Health Consultation

GARFIELD COUNTY

Public Health Implications of Ambient Air Exposures to Volatile Organic Compounds as Measured in Rural, Urban, and Oil & Gas Development Areas

GARFIELD COUNTY, COLORADO

MARCH 13, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

Colorado Department of Public Health and Environment
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Environmental Epidemiology Section has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the US Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) of the Environmental Epidemiology Section (EES) evaluates sampling data collected by our partners, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding the contents of this health consultation or the Colorado Cooperative Program for Environmental Health Assessments, please contact the author of this document:

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Summary and Statement of Issues

The purpose of this document is to identify any potential public health implications resulting from inhalation of volatile organic compounds in Garfield County and recommend actions to reduce the exposure, if necessary. The Garfield County Public Health Service requested assistance from the Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) to evaluate the potential public health hazards with respect to air pollution in the county.

Exploration for natural gas is dramatically increasing in Garfield County, the state of Colorado, and throughout the West. The oil and gas industry is a large source of volatile organic compound (VOC) emissions (CDPHE, 2006). Given the rapid development of the oil and gas industry within Garfield County, and the proximity to residential housing, this health consultation seeks to address concerns from local citizens about health effects related to air quality. This health consultation serves as one piece of a multi-pronged approach designed by Garfield County to address air quality concerns via different health assessment methodologies. The resulting assessments include a screening-level risk assessment by the Colorado Department of Public Health and Environment (CDPHE) according to the United States Environmental Protection Agency (EPA) National Air Toxics Program *Risk Assessment Reference Library,* a Community Health Risk Analysis of Oil and Gas Industry Public Health Concerns in Garfield County by the Saccomanno Research Institute, and this ATSDR health consultation by the CCPEHA.

Some Garfield County residents are experiencing health effects that they believe may have environmental causes. Community concerns range from mild complaints such as dizziness, nausea, respiratory problems, and eye and skin irritation to more severe concerns including cancer. Additionally, the community also has environmental concerns related to noise, odors, dust, and “toxic” chemicals in water and air.

Routine monitoring for VOCs was conducted at fourteen fixed sites for a 24-hour period on a once per month or once per quarter basis, and grab samples were collected at a number of locations based on odor complaints. After a thorough review of the available ambient air data across Garfield County, and considering both theoretical cancer risks as well as non-cancer health effects and the uncertainties associated with the available data, it is concluded that the exposures to air pollution in Garfield County pose an indeterminate public health hazard for current exposures. It should be noted, however, that the estimated theoretical cancer risks and noncancer hazards for benzene at Brock, which is within the oil and gas development area, appear to be significantly higher than those in typical urban and rural areas, causing some potential concern. These elevated levels are an indicator of the increased potential for health effects related to benzene exposure at Brock in the oil and gas development area . As with many health consultations, there is uncertainty when discussing future exposures. Here, the uncertainty is twofold; Garfield County is experiencing a period of rapid growth both in terms of population and in terms of the oil and gas industry. Both types of growth are likely to have some impact on the air quality of the county. Therefore, future exposures are also considered an indeterminate public health hazard.

Background

Site Description and History

Garfield County is a physically diverse county on Colorado's Western Slope. The far western portion of the County is sparsely populated, arid and contains mostly public lands. The central portion of the County, along the Colorado River Valley, contains five municipalities aligned along I-70 and supports the majority of the county's population and economic activity. The southeastern area of the county, defined by the Roaring Fork and Crystal River Valleys, is economically tied to the nearby resort communities, and has one municipality (Carbondale) (BBC, 2007).

Garfield County's economy is based primarily on tourism, regional services, natural gas development, and jobs in neighboring counties. In combination, tourism and regional services account for approximately half of the Garfield County economic base. Although some workers commute into Garfield County, a greater number of Garfield County residents commute to jobs in neighboring counties. Additionally, Garfield County attracts second homeowners and other "quality of life migrants" who move to the area for the local recreation opportunities, climate, and landscape. The County has generally experienced steady growth over the past three decades and is currently growing rapidly as both the recreation/retirement sector and the natural gas industry have expanded. Home and land values have increased substantially in recent years (BBC, 2007).

How has the Discovery and Production of Oil and Gas Lead to Changes in Garfield County?

Garfield County is located in the heart of perhaps the most oil and gas rich region of the United States. Although the immense richness of energy reserves in this community has been understood for some time, changes in the value of natural gas, along with technology improvements and federal energy policy changes, has caused the extraction of these resources to become expedited. As of mid-2006, about 4,000 wells had been completed, and well development is expected to continue at a pace of about 1,000 new wells per year. At the same time, it was estimated that 70 drilling rigs were actively working in Garfield County on behalf of a number of exploration and production companies (BBC, 2007).

Colorado, like most western states, recognizes separate ownership of the surface estate and the underground mineral estate. There are distinct property rights associated with each estate. This philosophy can result in different owners of the surface rights and mineral rights. If an oil and gas company has purchased or leased mineral rights, they are entitled to develop the mineral resource below the surface regardless of who may own the surface of the property. Colorado law provides for access to the mineral estate by allowing subsurface owners "reasonable use" of the surface estate (COGCC, 2007)

As such, natural gas wells and associated facilities are frequently within a few hundred feet of local residences. It has been estimated that 1,179 residential land parcels in Garfield County are within 500 meters of at least one well, and 276 residential land parcels were within 500 meters of at least five wells[1] (NRDC, 2007). Consequently, an increasing number of issues are arising with regard to environmental pollution and potential human health impacts.

Discovery and Production of Oil and Gas

Oil and natural gas furnish about three-fifths of our energy needs - fueling our homes, workplaces, factories, and transportation systems. Furthermore, they constitute the raw materials used to make plastics, chemicals, medicines, fertilizers, and synthetic fibers. Petroleum, otherwise known as oil, is a natural fuel formed from the decay of plants and animals buried beneath the ground, which have been under tremendous heat and pressure for millions of years. Natural gas is formed by a similar process, and is often is found in separate deposits (BLS, 2006).

Using a variety of methods, crews of specialized workers search for geologic formations that are likely to contain oil and gas (BLS, 2006). In rotary drilling, a rotating bit attached to a length of hollow drill pipe bores a hole in the ground by chipping at and cutting the rock. A stream of drilling "mud"—a mixture of clay, chemicals, and water—is continuously pumped through the drill pipe and through holes in the drill bit. When oil or gas is reached, the drill pipe and bit are pulled from the well, and metal pipe (casing) is lowered into the hole and cemented in place. The casing's upper end is fastened to a system of pipes and valves called a wellhead, or "Christmas Tree," through which natural pressure forces the oil or gas into separation and storage tanks (see Figure 1 & Figure 3)(BLS, 2006). For more information on the production of oil or natural gas, please see: http://www.bls.gov/oco/cg/cgs005.htm.

Possible Environmental Impacts During the Discovery and Production of Oil and Gas

In general, air, soil, and water qualities can be affected by extraction of natural gas that is rich in methane (EPA, 2000). Sometimes methane must be separated from fluids and other gases in processes that emit volatile organic compounds (VOCs) into the air. Chemicals containing VOCs may also be used when a well is drilled and also during a process known as hydraulic fracturing ("fracking"), in which chemical mixtures are injected into wells to break up rock formations and release gases. Compressors and other equipment also emit VOCs (Brown, 2007). In addition, VOCs are released during leaks from tubing, valves, tanks, or when wastes are brought to the surface and evaporated from open pits (EPA, 2000).

"Produced water," groundwater drawn from wells that can contain various salts as well as drilling and fracking chemicals, is usually reinjected underground or placed in evaporation ponds on the surface, from which chemicals including VOCs can be released to the atmosphere (Brown 2007). Other chemicals found in produced water include VOCs, metals, and radionuclides. The

1 NRDC report cites Garfield County Assessor's Office, "Parcels: Property Boundaries and Surface Land Ownership, Garfield County, Colorado," CD, 2007.

American Petroleum Institute estimates that nearly eight barrels of water are produced for every barrel of oil. Natural gas wells typically produce much lower volumes of water than oil wells (EPA, 2000). Methane and fracking chemicals can also migrate into shallow aquifers used for drinking water wells. Benzene, toluene, ethyl benzene, and xylenes are naturally present in many hydrocarbon deposits, and may be present in drilling and fracking chemicals (Brown, 2007).

Overall, VOCs are released to the air at all stages of oil and gas operations, from exploration and drilling to processing, including venting, dehydration, gas processing, compression, leaks from equipment, evaporation of produced water from pond, and evaporation of wastes from open pits. For example, benzene is released during venting and dehydration.

Demographics

The demographic data listed herein is U.S. Census 2000 data for Garfield County. In 2000, the county had a population of 43,791 – 21,302 (49%) females and 22,489 (51%) males. The median age was 34 years. Twenty-seven percent of the population were under 18 years old and 9% were 65 years and older. In 2000, there were 16,230 households in the census tract. The average household size was 2.65 persons. Within the county, for people reporting one race, 92% were White alone; 0.5% were Black or African American; 0.7% were American Indian and Alaska Native; 0.4% percent were Asian. Two percent reported two or more races. Seventeen percent of the people in the county were Hispanic or Latino. Ten percent of the people living in the county were foreign born. Among people at least five years old, 16% speak a language other than English at home (US Census 2000).

The population of Garfield County is projected to be 72,562 by 2010, 109,763 by 2020, and 147,864 by 2030. This projected increase in population is largely attributable to job increases in Eagle and Pitkin Counties, the need to house large proportions of those workers in Garfield County, and it further considers energy development jobs growth with the predicted number of wells drilled increasing to nearly 20,000 wells by 2025 (WCGSP, 2005).

A significant and growing proportion of the Garfield County population consists of residents with limited capabilities in reading and speaking English. It is estimated that there were about 3,500 County residents in 2005 with limited English proficiency (LEP), compared with approximately 3,200 such residents identified at the time of the 2000 Census. These estimates are based on residents who self-identify themselves as LEP by reporting that they speak English less than “very well” (BBC, 2007).

Community Health Concerns

Over a period of approximately two years, the Saccomanno Research Institute collected perceptions of individuals about community health and priority health concerns via a process of public meetings, focus groups, structured individual interviews, and unsolicited telephone calls to the Garfield County Health Department. The views and concerns of about 119 individuals are summarized below with the author's permission. It is, however, important to note that the following concerns may or may not have been associated with environmental exposures (Coons, Report In Preparation).

- Increase in or exacerbations of allergies and asthma
  - Related concerns: coughing, wheezing, other respiratory complaints
- Generalized chemical sensitivities
- Fibromyalgia/chronic pain
  - Related concern: chronic fatigue, lethargy
- Chronic colds
  - Related concerns: concern about compromised immune systems
- Headaches, dizziness, burning/itching eyes, nausea/vomiting, sinus problems – most often attributed to odors
- Burning/itching skin
- Mental health issues such as stress, depression, anger, inability to sleep
- Cancer (adrenal cancer, brain tumors, unknown/presumed cancers or "fear of developing cancer")
- Loss of voice or speech problems
- Trauma/work-related injuries
- Age-related illnesses
- Diabetes
- Obesity
- Perceptions that pre-existing health conditions have been exacerbated; people "feeling worse" than in the past

Additionally, the community also has environmental concerns related to noise, odors, dust, and "toxic" chemicals in water and air.

Discussion

Environmental Sampling and Data Used for Exposure Evaluation

Volatile organic compounds (VOC's) are a class of carbon-based compounds that readily evaporate at room temperatures. This evaluation used the data collected for an ambient air quality monitoring study conducted by the Garfield County and CDPHE (CDPHE, 2007). Overall, the data was collected from 14 fixed air monitoring sites. These 14 sites were divided into three categories; Oil and Gas development (8 sites); Urban (4 sites); and Rural Background

(2 sites). The results of the sampling analysis and summary statistics for the data used in this evaluation are presented in Appendix C and briefly discussed below.

During the 24-month sampling period, 24-hour VOC samples were collected on either a monthly or quarterly basis for a total of 232 samples. All samples were collected by Colorado Mountain College (CMC) under the direction of CDPHE or Garfield County. Monthly and quarterly sampling locations were predetermined by Garfield County and the sampling schedule was made to coincide with the nationwide EPA air sampling schedule. The sampling infrequency was due to the high analytical costs for VOC's. Due to sampling equipment limitations, VOC samples were set out late-morning or early afternoon on the sample day and were recovered at approximately the same time the following day.

Fixed VOC sites were selected based on population exposure, local citizen complaints, or willingness of land-owners. Fixed monitoring sites were chosen to represent urban centers, rural areas (very limited or no oil and gas development) and rural oil and gas areas. The location of fixed monitoring sites in relation to gas wells and residences is shown in Figure 6. There is a varying degree of oil and gas production in the oil and gas development areas depending on the energy companies plans. Yet all oil and gas sampling sites are in some stage of development and are confirmed to be in production.

In addition, 27 grab samples were collected during a number of odor events. All grab samples were taken outdoors. Grab samples collect air over a period of approximately 10 to 15 seconds. Grab samples were collected by Garfield County staff, contractors, and residents in response to odor complaints. Grab sample locations are shown in Figure 7. In comparing the geographic location of the grab samples collected to the location of oil and gas activities and other possible activities, it is likely that the odors were related to oil and gas. In addition, the majority of the grab samples were taken in an area that reports higher condensate production than other areas of the County.

