In-Situ Flooding Experiments to Elucidate Mass Transport Mechanisms of Uranium in Groundwater: A Case Study of Riverton, Wyoming

GSA 2021 North-Central/South-Central Joint Online Section Meeting

Rakiba Sultana

Department of Geosciences

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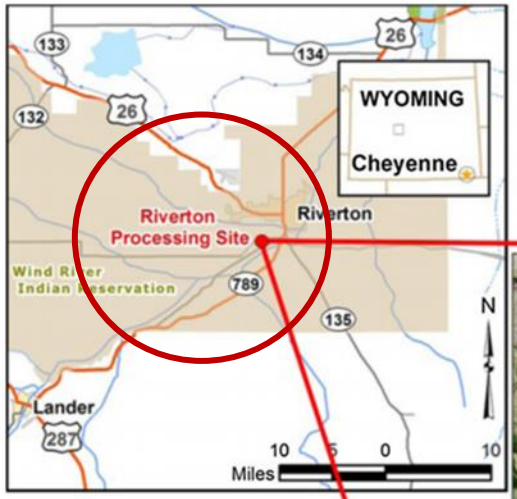
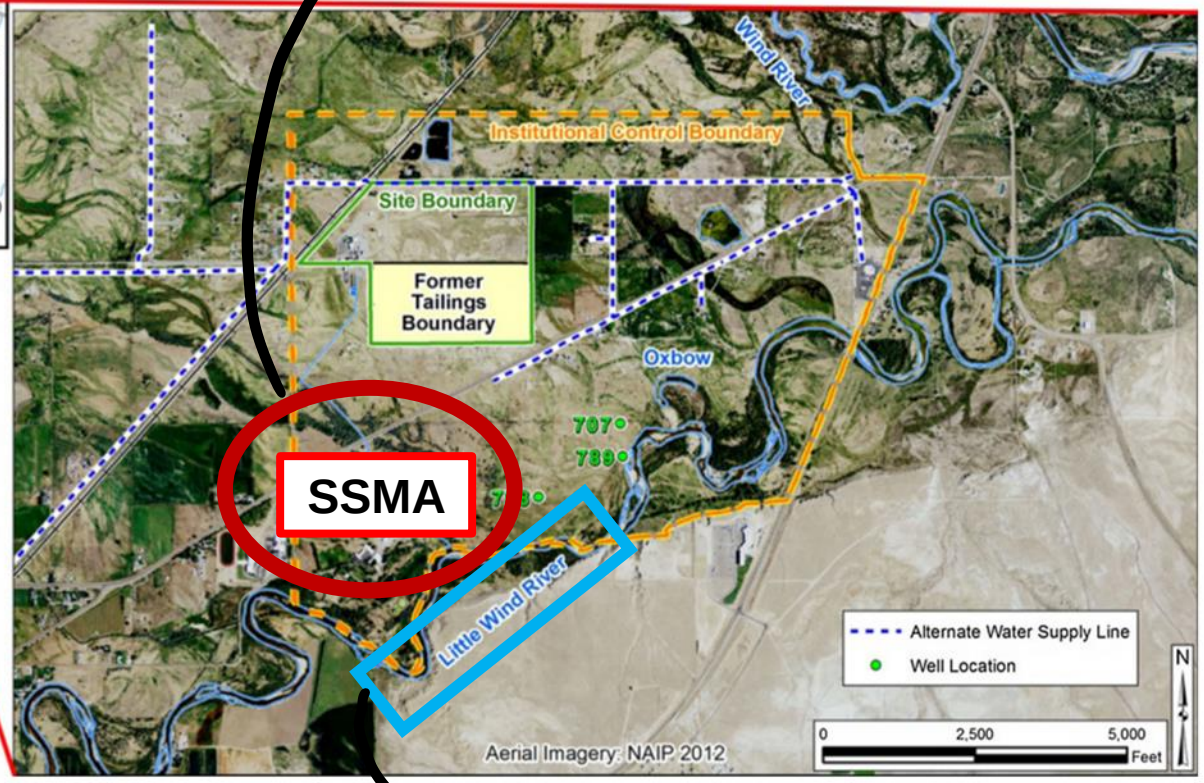
The Field Site:



Saint Steven's Mission Area



Little Wind River

Riverton, Wyoming, USA is a uranium contaminated site where the observed *concentrations of uranium* in the aquifer is substantially *higher* than the regulatory standards. It is hypothesized that flooding events are concomitant with high levels of uranium. (slide 2)

Dam et al., 2015

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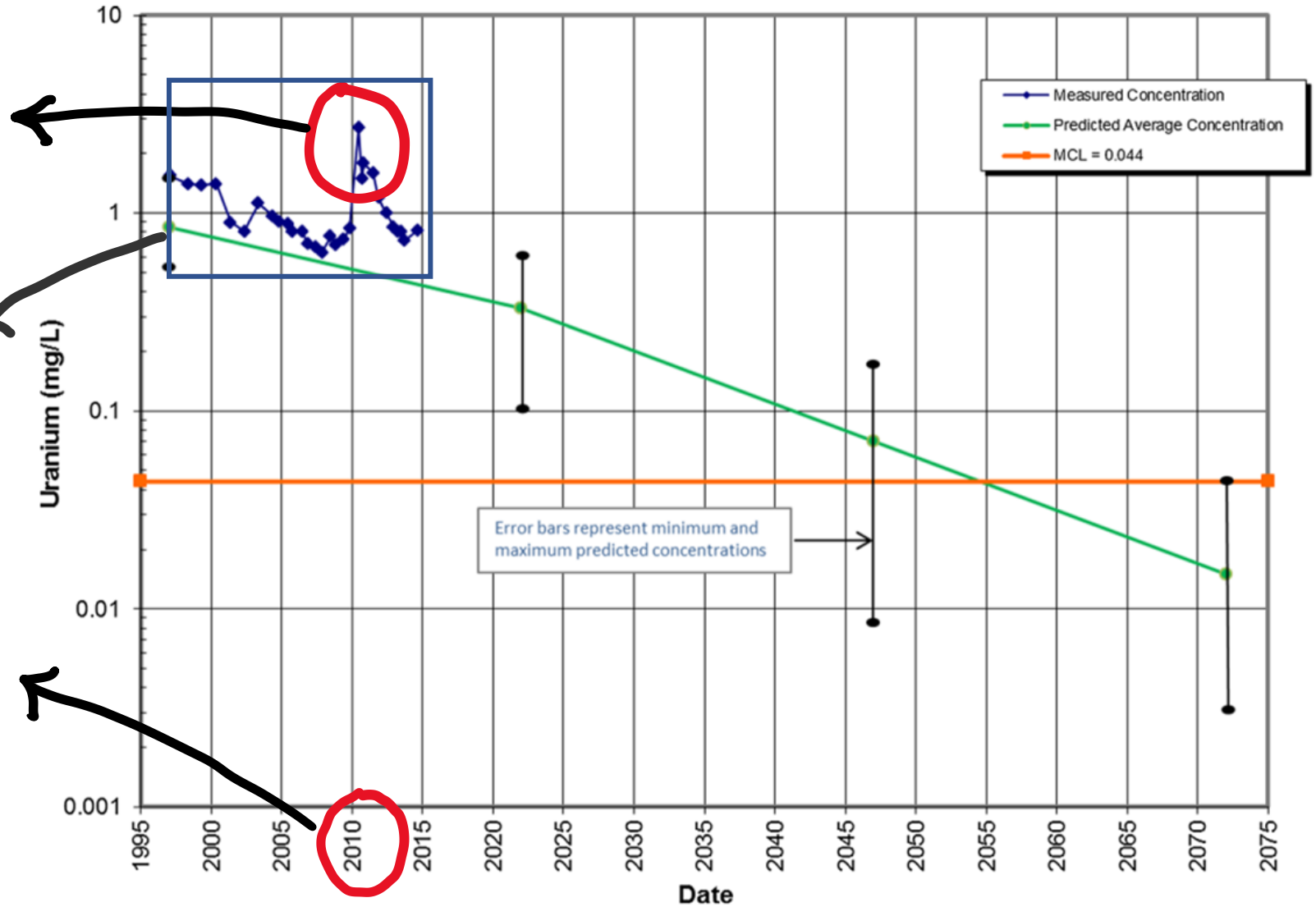
Uranium vs Time:

Spike in Uranium concentration

Model Prediction and Field Data analysis don't match!

Flooding event in 2010



Dam et al., 2015

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Answers we are trying to find!

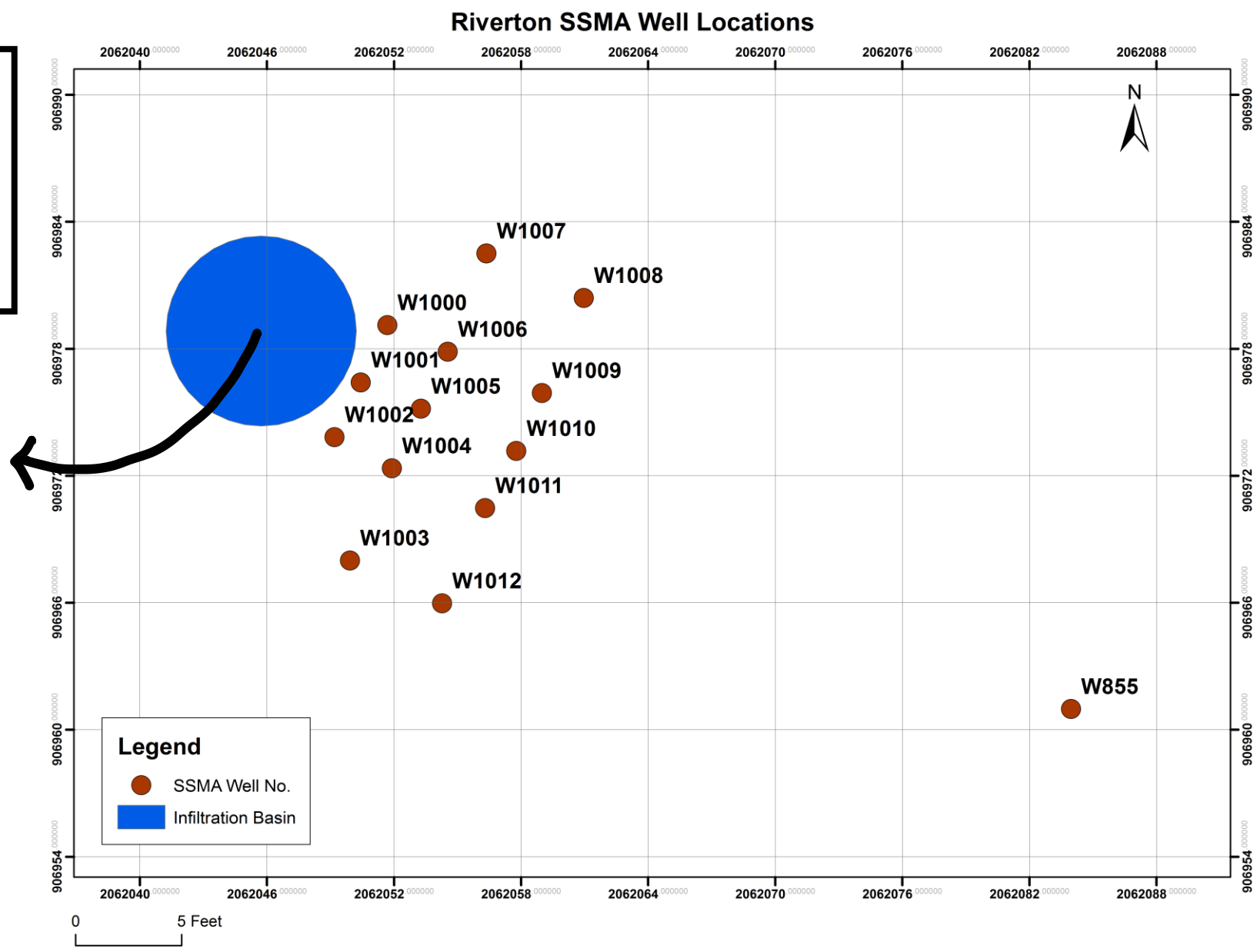
1. Why does uranium spike during flooding event? What are the connections between these two phenomenon?
2. Why don’t the model prediction and field data match?

Steps taken

1. A flood was simulated at a small-scale experimental site in **Summer 2020** field.
2. The events have been conducted via **surface infiltration** of **river water traced** with **Bromide and Difluoro benzene** in the **vadose zone of the SSMA**.
3. 2000 gallons infiltrated over 8 days. Test ran for 21 days after the end of the infiltration.
4. A huge chunk of tracer data from these 21 days has been collected and currently being analyzed to get the answers.
5. For this presentation six-day data with high concentration will be shown.

SSMA Field Site: Well Locations and Infiltration Basin

Infiltration pond that was used to conduct the surface infiltration in the vadose zone of SSMA.



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Why are we studying Halide and Benzoate behavior?

1. When we study the behavior of halides and benzoates, we will have an understanding for how a non-reactive solute behaves.
2. Then we will get an idea on the behavior of uranium that deviates from halides and benzoates.
3. Eventually the above understanding may be attributed to one or more uranium-specific mass transport processes.

Before Getting into Analysis, some Definitions

Advection: The process of bulk movement of solutes carried by groundwater.

Dispersion: Spreading of discrete volume of contaminants and becoming more dilute as it flows through the subsurface.

Matrix diffusion: migration of dissolved fluids from flowing pores to stagnant pores.

