

Converting a Lithology Model to Hydraulic Conductivity or Permeability Models

Converting a lithology model to hydraulic conductivity or permeability models (Figure 1) can be automated by using the new Lithology->K program. This document provides a step-by-step description of how this can be accomplished.

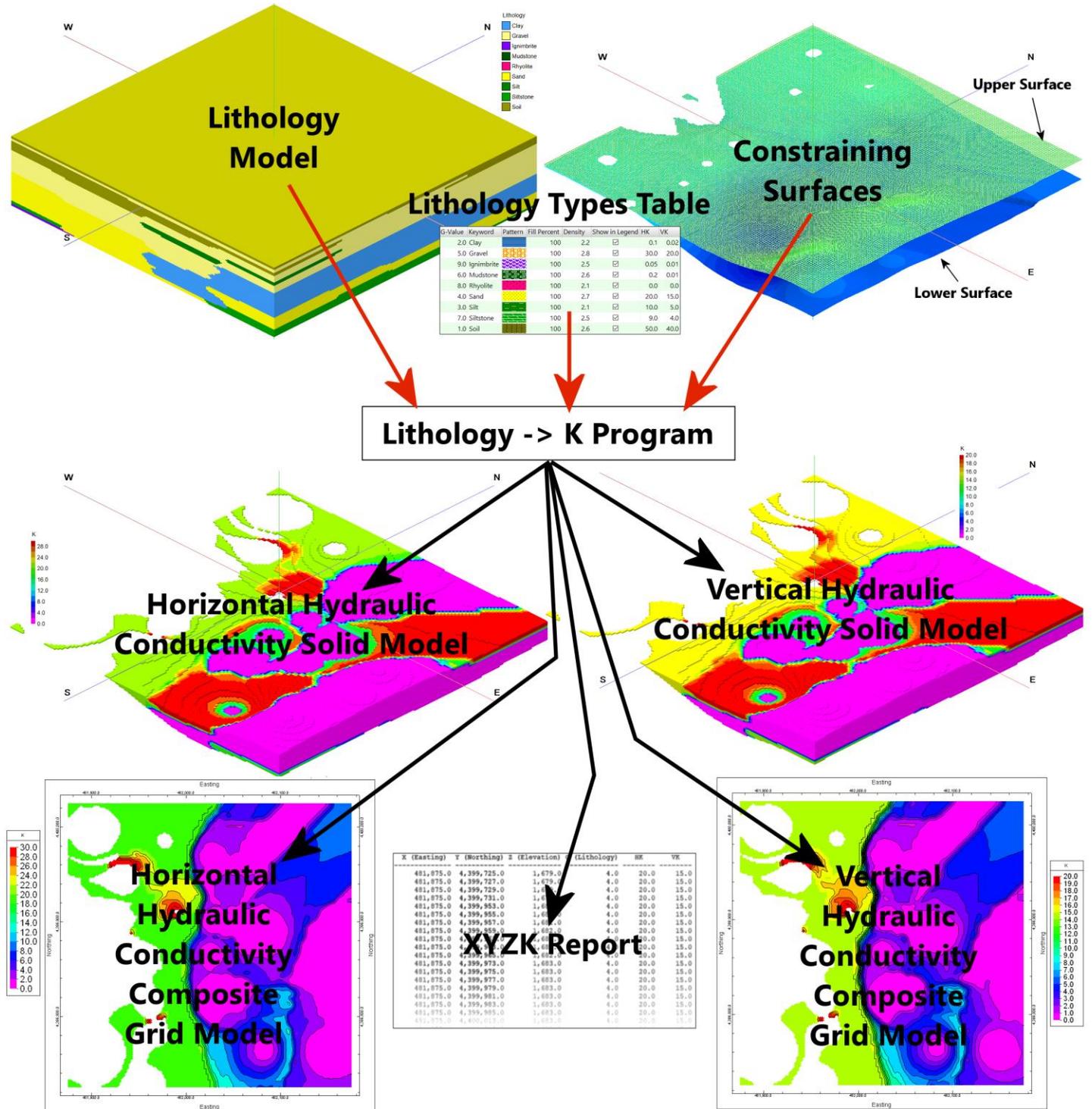


Figure 1

Step 1. Open the Lithology Types Table (Figure 2).

