Earth Volumetric Studio™

EVS Training Videos
Overview of EVS User Interfaces

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WINDOWS IN EVS

➢ Application: Where you connect and organize modules in your application: cannot be moved or undocked.

➢ Properties: Where module & object properties are edited.

➢ Viewer: Where your application is rendered.

➢ Modules: The Library of modules arranged in several (sub) Libraries

➢ Output Log: Where execution status, warnings and errors are reported.

➢ Information: Where statistics, volumetrics & probe results are reported.

➢ Packaged Files: Allows you to incorporate data into EVS applications.

➢ Overview: Provides a way to see your application extents.

➢ Options: Ability to set many EVS defaults for your user.
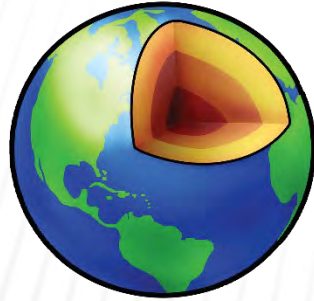
EVS PROGRAM TABS

- **File: Common program tasks such as New, Open, Save (As), Exit &**
  - Conversion of Packaged Applications "To Presentation"
  - Alternate access to Options window
- **Home:**
  - Application Properties: Z Scale and Explode, Application Origin, Snapshots and Application Colors
  - Application Information: Text about your application which is saved in .EVS files
  - (PYTHON) Scripting: New, Open and Run
  - Animation: New and Open
  - Help: Contents and Module specific help.

EVS PROGRAM TABS (CONTINUED)

- Options: Parameters to control the behavior, look & feel of EVS
    - Display: Edit / Presentation Mode; Windows Layouts; Windows Theme
    - Connections: Show and Connection restrictions; Style; Minor ports; Grid & Hide Viewer connections
    - Windows: Buttons to toggle visibility of all major windows
- Tools: Utility Programs which run independent of modules
    - Data Transformation Tools: Conversion from Excel to all major EVS file formats
    - FileTools, Data Reduction Tool, Import Legacy Fields, File Converters
    - Georeference Image Tool, Images to Animation
    - MODFLOW Converter
- Selected Module Tabs: The module selected in your application may present one or more additional tabs.

EVS KEY FEATURES (THINGS YOU LIKELY WON'T DISCOVER ON YOUR OWN)

- Global (linked) Parameters
  - Parameters found in multiple modules such as Z Scale, Explode Distance, Application Theme and (output) Application Colors affect the look of your application and model.
  - Light & Dark Themes for all windows.
  - White, Dark and Custom viewer background colors and corresponding key module output colors.
- Module Libraries: Quick search ability to find the right module
- Find and Open Sample Projects applications containing specific modules
- Creating and Saving EVS Window Layouts specific to your modeling tasks and refinement stage.
- Viewer Contents: How to control and use
- Toggle between Module's (Parameter) Properties and Display Properties

EVS Introductory Series Training
Data Considerations in EVS

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MODULES & CONCEPTS IN THIS VIDEO

➢ **Modules used.**

1. viewer (always included)
2. post samples
3. file statistics
4. legend
5. axes

➢ **Concepts introduced**

1. Data conversion from Excel
2. Creating an Application
   1. Instancing modules
   2. Connecting modules
3. Z Scale

4. Some features of *post samples*
5. Docking of Windows
6. Windows Layouts
7. Window Visibility (e.g. *Output Log*)
8. Probing with CTRL+Left Mouse button
9. File statistics features & outputs:
   1. Pixel size vs. spheres
   2. Data extents
   3. Data statistics
   4. Histograms
10. Application Colors

DATA OVERVIEW

➤ The development of a defensible 3D model begins with quality data that has been evaluated and confirmed to have consistent units and spatial extents. The data should be examined to determine if obvious outliers are present or other problems exist, and the model creator should understand what the data represents in order to plan the best way to analyze and visualize the data.

KNOW YOUR DATA

➤ Understanding your data must be the first step in the development of your site model(s).

➤ Exceptions to this rule do not exist!

➤ Even with quality data, a model created without understanding and informed judgement will be suboptimal (if not garbage).

  ➤ Blind Automation is not advisable.

COLLECT & PROCESS YOUR DATA

- Why is this the first step?
  - Garbage In, Garbage Out.
  - You cannot build a quality model with flawed data.
  - You must confirm that all data:
    - *Has similar 3D extents.*
    - *Uses the same coordinate projection & units*
      - The coordinate units for Z must be the same as X & Y (Lat-Lon cannot be used)

THREE FUNDAMENTAL DATA TYPES

- Analytical data can represent any type of analytical measurement such as:
  - Contamination
  - Mineral assay
  - Geophysics
  - Soil or water properties
- Lithologic data such as boring logs
  - We'll include lithology data which has been processed to represent stratigraphic horizons.
- Surface (horizon) data
  - Topography
  - Stratigraphic horizons
  - Water table (potentiometric) surface

ANALYTICAL DATA:

- Data which has x-y-z coordinates and one or more value representing measurements at the location.
  - Optionally:
    - *Boring IDs*
    - *Ground surface elevation for the boring*
    - *Elevation information may be provided as a Depth (positive number) below the ground surface.*
    - *Elevation information may be provided as Tops & Bottoms of intervals (i.e., well screens) along which a single measurement (sample) was taken.*
- Analytical data is used for:
  - Measurements made along borings such as contamination, assay, soil (lithologic) properties, temperature, etc.
  - 2D and 3D Geophysical data such as resistivity, magnetic, seismic, etc.
  - CTD (Conductivity, Temperature, and Depth) casts and other water quality data like O_2 levels, pH, etc.

LITHOLOGIC DATA (BORING LOGS)

➢ Data collected along borings which describes the observed material along depth intervals.

➢ May be used directly or to ascertain the stratigraphic horizons for a geologic model.

  ➢ The resultant class of data may also be referred to as a "Geologic Hierarchy".

SURFACE ELEVATION DATA

- Data representing the elevation of one or more surfaces over the site area. Examples are:
  - Topography
  - Groundwater elevation (potentiometric surface)
  - Stratigraphic horizons
  - Excavation surface(s)

AGGREGATION AND SEGREGATION

- Data must be appropriately Aggregated and Segregated
  - It may seem contradictory since these two words are antonyms.
  - It is important to your efficiency that you (and those who provide data to you) understand the requirements of 3D Modeling and therefore what is needed in EVS.

DATA AGGREGATION

- Data is often not Aggregated properly in that some individuals (and software) tends to focus on data in ways that ignore the requirements of 3D modeling. For example:
  - Boring logs are often displayed (and segregated) as one boring per page. Everything that we do with lithology data requires all borings for your project site to be aggregated into a single file.
  - A common and very serious problem is when analytical data is subsetted to include only detections, or worse yet only samples exceeding regulatory limits.
  - It is critical that analytical data include all valid samples at a site, especially the non-detects which bound the contaminant plumes.

DATA SEGREGATION

- Analytical data must be Segregated so that each EVS input file includes data from the same domain.
  - You want to segregate your data to include only samples from the site being modeled. You may be working on a large facility with several separate contaminated areas (zones) where the contamination was from unique events. Though you can later combine these into a single application, the estimation (kriging) process should ideally use only data from the same event where the samples are correlated to each other.
  - A spill that occurred at a different time will not correlate with another unrelated spill.
  - You must segregate your data so that each file contains only data with the same units! Don't include soil and groundwater contamination samples in the same file. However, you can combine multiple analytes in the same file if they apply to the same domain (e.g., vadose zone)

CONVERSION TO EVS FORMATS

➤ The EVS help system includes a few fundamental tutorials. These include step-by-step instructions to convert Excel files containing the required content into the appropriate EVS file formats which best represents that data.

➤ See: **Earth Volumetric Studio - Exporting from Excel to C Tech File Formats**

VISUALIZE & ANALYZE YOUR DATA

➤ Once your data is properly formatted for use in EVS, the next step should always be direct visualization of the data. There are two modules that should be considered to view your data:

  ➤ We strongly recommend a planning and review process where you view your data files in a simple application that does not include other objects such as shapefiles, drawings (DWG), aerial photos, etc.

VISUALIZE: *POST SAMPLES*

➢ **For many users their go-to module to view EVS data files is *post samples*. This module has a rich set of features to view EVS data files.**

  ➢ **Best for data that was collected from borings and where each sample includes a "Boring ID" and (ideally) ground surface elevation.**

  ➢ **If ground surface elevation is not included, the boring tubes cannot be properly drawn starting from the ground. For sites that are very flat (little or no topographic variation) a single ground surface elevation can be input to the module.**

POST SAMPLES (CONTINUED)

➢ **For large files with more than a few thousand samples, consider using a simpler glyph than the default spheres, or if the data is densely sampled in Z (or depth) colored tubes is usually the best option.**

➢ **Examples of EVS files for which post samples should usually be your first choice are:**

  ➢ **.APDV (analytical data collected at points**

  ➢ **.AIDV (analytical data collected along depth or elevation intervals)**

  ➢ **.PGF (borehole lithology)**

  ➢ **.LSDV (borehole lithology with some advanced features)**

  ➢ **.GEO (borehole based stratigraphic horizon data)**

ANALYZE & VISUALIZE: *FILE STATISTICS*

➤ Best for data that is not boring-centric.

 ➤ The file statistics module displays point data as either pixels or glyphs (e.g., spheres). The default use of pixels is highly preferred for large datasets with several thousand samples.

  ➤ *This module runs much faster than post samples for large files.*

  ➤ *Pixels are much more efficient in the viewer. Don't try to use post samples (especially with spheres) on a file with 50,000 or more samples!*

  ➤ *If boring information is included, it is ignored.*

 ➤ Another advantage is that file statistics provides a quantitative analysis of your data which includes basics statistics of your data such as:

  ➤ *Number of Samples*

  ➤ *Analytical Min, Max, Mean & Median*

  ➤ *Coordinate Limits and Extents in X, Y & Z*

  ➤ *Optional Histogram with user specified number of Bins.*

FILE READING ERRORS AND WARNINGS

➤ Keep your Output Log window open to see errors and warnings that are displayed as the files are being read. These problems are more likely If you don't use the EVS conversion tools.

➤ Duplicate samples is a common and often ignored issue!

  ➤ Duplicate X-Y-Z (or X-Y for some file types). Though this is treated as a warning, you should strive to resolve duplicate samples or data at the same coordinates.

  ➤ You may have measurements taken at different times and therefore expect duplicates in your files. But remember that EVS takes the average of all duplicates, and this can be problematic if:

    ➤ *One or more samples are non-detects.*

    ➤ *Minimum or maximum values are preferable to using averages.*

    ➤ *Your output should normally represent actual measured values. The average of multiple sampling events will not match any actual measured data.*

TROUBLESHOOTING: VISUALIZATION & STATISTICAL ANALYSIS

- Viewer is blank after reading the file is generally caused by x or y coordinate errors in one or more samples.
  - Samples with transposed X-Y coordinates is a typical cause.
  - Samples may have a dropped digit (x = 224,678.87 vs. x = 2,324,678.87)
- If the viewer becomes blank when two related files (e.g., lithology and analytical data) are both read (when both are individually okay), one of the files likely has completely transposed X-Y coordinates or the files may be using different coordinate projections.
- Visualization and/or a histogram will often expose if your analytical data has inappropriate Min or Max values. Add a legend to confirm that the data units are appropriate. This is critical if volumetric calculations are part of your project plan.

EVS Training Videos
Application Origin and Reusing EVS Apps

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APPLICATION ORIGIN

- EVS Applications have an Application Origin
  - This is used to optimize accuracy and performance on modern PC Graphics cards.
  - Graphic cards are limited to 32-bit Single Precision.
  - This is inadequate for many sites which have both large X or Y coordinates and modest site extents.
  - C Tech overcomes this by performing all computation and rendering in a local site coordinate system.
  - The transformation from original coordinates to local coordinates is a simple translation by the "Application Origin".
- This process is behind the scenes and can be ignored except when:
  - You try to reuse an application with data from a site with very different X-Y coordinates.
  - You read the wrong file first in a new application.

WHY WOULD WE WANT TO REUSE EVS APPLICATIONS?

- Earth Volumetric Studio Sample Projects
  - C Tech provides Studio Projects as a learning resource with over 530 EVS applications and associated data files.
  - This covers multiple disciplines and includes applications using most of the EVS modules.
  - These applications provide an excellent starting point for virtually any project you might tackle.
- Reusing applications that represent your organization's *style*, helps to make the work done by your personnel uniform and characteristically yours!
  - It also saves time, and time equals money!

APPLICATION REUSE

- The easiest way to reuse an EVS Application is to follow these steps.
  - Copy and rename the .EVS file you wish to reuse to a new folder far from the original project.
  - Copy (or move) all new data files to the new project folder.
  - Open the application file in EVS
- The new application will open but not run:
  - It cannot find the original data files
  - Problematic modules which do not read files or require input can run. Examples are:
    - If axes was originally only connected to the viewer, it will retain the original extents.
      - Connect post samples once you've read new data or re-run it.
    - 3d titles is problematic because its location was saved using the original data.
      - Correct the coordinates
    - 3d legend: Is a special case even though it requires a Red input port, its location was saved using the original data.
      - Correct the coordinates

APPLICATION REUSE (CONTINUED)

- Examine unlinked parameters in all modules.
  - Some parameters are unlinked if you type in a value.
  - This value may not be relevant for the new data!
  - Resetting the Link is usually a safe thing to do.
- From the Home tab, click the Origin: "Reset or Edit" button.
- Click on "Force Reset":
- Disconnect all problematic modules from the viewer for now.
- Read new data with a module connected to the viewer (e.g. post samples)
  - Your new Application Origin will be set.
- In the viewer, click Top to see your model
- Proceed to read files and run all other modules.

PROBLEMATIC MODULES WHICH ARE BEST REPLACED

- gridding and horizons with Finite Difference Gridding (FDG)
  - FDG needs an origin (which must be determined and set)
  - FDG grid extents are determined by cell sizes and number of cells.
    - Likely wrong for your new data
  - FDG grid rotation is likely not appropriate
- gridding and horizons with computational surfaces (e.g. Depth, Elevation, etc.)
  - Either change these values or start with a fresh module.
- draw lines : Does not need a data file. Lines can be "built into" module.
- place text & interactive labels: 3D text is "built into" module.
- buildings : Does not need a data file. 3D buildings can be "built into" module.
- create grid: The coordinates of the grid are set in the module.
- edit horizons: All probed control points will be wrong.

SOLVING APPLICATION ORIGIN PROBLEMS

➢ Rotation and/or Zooming is not smooth

➢ Objects in the viewer appear distorted.

  ➢ Spheres or tubes seem odd or jagged

  ➢ Grids (such as from gridding and horizons) don't seem uniform

➢ How to Detect and Correct Origin Inconsistency

  ➢ Ensure that all data files read in an application are from the same site

  ➢ Compare the Application Origin X-Y coordinates with Field Statistics from modules connecting to the viewer

  ➢ Force Reset on Application Origin if not consistent.
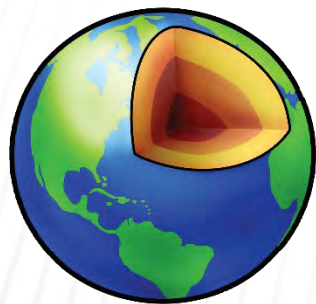
EVS Premium Training Videos
Stratigraphic Modeling
with gridding and horizons

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STRATIGRAPHIC MODELING

- Data Requirements
  - Stratigraphic models cannot be directly created from lithology (borings logs).
  - A Geologic Hierarchy must be determined by human intervention.
  - EVS has two file formats which represent stratigraphic horizons.
    1. The .GEO file format is the simplest format but is limited to stratigraphic data which is based solely upon vertical borings.
    2. The .GMF file format can include both boring data as well as irregular survey data where x-y coordinates are not necessarily correlated among all horizons.