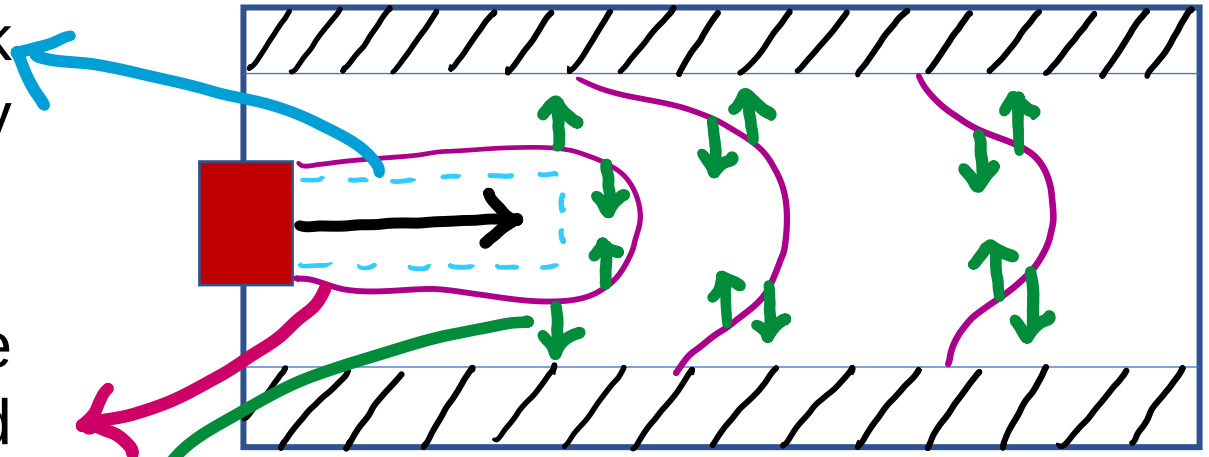


Figure 1: Advection, Dispersion and Matrix Diffusion

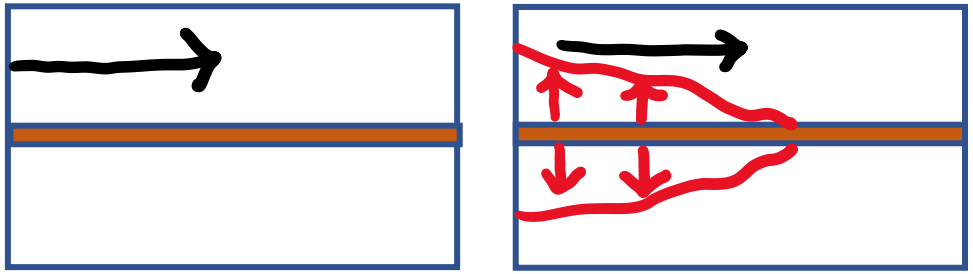


Figure 2: Matrix Diffusion

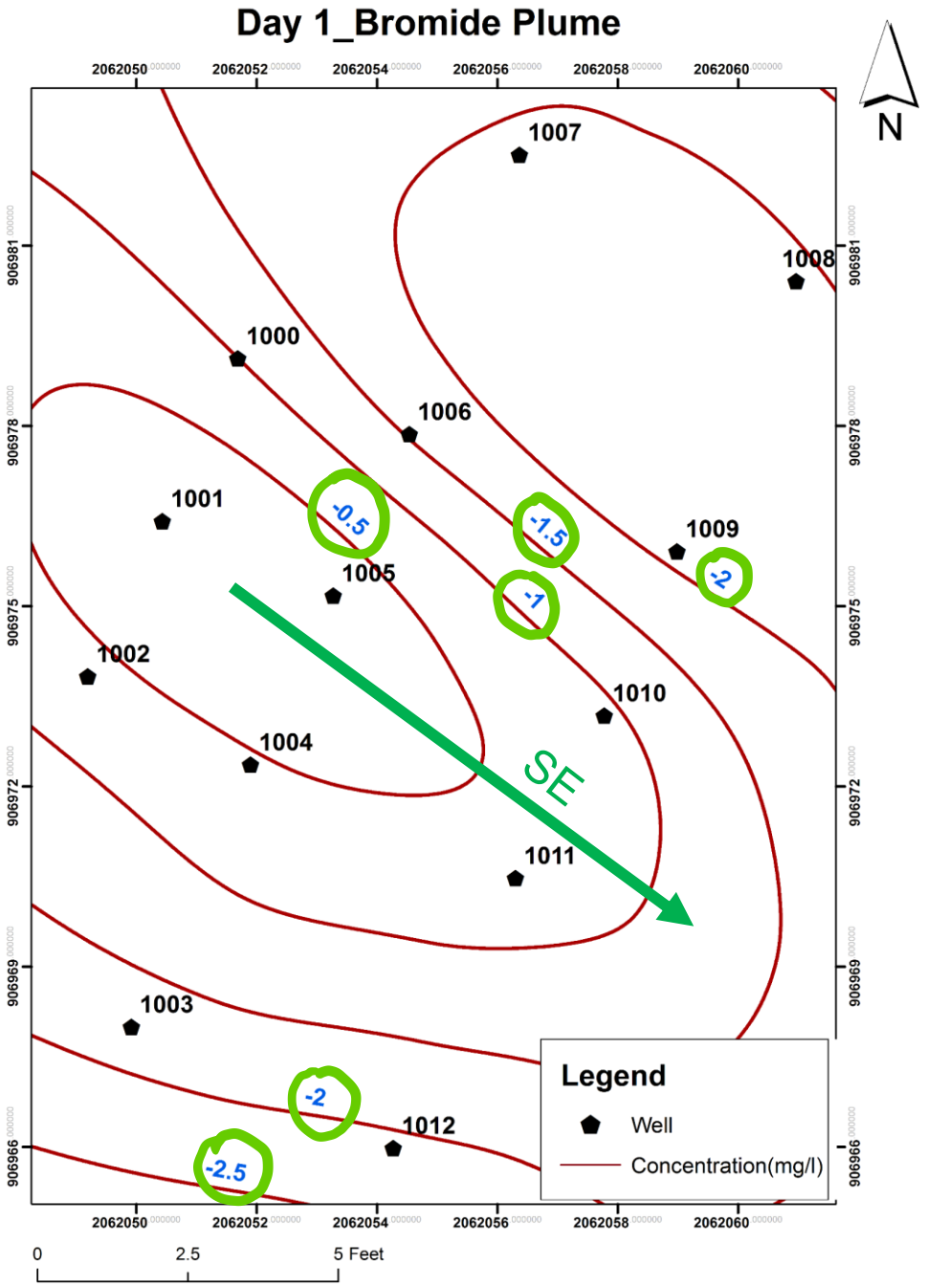
Objectives

1. Correlate *tracer (Br and DFB) plume* and ***'center of mass' of tracer plume*** to assess tracer ***Advection (v) and Dispersion (α) .***

2. Compare *Advection (v) and Dispersion (α)* of **halide (Br) and benzoate (DFB)** to assess if Matrix Diffusion is a dominant mechanism or not.

3. Interpret vadose zone properties and possible mass transport mechanism of Uranium.

Advection and Dispersion of Br



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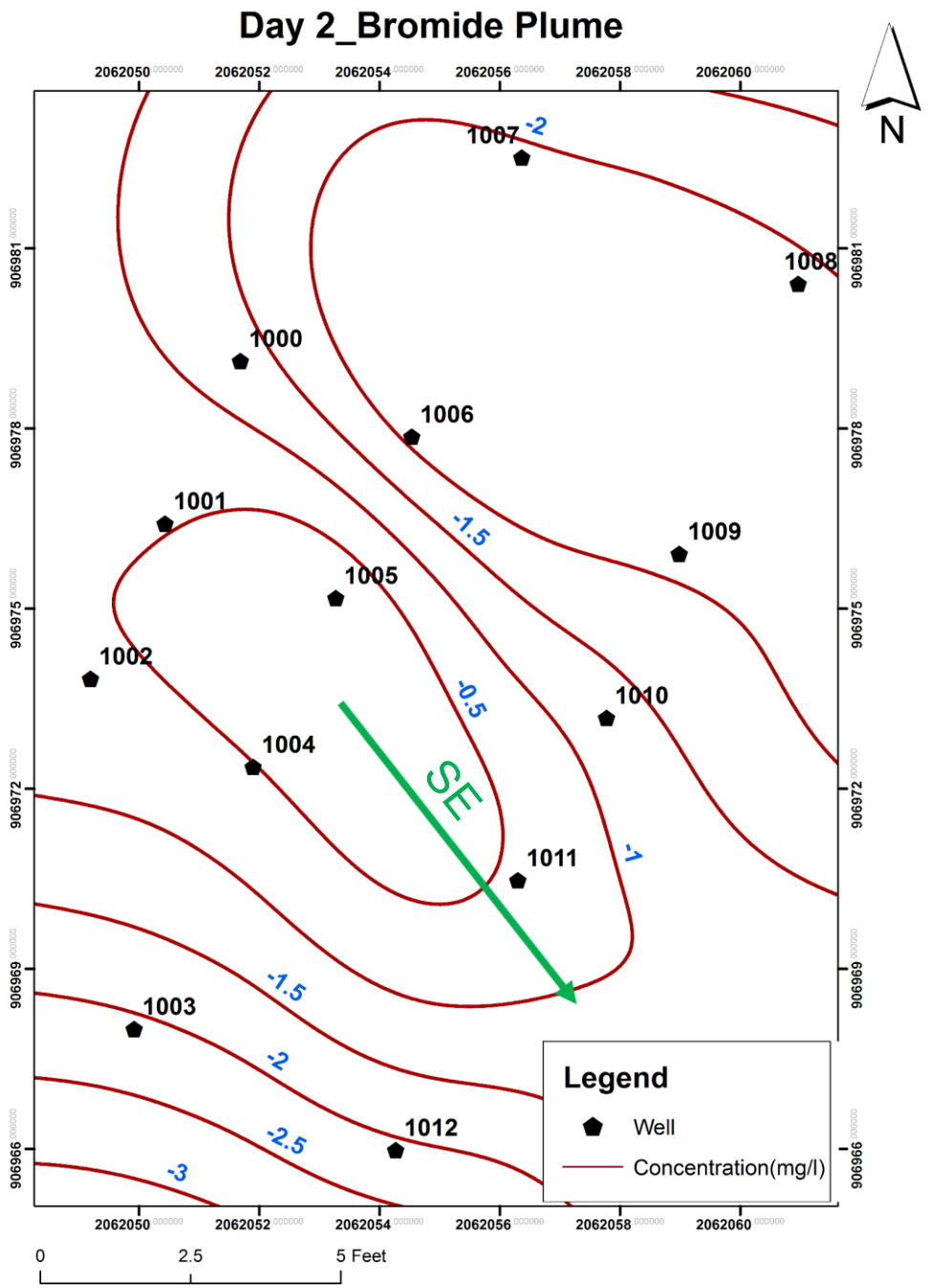

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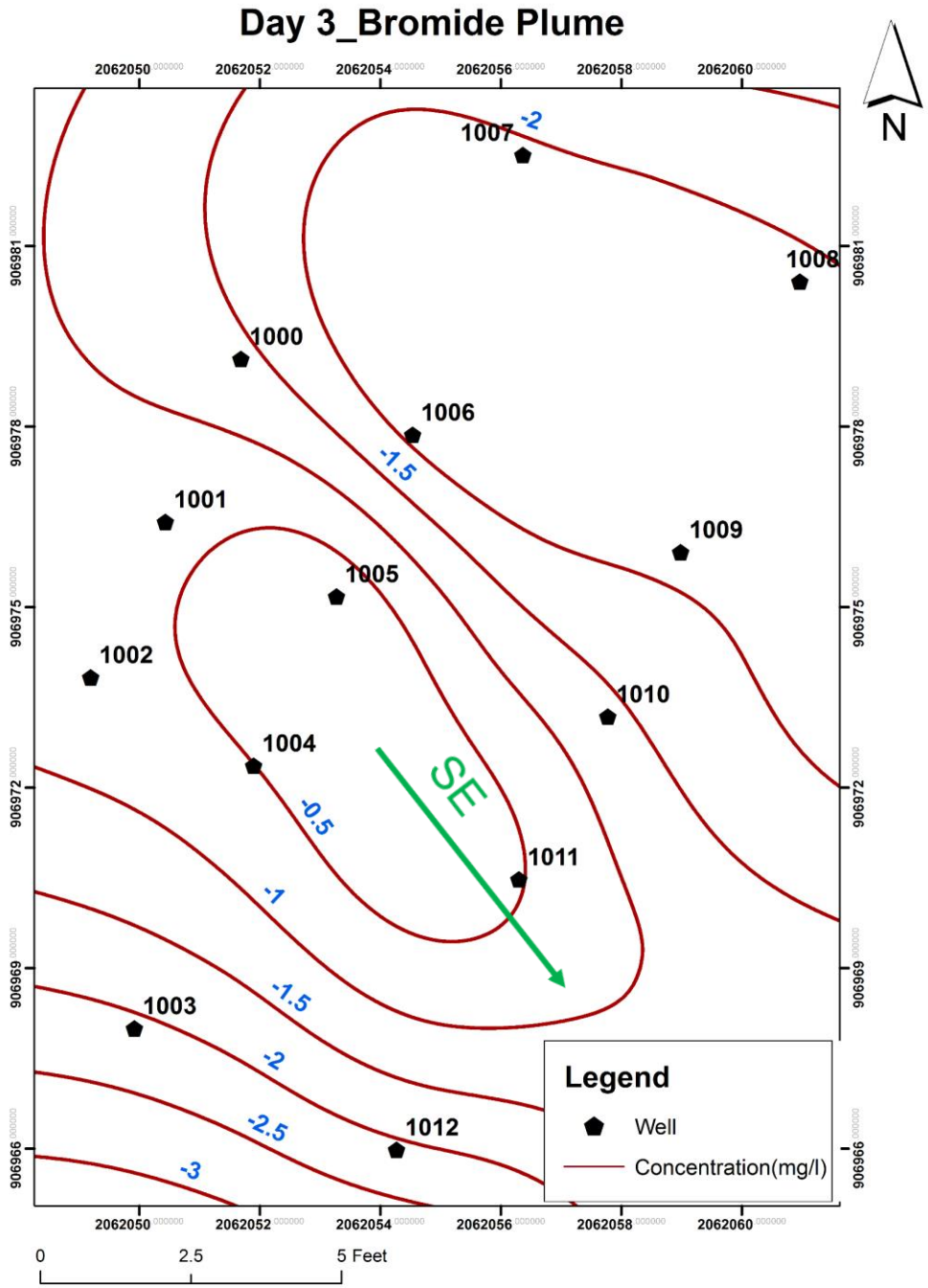

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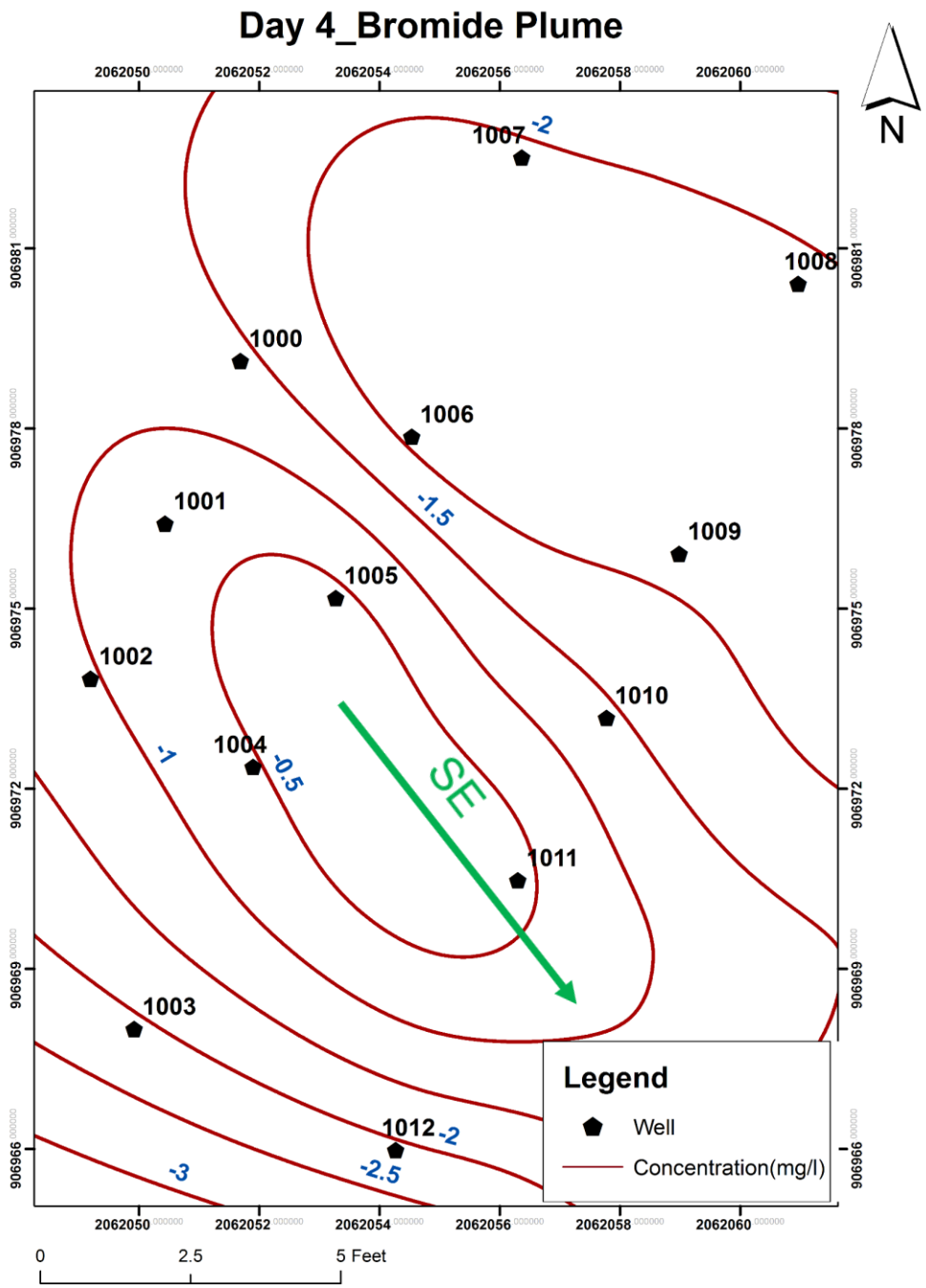

