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Cascade Hydrogeo Study: Questions and Clarification

Hydrogeo studies are complex and involve many inputs and assumptions. Accurate results depend on solid data, analysis and reporting. As Mark Twain noted, "Facts are stubborn, but statistics are more pliable."

We noticed a number of anomalies and missing information in the hydrogeo report presented by Mr. Zieff's team, which require answers and clarification:

1. **Missing drilling log:** The report notes in section 4.3 that "A 2003 well drillers log, completed by TJ Ogden, Inc. when an irrigation well was installed at the garden center, in the area of OSE-TP-14, reports that silt was encountered to a depth of about 20 ft. bgs, and was underlain by bedrock at 20 ft. bgs, see Appendix B." All of the logs in Appendix B are from Crawford Drilling Services. We could not find this log from TJ Ogden, which must be provided to ensure a complete and accurate record.

2. **Which GeoProbe unit:** Crawford Drilling Services used a GeoProbe "direct push" unit to place wells and assess soils at the site, which hammers a tube into the ground. (Not a drill.) Which GeoProbe unit was used? They come in a range of sizes and capabilities. For example see: https://geoprobe.com/direct-push-series-drilling-machines

3. **No bedrock found:** The report notes that "no bedrock" was encountered anywhere on the site. This is important because bedrock would affect the flow of septic effluent from the large septic leach. This statement also seems to contradict the missing TJ Ogden drilling log, which indicates that bedrock was encountered at 20 ft. How did Crawford Drilling Services determine that they did not hit bedrock at any location on this site?

4. **Silt layer never penetrated:** The report also notes, "The thickness of the silt layer was not penetrated by the GeoProbe at any of the borings." How did Crawford Drilling Services determine this?

5. **Unusual refusal depths:** "Refusal" is the point where the GeoProbe pipe stops – the unit cannot hammer the pipe into the ground any further. GeoProbe's website states that their 'direct push' systems are, "…typically used for site investigations to depths of 30 to 60 feet (9 to 18 m)… " At a test site in Tennessee, "…the 8040DT pushed 4.5 in. tooling through hard clays and dense sands to approximately 42 ft., with no cuttings." In contrast, most of the boreholes at this site hit refusal at 12' to 14.5'. B-2 hit refusal after 14.5' of "silty sand with gravel". How did Crawford Drilling Services determine why refusal was repeatedly encountered at such shallow depths?

6. **Soil analysis problems:** There are a number of issues with the test reports and data in Appendix C which would affect the hydrogeo model, including missing tests, different test protocols, tests based on an ASTM standard that was retired in 2015 due to accuracy problems, and inconsistent testing that did not follow the protocols.

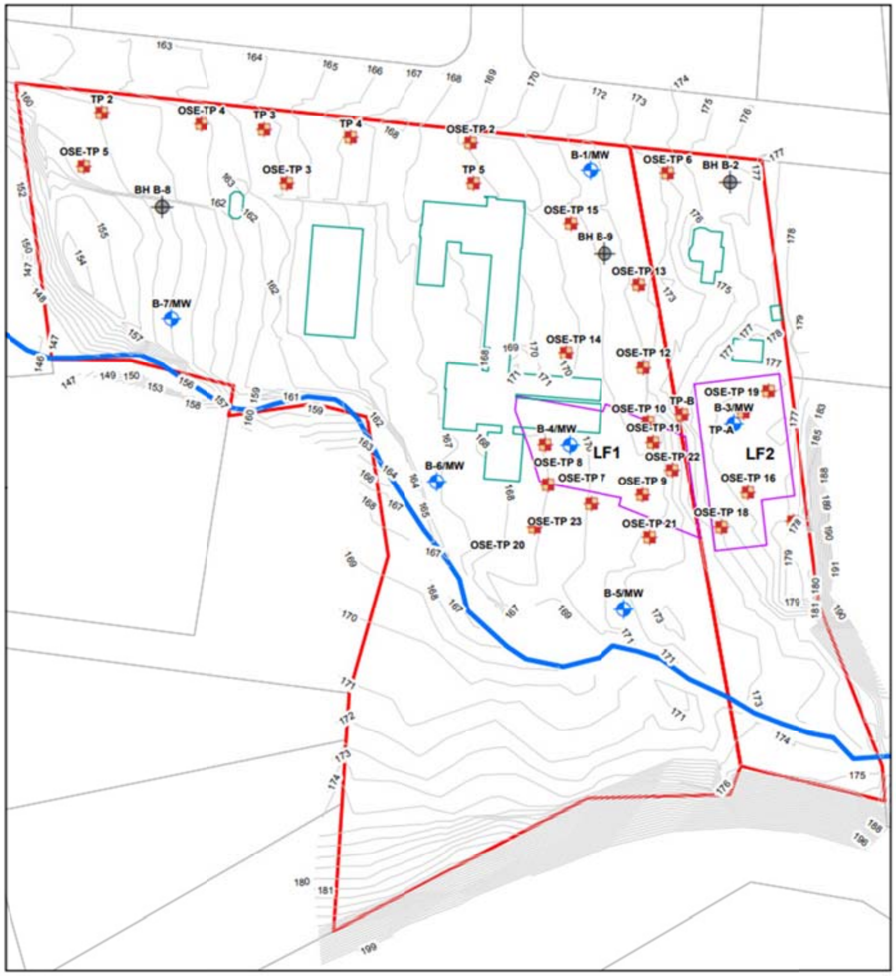
   Here is a summary of the tests and data in Appendix C:

