# RockWare Consulting
# Soil & Groundwater Contamination Model 3D Visualization
# Guidelines & Considerations

3/9/21/JPR

When providing data to RockWare for subsequent modeling and 3D visualizations, please provide the information listed below. This list may seem obnoxious, but consider this: Every phone call or email costs time and money. Stopping a project and waiting for a reply means that the persons doing the work must re-acclimate during the restart process which translates to more time and money.

- **Coordinate System**: Are the XY coordinates in UTMs, State Plane Coordinates, or something else?

- **Coordinate System Zone**: If the XY coordinates are in UTMs or State Plane Coordinates, please provide the zone number.

- **Coordinate Units**: Are the XY coordinates expressed in feet, meters, or something else? There is such a thing as UTM-Feet.

- **Elevation Units**: Do the collar elevations represent feet or meters? Assuming that the elevations are in the same units as the XY is a mistake. We often receive data in which the XYs represent meters while the Z's represent feet.

- **Depth Units**: Do the depths represent feet or meters. You'd think that depths would be expressed in the same units as the collar elevations, but this has proven to be an unsafe assumption when multiple contractors are involved.

- **Project Extents:** If unspecified, RockWare will define the project extents based upon a north/south/east/west rectangle that encloses the monitor wells. If a larger area or sub-set area is to be used for the maps and modeling, RockWare needs to know about it.

- **Digital Elevation Model (DEM)**: If available, a DEM is often used to truncate the top of an interpolated model. With the proliferation of UAVs (Unmanned Arial Vehicles) and 3D laser scanning, DEMs can dramatically improve the quality of a model. If a DEM is not available or not important (e.g., a flat parking lot), RockWare can readily create one based on the collar elevations.

- **Aerial Photograph**: If available, a UAV photograph can be used as a reference layer for 2D maps and 3D diagrams. If not available, RockWare can readily "scrape" an image from Google Earth. The advantage of UAV photographs is that they are typically more recent and higher-resolution than the Google Earth imagery.

- **Output Coordinates**: RockWare has the ability to perform many different types of coordinate conversions. Just because the data is provided in a given coordinate system doesn't mean we can't provide the output in something else. For example, if the XY data is provided in UTM meters and the provided depths are in feet, we can convert the XYs to State Plane Coordinates so that all output is in feet. Using the same units for all three dimensions is important when specifying vertical exaggeration factors and computing material volumetrics.

- **Vertical Exaggeration**: Most cross-sections and 3D diagrams require some level of vertical exaggeration to be usable. It is helpful (but not required) if the client provides some guidelines.

- **Target Audience:** It really helps if RockWare understands who the output is designed for because we can make recommendations based on our experience with other projects. There's a big difference between output designed for review by a technical expert versus a town council.

- **Non-Detects**: Analyte data often contains non-numeric flags (e.g., "ND", "<0.01", "N/A") that indicates if a sample fell below the detection limit of the analytical device. If such is the case, RockWare needs to know how the numeric modeling should handle these flags. For example, should we could use zero, one-half of the detection limit (in which case we'll need to know what the detection limit is), or some other strategy.

- **Cutoff Levels**: When plotting contamination plumes, the values below a threshold level are rendered transparent (Figure 1). Typically, these thresholds represent state or federal MCL (Maximum Contaminant Levels). It is important that these thresholds be provided by the client. This is not to say that multiple thresholds cannot be used (Figure 2), in which case we need to know what they are.

