the licensing tests for emissions inspectors and mechanics.

- The AIR Program covers all of Broomfield, Boulder, Denver, Douglas, and Jefferson counties and parts of Adams, Arapahoe, Larimer, and Weld counties.

- Vehicles in the Program Area must pass an emissions test before they can be registered. The frequency and type of emissions test performed depends on the age of the vehicle.

- RapidScreen, which was implemented in 2004, allows qualifying vehicles to be registered based on readings from roadside monitors, thereby skipping the need for the traditional emissions test at a brick-and-mortar facility.

- In Calendar Year 2019[1], which was selected as the primary analysis year for this evaluation given that it was the last year of normal AIR program operation prior to the pandemic, approximately 933,000 vehicles received an emissions test through the AIR Program. In addition, about another 136,000 vehicles were registered based on the results of passing RapidScreen readings rather than a traditional emissions test.

- The total net cost of the AIR Program in Calendar Year 2019 was about $61.8 million. Costs borne by vehicle owners include the emissions test fee, an additional registration fee that funds the AIR Program, repair costs on vehicles that failed the emissions test, and vehicle owner inconvenience costs. These costs are netted against cost savings to vehicle owners from improved fuel economy as a result of vehicle repairs.

Recommendations

1. The Colorado Department of Public Health and Environment (Department) should consider the following modifications with respect to the Automobile Inspection and Readjustment Program (AIR Program):

   a. The AIR Program should impose pre-pandemic test requirements, including:
      i. Exempting the newest 7 model years from AIR Program test requirements.
      ii. Performing IM240 tests on 1982 and newer model-year vehicles up to 12 model years old.
      iii. Performing OBD tests on 8 to 11-year-old vehicles. If these vehicles do not meet OBD readiness requirements but pass all other OBD pass/fail criteria, they should receive IM240 tests.
   b. If confirmatory IM240 testing is discontinued for 8 to 11 year old vehicles that do not meet OBD readiness requirements, the Department should instead require these vehicles to meet the OBD readiness requirements.

   Response 1a: The Department agrees to implement Recommendation 1.a by March 31, 2023, as long as the impacts of the pandemic remain as they are as of November 2022 and no additional pandemic restrictions are imposed in 2022 or the beginning of 2023. While unlikely, any new pandemic restrictions or mandatory closures may delay implementing some elements of Recommendation 1.a.

[1] Data from 2020 and 2021 were also analzyed but the results for those are not considered representative of the actual effectiveness of the AIR Program under normal circumstances.

Response 1b: The Department agrees to implement Recommendation 1.b. This program modification was implemented to reduce vehicle emissions testability issues created by the pandemic. Forgoing any additional pandemic restrictions, recommendation 1.b. will be fully implemented by March 31, 2023.

2. The Colorado Department of Public Health and Environment (Department) should perform an analysis to determine if the reductions in emissions that would occur in the Denver Metro/North Front Range (DM/NFR) area from expansion of the AIR Program to El Paso County would be a cost-effective strategy to assist in compliance (and maintenance of compliance) with the 2008 and 2015 ozone standards compared to the other control measures that are being considered for implementation in the DM/NFR area. After completing the analysis, the Department should determine the appropriate next steps based on the results of the analysis.

   Response: The Department agrees to perform an analysis to determine if expanding the AIR Program into El Paso County would be a cost effective strategy for reducing pollutants in the Denver Metro and Northern Front Range areas. Recommendation 2 will be completed by January 31, 2024. This allows the Department the opportunity collect additional data in 2023 and use contemporary emissions monitor results from the 2023 ozone season. The Department will determine the appropriate next steps depending on the results of the analysis.

GLOSSARY OF TERMS AND ACRONYMS

Automobile Inspection and Readjustment Program – Colorado's vehicle inspection and maintenance program authorized by Section 42-4-301, et seq., C.R.S.

AIR Program Area or Program Area – The geographic area defining those vehicles that are subject to the AIR Program's requirements. The Program Area includes five complete counties (Boulder, Broomfield, Denver, Douglas, and Jefferson) and four partial counties (Adams, Arapahoe, Larimer, and Weld). The Program Area excludes the primarily rural areas of Larimer and Weld Counties and is a subset of the larger Denver Metro/Northern Front Range area used for air quality planning purposes.

Area Sources – Area sources are small-scale industrial, commercial, and residential sources that generate emissions, such as gas stations and dry cleaners.

Attainment Demonstration – Refers to an analytic component of the State Implementation Plan demonstrating that the specific emissions reductions included in the State Implementation Plan are sufficient to attain the National Ambient Air Quality Standards by the applicable deadline for the nonattainment area.

Carbon Monoxide – A criteria pollutant emitted from the combustion of fossil fuels.

Criteria Pollutant – The six common, ground-level air pollutants named in the federal Clean Air Act for which National Ambient Air Quality Standards have been established: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.

Colorado Air Quality Control Commission – Responsible for overseeing Colorado's air quality program pursuant to the Colorado Air Pollution Prevention and Control Act, including the development of the State Implementation Plan and the promulgation of state rules and regulations to implement the Automobile Inspection and Readjustment Program.

Colorado Department of Public Health and Environment – The state agency responsible for administering the technical aspects of the Automobile Inspection and Readjustment Program, including maintaining and analyzing emissions inspection data, reporting emissions data to the Colorado Air Quality Control Commission, and administering the licensing tests for emissions inspectors and mechanics.

Denver Metro/Northern Front Range Area – The area defined by the U.S. Environmental Protection Agency that is collectively subject to attaining the National Ambient Air Quality Standards. The DM/NFR area includes seven complete counties (Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson) and two partial counties (Larimer and Weld).

Diagnostic Trouble Code – Technicians use diagnostic trouble codes from the vehicle's on-board computer to diagnose specific problems with the vehicle, such as a worn-out catalytic converter.

Exceptional Event – An unusual or naturally occurring high-pollution event that can affect air quality (e.g., volcano eruption, wildfire, stratospheric ozone intrusion) but is not reasonably controllable or preventable by pollution control measures.

Flagged Days – "Flagged days" represent days on which high pollutant concentrations are observed that may potentially be exceptional events.

Hydrocarbons – Organic compounds consisting entirely of hydrogen and carbon. Hydrocarbons are the primary components of transportation fuels including gasoline, diesel, natural gas, and propane.

Inspection and Maintenance Program – A program that reduces emissions from on-road vehicles by requiring periodic inspections to ensure that vehicles are properly maintained and low-emitting.

IM240 Test – A dynamometer-based (rolling road) test developed for use in vehicle inspection and maintenance (I/M) programs that uses a prescribed driving cycle of accelerations and decelerations to evaluate tailpipe emissions of hydrocarbons, carbon monoxide, and nitrogen oxides. The IM240 test is a driving cycle that corresponds to 240 seconds of the Federal Test Procedure, which is used on all new vehicles to determine if they meet new vehicle certification standards.

Malfunction Indicator Lamp – The "check engine" or "service engine soon" light on the vehicle's instrument panel that illuminates when a potential emissions-related problem is detected.

Motor Vehicle Emission Simulator – A state-of-the-science modeling system developed by the U.S. Environmental Protection Agency used to estimate ozone precursor emissions from on-road motor vehicles.

National Ambient Air Quality Standards – Established by the U.S. Environmental Protection Agency under the federal Clean Air Act to specify maximum allowable levels for criteria pollutants necessary to protect public health.

Nitrogen Oxides – Collectively refers to the two forms of gaseous oxides of nitrogen (nitric oxide and nitrogen dioxide) that are key to pollution formation. NO_X emissions are produced from the reaction between nitrogen and oxygen during the combustion of fossil fuels, such as those used in electric power generation and motor vehicles. NO_X emissions also occur naturally from lightning strikes and soil chemistry.

On-Board Diagnostic – Most model-year 1996 and newer light-duty vehicles sold in the United States are equipped with OBD systems that monitor virtually all components that make up the vehicle's engine management and emissions control systems. OBD systems can detect malfunctions or deterioration of components often well before the motorist becomes aware of any performance problems.

Ozone Design Value – Represents the fourth-highest daily maximum 8-hour ozone concentration over the course of a year from within a geographically designated attainment area and then averaged across three consecutive years.

Parts Per Billion – The number of units of volume of a contaminant per billion units of total volume.

Point Sources – Point sources are large, stationary sources of air pollutant emissions such as power generating stations.

Regional Air Quality Council – Serves as the lead air quality planning agency for the Denver Metro/Northern Front Range nonattainment area, including developing plans and proposing amendments to the State Implementation Plan to ensure compliance with the National Ambient Air Quality Standards.

Remote Sensing Device – A specially designed monitor placed at a fixed location or in a mobile unit that uses low-intensity infrared and ultraviolet beams to measure vehicle emissions under normal everyday driving conditions without the need for the vehicle to slow down or stop.

Relative Response Factors – Relative response factors related to the expected change in ambient ozone concentrations at a particular air quality monitor that would result from a given change in ozone precursor emissions.

State Implementation Plan – A state-prepared plan for complying with the federal Clean Air Act, subject to review and approval by the U.S. Environmental Protection Agency.

Two-Speed Idle Test – A non-driving test that monitors an idling vehicle's tailpipe emissions at two distinct engine speeds (e.g., revolutions per minute).

U.S. Environmental Protection Agency – The federal agency charged with administering the federal Clean Air Act.

OVERVIEW OF THE AUTOMOBILE INSPECTION AND READJUSTMENT PROGRAM

The federal Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS standards or air quality standards), which specify the maximum allowable ambient concentrations of six common pollutants in outdoor air to protect public health. The six pollutants, also called "criteria" pollutants, are carbon monoxide, lead, ground-level ozone, nitrogen dioxide, particulate matter, and sulfur dioxide. EPA periodically reviews and revises the standards associated with each criteria pollutant. EPA refers to a geographic area that fails to comply with the standards as being in "nonattainment." As of November 2022, the Denver Metro/Northern Front Range (DM/NFR) area is in attainment of the standards for all criteria pollutants except those that apply to ground-level ozone. The fact that ozone levels in the DM/NFR area exceed the ozone air quality standard has led the EPA to designate the area as being in non-attainment with the ozone standards.

Federal law requires states to implement pollution-reduction strategies, such as vehicle inspection and maintenance programs, in ozone nonattainment areas [see 42 USC 7511]. Colorado's inspection and maintenance program, known as the Automobile Inspection and Readjustment Program (AIR Program or Program), has existed since 1981 and is part of the State's overall strategy for ensuring compliance with the ozone air quality standards. Mobile source emissions, which include emissions from on-road motor vehicles, constitute one of the larger categories of controllable emissions that contribute to ground-level ozone concentrations. The AIR Program specifically targets excess emissions from on-road gasoline vehicles. Emissions from on-road diesel vehicles are addressed through the Colorado Clean Diesel Program[2], the performance of which was not evaluated as part of this audit.

Ozone Air Quality Standards

Ozone is the molecule formed from three oxygen atoms and is a powerful oxidant. Ozone is the common pollutant in smog and, in ground-level concentrations that exceed the ozone air quality standards, causes distress to humans, including chest pain, difficulty breathing, coughing, respiratory pathway irritation, diminished lung capacity, lung tissue damage, and premature death. Individuals who are most at risk from ozone pollution include those who are active outdoors, sensitive populations (e.g., children and older adults), and those with respiratory ailments such as asthma, emphysema, and chronic bronchitis. Children are at greatest risk from exposure to ozone because their lungs are still developing and they are more likely to be active outdoors when ozone levels are high, which increases their exposure. Children are also more likely than adults to have asthma.

Ground-level ozone is not a directly emitted pollutant. Rather, ozone is formed in the atmosphere by chemical reactions between gaseous oxides of nitrogen (NO_X) and volatile organic compounds in the presence of sunlight. Most volatile organic compound emissions from motor vehicles are in the form of hydrocarbons, which are the primary components of gasoline and other fuels.

Hydrocarbon and NO_X emissions are termed "ozone precursors" because they contribute to ground-level ozone formation. Carbon monoxide is also often included as an ozone precursor because it can contribute to ground-level ozone formation, although to a lesser extent than hydrocarbons or NO_X. Because increased sunlight and higher temperatures speed up the ozone- forming reactions, ground-level ozone pollution is generally a summer-season pollution phenomenon. The largest source of ground-level ozone precursors

[2] https://cdphe.colorado.gov/colorado-clean-diesel-program

comes from human activities, including fossil fuel combustion (e.g., motor vehicle emissions) and solvent usage. However, there are also naturally occurring sources of ozone precursor emissions including plants, soil, wildfires, and lightning.

The EPA qualifies ground-level ozone as "bad ozone" to differentiate it from the ozone occurring in the Earth's upper atmosphere (i.e., the stratosphere). The EPA qualifies stratospheric ozone as "good ozone" because it forms naturally and yields environmental benefits by absorbing most ultraviolet radiation hitting the Earth, thereby providing a protective layer for plants and animals. However, there are instances under certain meteorological conditions when air from the upper atmosphere folds into the lower atmosphere and can result in elevated ground-level ozone readings.

The EPA permits nonattainment areas to exclude "exceptional events" from ozone attainment calculations. Exceptional events are unusual or naturally occurring high-pollution events (e.g., volcano eruptions, wildfires, stratospheric ozone intrusions) that can affect air quality but are not reasonably controllable or preventable by pollution control measures. Wildfires and stratospheric ozone intrusions are exceptional events that are likely to affect air quality in the DM/NFR area. It is also important to note that "exceptional" does not mean infrequent; exceptional events can be common occurrences in certain areas. EPA approval must be received before a state can exclude exceptional events from its ozone attainment calculations.

