ARAPAHOE COUNTY

ARAPAHOE COUNTY PLANNING COMMISSION
November 8, 2023
6:30 P.M.

SUBJECT: CASE NO. LDC23-004 – OIL AND GAS LAND DEVELOPMENT CODE AMENDMENT

Diane Kocis, Energy Specialist, Public Works and Development Department **October 19, 2023**
Jason Reynolds, Planning Division Manager, Public Works and Development Department

PURPOSE AND REQUEST

This County-initiated application proposes amendments to the Oil and Gas regulations in Section 5-3.6 of the Land Development Code (LDC). The Planning Commission is requested, in accordance with CRS 30-28-116, to make recommendations on the amendments as proposed for setbacks and reduction options, air and water quality regulations, Wildland Urban Interface (WUI) measures, and other related language revisions as described in this Report and the amendments. On the proposed setback amendments, Planning Commission is requested to provide separate recommendations on different options for setback distances as well as for the proposed options for reductions from those setbacks. Attachment 1 is a matrix of the various setback and setback reduction options for reservoirs, occupied structures, platted lots, designated outside activity areas (DOAAs), other surface waters and riparian areas, and landfills. Attachment 2 is the proposed amendments with separate recommendation request stated and highlighted.

The proposed amendments for which the Planning Commission is asked to make its recommendations, including each separate setback distance option and the proposed variance procedures and criteria, are set forth in Attachment 2 and as follows:

- Increase setbacks from occupied structures, platted lots, landfills, Designated Outside Activity Areas (DOAAs) and riparian areas, streams, and perennial surface waters to the distances specified in the Attachment 1 feet, while providing the potential for setback reductions through an administrative process for most if the request meets criteria and interested parties (CPW, DOAA owner, nearby owners) have no objections.
- Increase the downgradient reservoir setback to 3,000 feet (set at 2,000 feet at the October 10, 2023, BOCC hearing) and add an ability to request a reduction in setback distances for the downgradient 3,000 feet and the 'upgradient' one-mile reservoir setbacks through a Use by Special Review ("USR") process. The USR would be decided by the Board of County Commissioners after a noticed public hearing and require meeting the specified criteria for approval.
- Add language for wildfire mitigation in the Wildland Urban Interface (WUI).
- Add language for air monitoring and sampling and increased water quality monitoring, to be performed by independent third-party consultants and paid for by industry.
- Add continuous surface water monitoring for surface waters downgradient of well pads.
- Add new requirements for Spill and Release Measures and Reporting.
- Increase the radius of notifications of neighborhood meetings and application submittals to 1.5 miles; and,

- Correct some language adopted in October 2023, such as changing existing references from COGCC (Colorado Oil and Gas Conservation Commission) to ECMC, to reflect the agency's new name (Energy and Carbon Management Commission) and eliminate a separate requirement for a Tactical Response Plan because the TRP information is provided in the Emergency Action Plan.

BACKGROUND

The proposed new regulations, shown as redlines to the existing Oil and Gas regulations in Attachment 2, reflect recent direction received from the Board of County Commissioners and staff-recommended changes to the Oil and Gas regulations adopted on October 10, 2023. Stakeholder comments provided prior to and during the Planning Commission and Board of County Commissioners (BOCC) public hearings included requests for increased setbacks, air/water quality measures, additional public notice, and wildland-urban interface protections.

Among the many health studies and analyses cited by the public, two were published recently: *Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations* (Journal of the Air & Waste Management Association - 2019) and the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel response to the California Geologic Energy Management Division (CalGEM letter - 2021) – see Attachment 5. The Journal of the Air & Waste Management Association article specifically modeled Colorado well sites and found that many risks – though not all risks – were reduced with setbacks of 2,000 feet from well sites. The GalGEM letter recommended 1 km (~3,280 feet) setbacks from occupied structures. Both of those documents predate Colorado's post Senate Bill 181 air quality rulemaking, which further strengthened protections in Colorado. The third document (Colorado Lawyer July 2019) provides some background on Senate Bill 181, including clarifications on the bill's intent regarding "necessary and reasonable" from Senator Foote, one of its sponsors. Senator Foote's comments encourage a broad interpretation of "necessary and reasonable," considering that the context of the bill is a "…clear desire to prioritize health and safety when it comes to oil and gas operations, permitting, and supervision…" In light of the developing nature of the science around safe setback distances from an oil and gas pad and the many factors that affect the making of such determinations, including varying geography, technology and advancements, differences in sensitivities of individuals, differences in uses around a pad, climate, and many other factors, it is the intent of these proposed regulations to adopt setback distances that lean to a larger and more protective distance, but provide options to reduce the setbacks if the operator can demonstrate that the circumstances of a particular location and/or engineered protections can provide substantially the same protections as the setback distance.

The amendments are being considered in phases to address concerns about how the existing regulations address new and potentially increased Oil and Gas development and to correct certain omissions discovered after the adoption of the regulations in November of 2021 and that were not

then included in those regulations. This Phase 2 addresses the matters identified above and otherwise in this Staff Report and Attachments, and the text of the proposed amendments, including the various options requested for separate recommendations from the Planning Commission, and are shown in the Attachment 2. These Phase 2 amendments and options for amendments were discussed with the BOCC study sessions in September and October of 2023.

Recent stakeholder comments included requests that the County adopt its own financial assurance regulations and a County oil and gas inspection program. There have also been requests to increase reverse setbacks (setbacks from new homes to existing oil & gas sites) and to consider prohibiting commercial injection wells. These topics will be part of a later phase of the Oil and Gas regulation amendments, planned for early next year.

PROPOSED REGULATION SUMMARY AND ANALYSIS

The proposed regulations are listed below. Proposed added, removed or revised language is depicted in italics.

- Correct references to the Colorado Oil and Gas Conservation Commission (COGCC) throughout, to update the agency's new name, Energy and Carbon Management Commission (ECMC).
- Amend Section E.2, **Neighborhood Meetings** to increase the neighborhood meetings notification radius to 1.5 miles.

- **Increases in Setbacks**: Amend Section F.2. **Setbacks and Setback Reductions**. The Phase 2 amendments propose increases the setbacks for reservoirs and planned reservoirs, occupied structures, platted lots, to designated outside activity areas (DOAAs), other surface waters and riparian areas, and landfills. The Phase 2 further proposes procedures, both administrative and through public hearing before the BOCC, for allowance of reductions for a proposed Oil and Gas Facility at a particular location based on meeting the specified criteria, which include showing that facility design and mitigation measures will provide substantially the same protection as the full setback. The setbacks being proposed for amendment are:

  Increase the existing 2,000-foot setback from any **Occupied Structure** as measured from the pad boundary to either 2,500 feet or 3,000 feet.

  Increase the existing 2,000-foot setbacks from the nearest boundary of a **Platted Lot smaller than 15 acres** to either 2,500 feet or 3,000 feet.

  Increase the existing 2,640-foot setback from an **Operating or Closed Landfill** to 3,000 feet.

  Increase the current 2,000 downgradient setback from any **Public Water Reservoir or Planned Public Water Reservoir** to 3,000 feet.

Increase the current 2,000-foot setback from a **Designated Outside Activity Area (DOAA)** as measured from the pad boundary to either 2,500 or 3,000 feet).

Increase the current 500-foot setback from a **Riparian Area, Perennial Surface Water, not a public water reservoir, and Stream** provided the site is outside any 100 year floodplain to 1,000 feet.

- **Reductions from Setbacks**: In order provide "off-ramps" for situations where application of the full setback distance may not be reasonable or necessary, the amendments propose various options for reductions for setbacks upon which the Planning Commission is requested to make separate recommendations as indicted in Attachment 2.

  These set back "off-ramps" are:

  For **Occupied Structures and Platted Lots**, the setback can be reduced through an administrative process, if all occupied structures or platted owners within that lesser setback agree to it. The current minimum setback in this situation is 500 feet and staff is including an option to increase the minimum setback to 1,000 feet. A larger "floor" would create a larger firefighting buffer around the pad site.

  If the affected **Occupied Structure/Platte Lot** owners do not consent to a lesser setback, an operator could request a setback reduction through a Use by Special Review with a public hearing. Currently the "floor" for the setback reduction is 500 feet. Staff offers options to increase that minimum setback to 1,000 feet or 1,500 feet.

  For **Public Water Reservoirs and Planned Public Water Reservoirs**, the base setback is one mile. If an operator can demonstrate that their facility is downgradient from the reservoir, they would be eligible for administrative approval of a 3,000-foot setback. Currently, the downgradient setback requirement is 2,000 feet, with no option for a reduction. The proposed regulations provide a Use by Special review with public hearings process and additional standards for downgradient or non-downgradient setback reductions. Options for a "floor" on downgradient setbacks are 1,500 or 2,000 feet. The proposed non-downgradient setback minimum is 3,000 feet.

  For **Designated Outdoor Activity Areas**, the 3,000-foot setback may be reduced administratively with the consent of the owner or manager of the Area (See Attachments 1 and 2). Options for a minimum required separation include 1,000, 1,500, or 2,000 feet.

  For **Riparian areas, Perennial Surface Waters and Streams**, provided that the facility remains outside any 100-year floodplain, the 1,000-foot setback may be administratively reduced to no less than 500 feet if supported by an independent third-party environmental analysis and recommended by CPW. Note, the existing setback is 500 feet. As such, if the increased 1,000 feet is not adopted this option for reduction would be removed and not apply.

- Amend **Reservoir terminology and definition of Planned and Permitted Reservoir**. The amendments change the terminology for referencing water reservoirs and planned reservoirs, and revises the definition of planned reservoirs. Such are now referred to as Public Water Reservoirs and Planned Public Water Reservoirs. This is primarily to distinguish other perennial surface waters that are not used for public water supplies, which have separate setback requirements. The requirements for the reservoir being a public water supply, under public ownership, and of a minimum size remain unchanged. Additionally, the amendments proposed to change the definition of a planned reservoir, which under the amendments is referred to as "**Planned Public Water Reservoir**," and is now defined as:

  > An unconstructed, but planned public water reservoir of qualifying capacity for which the location of such planned reservoir is established in the public record at a specific and mapped location within unincorporated Arapahoe County and that:
  >
  > *i.* has received or applied for approval through a water court adjudication; ***or***
  > *ii.* has received federal, state, or local permit approval required under applicable law for construction of a reservoir.

- Amend Section F.3.a. **Emergency Response Plan** to eliminate references to a separate Tactical Response Plan (TRP), because the TRP information is already provided in the required Emergency Action Plan (EAP).

- Amend Section F.3.i. **Fire Prevention and Procedures** to add mitigation measures for the Wildland Urban Interface. The amendment clarifies that the Fire Protection District will factor WUI into its review and may require additional protections for WUI areas.

- Amend Section F.3.n **Spill and Release Reporting** to add a new requirement for reporting of spills and to add continuous testing requirements for surface waters downgradient of and with a one-half mile of the well pad and testing, remediation and mitigation plans for any spill that leaves a pad.

- Amend Section F. 9. **Groundwater Sampling and Monitoring** to clarify language requiring testing of water wells if allowed by the property owner and to add additional documentation requirements for wells so tested. The amendments also add additional requirements for continuous surface water testing of surface waters that are downgradient of and within one-half mile of a well pad

- Add a new section for **Air Quality Monitoring**:
  The state requires air quality monitoring today. The proposed regulations would require monitoring from additional locations and require reporting to the county.

- Add requirement for Operators to provide continuous noise monitoring in Section F. 11 **Noise Mitigation.**

- Add new wording to Section F. 21. **New Technologies**:

  Clarifies that emissions monitoring is included in the list of potential new technologies.

DISCUSSION

At their October 16, 2023, study sessions, the Board directed staff to develop appropriate amendments to further protect public health, safety, and welfare and the environment, to include:

- New wording for reservoir setbacks to change the downgradient reservoir setback from 2,000 feet to 3,000 feet and allow for a setback reduction process for both the one-mile reservoir setback and the downgradient setback;
- Increased well pad setbacks from 2,000 feet to 3,000 feet for occupied structures, platted lots, landfills and DOAAs and to allow for a setback reduction process;
- Seek recommendations from Colorado Parks and Wildlife on a potentially greater setback for riparian areas;
- Air quality monitoring and testing by third party consultants, to be paid by operators;
- Increased water quality monitoring for both domestic water wells and surface water, conducted by a third party, to be paid for by operators;
- Investigate a potentially larger radius in some cases for neighborhood notifications of proposed well pads, which is currently set at one mile.

The items listed above, while not included in the Phase 1 amendments topics, were brought forward during BOCC study sessions prior to hearings and during the public comment period at the July 18, 2023, Planning Commission hearings and were then considered by the Board at subsequent Board study sessions on September 12, and October 16, 2023. Based on the stakeholder comments and Planning Commission recommendations, the Board directed staff to draft new rules or revise existing rules and proceed to a Planning Commission public hearing on November 8th.

The Board direction concerning air and water quality monitoring was to add new air quality monitoring and testing rules, to be conducted by a third party, paid for by industry and to enhance the existing domestic well testing requirements and add continuous surface water testing.

Staff is seeking Planning Commission's recommendations on specific increased setback distance options and on proposed procedures for reduction of the increase setback distances as set forth in this Staff Report and shown on the proposed amendments in Section 5-3.6.F.2 and called out for separate recommendations (see Attachment 2). Staff is also seeking Planning Commission's recommendation on the potential variance type options for reductions to the proposed increased

distances set forth in this Section of the proposed draft regulation. The specific text of all the amendments and the separate setback distances and potential reduction options for which separate recommendations are requested is contained in Attachment 2.

NOTICES AND REFERRALS

No referrals were sent to industry, residents or other stakeholders for these Phase 2a amendments of the Land Development Code Section 5-3.6, as the BOCC directed staff on October 10, 2023, to conduct a November 8, 2023, Planning Commission hearing for draft rule recommendations and a November 14th BoCC hearing for adoption of the Phase 2a rules. This tight timeline does not allow sufficient time for referrals or stakeholder meetings; however, staff is accepting comments sent to either Public Works and Development staff or the BOCC via email or letters. Furthermore, the proposed changes are a direct result of testimony received at both the Planning Commission and Board hearings. Public comments made at the November 8th Planning Commission hearing will become part of the record for the BOCC to review prior to the November 14th BOCC hearing.

It is important to note that a redlined version of these draft rules will be posted to both Legistar and the County's Oil & Gas website by November 3rd. Notifications of the Legistar and County website postings will be sent to over 500 people who have emailed Public Works and Development staff or the commissioners.

Notices of the November 8, 2023, Planning Commission public hearing and the November 14, 2023, BOCC public hearing were published in the Colorado Community Media and I-70 Scout newspapers on October 26th and October 24th, respectively.

STAKEHOLDER COMMENTS

Stakeholder comments previously on the topics covered in these changes were accepted, compiled for this hearing and summarized in Attachment 3. Any additional comments received after posting this staff report on the County's website will be presented to the Planning Commission at the hearing.

ALIGNMENT WITH COMPREHENSIVE PLAN

The proposed Land Development Code amendment is supported by, achieves, and addresses the following goals, policies and strategies of the 2018 Arapahoe County Comprehensive Plan:

Goal GM 3 – Reduce the Loss of Life, Health and Property Due to Risks Posed by Natural and Human-caused Hazards

Human-caused hazards in the Comprehensive Plan include airports, highway and railroad noise zones, Superfund sites, and oil and gas facilities. The proposed amendments to the oil and gas regulations will provide appropriate distances between well pads and protected water bodies such

as reservoirs, and will provide additional health and safety standards, thus reducing the risk of loss.

Policy GM 3.5 – Protect Existing and New Development from Human-caused Hazards

The proposed amendments to the oil and gas regulations seek to further protect the public health, safety, and welfare of Arapahoe County residents.

Strategy GM 3.5(b) – Establish Oil and Gas Operation Setbacks

The proposed amendments to oil and gas operation setbacks will align with comprehensive plan goals of establishing a safe distance between drilling operations and other uses such as outside activity areas, water reservoirs, and residents.

FISCAL IMPACT

The fiscal impact to the County of adoption of these amendments to the Oil and Gas Regulations is expected to be minor for the Planning Division to review more application materials, waiver requests, monitoring and testing data and additional recordkeeping.

RECOMMENDATION

Staff recommends approval of the Land Development Code amendments as proposed, including the various setback and setback reduction options as outlined in the proposed amendments with the following stipulation:

1. That Planning Commission make specific recommendations on separate amendment options presented in the proposed amendments, described in this Staff Report and outlined in the Staff proposed Motion to Recommend Approval; and
2. That Staff, with the approval of the County Attorney, may correct typographical errors and make such revisions to the Code amendment as are necessary to incorporate the approved amendment into the Land Development Code for publication.

ALTERNATIVES

The Planning Commission could take the following actions:

1. Recommend approval of the Land Development Code amendment as proposed or with modifications.
2. Continue the amendment to a time and date certain for more information.
3. Recommend denial of the Land Development Code amendment.

CONCURRENCE

The Public Works and Development Planning, Engineering, Zoning and the Office of Emergency Management, as well as the County Attorney's office, have reviewed the draft regulations, and the Arapahoe County Public Works and Development Department is recommending approval of this case.

DRAFT MOTIONS

Recommend Approval

In the case of LDC23-004, Oil and Gas Regulations, Land Development Code Amendment, I have reviewed the staff report, including all exhibits and attachments, and have listened to the presentation and any public comment as presented at the hearing and hereby move to recommend approval of the proposed amendment to the Land Development Code, subject to the following stipulations and specific recommendations:

1. That the setback from occupied structures be established at 2,000/2,500/3,000 feet *(pick one).*
2. That the setback from platted lots less than 15 acres be established at 2,000/2,500/3,000 feet *(pick one).*
3. That the minimum setback reduction that may be allowed for Occupied Structures and Platted Lots less than 15 acres be established at 500/1,000 feet with property owner permission through an administrative reduction *(pick one)*.
4. That the minimum setback reduction that may be allowed for Occupied Structures and Platted Lots less than 15 acres be established at 500/1,000/1,500 feet through a Use by Special Review (*pick one*).
5. That the setback from Designated Outside Activity Areas be established at 2,000/3,000 feet (*pick one*).
6. That the minimum setback from Designated Outside Activity Areas may be administratively reduced with consent of the owner or manager of the area but in no case may the setback be reduced below 1,000/1,500/2,000 feet (*pick one*).
7. That the minimum setback from operating or closed landfills as measured from the pad boundary be established at 2,640 feet/3,000 feet (pick one).
8. That the setback from riparian areas, perennial surface water (not a public water reservoir) and streams be established at 500 feet/1,000 feet with a procedure to administratively reduce the setback to no less than 500 if allowed by CPW *(pick one, 500 without an off-ramp or 1,000 with an off ramp).*
9. That the setback reduction procedures for the 3,000 feet downgradient reservoir setback as proposed in the amendments be adopted/not adopted *(pick one)* and that the Use by Special review option for reduction to no less than 1,500/2,000 feet (*pick one*) as proposed in the amendments be adopted/not adopted *(pick one).*
10. That the setback reduction procedures for the one-mile reservoir setback that does not qualify as downgradient as proposed in the amendments be adopted/not adopted *(pick one)* and that the Use by Special Review option for reduction to no less than 3,000 feet as proposed in the amendments be adopted/not adopted *(pick one)*.
11. That all other and additional amendments as proposed in the amendments be adopted as proposed.
12. That Staff, with the approval of the County Attorney, may correct typographical errors and make such revisions to the Code amendment as are necessary to incorporate the approved amendment into the Land Development Code for publication.

Recommend Denial
In the case of LDC23-004, Oil and Gas Regulations, Land Development Code Amendment, I have reviewed the staff report, including all exhibits and attachments, and have listened to the presentation and any public comment as presented at the hearing and hereby move to recommend denial of the proposed amendment to the Land Development Code.

1. *State any reason for denial.*

Continue to Date Certain:
In the case of LDC23-004, Oil and Gas Regulations, Land Development Code Amendment, I move to continue the hearing to [date certain], 6:30 p.m., to obtain additional information and to further consider the information presented.

ATTACHMENTS

1. Matrix of Potential Setback Variances
2. Oil and Gas Regulations Amendments, redlined draft
3. Stakeholder Comments Summary Table
4. Stakeholder Comments Received
5. Recent Publications

Journal of the Air & Waste Management Association

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Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations

Chris Holder, John Hader, Raga Avanasi, Tao Hong, Ed Carr, Bill Mendez, Jessica Wignall, Graham Glen, Belle Guelden & Yihua Wei

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TECHNICAL PAPER

Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations

Chris Holder[a], John Hader[a*], Raga Avanasi[a**], Tao Hong[b***], Ed Carr[b], Bill Mendez[c], Jessica Wignall[d], Graham Glen[a], Belle Guelden[e], and Yihua Wei[b]

[a]ICF, Durham, NC, USA; [b]ICF, San Francisco, CA, USA; [c]ICF, Fairfax, VA, USA; [d]ICF, Burlington, VT, USA; [e]ICF, Tiburon, CA, USA

ABSTRACT

Some states and localities restrict siting of new oil and gas (O&G) wells relative to public areas. Colorado includes a 500-foot exception zone for building units, but it is unclear if that sufficiently protects public health from air emissions from O&G operations. To support reviews of setback requirements, this research examines potential health risks from volatile organic compounds (VOCs) released during O&G operations.

We used stochastic dispersion modeling with published emissions for 47 VOCs (collected on-site during tracer experiments) to estimate outdoor air concentrations within 2,000 feet of hypothetical individual O&G facilities in Colorado. We estimated distributions of incremental acute, subchronic, and chronic inhalation non-cancer hazard quotients (HQs) and hazard indices (HIs), and inhalation lifetime cancer risks for benzene, by coupling modeled concentrations with microenvironmental penetration factors, human-activity diaries, and health-criteria levels.

Estimated exposures to most VOCs were below health criteria at 500–2,000 feet. HQs were < 1 for 43 VOCs at 500 feet from facilities, with lowest values for chronic exposures during O&G production. Hazard estimates were highest for acute exposures during O&G development, with maximum acute HQs and HIs > 1 at most distances from facilities, particularly for exposures to benzene, 2- and 3-ethyltoluene, and toluene, and for hematological, neurotoxicity, and respiratory effects. Maximum acute HQs and HIs were > 10 for highest-exposed individuals 500 feet from eight of nine modeled facilities during O&G development (and 2,000 feet from one facility during O&G flowback); hematologic toxicity associated with benzene exposure was the critical toxic effect. Estimated cancer risks from benzene exposure were < 1.0×10^{-5} at 500 feet and beyond.

Implications: Our stochastic use of emissions data from O&G facilities, along with activity-pattern exposure modeling, provides new information on potential public-health impacts due to emissions from O&G operations. The results will help in evaluating the adequacy of O&G setback distances. For an assessment of human-health risks from exposures to air emissions near individual O&G sites, we have utilized a unique dataset of tracer-derived emissions of VOCs detected at such sites in two regions of intense oil-and-gas development in Colorado. We have coupled these emission stochastically with local meteorological data and population and time-activity data to estimate the potential for acute, subchronic, and chronic exposures above health-criteria levels due to air emissions near individual sites. These results, along with other pertinent health and exposure data, can be used to inform setback distances to protect public health.

PAPER HISTORY
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Introduction

Colorado's rapidly growing population, in parallel with increased oil-and-gas (O&G) extraction in Colorado's Northern Front Range (NFR) and Garfield County (GC), has led to increasing numbers of people living and working in close proximity to O&G wells (McKenzie et al. 2016; McMullin et al. 2018).

The upper part of Colorado's NFR, in the Wattenberg Field area of the Denver-Julesburg (D-J) sediment basin (see Figure 1), saw population grow by 19% in 2008–2017 (CODOLA 2019). It is a particularly intense region of O&G development (COGCC 2007) where O&G production grew by over 300% in that period, almost entirely in Weld and Larimer counties (COGCC 2019).

CONTACT Chris Holder, chris.holder@icf.com ICF, 2635 Meridian Parkway, Suite 200, Durham, NC 27713, USA.
*Now at Stockholm University, Department of Environmental Science and Analytical Chemistry, Stockholm, Sweden
**No longer at ICF
***Independent researcher, Belmont, CA USA
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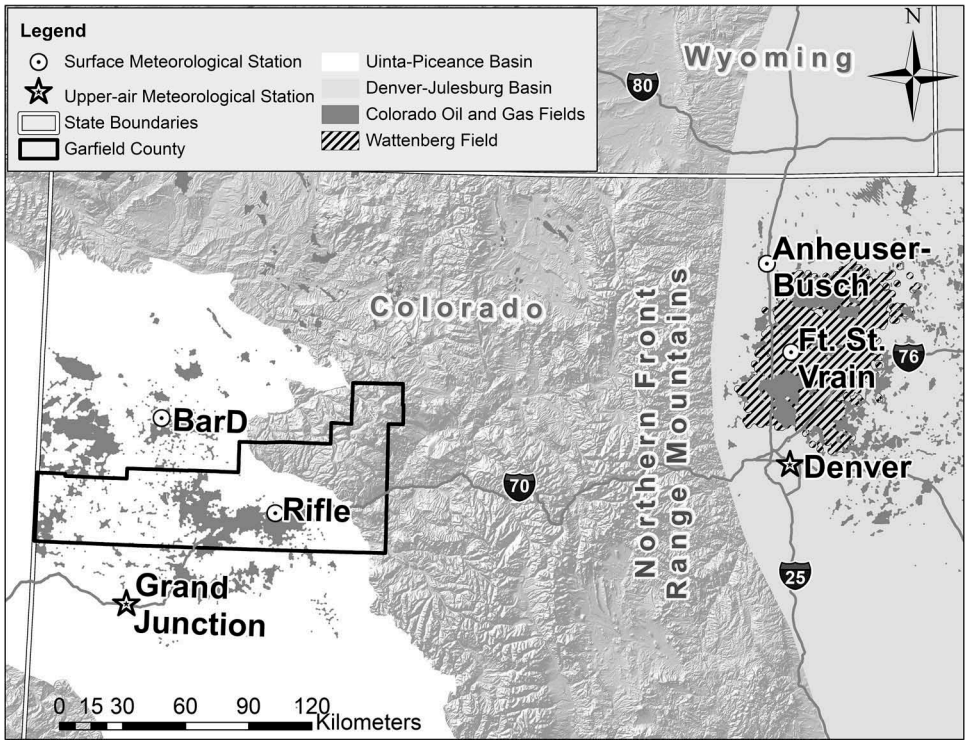

Figure 1. The major oil-and-gas-producing regions of Colorado and the locations of meteorological stations used for dispersion and exposure assessment. Interstate highways are also indicated.

In western Colorado, in GC and neighboring Rio Blanco and Mesa counties, population grew by 8% in 2008–2017 (CODOLA 2019). In those areas, O&G development of the Uinta-Piceance (U-P) basin (see Figure 1) has continued. O&G production declined 10% in 2008–2017 (peaking around 2012 at 26% over 2008 levels), though production in 2018 was higher relative to 2017, particularly in Mesa County with 48% growth (COGCC 2019).

In these Colorado regions, residential areas are often found within hundreds of feet (ft) of O&G wells. In 1992–2013, Colorado's Exception Zone Setback Distance was 350 ft (107 meters [m]) from the centre of new wells and production facilities to a building unit, and in 2013 the Colorado Oil and Gas Conservation Commission (COGCC) Rule #604 updated it to 500 ft (152 m). Analyses of residential locations in 2010 indicated 131,000 Coloradans lived within 400 m (1,312 ft) of a confirmed active well, with 255,000 people within 800 m (2,625 ft) (Czolowski et al. 2017). A more focused analysis of 2012 populations within 500 ft of active wells indicated 14,488 people in the D-J Basin live in such areas (up from 6,801 people in 2000) and 177 people in the more sparsely populated U-P basin live in that proximity (up from 72 people in 2000) (McKenzie et al. 2016). Because of continued population increases in these areas, a growing public-health concern has developed about the potential for inhalation health risks to people living near existing and future wells.

A number of studies have correlated proximity to O&G development with adverse health outcomes at different stages of life (Casey et al. 2016; Hill 2018; McKenzie et al. 2014, 2017; Rabinowitz et al. 2015; Stacy et al. 2015; Tustin et al. 2017; Whitworth, Marshall, and Symanski 2017, 2018). However, Haley et al. (2016) reviewed setback distances in Texas, Pennsylvania, West Virginia, Ohio, and Maryland, and they found the setbacks were not determined from peer-reviewed data analysis but were based on compromise between government agencies, the regulated community, environmental and citizen groups, and landowners. A limited number of studies which have provided more robust recommendations on safe setbacks (Maryland School of Public Health 2014) are based on limited data on epidemiology and air-quality monitoring.

Numerous studies in the literature analyzed ambient monitoring data near wells and locations of intense O&G development. Several studies analyzed airborne volatile organic compounds (VOCs) measured near O&G-production facilities in the Wattenberg Field (Gilman et al. 2013; McMullin et al. 2018; Thompson,

Hueber, and Helmig 2014) as well as in the vicinity of tank batteries and O&G-processing and disposal sites in the NFR (Halliday et al. 2016; McKenzie et al. 2018). Swarthout et al. (2013) and Colborn et al. (2014) respectively measured VOC signals in the Wattenberg Field area and in areas of O&G development in western Colorado.

Studies have used such monitoring data to estimate exposures for people living near O&G operations. Long, Briggs, and Bamgbose (2019) did so for areas in Pennsylvania. For Coloradans within 0.5 miles of active wells in 2008, McKenzie et al. (2012) used measurements along well-pad perimeters to make conclusions about incremental exposures to O&G-related hydrocarbon emissions: higher-end subchronic exposures could be slightly above health-criteria levels, while all other subchronic and chronic exposures were below non-cancer criteria levels for individual critical-effect groups and chemicals, and cancer risks from individual chemicals were $< 1 \times 10^{-5}$. Similarly, McMullin et al. (2018) used existing Colorado monitoring data, generally at hundreds-to-thousands of feet from well sites, to extrapolate that incremental acute and chronic exposures to O&G-related VOC emissions were below non-cancer criteria levels, and cancer risks were $\leq 1x10^{-5}$, at $\geq$ 500 ft from wells (beyond the current setback distance).

Most of the monitoring data used by McKenzie et al. (2012) and McMullin et al. (2018) were not at the hourly resolution ideal for acute-exposure analyses, and neither study used measured, source-attributable emission rates, nor human-activity patterns or other microenvironmental analyses, to more comprehensively examine spatiotemporal dispersion and exposure patterns. Studies or regulators conducting dispersion modeling of O&G operations often use limited, generic, and outdated emission factors (Small et al. 2014). This is particularly important because emissions from O&G activities can vary greatly in time and by phase of O&G activity (Adgate, Goldstein, and McKenzie 2014; Allen 2016; Brantley, Thoma, and Eisele 2015; CSU, 2016a, 2016b; McMullin et al. 2018; Thompson et al. 2017; Hecobian et al. 2019). This is especially pertinent to acute chemical exposures, which at high levels can be associated with headaches, nosebleeds, fatigue, dizziness, etc., depending on the chemical, intensity of exposure, and sensitivity of the individual.

In general, at sites using current well-development technologies, there remains a relative lack of studies utilizing measured emission rates to examine the direct impact from well-development and -production activities and corresponding patterns of acute human exposures. The relatively weak links between emissions and exposure must be strengthened to design and implement effective strategies to protect public health (Small et al. 2014). New studies are needed to help fill critical data gaps in O&G-related air-quality and exposure issues across geographies and communities, including using human-activity patterns to assess exposures that are epidemiologically meaningful (Shonkoff, Hays, and Finkel 2014).

In this article, we detail an assessment of human-health inhalation risks in Colorado regions of intense O&G activity (the NFR and GC), which helps to fill these data gaps. We utilized on-site VOC-emission rates derived by Colorado State University (CSU) during tracer studies, where during periods in 2013–2016 they measured 46 VOCs plus ethane (which we refer to as "47 VOCs" for convenience) at individual sites of O&G well development and production in the NFR and GC (CSU 2016a, 2016b; Hecobian et al. 2019). Their measurements indicated high intra-hour emission variability (by several orders of magnitude), occurring with no pattern. We used stochastic methods to model those variable emissions on an hourly basis, along with several sets of local hourly meteorological data and human-activity patterns in a variety of microenvironments (MEs). The modeled well sites are hypothetical because CSU measured the emissions at a variety of sites and times, and because the meteorological data we used in the modeling were not from the same sites and times. We stratified estimated risks by region, number of wells per well pad, O&G phase of activity (drilling, hydraulic fracturing ("fracking"), flowback, and production), VOC (and group of VOCs with similar critical effects), and duration of exposure (acute, subchronic, and chronic). The risk calculations, at distances $\leq$ 2,000 ft from the well pads, utilize health criteria issued by federal and state regulatory agencies, for non-cancer assessments of all VOCs and cancer-risk assessments for benzene. All exposures and risks are incremental (due only to each hypothetical well site being modeled) and do not consider aggregated exposure from background sources or other well sites. The risk estimates are only due to the 47 modeled VOCs and do not consider other compounds known to be emitted by O&G activities, and we do not account for synergistic health effects that may result from multi-chemical exposure.

While our chief concern is the highest simulated exposures (to determine if any exposure scenarios have the potential for adverse health impacts), we also characterize the distributions of potential non-cancer hazards across all modeled individuals at locations of higher average air concentrations.

The methodology developed and applied in this assessment can be applied to other O&G well operations which employ fracking and related processes. Ideally, local measurements of VOC emissions would be available, but the measurements used in this study could be used in a screening approach while still incorporating local meteorological, topographical, and human-activity data to inform determinations of safe setback distances.

Methods and approach

In this section, we describe the methods and approach of our assessment. We discuss the uncertainties of some of these methods, and the sensitivity of the assessment to those methods, in the Uncertainties and Limitations section as well as in Supplementary Sections F and G.

Air-dispersion modeling

Model selection

We used the American Meteorological Society/U.S. Environmental Protection Agency (EPA) Regulatory Model (AERMOD version 16216r) (EPA 2018a). AERMOD's formulation represents the state of the science, with similarity-theory-based boundary-layer calculations. The steady-state Gaussian assumption is appropriate over the distances under consideration in this study, which are 150–2,000 ft (46–610 m). Near-source air concentrations are largely determined from emission source strength and meteorological conditions.

Emission characterization

We used field measurements made by CSU (2016a, 2016b; Hecobian et al. 2019) in close proximity to individual O&G-well sites in GC and the NFR, for the 47 VOCs shown in Figure 2. They gathered measurements during O&G drilling (only at GC sites) as well as fracking and flowback (at GC and NFR sites), which are development activities, as well as during O&G production (only at NFR sites). There were ≥ 12 sampling events per O&G phase, and each event had at least one unique canister sample measurement. In their documentation, CSU does not provide the exact locations of the sampled sites. They derived emission rates using the tracer-ratio method (TRM; Lamb et al. 1995). Wells et al. (2015) analyzed of the accuracy of the TRM using several controlled-release experiments, finding a mean bias of +22.6% and a precision (relative standard deviation) of ±16.7%. The CSU studies did not examine any chemicals beyond these 47 VOCs and methane.

Measured 3-minute-average emission rates for each VOC were highly variable. From the 3-minute-average rates, we derived 1-hour-average rates appropriate for dispersion modeling (1 hour is also the shortest time scale for acute health/toxicity information). We provide in Supplementary Section A further details on the

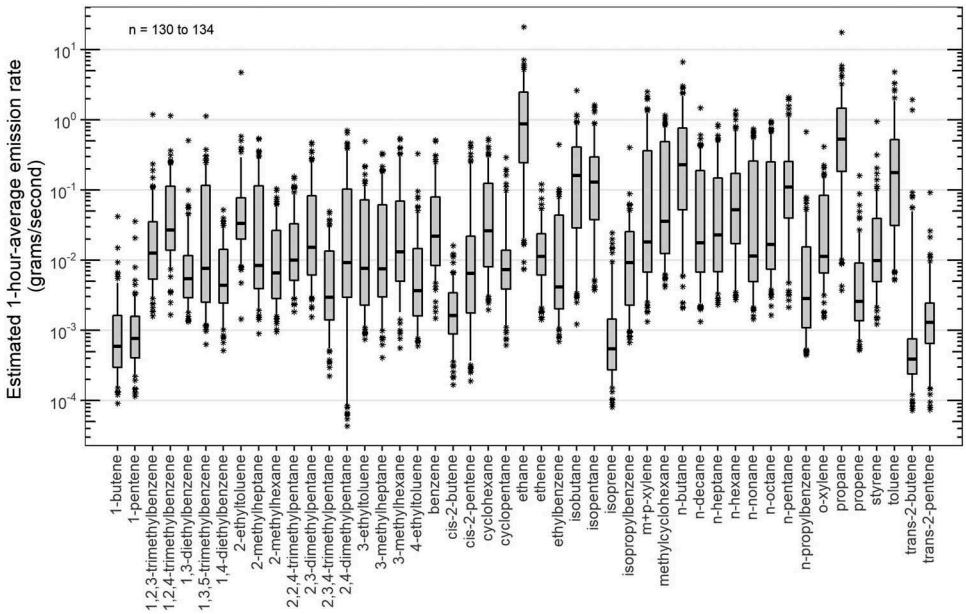

Figure 2. Emission rates utilized in this assessment. The values shown are the superset of rates from all sites and operations, and they are 1-hour-average rates derived from the 3-minute-average rates from CSU (2016a, 2016b; Hecobian et al. 2019). The bottom and top of the boxes are the 25th and 75th percentiles, respectively; the line inside the box represents the median; the bottom and top whiskers are the 5th and 95th percentiles, respectively; and the asterisks are outliers beyond the 5th and 95th percentiles.

characterization of emission variability and derivation of 1-hour-average emission rates. In Figure 2, for each VOC we show the superset of derived 1-hour-average emission rates (across all modeled sites and O&G activities).

To model emissions in AERMOD, we assumed multi-well development sites (which are increasingly common) would be larger than single-well sites. We modeled three source configurations for O&G development to reasonably represent current and near-future practices, based on professional judgement and recent O&G permits submitted to COGCC: a 1-acre site (for 1 well), a 3-acre site (for 8 wells in the NFR and 16 wells in GC), and a 5-acre site (for 32 wells). These acreages correspond to 0.4, 1.2, and 2 hectares. We modeled O&G well production using a 1-acre site (without consideration of the number of wells; production emissions were not well correlated with the number of producing wells). We characterized each site as a volume source, implying emissions come equally from all parts of the well pad, and with no chemical transformations during the short travel times/distances of interest (2,000 ft).

Meteorology

Meteorological data, provided by CDPHE, were representative of conditions in our two study areas (and generally representative of the regions where the CSU experiments occurred), and they included terrain-induced flows, mountain/valley wind systems, local-scale weather systems, and continental-scale weather effects. We show in Figure 1, and describe further in Supplementary Section B (including processing details and wind roses), the selected representative meteorological stations: a GC valley site (Rifle, Colorado), a ridge-top site 24 kilometres (km) north of GC ("BarD" site), an NFR site influenced by ridge flows (Anheuser-Busch site near Fort Collins, Colorado), and an NFR site influenced by mountain/valley flows (Ft. St. Vrain site near Platteville, Colorado). Terrain was generally flat within the immediate vicinity (500-m radius) of each station.

