# Garfield County Emissions Inventory

Prepared for Garfield County

Prepared by the Colorado Department of Public Health and Environment

Air Pollution Control Division

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## Executive Summary

The air we breathe in many U.S. cities is being polluted by activities such as driving cars and trucks, burning coal, oil, and other fossil fuels, and manufacturing chemicals. Air pollution can even come from smaller, everyday activities such as dry cleaning, filling your car with gas, and degreasing and painting operations. These activities add gases and particles to the air we breathe. When these gases and particles accumulate in the air in high enough concentrations, they can harm both our environment and us. More people in cities and surrounding counties means more cars, trucks, industrial and commercial operations, and generally means more pollution.

Garfield County's Environmental Health Program in collaboration with a number of partners in both government and the private sector began a comprehensive effort in 2005 to assess and better characterize the sources and amount of air emissions in the county. This emissions inventory report is a part of that analysis effort. The report describes both the natural and man-made emissions that contribute to air quality in the county. For a number of reasons, air pollutants that are transported into the county are not considered in this report.

The report provides the reader a general context of how to use the data presented and what are the pollutants that are inventoried. Pollutants inventoried include some of the "criteria" or health-based pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, particulates) as well as volatile organic compounds. The county inventory focuses on emission levels in 2007, which is the most recent year for a complete inventory. Other years are included to show the trends over time.

The report describes the largest sources of pollution by pollutant. In some cases the largest sources of emissions are natural or biogenic. This is particularly valid for volatile organic compounds. In many cases, man-made, or anthropogenic, emissions are the largest sources. Major man-made categories include mobile sources (cars and trucks), stationary sources (specific emission point sources large enough to require a permit) and area sources (small pollution sources located over a wide area, such as wood burning). For carbon monoxide and sulfur dioxide, highway vehicles are the largest source in Garfield County, followed by non-road vehicles. For nitrogen dioxide, stationary sources, highway vehicles and oil and gas sources are the primary contributors. For $PM_{10}$, construction and road dust are the largest sources.

The report describes the point source emission inventory in detail with a specific section on oil and gas development, due to public concerns in the area. It is noted that oil and gas sources provide the bulk of emissions in Garfield County. Because the county has experienced rapid growth and development of oil and gas in the past few years, it is important that the inventory be placed in context. Total emissions from several western Colorado counties as well as counties along the Front Range are included for comparative purposes.

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# 1.0 Introduction

The Garfield County Air Quality Technical Advisory Group is presently doing an assessment of the air quality issues in the Garfield County area. The purpose of this report is to present basic emission information to county officials and the public about the specific nature of air quality in Garfield County. This report will present the various contributions of air pollution that add to the air quality in the area and attempt to quantify the levels of pollution for each source. This report does not look at any monitored concentrations of pollutants in the ambient air. In order to provide a general understanding of emission inventories, the following sections provide a general description of the purpose of emission inventories, how they are prepared, and common methodologies used in preparing them.

## 1.1 What is an emissions inventory?

An emissions inventory is an estimation of the amount of pollutants emitted from pollution sources in a given area over a specific amount of time. Pollutants may be emitted naturally, such as from plants, or from anthropogenic (man-made) sources. Inventories are developed using geographic information system (GIS) techniques to determine the known sources of air pollution that exist in an area. These sources are typically broken into three categories: point, area, and mobile sources. More detailed information on subcategories may be found in Appendix C.

*Point Sources:*
Point sources are individual stationary facilities that emit pollutants. These include such industries as power plants, asphalt plants, refineries, compressor stations and quarries.

*Mobile Sources:*
Mobile sources are typically broken into two major subcategories: highway vehicles emissions (on-road), and non-road. On-road mobile sources include light-duty vehicles, light-duty trucks, heavy-duty vehicles, and motorcycles, used for transportation on the road. On-road vehicles may be fueled with gasoline, diesel fuel, or alternative fuels such as alcohol or natural gas. Non-road mobile sources include non-road gasoline equipment and vehicles, non-road diesel equipment and vehicles, aircraft, marine vessels, locomotives, and assorted other engines and vehicles.

*Area Sources:*
Area sources collectively represent individual sources that are small and numerous, and that have not been inventoried as specific point, mobile, or biogenic sources. They include such sources as residential and commercial fuel combustion, gas wells, biogenic emissions, structural fires, wild fires and prescribed burning. Biogenic emissions are pollutants from natural sources such as plants, animals, marshes, and the earth itself. Vegetation for example, emits large amounts of isoprene, terpenes, and other organic compounds that are potential precursors of ozone. Biogenic sources are not controllable sources of air pollution.

The process for preparing the emission inventory involves several steps. First, the boundary of the study area is defined, which in this case is Garfield County. Then the sources of data for each category must be identified. The Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE) has developed a statewide emission

inventorying system and uses a number of standardized methodologies to make emission estimates for various source categories. These methodologies are discussed in more detail for each category in section 1.4 of this report. Finally, once the source calculations are made, a summary report is prepared along with supporting tables, graphs and charts.

Some data are from an emissions inventory developed by the Western Regional Air Partnership (WRAP) that specifically relates to oil and gas sources. The methods and modeling associated with this emissions inventory use different inputs than the APCD inventory and thus, some differences can be noted. A more complete explanation can be found in Appendix D.

It needs to be kept in mind that an emissions inventory is constantly evolving. As industries start up, shut down or modify, emissions in an area change. Additionally, there are minimum reporting limits, so an emissions inventory probably underestimates the true total emissions in an area. These minimum reporting limits have been reduced over time, so older inventories may not be comparable to newer inventories for certain industrial sectors. Finally, emissions inventory values are based on permitted emissions limits, (not on monitoring), which are the maximum "potential to emit" amounts that a facility is allowed to release in a year. Thus, actual emissions may be less for the year and potentially could happen all on one day in an extreme case.

### 1.2 How can this emissions report be used?

Emissions reports can be used for a variety of planning areas. These include:

1. Identify sources and general emission levels;
2. Inputs for certain air quality models and to compare to results of other air quality models;
3. Evaluate trends and meeting of air quality goals;
4. Evaluate potential exposure risks; and
5. Provide reports to the public and to agencies.

In general, the ultimate goal of the planning process is to identify and achieve a level of emissions that does not result in violation of national and state ambient air quality standards.

### 1.3 What air pollutants are included in an emissions inventory?

The U.S. Environmental Protection Agency (EPA) has set national ambient air quality standards (NAAQS) for six common pollutants (also referred to as "criteria" pollutants) and uses these as indicators of air quality. These criteria pollutants are carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, particulates and lead. These pollutants are monitored to determine if an area has "clean" air or "dirty" air. Monitors are set up around the state to measure the concentrations of pollutants in the ambient air. If an air shed is determined to have dirty air, the regulating agency must implement stricter air pollution regulations.

An emissions inventory includes most of the same pollutants because they are often used for regional air quality planning and modeling. Ozone is not included as it is a secondary formation pollutant and is not directly emitted from sources. Lead is not included but nationally is included as a "hazardous air pollutant" (HAP) in certain inventories rather than as an individual pollutant.

Additional pollutants may also be included in an emissions inventory. The air shed above Garfield County is considered "clean" because the monitored air pollutants (and expected levels of non-monitored air pollutants) have not exceeded the national standards. Below is a brief discussion of each air pollutant that is included in this emission inventory report and some of the potential health effects from each pollutant. Health and risk information on these and other pollutants is available from the Agency for Toxic Substances and Disease Registry (ATSDR).

*Carbon Monoxide (CO):*
Carbon monoxide (CO) is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated CO levels can cause impairment of visual perception, manual dexterity, learning ability and performance of complex tasks.

*Nitrogen Dioxide ($NO_2$):*
Nitrogen dioxide ($NO_2$) is a brownish, highly reactive gas that is present in all urban atmospheres. $NO_2$ can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides (NOx), which include nitric oxide (NO) and $NO_2$, are an important precursor both to ozone ($O_3$) and acid rain, and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of $NO_2$ in the atmosphere is the oxidation of the primary air pollutant NO. NOx plays a major role, together with VOCs, in the atmospheric reactions that produce $O_3$. NOx forms when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

*Sulfur Dioxide ($SO_2$):*
High concentrations of sulfur dioxide ($SO_2$) affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. $SO_2$ is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country. This is especially noticeable in national parks. Ambient $SO_2$ is largely from stationary sources such as coal and oil combustion, steel mills, refineries, pulp and paper mills, nonferrous smelters and forest fires.

*Particulate Matter ($PM_{10}$ and $PM_{2.5}$):*
Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as $SO_2$ and VOCs are also considered particulate matter. Some of the health concerns include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive

pulmonary or cardiovascular disease or influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials, and is a major cause of visibility impairment in the United States. This report includes particulate matter with a diameter of 10 microns or less. However, smaller particulate matter with a diameter of 2.5 microns or less are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract.

*Volatile Organic Compounds (VOC):*
VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, gasoline, cleaning supplies, pesticides, building materials and furnishings, and office equipment such as copiers and printers. VOCs are also released from oil and gas development sources. VOCs are not considered one of the six "criteria" pollutants for which EPA has set a national standard. However, VOCs can act as precursors to the formation of ground level ozone ($O_3$). In this report, VOCs do not include benzene, which is listed separately.

*Benzene:*
Benzene is found in the air from emissions from burning coal and oil, oil and gas development, gasoline service stations, and motor vehicle exhaust. Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidence of leukemia (cancer of the tissues that form white blood cells) have been observed in humans occupationally exposed to benzene. EPA has classified benzene as a "Group A" human carcinogen. Benzene is one of the VOC compounds, but is broken out and discussed independently as it is typically associated with oil and gas production as well as mobile sources.

### 1.4 What methods were used in developing this emission inventory?

As discussed above, emission sources are divided into three major categories: stationary point sources, mobile sources, and area sources. Generally, emission estimates for each category are made using established emission factors multiplied by an activity rate. An emission factor is a representative value that attempts to relate the "potential to emit" quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. The general equation for emissions estimation is:

$$E = A \times EF$$

where:

E = emissions;
A = activity rate;
EF = emission factor

*Stationary/Point Source Methods:*
Point sources are also referred to as stationary sources. The APCD requires any source that emits two tons per year or greater of the above listed pollutants (excluding benzene) to submit an Air Pollutant Emission Notice (APEN). This means that sources that emit less than two tons per year are not necessarily accounted for in an emissions inventory. The point source emissions for Garfield County were obtained from this tracking system. The emission estimates are made using a variety of methodologies. Data from source-specific emission tests, or continuous emission monitors are preferable, but not always available. The EPA has developed a variety of emission factors to estimate emissions as well. Emission factors are frequently the best or only method available for estimating emissions. Appendix C provides more specific detail on methodologies for estimating emissions from point sources.

*Mobile Source Methods:*
Mobile sources are classified in two major subcategories: highway vehicle emissions (called on-road), and non-road.

*Highway Vehicles Methods:*
The EPA model MOBILE6 is an emission factor model for predicting gram per mile emissions of Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx), Carbon Dioxide ($CO_2$), Particulate Matter (PM), and toxics from cars, trucks, and motorcycles under various conditions. EPA is currently developing a new MOVES model that will replace MOBILE6 in the near future.

*Non-Road Methods:*
Emissions from non-road mobile sources were calculated using the EPA Non-road Emission Factor Model. The model provides emission estimates at the county level.

*Area Sources Methods:*
Area sources were based on the EPA National Emission Trends (NET) inventory. This is a county-by-county inventory that utilizes population apportionment methods and is corrected to minimize double counting with the point source inventory. Appendix C provides a more detailed explanation of the methods for each type of area source.

## 2.0 Garfield County Emissions Inventory

Table 2.1 provides a summary of the 2007 Garfield County emissions inventory for all sources. The values shown are in tons per year. This table was also used to produce Figures 2.1 through 2.7, which provide a pollutant percentage distribution as well as a percentage breakout of the sources of emissions for each pollutant in the inventory. As can be seen in both Table 2.1 and Figure 2.1, VOC's are the largest percentage of emissions followed by carbon monoxide. It can also be seen that these two pollutants are emitted in significantly higher quantities than the other pollutants.

**Table 2.1. Summary of 2007 Garfield County Emissions Inventory**

| Category | CO (tons/yr.) | $NO_2$ (tons/yr.) | $SO_2$ (tons/yr.) | $PM_{10}$ (tons/yr.) | VOC (tons/yr.) | Benzene (tons/yr.) |
|---|---|---|---|---|---|---|
| Agriculture | | | | 81.44 | | |
| Aircraft | 38.07 | 0.20 | 0.02 | 0.78 | 1.46 | 0.04 |
| Biogenic | 3,730.07 | 471.11 | 0.00 | 0.00 | 27,965.63 | 0.00 |
| Commercial Cooking | 12.44 | | | 32.68 | 4.34 | 0.46 |
| Construction | | | | 1,016.87 | | |
| Forest and Prescribed Fire | 2,241.20 | 59.87 | 18.79 | 306.71 | 142.81 | 10.74 |
| Fuel Combustion | 28.28 | 66.00 | 1.87 | 0.42 | 3.83 | 0.00 |
| Highway Vehicles | 21,255.37 | 2,010.40 | 16.23 | 46.01 | 1,288.10 | 36.78 |
| Non-Road | 3,964.10 | 324.29 | 10.39 | 33.18 | 374.98 | 12.40 |
| O&G Area | 4,147.00 | 4,639.00 | 185.00 | 664.00 | 14,635.00 | |
| O&G Point | 3,152.32 | 4,281.28 | 10.84 | 109.07 | 8,195.88 | 202.08 |
| Other Point Sources | 125.45 | 113.39 | 20.15 | 237.41 | 1,920.33 | 11.59 |
| Railroads | 50.02 | 507.72 | 28.92 | 12.60 | 18.90 | 0.04 |
| Road Dust | | | | 1,082.59 | | |
| Solvent Utilization | | | | | 123.60 | 4.80 |
| Structure Fires | 3.15 | 0.08 | | 0.57 | 0.57 | |
| Surface Coating | | | | | 190.92 | |
| Woodburning | 3635.83 | 38.78 | 7.68 | 507.44 | 978.70 | 24.58 |
| TOTAL | 42,383.29 | 12,512.11 | 299.90 | 4,131.75 | 55,845.06 | 303.52 |

Notes: VOC does not include Benzene, which is listed separately.
Zero values are for data that have been reported as zero or estimated to be zero.
Blank values are those for which no data has been reported or estimated.

**Figure 2.1. 2007 Garfield County Pollutant Distribution**

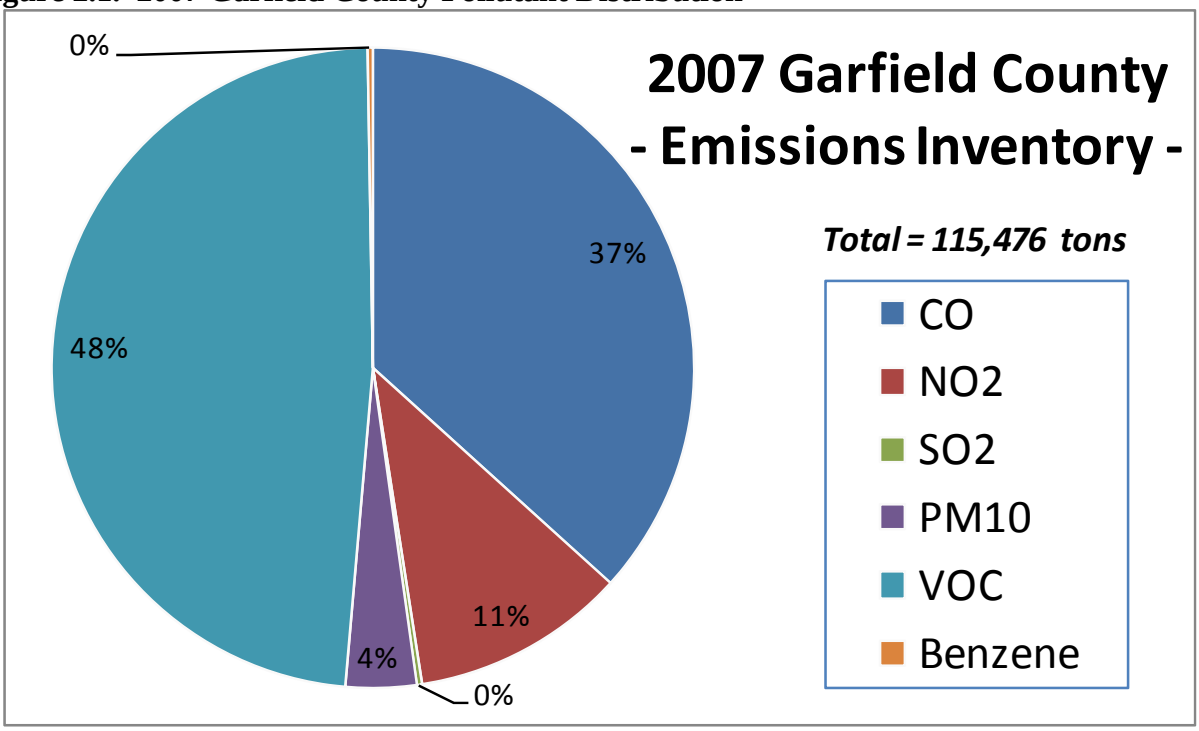



Figure 2.2 shows that highway vehicles are the largest contributor to carbon monoxide emissions. The oil and gas area and point sources, when combined, are the second largest contributor. Both of these source types are related to fuel combustion. Likewise, nitrogen dioxide emissions show a similar trend, though oil and gas sources are dominant over highway vehicles (Figure 2.3).