Compliance with Ozone Standards

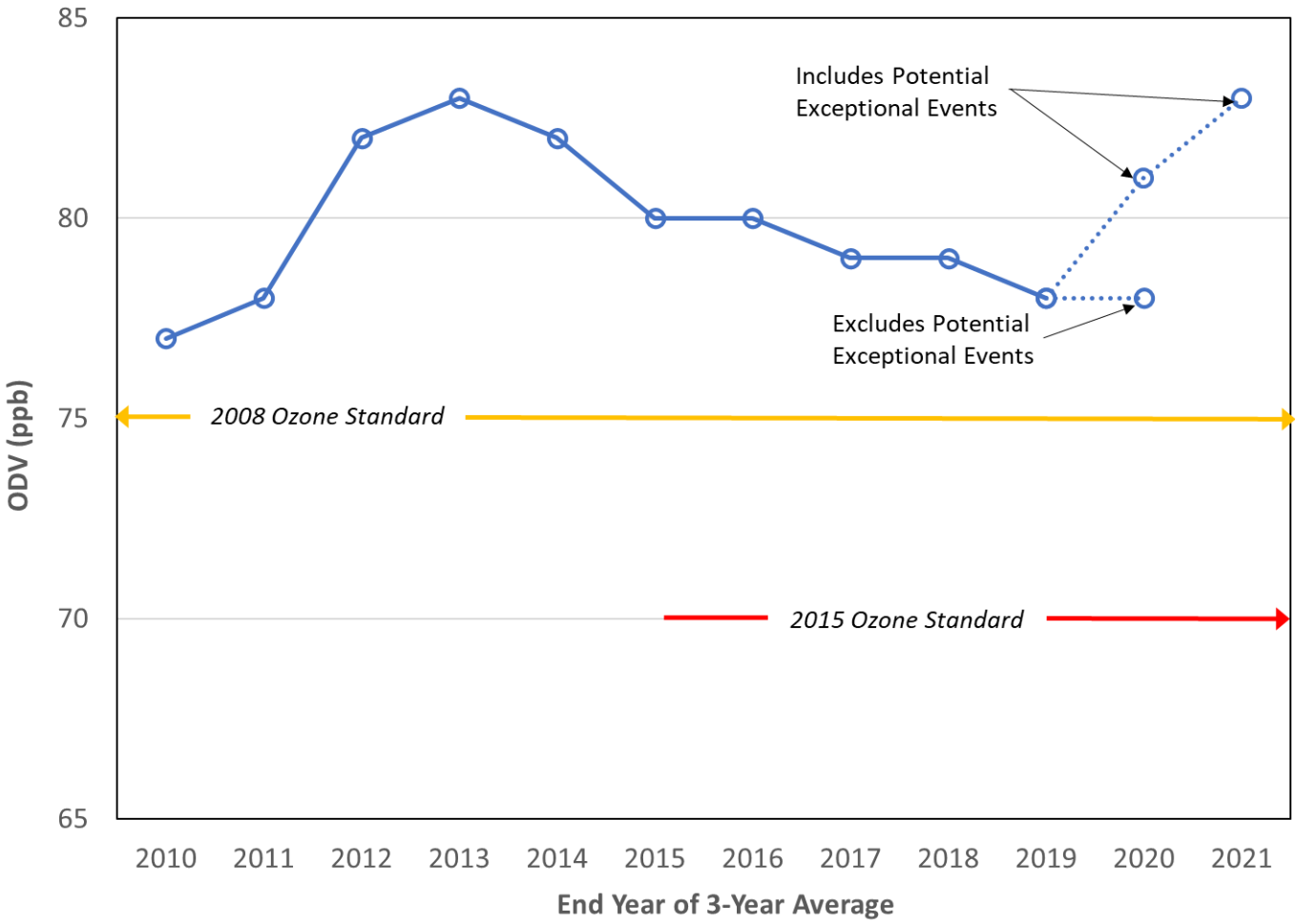
The EPA first established an air quality standard for ozone in 1971. There have been four revisions to the ozone air quality standards since that time, typically referenced by the year the revised standards were established. At present, there are two ozone air quality standards that are in force, (one promulgated in 2008 and the other promulgated in 2015), that are relevant to Colorado's current and future ozone planning and pollution-control efforts for the DM/NFR area. The maximum allowable eight-hour ozone concentrations under the 2015 and 2008 standards are 70 and 75 ppb, respectively. Although the 2015 standard is more stringent, the 2008 ozone standard and associated requirements remain in place and are legally enforceable until such time that the EPA revokes that standard.

Upon establishing new or revised standards, the EPA goes through an implementation process, which includes the identification and designation of specific areas that are not in compliance (nonattainment areas) with the ozone air quality standard based on air quality monitoring data. This process involves establishing the geographic boundary of a nonattainment area, assigning a classification that categorizes the severity of the pollution problem (i.e., marginal, moderate, serious, severe, or extreme), and setting an attainment deadline based on the classification assigned. Nonattainment areas that fail to comply with the ozone air quality standards by the specified deadline are redesignated to higher level classifications (e.g., from moderate to serious or serious to severe), which in turn, imposes more stringent requirements for reducing emissions as well as a new attainment deadline.

The EPA's classification of the DM/NFR area's compliance status with the ozone air quality standards is based on data from air quality monitors located throughout the area. These monitors record hourly ambient ozone levels from which a daily maximum 8-hour concentration is determined. At the end of each calendar year, the fourth-highest daily maximum 8-hour ozone concentration is identified for each monitor and then averaged with the monitor's fourth-highest daily maximum ozone reading from the previous two years. The resulting three-year average is known as the monitor's Ozone Design Value (ODV). If any individual monitor's ODV exceeds the maximum ozone standards, the entire area is considered to be in nonattainment. The ODV assigned to the nonattainment area is the maximum ODV of the individual monitors meeting certain data coverage criteria (i.e., three years of continuous measurement, 75% of valid hourly measurements per quarter).

Exhibit 1 presents the history of ODVs for the DM/NFR area relative to the 2008 and 2015 ozone standards since 2010. As shown, the DM/NFR area ODVs fluctuate fairly widely from year-to-year and each annual value is affected by a number of factors including meteorology, background ozone levels, as well as the emissions occurring in and around the DM/NFR area. The observed ODV trend from 2013 to 2019 is improving towards attainment. The 2021 ozone season measurements remain draft and are still under review. The final 2021 ODV may represent a setback towards achieving attainment.

Exhibit 1. Denver Metro / Northern Front Range 8-Hr Ozone Design Values (ODVs)



Source: analysis of processed ambient ozone measurement data provided by the Colorado Department of Public Health and Environment.

Currently, the EPA classifies the DM/NFR area as being in noncompliance with both the 2008 and 2015 ozone standards, as shown in Exhibit 1, where the most recent ODVs continue to exceed both standard levels. The designation with respect to the 2008 standard is currently "serious" but is expected to be revised by EPA to "severe". Under the "severe" designation, the DM/NFR area must come into compliance with the standard by the end of the 2026 ozone season. The DM/NFR area designation with respect to the 2015 ozone standard is currently "marginal," but based on current air quality data, EPA is expected to redesignate the area first to "moderate" and then to "serious". The attainment deadline under the serious designation for the 2015 ozone standard would again be the end of the 2026 ozone season. In addition to establishing

compliance deadlines, the higher non-attainment classification level is accompanied by stricter emission control requirements.

State Implementation Plan/Emission Control Strategies

The State is in the process of finalizing the draft 2022 State Implementation Plan (SIP), which is the air quality plan that must demonstrate how the DM/NFR area will come into attainment with both the 2008 and the 2015 ozone air quality standards. The draft SIP, which will be, after finalization and approval by EPA, a federally enforceable plan lists the emission control measures that have and will be implemented in order to reach attainment of the ozone air quality standards, including the current AIR program. This means that any changes that would be expected to reduce the benefits of the current AIR program would have to be offset by the achievement of additional emission reductions from other measures.

Colorado's AIR Program

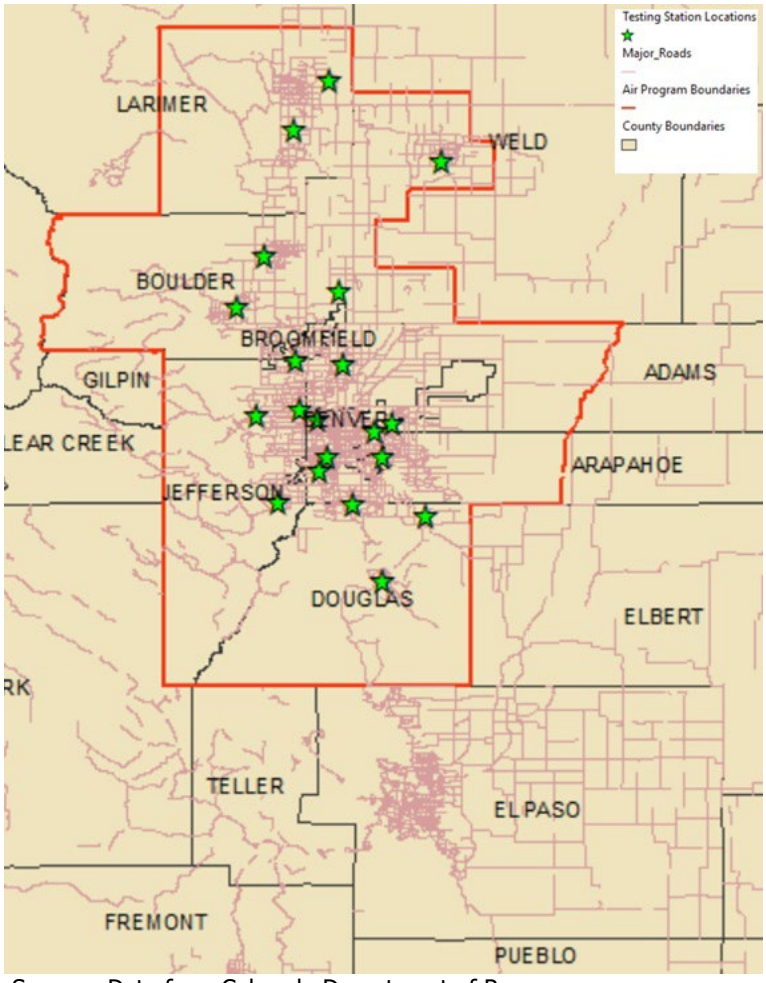
The AIR Program covers all of Broomfield, Boulder, Denver, Douglas, and Jefferson counties and parts of Adams, Arapahoe, Larimer, and Weld counties (Program Area). A map of the Program Area is shown in Exhibit 2. The AIR Program requires that gasoline-powered cars and trucks pass an emissions test before they can be registered in the Program Area. Diesel-powered vehicles are tested through a separate diesel-emissions program. Vehicles that fail the emissions test or inspection component must be repaired and undergo a successful retest before being registered. Program enforcement occurs through the denial of vehicle registrations by local county clerks' offices.

The frequency of emissions testing depends on the age of the vehicle, as follows:

- The seven most recent model years are exempt from emissions testing requirements.
- Model-year 1982 and newer vehicles are subject to biennial emissions testing after the seven-model-year exemption period.
- Model-year 1981 and older vehicles are subject to annual emissions testing.

With a few exceptions, vehicles must also undergo an emissions test upon a change in ownership or upon initial registration in the Program Area.

Exhibit 2. AIR Program Area



Source: Data from Colorado Department of Revenue

Emissions Testing Procedures

Vehicles registered in the Program Area receive one of the following three emissions tests, depending upon the age of the vehicle:

- IM240 Test – 1982 and newer vehicles that are more than 11 years old undergo a dynamometer test, called an IM240 test, which uses a treadmill-like device to simulate a driving cycle typical of urban driving. The IM240 test evaluates emissions of hydrocarbons, carbon monoxide, and NO_X. Colorado has established hydrocarbon, carbon monoxide, and NO_X "cut points" for the IM240 test that are much higher than the federal certification standards for new vehicles. Vehicles fail the IM240 test only when they exceed the cut points. The higher cut points help ensure that the IM240 test only fails those vehicles that clearly emit these pollutants at substantially higher rates than the federal standards for new vehicles.

- Two-Speed Idle (TSI) Test – Model-year 1981 and older vehicles and heavy-duty vehicles weighing more than 8,500 pounds receive a TSI test for emissions. This test measures emissions when the vehicle is at idle and at raised idle (i.e., the gas pedal is depressed to increase the engine speed to 2,500 revolutions

per minute). The TSI test measures only hydrocarbon and carbon monoxide emissions and does not evaluate NO_X emissions. Colorado's TSI test uses cut points that were developed by the EPA.

- On-Board Diagnostic (OBD) Test – Effective January 1, 2015, all OBD equipped vehicles that are 8 to 11 years old undergo an OBD inspection. All 1996 and newer vehicles less than 8,501 pounds are equipped with OBD systems. OBD systems have up to 11 major diagnostic monitors, which run periodic tests on specific systems and components (e.g., catalytic converter, oxygen sensors) to ensure that they are performing properly. If the OBD system detects a problem, the malfunction indicator lamp (MIL) is illuminated. The MIL is the dashboard "check engine" or "service engine soon" light. With an OBD test, the emissions test system is plugged into the vehicle's OBD connector and information on the status of the OBD system is downloaded. Vehicles will fail the OBD test if the MIL is commanded "on" during the test.

As of January 1, 2015, Colorado stopped performing IM240 or TSI tests on 8-to-11-year-old vehicles unless the vehicle has any of the following conditions:

- The OBD system is "not ready" to be tested. If the vehicle is not driven long enough or far enough for a monitor to complete its full diagnostic drive cycle, the monitor is "not ready" to relay OBD information. Some diagnostic monitors run whenever the vehicle is operating, whereas other monitors run only periodically. Depending on the vehicle, a full diagnostic drive cycle can include a combination of highway driving, stop-and-go driving, idling, and even an overnight cool-down period.

- The OBD systems' diagnostic link connector (connection port) is damaged or missing.

- The vehicle's OBD system could not communicate with the emissions inspection system.

Vehicles are also subjected to a gas cap test to ensure the cap is able to hold pressure and a visible smoke test to ensure there is no visible smoke being emitted from the tailpipe. Further, model year 1975 through 1995 vehicles receive an anti-tampering inspection to ensure that all of a vehicle's key emissions devices (i.e., catalytic converter, air injection, and oxygen sensor) are present and have not been subject to tampering. The IM240 test, TSI test, OBD test, gas cap test, visible smoke test, and anti-tampering inspection collectively represent the traditional emissions test currently conducted at the AIR Program's emissions testing facilities. As of November 2022, the price for an emissions test is $25 for 1982 and newer vehicles and $15-25 for 1981 and older vehicles. In Calendar Year 2019, approximately 933,000 vehicles received traditional emissions tests through the AIR Program. This value includes retests for initially failing vehicles as well as tests on vehicles that were later retired or operated without re-registration.

