**From:** Joel Geier
**To:** Coffin Butte Landfill Appeals
**Subject:** LU-24-027: Risk of impacts on water availability from wells and springs
**Date:** Monday, October 20, 2025 1:39:43 PM
**Attachments:** Well impacts Joel Geier 2025-10-20.pdf



Please add the attached PDF file to the public record for this proceeding. My address is included in the PDF.

Thank you,
Joel Geier

Dear Commissioners Wyse, Malone, and Shepherd:

Thank you again for this opportunity to provide testimony regarding LU-24-027. My address is 38566 Hwy 99W, Corvallis OR 97330. As detailed in earlier testimony, I work internationally as a consultant, with a specialization in hydrogeology of fractured rock. I have a doctorate in the field and have also taught both basic and advanced hydrogeology courses at the university level.

In this note, I will give you yet another reason to uphold the careful and thoroughly considered decision of your Planning Commission, to deny this permit application, specifically: **Risk of impacts on water availability from existing household and farm irrigation wells**

The risk of impacts on springs and wells on neighboring properties is easily understood in lay terms:  If you dig a deep pit below the water table, groundwater will flow into it. That water needs to come from the surrounding rock or soil. As that water flows into the pit, it will depress the water table in adjacent areas. If you continue to drain water from the pit, this impact will persist.

That this will happen is beyond dispute. The only question is, how much will springs or wells be impacted, depending on their distance from the excavation?

This question is central to assessing whether the excavation, and subsequent drainage as part of landfill operations, will be so great as to impose an "undue burden" on owners and/or residents of adjacent properties. Related impacts include on wildlife that rely on natural springs, and on established forestry uses that depend on accessible soil moisture.

Yours sincerely,
Joel Geier, Ph.D.

## Risk of impacts on water availability from existing household and farm irrigation wells

This relates directly to the review criteria in BCC 53.215, in particular interference with uses on on adjacent property and with the the character of the area. Both county staff and the applicant have acknowledged:

1. Access to groundwater is part of the existing residential and agricultural use of adjacent properties, and thus also important to the character of the area.[1]
2. Groundwater in the bedrock below Tampico Ridge is controlled by fractures, and how they interconnect.[2]
3. Excavation of the north end of Tampico Ridge could result in lowering groundwater levels as far away as wells on adjacent private properties.[3]

Thus the only issue in dispute is **the degree to which wells on neighboring properties will be affected**, and whether this is **significant enough to interfere with adjacent uses** and/or the character of the area.

**The applicant has not met the burden of proof on this issue.** County staff and their third-party consultants implicitly acknowledge this, by proposing four new, complex conditions of approval which mandate new site investigations, specifically to address the lack of certainty on this issue.

In the following pages, I will explain why:

1. The applicant's evidence is inadequate to resolve this issue, and
2. County staff's proposed conditions of approval are not sufficient to mitigate the risk of significant impacts on adjacent uses.

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1 Staff Report for the Planning Commission p.19, and Supplemental Staff Report p. 60, which notes that concerns about groundwater levels were also cited by the Environmental and Natural Resource Advisory Committee as a reason for recommending denial.

2 [ADD FOOTNOTE referencing applicant's statement]

3 Applicant Exhibit 68 states that water levels in wells on nearby properties could be lowered by up to 17 feet, although they discount the possibility that this might be a significant impact despite [COMPARE SCREENED LENGTH AND PAST HISTORY OF DEEPENING].

Some technical jargon may be needed for a few aspects, but the main points can be understood in common-sense terms.

## My specific qualifications

In addition to my qualifications as an internationally recognized expert on groundwater flow in fractured rock (which is the situation of concern here), I also have specific experience in evaluating impacts of excavations on wells[4] , effective field methods for investigating such situations,[5][6] and effects of excavations in situations where brackish or saline groundwater is known to occur below fresh water[7].