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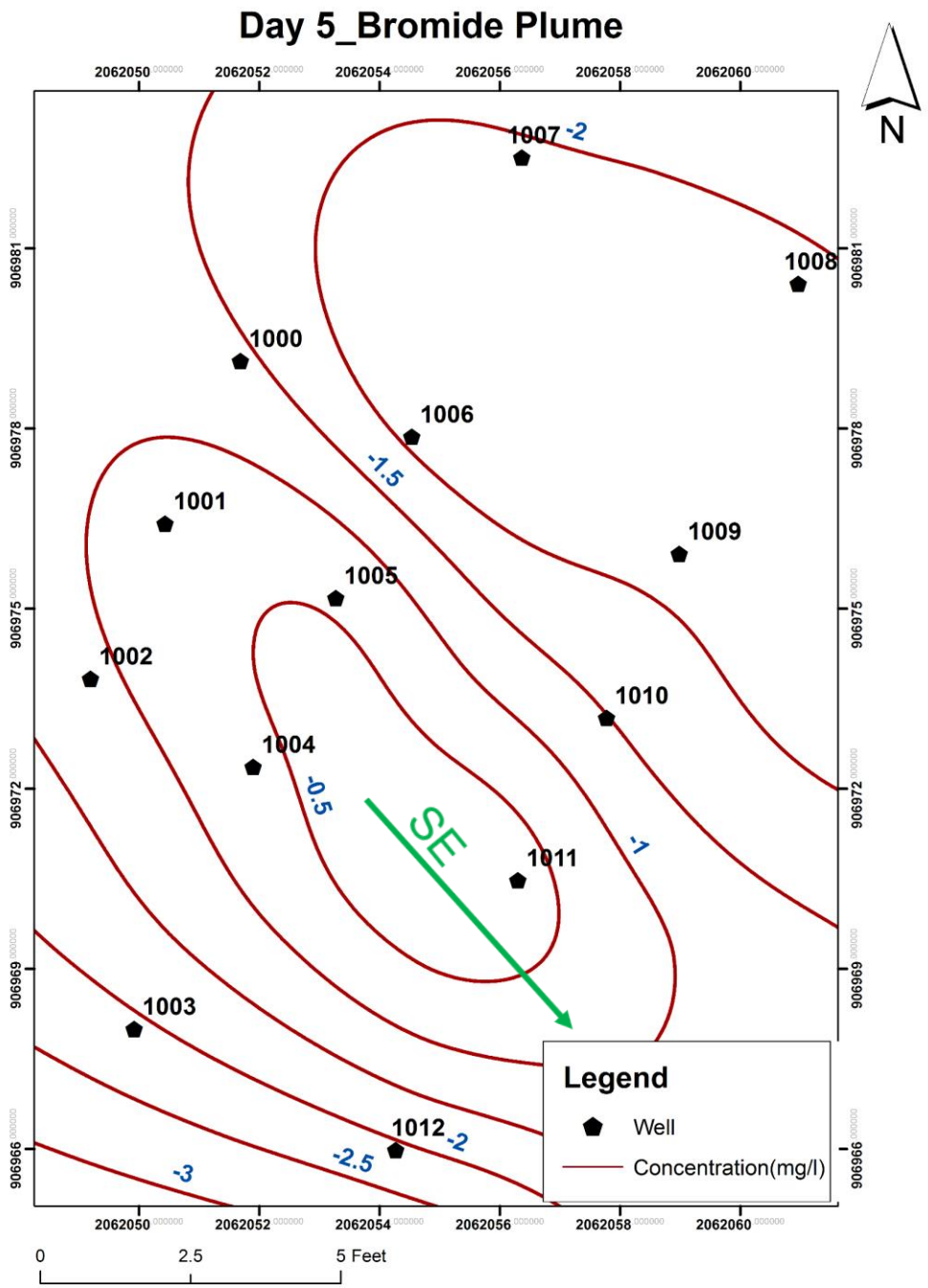

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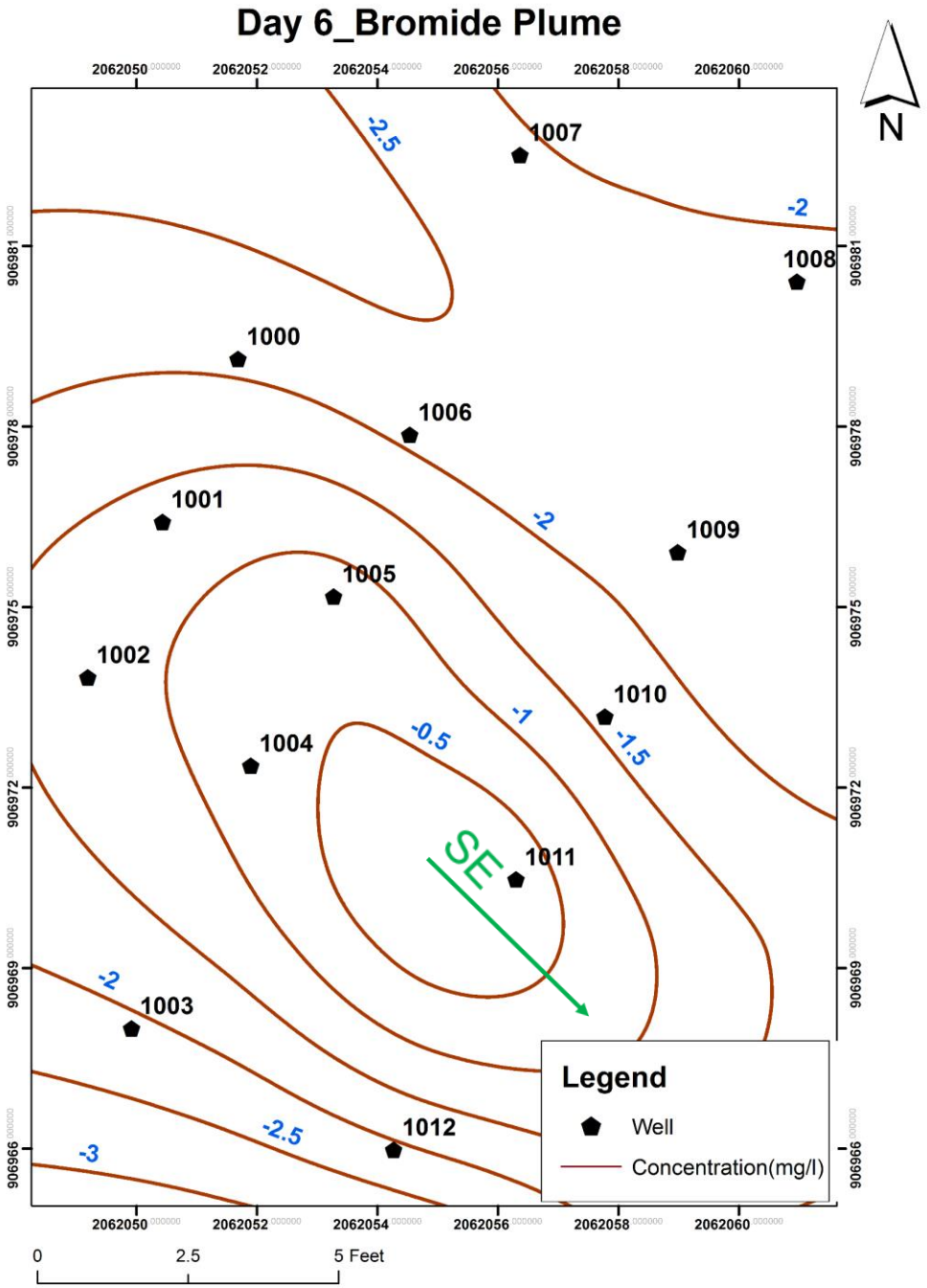

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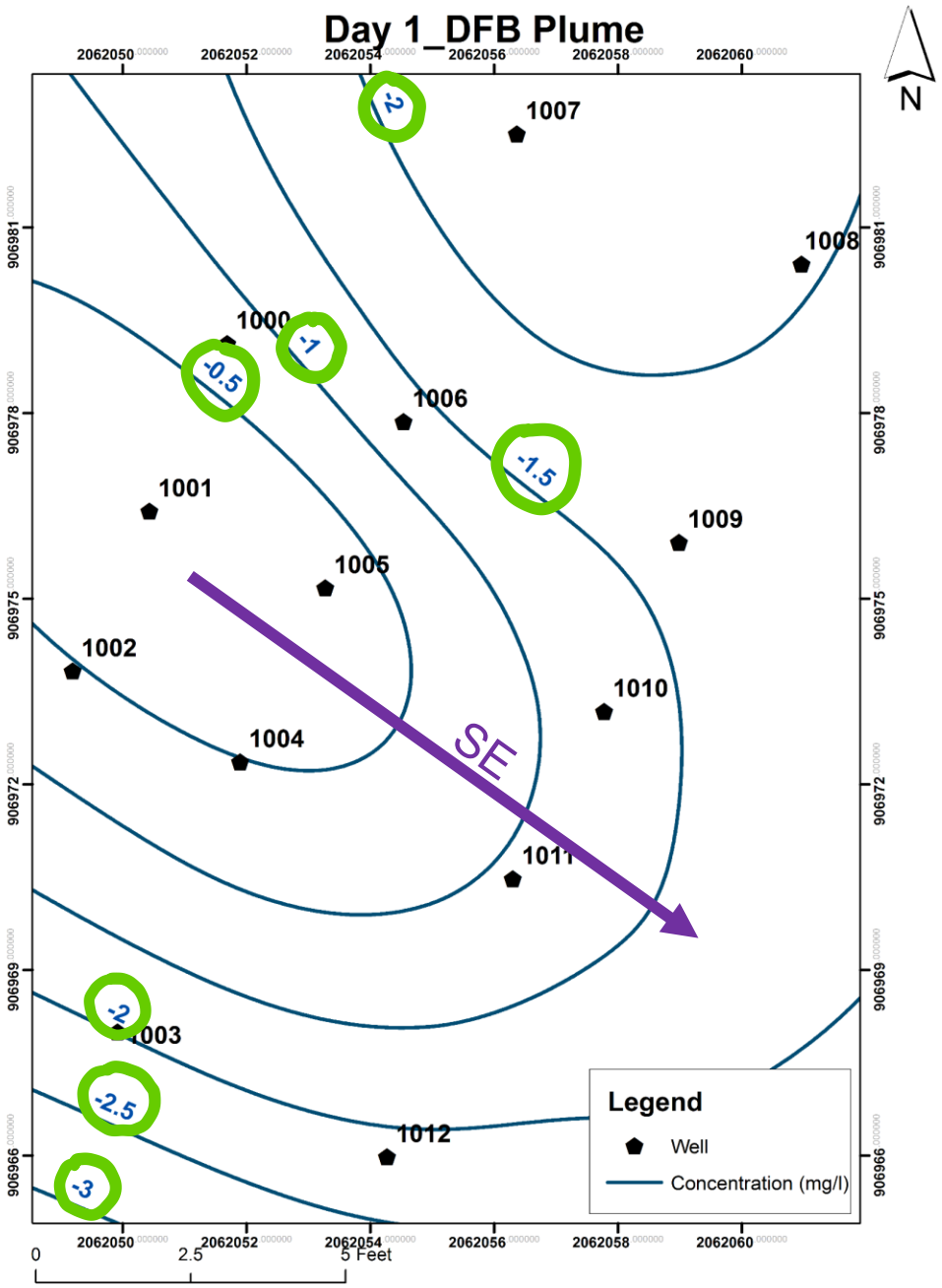
Advection and Dispersion of DFB



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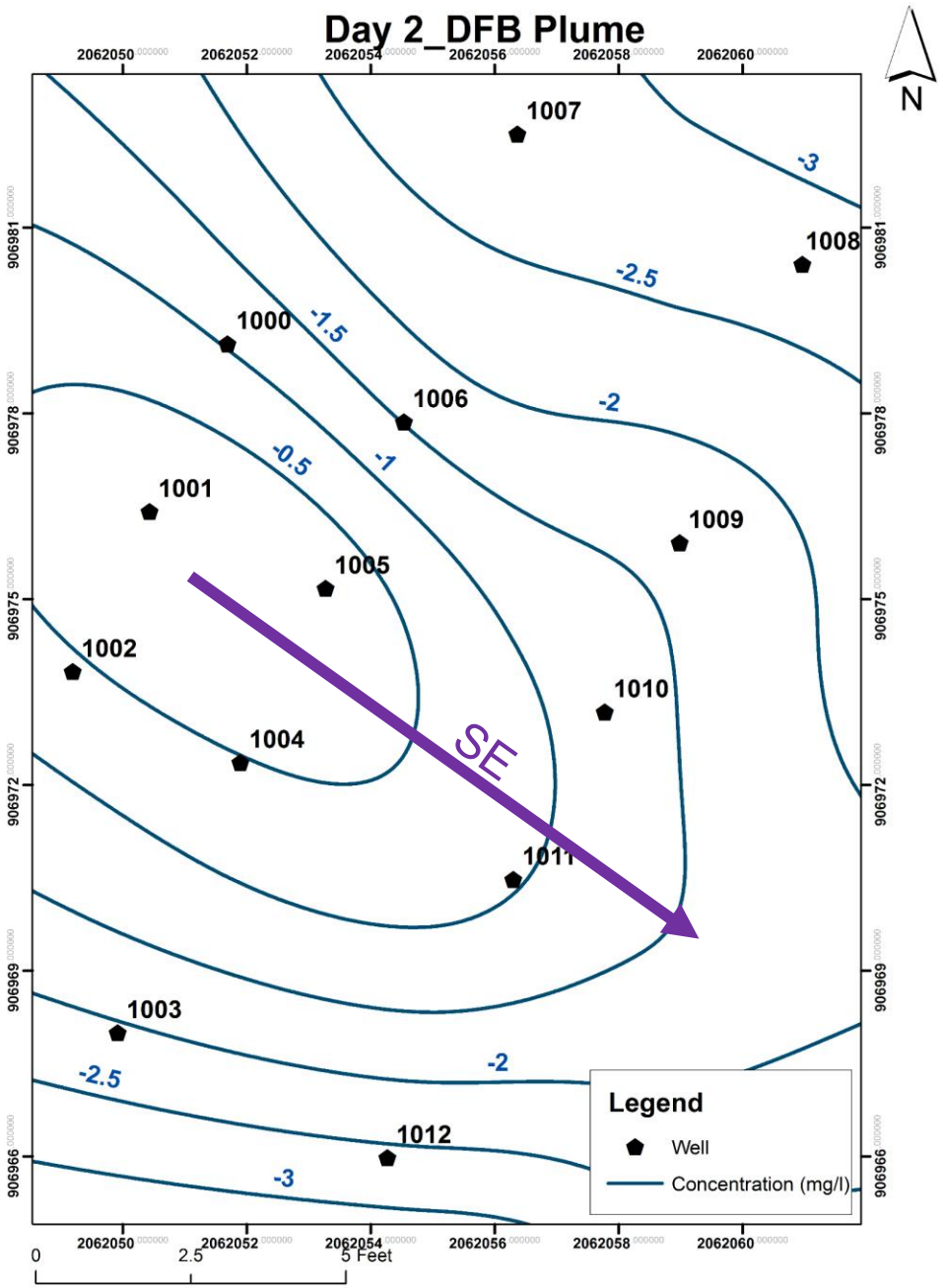