RapidScreen

RapidScreen, which was implemented in 2004, serves as an alternative to the traditional emissions test. RapidScreen uses remote sensing devices to measure emissions as vehicles drive by roadside monitors. Specifically, the monitors capture a vehicle's hydrocarbon, carbon monoxide, and NO_X emissions levels and license plate information. Vehicles that are observed to have low emissions based on the remote sensing device readings are given the opportunity to skip the traditional emissions test performed at a brick-and-mortar emissions testing facility. Two criteria are used to determine whether a vehicle passes emissions testing requirements based on RapidScreen results:

- 2-RSD – A vehicle qualifies for RapidScreen if it passes its two most recent consecutive readings within a 12-month window in the 14 months prior to registration renewal.

- Hybrid – A vehicle qualifies for RapidScreen if it has one passing reading within a 12-month window in the 14 months prior to registration renewal and the vehicle model has historically had an exhaust failure rate less than or equal to 4%.

If a vehicle qualifies for RapidScreen, the vehicle owner is notified that he or she can forego the traditional emissions test and use the RapidScreen results to register the vehicle, thereby saving a trip to one of the brick-and-mortar emissions testing facilities. If the owner chooses to use the RapidScreen results to register his or her vehicle, he or she must pay the $25 emissions testing fee along with the registration renewal fee. Vehicles that pass emissions testing requirements based on RapidScreen results do not receive a gas cap test, visible smoke test, or an anti- tampering inspection. In Calendar Year 2019, owners registered approximately 136,000 vehicles via RapidScreen, which is about 16% of the 865,000 vehicles in the Program Area that were registered after passing an inspection at an AIR Program facility.

Testing Locations

The nine-county Program Area is served by 18 emissions testing facilities with 97 inspection lanes. There are also two independent test-only stations for model year 1981 and older vehicles and 19 fleet stations that allow licensed vehicle fleet owners to self-inspect their own qualifying commercial and governmental fleet vehicles. The RapidScreen program consists of an average of 14 roadside remote sensing devices per day that are rotated among 124 locations throughout the Program Area, with the primary locations being highway entrance ramps. The State contracts with Envirotest Systems Corporation to operate and maintain all of the emissions testing facilities and the remote sensing devices.

Changes in the AIR Program Since 2017

Subsequent to the Office of the State Auditor's last evaluation of the AIR Program in 2017, there were no major changes made to the Program's requirements until the adoption of amendments to Regulation 11 (which establishes the AIR Program) in 2021. These amendments included lowering the exhaust emission standards that apply to vehicles subject to IM240 testing. This is expected to increase the number of vehicles that fail the initial inspection and require repair under the AIR Program and to result in additional emission reductions attributable to the program. The effective date of these amendments was January 2022; therefore, they are not addressed in the analysis presented in this report.

AIR Program Administration

Two departments share responsibility for the administration of the AIR Program. The Colorado Department of Public Health and Environment (Department) is responsible for the technical aspects of the AIR Program, including the following: 1) performing statewide air monitoring, pollutant analysis, and air emission modeling; 2) researching the causes and effects of pollution from mobile vehicles and implementing strategies aimed at reducing emissions from mobile sources; 3) permitting, monitoring, and inspecting factories, power plants, and other commercial air pollutant emitters for compliance with air pollutant emissions standards; 4) reporting emissions data to the Colorado Air Quality Control Commission; and 5) administering the licensing tests for emissions inspectors and mechanics. For Fiscal Year 2021, the Department was appropriated about $3.6 million in cash funds from vehicle registration fees for the AIR Program, which funded approximately 27 full-time-equivalent positions at the Department.

The Department of Revenue is responsible for most of the oversight of the emissions testing facilities. These duties include issuing all inspection station, facility, mechanic, and inspector licenses and performing announced and unannounced evaluations of emissions testing facilities and remote sensing devices to ensure compliance with statutes, rules, and regulations, and managing the Envirotest Systems Corporation

contract for emissions testing in the State. For Fiscal Year 2021, the Department of Revenue was appropriated about $1.2 million in cash funds from vehicle registration fees for the AIR Program, which funded 15 full-time equivalent positions for activities related to the AIR Program.

In addition to these two departments, the Colorado Air Quality Control Commission (Commission) and the Regional Air Quality Council (Council) have responsibilities for improving air quality in Colorado.

- The Commission is responsible for overseeing Colorado's air quality program pursuant to the Colorado Air Pollution Prevention and Control Act [Title 25, Article 7 of the Colorado Revised Statutes]. Among the Commission's duties are the development of the State Implementation Plan (SIP) and the promulgation of state rules and regulations to implement the AIR Program. The Commission's nine members are appointed by the Governor and confirmed by the Senate.

- The Council works closely with the Commission and serves as the lead air quality planning agency for the DM/NFR nonattainment area, including developing plans and proposing amendments to the SIP to ensure compliance with national air quality standards. Established by an Executive Order of the Governor, the Council's membership consists of no fewer than 24 members appointed by the Governor and includes state and local government leaders and representatives of the business community, environmental groups, and the general public.

Evaluation Purpose, Scope, and Methodology

Section 42-4-316, C.R.S., requires the State Auditor to conduct a performance evaluation of the AIR Program, as overseen by the Department of Public Health and Environment, every five years. The OSA contracted with the Trinity Consultants (Trinity), and its' subcontractors: dKC – De la Torre Klausmeier Consulting Company, Oak Leaf Environmental, and P Heirigs Consulting LLC to perform this evaluation. The members of the Project Team have extensive experience as they have been involved with performing similar evaluations, in both prime and subcontractor roles, including the 1997, 1998, 1999, 2006, 2009, 2012, and 2017 Colorado AIR Program evaluations. Work on this evaluation was completed from March through November 2022.

In accordance with statute, the overall purpose of this evaluation was to determine the ongoing public need for the AIR Program by taking into consideration the following factors:

1. The demonstrable effect of the AIR Program on ambient air quality.

2. The cost to the public of the AIR Program.

3. The cost-effectiveness of the AIR Program relative to other air pollution control programs.

4. The need, if any, for further reduction of air pollution caused by mobile sources to attain or maintain compliance with national ambient air quality standards.

5. The AIR Program's ability to assure compliance with legally required warranties covering air pollution control equipment.

To accomplish the evaluation's objectives, we performed the following work:

- Reviewed federal and state statutes and regulations related to the federal Clean Air Act, the National Air Quality Control Standards, and Colorado's AIR Program.

- Reviewed studies, reports, technical support documents, and other literature relevant to pollution control programs, air quality modeling, ambient data analysis and emission inventory development, control program cost-effectiveness, local pollutant transport and air circulation patterns, and implementation of the 2008 and 2015 ozone air quality standards.

- Obtained and analyzed data from the following sources:

  - Traditional emissions tests performed at emissions testing facilities during Calendar Years 2017 through 2021.

  - RapidScreen remote sensing device readings during Calendar Years 2017 through 2021.

  - AIR Program cost data for 2019 – the last full year the program was in normal operation prior to the COVID-19 Pandemic.

  - Air quality monitoring data for the DM/NFR area during Calendar Years 2015 through 2021.

- Reviewed information being developed by the Council for ozone planning purposes and, in particular, the 2023 attainment demonstration, including estimated ozone relative response factors and ozone source apportionment documentation and electronic modeling tools.

The analyses used in this evaluation of the AIR Program are complex. We communicated with AIR Program staff throughout the evaluation to ensure common understanding and agreement of the underlying datasets, time frames, assumptions, and methodologies we used for our analyses and the basis for our conclusions. However, due to differences in the underlying datasets, time frames, assumptions, and methodologies used, the specific figures reported in this report may differ slightly from those reported by the AIR Program. These differences are expected and, except where specifically noted, should not be construed as indicative of deficiencies in the AIR Program's analyses.

Scope Exclusions

The scope of this evaluation did not include:

- The activities of the Department of Revenue or its contractor, Envirotest Systems Corporation. The evaluation focused only on the Department of Public Health and Environment.

- The activities of the Air Quality Control Commission or the Regional Air Quality Council.

- Quantifying the specific health benefits resulting from the AIR Program's ozone reduction control measures. Although studies have associated excessive levels of ozone with various negative effects on public health, estimating the health benefits of reduced ozone levels was beyond the scope of this evaluation.

- Comparative analysis with the results of prior evaluations and audits due to changes in emissions testing technology, which affect the comparability of the data over time. This evaluation primarily examined Program data from Calendar Years 2017 to 2021, except where specifically noted in the report.

EFFECTS OF THE AIR PROGRAM ON AIR QUALITY

In accordance with state statute [Section 42-4-316, C.R.S.], the overall purpose of this evaluation was to determine the ongoing public need for the Automobile Inspection and Readjustment Program (AIR Program or Program). Overall, our analyses show that the AIR Program decreases emissions of ozone precursors in the Denver Metro/Northern Front Range (DM/NFR) area, thereby contributing to Colorado's efforts to attain compliance with the National Ambient Air Quality Standards (standards) for ozone. In particular, on days with conditions conducive to high ozone levels, the AIR Program provides a significant portion of the controllable emission reductions needed for compliance.

This chapter discusses the results of our analyses of the AIR Program's effect on ozone precursor emissions and ambient air quality, the cost to the public of the AIR Program, the Program's cost-effectiveness, and recommendations to the Department of Public Health and Environment (Department) for possible AIR Program improvements.

Ozone Precursor Emission Reductions

The goal of the AIR Program is to identify high-emitting vehicles and require that they be repaired to meet emission standards. Therefore, the AIR Program's benefits are primarily derived from the approximately 9% of vehicles that fail the emissions test and are (1) subsequently repaired and pass a retest or (2) removed from the vehicle fleet. Vehicle inspection and maintenance programs also have positive effects on emissions because they encourage proper vehicle maintenance before testing and deter vehicle owners from tampering with their vehicles' emissions control systems.

As described in the following sections, we relied on three different approaches to assess the AIR Program's impact on emissions reductions—statistical modeling, analysis of IM240 test data, and analysis of remote sensing device readings. Although the datasets and related methodologies are different from one another, they each provide independent and corroborating estimates of emissions reductions achieved through the AIR Program.

Emission Reductions Based on Emissions Inventory Modeling

The latest version of the Motor Vehicle Emission Simulator (MOVES3) developed by the U.S. Environmental Protection Agency (EPA) was used to estimate the AIR Program's effect on reducing levels of ozone precursor emissions—hydrocarbons, nitrogen oxides (NO_X), and carbon monoxide. MOVES3 is a state-of-the-science modeling system designed specifically for use in estimating emissions of ozone precursor and other pollutants from on-road motor vehicles. MOVES3 incorporates a broad array of modeling parameters, including vehicle miles traveled, type of driving (e.g., high-speed freeway driving versus stop-and-go in-town driving), vehicle fleet characteristics, fuel quality, the presence of a vehicle inspection and maintenance program, and ambient conditions (e.g., temperature, humidity, and altitude). MOVES3 is the model required by federal regulations to use for estimating on-road vehicle emissions for all areas of the United States except California.

We used MOVES3 and 2019 data from Colorado's AIR Program to calculate reductions in ozone precursor emissions both in terms of a percent reduction and a tons-per-day reduction. We used 2019 data because it reflects the latest program data that were not impacted by the effects of the COVID-19 Pandemic, including those resulting from temporary changes that the Department made to the AIR Program in response to the Pandemic. Exhibit 3 shows that, overall, we estimate that the AIR Program reduces ozone precursor

emissions from on-road sources (e.g., passenger cars and light-duty trucks) by about 13%, or 10 tons per day.

Exhibit 3. Estimated AIR Program Ozone Precursor Emissions Reductions from On-Road Sources in 2019 Based on MOVES3 Modeling

	Ozone Precursors			
	Hydrocarbons (HC) Exhaust [1]	Hydrocarbons (HC) Fuel Evaporation [1]	Carbon Monoxide (CO)	Nitrogen Oxides (NO_X)
Percent Reduction	21.6%	5.1%	16.6%	14.0%
Tons Per Day Reduction	3.03	1.04	88.67	4.57
All Ozone Precursors				
Percent Reduction	13.3%			
Tons Per Day Reduction [2]	10.11			

Source: MOVES3 model using input data provided by the Colorado Department of Public Health and Environment.

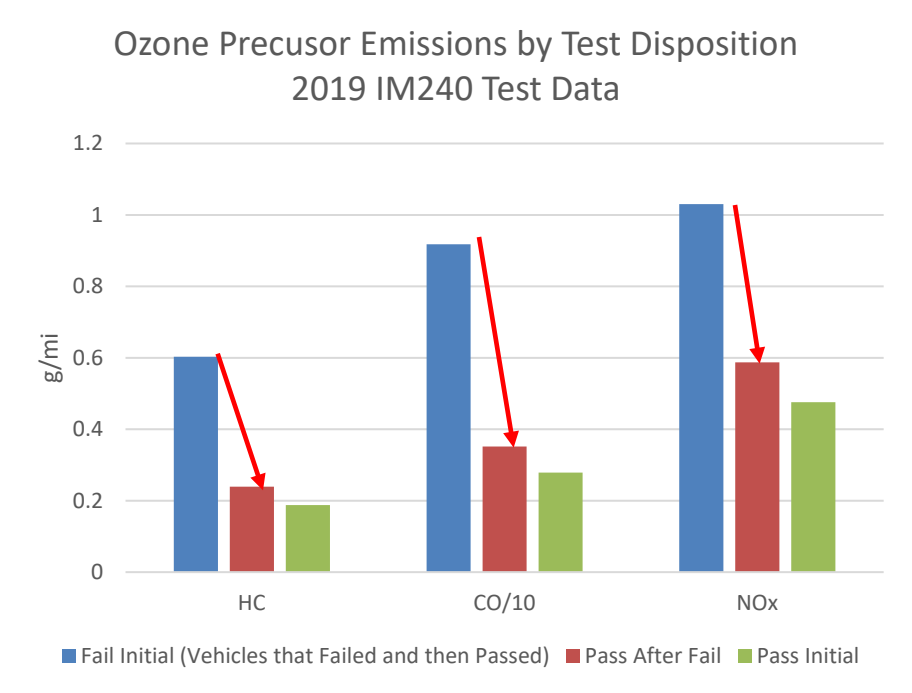
[1] Hydrocarbons are broken down into exhaust and evaporative emissions because gasoline is a volatile fuel and, as a result, about half of the hydrocarbon emissions are due to fuel evaporation.
[2] Tons-per-day reduction amounts estimated for the individual ozone precursors are combined using the following formula: $HC+NO_X+CO/60$. This formula discounts the tons-per-day reduction amounts for carbon monoxide when combining with the other ozone precursors to recognize that carbon monoxide has a smaller impact on ozone levels than hydrocarbons and NO_X.