Receptors

We placed air-concentration receptors in a polar grid extending to 2,000 ft from the centre of a modeled well pad, at relatively regular distance intervals starting at 300 ft (91 m) from the development pad – at 100-ft (30-m) intervals to 1,000 ft (305 m), and then at 200-ft (61-m) intervals to 2,000 ft. We also included a 350-ft distance, and for modeling of well production we included receptors at 150 ft and 250 ft (76 m). Some distances (e.g., 350, 500, and 1,000 ft) correspond to setback distances from the centre of well or production facilities as listed under the COGCC Rule #600 Series Safety Regulations.

Monte Carlo simulations for O&G development

Since O&G well development typically lasts days to months, the focus was on short-term concentrations, which can vary drastically depending on meteorology and activities at the well. Dispersion models are designed primarily for sources with known emission rates or well-defined temporal patterns. For sources like O&G facilities emiting with substantial irregularity, the acute health risk can be exaggerated when applying an air-dispersion model to the improbable coincidence of the highest emission rate with worst-case meteorological conditions. To provide information on the probability of these events, the results are best expressed as a probability distribution simulated by randomizing the emission rate, O&G-activity duration, and meteorological conditions through application of the Monte Carlo method. The Monte Carlo approach is widely used in addressing problems associated with emissions from irregularly emitting sources, as it provides more realistic estimates of health risk (Li, Huang, and Zou 2008; Lonati and Zanoni 2013). Monte Carlo has been used to determine protective zones for intermittent irregular sources (Balter and Faminskaya 2016). For irregularly varying power-plant emissions, the Electric Power Research Institute sponsored the development of a Monte Carlo tool, EMVAP (Paine et al. 2014), useful in assessing compliance with National Ambient Air Quality Standards (NAAQS; Guerra 2014). The approach has been endorsed by the State of Washington's Department of Ecology (Bowman and Dhammapala 2011) for use in compliance with the 1-hour NAAQS for nitrogen dioxide.

To determine the concentration distributions of VOCs emitted by development activities, we used the Monte Carlo approach illustrated in Figure 3, whereby we randomized key inputs: meteorology, emissions, and O&G-activity duration. Per-well activity durations ranged 3–7 days for drilling, 1–5 days for fracking, and 1–30 days for flowback (with typically longer flowback durations at GC sites) (see Supplementary Section A, Table A-1). These durations were developed from information provided by COGCC and O&G operators/supervisors in GC and the NFR. The output of the Monte Carlo approach provides a representative distribution of possible VOC concentrations (EPA 1994).

In Stage 1, for each of the four sites and three well-pad sizes, we ran AERMOD using unit-emission rates (1 gram/second/pad) for the full meteorological period, retaining all hourly results and producing

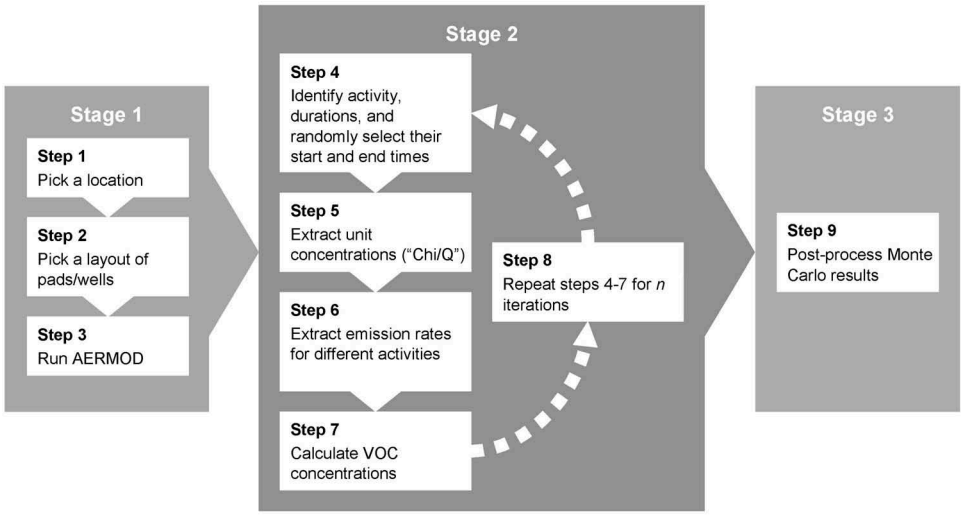

Figure 3. Monte Carlo simulation logic for estimating the concentration distribution of volatile organic compounds (VOCs) emitted by oil-and-gas well-development activities.

concentrations per unit emissions ("Chi/Q"). In Stage 2, for a given O&G development activity, we randomly selected a duration per well for the activity (from the ranges and probabilities shown in Supplementary Section A, Table A-1) and a time when the activity occurred. Then, for each VOC, we randomly selected an emission rate from available measurements and multiplied it by the Chi/Q values, resulting in a period of hourly modeled VOC concentrations (per well) based on the emission rate and meteorological variability. Each scenario developed in this way is termed an "iteration." This process was repeated 2,000 times for each well-pad size, meteorological dataset, O&G activity, and VOC. We identified 2,000 iterations was sufficient for result stability by running 10,000 simulations for VOCs with large emission-rate variations, examining maxima and standard deviations in the maximum concentrations. We assumed with all other O&G activities and VOCs that additional iterations would not noticeably alter the distributions of results, as they have less variability. Note: because the NFR is so large, neither meteorological station's data set fully characterizes the geographical region; as a result, for the NFR we randomly selected the iterations from the model outputs using the Anheuser-Busch or Ft. St. Vrain meteorological data, producing a blended single set of model results broadly representative of the NFR.

In Stage 3, we post-processed the Monte Carlo results by summarizing their statistical distributions. The goal was to constrain the amount of data passed to the exposure assessment of O&G-development emissions, utilizing only the receptors with the highest concentrations and only summary statistics of the Monte Carlo results at those receptors. First, we identified the maximum 1-hour-average concentration from each iteration, at each receptor for a specific O&G site (GC valley and ridge-top sites; NFR blended site), activity, and VOC. Second, we calculated the means from each set of maxima (the mean-maximum values, representing the expected maximum concentrations). Third, from among all the receptors at a given distance from the well pad, we identified the receptor with the highest mean-maximum concentration, for a specific O&G site, activity, and VOC. Fourth and finally, for each highest-mean-maximum receptor identified (one per receptor distance), we characterized the distribution of the concentrations from across the iterations for use in exposure assessment.

O&G production

Since O&G production typically lasts decades, the focus was long-term air concentrations. We used AERMOD to generate full years of hourly Chi/Q values for receptors at each O&G site, from which we calculated the annual-average values. As with O&G development, we sought to constrain the data passed to the exposure and risk assessments by focusing on the higher-concentration locations. We identified the year with the highest annual average for each site, and then we identified the receptor at each distance with the highest annual average. These receptors (one per receptor distance) with the highest annual-average Chi/Q represent the locations with the highest long-term concentrations, based on prevailing meteorological conditions. For each receptor identified, we later used the Chi/Q values directly in exposure and risk assessment, where we randomly combined the hourly Chi/Q values with

the VOC emissions rates, creating many random hourly combinations of emission rate and meteorological conditions.

Comparison with monitored data

We cannot compare directly to CSU's canister measurements (2016a, 2016b; Hecobian et al. 2019) because we were not attempting to simulate the conditions and other specifications under which they took the measurements. We considered comparison to samples collected in other O&G studies. Halliday et al. (2016) collected samples of ambient VOCs, but they mostly focused on a regional scale and captured other VOC sources such as on-road mobile sources, biogenic emissions, other O&G-processing facilities, and industrial sources. However, we considered one site in that study appropriate for comparison: the PAO site was located 9 km southeast of Platteville, Colorado (in the NFR), in a fairly isolated, primarily rural location surrounded by agricultural and grazing lands but with active wells in close proximity and collection tanks 500 m to the southwest. The maximum benzene concentration reported at this location, using observations at 1-second time resolution, was 29.3 parts per billion (ppb). Our Monte Carlo dispersion simulations during well-development activities using the Anheuser-Busch meteorological data found an expected-maximum 1-hour concentration of 87.3 ppb at the much closer distance of 152 m, decreasing to 13.8 ppb at 610 m. While these data cannot be directly compared given the different source mix and distances, they indicate peak benzene concentrations are likely to be in the range of 10–100 ppb in the nearby vicinity under reasonable worst-case conditions. Other studies such as Thompson, Hueber, and Helmig (2014) only measured concentrations from samples in close proximity to producing wells and lack information on meteorology or emission rate needed to make a model-to-monitor comparison. McMullin et al. (2018) argued the need for more extensive and detailed air and exposure monitoring to improve the body of real-world data.

Human-exposure modeling

Model selection

We conducted inhalation-exposure modeling using the U.S. EPA Air Pollutants Exposure (APEX) Model, a stochastic, ME model used by EPA for assessments of criteria air pollutants (e.g., assessments for NAAQS; see, for example, EPA 2018b) and other airborne-chemical scenarios (EPA 2017). It generates time series of estimated inhalation exposure across a population by combining data on demographics, human activity, pollutant-ME interactions, and ambient pollutant concentrations.

Characterization of ambient air concentrations

We developed APEX runs whose results could be combined with the modeled air concentrations to obtain exposure estimates for a wide variety of scenarios. As illustrated in Figure 4, each run utilized unit ambient-air concentrations, resulting in time series of exposure concentrations per unit outdoor VOC air concentration, specific to the O&G site as well as chemical-penetration group and age group (discussed later). We multiplied the exposure time series by time series of air concentrations constructed from the Monte Carlo dispersion iterations.

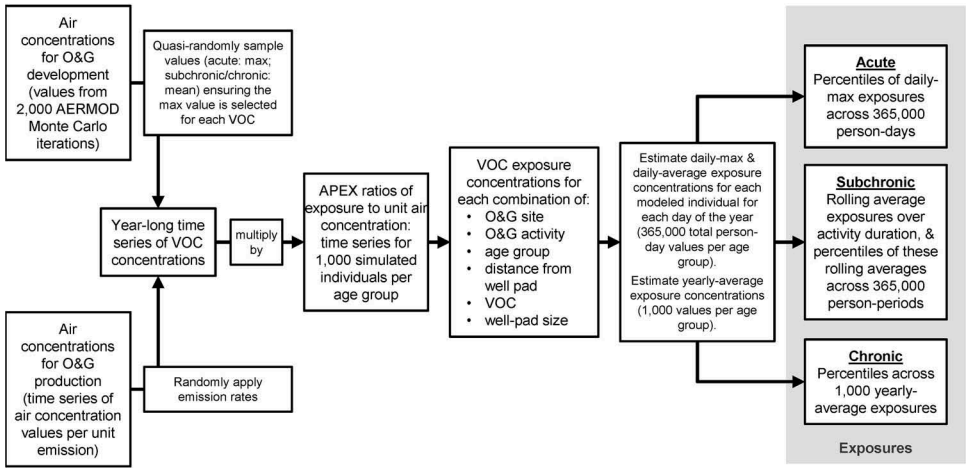

Figure 4. Flow diagram illustrating the steps in exposure assessment. Notes: O&G = oil and gas; VOC = volatile organic compound; AERMOD = American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model; APEX = U.S. Environmental Protection Agency Air Pollutants Exposure Model; max = maximum.

For estimating exposure concentrations during O&G-development activities, we used outputs from the Monte Carlo dispersion iterations of O&G development to construct year-long time series of outdoor VOC concentrations. Each time series was specific to a VOC, O&G site, and development activity. For estimating acute exposure above criteria levels, each hour utilized the absolute-maximum 1-hour outdoor concentration from a randomly selected dispersion iteration (acute effects are likely to begin shortly after exposure but may persist for 24 hours or longer; we based our 1-hour time frame on the durations used to calculate acute health-criteria values). For estimating the potential for subchronic and chronic exposures above criteria levels, each hour utilized the mean outdoor concentration from a random iteration. Concentrations for all VOCs for a given hour originated from the same CSU sampling experiment, enabling evaluation of simultaneous chemical exposures.

For estimating exposure concentrations during O&G production, we generated year-long time series of outdoor VOC concentrations by multiplying hourly production emission rates (55 values per VOC available from the CSU experiments) by the Chi/Q outputs of the dispersion modeling of production activities. Each time series was specific to a VOC and O&G site. Each hour corresponded to a randomly selected emission rate, with rates for all VOCs picked from the same experiment on a given hour. As was done in the Monte Carlo simulations, for NFR modeling we randomly selected dispersion outputs from one of the NFR sites by hour.

Population characteristics

Age can affect personal activities and exertion levels. While exposures during individual activities can vary greatly with age, preliminary modeling indicated our exposure estimates of primary interest (the highest exposures within the population) would not vary substantially between basic stages of life (child vs. adult vs. elderly) and even less from year to year. Further, the very young and very old are not well represented in the time-activity data (discussed below), and the health-criteria values (discussed later) are assumed protective of these and all other identifiable sensitive groups. We modeled a single group of children (ages 0–17 years) and two groups of adults (ages 18–59 and 60–99 years; the 60-year cut-point was informed by time-activity availability). This is a hypothetical population split equally among males and females. APEX samples national distributions of U.S. demographic data to assign characteristics like age, height, weight, and employment (EPA 2017). Through convergence testing similar to that used in the dispersion modeling, we determined 1,000 modeled individuals per age group and receptor location was sufficient to capture the expected variability in exposures across a larger population.

Human-activity patterns

APEX constructs a timeline of activities and their ME locations for each individual by sampling from EPA's Consolidated Human Activity Database (CHAD) (EPA 2016) based on age and outdoor temperature. CHAD contains hundreds of activities and their ME locations for thousands of diary-days; APEX pairs them with exertion levels to estimate breathing rate and exposure. We constrained activity diaries for adults 18–59 years to those surveyed from U.S. Mountain West states (including Colorado). A sufficient number of diaries from that region was not available for younger and older individuals, for whom we sampled activity diaries from across the US. As discussed in Supplementary Section G, the geographic origin of activity data made minimal difference in estimated exposures.

We made the conservative assumption that an individual's exposures take place at his/her modeled receptor location (assumed to be their residential property). That is, we assume all individuals spend all their time at their property, in MEs defined as either indoors, outdoors, or in-vehicle depending on the activity. We discuss in Supplementary Section G the effect of this assumption, particularly that people do not commute away to work, finding modeled exposures may be overestimated by ≤ 25% for typical working adults.

Chemical penetration

We organized the VOCs into several groups of penetration factors (PENs, or the fraction of ambient chemical infiltrating an ME) based on volatility-based clustering analysis (including vapor pressure [Vp]), literature search for ME penetration factors (see Supplementary Section C), and an assumption that PENs cannot exceed 1 because we are assuming O&G-related pollutant concentrations in MEs cannot be higher than in outdoor air (ignoring any time lags due to air-exchange delays). We set in-vehicle PENs to 0.9–1 for all VOCs (typical literature values were above 1, due to in-vehicle sources not utilized in our study). For the "benzene group" (benzene and toluene with functional groups, and very large alkanes; logVp = 0–9), we set indoor PENs to 0.1–1 based on numerous studies. For other (smaller) alkanes and alkenes (logVp>5), we set indoor PENs to 0.9–1; this was based on one study (for pentane), but high PENs

are health-protective (indoor exposure levels will be higher and closer to outdoor levels) and expected for high-Vp chemicals. For the entirety of the simulation, a modeled individual is randomly assigned one PEN per ME from these uniform distributions. Depending on the VOC, we discuss in Supplementary Section G an assumption of "tighter" homes and vehicles would substantially reduce chronic exposures, while an assumption of constant outdoor exposure would increase chronic exposures.

Post-processing

For calculating exposure statistics, we assumed an O&G activity could occur any hour and time of year. While the Monte Carlo dispersion simulations utilized distributions of O&G-activity durations (based on the prevalence of vertical vs. horizontal drilling and the distance of horizontal drilling), for exposure analysis we simplified the durations through prevalence-weighting so there was one duration per site, well-pad size, and O&G activity. Multi-well scenarios are longer than single-well scenarios, proportional to the number of wells, and in some cases a single development phase can last more than one year, requiring a chronic-exposure assessment. We assumed the production phase was 30 years. These exposure durations, along with which activities underwent an acute, subchronic, and/or chronic assessment, are shown in Table A-2 of Supplementary Section A. Note we assume durations of development activities scale directly with the number of wells being developed (drilling occurs on each well sequentially, then sequential fracking, then sequential flowback, with no concurrence).

The goal was not to analyze all of the potentially millions of individual exposure events in the modeling; rather, we identified the exposure results of most interest for characterizing the potential (if any) of exposures above criteria levels. We isolated particular exposure statistics for each simulated individual at the locations of highest air concentrations, as shown on the right side of Figure 4 and described below.

For acute assessments (for 1-hour-average exposures), we identified the maximum 1-hour exposure concentrations per day for each modeled individual, resulting in a collection of hundreds of thousands of daily-maximum acute exposures per receptor distance and VOC.

For subchronic assessments (for average exposures lasting 1–365 days; note we did not evaluate exposures more than 1 hour but less than 1 day), we calculated multi-day-average exposure concentrations, based on assumed O&G activity durations, for all possible multi-day periods in the year (i.e., "person-periods"). For sequences of development activities (i.e., drilling followed by fracking then flowback), we calculated average exposure concentrations from randomly selected person-periods for each of the activities in sequence, with averaging weighted by activity durations. This resulted in a collection of hundreds of thousands of person-period values per receptor distance and VOC.

For chronic assessments (for average exposures lasting more than 1 year), we identified each modeled individual's annual-average exposure concentration, assuming continuous exposure to emissions from O&G activities on the hypothetical well pad, and, for the production activity, assuming these exposures accurately reflect those expected over a 30-year period. This resulted in thousands of chronic-exposure concentrations per receptor distance and VOC. Following these calculations, for sequences of O&G activities together lasting more than 1 year, we calculated average exposure concentrations from randomly selected person-periods for each of the development activities in sequence, followed by the corresponding production-period exposures, with averaging weighted by activity durations, leading to hundreds of thousands of exposure values per receptor distance and VOC.

We then calculated mean and percentile acute, subchronic, and chronic exposure concentrations for use in risk estimations, based on the many exposure estimates discussed above per receptor distance and VOC.

Evaluation of potential health risks

Non-cancer hazards

We evaluated the severity of potential non-cancer health hazards associated with chemicals in accordance with guidance from ATSDR (Agency for Toxic Substances and Disease Registry) (2018) and EPA (2009). We calculated hazard quotients (HQs; ratios of time-weighted exposure concentrations to health criteria) for each VOC emitted by each individual well site, for acute, subchronic, and chronic exposure periods. To evaluate hazards from exposures to multiple VOCs, we calculated hazard indices (HIs) by summing HQs (effect additivity) for specified critical-health-effect groups (ATSDR 2018); we did not evaluate any possible synergistic effects or other toxicological interactions.

We calculated HQs for each VOC, exposed individual, pad size, O&G activity, and exposure duration, along with HIs for each critical-effect group. We stratified HQs and HIs into order-of-magnitude ranges from > 10, 1–10 (inclusive), 0.1–1, and < 0.1; values greater than 1 indicate increased potential for adverse

effects, but numerical values do not indicate the probability or severity of effects.

Sources of non-cancer health-criteria values

For each VOC and exposure duration when available, we identified acute, subchronic, and chronic health-criterion values (exposure levels defined as being without appreciable risk of adverse effects) issued by federal agencies (EPA, ATSDR). These included EPA RFCs (Reference Concentrations), PPRTVs (Provisional Peer-reviewed Toxicity Values) issued under EPA's Superfund program, and ATSDR MRLs (Minimal Risk Levels). When federally issued criteria were not available (which was frequent for acute exposures), we used inhalation criteria that were issued by states with active air-quality programs (California OEHHA [Office of Environmental Health Hazard Assessment], TCEQ [Texas Commission on Environmental Quality]) and were available in early 2018. Where we identified more than one criterion value for a VOC, we selected values according to the following principals. (a) We preferred criteria issued by EPA or ATSDR. (b) Preferred criteria were those intended for risk and hazard analysis (RFCs, MRLs, TCEQ Reference Values) rather than screening-level values tied to specific regulatory programs (PPRTVs, TCEQ ESLs [Effects Screening Levels]). (c) We did not consider welfare-based criteria. (d) We preferred criteria derived using the most current and complete data, and using adequate human databases rather than only animal studies. (e) We preferred criteria derived using state-of-the-science methods (benchmark dose) to extrapolation from no-observed - or lowest-observed-adverse-effect levels. (f) We included criteria based on read-across or structure-activity relationships only if no other values were available (for example, EPA's chronic PPRTV for n-hexane served as a surrogate for 2,2,4- and 2,3,4-trimethylpentane, cyclopentane, and n-octane).

We show in Table 1 the criteria selected for this assessment. We identified suitable values for chronic, subchronic, and acute exposures for 45, 32, and 44 VOCs, respectively. For benzene, which was among the most ubiquitously occurring of the VOCs in the assessment, there were substantial differences in the acute criteria values issued by federal and state agencies. Values ranged from 8 ppb (OEEHA Reference Exposure Level) to 180 ppb (TCEQ ESL). After reviewing the bases and derivations of the values, we chose 30 ppb as the acute non-cancer criterion for benzene (see Appendix C for a complete discussion). The implications of this value's uncertainty are discussed in Supplementary Section D.

As noted above, we calculated HIs for VOCs in various critical-effects groups, calculated as the sum of all VOC HQs in the group. The groups, with chemicals assigned separately for acute, subchronic, and chronic effects, comprised developmental, endocrine, hematological, hepatotoxicity, immune, nephrotoxicity, neurotoxicity, respiratory, and sensory toxicity, as well as "systemic" for nonspecific endpoints such as reduced body weight. We assigned VOCs to specific groups based on effects occurring at or near the criteria levels, and, as shown in Supplementary Section E, a given VOC could be included in more than one group if animal or human data indicated multiple effects at that exposure.

Cancer risks

Among the assessed VOCs, benzene is the only one EPA classifies as a known human carcinogen (EPA 2000). Three other chemicals detected in the monitoring (styrene, isoprene, and ethylbenzene) are identified by the International Agency for Research on Cancer (IARC) as "probably" or "possibly" carcinogenic to humans. We did not include them in the cancer-risk assessment because animal studies are the primary sources of carcinogenicity data, and EPA has not derived exposure-response relationships based on human data for any of them as of publication. In addition, we know (McMullin et al. 2018) O&G operations release other potentially carcinogenic compounds, such as formaldehyde and acetaldehyde, which were not measured by CSU (2016a, 2016b; Hecobian et al. 2019). Exclusion of these compounds means our simulated total cancer risks from O&G operations are underestimated, but the degree of underestimation cannot be assessed accurately.

We used EPA's inhalation unit risk value (IUR) to calculate lifetime cancer risks for benzene exposure. EPA's Integrated Risk Information System issued a benzene IUR for lifetime leukemia risk, defined as $2.2\text{x}10^{-6}$–$7.8\text{x}10^{-6}$ $(\mu g/m^3)^{-1}$, with a central tendency of 5×10^{-6} $(\mu g/m^3)^{-1}$ (EPA 2000). OEHHA (2009) recommends a higher value – 2.9×10^{-5} $(\mu g/m^3)^{-1}$ – but it was derived in 1988 based on a combination of animal and human data and was estimated before the most accurate exposure estimates for the Pliofilm cohort became available.

We estimated ranges of incremental lifetime cancer risk from each well site individually by multiplying the lifetime-average exposure concentration by the three EPA IURs noted above (the lower-bound, central-tendency, and upper-bound values). We calculated exposures as the 70-year time-weighted average of 30–32 years of exposure to O&G benzene emissions (depending on the O&G activity and site) and, after well production has stopped, 38–40 years of no benzene exposure. This approach aligns with the EPA

Table 1. Selected non-cancer criteria values (ppb).

	Chronic criterion value		Subchronic criterion value		Acute criterion value	
Chemical	Value	Source	Value	Source	Value	Source
1,2,3-trimethylbenzene	12	EPA RfC	41	EPA RfC	3000	TCEQ ReV
1,2,4-trimethylbenzene	12	EPA RfC	41	EPA RfC	3000	TCEQ ReV
1,3,5-trimethylbenzene	12	EPA RfC	41	EPA RfC	3000	TCEQ ReV
1,3-diethylbenzene	45	TCEQ ESL	182	EPA PPRTV	450	TCEQ interim ESL
1,4-diethylbenzene	45	TCEQ ESL	182	EPA PPRTV	450	TCEQ interim ESL, surr.
1-butene	2300	TCEQ ReV	NA	NA	27,000	TCEQ ReV
1-pentene	560	TCEQ ReV	NA	NA	12,000	TCEQ ReV
2,2,4-trimethylpentane	124	EPA PPRTV	5740	EPA PPRTV	4100	TCEQ ReV
2,3,4-trimethylpentane	124	EPA PPRTV	5740	EPA PPRTV	4100	TCEQ ReV
2,3-dimethylpentane	2200	TCEQ ReV	6543	EPA PPRTV	8200	TCEQ ReV
2,4-dimethylpentane	2200	TCEQ ReV	6543	EPA PPRTV	8200	TCEQ ReV
2-ethyltoluene	25	TCEQ ESL	204	EPA PPRTV	250	TCEQ interim ESL, surr.
2-methylheptane	390	TCEQ ReV	5740	EPA PPRTV	4100	TCEQ ReV
2-methylhexane	2200	TCEQ ReV	6543	EPA PPRTV	8200	TCEQ ReV
3-ethyltoluene	25	TCEQ ESL	204	EPA PPRTV	250	TCEQ interim ESL, surr.
3-methylheptane	390	TCEQ ReV	5740	EPA PPRTV	4100	TCEQ ReV
3-methylhexane	2200	TCEQ ReV	6543	EPA PPRTV	8200	TCEQ ReV
4-ethyltoluene	25	TCEQ ESL	204	EPA PPRTV	250	TCEQ interim ESL, surr.
benzene	3	ATSDR MRL	25	EPA PPRTV	30	Literature review
cis-2-butene	690	TCEQ ReV	NA	NA	15,000	TCEQ ReV
cis-2-pentene	560	TCEQ ReV	NA	NA	12,000	TCEQ ReV
cyclohexane	1744	EPA RfC	5232	EPA PPRTV	1000	TCEQ interim ESL
cyclopentane	202	EPA PPRTV	9348	EPA PPRTV	5900	TCEQ interim ESL
ethane	NA	NA	NA	NA	NA	NA
ethene	5300	TCEQ ReV	NA	NA	500,000	TCEQ ReV
ethylbenzene	230	EPA RfC	2074	EPA PPRTV	20,000	TCEQ ReV
isobutane	10,000	TCEQ ReV	NA	NA	33,000	TCEQ ReV
isopentane	8000	TCEQ ReV	9087	EPA PPRTV	68,000	TCEQ ReV
isoprene	140	TCEQ ReV	NA	NA	1400	TCEQ ReV, proposed
isopropyl benzene	81	EPA RfC	204	EPA PPRTV	510	TCEQ interim ESL
m + *p*-xylene	23	EPA RfC	91	EPA PPRTV	1700	TCEQ ReV
methylcyclohexane	400	TCEQ ESL	6677	EPA PPRTV	4000	TCEQ interim ESL
n-butane	10,000	TCEQ ReV	NA	NA	92,000	TCEQ ReV
n-decane	190	TCEQ ReV	NA	NA	1000	TCEQ ReV
n-heptane	2200	TCEQ ReV	977	EPA PPRTV	8200	TCEQ ReV
n-hexane	199	EPA RfC	625	EPA PPRTV	5500	TCEQ ReV
n-nonane	3.8	EPA PPRTV	38	EPA PPRTV	3000	TCEQ ReV
n-octane	124	EPA PPRTV	5740	EPA PPRTV	4100	TCEQ ReV
n-pentane	8000	TCEQ ReV	3391	EPA PPRTV	68,000	TCEQ ReV
n-propylbenzene	51	TCEQ ESL	204	EPA PPRTV	510	TCEQ interim ESL
o-xylene	23	EPA RfC	92	EPA PPRTV	1700	TCEQ ReV
propane	NA	NA	NA	NA	NA	NA
propene	1744	OEHHA REL	NA	NA	NA	NA
styrene	235	EPA RfC	NA	NA	5100	TCEQ ReV
toluene	1328	EPA RfC	1328	EPA PPRTV	2000	ATSDR MRL
trans-2-butene	690	TCEQ ReV	NA	NA	15,000	TCEQ ReV
trans-2-pentene	560	TCEQ ReV	NA	NA	12,000	TCEQ ReV

Notes: ppb = parts per billion; RfC = Reference Concentration; MRL = Minimum Risk Level; PPRTV = Provisional Peer-reviewed Toxicity Value; ReV = Reference Value; ESL = Effects Screening Level; REL = Reference Exposure Level; EPA = U.S. Environmental Protection Agency; ATSDR = Agency for Toxic Substances and Disease Registry; TCEQ = Texas Commission on Environmental Quality; OEHHA = California Office of Environmental Health Hazard Assessment; NA = not available; surr. = data for a surrogate compound was used to derive the criterion value.

Superfund approach for conducting site-specific risk assessments for inhaled contaminants (EPA 2009) and has been used when evaluating emissions from sources similar those in this assessment (McKenzie et al. 2012).

Potentially sensitive populations (developmental effects and cancer risks)

Consistent with stated policies of all agencies who derived the health-criteria values, we assumed the non-cancer criteria are adequately protective of all identifiable sensitive groups in the exposed population. In the special case of developmental and reproductive effects, effects in sensitive groups such as pregnant women, children, etc. are specifically taken into account by the issuing agencies when setting numerical criteria values. This is done by (1) using data from human or animal studies during sensitive life stages, and (2) making appropriate dosimetric adjustments where necessary. In this assessment, we calculated HQs and HIs using the same criteria for all age groups, recognizing reproductive and developmental endpoints may not be meaningful for the oldest (60–99-year-old) group, but such effects in the younger groups are adequately captured due to conservatism built into the criteria for these effects.

We also assume no age correction is necessary for the calculation of cancer risks associated with benzene exposure. This is consistent with current practice in the

absence of mechanistic evidence that could affect metabolism of the toxic compound or innate sensitivity to exposure. Lifetime exposures were weighted equally over the life stages when exposure takes place for each (hypothetical) individual in the simulation as well as for periods when exposure does not occur.

Results

To identify the potential for adverse health effects, we focused principally on the highest estimated HQs and HIs, particularly at the current 500-ft COGCC Exception Zone Setback for well facilities relative to a building unit. Using the available estimates, we also show distributions of potential HQs and HIs across modeled individuals, placing the highest results into the context of exposures occurring during more typical conditions. We present these HQs, HIs, and lifetime cancer risks to 2,000 ft from the centre of a well pad, and they are incremental metrics, reflecting only the modeled VOCs emitted by the individual hypothetical sites. We do not discuss age stratifications here because age had relatively little impact on exposure distributions. (Exception: at the lower ends of the distributions, we saw 10–20% lower exposures to lower-PEN VOCs for older adults relative to other individuals. We believe this reflects a higher proportion of older adults, relative to other people, who spend substantially more time indoors where concentrations of lower-PEN VOCs are often less than half the outdoor concentrations.) Detailed, stratified results (including by age group for non-cancer effects) are available in Supplementary Sections H and I.

Incremental acute exposures

At 500 ft from each individual development pad, the highest estimated 1-hour exposures exceeded criteria values for four VOCs (benzene, 2- and 3-ethyltoluene, and toluene) at the selected receptors, which were locations more often downwind from the emissions (Table 2). Particularly: maximum acute HQs were > 10 at 500 ft for 2-ethyltoluene (during flowback at the GC sites) and benzene (during drilling and flowback at the NFR site), and also at 2,000 ft for benzene during flowback at NFR. Table 2 also identifies the critical-effect groups with maximum HIs > 1 (hematological, respiratory, and neurotoxicity) and > 10 (hematological) for one or more O&G activities. We provide in Supplementary Section H the HQs and HIs for individual chemicals and critical-effect groups associated with different pad sizes, at all modeled distances and sites. Generally, large pad sizes were associated with somewhat lower HQs and HIs (sometimes ≥ 2 fold) vs. small pads because the plume from a larger source is less concentrated than one from a smaller source (when emission mass is constant).

The HQ and HI ranges shown in Table 2 refer to the maximum values seen at the selected receptors at two distances (500 and 2,000 ft) from the pads. In Figure 5 we show the distributions of acute HQs for benzene during flowback at all modeled distances from individual 1-acre pads, comprising the collections of daily-maximum acute HQs from across the modeled year and set of individuals at the selected receptors. The figure illustrates the large variations (across the modeled individuals and time periods) in the maximum values per distance. At the 500-ft selected receptors, for example, maximum benzene HQs during flowback were factors of 1.6–2.7 higher than median HQs (this difference was a factor of 14–22 during O&G production; see Supplementary Section H). The boxes in the figure, indicating 25th-through-75th-percentile values, indicate a larger spread of acute benzene HQs during flowback at the NFR site (factor of 5.3 spread at the 500-ft receptor) vs. the GC sites (factors of 0.7–0.9 spread).

In Figure 5, the generally small differences in HQ distributions between the GC sites result from differences in meteorology (we used the same emissions data at both sites). The acute benzene HQs during flowback are much higher at the NFR site relative to the GC sites; while there are differences in meteorology between the sites, the higher HQs at the NFR site result primarily from higher emissions (see Figure A-1, Supplementary Section A). Figure 5 also illustrates the dependence of HQs on distance. As anticipated, HQs at distances < 500 ft (inside the Colorado setback requirement) were usually higher than those at 500 ft. At these closer locations, as shown in Supplementary Section H, HQs and HIs reached as high as 27, with maximum HQs > 1 for 4-ethyltoluene, n-decane, n-propylbenzene, and m + *p*-xylene, and maximum HIs > 1 for respiratory and sensory groups, during fracking or flowback at the GC sites (plus the VOCs and groups already mentioned as having values > 1 at 500 ft). Finally, Figure 5 illustrates how the distributions of acute benzene HQs during flowback vary between the three hypothetical sites: median HQs at 500 ft were similar for the two GC sites (within about 30% of each other), while at the NFR site they were approximately 5 times higher. Additionally, the pattern of decreasing HQs with increasing distance differs between sites, owing primarily to

Table 2. Overview of the largest acute non-cancer hazard quotients for the highest exposed hypothetical individuals at 500 and 2,000 feet from the well-pad centre.

			500 ft from well pad			2,000 ft from well pad		
Range of HQs or HIs	HQ or HI?	O&G activity	GC: ridge top (BarD)	GC: valley (Rifle)	NFR	GC: ridge top (BarD)	GC: valley (Rifle)	NFR
≥10	HQ	Drilling	none	none	benzene [1]	none	none	none
		Fracking	none	none	none	none	none	none
		Flowback	2-ET [1,3,5]	2-ET [1,3]	benzene [1,3,5]	none	none	benzene [3]
		Production	none	none	none	none	none	none
	HI	Drilling	none	none	hematological [1]	none	none	none
		Fracking	none	none	none	none	none	none
		Flowback	none	none	hematological [1,3]	none	none	hematological [3]
		Production	none	none	none	none	none	none
Between 1 and 10	HQ	Drilling	benzene [1,3,5] toluene [1,3,5]	benzene [1,3,5] toluene [1,3,5]	benzene [3,5] toluene [1,3,5]	benzene [1,3,5] toluene [1,3]	benzene [1,3,5]	benzene [1,3,5]
		Fracking	benzene [1,3,5]	benzene [1,3,5]	none	benzene [1,3,5]	benzene [1,3,5]	none
		Flowback	3-ET [1,3,5] benzene [1,3,5]	2-ET [5] 3-ET [1,3] benzene [1,3,5]	none	2-ET [1,3,5] benzene [1,3,5]	2-ET [1,3,5]	benzene [1,5]
		Production	benzene	benzene	benzene	none	none	none
	HI	Drilling	hematological [1,3] neurotoxicity [1,3]	hematological [1,3] neurotoxicity [1,3]	hematological [3] neurotoxicity [1,3]	hematological [1,3] neurotoxicity [1,3]	hematological [1,3]	hematological [1,3]
		Fracking	hematological [1,3] neurotoxicity [1,3] respiratory [1]	hematological [1,3] neurotoxicity [1,3]	none	hematological [1,3]	hematological [1,3]	none
		Flowback	hematological [1,3] neurotoxicity [1,3]	hematological [1,3] neurotoxicity [1,3]	neurotoxicity [1,3]	hematological [1,3] neurotoxicity [1,3]	none	hematological [1] neurotoxicity [3]
		Production	hematological	hematological	hematological	none	none	none

Notes: Not showing chemicals with hazard quotients less than 1 or critical-effect groups with hazard indices less than 1. Corresponds to ages 0–17 years (results for other age groups are nearly identical). Numbers in superscript indicate the size of development well pad (in acres) associated with that entry (well-pad sizes are not shown for production activities because they were all modeled as 1 acre).
HQ = hazard quotient; HI = hazard index; O&G = oil and gas; GC = Garfield County; NFR = Northern Front Range; ft = feet; ET = ethyltoluene.

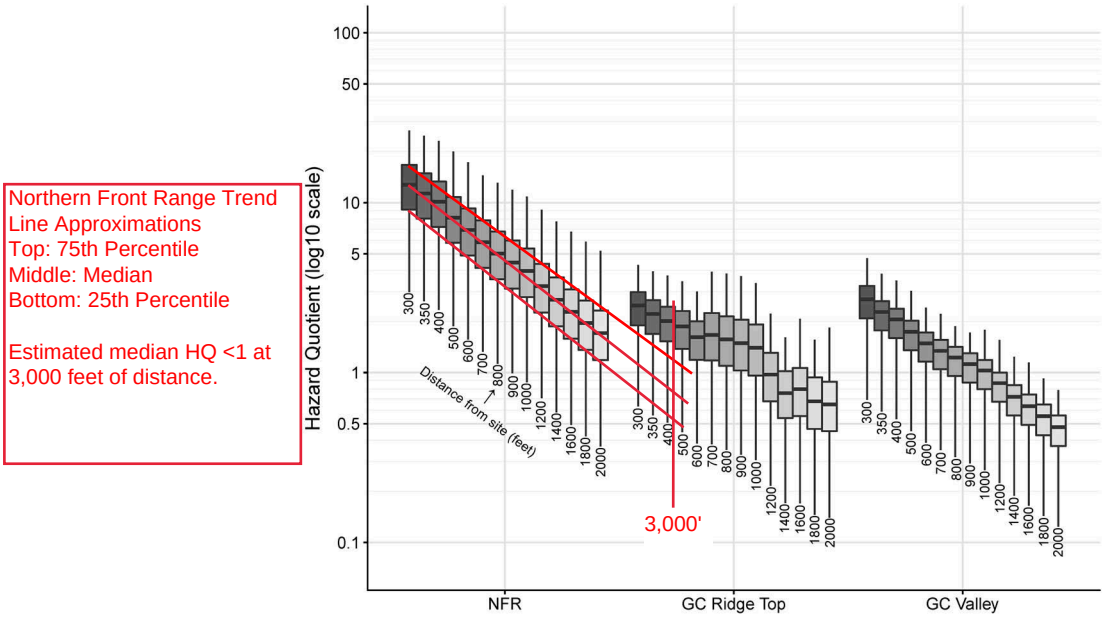

Figure 5. Distributions of daily-maximum acute non-cancer hazard quotients for benzene (across the hypothetical population) at distances from the centre of the 1-acre well pad during flowback activities. The bottom and top of the boxes are the 25th and 75th percentiles, respectively; the line inside the box represents the median; and the bottom and top whiskers are the minima and maxima. Notes: log10 = logarithm base 10; NFR = Northern Front Range; GC = Garfield County; GC Ridge Top refers to the BarD site; GC Valley refers to the Rifle site.

differences in meteorological conditions, with the GC ridge-top site showing the least (relative) decrease in acute HQ 500-to-2,000 ft.

