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A Computational Modeling Approach to Critical Pressure Calculations for Class VI Area of Review Delineation

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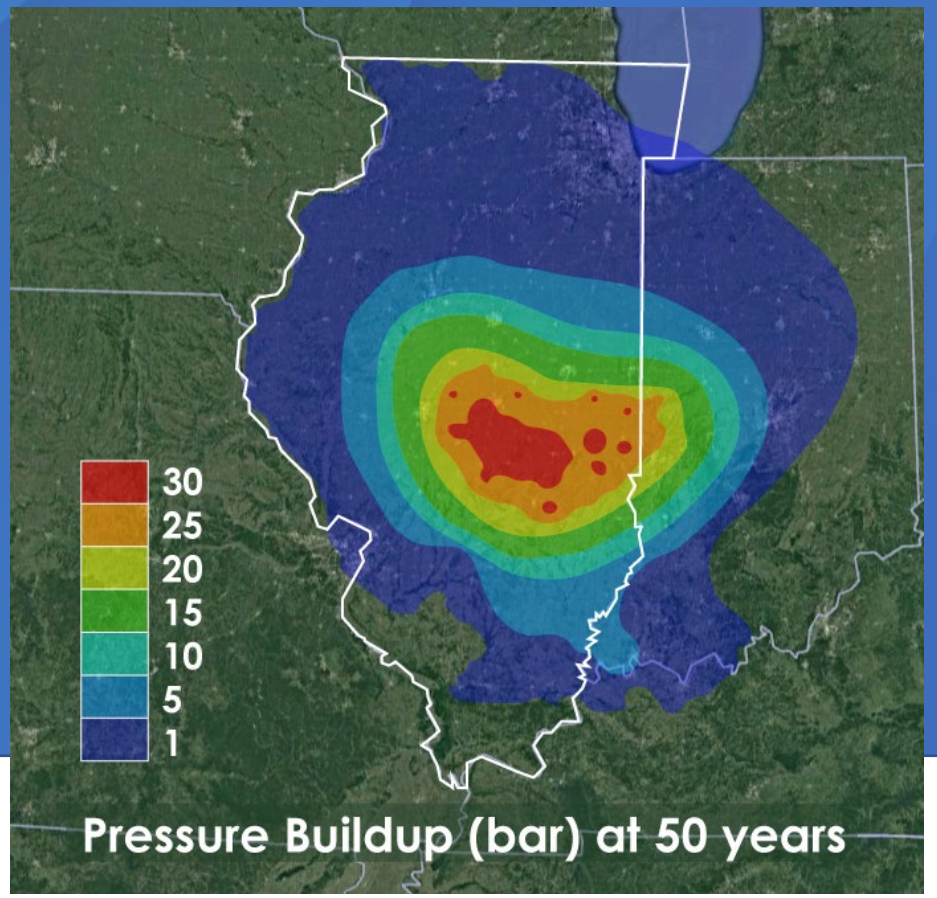
Groundwater Protection Council
Annual Forum



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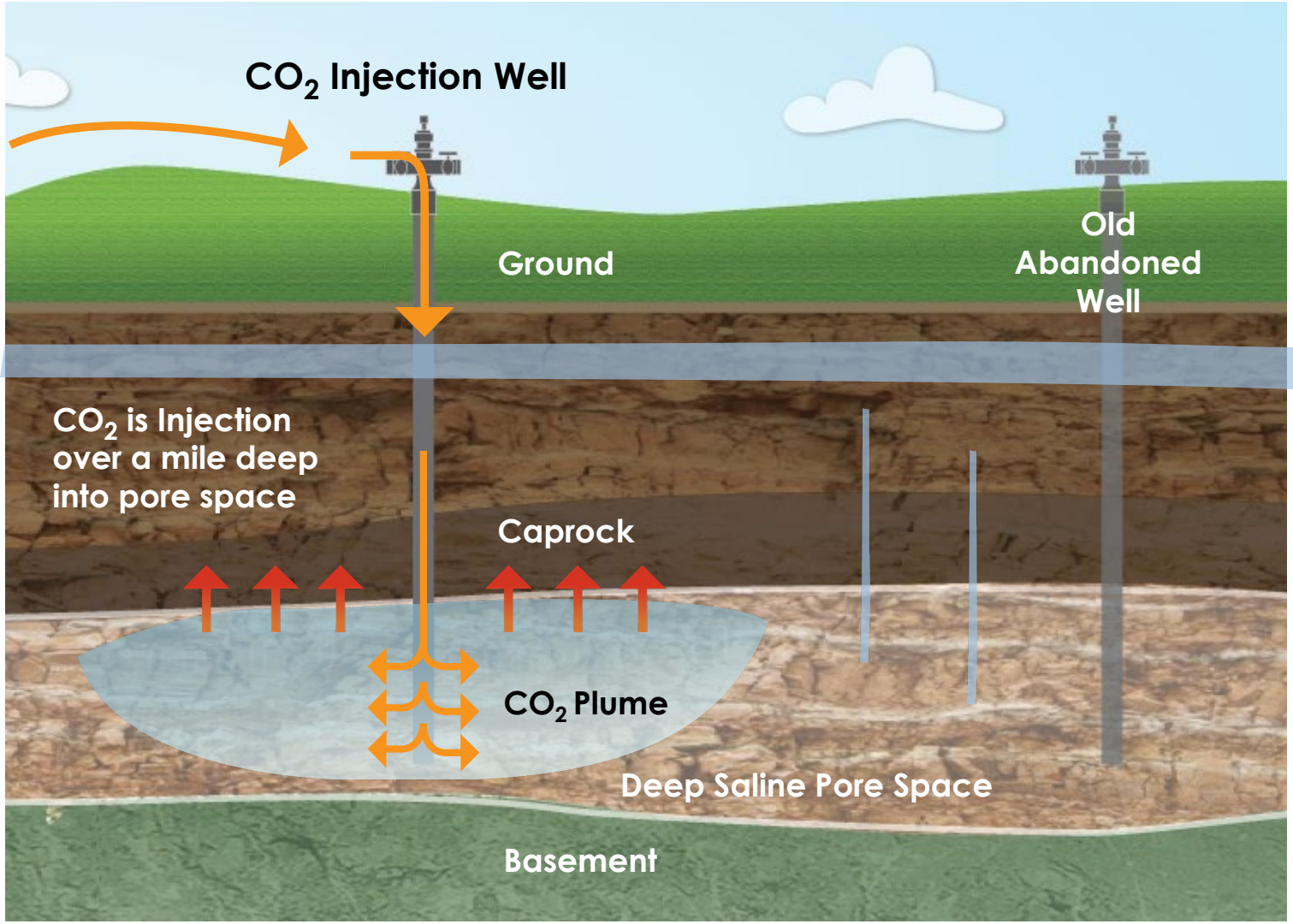
Endangerment of Underground Sources of Drinking Water

- Carbon sequestration in deep geologic units poses two risks to USDWs:
  - Upward migration of buoyant supercritical CO2
  - Upward flow of brine caused by the injection-induced pressure gradient



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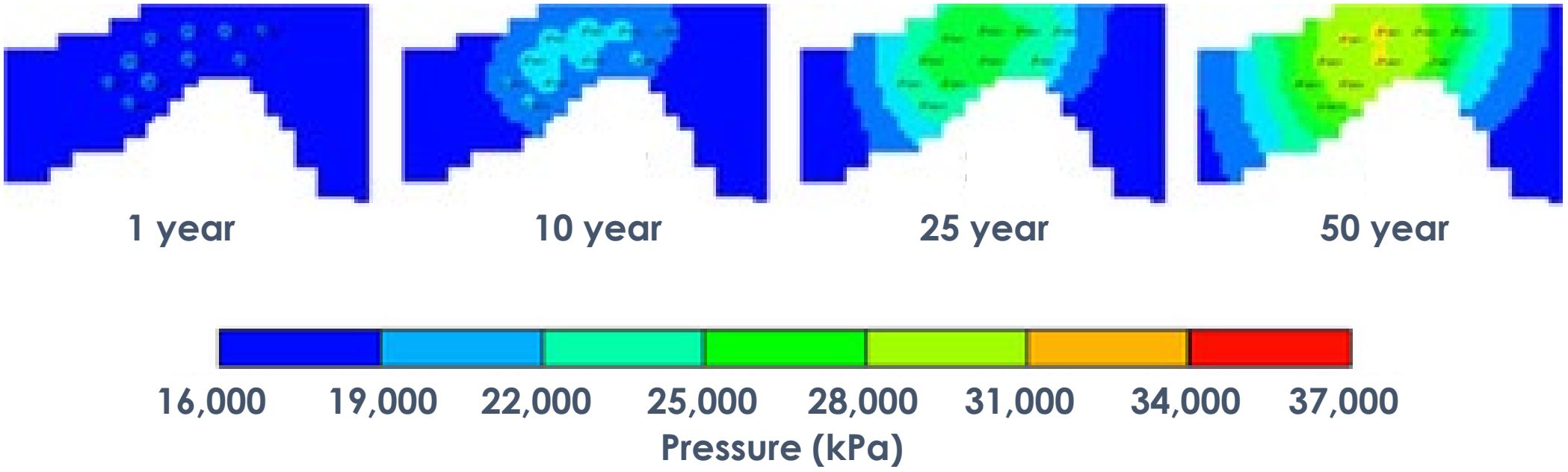
Pressure Buildup