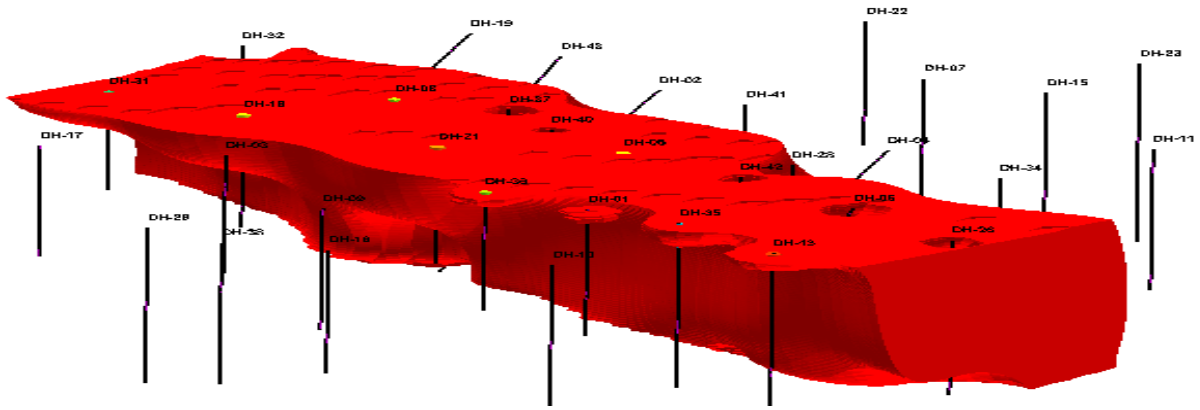



*Figure 1. Solid Model Isosurface: Voxels < MCL = Invisible Leaving Just The Voxels Above MCL*

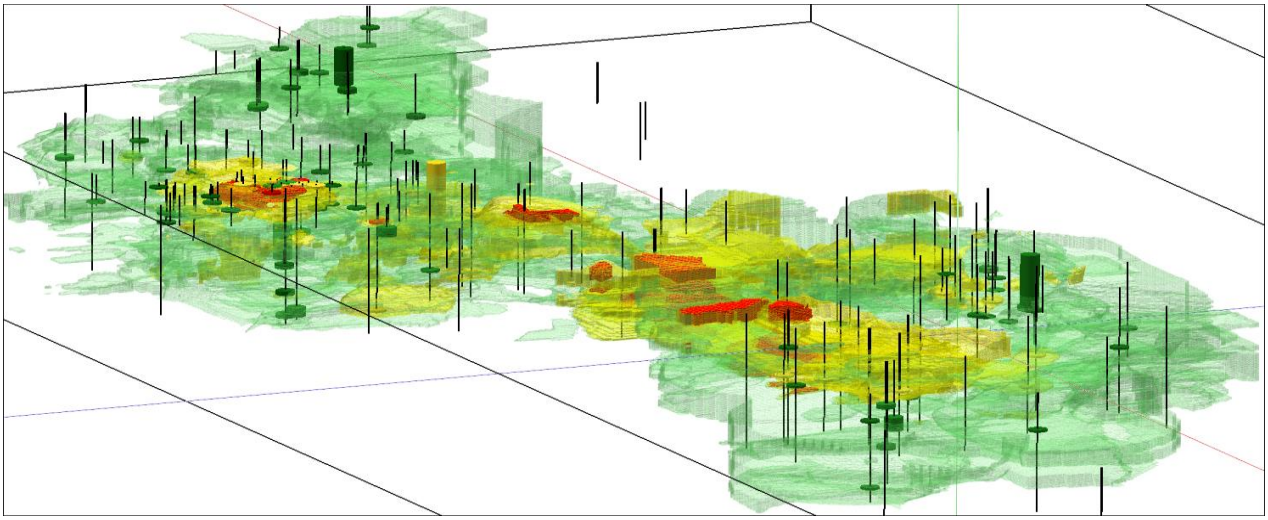


*Figure 2. Three Different Cutoff Thresholds: High Values = Opaque Red Isosurface, Medium Values = Slightly Transparent Yellow Mesh, Low Values = Very Transparent Green Mesh*

- **Sampling Periods**: When processing time-based data and creating time-based plume migration animations (e.g., RockWorks2020 Contaminant Plume Migration Voxel Animation - YouTube) , we need to know about the sampling periods. For example, let's say that a site was sampled on a quarterly basis and each sampling event took two or three days. We need to know the starting and ending data for the sampling intervals so that all of the data sampled between those dates can be filtered into a single data set for modeling purposes.

- **Lateral Interpolation Constraints**: Modeling algorithms can be very creative when data is sparse. Extending models too far outside the region occupied by control points is scientifically questionable and implicitly diminishes the credibility of the presentation. RockWare offers some simple methods for limiting the lateral extents of the interpolation such as arbitrary distance cutoff filters and convex hull truncation (Figure 3) that can be used to limit the modeling.