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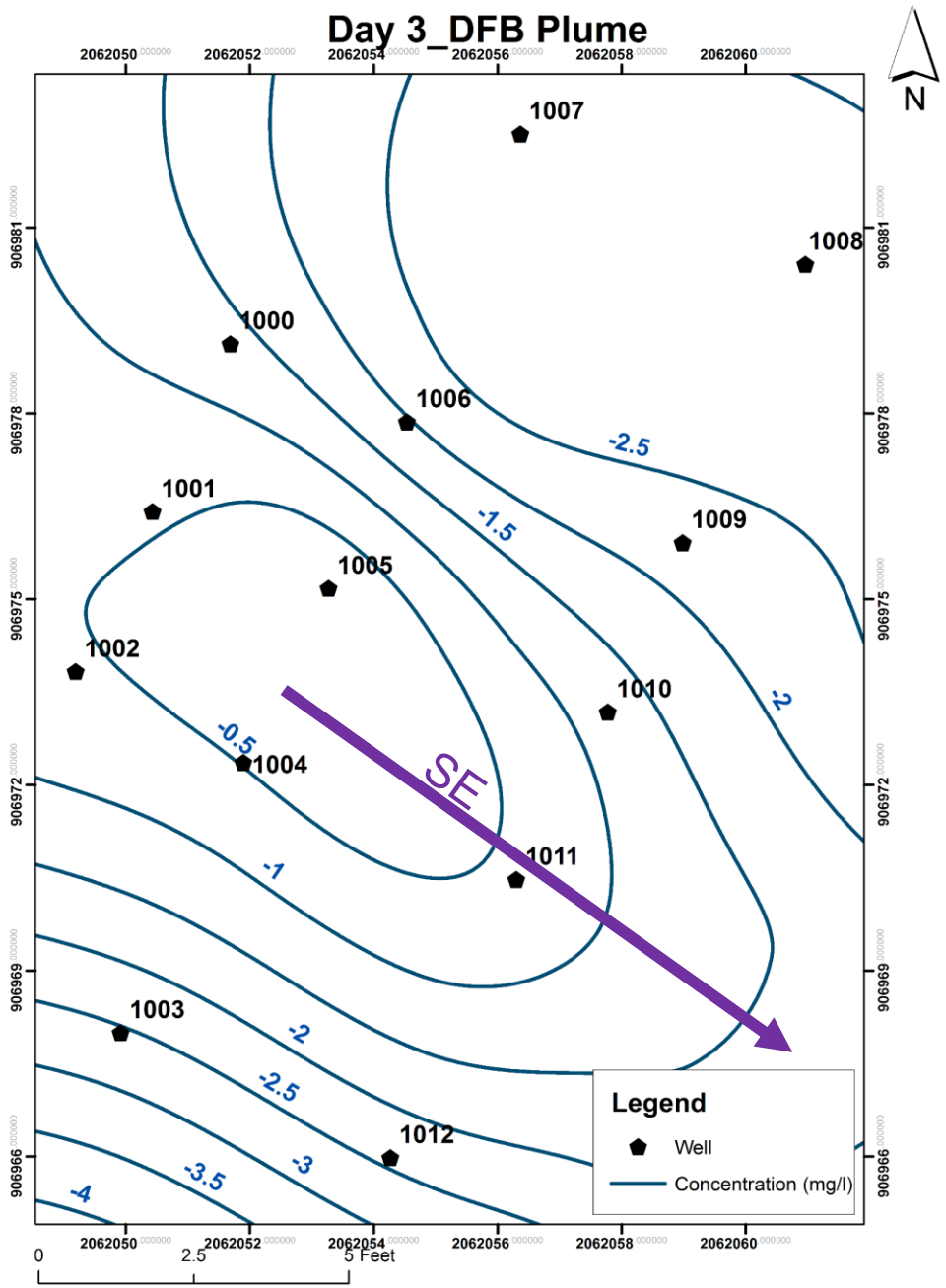

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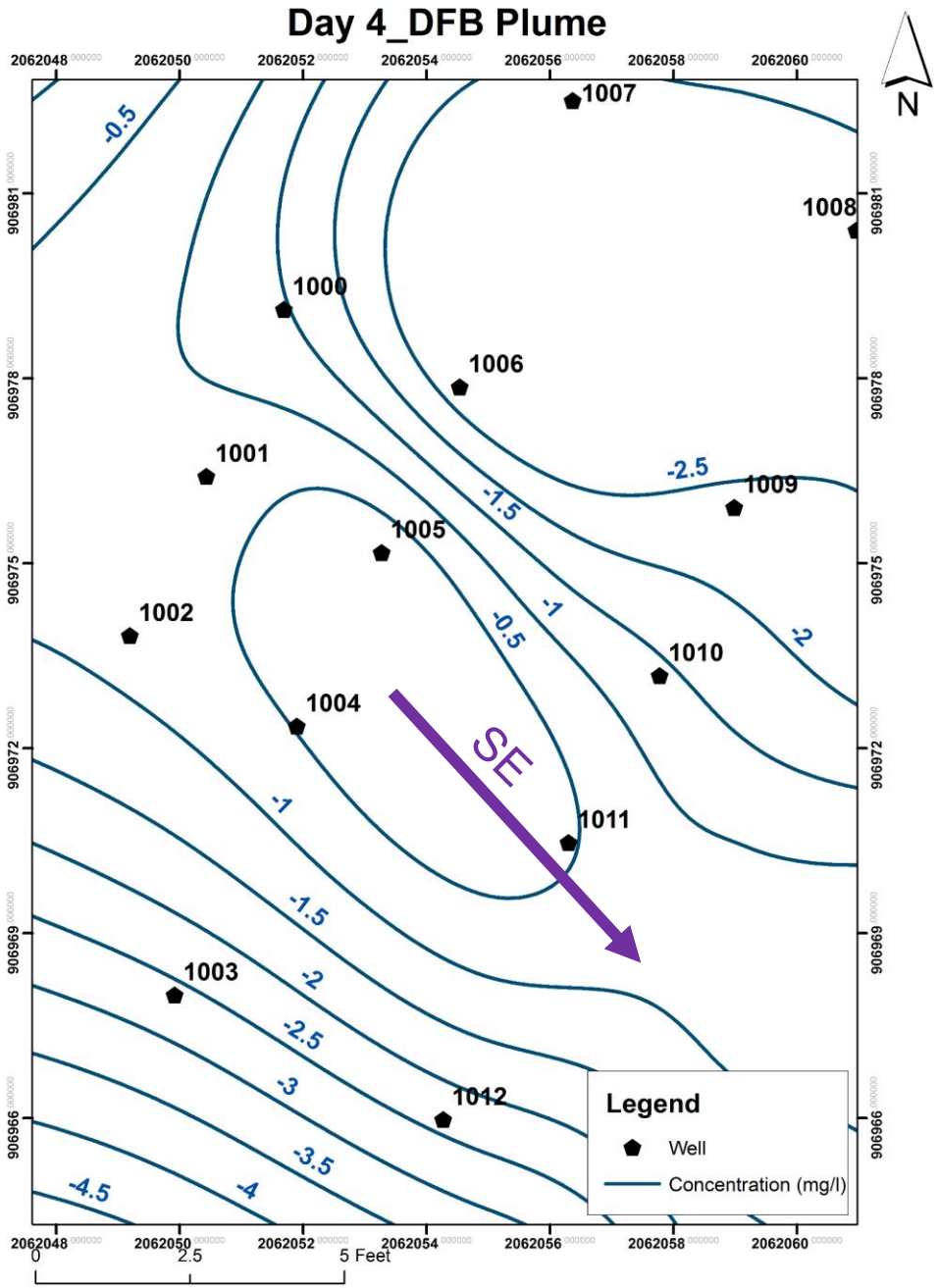

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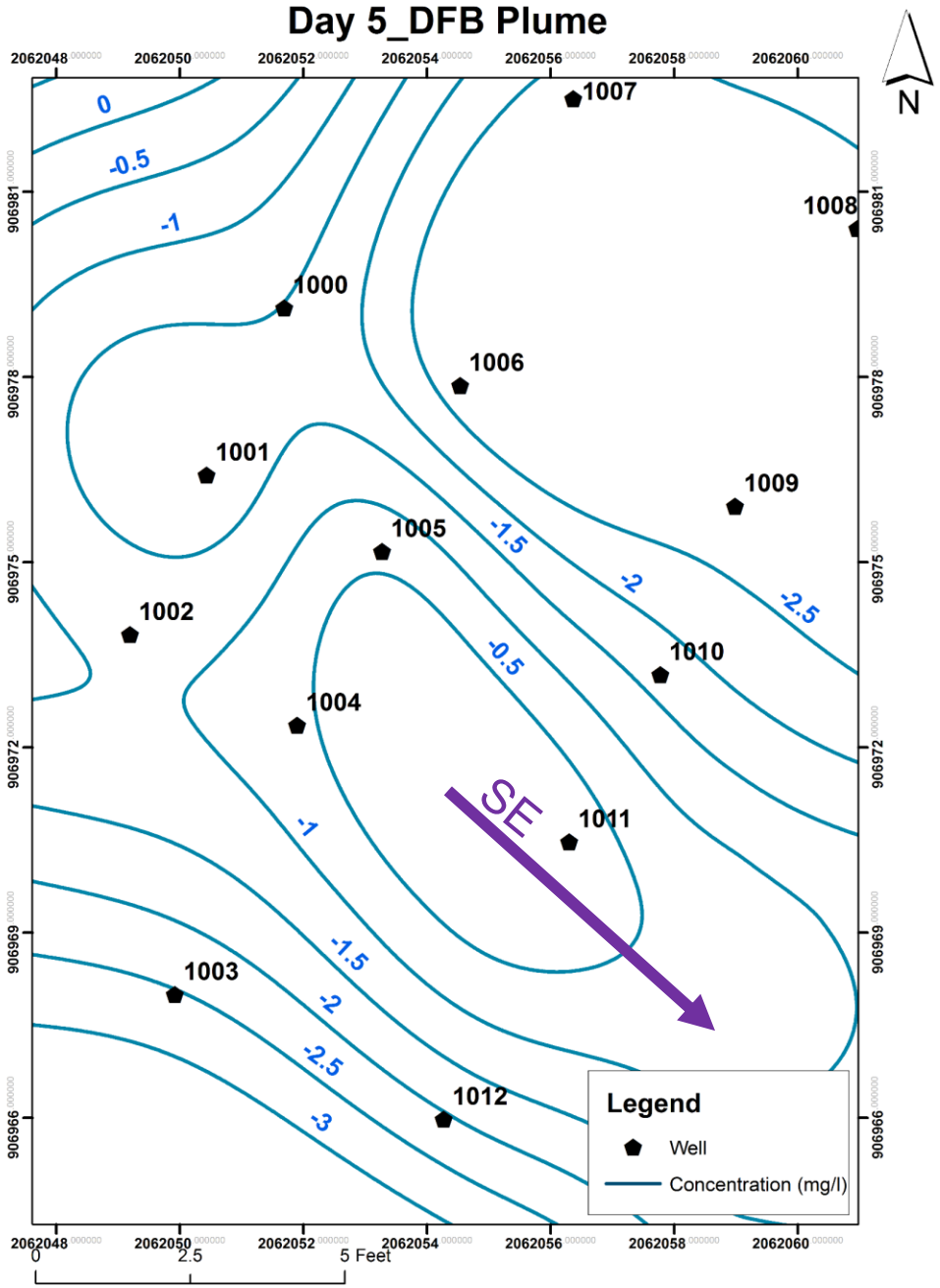

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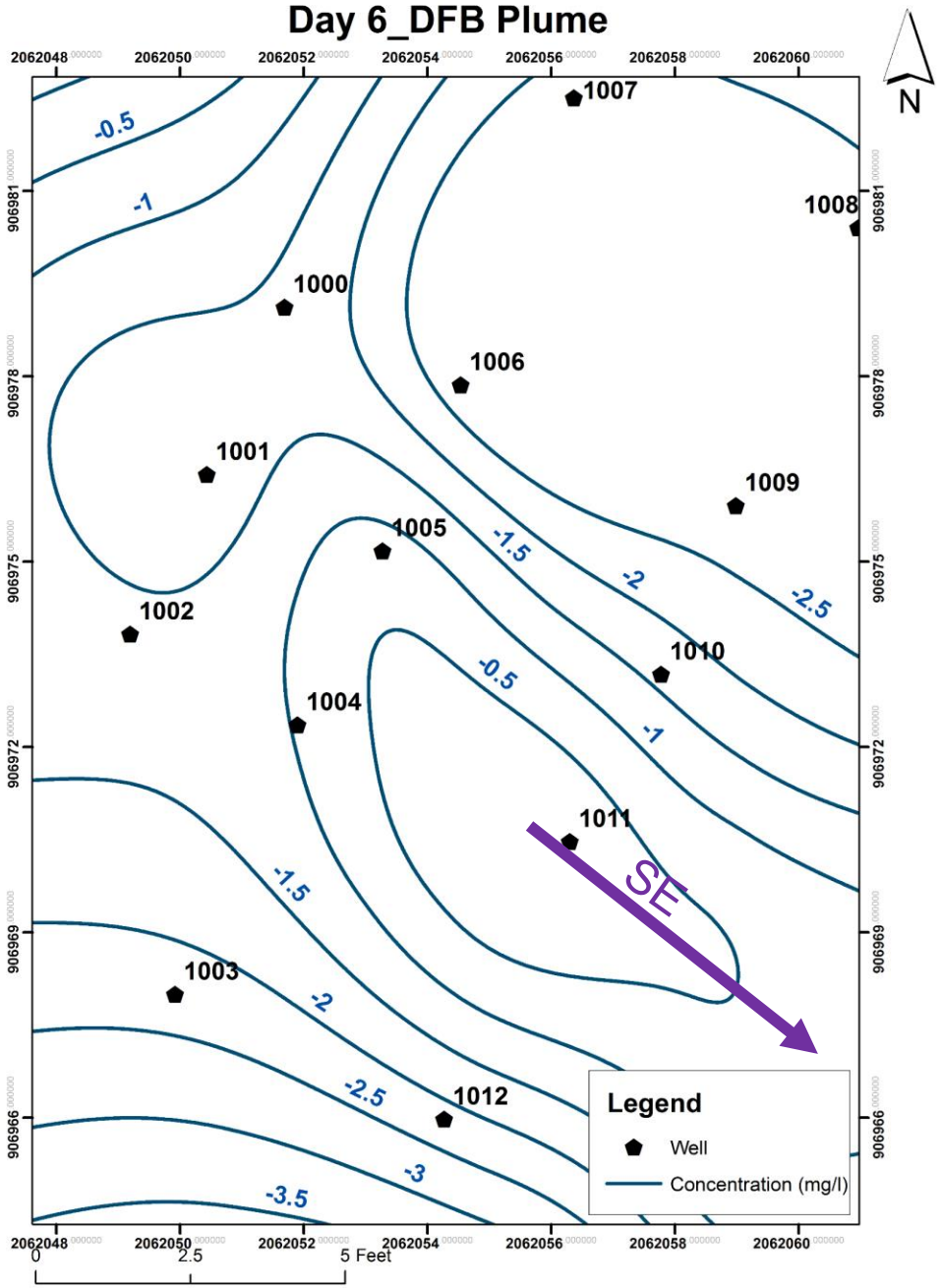