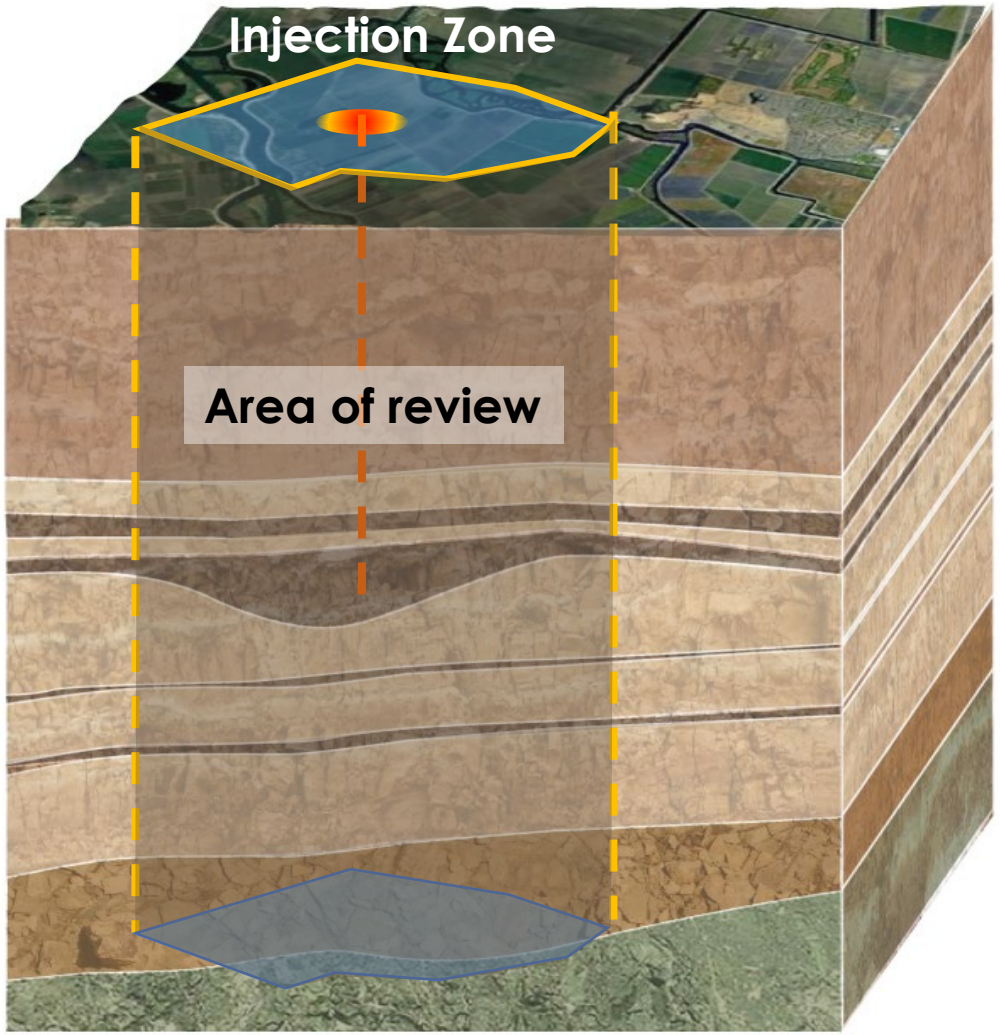
- Injecting CO2 into a deep geologic unit builds up a pressure front in the injection zone.
- For moderate-sized projects in reasonably permeable injection zones the area inside the pressure front can be surprisingly large.



Taken from: Ghaderi, Seyyed & Leonenko, Yuri. (2015). Reservoir modeling for Wabamun lake sequestration project. Energy Science & Engineering. 3. 10.1002/ese3.60.

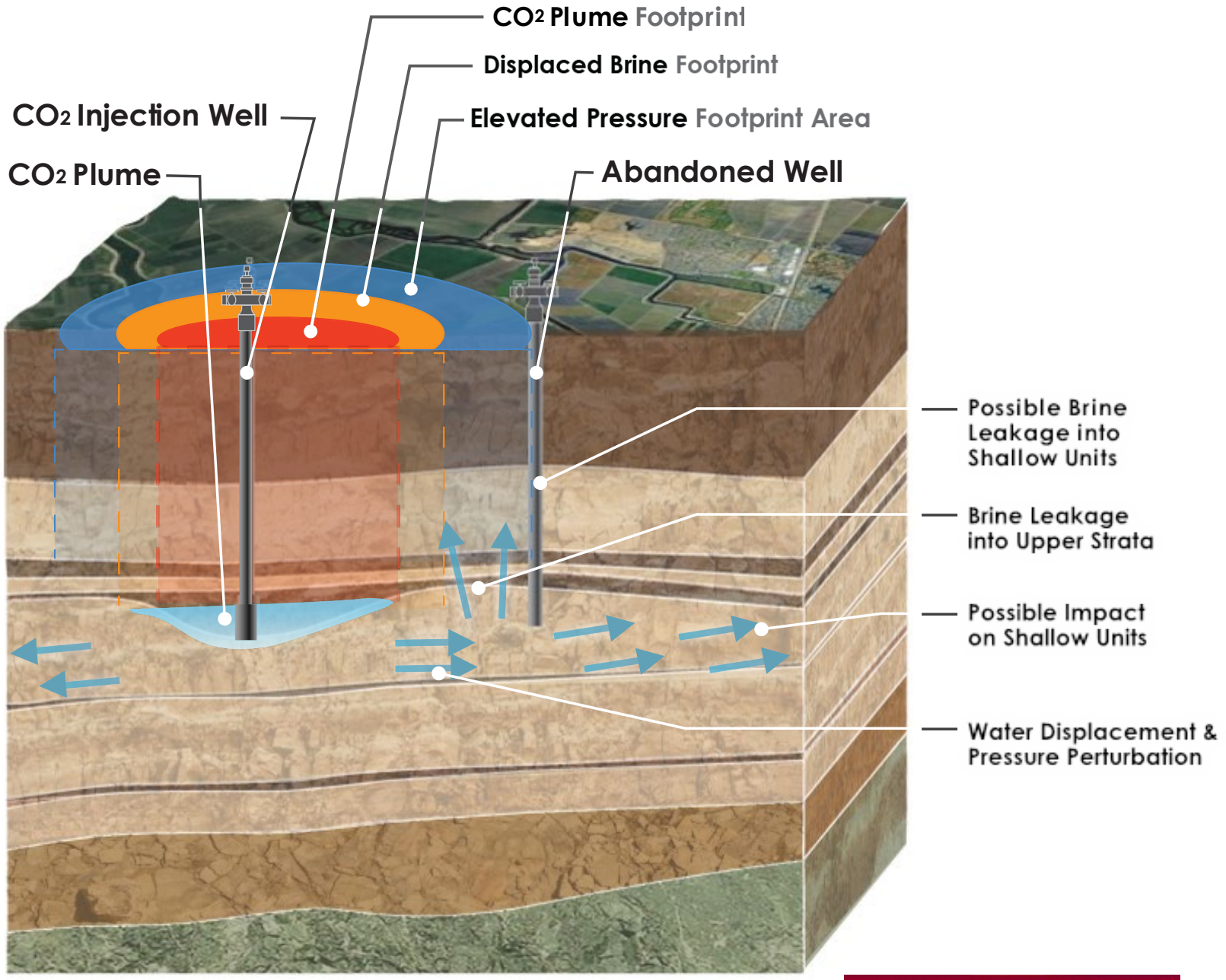
Area of Review

- Regulations require the applicant to evaluate the **area over which the pressure buildup** would be large enough to cause upward migration of brine from the injection zone through an improperly plugged well.
- This is part of the process called **AoR delineation**. It must be done in order to get a permit to construct a Class VI well and it must be reevaluated at least every 5 years and when certain conditions warrant.