VOC emissions, and thus the acute HQs, were generally much lower during O&G production vs. development. Benzene was the only chemical with a maximum acute HQ > 1 during production (2.9 and 1.6 at 150 and 500 ft, respectively, at the NFR site; corresponding HQs at the GC ridge-top site were 2.6 and 1.4, and 2.7 and 1.1 at the GC valley site). HQs were < 1 beyond 600 ft (183 m) from the pad at the GC sites and beyond about 1,200 ft (366 m) for NFR. Hematological toxicity (driven by benzene) was the only critical-effect group with HIs > 1 at any site and distance associated with production.

Incremental subchronic exposures

We did not calculate subchronic HQs or HIs for O&G activities lasting > 1 year; potential adverse effects from such long-term exposures are adequately captured by comparison to the generally more health-protective chronic criteria. For O&G development, estimated subchronic exposures to individual VOCs were below subchronic criteria at 500–2,000 ft from all modeling sites. For combined exposures at 500 ft, maximum HIs were > 1 (up to 2.2) for the hematological and neurotoxicity groups at the GC sites during fracking (all pad configurations at the ridge-top site; 1- and 3-acre pads at the valley site), and these HIs > 1 extended to 800 ft (244 m) from the pads and were higher at distances inside the Colorado setback requirement. This can be seen in Figure 6, where distributions of subchronic HIs are plotted for neurotoxicity at the selected receptors during fracking activities at a hypothetical 1-acre pad. The HIs composing the distributions are from across the modeled year (different periods of the year with durations corresponding to assumed activity durations) and the set of individuals. The span of subchronic neurotoxicity HIs during fracking was close to one order of magnitude at all sites and distances. M + *p*-xylene and n-nonane contributed the most to neurotoxicity effects, while m + *p*-xylene and benzene contributed the most to hematological effects, with m + *p*-xylene having an HQ near 1 at both GC sites for the 1-acre scenario. At locations < 500 ft from the pad, maximum HQs or HIs were > 1 for benzene, m + *p*-xylene, n-nonane, and the respiratory group (in addition to those already mentioned as being > 1 at 500 ft) during fracking and flowback activities individually and during all development activities in sequence (not shown), with maximum HQs near 2 and maximum HIs near 4.3 (we provide in Supplementary Section H the HQs and HIs for individual chemicals and critical-effect groups associated with different pad sizes, at all modeled distances and sites).

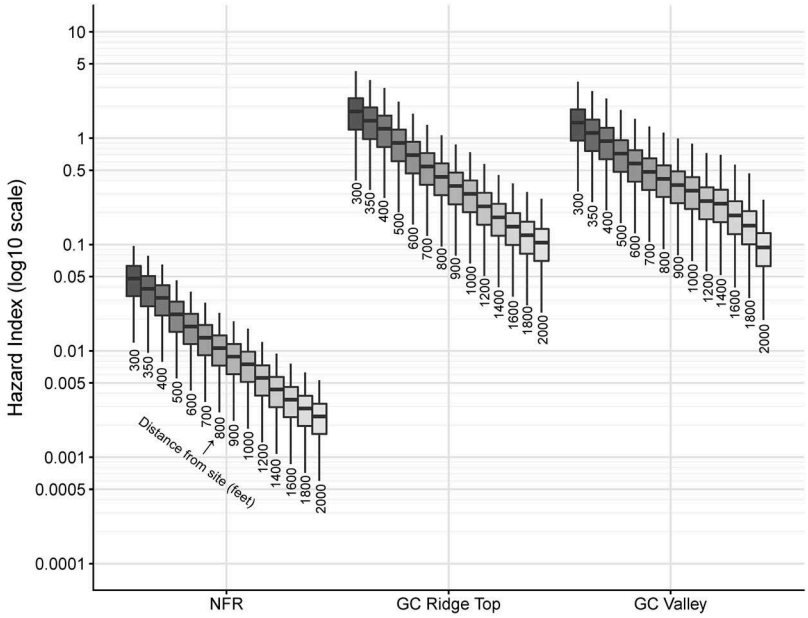

Figure 6. Distributions of subchronic non-cancer hazard indices for the neurotoxicity critical-effect group (across the hypothetical population) at distances from the centre of the 1-acre well pad during fracking activities. The bottom and top of the boxes are the 25th and 75th percentiles, respectively; the line inside the box represents the median; and the bottom and top whiskers are the minima and maxima. Notes: log10 = logarithm base 10; NFR = Northern Front Range; GC = Garfield County; GC Ridge Top refers to the BarD site; GC Valley refers to the Rifle site.

Incremental chronic exposures – non-cancer

We evaluated chronic non-cancer hazards for two sets of scenarios: those involving O&G production only (the modeled individual is not present for well development), and those involving development and production activities (the individual is present for all activities). During production, emissions are generally much lower than during the highest-emission development activities. Thus, notwithstanding the more demanding chronic health criteria, maximum chronic HQs and HIs were < 1 for production activities at 500 ft from each site, falling to < 0.1 at 2,000 ft. Only at the closest receptor (150 ft, much closer than setback requirements) were the chronic HQs > 1 (1.1–1.2) for benzene during production. At this distance during production, chronic HIs ranged 1.4–1.8 for hematological effects and 1.1–1.3 for neurotoxicity. We provide in Supplementary Section H the HQs and HIs for individual chemicals and critical-effect groups, at all distances.

Figure 7 illustrates the variability in chronic HIs for hematological effects during production at the selected receptors. The distributions are from across the modeled individuals, with modeled exposure durations defined as 1 year (assumed to reflect a 30-year average over the duration of production). The span of HIs was about a factor of 6–8 at all sites and distances. In contrast to the acute and subchronic results, generally the variability in chronic HI was < 15% between sites.

For the combined development-production scenario, long-term exposure varies with pad size; larger pads have longer development periods resulting in higher duration-weighted-average exposures. For 1-acre pads (a single well) and 3-acre pads (8 wells at NFR sites; 16 wells at GC sites), development is completed within weeks to months, so the resulting weighted-average chronic exposures were very similar to those for production alone and were below criteria in all cases.

For 5-acre pads (32 wells), at the GC sites the estimated development time exceeds 1 year, with flowback lasting over a year. During these development scenarios, all chronic HQs were < 1 at ≥ 500 ft, while maximum chronic HIs were > 1 at 500 ft for hematological and neurotoxicity effects (2.1 and 1.5, respectively, at the GC ridge-top site; 1.9 and 1.2 at the GC valley site). Benzene and n-nonane emissions from flowback contributed the bulk of the hematological and neurotoxicity HIs.

Chronic exposures – incremental lifetime cancer risks

We calculated 70-year incremental lifetime cancer risks associated with exposures to benzene for the 30–32-year combined development-production scenario, utilizing central-tendency and maximum chronic-exposure estimates. Risks were 8–14% higher at the 3-acre pads and 19–40%

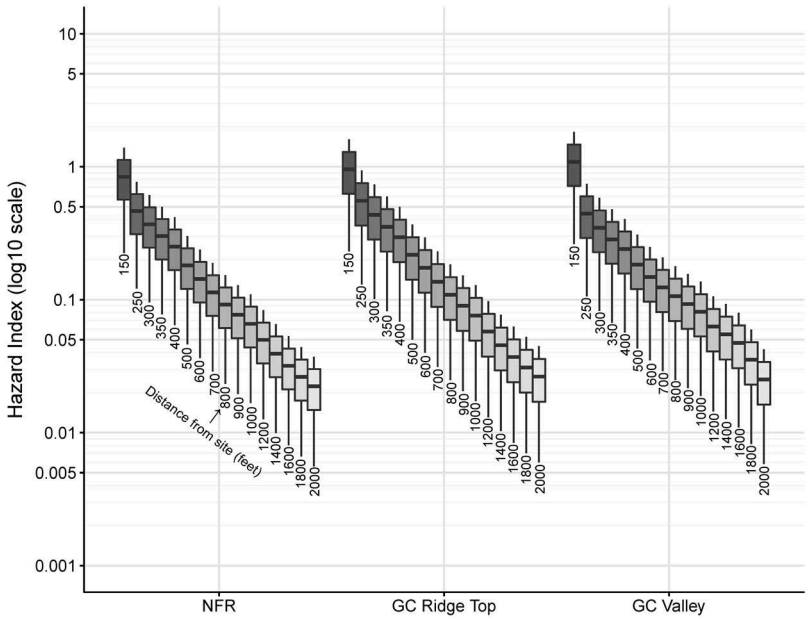

Figure 7. Distributions of chronic non-cancer hazard indices for the hematological critical-effect group (across the hypothetical population) at distances from the centre of the 1-acre well pad during production activities. The bottom and top of the boxes are the 25th and 75th percentiles, respectively; the line inside the box represents the median; and the bottom and top whiskers are the minima and maxima. Notes: log10 = logarithm base 10; NFR = Northern Front Range; GC = Garfield County; GC ridge top refers to the BarD site; GC Valley refers to the Rifle site.

higher at the 5-acre pads vs. the 1-acre pad, owing to longer durations of development at the larger sites. In areas < 500 ft from the well pad (inside the setback zone), maximum risks (maximum exposures with upper-bound IUR) reached 1.4×10^{-5} (for 1-acre sites) to 1.6×10^{-5} (for 5-acre sites), while central-tendency risks (average exposures with central-tendency IUR) were $5.2x10^{-6}$–$6.1x10^{-6}$.

All risk estimates fell to ≤ 8.2×10^{-6} at 500 ft, with central-tendency risks ≤ 3.1×10^{-6} and falling to ≤ 1.0×10^{-6} by 1,200 ft. All risks fell to ≤ 1.0×10^{-6} between 500 ft (average exposures using lower-bound IUR at 1- and 3-acre sites) and 2,000 ft (maximum estimates at all sites).

Figure 8 summarizes the cancer risks calculated at all distances from the GC ridge-top site, assuming a 1-acre pad and utilizing the three IURs (including the lower bound). For this scenario, estimated incremental lifetime cancer risks at 500 ft ranged from 1.1×10^{-6} (average exposure, lower-bound IUR) to 6.8×10^{-6} (maximum value). As shown in the full results presented in Supplementary Section I, maximum estimated lifetime cancer risks at 500 ft were 5.7×10^{-6} and 5.6×10^{-6} at the GC valley and NFR sites, respectively, decreasing with distance in a manner similar to that for the GC ridge-top site. Also, estimated cancer risks increased slightly with size of development pad, owing to longer durations of development activities.

Uncertainties and limitations

In this section, we summarize the major uncertainties and limitations of our assessment. See Supplementary Section F for additional analyses of the uncertainties and sensitivities of the assessment to various methodological choices and input parameters, and Supplementary Section G for a discussion of sensitivity analyses conducted on modeling inputs.

We estimate the emission rates, which directly and proportionally affect risk estimates, represented the highest uncertainty in the assessment, having perhaps ≥ 0.5 orders of magnitude of potential influence on the results. Emission measurements were at a limited number of sites, so we cannot be certain that they are representative of the full, real-world distribution of O&G emission and dispersion scenarios, particularly at the upper tail (as with any assessment, there is considerable uncertainty at the extreme tails of the data and outputs). O&G emissions can be highly variable with respect to configuration and operational practices, and the measurements reflected this high variability (as seen previously in Adgate, Goldstein, and McKenzie 2014; Allen 2016; Brantley, Thoma, and Eisele 2015; McMullin et al. 2018; Thompson et al. 2017). When we estimated 1-hour-avearge emission rates, there was uncertainty in assuming the means were similar to

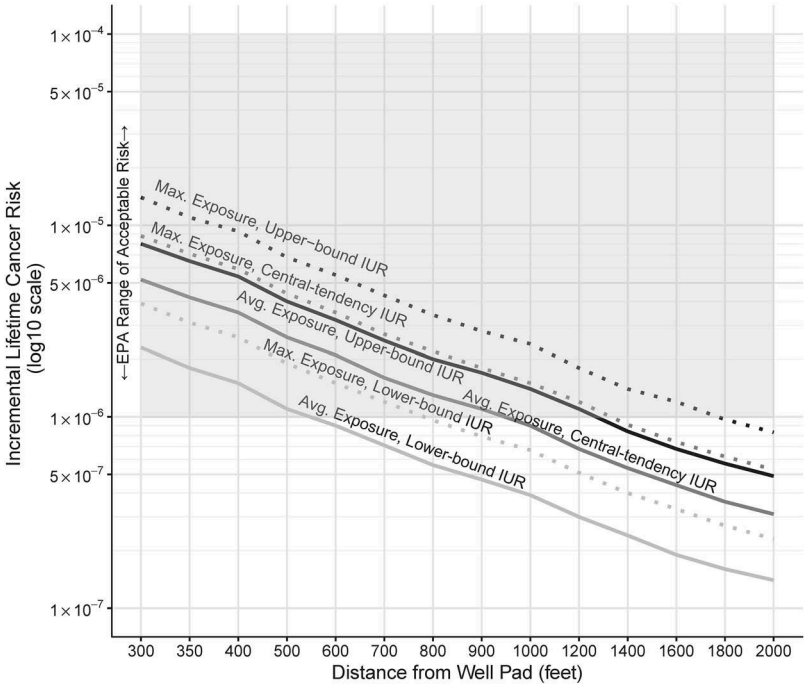

Figure 8. Incremental lifetime cancer risks from benzene exposure for average- and maximum-exposed hypothetical individuals at distances from the centre of the well pad during all activities in sequence at the Garfield County ridge-top site (1-acre development pad, 1-acre production pad). X-axis is not to scale. Grey box indicates the U.S. Environmental Protection Agency's range of acceptable cancer risk. Notes: Avg. = average; max. = maximum; IUR = inhalation unit risk.

those of the 3-minute measurements and fitting the values to a lognormal distribution.

The limited sampling and high variability in measured emissions necessitated use of stochastic methods to capture the resulting variabilities in exposure and generalize the results to different O&G-activity durations and geographic and meteorological settings. While these meteorology settings included several years of hourly meteorology in different locations, including wind speeds as low as 0.2 meters per second, we may not have captured all possible weather conditions (an estimated 2–3-fold uncertainty).

These uncertainties and limitations particularly affect the interpretation of "maximum" HQs and HIs. Maximum exposures, as defined in this assessment, occur only at the most-exposed locations during atypical times when simulations created a confluence of very conservative meteorological conditions, unusually high emissions, and personal activities leading to exposures far above average. Maximum exposures also assume individuals reside at the most-exposed locations. While these conditions are possible according to our assumptions and input data (and indeed they are the health-protective focus of our assessment), as outputs in the upper tails of our modeling results, they are not representative of "typical" exposures. Distributions of typical exposures will generally be shifted toward lower values, sometimes much lower, at other receptors. Additional analyses with site-specific monitoring and meteorological data would better characterize the relationship between the highest and typical exposures during well development and production (analyses such as McKenzie et al. 2012; Colborn et al. 2014 but including information on acute timescales and, in the case of Colborn et al. 2014, with measurements within a half-mile of the well-pad centre).

Previous studies and reviews suggested O&G emissions can contribute to exceedances of regulatory or guidance levels of health and ecological welfare on a local and regional scale (e.g., Shonkoff, Hays, and Finkel 2014; Thompson et al. 2017). While our study has the advantage of helping to understand the contribution of a single O&G facility toward an individual's exposure, multiple O&G facilities are increasingly intermingled with residential and recreational areas. The large numbers of chemical exposures experienced by any individual, across short and especially long (chronic) time scales, and their variable and sometimes compounding effects on human health, are complex and uncertain.

Another limitation of our analysis is that we used a limited number of generic well-pad configurations to represent several variations in possible release conditions, but risk estimates (particularly those close to the

well pad) can be sensitive to the exact locations and specifications of the emission sources (e.g., we estimated a < 3-fold potential risk-assessment uncertainty related to the AERMOD dispersion modeling, including source characterization). We did not utilize decline curves to account for variations in emissions during O&G production (as they are uncertain and dependent on the site and operator), nor did we utilize algorithms for downwash due to any obstructions that might be present (e.g., sound walls at development sites). Additional monitoring campaigns and modeling efforts near a variety of well-pad configurations and structures would provide important additional data on potential health risks.

Considering these limitations, the exposure concentrations we generated, while representative of higher-end values that would be seen at the modeling sites as-configured, do not constitute real-time measurements. We believe the exposure distributions are realistic, providing reliable summary statistics for the time frames examined, but new studies collecting additional exposure data would add to the body of knowledge. There is also some degree of uncertainty (probably < 2 fold) associated with applying APEX to estimate personal exposures, but on aggregate, these APEX-related uncertainties are small compared to those associated with emission estimation, air modeling, and health-criteria values.

There is an unavoidable degree of uncertainty associated with the values of health criteria and cancer slope factors used to estimate HQs, HIs, and lifetime cancer risks. The level of uncertainty associated with such values is generally estimated to be about one order of magnitude, and the toxic effects of some chemicals are currently less well understood than others like benzene. The HI estimates did not include examination of synergistic effects.

A final limitation of this study is it does not include all airborne chemicals previously detected near O&G sites. The canister sampling methodology used to characterize emissions measured only hydrocarbons; levels of polar oxygen-, sulfur-, and nitrogen-containing compounds were not quantified, though some (formaldehyde and acetaldehyde) have been frequently observed near O&G sites, and they are known or suspected human carcinogens (McMullin et al. 2018). We also did not calculate cancer risks for several chemicals in our assessment (styrene, isoprene, and ethylbenzene) classified by IARC or EPA as "possible" or "probable" human carcinogens, but for which human exposure-response models were not available. Exclusion of chemicals from our analysis results in lower estimates of HIs and total cancer risks than if we had included them.

Conclusions

Our study coupled stochastic dispersion modeling of emission rates with probabilistic risk-assessment methods to illustrate the potential non-cancer hazards and cancer risks associated with air emissions of certain VOCs from individual sites of O&G development and production in Colorado under plausible highest-exposure scenarios. The results will help in evaluating the efficacy of setback distances in protecting public health from such emissions. The emission studies (CSU 2016a, 2016b; Hecobian et al. 2019) utilized here were among the first of their kind in the US to use the TRM near individual facilities to characterize per-facility emission rates from individual phases of O&G development and production. Their measurements are likely comparable to similar sites elsewhere. The measurements were source-attributable because the facility's emission plume was identified with a mobile tracker, and other nearby chemical signals were removed via an upwind background monitor. This is in contrast to typical monitoring data (e.g., those used by Colborn et al. 2014; Gilman et al. 2013; Halliday et al. 2016; Long, Briggs, and Bamgbose 2019; McKenzie et al. 2018, 2012; McMullin et al. 2018; Swarthout et al. 2013; Thompson, Hueber, and Helmig 2014) which measure the ambient air both within and outside the plume (depending on conditions) and cannot necessarily differentiate a target source of emissions from other nearby emissions. Our stochastic approach to dispersion modeling, whereby we combined the on-site-measured emissions data with multiple datasets of variable meteorology, has the advantage of generating thousands of credible and representative short- and long-term VOC air-concentration scenarios at hundreds of possible exposure locations – many more than can be reasonably observed with monitoring. These include myriad acute (1-hour) scenarios that have been understudied to-date in O&G risk assessments. Further, rather than assuming constant exposure to outdoor air (as was done, for example, by McKenzie et al. 2012; McMullin et al. 2018), we estimated individual exposures across MEs using the state-of-the-science APEX model with time-activity-pattern data (including surveys from Coloradans) and distributions of ME PENs based on chemical volatility. From these data, we derived detailed distributions of acute, subchronic, and chronic exposures for each modeled site, pad size, and exposure

distance. We compared these exposures to toxicity criteria issued by federal and state agencies, chosen so as to generally prefer federal criteria based on the most current and complete data available and state-of-the-science methods.

Acute exposures were of greatest concern, primarily during O&G development and for a limited set of VOCs and critical-effect groups, sometimes at distances out to 2,000 ft from the well pad. While most acute HQs and HIs were < 1 for most VOCs and critical-effect groups, our results suggest the potential for HQs and HIs > 1, sometimes > 10, for several VOCs (particularly benzene and 2-ethyltoluene) and critical-effect groups (particularly neurological and hematological effects), during O&G development (particularly drilling and flowback). Benzene HQs, and hematological HIs driven by benzene emissions, were slightly > 1 during O&G production. These findings support increased concern for adverse effects in the exposed individuals, although the exact probability or severity of adverse effects cannot be estimated. Our results contrast somewhat with those of McMullin et al. (2018), who utilized ambient monitoring data and found all acute exposures to outdoor air were below criteria, except for the conservative "all-VOC" HI estimate (which we did not calculate) which was 1.2. However, nearly all monitoring data utilized by McMullin et al. (2018) were > 500 ft from the closest wells, and observations ≤ 500 ft were limited to regions of O&G activity rather than site-specific studies and were targeting either the lower-emitting production activities or were 24-hour integrated measurements rather than 1-hour averages. However, as in our study, McMullin et al. (2018) found benzene to be among the chemicals of highest relative concern and most VOCs corresponded to acute exposures far below criteria levels.

Nearly all HQs and HIs for subchronic effects were < 1 at ≥ 500 ft from the well pads. During fracking, subchronic HIs for hematological and neurotoxicity effects slightly exceeded 1 at 800 ft from the two GC locations. These findings were generally similar to those of McKenzie et al. (2012), who utilized ambient monitoring data close to well sources and found higher-end subchronic exposures to outdoor air (for people living within 0.5 miles of wells) that slightly exceeded criteria values for 1,3,5-trimethylbenzene (which had among the highest subchronic HQs in our study as well, though below criteria) and that lead to HIs ≤ 4 for several critical effects (particularly neurotoxicity and hematological).

Emissions during well production did not lead to chronic exposures above criteria levels at ≥ 250 ft from well pads. Chronic exposures due to well development lasting > 1 year resulted in chronic HIs for hematological and neurological effects that slightly exceeded 1 at 500 ft from 5-acre pads. These findings generally match those of McMullin et al. (2018) and McKenzie et al. (2012), who found for constant exposure to outdoor air that all chronic HQs, and all HIs for individual critical-effect groups, were below criteria levels.

Our largest estimated incremental cancer risks associated with benzene exposure were < 2.0×10^{-5} at all distances. We estimated central-tendency risks (average exposure, central-tendency IUR) to be $2.1\text{x}10^{-6}$–$3.1\text{x}10^{-6}$ (depending on pad size) at the 500-ft location most often downwind from the pad, decreasing to < 1.0×10^{-6} by 1,000–1,200 ft. The largest risk estimates fell below 1.0×10^{-6} by 2,000 ft. McKenzie et al. (2012) estimated similar benzene cancer risks ($3.3\text{x}10^{-6}$–$8.7\text{x}10^{-6}$, depending on the concentration used for constant exposure to outdoor air); risk estimates due to other chemicals were smaller than for benzene. McMullin et al. (2018) estimated benzene cancer risks in a higher range ($1.0\text{x}10^{-5}$–$3.6\text{x}10^{-5}$) due to constant exposure to outdoor air, which are similar to levels we estimated inside the 500-ft setback (up to 1.6×10^{-5}); here, too, risk estimates were highest for benzene.

These findings provide important information related to potential health hazards associated with O&G development and production activities in Colorado, and they shed light on the specific activities and chemicals of most concern for further analyses of such risks. These include, in particular, benzene and 2-ethyltoluene emissions during drilling and flowback, and hematological effects during most development phases. To a lesser degree, these also include 3-ethyltoluene and toluene emissions and neurotoxicity and respiratory effects during drilling and flowback; hematological and neurotoxicity effects during fracking (driven primarily by benzene, m + *p*-xylene, and n-nonane emissions); and hematological and neurotoxicity effects during extended development phases at large multi-well sites (driven primarily by benzene and n-nonane emissions). Acute exposures were of greatest concern: acute HQs and HIs were generally much higher than subchronic and chronic HQs and HIs, with acute values > 1 in some cases as far out as 2,000 ft from the well pad (our maximum modeled distance).

Relative to monitoring studies, we have high confidence that these chemical signals are attributed directly to O&G activities on the target well pad, due to the TRM used to derive on-site O&G emissions during specific O&G activities. We also have high confidence that the estimated exposures reasonably represent some real-life exposures that could be experienced by people living near O&G

facilities, due to the stochastic approaches to dispersion and ME assessment allowing the generation of thousands of acute-to-chronic exposure scenarios for individuals across the 2,000-ft radius. These approaches and findings can be used to further evaluate data needs and to support refinement of setback distances.

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About the authors

Chris Holder is an exposure scientist at ICF in Durham, NC, USA.

John Hader was an exposure scientist at ICF in Durham, NC, USA, and is now a Ph.D. candidate at the Stockholm University in Stockholm, Sweden.

Raga Avanasi was an exposure scientist at ICF in Durham, NC, USA.

Tao Hong was a programmer at ICF in San Francisco, CA, USA, and he is now an independent researcher in Belmont, CA, USA.

Ed Carr is an air quality scientist at ICF in San Francisco, CA, USA.

Bill Mendez is a toxicologist at ICF in Fairfax, VA, USA.

Jessica Wignall is a toxicologist at ICF in Burlington, VT, USA.

Graham Glen is an exposure scientist at ICF in Durham, NC, USA.

Belle Guelden is an air quality scientist at ICF in Tiburon, CA, USA.

Yihua Wei is an air quality scientist at ICF in San Francisco, CA, USA.

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David Shabazian, Director
Uduak-Joe Ntuk, California State Oil and Gas Supervisor
California Department of Conservation
801 K Street, MS 24-01
Sacramento, CA 95814

October 1, 2021

RE: Response to CalGEM Questions for the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel

Director Shabazian and Supervisor Ntuk,

Please find attached the responses from the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel to the written questions sent by the California Geologic Energy Management Division (CalGEM) on August 31, 2021.

We would be glad to answer any further questions that may arise.

Best Regards,

Seth B.C. Shonkoff, PhD, MPH
Co-Chair, California Oil and Gas Public Health Rulemaking Scientific Advisory Panel
Executive Director, PSE Healthy Energy
Visiting Scholar, Department of Environmental Science, Policy, and Management, University of California, Berkeley
Affiliate, Energy Technologies Area, Lawrence Berkeley National Lab

Rachel Morello-Frosch, PhD, MPH
Co-Chair, California Oil and Gas Public Health Rulemaking Scientific Advisory Panel
Professor, Department of Environmental Science, Policy and Management & School of Public Health, University of California, Berkeley, Berkeley CA

Joan A. Casey, PhD, MA
Assistant Professor, Department of Environmental Health Sciences, Columbia University Mailman School of Public Health, New York, New York

Nicole Deziel, PhD, MHS
Associate Professor, Department of Environmental Health Sciences, Yale School of Public Health, Yale University, New Haven, Connecticut

Dominic C. DiGiulio, PhD, MS
Senior Research Scientist, PSE Healthy Energy
Affiliate, Department of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder

Stephen Foster, PhD
Senior Principal, Geosyntec Consultants

Robert Harrison, MD and MPH
Clinical Professor of Medicine, Division of Occupational and Environmental Medicine, University of California San Francisco

Jill Johnston, PhD, MS
Assistant Professor of Environmental Health, Department of Population and Public Health Sciences, Keck School of Medicine, University of Southern California

Kenneth Kloc, PhD and MPH
Staff Toxicologist, Office of Environmental Health Hazard Assessment, California EPA

Lisa McKenzie, PhD and MPH
Clinical Assistant Professor, Department of Environmental and Occupational Health, Colorado School of Public Health, University of Colorado Denver Anschutz Medical Campus

Thomas McKone, PhD
Professor Emeritus, School of Public Health, University of California, Berkeley
Affiliate, Energy Technologies Area, Lawrence Berkeley National Laboratory

Mark Miller, MD, MPH
Director, Children's Environmental Health Center, Office of Environmental Health Hazard Assessment, California EPA
Associate Clinical Professor, Division of Occupational and Environmental Medicine, University of California, San Francisco

Andrea Polidori, PhD
Advanced Monitoring Technologies Manager, South Coast Air Quality Management District

CalGEM Questions for the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel

CalGEM requests the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel assistance with the following questions:

1. ***How would the panel characterize the level of certainty that proximity to oil and gas extraction wells and associated facilities in California causes negative health outcomes? Is there a demonstrated causal link between living near oil and gas wells and associated facilities and health outcomes?***

We have focused our review on epidemiological studies carried out in multiple oil and gas regions, including Colorado, which has a similar regulatory context as California. Given that similar environmental health hazards and risks are intrinsic to both conventional and unconventional oil and gas development (OGD), including exposure pathways, chemicals associated with hydrocarbon reservoirs, use of ancillary equipment, and non-chemical stressors (See section on "Similarities and Differences Between Unconventional and Conventional OGD"), the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel (Panel) concludes that the full body of epidemiologic literature is relevant to assess the human health hazards, risks and impacts of upstream OGD in California.

Our Panel concludes with a high level of certainty[1] that the epidemiologic evidence indicates that close residential proximity to OGD is associated with adverse perinatal and respiratory outcomes, for which the body of human health studies is most extensive in California and other locations.

Studies on Oil and Gas Development and Perinatal Outcomes

Perinatal outcome studies provide the largest [19 studies][2] and strongest body of evidence linking OGD exposure during the sensitive prenatal period with adverse health effects. The majority of studies that examine perinatal effects found increased risk of adverse birth outcomes in those most exposed to OGD (measured using metrics including, but not limited to proximity, well density, and production volume). It should also be noted that adverse perinatal outcomes, including preterm births, low birth weight, and small-for-gestational age births

[1] In this document, the statement, "a high-level of certainty" is based on the professional judgement of all California Oil and Gas Public Health Rulemaking Scientific Advisory Panel (Panel) members in their assessment of the scientific evidence. In terms of panel process, all Panel members agree with the responses to the questions in this document. Any Panel member could have written a dissenting opinion, but no one requested to do so. This document reflects the perspective of the Panel members and not necessarily the opinions of their employers or institutions.

[2] Apergis et al., 2019; Busby & Mangano, 2017; Caron-Beaudoin et al., 2020; Casey et al., 2016; Currie et al., 2017; Cushing et al., 2020; Gonzalez et al., 2020; Hill, 2018; Janitz et al., 2019; Ma, 2016; McKenzie et al., 2014, 2019; Stacy et al., 2015; Tang et al., 2021; Tran et al., 2020, *Forthcoming*; Walker Whitworth et al., 2018; Whitworth et al., 2017; Willis et al., 2021.

increase the risk of mortality and long-term developmental problems in newborns (Liu et al., 2012; Vogel et al., 2018) as well as longer term morbidity through adulthood (Baer et al., 2016; Barker, 1995; Carmody & Charlton, 2013; Frey & Klebanoff, 2016)**.**

Perinatal Outcomes Associated with Conventional and Unconventional Oil and Gas Development

While many perinatal outcome studies outside of California focus on unconventional OGD (e.g., high-volume hydraulic fracturing), a recent review of the literature (Deziel et al., 2020), highlighted the need for an updated assessment of the health effects associated with OGD more generally, as both conventional and unconventional OGD operations present health risks, especially to those living in close proximity. This bolsters conclusions reached by the authors of the 2015 independent scientific study of hydraulic fracturing and well stimulation in California led by the California Council on Science and Technology (CCST) (Long et al., 2015) pursuant to Senate Bill 4 (2013, Pavley). Recent studies in California have reported associations between exposure to OGD and adverse birth outcomes, considering wells under production using enhanced oil recovery including cyclic steam injection, steam flooding and water flooding -- methods that do not meet the definition of unconventional development (Gonzalez et al., 2020; Tran et al., 2020, *Forthcoming*). Similar findings regarding adverse birth outcomes have been reported while examining unconventional OGD in Colorado, Oklahoma, Pennsylvania and Texas (Apergis et al., 2019; Casey et al., 2016; Cushing et al., 2020; Gonzalez et al., 2020; Hill, 2018; McKenzie et al., 2019; Stacy et al., 2015; Walker Whitworth et al., 2018; Whitworth et al., 2017). In the California independent scientific study on well stimulation pursuant to Senate Bill 4 (2013, Pavley), the authors concluded that while hydraulic fracturing introduces some specific human health risks, the majority of environmental risks and stressors are similar across conventional and unconventional oil and gas operations (Long et al., 2015; Shonkoff et al., 2015). Further, a handful of epidemiological studies explicitly examine potential differences in associations between conventional or unconventional oil or natural gas development and adverse outcomes. For example, Apergis et al. (2019) reported statistically significant reductions in infant health index within 1 km of both conventional and unconventional drilling sites in Oklahoma. In summary, the Panel concludes with a high level of certainty that human health studies focused on unconventional and conventional OGD are relevant to consider in the California context where conventional development is most prevalent.

Consistency Across Perinatal Epidemiology Studies

We have a high level of certainty in the findings in the body of epidemiological studies for perinatal health outcomes because of the consistency of results across multiple studies that were conducted using different methodologies, in different locations, with diverse populations, and during different time periods (see **Table 1** below). Most of these studies entail rigorous, high quality analyses (i.e., study designs that establish temporality based on large sample sizes, control for potential individual and area-level confounders, apply rigorous statistical

modelling techniques, and conduct sensitivity analyses to assess the robustness of effects). A variety of pollutants (e.g., $PM_{2.5}$ and air toxics) and other OGD stressors are associated with these same adverse birth outcomes (Dzhambov & Lercher, 2019; Nieuwenhuijsen et al., 2017; Shapiro et al., 2013), which further strengthens the evidence of the link between OGD and adverse perinatal outcomes. Therefore, the totality of the epidemiological evidence provides a high level of certainty that exposure to OGD (and associated exposures) cause a significant increased risk of poor birth outcomes.

Further, imprecision in exposure assessment or non-differential exposure misclassification in some of the epidemiological studies is more likely to attenuate observed relationships, thus leading to an underestimate of the true adverse impacts of OGD on birth outcomes (**Figure 1**). In environmental epidemiologic studies, researchers often use surrogates to estimate exposures or assign individuals to exposure categories; these surrogates have some measurement error associated with them. When these errors in assigning or classifying participant exposures are similar between exposed and unexposed or those with or without the health outcome, this is referred to as non-differential exposure misclassification. This type of "noise" in the data tends to dilute or attenuate the true exposure-response relationship, as illustrated by the hypothetical dashed line in **Figure 1**, which has a shallower slope compared to the hypothetical "true" solid line.

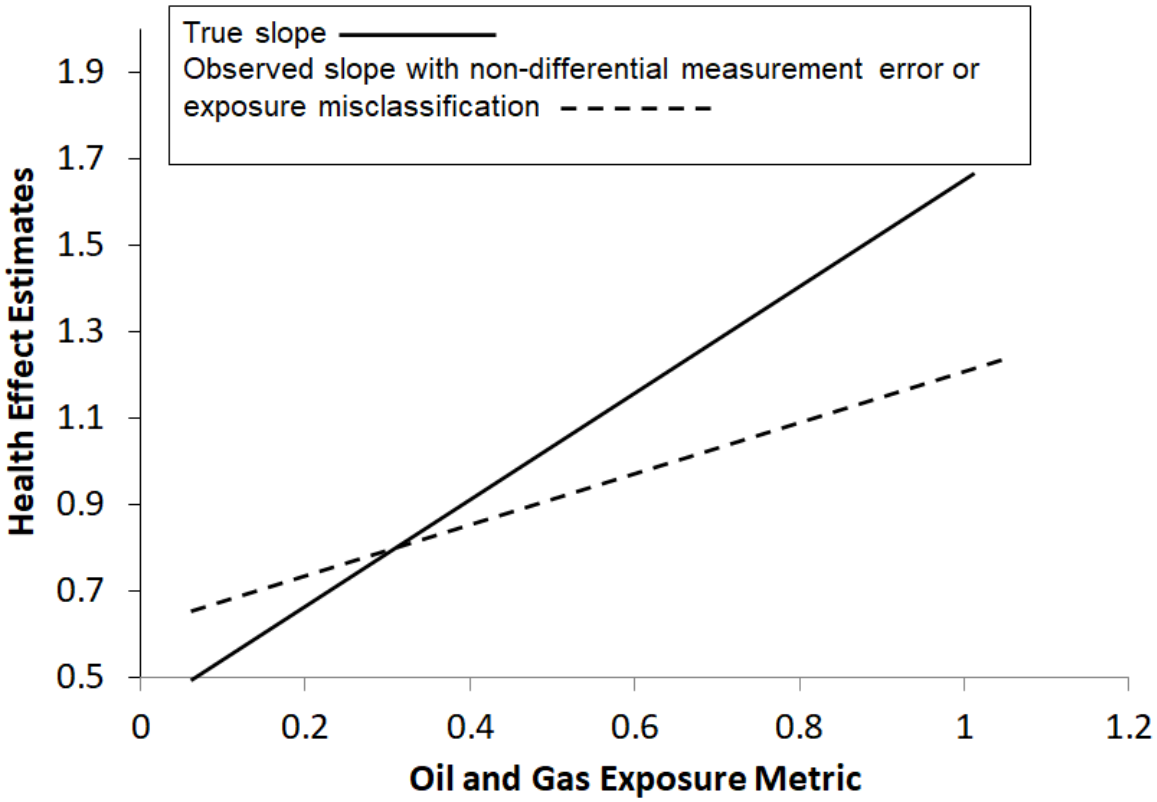

Figure 1. Effect of imprecise exposure estimates on a hypothetical exposure-response relationship (Source: Adapted from Seixas & Checkoway, 1995).

Respiratory Risks and Impacts from Oil and Gas Development

Respiratory health outcomes are the second most studied health outcomes in the epidemiological literature examining OGD, with eight peer-reviewed studies published to date. Two peer-reviewed studies in California found an association between OGD and self-reported and physician-diagnosed asthma, reduced lung function, and self-reported acute respiratory symptoms (e.g., recent wheeze) (Johnston et al., 2021; Shamasunder et al., 2018). Six studies in other oil and gas regions (Pennsylvania and Texas) reported an association between OGD and asthma exacerbations, asthma hospitalizations, and respiratory symptoms (Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2018, 2020).