Well	Samples	Soil Analysis?	Permeability Analysis?		Test Sample (inches)		
		ASTM D422	Test Standard Used	Test Equipment Used	Diameter	Height	Volume
B-1	**S-1 / S-2**	Yes	ASTM D2434	Unknown	4.00	1.10	13.80
B-2	**S-3**	No	No				
B-2	**S-4**	No	No				
B-2	**S-5**	No	No				
B-3	**S-6**	No	ASTM D2434	Unknown	4.00	3.00	37.70
B-3	**S-7**	Yes	No				
B-3	**S-8**	No	No				
B-5	**S-9**	No	ASTM D2434	Unknown	4.00	1.00	12.60
B-5	**S-10**	No	ASTM D5084	Flexible Wall Permeameter	2.96	2.55	17.50
B-5	**S-11**	Yes	No				
B-4	**S-12**	No	ASTM D2434	Unknown	4.00	1.20	15.10
B-4	**S-13**	No	ASTM D5084	Flexible Wall Permeameter	2.81	2.10	13.00
B-6	**S-14**	No	No				
B-7	**S-15**	Yes	No				
B-8	**S-16**	No	ASTM D2434	Unknown	4.00	2.80	35.20
B-8	**S-17**	Yes	No				
B-9	**S-18**	No	No				
B-9	**S-19**	No	ASTM D2434	Unknown	4.00	1.50	18.80
B-3	**S-20**	Yes	ASTM D2434	Unknown	4.00	3.70	46.50

The following anomalies are not explained and should be corrected:

- Six samples were not analyzed at all.
- Three samples were subjected to ASTM D422 soil analysis but not permeability analysis.
- Seven samples were subjected to permeability analysis but not ASTM D422 soil analysis.
- The report notes that the ASTM D2434 standard was withdrawn, but not that ASTM D422 was also withdrawn. (The report should also note that D2434 was withdrawn in 2015 due to accuracy issues, but D422 was withdrawn simply because it was not updated within ASTM's guidelines.)
- Two samples were tested for permeability using the current ASTM D5084 standard, and the type of test equipment was identified. Seven samples were tested for permeability using the ASTM D2434 standard, and the type of test equipment is not identified. No rationale is offered for the use of two different permeability test standards with two different types of test equipment, nor why most samples were tested using an ASTM standard that was withdrawn three years ago due to problems with accuracy. Note: Please see the study done for the Florida Department of Transportation highlighting D2434 accuracy issues, in Reference E on page 9.
- The volume of samples for S-10 and S-13 within the ASTM D5084 test equipment varies by more than 5%, the maximum limit in Section 8.1 to ensure accuracy. Height varies by 21% with a 35% variation in volume.
- The volume and height of samples within the ASTM D2434 test equipment also vary significantly, which does not meet the requirements of Section 6.5; all samples must start with the same height and volume. Wide variations in sample heights and volumes in these tests, from 1.0 to 3.7 inches, would affect test accuracy.
- Five of the samples tested under the ASTM D2434 standard were not previously tested for particle size and the maximum particle size is not reported, which is required in section 5.2.
- The report notes that material larger than 3/8" was screened out prior to testing under ASTM D2434, but the percentage that was removed is not noted in the report, as required in section 5.2

7. Elevation data: Elevation contours across the site were surveyed by Beals & Thomas, including Pine Brook. These elevations were included in the hydrogeo report on page 19 of 92:



The groundwater model created by J. Matthew Davis & Associates (Appendix D) used FEMA's 2010 LiDAR data instead, which is less precise and less accurate. Why wasn't the more precise and accurate survey data used? Accurate elevations are essential to determine the risk of wastewater breakout.

8. **Septic mound / ground water level:** A cross section graph is included at the top of page 5 in Appendix D, as shown below. The line that runs horizontally is not labeled. Is this the level of the septic mound and ground water, which is very close to the surface in the middle of the graph? Assuming this line represents the water table, sensitivity analyses (see comment 22 below) may demonstrate that breakout of wastewater would occur across the surface in these areas and next to Pine Brook - which would carry hazardous biocontamination downstream.

