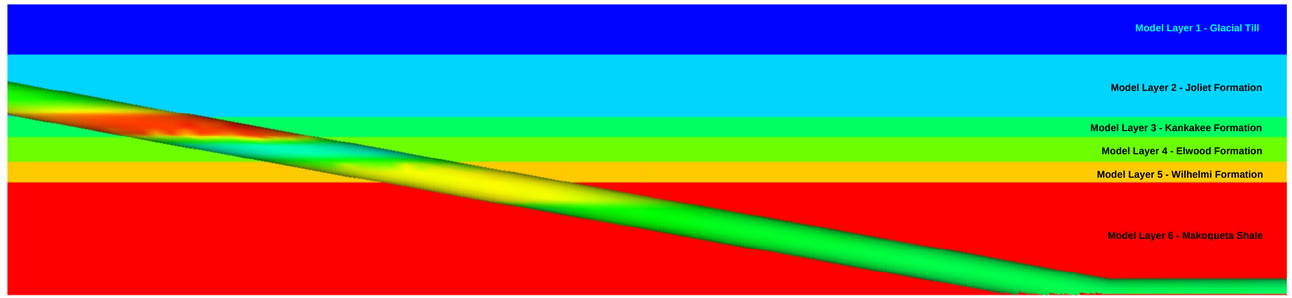
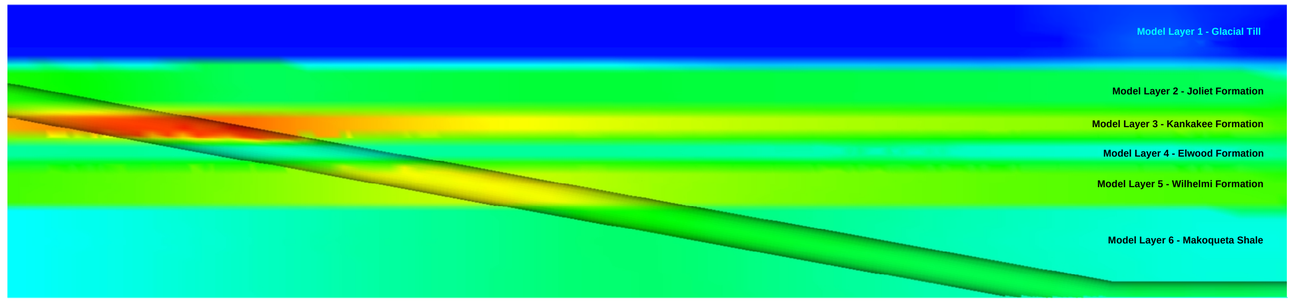
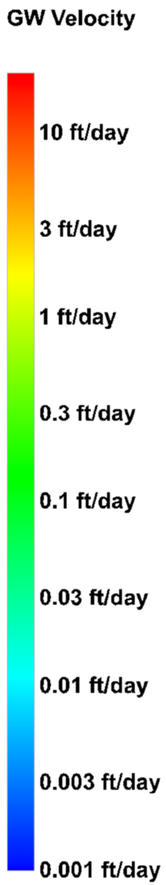
Cross Section A.

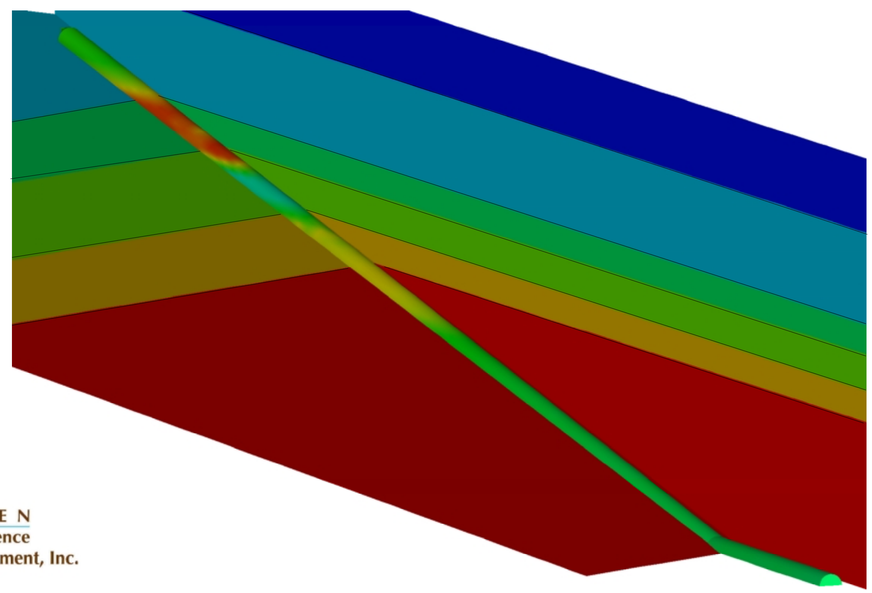


Cross Section B.