As a resident I did my own evaluation of the groundwater supply below Tampico Ridge by analyzing records for all neighboring wells before we purchased our home in 2004. When we hired a well driller I oversaw that work. Since then I've gained 21 years of very practical experience with the local groundwater system, both first-hand and from conversations with our neighbors when they have questions about their wells. So I have a good understanding, both professional and practical, of how and why wells on Tampico Ridge respond to seasonal changes and sustained pumping.

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4 Geier, Joel., 2019. Evaluation of hydrogeological risks associated with water-supply wells in a future warmer climate – Main review phase. In SSM's external experts' reviews of SKB's safety assessment SR-PSU –consequence analysis and hydrogeological aspects – Main review phase. SSM Report 2019:16, Swedish Radiation Safety Authority, Stockholm, Sweden.

5 Doe, Thomas, John Osnes, Michael Kenrick, Joel Geier, and Scott Warner, 1987. *Design of well testing programs for waste disposal in crystalline rock: Proceedings of the 6th International Congress on Rock Mechanics*, Vol 3, ICRM, Montreal, Quebec, 1987.

6 Geier, Joel, 2016. Hydraulic head responses to induced disturbances: Implications for models of sparsely-fractured rock at Olkiluoto. Technical report STUK-TR 23, Radiation and Nuclear Safety Authority, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-309-334-8

7 Lindgren, Georg, Clifford Voss, and Joel Geier, 2013. Brine intrusion by upconing for a high-level nuclear waste repository at Forsmark. Scoping calculations. SSM Research Report 2013:28, Swedish Radiation Safety Authority, Stockholm, Sweden.

## Why the applicant's evidence is inadequate to resolve this issue

The applicant's dismissal of these concerns turns out to be based almost entirely on rather rudimentary calculations, using a mathematical formula that's inappropriate for the groundwater circumstances under Tampico Ridge.

In their filings for the filings for the Planning Commission, the applicant described this "model" only in very general terms, and did not give documentation of its parameters, until a very late stage of this appeal process.[8] Applicant's inappropriate criticisms of members of your Planning Commission who tried to address the applicant's claims, in the absence of any substantial documentation of the claimed model, need to be considered in this context.

The mathematical formula, which was finally stated in Applicant's Exhibit 68, is based on **multiple assumptions**, including:

1. groundwater flows horizontally from one end of a cross-section to the other,
2. flow is driven by a fixed difference in hydraulic head, from one end of the cross-section to the other.
3. flow is homogeneous (uniform) within the cross-section,
4. the entire cross-section behaves as an unconfined aquifer
5. the aquifer is isotropic (meaning that flow in the vertical direction occurs just as easily as flow in the horizontal direction),
6. the aquifer has a flat, impermeable base.

**All of these assumptions are questionable** for the way in which this formula has been applied in Exhibit 68. Addressing these assumptions in the same order as above:

8 Applicant's Exhibit 68, which finally revealed the specific formula used, and the choice of parameters, was not filed until less than an hour before the 5 pm October 7th deadline for consideration in the Staff Report, and was not posted to the public record until sometime between 9 am October 10th and 9 am October 11th. This left no time for public response prior to the deadline for the Staff Report. It left only a very short time – perhaps as few as three working days – for the county's third-party consultants to evaluate the assumptions and results, and to give their opinions as input for the Staff Report.

1. Two different cross-sections are used, neither of which are aligned with the applicant's previous interpretations of groundwater flow directions on Tampico Ridge (compare Figure 1 of Applicant Exhibit 16). For most of their length, these sections are nearly at right angles or even opposite to the direction of flow claimed in Exhibit 16.
2. The hydraulic head $h_2$ at the end of the cross-section distant from the excavation is unknown and unconstrained. Exhibit 68 states that this parameter was "calibrated" for each cross-section, based on measured water levels in a more distant well along the same cross-section. However since the cross-sections are not aligned with the presumed direction of flow, this "calibration" is physically invalid.
3. Well drilling logs from Tampico Ridge (available from the same OWRD database as cited by the applicant) show that groundwater flow to domestic wells is usually in discrete fractured zones, rather than uniform with depth. Outside of these zones, flow through less-fractured sections of the basalt bedrock is minimal. Thus flow is not uniform within the cross-section; it is strongly heterogeneous (the opposite of "homogeneous").
4. Because the less-fractured basalt bedrock between fractured zones is relatively impermeable, there is no reason to expect that the entire cross-section behaves as an unconfined aquifer. Only the uppermost few tens of feet (typically referred to in drilling logs as "weathered basalt") are likely to respond as an unconfined aquifer. The deeper part of the bedrock is more likely to respond as a system of confined aquifers (the fractured zones) separated by aquitards (the less fractured bedrock).[9]
5. For the same reason, the bedrock is likely to be strongly **anisotropic** (the opposite of isotropic), with flow in horizontal direction occurring much more easily than flow in the vertical direction.
6. The applicant has not provided any geological explanation for why the base of the cross-section considered in their model should be "flat and