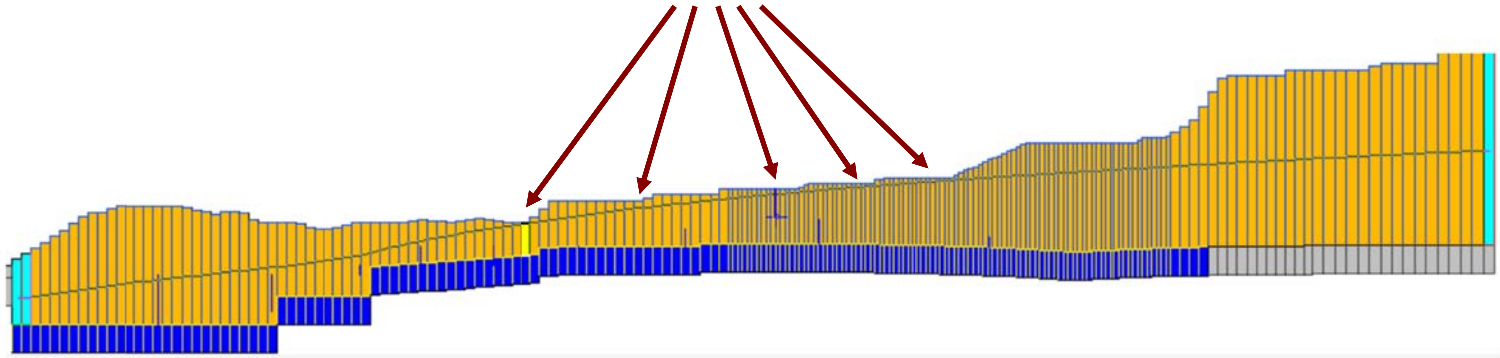
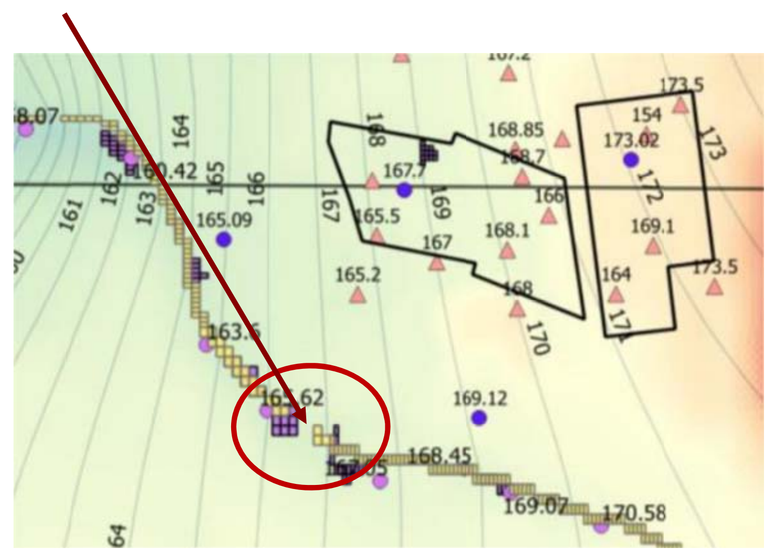


Figure 4. East-west cross section through MW4. Orange cells are Layer 1; dark blue = Layer 2; cyan = GHB; yellow = DRN; gray = No flow. Line of cross section shown in Figure 5.

9. **Gap in Pine Brook drain:** There is a gap in the Pine Brook 'drain' which appears in all of the model maps as shown below – next to two break-out areas. Why was a gap included in this key feature? Every indication is that the Brook is continuous and should be modeled as such.



10. **Elevation of Pine Brook:** A series of elevations along Pine Brook and the stream bed were surveyed by Beals & Thomas. On page 3 of Appendix D, the study notes, "In order to match heads with the April 2018 groundwater elevation at MW-6, it was necessary to raise the heads in the DRN cells (which model Pine Brook) by 0.5 feet to simulate surface water elevations that would correspond during periods of ESHGW." This is obviously a key part of the model; Pine Book functions as a drain and is the lowest point in the vicinity. What are the final stream elevations in the modeled DRN cells corresponding to WS#1 through WS#13 on the survey maps?