For sulfur dioxide (Figure 2.4), the primary contribution is from oil and gas area sources. This is most likely from diesel engines. It must be emphasized that for sulfur dioxide, the total tons per year is quite small in comparison to some of the other pollutants. $PM_{10}$ is another pollutant that has very small annual emissions from sources. Most emissions are in the "all other" category.

VOCs are the largest pollutant emitted in Garfield County and are dominated by the biogenic category. This is typical for most areas. Oil and gas area and point sources make up the bulk of the rest of the emissions, which is not as typical. Benzene, is a very small annual emission, but is dominated by the oil and gas point source category.

**Figure 2.2. 2007 Garfield County CO Emission Sources**

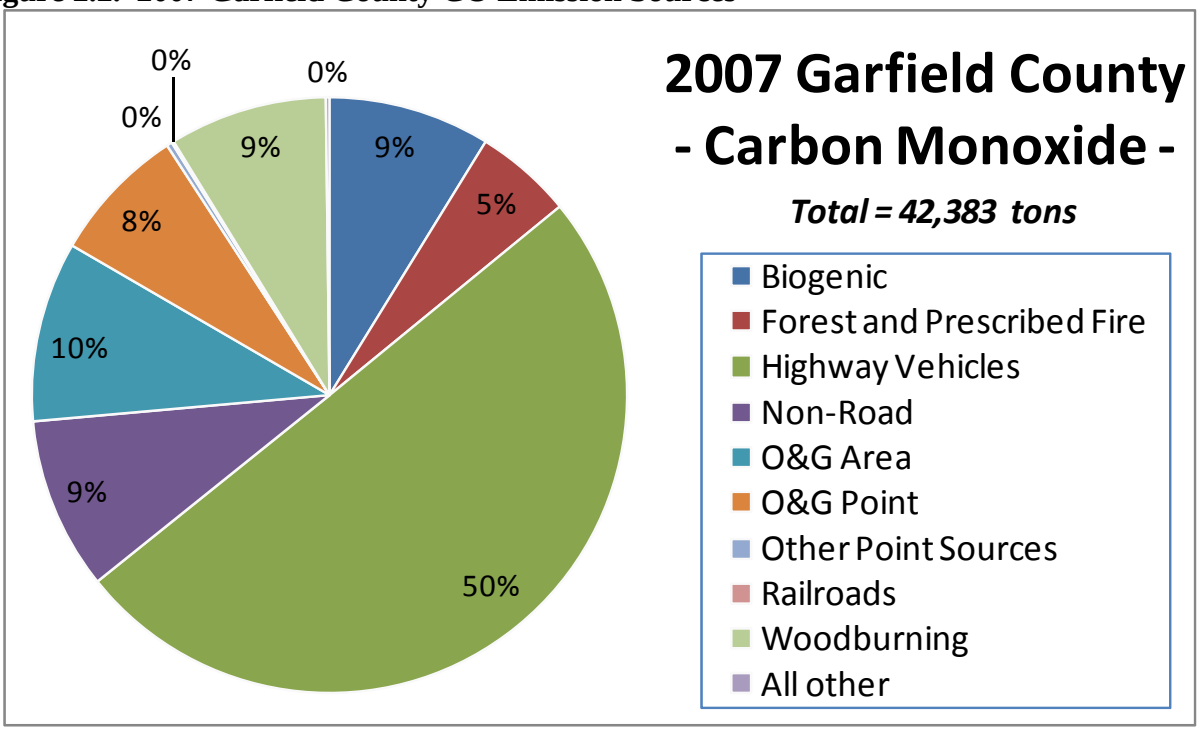



**Figure 2.3. 2007 Garfield County $NO_2$ Emission Sources**

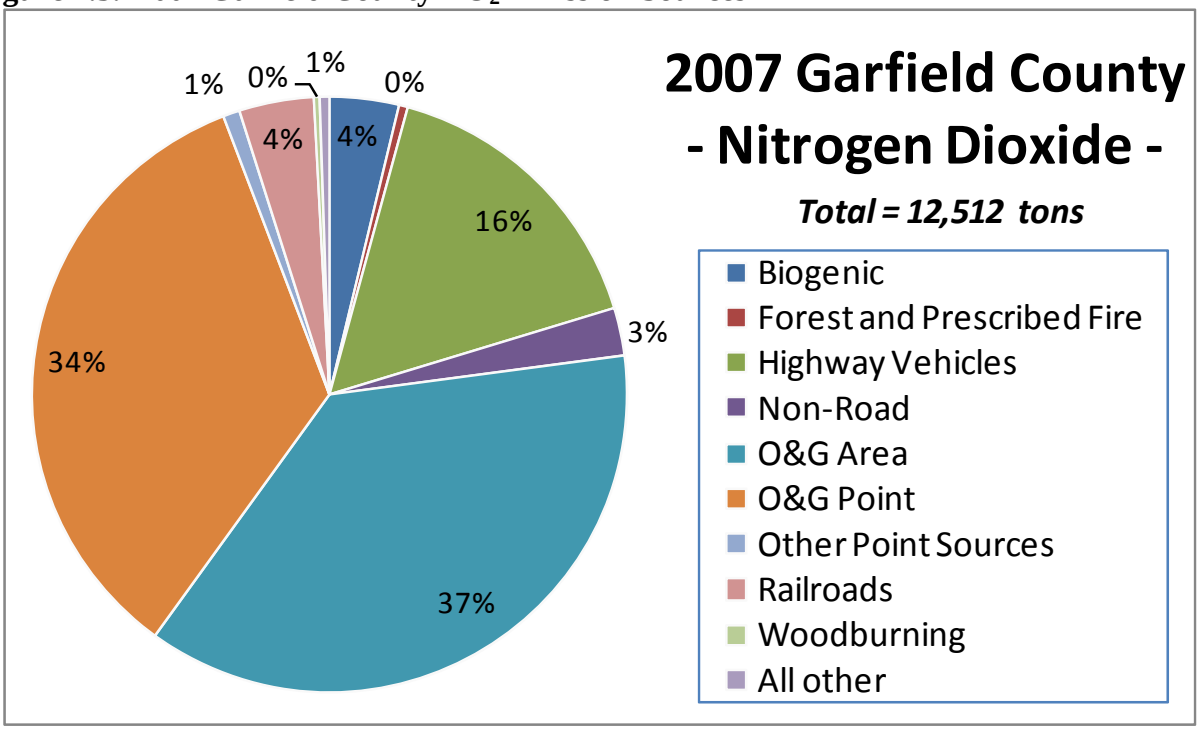


**Figure 2.4. 2007 Garfield County $SO_2$ Emission Sources**

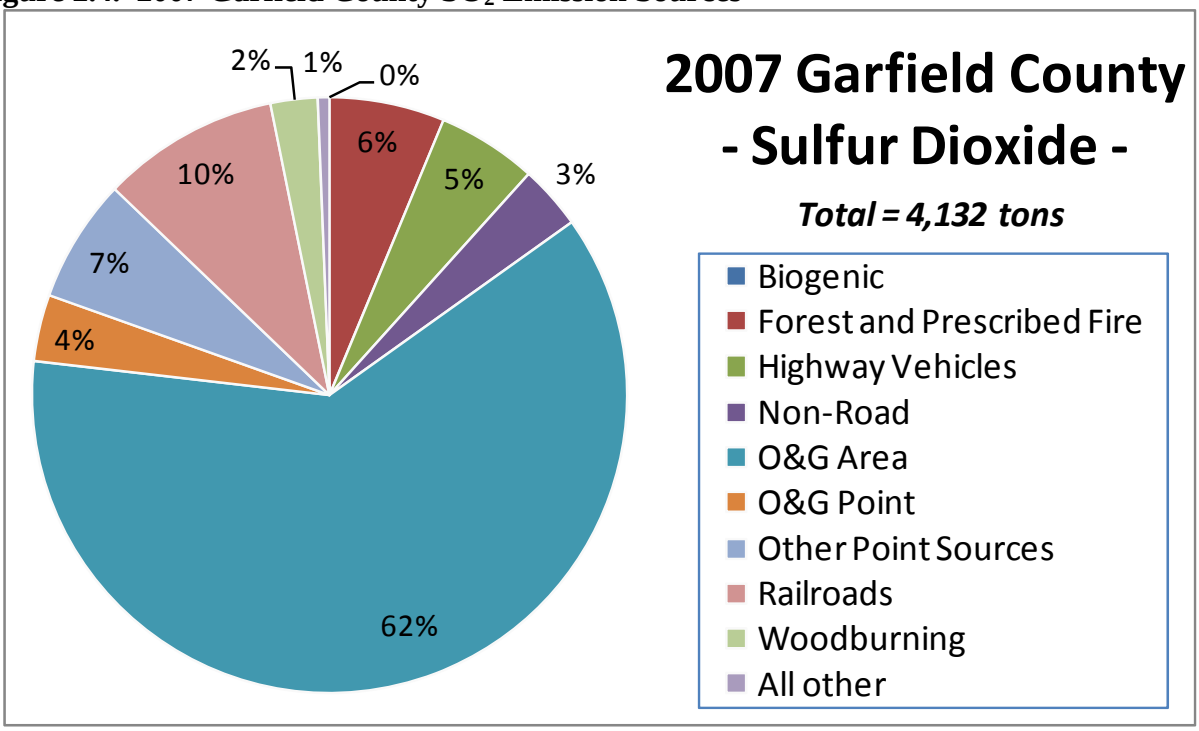



**Figure 2.5. 2007 Garfield County $PM_{10}$ Emission Sources**

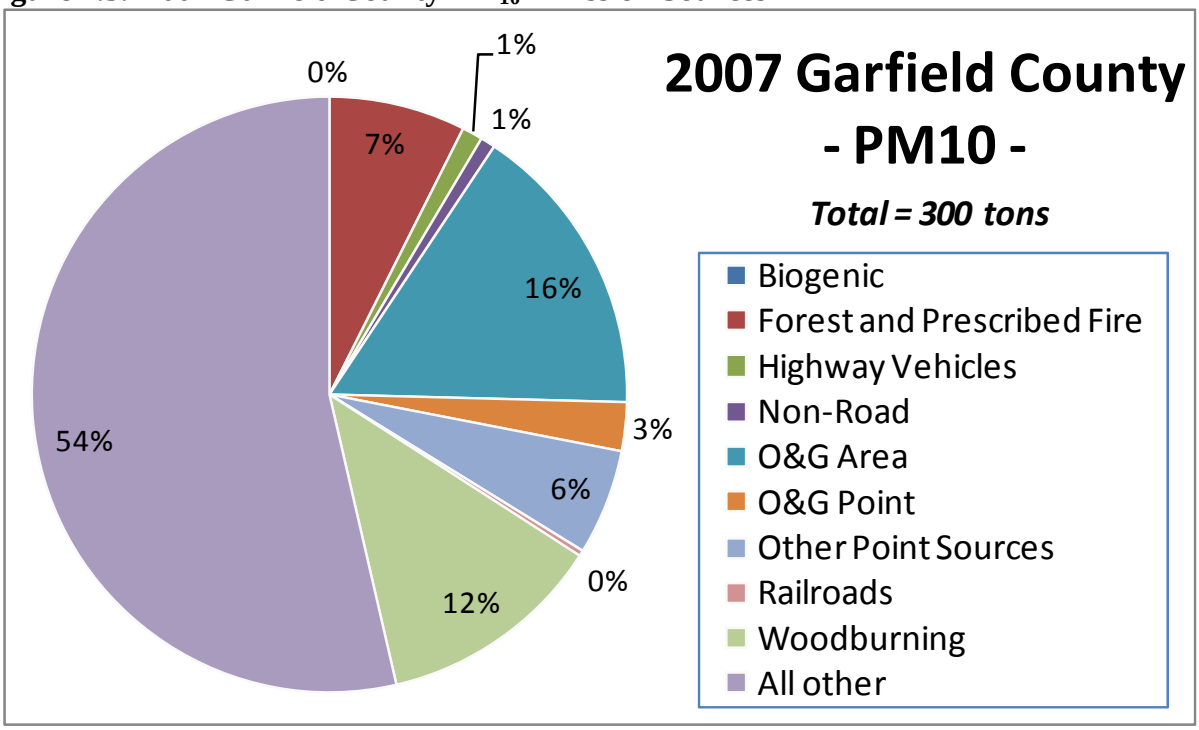


**Figure 2.6. 2007 Garfield County VOC Emission Sources**

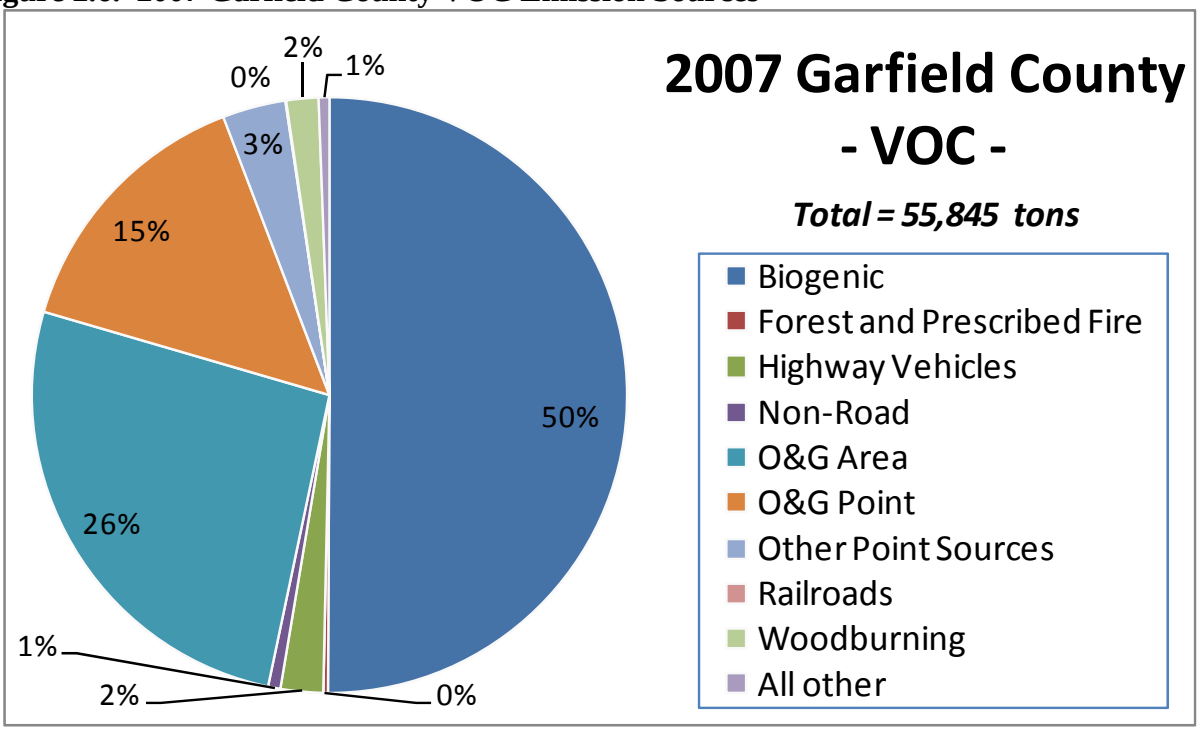
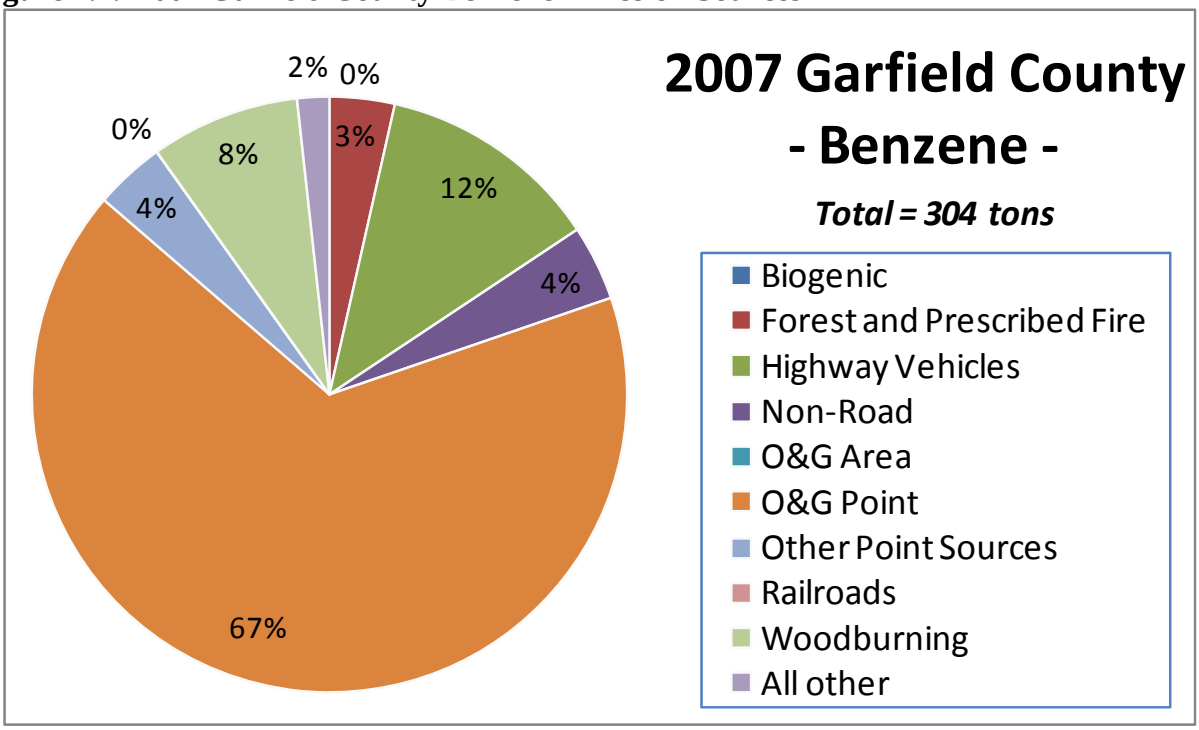



**Figure 2.7. 2007 Garfield County Benzene Emission Sources**



## 3.0 Garfield County Point/Stationary Source Emissions Summary

This section outlines total emissions from all point/stationary sources in Garfield County. These emissions are extracted from the APCD APEN database as described earlier. The APEN database is a dynamic system in which data are constantly added, changed or eliminated as new sources are reported and old sources are canceled or their emissions change. Figure 3.1 presents a map of Garfield County showing all documented point sources in EPA's EnviroFacts files in 2008. Table 3.1 is a break out of total emissions from all stationary sources in Garfield County, based on APCD's APEN database. Figure 3.2 provides a graphical representation of the different types of stationary sources by percentage of emissions.

**Figure 3.1. Map of Garfield County Point Emission Sources**

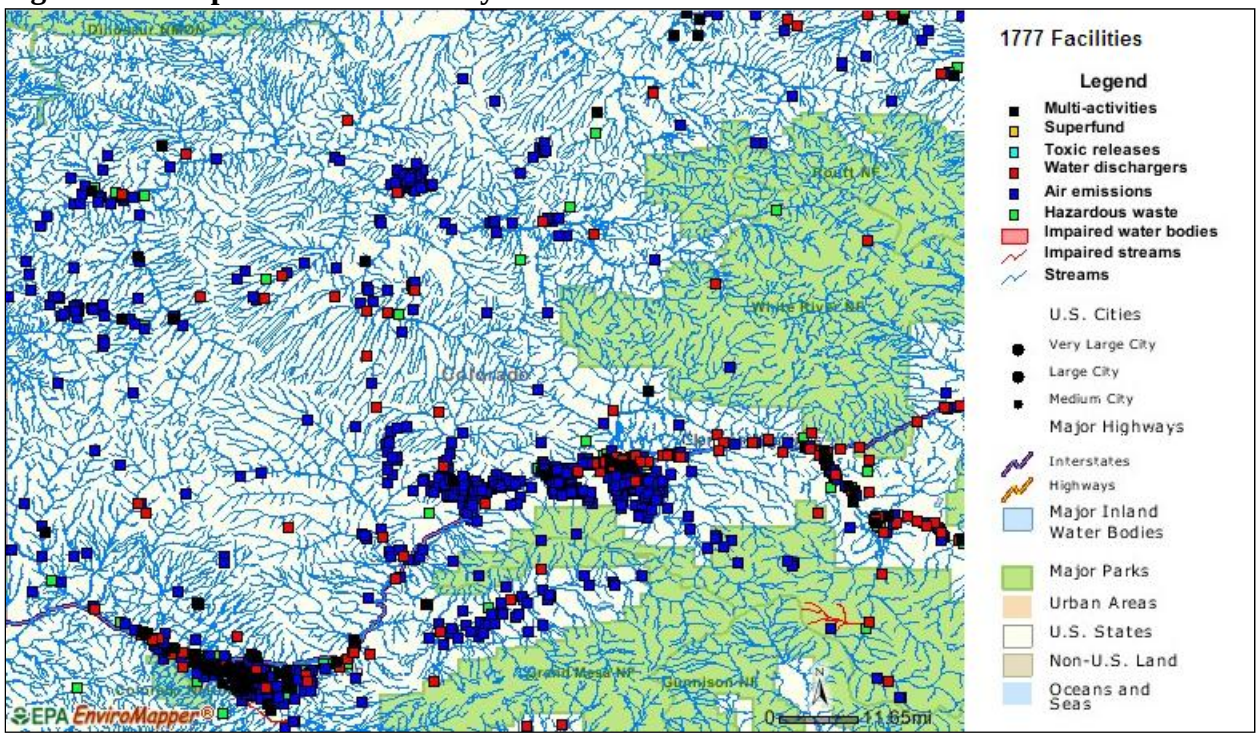
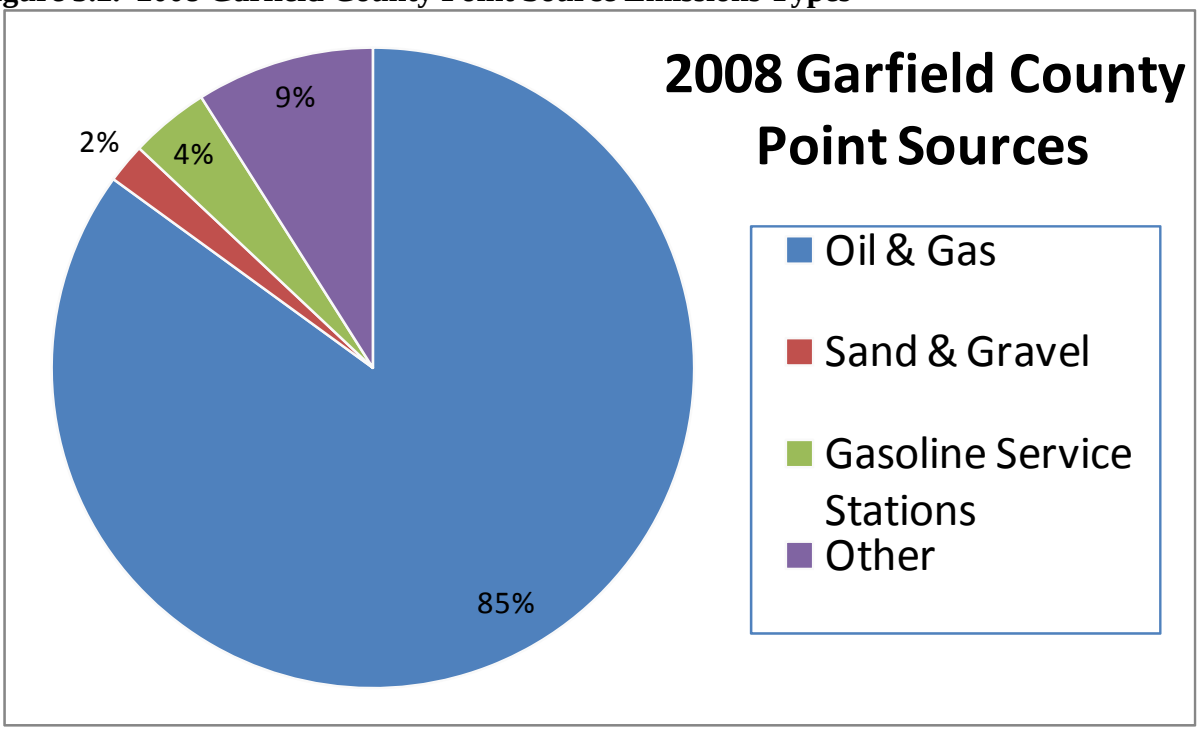


**Table 3.1. 2008 Garfield County Stationary Point Source Emissions**

| Pollutant | As of January 2008 (tons/yr.) |
|---|---|
| CO | 2576 |
| $NO_2$ | 3863 |
| $PM_{10}$ | 293 |
| $SO_2$ | 31 |
| VOC | 7521 |
| Total CAA HAPs | 1163 |
| Benzene | 205 |
| Ethyl Benzene | 7 |
| Toluene | 379 |
| Xylene | 359 |

NOTES: Clean Air Act HAP's do not include the BTEX compounds (benzene, toluene, ethyl benzene and xylene), which are listed separately.

**Figure 3.2. 2008 Garfield County Point Source Emissions Types**




These source types are broken down by Standard Industrial Codes (SIC). For a detailed description of all the sources by SIC, see Appendix E. As shown above oil and gas stationary sources are 85% of the total of stationary sources. Sections 3.1 and 3.2 provide a more detailed breakdown on oil and gas emissions.

### 3.1 APCD Oil and Gas Emissions Summary

Stationary sources, which include emissions from oil and gas development, are a major source of $NO_2$ and VOC (which includes benzene). A closer look at these sources is provided in Table 3.2, with the oil and gas industry listed separately. These emissions were extracted from the APCD APEN database, are listed in tons per year, and are current as of January 2008.

