

Critical evaluation of University of Maryland School of Public Health report "Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland

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Date:
October 3, 2014

Project Number:
22-36183A

ENVIRON

Contents

1 Executive Summary

An assessment of the potential public health impacts of natural gas extraction within Maryland's Marcellus Shale resource was conducted by the Maryland Institute for Applied Environmental Health School of Public Health at the University of Maryland, College Park (referred to in this document as U MD). The assessment was based heavily on methodologies for conducting a Health Impact Assessment (HIA). A report of the assessment process and findings, titled *Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland* was finalized in July 2014 and then opened for peer review and public comment. The assessment, evaluating unconventional natural gas development and production (UNGDP) in certain regions of Maryland (namely Allegany and Garrett Counties), was conducted as a "rapid" (also known as "desktop")[1] HIA and was comprised of some of the components specific to an HIA process including scoping, assessment, and recommendations. The report itself serves as one component, the reporting component, of the HIA. To complete the HIA process, U MD included suggestions for further monitoring, research and evaluation of the perceived impacts of the development of natural gas resources through unconventional natural gas development and production (UNGD & UNDGP) in Western Maryland and U MD recommendations following acceptance of the assessment.

ENVIRON was asked to review and provide comments on the U MD HIA and the recommendations provided therein. According to the Executive Summary provided by U MD, the HIA set out to accomplish the following:

a) Provide a baseline assessment of current regional population health; and

b) An assessment of potential health impacts; and

c) Possible adaptive and public health mitigation strategies should UNGD and UNGDP move forward within Maryland's Marcellus Shale resource, specifically looking at Allegany County and Garrett County.

The U MD report states that the study was designed to inform decisions by clearly describing risks and potential public health responses. During the scoping of the process U MD reports they sought input from "a wide range of stakeholders" through public meetings and publication of a draft scoping document. Further the researchers point to a focus on the public health impacts concentrated in and unique to Allegany County and Garrett County populations living and working near anticipated sites of shale gas development.

While the U MD report presents sources and data collected and assessed as to potential impacts and concerns, the usefulness and inferences as to potential impacts is limited by the choices of evidence presented in the study. Based on our review the U MD HIA is lacking in sound science and methodology to provide solid linkages to potential impacts or risks

[1] Rapid HIAs may be completed in a short time (weeks to months**), are often focused on smaller and less complex proposals** [emphasis added], and generally involve primarily literature review and descriptive or qualitative analysis (NRC 2011).

associated with UNDG and UNDGP. The report fails to achieve its objectives and many of the concerns raised apply to the industry in general and are based on anecdotal versus supportive evidence of incident and or occurrence. Data appears to be cherry picked to support initial inferences of linkages to questions of concern and U MD supporting data is inappropriately or inaccurately reported and cited. Many of the assumptions and inferences presented in the U MD report are flawed, outdated, and erroneous. The recommendations listed do not appear to mitigate concern but provide avenues of further concern and in some cases conflicting and inefficient additional research that will likely not provide the decision makers a guide to determination/s.

In summation, the U MD report serves as a gauge for the concerns and perceptions raised by stakeholders, residents, and decision makers revolving around the question of moving forward with UNDG and UNDGP in Allegany County and Garrett County. It provides a starting point to investigate, educate, answer and for further discussion. The U MD report however lacks substantive study to form reasonable and productive recommendations and therefore this study should not be used to draw conclusions.

2 General Comments

This section describes ENVIRON's comments on the report *Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland*, authored by a project team from the University of Maryland School of Public Health (U MD). The U MD project team for the report contains many very inexperienced members who worked under tight time constraints. ENVIRON believes that these limitations effect the quality of the resulting report.

The U MD Research Team was comprised of 1 full Professor, 1 Associate Professor, 3 Assistant Professors, a Graduate Assistant, and a Program Associate. They were assisted by 1 Assistant Scientist, 3 graduate students, 4 undergraduates, and a Geographical Information Systems Support individual. It is not clear that any of the members of the Research Team or their contributing students have had previous experience conducting Health Impact Assessments (HIAs).

The timeline for this Study was very tight. Although Maryland's "Marcellus Shale Safe Drilling Initiative" was initiated in 2011, with firm deadlines for each report's completion, the funding for the project was not achieved until Governor O'Malley's FY 2014 budget. The U MD Research Team therefore had less than a year to conduct the study and submit a report. Such a timeframe is difficult even for an experienced team. The tight timeline likely resulted in heavy reliance on student analysis, including undergraduates. While such an approach might be useful in other circumstances, this report will be submitted to the Governor and have policy implications. Thus, while we understand the time and manpower constraints, ENVIRON believes it should point out the many inconsistencies, biases, and inaccuracies that perpetuate throughout report.

Given these limitations, some sections relied on non-peer-review items, including newspaper articles. Yet these references were given equal weight with publications in the peer-reviewed literature. This tendency may, again reflect the inexperience of the project team.

Below, ENVIRON summarizes its comments on the U MD Study, then presents more detailed comments in Section 3.

2.1 General Comments on HIA

An assessment of the potential public health impacts of natural gas extraction within Maryland's Marcellus Shale resource was conducted by the Maryland Institute for Applied Environmental Health School of Public Health at the University of Maryland, College Park. The assessment was based heavily on methodologies for conducting a Health Impact Assessment (HIA). A report of the assessment process and findings, titled *Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland* was finalized in July 2014. The assessment, evaluating unconventional natural gas development and production (UNGDP) in certain regions of Maryland (Allegany and Garrett Counties), was

conducted as a "rapid" (also known as "desktop") HIA[2] and was comprised of components specific to the HIA process including scoping, assessment, and recommendations. The report itself served as the reporting component of the HIA. To complete the HIA process, the report included suggestions for further monitoring and evaluation of the impacts of the project and any recommendations implemented following acceptance of the assessment.

General comments on the HIA include:

- The report could be greatly improved by providing the reader with a summary of the project, even if just summarizing the findings of the Economic Report prepared by RESI (Regional Economic Institute 2014). As the U MD Report now stands, only minimal project-specific details are scattered throughout this report including the potential drilling scenarios (estimated number of wells and well pads per the two RESI scenarios - page 31) and an estimated number of migrant workers (page 70). For example, no discussion is provided regarding the numbers of jobs that may be created, how many of those might be taken by local workers versus workers who will migrate into the area, and the total influx of people expected including their families (which could impact the education systems and hospitals). No estimate of total truck traffic is given and there is no discussion of how well these counties will be able to accommodate new workers and families (housing, police).

  Without some understanding of what the project might look like, the majority of the discussion remains generic and vague. It is also critical for the reader to be able to determine the applicability of the studies referenced. e.g., are the studies cited applicable to the magnitude and duration of what is planned for Western Maryland?

- The rating system described by the U MD project team includes evidence of bias in its failure to consider that the effects of UNGDP might be neutral, or bring benefits to the communities affected. According to the National Research Council report, *Improving Health in the United States: The Role of Health Impact Assessment* (NRC 2011) "The credibility and relevance of HIA to the decision-making process rests on a balanced and complete examination of the health risks, benefits, and tradeoffs presented by the project, policy, program, or plan being assessed" (NRC 2011, pg. 44). The NAS report has a discussion on why HIA is a better tool than a health risk assessment concluding that traditional risk assessment tends to focus on adverse health effects rather than on beneficial *and* adverse effects. Nevertheless, the U MD report has failed to evaluate the potential health benefits of the project. None of the domains evaluated included, for example, improvements to local economies, increased tax revenue, or increased employment opportunities for local residents.

- The U MD report starts "HIA is not a quantitative risk assessment…." (Section 7.1, page 1, second paragraph). Although this statement is correct, an HIA can include a quantitative risk assessment and often does. For example, a quantitative risk

[2] Rapid HIAs may be completed in a short time (weeks to months), **are often focused on smaller and less complex proposals**, [emphasis added] and generally involve primarily literature review and descriptive or qualitative analysis (NRC 2011).

assessment was included in the HIA for Battlement Mesa, which is often cited in the U MD report (Witter et al 2010).

- The U MD report states "As outlined in the National Academy of Science Report, quantitative risk assessment is beyond the scope of HIA. As such, this study did not conduct a formal quantitative risk assessment" Section 7.1, page 2, first paragraph, last two sentence. This is an inaccurate statement. The NAS Report specifically states that "…quantitative estimates of health effects have value and should be provided when the data and resources allow and when they are responsive to decision-makers' and stakeholders' information needs" (NRC 2011, pg. 74).

2.2 General Comments on Baseline Health Assessment

As part of the scoping phase, the U MD team identified baseline public health status indicators for populations in Allegany and Garrett Counties. Indicators identified were vulnerable populations and physical and social determinants of health. The public health indicators where compared to those for the region and for the State of Maryland. The detailed Baseline Health Assessment is presented in Appendix 1 of the U MD report. An overview is provided in Section 9.0, with a brief summary in the Executive Summary.

General comments on the Baseline Health Assessment include:

- The baseline health assessment discusses numerous health indicators (preventable hospital stays, chronic disease, major causes of morbidity and mortality, and birth outcomes). But nowhere is the discussion tied to UNGDP activities. Would one expect UNGDP to influence these health outcomes, and if so, which ones? It would have been useful to the reader if the writers had explained their selection criteria.

- Appendix 1 relied heavily on available public databases for the health outcome data. While that is applicable, the report failed in most cases to include information from those sources regarding error/uncertainty in the estimates. For example, most of the databases contained information on the 95% confidence limit. However, the uncertainty is presented in very few cases in the Appendix, less frequently in the text, and never in the Executive Summary. The report compares point estimates (are they higher or lower) while ignoring the uncertainty.

2.3 General Comments on Impact Assessment

The assessment phase of the U MD report included an analysis of the potential impact of community-identified hazards and stressors associated with UNGDP activities. The report grouped the hazards and stressors into eight broad categories:

1. Air quality;
2. Flowback and production water-related;
3. Noise;
4. Earthquakes;
5. Social determinants of health;
6. Healthcare infrastructure;

7. Occupational health; and
8. Cumulative exposure/risk.

Each broad category of hazard or stressor was scored on seven criteria:

1. Vulnerable populations;
2. Geographic extent;
3. Duration of exposure;
4. Frequency of exposure;
5. Likelihood of health effects;
6. Magnitude of health effects; and
7. Effectiveness of setback.

The total score for each category was assigned a magnitude of its public health impact, ranging from no or low impact to high impact. A low public health impact was defined as a "low likelihood that UNGDP related changes will have negative impact on public health" while a high public health impact was defined as a "high likelihood that UNDGDP related changes will have negative impact on public health." Also included in the assessment phase was a review of the key determinants of human exposure to UNGDP-related hazards and potential chemicals of concern related to UNGDP activities.

General comments on the Impact Assessment include:

- Three items are identified in the U MD report upon which the magnitude of potential human exposure depends upon: 1) concentration of the hazard in the environment, 2) frequency of exposure to the hazard and 3) duration of exposure to the hazard. Although the frequency of exposure to hazard and the duration of exposure to the hazard are included in the hazard ranking for the HIA and used in this report to rank hazard/stressor categories, the concentration of the hazard in the environment is ignored. The *magnitude of the exposure* or exposure intensity is a key element, yet is missing in the hazard ranking. As it currently stands, the hazard ranking system just assumes exposure and does not take into account the potential magnitude or intensity of the exposure.

- It appears that the only real differentiating evaluation criteria in the U MD report are "likelihood of health effects" (range of 0-3), "magnitude of health effects" (range 0-3), and "geographic extent" (range 1-2) as all stressors (with the exception of Earthquake) earned the same score for vulnerable populations (2 out of a possible 2), duration of exposure (3 out a possible 3), frequency of exposure (2 out of a possible 2), and the effectiveness of setback (2 out a possible 2). Thus, each stressor category, with the exception of Earthquakes, started out with a score of at least 10 out of a possible 10, guaranteeing an overall evaluation of at least "moderately high likelihood that UNGDP related changes will have a negative impact on public health." It is therefore not surprising that all stressor categories, with the exception of Earthquakes, ended up being assessed as at least "moderately high likelihood that UNGDP related changes will have a negative impact on public health."

- Thus, the evaluation appears, on the surface, to be a matter of the U MD project team differentiating between “moderately high” and “high” likelihood, no matter what the individual evaluations within each stressor category showed. The evaluation methods adopted by this project team were therefore biased to find only negative results.

2.4 General Comments on the Recommendations

In total, 52 recommendations where made regarding potential UNGDP activities in Allegany and Garrett Counties. Recommendations R1 through R7 tend to be generic and are proposed for inclusion into the Comprehensive Gas Development Plans. None of these recommendations are discussed in detail in the U MD report. Recommendations R8 through R13, deal with disclosure of well stimulation materials. None of these recommendations are discussed in detail in the U MD report.

In Section 3 of these comments, ENVIRON discusses the support for each of the recommendations proposed in the U MD report, and comments on their validity.

3 Detailed Comments

This section presents the detailed comments on the U MD report. Section 3.1 addresses the comments on the HIA methodology including selection of hazards/stressors, linking exposures to hazards and adverse outcomes, hazard ranking, and the baseline assessment. Section 3.2 addresses the broad categories of hazards/stressors selected for evaluation in the HIA. Section 3.3 addresses Occupational Health Impact. Finally, Section 3.4 addresses the thirteen recommendations that are not discussed in the report.

3.1 Comments on the HIA

The report could have been greatly improved by providing the reader a summary of the project upfront and using this information in the evaluation of the studies provided. As noted in the U MD report, an Economic Report was developed for the project by RESI (Regional Economic Studies Institute 2014). The Economic Report assumes a drilling period from 2017 through 2026 and a ten-year long-term economic impact following the last well drilled in 2026. The Economic Report evaluates two scenarios for Garrett and Allegany Counties; one where 25 percent of the total shale gas would be extracted and one where 75 percent of the shale gas would be extracted; scenarios they consider to be conservative and feasible given the total natural gas reserves in Maryland. Based on these scenarios they estimate, among other parameters, number of well pads and wells drilled, impacts of truck trips to each scenario, increase/decrease in jobs by year, and impact on the housing market.

It appears that the U MD HIA relied on some of this information but nowhere in the U MD report is there a comprehensive discussion of the potential scenarios. As it stands, only minimal project-specific details are scattered throughout the U MD report, including the potential drilling scenarios (estimated number of wells and well pads per the two RESI scenarios - page 31) and an estimated number of migrant workers (page 70; which, as described in Section 3.2.6.1 of these comments, is incorrect). In all instances, the estimated numbers for Allegany and Garrett Counties are added together even though Allegany County's numbers are much lower. According to the Economic Report, "Allegany County anticipates lesser impacts compared to its western neighbor considering the Marcellus Shale play underlies nearly all of Garrett County, and a small western section of Allegany County" (RESI 2014). Without some understanding of what the project might look like, the majority of the discussion regarding hazard and outcomes remains generic and vague.

It is also critical for the reader to be able to determine the applicability of the studies referenced – are the studies being reviewed applicable to the magnitude and duration of what is planned for Western Maryland?

- For example, the U MD report (Section 10.3.5, page 63) includes a long discussion regarding studies of increased traffic in areas of UNGDP activity and adverse outcomes. However, the U MD report does not put this discussion into context by comparing the actual levels of truck traffic in the areas cited in their references (including Colorado, Montana, New Mexico, and Texas, (Haggerty et al 2011; Coussens and Martinez 2014; Witter et al 2010; Adgate et al 2014; Food and Water Watch [FWW] 2013), to the anticipated truck traffic due to UNGDP activity in Allegany and Garrett Counties.

- For example, the U MD report (Section 10.3.5, page 63) states “Local traffic would also increase since an average of 120 to 15 workers per day would commute into the community to work on site. This is stated as if it applies to this project, but it does not. The statement came from the Battlement Mesa HIA (Witter et al 2010) and is based on an economic and employment assessment forecasted specifically for Battlement Mesa. The U MD report needs to state why this would be applicable to Allegany and Garret Counties. For example, the U MD Report (Section 10.3.5.2 Crime, pages 64 and 65) discusses the results of a report by Food and Water Watch (2013) regarding crime in Pennsylvania. Based on the Food and Water Watch report, the U MD report discusses an increase in disorderly conduct (rising 17.1% from 1,336 prior to commercial UNGDP to an average of 1,563 per year after UNGDP), drunk driving (“steep increase”), and public intoxication arrests (rose 11.9%) in counties with UNGDP (Food and Water Watch 2013). However, if one goes back to the reference they would see that the area of Pennsylvania discussed was heavily “fracked” with 5,000 new wells in a six year period (2005-2011), and the increase in new UNGDP wells per year increasing to 1,972 in 2011 (Food and Water Watch 2013). This is very different than what is planned for Western Maryland. According to the Economic Report (RESI 2014), the estimated new wells in Allegany County over the next 10 years in the maximum scenario is 60; with a maximum of 12 new wells in any one year. The estimated new wells in Garrett County over the next 10 years in the maximum scenario is 390; with a maximum of 56 new wells in any one year (RESI 2014). This same incompatible study is referenced four times in Section 10.3.5.3 (Illness, Mental Health, and Substance Abuse) and twice in Section 10.3.5.4 (Impact on Residents, Police, and Health Care System).

3.1.1 Selection of Hazards/Stressors

The U MD project team went through a detailed scoping process, which included community input, to identify potential hazards of concern related to potential UNGDP activities. They grouped these into eight broad categories as shown below:

1. Air Quality;
2. Flowback and Production Water Related;
    a. Water Quality;
    b. Soil Quality;
    c. Naturally Occurring Radioactive Materials (NORM);
3. Noise;
4. Earthquakes;
5. Social Determinants of Health;
    a. Sexually Transmitted Infections;
    b. Traffic;
    c. Crime;
6. Healthcare Infrastructure;
7. Occupational Health; and
8. Cumulative Exposure/Risk.

The above list includes both chemical stressors (as related to air quality, water quality, soil quality, NORM and occupational health) and nonchemical stressors (as related to noise, earthquakes, social determinants of health and healthcare infrastructure). The U MD team should be applauded for their efforts to include the community in this process.