Monitoring was performed using Summa-polished stainless steel canisters with a stainless steel flow control orifice. The canisters are evacuated in the lab prior to sampling, so no power was required for operation. The sampled canisters were analyzed and cleaned by Columbia Analytical for 43 different VOC's following EPA Methods TO-15 and TO-14a.

Exposure Evaluation

Selection of Contaminants of Potential Concern (COPCs)

The maximum detected concentration of 15 contaminants was compared with conservative health based environmental guidelines or Comparison Values (CVs) to select COPCs at each of the 14 sites for further evaluation of potential health effects. Exposures to contaminants below the environmental guidelines are not expected to result in adverse or harmful health effects. However, exceeding the CV does not necessarily indicate that the contaminant poses a public health hazard. The amount of contaminant, duration and exposure route, exposure probability, and the health status and lifestyle of the exposed individual are important factors in determining the potential for adverse health effects.

The health based environmental guideline or screening values utilized as CVs in this evaluation are the Environmental Protection Agency's Region 3 Risk-Based Concentration (RBCs), Massachusetts Allowable Ambient Limits (AALs) for Ambient Air, and ATSDR's Chronic, Intermediate, and Acute duration Minimal Risk Levels (MRLs). EPA Region 3 RBCs for carcinogenic compounds in ambient air are based on an age-adjusted exposure covering 30 years from the time of birth to the age of 30 with an exposure frequency of 350 days per year. The inhalation RBCs for carcinogenic contaminants indicate that no more than one theoretical excess cancer case out of one million would be expected from exposures to this concentration in air. ATSDR's CVs for non-carcinogenic health effects are based upon acute, chronic and intermediate-duration inhalation exposures. When a cancer and non-cancer CV exist for the same chemical, the lower of these values is used as a conservative measure. In addition to exceeding the CV, only those COPCs that were detected in at least 5% of the samples were retained for further analysis.

Benzene, methylene chloride, tetrachloroethene, trichloroethene, and 1,4-dichlorobenzene were retained as COPCs for carcinogenic health effects since the maximum concentrations exceed EPA Region 3 RBCs for carcinogenic health effects (Appendix Tables C4-C17). Of these COPCs, benzene was retained at 12 sites, methylene chloride was retained at 1 site, tetrachloroethene was retained at 2 sites, trichloroethene was retained at 1 site, and 1,4-dichlorobenzene was retained at 8 sites.

In accordance with the CDPHE and EPA Region 8 protocol for the selection of COPCs, if multiple contaminants exist on-site, the CV values are multiplied by 0.1 (EPA, 1994). For non-carcinogenic contaminants, multiplying the CV by 0.1 is thought to account for any additive adverse effects from multiple chemicals. Two COPCs were retained based on the noncarcinogenic health effects (Appendix s C4-C18). Of these, m,p-xylenes was retained at 6 sites, and 2-hexanone was retained at 3 sites.

The Conceptual Site Model

The conceptual site model describes the primary contaminants of potential concern, contaminated sources, and the potential exposure pathways by which different types of populations (e.g. residents and outdoor workers) might come into contact with contaminated media. Exposure pathways are classified as either complete, potential, or eliminated. Only complete exposure pathways can be fully evaluated and characterized to determine the public health implications. A complete exposure pathway consists of five elements: a source, a contaminated environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population.

The overall conceptual site model for all complete and potential pathways in Garfield County is presented below.

Conceptual Site Model

Pathway Name	Exposure Pathway Elements						
	Source	**Contaminated Medium**	**Point of Exposure**	**Potentially Exposed Population**	**Route of Exposure**	**Time Frame**	**Pathway Complete?**
Outdoor Air	VOC emissions related to Oil and Gas extraction	Ambient Outdoor Air	Ambient Air	Residents and Workers	Inhalation	Present and Future	Yes

Public Health Implications

The purpose of this evaluation is to determine whether exposures to COPCs that exceed the CVs for the outdoor air exposure pathway might be associated with adverse health effects. This requires a calculation of site-specific exposure doses for an estimated duration of exposure on-site and comparison with an appropriate toxicity value (or health guideline).

To calculate theoretical cancer risks for the outdoor air pathway, the inhalation dose of contaminants in the ambient outdoor air samples is multiplied by the cancer slope factor (or health guideline) in accordance with the EPA Region 3 Risk-Based Concentrations methodology. A more detailed description of this methodology is available in Appendix D. The available toxicity values (or health guidelines) utilized here to evaluate the likelihood of possible cancer and noncancer effects are discussed in Appendix E. The results of health risk calculations are presented in Tables 2 – 6.

Overall, only m,p-xylene and 2-hexanone were selected based on the noncarcinogenic health effects. Noncancer adverse health effects are not likely to occur from exposure to the levels of m,p-xylene and 2-hexanone encountered in this evaluation, based on comparison with the ATSDR chronic health guidelines. In addition, methylene chloride is retained as a carcinogenic COPC, but it is not discussed further in this evaluation because it was detected only at one urban site with risk estimates below a cancer risk level of 1E-06 (Table 2). The four major carcinogenic COPCs, tetrachloroethene, trichloroethene, 1,4-dichlorobenzene, and benzene, have risk estimates above the lower-end of EPA's acceptable range of 1E-06 to 1E-04 (1 to 100 excess cancers per million individuals exposed) and are briefly discussed below.

Trichloroethene

Trichloroethene was retained as a COPC at only one site, an urban monitoring station (Table 2). At the Parachute site, the estimated theoretical cancer risk is 1.35E-04 (135 cancer cases per million person exposed). This risk estimate does raise concern about significant theoretical cancer risks. However, this risk calculation is based on the maximum value of the eight samples taken at one site. This maximum value is also the only sample of the eight where trichloroethene was detected. As such, there is much uncertainty associated with this risk calculation. Moreover, this risk is conservatively calculated based on the exposure assumption of 24 hrs/day for 350 days/year over 30 years. Overall, noncancer adverse health effects from exposure to trichloroethene are not likely to occur because comparison of the maximum detected value to the ATSDR MRLs for chronic (365 or more days), intermediate (15-364 days), and acute (1-14 days) duration exposures yield HQs that are less than 1.0 (Table 3). In total, trichloroethene in ambient outdoor air is not likely to constitute significant health concerns.

Tetrachloroethene

Tetrachloroethene was retained as a COPC at only one site (Table 2). At Haire, the oil and gas development site, the estimated theoretical cancer risk is 3.66E-06 (4 cancer cases per million persons exposed). This risk estimate does not appear to represent a significant theoretical cancer risk. Moreover, this risk is conservatively calculated based on the exposure assumption of 24 hrs/day for 350 days/year over 30 years. Overall, noncancer adverse health effects from exposure to tetrachloroethene are not likely to occur because comparison of the maximum detected value to the ATSDR MRLs for chronic (365 or more days), intermediate (15-364 days), and acute (1-14 days) duration exposures yield HQs that are less than 1.0 for all sites (Table 3).

1,4-Dichlorobenzene

1,4-Dichlorobenzene was retained as a COPC at seven sites (Tables 2). At the three oil and gas development sites where it was detected, the estimated theoretical cancer risk ranges from 4.24E-06 (4 cancer cases per million person exposed) to 1.10E-05 (10 cancer cases per million person exposed). At the three urban sites where it was detected, the estimated theoretical cancer risk ranges from 7.58E-06 (7 cancer cases per million person exposed) to 4.14E-05 (41 cancer cases per million persons exposed). At the one rural background site where it was detected, the estimated theoretical cancer risk is 1.59E-05 (16 cancer cases per million person exposed). These risk estimates do not appear to represent a significant theoretical cancer risk at any of the sites, nor does it appear that the theoretical cancer risk is elevated at oil and gas development sites as compared to urban or rural background sites. Moreover, these risks are conservatively calculated based on the exposure assumption of 24 hrs/day for 350 days/year over 30 years. Additional noncancer adverse health effects from exposure to 1,4-dichlorobenzene are not likely to occur because comparison of the maximum detected value to the ATSDR MRLs for chronic (365 or more days), intermediate (15-364 days), and acute (1-14 days) duration exposures yield HQs that are less than 1.0 for all sites (Table 3).

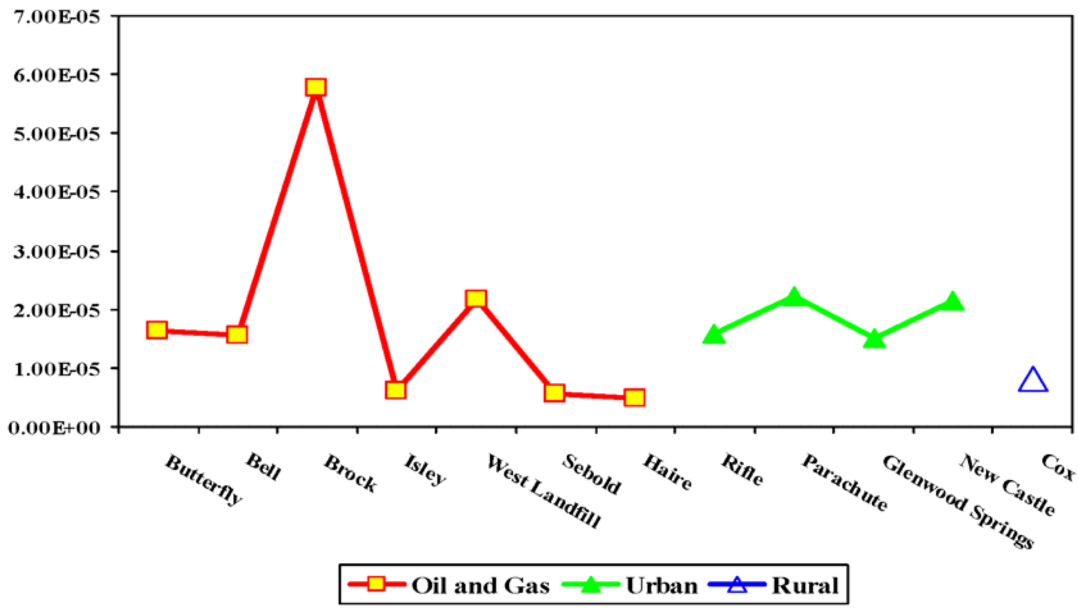
Benzene

Benzene was retained as a COPC at 12 sites (Table 2). At the seven oil and gas development sites where it was detected, the estimated theoretical cancer risk ranges from 4.97E-06 (5 cancer cases per million person exposed) to 5.77E-05 (58 cancer cases per million person exposed). At the four urban sites where it was detected, the estimated theoretical cancer risk ranges from 1.52E-05 (15 cancer cases per million person exposed) to 2.22E-05 (22 cancer cases per million person exposed). At the one rural background site where it was detected, the estimated theoretical cancer risk is 8.26E-06 (8 cancer cases per million person exposed).

These risk estimates are within the EPA's acceptable range of 1E-06 to 1E-04 (1 to 100 excess cancers per million individuals exposed). However, the theoretical cancer risk is close to the upper-end of the EPA acceptable range at Brock, an oil and gas development site, where the theoretical cancer risk is 5.77E-05. The theoretical cancer risk at Brock is elevated as compared to other oil and gas development sites, urban sites, and rural background sites (Figure 1). With the exception of the Brock site, these risk estimates do not appear to represent a significant theoretical cancer risk at any of the sites, nor does it appear that the theoretical cancer risk is elevated at oil and gas development sites as compared to urban or rural background sites (Table 2).

The sampling data collected at Brock is critical for several reasons. First, the estimated cancer risks for benzene at the Brock monitoring site are somewhat driven by one very high concentration (49.0 $\mu g/m^3$) over the 24-hour exposure period. Second, the maximum value detected at Brock is important because it could represent occasional events where peak concentrations of benzene in ambient outdoor air are as high as the levels seen in grab samples during odor complaint events. For example, the maximum detected benzene concentration in grab samples was 180.0 $\mu g/m^3$ (Table D2). Third, it is unknown why the levels of benzene are elevated at Brock; differences in topography, oil and gas activity, placement of the monitoring station, or sampling conditions could be the cause of the elevated levels. However, the high concentrations detected at Brock cannot be disregarded either. The high values could indicate that some residents are episodically exposed to significantly higher than ambient concentrations of benzene. Since residents may be repeatedly exposed to these peak concentrations of benzene, the concentrations detected via grab samples warrant careful monitoring and exposure evaluation. This high data point at Brock further illustrates the substantial variation between sampling points, due to the limited sampling frequency, and the resulting uncertainty in the data collected.