**Table 3.2. 2008 Garfield County Oil and Gas Breakout**

| Pollutant | Oil and Gas Emissions (tons/yr.) | Non-Oil and Gas Emissions (tons/yr.) | Total Emissions (tons/yr.) |
|---|---|---|---|
| CO | 2438 | 140 | 2445 |
| $NO_2$ | 3600 | 211 | 2671 |
| $PM_{10}$ | 82 | 228 | 284 |
| $SO_2$ | 11 | 8 | 18 |
| VOC | 7150 | 273 | 7453 |
| Total CAA HAPs | 1142 | 8 | 1200 |
| Benzene | 201 | 4 | 205 |
| Ethyl Benzene | 7 | 0 | 7 |
| **Toluene** | 379 | 0 | 379 |
| Xylene | 358 | 1 | 359 |

Clearly the oil and gas industry is a large contributor of emissions in Garfield County. Again, the emissions listed above in Table 3.2 are for those sources that are required to submit an APEN per the APCD regulations.

### 3.2 WRAP Oil and Gas Emissions Summary

Some activities associated with oil and gas development are not currently required to report emissions to the APCD. These sources fall under the reporting thresholds, are exempt from reporting, or are regulated by another entity, such as the EPA. These sources are considered area sources. In an attempt to quantify all the emissions from this sector, the WRAP estimated emissions from such activities as drill rig engines, well completions, and pneumatic devices. This effort was done on a regional basis for each state. Tables 3.3 and 3.4 show how these estimated emissions were apportioned to Garfield County in 2002 and 2004.

**Table 3.3. Garfield County VOC Emissions from Oil and Gas Activities**

| | VOC tons/year 2002 | | | | VOC tons/year 2004 | | | |
|---|---|---|---|---|---|---|---|---|
| | Wellsite Tanks | Wellsite Pneumatic Devices | Gas Well Completions | Estimated TOTAL 2002 | Wellsite Tanks | Wellsite Pneumatic Devices | Gas Well Completions | Estimated TOTAL 2004 |
| Colorado | 785 | 3525 | 21,075 | 25,385 | 1,043 | 4684 | 28,004 | 33,731 |
| **Garfield** | **56** | **252** | **2,852** | **3,160** | **74** | **334** | **3,790** | **4,198** |

**Table 3.4. Garfield County NOx Emissions from Oil and Gas Activities**

| | NOx tons/year 2002 | | | NOx tons/year 2004 | | |
|---|---|---|---|---|---|---|
| | Drill Rigs | Wellhead | Estimated TOTAL 2002 | Drill Rigs | Wellhead | Estimated TOTAL 2004 |
| Colorado | 5,734 | 15,924 | 21,658 | 7,619 | 21,160 | 28,779 |
| **Garfield** | **776** | **1,137** | **1,913** | **1,031** | **1,510** | **2,541** |

The WRAP is in the process of developing more detailed inventories for each oil and gas basin in the Rocky Mountain region. The oil and gas inventory for the Piceance Basin for 2006, which includes Garfield County, was recently completed. Much of the focus was on VOCs and NOx, which have large emissions in the oil and gas development sector. Figure 3.3 provides a breakdown of VOC emissions by different source types and Figure 3.4 shows a breakdown for NOx emissions.

For both pollutants, venting activities are the largest source sector or activity. With VOCs, venting accounts for 57% of the total oil and gas emissions and for NOx, venting accounts for 90% of the total. Most of this venting is related to completion activities. Condensate tanks are another significant source of VOCs, accounting for 14% of the total. With "green" completions becoming more common and new required controls on condensate tank emissions, it is expected that future VOC and NOx emissions from these sources and activities will decrease on a percentage basis.

