Commentary below is by William J Hughes, Wetzel County Solid Waste Authority, on the report titled:

Examination of Leachate, Drill Cuttings and Related Environmental, Economic and Technical Aspects Associated with Solid Waste Facilities in West Virginia

Report Submitted by: Marshall University Center for Environmental, Geotechnical and Applied Sciences Marshall University; and, Glenville State College
Report Submitted to: West Virginia Department of Environmental Protection: July 1, 2015

Simplified Summary Statements

(All page numbers are referenced to the PDF version of the 195 page report to the DEP)

1. Marcellus shale cuttings are Radioactive; 17/195; 139/195; 142/195; 154/195
2. We do not know if there is a long term problem 19/195; 96/195
3. About 30 million tons of waste in next few decades 176/195
4. Landfill liners leak 20/195
5. Owning and operating their own landfill would be expensive and risky for the gas companies 186/195; it appears that citizens might have to bear the environmental and financial risks related to new landfills.
6. Gas well drill cuttings are toxic to plants 97/195
7. Landfill leachate is toxic to plants and invertebrates 97/195
8. If **all** systems at landfills work as designed, leachate **might** not affect ground water. Pg. 41/195
9. Other landfills also have radioactive waste, 14-15/195
10. We have no idea if this will get worse 154/195
11. This has not been done before—78/195

Three categories of comments will be included here on various aspects of the total 195 pages of the Marshall University Report recently provided to the WV Department of Environmental Protection:

GOOD POSITIVE ASPECTS---GOOD SUGGESTIONS---IMPORTANT OBSERVATIONS

GEN is for General Comments

FLAW PROBLEMS---FLAWS---LIMITATIONS---

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Introduction: (All page numbers are referenced to the PDF version of the 195 page report to the DEP)

Any formal report comprised of 195 pages generated by a reputable school like Marshall University with additional input from Glenville State College, which is supported by over 2300 pages of semi-raw data and graphs and charts and tables, requires some serious

investigation prior to making comprehensive and final conclusions. However, some initial observations are needed to provide some independent perspective and to aid reflection on how sections of this report might be interpreted.

The overarching perspective that must be kept in mind is that the complete study was first limited by exactly what the legislature told the WV Department of Environmental Protection ***DEP*** *to do.* Second, then the **DEP** added other research guidelines and determined exactly what needed to be in the study and what did not belong. There were also budget and time constraints. And finally, the most constricting factor was the large body of existing data within the possession of the DEP which was provided to the researchers and report writers. Because of the time restrictions, only a small amount of additional raw data could be added.

And most importantly, similar to the **WVU** Water Research Institute (WVU WRI) report from two years ago, it must be kept in mind that these types of studies, initiated by those elected to our well-lobbied legislature and funded and overseen by a state agency do not occur in a political power vacuum. It was surely anticipated that the completed report might have the ability to affect the growing, natural gas industry which is supported by most in the political administration. Therefore we must be cautious here. The presence and influence of political and economic factors must be considered also. And for universities to receive research contracts and government paid study requests, the focus must include keeping the customer satisfied.

Comment ONE — Water Quality: EPA test protocols and data sets.

GEN It is obvious that a very smart and well trained set of researchers put a lot of long, detailed thought into analyzing all the available data. There must be tens of thousands of data points. Meticulous attention was put into how to assemble all the existing years' worth of leachate chemical and radiological information.

GOOD There is an elaborate and detailed discussion of how to best analyze everything and how to utilize the best statistical methods and generate a uniform and integrated report. This was made difficult with non-uniform time intervals and some non-detect values and some missing items. The researchers used a credible process, explaining how they applied the various appropriate statistical analysis methods to all the data. They provided some trends and observations and draw some conclusions.

FLAW However, the most glaring flaw and the greatest limitation is the nature of the very data set provided to the researchers from the DEP. It is to the commendable credit of the DEP that the leachate at landfills receiving black shale drill cuttings from the Marcellus and other shale formations were, from the beginning, required to start bi-monthly testing of leachate samples at landfills that were burying drill waste products. And in general, when compared to on-site disposal as done for conventional wells, it was initially a good requirement to have the drill cuttings put into some type of landfill. That way we could keep track of where the drill cuttings are when there are future problems.

To the best of my knowledge, until the black shale industry required it, regulatory agencies in other states also, have never knowingly deposited large quantities of industrial waste products which were known for decades by geologists and radiochemists to be radioactive, into generic municipal waste landfills. We just have not done it. We knew better. Therefore,

it is very understandable that we might not know how to best solve the problems of this particular waste product. This was and still is new territory.

Now we are a little better informed. We are slow, but learning. But three years ago, given the unfamiliarity of regulatory agencies with the uniqueness of this waste problem we chose the wrong test protocol to use when having all the leachate samples tested. We stipulated the commonly used and familiar clean drinking water test procedure. So now we have a massive set of test results all derived from using the wrong test protocol for the radiologicals. Fortunately most of the chemistry test results should still be accurate and useful .