Epidemiological studies, by design, often use aggregate measures of exposure to account for multiple potential stressors and pathways associated with OGD (e.g., air pollution, noise pollution, groundwater and/or drinking water contamination). Many criteria air pollutants (e.g., particulate matter, ozone, nitrogen oxides) and hazardous air pollutants emitted from OGD have a well-established body of scientific literature indicating that exposure to these pollutants causes an increased risk of development and exacerbation of respiratory disease (Bolden et al., 2015; Ferrero et al., 2014). We reiterate the relevance of studies on both conventional and unconventional OGD for respiratory health outcomes. For example, (Willis et al., 2020) found that both conventional and unconventional natural gas development at the ZIP code level was associated with pediatric asthma hospitalizations in Texas.

Comparing The Body of Perinatal and Respiratory Outcome Studies Against The Bradford Hill Criteria for Causation

Below, we demonstrate how the body of epidemiological studies on the relationship between OGD and perinatal and respiratory outcomes meets the nine Bradford Hill Criteria for Causation (Hill, 1965; Lucas & McMichael, 2005). The Bradford Hill Criteria are used to evaluate the strength of epidemiological evidence for determining a causal relationship between an exposure and observed effect. These criteria are widely used in the field of epidemiology and public health practice to guide decision-making. After considering these criteria, the Panel concludes with a high level of certainty that there is a causal relationship between close geographic proximity to OGD and adverse perinatal and respiratory outcomes (**Table 1**).

Table 1. Application of the Bradford Hill Criteria for Causation to the peer-reviewed epidemiological literature on oil and gas development and perinatal and respiratory health outcomes.

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
Strength of Association	Environmental studies commonly report modest effects sizes (i.e., relative to active tobacco smoking or alcohol consumption). A small magnitude of association can support a causal relationship, a larger association may be more convincing.	Reported effect sizes are in ranges similar to other well-established environmental reproductive and developmental hazards, such as $PM_{2.5}$ (Dadvand et al., 2013; C. Li et al., 2020). Some studies, particularly those in California, have found stronger effect estimates for OGD exposures among socially marginalized groups (Cushing et al., 2020; Gonzalez et al., 2020; Tran et al., 2020, *Forthcoming*).	Reported effect sizes are in ranges similar to other well-established environmental respiratory hazards. For example, effect sizes in reductions in lung function by Johnston et al. (2021) are similar in magnitude to reductions in lung function associated with secondhand smoke exposure among women (Eisner, 2002) and reductions in lung function among adults living near busy roadways (e.g., (Kan et al., 2007).
Consistency	Consistent findings observed by different persons in different places with different samples strengthens the likelihood of an effect.	Adverse birth outcomes have been observed in multiple studies using multiple methods in different populations at different times and locations (e.g., California, Pennsylvania, Colorado, Texas). While there is some variation in findings by specific perinatal outcomes, the overall body of evidence is highly consistent in supporting the association between OGD and adverse perinatal outcomes.	Various respiratory health outcomes are evaluated in the literature. For asthma -- the most commonly studied respiratory health outcome -- studies across California, Pennsylvania and Texas consistently show an association between OGD and asthma-related metrics (asthma prevalence, exacerbations, pediatric hospitalizations) (Koehler et al., 2018; Rasmussen et al., 2016; Shamasunder et al., 2018; Willis et al., 2018, 2020) .

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
Specificity	Causation is likely if there is no other likely explanation.	All peer-reviewed birth outcome studies included in our review controlled for other potential confounders by (i) accounting or adjusting for other individual-level or area-level factors (e.g., other air pollution sources, neighborhood socioeconomic status) in the analysis (Casey et al., 2016; McKenzie et al., 2014; Tran et al., 2020, *Forthcoming*). Other studies applied statistical modeling approaches such as difference-in-difference that accounts for temporal and spatial trends that may confound observed effects (Willis et al., 2021).	Most respiratory health studies have controlled for other potential explanatory or confounding factors by (i) accounting or adjusting for other individual-level (e.g., smoking status) or area-level factors (e.g., other air pollution sources) in the analysis (Johnston et al., 2021; Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2018, 2020), or in the study design, such as utilizing a difference-in-difference methodology (Peng et al., 2018; Willis et al., 2018).
Temporality	Exposure precedes the disease.	Most birth outcomes studies have proper temporal alignment between exposure and outcome and use a retrospective cohort, case control or other study design that allows retroactive assessment of exposures to OGD occurring before the onset of disease. They do not consider exposure that occurred at the time of disease or oil and gas wells drilled after the disease.	Some respiratory health studies do not allow for assessments of exposure that predate disease. However, of the studies with the proper temporal alignment (Johnston et al., 2021; Koehler et al., 2018; Peng et al., 2018; Rasmussen et al., 2016; Willis et al., 2018), authors report statistically significant associations between OGD and oral corticosteroid medication orders, asthma hospitalizations and asthma-related emergency department visits.

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
Biological Gradient (Dose-Response)	Greater exposure leads to a greater likelihood of the outcome.	Some studies have found dose-response relationships based on oil and gas production volume categories or metrics of inverse distance weighting and/or oil and gas well density in California and elsewhere (Casey et al., 2016; McKenzie et al., 2014, 2019; Tang et al., 2021; Tran et al., 2020).	Larger reductions in lung function observed with decreased distance from active oil development sites (Johnston et al., 2021).
Plausibility	The exposure pathway and biological mechanism is plausible based on other knowledge.	Individual health-damaging chemical pollutants are well-understood to be emitted from OGD (e.g., $PM_{2.5}$, benzene) and established as contributing to increased risk for the same adverse perinatal outcomes observed in the epidemiology studies. Stressors associated with OGD (e.g., psychosocial stress; (Casey et al., 2019) can also contribute to increased adverse perinatal outcomes.	Many air pollutants associated with OGD are well-known to contribute to respiratory morbidity and mortality, including exacerbations of existing respiratory conditions (Guarnieri & Balmes, 2014).
Coherence	Causal inference is possible only if the literature or substantive knowledge supports this conclusion.	In particular, the body of peer-reviewed literature is converging towards singular directions for adverse perinatal outcomes.	The body of peer-reviewed literature points in a singular direction for adverse respiratory health outcomes.

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
Experiment	Causation is a valid conclusion if researchers have seen observed associations in prior experimental studies.	N/A- Human population-based experimental studies are not available due to ethical issues.	N/A- Human population-based experimental studies are not available due to ethical issues.
Analogy	For similar programs operating, similar results can be expected to bolster the causal inference concluded.	Pollutants well known to be emitted during OGD including benzene, toluene and 1,3 butadiene are listed as reproductive or developmental toxicants under Prop 65 and thus are recognized as such by the State of California (CalEPA OEHHA, 2021). EPA's current Integrated Science Assessments of particulate matter and tropospheric ozone conclude that the evidence is suggestive of, but is not sufficient to infer, a causative relationship between birth outcomes, including preterm birth and low birth weight, and $PM_{2.5}$ and long term ozone exposures (US EPA, 2019, 2020). Additionally, increased stress during pregnancy can alter fetal growth and length of gestation (Fink et al., 2012).	EPA's current Integrated Science Assessments of particulate matter and tropospheric ozone conclude that there is: a casual relationship between respiratory outcomes, including asthma and short term ozone exposure; and likely a causal relationship between respiratory outcomes, including asthma and: short and long term $PM_{2.5}$ exposure; and long term ozone exposure (US EPA, 2019, 2020).

Similarities and Differences Between Unconventional and Conventional Oil and Gas Development

Though definitions of conventional and unconventional OGD may differ across different regulatory and policy landscapes, the majority of OGD in California is often considered conventional, involving vertical drilling at shallower depths into target geologies that hold migrated hydrocarbons. These attributes of development are often considered in contrast to unconventional OGD, which can involve horizontal directional drilling in deeper wells to access source rock formations by increasing the permeability of these tight formations using mostly hydraulic fracturing. In addition, these unconventional operations are often accompanied with greater masses of material inputs (e.g., water, chemical additives, proppants) and a greater magnitude of liquid and solid waste outputs (e.g., flowback fluids and produced water). It should be noted, however, that hydraulic fracturing that takes place in California often uses fluids (gels) with higher concentrations of well stimulation chemicals than those fluids used in high-volume slick water hydraulic fracturing of source rock in other parts of the United States (Long et al., 2015).

However, many environmental and health hazards and risks are intrinsic to both conventional and unconventional OGD (Hill et al., 2019; Jackson et al., 2014; Lauer et al., 2018; Stringfellow et al., 2017; Zammerilli et al., 2014). $PM_{2.5}$ and nitrogen oxides emissions result from the use of diesel-powered equipment and trucks and hazardous air pollutants such as benzene, toluene, ethylbenzene and xylene (BTEX) occur naturally in oil and gas formations, regardless of the type of extraction method employed. Noise pollution, odors, and landscape disruption are inherent to OGD. Investigations in other oil and gas states have noted radioactivity on particles downwind from unconventional oil and gas wells (Li et al., 2020b) and in sediment downstream of water treatment plants that treat waste from conventional as well as unconventional oil and gas operations (Burgos et al., 2017; Lauer et al., 2018).

In California, policy, regulatory and scientific emphasis has been placed on well stimulation activities, including hydraulic fracturing, matrix acidizing and acid fracturing. The 2015 Independent Scientific Assessment on Well Stimulation in California, which focused primarily on well stimulation activities pursuant to Senate Bill 4 (2013, Pavley), reported the following key conclusion: *"The majority of impacts associated with hydraulic fracturing are caused by the indirect impacts of oil and gas production enabled by the hydraulic fracturing"* (Long et al., 2015). Indirect impacts relevant to human health for the purposes of the study included: "proximity to any oil production, including stimulation- enabled production, could result in hazardous emissions to air and water, and noise and light pollution that could affect public health" (Long et al., 2015). Additionally, a recent evaluation of chemical usage during OGD in California found significant overlap in chemical additives used for well stimulation (including hydraulic fracturing) and those used in routine activities, such as well maintenance (Stringfellow et al., 2017).

2. ***What are the air pollutants released from these activities that cause negative health outcomes? How do we know exposure to these is likely from oil and gas extraction wells and associated facilities, as opposed to other sources?***

The wells, valves, tanks and other equipment used to produce, store, process and transport petroleum products at both unconventional and conventional OGD sites are associated with emissions of toxic air contaminants, hazardous air pollutants and other health-damaging non-methane VOCs (Helmig, 2020; Moore et al., 2014). Diesel engines used to power on-site equipment and trucks at unconventional and conventional OGD sites directly emit health-damaging hazardous air pollutants, fine particulate matter ($PM_{2.5}$), nitrogen oxides and volatile organic compounds (VOCs) (CalEPA OEHHA, 2001). Many VOCs and nitrogen oxides are precursors to ground level ozone (O_3) formation, another known health harming pollutant. Hazardous air pollutants that are known to be emitted from OGD sites include benzene, toluene, ethylbenzene, xylenes, hexane and formaldehyde--many of which are known, probable or possible carcinogens and/or teratogens and which have other adverse effects for non-cancer health outcomes (CalEPA OEHHA, 2008, 2009; Moore et al., 2014). In the San Joaquin Valley Air Pollution Control District, OGD activities are responsible for the majority of emissions of multiple toxic air contaminants including acetaldehyde, benzene, formaldehyde, hexane and hydrogen sulfide (**Figure 2**) (Brandt et al., 2015; Long et al., 2015).

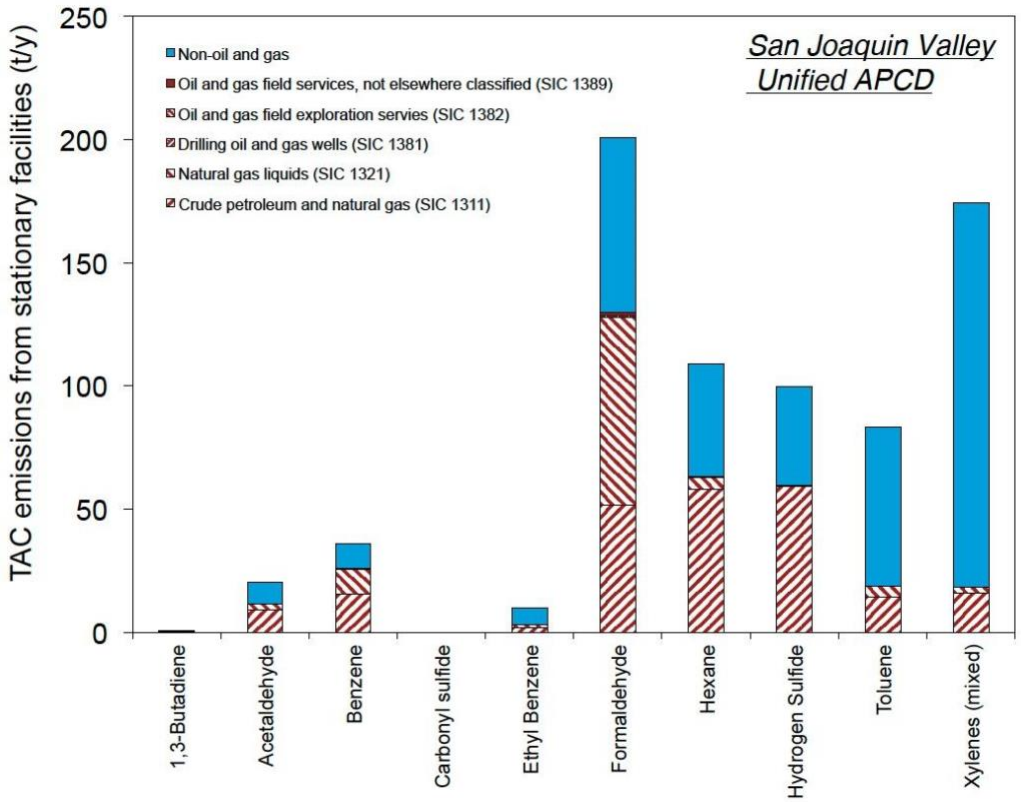

Figure 2. **Toxic Air Contaminant emissions from stationary facilities in the San Joaquin Valley Air Pollution Control District (Source: (Brandt et al., 2015).**

A recently published study using statewide air quality monitoring data from California investigated whether drilling new wells or increasing production volume at active wells resulted in emissions of $PM_{2.5}$, nitrogen dioxide (NO_2), VOCs, or O_3 (Gonzalez et al., 2021)**.** To assess the effect of oil and gas activities on concentrations of air pollutants, the authors used daily variation in wind direction as an instrumental variable and used fixed effects regression to control temporal factors and time-invariant geographic factors. The authors documented higher concentrations of $PM_{2.5}$, NO_2, VOCs, and O_3 at air quality monitoring sites within 4 km of pre-production OGD well sites (i.e., wells that were between spudding and completion) and 2 km of production OGD well sites, after adjusting for geographic, meteorological, seasonal, and time trending factors. In placebo tests, the authors assessed exposure to well sites downwind of the air monitors and observed no effect on air pollutant concentrations. **Table 2** summarizes the increases in each pollutant for each additional upwind well site by distance.

Table 2. Summary of air pollutant concentrations measured between 2006-2019 at 314 air quality monitoring sites in the EPA Air Quality System for California (Gonzalez et al., 2021*)*.

Distance	$PM_{2.5}$ µg/m^3*	NO_2 ppb	VOCs (ppb C)*	O_3 (ppb)
Estimated increase for each additional upwind pre-production well site				
Within 2 km	2.35 (0.81, 3.89)	2.91 (0.99, 4.84)	No increase	no increase
2-3 km	0.97 (0.52, 1.41)	0.65 (0.31, 0.99)	No increase	0.31 (0.2, 42)
3-4 km	no increase	no increase	no increase	0.14 (0.05, 0.23)
Estimated Increase for each 100 BOE of total oil and gas upwind production volume				
1 km	1.93 (1.08, 2.78)	0.62 (0.37, 0.86)	0.04 (0.01, 07)	no increase
1-2 km	no increase	no increase	no increase	0.11 (0.08, 0.14)

*No $PM_{2.5}$ or VOC monitoring sites with 1 km of pre-production well sites; BOE, barrels of oil equivalents.

These multiple stressors, along with other physical factors such as noise and vibration, are consistently found in exposure studies to be measurably higher near oil and gas extraction wells and other ancillary infrastructure in California. <u>As such, the Panel concludes with a high level of certainty that concentrations of health-damaging air pollutants, including criteria air pollutants and toxic air contaminants, are more concentrated near OGD activities compared to further away.</u>

3. ***Does the evidence evaluated clearly support a specific setback? If so, what is this setback distance and what oil and gas extraction activities would it specifically apply to? What is the supporting evidence?***
    a. ***How does this evidence justify the recommended setback distance, as opposed to another distance?***

Existing epidemiologic studies were not designed to test and establish a specific "safe" buffer distance between OGD sites and sensitive receptors, such as homes and schools. Nevertheless, studies consistently demonstrate evidence of harm at distances less than 1 km, and some studies also show evidence of harm linked to OGD activity at distances greater than 1 km. In addition, exposure pathway studies have demonstrated through measurements and modelling techniques, the potential for human exposure to numerous environmental stressors (e.g., air pollutants, water contaminants, noise) at distances less than 1 km (e.g., Allshouse et al., 2019; Holder et al., 2019; McKenzie et al., 2018; DiGiulio et al., 2021; Soriano et al., 2020), and that the likelihood and magnitude of exposure decreases with increasing distance.

    b. ***What are the health benefits from this setback? Can the panel quantify them or recommend a methodology CalGEM can use to quantify them? Can the panel establish that these health benefits can only be achieved with the setback? Or can they also be achieved with mitigation controls?***

Figure 3 presents a hierarchy of strategies to reduce human health hazards, risks and impacts from OGD activities. **Table 3** presents the advantages and disadvantages of each strategy from an environmental public health perspective.

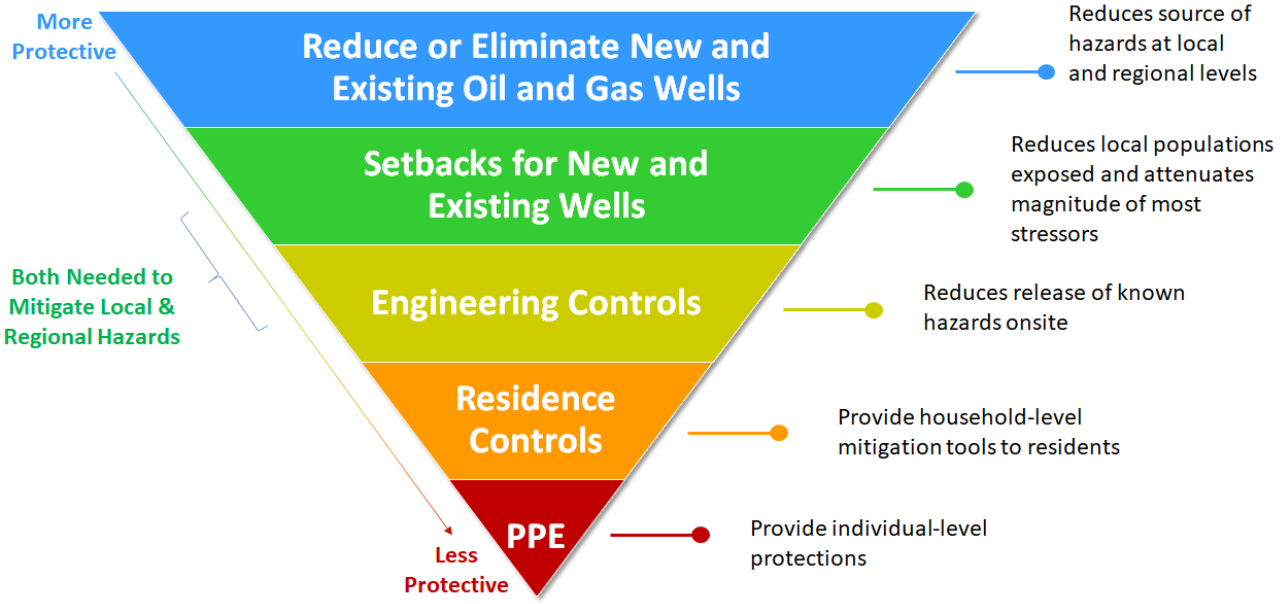

Figure 3. Hierarchy of strategies to reduce or eliminate public health harms for OGD activities. Note: the use of the term "wells" includes the ancillary infrastructure used to develop, gather and process oil and gas in the upstream oil and gas sector.

At the top of Figure 3 is the most health protective strategy: to stop drilling and developing new wells, phase out existing OGD activities and associated infrastructure, and properly plug remediate legacy wells and ancillary infrastructure.

If the development of oil and gas is to continue, the greatest health benefits would be gained from a strategy that includes the next two controls in the hierarchy depicted in Figure 3: the elimination of new and existing wells and ancillary infrastructure within scientifically informed setback distances and the deployment of engineering emission controls and associated monitoring approaches that lead to rapid leak detection and repair for new and existing wells and ancillary infrastructure. Because air pollutant concentrations and noise levels decrease with increasing distance from a source, adequate setbacks can reduce harm to local populations by reducing exposures to air pollutants and noise directly emitted from the OGD activities. However, setbacks do not reduce harms from OGD contributions to regional air pollutant levels, such as secondary particulate matter and ozone, or greenhouse gases, such as methane, which are nearly always co-mingled with health-damaging air pollutants (Michanowicz et al., *Forthcoming*). Engineering controls that reduce emissions at the well site are also necessary to reduce these harms.

Engineering controls include cradle-to-grave noise and air pollution emission mitigation controls on OGD infrastructure including new, modified and existing infrastructure, and proper abandonment of legacy infrastructure, prioritizing those nearest to residential sites and schools and those associated with the highest emissions, leaks and other environmental hazards.

However, engineering controls can fail and engineering solutions may not be available for or economically feasible to handle all of the complex stressors generated by OGD, including multiple sources and types of air pollution, noise pollution, light pollution, water pollution, and other stressors. <u>Therefore, neither setbacks or engineering controls alone are sufficient to reduce the health hazards and risks from OGD activities -- both approaches are needed in tandem</u>.

Finally, we note that while outside of CalGEM's jurisdiction, setbacks for new construction of housing or schools at a certain distance from existing or permitted OGD sites (commonly referred to as reverse setbacks), should be considered.

Table 3. Advantages and Disadvantages of Oil and Gas Development Control Strategies from an Environmental Public Health Perspective.

Control Strategy	Description	Advantage	Disadvantage
Elimination	Eliminate or reduce new and existing wells and ancillary infrastructure in combination with proper plugging and abandonment of wells and other legacy infrastructure.	Eliminates the source of nearly all environmental stressors (e.g., air and water pollutants, noise); protects local and regional populations	None.
Setbacks	Increase the distance between OGD hazards and sensitive receptors.	Reduces risk of exposures to populations living near OGD sites; environmental stressors are generally attenuated with increasing distance.	Setbacks alone without coupled engineered mitigation controls allow continued release of hazards and therefore does not adequately address air pollutant and greenhouse gas emissions from OGD and their impacts on regional air quality and the climate.
Engineering Controls	Reduces or eliminates release of specific hazards on site.	Reduces or eliminates certain hazards and therefore can have local and regional environmental public health benefits.	Tends to be disproportionately focused on air pollutant emissions. Often not feasible to apply engineering solutions to multiple, complex stressors each requiring different control technologies (e.g. noise, air and water impacts, social stressors) and lacks the important factor of safety provided by a setback when engineering controls fail.
Residence Controls	Provides households with devices to reduce hazard at the home (e.g., water filter, light-blocking shades, air filters).	Reduces intensity of certain hazards to nearby communities at the household level.	Places burden on individuals and households to use devices properly and to maintain and regularly replace controls to maximize effectiveness. Not feasible to apply devices to address numerous, complex stressors.
Personal Protective Equipment	Provide individuals with devices to reduce exposure (e.g., respiratory masks, ear plugs, eye masks).	Reduces intensity of exposure of certain hazards to nearby individuals.	Places burden on individuals to use PPE consistently and properly and is not feasible for the complex stressors.

Attributable Risk Calculations

One method to estimate health harms from OGD is to use the measures of association from the epidemiologic literature and population counts to calculate the excess number of specific health outcomes. This is what is known as an attributable risk method. We may be able to derive these estimates in the final report for birth outcomes using estimates of population counts for women of reproductive age in California living near OGD sites. We will also attempt to derive similar estimates for respiratory outcomes by using age appropriate population counts near OGD sites. This attributable risk method can allow us to estimate the number of adverse perinatal or respiratory cases that are attributable to OGD exposures and could be attenuated through the implementation of elimination or setback strategies.

c. Can the panel quantify or recommend a methodology CalGEM can use to quantify the health benefits associated with mitigation controls?

The Panel was not tasked to estimate health benefits of various setbacks and mitigation strategies, which pose significant methodological challenges and would require considerable time and effort. Among the challenges is the need to consider the benefits of reducing multiple stressors -- multiple air pollutants and other chemicals, noise, vibration, light, subsurface contamination, etc.

Known Health Benefits of Reducing Air and Noise Pollution

There is a significant body of literature and available tools that address the potential health benefits that can be achieved by reducing air and noise pollution exposures. The National Institute of Environmental Health Sciences has linked air pollution and specifically $PM_{2.5}$ to respiratory disease, cardiovascular disease, cancer, and reproduction harm and provides references supporting these links (NIEHS (National Institute of Environmental Health Sciences), 2021). Schraufnagel et al. (2019) examined in detail the health benefits of air pollution reductions in different geographic regions. Friedman et al. (2001) showed that improvements in air quality in preparation for the 1996 Atlanta Olympics resulted in significantly lower rates of childhood asthma events, including reduced emergency department visits and hospitalizations. Avol et al. (2001) demonstrated that children in southern California who moved to communities with higher air pollution levels had lower lung function growth rates than children who moved to areas with lower air pollution levels. Gauderman et al. (2015), examining the impact of reductions in $PM_{2.5}$ and nitrogen dioxide in the Los Angeles air basin, found that children who grew up after air quality improvements had less than ½ the chance of having clinically low lung function results. Ha et al. (2014) found $PM_{2.5}$ exposures in all trimesters to be significantly and positively associated with the risk of all adverse birth outcomes.

In an analysis of noise exposure reductions. Based on sound levels measured and/or modeled across the US together with an EPA exposure- response model for levels exceeding EPA standards, Swinburn et al. (2015) found that a 5-dB noise reduction scenario in communities with noise exceeding EPA standards would reduce the prevalence of hypertension by 1.4% and coronary heart disease by 1.8%. The types of health-benefit studies noted here provide a basis for conducting a health-benefits analysis using a tool such as US EPA's Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) (US EPA, 2021).

Possible Approaches to Quantify Health Benefits

CalGEM could obtain estimates of the health benefits achieved from different mitigation strategies individually or in combination with tools such as the Community Multiscale Air Quality Model (CMAQ) (Binkowski & Roselle, 2003) and/or other exposure assessment tools and link model output to EPA's BenMAP-CE (US EPA, 2021). However, these models and approaches are only focused on air quality and noise. It should also be noted that a significant drawback of using BenMAP-CE for this application is that it only considers impacts from criteria air pollutants and not from toxic air contaminants or other emerging air pollutants.

BenMAP-CE estimates the number and economic value of health impacts resulting from changes in air pollution concentrations. BenMAP-CE estimates benefits in terms of the reductions in the risk of premature death, heart attacks, and other adverse health effects. BenMAP-CE requires as input, pollutant concentrations at a scale that matches with population data. These concentrations can be obtained from a model such as CMAQ (Binkowski & Roselle, 2003) or from a monitoring network. BenMAP-CE takes the concentration fields for a base case and then for a pollution reduction (or increase) to assess health benefits (or detriments). BenMAP-CE then estimates changes in health endpoints, allowing the user to specify the concentration–response function and either use built-in population and baseline mortality rates or specify them as inputs.

It should be noted that in order to use a model such as BenMAP-CE to assess health benefits of setbacks and mitigation controls at well sites across California would involve a significant level of time and effort in data collection and model executions. In addition, these models are limited to characterizing the health benefits of criteria air pollutant reductions, but do not account for other OGD related exposures such as toxic air contaminants, other chemical exposures and exposures to other stressors through other environmental pathways (e.g., water and noise). Additionally, and importantly, the lack of spatially resolved emissions data from upstream OGD introduces challenges when assessing local- and sub-regional scaled health impacts that would be required for calculating benefits of specific policies such as setbacks and emission control. As such, attempts to quantify benefits using BenMAP-CE are likely to underestimate them.

4. ***CalGEM is aware of health risk assessments, health impact assessments, air exposure studies, and workforce safety studies that have been conducted but were not evaluated as part of your preliminary advice. How do these studies align with your causation determination, any recommended setback distance, and recommendations on health benefits quantification?***

The Panel determined early in its deliberations that it would limit the studies assessed in its report to those in the peer-reviewed scientific literature. This criterion ensures that studies have been evaluated by scientists who have not been involved with the study but have expertise in the relevant topic area and/or the methods used to carry out analyses, prior to publication. The peer-review process helps to ensure that high quality data and scientific interpretations are at the core of the science-policy decision-making process. Authors of peer reviewed studies are more likely to have been questioned about their methods, data interpretations, and conclusions, leading to greater confidence in the results.

In addition, the Panel was not tasked with assessing occupational studies. If CalGEM staff are aware of any peer-reviewed studies that were not included in our preliminary advice, we encourage them to send the Panel references so that we can evaluate them for inclusion in the final report. We intend to scan the literature again to assess whether relevant studies have been published since we completed the draft report. Should additional peer-reviewed studies be identified, the Panel will evaluate them to determine if they align with the scope of the report and should be added.

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Springtime for Home Rule over Oil and Gas

BY DANIEL E. KRAMER

This article discusses Colorado SB 19-181, which makes sweeping changes to the regulation of oil and gas extraction operations.

On April 3, 2019, the Colorado General Assembly passed SB 19-181, Protect Public Welfare Oil and Gas Operations (the Act), which makes sweeping revisions to several statutes governing oil and gas extraction operations. The Governor signed the bill into law on April 16, making the Act effective on that date. The changes encompass state agency rulemaking, the process for allowing oil and gas to be exploited without the consent of the mineral rights holder, financial guarantees to ensure the cleanup and reclamation of wells, and the essential mission of the Colorado Oil and Gas Conservation Commission (the Commission). But arguably the most pivotal change was the legislature's placement of the regulation of the surface impacts of oil and gas exploration firmly in the control of local communities, as coequals with the state.

This shift to local control abrogated the Colorado Supreme Court precedent that, in the event of a conflict between state and local laws on oil and gas, the state law prevails and the local law subsides.[1] Now, the state statute itself makes state laws the floor, not the ceiling, for local regulation. The General Assembly has effectively reinstituted a sort of legislative home rule over the subject, bucking the national trend of state legislatures favoring intrastate preemption on oil and gas regulation issues and reversing a decades-long process of eroding local control.

The Court's recent elaborations of Colorado intrastate preemption doctrine may well still hold for other matters,[2] but not for oil and gas.

SB 19-181: Changes in Local Control

In its 2016 decision overturning the City of Longmont's ban on hydraulic fracturing, the

Colorado Supreme Court set forth its test for whether a local oil and gas regulation would pass scrutiny under the existing statutory scheme. Boiled down, the question was whether the local law conflicted with the state law, which, in practical terms, meant whether the local law would materially impede the state's interest in oil and gas production.[3] The Court extended its previous tests to find preemption where it determined that the local restriction upset "exhaustive" and "pervasive" state regulations that implied a state interest in uniform regulation of the subject.[4]

Eliminating Preemption

By passing SB 19-181, the legislature has abrogated those holdings. The Act created new CRS § 34-60-131:

> **34-60-131. No land use preemption.** Local governments . . . have regulatory authority over oil and gas development, including as specified in section 34-60-105(1)(b). A local government's regulations may be more protective or stricter than state requirements.[5]

Now, the statute itself helps define what constitutes a conflict between the state act and local regulations. There is no question that local governments may properly regulate oil and gas. While local ordinances cannot reduce the minimum state standards for protecting health, safety, welfare, and the environment, they now can clearly regulate above and beyond state regulations. This is true regardless of those state regulations' complexity or thoroughness. The heightened local standards will be in harmony with the Act itself and cannot be considered to conflict with it.[6] As preemption is largely a matter of statutory interpretation[7]—putting the state and local laws side by side to determine whether they can coexist[8]—heightened local standards for oil and gas regulation will no longer be preempted by the state law.

Express Local Powers

The bill grants a long list of regulatory powers over oil and gas to local governments, some preexisting and some new:

I. Land use;
II. The location and siting of oil and gas facilities and oil and gas locations . . .;
III. Impacts to public facilities and services;
IV. Water quality and source, noise, vibration, odor, light, dust, air emissions and air quality, land disturbance, reclamation procedures, cultural resources, emergency preparedness and coordination with first responders, security, and traffic and transportation impacts;
V. Financial securities, indemnification, and insurance as appropriate to ensure compliance with the regulations of the local government; and
VI. All other nuisance-type effects of oil and gas development.[9]

Land use controls over oil and gas facilities are an example of a power that previously was within the authority of local government, so long as the controls did not conflict with state statute.[10] On the other hand, controls over local financial securities and noise, for example, had been held to be preempted.[11] Siting of facilities, meanwhile, had been a perennial source of contention without much guidance from the courts. And the phrase "nuisance-type effects" in subparagraph VI is potentially so broad that it is hard to say yet just how much it expands existing powers.[12]

In addition to these enumerated powers, the bill contains a catch-all provision: Local governments may also regulate to "protect and minimize adverse impacts to public health, safety, and welfare and the environment," although this can only be done "to the extent necessary and reasonable."[13]

In fact, both the catch-all minimization of adverse impacts and the list of enumerated powers are limited in two other ways: the statutory authorization extends only to the regulation of "surface impacts," rather than pure underground engineering, and the regulations may only be exercised "in a reasonable manner."[14]

Defining "Necessary" and "Reasonable"

The words "necessary" and "reasonable" are not defined and leave much to interpretation. While "necessary" applies only to the catch-all minimization of adverse impacts, the full list is subject to the "reasonable manner" limitation. Where the application of the statute to a particular local regulation may be ambiguous, the courts may consider the words of a Senate sponsor of the legislation before the final legislative vote on the bill:[15]

> [A] question has repeatedly come up about the, quote, "necessary and reasonable"

standard language that we added in the Senate. There have been several requests to further define it, but unfortunately that's proved to be difficult. I will say, though, that it's the sponsors' intent to have that phrase interpreted together, and in the context of, the bill as a whole, which is (1) a clear desire to prioritize health and safety when it comes to oil and gas operations, permitting, and supervision, without consideration of profitability from the state regulatory authority, the COGCC, and (2) an ability for local governments to do the same, and be more protective than the state if they choose. "Necessary and reasonable" is not intended to mean regulatory authorities can only make a land use decision or enact a regulation once all other options are exhausted. Instead, it is meant to be a guardrail against a regulatory or land use decision without reasonable justification. State and local governments should not be able to impose requirements, limitations, or decisions that defy explanation. However, they should be entitled to deference and allowed to use the precautionary principle to determine if a regulation or a land use decision is necessary and reasonable. Each locality's application of "necessary and reasonable" may be different depending on its circumstances, and should be examined on a case-by-case basis.[16]

How strict a local regulation can be while remaining "reasonable" will ultimately be decided by the courts. SB 19-181 did not finally settle the bounds of local authority, and litigation will continue to define the rules of engagement. But SB 19-181 dramatically changed the location of the battlefield, propelling local jurisdictions into a much stronger position. Rather than argue over whether it is interfering with the state's manner of regulation—which the state has the inherent advantage of *defining*—the local government now need only show that its method of regulation is reasonable.

Since local land use decisions already cannot be arbitrary and capricious,[17] "reasonable" may not prove to be a very high bar. A local government could demonstrate reasonableness through rough proportionality,[18] by more or less matching the strictness of the regulation to the severity of the oil and gas operation's potential surface impact. Reasonableness might also be demonstrated by the industry's ability to comply with similar regulations elsewhere, or the general application of similar regulations to other heavy industry. Conversely, unreasonableness probably could not be established based solely on the cost of a regulation to an operator, especially given the Act's removal of cost-effectiveness as a consideration elsewhere.[19]

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In addition to the courts, another new entity could also indirectly weigh in on the reasonableness of a local regulation. The Act creates a process for a local government or operator to request review of a local decision by a technical review board, with members appointed by the Commission director.[20] The board has authority to make a nonbinding report on the impacts of the decision to the recovery of the resource, whether the decision would require unavailable or impracticable technologies, and whether the operator is proposing to use best management practices.[21] While the local government can simply ignore an unfavorable report,[22] nothing in the Act would prevent a report from becoming evidence in a suit challenging the legality of the decision. However, because the reports will cover particular local decisions on particular applications, the reports would presumably receive judicial review only under CRCP 106(a)(4), which allows limited judicial review where a governmental body has exceeded its jurisdiction or abused its discretion.[23] The operator cannot force the technical review until after the decision is made, so the report would not likely be part of the administrative record, and thus not part of the judicial review.[24]

In sum, while courts will ultimately need to interpret "necessary" and "reasonable" on a case-by-case basis to define the outer boundaries of local power, SB 19-181 nevertheless firmly establishes local control, coequal with the state, over the surface impacts of oil and gas exploration. Local communities, through their elected representatives, will now be able to write wide-ranging and strict rules for using land within their jurisdictions, with much less risk of those rules being overturned.

Is There Authority for Local Bans?

This new local authority does not necessarily mean that local governments will now be able to entirely ban practices such as drilling or fracking. In advancing the bill in the Senate, one of its sponsors, the majority leader, cast doubt on whether the new local authority could extend to complete bans.[25]

However, the bill contains a potential sleeper provision. The preexisting law on minerals regulation, known colloquially as HB 1041 and

officially as the Areas and Activities of State Interest Act (the AASIA), allowed local governments to regulate mineral resource areas, much as they can regulate water projects.[26] The key difference is that previously, local governments had to seek the Commission's approval to regulate mineral resources. The Act removes that prerequisite.[27] While the bill sections described above sketch the outer bounds of local land use authority, those sections do not seem to limit local government authority under the AASIA. The Act's amendments to the AASIA might even allow a local government to go so far as to prohibit oil and gas activity where it determines that "extraction and exploration would cause significant danger to public health and safety,"[28] the sponsor's words notwithstanding.

Local Enforcement and Implementation

Enforcement mechanisms for local regulations have also been strengthened. Before, local governments could require inspections of oil and gas facilities if the Commission was willing to execute an intergovernmental agreement to that effect.[29] And local governments could not charge fees or fines except in limited circumstances.[30] Now, local power to impose inspections, fees, and penalties has been liberalized and broadened, without much limitation.[31]

While the enactment and enforcement of local regulations will continue to generate headlines, for the most part the Act's effect will play out behind the scenes, in negotiations between local governments and operators over memoranda of understanding covering the specifics of each operator's activity within each jurisdiction. These negotiations take place against the backdrop of the community's regulations and the state of the law. Whereas the industry was once able to use preemption law as leverage to get the deal it wanted, now the lever has a different fulcrum. Negotiating positions, and ultimately the deals that result, will begin to change accordingly.