STRATIGRAPHIC MODELING (CONTINUED)

➢ The stratigraphic hierarchy is the ordering of horizons that represent the tops and bottoms of stratigraphic (i.e., depositional) layers at your site.

➢ Each horizon is assumed to span the entire site, though the layer it defines may pinch-out to zero thickness where it thins or meets the ground surface.

➢ A seemingly continuous layer must be divided into two or more layers if that continuous layer contains one or more lenses.

➢ If you find that your hierarchy is becoming overly complex, consider the lithologic modeling process instead.

CREATE STRATIGRAPHIC HIERARCHY

- The *create stratigraphic hierarchy* module
  - This module is an interactive tool to develop the stratigraphic hierarchy based upon lithologic data contained in boring logs.
  - The module processes your borings logs by depth looking for common materials and pausing to allow you to rank the materials encountered.
  - If all borings had the same hierarchy, there would be no choices to make as each new material is encountered. However, for typical sites, horizon encounters can have two or more materials to choose from.
  - Visual examination of the set of borings often reveals the best selection, but the right choice can often be ambiguous. Different choices result in different hierarchies, where the resulting model can end up being nearly identical or quite different.

STRATIGRAPHIC DATA GEO VS GMF

- ➢ **GEO files have important functional benefits.**
  - ➢ gridding and horizons can estimate the data in <u>thickness space</u>, which offers more control over layer pinching.
  - ➢ However, thickness space requires that no boring can have a **SHORT** (or **UNKNOWN**) flag followed by data.
    - ➢ In other words, all remaining horizons for that borings must be SHORT.
    - ➢ This condition makes it impossible to define subsequent layers using thickness
- ➢ **GMF files can represent far more complexity**
  - ➢ High resolution topography or seismic surfaces can be combined with borehole horizon observations
  - ➢ GEO files can be converted to GMF, but the opposite is not true.

.GEO FILE FEATURES

- When two horizons share the same elevation at a boring, the layer defined between them was not observed at that location
  - In other words, the layer is pinched out.
- If the file defines horizon locations in Depth:
  - A layer is pinched if the horizon defining its bottom has zero depth relative the ground surface, or
  - Its depth is equal to the horizon above.
- When a Pinch occurs, it is optimal to use the Pinch flag in .GEO files for the defining (bottom of layer) horizon.
  - This allows gri*dding and horizons* to use its Pinch Factor to exercise more control over how and where a layer pinches. It also makes the file easier to understand.
- Layers defined by GMF files pinch where the horizons are coincident and/or when a lower horizon intersects and goes above horizon higher in the hierarchy.

Use Basic Stratigraphic Grids for Most 3D Models

➢ Models must be constrained to the domain of the data.

  ➢ Vadose zone: The minimal "stratigraphic" horizons would be:
    ➢ Ground surface
    ➢ Water Table or bottom of the model (arbitrary elevation or depth)

  ➢ Saturated Zone: (e.g., aquifer) The minimal "stratigraphic" horizons would be:
    ➢ Water Table
    ➢ Confining horizon or bottom of the model (arbitrary elevation or depth)

  ➢ Atmosphere: The minimal "stratigraphic" horizons would be:
    ➢ Top of model (arbitrary elevation above ground)
    ➢ Ground surface

MODULES USED IN THIS VIDEO

1. post samples
2. gridding and horizons
3. horizons to 3d
4. horizons to 3d structured
5. explode and scale
6. external faces
7. create tin
8. interpolate nodal data
9. polyline processing
10. legend
11. axes
12. texture cell sets
13. draw lines

EVS Premium Training Videos
Alternative Gridding Concepts in EVS

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TABLE OF CONTENTS:

2D ESTIMATION

- *2d estimation* has both convex hull and rectilinear gridding.
- It also has an adaptive gridding option which places a node at each x-y location of the sample data.
  - Adaptive gridding uses a quadrilateral (quad) inside of an existing quad cell and connects the nodes of the new (small) quad to the original quad's corners.
  - This works with both gridding options (convex hull and rectilinear)

3D ESTIMATION AND LITHOLOGIC MODELING

- Both of these modules only have a simple rectilinear option which ignores topography data and builds a rectangular grid with flat top and bottom.
- These modules were designed to receive the grid and surfaces from *gridding and horizons*.
  - Their built-in gridding should never be used alone.
    - *It is extremely rare that there is zero site topography (elevation variation).*
    - *Even when this is the case, the grid it will build does not automatically start at the proper elevation.*

IMPORT RASTER AS HORIZON

➢ *import raster as horizon* imports (reads) grid and dem type files which contain elevations on a rectangular (I, J) grid as an EVS horizon.

➢ It can be used in place of *gridding and horizons* to import rectilinear grids.

➢ *crop and downsize* can be used to reduce extents and resolution if the grid file has excessive extents or resolution.

➢ If you have multiple grids corresponding to stratigraphic horizons, they must have the exact same resolution and extents to be used directly to build a stratigraphic model

  ➢ *combine horizons* is used to merge multiple horizons (surfaces) from multiple *import raster as horizon* modules to accomplish what a single gridding and horizons module can accomplish.

  ➢ You can always use the *export nodes* module to convert a raster to a surface in gmf file format, and these files can easily be combined into a single GMF file representing multiple horizons.

GRIDDING WITH *CREATE TIN*

➤ A triangulated irregular network (TIN) is a grid formed by triangles which is the convex hull of all input (X-Y) points.

  ➤ Variation in the density of input points can result in a wide range of triangle sizes, which is often undesirable for 3D modeling.

  ➤ The *triangle refinement* module can be used to break large triangles into smaller ones, but the surface topography is not affected (large facets will remain).

➤ TIN surfaces can also be imported from CAD or GIS

  ➤ Geophysics: eagle-mountain-dam-tin-prism-grid-krige-sbt-as-continuum.intermediate.evs

➤ Once a 2D TIN surface is created (and/or refined), it can be extended to 3D using the *extrude* module.

  ➤ *extrude* can extrude by a set distance (positive or negative) or by nodal data.

    ➤ *A Python script in node computation can be used to extrude to a specific elevation or to another input surface.*

  ➤ This approach isn't practical for 3D grids with multiple horizons unless *export nodes* is used to convert the TIN nodal coordinates into an integrated GMF file.

DIRECT CROSS SECTION GRIDDING

➤ **Why Use This Approach?:**

   ➤ When the desired model is 3D cross sections, this method allows us to create extra fine grids with much faster computation times.

➤ **Procedure:**

   ➤ Use the *draw lines* module to set the path for cross sections

   ➤ Use *polyline processing* to determine the resolution along the path

   ➤ The *interpolate nodal data* maps elevation data onto the line paths

   ➤ The *node computation* module maps (assigns) the lines' elevation data to match the top & bottom of the sections

   ➤ Then we *extrude* in Z using that data

MODULES & CONCEPTS IN THESE GRIDDING VIDEOS

➤ **Modules Introduced**

1. gridding and horizons
2. horizons to 3d
3. horizons to 3d structured
4. explode and scale
5. external faces
6. 2d estimation
7. 3d estimation
8. plume
9. intersection
10. node computation
11. draw lines
12. extrude

➤ **Concepts Introduced**

1. Loading and Saving EVS Applications
2. Choosing the proper grid type
3. Determining optimal grid extents
4. Resolution requirements & consequences
5. Types of 2D grids
6. Probe and Set Center
7. Direct creation of cross sections
8. Volumetric grids from DEMs & Grids
9. Extrusion with Python Scripting
10. Working with TINs

EVS Premium Training Videos
3D Estimation

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THE 3D ESTIMATION MODULE

➢ **3d estimation** accepts 2d (x-y) grids and horizons from *gridding and horizons* and creates 3d volumetric grids into which it performs 3d estimation of analytical data. The baseline estimation process is kriging, but several other methods are also included. The full list is:

> ➢ Kriging performs geostatistical estimation with weighting factors based upon a variogram which is fitted using the sample data. Under the assumption of a proper variogram, kriging gives the best linear unbiased prediction at unsampled locations. The process computes standard deviations of the estimated values at each node and this underlying statistical data allows for quantification of the quality of the estimate.
>
> > ➢ Note: this module performs ordinary kriging.
>
> ➢ **IDW:** The two most common methods for Inverse Distance Weighting are included.
>
> > ➢ Warning: IDW methods do not take spatial correlation into account which often results in unrealistic anomalies.
>
> ➢ **Nearest Neighbor:** This method assigns the value of the nearest sample.
>
> > ➢ It is effectively a discontinuous estimation process since it performs no interpolation. However, C Tech's nodal data paradigm results in interpolation within individual cells since values are assigned to nodes.
>
> ➢ **Fast RBF:** The fast radial basis function method performs reasonable estimation, but it has no underlying statistical basis like kriging. It also often extrapolates in an indefensible manner.

CELL TYPES – 0 DIMENSIONAL

Does not have measurement of length, width, or depth

Point

Points occupy neither length, width nor height. They have ZERO Dimensionality

CELL TYPES – 1 DIMENSIONAL

Has measurement of length

Line

Lines occupy only length. No width or height. They have a Dimensionality of 1.

CELL TYPES – 2 DIMENSIONAL

Has measurement of length and width / Area
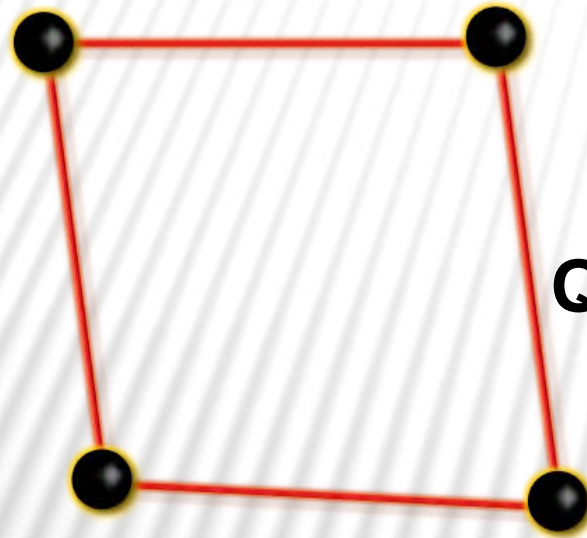
Triangle
(Tri)

Quadrilateral
(Quad)
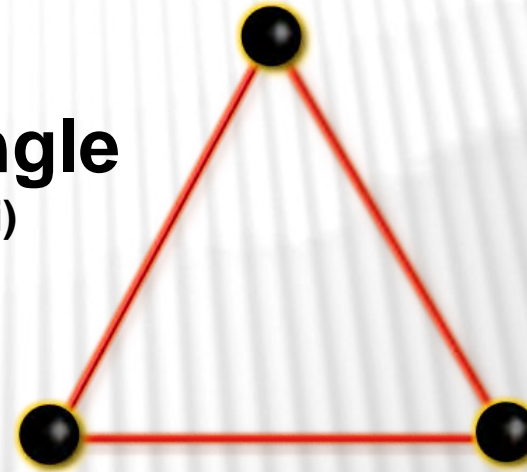
These surface elements have both length and width, but no height.

They have area, but not volume, therefore their Dimensionality is 2.

CELL TYPES – 3 DIMENSIONAL

Has measurement of length, width, and depth – Defines Volume
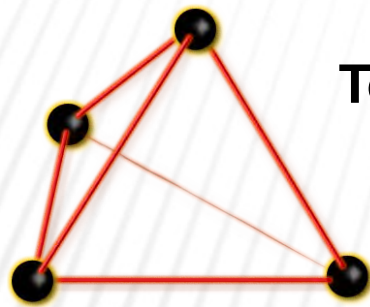
Tetrahedron
(Tet)
4 nodes
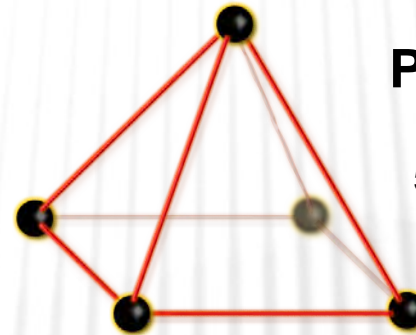
Pyramid
(Pyr)
5 nodes
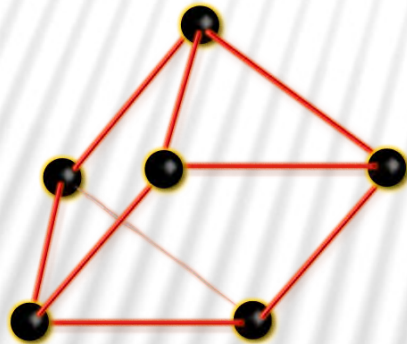
Prism
(Prism)
6 nodes
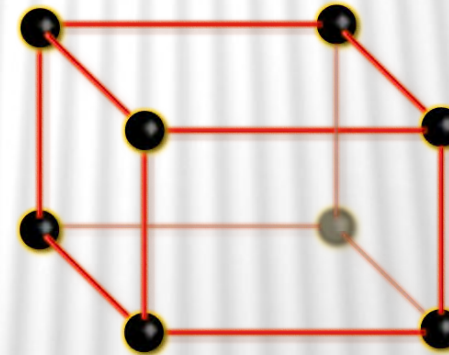
Hexahedron
(Hex)
8 nodes

These volumetric elements have length, width and height.

They define volumes; therefore, their Dimensionality is 3.

LOG PROCESSING OF DATA

- Data spanning several orders of magnitude generally benefits from Log Processing. This is an automated process in our estimation modules.
  - Log Processing is on by default in *2d estimation* and *3d estimation.* Though our file readers provide warnings when we detect seemingly inappropriate application, EVS cannot know whether Log or Linear is best for your data.
    - If your data has negative values that are meaningful, linear processing is always required.
- Why is this important?
  - We use various estimation methods and procedures to best simulate the physical processes involved in the migration of contaminants through soil and groundwater. These processes tend to be exponential by nature, and log processing of sample data results in distributions that better honor the physics of these migrations.