Figure 1. Theoretical Cancer Risks for Benzene Across all Monitoring Sites



Additionally, at the Brock oil and gas development site, the estimated chronic noncancer hazards for benzene are in the zone of potential concern based on the comparison of the average detected value of 13.3 µg/m^3 with the ATSDR health guideline (MRL) of 10 µg/m^3 for the chronic exposure duration (365 days or more) (Table 3). Furthermore, the estimated acute and intermediate noncancer hazards for benzene are in the zone of potential concern, based on the comparison of the maximum detected concentration of 49.0 µg/m^3 with the ATSDR MRLs of 20 µg/m^3 and 30 µg/m^3 for the intermediate (15-364 days) and acute (1-14 days) exposure durations, respectively. The maximum detected concentration at Brock of 49.0 µg/m^3 is significantly below the intermediate Lowest-Observed-Adverse-Affect-Level (LOAEL) of 5832 µg/m^3 in mice, the acute LOAEL of 8262 µg/m^3 in mice, and the chronic NOAEL of 97 µg/m^3 in humans (Tables 3 and 5).

Furthermore, it should, be noted that the estimated acute noncancer hazards also enter a range of potential concern based on the comparison of the maximum concentration in grab samples of 180 µg/m^3 to the ATSDR acute MRL of 30 µg/m^3 (for exposure duration of 1-14 days). Additionally, the maximum benzene concentration is well below the acute LOAEL of 8262 µg/m^3 in mice (Table 6). The maximum concentration in grab samples (180 µg/m^3) is well below the OEHAA acute health guideline value of 1300 µg/m^3 (for 6-hour exposure duration).

In total, benzene exposures are considered to be an indeterminate public health hazard. Three major sources of uncertainty were factored into this conclusion: (1) the inability to realistically and continuously monitor ambient air at all places of interest and in the breathing zone of the exposed population, (2) the reality that some of the monitoring locations may detect emissions from sources other than the oil and gas development activities; and (3) the inability to adequately capture intermittent peak exposures, as indicated by grab sampling events.

It should be noted that benzene, the major contaminant of potential concern in this investigation, is ubiquitous in the atmosphere. It has been identified in ambient outdoor and indoor air samples of both rural and urban environments (ATSDR, 2005). For example, benzene is a component of gasoline vapors or vehicle exhaust, cigarette smoke, wood smoke, paints, adhesives, and particleboard. Since benzene is a known human carcinogen and the estimated cancer risks are slightly below the upper-end of EPA's acceptable range, no matter what the source, exposure to benzene should be minimized based on prudent public health practice.

Overall, given the uncertainty in the limited available data and uncertainty in the exposure patterns of community, more air monitoring is urged. More data is needed to further characterize the source of benzene, the acute and chronic noncancer hazards, and the lifetime cancer risks related to benzene at oil and gas sites, especially those either near, or similar to, the Brock monitoring site.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

The health effects of some of the major components of gasoline, benzene, toluene, ethylbenzene, and xylene (BTEX) on young children are generally thought to be similar to the effects on adults. However, it is not known whether children are more sensitive to the effects of BTEX than adults. In general, children could have greater exposures than adults because BTEX are heavier than air and occur near the floor and children breathe air that is closer to the ground. Benzene is the primary contaminant of potential concern at this site. The unique susceptibility of children to adverse health effects from benzene exposures was considered in this evaluation by utilizing the risk-based concentrations that account for time-weighted early life exposures (0-6 years) through the age of 30. Children can be affected by benzene exposure in the same way as adults. It is not known if children are more susceptible to benzene poisoning. However, benzene can cross the placenta and can also be excreted in breast milk. Animal studies have shown low birth weights, delayed bone formation, and bone marrow damage when pregnant animals breathed benzene (ATSDR, 2005).

Conclusions

Data reviewed in this health consultation indicate that the ambient air quality in Garfield County constitutes an indeterminate public health hazard, for all current exposures, based on the estimated theoretical cancer risks as well as noncancer hazards and the uncertainties associated with the available data. It should be noted, however, that the estimated theoretical cancer risks and noncancer hazards for benzene at Brock, in the oil and gas development area, appear to be significantly higher than those in the urban and rural areas, causing some potential concern. These elevated levels are an indicator of the increased potential for health effects related to benzene exposure at Brock and in the oil and gas development area. Furthermore, the future exposures are considered to represent an indeterminate public health hazard, as changes in the oil and gas industry do not allow for use of the current data to predict future exposure scenarios. However, as Garfield County is expected to experience rapid population and industrial growth in the coming years, the air quality will likely be impacted. Should the air quality worsen, the conclusions made here will need to be revisited. Please see Appendix G for a description of ATSDR's public health hazard categories.

Recommendations

Based upon the data and information reviewed, CDPHE has made the following recommendations:

- In order to facilitate a more thorough health risk evaluation for short-term and long-term exposures, Garfield County should redesign monitoring of ambient air quality by increasing the frequency of sampling and including a complete list of contaminants associated with oil and gas development.
- Garfield County should investigate factors that might be related to higher levels of Benzene detected at the Brock site. Pending the results of this investigation, Garfield County should add monitoring sites that are similar to Brock.
- If feasible, Garfield County should begin groundwater sampling to determine if oil and gas development is impacting water quality.
- Garfield County should continue to work with state regulators to identify major sources of air pollution and implement remedial measures or regulations as appropriate.
- Garfield County should implement appropriate education and outreach efforts to residents and businesses to raise awareness of how their behaviors or practices impact air quality.
- Garfield County should implement appropriate education and outreach efforts to residents and to raise awareness of how air pollution can affect respiratory health.

Public Health Action Plan

The public health action plan describes the actions designed to mitigate or prevent adverse human health effects that might result from exposure to hazardous substances associated with site related contamination. The CCPEHA at CDPHE and Garfield County Public Health commit to do the following public health actions to reduce exposure to site related contamination:

- By request, CCPEHA will evaluate any additional air and groundwater data that may be collected in the future.
- Upon request, CCPEHA will collaborate with the Garfield County to conduct health education and outreach activities.
- CCPEHA will make this document available to the public through the CCPEHA website and through the information repositories located in the community.
- By request, CCPEHA will facilitate translation of this document into Spanish and will provide a Spanish language version on the website.

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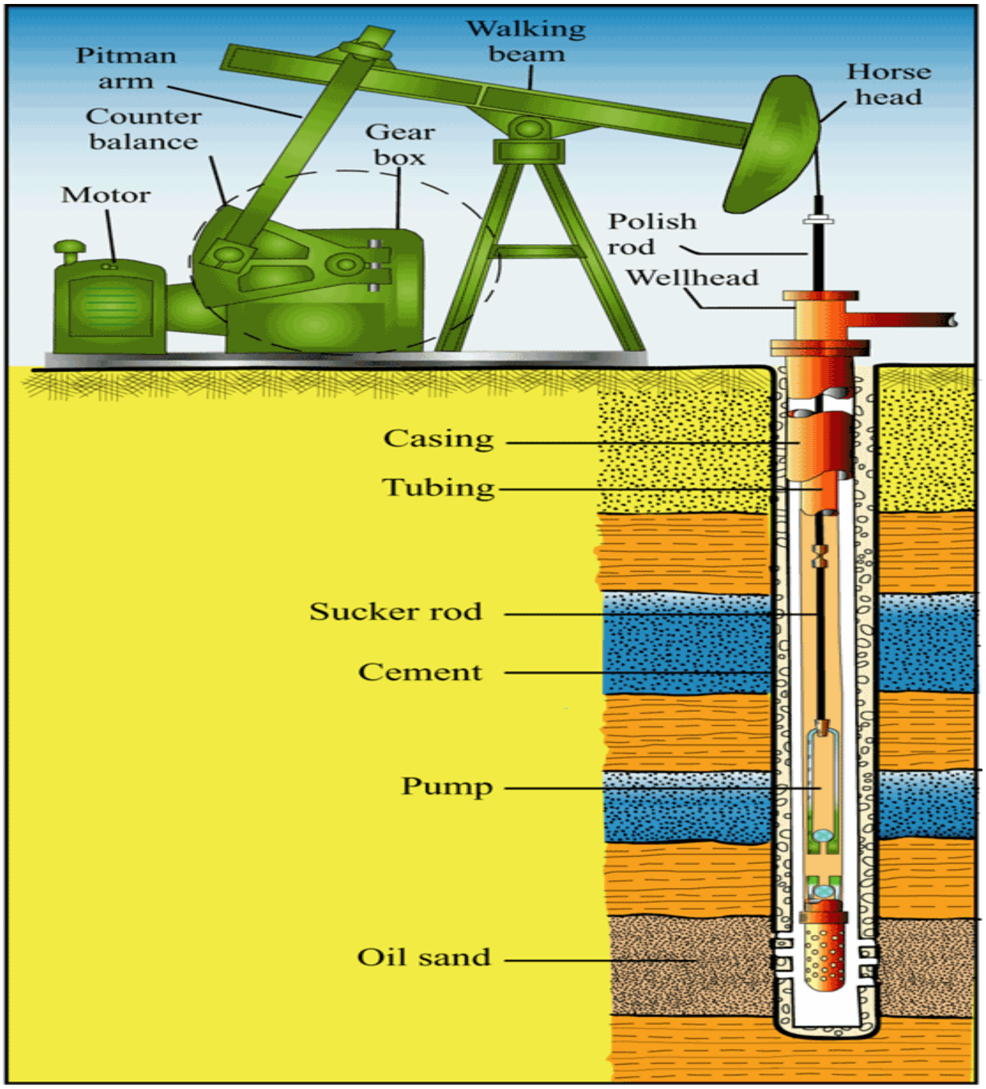
Tables and Figures

Figure 2. Picture of a Well, California Division of Oil, Gas, and Geothermal Resources

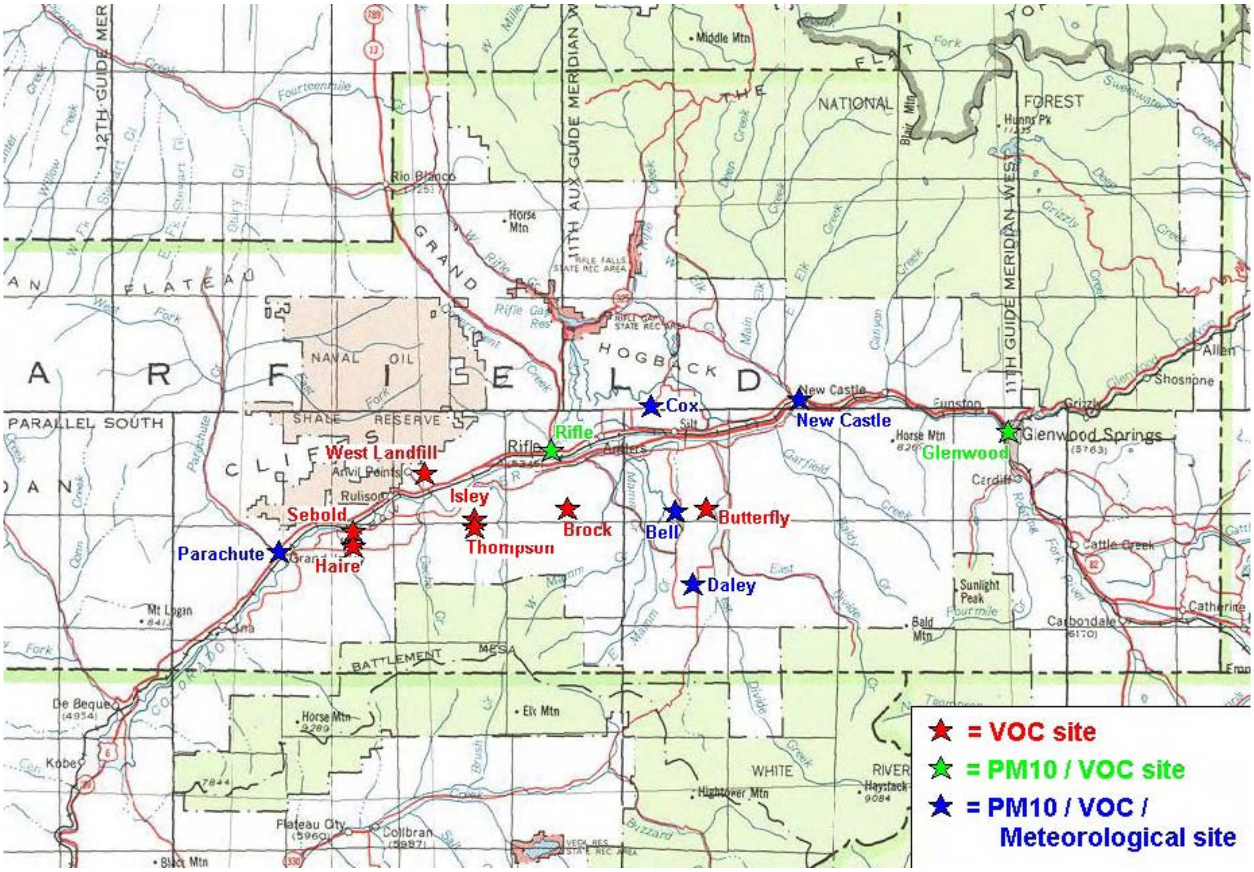


Picture (http://www.howstuffworks.com/framed.htm?parent=oil-drilling.htm&url=http://www.consrv.ca.gov/DOG/qh_well.htm, June 2007)

Figure 3. Photo of Gas Wells In Garfield County

EnCana Oil & Gas (USA), Inc

Figure 4. Location of 24-hour Monitoring Stations in Garfield County



Site Description	Location
Oil and Gas Development	Butterfly, Bell, Brock, Isley, West Landfill, Sebold, Haire
Urban	Rifle, Parachute, Glenwood Springs, New Castle
Rural Background	Cox, Daley

Table 1. Listing of Contaminants Retained for Further Analysis Based on Max Value, by site.