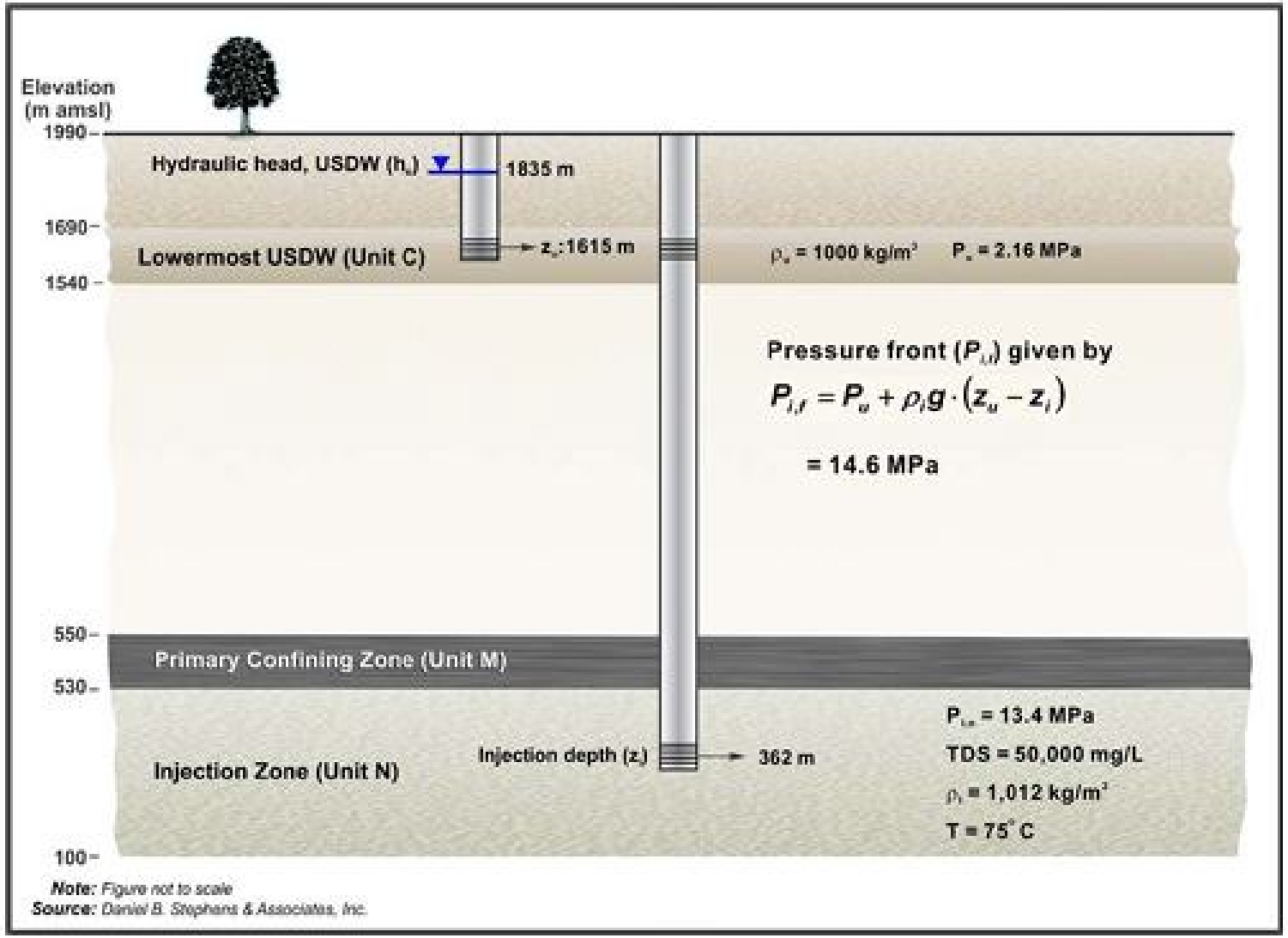
Critical Pressure

- For every site there is a critical pressure that needs to be determined
- The critical pressure is the pressure above which the flow of brine through an artificial penetration would be sufficient to endanger an USDW
- The endangerment could occur because of dissolved salts in the injection zone brine or other naturally occurring dissolved constituents.



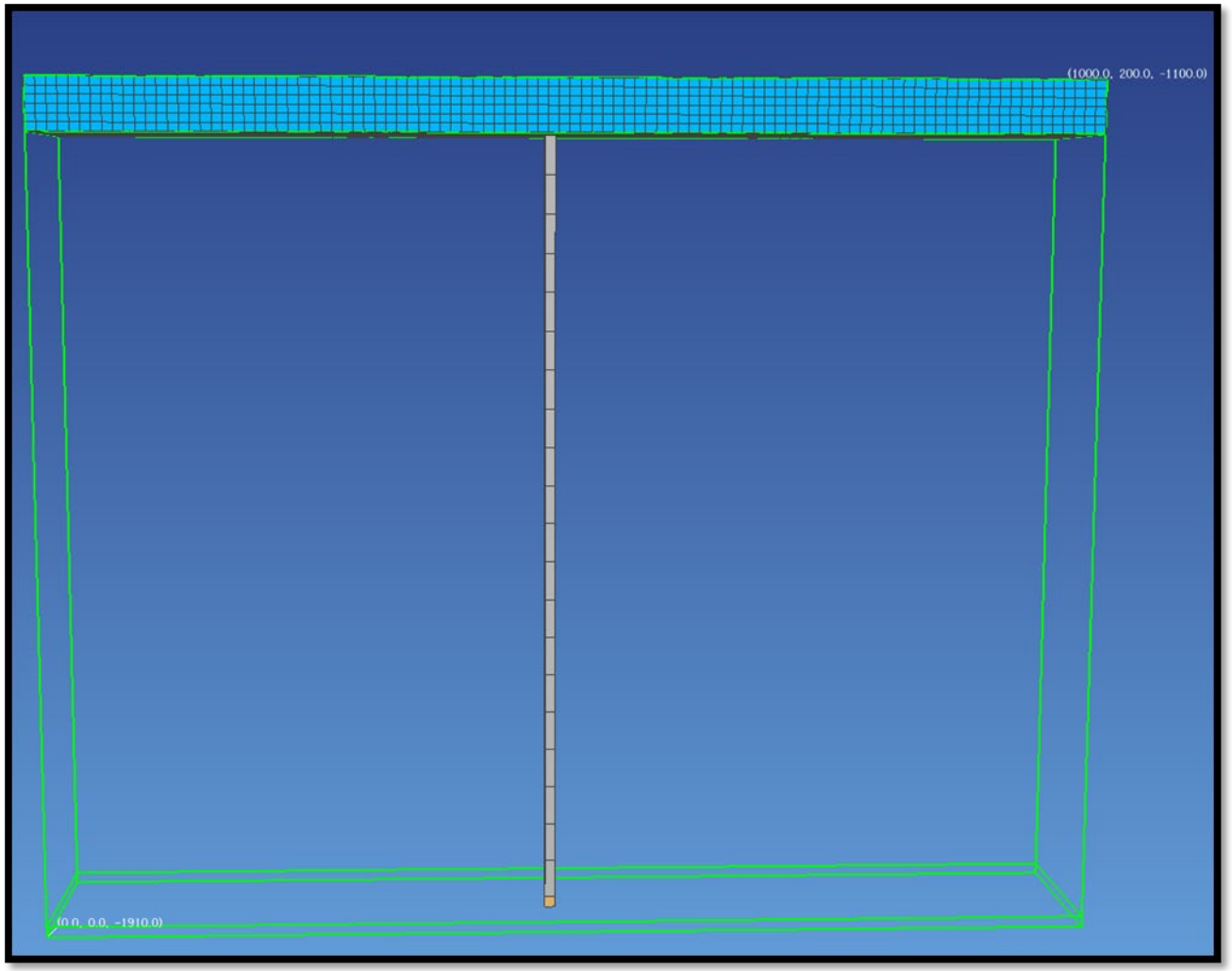
The simple method

- The EPA Class VI UIC Guidance gives you **examples of relatively simple ways to calculate the critical pressure**.
- They are **based on comparisons of the potential energy** of a brine-filled borehole with the potential energy of a borehole filled with some assumed starting condition.
- The **potential energy comparison** tells whether there will eventually be vertical migration (at hydrostatic equilibrium), **but not how long it would take** to reach this hydrostatic equilibrium state.