At first, three years ago, this was understandable and possibly not an intentional error. But now, it is widely known by hydrogeologists and radiochemists, at least at the PhD level, that the plain EPA 900 series of test methods for determining the radioactivity of contaminated liquids do not work on liquids with high TDS—Total Dissolved Solids. Method 900.0 is designed for low solid samples like drinking water supplies. There is general consensus on this now. And almost a year ago authoritative studies containing this information was provided directly to the DEP.

Despite this major and significant limitation, the effort by Marshall University still has some utility. For example, doing comparisons between and among the various landfills accepting drill waste might provide some interesting observations and correlations. But it is clearly known now that the protocols that were used for all samples all along when testing for Gross Alpha, Gross Beta and Radium 226 and Radium 228 in leachate, can only result in very inaccurate, under-reported data. Therefore, it is not possible to draw any valid conclusions on quite a few of some very important topics. These topics of concern include: surface water quality; potential ground water contamination; exposure levels at landfills; and public health implications; and policy and regulations considerations.

All the years of leachate test sample were processed using what is called the clean drinking water test protocols, also referred to as the EPA 900 series. Labs certified to test for radiological compounds and elements are very familiar with the 900 series of EPA test procedures. They use them regularly and have been widely used for years. They are intended to be used on ***clean drinking water***. They are not intended to be used on “sludgy” waters or liquids contaminated with high dissolved solids like all the many liquid wastes from black shale operations like flowback and produced water and brines and leachate. Using the uncorrect lab process for sample preparation and testing will guarantee that the results will continue to be incorrect.

It seems that the best suggestion so far to test liquids similar to leachate would be to use what is referred to as Gamma-ray Spectrometry with a high purity germanium instrument with at least a 21 day (30 days are better) hold period, while the sample is sealed then counted for at least 16 hours. Many of the old leachate test results indicate high uncertainties which might be attributed to short hold times and short counting times. This procedure is referred to as the 901.1 M (modified). If the sample is sealed, the sample will reach about 99% equilibrium after 30 days. The Radon 222 must not be allowed to escape.

We all know that if we want to bake an appetizing and attractive cake we must use the correct measuring cups for the ingredients. If we want to take our child’s temperature we need an accurate thermometer. When our doctor helps us understand our blood test results,

we all want to be confident the right test was used at the lab. The proper test instrument, recently calibrated and also designed for the specific sample is crucial to get useable test results from which conclusions can be drawn and policy enacted.

So far, in no place in the final 195 page report have I seen any discussion of exactly which EPA test protocol was used and why was it used. It has also not yet been seen in the 2,300 plus pages of supportive statistical and analytical results either. The fact that the wrong protocol was used three years ago is very understandable. However this conventional EPA 900 series was still being used on the additional very recent, (done in fall of 2014) new samples that were included in the final report. The researchers, without any justification or discussion or explanations continued to use the wrong test protocol. It might have been justifiable to ***also*** use the clean drinking water procedures **along** with the **901.1M** (gamma spec) process, for comparison. It is understandable that for the new data to be consistent with the very large existing data set that a case could be made for sticking with the incorrect protocol. But there should have been a detailed discussion of ***what*** and ***why*** *any* test method was being used. That type of discussion is usually one of the first topics investigated and explained. Having that type of discussion and justification seems to represent a basic science method and accepted research process. And that omission is a serious flaw.

The potential environmental impacts to water quality section of this report seems to demonstrate that if you do not want to find out something, that there are always justifiable options to avoid some inconvenient facts. Given the very narrow scope as defined, some the Marshall University folks did not seem to have the option to stray into important scientific foundational assumptions and for the most part, just had to work with the stale data sets given them. All of which, as we have known for close to a year now, have used the wrong test protocol. Therefore we have incorrect results.

Comment TWO — Marcellus is Radioactive

GOOD Wetzel County has had active Marcellus black shale exploration and drilling for at least eight years now. And finally we now have a public report that clearly, unambiguously states that Marcellus shale is radioactive. Of course, geologists have known that for many decades. But also for decades there has been great reluctance by the natural gas exploration and production companies to acknowledge that fact in public. They sort of wanted the topic and the waste and its radioactivity to just disappear. So finally now, a formal report is out here in WV, that actually says that the black shale cuttings are radioactive. We have known that, but now we can publicly discuss it and not pretend otherwise. Interestingly enough, it was not much more than a year ago that some on the WV House of Delegates Judiciary Committee seemed to be just echoing the industry's intentional deception by declaring that ***"...it is only dirt and rock…"*** So this report represents progress, and provides a very valuable contribution to beginning to recognize some of the potential problems with shale wastes and their disposal challenges.