Emission Reductions Based on IM240 Test Data

The AIR Program uses the IM240 test to measure ozone precursor emissions from vehicles that are more than 11 years old. We calculated the percent change in fleet emissions that resulted from the approximately 41,000 vehicles that failed their initial IM240 test and were subsequently repaired and passed a retest in the 2019 inspection cycle. Overall, our analysis showed that hydrocarbon, carbon monoxide, and NO_X emissions from the fleet of vehicles receiving IM240 tests were reduced by 14.4%, 14.7%, and 6.5%, respectively, from these repairs. These reductions are for one inspection cycle; as discussed later in this section, greater reductions are calculated for multiple inspection cycles.

Exhibit 4 shows the results for vehicles failing IM240 tests in terms of grams of precursor emissions emitted per mile. It should be noted that the HC results reflect only exhaust emissions as evaporative emissions are not measured as part of the IM240 test. In addition, the CO values presented in Exhibit 4 have been divided by 10 to put them on the same scale as the HC and NO_X results. The difference between emissions measurements for vehicles that failed the initial test and passed the retest, which are denoted by the red arrows in Exhibit 4, demonstrates that vehicle repairs were effective at reducing emissions. In fact, the data show that the after-repair passing retest values are close to the average values for those vehicles that passed their initial test and did not require repairs.

Exhibit 4. Ozone Precursor Emissions by Test Disposition, 2019 IM240 Test Data



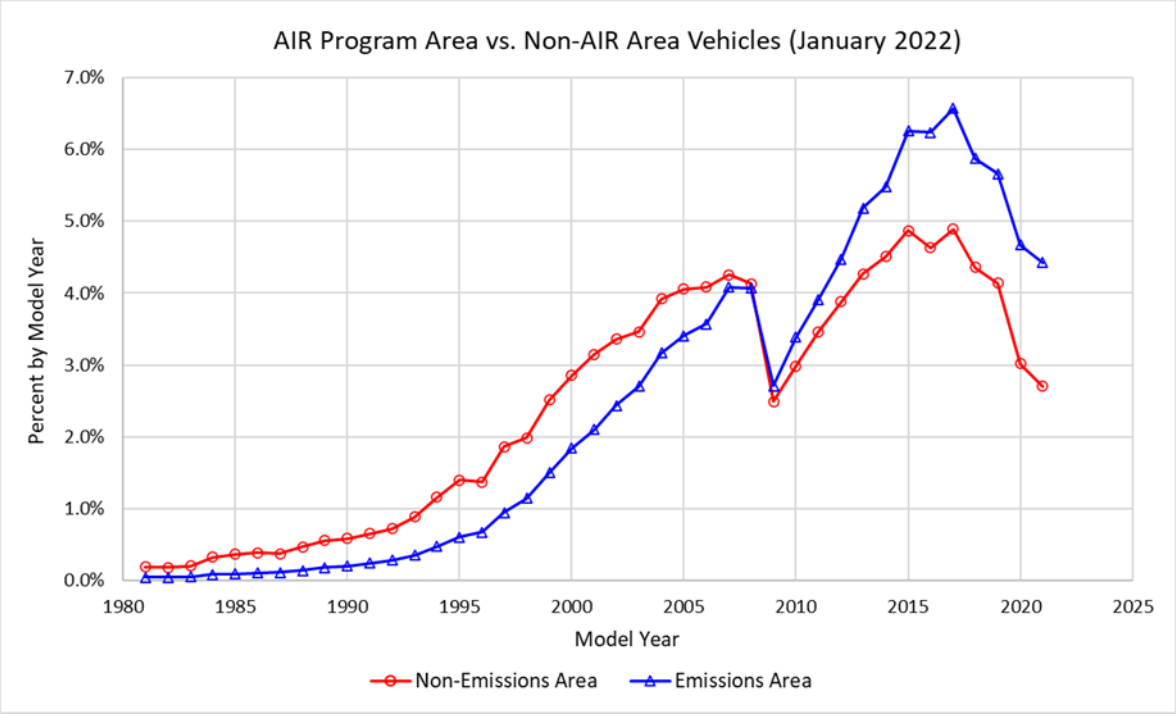
Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.

Emission Reductions Based on Remote Sensing Device Readings

While the RapidScreen (RSD) network is focused on measurement of vehicles registered in the AIR Program area, vehicles outside the Emissions Area also operate within the Emissions Area and are captured by the RSD units. As a result, it is possible to assess in-use emissions for both vehicles subject to and those not subject to the Air Program requirements. This approach accounts for the long-term impact of the AIR Program on emissions, not just the impact for one inspection cycle. The long-term impact includes the effect of the RapidScreen program on exhaust emissions.

There is however, one complicating factor in performing this analysis, which is that the fleet of vehicles not subject to the AIR Program for which RSD data exists is older than the fleet of vehicles subject to the AIR Program. That this is the case can be seen in Exhibit 5, which shows the vehicle age distributions of the two fleets of vehicles. The fact that the fleet not subject to the AIR Program is older than the fleet subject to the AIR Program is expected to lead to higher estimates of AIR Program benefits than if the vehicle age distributions of the two fleets were the same. Given this difference, the vehicle age distribution for the non-AIR Program fleet (non-Emissions Area) has been adjusted to match that of the AIR Program fleet (Emissions Area).

Exhibit 5. Percentage of Vehicles by Model Year Based Inside (AIR Area) and Outside (Non-AIR Area) the AIR Program Area



Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.

The results of this analysis are presented in Exhibit 6. The I/M scenario represents the AIR Program; the non-I/M scenario represents emissions without the AIR Program. The estimated emission benefits of the AIR program in 2019 based on RSD are as follows:

- CO: 9.5% reduction (compared to 16.6% reduction based on MOVES3),
- Exhaust HC: 17% reduction (compared to 21.6% reduction based on MOVES3),
- NO_X[3]: 17% reduction (compared to 14.0% reduction based on MOVES3).

The agreement between MOVES3 and these RSD-based data is remarkably good for exhaust HC and NO_X, and still reasonable for CO.

[3] The RSD device measures only NO, not NO_X. However, the bulk of tailpipe NO_X emissions from gasoline vehicles are NO and the RSD results are considered to be commensurate with a NO_X measurement.

Exhibit 6. RSD Emissions and AIR Program Emission Reductions for Calendar Year 2019

Pollutant/ Parameter	Scenario	RSD Emissions 2019
CO (percent)	Non-I/M	0.175
	I/M	0.159
	% Reduction	9.5%
HC (ppm)	Non-I/M	17.2
	I/M	14.2
	% Reduction	17%
NO (ppm)	Non-I/M	124.5
	I/M	103.5
	% Reduction	17%
RSD Counts	Non-I/M	188,643
	I/M	2,422,066

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.

Expanding Model-Year Exemptions

Section 42-4-306(8), C.R.S., grants the Commission the authority to exempt vehicles of any make, model, or model year from the testing requirements of the AIR Program. Effective January 1, 2015, the Commission expanded model-year exemptions from the most recent four model years to the most recent seven model years. Seven model years is currently the highest exemption limit in vehicle inspection and maintenance programs nationwide.

As part of our evaluation, we analyzed 2019 AIR Program data to determine whether additional model-year exemptions are warranted. Again, we selected 2019 as the evaluation year since it is the last year the AIR Program worked as intended by the regulation. Based on the results of our analysis, we do not recommend expanding model-year exemptions beyond the current seven model years, which was model year 2012 for our analysis. The primary reason for this is because, as discussed previously, the AIR Program's benefits are derived mainly from those high-emitting vehicles that fail the emissions test and are (1) subsequently repaired and pass a retest or (2) removed from the vehicle fleet. If greater numbers of older vehicles were exempted from AIR Program testing requirements, the emission benefits of the programs would be reduced because older vehicles tend to be higher-emitting.

Exhibit 7 shows the cumulative emissions reductions from the highest to lowest model year. The MOVES3 column shows the cumulative reduction in ozone precursors (HC + NO_X + CO/60). The remote sensing devices (RSD) column shows the cumulative NO_X reductions. NO_X is the primary ozone precursor. The newest model years falling just after the 7-year exemption period and that currently undergo emissions testing account for a significant portion of the emissions reductions. For example, emissions testing on model year 2012 vehicles is estimated to account for between 2% and 4% of the total emissions reductions. If three more model years were exempted from emissions testing requirements (i.e., model years 2010 through 2012), we estimate that emission reductions would drop by 7% based on MOVES3 model estimates and 9% based on analysis of remote sensing device data.

A secondary factor in assessing expanded model year exemptions is the impact on RapidScreen, which, due to its convenience, is a popular component of the AIR Program. When model year exemptions went from

four to seven years, the number of vehicles qualifying for RapidScreen dropped by 28% because relatively lower-emitting vehicles, which are prime candidates for RapidScreen, were exempted from emissions testing requirements. If three more model years were exempted, we estimate that the number of RapidScreen candidates would drop by an additional 30%. This drop in the number of RapidScreen candidates may ultimately affect the cost-effectiveness of this component of the AIR Program. The cost to collect the remote sensing device data would remain the same; however, fewer qualifying vehicles would be available to bear these costs.

Exhibit 7. Cumulative NO_X Emissions Reductions in 2019 by Model Year

Model Year	Cumulative Emissions Reductions	
	HC + NO_X + CO/60 Based on MOVES3 Model Estimates	NO_X Based on Remote Sensing Device Data [4]
2012	2%	4%
2011	4%	7%
2010	7%	9%
2009	11%	11%
2008	14%	18%
2007	17%	27%
2006	20%	36%
2005	22%	43%
2004	26%	51%
2003	29%	59%
2002	33%	68%
2001	36%	75%
2000	40%	82%
1999	45%	87%
1998	48%	90%
1997	52%	94%
1996	55%	96%
1995	59%	98%
1994	61%	99%
1993	64%	100%
1992	67%	100%
1991	69%	100%
1990	70%	100%
1989	100%	100%

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.

Enforcing OBD Readiness Standards

During the COVID-19 Pandemic, the Department made several changes to the AIR Program to decrease personal contact between motorists and AIR Program inspectors during inspections. Among those changes

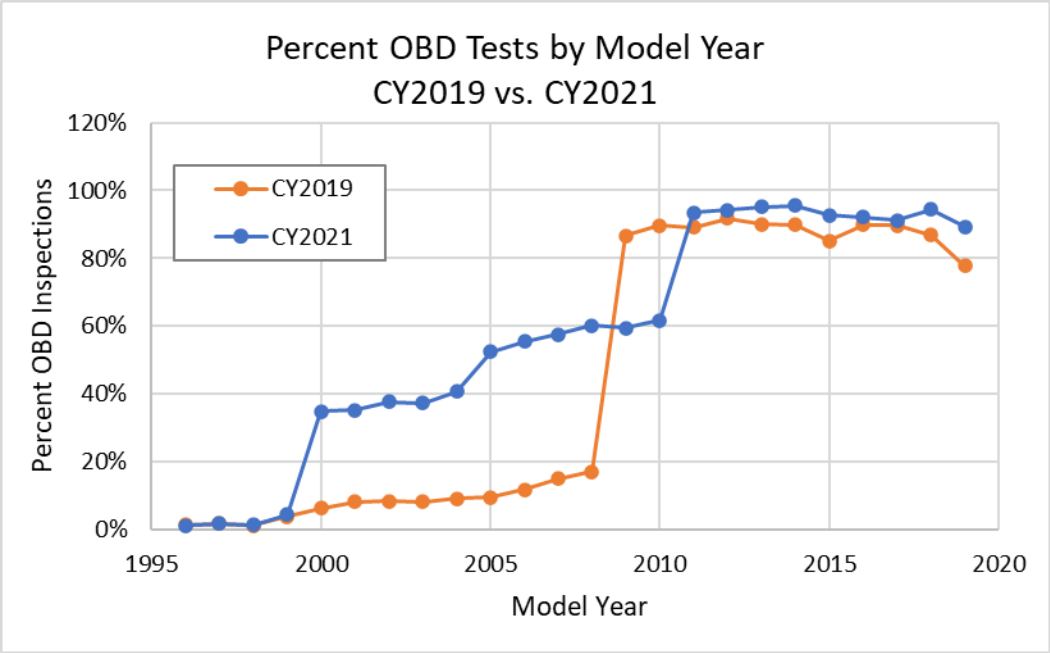
[4] Based on an analysis of remote sensing device readings for vehicles registered inside and outside the AIR Program area.

was implementation of OBD inspections for certain model year vehicles that would normally receive an IM240 inspection. This is shown in Exhibit 8, which compares the fraction of 1996 and newer vehicles tested via OBD in Calendar Year 2019 versus 2021. As noted above, the increased number of OBD tests in the 2021 data primarily displaced IM240 testing.

Another change to the program in response to the COVID-19 Pandemic was the suspension of 'readiness' requirements for OBD testing of 2000-2010 model year vehicles. Historically, the AIR Program would require IM240 testing of vehicles identified as 'Not Ready' during the OBD test. This was implemented for both consumer convenience and to ensure that there were no emission control system defects that would result in excessive emissions. From May 15, 2020, through June 30, 2021, model year 2000-2010 vehicles that were Not Ready did ***not*** receive a confirmatory IM240 inspection and were passed if the malfunction indicator light (MIL) was not illuminated.

Overall, the two changes described above are expected to decrease the effectiveness of the AIR Program because some vehicles with high emissions that would have been identified by IM240 testing were not tested and the lack of readiness requirements for the backup OBD inspection means that MIL lights that should have been illuminated to identify high emissions from these vehicles may not have been.