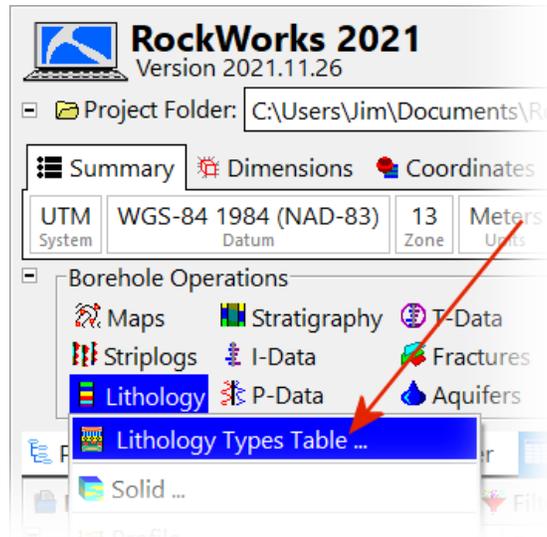


Figure 2

Step 2. Select the Edit Fields option from the Lithology Types Edit pull-down menu (Figure 3).

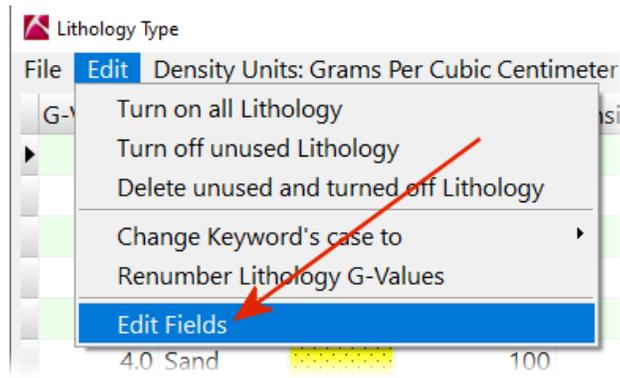


Figure 3

Step 3. Select the New File option from the Optional Fields menu (Figure 4).

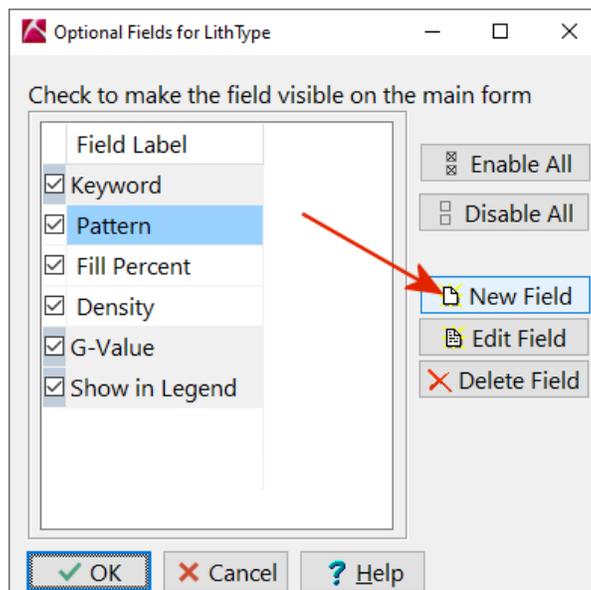


Figure 4

Step 4. Enter the properties for the new horizontal hydraulic conductivity (or permeability) field (Figure 5). These properties include;

1. Field Name: It is very important that the Field Name be unique. This is the text that will be used by the Lithology-K program when replacing the lithology data with K values. It is case-sensitive. Meaning that an error message will be displayed if the if Field Name differs from the name specified within the Lithology->K program menu (e.g., "HK" versus "Hk").
2. Field Type: Set this to "Floating Point".
3. Display Label: This is the column title that will appear within the Lithology Types Table. It is purely cosmetic.
4. Description: This is where any helpful information about the new field may be entered such as an explanation for the field acronym, units, date added, etc.