However, a major concern lies in the fact that the U MD team chose to focus on only adverse effects and not include the traditional HIA category of benefits. Thus, their categories do not include potential stressors that may have *positive* benefits such as community wellness. In addition to the potential adverse effects of UNGDP activities, these activities are also likely to bring benefits to the community including new local jobs, increased wages, improvement the local economy, and increased tax revenues. These benefits will likely lead to positive health impacts such as decreases in stress, increases in community cohesion and potentially increases in education and health care funding. Furthermore, positive economic benefits to the community may highly influence the health of those members of the community who are in a state of poverty, as those in poverty tend to have poorer healthcare and higher rates of adverse health. By not including positive benefits due to UNGDP activities in their analysis, the U MD team lost an important opportunity to present a more balanced HIA and better inform decision-making.

3.1.1.1 Identification of Chemical and Nonchemical Stressors

The discussion on the fluid composition used to hydraulically fracture a well lumps hundreds of chemicals together but doesn't supply any context concerning frequency or quantity of use or the likelihood that these chemicals will be used in Maryland.

3.1.2 Linking Exposure to Hazards with Adverse Health Outcomes

The U MD report discusses exposure and linking exposure to hazards with adverse health outcomes (Section 10.1). Looking at the source-to-exposure continuum, the UNGDP process is listed as the source of exposure, with potential pathways of exposure including air, dust, food, water and soil and potential routes of exposure including inhalation, ingestion, and dermal contact.

Three items are identified in the U MD report upon which the magnitude of potential human exposure depends (Section 10.1, Page 16): 1) concentration of the hazard in the environment, 2) frequency of exposure to the hazard and 3) duration of exposure to the hazard. Although the frequency of exposure to hazard and the duration of exposure to the hazard are included in the hazard ranking for the HIA (as described in Section 10.2.3) and used in this report to rank hazard/stressor categories, the concentration of the hazard in the environment is ignored. The *magnitude of the exposure* or exposure intensity is a key element, yet is missing in the hazard ranking. As it currently stands, the hazard ranking system just assumes exposure and does not take into account the potential magnitude or intensity of the exposure.

It is difficult to understand how the U MD team could rank likelihood of health effects and magnitude/severity of health effects without any consideration as to the actual exposure anticipated. The way that the U MD report appears to deal with exposure intensity is to assume worst-case exposure and then proceed to rank the hazard/stressor category.

For example, air quality only emissions were estimated, but none of the data was used to model exposure to the Allegany or Garrett County populations. The logic seemed to be that (1) air pollution can cause health effects, (2) UNCDP will potentially result in air pollution, and therefore (3) UNCDP is rated high in its potential to cause health effects that are chronic, irreversible or fatal. No consideration of the magnitude of exposure or any project-specific information (number of wells, number of trucks) is used to estimate exposure magnitude, and thus it is impossible for the U MD report to evaluate the potential impact of these stressors on the populations.

This lack of tying potential presence to a stressor to the magnitude anticipated also occurs in the U MD report with the analysis of the non-chemical stressors. As noted previously, no effort has been made in most cases to compare likely exposure scenarios for Allegany and Garrett County with the studies the U MD project team is using for evaluation. For example, the HIA discusses:

- Issues related to truck traffic in high density UNGDP areas (Colorado, Montana, New Mexico, and Texas), but never relates this to the truck traffic estimates provided by RESI in the Economic Report for this project (RESI 2014).

- Increases in crime rates, alcohol abuse, mental health, and sexually transmitted infections for high density UNCDP areas (such as Colorado, Montana, New Mexico, and Texas) but never relates the parameters related to high density (number of wells, number of pads, number of workers, number of migrant workers) to the estimates provided by RESI in the Economic Report for this project (RESI 2014).

The linkage between hazards, exposures, and adverse health outcomes is discussed in the U MD report (Section 10.1.2). The report states the "…it is important to note that this type of information is currently not available in the context of UNGDP for several reasons…" including UNGDP is a relatively new process and chronic studies take a long time. Although the UNGDP in total may be relatively new, the impact of many of the components of the process are not (including truck emissions, noise impacts and social determinants of health based on studies examining situations with a large influx of worker populations).

The U MD report, in describing their methods for identifying literature, states "All articles were screened for titles and abstracts. Articles that were not related to UNGDP were eliminated from the list" (page 19). As noted above, although UNGDP may be relatively new, all the hazards being discussed in the report are not necessarily new and the U MD report may be limiting itself by being overly selective with the information used.

3.1.3 Hazard Ranking

There is no single defined way to score stressors/hazards in an HIA. In order to evaluate the eight categories of stressors/hazards, the U MD team set up seven criteria that were adapted from the Battlement Mesa HIA (Witter et al 2010). The seven criteria are:

1. Vulnerable populations;
2. Geographic extent;
3. Duration of exposure;

4. Frequency of exposure;
5. Likelihood of health effects;
6. Magnitude of health effects; and
7. Effectiveness of the setback.

Each of the eight categories of hazards/stressors was given a cumulative score for public health impact which included:

> H: High likelihood that UNGDP related changes will have negative impact on public health.
>
> M: Moderately high likelihood that UNGDP related changes will have negative impact on public health.
>
> L: Low likelihood that UNGDP related changes will have negative impact on public health.

Note, one would expect that the middle category would be a "moderate likelihood" rather than a "moderately high likelihood." The leap from low likelihood to moderately high without some intermediate likelihood ranking speaks to the overall approach taken by the project team.

In adapting the seven criteria used in the Battlement Mesa HIA, two critical criteria were omitted from the U MD report: "direction" and "magnitude of positive health effects." In the Battlement Mesa HIA, "direction" indicates whether the potential health effect may *improve* or *detract* from the health of the community. "Magnitude of positive health effects" indicates a range from low to high regarding the potential to make improvements to health. According the National Academy of Science (NAS) report, *Improving Health in the United States: The Role of Health Impact Assessment (2011)* characterization of an effect should include direction - indicating whether the effect is adverse or beneficial (NRC 2011). The U MD report has failed to address health benefits, and therefore presents only a weighted portion of the story.

Another key missing component to the hazard ranking system is the magnitude or likelihood of exposure should UNDGP activities occur. The ranking system *assumes* exposure has occurred. However, without an understanding of the magnitude of exposure, it is difficult to estimate two of the other evaluation criteria, likelihood of health effects and magnitude/severity of health effects.

The evaluation criteria "effectiveness of setback" seems to be out of place in the U MD report. It would seem that a setback would be a recommendation, not a criteria, as it applies only to air and noise and is irrelevant to the other categories of hazards/stressors.

In retrospect, it appears that the only real differentiating evaluation criteria in the U MD report are "likelihood of health effects" (range of 0-3), "magnitude of health effects" (range 0-3), and "geographic extent" (range 1-2) as all stressors (with the exception of Earthquake) earned the same score for vulnerable populations (2 out of a possible 2), duration of exposure (3 out a possible 3), frequency of exposure (2 out of a possible 2), and the effectiveness of setback (2 out a possible 2). Thus, each stressor category, with the exception of Earthquakes, started out

with a score of at least 10 out of a possible 10, guaranteeing an overall evaluation of at least "moderately high likelihood that UNGDP related changes will have a negative impact on public health." It is therefore not surprising that all stressor categories, with the exception of Earthquakes, ended up being assessed as at least "moderately high likelihood that UNGDP related changes will have a negative impact on public health." Thus, the evaluation appears, on the surface, to be a matter of the U MD project team differentiating between "moderately high" and "high" likelihood, no matter what the individual evaluations within each stressor category showed. As stated above, the evaluation methods adopted by this team were biased to find only negative results.

3.1.4 Baseline Assessment

As part of the scoping phase, the U MD project team identified baseline public health status indicators for populations in Allegany and Garrett Counties. Indicators identified were vulnerable populations in the impacted regions, and physical and social determinants of health. The public health indicators in these two Counties were then compared to those for the region and for the State of Maryland. The region was identified as Allegany and Garrett Counties in Maryland, Bedford, Fayette, and Somerset Counties in Pennsylvania, and Grant, Hampshire, Mineral, Preston, and Tucker Counties in West Virginia.

Vulnerable populations cited as part of the baseline public health status included the more traditional groups such as children, the elderly, and those with disabilities. In addition, the U MD team included other populations who may be impacted by UNGDP including surface owners who do not have mineral rights. Also considered were occupational exposures and impacts to healthcare infrastructure that may affect vulnerable populations.

The indicators evaluated for physical determinants of health were health status, environmental health data, prevalence and incidence of chronic disease and cancer, and negative birth outcomes while the indicators considered indicative of social determinants of health were sexually transmitted infections, crime, injuries, mental health status, and substance abuse.

Specific comments on this section include:

Vulnerable Populations

- In the U MD Report, an entire section (Section 9.4, page 9) is devoted to discussing vulnerable populations which the report states is "commonly defined as how individuals or groups of individual or organisms respond to and recover from stressors inadequately or not as well as the average" (Kasperson and Kasperson 2001; DeFur et al 2007). However, this discussion of vulnerable populations appears to be unrelated to the first evaluation criteria used in the study, "Presence of vulnerable populations." The evaluation criterion presented in Table 10-2 (pages 20-22) of the U MD report assigns a score of 1 if the stressor effects all populations equally and a score of 2 if it disproportionately affects vulnerable populations. This is not the same as is usually defined as vulnerable populations, as reflected in the discussion and associated cited reports. However, throughout the U MD report, this evaluation criterion has been reinterpreted to indicate whether the stressor disproportionately affects residents near the UNGDP facilities, regardless of whether vulnerable populations are present. Since,

as pointed out earlier, the study authors have determined that all stressors (except potential earthquakes) will decrease with distance from the site, all stressors (except for earthquakes) have been ranked 2 for "Presence of Vulnerability," making this a meaningless evaluation criterion. It is counter to normal interpretation to classify workers as members of a "vulnerable" population, and in fact workers are often considered healthier than other individuals, as they wouldn't be working if they were ill. This is often referred to as the "healthy worker effect."

Environmental Health

- In the U MD Report (Section 9.5.1, Page 9, Environmental Health Indicators), there is a statement that "Annual average $PM_{2.5}$ concentrations were ~13 $\mu g/m^3$ in both Allegany and Garrett counties. These mean levels were higher than the mean concentrations for the state of Maryland as a whole." Unfortunately, there is no citation or reference provided supporting these $PM_{2.5}$ concentration values. However, Figure 15-10 (Appendix, page 137) appears to indicate that the annual average concentration of $PM_{2.5}$ in Allegany and Garrett Counties in 2011, ~13 $\mu g/m^3$, is the same as the regional concentration, and only marginally higher than $PM_{2.5}$ concentration in the state of Maryland (which appears to be ~12.5 $\mu g/m^3$ from the figure, although the concentration is not stated in the text of the report). No indication of the precision or variability of the estimate or the statistical significance of the difference is provided in the U MD report.

  In addition, this conclusion does not seem to be consistent with the seasonal comparisons of air quality for Garett County and the State of Maryland presented in Figure 10-4. Figure 10-4 shows that for all seasons except for fall, Garrett County has lower $PM_{2.5}$ concentrations than the State of Maryland.

Physical Health Indicators

- The majority of the data for this section was obtained from either the CDC Community Health Status Indictors website (CDC 2014) or the Behavioral Risk Factor Surveillance System (CDC 2012). Because estimates based on samples are subject to random error, both sites provide a 95% confidence interval which assists the reader in understanding the amount of variability in the estimates and assessing whether or not comparisons are statistically significant. Appendix 1, which includes the detailed discussion of physical health indicators, includes the confidence interval for one health indicator, "poor physical health days," but fails to provide confidence intervals for the other six physical health indicators addressed. None of this information is supplied in the text of the main document. Thus, the reader is left with the impression that the point estimates are more accurate than they really are.

  For example, the U MD report states "Both Allegany and Garrett counties had higher percentages of adults with high blood pressure (37% and 31% respectively) when compared to the State of Maryland (30%)" (Section 9.5.2.4.1, Adult Hypertension,). However, the 95% confidence interval for adult hypertension in Garrett ranges from 26.8% to 36%, while the 95% confidence interval for Maryland ranges from 29.2% to 30.7%. The overlap in the confidence intervals indicates that there is no statistically significant difference between the estimated prevalence of adult hypertension in Garrett

County compared with the state of Maryland, overall. In contrast, the 95% confidence interval for prevalence of adult hypertension in Allegany County ranges from 32.8% to 41.9%, which does not overlap with the confidence interval for prevalence of adult hypertension in the state of Maryland, indicating statistically significantly higher prevalence in the County compared with the State.

When considering both the very similar point estimates and the overlapping confidence intervals, it would appear that both Allegany and Garrett are consistent with the regional data for life expectancy, poor physical health days, preventable hospital stays, adult hypertension, obesity, diabetes, and cigarette use. By only presenting and drawing conclusions from point estimates, the U MD report puts more weight on the numbers than statistically warranted.

Major Causes of Morbidity and Mortality:

- The major sources for data in this section were CDC Wonder with Health Indicators Warehouse and National Vital Statistics System used for birth outcomes. Both of these databases include 95% confidence intervals but this information is only supplied in Appendix A of this report for cancer incidence rates. Even without 95% confidence intervals for the other health outcomes, it is clear that there are several endpoints that are nominal in difference yet presented as "increased" without context. For instance, although the mortality per 100,000 individuals from colorectal cancer, melanoma, prostate cancer, and breast cancers in Allegany and/or Garrett counties are increased compared to Maryland, the differences in mortality for these outcomes ranged from 0.4 to 2 individual deaths. Another example, "total cancer deaths," is presented as "slightly higher" for Allegany County compared to the State. However, the numbers in Allegany County are increased by 2 deaths per 100,000 individuals. Statements concerning differences between Allegany and Garrett counties and Maryland could have been improved by providing the proper context.

- The U MD report states that "All-Cause mortality rates for Allegany (853 per 100,000) and Garrett (808 per 100,000) were higher than the rate for Maryland (768 per 100,000)" (Section 9.5.3.2.6, All-Cause mortality). This statement fails to put the discussion in context of the data presented in the Appendix (Figure 15-25, page 153), which demonstrates that the all-cause mortality rates in both counties are *lower* than the regional and national all-cause mortality rates, and that these differences are much greater than the differences described between the Counties and the State rates.

Comments on Appendix 1: Baseline Health Assessment

- In discussing cancer rates in Allegany County, the U MD Report states "The estimated cancer risk for Allegany County was higher than the lifetime cancer risk for Garrett County and state of Maryland in 2002 and 2005" (Page 140, first paragraph, 2nd sentence). However, this statement does not correspond to Figure 15-12 which shows Allegany County has *lower* than the state of Maryland for both years.

- In a science-based document, the use of the work "significant" usually means a statistical test has been applied and the results are statistically significant. The U MD

team has used this word in a number of locations in Appendix 1 with a judgment rather than statistical basis. For example, "We found that the cardiovascular disease mortality rate for Allegany County (275.6) was significantly higher than the rate for Garrett, the region, and the state of Maryland" (page 150) and "These [suicide] rates are significantly higher than the state average of 8.7 (8.2-15.8 95% CI) per 100,000 and lower than the regional average of 13.9 per 100,000" (page 160). This use of the word significant in Appendix 1 appears to be solely based on the judgment of the writer with no supporting statistical documentation provided to the reader.

3.2 Community Impact Assessment

The U MD report groups hazards and stressors into eight broad categories. These categories are:

1. Air quality;
2. Flowback and production water-related;
3. Noise;
4. Earthquakes;
5. Social determinants of health;
6. Healthcare infrastructure;
7. Occupational health; and
8. Cumulative exposure/risk.

ENVIRON provides comments on each of these categories individually, below. For each category of hazards and stressors, ENVIRON provides comments on the assessment, and the resulting recommendations.

3.2.1 Air Quality

3.2.1.1 Comments on Air Quality Assessment

The U MD study concludes that there is a High Likelihood that UNGDP's impact on Air Quality will have a negative impact on public health in Garrett and Allegany Counties. The stated Air Quality concerns are based on the "limited but emerging epidemiological evidence from UNGDP impacted areas and air quality measurements as well as epidemiological evidence from other fields" (page xxi). ENVIRON disagrees with the High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below.

Air Pollutants Associated with UNGDP Activities (Section 10.3.1.1, pages 26-28)
The U MD Report states, ". . . Table 10-4 does not provide separate descriptions for two important pollutants (ozone and polycyclic aromatic hydrocarbons (PAHs)" (page 26, second paragraph, lines 5-7). There is no further description of why the report does not include ozone or PAHs, nor does it describe the effect (if any) that omitting ozone and PAHs from the assessment has on air quality impacts.

The U MD report cites a study by Colborn et al (2011) and states "In reviewing 353 chemicals associated with the UNGDP process, one study estimated that up to 75% of the chemicals have a potential to adversely affect eyes, skin and other sensory organs as well as respiratory and

gastrointestinal systems; an additional 40-50% have the potential to affect nervous, immune and cardiovascular systems; 37% have the potential to affect the endocrine system; and 25% may have carcinogenic potential . . .” (page 27, first paragraph, lines 1-5). As previously discussed, by omitting any evaluation of projected exposure magnitude, it is impossible to evaluate the actual risks posed by potential exposure to these chemicals. All substances, including air and water, are *potentially* toxic or poisonous, but the *amount* or *dose* of a substance that is inhaled or ingested is what differentiates a toxic or poisonous substance from a non-toxic or non-poisonous one. The U MD report, by relying on the paper by Colborn et al. 2011, is misleading readers by inferring toxic properties to all 353 chemicals associated with the UNGDP process, rather than acknowledging that evaluating the exposure concentration of a chemical people will potentially experience (the dose) is as important as understanding the inherent hazards (e.g., eye irritation, cardiovascular effects, cancer, etc.) of the chemical. This is a serious deficiency throughout the U MD report that should be addressed.

Overview of Studies related to Air Pollution (Section 10.3.1.2, pages 28-31)
Air dispersion modeling is a useful and commonly used tool to provide ambient air concentrations of pollutants experienced by receptors (i.e., residents), which can be used to estimate inhalation risk. USEPA’s Air Toxics Risk Assessment and Modeling Website recommends that even for relatively simple, screening-level risk analysis, simple modeling can be performed to determine whether more detailed analysis is required.