Exhibit 8. OBD Inspections by Model Year, 2019 versus 2021



Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.

Using the January 1, 2021, through June 30, 2021, AIR program data, the efficacy of requiring IM240 testing for vehicles 'Not Ready' on the OBD inspection was investigated. This analysis reviewed RSD data from model year 2000-2010 vehicles that had passed the OBD inspection in both 'Ready' and 'Not Ready' condition. Details of the analysis are summarized below:

- Model years 2000 to 2010 were included based on the discussion above and the data presented in Exhibit 8.

- Only initial, passing OBD tests were evaluated.
- Air Program data from January 1, 2021, through June 30, 2021, were considered.
- RSD data from July 1, 2020, through June 30, 2021, were merged with the I/M 240 data to ensure RSD measurements were available for up to 180 days prior to the AIR Program test. Mean RSD emissions were calculated for four, 45-day time bins: 0-45 days prior to the Air Program test, 45-90 days prior to the I/M 240 test, etc.
- Readiness was evaluated for the following trip-based monitors: catalyst, oxygen sensor, heated oxygen sensor, exhaust gas recirculation (EGR), and secondary air. Readiness for the evaporative control system monitor was not considered as it was unclear that it would influence the RSD data.

Depending on pollutant, the RSD emissions are 1.9 to 2.7 times greater for the 'Not Ready' vehicles than for the 'Ready' vehicles. Key observations are:

- 'Not Ready' vehicles are older than the 'Ready' vehicles, on average, by about 1.8 years (mean model year of 2004.5 vs 2006.3 for 'Not Ready' vs. 'Ready', respectively). While emissions from older vehicles are generally higher, the nearly two- to three-fold increase in emissions for 'Not Ready' vehicles is clearly not explained by vehicle age.
- There are more 'Ready' than 'Not Ready' vehicles in RSD data (~86% vs. 14%), but on a per-vehicle basis, emissions are much higher for the 'Not Ready' vehicles, implying significant loss in benefits when not requiring back-up IM240 testing for these vehicles.

As demonstrated above, the combination of exempting some vehicles from IM240 testing and suspension of OBD readiness code requirements implemented because of the COVID-19 Pandemic decrease the effectiveness of the AIR Program. With the lifting of most, if not all COVID-19 Pandemic-related public health restrictions, there appears to be no reason for the continued implementation of these changes to the AIR Program given that they decrease program effectiveness.

Air Quality and Attainment of the Ozone Air Quality Standards

We evaluated the air quality impact of the AIR Program on ground-level ozone concentration relative to both the 2008 and 2015 versions of the National Ambient Air Quality Standards (ozone air quality standards). The starting point for our analysis was to examine ambient air quality monitoring data for the past 11 years to ascertain ozone pollution trends and to quantify the State's progress in meeting the upcoming attainment deadlines for the 2008 and 2015 ozone air quality standards.

Status of Compliance with the Ozone Air Quality Standards

There are fifteen air quality monitoring stations located throughout the DM/NFR nonattainment area. Each monitor's Ozone Design Value (ODV) is defined as the fourth highest maximum daily 8-hour average (Maximum Daily Average) ozone concentration of a given year, averaged over a three-year period. ODVs are calculated for every monitor located within a nonattainment area, and the ODV assigned to the nonattainment area is the largest value over all monitors. Attainment of the standard occurs when all ODVs are at or below the air quality limit. As of November 2022, there are two versions of the federal ozone standard that are enforced, as shown in Exhibit 9. The limits are 75 and 70 ppb for the 2008 and 2015

versions of the ozone air quality standard, respectively. Again, as shown in Exhibit 1 on page 3, ODVs in the DM/NFR area have consistently been in the 76 to 84 ppb range, above both standards, over the course of the last decade.

The DM/NFR area remains out of attainment for both 75 (2008) and 70 (2015) ppb ozone air quality standards as shown in Exhibit 9. The DM/NFR area is currently classified as "marginal" nonattainment and "serious" nonattainment for the 2015 and 2008 standards, respectively. The nonattainment classification dictates the deadline by which attainment is required and the level of pollution controls that must be enacted. Attainment of both sets of standards was required by ODVs that concluded with the 2020 ozone season. The State is expecting the Environmental Protection Agency (EPA) to re-designate the DM/NFR area as being in "moderate" non-attainment for the 2015 ozone standard and in "severe" non-attainment for the 2008 standard. Attainment would then be required by the end of the 2023 and 2026 ozone seasons for the 2015 and 2008 ozone standards, respectively.[5] The state and local planning agencies are currently working on the 2023 moderate and 2026 severe ozone attainment demonstrations, which would include implementation of federal reformulated gasoline requirements.[6] These requirements would require additional gasoline volatility restrictions, including the elimination of 1 PSI volatility waiver for ethanol-containing gasoline.

Exhibit 9. DM/NFR Area Ozone Attainment Status

Standard Adoption Date	Ozone Standard**	Current DM/NFR Nonattainment Classification	Expected Nonattainment Reclassification	Attainment Date of Expected Reclassification††
2008	75 ppb	Serious	Severe	2026
2015	70 ppb	Marginal	Moderate	2023

Source: US Environmental Protection Agency

** Three-year average of the fourth highest maximum daily 8-hour average (Maximum Daily Average) concentration of each year.
†† Year reported here is the final ozone season (of the three-year average) that would determine attainment; as part of the attainment process, state planning agencies are allowed an additional year to review and validate ozone results before submitting to the EPA.

Background Ozone Levels

The EPA defines the United States Background (USB) as the estimated ozone concentration if all U.S. man-made emissions sources were eliminated. In the absence of U.S. man-made emissions, background ozone occurs from (1) international transport (i.e., ozone from transpacific sources, Canada, and Mexico); (2) ozone created from emissions from plants (biogenic emissions), lightning, volcanoes, and wildfires; and (3) stratospheric ozone intrusions.

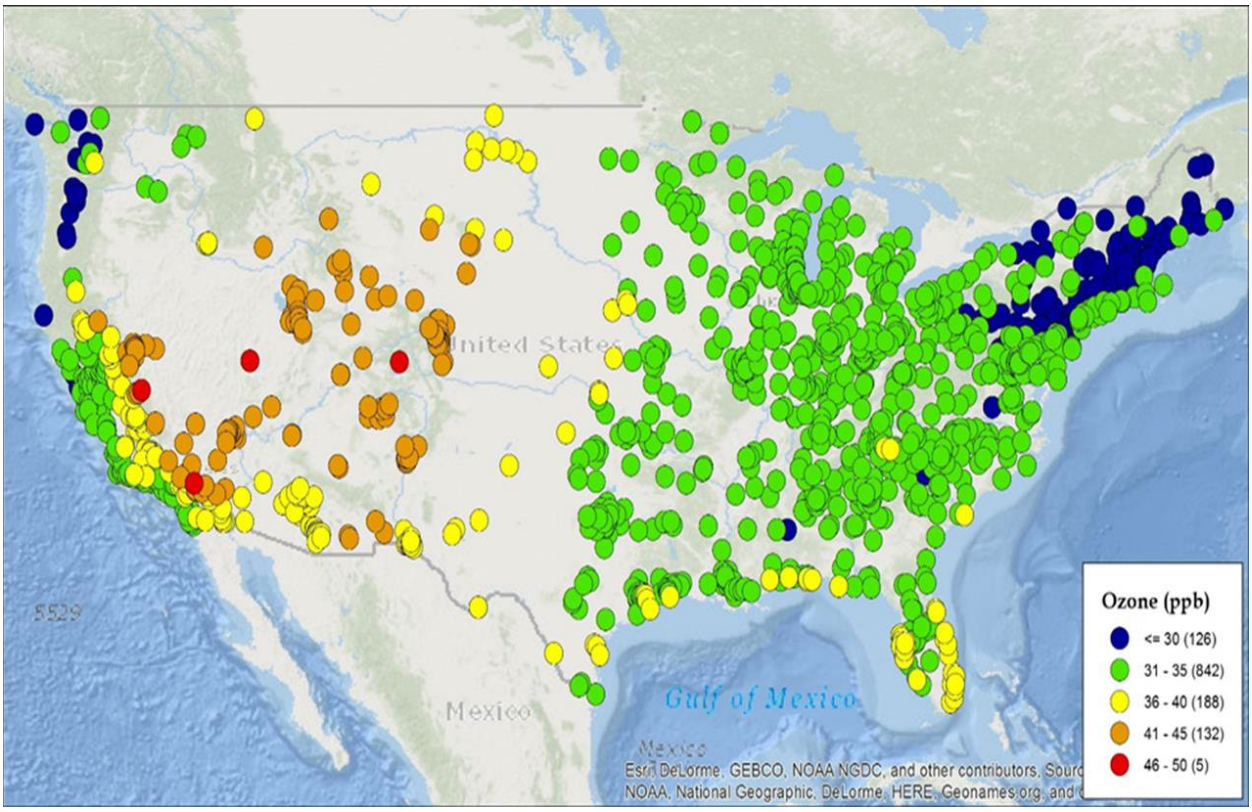
The Rocky Mountain states have some of the highest USB concentrations in the nation, in large part, because USB increases with altitude. Exhibit 10 is the graphical representation of the EPA's spatial analysis of the USB showing that 41 to 50 ppb is the typical range observed for the Rocky Mountain region, including the DM/NFR area. Although the EPA's allowances for excluding exceptional events from ODV calculations is

[5] EPA has proposed these reclassifications in April (EPA Federal Register FR-2022-07513); finalization of the reclassifications is pending.

[6] Federal reformulated gasoline would become a requirement under a severe ozone nonattainment classification.

intended to remove the influence of non-man-made events such as wildfires and stratospheric ozone intrusions, the higher levels of background ozone observed in the DM/NFR area puts it at a disadvantage in attaining the stricter 70-ppb ozone standards because the allowable threshold for ozone formation from local human-related activities is correspondingly less.

Exhibit 10. EPA-Estimated Seasonal Mean U.S. Background (USB) Ozone Concentrations at U.S. Surface Monitoring Locations



Source: EPA White Paper for Discussion, "Implementation of the 2015 Primary Ozone NAAQS: Issues Associated with Background Ozone," December 2015.

Ozone Data and Design Values

Exhibit 11 presents the most recent three years' monitoring data (2019 – 2021) for the 15 monitors currently operating in the DM/NFR nonattainment area. The estimated 2021 ODV for each monitor is calculated from the three-year average of the fourth highest maximum daily 8-hour average (Maximum Daily Average) concentration. The ODVs are calculated twice: including 2020 flagged days and excluding 2020 flagged days.[7] ODVs that exceed both standards are shown in bold red font; ODVs that exceed the 2015 standard only are shown in bold blue font. Exhibit 11 shows that the nonattainment area is estimated to remain out of attainment of both standards independent of whether the flagged dates are included.

The 2021 ODVs of Exhibit 11 should be considered "draft" as these values remain unofficial and unverified. The date flagging of the 2021 ozone season is on-going, and there was possible influence of wildfires in

[7] The flagged days represent potential exceptional events caused by wildfires in 2020.

2021 that has been noted.[8] With that understood, the potential removal of flagged dates in 2021 is not expected to be sufficient to bring the area into attainment of either version of the ozone air quality standards.

Exhibit 11 also includes the estimated fourth highest Maximum Daily Average that would bring the monitor into attainment of both ozone air quality standards after the 2022 season. It appears to be highly improbable that Colorado will achieve the fourth highest Maximum Daily Average values below 60 ppb due to local background concentrations and out-of-state transport – especially at those monitoring sites that will determine the attainment status, as there will be some contribution from nonattainment area emissions as well. A review of fourth highest Maximum Daily Average concentrations over the last 20 years indicates the lowest value ever recorded by any monitor in the nonattainment area was 61 ppb (which occurred once, in 2019).

Exhibit 11. Draft 2021 Ozone Design Values

Draft 2021 Ozone Design Values (ODVs), 2022 Concentration Needed for NAAQS Attainment
Denver Metro/Northern Front Range (DM/NFR) Non-Attainment Area

	4th Highest Maximum Daily 8-Hour Average (MDA8), ppb									
	Inclusive of 2020 Flagged Days*						Exclusive of 2020 Flagged Days*			
Monitoring Site	2019	2020	2021†	2021 ODV, 3-Year Average‡	2022 Max Allowable to Meet NAAQS 70 ppb	2022 Max Allowable to Meet NAAQS 75 ppb	2020	2021 ODV, 3-Year Average‡	2022 Max Allowable to Meet NAAQS 70 ppb	2022 Max Allowable to Meet NAAQS 75 ppb
Welby	60	78	79	72	55	60	72	70	61	66
Highland	73	83	84	80	45	50	71	76	57	62
Aurora East	66	77	77	73	58	63	67	70	68	73
Boulder Reservoir	69	76	82	75	54	59	74	75	56	61
CAMP	67	74	77	72	61	66	66	70	69	74
La Casa	65	78	83	75	51	56	71	73	58	63
Chatfield State Park	78	83	89	83	40	45	75	80	48	53
Rocky Flats - N	72	84	87	81	41	46	78	79	47	52
NREL	75	87	89	83	36	41	81	81	42	47
Evergreen	---	---	79	---	---	---	---	---	---	---
Fort Collins - West	71	75	85	77	52	57	72	76	55	60
Fort Collins - CSU	64	67	76	69	69	74	62	67	74	79
Greeley - Weld Tower	65	72	76	71	64	69	67	69	69	74
Platteville Observatory	---	---	83	---	---	---	---	---	---	---
NPS - Rocky Mtn. NP	65	73	77	71	62	67	67	69	68	73

Source: analysis of processed ambient ozone measurement data provided by the Colorado Department of Public Health and Environment.

* The 2020 flagged days include 6/17 and 8/21 - 8/25 wildfire smoke-influenced ozone events. The 4th maximum 2020 concentrations are reported with and without the readings on those dates.
† 2021 values are unofficial (unvalidated). The Department is still in the date-flagging process for the 2021 ozone season.
‡ NAAQS attainment when 3-year average ≤ 70 ppb (2015 Standard) or ≤ 75 ppb (2008 Standard). 3-year averages in red font exceed the both standards; 3-year averages in blue font exceed the 70-ppb standard only.