Another very important advance is that finally after eight years of drilling we have made progress at starting to try to actually test a sample from the horizontal bore. Two years ago, the WVU WRI study researchers were ***never given access*** to any sample taken from the horizontal bore material. Which was, of course, what they were supposed to have been allowed to do. But, they were only given access to study material from the vertical section of the well bore. Now, this report describes how we are getting closer to actually testing good

samples of the black shale. But it seems that we have only gotten closer. Let us see how close. The details hide the devil.

Page 11/195 describes that only three Antero wells in Doddridge County were chosen as the place to try to obtain samples from the horizontal bore. Considering that over 1000 deviated or horizontal wells or wells with laterals have been drilled in past few years that number represents a very small fraction of wells. It is less than **.3%** of the wells drilled. Even if a high quality sample was obtained it might be a challenge to extrapolate on test results. However it seems that there is a major problem with the samples from the three wells. And those limitations are also completely ignored in the report. Given the available documentation from the DEP, this seems to be a serious flaw or at least a significant oversight.

Comment THREE — Samples from vertical vs horizontal well bores

FLAW The problem is that it does **NOT** seem that the actual samples tested from at least two of the three wells used in the study were, in fact, from the horizontal bore material. It was just getting closer. The sample from the third well (Wentz 1H) might have come from the horizontal bore, but just barely. I will try to show this within the below chart using information which was provided by Antero to DEP Office of Oil & Gas. This information is in state records on Antero's well plats which become part of the well work application and also part of the final permit.

Below three wells which were included in the DEP — Marshall University report are located on **Antero Well Pads** in Doddridge County, WV. This chart is on report page 11 of 195.

Antero Well ID	API Number	Drilling depth when sample taken	Depth of Marcellus as given on Well Plat provided by Antero	Length of Horizontal Bore given on well plat	Comments
Morton 1H	47-017-06559	6,856 ft.	7,900 TVD*	10,600	Seems to be **1,044 feet short** of reaching the Marcellus formation
McGee 2H	47-017-06622	6,506 ft.	6,900 TVD	8,652	Seems to be **394 feet short** of actually reaching the Marcellus formation
Wentz 1 H	47-017-06476	8,119 ft.	7,900 TVD	8,300	Seems to have just drilled into the Marcellus shale by **219 feet**

* TVD = Total Vertical Depth

Antero is an active driller in Doddridge County. If any company knows where to find the Marcellus formation it is that company. The well pads where the samples were taken have between six and ten wells on the pads. The well plats are very detailed-filled technical documents provided to the DEP. We need to trust that the information on those plats is accurate and has been reviewed and approved by the permitting agency. Those plats give the depth of the Marcellus and the length of the lateral. The Marshall University report gives the drilling depth when the sample was taken. Using these available records from the DEP it

appears that on two of the wells the sample and its test results that were included in the report came from material produced when the experienced drilling operator was not yet into the shale formation.

Then, on the third well, the Wentz 1H, the numbers seem to indicate that they were just barely within the shale layer, by 219 feet. We need to keep in mind here that the total length of the lateral or horizontal bore in these three wells, as shown on the well plats, ranges in length from 8,000 feet to 10,000 feet. It would seem prudent that if a researcher wanted to get a good sample, that waiting a few days until the drilling operation was at least 3,000 to 4,000 feet into the lateral would have guaranteed that the sample would be more accurate. That would be scientifically required if someone wanted a good sample. Consider that even on the Wentz well, at 219 feet into the shale, that given the intermingling of cuttings, both on the shaker table and separators and in the centrifuge and in the mixing tubs, material from the curved section as drilling approached reaching horizontal, could easily still be mixed with the cuttings from the true horizontal bore which would just be beginning to arrive at the surface.

Would it not seem prudent, if one wanted a good, representative sample, to make absolutely sure that the operator was, in fact, drilling in the black shale and that the cuttings, returning to the surface, were in fact from the Marcellus bore? That would have been eminently defensible and easily accomplished by just waiting for drilling to progress for a few thousand feet further into the lateral bore.

These observations seem to address a very important limitation or possible flaw in this section of the report. It would seem that any informed scientist or geologist would go to great effort to guarantee that the sample actually came from where they said it came from and not just almost or getting close.

There might be plausible explanations for this apparent inconsistency or error. Of course, it might be speculated that the Antero provided information on the well plats are incorrect and not intended to be accurate, or that maybe the driller is not really sure yet where the Marcellus layer starts. There may be many other possible scenarios of explanations. Time will tell.