Simplified Case Study: Two samples, one prediction

LINEAR CASE

Linear Case, Equal Distance – Equal Weighting

Result: 50

Value: 0   Value: 100
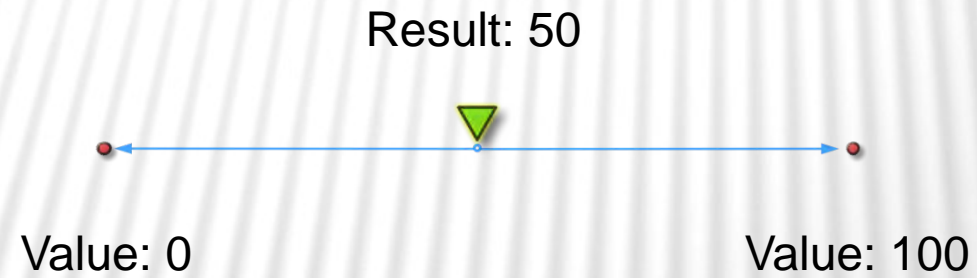
LOG CASE

Pre-Clip Min At 0.0001
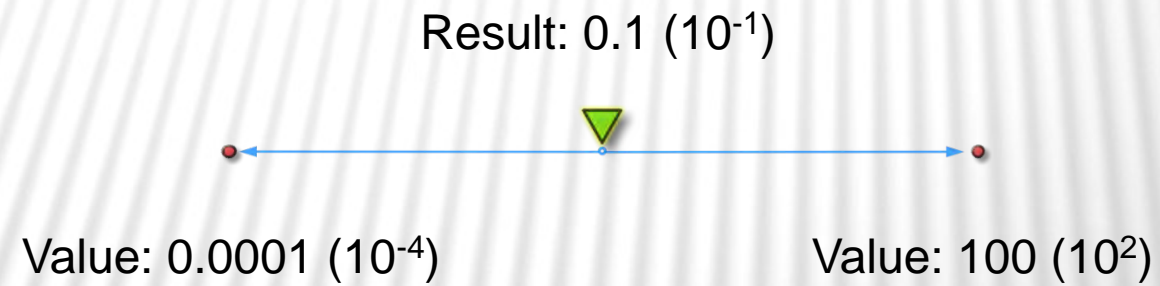
Result: 0.1 (10^{-1})

Value: 0.0001 (10^{-4})   Value: 100 (10^{2})

KRIGING VS. IDW

Simplified Case Study: Two samples, one prediction

Linear Case, Equal Distance – Same Answer in Kriging and IDW

Result: 5

Value: 1   Value: 9
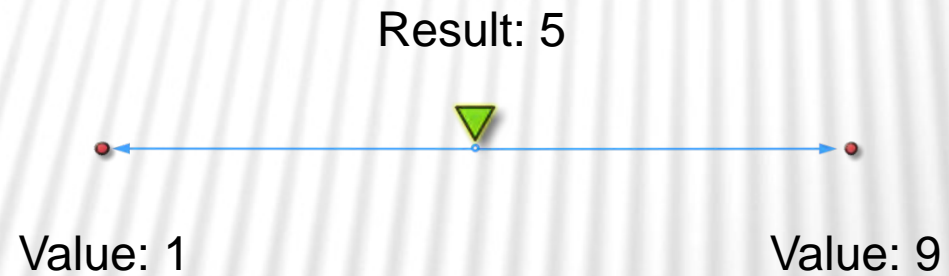
INTRODUCING SECOND POINT

How do Estimations Change?

Value: 9

Value: 1

Value: 9
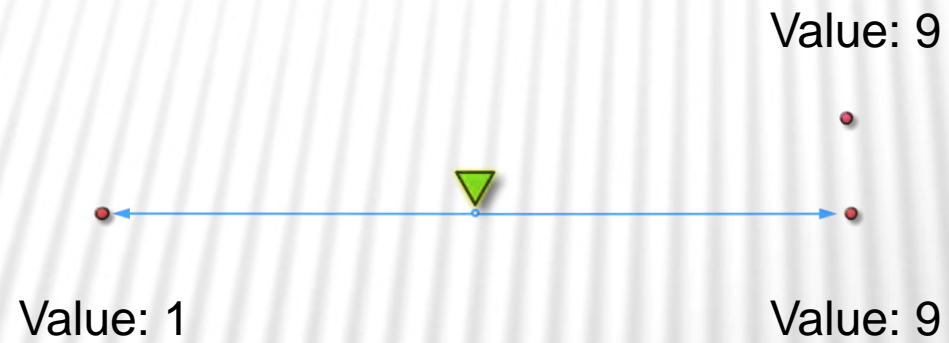
The distances between all data neighbors and their distances to the point being estimated all affect the results

Value: 9

Result: 5.1

Close Distance Here
Mitigates Weighting

Value: 1   Value: 9
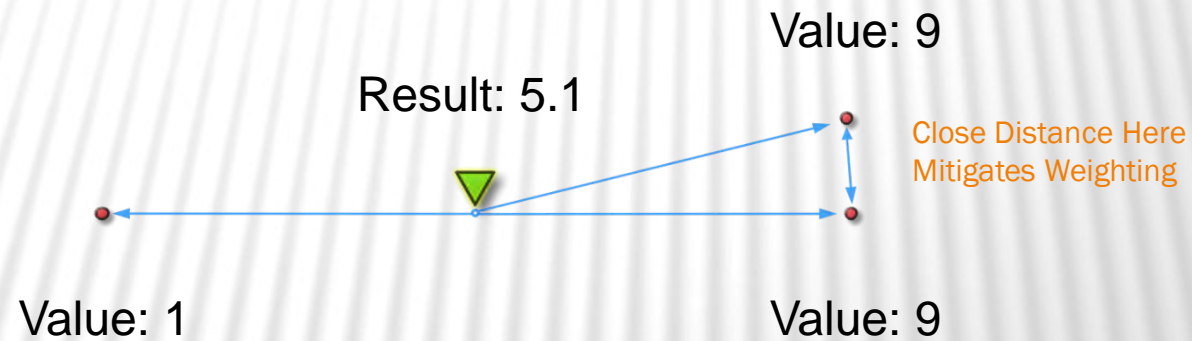
Result is not significantly skewed towards the 9.0 points since they are close together

WORSE CASE – DATA CLUSTERS

Effect Is Worsened With Clustered Data

KRIGING CASE

Distance Between Points Taken Into Account

Values In Cluster: 9

Result: 5.2

Value: 1
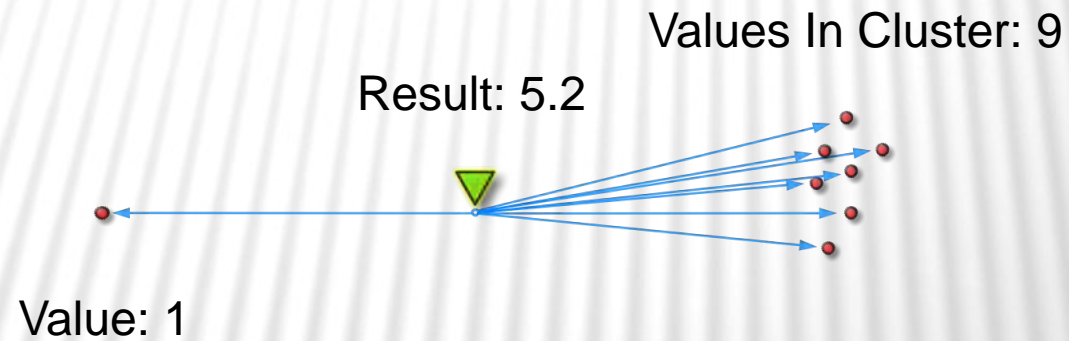
Result is not dramatically skewed towards the "9" points since they are close together. If the clustered points were infinitesimally close to each other, the result would be 5.0

IDW CASE

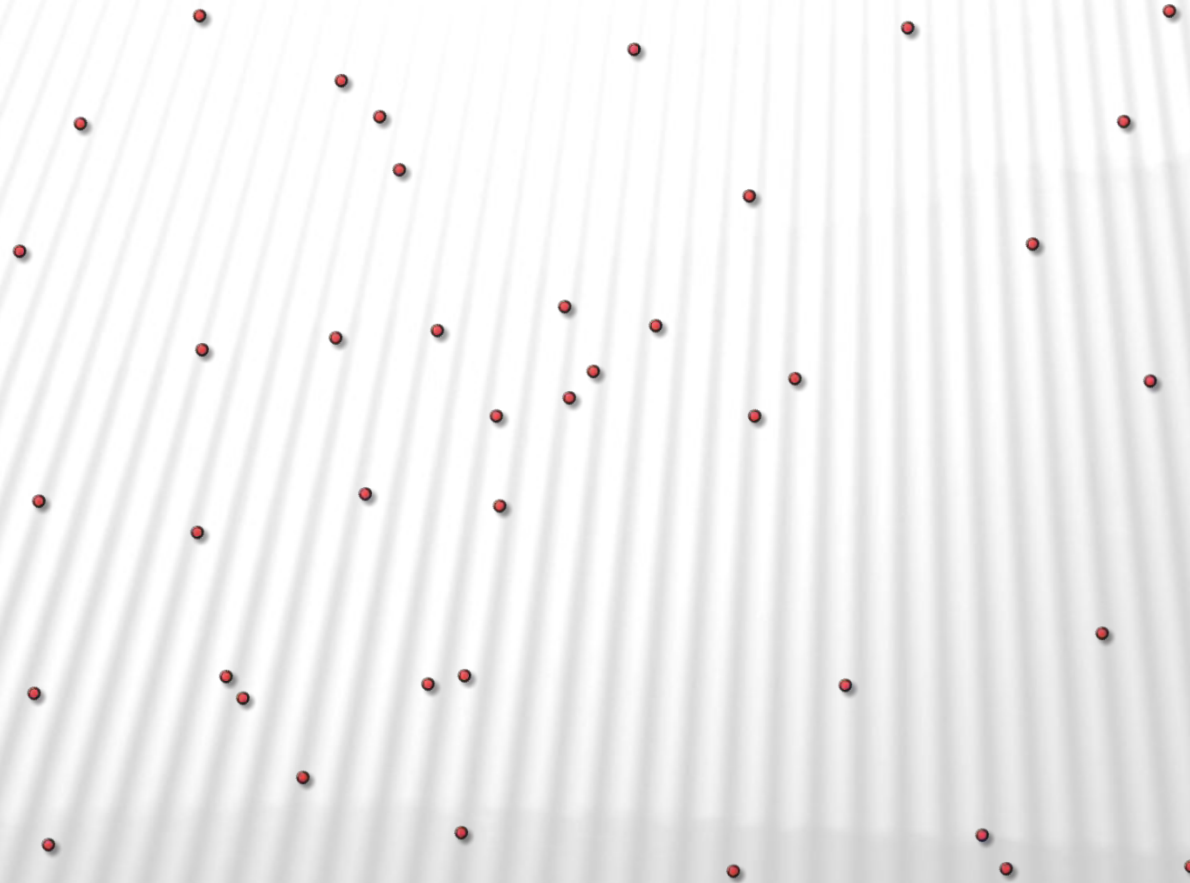Equal Weighting for Eight Points – All Eight Are ~Equal Distance

Values In Cluster: 9

Result: 8

Value: 1
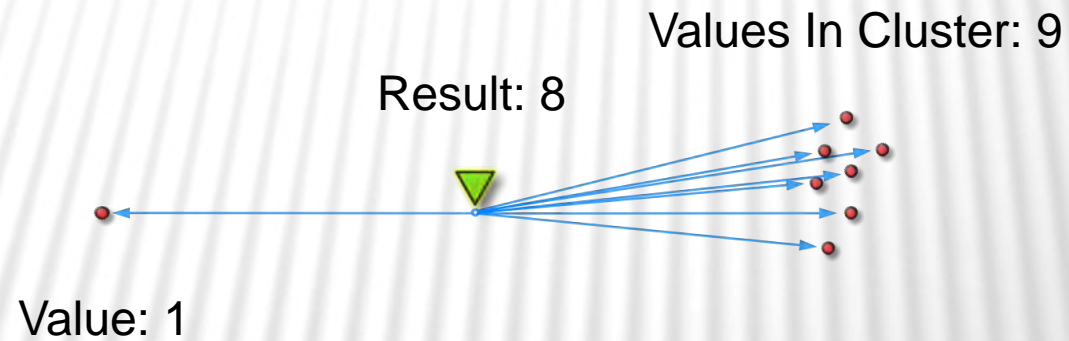
Result Dramatically Skewed Towards Points At "9"
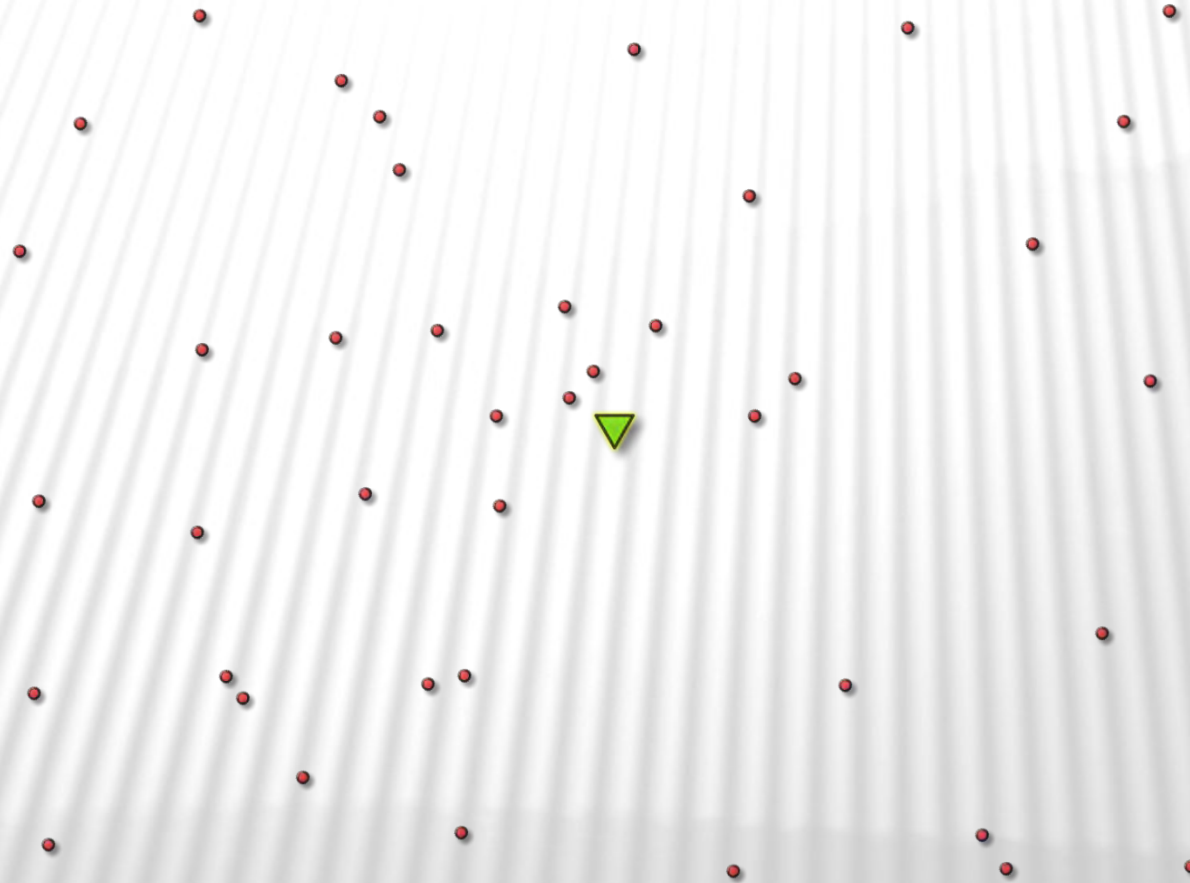
KRIGING CONCEPTS: DATA POINTS