9 This is acknowledged in the third-party consultants' suggestions for new conditions of approval, given in Attachment A of the Staff Report, where they recommend boreholes to identify water-bearing zones at depth in the bedrock, and subsequent hydraulic testing to see how these interact with neighboring wells.

impermeable." The only mapped major structural feature that could justify such an impermeable, no-flow boundary at depth is the Corvallis Fault (or a precursor thrust) which dips at an angle of about 20 degrees toward the WNW, from where it meets the ground surface along the railroad tracks just east of Adair County Park.[10] The projected depth of this feature under the cross-sections considered by the applicant is more than 2000 feet. Saline water at shallower depths may act to limit deeper circulation of fresh water, due to density differences, but this is not the same as a no-flow boundary. Recent hydrogeological modeling of the Oak Creek watershed suggests that the Corvallis Fault may play a role in bringing saline water to relatively shallow depths in this area[11]. This increases the risk of saline water moving upward from depth in response to drawdown of freshwater at shallower depths.

Taken together, these major discrepancies between reality and the assumptions of the applicant's model mean that the model is neither realistic nor credible, for the purpose of predicting impacts on neighboring wells.

Applicant's consultants assert, both in Exhibit 68 and earlier exhibits, that this model is "conservative." The term "conservative" in this context amounts to a claim that their model – despite not being realistic – will give an upper bound on the actual risk of impacts on neighboring wells. **This claim of conservativeness is just an assertion. It is not supported in the record by any technical arguments or justifications.**

One way to check if a model is conservative is to compare with predictions of an alternative model of the same system. **Figure 1** gives the results of calculations with a very simple model of the type of groundwater flow system that can be

10 Goldfinger, Chris, 1990. Evolution of the Corvallis fault and implications for the Oregon coast range, M.Sc. thesis, Geosciences Department, Oregon State University.

11 Ochoa, C.G.; Jarvis, W.T.; Hall, J. A hydrogeologic framework for understanding surface water and groundwater interactions in a watershed system in the Willamette Basin in western Oregon, USA. 2022, 12, 109. https://doi.org/10.3390/geosciences12030109 (Note this publication was included in full, in the public record for the Planning Commission hearing).

expected for domestic and farm wells on Tampico Ridge. The model follows an approach that has been applied in support of regulatory decisions by Swedish government agencies, for licensing of both high-level and low/intermediate-level radioactive waste disposal facilities. A paper prescribing the method and practical applications has undergone scientific peer review and was published in the official journal of the International Association of Hydrogeologists.[12] The assumptions of the model are stated below.

This model predicts that, on average, **wells or springs at a distance of 1000 ft (333 yards) will see a drop of over 50 ft**, and at a distance of 1350 ft (450 yards), a drop of over 20 ft. In 28% of the realizations, **drops of over 70 ft** are predicted.

The flow system considered by this model is a simple series (chain) of fractured zones, each of which behaves as a confined aquifer connecting between its ends. For the sake of simplicity, each fractured zone is assumed to be 5 feet thick (a typical thickness for water-bearing zones in local wells), and extends for 300 ft from end to end. The hydraulic conductivity of each zone is drawn from a lognormal distribution with median value of 2.7 ft/day (the geometric mean value cited by the applicant's Exhibit 68), with a standard deviation of 1.5 orders of magnitude (a typical range of variation for fractured bedrock).