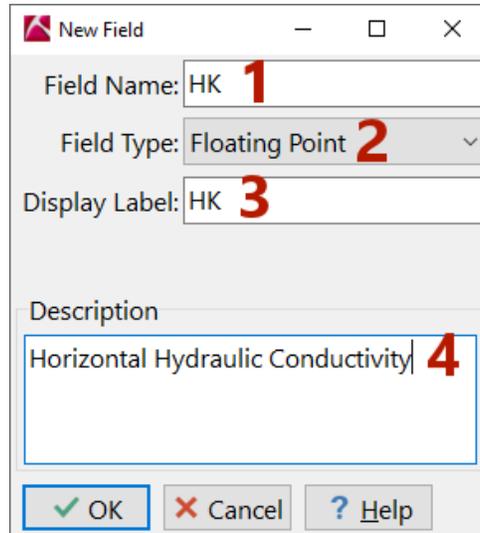


Figure 5

Step 5. Repeat the steps described in Step 4 for the vertical hydraulic conductivity (or permeability).

Step 6. Enter the hydraulic conductivities (or permeabilities) within the two new columns within the Lithology Types table (Figure 6).

G-Value	Keyword	Pattern	Fill Percent	Density	Show in Legend	HK	VK
2.0	Clay		100	2.2	<input checked="" type="checkbox"/>	0.1	0.02
5.0	Gravel		100	2.8	<input checked="" type="checkbox"/>	30.0	20.0
9.0	Ignimbrite		100	2.5	<input checked="" type="checkbox"/>	0.05	0.01
6.0	Mudstone		100	2.6	<input checked="" type="checkbox"/>	0.2	0.01
8.0	Rhyolite		100	2.1	<input checked="" type="checkbox"/>	0.0	0.0
4.0	Sand		100	2.7	<input checked="" type="checkbox"/>	20.0	15.0
3.0	Silt		100	2.1	<input checked="" type="checkbox"/>	10.0	5.0
7.0	Siltstone		100	2.5	<input checked="" type="checkbox"/>	9.0	4.0
1.0	Soil		100	2.6	<input checked="" type="checkbox"/>	50.0	40.0

Figure 6

Step 7. Select the new Lithology->K option from the Lithology pull-down menu (Figure 7)

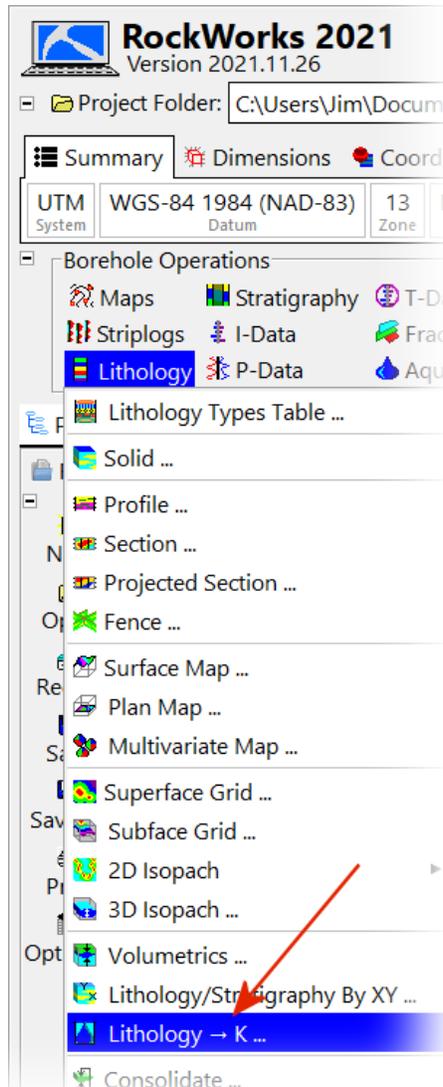


Figure 7

Step 8. Enter the name of the existing lithology model (Figure 8 – Item 1).