SB 19-181: Changes at the State Level

SB 19-181's broad changes to the Oil and Gas Conservation Act extend well beyond matters of local authority, making statewide changes by altering the Commission's fundamental purpose and composition.

The Commission's mission has changed from fostering the development of oil and gas to regulating it.[32] And where the Commission previously had only to *consider* concerns for health, safety, welfare, and the environment in making its decisions,[33] now its decisions must be "subject to the protection" of those concerns,[34] effectively making them criteria for approval of state permits and providing a new substantive means of challenging Commission decisions. The Commission is also explicitly authorized to make decisions that keep recoverable resources in the ground as necessary to protect health, safety, welfare, and the environment.[35]

The Commission will shrink from nine voting members to five by July 2020, including a decrease from three to one who must have substantial experience in the industry.[36] The Commission will also be "professionalized," meaning members will be paid as employees and barred from outside employment.[37]

Local prerogatives will factor into the Commission's own processes as well. To receive a state drilling permit, the operator must prove that the local jurisdiction has either approved of the siting of the facility, or does not regulate oil and gas siting at all.[38]

The Act directs the Commission to undertake a series of rulemakings, including to

- regulate oil and gas operations to protect and minimize adverse impacts to public health, safety, welfare, the environment, and wildlife;
- require operators to consider alternative locations in to-be-defined situations, to address the cumulative impacts of oil and gas development;
- conform its regulation of flowlines and shut-in wells to minimize safety and environmental risks;
- revamp financial assurances requirements and address the growing problem of orphan wells;
- revisit engineering requirements to ensure wellbore integrity; and
- introduce new professional certification requirements for the industry.[39]

In the interim, until the new rules specified in the first three bullet points are adopted, the Commission's director can delay approval of a

"While the enactment and enforcement of local regulations will continue to generate headlines, for the most part the Act's effect will play out behind the scenes, in negotiations between local governments and operators over memoranda of understanding covering the specifics of each operator's activity within each jurisdiction."

drilling permit pursuant to "objective criteria," if the Commission needs to consult with the local government or to determine whether health, safety, welfare, and the environment will be protected.[40] The Air Quality Control Commission will also have to adopt new rules to minimize various emissions, require leak detection and regular inspections, and continuously monitor some facilities' emissions.[41]

The Act removes limits on state permit and filing fees[42] and replaces them with a requirement that fees be sufficient to cover costs.[43]

Other statewide changes include the parameters of forced pooling, which is the mechanism by which an operator can effectively obtain a lease, by operation of law, from a nonconsenting mineral interest owner. Previously, any operator could obtain such a statutory lease, but now operators will be subject to a threshold requirement that they already have rights in at least 45% of the interests to be pooled together for the purposes of production.[44] The royalty rate for statutory leases has also increased marginally, from 12.5% to either 13% or 16%, depending on the type of well.[45] As with a drilling permit, the Commission can no longer approve a forced pooling application until the operator proves that the local jurisdiction has either approved of the siting of the facility, or does not regulate oil and gas siting at all.[46]

Broader Implications for Home Rule and Local Control

While the changes embedded in SB 19-181 may seem important enough on their own, the evolution of home rule in Colorado puts their significance into high relief. Colorado voters passed the Home Rule Amendment to the Colorado Constitution in a pair of votes in 1902 and 1912,[47] part of a wave of similar Progressive-era reforms around the country. Support for the constitutional amendment was probably due to a confluence of factors, including the general distrust of corrupt state governments, especially "[o]nce state invasion of city authority became a common occurrence" in the late 19th century.[48] Also, philosophies of localism began to pervade the public consciousness, rooted in both the desire of smaller towns to be free of bigger-city influence and the urging of socially minded reformers for the freedom to enact progressive policies on a local level.[49] Noted attorneys and jurists began to extol the "absolute right" of local self-government as "part of the liberty of a community, an expression of community freedom, the heart of our political institutions."[50] But as many commentators have noted, in Colorado and elsewhere, home rule has failed to live up to its hype,[51] as courts have often constrained the ability of home rule cities and towns to experiment in areas where the state has also expressed an interest.

Doctrinally, this traces to the constitutional language that home rule authority extends only to "local and municipal matters."[52] Courts have been inconsistent on whether a matter must be "solely" or "purely" local in nature, or only "predominantly" so, for a home rule municipality to regulate an issue.[53] The problem of how to classify an issue as a "state issue" or a "local issue" was never clearly resolved,[54] and the problem became more complex in 1961 with the advent of a third category: issues of mixed state and local concern.[55] In this zone, when state and local laws conflict, the local laws give way.[56] Given the proliferation of both state and local laws since that development, it should not be surprising that court holdings that matters are of mixed concern, resulting in preemption, have been steadily on the rise.[57] At the same time, state legislatures across the country have increasingly taken the matter into their own hands, expressly preempting local authority on a wide variety of subjects.[58]

There is no doubt that SB 19-181 makes dramatic changes to oil and gas industry regulation on the local level in Colorado. But only time will tell whether SB 19-181 presages Colorado's rejection of the national trend, represents a subtler inflection point, or is a mere blip. It does not change the law of home rule or preemption for any other issue, and does not disturb home rule doctrine regarding oil and gas, which jurisprudence is rooted in the constitution, not statutes. And SB 19-181 is not limited to home rule cities and towns, but applies to counties and statutory municipalities as well.

Nevertheless, given the political dynamics surrounding the failure of home rule to justify local restrictions in the courts,[59] the issue elections over the past seven years,[60] and the candidate campaigns in the 2018 statewide elections,[61] SB 19-181 clearly represents the intent of the people to legislatively enact, for at least one issue,[62] a variant of home rule not based in the constitution. The result is a more muscular, albeit issue-specific, home rule power that echoes the voters' intentions behind the original constitutional enactments.

Conclusion

With the enactment of SB 19-181, members of local communities will be able, much more than before, to control their own destinies in the area of oil and gas regulation. For this issue, over the coming years, we may witness a rare thing: a home rule renaissance. CL

The views and opinions expressed in this article are those of the author and do not reflect the opinions of his employer or anyone else.

Daniel E. Kramer is an assistant city attorney for the City of Longmont. As of July 15, 2019, he will be the Estes Park Town Attorney. He was counsel in *City of Longmont v. Colorado Oil & Gas Association*—dan.kramer@longmontcolorado.gov.

Coordinating Editor: Mary Elizabeth Geiger, megeiger@garfieldhecht.com

NOTES

1. *City of Longmont v. Colo. Oil & Gas Ass'n*, 369 P.3d 573, 579 (Colo. 2016).

2. *See generally* Kramer, "Colorado Preemption Law: The Evolving Meaning of 'Conflict,'" 48 *Colo. Law.* 38 (Apr. 2019). The article went to print as the General Assembly deliberated on SB 19-181. With this Act now the centerpiece of oil and gas preemption law, readers might consider these April and July articles as before and after photos.

3. *City of Longmont*, 369 P.3d at 583. While this might sound like a factual inquiry, the Supreme Court recently held this to be a facial matter of "assess[ing] the interplay between the state and local regulatory schemes." *Id. See also Colo. Oil & Gas Conservation Comm'n v. Martinez*, 433 P.3d 22, 32 (Colo. 2019) (while environmental protection was part of the Commission's interest, it was not a "condition precedent" to oil and gas development; instead, the Commission's principal objective was to ensure production proceeded economically).

4. *City of Longmont*, 369 P.3d at 584–85.

5. SB 19-181, § 17. The caption refers to "land use" preemption, but the body of the section prevents preemption of all local regulations that are stricter or more protective than the state's. *See* SB 19-181, § 4, amending CRS § 29-20-104(1)(h) (referenced by CRS § 34-60-105(1)(b) and containing the list of express local powers, of which land use is only the first. SB 19-181, § 11.). *See also People v. Rieger*, 436 P.3d 610, 613 (holding that the word "including" in a statute "denotes that the examples listed are not exhaustive or exclusive").

6. *Colo. Min. Ass'n v. Bd. of Cty. Comm'rs of Summit Cty.*, 199 P.3d 718, 730 (Colo. 2009) ("[L]ocal land use regulations could be consistent with the Oil and Gas Conservation Act if the local and state regulations could be harmonized.").

7. "Express and implied preemption are primarily matters of statutory interpretation." *City of Longmont*, 369 P.3d at 582 (internal quotation marks omitted). Even the more context-dependent operational conflict species of preemption was sensitive to interpretation of the statute and administrative regulations. *See id.* at 584–85.

8. *Id.* at 583 (Analysis of whether a conflict exists "requires us to assess the interplay between the state and local regulatory schemes. In virtually all cases, this analysis will involve a facial evaluation of the respective statutory and regulatory schemes . . . ."); *id.* at 582 (local oil and gas ordinance can "coexist" with a state statute absent a conflict).

9. SB 19-181, § 4.

10. *City of Longmont*, 369 P.3d at 583–84.

11. *Bd. of Cty. Comm'rs of Gunnison Cty. v. BDS Int'l, LLC*, 159 P.3d 773, 779 (Colo.App. 2006) (financial requirements); *Town of Frederick v. N. Am. Res. Co.*, 60 P.3d 758, 765 (Colo.App. 2002) (noise). *See also* SB 19-181, § 5 (removing a prohibition on counties regulating oil and gas noise).

12. Even for the word "nuisance" itself, "[i]t is not practicable to give other than a general definition." *Black's Law Dictionary*, Nuisance (10th ed. Thomson Reuters 2014) (quoting Joyce and Joyce, *Treatise on the Law Governing Nuisances* 22 (Matthew Bender & Co. 1906)).

13. SB 19-181, § 4.

14. *Id.*

15. *Union Pac. R. Co. v. Martin*, 209 P.3d 185, 188 (Colo. 2009). *See People v. Zapotocky*, 869 P.2d 1234, 1238 (Colo. 1994) (using sponsor's statements as an interpretive aide because, "if the intended scope of the statutory language is unclear, a court may apply other rules of statutory construction and look to pertinent legislative history").

16. Statement of Sen. Foote at 1:13:08, http://coloradoga.granicus.com/MediaPlayer.php?view_id=42&clip_id=13895.

17. CRCP 106(a)(4); *Ross v. Fire and Police Pension Ass'n*, 713 P.2d 1304, 1309 (Colo. 1986) ("'No competent evidence' [under CRCP 106(a)(4)] means that the ultimate decision of the administrative body is so devoid of evidentiary support that it can only be explained as an arbitrary and capricious exercise of authority.").

18. *Cf. Krupp v. Breckenridge Sanitation Dist.*, 19 P.3d 687, 693–94 (Colo. 2001) ("Because a service fee is designed to defray the cost of a particular governmental service, the amount of the fee must be reasonably related to the overall cost of the service. Mathematical exactitude is not required, however, and the particular mode adopted by the governmental entity in assessing the fee is generally a matter of legislative discretion." (emphasis added) (citation omitted)); *id.* at 695 ("No precise mathematical calculation is required for the rough proportionality test, but the governmental entity must make some sort of individualized determination that the required dedication is related both in nature and extent to the impact of the proposed development." (internal quotation marks omitted)).

19. SB 19-181, § 12, CRS § 34-60-106(2)(d); § 10, CRS § 34-60-104.5(3)(b)(II).

20. SB 19-181, § 4, CRS § 29-2-104(1)(i); § 10, CRS § 34-60-104.5(3).

21. SB 19-181 § 10, CRS § 34-60-104.5(3)(b).

22. SB 19-181, § 4, CRS § 29-20-104(3)(b).

23. "C.R.C.P. 106(a)(4) is the exclusive remedy for reviewing quasi-judicial decisions." *JJR 1, LLC v. Mt. Crested Butte*, 160 P.3d 365, 369 (Colo.App. 2007).

24. CRCP 106(a)(4)(I) ("Review shall be limited to a determination of whether the body or officer has exceeded its jurisdiction or abused its discretion, based on the evidence in the record before the defendant body or officer."). While the period to seek judicial review under Rule 106(a)(4) is tolled until the technical report comes out, the local government would have already made its decision based on the record in front of it at the time. *See* SB 19-181, § 4, CRS § 29-20-104(3)(c).

25. *See, e.g.*, statement of Sen. Fenberg at 1:10:19, http://coloradoga.granicus.com/MediaPlayer.php?view_id=42&clip_id=13895.

26. CRS § 24-65.1-201(1)(a).

27. SB 19-181, §§ 1 to 2.

28. CRS § 24 65.1-202(1)(a). Weld County has also expressed interest in using AASIA powers, apparently in an attempt to preempt the updated state laws. Weld County News Release, "Process begins to officially designate unincorporated Weld County as an oil and gas local-control county" (May 1, 2019). As one county commissioner put it, "We believe that 181 gives us the power of pre-emption over the state on land-use powers. If it pre-empts the state one way, it pre-empts the state the other way." "In 'new era' of oil and gas regulation, Colorado communities waste no time writing own rules," *Denv. Post* (May 6, 2019), www.denverpost.com/2019/05/06/colorado-oil-and-gas-local-regulations-181. It is unclear what authority, in either SB 19-181 or the AASIA, could allow a local government to supplant a more protective state standard. *See* SB 19-181, § 17, CRS § 34-60-131 (allowing local regulations to be more protective or stricter than the state's).

29. CRS § 34-60-106(15).

30. *Id.*; T*own of Frederick v. N. Am. Res. Co.*, 60 P.3d 758, 765–66 (Colo.App. 2002).

31. SB 19-181 § 4, CRS § 29-20-104(2).

32. SB 19-181, § 6, CRS § 34-60-102(1)(a)(I).

33. *See Martinez*, 433 P.3d at 32.

34. SB 19-181, § 6, CRS § 34-60-102(1)(b).

35. SB 19-181, § 7, CRS § 34-60-103(11)(b), (12)(b), (13)(b); § 12, CRS § 34-60-106(2.5)(b).

36. SB 19-181, § 9, CRS § 34-60-104.3(2)(a). The makeup of the Commission will also change in the interim, with the replacement of two slots reserved for industry members with technical experts. SB 19-181, § 8, CRS § 34-60-104(2)(a)(I).

37. SB 19-181, § 9, CRS § 34-60-104.3(2)(b).

38. SB 19-181, § 12, CRS § 34-60-106(1)(f)(I)(A). *See also* COGCC Operator Guidance, SB 19-181: Hearings and Permitting Groups at 3 (Apr. 19, 2019). However, the COGCC director indicated at a public meeting on May 15, 2019 that he may revisit whether a final determination by the local government will be necessary in circumstances where the local government requests concurrent state and local review.

39. SB 19-181, § 12, CRS § 34-60-106(11)(c), (13), (18)–(20).

40. SB 19-181, § 12, CRS § 34-60-106(1)(f)(III). During the debate on the bill, this provision was characterized by some as a moratorium.

41. SB 19-181, § 3.

42. SB 19-181, § 12, CRS § 34-60-106(7)(a).

43. SB 19-181, § 12, CRS § 34-60-106(7)(b).

44. SB 19-181, § 14, CRS § 34-60-116(3)(b)(I).

45. SB 19-181, § 14, CRS § 34-60-116(7)(c).

46. SB 19-181, § 14, CRS § 34-60-116(1)(b). *See also supra* note 38.

47. Hayes and Hartl, "Home Rule in Colorado: Evolution or Devolution," 33 *Colo. Law.* 61 (Jan. 2004). For more background on the home rule amendment, *see* Broadwell, "Municipal Home Rule in the 1990s," 28 *Colo. Law.* 95 (Sept. 1999); McCullough, "A Primer on Municipal Home Rule in Colorado," 18 *Colo. Law.* 443 (Mar. 1989); Bueche, A History of Home Rule (Colo. Municipal League Nov. 2009); Colo. Municipal League, Home Rule Handbook (2017).

48. Frug, "The City as a Legal Concept," 93 *Harv. L. Rev.* 1059, 1115–16 (1980); Barron, "Reclaiming Home Rule," 116 *Harv. L. Rev.* 2255, 2293 (2003). *See also* Fox, "Home Rule in an Era of Local Environmental Innovation," 44 *Ecology L.Q.* 575, 588–89 (2017) ("Home rule was also designed to combat the dangers of state control that had been evidenced in targeted special legislation, which interfered with appropriate city governance.") (citing Frug and Barron, *City Bound: How States Stifle Urban Innovation* 37 (Cornell Univ. Press 2008)).

49. Barron, *supra* note 48 at 2292–320.

50. Frug, *supra* note 48 at 1113–14 (quoting *People ex rel. Le Roy v. Hurlbut*, 24 *Mich.* 44, 93 (1871); Eaton, "The Right to Local Self-Government" (pts. 1–3), 13 *Harv. L. Rev.* 441, 570, 638 (1900), (pts. 4–5), 14 *Harv. L. Rev.* 20, 116 (1900); McQuillin, *The Law of Municipal Corporations*, vol. 1, § 268 Rise and Progress of Municipal Institutions at 679 (2d ed. Callaghan

and Company 1928)).

51. *See, e.g.*, Frug, *supra* note 48 at 1117 (Home rule "has not successfully created an area of local autonomy protected from state control."); Baker and Rodriguez, "Constitutional Home Rule and Judicial Scrutiny," 86 *Denv. U. L. Rev.* 1337, 1342 (2009) ("While constitutional home rule on paper points to a delineated realm of local sovereignty, the record of home rule in the state courts in this regard is more mixed.").

52. Colo. Const. art. XX, § 6.

53. *Compare, e.g.*, *Webb v. City of Black Hawk*, 295 P.3d 480, 486 (Colo. 2013) ("solely" and "purely") *with City and Cty. of Denver v. State*, 788 P.2d 764, 767 (Colo. 1990) ("In fact, there may exist a relatively minor state interest in the matter at issue but we characterize the matter as local to express our conclusion that, in the context of our constitutional scheme, the local regulation must prevail. Thus, even though the state may be able to suggest a plausible interest in regulating a matter to the exclusion of a home rule municipality, such an interest may be insufficient to characterize the matter as being even of 'mixed' state and local concern.").

54. Frug, *supra* note 48 at 1117 ("[T]he courts have grappled with determining what matters are of 'state concern' and what matters are 'purely local' in nature."). *See also City and Cty. of Denver*, 788 P.2d at 767–68 ("Those affairs which are municipal, mixed or of statewide concern often imperceptibly merge. . . . We have not developed a particular test which could resolve in every case the issue of whether a particular matter is 'local,' 'state,' or 'mixed.' Instead, we have made these determinations on an ad hoc basis, taking into consideration the facts of each case.").

55. *Woolverton v. City and Cty. of Denver*, 361 P.2d 982, 985–90 (Colo. 1961), *overruled*, 484 P.2d 1204.

56. *City of Aurora v. Martin*, 507 P.2d 868, 869–70 (Colo. 1973).

57. *See, e.g.*, *City of Longmont*, 369 P.3d at 581; *City of Fort Collins v. Colo. Oil & Gas Ass'n*, 369 P.3d 586, 591 (Colo. 2016); *Ryals v. City of Englewood*, 364 P.3d 900, 908–09 (Colo. 2016); *Webb*, 295 P.3d at 492; *MDC Holdings, Inc. v. Town of Parker*, 223 P.3d 710, 720 (Colo. 2010); *City of Commerce City v. State*, 40 P.3d 1273 (Colo. 2002); *City and Cty. of Denver v. Qwest Corp.*, 18 P.3d 748, 751 (Colo. 2001); *Town of Telluride v. Lot Thirty-Four Venture, L.L.C.*, 3 P.3d 30, 39 (Colo. 2000).

58. *See generally* Briffault, "The Challenge of the New Preemption," 70 *Stan. L. Rev.* 1995, 1997 (June 2018) ("This decade has witnessed the emergence and rapid spread of a new and aggressive form of state preemption of local government action. . . . [T]he real action today is the *new preemption*: sweeping state laws that clearly, intentionally, extensively, and at times punitively bar local efforts to address a host of local problems.") (emphasis in original); Scharff, "Hyper Preemption: A Reordering of the State–Local Relationship?" 106 *Georgetown L.J.* 1469, 1471, 1473 (2018) ("In recent years, state legislators have sought to limit local policymaking by passing increasingly broad state preemption statutes. . . . This new brand of preemption statutes, which I call 'hyper preemption,' seeks not just to curtail local government policy authority over a specific subject, but to broadly discourage local governments from exercising policy authority in the first place."); Schragger, "The Attack on American Cities," 96 *Tex. L. Rev.* 1163, 1164 (May 2018) ("American cities are under attack. The last few years have witnessed an explosion of preemptive state legislation challenging and overriding municipal ordinances across a wide range of policy areas."). These scholars have emphasized the apparent "partnership between the private interests that seek to avoid local regulation and legislators at the state level, exemplified by organizations such as the American Legislative Exchange Council (ALEC)." *Id.* at 1170. *See also* Briffault at 1997; Scharff at 1484 ("[M]any of these preemption ordinances are drafted by the American Legislative Exchange Council (ALEC), a business- backed think tank for conservative lawmakers that provides model legislation.").

59. *See, e.g.*, *City of Longmont*, 369 P.3d at 581; *City of Fort Collins*, 369 P.3d at 591; *Colo. Oil & Gas Ass'n v. City of Thornton*, Case No. 2017CV31640 (Adams Cty. Dist. Ct. Apr. 24, 2018); *Colo. Oil & Gas Ass'n v. City and Cty. of Broomfield*, Case No. 2014CV30232 (Broomfield Cnty. Dist. Ct. June 3, 2016); *Colo. Oil & Gas Ass'n v. City of Lafayette*, Case No. 13CV31746 (Boulder Cty. Dist. Ct. Aug. 27, 2014).

60. "All four Colorado oil, gas ballot measures withdrawn as promised," *Denv. Post* (Aug. 5, 2014), www.denverpost.com/2014/08/05/all-four-colorado-oil-gas-ballot-measures-withdrawn-as-promised; Aguilar, "Prop 112 fails as voters say no to larger setbacks for oil and gas," *Denv. Post* (Nov. 6, 2018), www.denverpost.com/2018/11/06/colorado-proposition-112-results.

61. Aguilar, "'Let's get real, guys': Oil and gas rules front and center for Colorado lawmakers following Prop 112's defeat," *Denv. Post* (Nov. 12, 2018), www.denverpost.com/2018/11/12/oil-gas-setback-legislature-regulation-prop-112.

62. This approach has already begun to spread to other spheres of regulation. The General Assembly followed up with an act allowing local governments to establish a local minimum wage, HB 19-1210. It also considered, but did not adopt, a bill allowing local governments to control residential rents, SB 19-225. The Colorado Supreme Court had previously held rent control to be a matter of mixed state and local concern. *Town of Telluride*, 3 P.3d at 39. And while there was no case on point, a local minimum wage previously "probably would not be viable" based on home rule, given the prior express preemption in state statute. Dalmat, "Bringing Economic Justice Closer to Home: The Legal Viability of Local Minimum Wage Laws under Home Rule," 39 *Colum. J.L. & Soc. Probs.* 93, 113 (2005).

Oil and Gas Setback Matrix

		Reservoir Up Gradient	Reservoir Down Gradient	Occupied Strructure	Platted Lots	Outdoor Activity Areas	Riparian Areas	Landfill
Current Status	Setback	1 Mile	2,000'	2,000'	2,000	2,000	500	2,640
	Variance	No	No	Yes	Yes	No	No	No
	Distance	N/A	N/A	500'	500'	N/A	N/A	N/A
	Process	N/A	N/A	Administrative or USR	Administrative or USR	N/A	N/A	N/A
	Criteria	N/A	N/A	All property owners <2,000' support (admin) or multiple criteria (USR)	All property owners <2,000' support (admin) or multiple criteria (USR)	N/A	N/A	N/A
Option No Variance	Setback	1 Mile	3,000'	2,500' or 3,000'	2,500' or 3,000'	3,000'	1,000'	3,000'
	Variance	No	No	No	No	No	No	No
	Distance	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Process	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Criteria	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Option High	Setback	1 Mile	3,000'	3,000'	3,000'	3,000'	1,000'	3,000'
	Variance	Yes	Yes	Yes	Yes	Yes	Yes	No
	Distance	3,000'	2,000'	1,000' or 1,500'	1,000' or 1,500'	2,000'	500'	N/A
	Process	USR	USR	Admin or USR	Admin or USR	Admin	Admin	N/A
	Criteria	Yes	Yes	All property owners <3,000' support (admin) or multiple criteria (USR)	All property owners <3,000' support (admin) or multiple criteria (USR)	Consent of DOAA Owner	3rd party biologist & hydrologist analysis support for reduction and consent of	N/A
um	Setback	1 Mile	3000	2,500'	2,500'	3,000'	1,000'	3,000'
	Variance	Yes	Yes	Yes	Yes	Yes	Yes	No
	Distance	3,000'	1,500'	1,000'	1,000'	1,500'	500'	N/A
	Process	USR	USR	Admin or USR	Admin or USR	Admin	Admin	N/A

Option Medi	Criteria	Yes	Yes	All property owners <3,000' support (admin) or multiple criteria (USR)	All property owners <3,000' support (admin) or multiple criteria (USR)	Consent of OAA	3rd party biologist & hydrologist analysis support for reduction and consent of CPW	N/A
Option Low	Setback	1 Mile (current)	2,000' (current)	2,000' (Current)	2,000' (Current)	2,000' (Current)	500' (Current)	2,640' (Current)
	Variance	No	No	Yes	Yes	Yes	No	No
	Distance	N/A	N/A	500' (current)	500' (current)	1,000'	N/A	N/A
	Process	N/A	N/A	Admin	Admin	Admin	N/A	N/A
	Criteria	Yes	Yes	All property owners <2,000' support (admin) or multiple criteria (USR)	All property owners <2,000' support (admin) or multiple criteria (USR)	Consent of OAA	N/A	N/A

5-3.6. Use By Special Review – Oil and Gas Facilities

A. Intent and Applicability

1. The intent of this Section 5-3.6 is to describe the approval process and approval criteria to locate an Oil and Gas Facility in unincorporated Arapahoe County and to regulate the surface impacts of an Oil and Gas Facility's operations to such extent as is reasonable and necessary to protect public health, safety, and welfare and the environment in accordance with the authority provided under SB19-181. Any Oil and Gas Facility and related site preparation or development, including any such Facility that requires a Colorado Energy and Carbon Management~~Oil and Gas Conservation~~ Commission ("ECMC~~COGCC~~") permit, shall not be located, constructed, or operated within the unincorporated jurisdiction of Arapahoe County without first obtaining Administrative Use by Special Review or Use by Special Review approval in accordance with the Arapahoe County Land Development Code, regardless of the zone district or category in which the operation will be located. If permitted in accordance with the requirements of the Arapahoe County Land Development Code, Oil and Gas Facilities are allowed in all zone districts, including Planned Unit Developments, subject to obtaining all required Federal, State, or other Local permits and approvals, and also subject to continued compliance with the requirements for the Oil and Gas Facility and the operations thereof as set forth in this Land Development Code, unless and to the extent waived or otherwise exempted pursuant to this Land Development Code.

   No person, firm or corporation shall establish, construct, or build a new Oil and Gas Facility, or modify an existing Oil and Gas Facility subject to the provisions of this Code, without first having obtained required land use approval(s) and permits as required by this Code. Applications to the County for new Oil and gas Facilities, may be submitted simultaneously with the Colorado Energy and Carbon Management (ECMC) permitting process. So long as they meet County requirements, application submissions to the ECMC or Colorado Department of Public Health and Environment (CDPHE) may be used to satisfy County application submittal requirements.

~~1.~~2. The Administrative Use by Special Review process available as provided under this Section 5-3.6 shall apply only to an "Oil and Gas Facility" as defined in Chapter 7-2 of this Land Development Code.

~~2.~~3. Nothing in this Section of the Land Development Code is intended to waive or modify any applicable provision of the Arapahoe County Regulations Governing Areas and Activities of State Interest (1041 Regulations).

~~3.~~4. All Oil and Gas development authorized by this section shall comply with applicable provisions of the Arapahoe County building and engineering standards, including but not limited to, the Floodplain Regulations, the Building Code, the Grading, Erosion, and Sediment Control (GESC) Manual, the Stormwater Management Manual, the Stormwater Ordinance, and the Infrastructure Design and Construction Standards.

B. Relationship to State of Colorado Rules

To the extent that there are differing standards or any conflict between an Arapahoe County requirement and any State of Colorado law, regulation or rule, the stricter standard or law, regulation or rule shall apply. The Operation of a Facility in violation of any applicable federal, state, or other local law or regulation that results in adverse or negative surface impact(s) on or to public facilities and services, water quality and source, noise, vibration, odor, light, dust, air emissions and air quality, land disturbance, reclamation procedures, cultural resources, emergency preparedness and coordination with first responders, security, or traffic and transportation shall constitute a violation of the Land Development Code which may be enforced by law as other violations of the Land Development Code.

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C. Relationship to Section 5-3.4 of the Land Development Code

1. This Section provides for an Administrative Use by Special Review process for Oil and Gas Facilities, so that if an applicant meets administrative approval criteria, as set forth in this Section 5-3.6, and obtains approval pursuant to the process set forth herein, then separate approval under Section 5-3.4.B (Use by Special Review) of this Land Development Code is not required.
2. As an alternative to the Administrative Use by Special Review process set forth in this Section for approval to locate a proposed Oil and Gas Facility in unincorporated Arapahoe County, an applicant may submit an application in compliance with Section 5-3.4 (Use by Special Review), except to the extent modified in 5-3.6.J of this Section. Any Oil and Gas Facility approved through the USR process in Section 5-3.4 as modified by Subsection J of this Section 5-3.6 shall be subject to and operate in compliance with the Operational Standards specified in subsection F of this Section 5-3.6.
3. This Section, and Section 5-3.4 for a USR application if applicable, shall govern all applications for a permit to locate, construct or operate an Oil and Gas Facility, including wells, well pads, access roads and other related infrastructure, within the unincorporated jurisdiction of Arapahoe County. These regulations do not apply to pipelines, gathering systems or transmission lines. Pipelines, gathering systems and transmission lines are governed by the Use by Special Review process outlined in 5-3.4 and by the Arapahoe County 1041 Regulations.

D. Administrative approval criteria

In order to obtain Administrative Use by Special Review approval for an Oil and Gas Facility, an applicant shall first satisfy the following Administrative Review Criteria:

1. Satisfy Submittal Requirements: The application and exhibits for the Administrative Use by Special Review must satisfy all applicable submittal requirements in this Section 5-3.6 and in the Development Application Manual.
2. Compliance with Land Development Code Requirements: The proposed Oil and Gas Facility must comply with all siting and design requirements and standards specified in this Section 5-3.6.
3. Environmental/Public Health and Safety Impacts: The proposed Oil and Gas Facility must be designed to protect against and minimize adverse impacts to public health, safety, and welfare and to the environment and wildlife. The Oil and Gas Facility must address and mitigate any site-specific conditions that, by reason of oil and gas operations at that location, present a risk of adverse impacts to the public health, safety, or welfare, or to the environment and wildlife. Approvals may be conditioned in accordance with these regulations to the extent necessary and reasonable to protect the public health, safety, or welfare, ~~and~~ the environment, and wildlife.
4. Emergency Service Providers: The Oil and Gas Facility applicant must provide a commitment to serve ("will serve") letter from the authority having jurisdiction for providing emergency services (fire protection and emergency medical services) for that facility, or if no authority has jurisdiction, provide proof of a contract for emergency services from an emergency services provider with the ability to provide such emergency services.
5. Facilities on Arapahoe County Owned Property: For Oil and Gas Facilities proposed on Arapahoe County owned property, including open space property, the applicant shall provide an Alternative Location Analysis (ALA) for the proposed location that meets the requirements of Rule 304(b)(2)(C). as adopted by the Energy and Carbon Management ~~Colorado Oil and Gas Conservation~~ Commission (ECMC) in its Rules and Regulations, as amended from time to time. In the event such ALA demonstrates that a location not on County owned property is technically feasible and can meet the requirements of this Land Development Code for approval, the application for location on County owned property may be denied. In the event the ALA demonstrates that no location other than on the County property is technically feasible, the application shall be processed as a USR in accordance with the provisions of Section 5-3.4 and Section 5-3.6.J of the Land Development Code.

E. Administrative process

1. Application Process

a. Applications for an Administrative Use by Special Review for proposed Oil and Gas Facilities will follow the application process outlined in Section 5-2.1.B of the Land Development Code, Common Procedures for an Application.
b. Once a complete application has been submitted, County staff will refer the application for review to the various divisions of the PWD and other Arapahoe County Departments or Offices, as deemed appropriate. An application may require and will be referred for review to outside agencies such as Colorado Parks and Wildlife (CPW), any life-safety providers, adjacent jurisdictions, local public health department, the U. S. Army Corps of Engineers, and others as may be deemed appropriate.
c. The applicant shall provide a written response to all staff and referral agency comments.
d. Upon completion of the referral process and acceptance of the final copy of the complete application and exhibits by the PWD, the application materials will be forwarded for final review to the PWD Director.

2. Neighborhood Meeting
Prior to submitting an application to Arapahoe County, the applicant shall conduct a neighborhood meeting to describe and take neighbors' input on the proposed Oil and Gas Facility. The applicant shall send notification of the meeting to the Planning Division and to all property owners of record, all occupied residences if occupants are different from record owner,- and all registered homeowners' associations for residential subdivisions where any portion of the platted subdivision's boundary is within one and a half (1.5) miles of the proposed facility pad boundary. Meetings may be conducted in person or utilizing an electronic virtual or remote meeting platform. Notice of the meeting must be sent no less than 15 days prior to the scheduled meeting date. At said meeting, the applicant must provide information concerning the development plans for the specific facility, including the timing and phasing of construction, drilling and completion, the planned access route, and mitigations planned to address noise, light, odor, traffic, and visual impacts. The applicant shall include with its application for the proposed facility a summary of the neighborhood meeting and the list of attendees from the sign-in sheet(s).

3. Application Notice Requirements
a. The applicant shall provide written notification by U.S. Mail to all property owners of record, all occupied residences if occupants are different from record owner, and all registered homeowners' associations for residential subdivisions where any portion of the platted subdivision's boundary is within one and a half (1.5) miles of the pad boundary of the proposed Oil and Gas Facility that an application for an Administrative Use by Special Review for an Oil and Gas Facility, will be filed with the County. The Notice of Application shall meet the format prescribed by the County and shall be mailed at the time of filing the application with the County. The property owners of record shall be those identified in the County Assessor's property records. The Planning Division will provide the applicant with the names and addresses of the homeowners' associations. The applicant shall determine whether a residence is occupied by someone other than the owner and shall be responsible for such occupants.
b. Within five (5) days of filing its application with Arapahoe County, the applicant shall also post a sign listing the case number and type of case (Oil and Gas Facility), the phone number of the Planning Division, and the distance from the sign to the facility. The sign shall meet the format specified in Section 5-2.2.A.3 of the Land Development Code and it shall be posted for a period of at least fourteen (14) consecutive days. The sign shall be posted adjacent to and off the shoulder of the County road or other public highway, and at or near the intersection of the proposed facility's access road and the public road, outside of the right-of-way or at such other location acceptable to and approved by Planning Division staff.

4. Application Submittal Requirements Found in the Development Application Manual (DAM)
Applications for an Administrative Use by Special Review or for a Use by Special Review for an Oil and Gas Facility shall also comply with all relevant submittal requirements as set forth in the Development Application Manual. Applications shall include an application narrative, photo-

simulations of the view of the well pad from nearby properties and documentation of floodplain, wetlands and riparian area boundaries.

5. Waiver Requests
An applicant may apply for a waiver or modification of the following requirements for a proposed Oil and Gas Facility: 1) neighborhood meetings; 2) the burying of temporary water lines at driveway and gravel road intersections; 3) visual mitigation; or 4) any other matter specifically identified as being eligible for a waiver or modification in this Section 5-3.6. A request to waive or modify a regulation shall be made in writing at the time of application and will be evaluated on the merit of the individual request. Requests, including requests for reduction of a setback as allowed in these Regulations, must be justified by specific and extraordinary conditions of the location that make compliance with the particular standard or requirement not reasonably achievable or unnecessary and a showing that granting the request will not be detrimental to public health, safety, or welfare or the environment and wildlife, and is not otherwise inconsistent with the intent and purpose of the standard or requirement. Any request for an administrative reduction in a setback must also demonstrate that by reason of the use of alternative Oil and Gas Facility design, best management practices, control technologies, or proposed conditions of approval the reduced setback will provide substantially the same protection as the required setback. A request under this Section 5-3.6.E.5 shall be submitted to the Director of Public Works and Development for decision. The applicant may appeal that decision to the Board of County Commissioners as provided in Section 5-3.6.G.7, below. A request for a waiver for a proposed Oil and Gas Facility will be decided in accordance with the provisions of this Section 5-3.6.E.5 and is not processed through the procedures for variances specified in Section 5-5.4 of this Land Development Code or subject to review by the Arapahoe County Board of Adjustment.

F. Standards Required for Oil and Gas Facilities

1. Regular Meetings
The Operator of any Oil and Gas Facility approved under this Section 5-3.6 or as a Use by Special Review as provided herein shall meet with the Director of Public Works and Development or his or her designee annually to monitor and discuss pertinent issues associated with the Operator's Facility or Facilities operating in the unincorporated territory of the County. At such Regular Meetings, the Operator and the Director or his or her designee will discuss the Operator's updated development plans, required reporting and recordkeeping, updates to the field-wide Emergency Response Plan (ERP), the facility-specific Emergency Action Plans (EAP) and Tactical Response Plans (TRP), updated leak detection and repair plan, outstanding training requirements, any health and safety issues, and potential implementation of new technology. An annual meeting may be conducted as a field visit to the Operator's Facility or Facilities and may be conducted more often than annually if desired by the Operator. Additional meetings in any one year may be required as necessary to address incidents, operational issues, or other issues related to the Facility or Facilities.

[Note: Planning Commission recommendations are required for the following setback distances and/or alternate distances where mentioned, italicized and highlighted; and Planning Commission recommendations are required for each of the setback reduction options where and as mentioned, italicized and highlighted, including whether to include such setback reduction options]

2. Setbacks
   a. All Oil and Gas Facilities shall be located at least:
      i. *[2,000 (no change) or 2,500 or 3,000]* feet from any occupied structure as measured from the pad boundary.
      ii. *[2,000 (no change), or 2,500 or 3,000]* feet from the nearest boundary of a platted lot smaller than 15 acres in area as measured from the pad boundary.