**Figure 3.3 WRAP 2006 VOC Oil and Gas Emissions by Source Type**

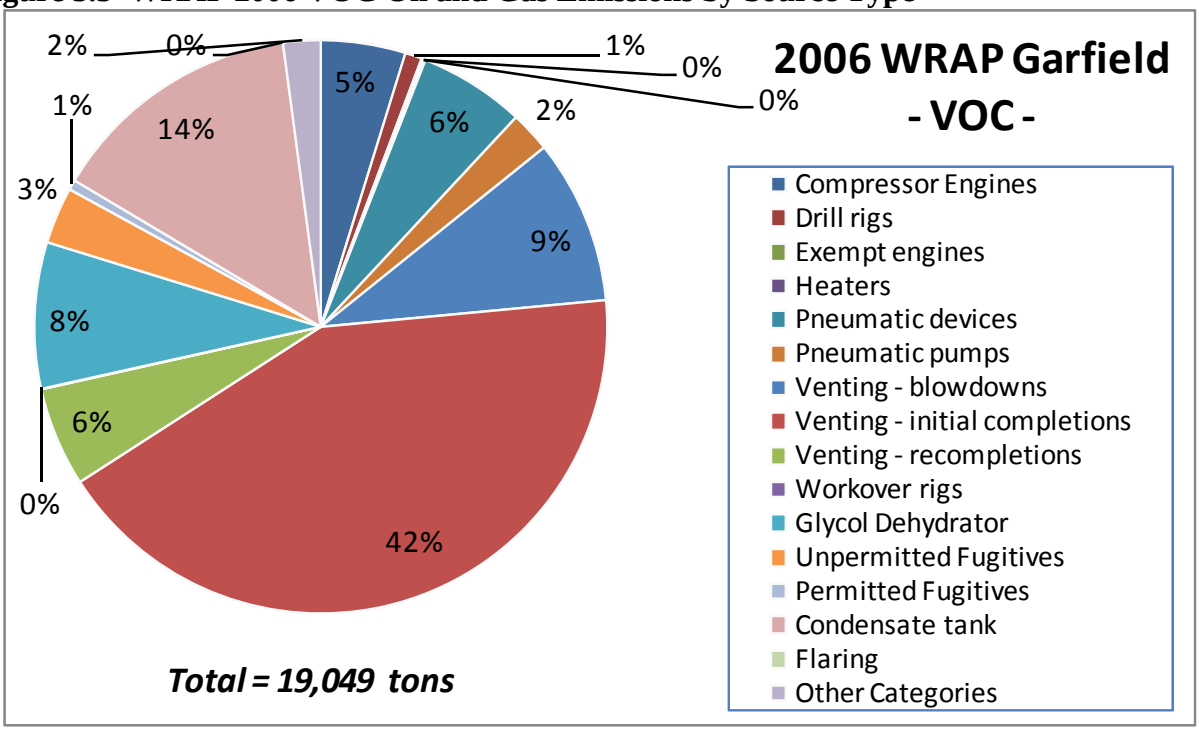
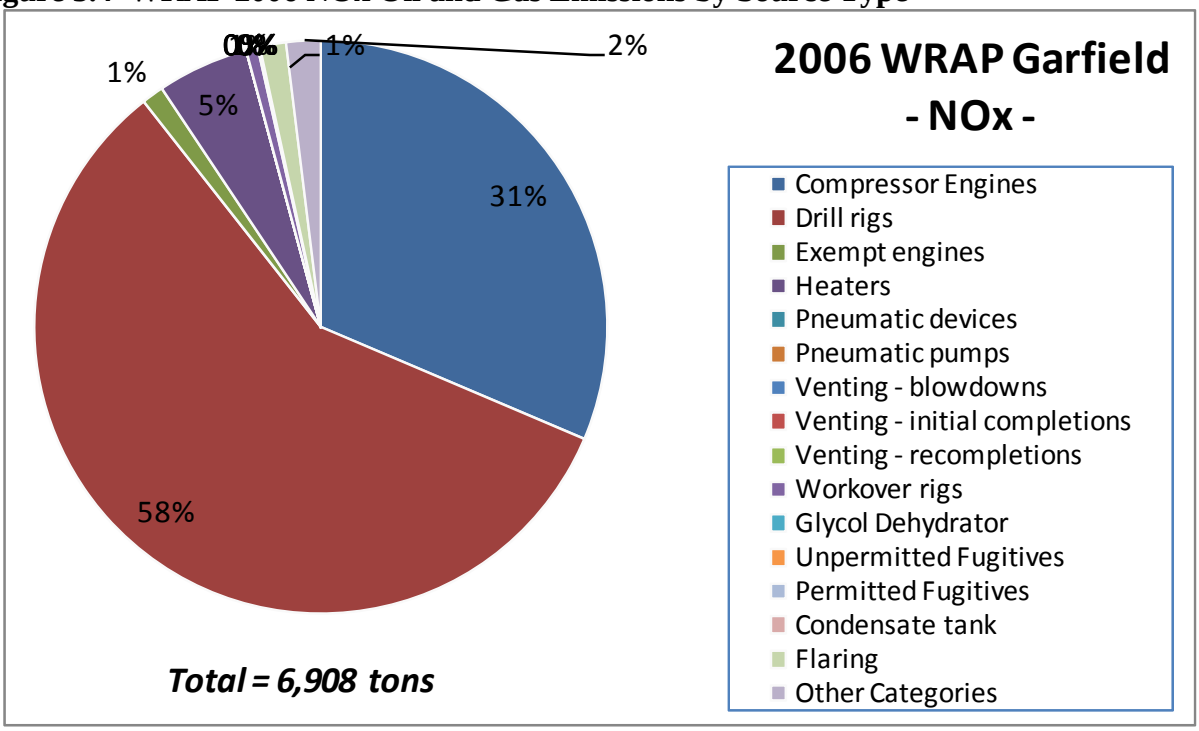


**Figure 3.4 WRAP 2006 NOx Oil and Gas Emissions by Source Type**




Figures 3.5 and 3.6 display VOC and NOx emissions from oil and gas sources for all counties in the Piceance Basin area. As can be seen, Garfield County is the largest contributor to oil and gas emissions in the basin. This is not unexpected due to the large number of wells in Garfield County. The graphs also show that venting is the largest contributor to VOC and NOx emissions in other counties as well.

**Figure 3.5 WRAP 2006 Piceance Basin Oil and Gas VOC Emissions**

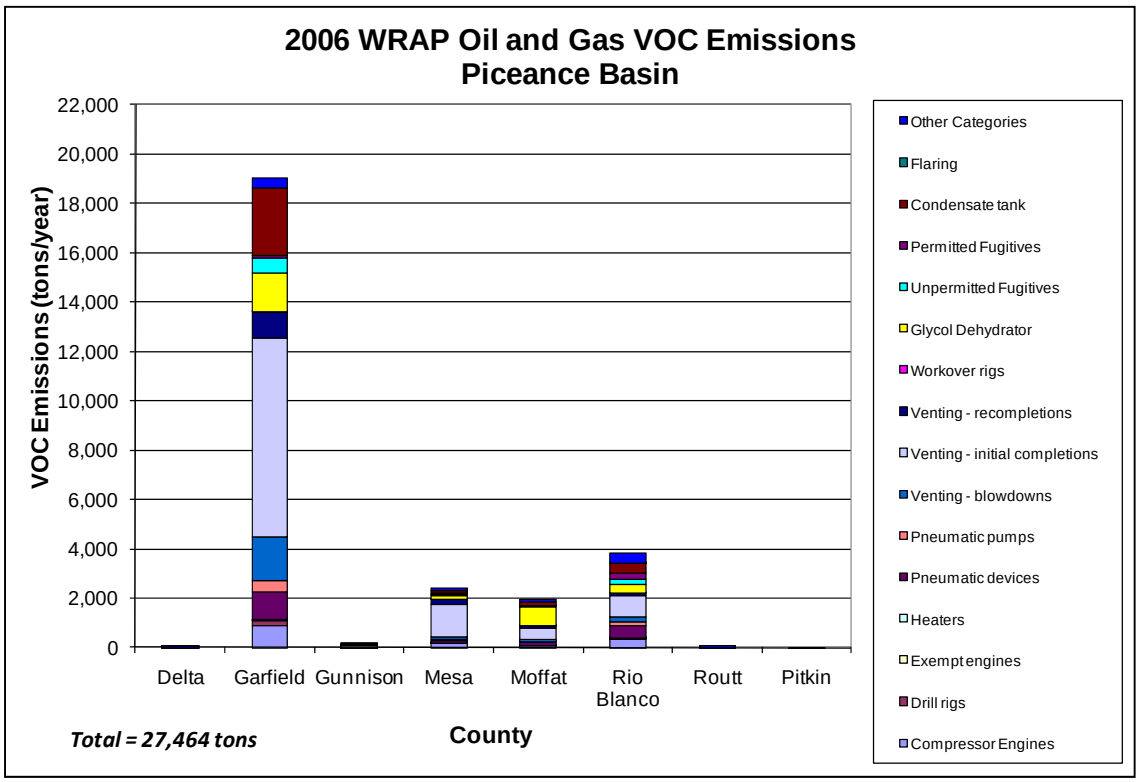
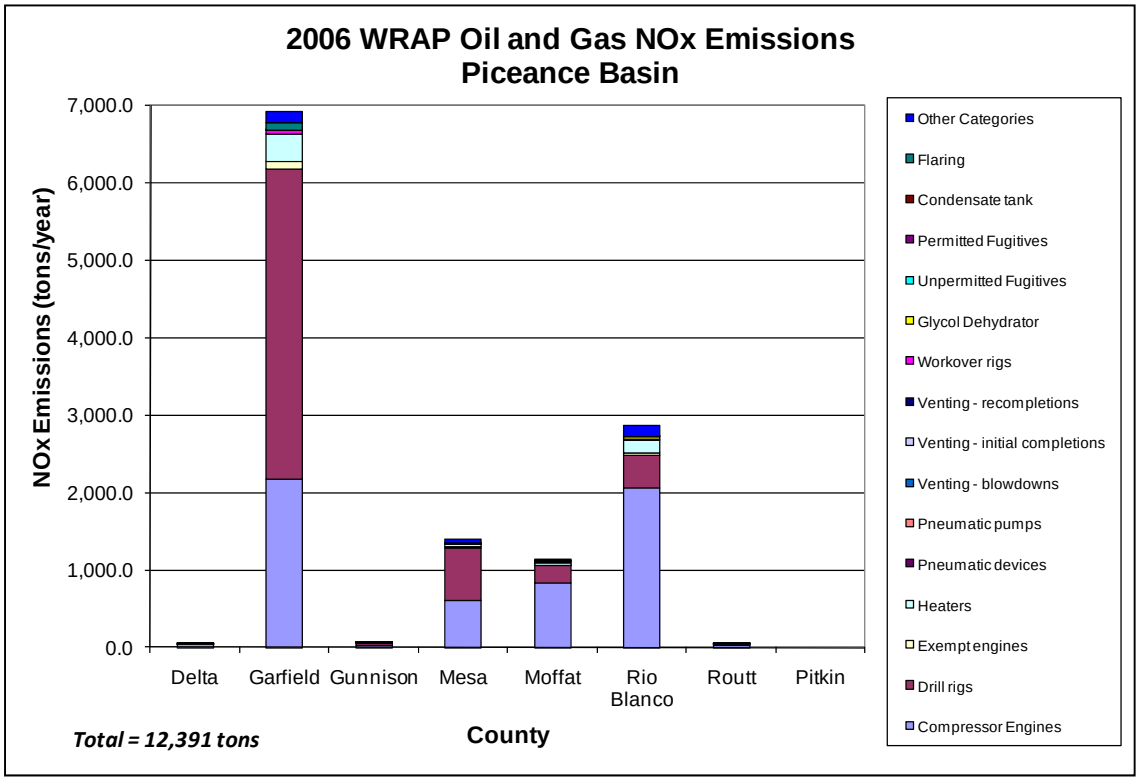



**Figure 3.5 WRAP 2006 Piceance Basin Oil and Gas NOx Emissions**



# 4.0 Emission Trends in Garfield County

Emission inventory reports are often used to evaluate trends for planning purposes and meeting air quality goals for a region. In this section, emission trends in Garfield County are demonstrated. The emission totals are figured both with and without fire emissions. Fire emissions are more unpredictable than the other categories of emissions, so removing the fire totals, give a more stable look at the emission trends through time. Biogenic emissions remain constant over the years as the forested area of the county has remained essentially the same over the period.

As emissions inventories have been refined over time and as new information becomes available, more detailed break-outs of source types is possible. The "Stationary Sources" category is an example of this, where it can be broken out into what are oil and gas-related sources and what are not. Tables 4.1 through 4.6 show emissions inventory data for the years 1996, 2000, 2005 and 2007, as well as the percent changes over time. It should also be noted that minimum reporting levels for pollutants have decreased over time, particularly for some industries. Thus, older inventories are not necessarily comparable to more recent inventories and comparisons should not be seen as definitive for trends.

## 4.1 Carbon Monoxide Emission Trends

Carbon monoxide emissions (Table 4.1), excluding fire, decreased from 1996 through 2005, likely due to better fuel standards and controls for vehicles, but increased dramatically for 2007, likely due to the increase in oil and gas development activity. The table shows that carbon monoxide emissions for highway vehicles decreased through 2005, but increased for 2007. This is likely due to the increase in oil and gas development activity which has increased traffic both from workers and from trucking equipment. Commercial cooking and woodburning emissions of carbon monoxide have also increased, likely due to the increased population, of which some is oil and gas related. The large increases in stationary source emissions of carbon monoxide are mostly due to oil and gas sources, though it is quite possible that some of this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Finally, the large increase in fire emissions in 2007 is likely due to wildfires that occurred that year. Excluding fires, which can be variable from year to year, overall carbon monoxide emissions decreased approximately 5% from 1996 to 2007.

**Table 4.1. Carbon Monoxide Emission Trends in Garfield County**

| Carbon Monoxide | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | | | | | | | |
| Aircraft | 20.51 | 31.82 | 35.05 | 38.07 | 55.1% | 10.2% | 8.6% |
| Biogenic | 3,730.07 | 3,730.07 | 3,730.07 | 3,730.07 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | 8.40 | 10.15 | 11.91 | 12.44 | 20.9% | 17.4% | 4.5% |
| Construction | | | | | | | |
| Forest, Prescribed & Structural Fires | 8,143.23 | 3,511.13 | 499.83 | 2,244.34 | -56.9% | -85.8% | 349.0% |
| Fuel Combustion | 30.11 | 33.14 | 27.06 | 28.28 | 10.0% | -18.3% | 4.5% |
| Highway Vehicles | 30,684.00 | 27,115.24 | 18,683.46 | 21,255.37 | -11.6% | -31.1% | 13.8% |
| Non-Road | 4,450.93 | 3,924.02 | 5,350.05 | 3,964.10 | -11.8% | 36.3% | -25.9% |
| Railroads | 51.62 | 51.99 | 46.05 | 50.02 | 0.7% | -11.4% | 8.6% |
| Road Dust | | | | | | | |
| Solvent Utilization | | | | | | | |
| Surface Coating | | | | | | | |
| Woodburning | 2,409.22 | 2,787.68 | 3,347.78 | 3,635.83 | 15.7% | 20.1% | 8.6% |
| Stationary Sources ** | 626.63 | 1,272.66 | 2,557.53 | | 103.1% | 101.0% | 190.3% |
| Oil & Gas Area | | | | 4,147.00 | | | |
| Oil & Gas Point | | | | 3,152.32 | | | |
| Other Point | | | | 125.45 | | | |
| TOTAL | 50,154.71 | 42,467.88 | 34,288.79 | 42,383.29 | -15.3% | -19.3% | 23.6% |
| Total without fire | 42,011.48 | 38,956.75 | 33,788.96 | 40,138.94 | -7.3% | -13.3% | 18.8% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

### 4.2 Nitrogen Dioxide Emission Trends

Nitrogen dioxide emissions (Table 4.2), excluding fire have increased over the 1996 to 2007 period, particularly from 2005 to 2007. Again, tightened fuel standards and controls likely caused highway vehicle emissions to decrease up to 2005, with significant increases in oil and gas related traffic causing an increase in 2007. As with carbon monoxide, the large increases in stationary source emissions of nitrogen dioxide are mostly due to oil and gas sources. It is quite possible that some of this is also an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Finally, the large increase in fire emissions in 2007 is likely due to

wildfires that occurred that year. Excluding fires, which can be variable from year to year, overall nitrogen dioxide emissions increased approximately 52% from 1996 to 2007.