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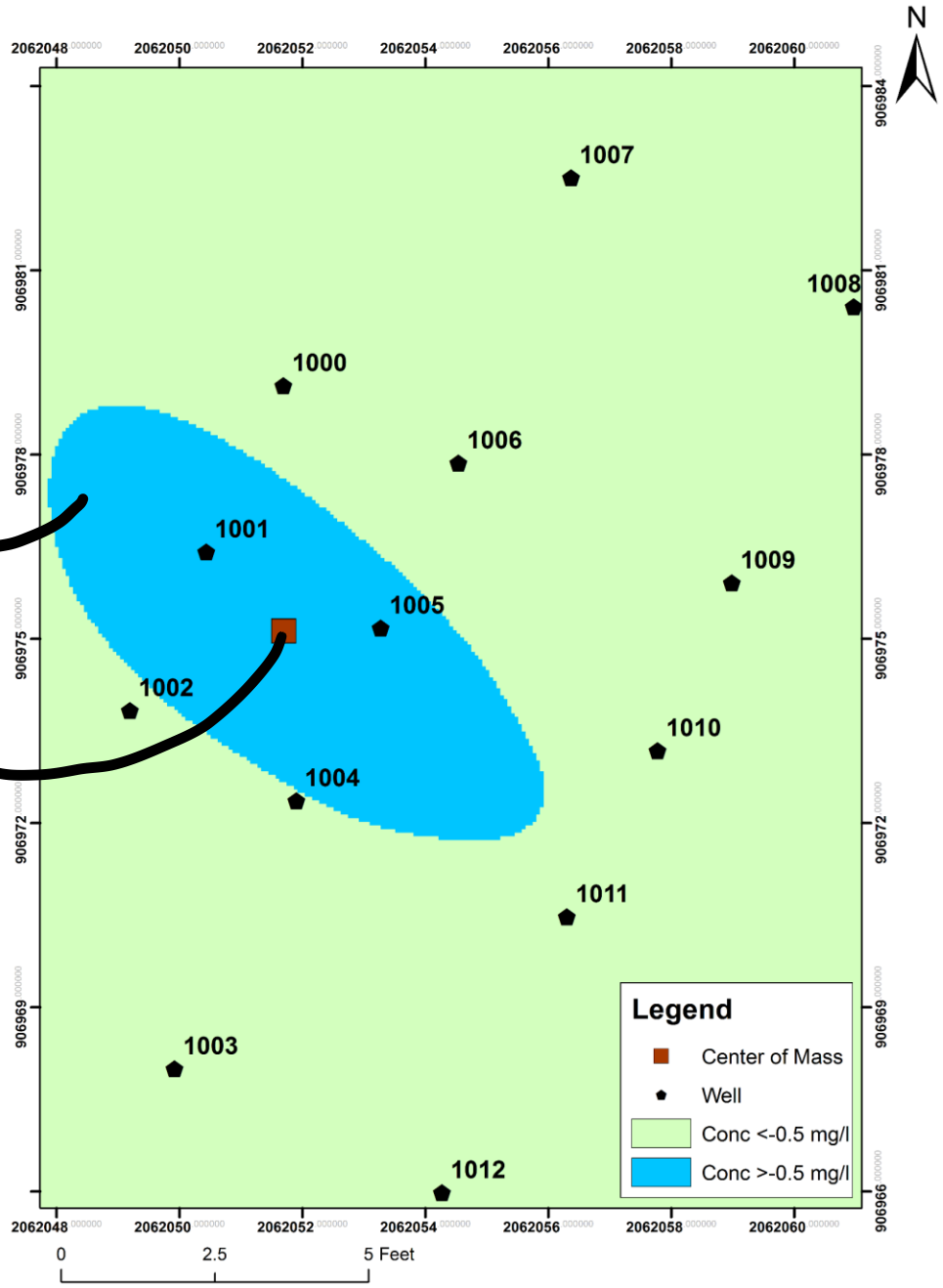
Advection and Dispersion: Br

Br Tracer Plume

Centre of Mass of the Br Plume



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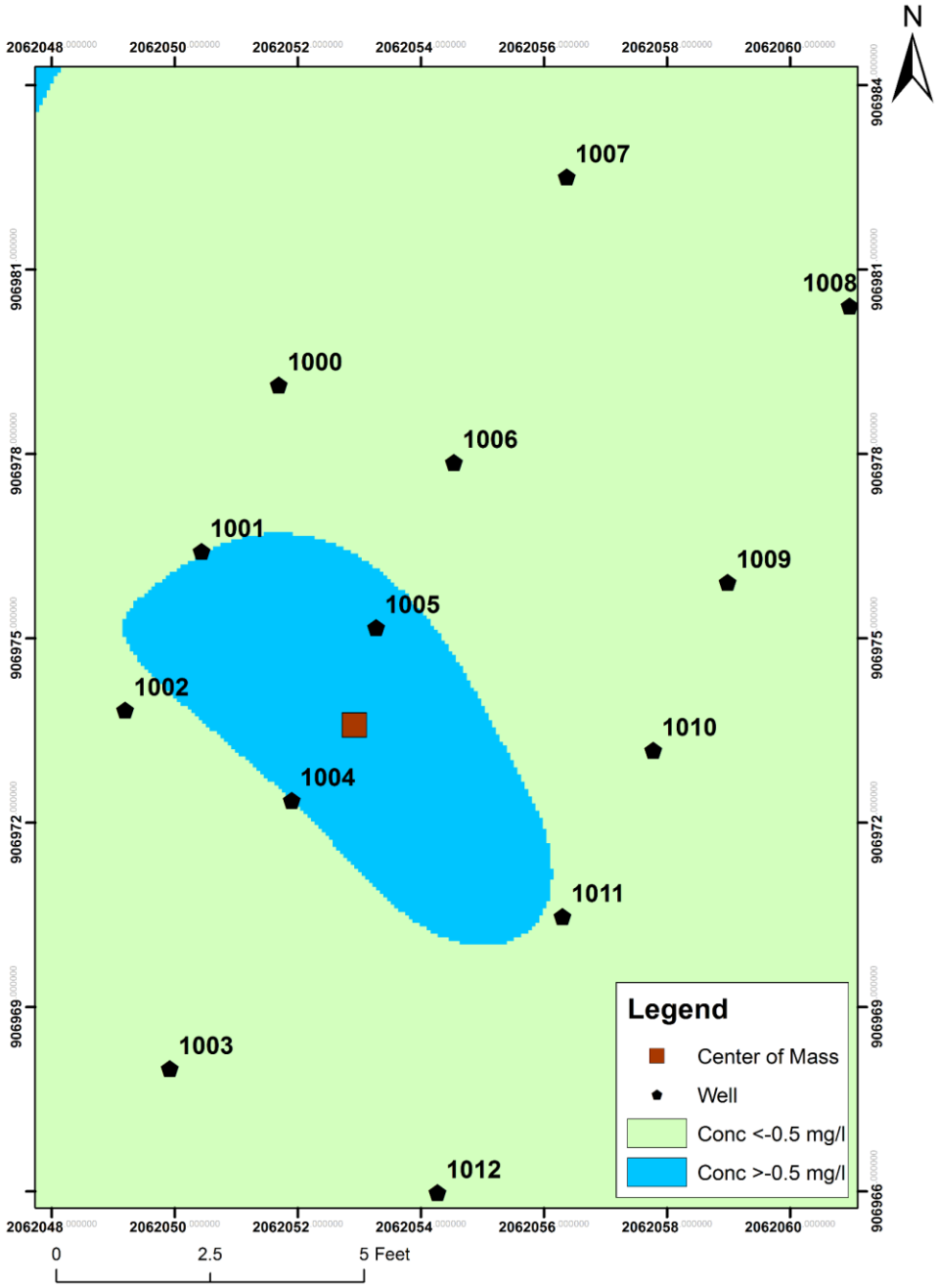
Day 2_Bromide Plume



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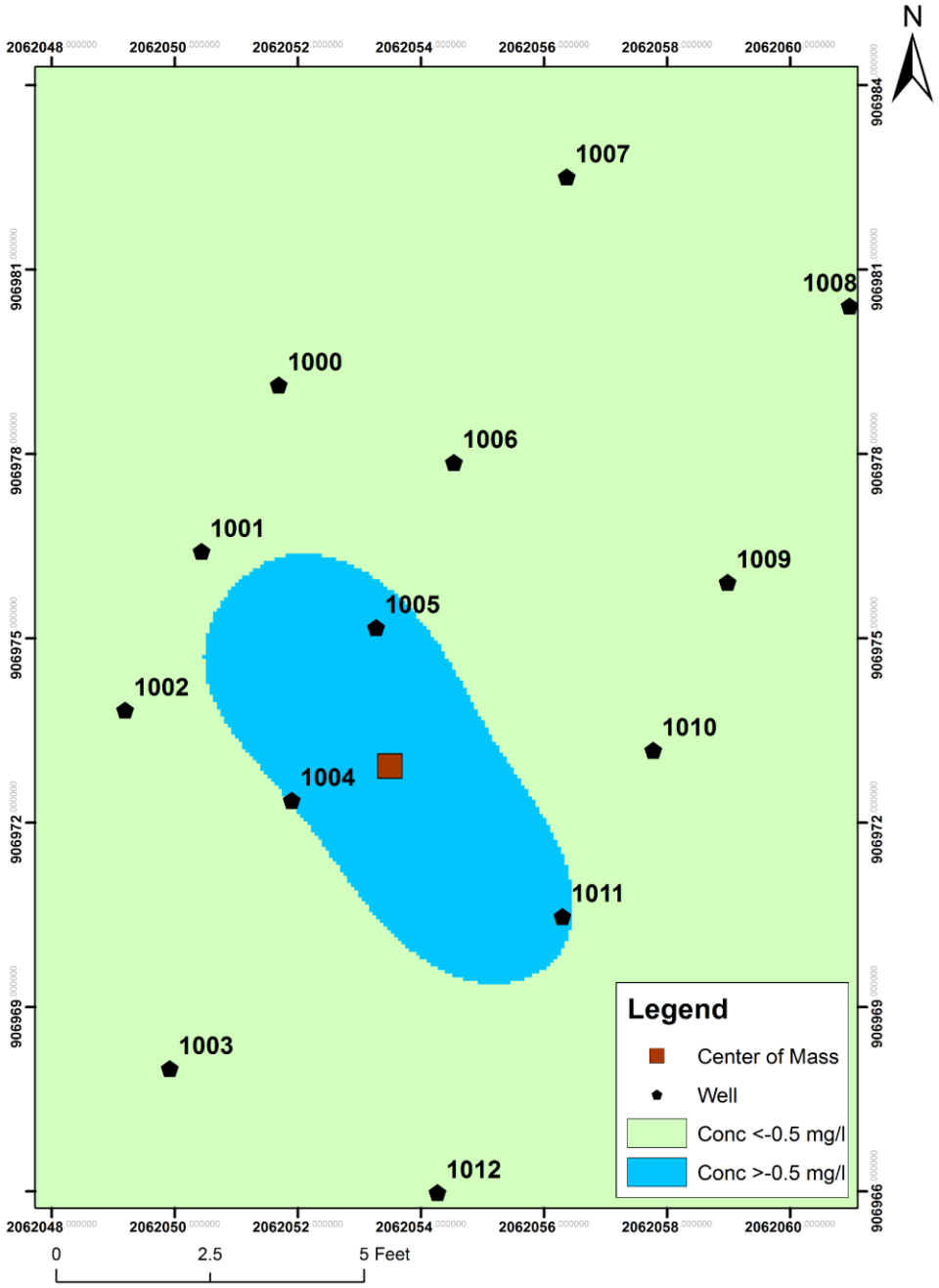
Day 3_Bromide Plume



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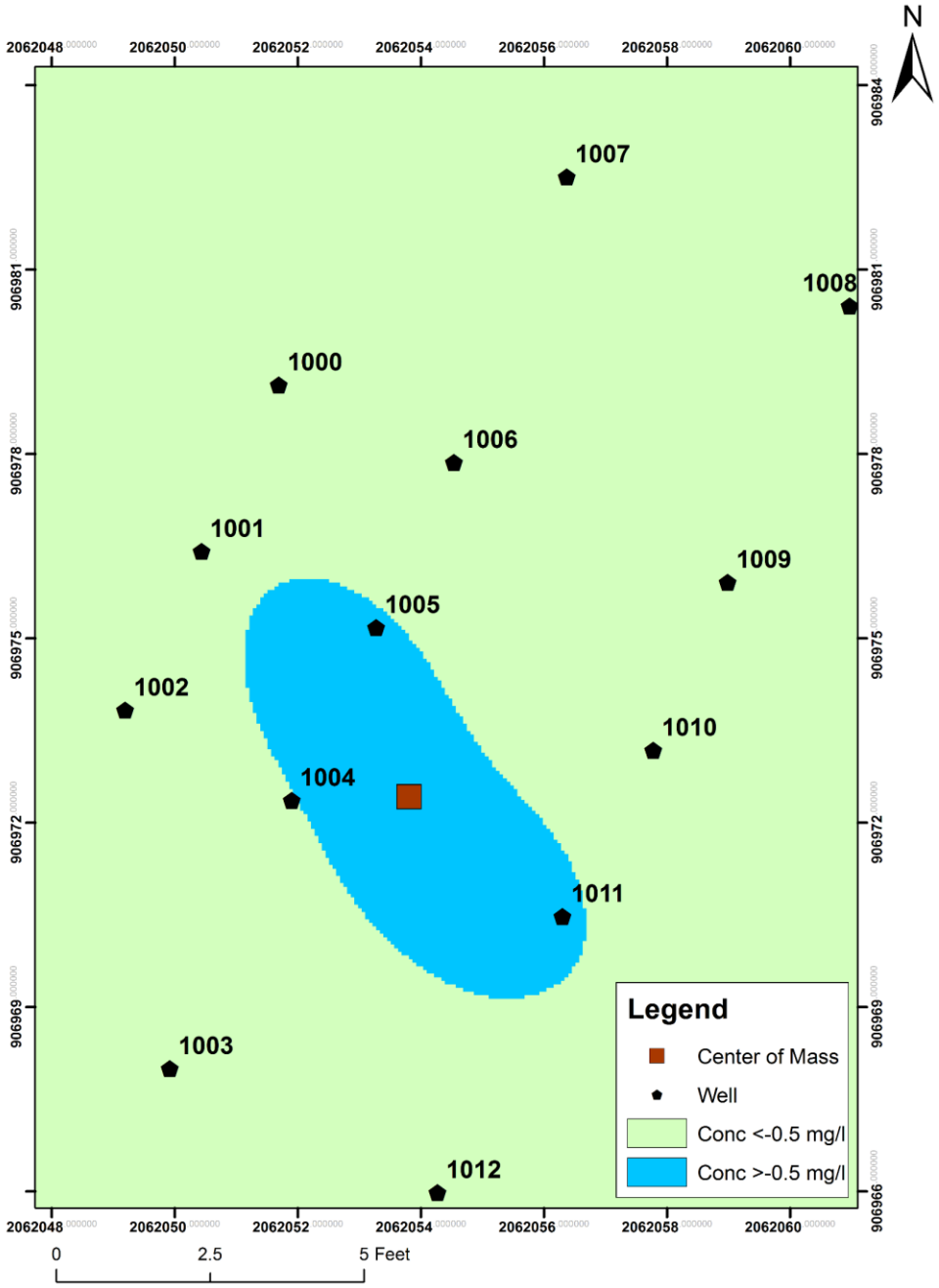
Day 4_Bromide Plume