Site Description	Location	Contaminant
Oil and Gas Development	Butterfly 21 samples	Benzene
		m,p-Xylenes
		1,4-Dichlorobenzene
Oil and Gas Development	Bell 24 samples	Benzene
		m,p-Xylenes
Oil and Gas Development	Brock 22 samples	Benzene
		m,p-Xylenes
Oil and Gas Development	Isley 20 samples	Benzene
		1,4-Dichlorobenzene
Oil and Gas Development	West Landfill 23 samples	Benzene
		2-Hexanone
		m,p-Xylenes
Oil and Gas Development	Sebold 21 samples	Benzene
		2-Hexanone
		1,4-Dichlorobenzene
Oil and Gas Development	Haire 22 samples	Benzene
		Tetrachloroethene
Urban	Rifle 23 samples	Benzene
		m,p-Xylenes
Urban	Parachute 8 samples	Benzene
		2-Hexanone
		m,p-Xylenes
		Trichloroethene
		1,4-Dichlorobenzene
Urban	Glenwood Springs. 8 samples	Benzene
		1,4-Dichlorobenzene
Urban	New Castle 21 samples	Benzene
		Methylene Chloride
		1,4-Dichlorobenzene
Rural Background	Cox 8 samples	Benzene
Rural Background	Daley 8 samples	1,4-Dichlorobenzene

Table 2. Theoretical Cancer Risk Estimates for Ambient Air in Garfield County

Site Description	Location	Contaminant	EPC	RBC	Cancer Risk	Total Cancer Risk per site
			µg/m³	µg/m³		
Oil and Gas Development	Butterfly 21 samples	Benzene	3.739	2.3E-01	1.63E-05	
		1,4-Dichlorobenzene	3.180	2.9E-01	1.10E-05	2.73E-05
Oil and Gas Development	Bell 24 samples	Benzene	3.555	2.3E-01	1.55E-05	
Oil and Gas Development	Brock 22 samples	Benzene	13.270	2.3E-01	5.77E-05	
Oil and Gas Development	Isley 20 samples	Benzene	1.385	2.3E-01	6.02E-06	
		1,4-Dichlorobenzene	1.639	2.9E-01	5.65E-06	1.17E-05
Oil and Gas Development	West Landfill 23 samples	Benzene	4.981	2.3E-01	2.17E-05	
Oil and Gas Development	Sebold 21 samples	Benzene	1.286	2.3E-01	5.59E-06	
		1,4-Dichlorobenzene	1.230	2.9E-01	4.24E-06	9.83E-06
Oil and Gas Development	Haire 22 samples	Benzene	1.143	2.3E-01	4.97E-06	
		Tetrachloroethene	1.135	3.1E-01	3.66E-06	8.63E-06
Urban	Rifle 23 samples	Benzene	3.658	2.3E-01	1.59E-05	
Urban	Parachute 8 samples	Benzene	5.10	2.3E-01	2.22E-05	
		Trichloroethene	2.7	2.0E-02	1.35E-04	
		1,4-Dichlorobenzene	2.2	2.9E-01	7.59E-06	1.65E-04
Urban	Glenwood Springs. 8 samples	Benzene	3.50	2.3E-01	1.52E-05	
		1,4-Dichlorobenzene	12.00	2.9E-01	4.14E-05	5.66E-05
Urban	New Castle 21 samples	Benzene	4.931	2.3E-01	2.14E-05	
		Methylene Chloride	2.767	3.79	7.30E-07	
		1,4-Dichlorobenzene	2.888	2.9E-01	9.96E-06	3.21E-05
Rural Background	Cox 8 samples	Benzene	1.90	2.3E-01	8.26E-06	8.26E-06
Rural Background	Daley 8 samples	1,4-Dichlorobenzene	4.60	2.9E-01	1.59E-05	1.59E-05

Table 3. Chronic Non-Cancer Hazards for Ambient Air in Garfield County, by site

Site Description	Location	Contaminant	EPC	CV	Non Cancer HQ	ATSDR Chronic MRL	HQ based on ATSDR Chronic MRL	EPA RfC	HQ based on EPA RfC
			µg/m³	µg/m³		µg/m³		µg/m³	
Oil and Gas Development	Butterfly 21 samples	Benzene	3.739			10	0.37	30	0.12
		m,p-Xylenes	15.340	1.1E+02	0.14				
		1,4-Dichlorobenzene	3.180			60	0.05	800	0.004
Oil and Gas Development	Bell 24 samples	Benzene	3.555			10	0.36	30	0.12
		m,p-Xylenes	4.329	1.1E+02	0.04				
Oil and Gas Development	Brock 22 samples	Benzene	13.270			10	**1.33** [a]	30	0.44
		m,p-Xylenes	4.425	1.1E+02	0.04				
Oil and Gas Development	Isley 20 samples	Benzene	1.385			10	0.14	30	0.05
		1,4-Dichlorobenzene	1.639			60	0.03	800	0.002
Oil and Gas Development	West Landfill 23 samples	Benzene	4.981			10	0.50	30	0.17
		2-Hexanone	1.330	10.880	0.12				
		m,p-Xylenes	13.420	1.1E+02	0.12				
Oil and Gas Development	Sebold 21 samples	Benzene	1.286			10	0.13	30	0.04
		2-Hexanone	1.104	10.880	0.10				
		1,4-Dichlorobenzene	1.230			60	0.02	800	0.002
Oil and Gas Development	Haire 22 samples	Benzene	1.143			10	0.11	30	0.04
		Tetrachloroethene	1.135			271.13	0.004	NA	
Urban	Rifle 23 samples	Benzene	3.658			10	0.37	30	0.12
		m,p-Xylenes	6.916	1.1E+02	0.06				
Urban	Parachute 8 samples	Benzene	5.10			10	0.51	30	0.17
		2-Hexanone	2.10	10.880	0.19				
		m,p-Xylenes	11.00	1.1E+02	0.10				
		Trichloroethene	2.7			NA		NA	
		1,4-Dichlorobenzene	2.2			60	0.04	800	0.003
Urban	Glenwood Springs. 8 samples	Benzene	3.50			10	0.35	30	0.127
		1,4-Dichlorobenzene	12.00			60	0.2	800	0.02
Urban	New Castle 21 samples	Benzene	4.931			10	0.49	30	0.16
		Methylene Chloride	2.767			1041	0.003	NA	
		1,4-Dichlorobenzene	2.888			60	0.05	800	0.004
Rural Background	Cox 8 samples	Benzene	1.9			10	0.19	30	0.06
Rural Background	Daley 8 samples	1,4-Dichlorobenzene	4.60			60	0.08	800	0.006

[a] The EPC of 13.3 µg/m³ is well below the chronic NOAEL of 97µg/m³ (in humans) of the ATSDR MRL (i.e., HQ_{NOAEL} of 0.14 is well below an acceptable level of 1.0).

Table 4. Acute and Intermediate Noncancer Hazards for Ambient Air in Garfield County at the Brock Site in Oil and Gas Development Area, based on the EPC (95% UCL on the mean)

Site Description	Location	Contaminant	EPC	ATSDR acute MRL	HQ based on ATSDR acute MRL	ATSDR Intermediate MRL	HQ based on ATSDR Intermediate MRL
			µg/m³	µg/m³		µg/m³	
Oil and Gas Development	Brock 22 samples	Benzene	13.270	30	0.44	20	**0.66**

Table 5. Acute and Intermediate Non-Cancer Hazards for Ambient Air in Garfield County Using Maximum Detected Values for Benzene, by site

Site Description	Location	Contaminant	Max	ATSDR acute MRL	HQ based on ATSDR acute MRL	ATSDR Intermediate MRL	HQ based on ATSDR Intermediate MRL
			µg/m³	µg/m³		µg/m³	
Oil and Gas Development	Butterfly 21 samples	Benzene	7.7	30	0.26	20	0.39
Oil and Gas Development	Bell 24 samples	Benzene	7.4	30	0.25	20	0.37
Oil and Gas Development	Brock 22 samples	Benzene	49.0	30	**1.63** [a]	20	**2.45** [b]
Oil and Gas Development	Isley 20 samples	Benzene	3.0	30	0.1	20	0.15
Oil and Gas Development	West Landfill 23 samples	Benzene	7.5	30	0.25	20	0.38
Oil and Gas Development	Sebold 21 samples	Benzene	2.7	30	0.09	20	0.14
Oil and Gas Development	Haire 22 samples	Benzene	2.3	30	0.07	20	0.12
Urban	Rifle 23 samples	Benzene	6.9	30	0.23	20	0.35
Urban	Parachute 8 samples	Benzene	5.1	30	0.17	20	0.26
Urban	Glenwood Springs. 8 samples	Benzene	3.5	30	0.12	20	0.18
Urban	New Castle 21 samples	Benzene	15.0	30	**0.5**	20	**0.75**
Rural Background	Cox 8 samples	Benzene	1.9	30	0.06	20	0.09

[a] The maximum detected concentration of 49µg/m³ is well below the acute LOAEL of 8262 µg/m³ for lymphocyte depression (immune system effects) in mice, based on the ATSDR MRLs (ATSDR, 2005).
[b] The maximum detected concentration of 49µg/m³ is well the below the intermediate LOAEL of 5832 µg/m³ for lymphocyte depression (immune system effects) in mice, based on the ATSDR MRLs (ATSDR, 2005).

Table 6. Acute Non-Cancer Hazards based on Max Values from Grab Samples

Compound	Result	COPC?	OEHAA acute / Mass. TEL value	ATSDR Acute MRL	HQ based on OEHAA acute / Mass. ALL value	HQ based on ATSDR acute MRL
	μg/m³		**μg/m³**	**μg/m³**		
Benzene	**180.0**	**Y**	**1300**	**30**	**0.14**	**6 [a]**
2-Hexanone	2.7	Y	10.88	NA	0.25	
m,p-Xylenes	1500.0	Y	22000	9000	0.07	0.17

[a] The maximum detected concentration of 180μg/m³ is well below the acute LOAEL of 8262 μg/m³ in mice, based on the ATSDR MRLs (ATSDR, 2005).

APPENDICES

Appendix A. ATSDR Plain Language Glossary of Environmental Health Terms

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

Antagonistic Effect: A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Bioavailability: See **Relative Bioavailability.**

Biota: Used in public health, things that humans would eat - including animals, fish and plants.

Cancer: A group of diseases, which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CDPHE: The Colorado Department of Public Health and Environment.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Comparison Value (CVs): Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Delayed Health Effect: A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (See **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

EES: Environmental Epidemiology Section within the Colorado Department of Public Health and Environment.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemical of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Exposure: Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

- Source of Contamination,
- Environmental Media and Transport Mechanism,
- Point of Exposure,
- Route of Exposure; and,
- Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, and twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure - by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:

- Breathing (also called inhalation),
- Eating or drinking (also called ingestion), and/or
- Getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic effect: A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together is greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Appendix B. Photographs and Maps