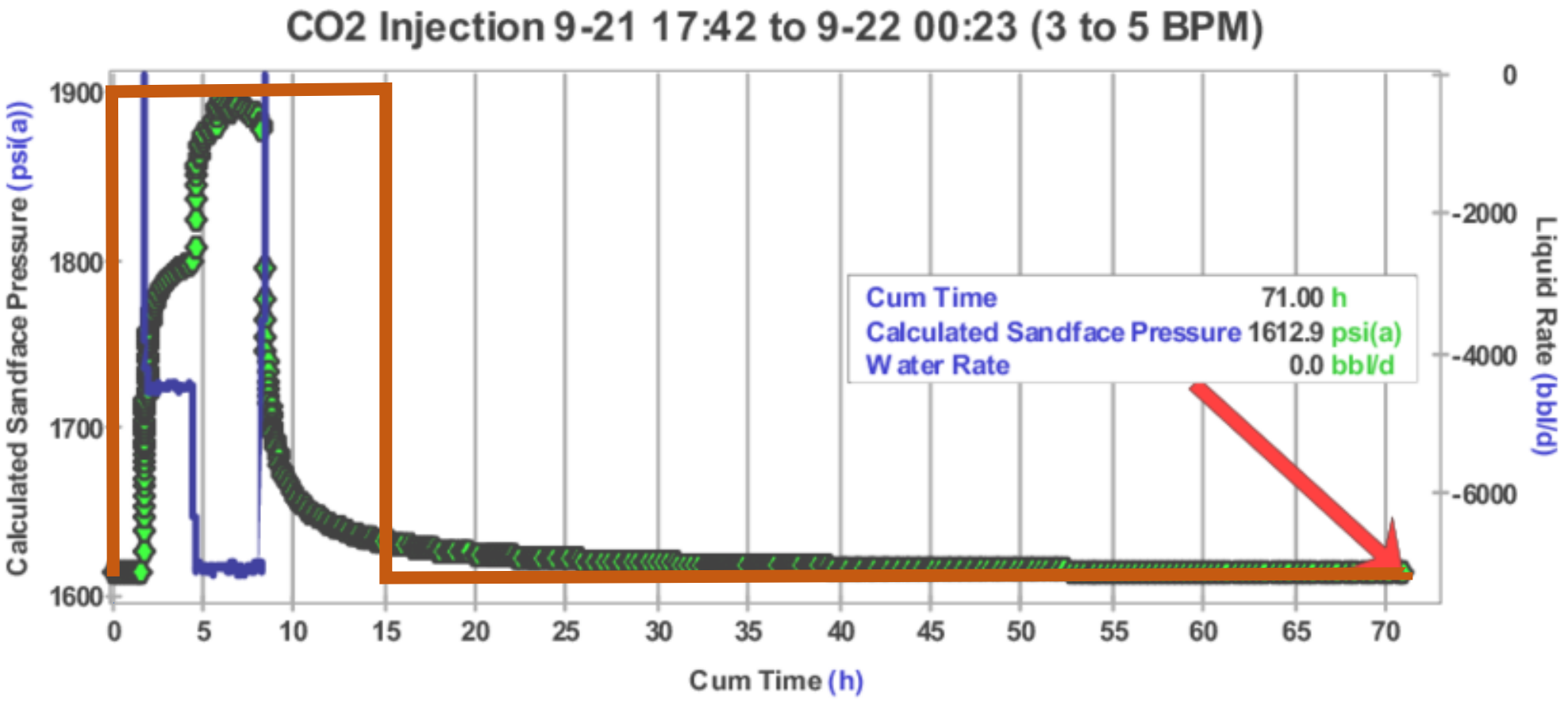


An Alternate Method

- The EPA Class VI UIC Guidance also states that you **can use numerical modeling** to determine the critical pressure.
- This approach has the **advantage** that it explicitly **takes into account the project-specific durations** of pressure buildup and dissipation; not just the eventual (hydrostatic equilibrium) outcome