No air dispersion modeling was conducted as part of the Air Quality assessment, and this lack of air modeling represents a major limitation of the U MD report. The Air Quality assessment rather relies solely on limited sets of air monitoring data which were not specific to Garrett and Allegany Counties. However, a reasonable amount of project-specific information may already be available as inputs into an air dispersion model, including emission source locations (well pad and centralized water storage pond locations), receptors (existing residents and areas that may be developed into residences in the future), and local meteorological and topographic data. The existing monitoring data on well development activities could be used to validate and improve the model. The effects of mobile source emissions can also be included in the model from the information on possible increased (e.g., truck) traffic.

In the absence of air modeling, ambient air concentrations for receptors in the vicinity of likely UNGDP activities have been estimated using air monitoring results from projects/sites that bear limited or no resemblance to the Marcellus Shale site. Air modeling would allow for predicting air concentrations at multiple locations in the vicinity of proposed site activities, and the impact of adopting different control technologies on off-site concentrations could be tested with the model. Given the variations in weather, topography, and local emission sources, relying on a limited amount of monitoring data to conduct an assessment has misrepresented expected concentrations and risks. In addition, the lack of a site-specific air model makes it difficult to prioritize mitigation strategies or evaluate whether the proposed mitigation strategies, such as those in the Air Quality recommendations section (Section 12.3), would be effective. The Air Quality assessment conducted no source characterization; as a result, when elevated pollutant concentrations were observed in the monitoring data, it is unknown what the key contributors were, whether it is flowback operations, production tanks, well pad truck traffic, diesel-powered

equipment, off-site road traffic, or non-project emissions. Without identifying emission sources and their contribution, it is impossible to determine the best strategy to control emissions.

Studies Based on Individual Level of Measurements

The U MD report states ". . . exposure data collected on individual respondents are ideal as they provide a good approximation of an individual's true exposure. Currently such data are not available for residents impacted by UNGDP" (page 28, first paragraph, lines 1-3). With this statement, the report identified an important data gap and thus, a shortcoming in the report itself. This shortcoming is compounded when the report attempts to close the data gap by citing the occupational study conducted by NIOSH investigators (Esswein et al 2013). The U MD report states "A study conducted by investigators from the National Institute for Occupational Safety and Health (NIOSH) measured workers exposures to respirable crystalline silica (frac sand) at 11 sites across five states . . . The authors collected 111 samples from the breathing zone of workers that showed unusually high levels of exposure to respirable crystalline silica among workers. In multiple instances, these exposures were > 10 times higher than the occupational health standards such as OSHA's permissible exposure limit or NIOSH's recommended exposure limit." (pages 28-29).

- Although the study by (Esswein et al 2013) identified several worker populations on UNDGP worksites as having higher exposure to crystalline silica and thus potentially being at increased risk, it does not address the exposures (or risks) of persons living near UNDGP sites. In fact, such individuals are likely to experience far lower exposures to crystalline silica, given their distance from UNDGP operations and the size of the crystalline silica particles, which will settle to the ground over these distances.

- Further, the U MD report states, "People living, working, or attending school near and downwind of a well pad would be at high risk of exposure. Because respirable crystalline silica particles are very small and remain airborne indefinitely in outdoor air, they can travel from well pads to nearby communities where they may disproportionately affect vulnerable populations such as children, the elderly, asthmatics and individuals living with chronic obstructive pulmonary diseases (COPDs)" (page 29, first paragraph, lines 7-12). This statement grossly mischaracterizes the potential transport of crystalline silica particles. Crystalline particles are, in fact, too large to be transported substantial distances, or carried in ambient air through a community. For example, studies of particle deposition near busy roadways and highways have found that greater than 90% of particles in the size range 10 to 25 µm are deposited within a few meters of their source (Health Effects Institute [HEI] 2010; CARB 2006). For particles in the 5 to 10 µm range, greater than 80% are deposited within 50 meters of their source.

Thus, the type of silica exposures that workers on UNDGP sites are potentially exposed to are not relevant in ambient, community settings because concentrations are much lower in the community compared to the workplace.

Studies Based on Area Level Measurements

The U MD report relies heavily on a publication by McKenzie et al (2012) as representative of

studies of area-level air quality in the vicinity of UNGDP facilities (page 29, second paragraph, lines 1-14). The McKenzie study collected 163 background air samples at locations >0.5 miles from well pads and compared them to area samples collected within <0.5 miles of well pads during the well completion phase at a UNDGP site in Garfield, Colorado. The median concentrations of benzene were reported as being significantly higher within 0.5 miles from the well pad compared to >0.5 miles from well pads – 2.6 $\mu g/m^3$ (range of 0.9-69 $\mu g/m^3$) versus 0.9 $\mu g/m^3$ (range 0.1-14 $\mu g/m^3$). The corresponding values for hexane were 7.7 $\mu g/m^3$ (range 1.7-255 $\mu g/m^3$) compared to 4.0 $\mu g/m^3$ (range 0.23-62 $\mu g/m^3$).

- It is important to note, however, that background benzene concentrations may exceed 120 $\mu g/m^3$ (37.5 ppb; median concentration) in U.S. cities (ATSDR 2007), and that hexane concentrations may exceed 85 $\mu g/m^3$ (24 ppb; average concentration) (Monson et al 1978) in urban settings. These background concentrations for benzene and hexane render the actual significance of the comparisons of concentrations >0.5 miles from well pads and within <0.5 miles of well pads for these chemicals meaningless. The U MD report further cites other studies of air monitoring in the vicinity of UNGDP sites, noting that benzene concentrations measured at other UNGDP sites were in fact much lower than those cited in the McKenzie et al. (2012) paper, and even report results of one UNGDP site in Fort Worth, Texas, where benzene concentrations were lower than background concentrations (page 29, third paragraph, lines 3-11).

- The U MD report also discusses another study of air quality near a UNGDP site in West Virginia, where concentrations of VOCs varied considerably across different well pads within the sites, as well as across different UNGDP sites. Collectively, these studies show that chemical concentration measurements are variable, and in fact are usually within the range of background concentrations in the community.

Estimated Emissions for Pollutants from UNGDP Activities (Section 10.3.1.3, pages 31-36)

Emission Estimates

The U MD report is contradictory regarding emissions estimates from UNGDP activities for NOx, $PM_{2.5}$ and VOCs. For example, it first states ". . . there will be significant decreases in the emissions from each source by 2020, compared to 2009, because of stricter emission controls" (page 32, second paragraph, lines 2-4), but then states, "We took the 2009 process level to calculate overall emissions. This was done because the likelihood of implementing stricter emission control policies . . . in the next 6 years (2020) remains unclear" (page 32, bullet 3). Using the potentially higher 2009 emissions estimates rather than accounting for decreased emissions over time due to stricter controls in the Air Quality assessment is an overly-conservative assumption.

Studies on UNGDP Related Exposures and Adverse Health Outcomes (Section 10.3.1.4, pages 36-37)

The U MD report again references the publication by McKenzie et al (2012) as appropriate for assessing possible health risks associated with UNGDP sites such as the Marcellus Shale site. The U MD report noted that McKenzie et al (2012) estimated the chronic and subchronic non-cancer hazard indices and the cancer risks for residents living within a 0.5 mile radius of

UNGDP facilities and compared them with that of residents living greater than 0.5 mile away, suggesting that residents who lived closer to the well site were at greater risk of adverse health outcomes from UNGDP-related air emissions compared to those who lived more than ½ mile away. Specifically, the subchronic hazard quotient (HQ) of 5 observed for residents <1/2 mile away from wells was considerably higher than the subchronic HQ of 0.2 observed for those living >1/2 mile away (discussed on page 36, first paragraph, lines 1-8).

- McKenzie et al (2012) stated (but the U MD report did not acknowledge) that their study may have over-estimated non-cancer hazard indices and the cancer risks due to:

    - Use of the 95% UCL (upper confidence limit) on the mean exposure concentrations;
    - Maximum detected values for 1,3-butadiene, 2,2,4-trimethylpentane, and styrene because of a low number of detectable measurements;
    - Default reasonable maximum exposure (RME) assumptions, such as an exposure time of 24 hours per day and exposure frequency of 350 days per year;
    - Upper bound cancer risk and non-cancer toxicity values for some of the major risk drivers (e.g., benzene and xylene); and
    - Use of (more conservative) chronic reference concentration (RfC) values rather than subchronic RfCs for 1,3-butadiene, n-propylbenzene, and propylene because subchronic RfCs were not available.
- Furthermore, the concentrations of many of the pollutants reported in the McKenzie et al. (2012) study are similar to concentrations of those pollutants near other urban settings within the state, and likely reflect vehicle and other combustion sources rather than the UNGDP site (see, for example, the concentrations of benzene in other Colorado locations as reported in the National Air Toxics Assessment 2005).

The U MD report discusses another study by McKenzie et al. (2014) as appropriate for assessing possible health risks associated with UNGDP sites such as the Marcellus Shale site. The U MD report noted that McKenzie et al. (2014), investigating the relationship between maternal residence near UNGDP wells and the risk of adverse birth outcomes in rural Colorado, found that mothers at the highest tertile of exposure were more likely to give birth to children with congenital heart defects (CHDs) compared to mothers at the lowest tertile of exposure (Odds Ratios (OR) 1.3, 95% Confidence Interval (CI): 1.2-1.5). The authors observed similar associations for neural tube defects (NTDs) (OR 2.0, CI:1.0-3.9) (page 36, second paragraph, lines 1-10).

- Although McKenzie et al. (2014) expected adverse birth outcomes associated with maternal residence near UNGDP wells, they actually found small negative (instead of expected positive) associations with term low birth weight and preterm birth in their study population. In addition, they noted (but the U MD report did not acknowledge) several study limitations:

    - Not all birth defects were confirmed by medical record review, possibly resulting in misclassification of defects.

- Data on covariates were obtained from birth certificates and were limited to basic demographic, education, and behavioral information available in the vital records. The study's incomplete ability to adjust for socioeconomic status, health, nutrition, prenatal care, and pregnancy complications may have resulted in residual confounding.
- Low event outcomes (e.g., CHDs) were adjusted only for elevation. The data set did not contain information on maternal folate consumption and genetic anomalies, which may have confounded the results. (McKenzie et al. 2014 reported that the scientific literature has indicated small increases in the prevalence of CHDs and oral cleft palates after the introduction of folic acid in 1998.)
- There was a lack of temporal and spatial specificity of the exposure assessment. Because study authors did not have maternal residential history, it was assumed that maternal address at time of delivery was the same as maternal address during the first trimester of pregnancy (the critical time period for formation of birth defects). Studies have estimated that 22 to 30% of mothers move residence during their pregnancy, and most mothers move within their locality, potentially introducing some exposure misclassification for the early pregnancy period of interest.
- The study determined only whether a well existed within the calendar year of birth and did not determine if a well existed within the first trimester of the pregnancy, resulting in some exposure misclassification.
- Lack of information on natural gas well activity levels, such as whether or not wells were producing or undergoing development, may have resulted in exposure misclassification. Actual exposure to natural gas-related pollutants likely varies by intensity of development activities.
- Information on the mother's activities away from her residence, such as work and recreation, as well as proximity of these activities to UNGDP, was not available and may have led to further exposure misclassification and residual confounding.

The U MD report discusses a study by Hill (2013a) as appropriate for assessing possible health risks associated with UNGDP sites such as the Marcellus Shale site. Hill (2013a) investigated maternal residency in areas impacted by UNGDP in Pennsylvania and risk of adverse birth outcome including low birth weight (LBW) and preterm birth (PTB) in 2,500 live births and reported that the prevalence of LBW and PTB increased in a 2.5 km-radius of the well after well development (pages 36-37).

- The Hill (2013a) study is not published in the scientific peer-review literature, but is instead an abstract of a talk given at a scientific conference (the 2013 meeting of the International Society of Environmental Epidemiology). Abstracts for such meetings do not go through a peer-review process for quality of data as a paper would, but instead evaluate the relevance to a meeting. Normally, meeting presentations are considered preliminary results, and are only considered part of the literature when the research is accepted into a peer-reviewed scientific journal. Although there is a draft of this paper available on the Cornell University web site (Hill 2013b), this paper has not been peer-reviewed or accepted into a scientific journal to date.

- Although the Hill (2013b) study results appear to contradict those of McKenzie et al (2014) with respect to LBW and PTB, the U MD report did not note this, and in fact discusses the consistency of these studies at public meetings.
- The study's author (Hill 2013b) noted in her abstract that "the research design does not allow for causal claims regarding the precise mechanisms of the effects of shale gas development on infant health."

The U MD report cites a study by Steinzor et al (2013) as appropriate for assessing possible health risks associated with UNGDP sites such as the Marcellus Shale site. Steinzor et al (2013)reported an increased prevalence of symptoms such as throat and nasal irritation, sinus problems, eye burning, severe headaches, persistent cough, skin rashes, and frequent nose bleeds among respondents living within 1,500 feet of UNGDP facilities in Pennsylvania compared to those who lived >1,500 feet away (page 37, second paragraph, lines 1-4).

- Steinzor et al (2013) noted (but the U MD report did not) several limitations of their study:
    - Small sample size (108 respondents) and non-random samples;
    - Lack of a control (unexposed) population;
    - No health history research for the individuals enrolled in the study;
    - No investigation of other potential sources of contaminants; and
    - No adjustment for potential confounders.
- The findings reported in this study – e.g., headaches, throat/nose irritation, skin rashes and nose bleeds – are sufficiently non-specific such that, given the listed limitations, are difficult to attribute to UNGDP operations.

The U MD report references a study by Fryzek et al (2013) as appropriate for assessing possible health risks associated with UNGDP sites such as the Marcellus Shale site. In this study, the authors investigated the association between childhood cancer incidence in Pennsylvania and UNGDP by linking childhood cancer data from 1990 through 2009 with 29,000 wells drilled during the same time period (page 37, third paragraph, lines 1-4).

- Although the authors reported no association between UNGDP and childhood cancer, it was noted that the first UNGDP well was drilled in Pennsylvania in 2006 with production starting in 2008, so the vast majority of cancer cases in the study predated the exposure of interest. Thus, the study overlooked the issue of lag time that is known to exist for chronic outcomes such as cancer, and consequently, the design of this study was such that it could not possibly have found an effect.
- The U MD report correctly noted that the Fryzek et al (2013) study highlights the need for high quality epidemiological investigations with robust exposure assessments that enable investigators to carefully match the temporal scale of exposure and outcome of interest. As such, one has to question why the Fryzek et al (2013) study is cited in the report in the first place.

External Evidence for the Health Effects of Air Pollution (Section 10.3.1.5, pages 37-39)
The U MD report cites 20 studies from the scientific literature as "external evidence for the health effects of air pollution." Studies are described that show associations between air

pollution constituents and specific health effects such as cardiovascular disease, cerebrovascular disease, all-cause mortality, low birth weight, and infant mortality. However, all of these studies are general, "hazard identification-type" studies and none are specific to UNGDP activities and the listed health effects in that, if exposure concentrations were reported in these general studies, the report made no attempt to relate those concentrations to those expected at the Marcellus Shale site.

- Furthermore, most of these studies discuss urban air pollution, and often mobile sources as the origin of air pollution. For example, in the category of air pollution and cardiovascular disease (Section 10.3.1.5.1), the seven cited studies described the effects associated with exposures such as "ambient carbon monoxide", "peak SO_2 levels", "traffic related pollution", and air pollution in Los Angeles. In the category of air pollution and all-cause mortality (Section 10.3.1.5.3), a cited study described the effects associated with exposures such as fine particulate pollution in nine California counties. In in the category of air pollution and low birth weight/infant mortality (Sections 10.3.1.5.4 and 10.3.1.5.4), cited studies described the effects associated with exposures such as fine particulate matter in Connecticut, traffic-related air pollution, carbon monoxide (CO) in Southern California, particulate air pollution and CO in Los Angeles County, and general air pollution in the United States.
- The U MD study project team may be implying that excess traffic associated with UNGDP activities will result in higher general air pollution concentrations, but they do not explicitly say so in their report. Furthermore, such increased traffic is only expected to occur during short periods of time, and is not analogous to the conditions in the studies cited in this section of the report.

Assessment (Section 10.3.1.6)

In the Assessment section of the U MD report (Section 10.3.1.6), the U MD project team concludes that:

> "Based on our evaluations of the limited but emerging epidemiological evidence from UNGDP impacted areas and air quality measurements as well as epidemiological evidence from other fields (external evidence), we conclude that there is a **High Likelihood** that UNGDP related changes in air quality will have a negative impact on public health in Garrett and Allegany Counties."

The assessment of Air Quality is summarized in Table 10-7 ("Air Quality Evaluation") of the U MD report, using individual scores for various evaluation criteria as discussed previously. Scores from the seven evaluation criteria in Table 10-7 are summed to determine an overall score – 15 in this case – whereby 15 indicated UNGDP-related changes in air quality will have a "high likelihood" of negative impact on public health.

This assessment of "High Likelihood" raises several questions regarding the individual evaluation criteria and the scores assigned to them:

- Exposure duration is assigned a score of 3 of a possible 3 as "exposures related to production, such as those associated with compressor stations will continue to persist for years/decades", even though the report admitted "exposure to air pollution resulting from site development may decrease once the site preparation is completed." As noted

previously, every single category with the exception of “Earthquakes” assigns a score of 3 to this parameter, leading to the question of whether this assessment is objective.