Measured, Scattered Data

www.ctech.com

KRIGING CONCEPTS: POINT TO INTERPOLATE

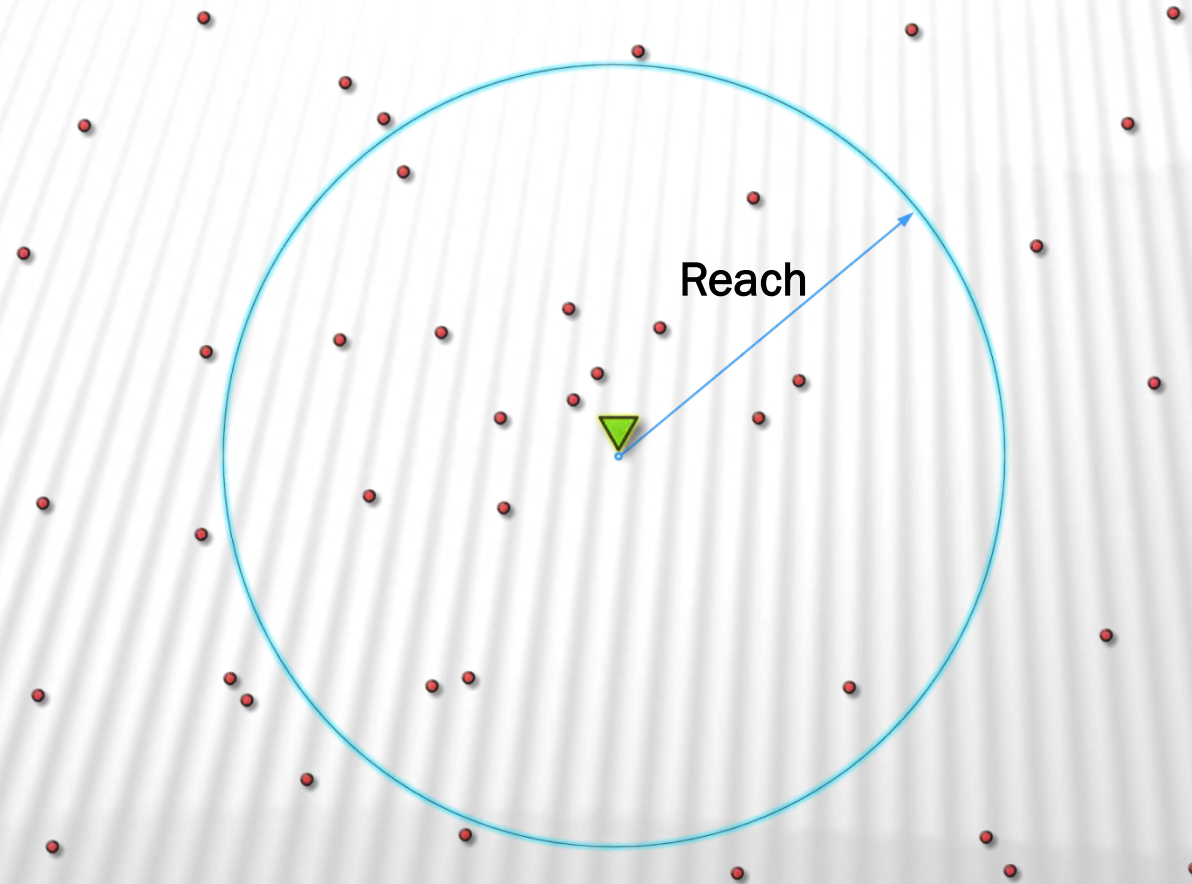Interpolation Point within Scattered Data

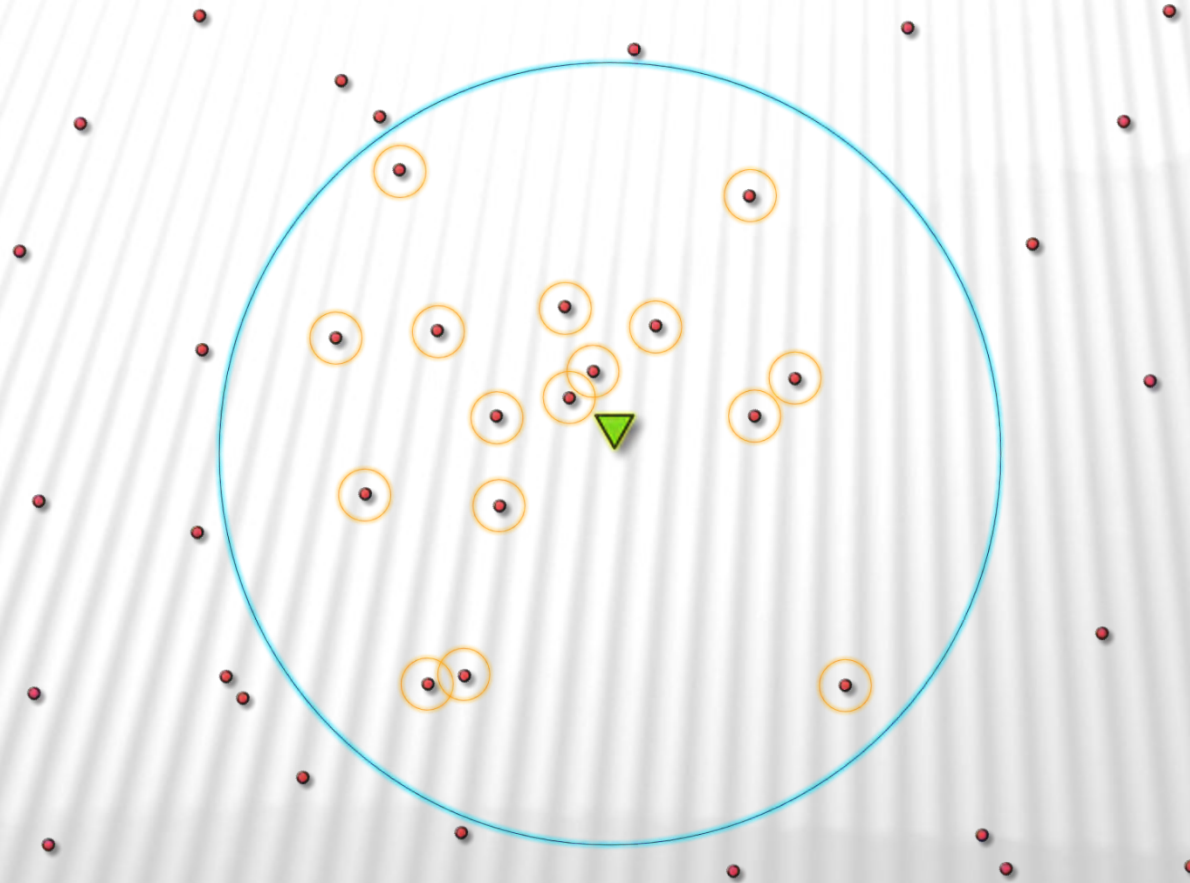# KRIGING CONCEPTS: REACH

Defines a Search Radius in Your Units

Reach

Circle is centered on the node (point) being estimated

SEARCH LIMITED BY REACH

Points=50, Reach=100
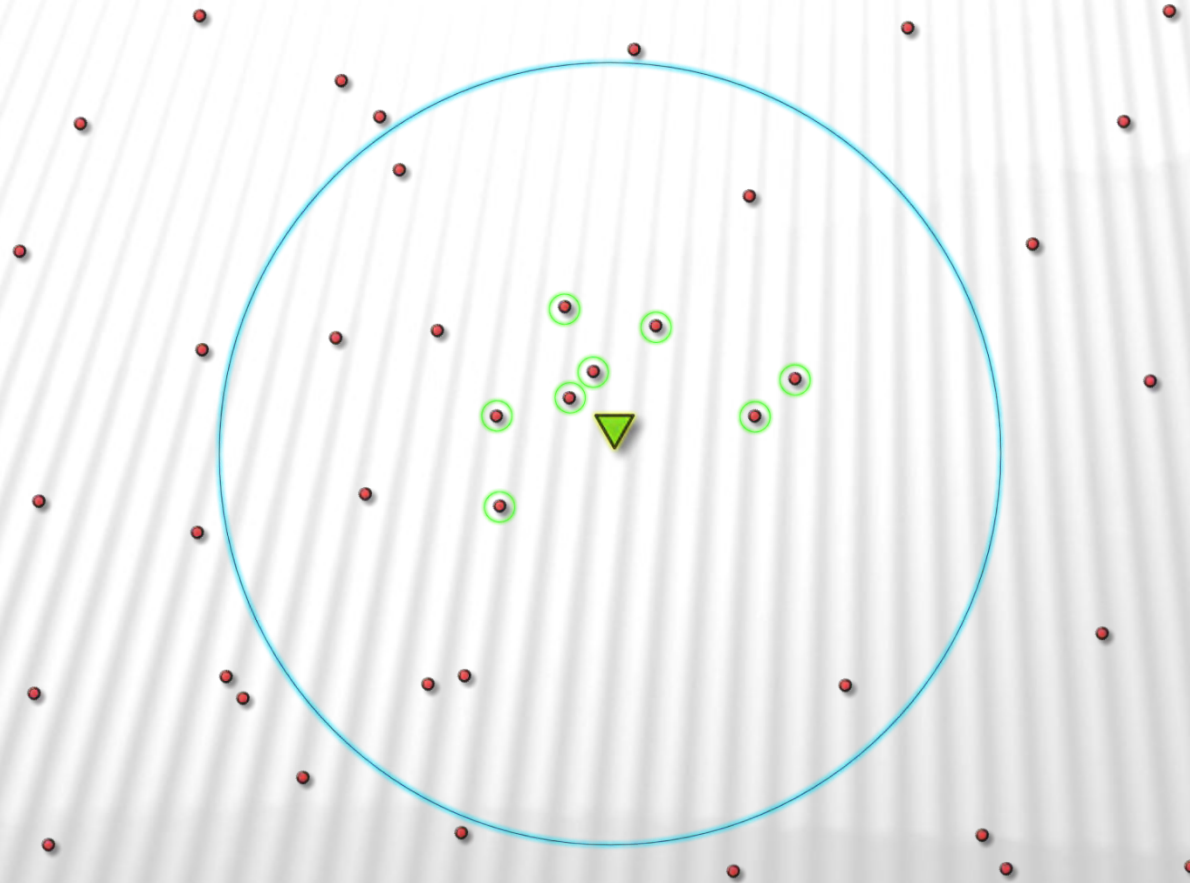
Nearest Sixteen Points Selected
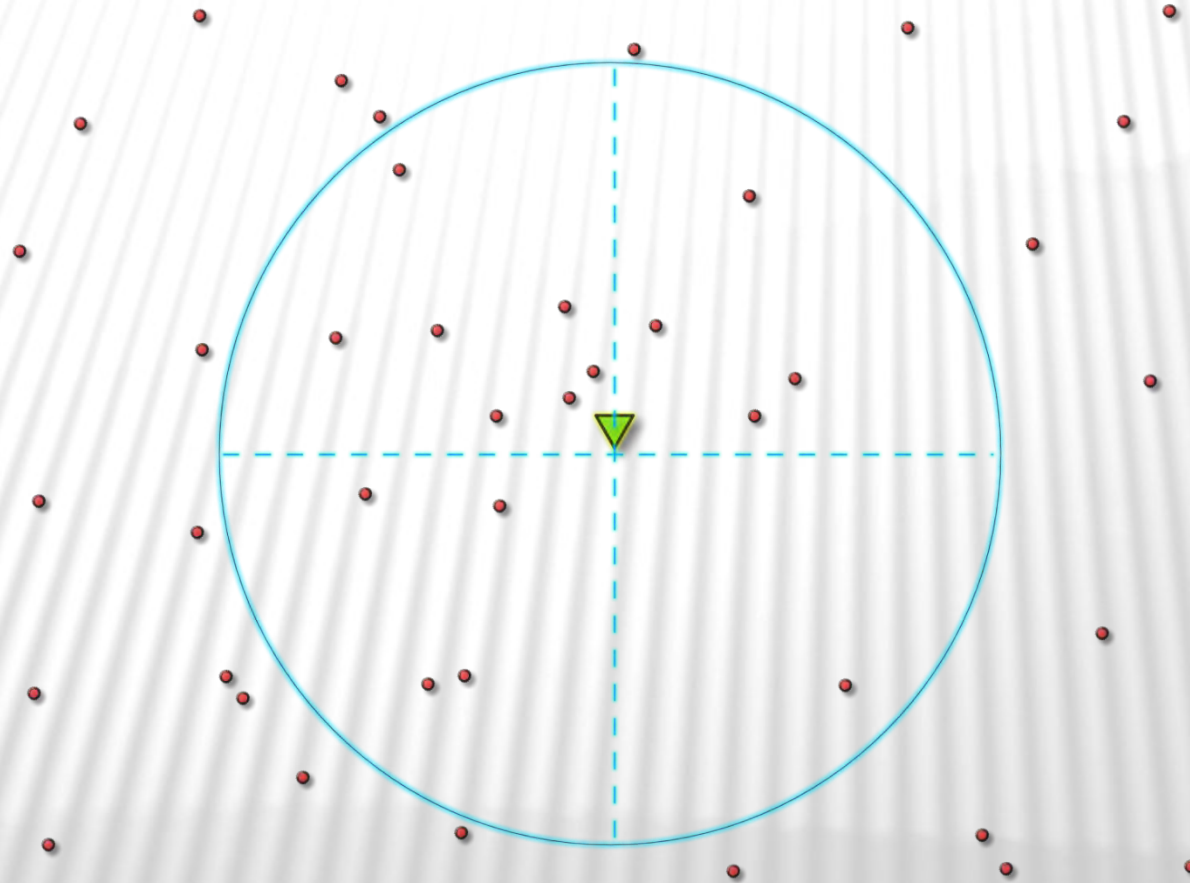
KRIGING CONCEPTS: SEARCH LIMITED BY POINTS

Points=8, Reach=100

Nearest Eight Points Selected

KRIGING CONCEPTS: QUADRANT SEARCH
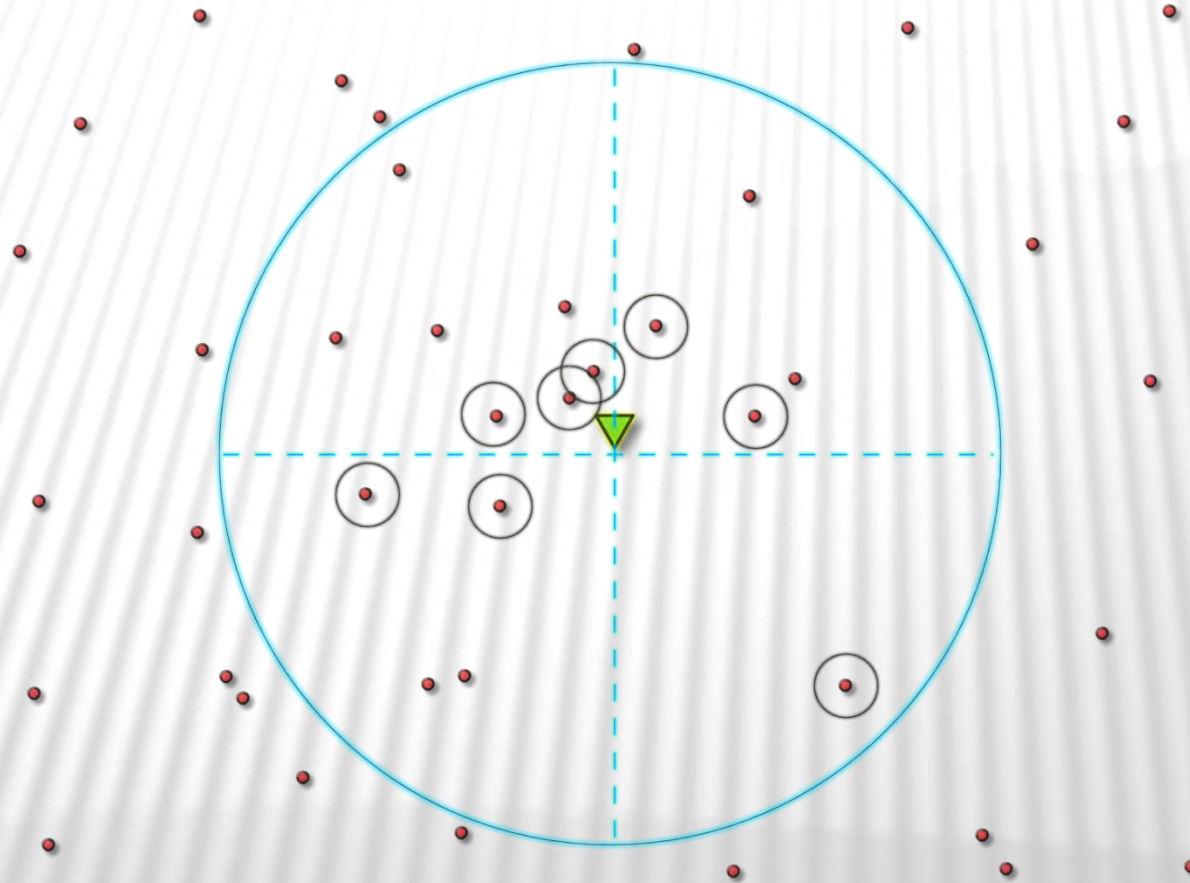
Model space is partitioned into quadrants