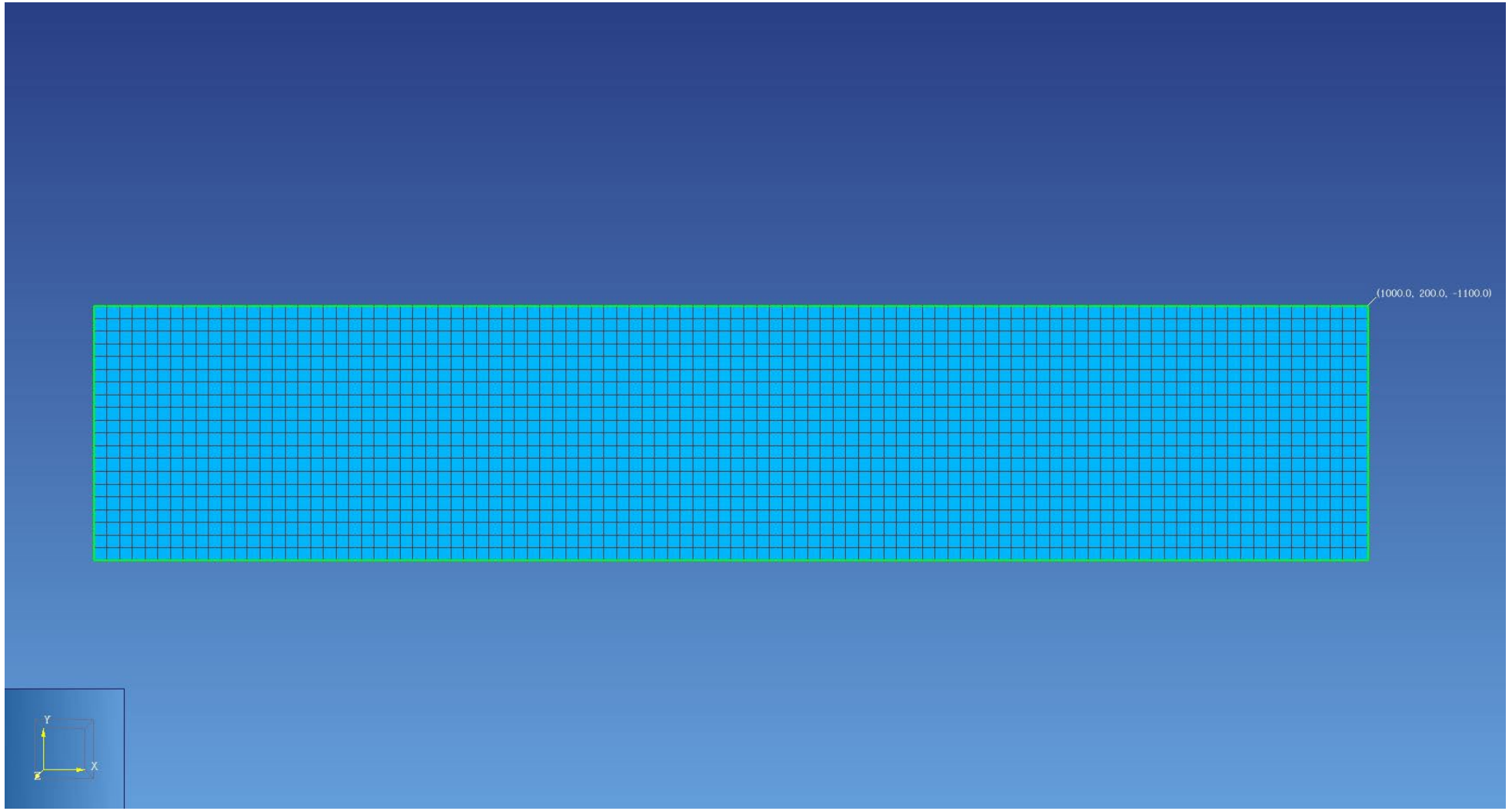


Typical Pressure Dissipation

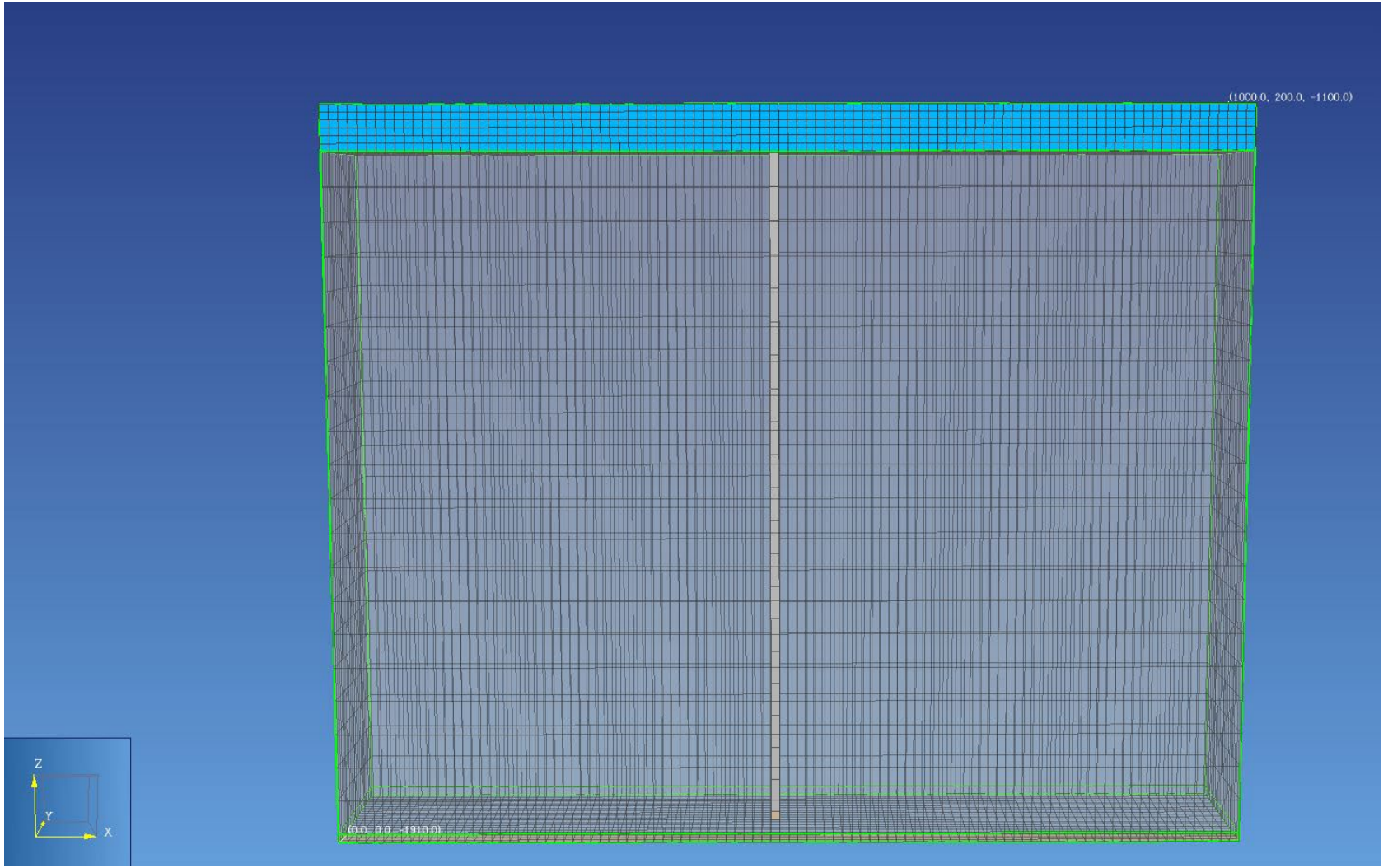


Gupta, Neeraj & Ball, David & Sminchak, Joel & Gerst, Jacqueline & Kelley, Mark & Bradbury, Judith & Cumming, Lydia. (2011). Geologic storage field tests in multiple basins in Midwestern USA–Lessons learned and implications for commercial deployment. Energy Procedia. 4. 5565-5572. 10.1016/j.egypro.2011.02.544.