**Table 4.2. Nitrogen Dioxide Emission Trends in Garfield County**

| Nitrogen Dioxide | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | | | | | | | |
| Aircraft | 0.44 | 0.17 | 0.19 | 0.20 | -61.2% | 11.2% | 7.6% |
| Biogenic | 471.11 | 471.11 | 471.11 | 471.11 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | | | | | | | |
| Construction | | | | | | | |
| Forest, Prescribed & Structural Fires | 233.76 | 100.01 | 19.97 | 59.94 | -57.2% | -80.0% | 200.2% |
| Fuel Combustion | 63.92 | 64.49 | 63.17 | 66.00 | 0.9% | -2.1% | 4.5% |
| Highway Vehicles | 3,178.85 | 2,852.22 | 1,919.34 | 2,010.40 | -10.3% | -32.7% | 4.7% |
| Non-Road | 211.37 | 478.28 | 400.48 | 324.29 | 126.3% | -16.3% | -19.0% |
| Railroads | 510.73 | 542.92 | 467.43 | 507.72 | 6.3% | -13.9% | 8.6% |
| Road Dust | | | | | | | |
| Solvent Utilization | | | | | | | |
| Surface Coating | | | | | | | |
| Woodburning | 25.70 | 38.62 | 35.71 | 38.78 | 50.3% | -7.5% | 8.6% |
| Stationary Sources ** | 1,558.31 | 1,747.97 | 2,916.80 | | 12.2% | 66.9% | 209.7% |
| Oil & Gas Area | | | 1,487.41 | 4,639.00 | | | |
| Oil & Gas Point | | | | 4,281.28 | | | |
| Other Point | | | | 113.39 | | | |
| TOTAL | 6,254.19 | 6,295.80 | 7,781.61 | 12,512.11 | 0.7% | 23.6% | 60.8% |
| Total without fire | 6,020.43 | 6,195.78 | 7,761.64 | 12,452.17 | 2.9% | 25.3% | 60.4% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

### 4.3 Sulfur Dioxide Emission Trends

Sulfur dioxide emissions (Table 4.3) in Garfield County are small as there are no major sources such as coal burning power plants. Emissions from highway vehicles have decreased significantly from 1996 to 2007, likely due to increased low sulfur diesel fuel standards. Emissions of sulfur dioxide from non-road sources have also decreased significantly since 2000, likely for the same reason. Stationary sources, particularly for oil and gas, have increased

dramatically since 2005. It is quite possible that this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Excluding fires, which can be variable from year to year, overall sulfur dioxide emissions increased approximately 27% from 1996 to 2007.

**Table 4.3. Sulfur Dioxide Emission Trends in Garfield County**

| Sulfur Dioxide | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | | | | | | | |
| Aircraft | 0.05 | 0.02 | 0.02 | 0.02 | -63.7% | 10.2% | 8.4% |
| Biogenic | 0.00 | 0.00 | 0.00 | 0.00 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | | | | | | | |
| Construction | | | | | | | |
| Forest, Prescribed & Structural Fires | 8.59 | 3.67 | 3.64 | 18.79 | -57.3% | -0.8% | 416.1% |
| Fuel Combustion | 13.93 | 12.55 | 1.78 | 1.87 | -9.9% | -85.8% | 4.8% |
| Highway Vehicles | 102.03 | 100.75 | 57.19 | 16.23 | -1.3% | -43.2% | -71.6% |
| Non-Road | 23.19 | 111.55 | 47.30 | 10.39 | 381.0% | -57.6% | -78.0% |
| Railroads | 31.95 | 24.67 | 26.63 | 28.92 | -22.8% | 7.9% | 8.6% |
| Road Dust | | | | | | | |
| Solvent Utilization | | | | | | | |
| Surface Coating | | | | | | | |
| Woodburning | 5.09 | 6.15 | 7.08 | 7.68 | 20.9% | 15.1% | 8.5% |
| Stationary Sources ** | 29.45 | 11.15 | 18.56 | | -62.1% | 66.4% | 1063.8% |
| Oil & Gas Area | | | | 185.00 | | | |
| Oil & Gas Point | | | | 10.84 | | | |
| Other Point | | | | 20.15 | | | |
| TOTAL | 214.28 | 270.52 | 162.20 | 299.90 | 26.2% | -40.0% | 84.9% |
| Total without fire | 205.69 | 266.85 | 158.56 | 281.11 | 29.7% | -40.6% | 77.3% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

### 4.4 $PM_{10}$ Emission Trends

Particulate emissions (Table 4.4) have decreased for a number of the more significant sources from 1996 to 2007. Road dust has increased from 2005 to 2007, likely due to the increase in oil and gas development activity. Stationary sources have increased as well, also due to oil and gas development activities. It is quite possible that some of this is an artifact in the inventory due to

better reporting, accounting and/or estimation techniques. Finally, the large increase in fire emissions in 2007 is likely due to wildfires that occurred that year. Excluding fires, which can be variable from year to year, overall $PM_{10}$ increased approximately 20% from 1996 to 2007.

**Table 4.4. $PM_{10}$ Emission Trends in Garfield County**

| PM10 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | 435.64 | 86.12 | 81.44 | 81.44 | -80.2% | -5.4% | 0.0% |
| Aircraft | 0.41 | 0.65 | 0.71 | 0.78 | 58.0% | 9.6% | 9.2% |
| Biogenic | 0.00 | 0.00 | 0.00 | 0.00 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | 22.04 | 26.63 | 31.27 | 32.68 | 20.9% | 17.4% | 4.5% |
| Construction | 599.14 | 972.79 | 973.16 | 1,016.87 | 62.4% | 0.0% | 4.5% |
| Forest, Prescribed & Structural Fires | 796.07 | 330.58 | 62.42 | 307.28 | -58.5% | -81.1% | 392.3% |
| Fuel Combustion | 2.65 | 2.73 | 0.40 | 0.42 | 3.0% | -85.3% | 5.8% |
| Highway Vehicles | 110.58 | 70.86 | 52.68 | 46.01 | -35.9% | -25.7% | -12.7% |
| Non-Road | 33.45 | 50.40 | 40.67 | 33.18 | 50.7% | -19.3% | -18.4% |
| Railroads | 12.74 | 13.21 | 11.60 | 12.60 | 3.7% | -12.2% | 8.6% |
| Road Dust | 902.60 | 1,090.79 | 950.22 | 1,082.59 | 20.9% | -12.9% | 13.9% |
| Solvent Utilization | | | | | | | |
| Surface Coating | | | | | | | |
| Woodburning | 336.25 | 386.68 | 467.24 | 507.44 | 15.0% | 20.8% | 8.6% |
| Stationary Sources ** | 590.51 | 195.06 | 290.00 | | -67.0% | 48.7% | 248.4% |
| Oil & Gas Area | | | | 664.00 | | | |
| Oil & Gas Point | | | | 109.07 | | | |
| Other Point | | | | 237.41 | | | |
| TOTAL | 3,842.07 | 3,226.49 | 2,961.81 | 4,131.75 | -16.0% | -8.2% | 39.5% |
| Total without fire | 3,046.00 | 2,895.92 | 2,899.39 | 3,824.47 | -4.9% | 0.1% | 31.9% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

## 4.5 Volatile Organic Compounds Emission Trends

Volatile organic compound emissions (Table 4.5) show a similar trend to carbon monoxide. VOC emissions decreased from 1996 through 2005 for highway vehicles, likely due to better controls for vehicles, but increased for 2007, likely due to the increase in oil and gas development activity. Woodburning emissions of carbon monoxide have also increased, likely

due to the increased population, of which some is oil and gas related. The large increases in stationary source emissions of VOCs are mostly due to oil and gas sources. Once again, it is quite possible that some of this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Finally, the large increase in fire emissions in 2007 is likely due to wildfires that occurred that year. Excluding fires, which can be variable from year to year, overall VOC emissions increased approximately 40% from 1996 to 2007.

**Table 4.5. Volatile Organic Compound Emission Trends in Garfield County**

| VOC | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | | | | | | | |
| Aircraft | 0.89 | 1.22 | 1.34 | 1.46 | 37.0% | 9.9% | 9.0% |
| Biogenic | 27,965.63 | 27,965.63 | 27,965.63 | 27,965.63 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | 2.93 | 3.54 | 4.15 | 4.34 | 20.9% | 17.2% | 4.5% |
| Construction | | | | | | | |
| Forest, Prescribed & Structural Fires | 1068.82 | 475.08 | 28.44 | 143.38 | -55.6% | -94.0% | 404.2% |
| Fuel Combustion | 2.44 | 2.77 | 3.67 | 3.83 | 13.7% | 32.3% | 4.5% |
| Highway Vehicles | 1,982.10 | 1,766.35 | 1,092.21 | 1,288.10 | -10.9% | -38.2% | 17.9% |
| Non-Road | 527.17 | 427.84 | 398.05 | 374.98 | -18.8% | -7.0% | -5.8% |
| Railroads | 19.12 | 20.80 | 17.40 | 18.90 | 8.8% | -16.4% | 8.6% |
| Road Dust | | | | | | | |
| Solvent Utilization | 504.12 | 338.53 | 118.28 | 123.60 | -32.8% | -65.1% | 4.5% |
| Surface Coating | | | 182.72 | 190.92 | | | 4.5% |
| Woodburning | 648.52 | 795.08 | 901.17 | 978.70 | 22.6% | 13.3% | 8.6% |
| Stationary Sources ** | 1,395.63 | 1,621.30 | 7,557.90 | | 16.2% | 366.2% | 227.5% |
| Oil & Gas Area | | | 3,995.42 | 14,635.00 | | | |
| Oil & Gas Point | | | | 8,195.88 | | | |
| Other Point | | | | 1,920.33 | | | |
| TOTAL | 34,117.38 | 33,418.15 | 42,266.38 | 55,845.06 | -2.0% | 26.5% | 32.1% |
| Total without fire | 33,048.56 | 32,943.07 | 42,237.94 | 55,701.68 | -0.3% | 28.2% | 31.9% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

### 4.6 Benzene Emission Trends

Benzene emissions (Table 4.6) are a small portion of the total air emissions in Garfield County. As with sulfur dioxide and $PM_{10}$, highway vehicle emissions have decreased, but stationary source benzene emissions have increased. This increase in the stationary source area is in large part due to the increased oil and gas development in the County. Excluding fires, which can be variable from year to year, overall benzene emissions increased approximately 38% from 1996 to 2007.

**Table 4.6. Benzene Emission Trends in Garfield County**

| Benzene | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1996 (tons/yr.) | 2000 (tons/yr.) | 2005 (tons/yr.) | 2007 (tons/yr.) | % change 2000-2005 | % change 2000-2005 | % change 2005-2007 |
| Agriculture | | | | | | | |
| Aircraft | | 0.05 | 0.07 | 0.04 | | 47.4% | -39.0% |
| Biogenic | 0.00 | 0.00 | 0.00 | 0.00 | 0.0% | 0.0% | 0.0% |
| Commercial Cooking | 0.32 | 0.38 | 0.44 | 0.46 | 20.9% | 14.7% | 4.5% |
| Construction | | | | | | | |
| Forest, Prescribed & Structural Fires | 78.39 | 34.45 | 2.10 | 10.74 | -56.0% | -93.9% | 411.3% |
| Fuel Combustion | 0.00 | 0.00 | 0.00 | 0.00 | 13.7% | -100.0% | 100.0% |
| Highway Vehicles | 73.83 | 65.79 | 40.84 | 36.78 | -10.9% | -37.9% | -9.9% |
| Non-Road | 13.99 | 11.35 | 10.98 | 12.40 | -18.8% | -3.3% | 12.9% |
| Railroads | 0.05 | 0.05 | 0.04 | 0.04 | 8.8% | -25.3% | 12.0% |
| Road Dust | | | | | | | |
| Solvent Utilization | | | 4.59 | 4.80 | | | 4.5% |
| Surface Coating | | | | | | | |
| Woodburning | 16.29 | 19.97 | 22.63 | 24.58 | 22.6% | 13.3% | 8.6% |
| Stationary Sources ** | 78.83 | 102.19 | 202.09 | | 29.6% | 97.8% | 5.7% |
| Oil & Gas Area | | | | | | | |
| Oil & Gas Point | | | | 202.08 | | | |
| Other Point | | | | 11.59 | | | |
| TOTAL | 261.70 | 234.24 | 283.78 | 303.52 | -10.5% | 21.1% | 7.0% |
| Total without fire | 183.31 | 199.79 | 281.68 | 292.78 | 9.0% | 41.0% | 3.9% |

** For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.
1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

## 5.0 Comparisons with Other Colorado Counties

Comparing Garfield County to other Colorado counties can help put the information in this emission inventory report into perspective. Other Colorado counties that have a large amount of oil and gas development, like Weld, Rio Blanco, and La Plata, were chosen for comparison. Also, those counties in close proximity to Garfield County were chosen for comparison, including Mesa and Eagle. The Denver metropolitan 7-county area was also included as a large urban area comparison. Table 5.1 provides a comparison using 2007 emissions inventory data. Figures 5.1 through 5.6 provide a graphical representation of the total emissions for each pollutant.

**Table 5.1. Emissions Comparison**

| 2007 Inventory (Tons per Year) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | CO | $NO_2$ | $SO_2$ | $PM_{10}$ | VOC | Benzene |
| **Garfield** | **Total Emissions** | **42,383** | **12,512** | **300** | **4,132** | **55,845** | **304** |
| Mesa | Total Emissions | 47,932 | 7,855 | 168 | 7,745 | 39,493 | 165 |
| Rio Blanco | Total Emissions | 13,959 | 5,508 | 126 | 2,999 | 35,965 | 86 |
| Eagle | Total Emissions | 29,958 | 3,623 | 80 | 3,636 | 15,576 | 74 |
| La Plata | Total Emissions | 28,899 | 10,164 | 56 | 3,449 | 24,001 | 70 |
| Denver Metro* | Total Emissions | 694,813 | 88,885 | 13,402 | 51,308 | 136,905 | 1,568 |
| Weld | Total Emissions | 95,943 | 28,078 | 519 | 26,278 | 92,041 | 356 |
| State Total | Total Emissions | 1,705,264 | 327,836 | 61,297 | 294,314 | 1,191,196 | 4,755 |
| | | | | | | | |
| | | CO | $NO_2$ | $SO_2$ | $PM_{10}$ | VOC | Benzene |
| **Garfield** | **All Stationary Sources** | 7,425 | 9,034 | 216 | 1,010 | 24,751 | 214 |
| Mesa | All Stationary Sources | 1,754 | 2,066 | 70 | 717 | 3,737 | 53 |
| Rio Blanco | All Stationary Sources | 4,321 | 4,426 | 114 | 2,031 | 6,180 | 65 |
| Eagle | All Stationary Sources | 4,344 | 8,017 | 7 | 284 | 2,531 | 5 |
| La Plata | All Stationary Sources | 175 | 212 | 10 | 159 | 188 | 2 |
| Denver Metro* | All Stationary Sources | 6,767 | 22,886 | 11,999 | 5,345 | 18,613 | 134 |
| Weld | All Stationary Sources | 11,242 | 14,932 | 311 | 2,581 | 62,796 | 178 |
| State Total | All Stationary Sources | 56,432 | 131,227 | 57,696 | 24,054 | 147,520 | 899 |
| | | | | | | | |
| | | CO | $NO_2$ | $SO_2$ | $PM_{10}$ | VOC | Benzene |
| **Garfield** | **O&G Sources Only** | 7,299 | 8,920 | 196 | 773 | 22,831 | 202 |
| Mesa | O&G Sources Only | 1,534 | 1,868 | 37 | 136 | 3,028 | 35 |
| Rio Blanco | O&G Sources Only | 4,246 | 4,359 | 112 | 303 | 6,104 | 64 |
| Eagle | O&G Sources Only | 0 | 0 | 0 | 0 | 0 | 0 |
| La Plata | O&G Sources Only | 4,341 | 8,011 | 7 | 71 | 2,341 | 3 |
| Denver Metro* | O&G Sources Only | 1,358 | 3,248 | 22 | 35 | 4,214 | 12 |
| Weld | O&G Sources Only | 8,833 | 12,431 | 51 | 425 | 59,138 | 166 |
| State Total | O&G Sources Only | 36,763 | 54,504 | 569 | 2,131 | 118,527 | 655 |
| | | | | | | | |
| *Denver Metro includes Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson Counties | | | | | | | |

In general, emission levels in Garfield County are higher than the nearby rural counties, but lower than the urban Colorado Front Range counties. Much of the reason the urban Front Range emissions are higher is due to the higher population and resulting mobile source emissions. Carbon monoxide in particular is primarily associated with motor vehicles, resulting in the Denver metropolitan area taking a large portion of the total (Figure 5.1). Sulfur dioxide, in contrast, is primarily associated with coal combustion in power plants, plus some from diesel combustion. As a result, only counties/areas with power plants show a significant contribution (Figure 5.3). Nitrogen dioxide is associated with combustion sources, so motor vehicles and power plants are the primary contributors (Figure 5.2).