12 Geier, Joel E., Georg A. Lindgren, and Chin-Fu Tsang, 2019. Simplified representative models for long-term flow and advective transport in fractured crystalline bedrock. *Hydrogeology Journal*, v. 27, n. 2, p. 595-614. https://doi.org/10.1007/s10040-018-1875-2.

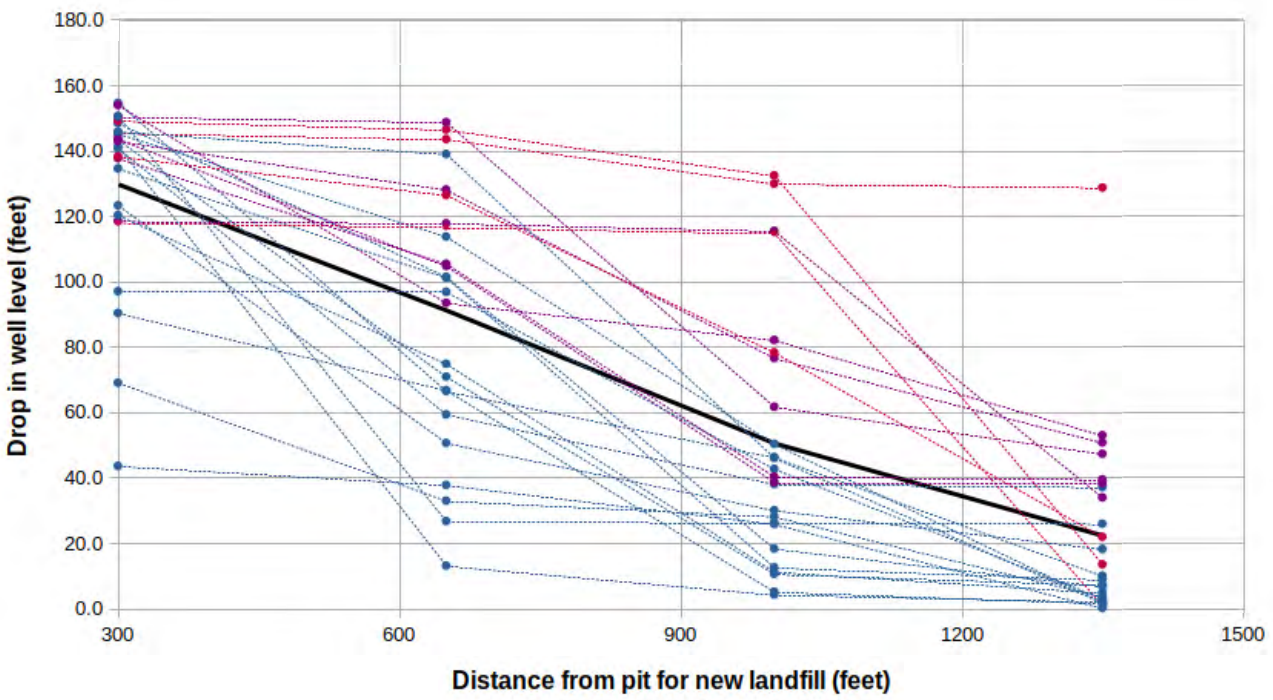


**Figure 1.** Impacts of landfill site excavation predicted for 25 plausible stochastic realizations of a simplified model for groundwater flow via fractured zones under Tampico Ridge, as described in the text. Red, purple and blue lines show results for individual realizations as a function of distance from the headwall of the open-pit excavation. The black line shows the average of all 25 realizations. A plausible realization is one for which capacity of the flow system is sufficient to support a well bearing at least 350 gallons/day under sustained pumping (a typical rate of use for a household).

This model assumes that groundwater wells rely on recharge from precipitation in the upper elevations of Tampico Ridge, and that water levels there remain within 15 feet of the ground surface. This is justified at least for current conditions, as Douglas-firs (which typically have root zones of 6 feet or less) grow vigorously up to the top of the ridge, so their root zones likely receive adequate moisture year-round[13].