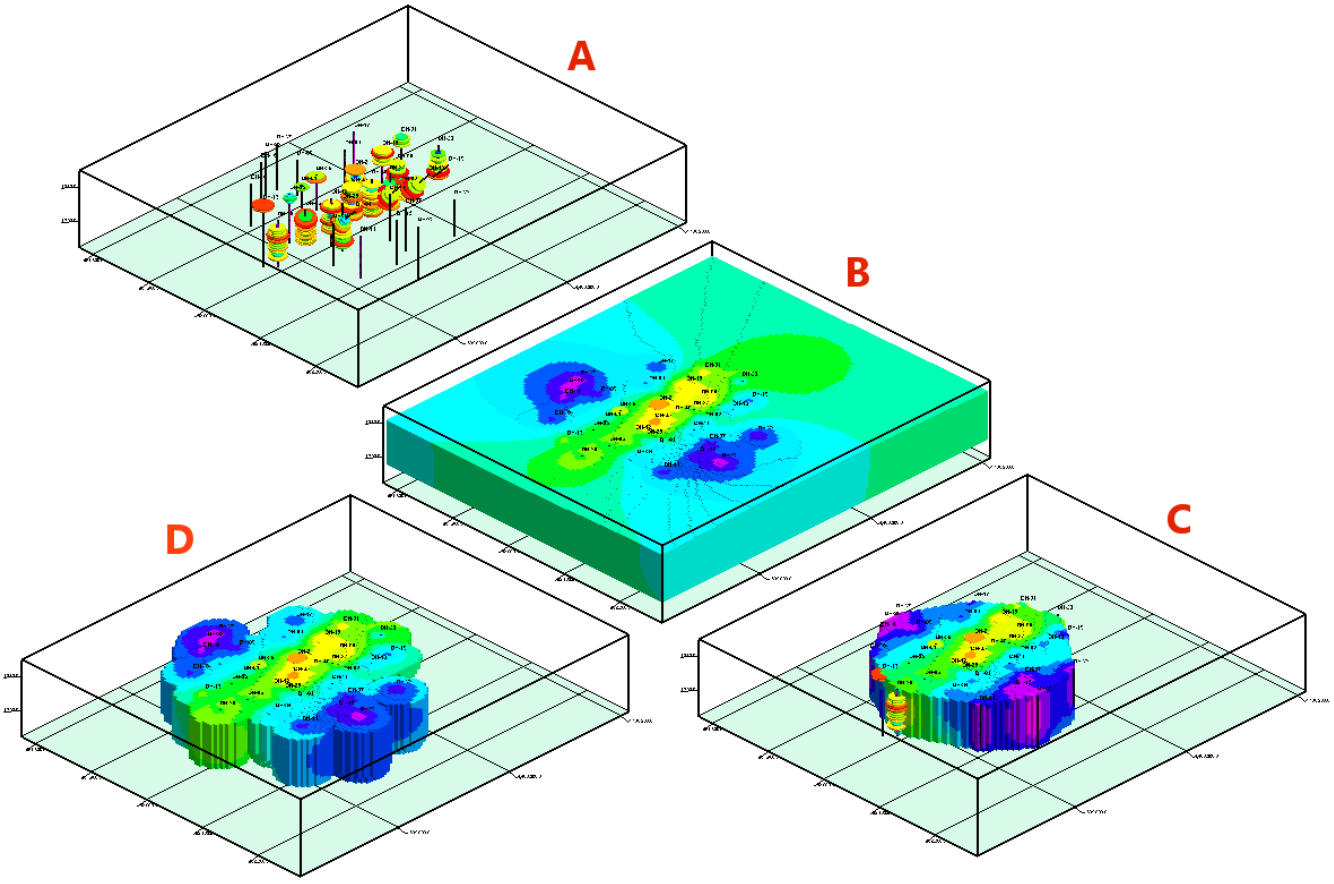



*Figure 3. (A) Boreholes (B) Model w/o Convex Hull Truncation (C) Model w/Convex Hull Truncation (D) Model w/Distance Truncation*

<Examples>

- **Vertical Interpolation Constraints**: When dealing with groundwater contamination, surfaces such as aquitards, aquicludes, and water levels can be used to vertically constrain the contaminant model. It is also possible to create three-dimensional hydraulic conductivity models to limit the contaminant modeling. This link provides a more thorough explanation of how these hydraulic models can be used to constrain the geochemical modeling: [Time-Based-Modeling-Analysis-Visualization.pdf (rockware.com)]