3-D Orthographic Project.



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The following plate presents the mapped, model simulated groundwater flow velocities, mapped onto a 3D tube, with a radius of 25 feet. The tube represents the NuMI Tunnel and the contoured groundwater flow velocities represent the inward groundwater flow velocities in each model later, mapped onto the surface the tube, at a radius of 25 feet from the center of the tunnel. This visualization illustrates the model simulated groundwater flow velocities, in each model/geologic layer, as groundwater enters the NuMI Tunnel.

Cross Section A. This visualization shows the groundwater flow velocities mapped within each model/geologic layer. The background shows a vertical slice plane through the geologic layers directly behind the tunnel. In this manner, the groundwater velocities, at a radius of 25 feet from the center of the tunnel, are shown within each geologic layer.

The results indicate that groundwater flow velocities, 25 feet from the center of the tunnel, are highest in the Kankakee (Layer 3) and Elwood (Layer 4) with groundwater flow velocities ranging from 10 to 24 feet/day.

The second highest groundwater flow velocities were simulated in the Wilhelmi Formation (Layer 5) and the upper portion of the Makoqueta shale (Layer 6) with groundwater flow velocities ranging from 1 to 3 feet/day.

Cross Section B. This visualization illustrates the groundwater flow velocities mapped onto the tube, with a vertical slice plane through the 3D groundwater velocity field behind it. Each model/geologic units is labeled as in Cross Section A.

This visualization effectively illustrates that the dominate groundwater flow vectors are horizontal towards the NuMI Tunnel within each geologic unit, and that the vertical component of groundwater flow, across each geologic unit, is significantly less. This is best illustrated in the Kankakee Formation (Layer 3) and the Wilhelmi Formation (Layer 5) which show much higher groundwater flow velocities with distance from the tunnel, than in the other geologic units. This is due to the higher horizontal hydraulic conductivities in layers 3 and 5, than in the other model layers.

In contrast to the other model layers, horizontal and vertical groundwater flow in the Makoqueta Shale appear to be similar in magnitude. This is due to the similar vertical and horizontal hydraulic conductivity in the Makoqueta. In addition, the depth of the tunnel in this unit is inducing significant downward vertical gradients. This allows groundwater flow velocities to remain relatively high in the Makoqueta Shale, even though the hydraulic conductivity in this unit is low compared with the other geologic units.

3D Orthographic Projection C.

The orthographic projection illustrates that groundwater inflow occurs around the entire circumference of the tunnel; top, bottom, and sides. This conclusion only pertains to groundwater flow within each geologic unit, not vertically across each unit, since as illustrated in A and B, vertical groundwater flow across each geologic unit is limited by the units vertical hydraulic conductivity. The exception to this, however, is the Makoqueta shale which has comparable vertical and horizontal hydraulic conductivities, therefore, horizontal and vertical groundwater flow velocities are similar.

Based on this analysis, the following conclusions are observed:

- The groundwater flow velocity into the NuMI Tunnel is highest in the Kankakee Formation (Layer 2) with model simulated groundwater flow velocities ranging from 10 to 24 ft/day, 25 feet from the center of the tunnel.

- The second highest groundwater flow velocity was observed in the Wilhelmi Formation (Layer 5) and the upper portion of the Makoqueta shale (Layer 6) with velocities ranging from 1 to 3 ft/day.

- Horizonal groundwater flow was the dominant flow direction within each geologic unit, with vertical groundwater flow across each geologic unit significantly lower. This was observed in all model layers with the exception of the Makoqueta shale (Layer 6) which showed comparable vertical and horizontal groundwater flow velocities due to the more isotropic conditions in this unit.

Plate D.

Model Simulated Groundwater Flow Velocities (ft/day) 25 feet from the Center of the NuMI Tunnel
NuMI Groundwater Flow Model
Fermi National Accelerator Laboratory
Batavia, Illinois