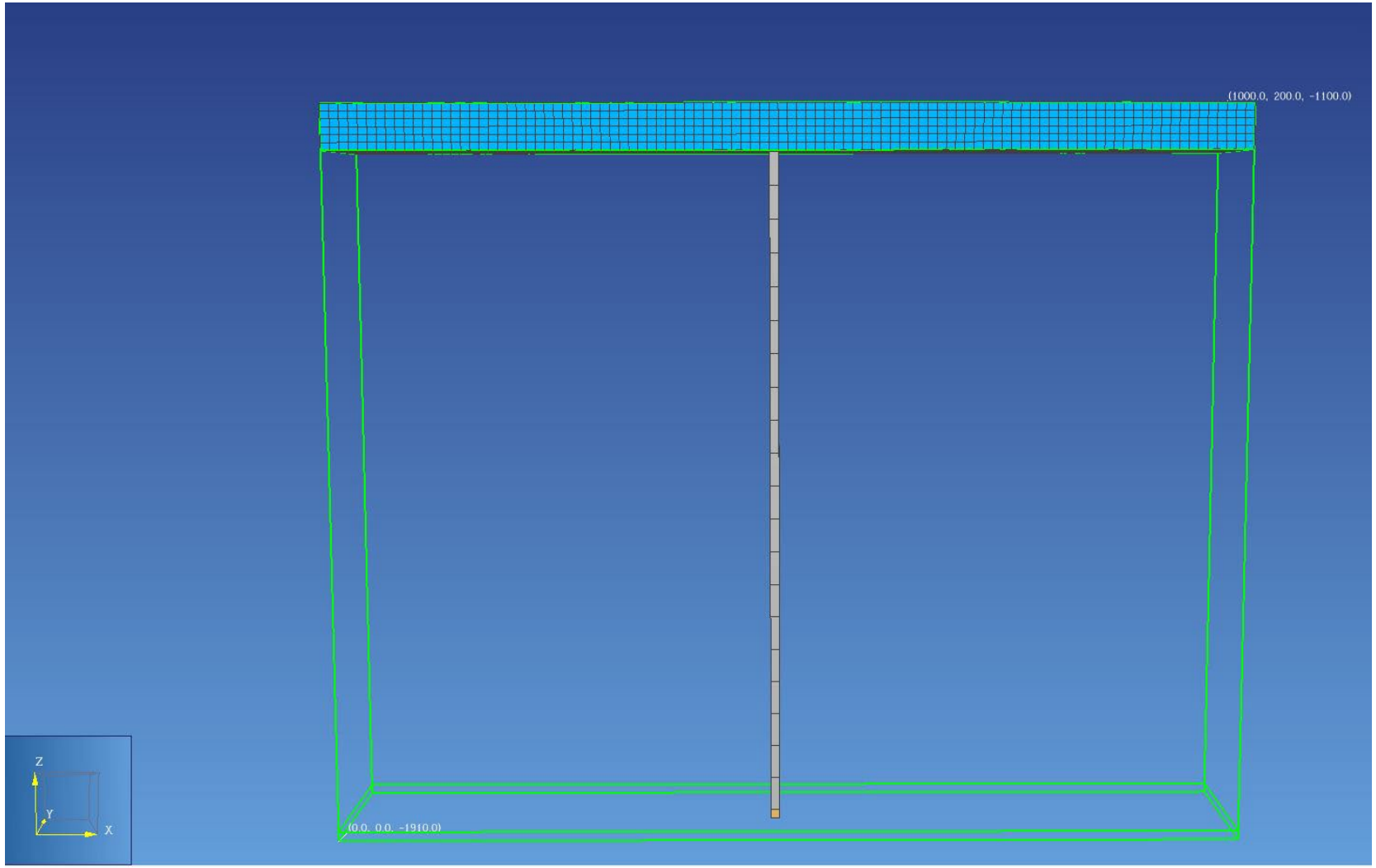
Single-Phase Two-Component Flow Model



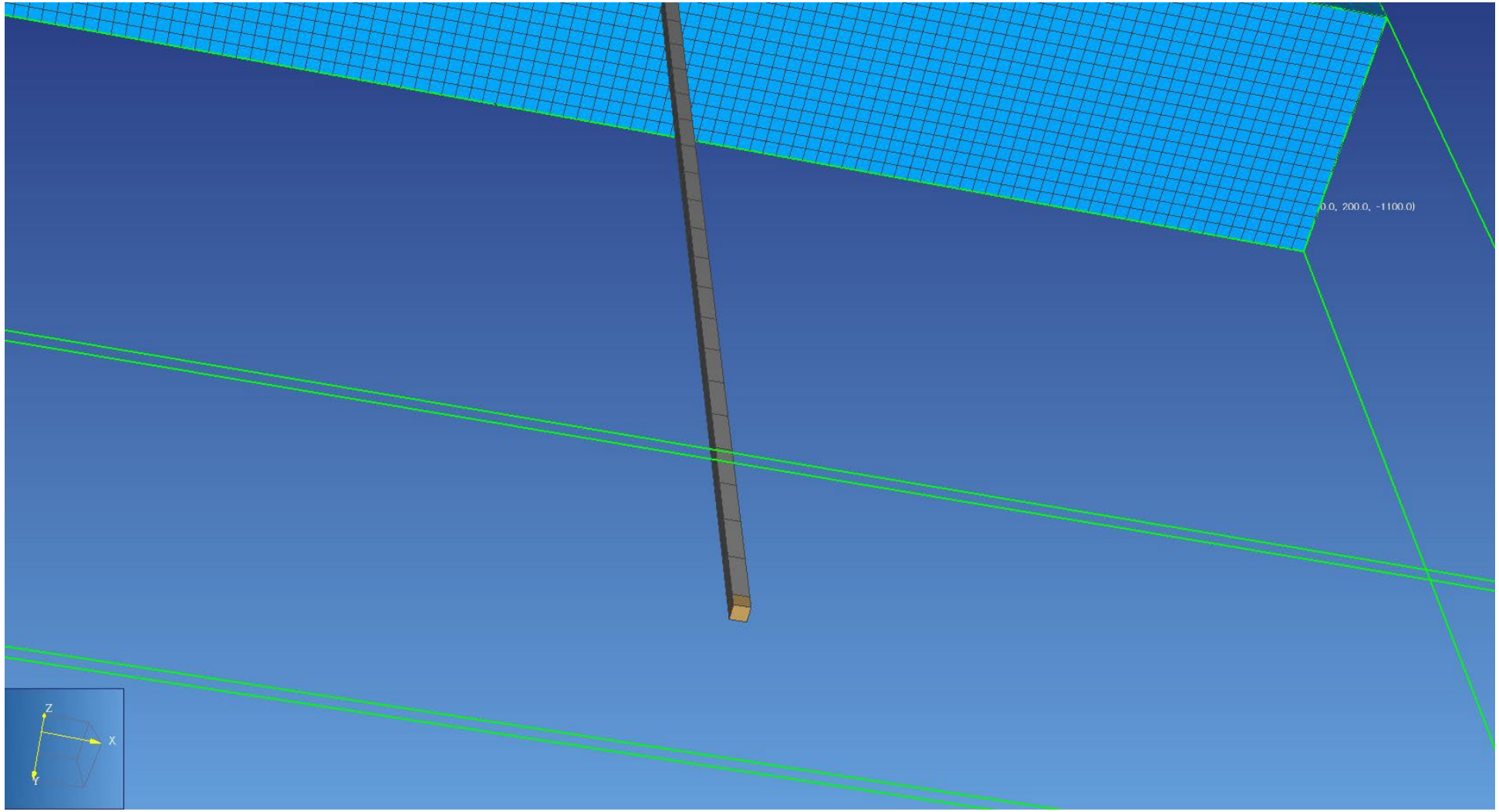
Rectangular Construction



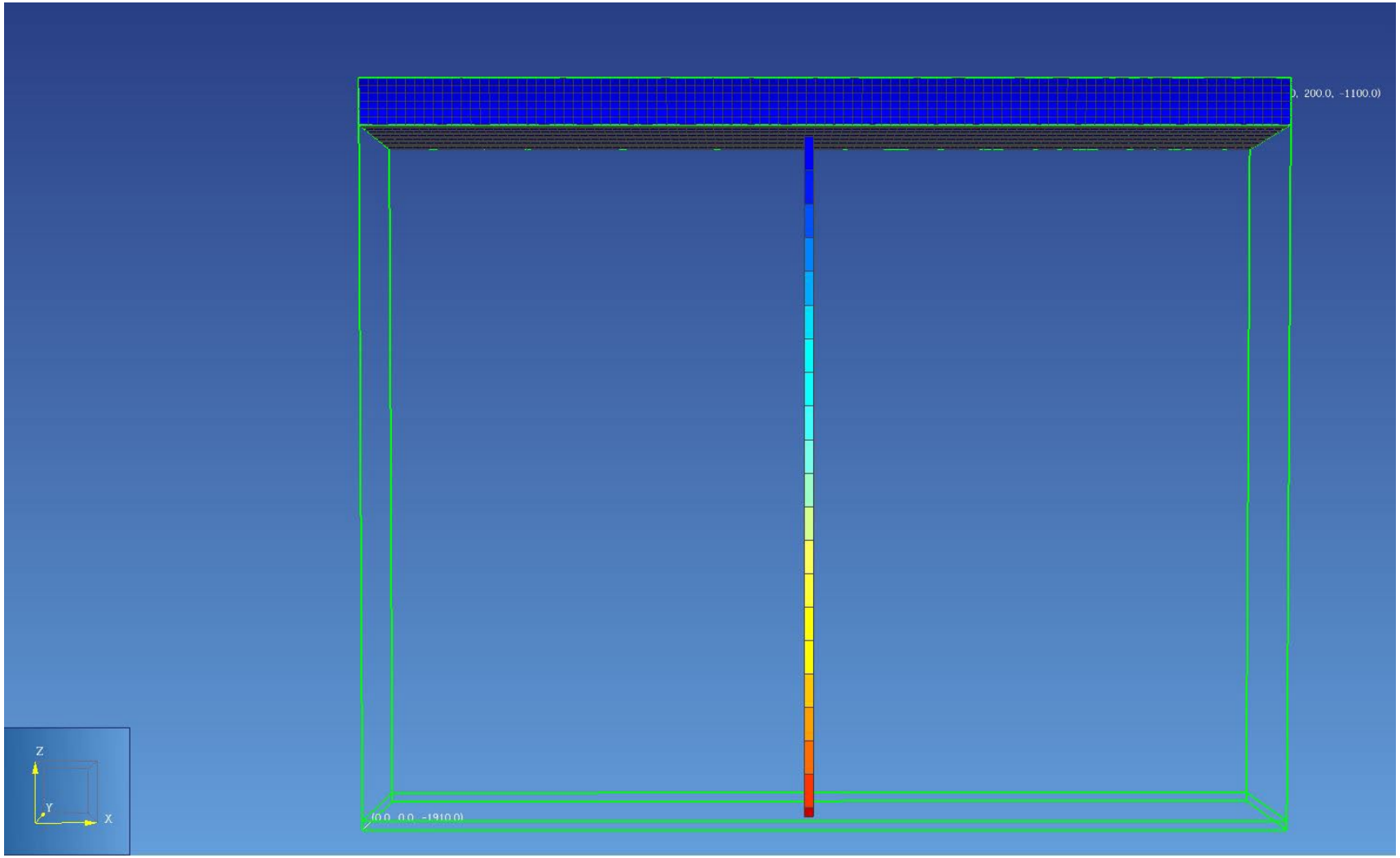
Designate Inactive Cells