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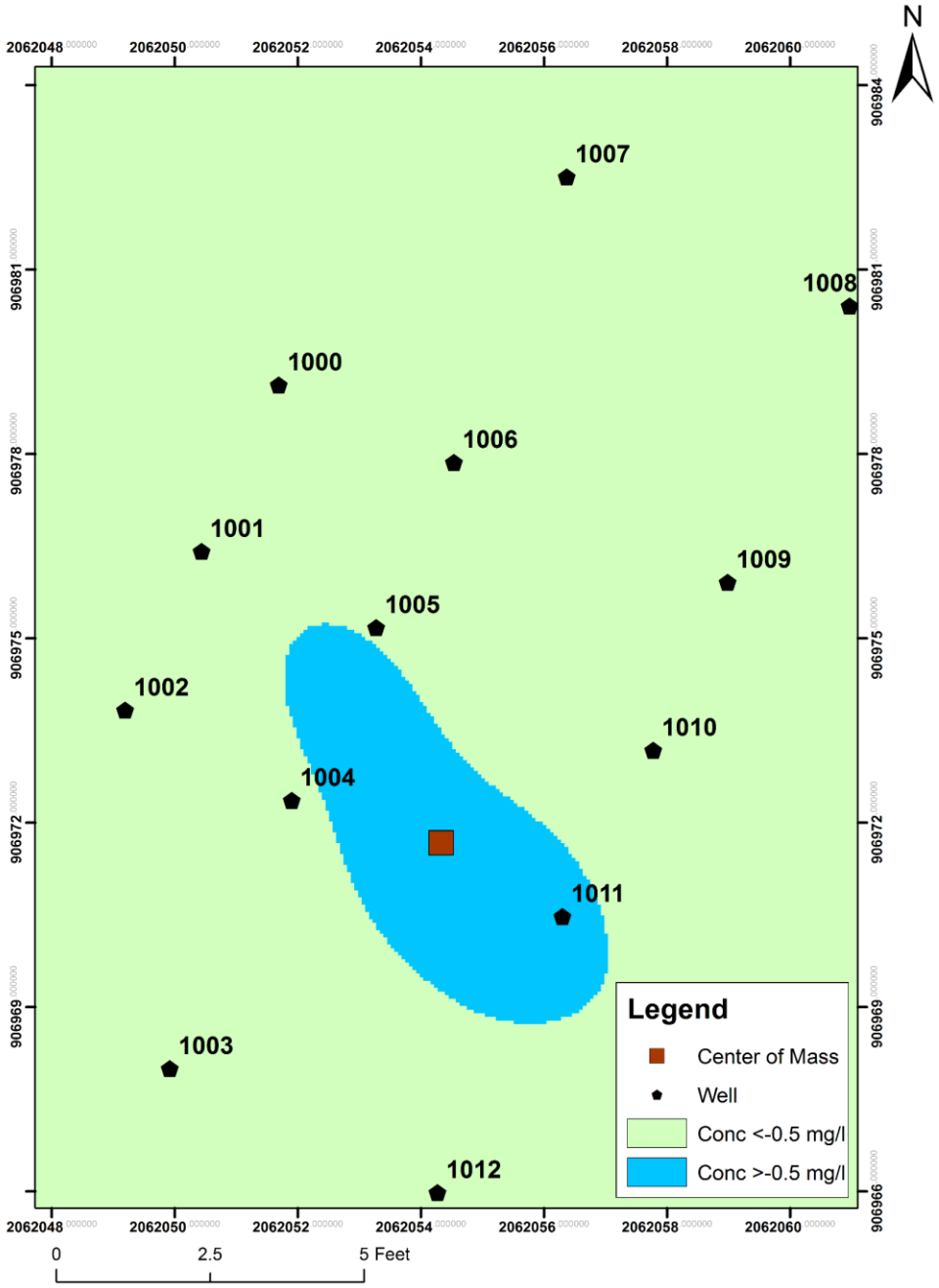
Day 5_Bromide Plume



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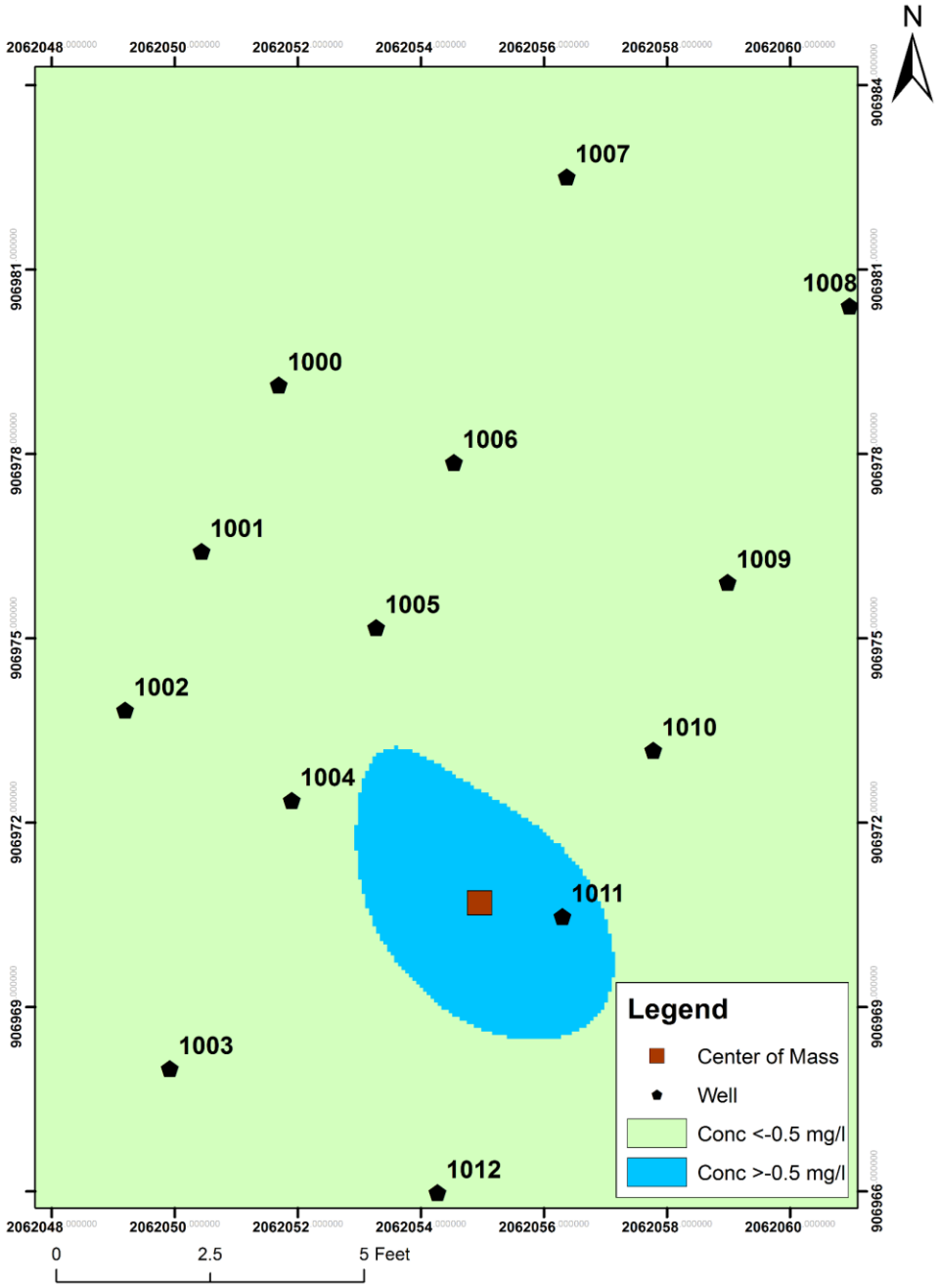
Day 6_Bromide Plume



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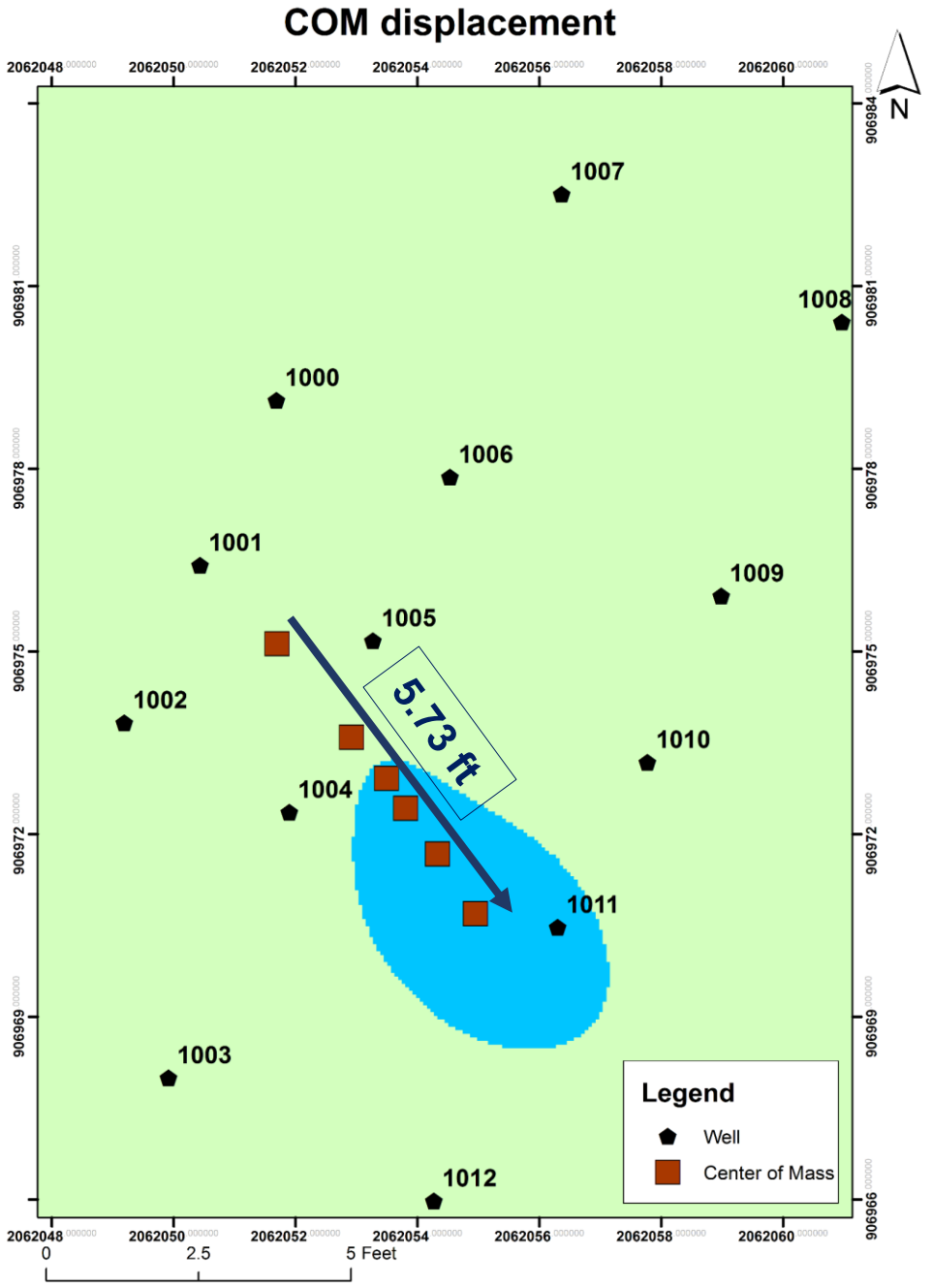
Center of Mass Displacement- Br Plume



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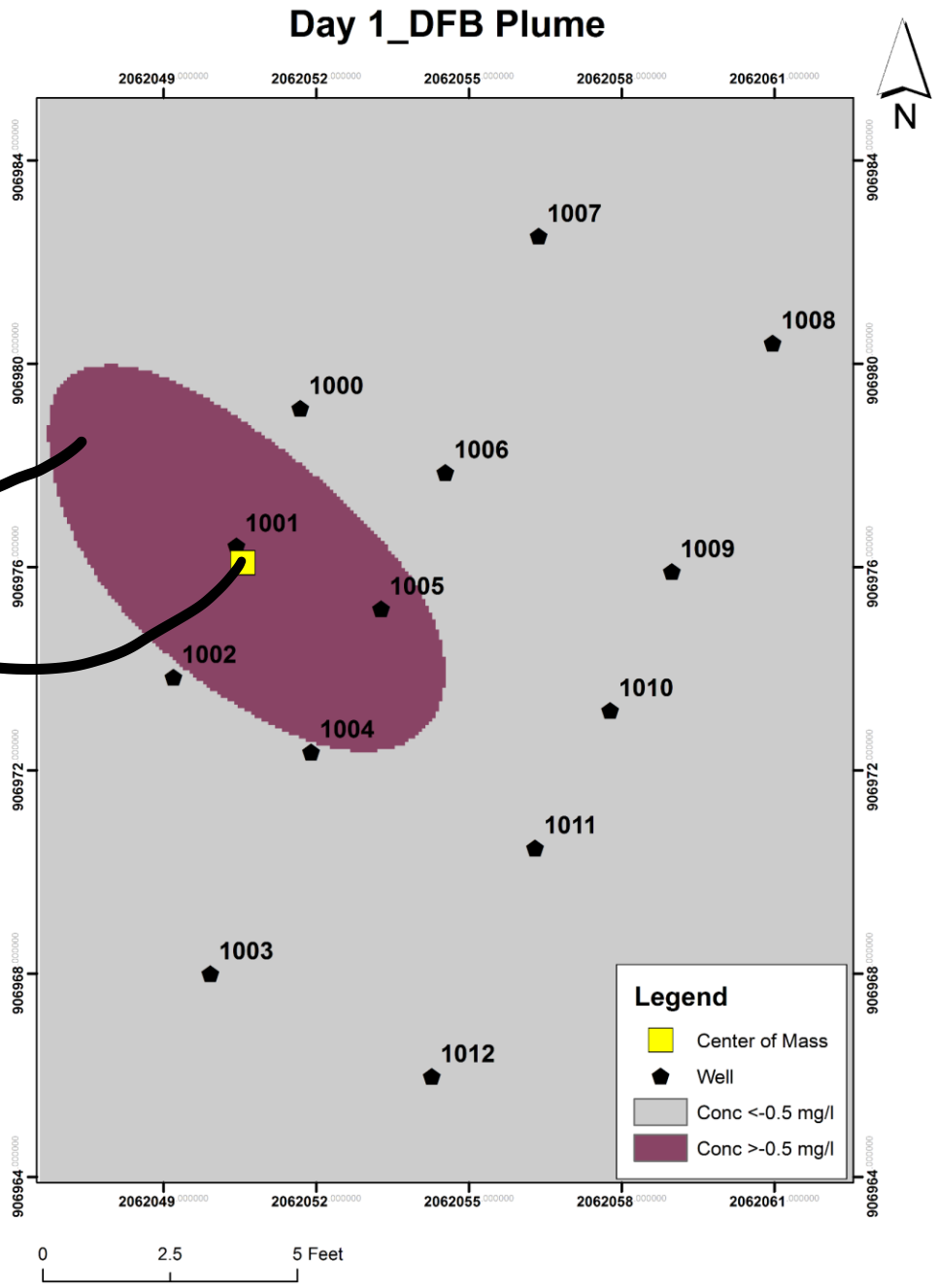
Advection and Dispersion: DFB