13 Kathy J. Lewis, Ché Elkin, Heather Klassen, Sari Saunders, Hardy P. Griesbauer, 2025. Soil moisture is a main driver of growth response of coastal Douglas-fir with high spatial variability, Forest Ecology and Management, Volume 595, 2025, https://doi.org/10.1016/j.foreco.2025.122993.

If drainage of the landfill footprint during landfill excavation and operation results in seasonal depletion of water storage at these upper elevations, this would result in worse impacts on wells, and **could also impact the viability of private timber production on adjacent properties.**

Prior to excavation, the model assumes that the bedrock is covered by 30 ft of sediments which have hydraulic conductivity of 0.75 ft/day (as cited by the applicant). During excavation, it is assumed that these sediments and that excavation proceeds for 50 ft into the bedrock after encountering the first flowing zone.[14]

As with any model, the detailed assumptions of this particular model could be discussed. However, the main purpose here is just to demonstrate that the model presented by the applicant is not conservative for the purpose of application.

Even the applicant's non-conservative model predicts that the proposed development could produce drops in well levels of as much as 17 feet. They dismiss the significance of this impact, arguing:

> *the change in water levels associated with the proposed development would be similar to changes in water levels associated with seasonal precipitation patterns.*

Even this amount could be a significant impact on existing uses, if the impacts of excavation occur during the season when groundwater levels are seasonally low, and these effects are additive. Indeed, that seems likely given statements by VLI given in oral testimony on July 8, 2025, that construction would generally occur over 6 to 8 months in the warmer/drier part of the year.

14 This is reasonable considering that flowrates sufficient to sustain a domestic well could be just a gallon per minute or less, which is likely to be small in relation to water flowing in from the rim of the excavation in spring or early summer months. Access to the working face by qualified hydrogeologists is likely to be limited by the cycle of blasting and mucking operations, even if the applicant is willing to pay the cost of keeping consultants on site on a full-time basis.

The applicant's modeler asserts that a drop in groundwater levels is not a problem, due to "water column thicknesses ranging from 189 to 357 ft." [15] This remark indicates a lack of familiarity with how local groundwater conditions differ from the idealized assumptions of his model.

Wells in basalt around Tampico Ridge are typically installed with pumps just below the depth at which a sufficiently conductive zone is encountered. Even if the static water level at the time of drilling was shallower, presence of a water column above the screened depth during drilling does not represent water levels that can be sustained with regular household or farm use.

For example, the Frazier well (BENT 7799 in OWRD's database), completed at a depth of 299 ft, showed an initial static water depth of 42 ft, but this dropped by 238 ft during 2-1/2 hours of pumping at under 10 gallons per minute, leaving a water column height just 19 feet above the bottom of the well. The Anderson well (BENT 7864) which now serves both the Searles (Smile Farms) and Merrill properties, showed a 100 ft drop in 4 hours of pumping at 50 gpm, leaving the top of the water column at 118 ft depth. At that depth, it was below three of the four main water-bearing zones, which account for 68% of the well capacity.

**Saline well water at depth** is a well-known problem for rural Benton County residents, in Coast Range areas including the Soap Creek Valley. Just about everyone who lives in the Coast Range knows that, if you drill deeper, the water just gets saltier. This problem has not recognized by the applicant's consultants. If the water level drops by 20 or 40 feet, deepening the well may not be an option because of the risk of encountering saline water which would render the well unusable.

15 Applicant Exhibit 68, p. 3

## Why county staff's proposed conditions of approval are not sufficient

The new Staff Report recommends four new Conditions of Approval recommended by their third-party consultants, MFA, which are supposed to address the risk of impacts on neighboring wells and springs. These conditions are simply stated, without any explanation of why they should be expected to be effective to eliminate the risk of serious interference with adjacent properties.

Several of the conditions are stated in terms of numbers ("two years," "four borings", "ten feet" etc.) but there are no calculations or arguments based on geological reasoning in the record, which would explain how staff or their consultants arrived at those numbers. It seems that, since the applicant offered to drill four wells, staff decided that this was a good number to recommend.