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iii. 200 feet from any adjacent property's boundary line as measured from the pad boundary.
iv. 100 feet from public rights-of-ways as measured from the pad boundary.
v. *[2,000 (no change) or 3,000]* feet from a Designated Outside Activity Area as measured from the pad boundary.
vi. *[2,640 (no change) or 3,000]* feet from the nearest property line of an operating or closed landfill as measured from the pad boundary.
vii. Outside of a 100-year floodplain or at least *[500 (no change) or 1,000]* feet from the edge of any perennial surface water body that is not a public water reservoir, the ordinary highwater mark of any perennial or intermittent stream, or the edge of any riparian area, whichever is the greater distance, as measured from the pad boundary. Nothing in this setback shall be interpret as modifying any specific requirement for stream, surface water or riparian areas established with CPW~~, unless CPW has waived or modified the setback from the stream, surface water, or the riparian area following~~ in accordance with ECM~~COGCC~~ Rules 309 and 1202.
viii. All access roads shall be at least 250 feet from a residential or non-residential property line, excluding light or heavy industrially zoned properties.

b. The ~~s2,000 feet s~~etback~~s~~ from occupied structures or platted lots referenced in subparagraphs 5-3.6.F.2.a.i and ii above may also be reduced to ~~-~~a lesser setback:
i. If the owner(s) of all of the occupied structure(s) or all owners of the affected platted lots agree in writing to a lesser setback in response to a request for informed consent made in accordance with ECMC requirements for informed consent, and the fire district agrees to provide service to the Oil and Gas Facility; however, even with owner consent, in no case may the setback be reduced below *[500 (no change) or 1,000]* feet; or
ii. If, as shown on the Oil and Gas Facility Operations Plan submitted with the application, any and all wells, tanks, separation equipment, compressors and any stored hazardous or explosive materials on the Oil and Gas Facility pad will be located or stored more than the distance of the required setback ~~2,000 feet~~ from the nearest occupied structure or all affected platted lots; or
iii. The platted lot and occupied structures setback as measured from the pad boundary may be reduced below [2,000, 2,500, or 3,000] feet if~~If an Oil and Gas Facility application that includes a lesser setback is submitted, it must be~~ approved by the Board of County Commissioners through the Use by Special Review process provided in Section 5-3.4 of the Land Development Code. For approval of any lesser setback under this subparagraph, in addition to the criteria set forth in Section 5-3.4, the Operator must establish that the lesser setback as proposed will provide substantially equivalent protection to the~~a 2,000 foot~~ setback requirement and that granting the lesser setback will not adversely impact public health, safety, or welfare or the environment. In reviewing the proposed lesser setback, the Board of County Commissioners shall consider the extent to which the operator provides an alternative Oil and Gas Facility design, best management practices, control technologies, or proposes conditions of approval that will be effective to avoid, minimize, or mitigate adverse impacts on the affected properties, considering:
(a) geology, technology, and natural features, hazards or topography;

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~~(a)~~(b) ~~(b)~~ the location and use of occupied structures and proximity to those structures; ~~and~~

~~(b)~~(c) the anticipated size, duration, and intensity of all phases of the proposed oil and gas operations at the proposed oil and gas location; and~~.~~

~~(c)~~(d) the anticipated size, duration, and intensity of all phases of the proposed oil and gas operations at the proposed oil and gas location.

iv. However, in no case may the ~~2000 feet~~ setback from occupied structures or platted lots be reduced below [*500 (no change) or 1,000 or 1500*] *feet*.

c. The setbacks from a Designated Outside Activity Area may be reduced with the consent of the owner or manager of the Designated Outside Activity Area, but in no case may the setback be reduced below [*2,000, or 1,500, or 1,000*] feet for a designated outside actively area.

d. Provided that the Oil and Gas Facility remains entirely outside the boundary of any 100-year mapped floodplain, the setback from a perennial surface water body that is not a public water reservoir, the ordinary highwater mark of any perennial or intermittent stream, or the edge of any riparian area may be reduced in accordance with the provisions of Section 5-3.6.E.5 and provided that the reduction in setback is supported by an independent third-party professional engineering consultant with appropriate wetlands expertise or an independent third-party Wetlands Scientist, retained and paid for by the operator, and provided such reduction is consistent with any requirement of CPW and is not otherwise opposed by CPW. However, in no case may the setback be reduced below *500 ~~or~~* feet.

~~c.~~e. Reverse Setbacks: No new occupied structure shall be constructed less than:

i. 250 feet from an existing Oil and Gas well of any status (permitted but not drilled yet, drilling, completing, producing, active gas storage, injecting, shut-in, temporarily abandoned, dry and abandoned, or that was plugged and abandoned prior to 2014~~)~~.

ii. 150 feet from a plugged and abandoned oil and gas well or remaining equipment that was plugged and abandoned in~~from~~ 2014 or later~~onward~~.

~~d.~~f. Public Water Reservoir Setbacks: All Oil and Gas Facilities shall be located:

i. At least one mile (5,280 feet) from existing or planned public water ~~and permitted water~~ reservoirs with a capacity of 100 acre/feet or more and used or to be used for a potable water supply, unless the applicant can demonstrate that the Oil and Gas Facility is downgradient from the reservoir, in which case the setback shall be ~~2,000~~ 3,000 feet. The water reservoir setback shall be measured from the Oil and Gas Facility's pad boundary to the nearest high watermark of the reservoir or as mapped on reservoir plans approved with permitting for a planned ~~and permitted~~ reservoir.

ii. The *[downgradient reservoir and planned reservoir setback may be reduced below 3,000 feet]* if approved through the Use by Special Review process provided in Section 5-3.4. For approval of a lesser setback under this subparagraph, in addition to the criteria set forth in Section 5-3.4, the Operator must establish the following criteria: 1. The owner or operator of the reservoir does not object to the lesser setback; 2. Due to topography or other special condition of the site location, the lesser setback is necessary to allow for safe construction, installation, or operations at the Facility; 3. Alternative Oil and Gas Facility design, best management practices, control technologies, and/or proposed conditions of approval proposed for the Facility will be effective to avoid, minimize, or mitigate adverse impacts upon such drinking water sources, and that with such mitigative measures, the lesser setback as proposed will provide substantially equivalent protection as the setback requirement; 4. That

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granting the lesser setback for the Facility as proposed and designed will not adversely impact public health, safety, or welfare or the environment; and 5. No setback may be reduced below *[1,500 or 2,000] feet*.

iii. The one-mile reservoir and planned reservoir *setback for an Oil and Gas Facility (not downgradient) may be reduced if approved through the Use by Special Review process]* provided in Section 5-3.4. For approval of a lesser setback under this subparagraph, in addition to the criteria set forth in Section 5-3.4, the Operator must establish the following: 1. The owner or operator of the reservoir does not object to the lesser setback; 2. There is no evidence of any hydrological connection to the reservoir or planned reservoir; 3. Due to topography or other special condition of the site location, the lesser setback is necessary to allow for safe construction, installation, or operations at the Facility; 4. Alternative Oil and Gas Facility design, best management practices, control technologies, and/or proposed conditions of approval proposed for the Facility will be effective to avoid, minimize, or mitigate adverse impacts upon such drinking water sources, and that with such mitigative measures, the lesser setback as proposed will provide substantially equivalent protection as the one mile setback; 5. That granting the lesser setback for the Facility as proposed and designed will not adversely impact public health, safety, or welfare or the environment; and 6. No setback may be reduced below *3,000* feet.

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3. Health and Safety Requirements
   a. The Operator must submit an initial facility-specific Emergency Action Plan (EAP), which shall include ~~and~~ an initial facility-specific Tactical Response Plan (TRP), with any application for any new Oil and Gas Facility. The initial EAP ~~and the initial TRP~~ shall be forwarded to the County Office of Emergency Management ("OEM") for review. OEM shall review and approve or deny approval of the EAP and TRP within two weeks of submission by the Operator. ~~.~~ Provided that an Administrative Use by Special Review or full USR has been approved for the proposed Oil and Gas Facility and provided that OEM has approved the initial EAP ~~and the initial TRP~~ and further provided that required engineering permits have been obtained from Arapahoe County, the applicant or other Operator may commence construction of the pad and access road for the proposed Oil and Gas Facility. After the pad and access road have been constructed, the Operator shall prepare ArcGIS Shape files for the well pad and access road. ~~.~~ The initial and detailed EAP and TRP shall follow the templates as specified in the DAM.
   b. The EAP, including the TRP provisions, ~~and TRP~~ shall be updated annually and whenever there is any change in or need to change any of the content of the EAP or TRP, such as but not limited to, the addition or subtraction of chemicals used or stored on site.
   c. The Operator shall coordinate with the fire district having jurisdiction at the facility in establishing evacuation routes in the event of an emergency at the facility. Evacuation route considerations will include any occupied structures, platted lots, critical infrastructure, public facilities, schools, or other high-occupancy buildings that are within proximity to the oil and gas facility, and routes shall be based on guidance from the fire district and OEM.
   d. The Operator shall provide and maintain 24-hour contact information for the Operator and maintain 24-hour contact information for all contractors and subcontractors working at the facility. Operator shall provide all such contact information to the County upon request.
   e. The Operator shall maintain a Hazardous Materials Inventory Statement for all hazardous materials on site at the facility and shall provide the Statement to the fire district having jurisdiction at the facility and OEM on an annual basis.

f. The Operator shall provide OEM and the fire district having jurisdiction at the facility with a list of all reportable chemicals used or stored on each site from the time of construction to abandonment of the facility. The list of chemicals will be updated whenever new chemicals are added or removed, and such updated list shall be provided promptly to OEM.

g. Upon reasonable advance notice, no less than 8 hours, to the Operator, the Operator shall provide access to the fire district having jurisdiction over the facility and to County staff for inspection of the Oil and Gas Facility to determine compliance with applicable provisions of this Land Development Code, fire codes, and public safety standards.

h. The Operator shall mark all wells and all well pads with directional signage in a conspicuous place at or near the intersection of the access road with the public road, from the time of initial drilling until final abandonment. The Operator shall maintain signs in a good and legible condition and shall replace damaged or vandalized signs within fourteen (14) days. Directional signs shall be placed at locations and shall contain directions sufficient to advise emergency crews where drilling or completion is taking place.

i. A sign with the Operator's 24/7 contact information, ~~COGCC~~ECMC complaint website, shall be placed at the entrance to the Oil and Gas Facility. All signage content shall follow ~~COGCC~~ECMC regulations for such signage, except to the extent that ~~COGCC~~ECMC regulations are inconsistent with the above stated County signage content requirements.

j. The Operator shall repair any damages to County infrastructure or property caused by Operator's activities or omissions, or that is caused by any emergencies that occur at the facility, in compliance with the Operator's Road Damage Agreement.

k. Training
   i. The Operator shall conduct a coordinated training exercise with OEM and the fire district having jurisdiction at the facility for at least one well pad every year. If the Operator's standard well pad design layout changes, then an additional coordinated training exercise will be conducted that year and every time the standard pad design changes.
   ii. Key personnel at an Oil and Gas Facility are required to complete the National Incident Management System (NIMS) training courses IS-100.C and IS-700.B prior to commencement of drilling operations at the Oil and Gas Facility. Key personnel shall include those employees of the Operator and any field consultants who are team leads or equivalent having supervisory authority over any of the oil and gas operations conducted at the Facility. OEM may also specify additional specific training requirements pertinent to the proposed Facility that will be required for key personnel prior to the start of drilling. The Operator shall provide to County certificates of completion of the NIMS trainings required in this paragraph at least one week prior to the start of drilling and shall provide certificates of completion for any new or replacement key personnel at a Facility within one month of the person commencing work at the Facility.

l. Fire Prevention and Procedures
   i. The Operator shall work directly with the fire district having jurisdiction over the facility to determine if existing response capabilities are adequate to serve the site. If additional response capabilities are deemed necessary by fire district having jurisdiction over the facility, including provision for additional protections as determined to be necessary and reasonable by the Fire Protection District having jurisdiction over the Oil and Gas Facility for areas containing wildland urban interfaces, the operator will work with the fire district having jurisdiction to provide such additional response capabilities, including but not limited to fire suppression or emergency response assets, as are determined to be needed. The

operator will provide the identified assets to the fire district having jurisdiction to maintain and control for emergency response unless otherwise agreed upon in writing by both parties. The need for these additional assets shall be determined~~judged~~ on a case by case basis per well pad and may be viewed in terms of the cumulative impact of overall oil and~~&~~ gas development within the fire district having jurisdiction.

ii. No open burning, except flaring, shall occur on the site of any Oil and Gas Facility.

m. Incident Reporting

i. All emergencies shall be reported to 911 immediately upon discovery, and as soon as reasonably possible to Office of Emergency Management and the County Local Government Designee (LGD). In the case of an emergency situation where a delay caused by reporting would endanger public health, safety, welfare, or the environment or wildlife, the initial notice may be given orally. Formal incident reports are required for, but not limited to, the following incidents: spills, releases, uncontrolled release of pressure, loss of well control, vandalism, terrorist activity, fires, explosions, detonations, lightning strikes, any accidental or natural event that damages equipment, accidents resulting in fatalities, significant injuries or chemical exposures, or any condition or occurrence that threatens or harms safety on any of the Operator's facilities, including pipelines. Formal written incident reports for all reportable incidents shall be submitted to the Office of Emergency Management, the fire district having jurisdiction at the facility, and the County LGD within three (3) calendar days of the incident. When in doubt as to whether the incident is reportable, the Operator will contact the County LGD.

ii. In addition to the formal incident report, a post-incident meeting shall be required with County staff. The date, time and location of the post-incident meeting shall be determined by the Public Works and Development Director.

iii. The Operator shall submit copies of any initial and supplemental spill report filed with the ~~COGCC~~ECMC to the County LGD, OEM, and the fire district having jurisdiction at the facility, as well as any associated remediation reports, all within three calendar (3) days of filing with the ~~COGCC~~ECMC. Those copies may be submitted electronically, if electronic submission is available.

n. Spill and Release Reporting

i. The Operator shall provide a copy of the Spill Prevention, Control and Countermeasures (SPCC) Plan for each facility, prepared in compliance with 40 CFR Part 112 (as amended), to the fire district having jurisdiction at the facility and to OEM prior to the start of production. The Operator shall also provide to the fire district and OEM a listing of hazardous chemicals used on site if required by the Emergency Planning and Community Right-to-Know Act (42 USC 11001, *et seq*. as amended) and related regulations. If the holding capacity of any planned on-site equipment or storage tank is changed from what is identified in the SPCC or if the listing of hazardous chemicals is changed from what was identified in the SPCC, the Operator shall update the SPCC and provide the update to the fire district with jurisdiction over the Facility, to OEM and to the LGD.

ii. The Operator shall make available at each well pad and shall require its field staff or contractors to carry, spill response kits capable of mitigating small to mid-size spills (5 to 50 gallons).

iii. Operator shall submit all reports required under ~~COGCC~~ECMC Rule 912.b to OEM, the fire district serving the facility, and to the LGD. Spill containment and treatment does not relieve the Operator of any spill incident reporting obligations required under these or other applicable federal, State, or local law or regulations.

iv. The Operator will install automated safety systems on all new facilities. Each system will include a Surface Safety Valve ("SSV") or wellhead master control valve, installed before the commencement of the production phase and connected to the production tubing at the surface. The SSV or wellhead master control valve shall be capable of remotely shutting the well in should upset conditions be detected. The SSV will have documented, quarterly testing to ensure functionality per manufacturer's specifications. The Operator shall maintain and keep the quarterly testing results records for at least three years and said records shall be made available to the County upon request by the PWD Director.

v. The Operator shall conduct soil contamination sample testing at any location where a spill or release of any fluids have moved off the pad and shall provide the County with the results of such testing upon receipt of the results. Such testing shall include all areas where any fire-fighting fluids, whether in connection with fighting a fire on the pad or otherwise, have moved off the pad. Such testing shall analyze for the materials identified in ECMC Rule 615.e and shall include testing for PFAS contamination. Such testing shall be conducted in accordance with the requirements set forth in ECMC Rules 615.e and 913.b.(2) or as such Rules may be amended from time to time.

vi. In the event that any surface water located proximate to an Oil and Gas Facility may have been contaminated by a spill or release from the pad, the Operator shall test such surface water for any contamination from the pad and shall provide the County with the results of such testing upon receipt of the results. Such testing shall be done in accordance with the standards set forth in ECMC Rules 615. e and 913.b.(2) or as such Rules may be amended from time to time.

~~iv.~~vii. In the event that any of the testing shows material contamination from the pad, the Operator shall develop and implement a remediation plan to correct issues that caused the spill or release and to avoid or minimize and mitigate against future such spills or releases. Remediation shall be completed in accordance with all applicable State and Federal laws and regulations.

o. Operator shall provide hand washing facilities meeting Arapahoe County Public Health Department requirements at portable restrooms during drilling and completion operations.

4. Lightning Response
   a. If damage is sustained to any portion of a facility due to a lightning strike, the entire facility shall be shut in immediately and inspected by the Operator prior to restarting operations at the facility.
5. Secondary Containment for Onsite Storage Tanks
   a. Secondary Containment is required around aboveground produced water and crude oil storage tanks and shall be constructed of steel berms with synthetic liners or earthen berms constructed of compacted soil and armored with cobbles. Secondary containment shall be of sufficient capacity and effective to contain at least 1.5 times the volume of the largest tank.
   b. Secondary containment is required around any other aboveground storage tanks or containers of any liquid substance other than fresh water on well pads, and specifically including but not limited to solvents, methanol, fuels, coolants, antifreezes, or lubricants or

lubricating oil, and shall have sufficient capacity and be effective to contain at least 1.5 times the volume of the largest tank.

c. All secondary containment shall be inspected for evidence of discharge weekly by the Operator or their contractors and within 48 hours of any precipitation event sufficient to reduce the capacity of the secondary containment to less than 1.5 times the volume of the largest tank. Such accumulated precipitation must be removed within 24 hours of an inspection.

d. The Operator shall keep written records of secondary containment inspections and shall maintain such for at least three (3) years; the Operator shall make such records available to the County upon the written request of the PWD Director.

6. Disposal of Drill Cuttings
   a. Drill cuttings must be disposed offsite at least twice weekly, at a State-approved solid waste facility. No onsite disposal is allowed.
7. Pad Surface
   a. The surface of a pad shall be paved with either crushed granite or gravel, in a sufficient amount to eliminate of mud-tracking offsite and to comply with the County's Grading Erosion and Sediment Control regulations.
8. Number of Tanks and Tank Separation Requirements
   a. All oil and produced water storage tanks shall be spaced at least 3 feet apart.
   b. No Oil and Gas Facility shall be permitted to have more than a combined total of nine (9) oil, produced water and/or condensate tanks, or a total Facility capacity of no more than 6750 barrels.
9. Groundwater and Surface Water ~~Baseline~~ Sampling and Monitoring
   a. The report/plan shall demonstrate how the development and operations of the facility will avoid adverse impacts to surface and ground waters in Arapahoe County, identify all private and community permitted water wells of public record within ½ mile (2,640 feet) and demonstrate compliance with and implementation of standards in this section of this Code.
   ~~a.~~b. The Operator shall, at its own cost, perform initial baseline sampling and testing of all water sources located within one-half (1/2) mile radius of Oil and Gas Facility if requested by the owner of such water source or owner of land upon which such water source is located. If no water sources are available in a one-half mile radius of the proposed Facility, the Operator shall sample and analyze up to two (2) down-gradient water sources in a one-mile radius of the proposed Facility. The written results of such baseline testing shall be provided to the requesting property owner, ~~COGCC~~ECMC and to the County.
   ~~b.~~c. Water sampling and testing shall be performed in accordance with the standards and requirements specified in ECMC~~COGCC~~'s Rule 615(-e)~~a. through f.~~ or~~and~~ as may amended from time to time and shall be performed by independent third-party testing laboratories~~, except for 615 b. (2) and 615 c. (1)~~. The Operator shall document the GPS location of all water sources tested under this regulation.
   ~~c.~~d. The requirement to perform baseline testing of a water source~~all~~ upon request does not apply if the water source~~well~~ has~~already~~ been tested within the last twelve (12) months by any Operator in accordance with the requirements of this regulation and for which prior testing the Operator is able to furnish the~~such~~ results to County. Such testing is not required if the owner denies access to the water source for testing.
   e. The Operator shall also sample and test, on a one-time basis, down-gradient and perennial surface water within a one-half (1/2) mile of a proposed well pad prior to the construction phase.
   ~~d.~~
   ~~e.~~f. The Operator shall provide a letter notice to all owners of properties within a one–half (1/2) mile radius of the proposed pad with a water well listed in the State of Colorado Division of Water Resources database, to inform those water well owners of the opportunity to have their water wells sampled prior to drilling.

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g. For all water sources for which the Operator has performed initial baseline sampling at the request of the property owner in accordance with these regulations, including water well and surface water testing required herein, the Operator shall also perform subsequent sampling and testing within six (6) months of drilling of the Oil and Gas Facility~~of~~, again within twenty-four (24) months of completion of any well on the Facility, and thereafter every twenty-four (24) months for the life of all oil and gas wells on the Oil and G~~B~~as Facility pad.~~such water sources on the schedule specified in and in accordance with COGCC Rule 615.d.~~ The written results of such subsequent testing shall be provided to the requesting property owner, ~~COGCC~~ECMC and to the County.

h. If any of the above testing shows contamination from any of the materials identified in ECMC Rule 615.e, including but not limited to free gas or dissolved methane in excess of 1 mg/l or any thermogenic or a mixture of thermogenic or biogenic contamination, the Operator shall develop and implement an action plan to identify any sources of leaks, spills or releases from the pad or from the oil and gas operations that contributed to the contamination, and the Operator shall implement appropriate and effective corrective measures. The operator shall provide such plan to the County for comment and review.

i. The Operator shall perform periodic testing on a frequency of at least every 6 months, or in the event there is evidence of contamination, of any perennial surface water located within one half mile of Oil and Gas Facility. Such monitoring shall be performed at the point of the surface water body or stream that is closest to the Oil and Gas Facility and reasonably accessible for installation of the monitoring equipment. The Operator shall conduct flowline monitoring in accordance with the requirements of ECMC Rule 1102.

j. All surface and ground water testing required under this regulation shall be conducted in accordance with the requirements of ECMC Rules 615.e and 913.b.(2) and shall be conducted by an independent third party consultant approved by the County and paid for by the Operator.

k. If any of the periodic surface water testing shows any material contamination from any of the substances identified in ECMC Rule 615.e, including but not limited to free gas or dissolved methane in excess of 1 mg/l or any thermogenic or a mixture of thermogenic or biogenic contamination, the Operator shall develop and implement an action plan to identify any sources of leaks, spills or releases from the pad or from the oil and gas operations that contributed to the contamination, and the Operator shall implement appropriate and effective corrective measures. The operator shall provide such plan to the County for comment and review.

l. The requirements of this Section shall not prevent discharges reviewed and permitted by the CDPHE Water Quality Control Division, the ECMC, the EPA, and the Army Corps of Engineers.

10. Air Quality Monitoring

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a. **An Air Quality Mitigation Plan** shall be submitted with all O&GF applications to demonstrate how the development and operation of the facility will minimize and mitigate adverse impacts to air quality, and will demonstrate compliance with and implementation of standards in this section of the Code.

~~f.~~b. **Air Quality Monitoring**. The air quality mitigation plan will include a section on air quality monitoring that describes how the Operator will conduct baseline monitoring prior to construction of the O&GF. The monitoring plan shall also describe how the Operator will conduct monitoring on a frequency as specified in these regulations, and collect periodic canister samples (or equivalent method capable of speciated air samples) when standards are exceeded during the drilling, completion, and production phases of development. Air pollutants monitored shall include methane and total VOCs (including BTEX). At Operator's cost, a third-party consultant approved by the County shall conduct baseline and ongoing air sampling and monitoring. Such sampling and monitoring shall comply with the following requirements:

i. Baseline Testing: Prior to commencing any construction activities at a new Oil and Gas Facility, the Operator shall conduct baseline sampling of air quality at the site of the proposed facility using a continuous monitoring system that detects the following: wind speed, wind direction, temperature, humidity, pressure, particulate matter (PM2.5 and PM10),and all other possible emissions including but not limited to sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO), methane, ethane, propane, butane, total volatile organic carbon (VOC). Baseline testing shall also include a sample to be analyzed by EPA Method TO-15 (Determination of Volatile Organic Compounds (VOCs) in Air), which includes benzene, toluene, ethylbenzene and xylene. Operator shall conduct baseline testing within 500' of a proposed O&GF over a 30 day period immediately prior to drilling and provide a wind rose diagram to the County (division?) for evaluation of 4 proposed monitoring locations.

ii. Continuous Air Monitoring: During Drilling, Completion, and Production Phases, the Operator shall conduct continuous air monitoring using a system with the same detection capabilities as required for Baseline Testing. Continuous air monitoring is defined as sampling on a frequency of at least once per minute every twenty-four hours. Each hydrocarbon monitor shall include a sampling device to automatically collect a speciated air sample when the monitor levels reach a threshold concentration level defined by the third-party consultant or in response to a request by Arapahoe County Department of Public Works and Development. Meteorological monitoring is also required during the time period that air quality monitoring is conducted. Continuous monitoring of production operations will continue until three years have passed from the date the last well drilled on the site has entered the production phase, unless a school, licensed child care center, hospital, or residence is within 3,000' of the edge of the well site. In such instance, continuous monitoring shall be required until all wells are plugged and abandoned. Continuation of continuous monitoring may also be required at the discretion of the Director if repeated emissions at threshold concentrations are detected or as a result of repeated odor violations.

c. In the event a speciated sample is triggered, the County shall be notified as required by the Director. Depending on the circumstances, expedited lab analysis may be required.

d. The air quality monitoring plan shall meet the minimum requirements of AQCC Regulation 7 section VI.C. and receive approval from the Air Pollution Control Division prior to beginning air quality monitoring at the permitted site of the O&GF.

i. When submitting the air quality monitoring plan to ACPD the operator shall submit at least 90 days in advance of the pre-drilling monitoring to account for the County's 30-days of pre-drilling air quality monitoring requirement.

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ii. The air quality monitoring plan submitted to ACPD for review shall include the pollutants identified in this Section.

iii. APCD will review the monthly reports of the air quality monitoring plan through the 6 months of early production. After the 6-months, the Operator shall retain a third-party consultant to implement the approved monitoring plan to monitor air quality for the timelines identified in 11.b.c. Monthly reports would then be submitted to the County rather than APCD by the last day of the month.

iv. The Air Quality Mitigation Plan must consider the cumulative impacts to existing air quality including ambient air quality standards for ground-level ozone, meeting oil and gas sector greenhouse gas reduction targets, and the cumulative impacts of all approved and existing oil and gas operations within the County. The cumulative impacts plan prepared for the ECMC may be used to meet this requirement.

e. In addition to all federal and state laws, rules and regulations, applications for O&GFs shall demonstrate how exploration, construction, and standard operations of an O&GF will comply with the rules and regulations of the Colorado Air Quality Control Commission (AQCC). Information to be provided shall include all appropriate applications of notifications and permits for sources of emissions.

f. Reduced Emission (Green) Completions, as defined in ECMC Rule 903.c.1, as may be amended, shall be used for all completions and well workovers.

g. The Following Air Quality Best Management Practices shall be required unless an equal or better system exists:

i. Zero emission desiccant dehydrators.
ii Emission controls of 98% or better for glycol dehydrators.
iii. Pressure-suitable separator and vapor recovery units.
iv Zero emission pneumatic devices.
v. Automated tank gauging.
vi Require dry seals on centrifugal compressors.
vii Routing of emissions from rod-packing and other components on reciprocating compressors to vapor collection systems.
viii Control emissions by 98% during storage tank hydrocarbon liquids loadout (i.e. loading out liquids from storage tanks to trucks).
ix Reduction or elimination of emissions from flowline maintenance activities such as pigging, including routing emissions to a vapor collection system.

h. Leak Detection and Repair: During the Production Phase, the Operator shall develop and maintain a Leak Detection and Repair (LDAR) program as required by CDPHE using modern leak detection technologies such as infra-red (IR) cameras for equipment used on the Oil and Gas Facility. Inspections must occur at least monthly. More frequent inspections may be required based on the design, size and location of the facility, or as appropriate based on continuous monitoring. If an infrared (IR) camera is used, operator shall retain an infrared image or video of all leaking components before and after repair. Any leaks discovered by operator, including any verified leaks that are reported to the operator by a member of the public, shall be reported to the County immediately upon discovery. Any leaks detected shall be promptly repaired within 72 hours, and a written report thereof documenting what leaked, the duration of the leak, the estimated volume of the leak, and such remediation and repair measures taken in response.

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i. **Leak Detection and Repair Plan** shall be submitted with all O&GF applications and updated at least once every three years. The plan shall disclose techniques, methods and protocols that will be utilized at the proposed O&GF to identify, prevent, contain, document, repair, and report leaks, and shall demonstrate how it will comply with and implement the standards in this section of the Code.

ii. The provisions of this section of the Code are applicable to both new and existing O&GF.

iii. Operators shall conduct leak detection and repair inspections at every O&GF a minimum of once every month or at greater frequencies as required by the APCD (Air Pollution Control Division) or Arapahoe County PWD, for the emission source using modern leak detection technologies (infrared cameras, etc.) and equipment. The results of said inspections, including all corrective actions taken, shall be reported to the Arapahoe County PWD and ACHD and County Local Government Designee (LGD) upon request.

iv. Repair of leaks shall occur within 72 hours of detection. If a leak is not repaired within 72-hours, the Operator must use other means to stop the leak including, but not limited to, isolating the component or shutting in the well, unless such other means will cause greater emissions. If it is anticipated that a repair will take longer than 72 hours, the Operator shall provide a written explanation to the LGD and ACHD as to why more time is required and how the leak will be contained.

v. Equipment leaks that pose an imminent safety risk to persons, wildlife, or the environment require the Operator to take the most appropriate safety response action, which may include shut down of the affected equipment or facility and not be allowed to resume operation until the Operator has provided evidence that the leak has been repaired.

vi. At least annually, Operators shall provide a 2-week notice of a routine leak inspection to the LGD and ACHD inviting them to attend and observe the inspection.

j. Data: The Operator shall maintain the data collected from such baseline sampling, continuous monitoring and LDAR program and equipment maintenance logs for a period of three (3) years from the date of its collection and shall supply such data to Arapahoe County PWD and to CDPHE and ECMC on a monthly basis.

j. Sampling and Monitoring: Continuous monitoring to detect leaks or measure hydrocarbon emissions and monitor meteorological data shall be required as provided in these regulations. All sampling and monitoring shall be performed by an independent third-party consultant, approved by the County and paid for by the Operator. Samples shall be taken at such locations as are established by the consultant as most effective, and continuous monitoring equipment shall be maintained at a minimum of four locations on and around the Oil and Gas Facility. Any continuous monitoring system shall be able to alert the operator of increases in air contaminant concentrations. Operator shall report any onsite events that may have contributed to excess emissions within 24 hours of the emission concentration exceedance.

k. Air quality requirements for both new and existing facilities.

i New and existing O&GF shall utilize operational provisions to the extent practical to reduce emissions on Air Quality Action Advisory Days posted by the CDPHE for the Front Range area. The provisions shall include how alerts are received, outline specific emission reduction measures, and include requirements for documenting the measures implemented. Measures should include:

a. Minimizing vehicle traffic and engine idling,

b. Reducing truck and worker traffic,

c. Delaying vehicle refueling,

d. Suspending or delaying use of fossil fuel powered equipment,

e. Postponing construction and maintenance activities unless repairing identified leaks or releases,

f. Postponing well maintenance and liquid unloading that would result in emission releases to the atmosphere, and

g. Postponing or reducing operations with high potential to emit VOCs of NOx.

ii Venting is prohibited except as allowed in ECMC rules.

Iii Flaring is prohibited except as allowed in ECMC rules.

~~10.~~11. Noise Mitigation Requirements

a. Beginning with construction and up to the first 6 months of production, a third-party consultant approved by the County must conduct continuous noise monitoring in fifteen-minute increments near well sites and maintain records for two years to verify the noise mitigation is effect and meets standards. All data shall be made available to the County on request.

~~a.~~b. Noise emitted from the facility pad shall not exceed 60 dBA or 65dBC, measured at the nearest property line of the property with the nearest occupied structure. These noise levels, as measured, constitute the Maximum Permissible Limit of noise that may be allowed to emanate off site from the Oil and Gas Facility.

~~b.~~c. During the hours between 7:00 AM and 7:00 PM, the maximum permissible noise levels may be increased 10 dB(A) for a period not to exceed 15 minutes in any 1-hour period. The increase is permissible only for a 1-hour period during any 12 hours.

~~c.~~d. The Operator may apply for a modification or waiver to exceed the Maximum Permissible Limit in accordance with and subject to the standards in Section 5-6-3.6.E.5 above where the Oil and Gas Facility is proposed to be located in an area with existing ambient background noise levels that are at or above the Maximum Permissible Limit or if proposed for an area that is sufficiently remote from any property with an occupied structure or any High Priority Habitat, provided that the lack of High Priority Habitat is supported by recommendation of

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CPW. The Operator may also apply for a waiver in accordance with and subject to the standards in Section 5-6.3.6.E.5 of the requirements below to prepare a noise survey and noise mitigation plan for a pad site that will not contain any oil and gas wells and will not be drilled or fracked.

~~d.~~e. The Operator shall conduct an ambient noise survey for each proposed well pad no more than 90 days prior to application in order to establish baseline noise levels for the site, and the Operator shall also conduct noise modeling for the well pad to simulate noise during drilling and completion.

~~e.~~f. The noise surveys and the noise modeling shall be used to create a Noise Mitigation Plan for the site for keeping sound emissions from the site within the Maximum Permissible Limit. The Noise Mitigation Plan shall describe noise mitigation practices, equipment, strategies, infrastructure, or other strategies to be used and implemented at the Oil and Gas Facility in order to comply with the Maximum Permissible Level of noise emanating from the Facility. The Operator shall update the Noise Mitigation Plan for any changes in equipment that may reasonably be expected to affect the ambient noise levels at the site or if the Facility is not constructed within two (2) years of the date of the County's Administrative Use by Special Review or Use by Special Review approval for the Facility. The Noise Mitigation Plan shall also be updated if any new occupied structure is constructed within 2,000 feet of the pad boundary, between the time of Administrative Use by Special Review or Use by Special Review approval of the Facility and the commencement of drilling. The Operator shall provide the updated Noise Mitigation Plan and implement any strategies identified in the updated plan prior to putting such new equipment into operation or prior to commencing construction of the Facility as applicable.

~~f.~~g. If the noise modeling indicates that noise levels for either or both A-Scale (dBA) and C-Scale (dBC) noise for drilling and completion will exceed the Maximum Permissible Level at the property line of any property with an occupied structure, where that structure is within 2,000 feet of the pad, additional noise mitigation measures will be required as necessary to achieve the Maximum Permissible Level.

~~g.~~h. If the noise modeling indicates that drilling or completion activity or production equipment on a well pad without noise mitigation will exceed the Maximum Permissible Limit, notwithstanding other mitigations that may be proposed in the Noise Mitigation Plan, sound walls shall be constructed prior to both drilling and completion commencing.

~~h.~~i. The Noise Mitigation Plan shall address noise/vibration through sound walls and other practices such as, but not limited to, utilizing electric equipment, Tier 4 diesel engines, installing mufflers or covers on noisy equipment or the use of Quiet Fleet™, or similar noise mitigation. If sound walls will be required for mitigation of noise during completion, they shall be erected prior to drilling.

~~i.~~j. Additional mitigations, as necessary to achieve the compliance with the Maximum Permissible level, must be described and used by the Operator if C-scale noise levels are increased to the larger of either (i) 5db over ambient or (ii) 65 dBC at the property line of the property upon which the nearest occupied structure exists. The County may require larger setbacks and/or sound walls or other structures on a case-by-case basis for mitigation of C scale noise, based on data from the noise model.

~~j.~~k. The Operator shall follow the most recent and most appropriate BMPs to reduce noise related to drilling and completion.

~~k.~~l. Tubular goods may not be unloaded from 8 PM to 7 AM unless there are no occupied structures within 2,640 feet

~~l.~~m. Engine idling shall be minimized. Between the hours of 7:00 p.m. and 7:00 a.m., engine idling is limited to 10 minutes.

~~m.~~n. The Operator shall provide a 24-hour contact number for noise complaints on the facility sign required in section 5-3.6.F.3.h, as well as the ~~COGCC~~ECMC's complaint hotline number.

~~11.~~12. Access Road Standards

a. Prior to commencing construction of the Oil and Gas Facility, the Operator shall connect the site via an access road designed to support an imposed load of 80,000 pounds that will accommodate emergency response vehicles such as, but not limited to, law enforcement, emergency command vehicles (cars/SUVs), ambulances, hazardous materials response vehicles, water tenders, and fire apparatus during construction and operation of new tank batteries, new drilling activity and reworks or recompletions of existing wells, unless a local fire department or fire district agrees in writing to a different or lesser standard for the access road..

b. Access roads shall be constructed to be at minimum twenty (20') feet wide with at least six (6") inch road base.

c. The Operator shall maintain such access roads in good condition and suitable for emergency vehicle use until such time as the Oil and Gas Facility has been plugged and abandoned.

~~c.~~d. If an Oil and Gas Facility site incident could prevent emergency access on public or private roads, the Operator shall construct an alternative access road meeting these standards, unless Office of Emergency Management staff and the fire district having jurisdiction at the facility, determine that the current condition is adequate.

~~d.~~e. Best efforts will be made to improve inadequate access to existing tank battery sites identified by the fire district or County as determined through service calls and demonstrated problems of access to the site.

~~e.~~f. The County and/or appropriate emergency response agency may conduct spot inspections of access roads to ensure that emergency access in accordance with this section is maintained.

~~12.~~13. Odor Mitigation

a. The Operator shall prevent odors migrating offsite during drilling through the use of low-odor ~~Category III~~ drilling fluid, unless a waiver or modification is allowed under 5-3.6.E.5 of these regulations

b. The Operator shall use closed-loop systems in place of open pits.

c. The Operator shall proactively respond to and address odor complaints.

d. The Operator may be required to address odor complaints with additional measures such as wiping down drill pipe, increasing mud additives, using filtration systems, enclosing shale shakers and frequently transporting drill cuttings offsite for disposal.

~~13.~~14. Site Lighting

a. All site lighting shall be directed downward and inward to prevent light spill outside the pad.

b. Wherever possible, lights will be mounted on the inside of the sound wall.

c. Any lights not concealed by a sound wall must be IES (Illuminating Engineering Society) full cutoff or shielded/screened to minimize the amount of light leaving the pad

d. During the production phase, site lighting shall be turned off between the hours of 10:00 PM and dawn. Motion-sensing lights may remain active during those hours.

e. Upon receipt of a lighting complaint and review by the Planning Division, the Operator may be required to address lighting complaints within 24 hours of the Planning Division's review of the complaint, with additional mitigation measures.

~~14.~~15. Visual Mitigation

a. Well pads within 1,320 feet of a property line of a property containing an occupied structure, a platted lot, or a parcel of 40 acres or smaller, shall be designed with some form of visual mitigation, to include but not be limited to, low-profile production equipment, opaque fencing, berming, or landscaping.

b. Landscaping or fencing around the perimeter of the pad shall be installed within nine (9) months ~~one year~~ of the first well's completion. The screening shall be designed to minimize visual impacts from adjacent properties and the nearest streets.

c. Production pads shall be maintained free of vegetation, except such vegetation as may be required for interim reclamation or Arapahoe County GESC regulation requirements, and shall be maintained free of rubbish and debris. For the purposes of this Visual Mitigation regulation only, a production pad may exclude the reclaimed area, approved through a County-issued GESC permit.

d. Storage of equipment not associated with the on-going oil and gas operations at a specific pad is prohibited on that pad.
e. Privacy or solid fencing shall be Class 5 – Solid Fencing as defined in section 4.3 of the Land Development Code, at least 8 feet high and painted or stained with natural wood colors.
f. Whenever possible, the Operator shall use existing natural contours and existing vegetation to conceal the site from view.
g. Whenever possible, the Operator shall minimize the size and number of tanks and equipment installed or maintained on a production pad. When available, as provided below, use of pipelines to reduce the size and number of tanks and equipment maintained on a production pad is encouraged.