- **Model Resolution**: The voxels within a 3D (solid) geologic model are not cubes. Instead, they are parallelopipeds in which the height is much smaller than the horizontal dimensions. This is because geological properties are much more variable in a vertical direction than the horizontal (thanks to gravity). As a consequence, the height of a voxel essentially determines the resolution of a model. For example, if ½" thick zones are to be identified, the voxel height should be set to ¼". Conversely, the x and y dimensions of a voxel is typically set to ½ of the average minimum distance between control points (e.g., monitor wells). This means that geological models are typically made up of very thin voxels. As a consequence, it is helpful to let RockWare know the level of vertical resolution that you're interested in. For example, if you tell us that you want to discriminate zones that are 1" think, we'll need to set the model dimensions accordingly.

- **Model Opacity**: Adjusting the model opacity to 50% allows the user to see the borehole information inside the model. Although it's not as pretty as the 100% opaque model, a transparent model provides the viewer with an understanding of the relationship between the plume outline and the original data. Telling a jury that the "boreholes are real while the blob is conjecture" will elicit nods of understanding and trust.

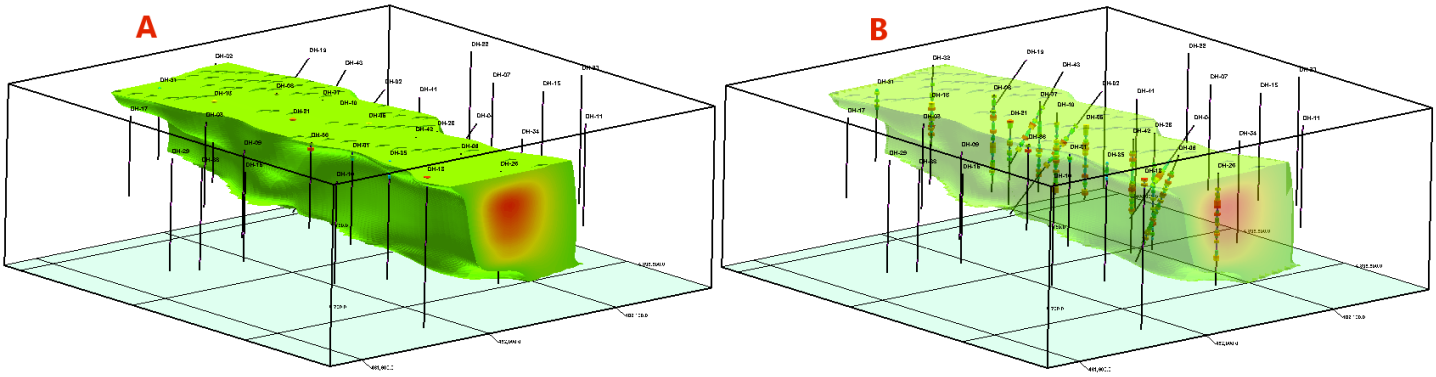



*Figure 4. (A) Opaque Model Hides Portions of Boreholes Within Isosurface (B) Transparent Isosurface Shows All Borehole Data*

- **Existing Diagrams**: Any existing diagrams, even conceptual sketches, can help by bringing RockWare staff "up to speed". Diagrams can be especially helpful if complex geology or a complex groundwater system is controlling the contamination spread.

- **Infrastructure**: Plotting infrastructure features (e.g., buried tanks, buildings, pipes, etc.) can visually orient the viewer (Figure 5). If infrastructure is to be included, we'll need to mutually establish the most expedient way of going about it (e.g., importing Shape files, digitizing features from imagery).