- Exposure frequency is assigned a score of 2 of a possible 2 based on “exposure to air pollution occurs continuously, 24 hrs/day, 7 days/ week.” Again, the period of time in which such high intensity activity is expected to be relatively short. As noted previously, every single category with the exception of “Earthquakes” assigns a score of 2 to this parameter, leading to the question of whether this assessment is objective.
- Likelihood of effects was assigned a score of 3 of a possible 0-3 range because “emerging epidemiological evidence shows that exposure to UNGDP related changes in air quality may be associated with adverse birth outcomes including NTD and CHD. There is also strong epidemiologic evidence from studies outside of UNGDP settings that show exposures to air pollutants associated with UNGDP related activities, including crystalline silica, VOCs, and PM have negative effects on human health.” However, as previously noted, the evidence for adverse birth outcomes including NTD and CHD is conflicting at best (some studies are positive; some are negative). In addition, the evidence presented in the report that air pollutants associated with UNGDP activities such as crystalline silica, VOCs, and PM has negative effects on human health is not specific to UNGDP activities but rather is associated more generally with urban air pollution (mostly in California), including traffic-related pollution. This assessment is therefore not based on a critical review of the available literature.
- Magnitude/severity of health effects was assigned a score of 3 of a possible 0-3 range because “exposure to air pollutants that are present in UNGDP processes are known to cause human health effects that can be irreversible, chronic, and at times fatal.” However, one of the principal studies relied upon in the report – by Steinzor (2013)– noted an increased prevalence of symptoms such as throat and nasal irritation, sinus problems, eye burning, severe headaches, persistent cough, skin rashes, and frequent nose bleeds among respondents living within 1,500 feet of UNGDP facilities in Pennsylvania compared to those who lived >1,500 feet away. None of these effects are specific to UNGDP activities nor are they “irreversible, chronic, and at times fatal.” A hallmark severe effect – cancer – couldn’t be assessed as it related to UNGDP activities since the vast majority of cancer cases in the Fryzek et al (2013) study predated possible UDGDP-related exposures, thus overlooking the issue of lag time that is known to exist for chronic outcomes such as cancer. This assessment is therefore not based on a critical review of the available literature.
- Geographic extent received a score of 1 of a possible 2 because “the impact will be more pronounced in the immediate vicinity of the UNGDP facilities.” However, this criterion appears to be accounted for in the scoring of the “vulnerable populations” criterion (see above) and thus appears to represent a “double dip” in scoring.

For these reasons, the report’s assignment of individual evaluation criteria scores, as well as the overall score and hazard rank, seems arbitrary and does not follow the discussion of the literature in the report.

3.2.1.2 Comments on Air Quality Recommendations

The U MD report offers six recommendations be implemented to prevent or minimize potential negative impacts on human health with respect to Air Quality, Recommendations R14-R19 (Section 12.3, pages 91-92).

Air Quality

R14. Require a minimal setback distance of 2000 feet from well pads and from compressor stations not using electric motors.

R15. Require electrically powered motors wherever possible; do not permit use of unprocessed natural gas to power equipment. This recommendation is designed to reduce VOCs and PAHs emissions from drilling equipment and compressors.

R16. Require all trucks transporting dirt, drilling cuttings to be covered.

R17. Require storage tanks for all materials other than fresh water and other UNGDP equipment to meet EPA emission standards to minimize VOC emissions.

R18. Establish a panel consisting of community residents and industry personnel to actively address complaints regarding odor.

R19. Conduct Air Quality Monitoring
- a. Initiate air monitoring to evaluate impact of all phases of UNGDP on local air quality (baseline, development and production).
- b. Conduct source apportionment that allows UNGDP signal to be separated from the local and regional sources.
- c. Conduct air monitoring with active input from community members in planning, execution, and evaluation of results.
- d. Conduct air monitoring in a manner to capture both acute and chronic exposures, particularly short-term peak exposures.
- e. Clearly communicate to community members expectations about what is achievable through air monitoring.

While ENVIRON agrees that many of these recommendations –requiring all trucks transporting dirt and drilling cuttings to be covered (R16), minimizing VOC emissions (R17), and establishing a joint panel comprised of community residents and industry personnel to address odor issues (R18) are excellent steps intended to ensure that a proposed UNDGP project is as health protective as possible, several of the recommendations are not supported by the data or will simply not be workable under existing real world conditions; specifically recommendations R14, R15, and R19. The problems with each are discussed further below.

Recommendation R14, requiring a minimal setback distance of 2000 feet from well pads and from compressor stations not using electric motors, is not based on actual data. As discussed above, 80% of particulate matter in the 5 to 10 µm range generated by combustion processes is deposited within 50 meters (164 feet) of their source. VOCs similarly dissipate with distance, and tend to fall to background levels within 100 meters (328 feet) of their sources (Zielinska et al

2011). Setback requirements for busy highways, railroad tracks, and industrial facilities are typically in the range of 100 – 500 feet, even when a location with a sensitive subpopulation such as a school is being considered (RILS 2006). Greater setback distances, applied to all locations needs better justification than is supported by the data in the U MD report.

Recommendation R15, which involves using electric motors whenever possible on-site has good intentions but is much more stringent than used in other industrial settings. Even pollution-control requirements used in busy ports in states with stringent requirements such as California allow other engine technologies, such as new technology diesel. Furthermore, the requirement for all-electric engines only shifts the burden of pollution to another site, where electricity is frequently generated with higher-polluting fuel sources.

Recommendation R19, which involves conducting air quality monitoring including evaluation of the impacts of all phases of UNGDP on local air quality (baseline, development and production); conducting source apportionment that allows UNGDP sources to be separated from local and regional sources; and conducting air monitoring in a manner to capture both acute and chronic exposures, particularly short-term peak exposures, on the surface appears reasonable, however it is a large undertaking and will require significant resources. If performed incorrectly, it will not provide useful information.

3.2.2 Flowback and Produced Water-Related

The U MD study concludes that there is a "Moderately High Likelihood" that UNGDP's impact on water quality, soil quality and naturally occurring radioactive materials related to Flowback and Production Water will have a negative impact on public health in Garrett and Allegany Counties. The stated Flowback and Production Water concerns are related to water quality and the large fraction of population relying on well water. While, ENVIRON agrees with the Moderately High Hazard Ranking based on our review of the report and supporting literature; as discussed below the hazard is not as dire as U MD described (as discussed below).

According to the most recent draft of the Marcellus Shale Safe Drilling Initiative Study dated June 2014, the Maryland Department of Natural Resources (MDNR) and the Maryland Department of the Environment (MDE) will require that at least 90% of flowback and produced water to be recycled at the pad site where it was generated unless the permittee can demonstrate that it is not feasible (Maryland Department of the Environment (MDE) 2014).

3.2.2.1 Comments on Flowback and Produced Water-Related Assessment

Our review of the U MD study indicates that the assumptions related to Flowback and Production Water issues are in some cases flawed and in other cases the facts are misinterpreted or misrepresented. The Flowback and Production Water related issues fall into three categories: water quality, soil quality and naturally occurring radioactive materials (NORM). Flawed or misrepresented assumptions related to each is discussed separately in subsequent paragraphs.

Water Quality

Volume of Chemicals used in the Marcellus Shale Play

The U MD report states that the fluid composition used to hydraulically fracture a well is a mixture of 99.2% water and 0.79% additives (Section 10.2.4 Identifying Chemicals of Concern, page 23). The report acknowledges that these additives are a small fraction of the hydraulic fracturing fluid, but state that nevertheless these additives need to be discussed in the right context *i.e.*, the volume of water produced. The report provides the following calculation:

- 3 to 7 million gallons of water used per well (USGS)
- 5 to 12 wells are located in a single well pad
- 0.8% of the total volumes are additives
- Equals 120,000 to 672,000 gallons of chemicals used per well pad.

However, these calculations in the U MD report are misleading because they are not specific to the Marcellus (Penn State Public Broadcasting 2014). Using actual averages from the Marcellus shale play results in the following, revised, calculations:

- 3 to 5 million gallons of water used per well
- 3 to 6 wells are located in a single well pad (Ladlee 2011; Murphy 2010)
- 0.5% of the total volumes are additives,
- Equals 45,000 to 150,000 gallons of chemicals used per well pad.

While still a significant range in volumes of chemicals used, the volume is considerably less (45,000 to 150,000 gallons compared to 120,000 to 672,000 gallons of chemical additives used per well pad) than portrayed in the U MD report.

It should also be noted that MDNR and MDE will require the disclosure of all chemicals expected to be used on site (MDE 2014).

Mobilization of Chemical during the Drilling and Wastewater Recovery Phases

The U MD report states that evidence provided in the scientific literature suggests that gases, chemical compounds, and to a lesser extent NORM, are mobilized during the drilling and wastewater recovery phases of the fracturing process. They contend that this mobilization of contaminants may result in contamination of ground waters used for drinking water. The U MD report also suggests that poorly constructed wells or faulty well casings could create a conduit for chemicals present in flowback and produced waters to migrate into the surrounding geologic units and result in contamination of shallow aquifers used for drinking water. ENVIRON disagrees with the basis for these assertions based on the following:

- EPA and State authorities require that certain measures be taken to protect potable groundwater during the drilling process. Potable groundwater is defined as an underground source of drinking water (USDW) having less than 10,000 parts per million (ppm) total dissolved solids (TDS). These sources are usually near surface or quite shallow, as TDS concentration (salinity) increases with depth. The shallow subsurface is

usually drilled with a water-based "spud" mud. Other methods used to drill through potable water zones include drilling with air, mist or water (Halliburton 2012). The surface casing is then set to a depth below the deepest USDW and drilling is continued using a heavy drilling mud. The mud weight provides the necessary downhole pressure to prevent hydrocarbons or formation water present in the geologic units being drilled through from flowing into the well. Based on these facts, the potential for drilling fluids to negatively impact shallow sources of drinking water is very unlikely.

- Before the wastewater recovery phase is even implemented, the well will be completed (i.e., steel casing will be set). Well construction includes the setting of surface casing, as mentioned above, to a depth below the deepest USDW and a secondary or intermediate casing set into the shale formation to be hydraulically fractured. Each of these casings is cemented in place, to the borehole or the previous casing run. Therefore, the potential for shallow groundwater supplies to be impacted by the wastewater recovery phase or casing failure is negligible. A Society of Petroleum Engineers (SPE) paper states actual well integrity failures where all barriers fail and a leak actually occurs are very rare; two to three orders of magnitude lower than single barrier failures (SPE 2013).

- Best Practices identified in the Marcellus Shale Safe Drilling Initiative Study, the most recent draft of which is dated June 2014, indicates that the Departments will require all drilling at depths shallower than a depth of 100 feet below the deepest fresh water bearing zone (or workable coal seam) be drilled using air, fresh water or a freshwater based drilling fluid (MDE 2014).

Evidence of well water contamination

The U MD report provides summaries of several cases that are reportedly evidence of water well contamination resulting from hydraulic fracturing activities (Section 10.3.2.5, Evidence of well water contamination, pages 45-47). However, only three of the five reported cases were from the Marcellus shale play area. The Osborn et al study (2011) referenced in the U MD report examined drinking water wells located in active drilling areas in New York and northeastern Pennsylvania. It found no evidence of contamination from brine or fracturing fluids from drilling. The literature published to date does not indicate any documented cases in which fracking fluids have been linked directly to contamination of drinking water supplies.

Gases

The Osborn et al study (2011) found that methane concentrations in drinking water wells located in active drilling areas in northeastern Pennsylvania were higher in those located within 1 km of unconventional gas wells than those in the areas greater than 1 km away. The U MD report states that a separate investigation (Jackson et al 2013), consisting of samples from 141 drinking water wells in the Appalachian Plateaus of Pennsylvania, supports these findings (*i.e.*, drinking water wells less than 1 km from gas wells had average methane concentrations higher than those further away). However, the Jackson and colleagues study (Jackson et al 2013), actually only collected a total of 81 samples from drinking water wells and these results were combined with 60 previous samples described in the work by Osborn et al (2011). So, in

essence, the study is a continuation of the previous study and could be unintentionally biased toward the original outcome by using the previous data.

The U MD report does state that the (Molofsky 2013) study of 1,701 water wells in the Marcellus concluded that methane contamination of water is related primarily to topography (higher in low lying areas) and groundwater geochemistry, rather than shale-gas extraction activities.

Soil Quality

Evidence of soil contamination (discussed under section 10.3.2.6, page 47) indicates that the limited evidence in the literature suggests that the practice of land application of flowback and produced water could lead to "severe vegetation damage and mortality" (Sang 2014; Adams 2011; Adams et al 2011) and that land application is a common waste disposal method in several states (Sang 2014; Adams 2011; Adams et al 2011). ENVIRON found little evidence in the literature that land application other than the use of brine for road de-icing is occurring in states within the Marcellus shale play.

NORM

The U MD report correctly states that the presence of NORM, and the nature of NORM, is highly dependent on the shale formation in which fracturing is occurring (Adgate et al 2014). Prominent NORM found in production water from the Marcellus Shale includes radioactive radium (often Ra^{226} and Ra^{228}) [66]. There is some suggestion in the literature (Rich and Crosby 2013) that the common use of radium isotopes (Ra^{226} and Ra^{228}) alone as indices of radiological contamination may be an inadequate surrogate for monitoring radiological activity. The U MD report indicates that results from a Texas study showed that radium and other radionuclides did not exceed regulatory guidelines for any one particular radionuclide; however, the total beta activity in one sludge sample exceeded regulatory guidelines by more than 8 times (Rich and Crosby 2013). However, these findings should be caveated, as only a total of four samples were collected for the study and the one total beta exceedance was a complete anomaly. The reported result was three orders of magnitude higher than the results from the other three samples.

The Skalak, et al (2014) study examined the application of brine for deicing. The study compared sediments recovered near roads where brines from conventional oil and gas wells were used for de-icing with background levels from soil samples collected on topographic highs at locations 20 to 30 meters from the road way. Their findings indicated that Ra^{226} concentrations in samples collected near roadways were 20% above background concentrations. What is not stated is that none of the reported concentrations exceed Ra^{226} remedial action levels established for Ra^{226} under 40 CFR Part 192.

The Skalak study (2014) showed no significant increases in Ra^{226} in effluent from publically owned treatment works (POTWs) that received UNGDP recovered water from fracking wells and CNGDP produced water based on the sediment samples collected upstream, at and downstream of POTW outfalls. According to the authors the results were unexpected given the elevated levels of radium and associated radionuclide isotopes in the produced water brines. The authors suggested two possible reasons for this finding. The most likely

explanation is that these elements were removed during the treatment process. As referenced in the report, previous studies have shown these radionuclide isotopes, particular Ra^{226}, concentrate in the wastewater sludge. The other explanation is that the sediment containing any elevated levels had been transported further downstream in the years since disposal practice have changed (produced water is no longer disposed via POTWs). Though as the authors of the report admit, the samples size is too small to support broad conclusions. ENVIRON believes that the U MD report played down these positive findings that NORM issues can be managed via disposal at POTWs. That said, the MDE does not intend to allow flowback or produced water to be accepted by any POTW that discharges to fresh water (MDE/MDNR, 2014).

3.2.2.2 Comments on Flowback and Produced Water-Related Recommendations

The U MD report provides seven recommendations related to Flowback and Produced Water, Recommendations R20-R26. Of these, six findings related to water and soil quality, Recommendations R20–R25; and one finding related to NORM, Recommendation R26:

Water & Soil Quality

R20. Prohibit well pads within watersheds of drinking water reservoirs and protect public and private drinking water wells with appropriate setbacks.

R21. Implement UMCES-AL/MDE water monitoring plan. Require monitoring of water quality during initial gas production and at regular intervals thereafter.

R22. Implement the UMCES-AL recommendations for management and recycling of flowback and production fluids.

R23. Require identification and monitoring of “signature” chemicals in fracturing fluids to allow for future identification of ground water infiltration/contamination.

R24. Conduct soil monitoring in areas potentially impacted by UNGD upset conditions.

R25. Prohibit flowback and production wastewater or brine use to suppress road dust, de-ice roads, or other land/surface applications.

NORM

R26. Conduct research to identify the appropriate suite of priority radionuclides for assessment of radiological activity.

Many of these recommendations are not supported by the data or will simply not be workable under existing real world conditions; specifically recommendations R20, R23, R24, and R26. The problems with each are discussed further below.

- R20 - Prohibit well pads within watersheds of drinking water reservoirs and protect public and private drinking water wells with appropriate setbacks.
    - The data in the U MD report does not support this recommendation. As stated above in our comments to the assessment there is very little to no evidence of impacts to drinking water from UNGDP.
    - The unworkability of this recommendation is illustrated in Appendix 1 of the U MD report which states that of the 14,200 water well location records available

for Garrett County, approximately 8,250 or 58% of the well records occur in grid cells that contain Marcellus shale gas leases (Mccall 2012). This would mean that implementation of this recommendation would instantly eliminate at least nearly 60% of the potential drilling leases from UNGD. Since the State of Maryland has allowed CNGD to occur in Garrett County and many of these wells are located within drinking water reservoir watersheds, it is unlikely that any new regulations would be passed that would affect current gas production in the county.

- Maryland is already establishing setback distances from private drinking water supply wells of 2,000 feet if the well pad is located up-gradient of the supply well and between 1,000 and 2,000 feet if it can be demonstrated that the well pad is not up-gradient (MDE/MDNR, 2014).

- R23 - Requires identification and monitoring of "signature" chemicals in fracturing fluids to allow for future identification of ground water infiltration/contamination.
    - The UMCES-AL (Eshleman and Elmore 2013) recommends, that at minimum, the following water quality parameters be tested: conductivity, total suspended solids or turbidity, total dissolved solids (TDS), chloride, bromide, sulfate, barium, strontium, naturally occurring radioactive materials (NORM), chemical oxygen demand (COD), and BTEX (benzene, toluene, ethylbenzene, and xylene). These parameters are more than sufficient to characterize any potential release from UNGDP. Many of these recommended parameters are specifically associated with oil and gas development (UNGDP and CNGDP); therefore, there is no need to identify an additional panel of "signature" chemicals associated with UNGDP.
- R24 - Conduct soil monitoring in areas potentially impacted by UNGD upset conditions. Periodic soil monitoring should be conducted to track potential contamination with semi-volatiles, heavy metals, and radionuclides. These sampling plans should be augmented with more intensive campaign if there is evidence of accidental spills (upset conditions).
    - A soil monitoring program would be very likely unworkable. UNGD well pad sites are very active and rapidly changing with relation to where tanks, treatment trailers, etc. are located. A more appropriate approach would be to conduct soil screening following completion of all drilling and well completion activities. At this point any soil impacts identified that require follow-up (impacts identified over applicable standards) could be readily addressed.
- R26 - Conduct research to identify the appropriate suite of priority radionuclides for assessment of radiological activity. The rationale provided in the U MD report is that studies have relied on radium as a surrogate for overall radioactivity. Emerging evidence suggest that there may be additional radionuclides that may be of concern to human health, and may in fact be present at appreciable concentration. There is a need to characterize a suite of radionuclides that are of concern and use them in the monitoring studies. In the meantime, metrics such as total alpha activity, or total gamma activity should be used to assess radiological contamination and support decision-making.