Bottom Active Cell is in Injection Zone



Initial Hydrostatic Pressure Gradient



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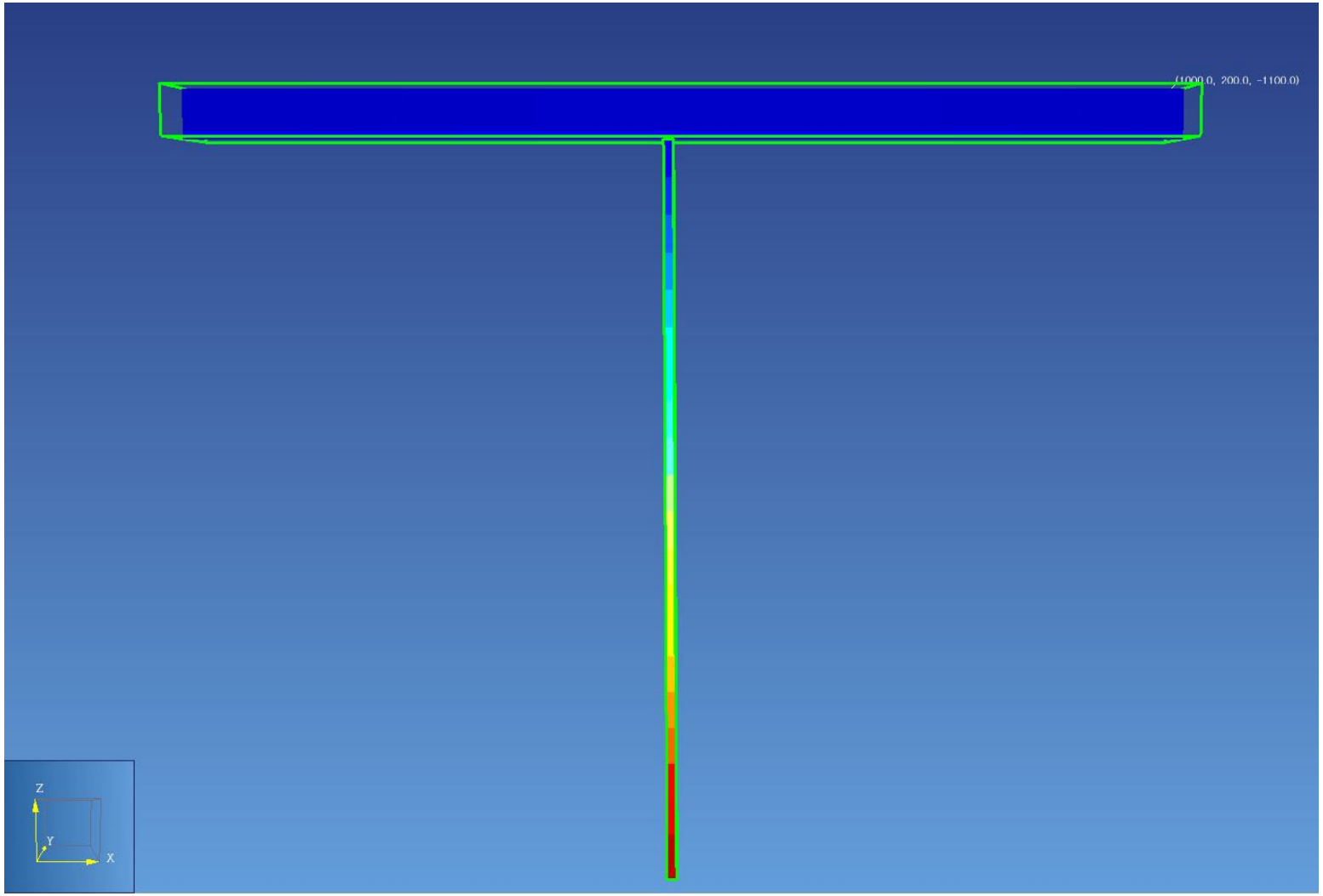
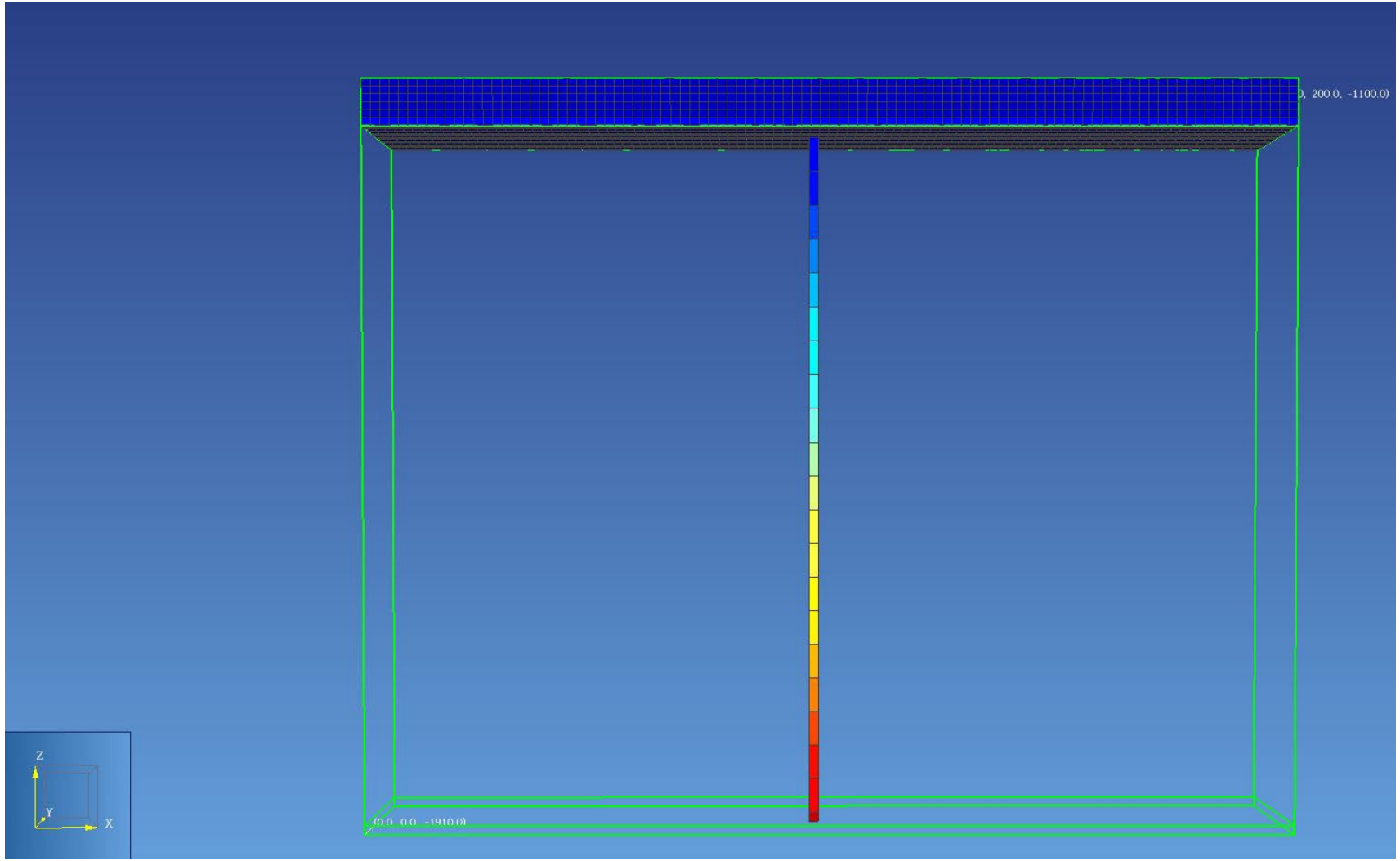
Final Calculated Pressure