11. **Width and depth of Pine Brook:** The "drain" (DRN) function was used to simulate Pine Brook in the model. Were the following Conductance variables used? If so, how were they set? Conductance is described as having units of L2/T and is equal to KLW/M where

    K = the hydraulic conductivity of the sediment in the boundary condition such as a river or drain,

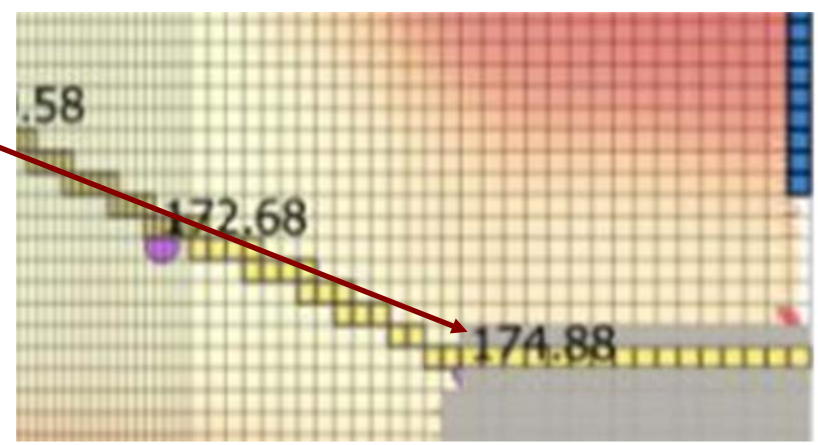
    L = the length of the boundary condition in the cell,

    W = the width of the boundary condition, and

    M = the thickness of the sediment in the boundary condition perpendicular to flow between the boundary and the cell. Usually this will be vertical thickness of the sediment.

    If Conductance variables were not used, please clarify which variables were used to define the Pine Brook drain, and how they were set.

12. **No-flow boundary along Pine Brook**: A band of no-flow cells were created above the eastern end of Pine Brook, which blocks the 'drain' function in this area. What is the purpose of this no-flow boundary?



13. **Varying cell size?** The size and proportion of cells appear to vary across the model; one example is shown in the close-up below. This can be significant; when the grid size changes, the head in the cell will be averaged over a different area than before. Why do cell sizes and proportions vary significantly on arbitrary boundaries? While it is possible to apply varying cell sizes in a hydrologic model, no rationale is provided in this case.

14. **Single layer model:** The entire site was modeled with almost all of the flows in one layer even though there are multiple sources, e.g. the large septic systems and ground water. Why was the model based on a single flow layer?

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15. **Which version of ModPath?** Which version of ModPath was used in the study?

16. **Which version of Modflow?** Which version of ModFlow was used in the study?

17. **ModFlow packages used?** ModFlow includes many 'package' options, e.g. to simulate stream flow (Pine Brook), lakes, wells, etc. Which packages did J. Matthew Davis & Associates use? The report does not note, for example, that the "RIV" package was added to simulate stream flow – even though Pine Brook runs through the property.

18. **Outdated version of Groundwater Vistas**: Groundwater Vistas is an important part of this study and is used to drive the ModFlow model. The current version (V7) was released in September of 2017. V6 was released in April, 2011. Why was outdated Version 5.51, released in 2009, used in this study?

19. **Model settings?** Computer driven simulations / models like these are completely dependent on setup and configuration values. You can radically alter the output of the ModFlow model based on these settings. Please provide original digital copies of all of the setting files used in this model.

20. **Ghost Nodes?** Did J. Matthew Davis & Associates use any Ghost Nodes in this model?

21. **Math problem?** Mr. Zieff explained that the hydrogeo study was not available before the June hearing due to a "math problem". Please describe this problem and how it affected the hydrogeo report and/or model results.

22. **Sensitivity analyses missing:** Given the numerous assumptions that need to made in any modeling effort and the questions outlined above, sensitivity analyses should be provided to more clearly identify the range of possible outcomes. Sensitivity analysis is common (and integral) to hydrologic modeling, and recommended by USGS. It involves multiple runs of the model by varying each input variable independently and in combination to test the model's sensitivity to the various inputs and assumptions. Generally, a worst-case (conservative) analysis is provided to predict possible outcomes. Sensitivity analysis is not provided in this report.

References:

a. **Hydrogeologic Report: Groundwater Mounding Analysis for Proposed Subsurface Disposal System**
Geosphere Environmental Management Inc., Project No. 17205, June 26, 2018
(Copy previously submitted by Mr. Zieff to the Wayland ZBA)

b. **ASTM D2434 – 68** (Withdrawn 2015)
Standard Test Method for Permeability of Granular Soils (Constant Head)
(Copy attached)

c. **ASTM D5084 – 03**
Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
(Copy attached)

d. **Guidelines for Evaluating Ground-Water Flow Models**
USGS, Thomas E. Reilly and Arlen W. Harbaugh, 2004
(Copy attached)

e. **Examining the Variability of Granular Soil Permeability Testing Methodology across FDOT Districts**
University of Florida, under contract with the Florida Department of Transportation, 2003
See: www.fdot.gov/research/completed_proj/summary_rd/fdot_bb897_rpt.pdf