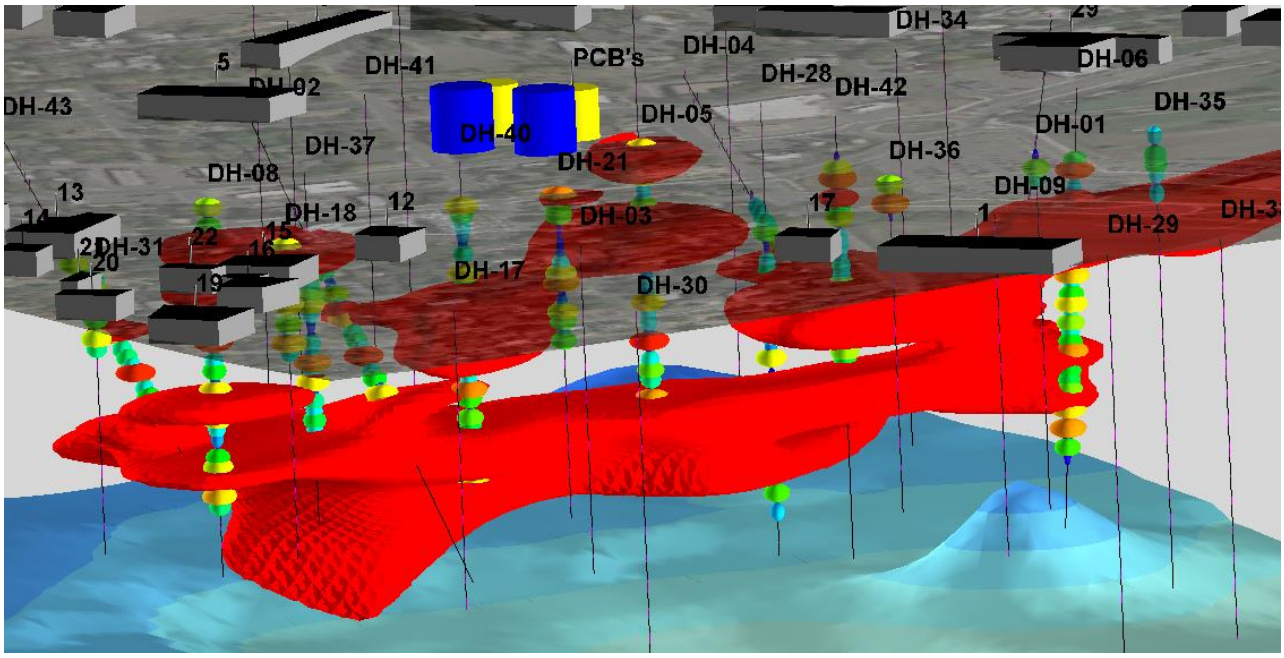
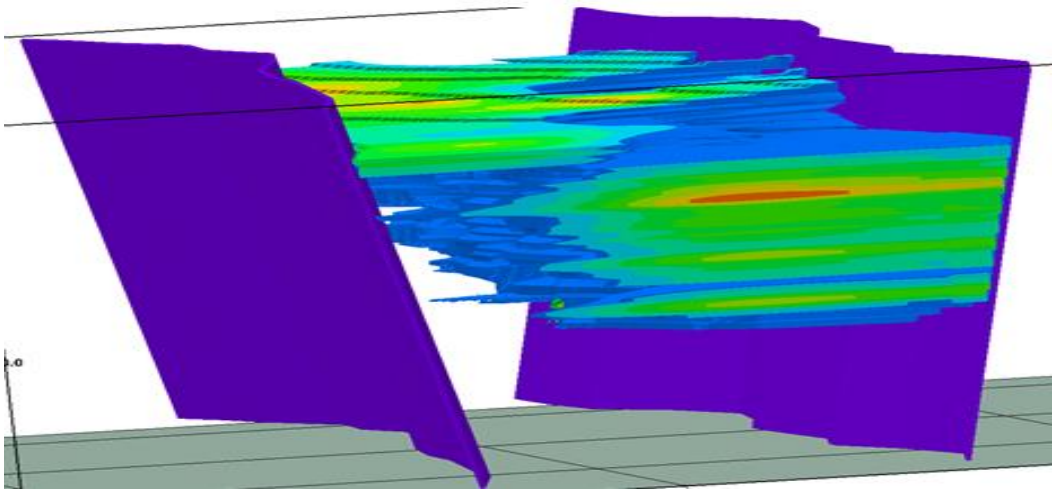



*Figure 5. Infrastructure Floating Above Contaminant Model*

- **Faults**: If the contaminant is constrained by faults (Figure 6), we'll need the fault data (e.g., points along the fault(s) with dip information).



- *Figure 6. Fault-Constrained Geochemical Model*