Initial Temperature Profile from Geothermal Gradient



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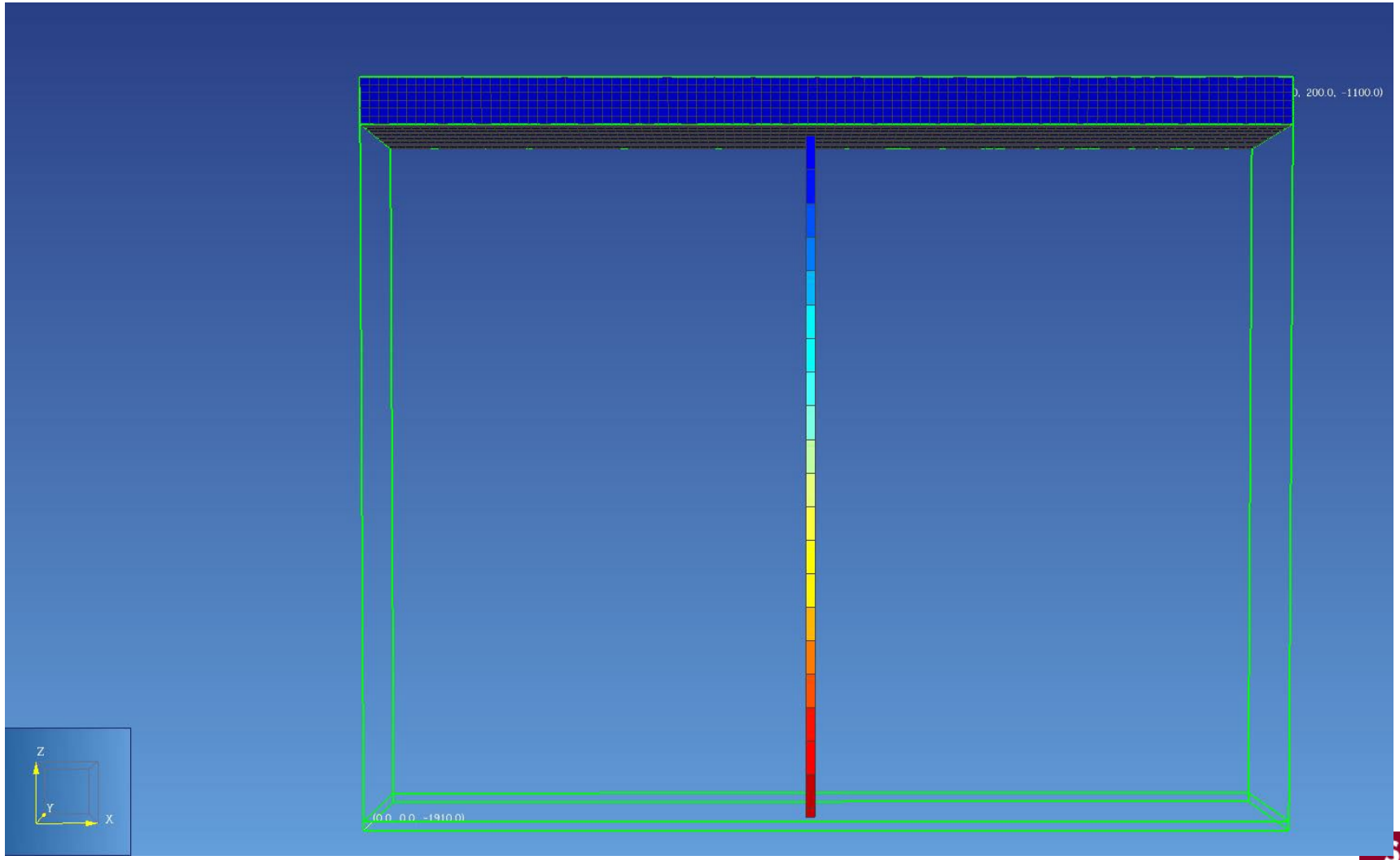
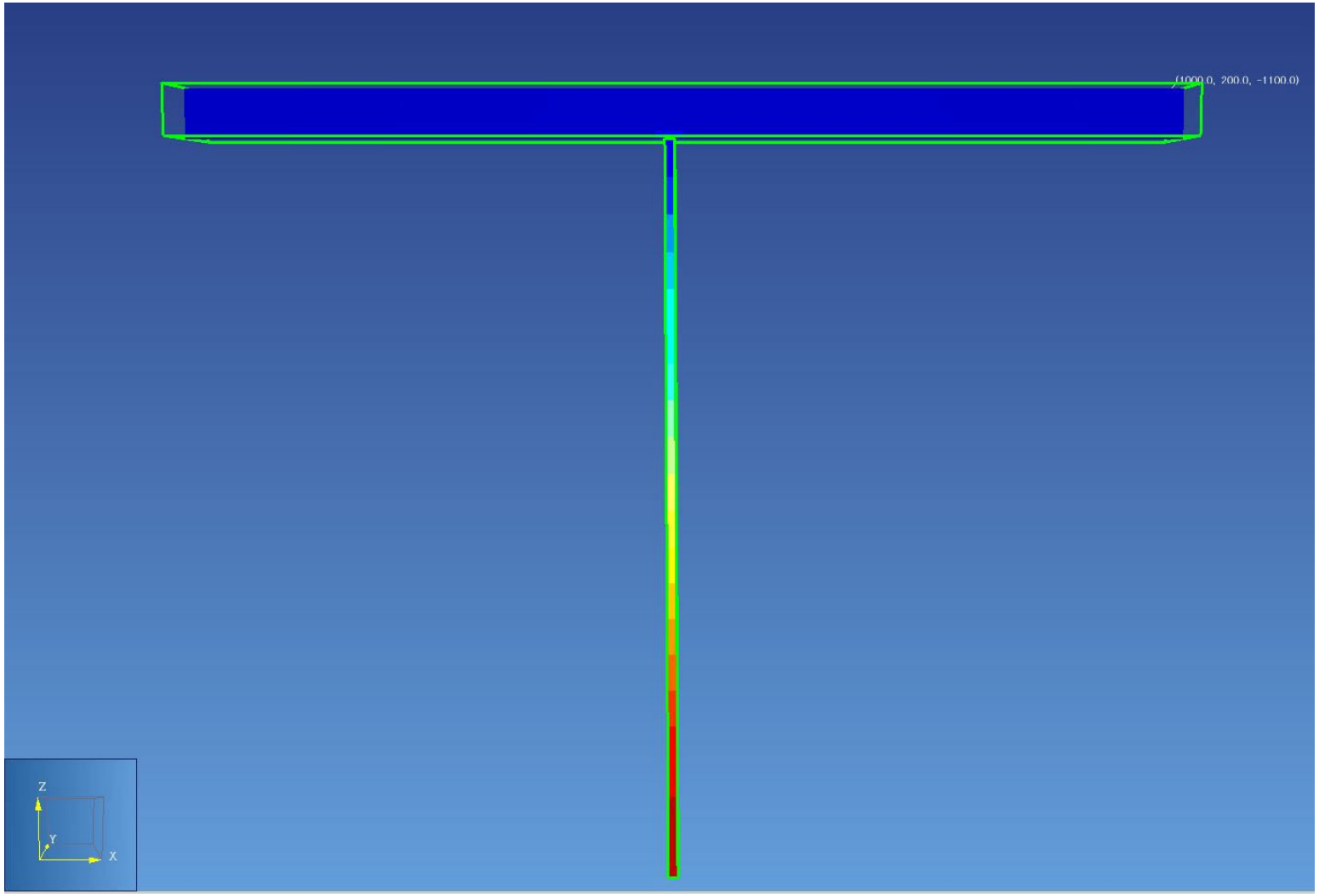
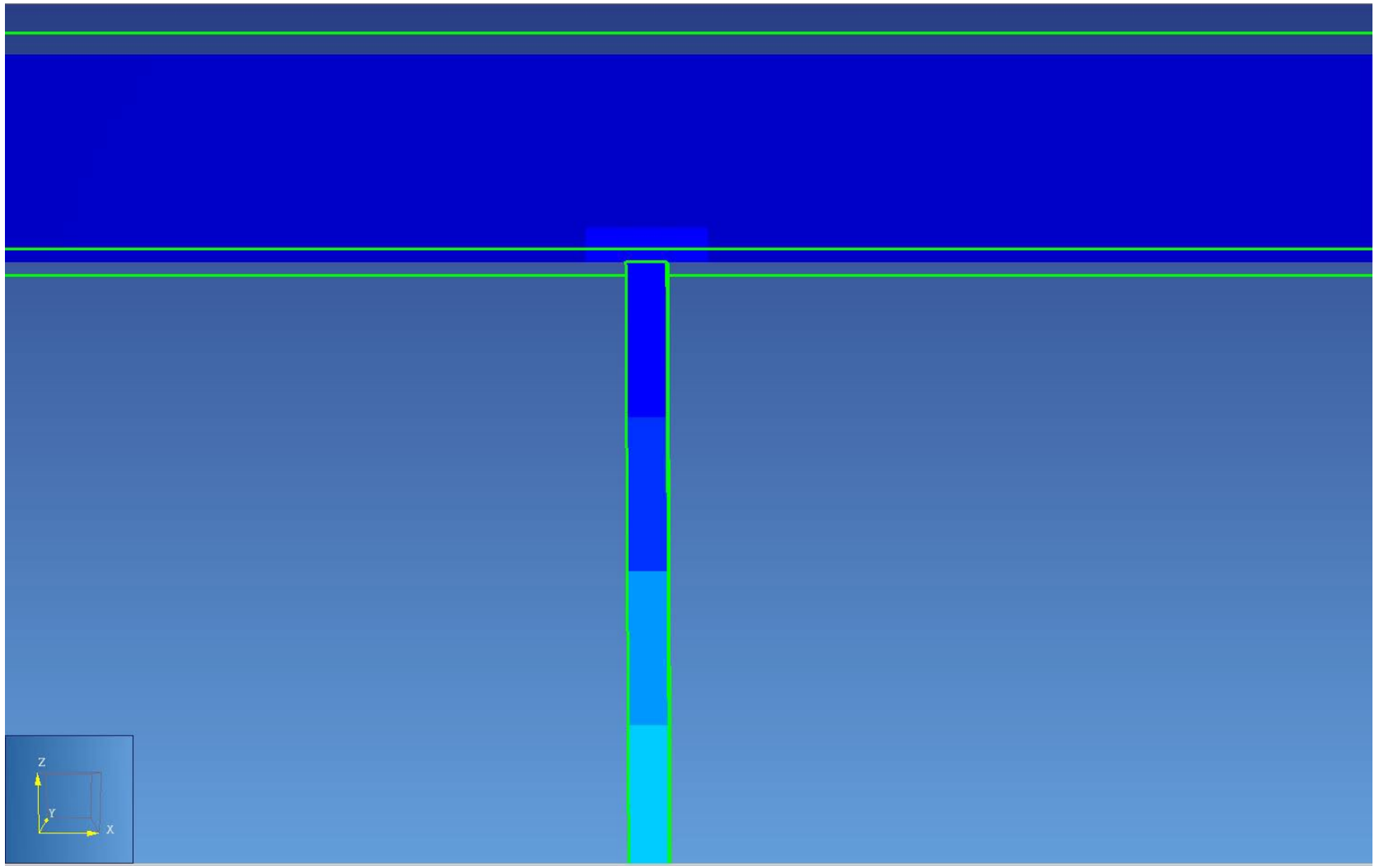
Initial Brine Composition is a Gradient Between USDW and Injection Zone



Final Brine Composition



Final Brine Composition



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Summary

- Compared to the simple potential-energy based approaches, the computational modeling approach to critical pressure calculations:
  - Is **more complicated** and **time consuming**
  - Requires **additional documentation**
  - Requires an **operational definition of endangerment**
- On the other hand, the computational modeling approach:
  - Is **more mechanistic and conceptually understandable**
  - Explicitly **addresses uncertainty**
  - **Can be updated** as additional Testing & Monitoring data become available
  - Provides a **more authentic representation** of the critical pressure, and hence the AoR

Thank you!

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