~~15.~~16. Locks/Emergency Access Hardware

a. The Operator shall provide approved emergency access hardware for any locked facility gates or access points.

~~16.~~17. Traffic Mitigation and Reduction Measures

a. The Operator shall make best efforts to schedule its traffic to limit heavy truck traffic on County roads during peak commuting hours and during school bus hours and shall comply with any restrictions established in accordance with the Road Damage Agreement.
b. The Operator shall use pipelines for the transport of produced water and hydrocarbon liquids from the well pad, wherever available.
c. To reduce traffic associated with the Operator's drilling and completion activities, the Operator is allowed to use temporary surface lines for transportation of water needed during drilling and completion or Modular Large Volume Tanks (MLVTs) for storage of water needed during drilling and completion. Provided that the MLVT is located on or contiguous with the Oil and Gas Facility pad, the MLVT may be approved with the Administrative Use by Special Review application or by amendment to an approved Administrative Use by Special Review. The Operator may use County Road Right-of-Way, and County drainage culverts, where practical, for the laying and operation of temporary water lines on the surface, provided that the County's Engineering Services Division approves the locations of the temporary water lines through a street-cut/right-of-way permit issued in accordance with the Arapahoe County Infrastructure Design and Construction Standards. The Operator will bury temporary water lines at existing driveway and gravel road crossings, unless the PWD Director approves an alternative to burying the lines in accordance with section 5-3.6.E.5 above.
d. Prior to commencing construction of an Oil and Gas Facility, the Operator shall execute a Road Damage Agreement for the site or shall have executed a field wide Road Damage Agreement for all sites within the County. Such agreement shall be in a form approved by and acceptable to the County.
e. Consistent with the Road Damage Agreement, the Operator shall provide the County with a truck access route for evaluation and approval by the County. The County may require a route that minimizes impact on nearby residents and/or a particular County roadway.

~~17.~~18. Wildlife, Wetlands, Riparian Areas and Stream Channel Measures

a. The Operator shall implement the recommendations of Colorado Parks & Wildlife (CPW) that address any site-specific site conditions. unless a waiver or modification is approved in accordance with Section 5-3.6.E.5 above.
b. Wetlands boundaries shall be determined by a Professional Wetland Scientist (PWS) and those boundaries shall be indicated on the Administrative Use by Special Review plan.
c. Crossings of defined streambed and banks (stream channels) by flowlines and pipelines must be bored underneath and not trenched.
d. All crossings of riparian areas by flowlines and pipelines shall be bored under, starting 500 feet from the edge of the riparian area. All crossings of riparian corridors by access roads will be constructed with culverts, approved by Engineering Services Division.
e. The Operator shall avoid constructing in CPW-mapped High Priority Habitats (HPH) to the maximum extent possible. If an operator elects to construct in an HPH polygon, then they will

be subject to minimization and/or mitigation measures as specified in ~~COGCC~~ECMC's 1200 Series Rules, as well as any applicable CPW recommendations.

f. Fencing that bisects streams is prohibited.

~~18.~~19. Floodplains/Floodways Restrictions

a. Storage of hazardous or floatable materials in the floodplain is prohibited.

b. Oil and Gas facilities shall not be located in a floodplain. Access roads, and underground pipelines and flowlines are permitted to cross floodplains provided that they are designed to meet Arapahoe County Floodplain Regulations and the Infrastructure Design and Construction Standards or other applicable Engineering Standards and those crossings are in accordance with a F~~f~~loodplain Development permit issued by the Arapahoe County Floodplain Administrator in accordance with Section 5-4.3 of the Land Development Code.

~~19.~~20. Notification of Commencement of Geophysical Exploration/Seismic Testing, Construction, Drilling, Completion, and Flaring

a. The Operator shall provide advance written notice to the Planning Division of the projected commencement of geophysical exploration/seismic testing; the construction phase, drilling phase, and completion phase of each new well; and each workover one week prior to the start of each phase.

b. Flaring shall be reported to the County LGD via email or text message prior to flaring whenever possible, or during the flaring event. An updated notice will only be required if the commencement of any phase is delayed more than one week from the original date indicated in the notice.

~~20.~~21. New Technologies

The County may require modifications to equipment for drilling, completion, or production operations, and monitoring of emissions to incorporate new technologies for reduction of noise, odor, dust or for mitigating other surface impacts caused by the Oil and Gas Facility or its operations if such new technologies are technologically sound, economically practical, and commercially available to the Operator.

~~21.~~22. Compliance With Laws and Regulations

The Oil and Gas Facility shall be operated in compliance with all applicable federal, state, and local laws and regulations.

G. Approval/Denial/Conditions of Approval of Administrative Use By Special Review/Appeal

1. Action to Approve, Conditionally Approve or Deny

The PWD Director may approve, approve with conditions, or deny an Administrative Use by Special Review application for an Oil and Gas Facility. Written notice of the decision shall promptly be provided to the applicant, and, if denied, the notice shall include a statement of the reason(s) for denial.

2. Revocation of Approval

Approval may be revoked, after notice of the grounds for such proposed revocation and a hearing before the Arapahoe County Board of County Commissioners, if the Operator fails to meet or fails to continue to meet any requirements of this Land Development Code or any Conditions of Approval governing the installation and operation of an Oil and Gas Facility. The hearing will be conducted as a general business item at a regular meeting of the Board of County Commissioners. At said hearing, the Planning Division shall present evidence of the grounds for revocation of the approval and the Operator shall be afforded the opportunity at such hearing to present evidence in response to the proposed revocation. The Operator may appeal the Board of County Commissioners' decision in accordance with Rule 106(a)(IV) of the Colorado Rules of Civil Procedure.

3. Recordation

Arapahoe County Public Works & Development shall record the approved permit for an Administrative Use by Special Review or for a Use by Special Review under Section 5-3.4 of the

Land Development Code and the approved site plan in the Office of the Arapahoe County Clerk and Recorder within 30 days of the approval. The applicant shall pay any recordation fees.

4. PWD Director's Discretion to Refer to the Board
   In lieu of the PWD Director making a decision on an application, the Director has the discretion to refer any application for Administrative Use by Special Review or amendment thereto to the Board for its consideration and decision at a public hearing. In such event, the Board shall make its determination based upon the requirements of this Section; however, unless waived by the Board, compliance with the notice requirements set forth in Section 5-3.4.C.2. is required prior to the Board hearing. At such public hearing, the Board may approve, approve with conditions, or deny the application.
5. Expiration of Approval
   a. An approval of the Administrative Use by Special Review, as delineated in the application, shall automatically expire three (3) years after the date of recordation, unless the facility is already substantially commenced by the drilling of at least one well on a pad.
   b. For good cause shown, the Planning Division Manager or designee may grant a time extension to the expiration date stated in this Section for up to one year, upon a written request by the applicant. Such request shall be submitted in writing to the Planning Division Manager no less than sixty (60) days before the date of expiration of the approval.
   c. The Board may, for good cause shown, grant an additional extension for an additional one-year period.
   d. If drilling of a well is not completed within the time allowed under the original permit or any extension granted pursuant to this Section 5-3.6.G.5, the approval shall lapse and a new application is required. After a lapsed approval, the Oil and Gas Facility may be constructed, completed, or produced only in compliance with the Land Development Code in effect at the time of the new application.
6. Permits Required Prior to Commencement of Operations
   a. If applicable under the Land Development Code or other Arapahoe County code or regulation, an Access Permit issued under the Infrastructure Design and Construction Standards, a GESC Permit, a Roadway Damage Agreement and Oversize/Overweight Vehicle Permit shall be required prior to the development of an Oil and Gas Facility. A Floodplain Development Permit shall be required prior to any work within a floodplain. A Building Permit may be required prior to construction of structures or the erection of equipment within the Oil and Gas Facility in accordance with the Arapahoe County Building Code.
7. Appeal of Decision on Application for Administrative Use by Special Review
   a. An applicant may appeal the Public Works and Development Director's denial of an application for an Administrative Use by Special Review for an Oil and Gas Facility, denial of a waiver request, or any conditions of approval, to the Board of County Commissioners for a *de novo* hearing. The Applicant must file the appeal within fourteen (14) calendar days of the date of the PWD Director's decision by submitting a letter of appeal to the Planning Division Manager. Thereafter, the matter will be scheduled on the next available agenda of the Board, following public notice required by Section 5-3.4.C.2. At such hearing, the Board may affirm, reverse, or modify the decision of the PWD Director, based upon the criteria set forth in this Section 5-3.6.

H. Administrative Amendment

If the Applicant or the Operator proposes changes from the plans approved through the Administrative Use by Special Review, including but not limited to any changes in the source or location of water to be used by the Oil and Gas Facility, the type and size of equipment on the facility or visual mitigation measures, the Applicant is required to submit an amendment to the approved Administrative Use by Special Review plans showing the proposed changes. The PWD Director may approve, conditionally approve, or deny the proposed amendment in accordance with the provisions of this Section 5-3.6. The proposed amendment will be reviewed by PWD staff and, as needed for the review of the application, PWD Staff may require additional information. The amended application will need to meet

all requirements of this Section and be approved in writing. If the BOCC approved the original application on appeal, as a USR, or by reason of its otherwise having been elevated to the BOCC for decision under this Section 5-3.6, the proposed amendment shall be referred to the BOCC for consideration and decision following public hearing as provided in Section 5-3.6.G.4 above. The PWD Director may exercise his or her discretion to elevate any proposed amendment to the BOCC for consideration and decision as provided in Section 5-3.6.G.4 above. Upon recommendation of PWD Staff, the PWD Director may waive the need for amendment of the Administrative Use by Special Review or other BOCC approved Oil and Gas Facility permit provided that the proposed change is found to be minor, with no material effect to or departure from the original approval, and without the potential for significant surface impacts to public health, safety, welfare, or the environment at the Facility site.

I. Transfer/Sale of Facilities to a New Operator

The Operator must notify the Planning Division in writing within seven days of the closing of any transfer of an Oil and Gas Facility or Facilities to a different Operator or other successor owner. Prior to commencing any operations at the site of the transferred Oil and Gas Facility, the new Operator or successor owner must first provide the following to the County:

1. Letter(s) authorizing the transfer of the Oil and Gas Facility operation as approved through the original Administrative Use by Special Review or Use by Special Review approval for the Facility to the new Operator and the new Operator's written acceptance of responsibility for the operations at the Oil and Gas Facility and agreement to abide by all terms and conditions of the Administrative Use by Special Review or Use by Special Review approval.
2. The Operator must meet with the LGD to discuss any pertinent issue relative to the new Operator's assumption of operations of the Oil and Gas Facility, including plans for development of pipeline installation to serve the Oil and Gas Facility.
3. An updated Emergency Action Plan (EAP) and Tactical Response Plan (TRP), two weeks prior to the transfer, with contact information for at least two employees of the new Operator.

J. Non-Administrative Approval Process

Use by Special Review approval for an Oil and Gas Facility may also be requested through the process described in Section 5-3.4 of this Code, subject to the following modifications:

1. Plan Format
   The site plan shall comply with the requirements of the Development Application Manual, Non-Administrative Use by Special Review for Energy Facilities. In addition, the final document shall be submitted in both paper and electronic forms instead of Mylar, notwithstanding the requirements for a Use by Special Review contained in the Development Application Manual.
2. Criteria and Standards
   In addition to the criteria set forth in Section 5-3.4 of the Land Development Code, an application for Use by Special Review for an Oil and Gas Facility will also be evaluated under the criteria specified in Section 5-3.6.D above and shall comply with the Standards specified in Section 5-3.6.F above, and shall be operated in compliance with the requirements of this Section 5-3.6. In addition, the provisions of Section 5-3.6.G.1 through 7 shall apply to an Oil and Gas Facility approved as a Use by Special Review. Also, Section 5-3.6.I shall apply to the transfer of any Oil and Gas Facility approved by a Use by Special Review.
3. Expiration of Approval
   An approval of a Use by Special Review shall automatically expire three (3) years after the date of recordation, unless the facility well pad is already substantially commenced by drilling of at least one well. The Operator may request and extensions as described in Section 5-3.6.G.5 above.

K. ~~COGCC~~ECMC and County Approvals Required

Development of an Oil and Gas Facility shall not commence until and unless any required permits from the State or County, and a Use by Special Review (administrative or non-administrative) from the

County, have both been approved. Prior to construction, the Operator must submit proof of any insurance and bonding that are required or may be required by these rules.

Chapter 6:

6-1 DEFINITIONS

Downgradient
At lower elevation from that of the reservoir measured at its average water level elevation or that there is intervening natural terrain or topography that prohibits the surface mitigation of liquids to the reservoir and there is no evidence of other hydrological connection from the proposed location to the reservoir.

Flowline
A segment of pipe transferring oil, gas, or condensate between a wellhead and processing equipment to the load point or point of delivery to a U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration or Colorado Public Utilities Commission regulated gathering line or a segment of pipe transferring produced water between a wellhead and the point of disposal, discharge, or loading. This definition of flowline does not include a gathering line as defined by ~~COGCC~~ECMC Rules or any line that would otherwise meet the foregoing description will not be considered a flowline if all of the following are satisfied:

-the operator prospectively marks and tags the line as a support line;
-the line is not integral to production;
-the line is used infrequently to service or maintain production equipment;
-the line does not hold a constant pressure; and
-the line is isolated from a pressure source when not in use.

Pipeline
A crude oil transfer line or gathering line as defined in the ~~COGCC~~ECMC rules.

Planned ~~and Permitted~~ Public Water Reservoir
An unconstructed, but planned public water reservoir of qualifying capacity for which the location of such planned reservoir is established in the public record at a specific and mapped location within unincorporated Arapahoe County and that:

i. has received or applied for approval through a water court adjudication; ***or***
ii. has received federal, state, or local permit approval required under applicable law for construction of a reservoir.

Attachment 7: Proposed Rules Stakeholder Comments Summary

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
Industry		
Colorado Oil & Gas Association (COGA)	One-mile Setback from Existing Water Reservoirs	Not reasonable or necessary to protect public health, safety, welfare, or the environment and wildlife resources. Water Quality Control Division ("WQCD"), amended prior Rule 317B into current Rule 411 and set a conservative setback from surface water supply areas. Under Rule 411.a.(2)i. operators may not conduct any new surface disturbance within an area between 0 and 1,000 feet hydraulically upgradient from the water source. The Statement of Basis, Purpose, and Specific Statutory Authority ("SBP") to Rule 411 explains the Commission's finding that even "larger volume spills or releases are highly unlikely" to migrate 1,000 feet. Based on this finding, arrived at after extensive consideration of scientific literature and party testimony on top of consultation with the [CDPHE Water Quality Control Division] WQCD, "[t]he Commission accordingly adopted the 1,000 foot internal buffer to provide a reasonably protective margin of error to protect public health from potential spills and releases." There is no COGCC setback for oil and gas facilities downgradient of surface waters. … also take issue with the language providing that the Water Reservoir Setback "may be" reduced with approval of the reservoir owner or operator. First, this gives the reservoir owner and operator too much authority. The setback should be based on hydrological science.... Second, should a variation of this language persist in future regulation drafts, there is no reason why approval should not automatically reduce the setback. This draft language states that the setback permissively "may" be reduced, but doesn't explain under what circumstances it would not be reduced. The County should adopt language to clarify an upgradient setback of 1,000'—as is consistent with COGCC and WQCD findings—and allow downgradient oil and gas operations to proceed within 1,000' where hydrologic data supports a lesser setback. Recommend the County adopt a 1,000 ft setback from existing water reservoirs and provide for a lesser setback where geologic features support a lesser setback, consistent with COGCC's Rule 411 and would represent combined wisdom of the COGCC and WQCD.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
	One-mile Setback from Planned Reservoirs	Planned water reservoirs should not be included in the Water Reservoir Setback provision. A planned reservoir may never come into being. Or, the reservoir's construction timeline might be such that an oil and gas operator could drill and complete wells before the reservoir is even constructed.
	Relationship to State of Colorado Rules - Finding Violations under Federal and State Law	Duplicative. This provision allows the County to prosecute violations of state and federal law and … it could easily lead to duplicative and inconsistent enforcement actions. The County is the proper arbiter of its rules, whereas other state and federal agencies are the appropriate entities to determine whether there has been a violation of their respective schemes and what the outcome should be. The County lacks insight into state or federal agencies' enforcement policies and cannot prosecute violations with the nuance expected of those laws' seasoned experts. Foisting this responsibility on to the County runs a palpable risk that its enforcement actions will not be in keeping with the desires of the state and federal bodies in charge of overseeing the applicable laws' enforcement. … the language uniquely purports to allow the County to enforce state and federal law, whereas in the many other instances where the County's regulations refer to state and federal law, the County never purports to give itself enforcement of the same.
	Alternative Access Roads	Vague and ambiguous. Could lead to unnecessary surface disturbance to construct a secondary access road that is unnecessary to ensure that traffic can circulate in the event of an emergency at an oil and gas facility. .,.. adopt the alternative language it has provided for Section 1-1.1.F.11.b. [Access Road Standards]. This language … reflect[s] the intent … which is to ensure an emergency at an oil and gas facility does not impede general traffic circulation.
Civitas Resources	One-mile Setback from Existing Water Reservoirs	No basis in hydrologic and technological realities. When COGCC promulgated Rule 411 they found that spills and releases are "highly unlikely" to migrate 1,000 feet from well pads, even in the case of larger volume spills or releases. One mile is over 5 times the state's conservative analogous setback to protect water quality and public health. … fluids cannot be reasonably expected to travel that distance, especially if the oil and gas facility is downgradient of the reservoir or is otherwise isolated by topography from the reservoir. Moreover, the risk that a spill or release capable of leaving an oil and gas facility and migrating into a water source will occur has been drastically minimized over the past few years because of improved industry best management practices and heightened state

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
		requirements. Relevant requirements include, among others, stringent wellbore integrity rules and heightened rules regarding secondary containment.
	One-mile Setback from Planned Reservoirs	Reservoir permitting and construction is a decades-long process that requires significant capital backing and approvals from numerous agencies. Applying broad setbacks from water bodies that may never be built, and whose construction may lie decades in the future after oil and gas operations are concluded if they are, is over-restrictive and does not fairly balance stakeholders' land use entitlements [i.e. mineral rights].
	Relationship to State Rules	The County does not have authority to enforce state or federal law. Had it the authority, the County attempting to enforce state or federal law may lead to duplicative and inconsistent enforcement actions. Also it's an outlier to other parts of the Code where the County requires applicant to comply with state and federal law. It's unreasonable and unnecessary to treat the oil and gas industry differently from other uses.
	Alternative Access Roads	Unnecessary and unreasonable surface disturbance and damage on private property. A mandatory second access road should not be regularly required. If an Operator evaluation determines that a residential building owner's access may be affected by an emergency at an oil and gas facility, then the Operator should have the ability to address this evaluation during the permitting process with County Staff and in consultation with Emergency Responders.
GMT Exploration	Relationship to State rules	Recommend changing this language. This would place a large burden on the County to begin enforcing Federal and State rules. Do not believe the County has the resources, expertise or desire to.
	One-mile Existing Water Reservoir Setbacks	Read COGCC Rule 411. Adequately protects waters in Arapahoe County.
	Alternate emergency access	Recommend striking the language and using the existing permitting process to work collaboratively with an operator to solve situation that may arise. [i.e. Conditions of Approval]. If the County adopts this language, it would need to be expanded to clarify several issues. The Operator may not have adequate rights to secure an alternative access. Topography and existing land use may make and another access impossible.
	Definition of Water	

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
	Reservoir Infrastructure suggested by Water Providers (see page 10).	[Internal Note:] Not in the comments letter but Max Blair expressed a strong objection to "water wells" being included as part of the definition of reservoir infrastructure.
Renegade Oil & Gas	General comment	This rulemaking is completely unnecessary, as well as Phase 2. Concerns of the County and interested parties can be addressed through Conditions of Approval attached to an individual application as necessary. Renegade generally supports the comments of other industry stakeholders. Arapahoe County, in conjunction with the State of Colorado, have regulations that are more than protective of the public interest.
	Preliminary definition of Water Reservoir Infrastructure suggested by Water Providers	The attempt by the water providers to expand this definition [of water infrastructure] is a huge overreach … wholly unfair to the stakeholders. … started out as a knee-jerk reaction … near some neighborhoods and the Aurora Reservoir, has devolved into a power grab. … once the Civitas drilling sites are … approved and drilling, we don't believe this situation will ever occur again as there are no more reservoirs in Arapahoe County. The minutiae of how bitcoin is earned is wholly irrelevant to this topic. A definition of what occurs on an oil and gas location can be as simple as, "Electric Generation for Onsite Computing. This covers cryptocurrency mining, cloud services and other remote computing operations. .. reeks of "nannyism". Oil and gas drilling companies have been providing for the onsite needs of their employees for many decades. Codifying this degree of micromanagement is ridiculous.
	Crypto-Mining	"Electric Generation for Onsite Computing. This covers cryptocurrency mining, cloud services and other remote computing operations.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
		A definition … can be as simple as, "Electric Generation for Online Computing". This covers cryptocurrency mining, cloud services and other remote computing operations.
	Handwashing Supplies	Oil and gas drilling companies have been providing for the onsite needs of their employees for many decades. Codifying this degree of micromanagement is ridiculous. [Internal Note: Not in the comment letter but Renegade expressed a strong objection to water wells being included in the definition of reservoir infrastructure and pointed out that there are hundreds of private water wells on State Land Board property.]
American Petroleum Institute		The letter contains several general comments and comments on Arapahoe County's existing rules adopted in 2021 that are currently not proposed for revisions.
	Neighborhood Meeting and Application Notice - Requirement to notify property owners and occupants within one mile about neighborhood meetings and filing of applications	Objected to wording that applicants are required to notify tenants of property owners. Requested alternative forms of notification outside of U.S. mail. "It may be difficult to ascertain if someone other than the homeowner occupies a property". [Staff note; Other operators have notified tenants by addressing letter to "Current Resident" at the specific addresses.]
	The County's Authority	Reminds the County that its authority is limited to surface impacts and must be both necessary and reasonable.
	Alternative Location Analysis (ALA) required for Facilities on County Owned Property (Staff note: This is an existing rule,	Recommend the County rely on COGCC requirements for ALA to prevent unnecessary duplication or work to ensure the County's ALA requirements align with COGCC's requirements or work with the COGCC and operators to identify sites that are both technically feasible and minimize adverse impacts.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
	not newly proposed). Setbacks from the nearest boundary of a platted lot on properties smaller than 15 acres (Staff note: This is an existing rule, not newly proposed). Water Reservoir Setbacks Reportable Chemicals Incident Reporting	 May limit the county's and operators' ability to identify feasible locations. Suggest the county rely on and participate in COGCC's process. We note it is inherently difficult to determine what reservoirs may be planned. … we suggest that this provision be limited to existing reservoirs. … seek justification for the setback distance being set at one mile. Seek further clarification on this provision, specifically the intent of this requirement. API recommends further clarification around what defines an emergency. We recommend the county define an emergency as an incident requiring immediate medical attention.
Bill Donovan, Petroleum Engineer	General comments	… these proposed regulations are not about safety, clean water, or clean air but an attempt to prevent access and beneficial use of property owners to their property. … the oil and gas industry contributes as much or more to the betterment of Arapahoe County than the gaming, cannabis, and alcohol industries, which have a less stringent and [less] hostile regulatory environment. The proposed regulations should embrace this new paradigm instead of proposing more stringent setback requirements. Please consider setting aside 40 acres zoned for oil and gas development in the center of every five square miles. There are 805 square miles in Arapahoe County. Thirty-two, 40-acre zoned oil and gas sites would be sufficient to exploit every prospective oil and gas reservoir in Arapahoe County. That is a total of two square miles or 0.25% of Arapahoe County's surface zoned for oil and gas development. After the Marshall fire, [we] calculated that the drill pad in the center of five square miles and in the burn scar could generate as much as $600 million in severance taxes to the local taxing districts, including the County. Of course, oil and gas is a risk industry, and tax revenue is not certain until the wells are depleted. As

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
		the Planning Commission, you would be tasked to determine these zoned areas. Also, surface owners willing to be in these zoned oil and gas areas could be compensated from a percentage of proceeds. This concept is not new; Union Pacific Rail Road gave "phantom overrides" to surface owners with some conditions. I believe the stipulations were the proximity to the well pad, home ownership, and that the home was the owner's principal residence.
	Access Road Standards and Alternative Access Roads	The access road standards and alternative access could be better thought out and are cost-prohibitive. It is galling that this proposal reached this level without one whit of risk analysis. Remember, a massive drilling rig that weighs hundreds of tons was moved on the access road. Also, how many Colorado drilling accidents required an alternative road, and was the alternative road built to such load requirements? Let us look to data-driven solutions. If you think you have an orphaned well problem now, try restoring land with a road built to these requirements.
	Handwashing Supplies	All the permanent support staff [on drilling and completion sites] are provided trailers with potable water, bathrooms, and toilets. The drilling crews and the temporary service providers use the porta-potties and have access to hand washing. The roughneck wives would raise hell if their loved ones came home with greasy and dirty hands. This is a regulation in search of a problem. A visit to a drilling rig for your staff might be in order.
	Operation of oil and gas facilities in compliance with Federal, state and local laws and regulations	Leave for lawyers.
	Crypto-Mining	Yes.
	Additional application information	Yes.
Agencies		
ECMC (formerly COGCC)		At the time this table is being finalized, we are still waiting for a response. They intend to issue an identical letter for all local governments that are revising their rules.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
Colorado Geologic Survey	Application for a lesser setback	… concerned that this could be construed to mean that approval is mandatory, which I don't think is the intent. I think reviewed would be better here than approved.
Division of Water Resources	Additional application information	The County may also want to consider whether to also request the source of water … as part of the application process.
CDPHE Air Quality Control Division	All of the proposed rules Crypto-Mining (AQCD Rich Coffin)	We generally do not provide comments on proposed local government regulations, although we do provide assistance during development, as time permits. Crypto-Currency Mining (CCM) produces a list of air contaminants; some are different than flaring and venting emissions. CCM equipment is subject to the same permitting requirements for any O&G facility per AQCC Regs 3 and 7. Upstream oil and gas operators are also subject to GHG reporting and intensity targets pursuant to AQCC Reg 22. "APQD has not evaluated whether the emissions produced [by CCM] are less than, equal to or more than combusting. Both flares and engines produce criteria pollutants (including VOCs and NOX – ozone precursors) and hazardous air pollutants (HAPs) and these emissions should be taken into account".
CDOT	No reply	
U.S. Army Corps of Engineers	No reply	
Arapahoe County Public Health	Existing Reservoir Setbacks Reservoir Infrastructure Crypto-Mining	Topography limitations, cultural resources constraints and State Land Board constraints (regarding pad locations - should be placed in previously disturbed areas) strongly limit the pad locations on State Land Board [property]. Whoever owns the dams could agree to lesser setbacks. Re a water well setback: OWTS [on-site wastewater treatment systems have a setback of 100 ft between a well and a septic system. 400 – 1,000 ft might be better. There is Title V air permitting (considered to be a Major Source, emitting > 25 tons/year of NOx or VOCs) for data centers [i.e. CCM] using 16 cylinder engines. If the data center has to meet Title V requirements it might not be profitable.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
Aurora Water	Existing Reservoirs, Planned Reservoirs and Infrastructure . 	1-mile setback from existing and planned reservoirs. 500-ft setback from Water Source [explain] or Critical City Infrastructure. Critical Infrastructure includes "all existing or planned critical public utility infrastructure, including all source water pipelines, potable waterlines (16: or greater), storm sewer pipelines (or box culverts) greater than 36", water tanks, pump stations, lift stations and bridges. A setback of less than 1 mile would be considered for a well that is clearly downgradient from a water reservoir, based on site-specific data. Another important consideration for planned reservoirs is the state of the planning (is it a concept, has permitting been completed, has it been designated, etc.). Established criteria to be protective in all situations and include a variance process to consider smaller setbacks where appropriate. Multiple conditions should be evaluated for any O&G well siting – Hydraulic gradient (surface and subsurface) between the proposed O&G well and the water reservoir is one of the most important considerations.
Rangeview Metro District (has 2 planned Reservoirs on State Land Board property)	One-mile setback from existing Reservoirs or Planned Reservoirs Infrastructure setbacks	Supports: One-mile setback from existing or planned water reservoirs, unless the applicant can clearly demonstrate the facility is downgradient from the reservoir, in which case a 2,000 ft setback may apply. Supports: With approval from the reservoir owner or operator, the setback may be reduced to the 500-ft setback applicable to other perennial surface water bodies In addition to the reservoir setbacks, supports a 500-ft setback from existing and planned Water Infrastructure, defined as water wells, water storage facilities, pump stations, lift stations, treatment facilities, maintenance facilities, water fill stations, diversion structures and data communication infrastructure. Supports a variance process.
Internal Stakeholders		

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
Engineering Services Division	Access Roads Standards	Fire department standard may change- should we also add the following "and to meet the emergency response agency such as Fire Department's minimum requirement for access roads" or similar language?
Office of Emergency Management	Emergency Response Plan (EAP)	No comments on Relationship to State of Colorado Rules, Neighborhood Meetings, Applications that Include a Lesser Setback, Reservoir Setbacks, Handwashing Facilities and Access Road Standard. Regarding Post-Incident Meeting: This appears to be a duplicate requirement Regarding Crypto-Mining: Are these powered by grid or are there large banks of Lion or LiPo type batteries that would provide power if the grid were disconnected? If so, it should be posted so fire [department] is aware.
Transportation	No Reply	
Open Spaces		For Open Spaces the increased setback from reservoirs sounds good. Question – I see it says "Planned Reservoir" – how planned does it have to be? I know PureCycle [Rangeview Metro District] has some planned-on Lowry property but not sure if how far along they are? The lesser setback BoCC approval is also a good addition.
Citizen Stakeholders		
John Granger Aurora Resident	California Public Health Rulemaking	2. What are the air pollutants released from these activities that cause negative health outcomes? How do we know exposure to these is likely from oil and gas extraction wells and associated facilities, as opposed to other sources? The wells, valves, tanks and other equipment used to produce, store, process and transport petroleum products at both unconventional and conventional OGD sites are associated with emissions of toxic air contaminants, hazardous air pollutants and other health-damaging non-methane VOCs (Helmig, 2020; Moore et al., 2014). Diesel engines used to power on-site equipment and trucks at unconventional and conventional OGD sites directly emit health damaging hazardous air pollutants, fine particulate matter (PM2.5), nitrogen oxides and volatile organic compounds (VOCs) (CalEPA OEHHA, 2001). Many VOCs and nitrogen oxides are precursors to ground level ozone (O3) formation, another known health harming pollutant. [Emphasis in original] Hazardous air pollutants that are known to be emitted from OGD sites include benzene, toluene, ethylbenzene, xylenes, hexane and formaldehyde--many of which are known, probable or possible carcinogens and/or teratogens and which have other adverse effects for non-cancer health outcomes (CalEPA OEHHA, 2008, 2009; Moore et al., 2014)…. A recently published study using statewide air quality monitoring data from California investigated whether drilling new wells or increasing production volume at active wells resulted in emissions of PM2.5, nitrogen dioxide (NO2),

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		VOCs, or O3 (Gonzalez et al., 2021). To assess the effect of oil and gas activities on concentrations of air pollutants, the authors used daily variation in wind direction as an instrumental variable and used fixed effects regression to control temporal factors and time-invariant geographic factors. The authors documented higher concentrations of PM2.5, NO2, VOCs, and O3 at air quality monitoring sites within 4 km of preproduction OGD well sites (i.e., wells that were between spudding and completion) and 2 km of production OGD well sites, after adjusting for geographic, meteorological, seasonal, and time trending factors. [Emphasis Supplied.] [Responses from the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel to the written questions sent by the California Geologic Energy Management Division (CalGEM) on August 31, 2021. pp. 10-11]
John Granger Aurora Resident	Reservoir Setbacks [Staff note: Please see Mr. Granger's complete statements in the attached letters.]	Commissioners, Staff, and County Attorney: This letter is written on behalf not only of me, as a concerned citizen and former land use/environmental attorney, but also on behalf of the 30,000 concerned citizens of Ward VI who speak through the non-profit Save-The-Aurora-Reservoir (STAR). This letter will deal with the language of the proposed Reservoir Setback only. The second letter will deal with critical missing regulatory changes that need to be dealt with in Phase I rather than Phase II of the regulatory amendment process. Breach of the Duty to Regulate: SB-19-181, signed in 2019, completely dispelled that notion, and put the emphasis back fully on "protection" not balancing development and protection. As stated in the Legislative Summary of the authorizing legislation for the COGCC, SB-19-181: Section 6 states that the public interest is to "regulate" oil and gas development to "protect" those values. [Emphasis supplied] The County of Arapahoe has an express duty to be a steward of the Public Trust and must "carry out their duties for the benefit of the people of Arapahoe County." [Arapahoe County Code of Ethics, Art. III.1] Therefore, it is inappropriate to compromise the protection of health, safety, welfare, or environmental protection…. I make this observation because of the two proposed "carve outs" in subsections i. and ii. of the Proposed Setback. These "carve outs" are convoluted and completely emasculate the one (1) mile setback proposed.[1] They are vague and ambiguous in wording. And subsection ii. is likely illegal in application. They appear to be an obvious effort to cater to CAP applicants

[1] It is noteworthy that the City of Aurora's one (1) mile reservoir setback [Aurora City Code Chap. 135, 4.c.], upon which these provisions are based, contains no such "carve-outs" and remains a clean one (1) mile setback.

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		who believe they can work out a "compromise" in moving certain well pads in exchange for an agreement not to move others. Subsection ii. of the proposed Setback is also inconsistent with statutory duty and must be wholly abandoned for a second reason. It attempts to delegate rather than regulate. This means that either a reservoir owner or an operator, neither of which needs to be a public entity charged with the public trust duties of the County, can on their own initiative, without regard to public health and safety considerations, approve collapse of the setback from one (1) mile to 500 ft. -- an over 90% difference. This is an attempt at delegation rather than regulation and is manifestly improper because it violates the statutes cited above. Vague and Ambiguous Language: The "carve-out" Section i. of the Proposed Setback is so vaguely and ambiguously worded as to be unenforceable. It purports to allow the collapse of the one (1) mile reservoir setback to 2,000 ft. if the Oil and Gas Facility is "downgradient" from the reservoir. It reads: i. At least one (1) mile from existing or proposed reservoirs, unless the applicant can demonstrate that the Oil and Gas Facility is downgradient from the reservoir, in which case a 2,000 ft. setback may apply. Does it mean it that approval remains discretionary with the County or is it a substitute for the word "shall"? The carve-out, if it is too be applied at all, needs to be clear and unambiguously protective. Furthermore, berms and gradients alone are insufficient barriers upon which to rely for health and safety protection. The Solutions: For these reasons, the County is urged first to simply consider total elimination of the "carve-out" wording with a return to a simple-straight forward one (1) mile reservoir setback identical to the City of Aurora. That is clearly the most protective and best approach which places public health and safety as the appropriate goal. Absent that approach, if the County insists upon a carve- out based upon topography, we strenuously urge the County to: 1. Recognize that, because of both the unreliability of berms and the need to consider air borne pollutants, the distance of the carve–out Setback for section i. must be increased to a distance that recognizes potential sources of reservoir contamination beyond simply well pad spills. We have not suggested what figure that distance should be

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		because we disfavor this approach and believe a clean one (1) mile setback is the proper approach. We note, however, that maintaining just a 2,000 ft. setback is inconsistent with the announced goal of developing the "best oil and gas regulations in Colorado." 2. Use a version of the County's relief from setbacks approach already found in subsection 2.b.iii. and follow the Use by Special Review process under which the Operator must establish that the lesser setback "will provide substantially equivalent protection…and…will not adversely impact public health, safety, or welfare or the environment." Summary Conclusion: In summary, the Proposed language, due to the two "carve outs" being included, is fatally flawed. STAR on behalf of the citizens of Ward VI and I therefore implore you to; • First, do away with the improper and likely illegal delegation rather than regulation found in sub-paragraph ii. • Show the courage of your convictions and drop the carve-out in section i. altogether, keeping only the one (1) mile setback language. EXHIBIT 2 PROPOSED SUBSTITUTE RESERVOIR SETBACK LANGUAGE ALTERNATIVE ONE: d. Water Reservoir Setbacks: All Oil and Gas Facilities shall be located at least one (1) mile away from all existing or planned (adjudicated) reservoirs. ALTERNATIVE TWO: [Note: Items in red indicate new or revised language outside of the existing language in subsection 2.b.iii.] d. Water Reservoir Setbacks: All Oil and Gas Facilities shall be located: i. At least one (1) mile away from all existing or planned (adjudicated) reservoirs. ii. The 1 mile setback may be reduced to a lesser setback only under the circumstances described below: [Note: the language from this point to the end is drawn directly from the existing regulations for "occupied dwellings and 'platted lots" setbacks.] (a) If an Oil and Gas Facility application that includes a lesser setback is submitted, it must be approved by the Board of County Commissioners through the Use by Special Review process provided in Section 5-3.4 of the Land Development Code. For approval of any lesser setback under this subparagraph, the Operator must establish that the lesser setback as provided will provide substantially equivalent protection to a one (1) mile setback and that the granting of the lesser setback will not adversely impact public health, safety, or welfare or the environment.

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		(b) In reviewing the proposed lesser setback, the Board of County Commissioners shall consider the extent to which the operator provides an alternative Oil and Gas Facility design, best management practices, control technologies, or proposes conditions of approval that will be effective to avoid, minimize, or mitigate adverse impacts on the affected properties, considering: (1) geology, technology, and natural or added features (such as gradients and berms), hazards, or topography; (2) the location and use of occupied structures and areas zoned residential and the proximity to thereto (3) potential leaks from well pad equipment, including but not limited to associated flowlines, tank batteries, spill containment areas, or similar equipment; (4) potential contamination from airborne pollutant chemicals emitted from the Facility; (5) the anticipated size, duration, and intensity of all phases of the proposed oil and gas operations at the proposed oil and gas location. iii. However, in no case may the one (1) mile setback from Reservoirs be reduced below ___2 feet.
John Granger Aurora Resident	Setbacks [Staff Note: Mr. Granger has proposed alternative language for the existing setback rules and the Wildland Urban Interface. These will be discussed for future amendments. Please see his complete statements in	Re: Proposed Arapahoe County Oil and Gas Facilities Regulation Amendments and Additions Commissioners, Staff, and County Attorney: This letter now deals with both an existing setback that requires modification and a critical new missing regulation to protect against fire risk. Because the non-profit Save-The-Aurora-Reservoir (STAR), on behalf of the 30,000 citizens of Ward VI, and I fully agree on the content of this second letter, I am sending it on its behalf as well as my own. Both of these changes are important enough to require implementation now in Phase 1 (rather than later in Phase 2) of the regulatory amendment process. In conclusion, we urge the County to do the following: 1. Eliminate the references to “platted lots” in their setback regulations and instead reference “areas zoned residential”; 2. Establish a setback distance from both “occupied structures” and “areas zoned residential” of one (1) mile (consistent with drinking

[2] A reasonable figure should be inserted here by the County but given the goal of developing the “best oil and gas regulations in Colorado” it should remain well above a 2,000 ft. distance.