Octant Search in 3D – Additional Partition Between Upper and Lower Hemispheres

QUADRANT SEARCH BY POINTS

Points in Quad=4 (Total 8), Reach=100, Quadrant Searching
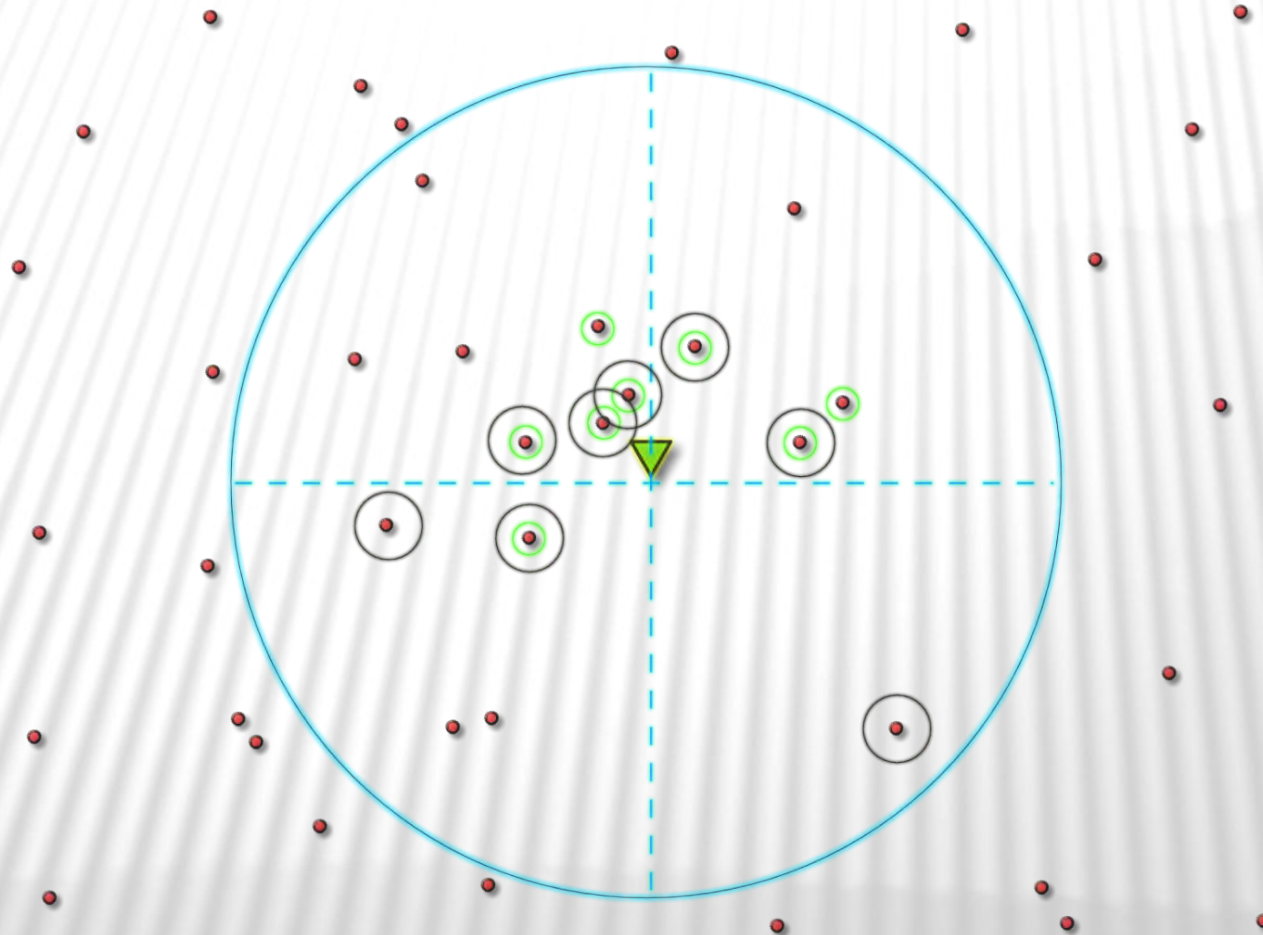
All Four Quadrants Represented

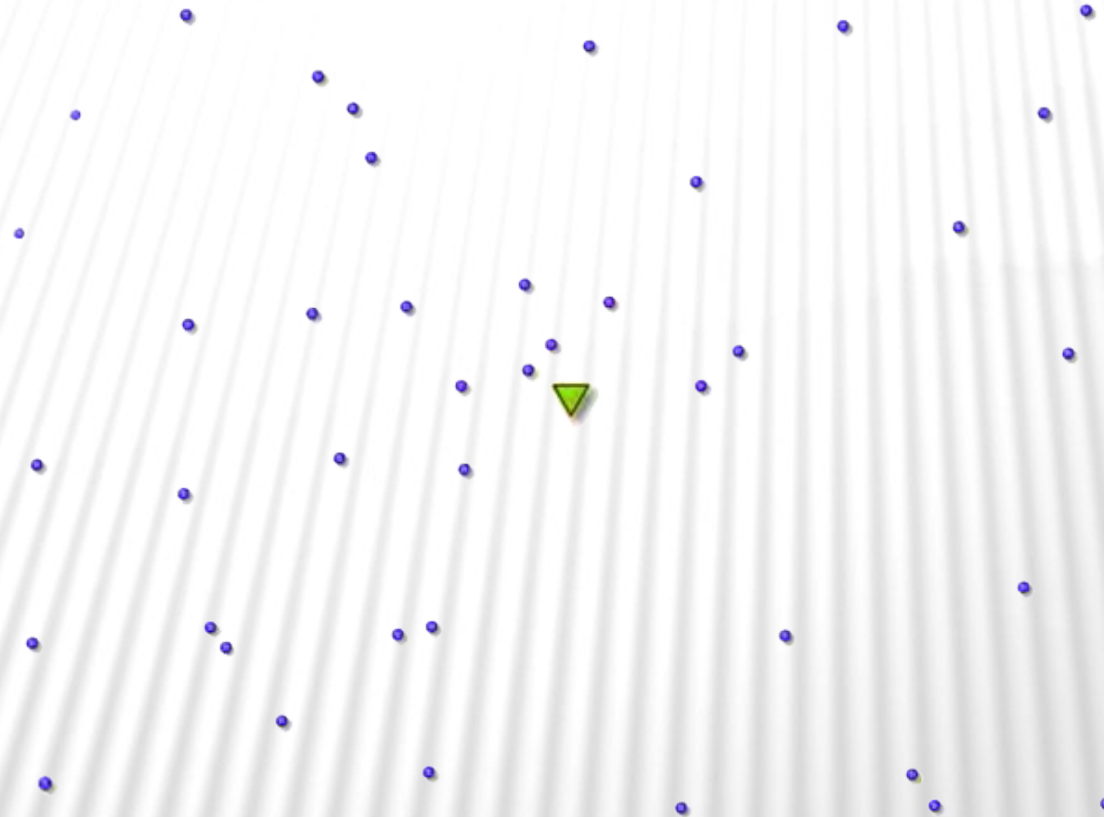# QUADRANT COMPARED

Points=8, Reach=100 / Points in Quad=4, Total Points=8

Quadrant Search ON: Samples selected in all four quadrants (larger black circles)
Quadrant Search OFF: Only the closest eight samples selected (small green circles)

"USE ALL POINTS" OPTION

Bypasses Reach and Points subsetting to use all site data when estimating any node in the grid

"USE ALL POINTS" (CONTINUED)

➤ Eliminates estimation discontinuities when samples arbitrarily fall out of Reach/Point criteria

   ➤ These discontinuities are mathematical constructs resulting from standard kriging practices

   ➤ There is no justification for discontinuities, nor any physical phenomenon which they mimic

➤ Provides the smoothest results

   ➤ Data distributions and plumes will always be smoother and generally more reasonable

➤ This method generally matches the physics of the system best

   ➤ Real-world discontinuities in Earth Science systems can be caused by faults and/or geologic boundaries. They should not be artifacts of how we collect data or perform estimation.

➤ Can have severe consequences on compute times for kriging.

   ➤ Compute time (T) is proportional to $S^{\sim 2.5}$ (where S is the number of samples) and is directly proportional to N (the number of nodes in the grid). $T \propto N * S^{2.5}$

   ➤ However, the same matrix can be reused for the estimation of all nodes in the grid. This can sometimes make All Points a faster option, especially when S is relatively small (less than ~200)

   ➤ These factors compete to make the compute time when using "All Points" difficult to assess.

HANDLING OF NON-DETECTS

- Handling of Non-Detect samples is critical to proper estimation of contaminant and assay data.

- **Do not exclude** non-detects from your data files, but even when they are included, proper handling of the known information is essential to defensible results.

- What is a Non-Detect?: The rigorous definition is that the analyte was not detectable based on the analytical methods used subject to a detection limit.

  - If the detection limit for this sample is near or above your reporting limits, then you should exclude the sample. <u>The sample offers no relevant information.</u>

  - If the detection limit for this sample is well below your reporting limits, specify this sample as "less than the detection limit" (e.g., <0.02, where 0.02 is the detection limit).

  - When your data spans several orders of magnitude, the value that should be used for a non-detect during estimation should be a small fraction of the detection limit. We recommend $1/10^{th}$.

DENSE DATA AND THE DATA REDUCTION TOOL

- **What is Dense Data?**
  - Data which is collected on a fine spatial interval along specific paths
- **Why is Dense Data Problematic?**
  - Dense Data normally contains redundant samples which don't contribute to model fidelity.
  - It causes horrible results when traditional Reach/Points subsetting is used in Kriging
    - Severe discontinuities caused by math constructs which have no physical analog
  - When "Use All Points" is applied, the kriging time $T \propto S^{2.5}$ where S is the number of samples
    - If we reduce S by 50%, we reduce run times by >82% (almost 5 times faster)
    - If we reduce S by 70%, we reduce run times by >95% (over 20 times faster)
- **Shorter execution times results in costs savings and/or better optimized models.**
- **The Data Reduction Tool helps remove data redundancy without loss of fidelity.**
  - It also can help us determine proper Z resolution for these models.

UNDERSTANDING ANISOTROPIC VARIOGRAPHY

➤ Kriging estimates are governed by the variogram being used

➤ Variogram asymmetries affect the apparent distance and direction between samples and the node being estimated.

➤ We've created a dataset and application to better understand these impacts.

  ➤ *variogram-study-theoretical-dataset.advanced.evs*

   ➤ *I*n the "Analytical (Contaminant) Modeling" folder.

  ➤ One hot sample of 1,000 mg/kg at the origin surrounded by a spherical cloud of .001 values.

  ➤ We expect a perfectly symmetrical variogram (all ratios at 1.0) to yield a spherical plume.

MODULES USED IN THIS VIDEO

1. post samples
2. gridding and horizons
3. horizons to 3d
4. horizons to 3d structured
5. explode and scale
6. external faces
7. cross section
8. create tin
9. interpolate nodal data
10. polyline processing
11. legend
12. axes
13. texture cell sets
14. draw lines
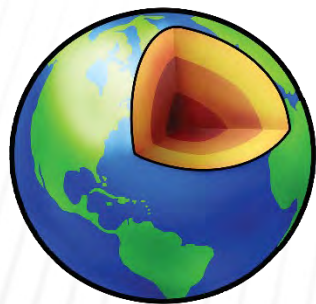
Earth Volumetric Studio™

EVS Premium Training Videos
Lithologic Modeling in EVS

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LITHOLOGIC MODELING – DATA FORMATS

➤ **Lithologic models can be directly created from lithology data such as borings logs and/or lithologic observations.**

➤ **EVS has three file formats which represent lithology data.**

1. The .PGF file format is the original EVS format for boring logs but is limited by its inability to accommodate data gaps. It is a succinct format.

2. The .LSDV format also supports boring logs but with each material observation being defined using the start and end of each material interval. This allows it to accommodate data gaps.

3. The .LPDV file format is designed for lithologic observations rather than boring logs, although there is a tool to convert .LSDV to .LPDV which allows you to integrate borings logs and observations such as surficial data.

LITHOLOGIC MODELING – FUNDAMENTALS

- Lithologic modeling is performed with the *lithologic modeling* module.

- This module is generally the most compute intensive module in EVS.

- The compute time (T) to create a lithologic model is governed by many factors in addition to computer speed, including:

  1. The total number of materials (M) defined in the data file. $T \propto M$

  2. The total number of nodes (N) in the grid. $T \propto N$

  3. Each point in a .LPDV files is an observation, but each material interval in a .LSDV or .PGF will represent multiple observations with M_o dependent on the interval length and the Refine Distance. $T \propto M_o^{2.5}$

- Total Compute Time : $T \propto M * N * M_o^{2.5}$

- This discussion may seem overly technical but understanding how to optimize your model is critical to the quality of your results and your overall efficiency.

- In other words:

  - Understand your data.

  - Simplify your data if possible.

  - Don't rely on default settings.

LITHOLOGIC MODELING – 2 LITHOLOGY METHODS

1. **Block is the simplest & fastest method and has two estimation types.**
   - **When Kriging is the Estimation Type:**
     - Material probabilities are computed for each of your 2D or 3D grid cells and for each of the M materials in your model
     - The material having the highest probability in each cell is assigned to that cell.
     - No nodal data is involved in this method.
   - **When the Estimation Type is Nearest Neighbor (quickest but poorest method)**
     - The material closest to the center of each cell is assigned to that cell.
     - Nearby (but not closest) materials have no impact.
     - No probability computations or nodal data is involved in this method.

2. **Smooth**
   - **Only works with Kriging**
   - **Material probabilities are computed for each node and for each of the M materials in your model**
   - **The material having the highest probability for each node is assigned to that node.**
   - **Nodal probabilities are used to refine (subdivide) cells, smooth the grid and assign materials.**

LITHOLOGIC MODELING – OPTIMIZING KRIGING TIME

➤ Optimization of lithologic modeling can be divided into two categories:

1. Reducing compute times to improve modeling efficiency and reduce the time to converge on an optimal model.

2. Building optimal geologic models which honor the data and known site characteristics

➤ Given that we understand the factors which drive compute time : $T \propto M * N * M_o^{2.5}$, what can we do speed up model creation?