Comment Four — The Report Gives Some Good suggestions observation

GOOD There are a number of recommendations and suggestions in the study on landfills and leachate related conditions. It seems that a number of these are very accurate and should be implemented. For example: since the report clearly restates the fact that drill cuttings are known to contain radioactive compounds and since all landfill liners will eventually leak, and since landfills already have ground water test wells for monitoring for potential ground water contamination due to leaking liners, then the test well samples should be tested for radiological isotopes. Good idea. They are not required to do that now. This should be implemented immediately. Actually, should have and could have been implemented years ago. Page 17/195; and 21/195

GOOD The report also recommends that the Publicly Owned Treatment Works (POTW) or in the case of Wetzel County, the on-site waste water treatment plants should also test their effluent for radioactive isotopes. Page17/195. This is very important since there is no way to

efficiently filter out many of the radioactive isotopes. They will pass thru traditional waste water treatment plants.

It is also very useful that the report does recommend that all the National Pollution Discharge Elimination System (NPDES) limits at the POTWs be reviewed and they should now be required to also take into consideration the significantly more challenging chemical and radiological makeup of the shale products waste stream..

Comment FIVE — Economic Considerations on an gas industry supported mono-fill

The legislature asked that the DEP evaluate the feasibility of the natural gas industry to build, own or operated their own landfill solely for the disposal of the known radioactive waste. This seems to be a very reasonable approach since for decades we have only put known radioactive waste products into dedicated landfills that are exclusively and specifically designed for the long term storage of the special waste material.

The discussion of the economic considerations is extremely complete and detailed. They are given in **Appendix I**. They take into consideration a very thorough economic feasibility study of such a proposed endeavor. And it seems to have been done by a very talented professional team.

However some of the basic assumptions seem to be a bit askew. For example, in the initial Abstract of the financial analysis, it is stated that two new landfills would be needed because we do not want to have the well operators have to drive any further than they do now. Interesting. This seems to be not too different than a homeowner while in search for privacy and quiet, builds a home far out into the country and then expects the public sewage lines to be extended miles to his new home so he would not have to incur the cost of a septic system. Home builders in rural settings should know they will have to incur expenses for their waste disposal needs. It seems, however, that the gas company might want the communities to provide cheap waste disposal for them.

More than 15 pages later, the most important aspect is clearly stated that …the most salient benefit of establishing a separate landfill sited specifically to receive (radioactive) drill cuttings would be the preservation of **EXISTING** disposal capacity of existing fills for future waste disposal. (Meaning for my (our) grandchildren) See page 175/195.

Then, comprehensive and sound financial details in the report explain that having the natural gas operators build their own radioactive waste depository landfill, and then to operate it, and set aside closure funds, would involve a lot of their capital and some risk to them. Pg. 187/195 It is stated that their money would be better used drilling more wells which would produce more waste. The conclusion then seems to be that, all around, it is cheaper and less risky for the gas industry to just put all their waste products into our Municipal Solid Waste Landfills, and later our residents, our children and grandchildren can incur the costs and risk to build another landfill for their household garbage when needed.

Comment SIX — Omissions within the report

1. Within the report section dealing with the leachate test results, it is casually mentioned that not only do the landfills receiving shale waste materials have radioactive contaminated

leachate, but the other tested landfills do also. However, rather than raising a very large red flag and expressing concern over a problem that no one has looked at the implication seems to be that therefore we should not worry about any radioactive waste anywhere because it might be in all landfills. Page 139/195

2. Nowhere within the radiological discussion is there any discussion of what might be called speciation of radioactive isotopes. The report does state that the test for both gross alpha and gross beta, are considered a “scanning procedure”. The speciation process is sort of a slice it and dice it procedure. It would then show exactly what isotopes are responsible for the activity that is being indicated. It does not seem that it has ever been done on the landfill leachate test samples. The general scanning process cannot do that. Appendex H, pages 141-142/195, contains detailed facts on radiation dose, risk, and exposure. This might have been a good place to also discuss the proper EPA testing protocols, used or not used and why.

3. A short discussion of the DEP required landfill entrance radiation monitors is included on page 146/195. The recently installed landfill entrance monitors are the goalpost type. Trucks will drive between them when they cross the scales. It seems that the report should have emphasized that that type of monitor will primarily only detect high energy gamma radiation. However what is omitted from page 144 is that the primary form of decay for radium 226 is releasing alpha particles. The report is ambiguous in saying the decay products of Radium 226 include both alpha particles and some gamma radiation. It is not a strong gamma emitter. It is very unlikely that a normal steel enclosed roll-off box would ever trip the alarm setting with a load of drill cuttings. However those monitors are still useful since they will detect the high energy gamma radiation from a truck carrying a lot of medical waste. Page 17/195

4. On page 144/195 it is stated that the greatest health risk due to the presence of radium 226 is the fact that its daughter products is radon 222. Radium 226 has a half-life of 1600 years. Since radon has a half-life of only 3.8 days, it might seem to be less of a concern. What is not mentioned is that we have essentially an infinite supply of radium 226 going into our landfills now which will essentially be creating radon forever.