- The UMCES-AL (Eshleman and Elmore 2013) provides a suite of radionuclides for testing. On page 4-7 of that document, Table 4-1 provides a list of parameters that the Maryland Geological Survey (MGS) test for when they collected well samples. That list includes both gross alpha and beta activity as well as strontium, thallium and uranium. These parameters should be sufficient if supplemented with testing for Ra^{226} and Ra^{228}.
- It is interesting that the U MD report recommends that total alpha activity or total gamma activity be used to assess radiological contamination until an appropriate suite of priority radionuclides can be developed, since the Texas study that U MD references in the text found that total beta activity exceeded regulatory standards (Rich and Crosby 2013).

3.2.3 Noise

The U MD study concludes that there is a "Moderately High Likelihood" that UNGDP's impact on Noise will have a negative impact on public health in Garrett and Allegany Counties. The stated Noise concerns are based on the U MD's pilot noise monitoring study in West Virginia (page xxii). ENVIRON disagrees with the Moderately High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below, and our experience in measuring sound and assessing impacts and mitigation of environmental noise.

- Section 11 of the U MD report (Regulatory Landscape, pages 83-87) omits any discussion of noise limits established by the State of Maryland. Chapter 26.02.03 of the Code of Maryland (COMAR 26.02.03) specifies noise limits for both construction and operation of facilities, including those related to UNGDP. COMAR 26.02.03.02(A)(2) specifically states "The environmental noise standards set forth here represent goals expressed in terms of equivalent A-weighted sound levels, which are ***protective of the public health and welfare***." (emphasis added)

- As established in COMAR 26.02.03.02, noise levels emitted from operation of a facility and received at a residential property are limited to an hourly L_{eq} of 65 dBA during daytime hours (i.e., between 7 AM and 10 PM) and 55 dBA during nighttime hours (i.e., between 10 PM and 7 AM).[3] Construction or demolition activities may not emit sound levels received off site that exceed 90 dBA during daytime hours. During nighttime hours, the noise limits applied to operation of a facility (e.g., 55 dBA at residential receiving properties) apply to construction and demolition activities.

3.2.3.1 Comments on Noise Assessment

Examination of the literature review, the direct measurements, and the resulting findings of the U MD analysis reveals 1) unsubstantiated conclusions drawn from reference materials, 2) improper selection and/or use of sound level measuring equipment, and 3) application of inadequate measurement study methods. These flaws appear to have been based on basic unfamiliarity with the standard methods and equipment used in environmental noise studies coupled with potential biases towards the subject matter. The resulting conclusions are, at best,

[3] The L_{eq} is a sound energy average over a specified time interval measured in accord with internationally accepted procedures.

questionable. The apparently key underlying U MD assumptions and conclusions regarding potential environmental noise impacts and our review of these issues follow.

- The U MD report concludes that long-term exposure to environmental noise is associated with a myriad of negative health effects including stress and annoyance, sleep disturbances, hypertension, and cardiovascular disease. While high levels of environmental noise may be associated with various negative health effects, the U MD conclusion of negative health effects due to potential UNGDP activities and facilities are overstated and appear to result from misrepresentations of the referenced studies as described below.

    - As discussed in Passchier-Vermeer and Passchier (2000), hypertension, cardiovascular disease, and other stress-related diseases may be associated with long-term levels of 70 dBA Ldn or more. [4] But this sound level exceeds the level allowed by existing Maryland law for long-term operation of compressor stations, which limits noise to an Ldn of 65 dBA or less (i.e., calculated based on sound levels *at* the limits of 65 dBA between 7 AM and 10 PM and 55 dBA between 10 PM and 7 AM). [5] Furthermore, because compressor station noise is fairly continuous over 24-hours a day, each station would need to be designed to comply with Maryland's stricter nighttime hourly noise limit of 55 dBA, which over a 24-hour period would result in an overall Ldn of 62 dBA or less. Hourly levels meeting this limit would be much lower than the sound levels identified as being associated with the adverse health effects identified above.

    - The potential for noise-related sleep disturbance is more difficult to study and assess, and the findings of numerous studies are varied. While some studies have identified subjective sleep quality being affected at fairly low noise levels (i.e., Leq of 40 dBA), changes in sleep pattern and next-day mood are generally associated with levels nearer 60 dBA Leq. Van Kamp and Davies (2013) identify sleep impacts at levels <60 dBA but does not identify a specific lower level associated with an impact. Long-term nighttime sound levels associated with UNGDP would be continuous noise from compressor stations and would be limited to 55 dBA or less. Other sleep effects (e.g., awakenings, changes in sleep stages, changes to heart rates) have been associated with more discrete, usually louder events such as aircraft overflights, which are characterized with Sound Exposure Levels or SELs. Data suggesting human sleep impacts stemming from continuous exterior sound levels of 55 dBA or lower, as would be required under existing Maryland law, are scant. Therefore, contrary to the U MD findings, no firm conclusions can currently be drawn about the potential for levels expected from UNGDP activities to result in long term detriment due to sleep disturbance.

[4] Ldn is an abbreviation for day-night sound level, a 24-hour noise metric computed from hourly equivalent sound levels, or Leqs. The Leq is a sound energy average over a specified time interval measured in accord with internationally accepted procedures.

[5] Title 26.02.03 Code of Maryland (COMAR 26.02.03)

- The U MD report claims "Children, elderly, chronically ill, and hearing impaired individuals have been found to be more susceptible to environmental noise." Van Kamp and Davies (2013)

    - This statement is misleading, overstated, and not supported by the referenced document by Van Kamp and Davies (2013), which state that children and the elderly are often *less* susceptible to annoyance and disturbance from noise. Children may be susceptible to cognitive disruptions when exposed to high levels of noise, but Passchier-Vermeer and Passchier (2000) identifies a level of 70 dBA at which this might occur.

    - The paper by Van Kamp and Davies (2013) states "Vulnerable groups regarding environmental noise have been understudied, are generally underrepresented in study populations and evidence of differential effects is still highly anecdotal. As a consequence, clear effects are few… Setting specific limit values to protect susceptible groups is not yet possible based on the available evidence…" So contrary to the U MD contention, the evidence is *unclear* about the mechanisms and levels at which some target populations might be more susceptible to noise than others, and firm conclusions regarding the increased effects of environmental noise on specific populations cannot be made with the certainty exhibited in the U MD report.

- The U MD report states "The Colorado School of Public Health conducted a HIA to assess the potential health impacts associated with natural gas drilling in Battlement Mesa. They determined that noise associated with natural gas extraction would produce negative health effects" (Witter et al 2010).

    - The referenced Colorado study (Witter et al 2010) does not state that natural gas extraction "would" produce negative health effects, but instead indicates negative health effects are "possible." The Colorado study defined "possible" as "Evidence suggests that health effects *may* occur, but are *not common in similar situations*." (Emphasis added.)

    - The Colorado study characterized potential negative health effects associated with natural gas drilling as "Low-Medium" at an expected setback of 500 feet. The citizens near the Colorado facilities were requesting a 1,000 foot setback to mitigate potential effects, which is the minimum setback identified by the State of Maryland for such facilities. The Colorado study does not, therefore, support the U MD conclusion of a "Moderately High Likelihood" of health impacts at a 1,000 foot setback.

    - The U MD study states "The literature on UNGDP noise is very limited, however a few studies have shown that at 1,000 to 2,000 feet from a well pad noise levels can be expected to range from 44 dBA to 76 dBA, depending on the phase."

    - The reported well pad noise levels are primarily based on a severely flawed noise study conducted by McCawley (2013).

- The McCawley study used inappropriate equipment for measuring fluctuating environmental noise, in some places identified as a dosimeter and in others as a datalogger. The American National Standards Institute (ANSI) has published several standards for the measurement and description of environmental noise. Parts 1 through 3 of ANSI S12.9 “Quantities and Procedures for Description and Measurement of Environmental Sound” identify appropriate types of equipment for the measurement of environmental sound (ANSI 2013; ANSI 1992; ANSI 1993). Although Part 1 indicates that a datalogger may be used for the measurement of sound if it is set with an adequate sampling rate and range, it states that an integrating sound level meter is the preferred equipment for fluctuating noise sources, such as would be emitted by an active well development site. Parts 2 and 3 of S12.9 identify an integrating sound level meter as the preferred equipment to be used for measuring environmental sound. Neither such Furthermore, for establishing compliance with its noise limits, the State of Maryland also requires the use of a sound level meter that meets or exceeds the specifications for a Type II sound level meter (COMAR 26.02.03.02(D)(3)). It should be noted that a dosimeter is never identified as appropriate for measuring environmental noise.

- The McCawley study applied inappropriate and inadequate methodologies and failed to characterize which measured sound levels were associated with pad activities and which were from other sources. The measurements were taken using equipment set out for days at a time at locations affected by multiple noise sources, but the study made no attempt to identify which noises were pad-related and which were from extraneous sources (e.g., traffic, local activity, weather-related, wildlife, aircraft, etc.).

- The McCawley study made no attempt to capture simultaneous sound levels near the well pad (and dominated by well pad activities) and at more distant locations, in order to clearly identify which measured levels at a distance were related to well pad activities.

- The McCawley report averaged together the sound levels from multiple measurement locations, which is inappropriate. Noise sources can be directional, resulting in markedly varying sound levels at locations of similar distance to the source but in different directions from the source. In addition, noise at a distance from the source can be attenuated by various features or conditions (e.g., distance, terrain, structures, vegetation, etc.) (International Standards Organization 1996). As identified by the Federal Transit Administration (FTA) when discussing the appropriate methods to use when assessing environmental noise impacts, receivers of interest should be identified separately for isolated residences. While a group of residences could be clustered together for an analysis, “it is essential that the receiver selected provide an accurate representation of the noise environment of the cluster.” In other words, a noise analysis should not average together multiple receivers at

wide ranging distances from a source and at different directions from a source in an area with varying terrain and vegetation.

- In summary, the equipment and methodology used were flawed and indicate that the team members were not familiar with the study of environmental noise. As a result, the McCawley data are not useful for characterizing UNGDP sound levels.

- The U MD report references another study, (New York State Department of Environmental Conservation [NYSDEC] 2011) which examined natural gas development in New York State. This study appears to have used more standard measurement and analytical techniques for assessing potential environmental noise impacts due to the development of wells.

  - This study estimated rotary air well and horizontal drilling sound levels as approximately 50 to 52 dBA at 1,000 feet.

  - The loudest activity, high-volume hydraulic fracturing, could last from 2-5 days and was estimated to be as loud as 73 to 78 dBA at 1,000 feet. (Published FHWA data for similar equipment suggests a potential sound level of 68 dBA.) (Federal Highway Administration [FHWA] 2006)

  - This study presents very simple, conservative calculations of potential noise levels from well development and does not include any potential noise mitigation measures or attenuation factors other than distance.

- As indicated previously, hydraulic fracturing is a 24-hour a day process and would be required to either comply with Maryland's nighttime noise limit of 55 dBA, presumably by employing noise mitigation, or to apply for a variance from this limit. As part of the process to get a variance, it is expected that noise mitigation would be required and the levels would be lower than identified above.

- Well development noise would result in short-term noise. Once developed, an operating well would not be expected to produce much noise, so there would be no long-term noise impacts. Substantial health effects from short-term noise events have not been identified.

- The U MD report concludes (Section 10.3.3.4) that “Both daytime and nighttime noise levels associated with natural gas compressor stations routinely exceed the Maryland's maximum allowable noise level of 65 dBA for residential areas, the nighttime noise level is just above the maximum allowable noise level of 55 dBA, as depicted in Figure 10-14.

  - This finding is based on noise measurements conducted by the U MD project team. However, the measurement procedures used by the U MD team were clearly flawed, and the resulting reported levels should not be used to characterize typical noise from compressor stations. The identified flaws are outlined below.

- First and foremost, the data and charts (Figures 10-13 and 10-14 and Table 10-12) clearly show that during most of the measurements the meters' minimum/maximum measurement ranges were set too high.

    - The meters employed in these measurements allow the user to define the range of noise levels to be measured, in 90 dBA increments. Once this range is set, levels of sound near the lower limit of the range can be affected by instrument noise while levels of sound near or above the upper limit can be distorted.

    - It is clear that the measurement ranges were set such that most of the measurements did not capture the lowest sound levels that occurred during the measurement intervals. This is evident by the numerous "lowest" measured level of 35.3 dBA at numerous locations, the 55.3 dBA at the outdoor location <1,000 feet, and likely the 45.3 dBA recorded for the short measurement taken between 2,000 and 2,500 feet. The truncation of the data is also obvious from the data charts with flat lines at the bottom.

    - This means the overall captured levels represented by measurement L_{eq}s are too high, overstating the actual sound levels that occurred.

- The measurements make no distinction between compressor-related noise and extraneous noises. This is particularly egregious for the indoor location <1,000 feet, where the residence was clearly occupied and the measured sound levels were substantially affected. For example, contrary to the implication in the U MD report, a compressor station is not going to suddenly result in an interior level of 95 dBA.

- Compressor station noise generators are fairly steady, continuous sources (e.g., turbines, fans, compressors). So there should be minimal fluctuation in compressor station noise levels over time. However, the U MD study identifies a range of <u>indoor</u> noise levels of 35 to 95 dBA and outdoor levels of 35 to 85 dBA. Clearly, much of the measured noise was not due to the compressor stations. In addition, compressor stations operate continuously and fairly consistently over a 24-hour period, and the U MD report identifies diurnal trends (e.g., louder during the day and quieter at night) that are typically associated with extraneous noise sources such as traffic. It is, therefore, clear that the sound data used to characterize "compressor station noise" is actually an amalgam of all noise sources with no attempt to isolate compressor station noise.

- The U MD noise study indicates that noise levels were higher indoors than outdoors for homes within 2,500 feet of a compressor station. This is a highly dubious claim, yet the data analysis made no attempt to explain this anomaly or to separate extraneous events from the actual

compressor station noise. The results of the study imply that the noise came from indoor sources rather than outdoor sources.

- An argument can be made that compressor-station noise is actually represented by the *lowest* values measured (i.e., a continuous noise source operating in the absence of all extraneous sources). Unfortunately, as noted above, the noise floor on the meters was generally not set low enough to capture the lowest levels, so the U MD study did not actually measure the lowest noise levels near most locations.

- As with the McCawley study, the U MD study averaged together all of the sites instead of identifying sound levels at specific receivers of interest. This results in meaningless data. As identified by the Federal Transit Administration (FTA), receivers of interest should be identified separately for isolated residences. While a group of residences could be clustered together for an analysis, "it is essential that the receiver selected provide an accurate representation of the noise environment of the cluster." (FTA 2006) This cannot be achieved for multiple receivers at wide ranging distances from a source and at different directions from a source in an area with varying terrain and vegetation.

- While the measured levels at some locations might routinely exceed Maryland's noise level of 65/55, there is no evidence presented that these levels were due to compressor station operation. As a matter of fact, the lowest outdoor level at <1,000 feet of 55 dBA, which would have been even lower if the meter measurement range had been set appropriately, would comply with both Maryland's daytime and nighttime noise limits. And, because compressor stations run consistently day or night, any station would need to be designed to be 55 dBA or less at the nearest residential locations.

3.2.3.2 Comments on Noise Recommendations

The U MD report provides three recommendations on Nose, Recommendations R27-R29, based on the conclusions drawn from the referenced data.

R27. Implement noise reduction strategies recommended by UMCES-AL in the MD Best Management Practices, including requiring electric motors wherever power supplies are available and construction of artificial sound barriers. Currently technologies do exist to reduce noise levels. In fact such technology is used in urban locations such as Fort Worth, TX (personal communication, API). But because of the cost associated with them, such technologies are not used in places such as Doddridge County, WV. Maryland should require such noise reduction strategies at all locations.

R28. Require a setback of 2,000 feet for natural gas compressor stations using diesel engines, 1,000 feet for stations using electric motors and sound barriers. Based on our data from WV, noise hazard can be minimized through setback distance. Therefore, Maryland should require a setback of 2,000 feet for facilities using diesel engines.

R29. Establish a system to actively address noise complaints.

Panel established with community and industry representatives to monitor the issues related with odor should also be tasked with monitoring the noise complaints and addressing them.

- Some or all of the noted noise reduction practices suggested in R27 could well be required to ensure compliance with *existing* Maryland noise limits. Any such noise control measures should be considered as part of site specific analyses and employed only if and when they are determined to be necessary based on objective analyses of the situation. Simply imposing all such requirements in all instances would be excessive and unnecessary.
- Imposing an arbitrary minimum setback based on potential noise impacts as suggested in R28 would be excessive because as indicated in R27, noise control methods exist and can be employed when necessary. Minimum setbacks are more typically employed when effective control measures are not available.

ENVIRON concurs that establishing a process to consider noise complaints would be an effective method of bringing perceived noise issues to the attention of the project proponent. This system should be coupled with the use of objective means to assess the issues and a process to resolve them.

3.2.4 Earthquakes

The U MD study states that there is a "Low Likelihood" that UNGDP related earthquakes will have a negative impact on public health in Garrett and Allegany Counties provided that Maryland does not allow deep well injection of wastewater. As discussed above, this stressor category appears to be the only category that the U MD project team did not start their evaluation with default assumptions resulting in at least a "Moderately High" evaluation, based on the fact that there are no deep injection wells located within the State. ENVIRON agrees with the Low Likelihood Hazard Ranking based on our review of the report and supporting literature.

3.2.4.1 Comments on Earthquake Assessment

A review of the U MD study indicates that the assumptions the findings are based upon in most cases appear sound. All available evidence does indicate:

- that there is a connection between deep well injection of large volumes of conventional NGDP or UNGDP wastewater and the occurrence of earthquakes that are greater than magnitude 3; and

- that the process of hydraulic fracturing itself creates micro earthquakes (less than magnitude 2) as the rock is fractured.