➤ Reduce M: Though it may seem ideal to honor all observed (even subtle) material designations, it is important to know the purpose of your model in order to simplify it wherever possible. A model with more than a dozen materials (let alone 30-50 materials) creates many unforeseen problems.

➤ It is difficult for most people to discriminate more than ~8 colors or patterns which correspond to materials.

➤ If you're trying to assess possible contaminant migration pathways through your site, grouping materials into a small number of categories such as high, medium and low hydraulic conductivity make it easier to understand pathways.

➤ If you're dealing with a mine, choose material groups which identify regions worth exploiting. Adding a large number of irrelevant material designations is counterproductive.

- Coarsen your grid by reducing X, Y & Z resolutions subject to honoring the data.

- Alternatively, reduce the model's extent or dimensionality (3D → 2D cross sections)

- Without discarding data, the only other way to reduce N is to increase Refine Distance
  - Refine Distance defines how we convert lithologic intervals into lithology points.
    - Kriging requires that our data be assigned to points, not intervals.
  - Increasing Refine Distance additionally reduces M_o which has an even more profound impact on compute time.
  - Interval refinement is a complex process that ensures that short intervals are defined by their centers or a point near the top & bottom of the interval and longer intervals receive multiple points along their lengths.
  - Our model's Z resolution must be adequate to resolve fine point spacing which is governed by Refine Distance.
  - N is the product of X, Y & Z resolutions. If we double the Z resolution, then N is doubled and so is our compute time.

- It may not be obvious, but reducing M is often the quickest way to reduce N.
  - Imagine a scenario where there are repeating fine intervals of "Sandy Silt" and "Silty Sand". The composition and properties of these two materials may be very similar, but if we want to honor these fine intervals, we need to have a small refine distance, which will increase M_o as well as N because of smaller cells in Z (a higher Z resolution).
  - Merging these two materials into one category will decrease M and possibly N and M_o. The overall affect can be significant.

LITHOLOGIC MODELING PROCEDURE

- ➢ View your data file (.lsdv, .lpdv or .pgf) in post samples
  - ➢ LINK Screen Refine Distance
- ➢ Set and Confirm the following:
  - ➢ Appropriate Screen Refine Distance (if possible, increase to reduce compute time)
  - ➢ Proper spatial extent
  - ➢ Correct material designations.
    - ➢ Look for duplicate materials such as "Silty Sand" and "Silty-Sand". Merge these in Excel and re-convert to EVS format.
- ➢ Develop your grid while conforming to these guidelines:
  - ➢ In X-Y plane:
    - ➢ Keep grid as coarse as reasonable during early model optimization
    - ➢ Don't include a few errant borings which create large spatial gaps in data distribution.
    - ➢ Use convex hull grid or better yet create areal surface mask to crop grid.
    - ➢ Maintain 3 or more cells between borings with markedly different lithology
  - ➢ Z Extent:
    - ➢ A few deep borings should not force the grid bottom elevation to extend well below 80% of data.
    - ➢ Use Computation Surface (in gridding and horizons) to create a more appropriate bottom of model.
    - ➢ Use a Z Resolution capable of honoring your Screen Refine Distance.

LITHOLOGIC MODELING PROCEDURE (CONTINUED)

- Connect Refine Distance and Filename ports from *post samples* to *lithologic modeling*

- Pass Output Geologic Field (grid) from *gridding and horizons* to *lithologic modeling*
  - Consider using *mask geology* with a 2D Surface Mask if your model has large data-gap regions

- For complex models with large datasets, consider starting with a "cross sections" grid to quickly assess:
  - Required cell sizes in X, Y & Z
  - Optimal Refine Distance
  - (Anisotropic) Variography settings

- Create your model and carefully assess the model's quality

- Refine your modeling parameters based on model quality
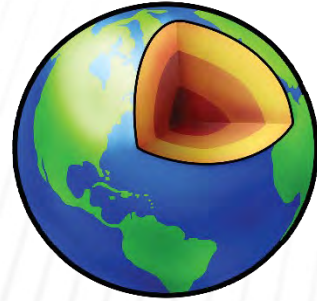
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Advanced Lithologic Modeling in EVS

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DIRECT CROSS SECTION GRIDDING

- Why Use This Approach?:
  - cross sections allow us to create extra fine grids with reasonable computation times.
  - It is often easier to see boring-to-boring material paths when using cross-sections.
- *Cross Sections from Stratigraphic Model* Procedure:
  - Create a 2D grid in *gridding and horizons* including the entire region for cross sections
    - Include Top and Bottom of model surfaces at a minimum
    - X, Y resolutions (cell sizes) will be mimicked in the cross-sections.
  - Use *horizons to 3d (structured)* to build a 3D grid
    - Z resolution used in this module sets the Z resolution of the cross sections
  - Use the *draw lines* module to set the path for cross sections
  - Use *cross sections* module to create the cross-sections.

ALTERNATE: DIRECT CROSS SECTION GRIDDING

- Direct *Lines to Cross Section* Procedure: (no 3d grid created)
  - Use the *draw lines* module to set the path for cross sections
  - *polyline processing* may help control the resolution along the path depending on the method used.
  - The *interpolate nodal data* maps elevation data onto the line paths
  - The *node computation* module maps assigns the lines' Z coordinate to the ground surface and data corresponding to the bottom of the sections
  - Then we *extrude* by that data

ANISOTROPIC VARIOGRAPHY

- When to apply in *lithologic modeling* module
  - Directional trend in the data.
  - Site ground surface is not level, and down-slope direction seems to be mimicked by subsurface materials.
  - Highly asymmetrical data collection is resulting in unacceptable kriging artifacts.
- How to apply in *lithologic modeling*
  - Switch *Anisotropy Mode* to Advanced
  - Visualize ellipsoid and vectors from *lithologic modeling*'s red port.
  - Adjust Primary and Secondary Variogram Ratios
  - Orient ellipsoid using Heading, Dip (and possibly roll)
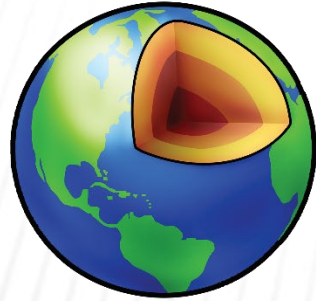
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Changing Content in 3D Web Scenes
Part 1: Driven Sequences

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WHAT IS A SEQUENCE

- Sequences allow you to have content that changes and is easily selected by the end user.
- Sequences are most useful when exporting to C Tech 3D Web Scenes and when saving applications as EVS Presentations.
  - Though they can be useful in your working applications to quickly return to a model state.
- Sequences are a set of model states which are generated automatically based upon your settings.
- Applications can have multiple sequences in parallel, nested sequences in series and combinations of both.

DRIVEN SEQUENCE: QUICK AND EASY

- The driven sequence module provides a simple way to generate sequences.
- The following are the only "Supported Modules":
  - *cut*
  - *slice*
  - *plume*
  - *plume shell*
- Most sequencing options are properties of the "Supported Modules"
  - These are specific to the module type (plume vs. cutting)
- *State Names* are automatically generated based upon your *Status Expression* and cannot be individually edited.

DRIVEN SEQUENCE WITH CUT AND SLICE

➢ The slice and cut modules work identically with sequences.

  ➢ For both modules I will refer to cuts (vs. slices)

➢ There are three methods to set the position of cuts

  ➢ **Linear by step** requires Min, Max and Anchor coordinates.

    ➢ It creates all cuts from Min to Max including the Anchor.

    ➢ If Min or Max are not included, the extreme values are offset ~5%

  ➢ **Linear by count** creates n equal spaced cuts between (& including) Min & Max

    ➢ If Min or Max are not included, the extreme values are offset ~5%

  ➢ **User entry** allows for arbitrary user defined cut positions.

➢ Rotatable option is not supported for sequences.

  ➢ It is supported with *scripted sequence*

DRIVEN SEQUENCE WITH PLUME AND PLUME SHELL

➢ The *plume & plume shell* modules work identically with sequences.

➢ There are four methods to set Subsetting Levels in the sequence.

  ➢ **Linear by step** requires Min, Max and Anchor coordinates.

    ➢ It creates all plumes from Min to Max including the Anchor.

    ➢ If Min or Max are not included, the extreme values are offset ~5%

  ➢ **Linear by count** creates n equal spaced plumes between (& including) Min & Max

    ➢ If Min or Max are not included, the extreme values are offset ~5%

  ➢ **User entry** allows for arbitrary user defined subsetting levels.

  ➢ **Log steps per decade** is generally most appropriate for (quasi) uniform steps when you have Log processed data.

PAINTING-FACILITY-PLUME-DRIVEN-SEQUENCE.EVS

- This app has only one plume sequence using driven sequence.
- The plume module (sequence) settings are:
  - Use Sequencing ON
  - *State Control* set to Slider
  - Sequence generated using "Log steps per decade"
  - Per Log Decade: set to 3 (e.g., 1, 2, 5, 10, etc.)
  - Include Min & Max OFF
- A titles module displays the state information for each state
- 21 total states from 0.01 to 50,000

PAINTING-FACILITY-PLUME-3-ORTHO-SLICES-DRIVEN-SEQUENCE.EVS

- This application has 4 parallel sequences:
  - One plume sequence using driven sequence with 15 states.
  - Three slice sequences using driven sequence with 22, 17 & 11 states in X, Y & Z.
  - 65 total states in 4 parallel sequences.
  - 15 * 22 * 17 * 11 = 61,710 possible display combinations
- The plume module settings are 2 Log Steps per Decade
- The slice module step sizes are 25, 25 & 5 in X, Y & Z
- *State Control* set to *Slider* for all four driven sequence modules.
- Include Min & Max OFF
- Four titles modules display information for each sequence's states

PAINTING-FACILITY-SLICES-IN-PLUME-DRIVEN-SEQUENCE.EVS

- This application has 2 serial (nested) sequences both using sliders:
  - One plume sequence using driven sequence with 17 states.
  - One slice sequence using driven sequence with 12 states in X.
  - 204 total states in 2 nested sequences.
  - Only 204 possible display combinations (same at the total states)
- The plume module settings are 3 Log Steps per Decade
- The slice module is set to 12 Linear by count
  - Therefore, the slice states will not be at specific intervals (e.g., 25, 50, 75)
- Two titles modules are still needed

DRIVEN SEQUENCE SUMMARY
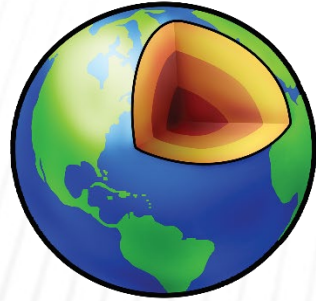
➤ The driven sequence module combines power with ease of use.

➤ There are multiple ways to set Levels in sequences.

➤ You have some control over parametrically driven state naming.

➤ Applications can have driven sequences that are parallel, nested or both.

➤ The slice, cut & plume (shell) modules have new sequencing options which are an essential part of creating sequences.

➤ Other modules affected by plumes, slices or cuts can have changing content which can be included in the sequence, such as:

   ➤ isolines, band data, edges, etc.

FINDING EVS APPLICATIONS WITH SEQUENCES
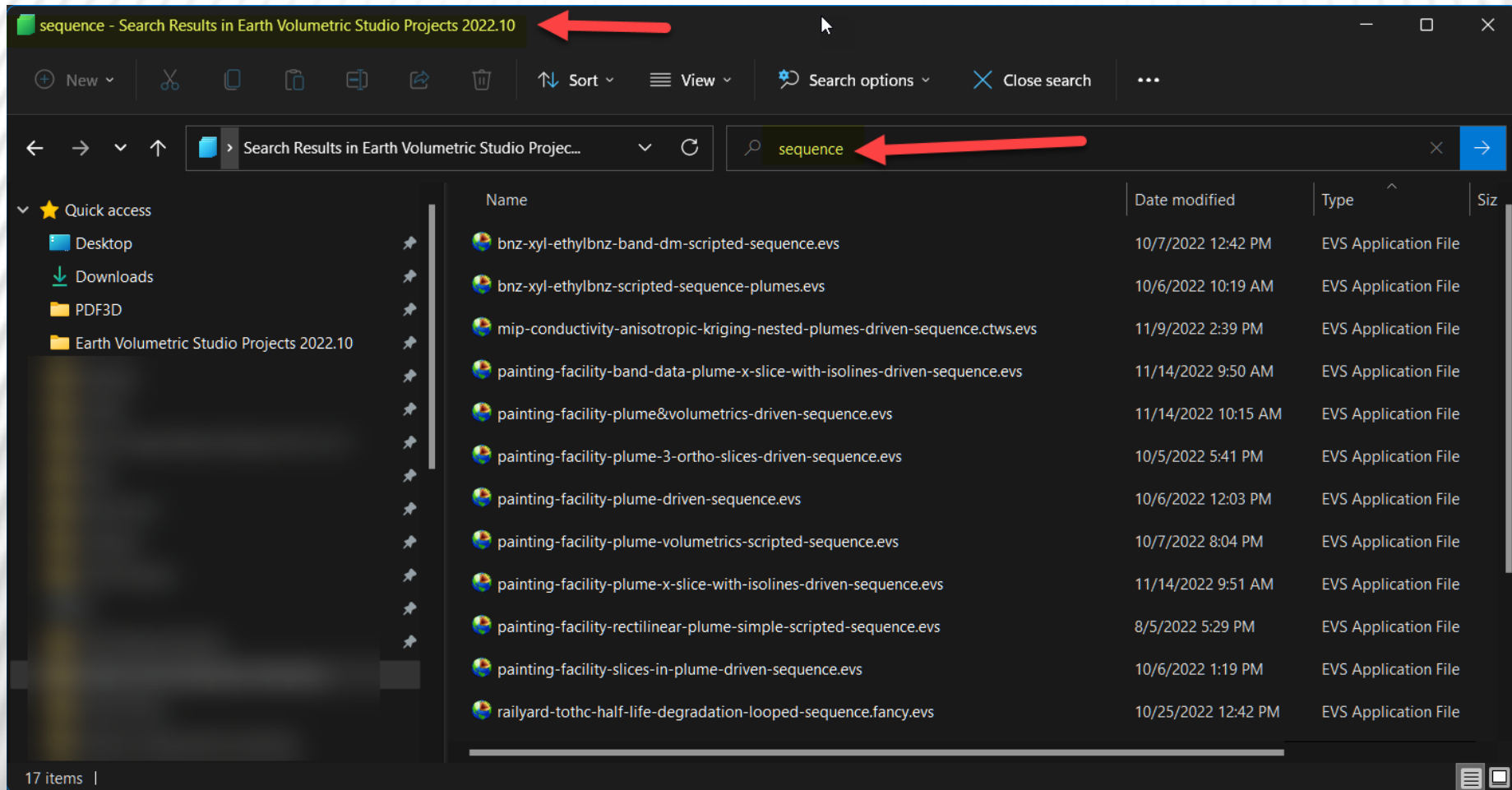
To quickly find applications in Studio Projects with either driven sequence or scripted sequence, just use the search function in Windows File Explorer.

We have explicitly included driven sequence or scripted sequence in all examples.