VOCs are associated with oil and gas development, along with other sources. Figure 5.5 indicates this association in that Garfield and Weld Counties, which both have significant oil and gas development, have a proportionately larger percent of the total VOC emissions that one would typically expect based on population. This is also reflected for benzene as well, which is also associated with oil and gas development (Figure 5.6).

To follow up, Figures 5.7 and 5.8 provide a breakdown of oil and gas source emissions inventory totals for VOCs and benzene. These include both point and area sources. As expected in this view of the data, it is evident that both Garfield and Weld Counties contribute a significant portion to the totals compared to counties with no oil and gas development.

**Figure 5.1. 2007 Colorado Counties Comparison for Carbon Monoxide**

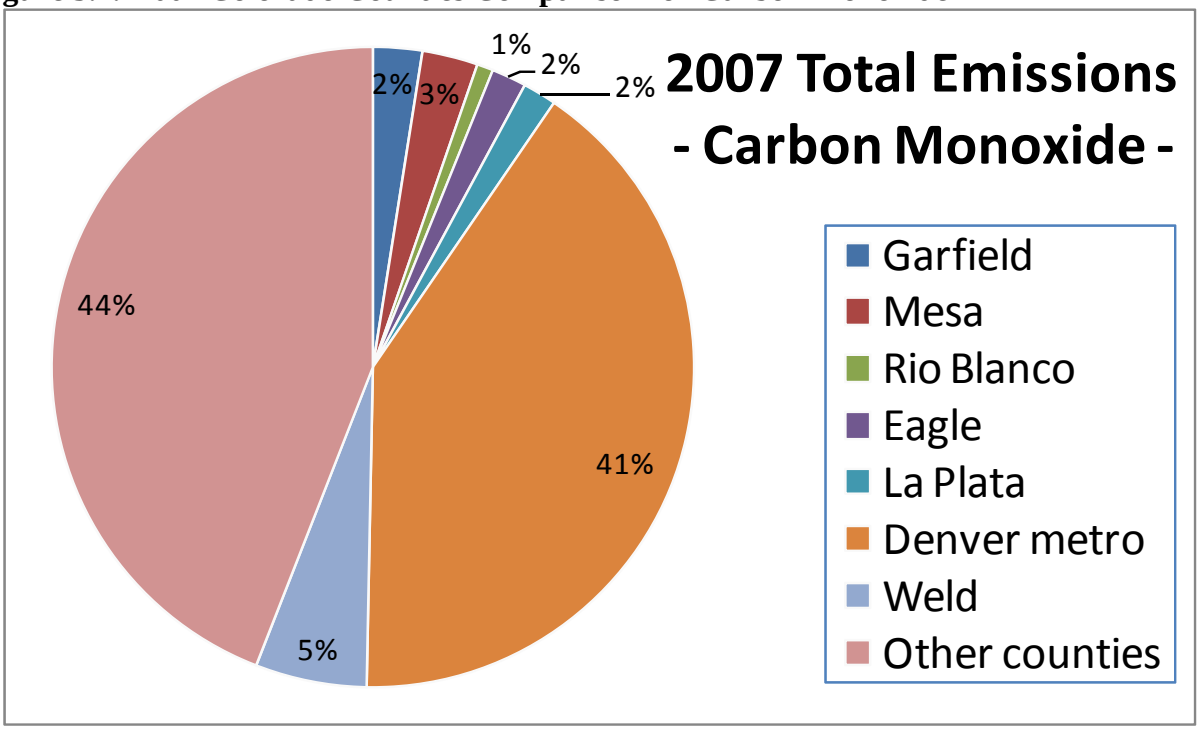


**Figure 5.2. 2007 Colorado Counties Comparison for Nitrogen Dioxide**

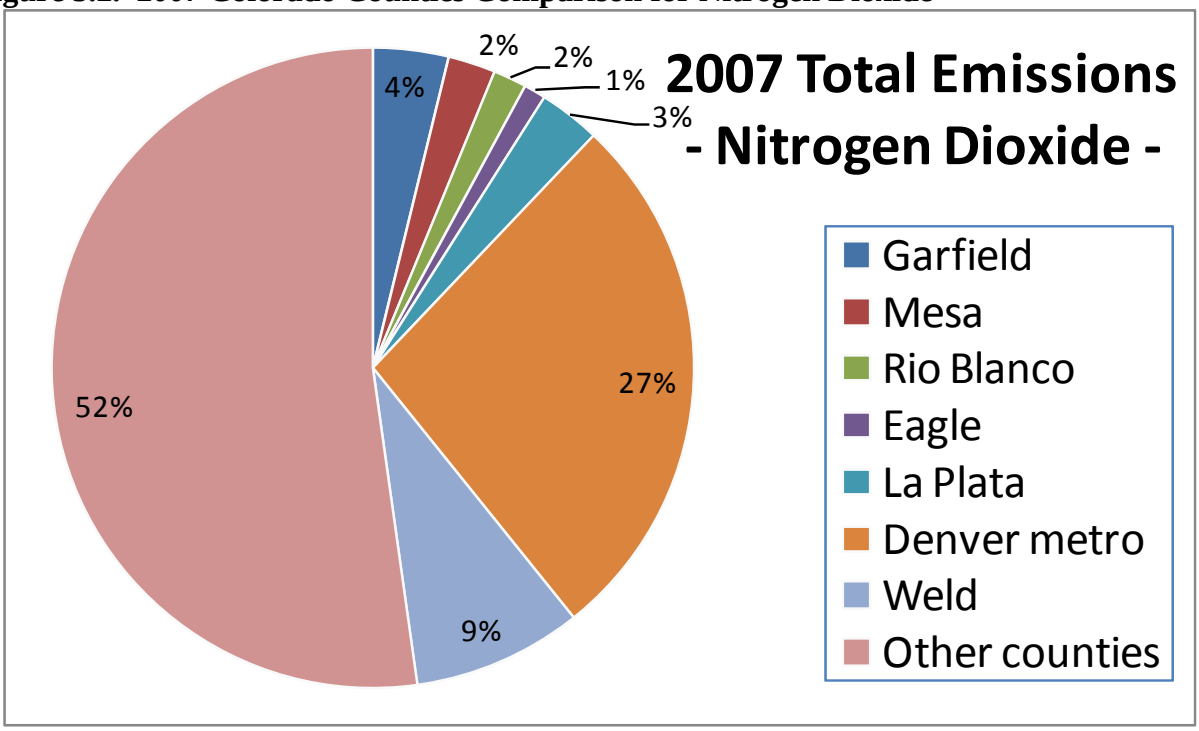



**Figure 5.3. 2007 Colorado Counties Comparison for Sulfur Dioxide**

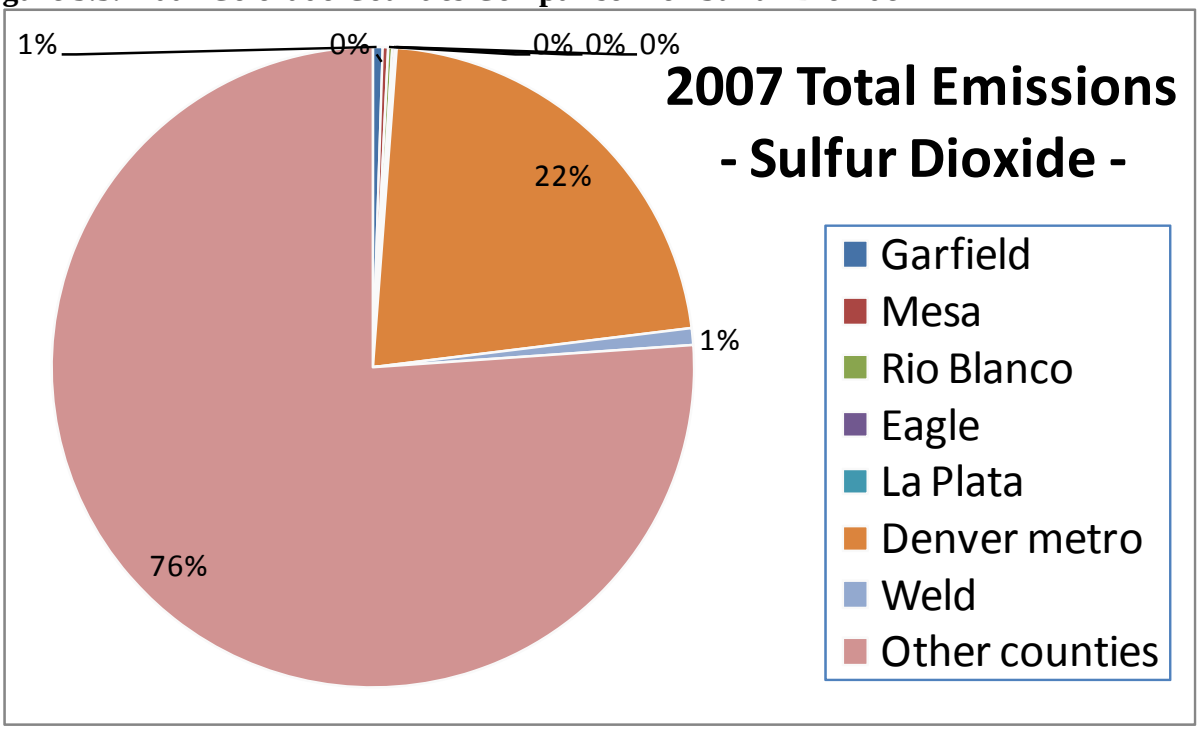


**Figure 5.4. 2007 Colorado Counties Comparison for $PM_{10}$**

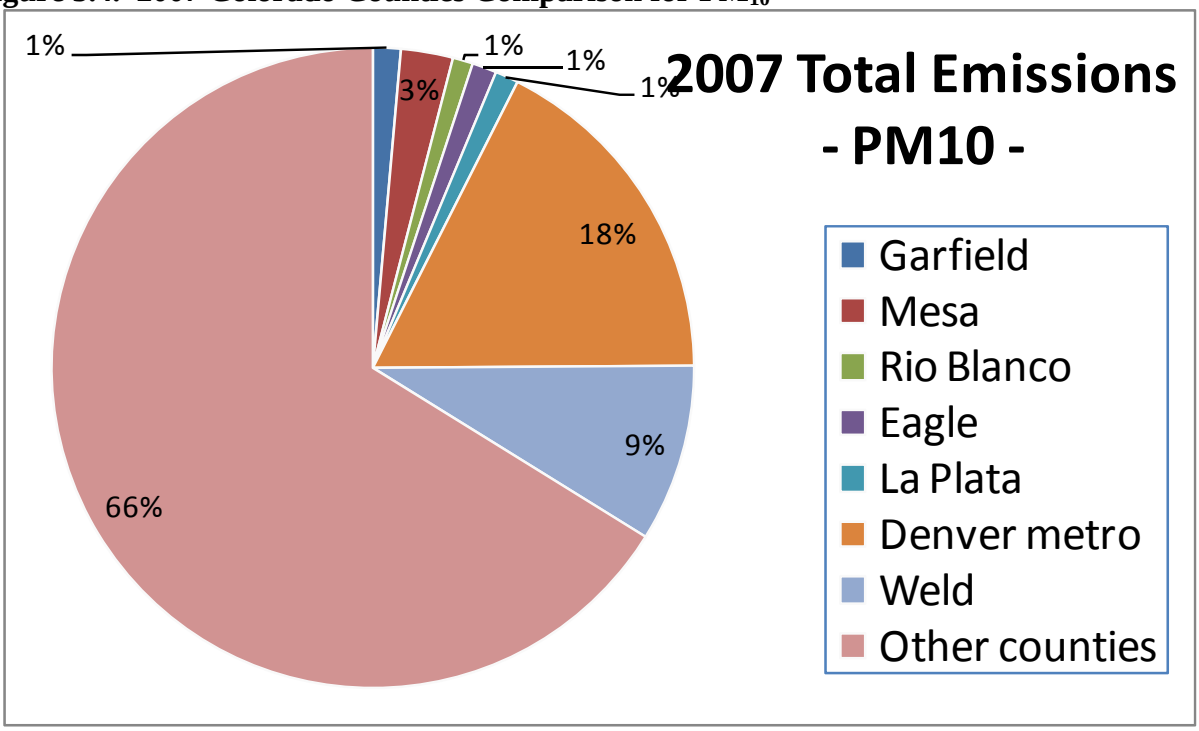



**Figure 5.5. 2007 Colorado Counties Comparison for VOC**

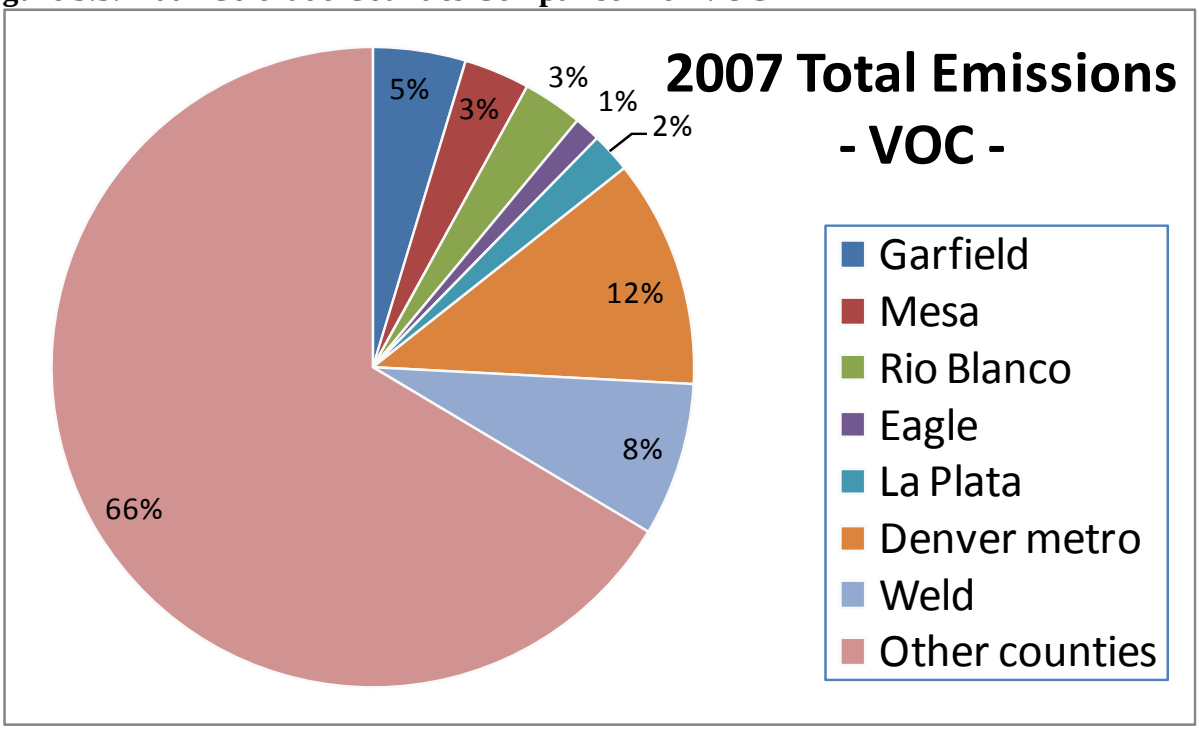


**Figure 5.6. 2007 Colorado Counties Comparison for Benzene**

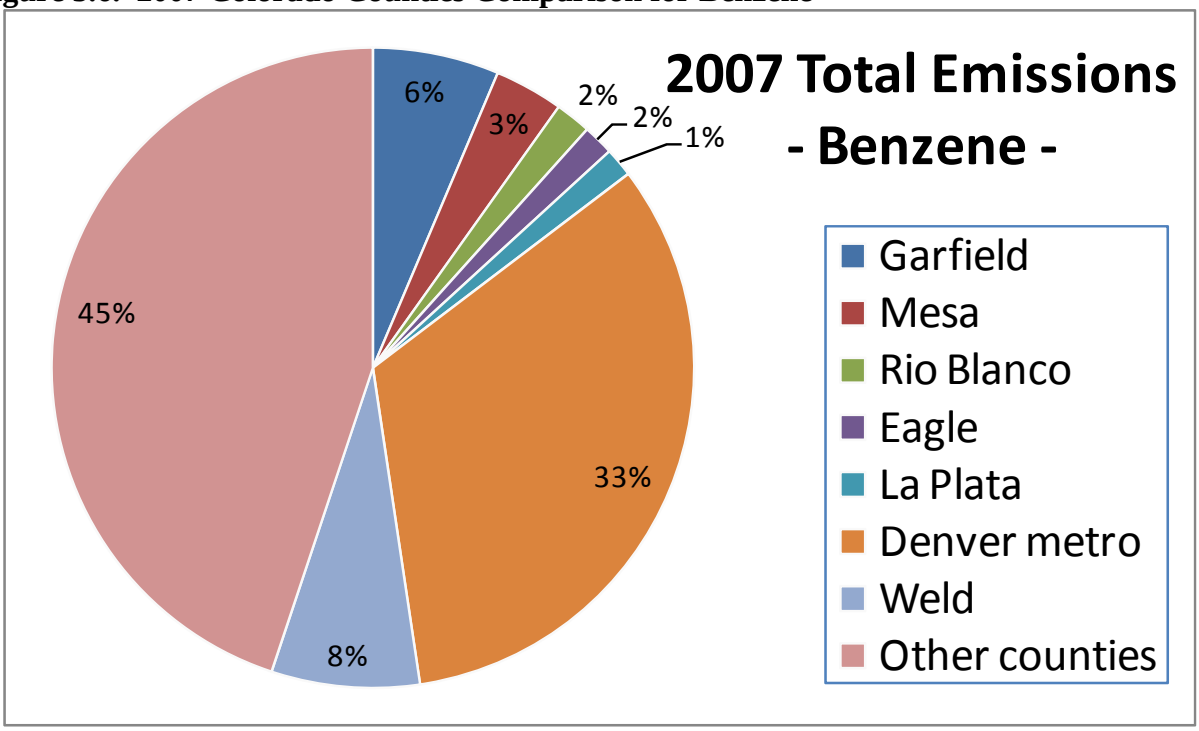



**Figure 5.7. 2007 Colorado Counties Oil and Gas Comparison for VOC**

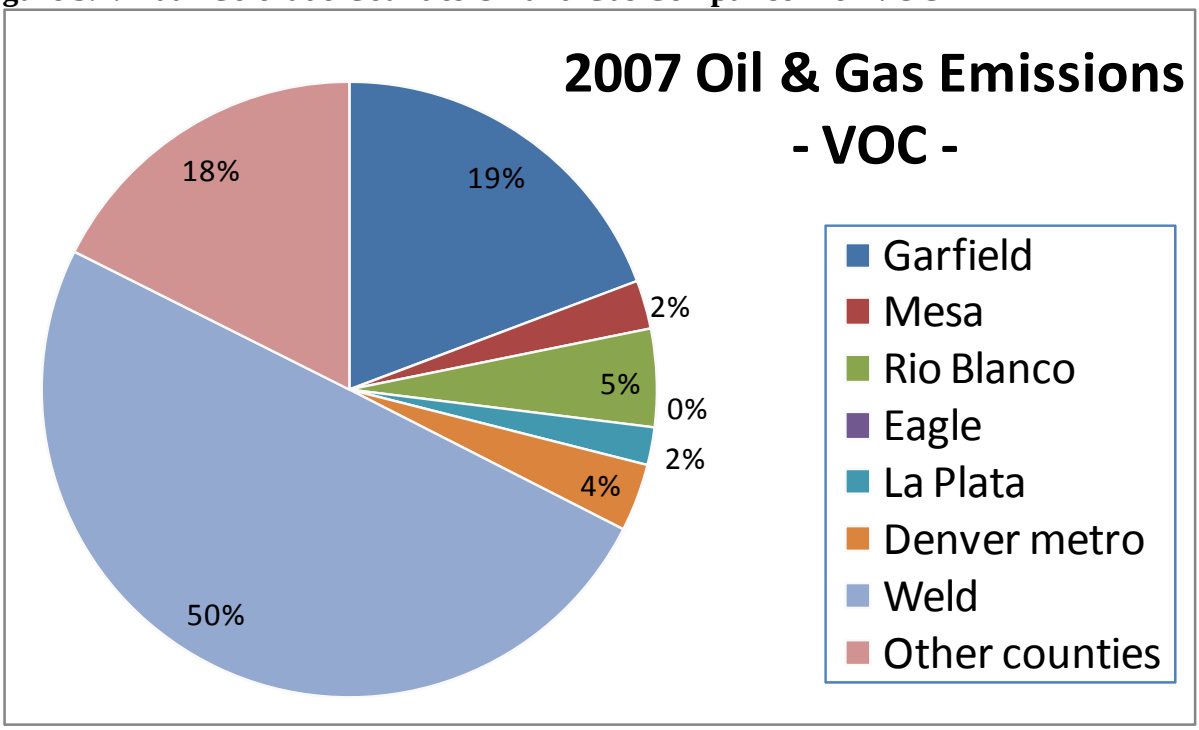
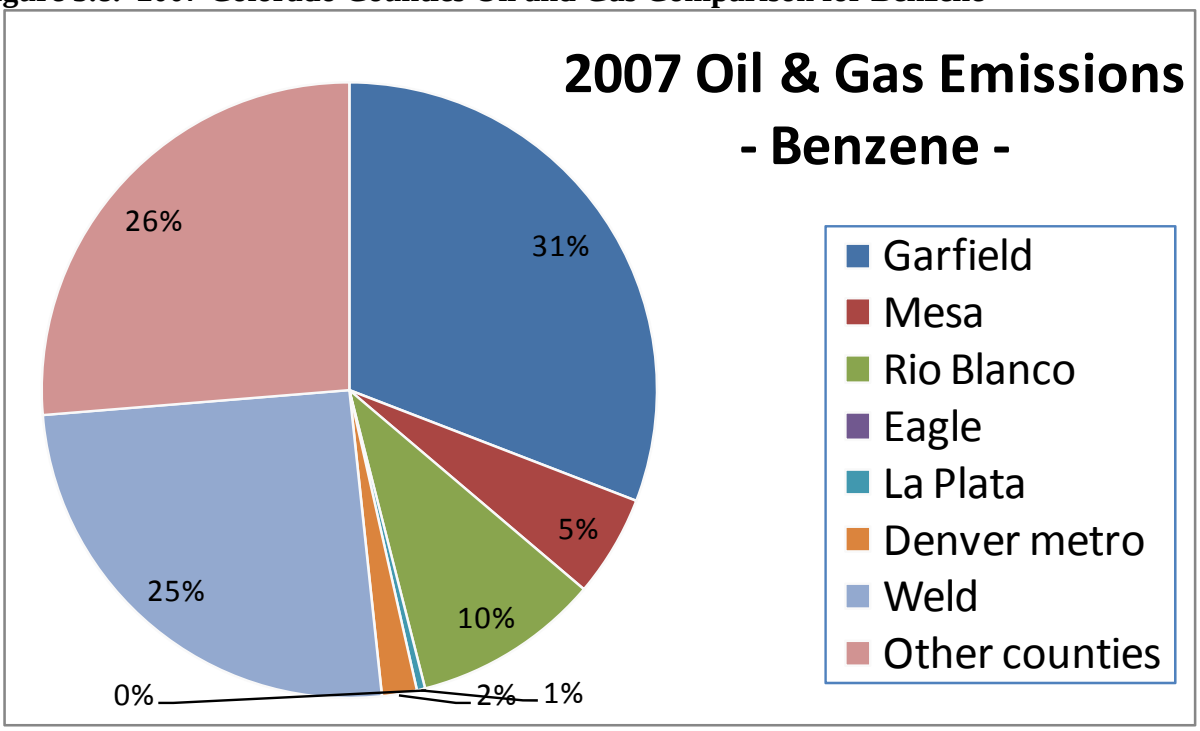


**Figure 5.8. 2007 Colorado Counties Oil and Gas Comparison for Benzene**



## 6.0 Conclusions

This report provides a general context of what an emission inventory is, and what pollutants and sources are inventoried. Pollutants inventoried include some of the criteria or health-based pollutants (carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide and particulates) and volatile organic compounds. The county inventory presented in this report is for 2007, which is the most current complete inventory that is available. Other years are included to show trends.

This report describes the largest sources of air pollution for each pollutant. In some cases one of the largest source of emissions are natural or biogenic. This is particularly valid for volatile organic compounds. In many cases, anthropogenic (man-made), emissions are the largest sources. Major anthropogenic categories include mobile sources (cars and trucks), stationary point sources (specific emission points large enough to require a permit) and area sources (small pollution sources located over a wide area, such as wood burning). For carbon monoxide and sulfur dioxide, highway vehicles are the largest source followed by non-road vehicles. For nitrogen dioxide, stationary sources, highway vehicles and oil and gas sources are the primary contributors. For $PM_{10}$, construction and road dust are the largest sources.

The report describes the point source emission inventory in detail with a specific section on oil and gas development, due to public concerns in the area. It is noted that oil and gas sources provide the bulk of emissions in Garfield County.

Emission trends are also reported for the pollutants where information was available going from 1996 to 2007. In general (excluding fires), carbon monoxide emissions have decreased 5 percent from 1996 to 2007, nitrogen dioxide emissions have increased 52 percent, sulfur dioxide emissions have increased 27 percent, $PM_{10}$ emissions have increased 20 percent, volatile organic compound emissions have increased 40 percent, and benzene has increased 38%. Much of the increases have been in the past few years and thus are likely associated with the large increase in oil and gas development activity in the county. It should be noted, however, that due to changes in the minimum reporting levels and better accounting and estimation techniques over time, comparisons in inventories over the years are not definitive.

Total emissions from several western Colorado counties as well as counties along the Front Range are included for comparative purposes. These comparisons show that oil and gas sources play a significant role in Garfield County while other types of sources are issues in other counties.

## Appendix A: References

U.S. Environmental Protection Agency
Clearinghouse for Inventories and Emission Factors
http://www.epa.gov/ttn/chief/

U.S. Environmental Protection Agency
Envirofacts Data Warehouse
http://www.epa.gov/enviro/

U.S. Environmental Protection Agency
Support Center for Regulatory Atmospheric Modeling