Neither staff nor their consultants have provided any evidence of credentials for designing site investigations in fractured bedrock. From my nearly 30 years of experience in this environment[16], I can tell you this is not an easy thing to do.

16 For example:
Golder Associates Inc., 1987. Hydraulic fracturing stress measurements in the shaft probe hole at the Underground Research Laboratory, Manitoba: GAI report to the Battelle Memorial Institute, Office of Waste Technology Development, Willowbrook, Illinois, USA.
Doe, T.W. and Geier, J.E. 1991. Interpretation of fracture system geometry using well test data: Stripa Project Technical Report 91-03, Swedish Nuclear Fuel and Waste Management Company, Stockholm, Sweden.
Geier, J., 1998. Site-characterization data needs for hydrogeological evaluation, SKI Report 98:01, Swedish Nuclear Power Inspectorate, Stockholm.
Chapman, N., Bath, A., Geier, J., and Stephansson, O. 2015. The disposal site and underground construction: Part I: The disposal site and the natural barrier: Part II: Preserving the favourable properties of the bedrock during construction. Technical Report STUK-TR 17, Radiation and Nuclear Safety Authority, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-309-274-7.
Geier, J.E., 2015. *Programme de simulations UPS1 Hydraulic champ lointain* Phase 2010-2012. Critical analysis and summary of the modelling work of the present hydrogeological situation, past and future hydrogeological evolution Task 4: Synthesis and critical analysis: Final summary report. ANDRA report C.G.NT.FEAP16-0003, National Radioactive Waste Management Agency, Chatenay Malabry, France.
Meier, T., Backers, T., Eberhardt, E., Fisher, B., Geier, J., Kwon, J., Min, K-B., Blaheta, R., Hančilová, I., Hasal, M., Řiha, J., and Lanaro, F.,, 2021. Reliability, feasibility and significance of measurements of conductivity and transmissivity of the rock mass for the understanding of the evolution of a repository of radioactive waste. SSM Report 2021:14, Swedish Radiation Safety Authority, Stockholm, Sweden.

In the Staff Report and Supplementary Staff Report provided to the Planning Commission, county staff did not even attempt to review the applicants claims regarding groundwater impacts. Instead staff just endorsed assertions by the applicant, even while acknowledging a lack of technical expertise.

Our community was fortunate that several of the members of the Planning Commission, in particular Commissioner Lee, showed a practical understanding of how groundwater responds in fractured basalt such as we have in much of Benton County.

In the new Staff Report, county staff have attempted to address the previous gap, by including a brief letter signed by a hydrogeologist employed by Maul Foster Alongi (MFA). The letter is dated October 13, 2025 but references only materials submitted by the applicant up to September 12, 2025. It does not refer to Exhibit 68 which was delivered later, on October 5th, and not posted to the public record until October 10th. Thus there is no indication that MFA's hydrogeologist reviewed the actual model, but only the applicant's claims regarding the predictions of the model.

Less than one page of the MFA letter is dedicated to comments on the applicant's materials. These few paragraphs do not mention any independent calculations to check if the applicant's claims are reasonable, or reference to any other research that supports MFA's conclusions. There just statements of professional opinion based on a reading of the materials provided in the appeal filing.

Most of the remainder of the letter consists of recommendations for Conditions of Approval, which have been adopted almost verbatim in the Staff Report.

**Condition P1-1** combines three of MFA's suggested conditions into one very complicated condition that runs for nearly two pages in the Staff Report.

This recommends *"at least four borings to an elevation below the bottom of the neighboring water supply wells"* but says nothing about where these borings should be located, or how the number 4 was chosen. Normally such a specification should be justified by structural geological information, but none is referenced.

**Lateral extent of water-bearing zones in this geological environment cannot be determined just from a handful of random boreholes.** Normally as a first step this requires structural geological investigations to characterize the structural fabric, plus geophysical investigations to identify potential water-bearing zones which are then confirmed by drilling. But the proposed condition doesn't call for either structural geological or geophysical investigations.