DFB Tracer Plume

Centre of Mass of the Br Plume



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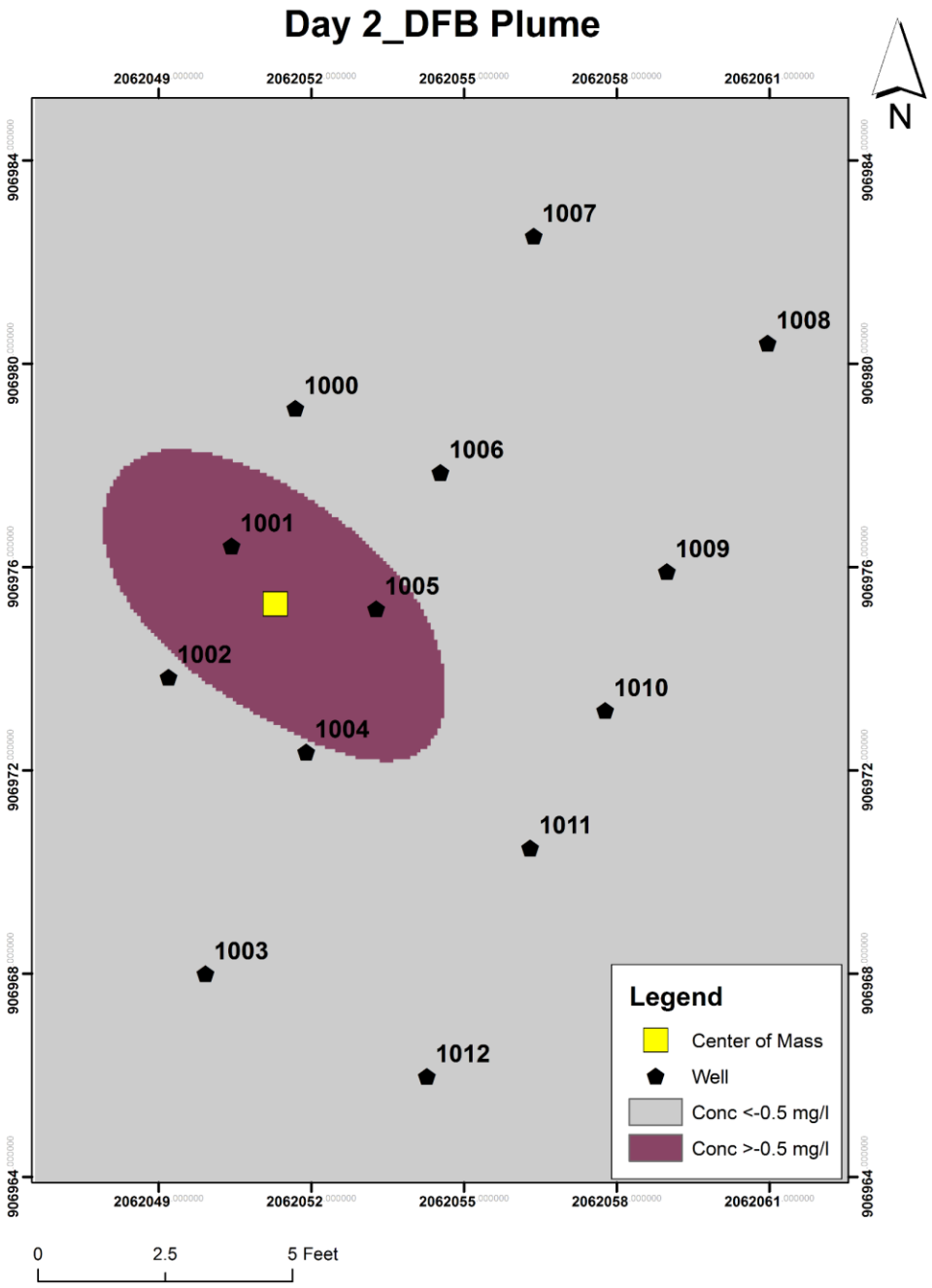

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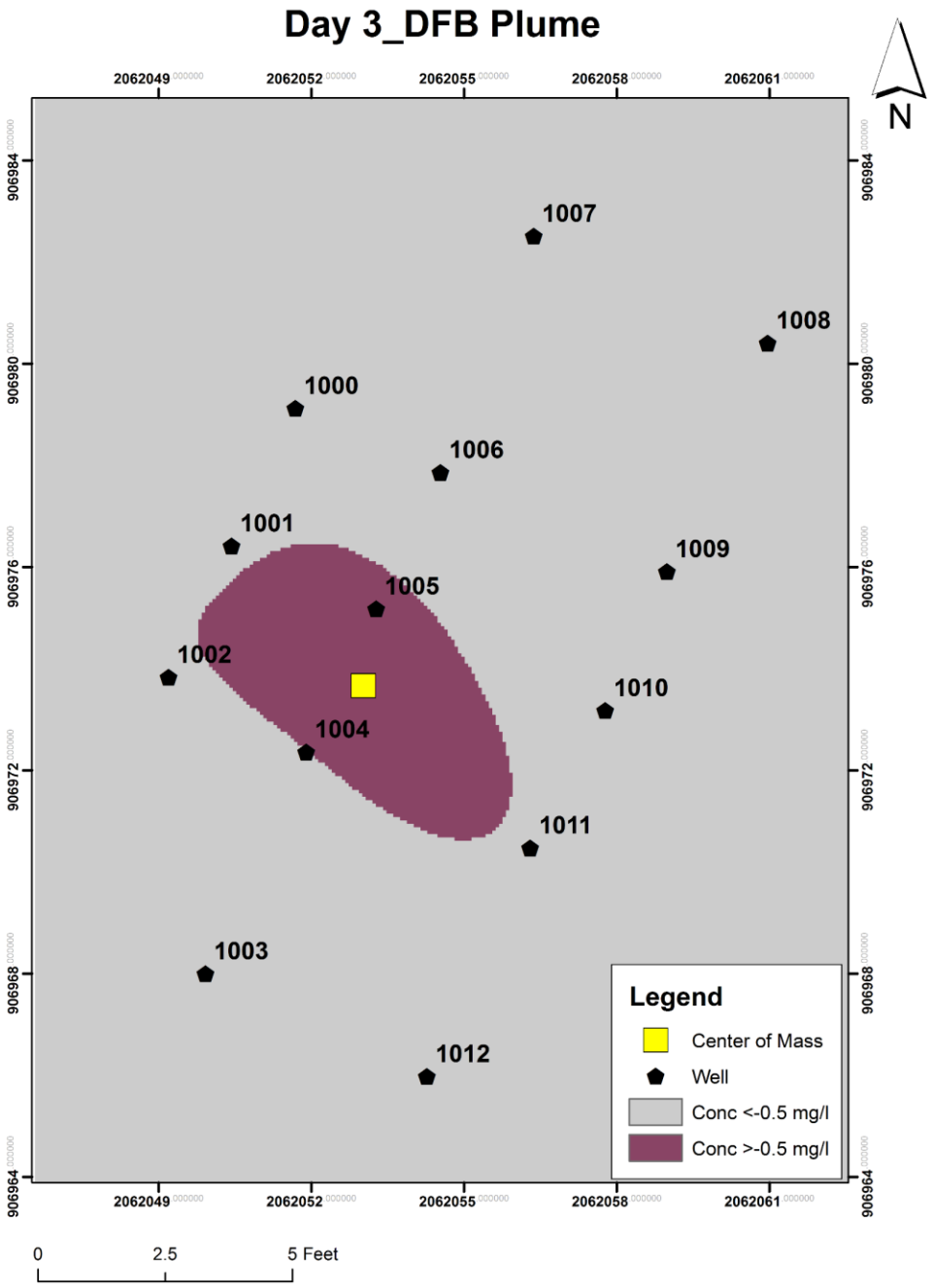

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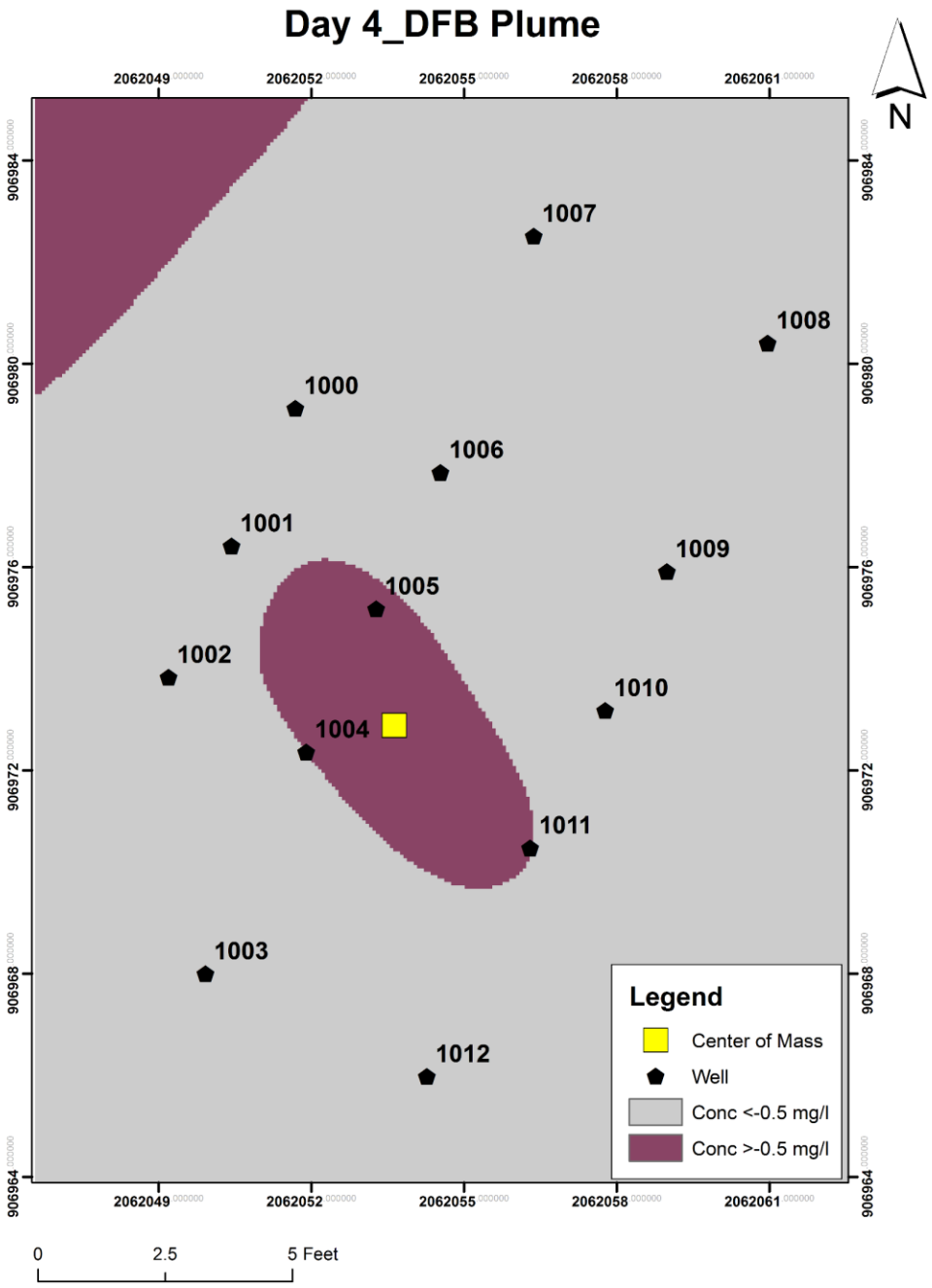

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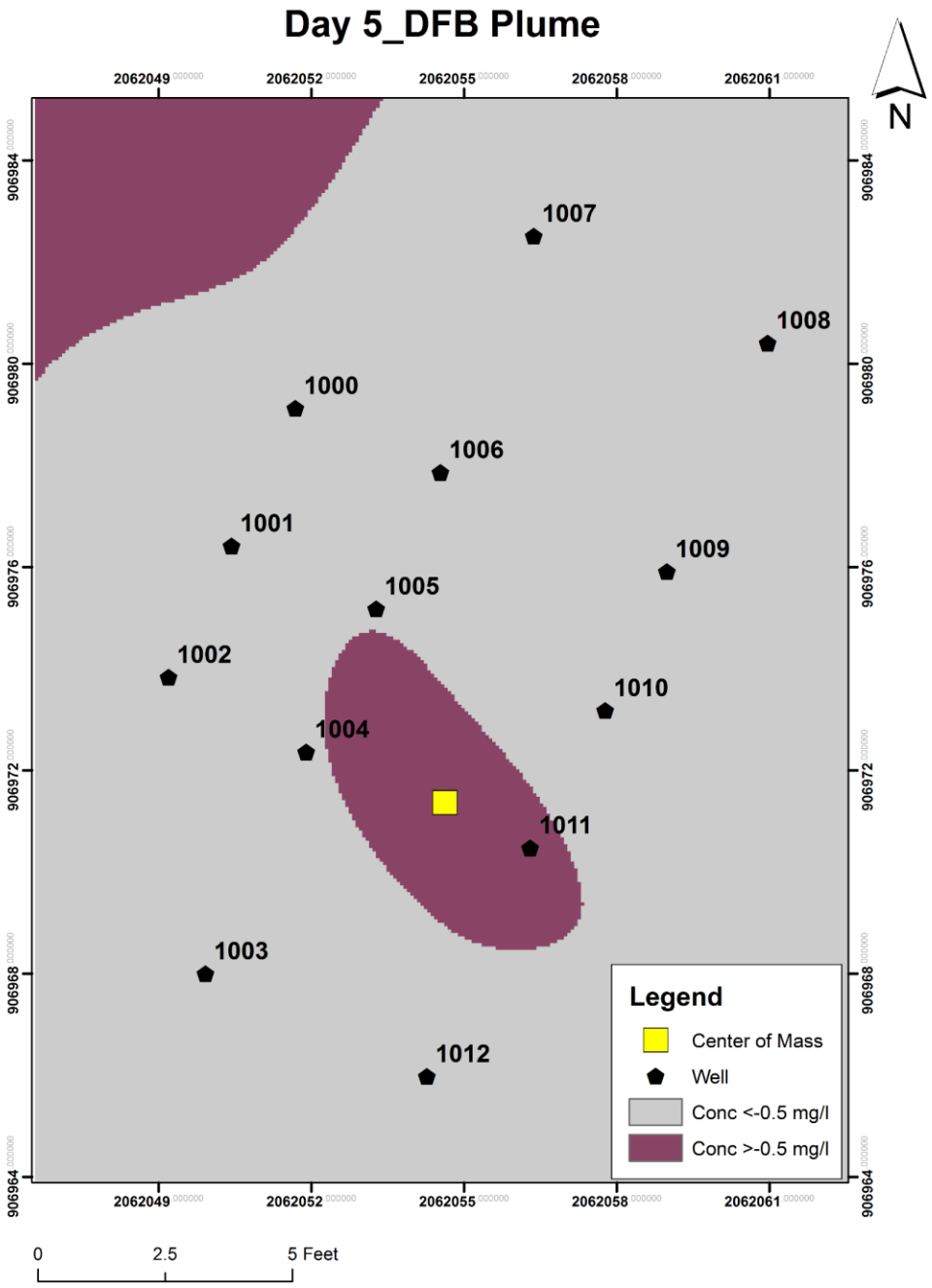