Figure 5. Location of Oil and Gas Wells in Garfield County

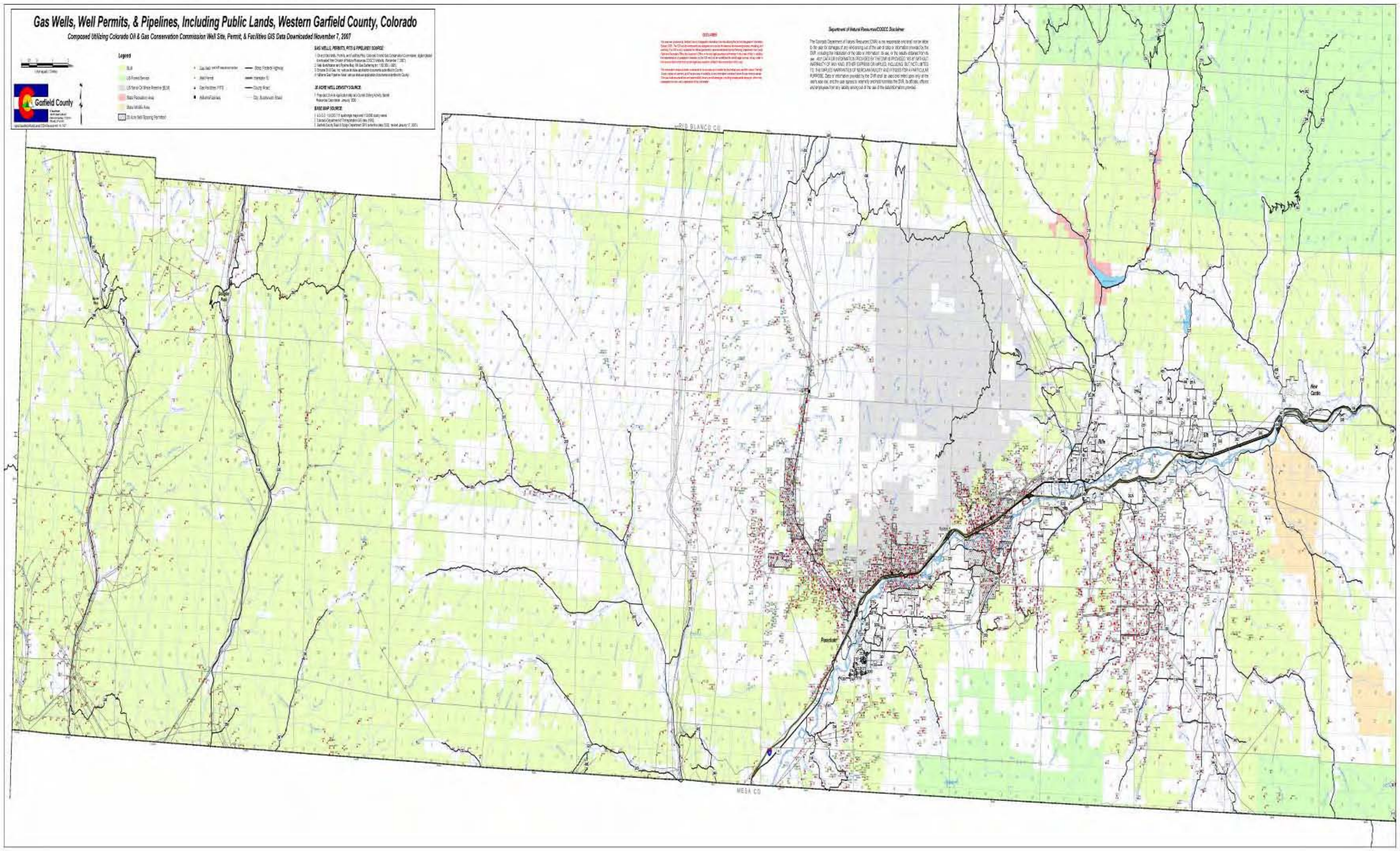


Figure 6. Location of Fixed Monitoring Stations in Garfield County

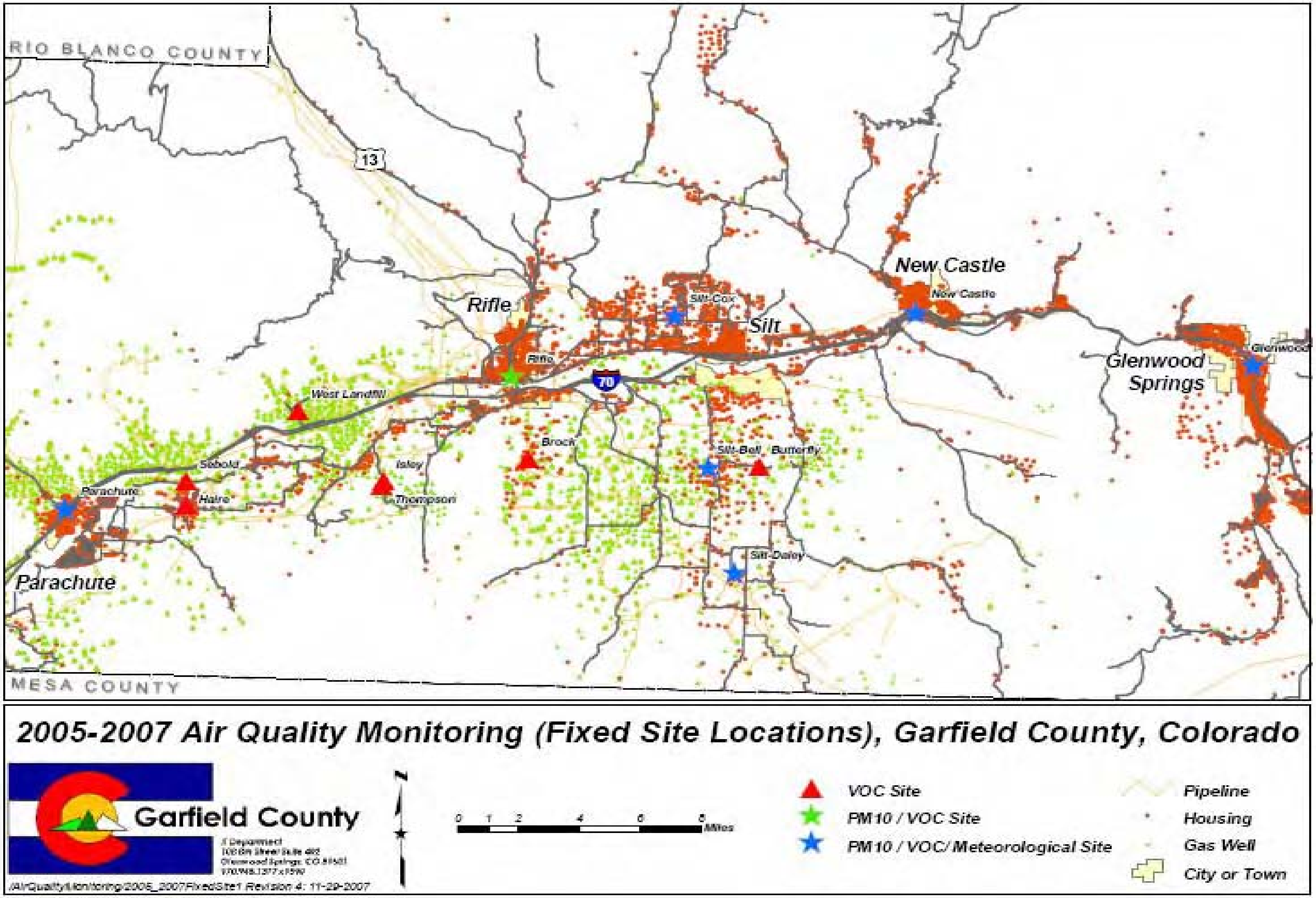


Figure 7. Location of Grab Samples Taken in Garfield County

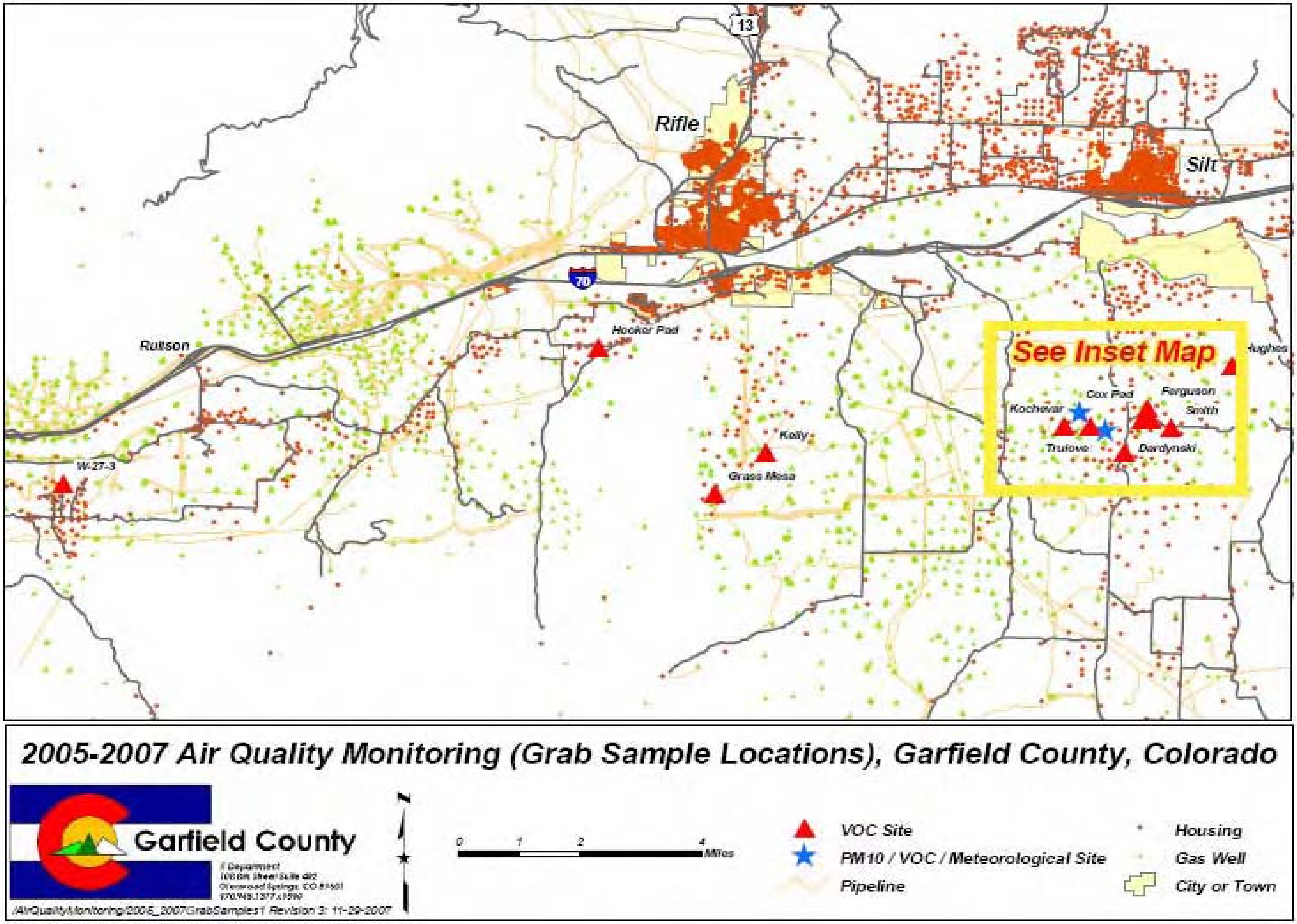


Figure 8. Glenwood Springs - Courthouse Monitoring Station, Looking Northeast

Figure 9. New Castle – Library Monitoring Station, Looking West-southwest

Figure 10. Rifle – Henry Building Monitoring Station, Looking South-southwest

Figure 11. Parachute Monitoring Station, Looking South-southwest

Figure 12. Silt – Bell Ranch Monitoring Station, Looking West

Figure 13. Silt – Daley Ranch Monitoring Station, Looking West-southwest

Figure 14. Silt – Cox Ranch Monitoring Station, Looking West

Figure 15. Butterfly Monitoring Station

Figure 16. Brock Monitoring Station

Figure 17. Isley Monitoring Station

Figure 18. West Landfill Monitoring Station

Figure 19. Sebold Monitoring Station

Figure 20. Haire Monitoring Station

Appendix C. Data Summary and Selection of Contaminants of Potential Concern (COPCs)

Table C1. Summary of available data

Location	CAS#	Compound	EPC µg/m³	AVG µg/m³	MAX µg/m³	MIN µg/m³	% Detected
Glenwood Springs-Courthouse (8 samples)							
	67-64-1	Acetone	37.0	18.3	37.0	4.3	75.0%
	75-09-2	Methylene chloride	2.3	1.1	2.3	0.8	12.5%
	108-05-4	Vinyl Acetate	6.2	2.0	6.2	0.8	25.0%
	78-93-3	2-Butanone (MEK)	3.9	2.0	3.9	0.8	62.5%
NOTE: listed compounds were detected in at least 4% of the samples	71-43-2	Benzene	3.5	1.2	3.5	0.8	12.5%
	108-88-3	Toluene	57.0	10.4	57.0	2.4	100.0%
	136777-61-2	*m,p*-Xylenes	5.4	2.5	5.4	0.8	50.0%
	106-46-7	1,4-Dichlorobenzene	12.0	2.3	12.0	0.8	12.5%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
New Castle-Library (21 samples)							
	67-64-1	Acetone	23.33	15.8	73.0	3.6	71.4%
	75-09-2	Methylene chloride	2.767	1.2	8.4	0.7	4.8%
	108-05-4	Vinyl Acetate	4.443	1.7	14.0	0.7	14.3%
	78-93-3	2-Butanone (MEK)	2.719	1.7	4.5	0.7	42.9%
	71-43-2	Benzene	4.931	2.0	15.0	0.8	33.3%
	108-88-3	Toluene	54.550	8.6	100.0	0.8	90.5%
NOTE: listed compounds were detected in at least 4% of the samples	100-41-4	Ethylbenzene	1.173	1.0	3.1	0.7	4.8%
	136777-61-2	*m,p*-Xylenes	2.993	2.3	6.6	0.8	66.7%
	95-47-6	o-Xylene	1.159	1.0	3.0	0.7	4.8%
	106-46-7	1,4-Dichlorobenzene	2.888	1.2	8.8	0.7	4.8%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Silt-Cox (8 samples)							
	67-64-1	Acetone	32.0	18.1	32.0	4.1	87.5%
	108-05-4	Vinyl Acetate	7.9	2.1	7.9	0.8	25.0%
NOTE: listed compounds were detected in at least 4% of the samples	78-93-3	2-Butanone (MEK)	2.9	1.9	2.9	0.8	62.5%
	71-43-2	Benzene	1.9	1.0	1.9	0.8	12.5%
	108-88-3	Toluene	10.0	2.6	10.0	0.8	50.0%
	136777-61-2	*m,p*-Xylenes	4.2	1.5	4.2	0.8	25.0%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Butterfly (21 samples)							
	67-64-1	Acetone	21.95	17.1	61.0	4.0	85.7%
	108-05-4	Vinyl Acetate	4.210	2.0	9.7	0.8	23.8%
	78-93-3	2-Butanone (MEK)	2.523	1.6	4.1	0.8	42.9%
	71-43-2	Benzene	3.739	2.0	7.7	0.8	38.1%
	108-88-3	Toluene	10.360	6.8	43.0	0.9	85.7%
NOTE: listed compounds were detected in at least 4% of the samples	100-41-4	Ethylbenzene	0.992	0.9	1.7	0.8	4.8%
	136777-61-2	*m,p*-Xylenes	15.340	4.1	19.0	0.8	47.6%
	95-47-6	o-Xylene	1.430	1.2	3.1	0.8	19.0%
	106-46-7	1,4-Dichlorobenzene	3.180	1.3	9.9	0.8	4.8%