The same complicated condition calls for "identification of which water-bearing zone(s) supply water to neighboring property owners." This implies that the applicant should carry out large-scale pumping tests, also known as interference tests, to check for interference with neighboring wells.

As the name suggests, **a hydraulic interference test in itself would interfere with uses on neighboring properties.** The neighboring wells would need to be instrumented and shut down for the duration of the interference test.

Why should neighboring property owners consent to this interference with the use of their wells? What statute gives Benton County any legal authority to mandate such a gross infringement on private property rights, just to help this Fortune 500 company develop their property for their own profit motivations?

The condition asks the applicant to estimate the transmissivity and hydraulic conductivity of any water-bearing zones, but does not take into account the likelihood that these properties will vary within each zone (so values measured in a single well will not necessarily be representative).

The condition also does not consider that groundwater flow in fractured bedrock may involve multiple fractured zones, in which overall flow may be controlled by a few "key bridges" that connect between different water-bearing features.[17]

Part (A)(ii) of Condition P1-1 simply restates what the applicant has already offered to do by monitoring four "sentry" wells, but adding a statement that these should be "screened within the same water-bearing zones as the water supply wells on neighboring properties." As discussed above, **it will be very difficult to establish that these are located within the same water-bearing zones, and this disregards the likelihood of flow being controlled by network connections.**

Part (B) of this condition pertains to a mostly unrelated issue, namely the possibility that arsenic will leach out of the landfill and migrate with groundwater. Currently this problem is indicated to be in the area east of the landfill. **Sampling residential wells south of the landfill for arsenic has no bearing on main issue that has been identified.** This is at best an empty public-relations gesture that deflects attention away from the real areas of concern.

Again, there is no reason why landowners should be expected to consent for this company to be sampling their wells, nor any reason why we should have confidence that this will be done objectively. **Benton County would do better to initiate its own independent sampling program, using revenues from the existing landfill, and engage directly with concerned residents on this topic.**

17 Sharma, K.M., Tsang, C-F., Geier, J., Pensado, O., Stothoff, S., and Niemi, A., 2025. Characteristics of flow and transport in low-permeability fractured rock based on a channel network model. *Advances in Water Resources*, vol. 202, 105016, ISSN 0309-1708, https://doi.org/10.1016/j.advwatres.2025.105016.

***In summary, this Condition P1-1, while imposing new and undue burdens on neighboring property owners and residents, gives no assurance of protecting wells on adjacent properties from permanent impacts.***

**Condition P2-4** incorporates the fourth of MFA's suggested conditions into the applicant's previous proposal to install and monitor a few "sentry wells." Like Condition P1-1, this proposed condition reflects a poor understanding of what is practical for site investigations in fractured rock. It is likely unworkable if the goal is truly to protect neighboring wells.

The condition, as written, also gives the applicant several "escape clauses" where they can simply apply their own subjective judgment:

- *"dramatic change,"*
- *"not associated with local climactic[18] conditions,"*
- *"mutually agreeable solutions,"*
- *"not including shallow perched groundwater water,"*
- *"prepare an analysis of sources and remedies,"*
- *"document their conclusion that groundwater was not encountered," etc.*

The condition also gives no clue as to who will check for compliance. Does Benton County plan to retain a professional hydrogeologist who is competent to make an independent assessment on all of these "judgment calls," for the duration?

This condition again relies upon neighboring property owners to grant access to the company to monitor their wells. Again, what authority does the County have to impose this condition on existing residential and farm uses? If residents don't wish to give permission, will we lose our legal rights for remedy?

18 s.i.c. but I suppose they mean "climatic" rather than "climactic" conditions, which would be an entirely different thing unrelated to groundwater.

In summary, County staff's proposed conditions of approval regarding groundwater are both unworkable and insufficient to mitigate the risk of significant impacts on adjacent uses. **By framing these conditions staff acknowledge the real risk of significant impacts, but their proposed conditions are not sufficient to prevent significant impacts.**