http://www.epa.gov/ttn/scram/

Colorado Department of Public Health and Environment
Emissions Inventory Viewer
http://www.colorado.gov/airquality/county_inventory.aspx

Agency for Toxic Substances and Disease Registry
ToxFAQs Fact Sheets of Toxic Compounds and Health Effects
http://www.atsdr.cdc.gov/toxfaq.html

## Appendix B: Acronyms and Definitions

| | |
|---|---|
| APCD | Air Pollution Control Division |
| APEN | Air Pollution Emission Notice |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| CAA | Clean Air Act |
| CDPHE | Colorado Department of Public Health and Environment |
| CO | Carbon monoxide |
| EPA | U.S. Environmental Protection Agency |
| GIS | Geographic Information Systems |
| HAP | Hazardous air pollutant |
| NET | National Emission Trends |
| NO | Nitric oxide |
| $NO_2$ | Nitrogen dioxide |
| NOx | Oxides of nitrogen |
| $PM_{10}$ | Particulates 10 microns in diameter and smaller |
| SIC | Standard Industrial Code |
| $SO_2$ | Sulfur dioxide |
| VOC | Volatile organic compound |

## Appendix C: Methods

More detailed methods for each emission category are provided in this appendix.

*Agriculture:*
These emissions include tilling activities based on crop types. The information comes from the agriculture census. Total acres of agricultural land are established for the area, and then an emission factor is applied to the acreage based on general assumptions about crop cover in the area.

*Aircraft:*
These emissions consist primarily of combustion emissions of fuel during take offs and landings. The number of take-offs and landings are estimated on an annual basis.

*Biogenic*:
Biogenic emissions are those produced by living organisms or biological processes. They are emissions are from plant life and soils, and are not a controllable source. Total acreage and plant cover is estimated and an emission factor is applied. The following table shows a breakdown of all biogenic emissions, but specifically speciates the VOC portion of biogenic emissions. Biogenic VOCs makes up 75% of all the VOCs in Garfield County. This table shows the types of VOCs that make up the biogenic contribution to the total VOCs.

| **Biogenic Emissions (Garfield County)** | **Tons/Year** |
|---|---|
| CO | 3,730 |
| Nitrogen oxide | 307 |
| Aldehyde ** | 1,652 |
| Ethane | 560 |
| Formaldehyde | 533 |
| Isoprene | 11,870 |
| Nonreactive VOC * | 1,842 |
| Olefin | 2,336 |
| Paraffin *** | 9,003 |
| Toluene | 161 |
| Xylene | 10 |
| Terpenes | 5,335 |

* Nonreactive VOC do not contribute to the formation of ozone because they have a low reactivity in the atmosphere.
** Aldehydes do not include formaldehyde and acetaldehyde, which are listed separately.
*** Paraffin does not include ethane, which is listed separately.

*Commercial Cooking:*
This category includes emissions from commercial restaurants. The emission factors come from EPA National Emission Inventory (NEI) data. The activity level, or number of restaurants comes from a per capita number.

*Construction:*
These emissions include dirt moving operations for residential and commercial construction.

*Fuel Combustion:*
These emissions include natural gas/propane used for space heating. The activity level is based on per capita numbers and utility company fuel usage numbers.

*Highway Vehicles:*
These emissions were calculated based on vehicle miles traveled (VMT) and the EPA Mobile emission factor model (MOBILE 6). The VMT were obtained from the Federal Highway Performance Management System.

*Non-road:*
This category includes emissions from heavy equipment.

*Railroads:*
This category estimates emissions based on fuel usage of the trains. The activity level is apportioned by the miles of track in the area.

*Solvent Utilization:*
These emissions include commercial and residential products and are assigned an emission factor. The activity level is based on a per capita basis.

*Surface Coating:*
These emissions include small coating operations that would not be required to submit APENs, and are considered area sources. The activity level is based on per capita information.

*Wild and Prescribed Fire:*
These emissions are based on reports and aerial photography to determine the number of acres burned, the type of vegetation and the vegetation density.

*Woodburning:*
These emissions are based on per capita wood use.

# Appendix D: APCD versus WRAP Emissions Inventory Differences

There are differences between the emission inventory from the air Pollution Control Division (APCD) and the Western Regional Air Partnership (WRAP), as can be seen in Table D-1. This is a typical occurrence as different inventories use different compilation and estimation techniques.