Based on referenced literature, the potential public health effects associated with micro earthquakes resulting from hydraulic fracturing are negligible.

Unsupported Assumptions or Conclusions

The assumption that there is considerable evidence to suggest that earthquakes can persist years after the start or stop of well activities is not well-founded. The U MD report bases this finding on the results presented in the study by Keranen et al (2013). This study examines three deep wastewater injection wells located within or near the Wilzetta North field. The U MD report indicates that the study "suggests that decades-long timeframes between the beginning of fluid injections and the induction of earthquakes are possible." While technically true, this statement - absent further context - is perhaps misleading. Our review of this document indicates injection began after 1993 (as U MD stated) and continued to occur until at least the 2011 M_w 5.7 earthquake sequence. Furthermore, it also indicates that at least one injection well was installed as recently as 2006. Therefore, it appears that the earthquakes may more appropriately be related to the cumulative volume and pressure, augmented by the addition of a new injection well. It should also be noted that the wastewater injection in this particular case study is into former oil and gas production zones. Production zones are typically at shallower depths than the geologic units typically selected for disposal wells permitted and drilled specifically for the purpose of oil and gas associated wastewater. As a point of comparison, the wastewater injection well in the Ohio study "Induced seismicity associated with fluid injection into a deep well in Youngstown, Ohio (Kim 2013) was completed at a depth of approximately 9,193 feet below ground surface (bgs).

The U MD report mistakenly interprets the Rutqvist et al (2013) study as modeling waste injection. The U MD report states "They concluded that any fractures to the earth caused by waste injection would occur at great depths below the ground, too low to activate faults or impact drinking water supplies." In reality, the modeling was based on conditions usually encountered in the Marcellus shale play while conducting hydraulic fracturing. The authors' actual findings are stated as follows: "Our simulation results indicate (a) that the possibility of hydraulically-induced fractures for shale stimulation causing activation of faults and new flow paths that can reach shallow groundwater resources (or even the surface) is remote, and (b) that shale gas hydraulic fracturing operations might only give rise to micro-earthquakes, consistent with field observations to date" (Fisher and Warpinski 2011). The U MD report faulted the study for using only "mathematical models to assess the impact of massive physical events that have been previously shown in Oklahoma and Ohio to be of significant concern." In fact, the modeling by Rutqvist et al (2013) in the Marcellus demonstrates that the process of hydraulic fracturing itself is unlikely to cause activation of existing faults in the area and therefore does not pose a significant concern.

3.2.4.2 Comments on Earthquake Recommendations

The U MD report provides three recommendations based on the conclusions drawn from the referenced data, R30-R21:

R30 – Collect baseline data on seismic activities using methods that can record earthquakes smaller than magnitude 3.

R31 – Restrict issuing UIC Class II permits for disposal of UNGDP fluids until licensing requirements adequately addresses earthquake risk.

R32 – Implement use of sensitive seismic monitoring technology to better detect small earthquake activity that could presage larger seismic events as well as using a "traffic-light system" that sets thresholds for seismic activity notification.

Two of the three recommendations R30 and R32) are not supported by the data presented in the U MD report. They claim that although earthquakes associated with hydraulic fracturing are of small magnitude, there is a need to collect baseline data so changes in trends over time can be established. However, the results presented in the U MD report clearly demonstrate that, in spite of numerous previous studies, the potential public health effects associated with micro earthquakes resulting from hydraulic fracturing are negligible and that the possibility for micro fractures to cause activation of nearby faults and therefore create viable conduits that can reach shallow groundwater resources is remote (Rutqvist et al 2013).

With respect to recommendation R31, U MD further elaborates that Maryland should restrict issuing UIC Class II permits for disposal of UNGDP fluids until licensing requirements adequately addresses earthquake risk due to the established link between deep well injection of wastewater and increased incidence of earthquakes. The recommendation goes on to state that deep well injection of UNGDP fluids in existing wells should also be banned although, as stated in the U MD report, none of the earthquakes recorded in Maryland, to date, have been linked to NGDP.

Wastewater generated from the hydraulic fracturing process in the Marcellus shale play is typically disposed via deep well injection using Class II disposal wells. The majority of the hydraulic fracturing-related wastewater produced in Pennsylvania is disposed via Class II injection wells located in Ohio (Kim 2013). The Underground Injection Control (UIC) program defines Class II wells as those that inject fluids associated with oil and natural gas production. Most of the injected fluid is salt water (brine), which is brought to the surface in the process of producing oil and gas. Currently the State of Maryland has no permitted Class II wells for disposal of oil and gas production wastewater or for enhanced recovery of depleted oil and gas fields [U MD study]. The state of Maryland has primacy with regard to the UIC Program and therefore has the authority to develop regulations to regulate or ban these types of wells [USEPA]. Maryland has reportedly deferred the decision on allowing Class II injection wells until such time that someone actually applies for a Class II injection well permit (MDE/MDNR, 2014).

3.2.5 Social Determinants of Health (includes Traffic Safety; Empower Communities)

The U MD report concludes that there is a "High Likelihood" that UNGDP related activities will have a negative impact on the Social Determinants of Health for Garrett and Allegany Counties. The stated Social Determinants of Health concerns are based on information from other

UNGDP communities, as well as “previous knowledge of boom town.”

3.2.5.1 Comments on Social Determinants of Health Assessment

Traffic (Section 10.3.5, Social Determinants of Health, pages 62-64)
The U MD report cites several studies multiple times in support of their assessment. The study by Levy 2013 is cited most often (n=7) within this section, and is independently cited to support the following statements:

1. “… heavy-truck crashes rose 7.2% in rural Pennsylvania counties heavily impacted by UNGDP.”
2. “In fact, Pennsylvania counties with the highest density of UNGDP operations had the largest increase in large-truck crashes after UNGDP activity began in 2005.”
3. “In Pennsylvania, a large-truck accident can cost a local community over $200,000 related to deaths, injuries and property damage.”
4. “In fact, in Bradford County, PA, the increased traffic has delayed the response times of emergency vehicles… placing those who requested them in great danger.”

The Levy 2013 “study” is actually a newspaper article from the Associated Press, not a scientific study. The article broadly discusses occurrences of crime and “carousing” in oil and gas boom towns Levy (2013). Most of the “data” reported in this article originates from interviews with individuals, police officers, and other town officials, who share anecdotes or individual observations. None of the statements listed above, which were independently cited as originating from Levy 2013, can be verified within the contents of the reference article.

Another oft-cited reference in this section of the U MD report, (Haggerty et al 2011), is cited five times alongside additional references to support statements related to increased traffic and fatalities in hydraulic fracturing communities. The Haggerty et al (2011) reference, however, does not discuss traffic, the impacts related to the increased presence of trucks and vehicles, nor any traffic-specific issue related to hydraulic fracturing communities (Haggerty et al 2011). Furthermore, a closer look at one sentence in the U MD report, “The Texas Department of Transportation noted a 40% increase in reported fatal motor vehicle accidents from 2008 to 2011 in 20 counties with UNGDP operations” cites other references (Witter et al 2013; Haggerty et al 2011) that do not mention the Texas Department of Transportation, nor a 40% increase in motor vehicle accidents following UNGDP operations, in any capacity.

While the investigators pose a reasonable assumption (i.e., that the increased presence of trucks and vehicles may contribute to increased frequencies of accidents) the data relied upon by the team to support this idea are misleading and sourced inappropriately. Understanding traffic patterns, routes, and regularity; road conditions; and weight could assist in the decision making process and particularly resource allocation.

Crime (Section 10.3.5.2, Crime, pages 64-65)
The inferences made by the U MD project team are inconsistently linkable to the sources presented and are not fully vetting for the State and Counties under evaluation. For example, the U MD report largely relies upon two references: the Haggerty et al 2011 peer-reviewed

study, and a Food and Water Watch (2013) report discussing a Pennsylvania case study. While the general conclusions from the Haggerty study are adopted correctly, data from the Food & Water Watch (2013) report are not fully represented. For instance, the U MD researchers cite a 17.1% increase in disorderly conduct arrests following the introduction of commercial fracking in "heavily fracked" Pennsylvania communities, representing an average increase of 6.9% a year from 2005-2010. However, the U MD researchers do not include the fact that disorderly conduct arrests in "unfracked" communities also rose 12.7% in the same time period, representing an average increase of 1.9% a year (FWW 2013). Further, U MD's reporting is limited to observations in "heavily fracked" areas; when considering "all fracked" areas, disorderly conduct arrests rose 2.1% from 2005-2010, representing an average decline of 0.9 during this time period (FWW 2013). The researchers' reliance upon data for "heavily fracked" areas is not justified in the text, nor do the researchers provide evidence that Allegany and Garrett counties will become "heavily fracked." Crime rates and incident type may rise and fall statistically due to various stressors including economic opportunities, population composition, age and ethnicity differences, and availability of guns to name a few.

Illness, Mental Health, and Substance Abuse (Section 10.3.5.3, pages 65-66)
The U MD report largely relies upon two references (FWW 2013; Witter et al 2010) for most of this section's statistics. The section begins by observing a "rise in sexually transmitted infections" linked with "the development of UNGD operations in Pennsylvania." A close look at the corresponding references cited by both U MD report and the authors of the Food and Water Watch 2013 report indicates that this idea is supported by newspaper articles, which are not robust sources of data and largely report anecdotal evidence (FWW 2010).

The data presented in Table 10-16 presents changes in STIs, disorderly conduct arrests, and substance abuse arrests in Pennsylvania (FWW 2013) and Battlement Mesa, Colorado (reference #7) during "peak [UNGD] production." While the U MD researchers highlight caveats that may help explain the observations in each of these categories, the U MD researchers do not include additional data that may provide context. For instance, the U MD researchers report a 32.4% increase in STIs (chlamydia and gonorrhea) cases during "peak" Pennsylvania UNGD production. However, the U MD researchers do not mention that, within the same cited reference, "unfracked" counties also experienced a 20.1% increase in the same STIs during the same time period (FWW 2013). Additionally, there is no indication of whether the differences between "heavily fracked" and "unfracked" counties are statistically significant; only numerical increases are reported by both the U MD researchers and the cited reference (FWW 2013). The U MD researchers do not comment on whether or not the reported observations represent a global increase in chlamydia and gonorrhea prevalence. Similarly, while the U MD researchers report a 216.7% increase in STIs in Battlement Mesa, Colorado, a close look at the cited reference indicates that this percentage is not fully contextualized. Specifically, the number of female chlamydia cases in Battlement Mesa increased from 4 to 12 during the time period of interest; male chlamydia cases increased from 2 to 7 (Witter et al 2010). Thus, while there was an increase in chlamydia cases during this time, the increase was nominal (< 10 cases) (Witter et al 2010).

The U MD report attempts to link UNGDP and increases in alcohol and illicit drug use (Witter et al 2010; Forsyth et al 2007; Wernham 2007; Kettl 1998) yet these linkages are not supported by

the data. For example, the U MD report attempts to link substance abuse to a "somewhat elevated" crime rate but further note there is no "consistent trend" across the period (2000-2009) examined in Colorado. The Colorado study further notes an overall healthier community population than the overall state population and states that there are studies that find no linkage between UNGD and social or psychological health (Witter et al 2010). The U MD report references a Louisiana study as a representation of the links between the oil industry (offshore) and increases in social disruption including drug use (Forsyth et al 2007). This Louisiana study used anecdotal extracted from personal interviews of long-time residents to frame perceptions, however the U MD researchers failed to note the resident interviews included feelings of well-being, positive, and benign coming from the oil industry (Forsyth et al 2007). The Alaska HIA by Wernham (2007) incorporated public input and an Environmental Impact Study (EIS) reported economic development mitigating sociocultural change and reflected a decrease in unintentional injury. Funding from the industry was used in infrastructure and health care improvement (Wernham 2007). Further the U MD researchers pointed to a study reporting changes in Alaskan native suicide and reports an increase in rates of young men and a decrease to zero of rates in elders there is no mention of employment or linkage to the oil industry (Kettl 1998). Such rates can be reflective in limited access to job opportunities.

The U MD report infers linkages between UNGDP and social, cultural and psychological adaptations and changes in communities; however the studies and perceptions presented do not validate such a link. Changes of social, cultural and psychological nature that occur or are perceived in a community are subject to various conditions, things that occur, have occurred in the past, or are now occurring are difficult to measure and accurately determine root cause. To properly determine cause and effect long term data collection and assessment is desired so that trends may be assigned and evaluated. Further comparison with an accurate and true baseline is imperative to produce scientifically meaningful, transparent, and reproducible results and data.

Impact on Residents, Police, and Healthcare System (Section 10.3.5.4, pages 66-67)
The U MD report does not cite specific statistics to support their conclusions of impact on residents, police, and healthcare system, but rather focuses on potential impacts that UNGDP may have on community land values, public safety, and accessibility of medical facilities. The commentary presented in this section is largely speculative, with the occasional citation of supporting documents for other states or communities.

For example, with regard to public safety, the U MD report appears to assume that "local and state police departments may be ill-equipped to handle the additional increases in crime," and that, "when small-staffed and already stretched departments see large increases in crime, it keeps them preoccupied and unable to handle all the situations." The report makes such statements without directly evaluating the current capacity of police departments within Garrett and Allegany counties, which may have been more useful for driving U MD's final conclusions. In fact, the Appendix indicates that the overall crime rates in Garrett and Allegany counties are either lower or slowly but steadily increasing compared to Maryland state averages. The U MD report could have integrated these ideas into their public safety commentary when evaluating the capabilities of local and state police departments, rather than assuming a negative impact to public safety.

Assessment

The U MD report concludes that there is a “High Likelihood” that UNGDP activities will have a negative impact on the Social Determinates of Health in Garrett and Allegany Counties. The stated social determinants on health concerns are based on previous studies of UNGDP communities. ENVIRON disagrees with the High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below.

3.2.5.2 Comments on Social Determinants of Health Recommendations

The U MD report provides seven recommendations related to Social Determinants of Health, R33-R39. Of these, four Recommendations are related to traffic safety, Recommendations R33–R36; and three Recommendations are related to Empower Communities, R37-R39:

Traffic Safety

> R33. Increase state and local highway patrols to closely monitor and track truck traffic subject to all highway safety rules and/or exceptions.
>
> R34. Empower local communities to control truck speed and traffic pattern.
>
> R35. Route truck traffic to maintain separation between UNDGP activities and the public.
>
> R36. Consider use of pipelines to move UNGDP fluids between sites.

Three of the recommendations R33 through R35 are not supported by the data presented in the U MD report. The U MD reported an increase in unintentional injuries and motor vehicle accidents based on State of Maryland statistics for the years 2006 through 2010. It has not been made clear the basis for the claimed link made by the U MD researchers through the sources cited of the projected relationship between communities from different regions, with different stressors, and different concerns. However the recommendations could be answered through a pattern study of traffic (routes, schedules, and load weights) and control (engineered controls and enforcement). A full community/communities study of patterns, schedules, and frequency of citations would be useful in determining infrastructure and support needs. Such a study would be useful for county and municipal agencies in road development, community needs and infrastructure with or without UNGDP. According to the National Motorist Association, engineered traffic controls located unnecessarily and without intention can lead to increased traffic problems and accidents. (Dornsife 2014; Swanson et al 1998; Warren 1982) Typically left to local or regional rule, controls should be limited to specific need (school, hospital, etc.) and not capriciously placed. A feasibility study detailing economic costs, community disruption, terrain, patterns, infrastructure, and controls could be useful in answering the questions raised by U MD in this report.

Empower Communities

> R37. Enact a Surface Owners Protection Act as recommended in the MDE Part 1 report.

R38. Engage local Communities in monitoring and ensuring that setback distances are properly implemented.

R39. Create a mapping tool for community members using buffer zones (setback distance) around homes, churches, schools, hospitals, daycare centers, public parks and recreational bodies.

The perceptions, comments, and studies referenced by U MD are not reflective of the references and do not support the conclusions and recommendations. The sources and data reveal evidence of positive, negative, and indifference to UNGDP activities. Determining state, region, and local rules on ownership rights, responsibilities, and access may could be useful in moving forward. In the communities of concern (Allegany and Garrett) mining has had a long history, a review of historic land rights and ownership would be useful in proving a path forward to determine governmental controls. A review of neighboring states drafts, proposals, and determinations on owners' rights may provide guidance on further determining need and effectiveness. Setback distances may be under the control and direction of local/municipal/County zoning and easement process and procedures already in place. A study of local zoning rules would be in order. Further study and particularly study in the communities of interest, their particular needs, growth capability, economic health, and infrastructure, would be a useful step.

3.2.6 Healthcare Infrastructure

The U MD team concluded that there is a "High Likelihood" that UNGDP activities will have a negative impact on the healthcare infrastructure of Garrett and Allegany Counties. The stated Healthcare Infrastructure concerns are based on the "substantial" healthcare needs within Garrett and Allegany Counties, the large size of the population that is "vulnerable", and the large anticipated number of long-term migrant workers. ENVIRON disagrees with the High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below.