Table C1. Summary of available data, continued

Location	CAS#	Compound	EPC µg/m³	AVG µg/m³	MAX µg/m³	MIN µg/m³	% Detected
Silt-Bell (24 samples)	67-64-1	Acetone	26.850	19.2	57.0	4.1	87.5%
	108-05-4	Vinyl Acetate	4.953	2.1	13.0	0.8	16.7%
	78-93-3	2-Butanone (MEK)	4.515	2.5	9.8	0.8	58.3%
	71-43-2	Benzene	3.555	2.0	7.4	0.8	41.7%
	108-88-3	Toluene	8.669	6.2	27.0	0.9	95.8%
NOTE: listed compounds were detected in at least 4% of the samples	591-78-6	2-Hexanone	1.314	1.0	4.4	0.8	4.2%
	136777-61-2	*m,p*-Xylenes	4.329	3.2	14.0	0.8	66.7%
	95-47-6	o-Xylene	1.069	1.0	2.3	0.8	4.2%
	106-46-7	1,4-Dichlorobenzene	1.071	1.0	2.3	0.8	4.2%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Silt-Daley (8 samples)	67-64-1	Acetone	21.0	12.1	21.0	4.4	87.5%
	108-05-4	Vinyl Acetate	3.2	1.2	3.2	0.8	12.5%
NOTE: listed compounds were detected in at least 4% of the samples	78-93-3	2-Butanone (MEK)	3.7	1.6	3.7	0.8	37.5%
	108-88-3	Toluene	27.0	5.1	27.0	0.8	37.5%
	136777-61-2	*m,p*-Xylenes	4.9	1.4	4.9	0.8	12.5%
	106-46-7	1,4-Dichlorobenzene	4.6	1.4	4.6	0.8	12.5%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Rifle-Henry Bldg. (23 samples)	67-64-1	Acetone	27.790	23.1	55.0	4.1	95.7%
	108-05-4	Vinyl Acetate	12.630	3.3	15.0	0.8	26.1%
	78-93-3	2-Butanone (MEK)	4.081	3.0	12.0	0.8	65.2%
	71-43-2	Benzene	3.658	2.9	6.9	0.8	78.3%
	108-88-3	Toluene	10.200	8.6	19.0	2.6	100.0%
	591-78-6	2-Hexanone	1.204	1.0	3.0	0.8	4.3%
NOTE: listed compounds were detected in at least 4% of the samples	127-18-4	Tetrachloroethene	1.135	1.0	2.3	0.8	4.3%
	100-41-4	Ethylbenzene	1.188	1.0	2.2	0.8	8.7%
	136777-61-2	*m,p*-Xylenes	6.916	5.9	12.0	1.7	100.0%
	95-47-6	o-Xylene	2.146	1.4	3.0	0.8	34.8%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Brock (22 samples)	67-64-1	Acetone	24.700	19.5	56.0	4.4	86.4%
	108-05-4	Vinyl Acetate	4.759	2.1	13.0	0.8	22.7%
	78-93-3	2-Butanone (MEK)	3.098	2.4	6.7	0.9	63.6%
NOTE: listed compounds were detected in at least 4% of the samples	71-43-2	Benzene	13.270	3.9	49.0	0.9	45.5%
	108-88-3	Toluene	69.940	11.6	130.0	0.9	90.9%
	100-41-4	Ethylbenzene	1.432	1.2	3.4	0.8	9.1%
	136777-61-2	*m,p*-Xylenes	4.425	3.2	12.0	0.9	63.6%
	95-47-6	o-Xylene	1.309	1.1	2.7	0.8	9.1%

Table C1. Summary of available data, continued

Location	CAS#	Compound	EPC µg/m³	AVG µg/m³	MAX µg/m³	MIN µg/m³	% Detected
Isley (20 samples)							
	67-64-1	Acetone	21.20	15.2	51.0	4.0	65.0%
	75-09-2	Methylene chloride	1.043	0.9	1.8	0.8	5.0%
	108-05-4	Vinyl Acetate	4.962	2.4	8.5	0.8	35.0%
	78-93-3	2-Butanone (MEK)	3.254	1.9	6.0	0.8	55.0%
	71-43-2	Benzene	1.385	1.2	3.0	0.8	20.0%
NOTE: listed compounds were detected in at least 4% of the samples	108-88-3	Toluene	4.939	4.1	10.0	2.2	100.0%
	136777-61-2	*m,p*-Xylenes	2.517	2.0	4.8	0.8	55.0%
	100-42-5	Styrene	1.639	1.2	6.0	0.8	5.0%
	106-46-7	1,4-Dichlorobenzene	1.639	1.2	6.0	0.8	5.0%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Thompson (3 samples)							
	67-64-1	Acetone	15.0	11.2	15.0	4.5	66.7%
	78-93-3	2-Butanone (MEK)	2.1	1.3	2.1	0.9	33.3%
NOTE: listed compounds were detected in at least 4% of the samples	108-88-3	Toluene	3.8	3.3	3.8	2.3	100.0%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
West Landfill (23 samples)							
	67-64-1	Acetone	32.360	24.5	80.0	3.9	87.0%
	75-09-2	Methylene chloride	1.232	1.0	3.5	0.8	4.3%
	108-05-4	Vinyl Acetate	4.384	2.1	11.0	0.8	30.4%
	78-93-3	2-Butanone (MEK)	4.011	2.3	6.6	0.8	52.2%
	71-43-2	Benzene	4.981	4.4	7.5	0.8	95.7%
NOTE: listed compounds were detected in at least 4% of the samples	108-88-3	Toluene	16.09	14.1	26.0	2.4	100.0%
	591-78-6	2-Hexanone	1.330	1.1	2.7	0.8	13.0%
	100-41-4	Ethylbenzene	1.151	1.0	2.9	0.8	4.3%
	136777-61-2	*m,p*-Xylenes	13.420	11.5	24.0	1.8	100.0%
	95-47-6	o-Xylene	2.303	1.5	4.3	0.8	30.4%
Location	**CAS#**	**Compound**	**EPC µg/m³**	**AVG µg/m³**	**MAX µg/m³**	**MIN µg/m³**	**% Detected**
Sebold (21 samples)							
	67-64-1	Acetone	24.260	18.1	58.0	3.6	76.2%
	108-05-4	Vinyl Acetate	4.154	2.1	8.8	0.7	33.3%
	78-93-3	2-Butanone (MEK)	3.853	2.8	8.1	0.7	66.7%
	71-43-2	Benzene	1.286	1.1	2.7	0.8	14.3%
	108-88-3	Toluene	5.246	3.9	10.0	0.8	90.5%
NOTE: listed compounds were detected in at least 4% of the samples	591-78-6	2-Hexanone	1.104	1.0	2.1	0.7	4.8%
	136777-61-2	*m,p*-Xylenes	3.037	2.6	5.1	0.8	81.0%
	106-46-7	1,4-Dichlorobenzene	1.230	1.0	3.0	0.7	4.8%

Table C1. Summary of available data, continued

Location	CAS#	Compound	EPC µg/m³	AVG µg/m³	MAX µg/m³	MIN µg/m³	% Detected
Haire (22 samples)							
	67-64-1	Acetone	20.56	15.8	56.0	4.3	77.3%
	108-05-4	Vinyl Acetate	3.482	1.6	8.6	0.8	13.6%
	78-93-3	2-Butanone (MEK)	2.723	1.7	4.1	0.8	50.0%
	108-88-3	Toluene	8.334	3.3	27.0	0.9	77.3%
NOTE: listed compounds were detected in at least 4% of the samples	71-43-2	Benzene	1.143	1.0	2.3	0.8	9.1%
	127-18-4	Tetrachloroethene	1.135	0.9	1.7	0.8	4.5%
	100-41-4	Ethylbenzene	1.005	0.9	1.7	0.8	4.5%
	136777-61-2	*m,p*-Xylenes	2.451	1.5	5.0	0.8	31.8%
	100-42-5	Styrene	1.018	0.9	1.8	0.8	4.5%

Location	CAS#	Compound	EPC µg/m³	AVG µg/m³	MAX µg/m³	MIN µg/m³	% Detected
Parachute (8 samples)							
	67-64-1	Acetone	46.0	20.9	46.0	6.5	87.5%
	75-69-4	Trichlorofluoromethane	26.0	4.0	26.0	0.8	12.5%
	108-05-4	Vinyl Acetate	12.0	2.4	12.0	0.8	25.0%
	78-93-3	2-Butanone (MEK)	7.2	2.6	7.2	0.8	62.5%
	71-43-2	Benzene	5.1	3.0	5.1	0.8	62.5%
	79-01-6	Trichloroethene	2.7	1.2	2.7	0.8	12.5%
NOTE: listed compounds were detected in at least 4% of the samples	108-88-3	Toluene	13.0	10.0	13.0	2.1	100.0%
	591-78-6	2-Hexanone	2.1	1.1	2.1	0.8	12.5%
	136777-61-2	*m,p*-Xylenes	11.0	6.6	11.0	0.8	87.5%
	95-47-6	o-Xylene	1.9	1.1	1.9	0.8	12.5%
	106-46-7	1,4-Dichlorobenzene	2.2	1.1	2.2	0.8	12.5%

Table C2. Summary of Available Data Collected from Grab Samples, all sites

Compound	Avg	Max	Min	% Detects
	µg/m³	**µg/m³**	**µg/m³**	
Chloromethane	1.5	15.0	0.7	3.7%
Acetone	26.0	81.0	3.7	77.8%
Trichlorofluoromethane	1.5	15.0	0.7	7.4%
Vinyl Acetate	2.5	15.0	0.7	14.8%
2-Butanone (MEK)	3.0	15.0	0.8	70.4%
Chloroform	1.5	15.0	0.7	3.7%
Benzene	28.2	180.0	0.8	92.6%
Toluene	91.4	540.0	0.8	92.6%
2-Hexanone	1.7	15.0	0.7	14.8%
Ethylbenzene	8.3	96.0	0.8	63.0%
m,p-Xylenes	106.6	1500.0	0.8	92.6%
o-Xylene	18.1	260.0	0.8	81.5%

Table C2. Summary of Available Data Collected from Grab Samples, all sites, continued

Compound	W-27-3	Ferguson	Bell	West Landfill	Bell (2)	CR 326	CR 326 (2)	Trulove	1921 CR 322	Hooker Pad	Trulove (2)
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Chloromethane		2.2									
Acetone	18.0		49.0	13.0	50.0	81.0			17.0		45.0
Trichlorofluoromethane								1.5			
Vinyl Acetate	5.9										
2-Butanone (MEK)	2.2	1.9		1.5	10.0			1.5	1.7		4.3
Chloroform		1.6									
Benzene		4.5	21.0	4.0	10.0	67.0	180.0	29.0	5.1	68.0	56.0
Toluene		22.0	35.0	11.0	60.0	190.0	540.0	74.0	19.0	440.0	120.0
2-Hexanone											
Ethylbenzene		2.7			7.8	9.5	28.0	3.7		96.0	5.6
m,p-Xylenes		33.0	13.0	7.6	69.0	97.0	290.0	37.0	12.0	1500.0	75.0
o-Xylene		5.9			13.0	16.0	46.0	6.0	1.6	260.0	12.0

Table C2. Summary of Available Data Collected from Grab Samples, all sites, continued

Compound	Smith	Bell (3)	Trulove (3)	Kelly	Trulove (4)	Trulove @ Kitchen Door	Trulove (5)	Dardynski	Grass Mesa Smoke Plume	Hoffmeister
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Chloromethane										
Acetone	29.0	39.0	11.0	65.0	26.0	14.0	15.0	12.0	10.0	
Trichlorofluoromethane								1.8		
Vinyl Acetate		9.4		15.0				3.2		
2-Butanone (MEK)	2.4	2.6		9.2	3.4	1.9	2.3	1.7		
Chloroform										
Benzene	11.0	3.6	15.0	4.5	5.0	73.0	3.6	22.0	1.5	130.0
Toluene	55.0	26.0	53.0	15.0	14.0	150.0	15.0	78.0	3.0	390.0
2-Hexanone				1.9	2.4					
Ethylbenzene	5.3	3.9	1.9			6.0		8.4		26.0
m,p-Xylenes	66.0	42.0	22.0	15.0	11.0	67.0	16.0	86.0	2.6	290.0
o-Xylene	11.0	7.3	3.3	2.4	1.5	9.8	2.8	16.0		48.0