[8] "Summer Ozone Season Review," Briefing to the Colorado Air Quality Control Commission and Colorado Board of Health by Gordon Pierce and Scott Landes, Colorado Department of Public Health and Environment, Air Pollution Control Division, October 21, 2021.

There are five monitoring sites that historically represent the highest ozone concentrations in the DM/NFR area: Highland, Chatfield State Park, Rocky Flats North, the National Renewable Energy Lab (NREL), and Fort Collins West. The air quality impacts, and source contributions as observed relative to these five monitors is the focus of the air quality analysis, as these are the locations most likely to affect attainment.

Exhibit 12 presents the historical ODV trend (2015 to 2021) coupled with draft projected ODVs for 2023 and 2026 for the five monitoring sites with the highest readings. ODVs that exceed both standards are shown in bold red font; ODVs that exceed the 2015 standard only are shown in bold blue font. 2021 ODVs are unofficial (unverified). The projected ODVs are those from the May draft attainment demonstration and include all currently enacted control measures.

Exhibit 12. Historical ODVs and Projected ODVs for 5 Select Monitoring Sites

Site	2020 Flagged Days	Ozone Design Values (Three-Year Average, Year Ending) 2015	2016	2017	2018	2019	2020	2021[9]	Projected ODVs (Draft Attainment Demonstration) 2023	2026
Highland	Including	--	--	**73**	**73**	**74**	**77**	**80**	67	65
	Excluding	--	--	--	--	--	**73**	**76**		
Chatfield State Park	Including	**79**	**77**	**77**	**78**	**78**	**81**	**83**	70	68
	Excluding	--	--	--	--	--	**78**	**80**		
Rocky Flats North	Including	**79**	**77**	**77**	**78**	**76**	**79**	**81**	69 - 70	68
	Excluding	--	--	--	--	--	**77**	**79**		
National Renewable Energy Laboratory	Including	**80**	**80**	**80**	**79**	**76**	**80**	**83**	**72 – 73**	70 – **72**
	Excluding	--	--	--	--	--	**78**	**81**		
Fort Collins West	Including	**77**	**77**	**75**	**77**	**75**	**75**	**77**	68 – 70	67 – 69
	Excluding	--	--	--	--	--	**74**	**76**		

Source: analysis of processed ambient ozone measurement data provided by the Colorado Department of Public Health and Environment.

In order to show the relevant contributions of different sources to the total emissions of ozone precursors in the DM/NFR, the draft ozone SIP planning inventory data were reviewed relative to the ODVs shown in Exhibit 12. The inventory data are summarized in Exhibit 13. The inventory data provided by the State were grouped into the following source sectors.

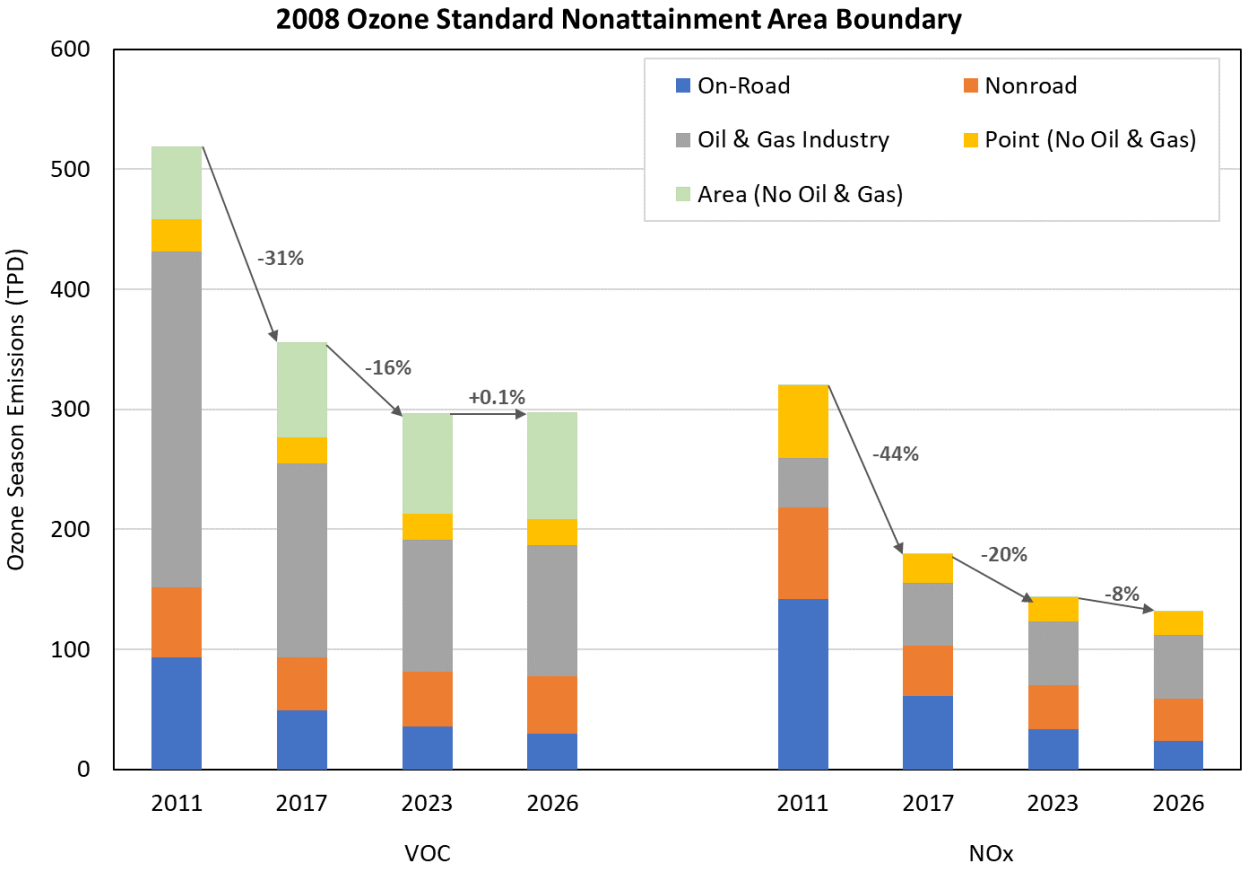
- "On-road" represents all highway vehicles.
- "Nonroad" represents the balance of mobile sources including nonroad equipment, aircraft and trains.
- "Oil & Gas" represents stationary sources from the oil and gas industry.

[9] 2021 ODVs are unofficial (unverified).

- "Point (No Oil & Gas)" represents point sources outside the oil and gas industry where "point" is a term used to denote large stationary sources, such as power generating stations.
- "Area (No Oil & Gas)" represents area sources outside the oil and gas industry where "area" is a term used to denote small, numerous stationary sources, such as dry-cleaning operations.

As shown in Exhibit 13, both VOC and NO_X emissions within the nonattainment area are generally trending downward although the VOC emissions trend flattens between 2023 and 2026.

Exhibit 13. DM/NFR Ozone Planning Inventories



Source: analysis of draft SIP emission inventory data provided by the Colorado Department of Public Health and Environment.

Key points relative to the review of Exhibit 12 and Exhibit 13 include the following:

- Currently enacted control measures are not sufficient to bring the DM/NFR area into attainment of the 2015 ozone standard (70 ppb) by 2023, according to the May draft attainment demonstration results[10].

[10] "Draft SIP Elements: Attainment Demonstration," presentation by Jessica Ferko, Wayne Chuang, and Mike Silverstein to Denver Regional Air Quality Board, May 2022.

The National Renewable Energy Laboratory (NREL) monitor is forecasted to continue to exceed the standard while the remaining sites are forecasted to be at or below the 70-ppb limit[11].

- The projected ODVs are presented as a range. They are estimated from the application of monitor-specific relative response factors (RRFs) defined relative to the 2016 monitored base year[12]. The dual values (shown as a range in Exhibit 12) are the product of the impact of potential exceptional events in the base year, which are yet to be finalized. If the base year exceptional events are approved, then the NREL monitor is estimated to achieve the 70-ppb limit by 2026, as shown by the lower value in Exhibit 12.

- While ozone precursor emissions occurring in the nonattainment area are trending downward, reductions in historical ODVs appear stalled. There remains uncertainty in these historical ODVs in that the impacts of exceptional events may not be fully accounted for. Despite the uncertainty, there is a visible disconnect between current ODV trends and the forecasted 2023 ODVs. A portion of that disconnect may be due to out-of-state, regional wildfire impacts and/or atypical meteorology, as described previously.

Sources of Ozone Precursor Emissions in the DM/NFR Area

As part of the ozone planning process, the Denver Regional Air Quality Council (Council) has commissioned ozone source apportionment modeling that estimates the proportion of monitored ozone concentrations by geographic origin and emissions source sector. These modeling results provide invaluable information to estimate the origins of ozone air pollution in the DM/NFR area. The source apportionment modeling addresses the contributions of different emissions sources to the forecasted 2023 Maximum Daily Average ozone concentrations for each monitored site; the analysis described here is focused on the ten highest Maximum Daily Average concentrations for the five monitors in the DM/NRF area recording the highest ozone concentrations (as shown in Exhibit 11).[13]

Exhibit 14 presents the five-monitor mean concentrations showing the proportion of ozone formation coming from human activities (i.e., anthropogenic emissions). The forecasted 2023 mean representing the 10 highest Maximum Daily Average concentrations equals 63.54 ppb of ozone. By this metric, approximately 59% of the measured DM/NFR ozone originates from "boundary conditions, which are local background concentrations of ozone from transport outside the North America modeling domain and from stratospheric ozone incursions.[14] Approximately 38% of ozone originates from anthropogenic emissions (i.e., human

[11] In an anomaly in the planning process, the DM/NFR is required to demonstrate attainment of the stricter 70-ppb standard by 2023 (due to the moderate nonattainment classification) and the less strict 75-ppb standard by 2026 (due to the severe nonattainment classification). If the area fails to attain the 70-ppb standard by 2023, the option of a 1-year extension exists or the area may be reclassified to "serious" nonattainment with respect to the 2015 ozone standard. If reclassified to serious, then attainment must be demonstrated by 2026.

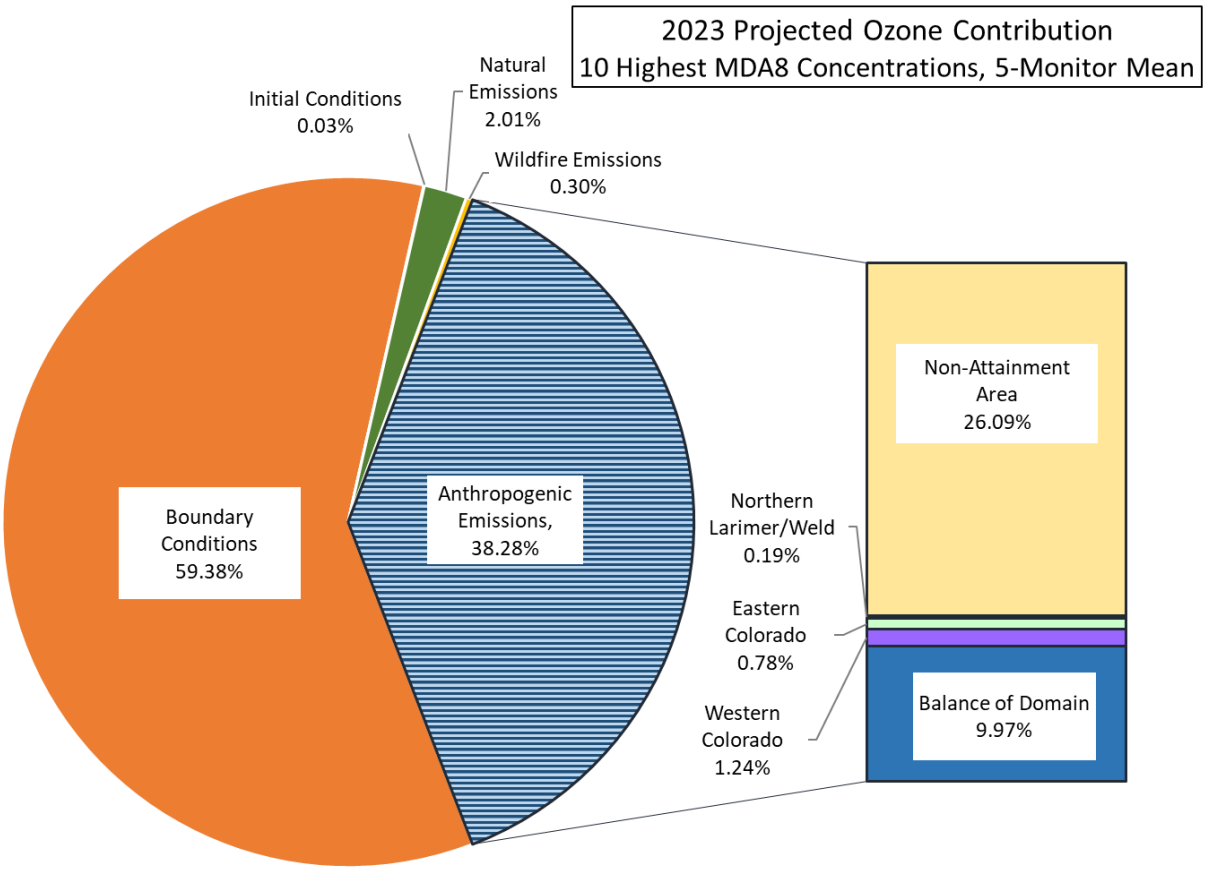
[12] Relative response factors are a monitoring location's estimated change in ambient ozone concentrations occurring from known changes ozone precursor emissions. RRFs are determined from photochemical modeling of the DM/NFR SIP emission inventory changes from the base year (2016) to the attainment year (2023). RRFs used in this study are those from the draft attainment demonstration publicly posted on the RAQC web site: "Draft SIP Elements: Attainment Demonstration," presentation by Jessica Ferko, Wayne Chuang, and Mike Silverstein to Denver Regional Air Quality Board, May 2022.