Step 9. Enter the names of the two Lithology Types Fields (Figure 8 – Item 2) that were added to the Lithology Types Table in Steps 4 and 5.

Step 10. If the output is to be restricted to a given zone (e.g., a hydrostratigraphic unit), specify the names of existing grid models (Figure 8 – Items 3 & 4) that will limit the output to just the data below the upper constraining surface and/or above the lower constraining surface. Note that the corresponding check-boxes must be checked to enter data into these fields. Also note that it is possible to only use a single surface.

Step 11. If desired, horizontal hydraulic conductivity and vertical hydraulic conductivity solids can be created by checking the boxes and entering the names for the output files (Figure 8 – Items 3 & 4). These models will be created by simply replacing the G-values within the Lithology model with the numbers that were entered into the Lithology Types Table. All node values above or below the constraining surfaces (if used) will be replaced with null (-1.0e27) values.

Step 12. If desired, horizontal hydraulic conductivity and vertical hydraulic conductivity grids can be created by checking the boxes and entering the names for the output files (Figure 8 – Items 7 & 8). These grid models will be created by averaging (see Step 13) all of the solid model voxels within each corresponding grid cell. Cells that do not have any corresponding non-null voxels will be set to null.

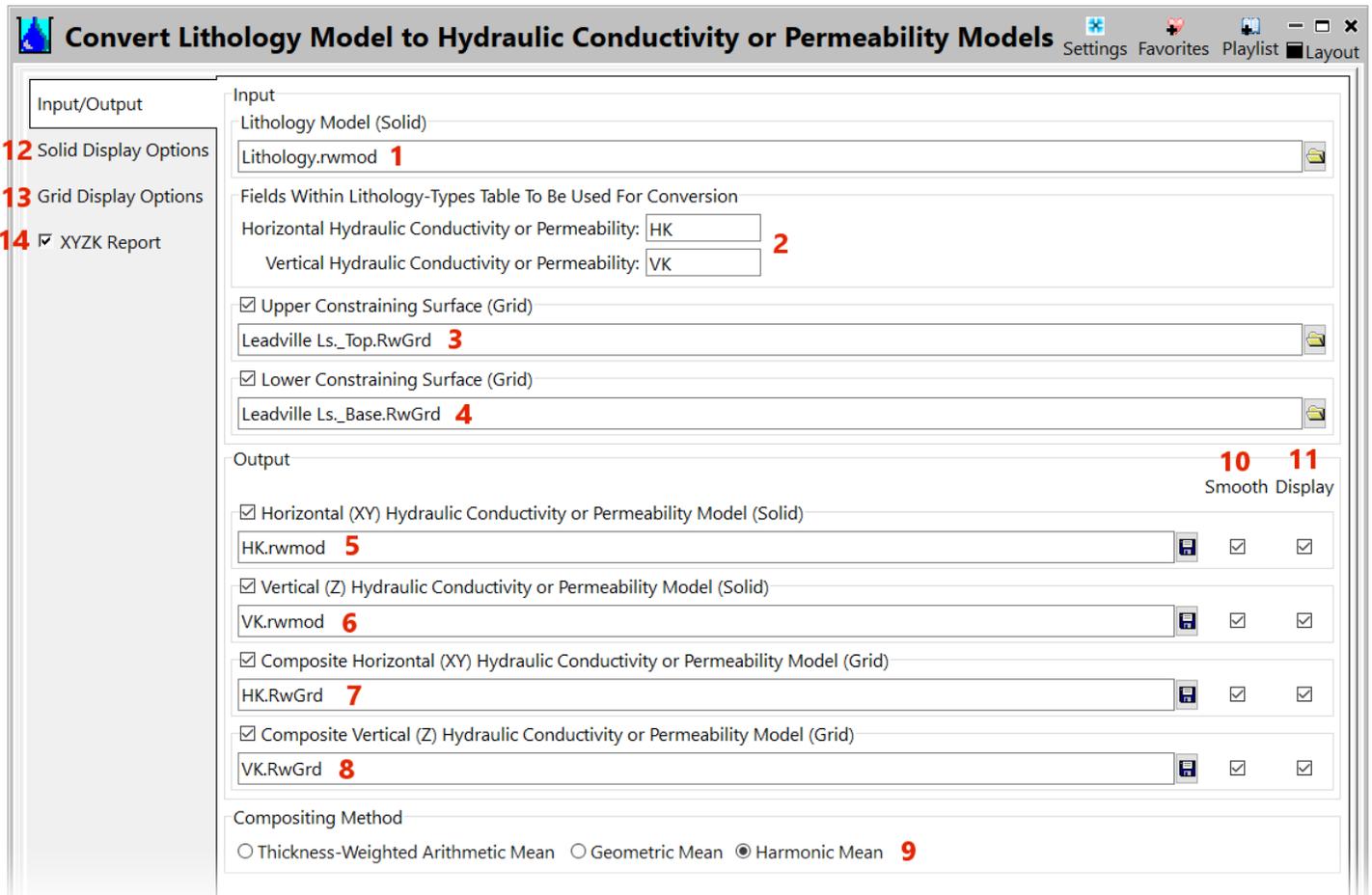


Figure 8

Step 13. The available methods used to average the voxels (Figure 8 – Item 9) in Step 12 are defined as follows;

- Thickness-Weighted Arithmetic Mean: For each cell, the corresponding voxel g-values will be multiplied by the voxel height. The total of these g x height results will be divided by the total height of the non-null voxels to compute the average. Unlike the other two averaging methods, this method will account for voxels that partially protrude above the upper constraining surface or partially protrude below the lower constraining surface, hence the “Thickness-Weighted” designation.

$$\frac{a_1 + a_2 + \dots + a_n}{n}$$

- Geometric Mean: For each cell, the corresponding voxel g-values will be multiplied by each other and the total will be divided by their population.

$$\sqrt[n]{x_1 x_2 \dots x_n}$$

- Harmonic Mean: For each cell, each of the corresponding voxel g-values reciprocals will be totaled. The population of voxel will then be divided by this total. Note that this is a trick to compute the nth-root of the total g-values.

$$\frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + \dots + \frac{1}{x_n}}$$

A comparison of the three different mean-computation methods is depicted within Figure 9.