3.2.6.1 Comments on Healthcare Infrastructure Assessment

Examination of the assumptions underlying the U MD analysis reveals many gaps in logic and biases that render the conclusions questionable. The key assumptions underlying the U MD conclusions are:

- Assumption 1: UNGDP will bring uninsured migrant workers to staff the wells.
    - The development of shale gas resources may attract people to the region who are likely to remain for some number of years during drilling and active production (i.e., "long term migrants"). It is also conceivable that current residents of Garrett and Allegany Counties will have new employment opportunities with the oil and gas companies. While U MD acknowledges the unknown health insurance status of migrant workers, the assumption that UNGDP workers (migrant or otherwise) will lack health insurance is not well founded. Firstly, the RESI (2014) report, the source of new worker estimates used by the U MD team, projected increases in jobs and wages in Garrett and Allegany counties. It is not yet known what proportions of these jobs will be permanent vs. contract (i.e., temporary), nor the benefits that permanent vs.

contract employees will receive from companies seeking to engage in UNGDP in Maryland. However, permit application information available on the Maryland Department of the Environment website could have assisted the U MD researchers in determining what benefits, if any, interested UNGDP companies might provide. Specifically, the Maryland Department of the Environment has received applications for permits to develop UNGDP from two companies, Samson Resources Company and Chief Oil & Gas, LLC. The website for Samson Resources Company states, "At Samson Resources, we are committed to providing our employees with a competitive and comprehensive compensation and benefits package including: Highly competitive salaries… Long-term incentive plan… Medical, dental, vision and prescription health care coverage… Flexible spending account… 401(k) retirement plan with attractive employer matching contributions… Group life insurance…," among others (Samson 2014). No similar information was evident on the website for Chief Oil & Gas, LLC, and the extent to which employment packages offered by Chief Oil & Gas, LLC and other companies compare to those offered by Samson Resources is unknown. At least some jobs created by UNGDP are likely to be well-paid and to include health insurance among the employment benefits, however, and it is not likely that all new jobs will fail to include health insurance benefits. Secondly, provisions of the Affordable Care Act have expanded health insurance coverage. At the national level, for example, the proportion of the population with health insurance has increased by 9.3 million people, or about 6 percentage points between September 2013 and March 2014 (Carman and Eibner 2014). Thus, the assumption that UNGDP will lead to an increase in the proportion of the population without health insurance is not substantiated.

- The individual section dealing with Healthcare Infrastructure in the U MD report (Section 10.3.6, page 68) contains a more balanced statement than appears earlier in the report. This section specifically acknowledges the possibility that revenue generated by new extraction activities might result in increased funding for public services, including healthcare infrastructure, as well as an increase in the proportion of the population with health insurance. The RESI report predicts an increase in tax revenues of $0.6m annually during drilling and $0.3m annually during extraction activities. This increase in tax revenue can be expected to benefit the infrastructure of the region RESI (2014).

- The U MD team also acknowledges that a benefit could be realized if the population and economic changes in the region were attractive to health care providers, leading to an increase in the number of health care providers and a positive effect on the healthcare infrastructure. These positive effects apparently were not considered in the final assessment of risk to the healthcare infrastructure, however.

- Assumption 2: Existing gaps in the healthcare infrastructure are such that an influx of migrant workers would overwhelm an already fragile system.

- There are inconsistencies between the numbers of migrant workers that the U MD report predicts UNGDP will introduce to the area, and the source that that the U MD report cites. According the report, "… we can expect 1327-2825 migrant workers on average during the first 10 years of drilling, and 151-189 migrant workers on average during the 10-year period after drilling..." The U MD researchers cite the RESI report as a source of these migrant population estimates. However, a closer look at the RESI report shows that these values are overestimated RESI (2014). According to the RESI report, these values correspond to the total number of average annual jobs estimated RESI (2014). Also, according to the RESI report (page 59), "Existing research shows that approximately 37 percent of gas workers will move in from out of state" RESI (2014). This means the correct range is 491-1045 average annual jobs for migrant workers during the first 10 years of drilling.

- The assumption that the migrant workers will overwhelm the healthcare infrastructure is partially contradicted by the findings reported by the U MD team, that UNGDP workers are most likely to utilize emergent, urgent, and trauma care. The medical specialties identified by U MD as lacking in the region are primary care, mental and dental health, not emergency and trauma medicine, and the U MD team identified the uninsured population as the group most severely affected by the lack of these services. Based on estimated numbers of providers in relevant specialties, the conclusion that an influx of workers would overwhelm the health care delivery system is unfounded.

- One element of the healthcare infrastructure apparently not considered by the U MD project team, however, is first responder capacity. The U MD report does not discuss the capacity of first responders in Garrett and Allegany Counties to potentially handle large-scale emergencies whose probability would be increased simply by adding new industrial activity to the area, but whose risk may be offset by emergency services provided by the UNGDP companies.

The assessment of High Likelihood that UNGDP's impact on Healthcare Infrastructure will have a negative impact on public health in Garrett and Allegany Counties is not supported by data cited in the U MD report indicating that the current unmet needs in these counties primarily affect low income and uninsured residents. Although there is no specific wage or employment benefit (i.e., health insurance) information available for UNGDP companies that may seek to develop shale gas resources in Garrett and Allegany Counties in the future, at least some of the UNGDP companies are likely to offer health insurance to at least some employees. Samson Resources Company, a company that has sought permission to develop shale gas resources in Allegany and Garrett Counties, indicates that competitive salaries and health insurance packages can be expected, for example. Furthermore, although data for calendar year 2014 are not available at this time, it is reasonable to assume that the Affordable Care Act has increased the availability of health insurance and rates of health insurance coverage in Maryland. Nationally, the rate of uninsured persons declined by six percentage points between September 2013 and March 2014 (Carman and Eibner 2014). Concerns about an influx of uninsured workers may, therefore, have been exaggerated by the U MD team. In addition, both

wages and tax revenues are expected to increase in both counties for at least ten years, which will provide additional resources to the communities above those currently available (RESI 2014).

Finally, the sources relied on in the U MD report suggest that UNGDP workers are most likely to access emergency and trauma care to treat injuries due to accidents, and therefore emergency and trauma would be the medical specialties experiencing increased demand (Coussens and Martinez 2014; Policy Matters Ohio 2014; OSHA 2012; US Department of Labor 2010). These medical specialties were not among the specialties found to be lacking in the two counties. The capacity of existing emergency services to respond to any large scale industrial accident was not addressed.

3.2.6.2 Comments on Healthcare Infrastructure Recommendations

The U MD report provides six recommendations related to Healthcare Infrastructure, Recommendations R40-R45.

> R40. Closely monitor whether prospective UNGDP companies provide adequate health insurance coverage for all employees.
>
> R41. Organize a local health care forum with key stakeholders to assess health care services and anticipated needs related to UNGDP.
>
> R42. Inform and train emergency and medical personnel on specific medical needs of UNGDP workforce.
>
> R43. Review and monitor county-level tax revenues and assess improvements necessary to meet increased services need.
>
> R44. Establish a committee of state and local stakeholders (including UNGDP officials and local providers and residents) for early identification of impacts to healthcare infrastructure.
>
> R45. Initiate monitoring of UNGDP healthcare-related costs.

Because the U MD team's assessment of the potential impact of UNGDP on the healthcare infrastructure of Garrett and Allegany Counties is not supported by data cited in the U MD report, and because it appears these recommendations were developed in isolation from community stakeholders, only recommendations R41 and R44 are supportable at this time.

As noted above, the assessment that UNGDP has High Likelihood of negatively affecting the Healthcare Infrastructure and would result in a threat to the public health in Garrett and Allegany Counties is not supported by data cited in the U MD report. Furthermore, it appears that the U MD team failed to involve local officials, county healthcare agencies or other stakeholders in their assessment of the current healthcare infrastructure or in the development of their recommendations, based on comments made by a county healthcare agency at a September 25, 2014 public meeting. It is ENVIRON's understanding that the Health Officer of the Garrett County Health Department disagreed that the health delivery infrastructure was inadequate, and

believes that the existing system is adequate for the expected influx of UNDGP workers[6]. Thus, recommendation R41, "Organize a local health care forum with key stakeholders to assess health care services and anticipated needs related to UNGDP" should be of the highest priority among this group of recommendations, as it will provide the data needed to develop realistic and necessary recommendations for the communities. Recommendation R44, "Establish a committee of state and local stakeholders (including UNGDP officials and local providers and residents) for early identification of impacts to healthcare infrastructure" is also a high priority, as it will enable detection both of benefits and of emerging healthcare infrastructure needs that may follow from UNGDP. All other recommendations in this section are premature, and/or based on faulty or ill-supported assumptions.

3.2.7 Cumulative Exposure/Risk

The U MD study concludes that there is a "Moderately High Likelihood" that UNGDP's impact on Cumulative Exposure/Risk will have a negative impact on public health in Garrett and Allegany Counties. The stated Cumulative Exposure/Risk concerns are based on an anticipation of a mixture of chemical, physical, and psychosocial stressors, and the speculation that such stressors "will be greater than the sum of individual risks." The U MD study also anticipates that the impact will be felt more by vulnerable subpopulations. ENVIRON disagrees with the Moderately High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below.

Every debate needs a thorough examination of all the issues and consideration of consequences of action or inaction. At the core of the merits of the debate is whether the arguments being forwarded are grounded in good science or not. The U MD team appears to put forward their arguments interpreting the Precautionary Principle as suggesting nothing should be done if there are any less than fully understood hazards involved. Others view the Precautionary Principle through a different and more scientific lens: view the evidence, weigh the information, and proceed with caution.

Cumulative Exposure/Risk Assessment is a relatively new concept and methods are just being developed to address or interpret the concept. The U MD project team acknowledges this in their report, stating that "the emerging field of cumulative risk assessment is still in its infancy." The scientific literature on the subject is exploring protocols and methods and just beginning to explore how to test, reproduce, and interpret the findings of a Cumulative Exposure/Risk Assessment (Sexton 2012). Although all things are at some point connected and thus the most insignificant event can have influence over all other things, the current Cumulative Exposure/Risk Assessment methods and skills do not allow for a meaningful examination at such a level of granularity.

The U MD report appears to focus on the concept of "risk" being exclusively about "loss," in a vacuum as it were, without suggesting anything lasting or meaningful is to be "gained." More than 30 years ago, Nobel Prize recipient Daniel Kahneman in his manuscript "Prospect Theory:

[6] Garrett County Public Health Study Meeting, September 25, 2014. http://www.garrettcounty.org/economic-development/news/2014/09/shale-gas-public-health-study-meeting-set

An Analysis of Decision under Risk" (1979) demonstrated how the human thought process does not lead to the optimal choice. More than 20 years ago, Peter Sandman published his book "Responding to Community Outrage: Strategies for Effective Risk Communication" (1993) in which he explained how outrage influences human thinking regarding hazards and risk. Based on the writings of both Kahneman and Sandman, which identify "fear of the unknown" as a roadblock to communication of risk; such unknowns are frequently highlighted throughout the U MD report.

3.2.7.1 Comments on Assessment and Recommendations for Cumulative Exposure/Risk

The lead sentence in the U MD report Executive Summary section dealing with Cumulative Exposure/Risk (Section 6.2.9, page xxiv) begins "Exposure does not happen in a vacuum." However, humans do not live in vacuums either, and even the necessities of life (air, water, food) create "exposure." The U MD report appears to suggest exposure, of any sort to anything, is deleterious and must be prevented. There is no logical or scientific basis for such an argument, as the intensity of exposure is important to understand to assess toxicity (as discussed earlier). Humans are continuously exposed to a multitude of stressors, and there is no such state as "zero risk." A common fallacy is that man-made chemicals and stressors are always bad and that natural chemicals and stressors are always good. Nevertheless in the U MD report sections addressing Cumulative Exposure/Risk (Section 10.3.7, pages 73-76), the U MD project team strings together a series of leaps of faith and home-made algorithms to conclude that "it is reasonable to assume that the combined effect of UNGDP related hazards described in this report may be higher than the simple sum, and that the impact will be more pronounced in disadvantaged communities and will be disproportionately felt by vulnerable subpopulations such as property owners without mineral rights, elderly, children, and individuals with preexisting diseases." The Report cites a number of references (~15) in support of its conclusions. However, an examination of those references in the context of how they are portrayed in the U MD report reveals that the project team has taken a few liberties with interpretation, wording, or meaning.

- The U MD report states "Conventional risk assessment methods were designed to assist regulators and risk managers in addressing threats resulting from a single chemical or source to a hypothetical individual, instead of a population (Callahan and Sexton 2007; USEPA 2003; Zartarian and Schultz 2010)."
    - "Threat" is not a word used in the Callahan and Sexton (2007) paper, and the statement is not what is written in the Sexton (2012) publication. The Callahan and Sexton (2007) paper recognizes that "risk" is societally constructed and not something intrinsic. The latter Sexton (2012) publication further explores the debate regarding environmental justice.
- The U MD Statement report states "This shortcoming of traditional risk assessment has given rise to cumulative risk assessment (CRA) or community-based risk assessment approaches (USEPA 2003)."

- "Shortcoming" is not a word used in the US Environmental Protection (2003) Framework for Cumulative Risk Assessment report. (USEPA 2003)

- The U MD report states "Cumulative risk is the combined risk from aggregate exposures from all relevant routes, to multiple hazards or stressors, including chemical, biological, physical and psychosocial stressors" (Callahan and Sexton2007; USEPA 2003; Zartarian and Schultz 2010).

    - The US Environmental Protection (2003) Framework for Cumulative Risk Assessment report states that while such may be the definition of cumulative risk, it doesn't mean that these risks should be added together. In their paper discussing the EPA's human exposure program addressing cumulative risk, Zartarian and Schultz (2010) essentially calls for more research. The U MD report makes this same request, highlighting the need for further work before cumulative risk is understood.

- The U MD report states "CRA is a tool for organizing and analyzing information to examine, characterize and possibly quantify the combined adverse human health effects from multiple stressors" (DeFur et al 2007; Callahan and Sexton; USEPA 2003; Zaratarian and Schultz; Menzie 2007; USEPA 2007).

    - The first cited reference for this statement, DuFur et al (2007) is not about the CRA tool but rather about community and individual resources. The US EPA (2003) Framework report does not make this statement. A later US EPA report (US EPA 2007) discusses "variables" rather than "multiple stressors;" such a distinction is important as the U MD choice of words stirs an emotional reaction whereas the references note that there are differences to be understood scientifically.

- The U MD report states "CRA is often not quantitative like conventional risk assessment. (Callahan and Sexton 2007; USEPA 2003; USEPA 2007)"

    - The US EPA 2007 report discusses several areas where data can be used in a quantitative manner for the CRA process. One example discussed by US EPA 2007 describes several circumstances where quantitative data can be used in a CRA: "Quantification of exposure for cumulative risk assessment begins with a clear definition of the population and study area so that the analyst can identify all existing and future completed pathways."

- The U MD report states "CRA deals with the combined effects of multiple hazards (chemical, physical, and biological) and psychosocial stressors, and calculating specific risk, including interactions among various mixtures/stressors is methodologically complex (DeFur et al 2007; Callahan and Sexton; USEPA 2003; Zaratarian and Schultz; Menzie 2007; USEPA 2007)."

    - The paper by Zartarian and Schultz (2010) discusses a thoughtful, phased approach to a CRA.

- The Menzie et al (2007) paper uses the terms “target risk” and “relative risk” but not “specific risk” as used in the U MD report.

- A discussion by Clougherty et al (2007) highlights ways in which a CRA can yield highly suggestive findings that have many limitations.

- Finally, Sexton and Hattis (2007) recognizes probability is an important consideration with a risk assessment including a CRA. Interestingly, nowhere in the U MD report does the word “probability” appear. Instead, the U MD report is based on speculation, possibilities, and potentials. A CRA should not only focusing on random combinations of hazards, but instead identify those combinations that are the most important mixtures for public health (Sexton and Hattis 2007).

- The U MD report states “However, studies on extractive industries have shown loss of jobs and increase in unemployment rates in boom towns during the “bust” phase (Sexton and Hattis 2007; Barth 2013).”

    - Economic cycles have always been about booms and busts. The tradeoffs between benefits to a nation verses damage to a locality are discussed by Barth (2013), who implying someone always gains and someone always loses. This paper implies that no changes should be made, because positive changes will always be balanced by negative changes. With respect to employment, for example, such a position would lead one to believe that any industry that uses a limited resource will have a positive impact on employment initially, and will later have a negative impact when the resource is gone and employment rates will decline. Such an outlook, however, does not imply a resource should not be exploited simply because eventually those new jobs will disappear (Barth 2013).

- The U MD report states “Other industries that need clean environments including good air and water quality and healthy ecosystems including agriculture, tourism, fishing, and recreational industries are incompatible with UNGDP (Barth 2013; Kaufmann et al 2011; Kühn and Münch 2013).”

    - The economics in the area of focus regarding the U MD report are apparently not the most robust. The impression given by the U MD report is that these areas of interest for UNGDP development will be better off remaining economically weak, as if such development will create economic dichotomies only and never economic dualities. The Barth (2013) citation has been discussed (above). The paper by Kaufmann et al (2011) is unrelated to CRA. The Kühn and Münch (2013) citation is a report proposing a fracturing method using carbon dioxide, and does not involve CRA at all.

- The U MD Report states “For reasons mentioned above, public health advocates have long stressed the need to incorporate cumulative exposure/risk as the true impact of UNGDP activities simply cannot be quantified by simple measure of criteria air pollutants, VOCs, contaminants in drinking water supplies, or any other hazards for that

matter. What these quantitative measures fail to account for, are the slow and hidden sufferings encountered on daily basis by impacted community members that simply cannot be measured."

- CRA simply cannot address all the questions and does not hold all the answers. CRA is a new, undeveloped, and unvalidated tool. The implication that "the true impact" is not being addressed is sensationalization of the issue. The implications that, first of all, there are "slow and hidden sufferings encountered on daily basis by impacted community members" is emotional and judgmental and, almost importantly, unsubstantiated as having anything to do with UNGDP.

- The U MD report states "It is clear that communities currently impacted by UNGDP activities need a place-based cumulative exposure/risk assessment to capture their cumulative risks from exposures to multiple chemicals, media, pathways and non-chemical stressors (e.g., psychosocial stressors) or the stakeholders' underlying vulnerabilities, as described in the NRC report" (2009).

    - The National Research Council (2009) book makes no such statement but rather says the purpose of a risk assessment needs to be defined before it is conducted. The National Research Council book also states that epidemiological studies have limitations regarding CRA. (In contrast, the U MD report advocates conducting CRA-related epidemiological studies.) The National Research Council (2012) report "Exposure in the 21st Century expresses a vision regarding exposure science and recognizes the importance of understanding background conditions. Essentially, it supports the alternative explanation for the "slow and hidden sufferings" statement in the U MD report, bringing up (among other possibilities) that effects may be related to background conditions.