[13] Five-monitor means are estimated from projected 2023 ozone concentrations from these sites: Highland, Chatfield State Park, Rocky Flats North, NREL and Fort Collins West.

[14] Stratospheric ozone intrusions occur when meterological conditions force ozone present in the protective stratopsheric ozone layer into the troposphere.

activities).[15] Of that 38%, 26% is from emissions occurring in the DM/NFR area, 2% is from emissions elsewhere in Colorado[16], and 10% is from emissions in the balance of the geographical modeling domain (i.e., Canada, Mexico, and the remainder of the US). About 2% of ozone comes from emissions from natural sources and wildfires.[17] The 26% of ozone coming from the DM/NFR anthropogenic emissions provides an estimate of how much ozone is controllable through local control measures in 2023.

Exhibit 14. Project Sources of Ambient Ozone in the DM/NFR Area in 2023



Source: analysis of ozone source apportionment data sponsored by the Regional Air Quality Council (RAQC) and publicly posted on the RAQC web site.

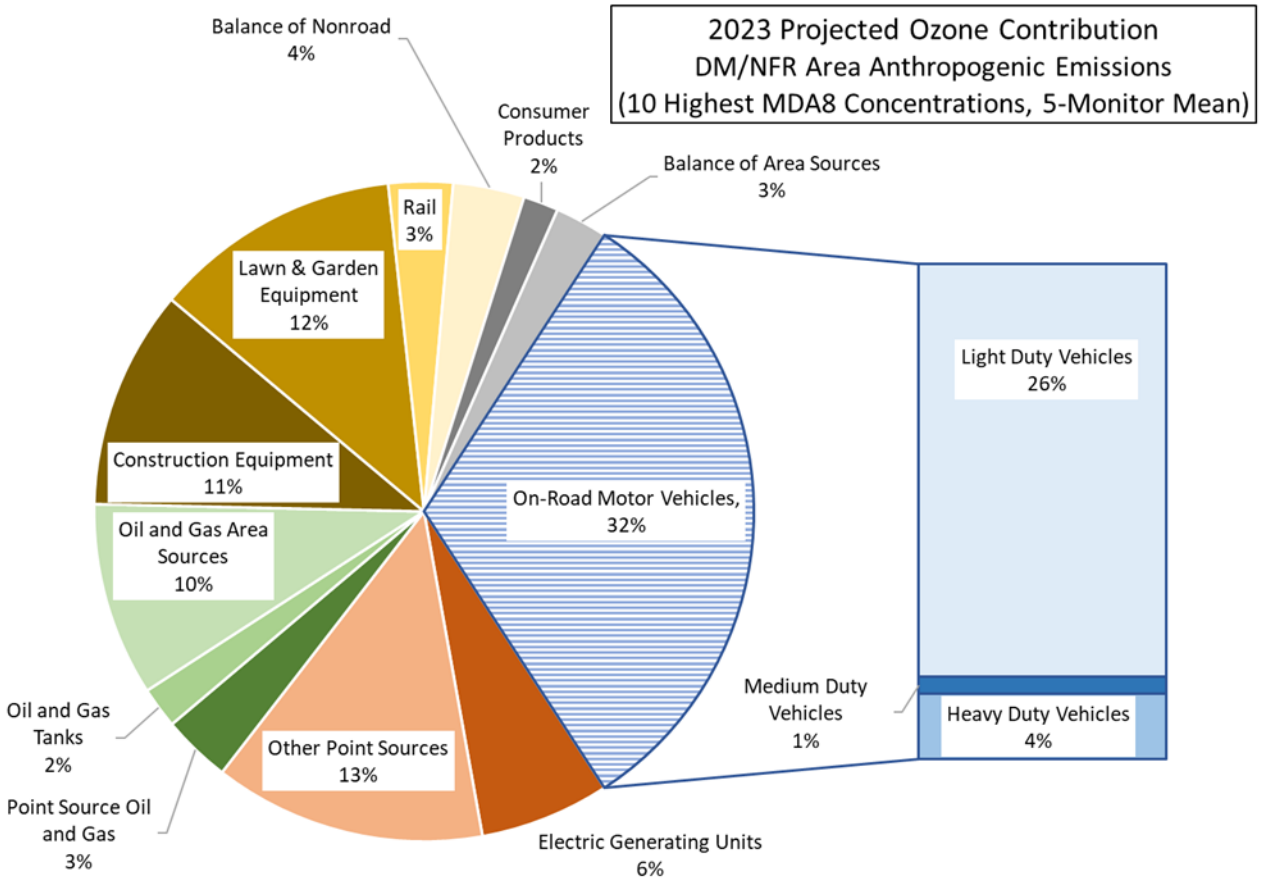
[15] Athropogenic means all human activites occuring in the modelling domain (i.e., North America) that cause emissions including transprotation, power generation, agricultural operatins, manufacturing, fuel production and disribution, residential heating, etc.

[16] Colorado source apportionment modeling is subdivided into the 9-county nonattainment area of the 2008 standard, the northern portions of Larimer and Weld Counties outside the nonattainment area, 20 counties of Eastern Colorado (including El Paso County) and 35 Western Colorado counties.

[17] Wildfire emission modeled as long-term historical norms occurring during the June – August ozone season and may not be representative of more recent trends.

Exhibit 15 presents ozone formed from DM/NFR anthropogenic emissions as reported by individual source sectors. Emissions from mobile sources (on-road and non-road combined) make up an estimated 61.2% of ozone formed from DM/NFR human activities. Stationary sources (electricity generation and other facilities) account for 22%, with oil and gas production activities accounting for 10%. Within the on-road sector, light-duty vehicles are the predominate source of emissions.

Exhibit 15. Projected Contribution of Anthropogenic Sources of Ambient Ozone in the DM/NFR Area in 2023



Source: analysis of ozone source apportionment data sponsored by the Regional Air Quality Council (RAQC) and publicly posted on the RAQC web site.

AIR Program Impact on Ozone Levels

We calculated the ambient air quality impacts resulting from the estimated AIR Program benefits in 2023 using two separate approaches: applying the Light-Duty Vehicle (LDV) source apportionment and applying the relative reduction factors (RRFs) of the draft attainment demonstration (see Footnote 13). The first approach estimates the program impact on the 10 highest Maximum Daily Average concentrations and the underlying method is specific to light-duty vehicle impacts on ozone formation. The second approach estimates the program impact on forecasted 2023 ODVs; however, the RRFs are collective over all source

sectors (and are not specific to LDV emissions). Under both approaches, we estimated the impacts relative to five-monitor mean concentrations.

Based on the estimated emission benefits of the AIR Program using a combination of RSD and MOVES data, we determined the impact of the AIR Program on 2023 ozone levels based on the source apportionment data. As shown in Exhibit 16, we estimate that the ozone benefit of the AIR Program in 2023 will be 0.6 ppb.

Exhibit 16. Estimated 2023 Benefit of AIR Program and Ambient Ozone Impact Using LDV Source Apportionment Factor

Ozone Precursor Reductions Achieved by AIR Program (tons/day)	Percent Increase in LDV Emissions, No AIR Program	Ozone Benefit (ppb) of AIR Program (10 highest MDA8, Five-Monitor Mean)
7.7	13%	0.6

Source: analysis relying on multiple data sources described in this report including ozone source apportionment data sponsored by the Regional Air Quality Council (RAQC) and publicly posted on the RAQC web site.

Under the second approach, we incorporated the ozone precursor reductions of 7.7 tons/day with 2023 RRFs of each monitoring site from the draft attainment demonstration to estimate the impact on forecast ODVs. Overall, we estimate the resulting five-monitor mean impact to be 0.5 in 2023 under this approach, as shown in Exhibit 17.

Exhibit 17. Estimated AIR Program Ambient Ozone Benefit, 2023 Using Monitor RRFs from the May, Draft Attainment Demonstration

Air Program Impact (ppb) on Projected 2023 ODVs					
Rocky Flats N	NREL	Ft. Collins W	Chatfield SP	Highland	Five-Monitor Mean
0.56	0.47	0.42	0.54	0.46	0.5

Source: analysis relying on multiple data sources described in this report including monitor-specific relative response factors (RRFs) from the draft (May 2022) Ozone Attainment Demonstration publicly posted on the RAQC web site.

Overall, across both approaches, the range of ambient ozone impact in the 2023 attainment year is between 0.5 to 0.6 ppb – for the five monitors recording the highest ozone in the DM/NFR area. These are meaningful impacts that can alter attainment demonstration and demonstrate that if the AIR Program were not in place presently, there would be an increase in ozone pollution. This incremental impact is sufficient to change the attainment status of three additional monitors (Rocky Flats North, Ft. Collins West and Chatfield State Park), as evaluated in the draft attainment demonstration (see 2023 forecasted ODVs of the attainment demonstration as reported in Exhibit 12 above). With this additional ozone pollution, four out of five monitors (all but Highland) have the potential to exceed the 70-ppb limit in 2023. It is useful to note that the ozone planning process is ongoing, and these results rely on, in part, draft attainment modeling results for the reported RRFs; it is also expected that additional control measures may be proposed as part of the finalization of the attainment demonstration.

Lastly, it is an important consideration to note that an "enhanced" inspection and maintenance (I/M) program (such as the AIR Program) becomes a legally required SIP element for any area classified as serious, severe, or extreme nonattainment for ozone. This requirement applies to the DM/NFR area, which

is currently classified as serious nonattainment for the 2008 standards (and expected to be reclassified to severe nonattainment sometime in 2022).

Potential Ozone Impacts of Expanding the AIR Program to Include El Paso County

When the AIR Program was initiated in 1980, Colorado Springs was included as a mandatory inspection area for compliance with the Colorado Carbon Monoxide State Implementation Plan. In 1999, Colorado Springs was re-designated as "in attainment" for federal carbon monoxide standards and the basic emissions program requirements were removed in 2006 by the Colorado Air Quality Control Commission. However, since that time, El Paso County has grown and, while the area has not yet been designated as non-attainment for ozone, recent ambient air quality monitoring data shows monitored values in the area above the 2015 ozone air quality standard. Given this and the potential contribution of vehicles registered in El Paso County to ambient ozone levels in the DM/NFR area, we assessed the potential impact that expanding the AIR Program to El Paso County would have on ozone levels in the DM/NFR area.

We assessed the impact on DM/NFR ozone concentrations under the hypothetical case of the AIR Program requirements extending to gasoline-powered LDVs registered in El Paso County. In order to dovetail with existing data sources and methods, we estimated that impact relative to 2023 Maximum Daily Average ozone concentrations. There would be two distinct benefits of this action. The first would be a reduction in emissions from El Paso registered vehicles that operate in the DM/NFR area. The second would be reduced emissions from vehicles operating in El Paso County given that those emissions can be transported by the wind to the DM/NFR area where they contribute to ozone formation.

According to RSD measurements, 1.6% of LDV operation in DM/NFR occurs from vehicles registered in El Paso County. Applying the 1.6% increment to the estimated AIR Program benefit range of 0.5 to 1.1 ppb, would generate an additional 0.01 to 0.02 ppb of ambient ozone reductions in the DM/NFR area in 2023 (five-monitor mean).

Because source apportionment modeling data is not separately available for El Paso County, we instead looked at data from the 20-county Eastern Colorado region that includes El Paso County. This data indicates that emissions from LDVs operating in the region contribute to 0.12 ppb ozone in the DM/NFR area (10 highest Maximum Daily Average concentrations, five-monitor mean). This is the estimated amount of ozone that would be reduced in the DM/NFR area if all LDVs were eliminated in Eastern Colorado. Under a simplifying, conservative assumption that El Paso County LDVs alone make up 0.12 ppb of ozone concentrations in the DM/NFR, then the estimated AIR Program benefit applied to El Paso County would result in a maximum ozone reduction of approximately 0.02 ppb in 2023 (five-monitor mean).[18]

Overall, combining the two sources of benefit indicate that if El Paso County were subject to AIR Program requirements in 2023, it would achieve an ozone reduction of 0.04 ppb or less in ambient Maximum Daily Average ozone concentrations at the five key monitors of the DM/NFR area. In order to determine whether or not action should be taken to expand the AIR Program into El Paso County, the emissions and ozone impacts in the DM/NFR would have to be analyzed in light of the other control measures being developed for the air quality plan, as would the cost-effectiveness of those measures relative to the AIR Program expansion.

[18] A sensitivity case examined just the two nonattainment area monitors closest to El Paso County (Highland and Chatfield State Park). This case yielded the same 0.02 ppb estimated impact in 2023.

Costs and Cost-Effectiveness of the AIR Program

Vehicle owners in the Program Area are required to pass an emissions test before their vehicles can be registered. The fee for the emissions test, the time involved to have the test performed, and any related vehicle repair costs are all costs to the individual vehicle owner that must be weighed against the public benefits and outcomes the Program is intended to achieve. We used data provided by the Department on inspections conducted in 2019 and other publicly available information to assess the cost-effectiveness of the AIR Program. Cost-effectiveness is a measure that quantifies the degree to which something is effective or productive in relation to its cost. For vehicle inspection and maintenance programs, cost-effectiveness typically is expressed as a ratio of the cost of a control program per ton of pollutant emissions reduction. The determination of whether or not an emissions control program is cost-effective is usually made by comparing its cost-effectiveness ratio to those of other programs that have already been implemented.

Total Net Costs

We estimated the total net costs for the AIR Program, which represents the numerator of the cost-effectiveness ratio. The following costs are borne by vehicle owners as a result of having to comply with the AIR Program's emissions testing requirements:

- **Test Fee**. Vehicle owners pay a fee to have their gasoline powered vehicles tested at an emissions testing facility. The fee for OBD and IM240 tests is $25; the fee for the TSI test is $15 or $25, depending on the vehicle's age. Vehicle owners whose vehicles pass emissions based on RapidScreen's remote sensing device readings also pay a $25 test fee. Total costs for test fees were estimated based on the number of vehicles receiving paid emission tests in 2016 multiplied by the applicable test fee.

- **Additional Registration Fee**. Vehicle owners pay a $2.20 administrative fee when registering their vehicles. This fee, which is in addition to other license fees and ownership taxes paid upon vehicle registration, funds the AIR Program's administration and activities. Total costs for the additional registration fee were estimated based on the number of vehicles registered in the Program Area multiplied by the additional registration fee amount.