Table C2. Summary of Available Data Collected from Grab Samples, all sites, continued

Compound	Hughes	Bell (4)	Hughes (2)	Kochevar	Bell (5)	Bell/Curry
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Chloromethane						
Acetone	25.0	8.2	9.6		38.0	30.0
Trichlorofluoromethane						
Vinyl Acetate						
2-Butanone (MEK)	3.1	2.4	1.7		2.3	1.7
Chloroform						
Benzene	2.9	9.6	11.0	6.9	16.0	
Toluene	20.0	28.0	43.0	23.0	43.0	
2-Hexanone	2.6	2.7				
Ethylbenzene	1.6	1.5	3.7		2.1	
m,p-Xylenes	19.0	17.0	45.0	21.0	24.0	
o-Xylene	3.1	2.7	7.5	3.4	3.8	

Table C3. Compounds Not Detected in Analysis of Grab Samples, all sites

CAS #	Compound
75-01-4	Vinyl Chloride
74-83-9	Bromomethane
75-00-3	Chloroethane
75-35-4	1,1-Dichloroethene
75-09-2	Methylene chloride
76-13-1	Trichlorotrifluoroethane
75-15-0	Carbon Disulfide
156-60-5	trans-1,2-Dichloroethene
75-34-3	1,1-Dichloroethane
1634-04-4	Methyl tert-Butyl Ether
156-59-2	cis-1,2-Dichloroethene
107-06-2	1,2-Dichloroethane
71-55-6	1,1,1-Trichloroethane
56-23-5	Carbon Tetrachloride
78-87-5	1,2-Dichloropropane
75-27-4	Bromodichloromethane
79-01-6	Trichloroethene
10061-01-5	cis-1,3-Dichloropropene
108-10-1	4-Methyl-2-pentanone
10061-02-6	trans-1,3-Dichloropropene
79-00-5	1,1,2-Trichloroethane
124-48-1	Dibromochloromethane
106-93-4	1,2-Dibromoethane
127-18-4	Tetrachloroethene
108-90-7	Chlorobenzene
75-25-2	Bromoform
100-42-5	Styrene
79-34-5	1,1,2,2-Tetrachloroethane
541-73-1	1,3-Dichlorobenzene
106-46-7	1,4-Dichlorobenzene
95-50-1	1,2-Dichlorobenzene

Table C4. Selection of Contaminants of Potential Concern based on Max value – Glenwood Springs (8 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	37.0	3.3E+03	N	75.0%
Trichlorofluoromethane	1.1	7.3E+02	N	0.0%
Methylene chloride	2.3	3.8E+00	N	12.5%
Vinyl acetate	6.2	2.1E+02	N	25.0%
2-Butanone (MEK)	3.9	5.1E+03	N	62.5%
Benzene	**3.5**	**2.3E-01**	**Y**	**12.5%**
Trichloroethene	1.1	2.0E-02	Y	0.0%
Toluene	57.0	5.1E+03	N	100.0%
2-Hexanone	1.1	10.880	N	0.0%
Tetrachloroethene	1.1	3.1E-01	Y	0.0%
Ethylbenzene	1.1	1.1E+03	N	0.0%
m,p-Xylenes	5.4	1.1E+02	N	50.0%
Styrene	1.1	1.0E+03	N	0.0%
o-Xylene	1.1	1.1E+02	N	0.0%
1,4-Dichlorobenzene	**12.0**	**2.9E-01**	**Y**	**12.5%**

Table C5. Selection of Contaminants of Potential Concern based on Max value – New Castle (21 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	**µg/m³**		
Acetone	73.0	3.3E+03	N	71.4%
Trichlorofluoromethane	1.3	7.3E+02	N	0.0%
Methylene chloride	**8.4**	**3.8E+00**	**Y**	**4.8%**
Vinyl acetate	14.0	2.1E+02	N	14.3%
2-Butanone (MEK)	4.5	5.1E+03	N	42.9%
Benzene	**15.0**	**2.3E-01**	**Y**	**33.3%**
Trichloroethene	1.3	2.0E-02	N	0.0%
Toluene	100.0	5.1E+03	N	90.5%
2-Hexanone	1.3	10.880	N	0.0%
Tetrachloroethene	1.3	3.1E-01	N	0.0%
Ethylbenzene	3.1	1.1E+03	N	4.8%
m,p-Xylenes	6.6	1.1E+02	N	66.7%
Styrene	1.3	1.0E+03	N	0.0%
o-Xylene	3.0	1.1E+02	N	4.8%
1,4-Dichlorobenzene	**8.8**	**2.9E-01**	**Y**	**4.8%**

Table C6. Selection of Contaminants of Potential Concern based on Max value – Cox (8 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	32.0	3.3E+03	N	87.5%
Trichlorofluoromethane	1.1	7.3E+02	N	0.0%
Methylene chloride	1.1	3.8E+00	N	0.0%
Vinyl acetate	7.9	2.1E+02	N	25.0%
2-Butanone (MEK)	2.9	5.1E+03	N	62.5%
Benzene	**1.9**	**2.3E-01**	**Y**	**12.5%**
Trichloroethene	1.1	2.0E-02	Y	0.0%
Toluene	10.0	5.1E+03	N	50.0%
2-Hexanone	1.1	10.880	N	0.0%
Tetrachloroethene	1.1	3.1E-01	Y	0.0%
Ethylbenzene	1.1	1.1E+03	N	0.0%
m,p-Xylenes	4.2	1.1E+02	N	25.0%
Styrene	1.1	1.0E+03	N	0.0%
o-Xylene	1.1	1.1E+02	N	0.0%
1,4-Dichlorobenzene	1.1	2.9E-01	Y	0.0%

Table C7. Selection of Contaminants of Potential Concern based on Max value – Butterfly (21 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	61.0	3.3E+03	N	85.7%
Trichlorofluoromethane	1.1	7.3E+02	N	0.0%
Methylene chloride	1.1	3.8E+00	N	0.0%
Vinyl acetate	9.7	2.1E+02	N	23.8%
2-Butanone (MEK)	4.1	5.1E+03	N	42.9%
Benzene	**7.7**	**2.3E-01**	**Y**	**38.1%**
Trichloroethene	1.1	2.0E-02	N	0.0%
Toluene	43.0	5.1E+03	N	85.7%
2-Hexanone	1.1	10.880	N	0.0%
Tetrachloroethene	1.1	3.1E-01	N	0.0%
Ethylbenzene	1.7	1.1E+03	N	4.8%
m,p-Xylenes	19.0	**1.1E+02**	**Y**	**47.6%**
Styrene	1.1	1.0E+03	N	0.0%
o-Xylene	3.1	1.1E+02	N	19.0%
1,4-Dichlorobenzene	**9.9**	**2.9E-01**	**Y**	**4.8%**

Table C8. Selection of Contaminants of Potential Concern based on Max value – Bell (24 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	57.0	3.3E+03	N	87.5%
Trichlorofluoromethane	1.1	7.3E+02	N	0.0%
Methylene chloride	1.1	3.8E+00	N	0.0%
Vinyl acetate	13.0	2.1E+02	N	16.7%
2-Butanone (MEK)	9.8	5.1E+03	N	58.3%
Benzene	**7.4**	**2.3E-01**	**Y**	**41.7%**
Trichloroethene	1.1	2.0E-02	N	0.0%
Toluene	27.0	5.1E+03	N	95.8%
2-Hexanone	4.4	10.880	N	4.2%
Tetrachloroethene	1.1	3.1E-01	N	0.0%
Ethylbenzene	1.1	1.1E+03	N	0.0%
m,p-Xylenes	**14.0**	**1.1E+02**	**Y**	**66.7%**
Styrene	1.1	1.0E+03	N	0.0%
o-Xylene	2.3	1.1E+02	N	4.2%
1,4-Dichlorobenzene	2.3	2.9E-01	N	4.2%

Table C9. Selection of Contaminants of Potential Concern based on Max value – Daley (8 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	21.0	3.3E+03	N	87.5%
Trichlorofluoromethane	1.2	7.3E+02	N	0.0%
Methylene chloride	1.2	3.8E+00	N	0.0%
Vinyl acetate	3.2	2.1E+02	N	12.5%
2-Butanone (MEK)	3.7	5.1E+03	N	37.5%
Benzene	1.2	2.3E-01	Y	0.0%
Trichloroethene	1.2	2.0E-02	Y	0.0%
Toluene	27.0	5.1E+03	N	37.5%
2-Hexanone	1.2	10.880	N	0.0%
Tetrachloroethene	1.2	3.1E-01	Y	0.0%
Ethylbenzene	1.2	1.1E+03	N	0.0%
m,p-Xylenes	4.9	1.1E+02	N	12.5%
Styrene	1.2	1.0E+03	N	0.0%
o-Xylene	1.2	1.1E+02	N	0.0%
1,4-Dichlorobenzene	4.6	**2.9E-01**	**Y**	**12.5%**

Table C10. Selection of Contaminants of Potential Concern based on Max value – Rifle (23 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	55.0	3.3E+03	N	95.7%
Trichlorofluoromethane	2.2	7.3E+02	N	0.0%
Methylene chloride	2.2	3.8E+00	N	0.0%
Vinyl acetate	15.0	2.1E+02	N	26.1%
2-Butanone (MEK)	12.0	5.1E+03	N	65.2%
Benzene	**6.9**	**2.3E-01**	**Y**	**78.3%**
Trichloroethene	2.2	2.0E-02	N	0.0%
Toluene	19.0	5.1E+03	N	100.0%
2-Hexanone	3.0	10.880	N	4.3%
Tetrachloroethene	2.3	3.1E-01	N	4.3%
Ethylbenzene	2.2	1.1E+03	N	8.7%
m,p-Xylenes	**12.0**	**1.1E+02**	**Y**	**100.0%**
Styrene	2.2	1.0E+03	N	0.0%
o-Xylene	3.0	1.1E+02	N	34.8%
1,4-Dichlorobenzene	2.2	2.9E-01	N	0.0%

Table C11. Selection of Contaminants of Potential Concern based on Max value – Brock (22 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	56.0	3.3E+03	N	86.4%
Trichlorofluoromethane	1.2	7.3E+02	N	0.0%
Methylene chloride	1.2	3.8E+00	N	0.0%
Vinyl acetate	13.0	2.1E+02	N	22.7%
2-Butanone (MEK)	6.7	5.1E+03	N	63.6%
Benzene	**49.0**	**2.3E-01**	**Y**	**45.5%**
Trichloroethene	1.2	2.0E-02	N	0.0%
Toluene	130.0	5.1E+03	N	90.9%
2-Hexanone	1.2	10.880	N	0.0%
Tetrachloroethene	1.2	3.1E-01	N	0.0%
Ethylbenzene	3.4	1.1E+03	N	9.1%
m,p-Xylenes	**12.0**	**1.1E+02**	**Y**	**63.6%**
Styrene	1.2	1.0E+03	N	0.0%
o-Xylene	2.7	1.1E+02	N	9.1%
1,4-Dichlorobenzene	1.2	2.9E-01	N	0.0%

Table C12. Selection of Contaminants of Potential Concern based on Max value – Isley (20 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	μg/m³	μg/m³		
Acetone	51.0	3.3E+03	N	65.0%
Trichlorofluoromethane	1.4	7.3E+02	N	0.0%
Methylene chloride	1.8	3.8E+00	N	5.0%
Vinyl acetate	8.5	2.1E+02	N	35.0%
2-Butanone (MEK)	6.0	5.1E+03	N	55.0%
Benzene	**3.0**	**2.3E-01**	**Y**	**20.0%**
Trichloroethene	1.4	2.0E-02	N	0.0%
Toluene	10.0	5.1E+03	N	100.0%
2-Hexanone	1.4	10.880	N	0.0%
Tetrachloroethene	1.4	3.1E-01	N	0.0%
Ethylbenzene	1.4	1.1E+03	N	0.0%
m,p-Xylenes	4.8	1.1E+02	N	55.0%
Styrene	6.0	1.0E+03	N	5.0%
o-Xylene	1.4	1.1E+02	N	0.0%
1,4-Dichlorobenzene	6.0	**2.9E-01**	**Y**	**5.0%**

Table C13. Selection of Contaminants of Potential Concern based on Max value – Thompson (3 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	μg/m³	μg/m³		
Acetone	15.0	3.3E+03	N	66.7%
Trichlorofluoromethane	1.0	7.3E+02	N	0.0%
Methylene chloride	1.0	3.8E+00	N	0.0%
Vinyl acetate	1.0	2.1E+02	N	0.0%
2-Butanone (MEK)	2.1	5.1E+03	N	33.3%
Benzene	1.0	2.3E-01	Y	0.0%
Trichloroethene	1.0	2.0E-02	Y	0.0%
Toluene	3.8	5.1E+03	N	100.0%
2-Hexanone	1.0	10.880	N	0.0%
Tetrachloroethene	1.0	3.1E-01	Y	0.0%
Ethylbenzene	1.0	1.1E+03	N	0.0%
m,p-Xylenes	1.0	1.1E+02	N	0.0%
Styrene	1.0	1.0E+03	N	0.0%
o-Xylene	1.0	1.1E+02	N	0.0%
1,4-Dichlorobenzene	1.0	2.9E-01	Y	0.0%