The assessment of cumulative exposure/risk in the U MD report (section 10.3.7.1 Assessment, pages 75-76) uses an Evaluation Criteria that is arbitrary and looks only at those aspects classified as "loss." Positive impacts are ignored. The resulting Hazard Rank of "Moderately High Risk" is thus arbitrary, without basis; no references are provided for meaning or interpretation. A fair assessment of "risk" requires a fair assessment of "reward." The U MD report is, in essence, suggesting there is nothing measurable to be gained from UNGDP either at a personal level or at a community level. Clearly, such a conclusion cannot be true..

3.2.7.2 Comments on Cumulative Exposure/Risk Recommendations

The U MD report provides three recommendations related to Cumulative Exposure/Risk, Recommendations R46-R48.

R46. Initiate a birth outcomes surveillance system

R47. Initiate a longitudinal epidemiologic study of dermal, mucosal, and respiratory irritation

R48. Develop a funding mechanism for public health studies

None of these recommendations are supported by the data, and all will be very costly.

3.3 Occupational Health Impacts

The U MD study concludes that there is a "High Likelihood" that UNGDP will cause adverse outcomes on Occupational Health in Garrett and Allegany Counties. The stated Occupational Health Impact concerns are based on worker exposures to crystalline silica. ENVIRON disagrees with the High Hazard Ranking based on comments related to the HIA methodology (described above) as well as our review of the report and supporting literature, as described below.

3.3.1 Comments on Occupational Health Impacts Assessment

- Based on the NIOSH study by Esswein et al (2013) the U MD report concludes that UNGDP workers are exposed to an "unusually high" level of crystalline silica.
    - The NIOSH study (Esswein et al 2013) does not, in fact, make this assertion. Instead, the NIOSH team went into various UNGDP sites around the country and identified areas where silica exposures were high. They then worked with the companies to reduce exposures (tightening loose fittings, closing open "thief hatches," or recommending worker use of personal protective equipment for certain higher-exposure tasks). The resulting measures led to decreased exposures. It is not clear what the U MD report considers *unusual* about such occupational exposures; no further elaboration is provided.
- As discussed previously, the hazard ranking methodology described in the methods section of the U MD report (Section 10.2.3, Ranking of Hazards, pages 20-22) cites methods for HIAs but does not follow these methods. Instead, fundamental changes have been made to the methodology that separate the hazard ranking table in the U MD report from the cited references, as follows:
    - For the *Likelihood of health effect* evaluation criterion, rank variables were added and others were changed in scoring value. An "unknown" variable was added with a score value of 1 and the "unlikely" variable was changed from scoring value of 1 to 0 in the U MD report.
    - The *Magnitude/Severity of Health Effects* evaluation criterion was modified from the source report by adding a "None" variable with a score value of 0. An "Unknown" variable was added with a score value of 1. Both the "Low" and "Unknown" variables correlate with a score value of 1, the only such criterion with duplicate scoring values.
    - The *Geographic extent* evaluation criterion was slightly modified. For the "Community-wide" variable the source report specifies "Effects occur across most or all of the Battlement Mesa PUD." The U MD report generalizes the area of focus in saying "Effects occur across most of the community." This generalization of the description complicates interpretation of the geographic locations implied by the criterion.

- The *Effectiveness of Setback* evaluation criterion was not included in the cited reference and is unique to the UMD report. A setback which is "anticipated to minimize health effects" is given a score value of 1, meaning the public health impact increases in severity. A setback which is "not anticipated to minimize health effects" is given a score value of 2. As such, the scoring system for this criterion can only raise the overall public health impact rating and a null value option is not presented.

- The *Direction of Potential Health Effect* evaluation criterion present in the cited reference was omitted in the UMD report. This evaluation criterion added a variable assigned to a + or – depending on if the change improved health (+) or detracted from health (-). While this criterion would not affect the calculated Public Health Impact Score, its omission removes a fundamental aspect of the hazard ranking present in the cited reference.

- The overall hazard ranking scale was also modified from the original 6-15 range to a 5-17 range. It was also noted that there is a typo in the UMD report regarding this range. The minimum score is stated as a 6, but the lowest possible score sums to a score value of 5.

- The most glaring difference outside of the rework for the scoring criteria is the labeling of categories to rate *Public Health Impact*, as calculated by the sum of all scores. The cited reference does not provide categories for the suggested health impact that the numerical rank may imply. In the cited reference, the rank-order is only used for comparative purposes. The UMD report separates the scores into three arbitrary categories and assigns labels to describe the supposed public health impact. There is no basis provided which justifies the selected division points. Furthermore, the UMD report changes the meaning of the rankings by categorizing score ranges into a three tiers correlated to a color scale with the inconsistent descriptors of "*Green, Yellow, and High."*

- The U MD report cites the FracFocus Chemical Disclosure Registry database (2014) in Section 10.2.4 (Identifying Chemicals of Concern), and cites a reference that describes the percentages of additives present. The information presented in the UMD report omits certain information, skewing the interpretation of the data presented in the cited reference. The fluid composition used to hydraulically fracture a well is a mix of 99.2% water and 0.79% additives according to the figure in the cited reference. The list of additives that the UMD report lists as constituents within the 0.79% fraction is incomplete. The list omits gellant which accounts for 0.5% of the total fluid composition and 63% of all additives. This omission in the UMD report is misleading in that it implies the listed chemicals comprise the entirety of the non-water fluid composition, when in fact the volume of the listed additives accounts for less than half of the non-water fluid composition.

- The U MD report cites a FracFocus paper (2013) in Section 10.2.4 (Identifying Chemicals of Concern), referencing a table of fracturing chemical additives from a website. The table the UMD report presents bears little resemblance to the one from the

source material. Both tables contain three columns, but the headings and table content do not match. Differences between the two tables include:

  - The first column loosely follows the list of chemicals from the source material, but modifies some, adds one, and excludes others. Gel was modified to "Gelling agents", "oxygen scavenger" was added, and six additives were excluded. Excluded additives include *Iron control, Non-Emulsifier, pH Adjusting Agent/Buffer, Propping Agent, Scale Inhibitor*, and *Surfactant*.

  - The second column replaces the heading "Purpose" as was presented in the source report with "use" in the UMD report. The descriptions for each chemical completely replace those in the source material with approximate descriptions based on the original "Purpose" column from the source table.

  - The third column replaces "Downhole Result" with "Consequence of not using the chemical." It is unclear from where such information was derived.

- The U MD report cites an article by Pataki (2011) from New York Daily News. Newspaper articles are not reliable sources of scientific information.

- The U MD report also cites a Bureau of Labor Statistics report (2011) in Section 10.4.1, referring to statistics from a report detailing the number of nonfatal occupational injuries and illnesses for various population groups. The U MD report refers to the source report as describing nonfatal injuries only, never mentioning that those same statistics include illnesses. This distinction made by the U MD report is problematic because the source report makes no distinction to separate the two in the data referenced.

  - When describing statistics presented in the Bureau of Labor Statistics report (2011) the U MD report mislabels the significance of the data when describing the "average" number of days away from work. The source report provides median values, not average or mean values.

  - Multiple other data reporting errors are present in Section 10.4.1 of the U MD report when discussing the Bureau of Labor Statistics report, as follows:

    - *"Contact with objects (33.7 per 10,000 full-time employees (FTE)), overexertion in lifting and lowering (8.8 per 10,000 FTE), and fall on the same level (8.3 per 10,000 FTE) are the most common events leading to nonfatal injuries [158]. These injuries are due to sprains, strains, and tears (34.9 per 10,000 FTE) and fractures (12.9 per 10,000 FTE) [158]. Over half of the nonfatal injuries occurred in workers who have been with their employer for at least one year. This correlates with the age of employees at the time of injury – there were 10,060 injuries among workers aged 16-34 and 12,360 injuries among workers 35-64."*

    - The first statistic stated concerns the incidence rate of events or exposures in the mining industry to contact with objects. Previous to the

quoted section above, the UMD report states, from the table in the source report, the number of incidences specifically in the mining industry. It correctly states that value as 7,060. The next sentence, starting with the quoted section above states contact with objects as having an incidence rate of 33.7 per 10,000 full time employees for mining. The table in the source report states this value as 43.3. Similarly, lifting and lowering is said to have an incidence rate of 8.8 per 10,000 for mining when the source report states this value is 7.3. Falls on the same level are stated in the UMD report as 8.3 for mining when it is listed as 8.9 in the source report.

- The quoted statement above goes on to say the injuries are due to sprains, strains, and tears, as well as fractures. Both of the values reported are incorrect. Sprains strains, and tears are listed in the source report as 30.6, while the U MD report states it is 34.9. Fractures are listed in the source report as 20.5, while the U MD report lists that value as 12.9. Furthermore, the U MD report asserts the incidence rates listed prior to the statement concerning sprains, strains, tears, and fractures all resulted in those types of injuries, which the source report does not suggest. In fact, another section of the report analyzes the distribution of sprain, strain, and tear cases and shows the actual distribution, which is more varied than the U MD report suggests.

- The U MD report states *"Fatalities are most likely to occur in operations run by small subcontractors (those with less than 19 employees), whether they are engaged in drilling or well servicing."* The paper cited here (King 2013) makes no claims to the above statement. It does mention contractors, but makes no mention of "small subcontractors…with less than 19 employees." Additionally, no comments on fatalities related to any contractors or subcontractors are provided (King 2013).
    - Furthermore, other statistics from this paper (King 2013) are cited. However the King (2013) report is not a primary source for the data. The U MD report should have gone back to the original source of information to make certain it was cited correctly.

- The U MD report references a document entitled *Employer Firms, & Employment by Employment Size of Firm by NAICS Codes, 2007* (US Small Business O of A 2007). They state *"In 2012, the top three events that led to the fatalities were transportation incidents (49%), contact with objects or equipment (18%), and fires and explosions (15%) [160]."*
    - However, the above statement and statistics bear no resemblance and are completely off topic to any of the information provided in the source material. The source material makes no assertions about fatalities, or anything concerning hazard incidence rates.

- The U MD report cites an article published in the New York Times (Urbina 2012) related to a Department of Transportation regulation. The U MD report cites the DOT regulation under a secondary source. The U MD report goes on to reference a statement made by the New York Times article: *"The increased transportation fatalities are due, in part, to a fifty year old Department of Transportation exemption that allows drivers in the oil and gas industry to work longer hours than most truck drivers."*

    - Again, newspaper articles are not the proper source of such information, and are, at best a secondary source of information.

- The U MD report references a study measuring ambient sound levels (NYSDEC 2011), yet compares those levels to OSHA implying the data represents employee noise exposure. An ambient noise level is not a measure of an employee's noise exposure.

- The U MD report states the following *"Limited monitoring data available showed a quarter of the UNGD sites monitored exceeded the 20 mg/m^3 threshold [168]."*

    - This number is a typo; the referenced data (Esswein and Breitenstein 2014) contains the value of 20 µg/m^3 (micrograms per cubic meter) rather than 20 mg/m^3 (milligrams per cubic meter). This typographical error represents a 1,000-fold difference due to the misapplication of measurement units. Furthermore, the criterion upon which the data is compared against contains the same error in units.

    - The U MD report claims that the OSHA report on diesels (2013) provides a Cal-OSHA occupational exposure limit of 20 mg/m^3 for diesel particulate matter (DPM) as an 8-hr TWA. However this reference presents no such value, and represents a federal OSHA webpage, not a Cal-OSHA webpage. Furthermore, the statement that Cal-OSHA provides an occupational exposure limit for DPM is factually incorrect. Cal-OSHA does not regulate DPM. The Cal-EPA Office of Environmental Health Hazard Assessment *recommends* that workplace exposure be kept below 20 ug/m^3 based upon the findings of a risk assessment (Hazard Evaluation & Information Service 2002) Note that the units for the recommended value are in micrograms, not milligrams, for the numerator.

- The U MD report states *"Short-term exposure to hydrogen sulfide has been linked to nausea, headache, shortness of breath, sleep disturbance, throat and eye irritation, while long-term exposure causes olfactory nerves paralysis, respiratory inflammation, chronic bronchitis, and chronic tearing of the eyes [169]."*

    - The cited OSHA webpage for this statement (OSHA 2009) does not discuss short or long term exposures. The webpage describes health effects based on certain concentrations, but does not specify exposure duration.

- The U MD report cites several OSHA news releases describing serious incidents involving hydrogen sulfide (H_2S) (OSHA 2010; 2011). Both incidents are a result of

inadequate safety measures or non-compliance, and represent scenarios which are not unique to UNGDP sites or specific to H_2S. The citations appear to be included only because they include the word H_2S.

The U MD assessment for Occupational Health (Table 10-20) misapplies the evaluation criteria even more egregiously for occupational settings than the report did for Public Health. The criteria "geographic extent" does not appear to have been applied here consistent with the definition in Table 10-2. In Table 10-2, geographic extent is receives a score of 1 if effects occur in close proximity to UNG-Development and/or production and a score of 2 if the effects occur across most of the community. Worker effects would be anticipated to occur close to a work site, giving it a score of 1, but instead the report has given it a score of 2 "because workers are from different areas." This is apparently confusing effect with where the workers come from.

3.3.2 Comments on Assessment and Recommendations for Occupational Health

The U MD report provides four recommendations related to Occupational Health, Recommendations R49-R52:

- R49. Require implementation of NIOSH and OSHA recommended controls for silica exposure in UNGDP operations.
- R50. Provide NIOSH with resources to regularly inspect UNGDP workplaces and monitor worker exposures.
- R51. Establish community outreach programs to help transient workers feel more welcome in the community as a means of reducing rates of depression, suicide, and drug use.
- R52. Require employers to provide employee assistance programs including counseling and substance abuse treatment.

Many of these recommendations are reasonable, but are already being done on the Federal level by NIOSH (for example R49, R50). Establishing outreach programs to help workers feel welcome in the community (R51) is a laudable recommendation. It is not clear why recommendation R52 is made for the UNGDP industry, when it is not required for others. Although greater resources with respect to mental health are needed nationwide, it is not clear why the responsibility for this lies on the UNGDP industry, especially as the U MD report did not provide evidence that this will be an issue.

3.4 Recommendations Not Addressed Specifically in the U MD Report

In total, 52 recommendations where made regarding potential UNGDP activities in Allegany and Garrett Counties. Recommendations R1 through R7 tend to be generic and are proposed for inclusion into the Comprehensive Gas Development Plans. None of these recommendations are discussed in detail in the U MD report. Recommendations R8 through R13, deal with disclosure of well stimulation materials. None of these recommendations are discussed in detail in the U MD report.

R1. Require assessment of air quality and other potential health impacts and propose strategies to protect the community and workers from exposure to hazardous air pollutants.

R2. Require assessment of whether application of standard setback distances will be adequate to protect public health, including consideration of prevailing winds and topography.

R3. Require disclosure of planned well stimulation methods and classes and amounts of chemicals used.

R4. Require a quality assurance plan.

R5. Require an air, water, and soil-monitoring plan.

R6. Require assessment of impact on and a monitoring plan for potential fugitive emissions from existing and historic gas wells within the horizontal extent of the fractured area.

R7. Require that all UNGDP materials and wastes be stored closed tanks; open pits shall only be used for storage of fresh water.

None of these recommendations are discussed in detail in the U MD report.

- R1 is overly broad, and will need to be better defined prior to implementation. However, this recommendation is essentially the same as R19 – Conduct Air Quality Monitoring – and has been addressed in detail in the comments on the Air Quality recommendations section of the report (Section 12.3). To reiterate, ENVIRON agrees in general with this recommendation and noted that conducting air dispersion modeling to assess air quality would address a major limitation in the report.

- R2 depends on the distance to the nearest receptor, which at this time is poorly defined. However, consideration of prevailing winds and topography, as noted in the detailed comments on the Air Quality recommendations section (Section 12.3), is easily accounted for in the air dispersion modeling that ENVIRON noted was absent from the report.

- ENVIRON agrees with R3, as more communities are requesting a better understanding of chemicals used in the UNGDP process.

- R4 is poorly defined. Quality assurance plans are typically developed for multiple aspects of complex projects such as UNGDP projects.

- R5 overlaps with recommendations for specific identified hazards/stressors. See comments on R19, R21 and R24.

- R6 appears to be over-reaching; justification needs to be supplied for why this information is needed.

- It would appear that R7 was made to limit the potential for fugitive emissions from UNGDP materials and wastes; however, no information is provided in this report to indicate that this would be an issue at the proposed UNGDP site.

Recommendations R8 through R13, deal with disclosure of well stimulation materials. These recommendations are as follows:

> R8. Require preliminary disclosure at time of CGDP submission (See CGDP recommendations), detailed disclosure at time of well permit application, and detailed reporting of actual materials used within 30 days of finishing well stimulation activities. Require notification of MDE, local emergency responders and public notice of significant variances from materials and concentrations proposed in the permit within 24-hours of occurrence.
>
> R9. Require detailed disclosures to include CAS numbers, volume and concentration of every chemical or distinct material including proppants, their physical form, and identification of engineered nanomaterials – including drilling muds and hydraulic fracturing and other fluids – used in well stimulation. Do not allow claims of trade secrets for identified and concentrations of specific chemicals or nonmaterial used in well stimulation.
>
> R10. Require detailed disclosures to include base fluid volume and sources including percentages that are recycled fracturing fluid, production water, and fresh water.
>
> R11. Require simultaneous submission to state regulators and FracFocus.
>
> R12. Collaborate with California to develop a State controlled and archived Internet Web site consistent with the provisions of California SB4.
>
> R13. Implement the provisions of H.B. 1030 for timely access to disclosed information by medical professionals, emergency responders, poison control centers, local officials, scientists, and the public.

- Recommendations R8 through R13 deal with disclosure of well stimulation materials. As it appears that the U MD team has failed in general to involve local officials, county healthcare agencies or other stakeholders in their assessment of impacts of UNGDP activities and disclosures regarding same, R8, R10, R11, R12, and R13 have some merit. However, R12 – "Collaborate with California to develop a State controlled and archived Internet Web site consistent with the provisions of California SB 4" – may not be the most cost-effect approach for Maryland, as California and Maryland may differ significantly with respect to disclosure requirements. Instead, Maryland should develop its own Web portal, consistent with Maryland law and provisions for disclosure, rather than partnering with California.

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