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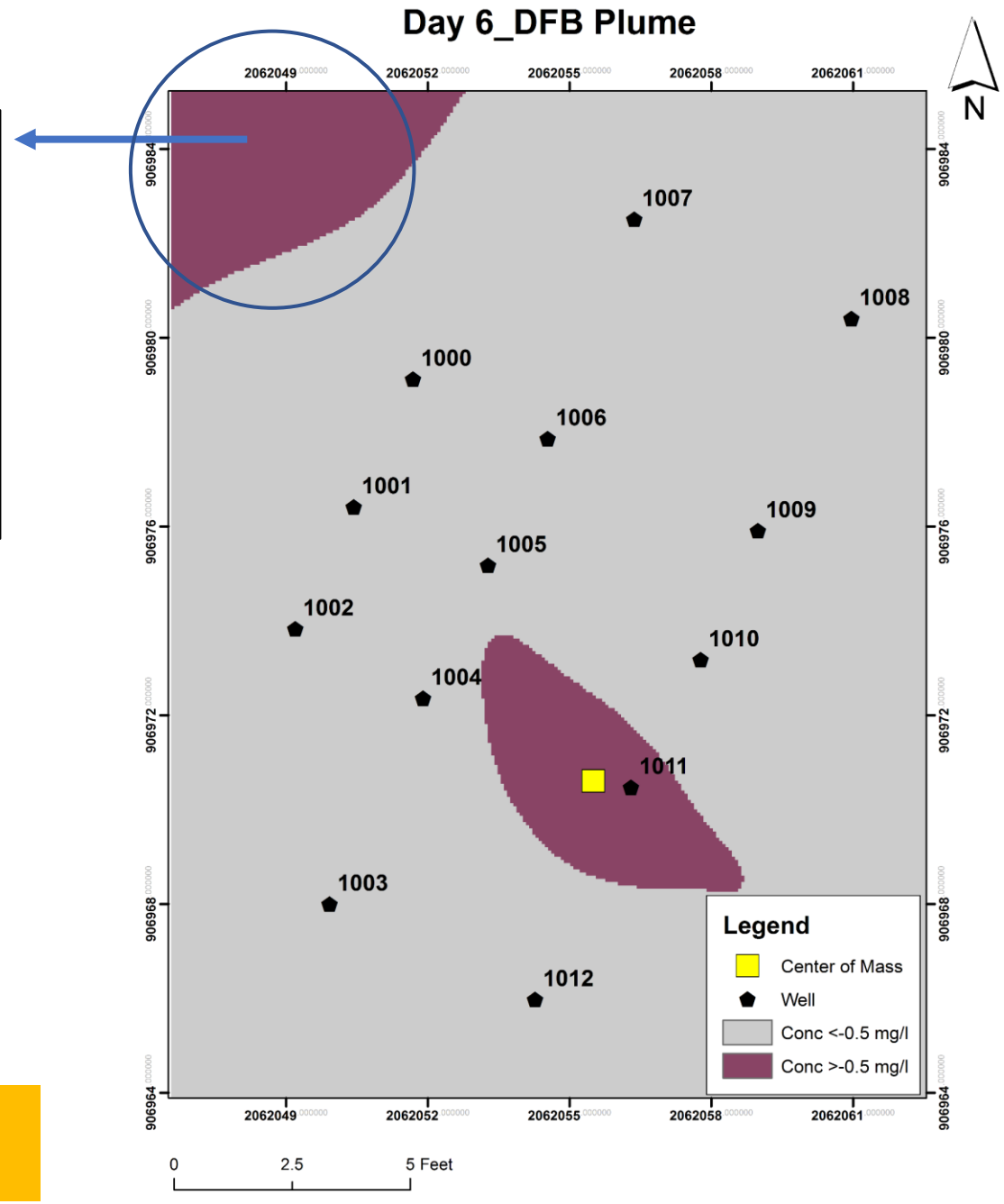
This section does not represent lower concentrations. It is an Artifact created by ArcMap. As this section is out of the field site range, there is no data hence ArcMap extrapolated.



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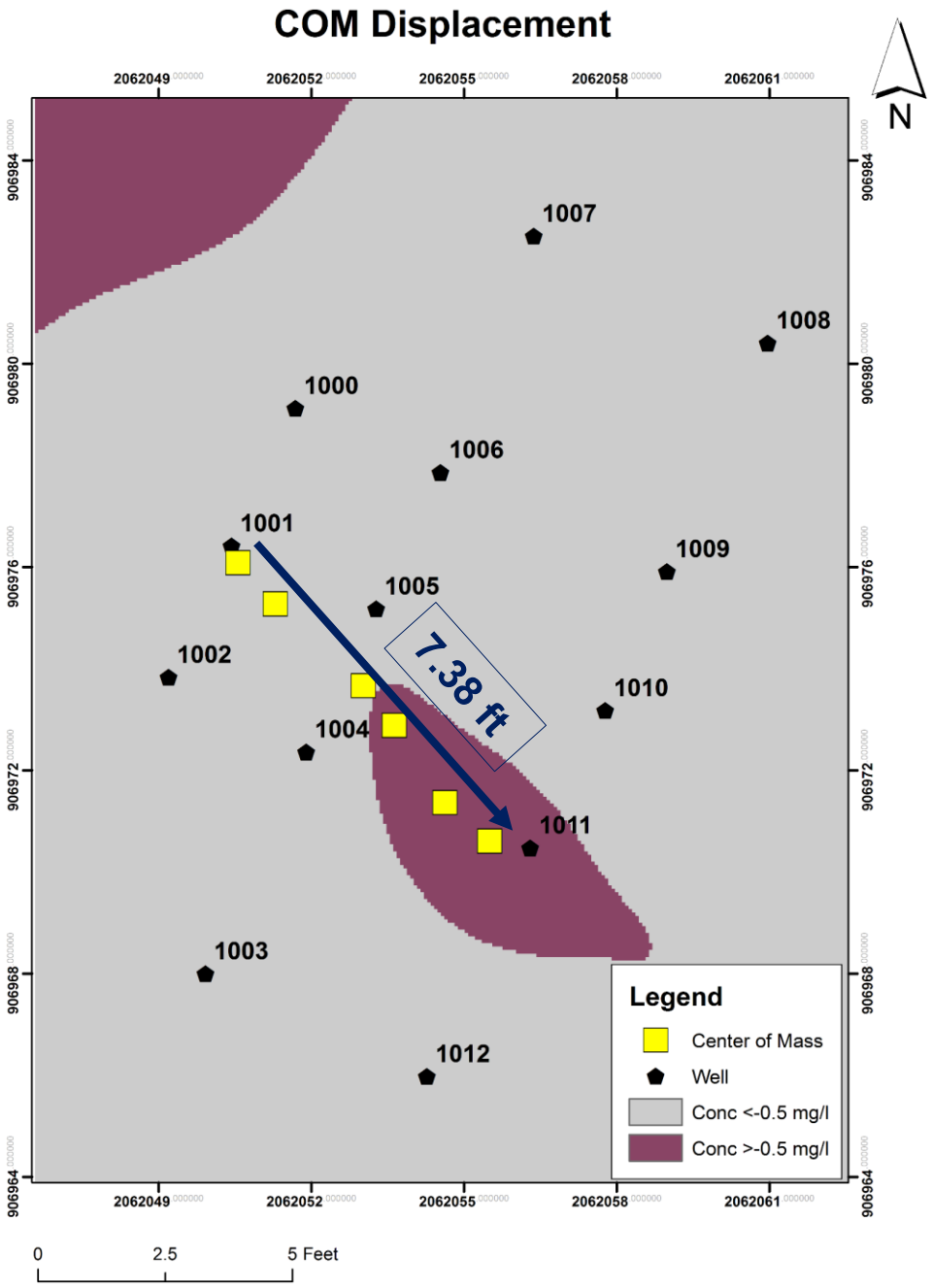
Center of Mass Displacement- DFB Plume



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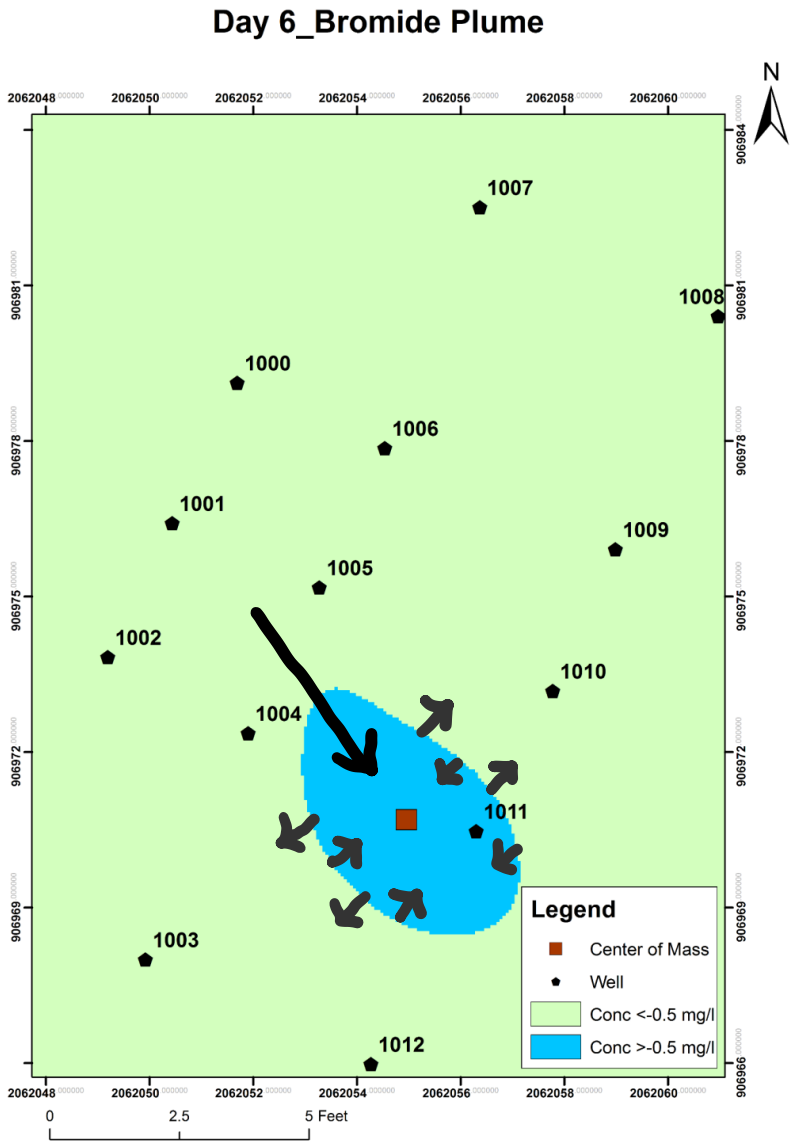
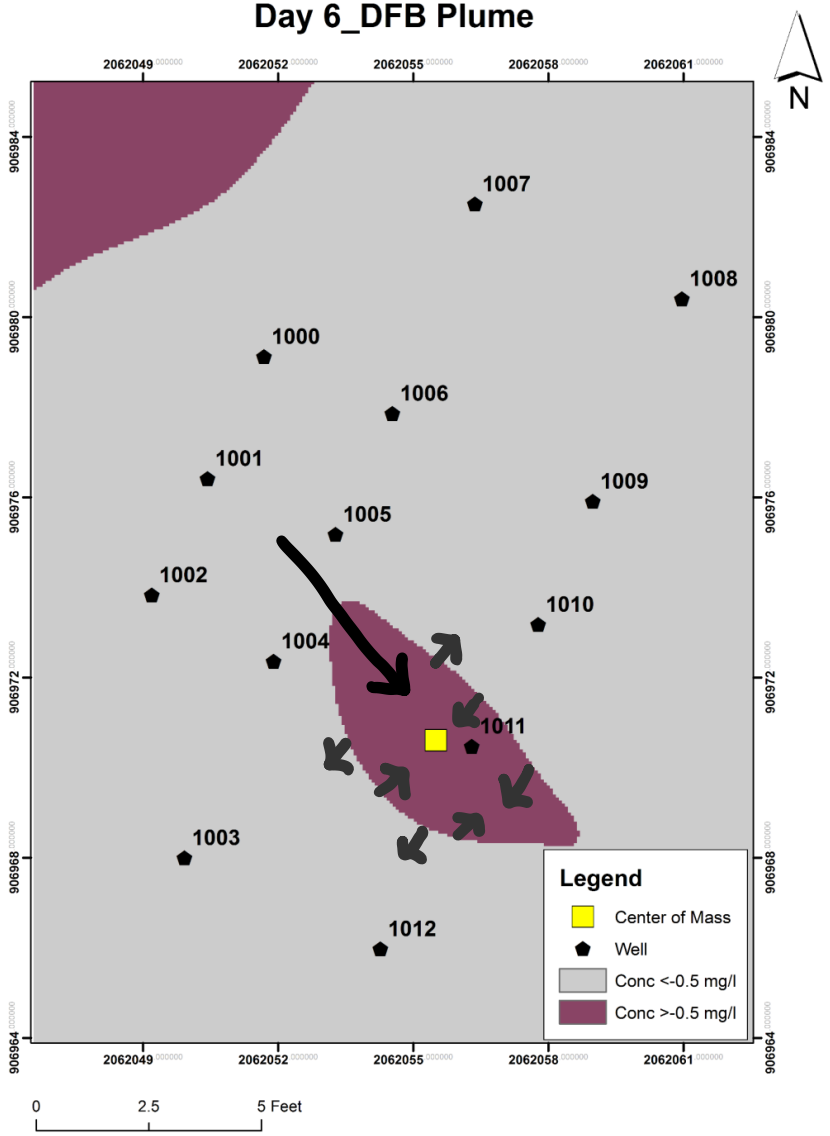
Comparison of Day 6 Halide and Benzoate Plume





Br is high diffusivity tracer and DFB is low diffusivity tracer which allows for assessing Matrix Diffusion.

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Summary

1. Geospatial models show non-reactive mass transport: Advection, v and Dispersion, α of tracers which also indicate flow path, flow direction and extent of contamination, hence mobilization of tracers.
2. v and α are well-behaved so it can be hypothesized that the vadose zone is homogeneous and isotropic.
3. The v and α are similar for halide and benzoate hence matrix diffusion is negligible.

Next Steps

1. Summer 21 field- infiltration with added alkalinity as U(VI) is highly dependent on alkalinity and to find answers to possible sorption mechanism.

References

1. Ricker, J.A. , A Practical Method to Evaluate Groundwater Contaminant Plume Stability, Groundwater Monitoring and Remediation.
2. Dam, W.L. et al, 2015, Refining the Site Conceptual Model at a Former Uranium Mill Site in Riverton, Wyoming, USA, Environmental Earth Sciences.

THANK YOU!

Questions?

Email: sultanar@uwm.edu
Affiliation: University of Wisconsin Milwaukee

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