**Table D-1: WRAP 2002 Emission Inventory for Garfield County**

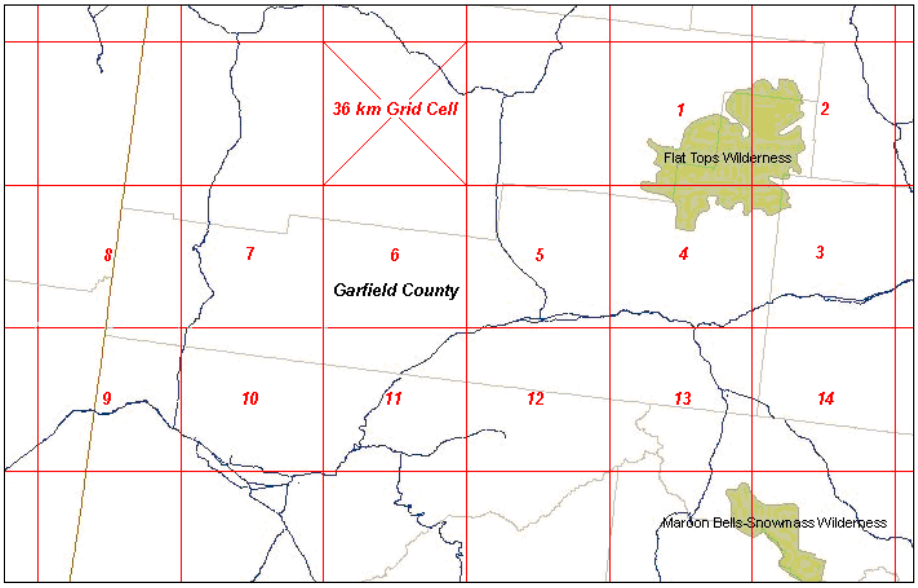
**Garfield County Emission Estimates**

***2002 Emissions in tons per year***

| County | Scenario | Year | Point | Anthro Fire | Natural Fire | Area | WRAP Area O&G | On-Road Mobile | Off-Road Mobile | Road Dust | Fugitive Dust | WB Dust | Polllutant | Totals [tpy] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Garfield | Plan02d | 2002 | 10.2 | 0.2 | 169.5 | 44.5 | 45.2 | 66.0 | 57.6 | | | | Sulfur Dioxide | 393 |
| Garfield | Plan02d | 2002 | 10.2 | 0.2 | 290.1 | 47.4 | 45.2 | 70.5 | 66.7 | 0.0 | 0.0 | | Sulfur Oxides (gas and particulate) | 530 |
| Garfield | Plan02d | 2002 | 2,555.4 | 0.8 | 618.8 | 108.3 | 2,240.7 | 2,809.4 | 1,086.0 | | | | Nitrogen Oxides (gas) | 9,419 |
| Garfield | Plan02d | 2002 | 2,555.4 | 0.8 | 630.8 | 109.3 | 2,240.7 | 2,809.4 | 1,086.0 | - | 0.0 | | Nitrogen Oxides (gas and particulate) | 9,432 |
| Garfield | Plan02d | 2002 | - | 0.8 | 4,642.5 | 275.4 | - | 24.7 | 16.0 | 0.5 | 0.8 | | Organic Carbon | 4,961 |
| Garfield | Plan02d | 2002 | - | 0.2 | 964.4 | 47.3 | - | 31.9 | 35.2 | 0.0 | 0.1 | | Elemental Carbon | 1,079 |
| Garfield | Plan02d | 2002 | - | 0.0 | 290.1 | 144.6 | - | - | - | 4.8 | 14.4 | 20.6 | Fine Particulate Matter | 475 |
| Garfield | Plan02d | 2002 | 269.8 | - | 398.8 | 13.6 | - | 15.1 | - | 36.4 | 126.8 | 185.3 | Coarse Particulate Matter | 1,046 |
| Garfield | Plan02d | 2002 | - | 0.1 | 130.0 | 1,027.5 | - | 68.9 | 0.7 | | | | Ammonia | 1,227 |
| Garfield | Plan02d | 2002 | 4,362.2 | 0.8 | 1,357.5 | 1,337.3 | 4,462.5 | 1,909.4 | 561.4 | | | | Volatile Organic Carbon | 13,991 |
| Garfield | Plan02d | 2002 | 2,344.2 | 9.2 | 28,824.6 | 3,202.5 | 526.5 | 28,634.1 | 5,626.6 | | | | Carbon Monoxide | 69,168 |

The APCD inventory is based on a ground-up approach that utilizes local activity data for various source categories, whereas, the WRAP inventory is based on a top-down approach that determines county-level emissions based on a spatial re-allocation of emissions in each 36 kilometer grid that overlays the county. The WRAP method determines county-level emissions for each pollutant by multiplying grid cell emissions with the percent of land area occupied by each county in the grid cell. For Garfield County (see Figure D-2), there are 14 grid cells that are used to determine the county level emissions. Depending on the location and concentration of emission sources, discrepancies can result when a grid cell overlays several counties with large differences in point/area/mobile source emissions.

**Figure D-2: Garfield County, Colorado with overlay projection of WRAP 36 km grid cells**

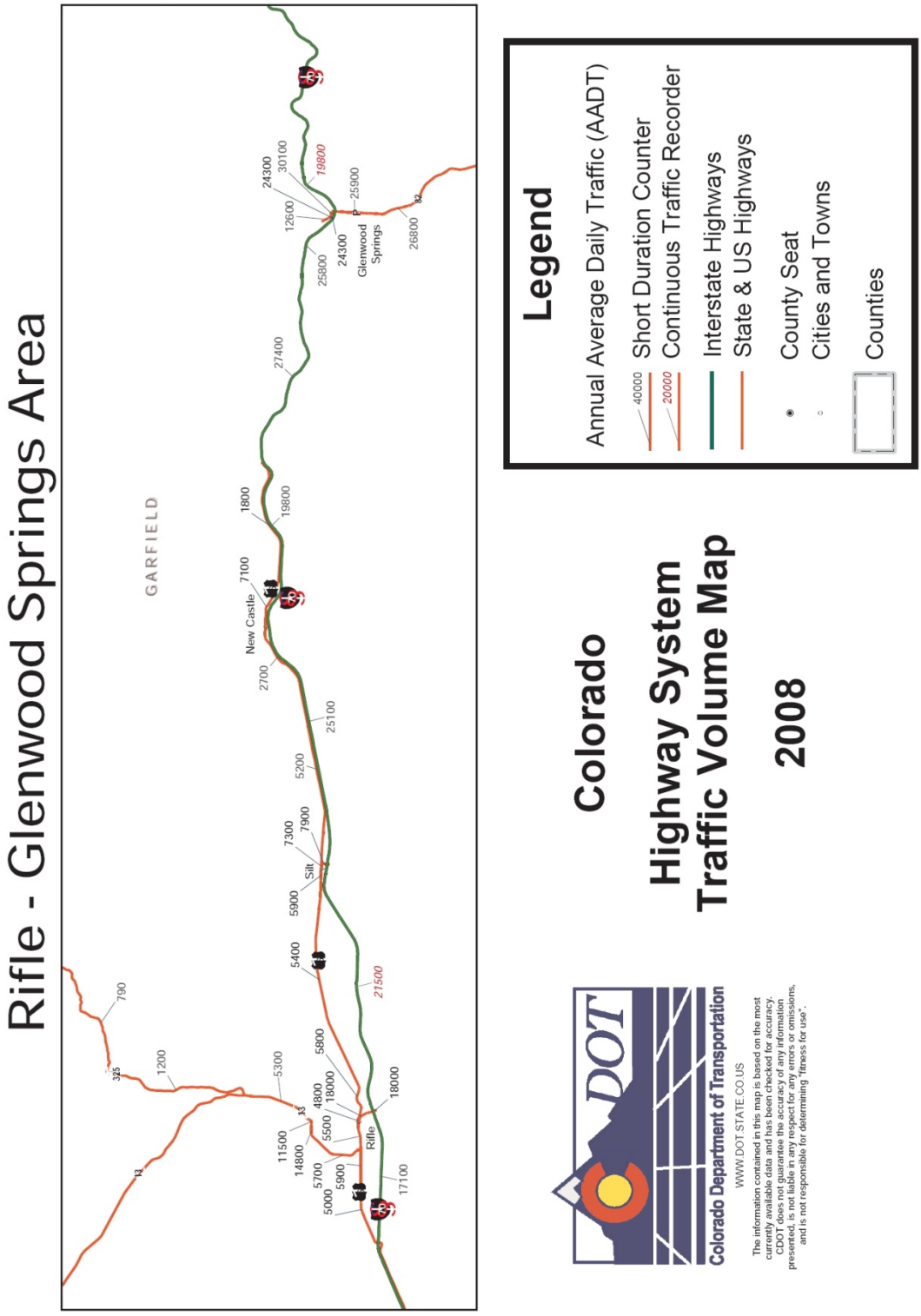


## Appendix E: Stationary Sources by SIC Codes

| Standard Industrial Code (SIC) Description | SIC Code | # of Sources |
|---|---|---|
| Oil and Gas Extraction – Crude Petroleum and Natural Gas | 1311 | 406 |
| Oil and Gas Extraction – Natural Gas Liquids | 1321 | 236 |
| Electric Gas and Sanitary Services – Natural Gas Transmission | 4922 | 5 |
| Mining and Quarrying of Nonmetallic Minerals – Construction Sand and Gravel | 1442 | 15 |
| Automotive Dealers and Gasoline Service Stations – Gasoline Service Stations | 5541 | 29 |
| Agricultural Services – Veterinary Service Specialties | 0742 | 1 |
| Coal Mining – Bituminous Coal & Lignite – Underground | 1222 | 1 |
| Mining and Quarrying of Nonmetallic Minerals – Potash Soda | 1474 | 1 |
| Heavy Construction Other than Bldg Const – Contract | 1629 | 1 |
| Petroleum Refining & Related Industries - Petroleum Refining | 2911 | 1 |
| Petroleum Refining & Related Industries - Paving Mixtures & Blocks | 2951 | 1 |
| Stone Clay Glass & Concrete Products - Ready-Mixed Concrete | 3273 | 1 |
| Transportation Services - Transportation Services Misc | 4789 | 1 |
| Electric Gas And Sanitary Services - Electric Services | 4911 | 1 |
| Electric Gas And Sanitary Services - Refuse Systems | 4953 | 1 |
| Wholesale Trade-Durable Goods - Brick Stone & Related Materials | 5032 | 1 |
| Wholesale Trade-Nondurable Goods - Petroleum Bulk Stations & Terminals | 5171 | 1 |
| Personal Services - Dry Cleaning Plants Except Rugs | 7216 | 3 |
| Personal Services - Funeral Service And Crematories | 7261 | 1 |
| Automotive Repair Services & Parking - Top And Body Repair & Paint Shops | 7532 | 1 |
| Health Services - General Medical & Surgical Hospitals | 8062 | 1 |

# Appendix F: Traffic Counts

## Garfield County Traffic Volumes – State Highways – 2008




*(Courtesy of the Colorado Department of Transportation)*

**Garfield County Traffic Volumes**
County Road System
2002 Transportation Study
Garfield County, Colorado

| Road No. | County Road Name | Avg. Daily Traffic | Road No. | County Road Name | Avg. Daily Traffic |
|---|---|---|---|---|---|
| 83 | 83 | 434 | 133 | **Mel Ray Rd** | 1577 |
| 334 | 334 | 27 | 257 | Mesa Dr | 198 |
| 259A | 259A | 103 | 219 | Middle Rifle Creek | 256 |
| 346 | Airport Rd | 1344 | 262 | Mid-Valley Ln | 336 |
| 314 | Alkali Creek Rd | 205 | 210 | Mile Pond Rd | 820 |
| 225 | Antlers Ln | 242 | 227 | Miller Ln | 931 |
| 216 | Antonelli Ln | 193 | 102 | Missouri Heights | 583 |
| 246 | Anvil Points Rd | 366 | 132 | Mitchell Creek Rd | 197 |
| 266 | Asgard Subdivision | 119 | 301 | Morrisania Mesa Rd | 600 |
| 286 | Atchee Rd | 5 | 118 | Mt Sopris Ranch Rd | 132 |
| 300 | Battlement Pkwy | 2527 | 129 | No Name Ln | 144 |
| 201 | Baxter Pass Rd | 45 | 247 | North Cutoff Rd | 100 |
| 317 | Beaver Creek Rd | 104 | 200 | North Dry Fork Rd | 71 |
| 250 | Bendetti Rd | 312 | 293 | North Graham Rd | 1117 |
| 153 | Big Four Rd | 38 | 251 | North Hasse Ln | 126 |
| 126 | Black Diamond Mine Rd | 185 | 456 | Odin Dr | 140 |
| 240 | Bruce Rd | 175 | 110 | Old Dump Rd | 447 |
| 209 | Brush Creek Rd | 27 | 154 | Old Highway 82 | 2564 |
| 245 | Buford Rd | 1464 | 170 | Panorama Dr | 325 |
| 137 | Canyon Creek Rd | 309 | 451 | Panoramic Dr | 129 |
| 207 | Carr Creek Rd | 16 | 215 | Parachute Creek Rd | 919 |
| 100 | Catherine Store Rd | 4813 | 214 | Peach Valley Rd | 758 |
| 105 | Cerise Rd | 56 | 223 | Peterson Ln | 991 |
| 326 | Chipperfield Ln | 150 | 325 | Porcupine Creek | 43 |
| 211 | Clear Creek Rd | 16 | 206 | Prairie Canyon Rd | 1 |
| 114 | CMC Rd | 1979 | 265 | Prefontaine Rd | 951 |
| 140 | Coffee Pot Rd | 215 | 228 | Pretti Ln | 196 |
| 335 | Colorado River Rd | 2712 | 111 | Prince Creek Rd | 783 |
| 213 | Conn Creek Rd | 9 | 455 | Rainbow Dr | 262 |
| 113 | Cottonwood Pass Rd | 812 | 332 | Ramsey Gulch Rd | 158 |
| 121 | Coulter Creek Rd | 39 | 343 | Raven Rd | 56 |
| 112 | Crystal Springs Mtn | 459 | 115 | Red Canyon Rd | 275 |
| 103 | Crystal Springs Rd | 1373 | 107 | Red Hill Rd | 250 |
| 235 | Davis Point | 307 | 320 | Rifle-Rulison Rd | 1496 |
| 311 | Divide Creek Rd | 2249 | 204 | Roan Creek Dr | 337 |
| 296 | Dokes Ln | 87 | 323 | Rulison Rd | 699 |
| 331 | Dry Hollow Rd | 1102 | 309 | Rulison/Parachute Rd | 378 |

| Road No. | County Road Name | Avg. Daily Traffic | Road No. | County Road Name | Avg. Daily Traffic |
|---|---|---|---|---|---|
| 125 | Dry Park Rd | 211 | 352A | Runway Rd | 248 |
| 313 | East Divide Creek Rd | 137 | 205 | Salt Wash | 13 |
| 241 | Elk Creek Rd | 313 | 322 | Shaeffer Rd | 414 |
| 342 | Fairview Rd | 267 | 233 | Silt Mesa Rd | 896 |
| 231 | First Street | 942 | 238 | Slaughter Gulch Rd | 23 |
| 117 | Four Mile Rd | 2077 | 138 | Slaughterhouse Rd | 63 |
| 244 | Fravert Reservoir Rd | 317 | 298 | Smith Doll Coal Mine Rd | 7 |
| 352 | Garfield County Airport | 1139 | 134 | South Canyon Creek Rd | 525 |
| 312 | Garfield Creek Rd | 211 | 222 | South Dry Fork Rd | 72 |
| 226 | Grass Valley Rd | 325 | 294 | South Graham Rd | 702 |
| 221 | Green Ln | 392 | 329 | Spruce Creek | 89 |
| 261 | Groff Ln | 334 | 291 | Stephens Hill | 283 |
| 327 | Halls Gulch | 212 | 88 | Sunlight Peak Rd | 144 |
| 109 | Hardwick Bridge Rd | 2031 | 151 | Sweetwater Cow Camp Rd | 51 |
| 236 | Harness Ln | 181 | 150 | Sweetwater Lake Rd | 267 |
| 237 | Harvey Gap Rd | 908 | 321 | Taughenbaugh Mesa Rd | 128 |
| 333 | Hunter Mesa Rd | 220 | 108 | Thompson Creek Rd | 1492 |
| 261A | Ingersoll Ln | 137 | 127 | Three Mile Rd | 427 |
| 336 | Jenkins Cutoff | 253 | 260 | Tippitt Ln | 143 |
| 259 | Jewell Ln | 309 | 229 | Ukele Ln | 356 |
| 242 | JQS Rd | 84 | 302 | Underwood Ln | 82 |
| 202 | Kimball Creek Rd | 14 | 122 | Upper Cattle Creek Rd | 123 |
| 119 | Kindall Rd | 17 | 357A | Village Dr | 840 |
| 316 | Knuckles Creek Rd | 49 | 306 | Wallace Creek Rd | 159 |
| 162 | La Casita Rd | 87 | 263 | Weare Ln | 99 |
| 217 | Little Box Canyon Rd | 210 | 344 | West Divide Rd | 140 |
| 120 | Lookout Mountain Rd | 40 | 319 | West Mamm Creek Rd | 1341 |
| 243 | Main Elk Rd | 174 | 252 | West Rifle Creek Rd | 283 |
| 315 | Mamm Creek Rd | 1300 | 69 | Westbank Rd | 847 |
| 123 | Marion Cemetry Rd | 19 | 101 | White Hill Rd | 366 |
| 324 | Maxfield Rd | 195 | 297 | Wittwer Ln | 59 |