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	the attached letters.]	water reservoir protection and current national pollution dispersal studies); 3. Adopt language allowing reduction of this one (1) mile setback to some reasonable distance (greater than a minimum of 2,500 ft. used in Boulder) only through the Use by Special Review process upon a showing the "lesser setback will not adversely impact public health, safety or welfare or the environment"; 4. Eliminate provisions that allow further setback distance reductions based upon owner consent agreements as delegations inconsistent with the County's duty to regulate to "protect the public health, safety, and welfare, and the environment"; and 5. Add a specific protection provision dealing with those Wildland Urban Interface areas designated by OEM to have a "significant risk" of fire spread. Exhibits A and B to this letter contain the necessary language to meet these important goals, and we urge the County to adopt them now. Diane, Jason and Bryan: Enclosed please find my proposed amendments to your latest draft of the Oil and Gas Regulations following the Open House. These are my own suggested amendments (not STARs) since they vary somewhat from the earlier stated position on behalf of STAR; They use your existing draft regulations and show my suggested changes and edits; They apply the same test to reducing water reservoir setbacks as used for occupied dwellings, that is a "substantial equivalency" test rather than a "downgradient test" or "agreement of owners/operators" test. They apply setbacks to areas zoned residential rather than platted lots. They use appropriate setback distances which meet the Commissioner's objective of "creating the best regulations in the state of Colorado" and recognize the impact of the latest national studies on protection of public health and safety, but without going overboard and risking industry litigation.

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		Thanks for your consideration of these amendments and edits. Setbacks a. All Oil and Gas Facilities shall be located at least: i. 3,000 feet from any occupied structure as measured from the pad boundary. ii. 3,000 feet from the nearest boundary any area zoned residential as measured from the pad boundary. iii. 500 feet from any adjacent property's boundary line as measured from the pad boundary. iv. 250 feet from public rights-of-way as measured from the pad boundary. v. 3,000 feet from a Designated Outside Activity Area as measured from the pad boundary. vi5,000 feet from the nearest property line of an operating or closed landfill as measured from the pad boundary. vii. Outside of a 100-year floodplain and at least 1,000 feet from the edge of any perennial surface water body, the ordinary high water mark of any perennial or intermittent stream or the edge of any riparian area, whichever is the greatest distance, as measured from the pad boundary, unless CPW has waived or modified the setback from the stream, surface water, or the riparian area following in accordance with COGCC Rules 309 and 1202. viii. Water Reservoir Setbacks: All Oil and Gas Facilities shall be located: (1) At least 5,000 feet from existing or planned and adjudicated water reservoirs, over 100 acre feet in size or used for drinking water storage. ix . All access roads shall be at least 500 feet from a residential or non-residential property line, excluding light or heavy industrially zoned properties. b. The 3,000 and 5,000 feet setbacks from occupied structures, Designated Outside Activity Areas, areas zoned residential, or water reservoirs referenced in subparagraphs 5-3.6.F.2.a.i, ii, v and viii above may be reduced to a lesser setback: c. Reverse Setbacks: No new occupied structure shall be constructed less than: i. 500 feet from and existing Oil and Gas well of any status (permitted but not drilled yet, drilling, completing, producing, active gas storage, injecting, shut-in, temporarily abandoned, dry and abandoned, or plugged and abandoned prior to 2014). ii. 300 feet from a plugged and abandoned oil and gas well or remaining equipment that was plugged and abandoned from 2014 onward.

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Marsha Kamin Aurora resident	Reservoir Setbacks Notifications Fire Risk [Not included in the proposed amendment. Will be a topic of discussion for future amendments.]	Should apply to all occupied structures, schools and future housing sites. CA air quality study supports larger setbacks. Notifications should be for everyone within 1 mile of the extent of the horizontal wellbore. Extreme fire risks due to typically windy conditions.
Kristen Miller Aurora Resident		• Especially considering the density of our housing within 2,000 feet of the proposed oil and gas development, the draft regulations have definitive loopholes for less than 2,000 foot setbacks, and this needs to be amended (in 2a): o If the owner(s) of the occupied structure(s) or all owners of the affected platted lots agree in writing to a lesser setback and the fire district agrees to provide service to the Oil and Gas Facility; however, even with owner consent, in no case may the setback be reduced below **500 feet** o 2C: No new occupied structure shall be constructed less than **250 feet** from an existing Oil and Gas well of any status (permitted but not drilled yet, drilling, completing, producing, active gas storage, injecting, shut-in,temporarily abandoned, dry and abandoned, or plugged and abandoned prior to2014). o 2C: Reverse Setbacks: No new occupied structure shall be constructed less than **150 feet** from a plugged and abandoned oil and gas well or remaining equipment that was plugged and abandoned from 2014 onward. o 2d: Water Reservoir Setbacks has too many loopholes "All Oil and Gas Facilities shall be located: At least one mile from existing or planned water reservoirs, unless the applicant can demonstrate that the Oil and Gas Facility is downgradient from the reservoir, in which case a 2,000 foot setback may apply. With **approval from the reservoir owner or operator, the setback may be reduced to the 500-foot setback applicable to other perennial surface water bodies**." • Visual mitigation requirements only allow for required visual mitigation for those "Well pads within 1,320 feet of a property line of a property containing an occupied structure, a platted lot, or a parcel of 40 acres or smaller"—**because our current stance is 2,000 feet, this regulation doesn't hold the operator**

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		responsible for hiding the well pads. And the operator has **a year** to install visual mitigation—far too long! • Traffic mitigation (16a): "shall make **best efforts** to schedule its traffic to limit heavy truck traffic on County roads during peak commuting hours and during school bus hours"—why is the County not prohibiting this, rather than asking for best efforts? For many neighbors commuting along this route to toward DIA/Buckley, this will definitely affect our commute pattern with additional traffic and damage to our roadways from heavy trucks. • Groundwater Baseline Sampling and Monitoring (9) is limited to within a ½ mile radius and **depends upon a request from the owner** of such water source or owner of land upon which such water source is located. And the "**requirement to test a well upon request does not apply if the water well has already been tested** by any Operator and the Operator is able to furnish such results to County"—these regulations do not protect our water. • Noise Mitigation Requirements: Section 10 defines the maximum permissible noise level and then proceeds to allow loopholes around it. This needs to be tightened significantly. ○ "Noise emitted from the facility pad shall not exceed **60 dBA or 65dBC**, measured at the nearest property line of the property with the nearest occupied structure. These noise levels, as measured, constitute the Maximum Permissible Limit of noise that may be allowed to emanate off site from the Oil and Gas Facility." Per Centers for Disease Control and Prention, "Loud Noise Can Cause Hearing Loss," November 8, 2022, (https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html) 60 decibels is comparable to the sounds of normal conversation, air conditioner. Increasing to 70 decibels contributes to annoyance by the noise, and these regulations allow this level for up to an hour per day between 7 a.m. to 7 p.m.: ○ (10b): During the hours between 7:00 AM and 7:00 PM, the maximum permissible noise levels may be increased 10 dB(A) for a period not to exceed 15 minutes in any 1-hour period. The increase is permissible … for a 1-hour period during any 12 hours. **Why would the County allow for this level?** • **Furthermore, 10c allows for applications for waivers** ("to exceed the Maximum Permissible Limit in accordance with and subject to the standards in Section 5-6-3.6.E.5 above where the Oil and Gas Facility is proposed to be located in an area with existing ambient background noise levels that are at or above the Maximum Permissible Limit or if proposed for an area that is sufficiently remote from any property with an occupied structure or any High Priority Habitat, provided that the lack of High Priority Habitat is supported by recommendation of CPW") without defining what **sufficiently remote** is.

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		When I reviewed the draft regulations, I saw nothing in them to protect or measure air quality as a result of the proposed oil and gas operations. That appears to be missing entirely.
Robert Graham Aurora Resident		I would hope and expect that you have provided a detailed copy of the Denver Post Article that covers this Oil and Gas Leak and the impact the leak has to families - the key is the time to restitution: "Mark and Julie Nygren didn't set out to be activists, but they are suggesting changes to the oversight of Colorado's oil and gas pipelines based on their experience of losing their home and seeing part of their farm contaminated by a leaking gas line. More than four years after discovery of the leak, the Nygrens are still renting a house in Johnstown, just north of their Weld County property, and remain embroiled in a lawsuit against DCP Midstream Operating Co., which owned the pipeline. As the Colorado Public Utilities Commission considers new pipeline-safety rules, the Nygrens want to share their hard-won insights with regulators.
Seema Rajapurohit Aurora Resident		We bought this beautiful, big dream house just opposite the Aurora Reservoir with the intention to enjoy the nice Lake and the peaceful residential neighborhood. Unfortunately, that is not the case as Civitas is planning to frack near this reservoir and we totally oppose this. The entire neighborhood and area will be smelling of horrible chemicals, the beauty of the reservoir will be lost, and people will get sick with all kinds of cancer, dental problems, skin diseases etc. Moreover, The water will no longer be clean, fresh, and potable. Also, the oil and gas wells will catch fire and burn the entire area (grasslands) and also people's homes. We don't want our dream home to be burned down. We don't want any fracking and oil and gas wells anywhere near us nor the Aurora Reservoir. This proposed fracking project is life-threatening, which is why we are fully against this project. Please make it a rule that any fracking and oil and gas should be 50 miles away from the Aurora Reservoir area. Please stop this project now.
Tisha Foard Aurora Resident		I am writing to you as a concerned citizen and mother. I stand in opposition to any and all fracking within Arapahoe County, especially any located near communities with children, like the proposed Lowry CAP by Civitas. Please consider sticking to a MINIMUM of a mile setback from all rivers, reservoirs, and homes, or better yet, stop the project all together. Here's why: **Air Quality/Pollution** The EPA has reclassified Colorado's Front range non-attainment as a "severe" violator of federal air quality standards. In 2021 there were 65 ozone action

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		days from May 31 to Aug 31, the highest number recorded since recording started in 2011. The fracking proposed at the Lowry Ranch CAP will produce volatile organic compound (VOC) emissions which form ozone. This can cause lung damage and premature death. The common air pollutants from drilling and fracking chemicals are linked to higher rates of cancers, childhood leukemia, sperm abnormalities, reduced fetal growth, cardiovascular disease, and respiratory dysfunction. (Colorado Fiscal Institute 2023). In light of this, it is little wonder that the Center for Biological Diversity has sued the EPA for its approval of Colorado's State Implementation Plan for air pollution emissions. Additionally (and more importantly for my particular family), the National Library of Medicine has published a study that finds "a significant association between CO concentrations and epileptic seizure risk . . . with an increased seizure risk of 4%" (Zhuying et al. 2022). My nine year old son has epilepsy. Exposing him to such concentrations of air pollution as will be generated by this project is not just unfair. It's unconscionable. My son is certainly not the only child living with epilepsy near this proposed site. In fact, one of the drill pads planned will be less than a mile away from my son's elementary school, exposing ALL of the children at Altitude Elementary AND Woodlands Elementary to unsafe levels of air pollution. **Water** Colorado is currently a part of a superdrought located in all of the western United States. The EPA estimates that the annual water requirement for horizontal wells is as high as 140 billion gallons of water per year. With the current watering restrictions (2 times/week) for Aurora residents, this seems needlessly wasteful. The Lowry Cap cumulative impacts statement itself states that it intends to use 17,858,400 gallons of water PER WELL, and that the water will come from three sources: 1. "excess surface water" 2. Farmers Reservoir Irrigation Company and 3. Rangeview Metropolitan District water. What excess surface water do we possibly have? Rangeview services the Lowry Range, which is where the Aurora Reservoir is located. This reservoir is currently only at 54% of its capacity (auroragov.org 2023). Drilling so close to the reservoir that serves such a large portion of the Aurora population is untenable. **Cancer** A peer-reviewed Yale study published in August 2022 found that living within one mile of fracking made small children aged two to seven years 2-3 TIMES more likely to develop leukemia than children not living near wells (Yale News 2022). How can we possibly justify allowing wells to be located so near to five Cherry Creek Schools, my school of employment and my son's elementary school included? In what world is it acceptable to cause such risk to the lives of thousands of children for the monetary gain of an oil and gas conglomerate that will not return any of that profit to our community?

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		Impacts on Families On a personal level, my son has epilepsy. This causes him to be especially susceptible to loud noises and stress. A peer-reviewed study published in both the journal Science of the Total Environment and Berkeley News found that "Fracking creates noise at levels high enough to harm the health of people living nearby" (Isreal 2017). Stressful situations and loud, continuous noises have proven to cause seizures that occur more often and with greater intensity in my son. It has been heartbreaking to watch his struggles, and it continues to be heartbreaking to consider the future noise, stress, and pollution from these proposed wells and the effect they will have on my son. My husband and I provide for our family with modest Department of Defense and public school teacher incomes. We cannot afford to move with the housing market and interest rates the way that they are right now. This situation has caused us severe anxiety and emotional distress that we, of course, must hide from our son so as to not adversely impact his health and neuro activity. We have no other way to protect our only child than to appeal to government entities like you. What is happening to our community is simply put, evil. A large, powerful corporation can come to our idyllic community, use predatory and dishonest tactics to gain mineral rights, hurt our children, use up our precious natural resources, and destroy the environment and wildlife in the area simply because they want more than their already record profits from the last few years. This is just ONE story of how an individual family will be impacted. Can you imagine the impacts on the thousands of other residents near these wells? Please, we are begging you to help us. Stick to the MINIMUM of a mile setback from all homes, reservoirs, rivers and streams. Better, stand in opposition to any and all fracking in our area. It is the right thing to do. Please put the children and elderly of Arapahoe County before monetary gain. Thank you so much for your time.
Hundreds of Aurora Residents [Same message]		Dear Arapahoe County Commissioners and Staff, Thank you for working to strengthen the County's oil and gas regulations to be in greater alignment with its required duty to protect the public health, safety, welfare, and the environment. I believe the proposed changes to the regulations are not sufficiently protective. I urge the County to make the following changes to strengthen them: 1. Add a provision that will not allow oil and gas permits to be permitted in areas that are in violation of federal air quality standards; such areas are already burdened by the effects of poor air quality.

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		2. Establish a setback distance of at least one mile from both occupied structures and residential areas/zones. This is the same setback distance being proposed for reservoirs; protections for the safety of residents should be at least on par with protections for drinking water reservoir safety. 3. Eliminate provisions allowing setback distances to be reduced to 500 feet by owner consent agreements. Such provisions simply allow oil and gas applicants to negotiate with developers to reduce setback distances- irrespective of the safety and health impacts to the general public. 4. Develop regulations to prevent fires in wildlands adjacent to residential and urban areas. This can be accomplished by authorizing the Office of Emergency Management to identify portions of such wildlands which pose risks of fire spread, and by disallowing oil and gas facilities from being located within them. 5. Disallow oil and gas companies from being able to request exemption from conducting neighborhood meetings with residents living within one mile of their proposed plan. Companies must engage with and solicit input from residents most impacted by oil and gas development plans. 6. Explicitly prohibit the practice of flaring gas to produce cryptocurrency. Cryptomining is energy intensive, and it produces large amounts of electronic waste, which present environmental risks to air and water. The pollution from this industry will remain local, but jobs and benefits to communities are slim as all work is virtual. Please consider these revisions that will result in greater protections for our health, safety, and natural world.
Save the Aurora Reservoir Group (STAR)		The 3 most important missing setbacks/regulations in order of importance are: 1. Effective setbacks from areas zoned residential/urban a. The County has been operating under the mistaken belief based upon a single State CDPHE study that air dispersal of pollutants is limited to a 2,000 ft. radius. This is based on monitoring of a single well [not a 12 well pad]. The County therefore relies now on a 2.000 ft. setback. b. Nationally accepted studies now show that even without wind drift the area of dispersal is actually 1.25 -2.5 miles c. We therefore suggest at least a minimum 1 to 1.5 mile setback from residential/urban areas (including schools and other public gathering spots), particularly when you are dealing with a multiple well pad site. 2. Fire setbacks and regulations in the Wildlife Urban Interface a. The Marshall fire proved how dangerous fires starting in grasslands

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		adjacent to residential neighborhoods can be. b. The key to fire safety is time to suppress, coupled with resources to suppress 1. A 2,000 ft. setback leaves totally insufficient time to suppress – less than 8 minutes in a grassland fire pushed by a 25 mph wind. Even 1 mile is problematic with 18 minutes to suppress but far better when coupled with regulations such as fire hose hook-ups and suppressive foam required on well pads in the WUI. c. We therefore suggest a WUI fire setback of at least 1 mile, coupled with fire hose hook –ups and suppressive foam on any well pads adjacent to the WUI. . [See for example: Broomfield Oil and Gas Code Regs. 17-54-060(T)(8) and (11)] 3. Setbacks from drinking water reservoirs a. County has 500 ft. City of Aurora has 1 mile. b. Even with berms or up-slopes to protect against spills entering these reservoirs, the same zone of protection of 1 to 1.5 miles for air pollutant dispersal is needed as is the case for residential /urban neighborhoods. B. Other level 2 tier regulations of particular concern (in no particular order of priority) include: 1. Flowline, gathering line, and transfer line regulation: a. A detailed plan of the location of gathering lines, on- and off-location flowlines and crude oil transfer lines should be required. b. Flowline should be defined as all categories of "flowlines" included in the definition of the COGCC rules (including wellhead lines, production lines, dump lines, manifold piping and process piping). c. All flowlines, gathering lines, and transfer lines located within ¼ mile of "ecologically sensitive areas" [such as drinking water resources and sensitive grasslands and wildlife habitats] or residentially/urban zoned neighborhoods should comply with the 2006 Pipeline & Hazardous Material Safety Administration PHMSA regulations as amended. d. Because flowlines are prone to methane leakage, and according to the EPA are "one of the largest sources of emissions" in the oil and gas industry: 1. Flowlines, gathering lines and transfer lines should be setback a minimum of 1,000 ft. from drinking water sources, riparian waterways, and residential/urban neighborhoods; and 2. Should be monitored for airborne leakage leaks and spills at least every 3 months and, when located in "ecologically sensitive areas" or ¼ mile of residentially zoned areas , at least twice monthly.

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		d. Construction of flowlines should be required to comply with appropriate ASME B31.4 and B31.8 standards, as amended 1. Applicants should be required to provide appropriate clearances between flowlines needed for appropriate inspections and hydro testing of flowlines and associated isolation valves. 2. Off-location flowlines, Crude Oil Transfer Lines (COTL) and Produced Water Transfer Systems (PWTS): a. Operators are now required in Form 44 to register and provide as-built information to the COGCC of these lines for the purposes of emergency management and planning. Accordingly, this geo-database information should be required to also be provided to the County so that first responders have the necessary information to address potential emergencies. b. Setbacks of COTL and PWTS lines and systems from residential, commercial, or industrial buildings, places of public assembly, any surface water body, or sensitive environmental feature should be determined on a case-by-case basis based upon the consideration of the size and type of line and the features of the proposed siting. [See for example: Broomfield Oil and Gas Code Regs. 17-54-060(Q)(1) thru (3)] 3. Surface and groundwater pollution: a. In order to minimize adverse impacts to surface and sub-surface water bodies, use of chemicals dangerous to human health should be prohibited, including: i. All chemicals listed in COGCC Table 437-1; ii. Polysorbate 80; and iii. Perfluoroalkyl and polyfluoroalkyl substances or “PFAS chemicals” defined as a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom. 4. Water source quality, sampling and testing: a. Applicants should be required to sample one up-grade and two downgrade available surface and ground water sources located within a radius of one-half mile of a well pad or facility. If no such water sources are available, samples should be collected within one-mile. c. Water source testing should be conducted by a qualified independent professional consultant approved by the County at the operator’s expense, and include: i. Major ions, including: bromide, fluoride, sulfate and nitrate; ii. Metals, including: arsenic, barium, boron, chromium, copper, iron, lead, manganese, selenium, strontium; and

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		iii. Dissolved gases and VOCs, including methane, ethane, propane, BTEX as Benzene, Toluene, Ethylbenzene, Xylenes, and Total Petroleum Hydrocarbons (TPH) 1. Should a water source test show a concentration increase of methane or other dissolved gas concentration increases of greater than three (3) mg/l (micrograms per liter) between sampling periods or any presence of a listed VOC, BTEX or TPH, immediate notification of both the COGCC and County so that the source can be identified and remedial action taken. [See for example: Broomfield Oil and Gas Code Regs. 17-54-060(T)(1) a. thru n.] 5. Air quality, sampling and testing: a. Air emissions from proposed facilities should be required to comply with all federal air quality rules and standards, including EPA's New Source Performance Standards and National Emission Standards for Hazardous Pollutants; i. Air emissions from proposed facilities should be required to comply with all COGCC and CDPHE air quality standards and rules, and any and all County emission regulations. ii. Emissions should be required to be below the currently most protective health-based guidelines, including those used by EPA and CDPHE. iii. Carbon-reduction requirements of Arapahoe County should not be allowed to be offset by purchased credits. iv. An Air Quality Control Plan should be required that requires that the Operator use both most effective management techniques and best management practices to minimize impacts to air quality. This should include the use of electric versus gas powered generators. v. A County approved air monitoring plan to be conducted by a qualified third-party consultant, approved by the County should be required. Baseline monitoring should be required within a 500 ft. radius of all well pads and 2,000 ft. of any well pad located within 2 miles of residentially/urban zoned property, a school, public gathering place or a drinking water source. vi. The air quality monitoring plan should require constant monitoring both prior to construction, and during all phases of development including drilling and production. vii. Monitoring should include: VOCs, Hazardous Air Pollutants (HAPs), BTEX, Hydrogen Sulfide, Oxides of Nitrogen (NOx), Particulate Matter, Fine Particulate Matter, Carbon Monoxide, methane, and carbon dioxide.

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		viii. Any increases in the monitored pollutants should be required to be reported to both the COGCC and County so that the source can be identified and appropriate remedial actions taken, including notification of affected citizens. [See for example: Broomfield Oil and Gas Code Regs. 17-54-060(O) and (P).] 6. Wastewater injection wells should be prohibited in Arapahoe County. 7. Use of water for oil and gas drilling operations which could otherwise be used for drinking water, should be prohibited during Arapahoe County's Stage D2 and above categorized drought years. 8. An effective neighborhood alert process should be developed in the event there is a "significant" contaminant spill; a "significant" spike in airborne toxins; a "significant" drinking water contamination; or a well pad fire. "Significant" should be defined as an incident which exceeds applicable Federal, CDPHE, COGCC, or County standards. 9. Special regulations should be developed to monitor any fracking-related hazard which may affect the integrity of areas of particular environmental concern (such as the EPA Superfund site), to include baseline studies to determine special risks. This should include, but not be limited to, seismic risks from fracking and truck traffic. To monitor these risks, regulations should include, but not be limited to, continuous seismic monitoring at these areas and annual studies to check for significant new environmental risks to health and safety. 10. Special regulations should be developed to ensure proper containment of wastewater pools, particularly against the risk of overflow caused by the capture of rainwater or excess sediment.
Comments Provided at Open House on June 21, 2023	Reservoir Setbacks Poster [Staff note: These existing setback rules are not proposed for revisions at this time.] Meeting Notifications rather than the	• Reservoir owners and operators are not tasked with duty to protect public health, safety, welfare and the environment. Cannot delegate decision to them. 1 mile is minimum start. 500 feet is never acceptable. 3,000-feet is absolute minimum. • What is the scientific basis for a 2,000-foot setback from homes when research shows negative health impacts at much greater than 2,000 feet?

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	Reservoir Setbacks Poster continued General comment [Staff note: the existing regulations address noise and wildlife and operators must have a fire district Will Serve Letter]	• Neighborhood meetings should notify homeowners within 5 miles of change that is not 1 mile. • Fracking under homes results in the release of additional radon. Worsening of air quality; increase ozone. [Staff note: The Colorado Geologic Survey stated that fracking at over a mile beneath the surface does not cause any foundation damage/cracks and further stated that foundation cracks/settling are due to irrigation at the surface near foundations, due to clayey soils that alternately expand and contract when wet and when dry]. • How do the regulations address noise issues? Wildlife? Fire? • What is downgradient? One mile is the bare minimum. No oil and gas should be nearby reservoir. • If a regulation has to be reasonable and justified, what better reason than to protect our population? • Continue to monitor well water/aquifer for rural homeowners • Unless downgradient conditions can be satisfied" as explained to me by Mr. Weimer, this only is determined by surface gradient. For vertical drilling, different gradients may exist at different depths. Gradients must be considered at surface conditions. • The comment "with approval from the reservoir owner or operator, the setback may be reduced to a 500-foot setback" lacks protection from the public, and lacks standards for quasi-judicial review. • What is the basis for reducing setbacks to 2,000 feet? Is there scientific basis that is sufficient? • Downgradient condition" appears to be based solely on the well site location. But oil and gas and wastewater will be transported away from well, leading to possible spills.

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		• Downgradient allowance must be proven through use of independent scientifically based studies and investigation to be at least as safe as 1 mile or more. • How will house settling issues be resolved? [Staff note: The Colorado Geologic Survey stated that fracking at over a mile beneath the surface does not cause any foundation damage/cracks and further stated that foundation cracks/settling are due to irrigation at the surface near foundations. Soils expand and contract due to clay content.] • Air quality concerns, health concerns, noise issues, wildlife impact, earthquake-stability of reservoir dam, fire potential, water contamination. • You can't justify 2,000-ft setback using latest scientific studies. • Neutral downgradient study must be done. Follow science. • The topography and hydrology of the drill site matter more than setback. Increase setback if drill pad is in same watershed as reservoir.
Comments Provided at Open House on June 21, 2023	Lesser Setbacks Poster	• Civitas Arena welcome banner was a slap in the community's face. Need a neutral space. • This will be heavily abused by the oil/gas industry. • No thanks! 2,000 feet is close enough. • Let us fundraise to help make up the difference of money made – when the CAP is cancelled. • County rule must be no less than 3,000 feet under any circumstances. Must show major independent study to justify less than 1 mile. • The provision that lesser setbacks may be approved by BOCC appears to lack standards for the BOCC to make that determination. "Substantially equivalent protection" is too vague – protection from spills? Protection from emissions? Protection from noise? All of the above? • There needs to be a presumption that the setback must be followed unless the operator can show a lesser setback is necessary to preserve public health, safety and environment. • People want the rule to be the rule. Stop the back and forth. 2,000 feet +. • No allowed lesser setbacks. Setbacks are not far enough as proposed. • No allowed lesser setbacks. • The setback must be 2,000+ feet, not 500 feet. What about Fires? Wildlife? Stricter setbacks for schools. • Cancel the CAP. Community to fundraise the $ to support County programs. • Please share with the residents of Arapahoe County the $ amount of campaign donations from O&G to each Commissioner.

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		• The rule should be at least one mile, not 2,000 feet. Any justification less than 1 mile must be done through an independent certified 3rd party to be equivalent to 1 mile or more.
Comments Provided at the Open House on June 21, 2023	Cryptocurrency Poster	• Need to address high frequency noise similar to data farms • How are locals protected from the burning/exhaust of the gas used to power the mining? • I agree with the letter sent by John Granger re cryptocurrency • How will the noise be addressed? • Do mineral right owners get a share of the crypto income that the operator gets? • What regulations govern infrastructure required for crypto mining sites? These are huge consumers of energy and water. • How often are capped pads inspected? • How will you regulate and monitor the emissions from the burned gas? Must be highly controlled and scrubbed to not contribute to our already poor air quality? • The crypto mining use of gas is just another huge source of local fossil fuel pollution. Why note mandate the oil and gas companies build their own pipeline to move it elsewhere away from populated areas? • Will the profits pay for the healthcare of local residents?
Comments Provided at the Open House on June 21, 2023	Additional Information Poster	• How do the rules address wildlife and other features affected by well pad locations, flowlines, access roads, traffic, noise, etc.? Are impact statements required? [Staff note: the existing rules do address wildlife, traffic and noise. The proposed rules create stricter access road standards].

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Comments Provided at the Open House on June 21, 2023	Post-Incident Meeting Poster	• Will an alert be blasted on a loud speaker? How will this be informing all affected? • Citizens should be made aware of all incidents with a timely manner (max 3 days). Transparency is vital to public trust. • Incident reports should be made available to the public on the Arapahoe County website within 3 calendar days of incident. • Where a formal incident report is required, further drilling or operations activity should be stopped until the post-incident meeting with County staff is held and the staff determine it is safe to proceed. • There must be readily accessible public records of all incidents. • Must be immediate notification/alarms to the public when health, safety and welfare is threatened. • Since you have post-incident reporting you already know there will be incidents. One incident is too many. Are you willing to gamble with our lives? Put all incidents on the County website.
Comments Provided at the Open House on June 21, 2023	Facilities Needing to be in Compliance with State and Federal Laws Poster	• State and Federal laws are not strict enough. Arapahoe County can and should hold to a higher standard. • Useless amendment. Just for show. Federal and state laws and regulations already apply. • Arapahoe must follow Commissioner Warren-Gully's statement and set our own level of standards and best practices to be a leader (the best) in protecting public health, safety welfare and the environment. Set the example for other local government units in the state and country. Don't rely on others that we know are lacking. • The current standards are not strict enough for this urban dense populated area. • What exactly do the current standards protect? Rules and regulations should protect the health and safety of the environment, communities and wildlife. Fines are not severe enough to deter bad practices. • Greed.

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Comments Provided at the Open House on June 21, 2023	Access Roads Standards Poster	• Access roads are critical to prevent runoff and damage from spills. These are not sufficient for all of Arapahoe County oil and gas. • Access road standards should include protection from spills, such as culverts, drainage, etc. to divert spills way from land nearby. • How close will these roads be to the Superfund site? How will the vibrating affect it? • How will the trucks affect the local residents? Noise, traffic, gas, school kids. • How will these protect the potential spills? • Distance from homes and schools – noise, dust are pollution issues. Setbacks from waterways (spills!) and Superfund site. Vibrations from heavy trucks affect site integrity that's already leaking. • Must have sufficient equipment on-site for immediate reaction to emergencies. Must be approved by emergency management services organization (OEM) and fire department.
Comments Provided at the Open House on June 21, 2023	Handwashing Facilities Poster	• Will gas masks/hazmat suits be provided for local children? Will you cover my costs for inhalers so my children don't die? • This should've been hosted at a neutral space. Arriving to see "Civitas Arena" is not a warm welcome to the community. • Can you also provide public health financial assurances for those of us breathing the toxic fumes? • Concerned regarding increased radon infiltrating our homes, increased ozone and negative health impacts. Concern about fracturing and creating issues with my home's stability. Poison leaking into water supplies. • Yes but there are much more important topics that must be addressed in Phase 1 – air quality, monitoring, financial assurances, superfund site protection, and more! • Visual representation showing red lines to show revisions/updates. • Please load each poster as a PDF with comment option for those who couldn't attend tonight.

Comment Provider	Proposed Phase 1 Rule Topic and Criteria	Rule Wording/Stakeholder Comments
Comments Provided at the Open House on June 21, 2023	Neighborhood Meetings Poster	• Does the County perform air quality modeling? If so, could folks down-wind be included in notifications? • Must notify folks and businesses within at least 10 miles if not the entire County. This will affect everyone's environment as well as public health, safety and welfare. Best science of recent studies shows 5-10 miles and fire issues are more than 1 mile away. • Arapahoe County needs to be the lead on human life – notices to those only 1 mile away is a joke. This needs to be a minimum of 10 miles. • Notification should be sent to all owners and HOA's within entire pooling area and not just drill site. • Notify the entire County of this. Follow the science. • "Homeowner Association" should be expanded to include all metro districts and other neighborhood organizations. • Notice area needs to be much farther – 10 miles. • "One mile of proposed facility" is ambiguous – should include one mile of any portion of the proposed facility, including underground drilling or transportation of oil/gas or wastewater.
Comments Submitted through the Oil & Gas Webpage		1. Section 5-3.6.E.2 Neighborhood meeting: metropolitan districts (e.g., Tollgate Crossing metropolitan district, Beacon Point metropolitan district) and authorities (e.g., Tallyn's Reach Authority, Saddle Rock Authority) today are replacing homeowner associations in many neighborhoods. The metropolitan districts and authorities should be notified as well as homeowners association. 2) Section 5-3.6.E.2 notification only of those homeowners, residents and associations "within one mile of the pad boundary" is too limited. Drilling-related activity may affect properties far from the pad boundary for example if the wells are drilled under their property or if roads will necessarily carry fracking fluid, waste fluids, etc. Notice should be given to all property owners, associations, etc. within 1 mile of ANY proposed drilling-related activity. 3) Section 5-3.6.F.2.d reservoir setbacks - the term "downgradient" does not appear to be defined. It seems this applies only to the surface topography (i.e., so long as any leaking oil or contaminants AT THE SURFACE flows away from the reservoir it is OK to reduce the setback to 2000 ft). However, this is not appropriate for example if there are subsurface features (rock or clay structures for example) that would direct SEEPING oil in a different direction, or if there are gradients/rock formations that would direct oil spills from defective casing, for example, below the surface toward the reservoir. This exception either needs to be eliminated or much broader. In addition, the downgradient condition should be required for ALL operations associated with the oil and gas operations near the well pad such as oil pipelines, roads that would carry contaminated fluids or oil, etc. as those pipelines and roads may direct oil spills, etc., back toward the reservoir. 4) Section 5-3.6.F.2.d the 500 foot alternative setback "with consent of owner" is illogical and does not promote public safety - if the reservoir owner is corrupted in some way such as a ginormous payment from the oil company, it is illogical for the county to allow public safety and precious water supplies to be

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		compromised just because of the consent of the owner. 5) Section 5-3.6.F.3.m incident reporting - the post-incident meeting is a good idea but it should be open to the public and operations related to the incident should cease until the meeting occurs. 6) Section 5-3.6.F.11 access road standards - there should be a requirement that access roads provide appropriate gutters or other facilities to direct any spills or contaminants away from surrounding terrain. 7) Section 5-4 definitions - downgradient needs to be defined. These proposed amendments are grossly insufficient in addressing the documented concerns of Arapahoe County Citizens. Specifically: 1. The setback exceptions undermine the intent of the 1 mile set-back. It creates subjective loop-holes that puts the power in the hands of the oil and gas operators and nullifies the voice of citizens who are directly impacted. 2. The cryptocurrency use is woefully undefined in the amendment. And I believe that is intentional because a use like this only increases concerns regarding pollution. Furthermore, the argument made by oil and gas is that fracking projects are necessary for "our" energy needs as local residents. However this accessory use is definitively NOT for the production of energy used by consumers and the likely beneficiary would be wealthy investors well beyond our county. In summary, this set of amendments feels like lip service to citizens and a wink and a nod to the oil and gas operators. There is nothing substantive to remove the pollution risk to the community let alone anything that improves the benefit to the community. Hello Arapahoe County Officials, I know you have a lot on your minds, and I'm sure you're trying to find balance and keep a lot of people happy. However, your residents should be the #1 priority. Do you agree? Please take my comments below to heart. I know your jobs are not easy, but the decisions you are making will affect the future of Arapahoe County for generations to come. My primary concern is about setbacks. What is the point of a 1-mile setback from reservoirs and proposed reservoirs if you already bake loopholes and exceptions into the proposed amendment? Should we propose laws that say it's ok to speed, as long as you're going uphill? Truth be told, 1-mile setbacks from these fracking operations are nowhere NEAR far enough. But, I understand there's no chance you'd go up from 1 mile. Additionally, reverse setbacks are already a loophole in themselves. When you look at a proposed project like the Lowry Ranch CAP, a residential development is planned immediately to the east of the Blackstone community that will be right next to a proposed drilling site, much lower than your county setbacks. Why is this ok? The order of operations make it ok? Since the drilling site will likely come first, the safety of the community doesn't matter? This makes zero sense... Reverse setbacks should be eliminated altogether. By continuing to entertain O&G projects like the Lowry Ranch CAP, you're opening the door to permanent damage in our county, not to mention making this a far less desirable place to live. Are long-term impacts not considered at all? Doesn't Arapahoe County have more to offer than a bunch of fracking sites? Can't we capitalize on retail, housing, tourism and recreation? Can't we build long-term value for OUR people, not for multi-billion dollar

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		publicly traded companies that are majority owned by foreign investors? Wow, Civitas has a corporate sponsorship for something at the Arapahoe County Fairgrounds... they must really care about the people of our county. Do your research. The Canada Pension Plan owns the most shares of Civitas Resources, followed by about ten other private equity groups. Do you really think they care about the people of Arapahoe County? Are we really that naïve? This is ALL about money, otherwise it would not be happening in our county. And what in the world is this about cryptocurrency mining? There's no way that's beneficial for our "health, safety, wildlife and the environment." PLEASE, do the right thing. Come up with some loophole-free regulations. Stand up for your residents. And please, DON'T cave to billionaires that have promised the world to you. We don't need them. Arapahoe County is great. The Aurora Reservoir is great. The city of Aurora is great. Open space is great. Why must we ruin it? Thank you for your time and consideration of my comments Do not make exceptions to the one mile setback! One-mile setbacks should be increased to something higher in order to reduce the impact on the local populace. Additionally, this would apply to the burning of natural gas in order to power cryptocurrency mining, which should be further than one-mile. Please stick to a minimum of a one mile setback from all homes and bodies of water (current or planned). Better yet, so not allow this project to happen at all. We do not have the water table to support this, they will frack under an unstable (and already leaking) superfund site, and fracking has proven to cause children who live within a mile of fracking to develop cancer at 2-3 times the rate of others. Additionally, our air quality is already horribly rated by the EPA, and fracking releases VOCs and CO at a level harmful to all, but especially children and the elderly. Don't let this company destroy our community!
League of Women Voters	Reservoir Setbacks Cryptocurrency Mining Other Items	The attached letter from the League of Women Voters requests that the one-mile setback not have any waiver allowances. They also recommend a 2,000-foot setback from 100-year floodplains, wells, streams and from the edge of riparian areas. They do not support including cryptocurrency mining as an allowed use. They would like expanded residential setbacks to be included as an additional code amendment at a later date and would like wildland urban interface addressed in a future code update.

Notes:

1. Many of the comments received in the last several weeks relate to the rules adopted in November 2021, rather than the currently proposed rules. They are included in this table. Our focus with the currently proposed rules is to further protect health, safety, welfare and the environment. Specifically water reservoirs public drinking water systems.
2. No internal stakeholder comments were received from Transportation.
3. Staff provided posters for the rules topics at the open house, hence the open house comments are sorted by the poster/rule topics. Comments received at the poster tables don't always relate to the poster topics.