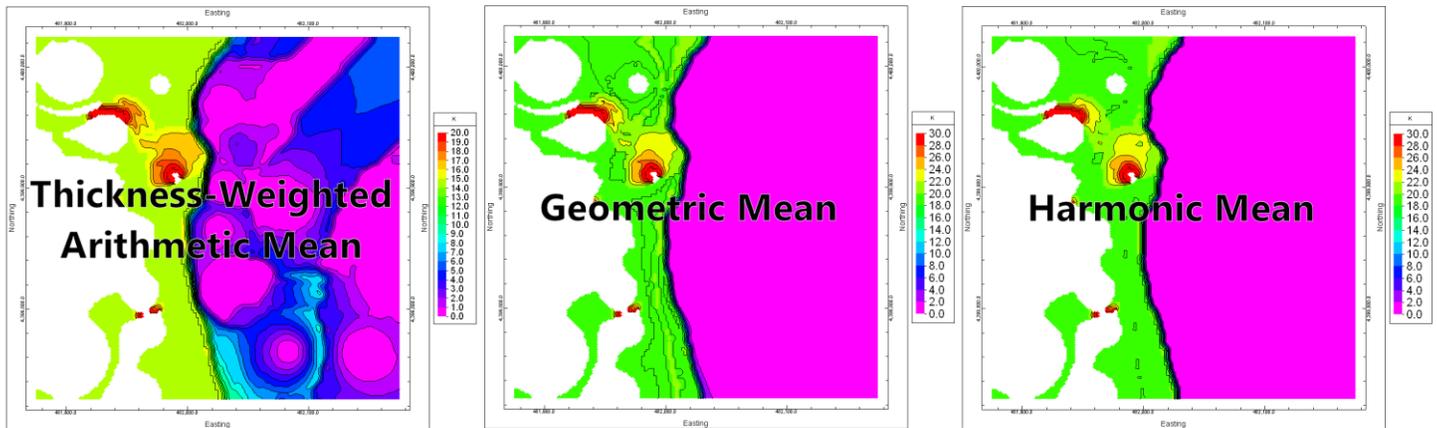


Figure 9

Step 14. Checking the Smooth boxes (Figure 8 – Item 10) will apply simple 3x3 (for grids) or 3x3x3 (for solids) distance-weighted averages to the nodes resulting in less crenulation within the contours and the block models and slightly smoothing the abrupt transitions. For more powerful smoothing, use the Grid/Filters/Smooth and Solid/Filters/Smooth programs.

Step 15. Checking the Display boxes (Figure 8 – Item 11) will cause the program to use the settings within the Solid Display Options menu (Figure 8 – Item 12) and/or the Grid Display Options menu (Figure 8 – Item 13). A notable limitation is that these settings will be applied to all of the possible solid and grid outputs. For more flexibility, it is recommended that the Grid/Display and/or Solid/Display programs be used to independently adjust the display parameters.

Step 16. Checking the XYZK Report option (Figure 8 – Item 14) will save the results of the conversion data as a series of columns (Figure 10) that list the attributes for every voxel within the solid models.

X (Easting)	Y (Northing)	Z (Elevation)	G (Lithology)	HK	VK
481,875.0	4,399,725.0	1,679.0	4.0	20.0	15.0
481,875.0	4,399,727.0	1,679.0	4.0	20.0	15.0
481,875.0	4,399,729.0	1,679.0	4.0	20.0	15.0
481,875.0	4,399,731.0	1,679.0	4.0	20.0	15.0
481,875.0	4,399,953.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,955.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,957.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,959.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,961.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,963.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,965.0	1,682.0	4.0	20.0	15.0
481,875.0	4,399,973.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,975.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,977.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,979.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,981.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,983.0	1,683.0	4.0	20.0	15.0
481,875.0	4,399,985.0	1,683.0	4.0	20.0	15.0
481,875.0	4,400,013.0	1,683.0	4.0	20.0	15.0

Figure 10

The columns within the XYZK report are described as follows;

- X: The voxel midpoint Easting in project units.
- Y: The voxel midpoint Northing in project units.
- Z: The voxel midpoint Elevation in project units.
- G: The G-value for the lithology represented by the voxel.
- HK: The horizontal hydraulic conductivity or permeability represented by the voxel. Note that the actual column title is based on the field name specified within Steps 4 & 5.
- VK: The vertical hydraulic conductivity or permeability represented by the voxel. Note that the actual column title is based on the field name specified within Steps 4 & 5.

In the event that an upper or lower constraining surface was used (Step 10), the data contained within the report will be restricted to voxels that reside below the upper constraining surface and/or above the lower constraining surface.

Be forewarned that report output from large models can be very large. If such is the case, it is recommended that the output be limited to ASCII text files. It is assumed that the primary use for the reporting option is to create ASCII input for simulation programs such as MODFLOW.

Faults:

This program does not use the RockWorks fault table. Instead, it is recommended that faults be assigned a lithotype and modeled accordingly when creating the original lithology model. This will allow for hydraulically conductive faults (e.g., extensional faults with voids) as well as faults that serves as aquitards (e.g., thrust faults with clay gouge). By assigning K values to the different fault lithotypes, it is possible to incorporate their hydraulic conductivities into the K-models.