Table C14. Selection of Contaminants of Potential Concern based on Max value – West Landfill (23 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	80.0	3.3E+03	N	87.0%
Trichlorofluoromethane	1.0	7.3E+02	N	0.0%
Methylene chloride	3.5	3.8E+00	N	4.3%
Vinyl acetate	11.0	2.1E+02	N	30.4%
2-Butanone (MEK)	6.6	5.1E+03	N	52.2%
Benzene	**7.5**	**2.3E-01**	**Y**	**95.7%**
Trichloroethene	1.0	2.0E-02	N	0.0%
Toluene	26.0	5.1E+03	N	100.0%
2-Hexanone	**2.7**	**10.880**	**Y**	**13.0%**
Tetrachloroethene	1.0	3.1E-01	N	0.0%
Ethylbenzene	2.9	1.1E+03	N	4.3%
m,p-Xylenes	**24.0**	**1.1E+02**	**Y**	**100.0%**
Styrene	1.0	1.0E+03	N	0.0%
o-Xylene	4.3	1.1E+02	N	30.4%
1,4-Dichlorobenzene	1.0	2.9E-01	N	0.0%

Table C15. Selection of Contaminants of Potential Concern based on Max value – Sebold (21 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	58.0	3.3E+03	N	76.2%
Trichlorofluoromethane	1.4	7.3E+02	N	0.0%
Methylene chloride	1.4	3.8E+00	N	0.0%
Vinyl acetate	8.8	2.1E+02	N	33.3%
2-Butanone (MEK)	8.1	5.1E+03	N	66.7%
Benzene	**2.7**	**2.3E-01**	**Y**	**14.3%**
Trichloroethene	1.4	2.0E-02	N	0.0%
Toluene	10.0	5.1E+03	N	90.5%
2-Hexanone	**2.1**	**10.880**	**Y**	**4.8%**
Tetrachloroethene	1.4	3.1E-01	N	0.0%
Ethylbenzene	1.4	1.1E+03	N	0.0%
m,p-Xylenes	5.1	1.1E+02	N	81.0%
Styrene	1.4	1.0E+03	N	0.0%
o-Xylene	1.4	1.1E+02	N	0.0%
1,4-Dichlorobenzene	**3.0**	**2.9E-01**	**Y**	**4.8%**

Table C16. Selection of Contaminants of Potential Concern based on Max value – Haire (22 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	56.0	3.3E+03	N	77.3%
Trichlorofluoromethane	1.1	7.3E+02	N	0.0%
Methylene chloride	1.1	3.8E+00	N	0.0%
Vinyl acetate	8.6	2.1E+02	N	13.6%
2-Butanone (MEK)	4.1	5.1E+03	N	50.0%
Benzene	**2.3**	**2.3E-01**	**Y**	**9.1%**
Trichloroethene	1.1	2.0E-02	N	0.0%
Toluene	27.0	5.1E+03	N	77.3%
2-Hexanone	1.1	10.880	N	0.0%
Tetrachloroethene	**1.7**	**3.1E-01**	**Y**	**4.5%**
Ethylbenzene	1.7	1.1E+03	N	4.5%
m,p-Xylenes	5.0	1.1E+02	N	31.8%
Styrene	1.8	1.0E+03	N	4.5%
o-Xylene	1.1	1.1E+02	N	0.0%
1,4-Dichlorobenzene	1.1	2.9E-01	N	0.0%

Table C17. Selection of Contaminants of Potential Concern based on Max value – Parachute (8 Samples)

	Max	Region 3 RBC	COPC?	% Detected
	µg/m³	µg/m³		
Acetone	46.0	3.3E+03	N	87.5%
Trichlorofluoromethane	26.0	7.3E+02	N	12.5%
Methylene chloride	1.3	3.8E+00	N	0.0%
Vinyl acetate	12.0	2.1E+02	N	25.0%
2-Butanone (MEK)	7.2	5.1E+03	N	62.5%
Benzene	**5.1**	**2.3E-01**	**Y**	**62.5%**
Trichloroethene	**2.7**	**2.0E-02**	**Y**	**12.5%**
Toluene	13.0	5.1E+03	N	100.0%
2-Hexanone	**2.1**	**10.880**	**Y**	**12.5%**
Tetrachloroethene	1.3	3.1E-01	Y	0.0%
Ethylbenzene	1.3	1.1E+03	N	0.0%
m,p-Xylenes	**11.0**	**1.1E+02**	**Y**	**87.5%**
Styrene	1.3	1.0E+03	N	0.0%
o-Xylene	1.9	1.1E+02	N	12.5%
1,4-Dichlorobenzene	**2.2**	**2.9E-01**	**Y**	**12.5%**

Appendix D. Exposure Parameters, Estimation of Exposure Dose, Derivation of Risk Based Concentration, and Risk Estimation

Estimation of Exposure Point Concentration

The Exposure Point Concentration (EPC) is a high-end, yet reasonable concentration of a contaminant that people could be exposed to based on the available environmental data. The standard procedure for calculating EPCs is to use the 95% Upper Confidence Interval on the mean of the data for each COPC. EPA's statistical software package, ProUCL Version 4.0, was used to calculate the EPCs. The 2005-2007 data for ambient outdoor air in Garfield County was analyzed by this method, and thus, the EPCs in these locations is the 95% UCL.

If the data is not normally distributed, ProUCL recommends an alternative value to use in lieu of the 95% UCL depending on the type of data distribution. There were a number of instances where the data was not normally distributed and the alternate value was accepted instead of the 95% UCL. Furthermore, when there were less than ten samples available per site, the maximum value was used to represent the EPC instead of the 95%UCL.

Estimation of Exposure Dose and Risk Estimation

Exposure doses are estimates of the concentration of contaminants that people may come into contact with or be exposed to under specified exposure conditions. These exposure doses are estimated using: (1) the estimated exposure point concentration as well as the intake rate; and (2) the length of time and frequency of exposure to site contaminants.

Assumptions made for the residents of Garfield County included exposure duration of 24 hours per day for 350 days per year for 30 years. In today's mobile society, it is unlikely that people will spend this much time in the county and therefore the calculated risk estimates are conservative. Cancer risks are calculated using EPA Region 3 RBCs available at http://www.epa.gov/reg3hwmd/risk/human/index.htm.

Calculation of the Noncancer hazard quotient (HQ) for Inhalation of Non-carcinogenic COC by Nearby Residents

$$\textbf{Noncancerous HQ} = \frac{\text{Indoor Air concentration (EPC)}}{\text{ATSDR MRL or EPA IRIS RfC}}$$

Calculation of Theoretical Cancer Risk for Inhalation of Carcinogenic COC by Nearby Residents

$$\textbf{Cancer Risk} = \frac{\text{Indoor Air concentration (EPC)} \times 10^{-6}}{\text{EPA Region 3 RBC}}$$

Appendix E. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. In addition, the toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (acute, subchronic, chronic or lifetime). It is important to note that estimates of human health risks may be based on evidence of health effects in humans and/or animals depending on the availability of data. This evaluation, like most other toxicity assessments, is divided into two parts: the cancer effects and the non-cancer effects of the chemical.

EPA, IARC, and the Department of Health and Human Services have concluded that benzene is a human carcinogen. The Department of Health and Human Services determined that benzene is a known carcinogen based on human evidence showing a causal relationship between exposure to benzene and cancer. IARC classified benzene in Group 1 (carcinogenic to humans) based on sufficient evidence in both humans and animals. EPA classified benzene in Category A (known human carcinogen) based on convincing evidence in humans supported by evidence from animal studies. Under EPA's most recent guidelines for carcinogen risk assessment, benzene is characterized as a known human carcinogen for all routes of exposure. Based on human leukemia data, EPA derived a range of inhalation unit risk values of 2.2x10-6– 7.8x10-6 $(\mu g/m3)^{-1}$ for benzene. For cancer risks ranging from $1x10^{-4}$ to $1x10^{-6}$, the corresponding the corresponding air concentrations ranges from 13.0–45.0 µg/m3 (4–14 ppb) to 0.013–0.045 µg/m3 (0.004–0.014 ppb), respectively. The high-end unit risk factor corresponds to the cancer slope factor of 0.027 per mg/kg/day. The consensus conclusion that benzene is a human carcinogen is based on sufficient inhalation data in humans supported by animal evidence, including the oral studies in animals. The human cancer induced by inhalation exposure to benzene is predominantly acute nonlymphocytic (myelocytic) leukemia, whereas benzene is a multiple site carcinogen in animals by both the inhalation and oral routes (ATSDR, 2005).

The above noted high-end cancer slope factor is used to calculate EPA Region 3 Risk Based Concentrations (RBCs) that are used in this assessment to estimate risks. The RBC used in this assessment is based on age-adjusted theoretical cancer risks spanning 30 years from the time of birth to the age of 30. They account for exposure for 350 days per year over the thirty-year time period and lower body weights of children.

ATSDR has derived acute, chronic, and intermediate duration inhalational minimal risk levels (MRLs) or health guidelines to assess noncancer hazards. An MRL is the dose of a compound that is the estimate of daily human exposure that is likely to be without an appreciable risk of adverse non-cancerous health effects for each specified exposure duration. The acute, intermediate, and chronic MRLs address exposures of 14 days or less, 14-365 days, and 1 year – lifetime, respectively.

For many contaminants there are additional considerations of noncancer toxicity. The COPCs selected here can cause a wide range of symptoms that include dizziness, headaches, nausea, eye irritation, unconsciousness, numbness or tingling, kidney problems, and even death. For more detailed health information, please see Appendix E for the health effect fact sheet (Tox FAQs) on Benzene.

Appendix F. ATSDR ToxFAQs for Benzene

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

BENZENE
CAS # 71-43-2

Division of Toxicology and Environmental Medicine ToxFAQs™ **August 2007**

This fact sheet answers the most frequently asked health questions (FAQs) about benzene. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Benzene is a widely used chemical formed from both natural processes and human activities. Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is benzene?

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities.

Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and other synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include emissions from volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke.

What happens to benzene when it enters the environment?

- ❑ Industrial processes are the main source of benzene in the environment.
- ❑ Benzene can pass into the air from water and soil.
- ❑ It reacts with other chemicals in the air and breaks down within a few days.
- ❑ Benzene in the air can attach to rain or snow and be carried back down to the ground.
- ❑ It breaks down more slowly in water and soil, and can pass through the soil into underground water.
- ❑ Benzene does not build up in plants or animals.

How might I be exposed to benzene?

- ❑ Outdoor air contains low levels of benzene from tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions.
- ❑ Vapors (or gases) from products that contain benzene, such as glues, paints, furniture wax, and detergents, can also be a source of exposure.
- ❑ Air around hazardous waste sites or gas stations will contain higher levels of benzene.
- ❑ Working in industries that make or use benzene.

How can benzene affect my health?

Breathing very high levels of benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death.

The major effect of benzene from long-term exposure is on the blood. Benzene causes harmful effects on the bone

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Agency for Toxic Substances and Disease Registry

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marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection.

Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries, but we do not know for certain that benzene caused the effects. It is not known whether benzene will affect fertility in men.

How likely is benzene to cause cancer?

Long-term exposure to high levels of benzene in the air can cause leukemia, particularly acute myelogenous leukemia, often referred to as AML. This is a cancer of the blood-forming organs. The Department of Health and Human Services (DHHS) has determined that benzene is a known carcinogen. The International Agency for Research on Cancer (IARC) and the EPA have determined that benzene is carcinogenic to humans.

How can benzene affect children?

Children can be affected by benzene exposure in the same ways as adults. It is not known if children are more susceptible to benzene poisoning than adults.

Benzene can pass from the mother's blood to a fetus. Animal studies have shown low birth weights, delayed bone formation, and bone marrow damage when pregnant animals breathed benzene.

How can families reduce the risks of exposure to benzene?

Benzene exposure can be reduced by limiting contact with gasoline and cigarette smoke. Families are encouraged not to smoke in their house, in enclosed environments, or near their children.

Is there a medical test to determine whether I've been exposed to benzene?

Several tests can show if you have been exposed to benzene. There is a test for measuring benzene in the breath; this test must be done shortly after exposure. Benzene can also be measured in the blood; however, since benzene disappears rapidly from the blood, this test is only useful for recent exposures.

In the body, benzene is converted to products called metabolites. Certain metabolites can be measured in the urine. The metabolite S-phenylmercapturic acid in urine is a sensitive indicator of benzene exposure. However, this test must be done shortly after exposure and is not a reliable indicator of how much benzene you have been exposed to, since the metabolites may be present in urine from other sources.

Has the federal government made recommendations to protect human health?

The EPA has set the maximum permissible level of benzene in drinking water at 5 parts benzene per billion parts of water (5 ppb).

The Occupational Safety and Health Administration (OSHA) has set limits of 1 part benzene per million parts of workplace air (1 ppm) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Benzene (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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Appendix G. ATSDR Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.
C. Indeterminate Public Health Hazard This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgment that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgment, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgment based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

Certification

This Garfield County health consultation was prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures existing at the time, the health consultation was conducted. Editorial review was completed by the cooperative agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation, and concurs with its findings.

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CAT, SPAB, DHAC, ATSDR