- **Repair Costs**. Vehicle owners whose vehicles fail the emissions test incur costs to repair the vehicle and pass a retest. Repair costs are reported to the Department by the vehicle owner and are maintained as part of the vehicle test database. Based on our analysis of repair cost data for 2019, the average repair costs for each test type are as follows:

  - $381 for IM240 test failures
  - $392 for OBD test failures
  - $389 for TSI test failures

  Data on gas cap repairs are not collected; therefore, for estimation purposes, we assumed a $20 cost to repair gas cap failures. Total repair costs were estimated using the average repair cost multiplied by the number of vehicles that failed the emissions test.

  The average repair cost includes vehicles that received warranty coverage. When evaluating the public need for the AIR Program, Section 42-4-316, C.R.S., requires the State Auditor to consider the AIR Program's ability to assure compliance with legally required warranties covering air pollution control equipment. For example, the federal Clean Air Act requires vehicle manufacturers to provide a Performance Warranty that covers specific major emission control components (i.e., the catalytic

converters, the electronic emissions control unit or computer, and the OBD device or computer) for the first eight years or 80,000 miles, whichever occurs first.

The AIR Program's emissions testing requirements should help ensure that vehicle manufacturers comply with emissions control system warranty requirements, because owners of vehicles that fail the emissions test would seek out eligible warranty repairs (if the vehicle is still under warranty) prior to retesting the vehicle. We did not find any information in the course of performing this evaluation to suggest that vehicle owners have been unable to get emissions systems repairs completed under warranty when those warranties were still in effect.

- **Inconvenience Costs**. Vehicle owners also bear an "inconvenience" cost, which generally represents the time and effort expended in order to complete the emissions test at a brick-and-mortar emissions testing facility. Vehicle owners who pass emissions through RapidScreen do not incur an inconvenience cost because the test data are collected remotely as they drive by the roadside monitors. We used data on average distance and time spent traveling to and from an emissions testing facility, average times spent waiting in line prior to the test and while the test is performed, and consumer wage rates reported by the U.S. Bureau of Labor and Statistics as inputs for our analysis. Inconvenience costs were estimated by calculating the total inconvenience cost per test multiplied by the total number of tests performed.

Vehicle owners realize some degree of cost savings from improved fuel economy as a result of vehicle repairs precipitated by the AIR Program's emissions testing requirements. Therefore, it is important to offset the total costs by these fuel economy savings. We estimated that the AIR Program reduces fuel consumption by approximately 1.5 million gallons per year based on emissions test data for those vehicles that received full-length IM240 tests for both the initial and final tests. Total fuel economy savings were estimated using the total estimated gallons of fuel saved per year multiplied by the average cost per gallon ($2.64) for the Denver Metropolitan Area in 2019. This was the cost per gallon reported by the Energy Information Agency for regular unleaded gasoline in 2019. Fuel economy savings reduce the overall estimated costs of the AIR Program to vehicle owners.

Overall, as shown in Exhibit 18, we estimate that the total net cost of the AIR Program to vehicle owners was about $61.8 million in 2019. Detailed information about our cost analysis is available in Appendix A.

Exhibit 18. Estimated Total Net Costs of the AIR Program, Calendar Year 2019

	Estimated Cost (in millions)	Percent of Total
Test Fee	$23.3	38%
RapidScreen Fee	$3.4	5%
Registration Fee	$7.1	11%
Repair Costs	$14.7	24%
Inconvenience Cost	$18.0	29%
Fuel Economy Savings	($4.6)	-7%
Total Net Cost	**$61.8**	**100%**

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment and other publicly available information.

Cost per Ton of the Ozone Precursors Removed

Earlier in this chapter, we provided the results of our analysis to estimate reductions in ozone precursor emissions as a result of the AIR Program (see related discussion of Exhibit 3). This tons-per-day emissions reduction benefit represents the denominator of the cost-effectiveness ratio.

Exhibit 19 shows the calculation of the cost-effectiveness ratio for the AIR Program in 2019. Overall, our analysis shows that the AIR Program reduces ozone precursor emissions at a cost of about $16,759 per ton. This value can be compared to that determined in the 2017 audit of the AIR Program, which was $7,481 per ton, less than half of the cost per ton calculated in this audit. The primary reason for the much higher cost per ton shown for Calendar Year 2019 in Exhibit 19 is that the emissions benefits in the 2017 audit were estimated to be 25.5 tons per day, while the current audit estimates the benefits to be 10.11 tons per day. The primary reason for this is that emissions from gasoline powered light-duty vehicles as estimated by EPA's latest MOVES3 model are lower than those estimated by the older and now obsolete MOVES2014 model used in the 2017 audit.[19] Another important factor is that overall emissions from the DM/NFR area vehicle fleet are declining over time because of more stringent emission standards that apply to newer model-year vehicles.

Exhibit 19. Cost-Effectiveness of the AIR Program, Calendar Year 2019

Total Net Cost	$61.8 million
Total Daily Emissions Reduction Benefit [1]	10.11 tons per day
Total Annual Emissions Reduction Benefit (daily emissions reduction benefit × 365 days)	3,690 tons
Cost-Effectiveness Ratio (Total Net Cost/Annual Benefit)	**$16,759 per ton**

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.
[1] Based on the results of MOVES3 modeling.

There are no generally accepted criteria for determining what is or is not a cost-effective emission control strategy. However, in our experience, $16,759 per ton is a reasonable value at this point in time. One point of reference are voluntary actions that have been taken to implement emission control measures in California where a 2021 California Air Resources Board report (California)[20] found that cost-effectiveness ratios for mobile source control measures range from $12,000 to $100,000 per ton, but are based on control of HC, NO_X and particulate matter and do include CO.

Given this, it is also instructive to examine cost-effectiveness ratios on a pollutant specific basis, as shown in Exhibit 20, where all program costs are allocated to reducing each pollutant individually, the combination of HC+NO_X and HC+NO_X+CO/60. Focusing on HC+NO_X, the most relevant comparison to California's cost-effectiveness values, the value for the AIR program in 2019 is $19,386 per ton, which is still well within the range of the California values. The conclusion that the AIR program is cost-effective is also supported by the DM/NFR area ozone source apportionment data, which indicate that ambient ozone levels are more sensitive

[19] EPA periodically updates its emission inventory models and requires that the latest version be used for air quality planning. MOVES3 was released in 2021.

[20] See Appendix H of the Proposed FY 2021-22 Funding Plan for Clean Transportation Incentives which is available at https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1

to motor vehicle emissions than other sources of emissions. This means that from the perspective of ozone control, a ton of emission reductions from motor vehicles has a greater benefit than a ton of emission reductions from other sources, making the motor vehicle reductions more valuable and justifying a higher cost-effectiveness ratio for their control.

Exhibit 20. Cost-Effectiveness of the AIR Program by Pollutant, Calendar Year 2019

Pollutant	Emission Reductions (Tons Per Day [1])	Cost-Effectiveness Ratio (Annual Cost Per Ton Reduced)
Hydrocarbons (HC)	4.07	$41,631
Carbon Monoxide (CO)	88.67	$1,910
Nitrogen Oxides (NO_X)	4.57	$37,076
HC + NO_X	8.63	$19,634
HC + NO_X + CO/60 [2]	10.11	$16,759

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.
[1] Based on the results of MOVES3 modeling.
[2] Tons-per-day reduction amounts estimated for the individual ozone precursors are combined using the following formula: HC+NO_X+CO/60. This formula discounts the tons-per-day reduction amounts for carbon monoxide when combining with the other ozone precursors to recognize that carbon monoxide has a smaller impact on ozone levels than hydrocarbons and NO_X.

Assessment of Potential Program Modifications

In the legislative declaration to the Colorado Air Pollution Prevention and Control Act [Section 25-7-102, C.R.S.], the General Assembly states its intention that the State of Colorado "use all available practical methods which are technologically feasible and economically reasonable so as to reduce, prevent, and control air pollution" and develop an air quality control program in which "the benefits of the air pollution control measures utilized bear a reasonable relationship to the economic, environmental, and energy impact and other costs of such measures." To achieve this legislative intent, the Department, in partnership with the Commission and the Council, is continually assessing ways to improve Colorado's overall air quality control program, including the AIR Program.

Although the DM/NFR area has not yet attained the ozone air quality standards, our analyses in the previous sections show that the AIR Program has a positive effect on the DM/NFR area's current and future compliance efforts and that there are several possible opportunities for making targeted changes to the AIR Program to help it operate as effectively as possible, while also considering the cost impacts to vehicle owners and operational realities. These opportunities are reflected in the recommendations presented below.

Recommendation No. 1

The Colorado Department of Public Health and Environment (Department) should consider the following modifications with respect to the Automobile Inspection and Readjustment Program (AIR Program):

a. The AIR Program should impose pre-pandemic test requirements, including:
   i. Exempting the newest 7 model years from AIR Program test requirements.
   ii. Performing IM240 tests on 1982 and newer model-year vehicles up to 12 model years old.

iii. Performing OBD tests on 8 to 11-year-old vehicles. If these vehicles do not meet OBD readiness requirements but pass all other OBD pass/fail criteria, they should receive IM240 tests.

b. If confirmatory IM240 testing is discontinued for 8 to 11 model-year vehicles that do not meet OBD readiness requirements, the Department should instead require these vehicles to meet the OBD readiness requirements.

Response from Department of Public Health and Environment

a. Agree
Implementation Date: March 31, 2023

The Department agrees to implement Recommendation 1.a by March 31, 2023, as long as the impacts of the pandemic remain as they are as of November 2022 and no additional pandemic restrictions are imposed in 2022 or the beginning of 2023. While unlikely, any new pandemic restrictions or mandatory closures may delay implementing some elements of Recommendation 1.a.

b. Agree
Implementation Date: March 31, 2023

The Department agrees to implement Recommendation 1.b. This program modification was implemented to reduce vehicle emissions testability issues created by the pandemic. Forgoing any additional pandemic restrictions, Recommendation 1.b. will be fully implemented by March 31, 2023.

Recommendation No. 2

The Colorado Department of Public Health and Environment (Department) should perform an analysis to determine if the reductions in emissions that would occur in the Denver Metro/North Front Range (DM/NFR) area from expansion of the AIR Program to El Paso County would be a cost-effective strategy to assist in compliance (and maintenance of compliance) with the 2008 and 2015 ozone standards compared to the other control measures that are being considered for implementation in the DM/NFR area. The Department should determine the appropriate next steps based on the results of its analysis.

Response from Department of Public Health and Environment

Agree
Implementation Date: January 31, 2024

The Department agrees to perform an analysis to determine if expanding the AIR Program into El Paso County would be a cost effective strategy for reducing pollutants in the Denver Metro and Northern Front Range areas. Recommendation 2 will be completed by January 31, 2024. This allows the Department the opportunity collect additional data in 2023 and use contemporary emissions monitor results from the 2023 ozone season. The Department will determine the appropriate next steps depending on the results of the analysis.

APPENDIX A: AIR PROGRAM COST DATA

Exhibit A-1. Test Fees by Test Type Calendar Year 2019

Test Type	Number of Paid Tests [1]	Test Fee	Total
IM240	596,719	$25	$14,917,975
OBD	293,182	$25	$7,329,550
TSI [2]	43,025	$15-25	$1,025,485
RapidScreen	136,304	$25	$3,407,600
Total	**1,069,230**		**$23,273,010**

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.
[1] Paid tests include vehicles that receive two or more retests.
[2] The fee for the TSI test is $15 or $25, depending on the vehicle's age.

Exhibit A-2. Additional Registration Fees Calendar Year 2019

Number of Registered Vehicles [1]	Fee	Total
3,207,812	$2.20	$7,057,186

Source: AIR Program 2019 Annual Report by the Colorado Department of Public Health and Environment.
[1] Based on the number of passenger vehicles and light-duty trucks registered in the AIR Program Area, including those newer vehicles that are exempt from emissions testing requirements.

Exhibit A-3. Estimated Total Repair Costs by Test Type Calendar Year 2019

Test Type	Average Cost to Repair Failed Vehicles	Count of Test Failures	Count of Gas Cap Failures [1]	Total Repair Cost
IM240	$381	22,645	25,396	$9,135,665
OBD	$392	11,253	7,221	$4,555,596
TSI	$389	2,542	450	$997,838
	Total	**36,440**	**33,067**	**$14,689,099**

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment.
[1] Each gas cap repair is assumed to cost $20.

Exhibit A-4. Fuel Savings Calculated from Repairs 2019

Fail Reason	Miles per Gallon Before Repairs [1]	Miles per Gallon After Repairs [1]	Percent Increase	Number of Vehicles [2]	Annual Miles [3]	Gallons Saved
IM240	19.98	21.42	7.21%	41,156	7,634	1,057,141
Fail OBD	20.53	21.92	6.77%	16,123	10,447	520,263
TSI [4]	19.98	21.42	7.21%	2,383	5,253	42,119
Total from Exhaust Repairs						**1,619,790**
Total from Evaporation Repairs (Based on Evaporative Emission Reductions)						**126,533**
Total Gallons Saved per Year						**1,746,323**
Cost Savings at $2.64 per Gallon [5]						**$4,610,292**

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment and other publicly available data.
[1] Based on vehicles receiving full-length IM240 tests.
[2] Number of vehicles that failed and then passed.
[3] Based on mileage accumulation rates from dKC's MOVES modeling.
[4] Assumed to be the same as the IM240 test.
[5] Energy Information Agency.

Exhibit A-5. Parameters Used to Estimate Customer Inconvenience Cost for AIR Program Inspections Calendar Year 2019

Parameter	Assumed Value
Distance to station (miles)	7
Average speed	11.12
Average cost to operate vehicle	$0.58
Consumer wage rate/hr.	$27.73
Average wait time (min)	7.5
Average test time (min)	14
Total Time per Test	43.74
Cost per test @ 50% average wage	$18.23
# of tests (including retests)	989,070
Inconvenience Cost	$18,028,357

Source: dKC's analysis of AIR Program data provided by the Colorado Department of Public Health and Environment and other publicly available data.