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Changing Content in 3D Web Scenes
Part 2: Scripted Sequences

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FEATURES OF BOTH SEQUENCE MODULES

- ➤ This discussion applies to both driven and scripted sequences.
- ➤ Multiple sequences can exist in the same application
- ➤ Sequences can be nested, which creates more total states.
  - ➤ If sequence1 has 10 states and is nested into sequence2 with 8 states, there will be 80 total states created.
  - ➤ Nested sequences have only one sequence module connected to the viewer. Consider them as being in *series* versus *parallel*.
- ➤ The total number of states is the SUM of parallel sequence's states and the PRODUCT of series sequence states.
- ➤ The total number of possible display combinations is always the product.

➢ **Both driven and scripted sequences have 3 user interface options.**
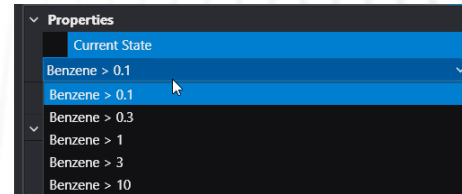
1. **Slider:**
   ✕ **Good for any number of states**

2. **Combo Box**
   ✕ **Best for fewer than 8 states because it cannot scroll**
   ✕ **Screen resolution may drop states off the bottom**

3. **List Box**
   ✕ **Best for under 20 states because it can scroll**
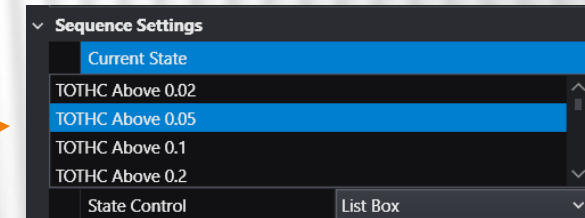
➢ **The type used is set in the "State Control" parameter**

➢ **Driven and scripted sequences have otherwise identical user interfaces within 3D Web Scenes (.ctws files).**

SCRIPTED SEQUENCE: UNIQUE FEATURES

➢ The *scripted sequence* module contains the parameters and settings controlling the state names and user interface options.

➢ This modules power and control relies on Python.

  ➢ All EVS Modules can be controlled via Python.

  ➢ Sequencing functions and behavior depend on your Python Script

  ➢ Four numeric values (N1 – N4) provide some control without modifying Python

SCRIPTED SEQUENCE: POWER THROUGH PYTHON

➤ The *scripted sequence* module provides a more powerful and less restricted method to generate sequences.

➤ This module cannot be used without Python skills (writing a script)

➤ All EVS Modules can be controlled.

➤ Sequencing options are determined by your Python Script

➤ State Names are explicitly set in Python and/or edited in the UI.

➤ All modules connected to *scripted sequence (vs. the viewer) can have different content in each state.

   ➤ Modules with static content can be in the sequence group with little impact on .CTWS file size or efficiency.

PAINTING-FACILITY-PLUME-VOLUMETRICS-SCRIPTED-SEQUENCE.EVS

- This application has one scripted sequence module:
  - Controlling *plume, volumetrics* and *titles*
  - Python provides functionality not possible with driven sequence
- The script cycles through 3 analytes & multiple thresholds
  - TOTHC, 80%Max:TOTHC & 80%Min:TOTHC
  - Subsetting Levels are not identical for all analytes
  - *volumetrics' Nodal Data Component* controlled
  - Customized title string created from volumetrics outputs

NOTE: Unless we use *change minmax, post samples'* colors will not match Max or Min legends.

- This application has one scripted sequence module controlling:
  - *post samples, plume, external edges, legend, volumetrics and titles*
  - Level of control would be impossible without Python
- The script cycles through 3 of 4 analytes & multiple thresholds
  - Benzene, (Toluene skipped), Xylene & Ethylbenzene
    - Proper analyte set in all modules
    - The legend module customized for each analyte
  - Subsetting Levels are unique for each analyte
  - Customized title string created from volumetrics outputs

BNZ-XYL-ETHYLBNZ-BAND-DM-SCRIPTED-SEQUENCE.EVS

- ➢ **Based upon bnz-xyl-ethylbnz-scripted-sequence-plumes.evs**
  - ➢ **Plume displayed with contours (*band data*)**
- ➢ **Benzene, (Toluene skipped), Xylene & Ethylbenzene**
  - ➢ **Proper analyte set in all modules**
  - ➢ **Unique datamaps applied to each analyte for all relevant modules.**
  - ➢ **The legend module customized for each analyte**
- ➢ **Subsetting Levels are unique for each analyte**
- ➢ **Customized title string created from volumetrics outputs**

SCRIPTED SEQUENCE SUMMARY

➢ The *scripted sequence* module with Python provides functionality which was previously not available.

➢ You may need to control modules which are not connected to *scripted sequence*.

➢ The converse is that modules which are indirectly driven by other modules may need to be connected to *scripted sequence*.

➢ Applications can include both *driven sequence* and *scripted sequence*.

➢ The power of this module is limited only by your imagination and Python skills.

EVS Premium Training Videos
Changing Content in 3D Web Scenes
Part 3: Advanced Scripted Sequences

C TECH DEVELOPMENT CORPORATION   REED D. COPSEY, PRESIDENT

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SCRIPTED SEQUENCE REVIEW

➢ Any module whose content changes as a result of your Python script, must be connected to the red input port of scripted sequence.

➢ Modules which are indirectly driven by other modules may need to be connected to *scripted sequence*.

➢ Applications can include both *driven sequence* and *scripted sequence*.

➢ The power of *scripted sequence* is limited only by your imagination and Python skills.

ADVANCED SCRIPTED SEQUENCE APPLICATIONS

➢ In this video we will demonstrate several advanced script driven applications.

➢ Each uses the *scripted sequence* module to create powerful and interesting applications and web scenes such as:

  ➢ Multiple cross-sections changing under sequence control

  ➢ Orthogonal East and North slices passing through each boring

  ➢ Orthogonal East, North and Horizontal slices passing through each sample location

  ➢ Nested sequences controlling multiple analytes and unique plume thresholds for each analyte.

MULTIPLE CROSS-SECTIONS UNDER PYTHON CONTROL

- ➤ Cross sections have the advantage of being able to pass through multiple borings.
    - ➤ But showing the relationship between all of the data and 3D models (analytical or geologic) generally requires multiple cross-sections.
- ➤ We can then use sequences to select cross-sections from line files with multiple line segments and cell data.
    - ➤ These can be single, nested or parallel.

Lithologic Geologic Modeling\thalen-road-lithology.evs
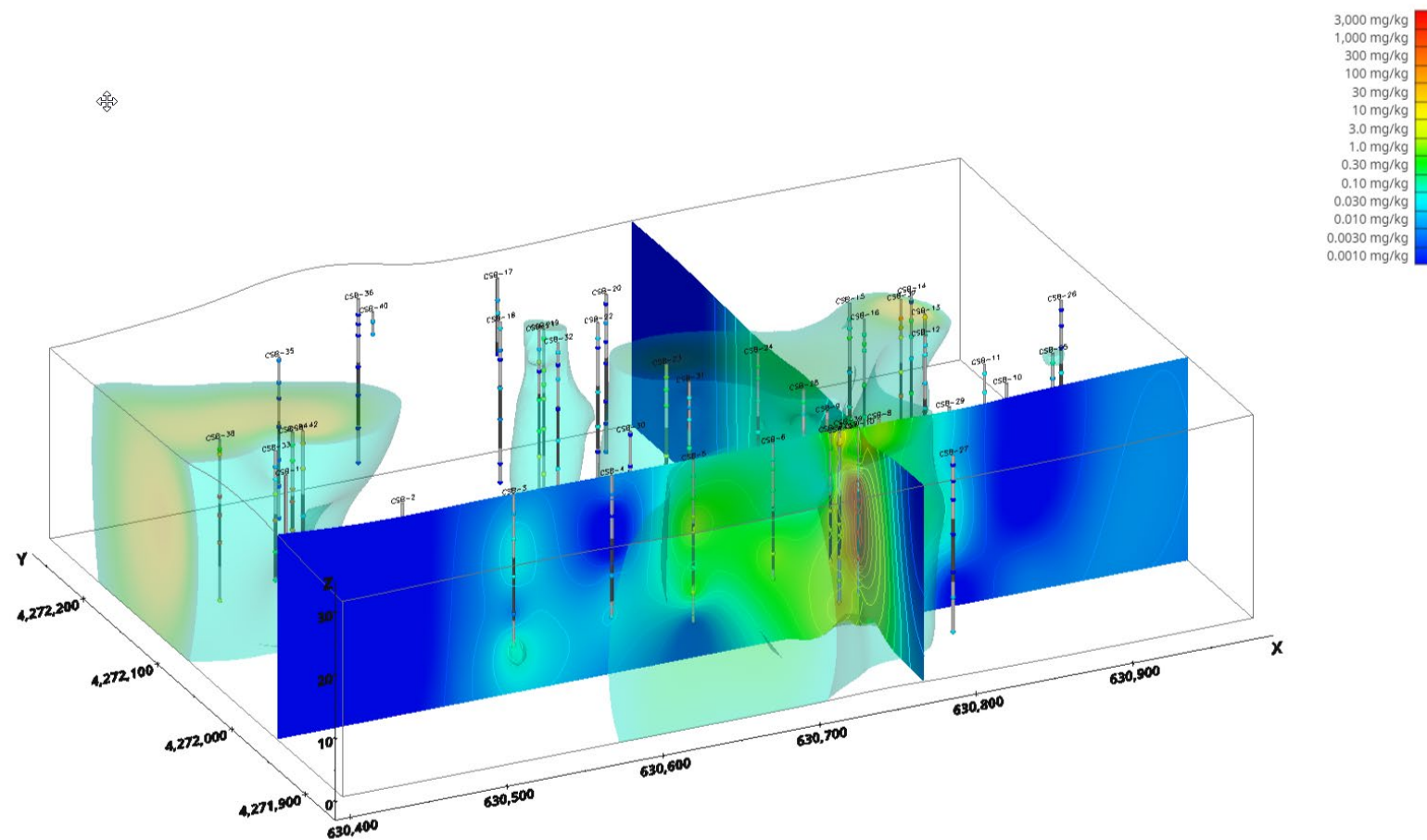
ORTHOGONAL SLICES PASSING THROUGH BORINGS

➤ Creating a pair of orthogonal slices passing through each boring of a 3D model is a great way to examine the relationship of each boring and the 3D model to which it contributes.

➤ This requires having access to the X & Y coordinates and Boring ID for the relevant dataset.

➤ We will demonstrate how to create this list to add to our Python script from the EVS data file using Excel.

➤ Other sequences such as plume levels can contribute the functionality of this application

Analytic and Stratigraphic Modeling\railyard-tothc-.sequenced-plumes_&_xy-slices-with-isolines.evs.
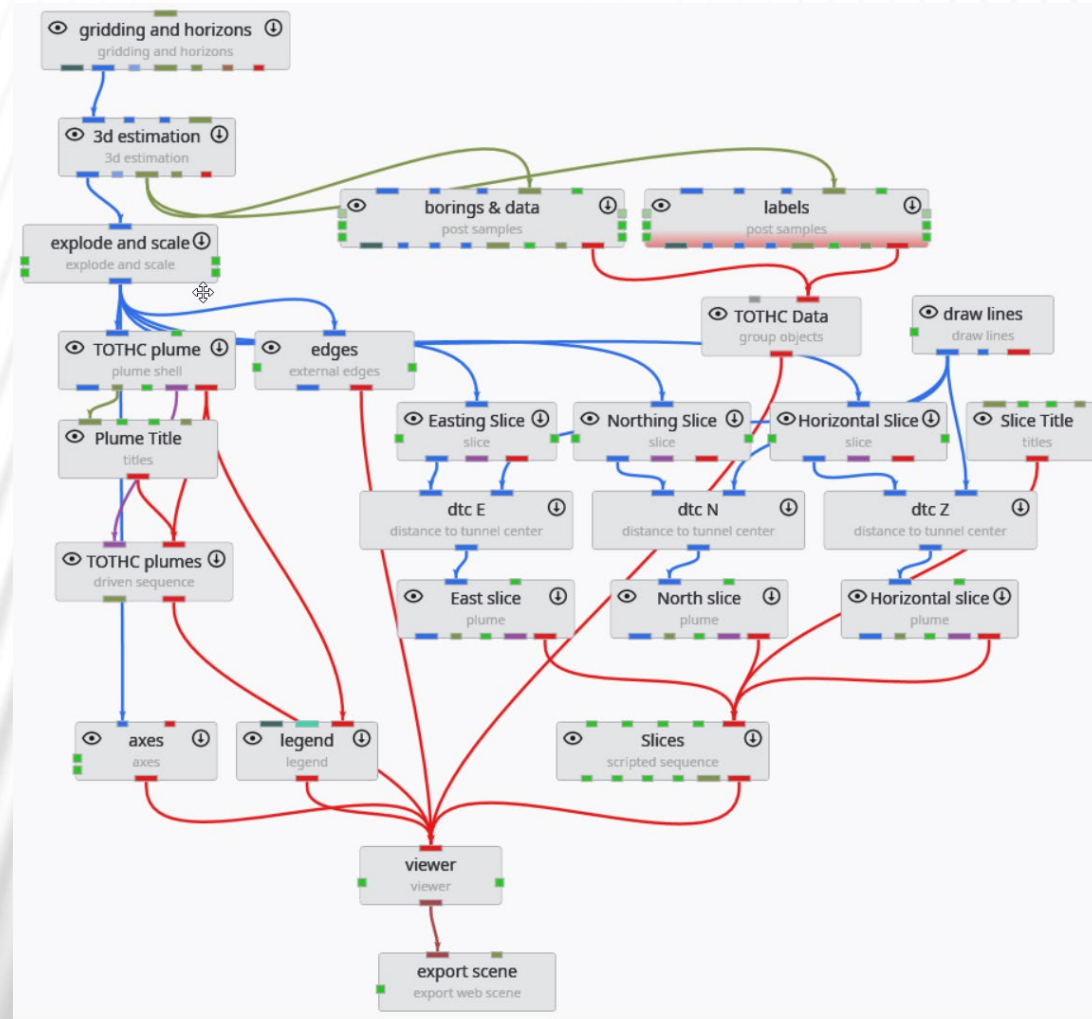
TOTHC Above 0.1 mg/kg
Slices through Boring CSW-10
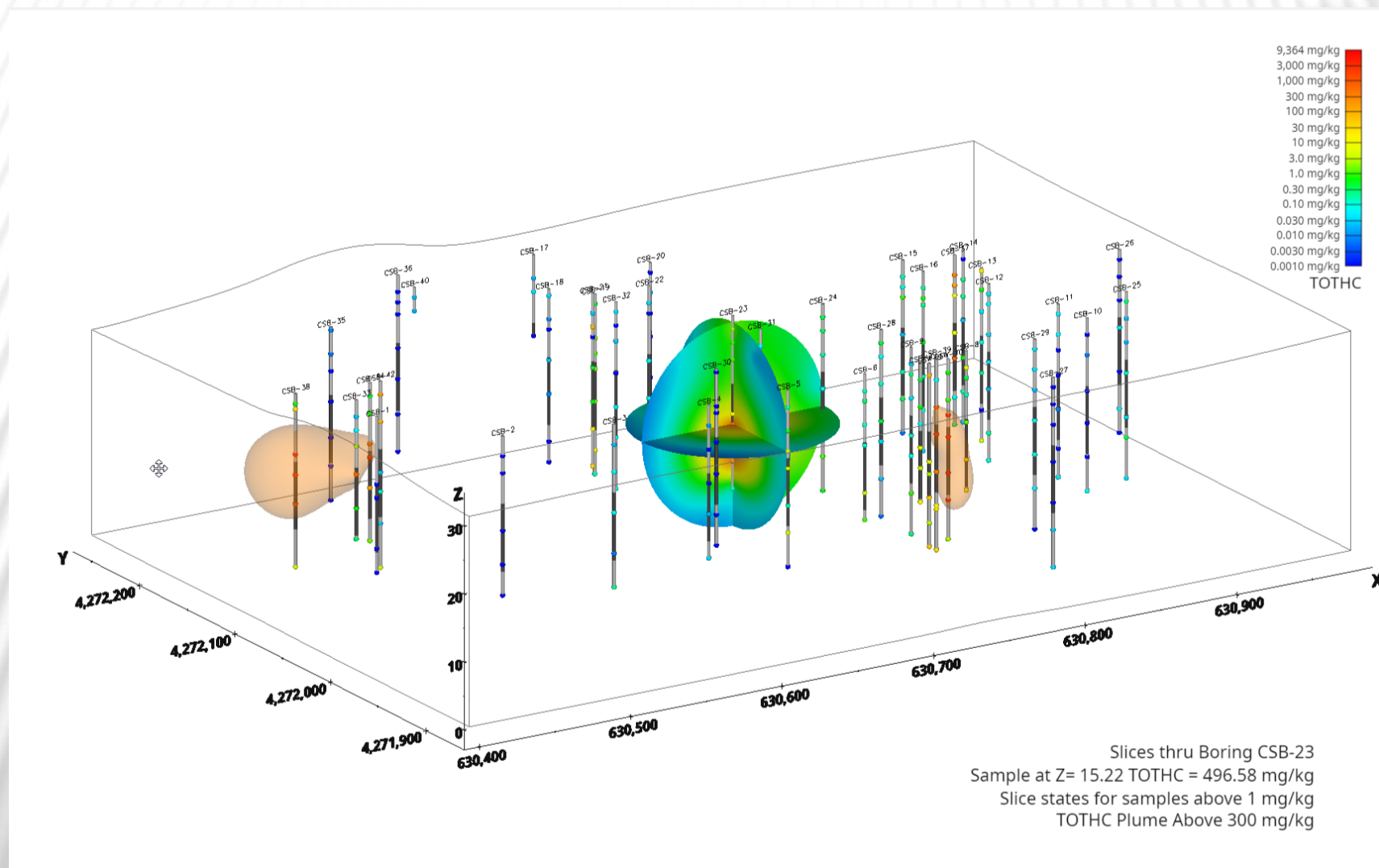
ORTHOGONAL SLICES PASSING THROUGH SAMPLES

➢ One step up in complexity is this application which places three Orthogonal slices at each selected sample location.

➢ This requires the following information for our coords list in Python:

　➢ X, Y & Z coordinates

　➢ Boring ID &

　➢ Sample analyte value.

➢ Large datasets could result in a very large web scenes, therefore we demonstrate:

　➢ Culling the dataset to reduce the list size and focus on the most important samples.

　➢ Reducing the physical extent of the slices using the *distance to tunnel center* module.

Analytic and Stratigraphic Modeling\railyard-tothc-sequenced-xyz-slices.evs
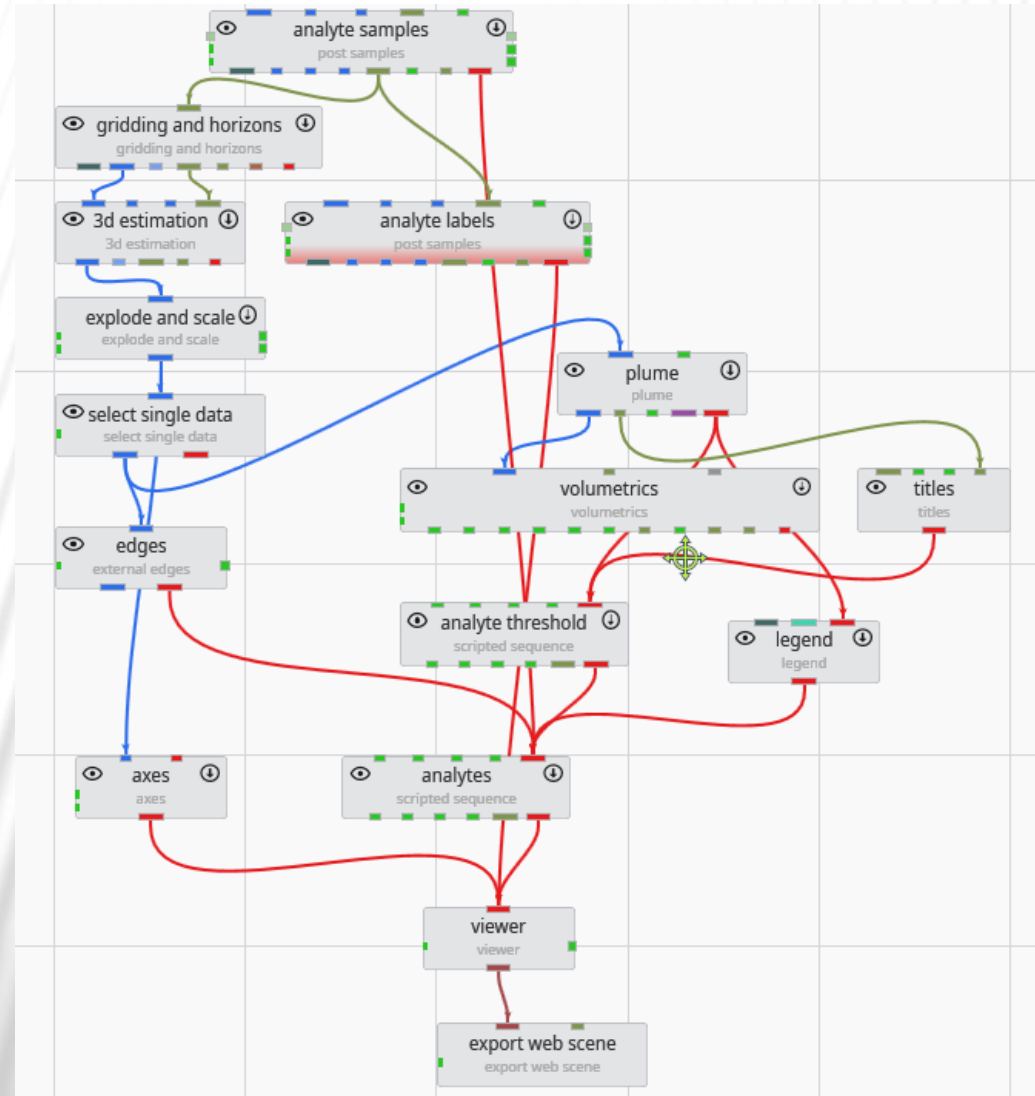
MULTIPLE ANALYTES & THRESHOLD SEQUENCES

➢ **Nested sequences controlling multiple analytes and unique plume thresholds for each analyte.**

  ➢ The Python script will extract the analyte names & units from the application.

  ➢ Each analyte can have different numbers of user defined plume thresholds specified in the Python script.

➢ **Requires advanced Python techniques to control two *scripted sequence* modules with a single unified script.**

  ➢ The extra complexity of determining which *scripted sequence* module is being controlled is offset by the advantages of managing a single script.

Analytical (Contaminant) Modeling\8-analytes-scripted-sequence.evs

MULTIPLE ANALYTES & THRESHOLD SEQUENCES
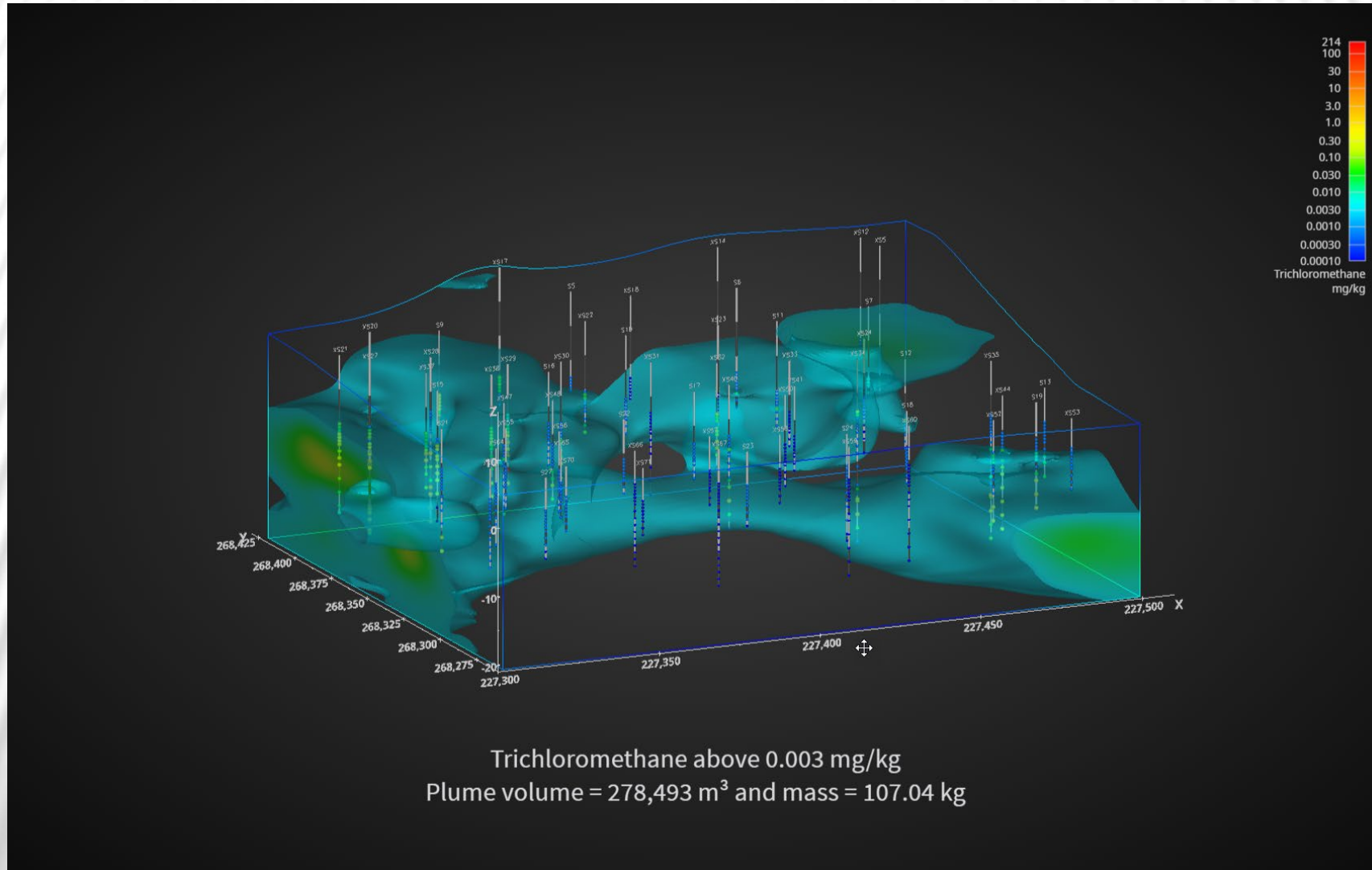
Trichloromethane above 0.003 mg/kg
Plume volume = 278,493 m³ and mass = 107.04 kg

PYTHON USE IN THIS CLASS

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- I warn all attendees that this is a very Python centric class.

- If you have no Python experience, I recommend you forego attending and learn Python first.

- Then you'll be ready to tackle this class when it becomes available as a recorded video.

- Without Python experience you can likely understand the concepts, but not the methods.

MODFLOW INITIALIZATION

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- **Traditional use of EVS for MODFLOW initialization involved building stratigraphic models and applying flow properties by model layer within your preprocessing software (e.g., Groundwater Vistas)**

- **This forces an assumption that properties within each stratigraphic (MODFLOW) model layer were homogeneous.**

- **Many sites have much more complex geology and are better served with EVS's Lithologic Modeling.**

- **This class will demonstrate several options for parameter assignment on a cell-by-cell basis.**

MODFLOW PARAMETERS OF INTEREST

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- The techniques we will cover can be applied to any arbitrary property desired.

- In this class I will focus on:

  - Kx

  - Ky

  - Kz

  - Effective Porosity

- We will focus on the assignment of cell properties since that is most common in MODFLOW, but our methods are equally applicable to nodal properties.

PARAMETER ASSIGNMENT METHOD #1

- ## INDEX ASSIGNMENT

  - **The simplest method that I will demonstrate is "Index Assignment", which uses each lithologic material's *Index* (ID) to assign any number of properties to each cell.**

  - **The ID of the material assigned to each cell is used as a "lookup" to assign one or more properties to each cell.**

  - **The pattern of properties within our 3D grid will match the pattern of the lithologic materials.**

    - **The colors will change because the assigned values will not be integer values.**

PARAMETER ASSIGNMENT METHOD #2

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- **INDEX ASSIGNMENT with FGR**

  - **We can extend the concepts of Index Assignment to include different realizations of the lithologic materials based on C Tech's Fast Geostatistical Realization technology.**

  - **FGR will change the pattern of lithologic materials within our 3D grid.**

  - **The pattern of properties within our 3D grid will match the pattern of the lithologic materials resulting from the FGR realization.**

  - **This provides a methodology to perform MODFLOW realizations which represent unique but statistically valid potential groundwater models.**
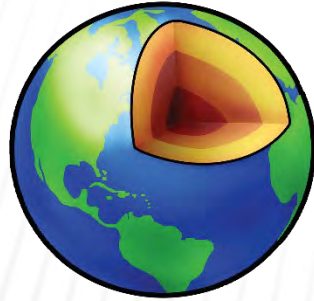
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- ## PROBABILISTIC ASSIGNMENT

  - Probabilistic Assignment takes advantage of the individual material probabilities inherently available with C Tech's *lithologic modeling* module.

  - Material probabilities are normalized so that they will always sum to 100% for any cell (or node).

  - We use the probabilities as weighting factors for assignment of properties.

  - The pattern of properties within our 3D grid will not match the pattern of the lithologic materials.

    - Rather than an obviously discontinuous pattern of properties, each property will have a continuum nature.

  - This provides a methodology to perform a singular MODFLOW realization which represents a fuzzy-average groundwater model case.

PARAMETER ASSIGNMENT METHOD #4

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- ## PROBABILISTIC ASSIGNMENT with FGR

  - Extending Probabilistic Assignment to include Fast Geostatistical Realizations of the Lithologic Model provides a methodology to create multiple MODFLOW realizations with this fuzzy-average parameter assignment methodology.

  - It may seem counter intuitive that each Lithologic Material Probability is changing because we are using FGR realizations as input rather than *lithologic modeling's* output.

  - The probabilities used in *lithologic modeling* are the (normalized) <u>Nominal</u> (kriged) Probabilities for each material.

  - FGR computes a different realization of those probabilities in order to determine a different realization of the lithologic materials.

  - Probabilistic Assignment with FGR uses the realizations of the individual probabilities.

Advanced MODFLOW Initialization Concepts
Online Training Class: February 10, 2022

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