OpenRoads Designer User Manual

U.S. Department of Transportation
Federal Highway Administration

Chapter 5

SURVEY PROCESS AND TERRAIN MODELS

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Chapter 5 Survey Process and Terrain Models

This chapter provides an overview of the survey processes used to create the Survey ORD File and Existing Terrain Model. Manipulating the appearance of the Existing Ground Terrain Model is also discussed.

Additionally, this chapter provides workflow for acquiring LiDAR data and converting it into a Terrain Model. The LiDAR Terrain Model can be used for initial design or merged with the Existing Ground Terrain Model to expand and/or fill in a gap.

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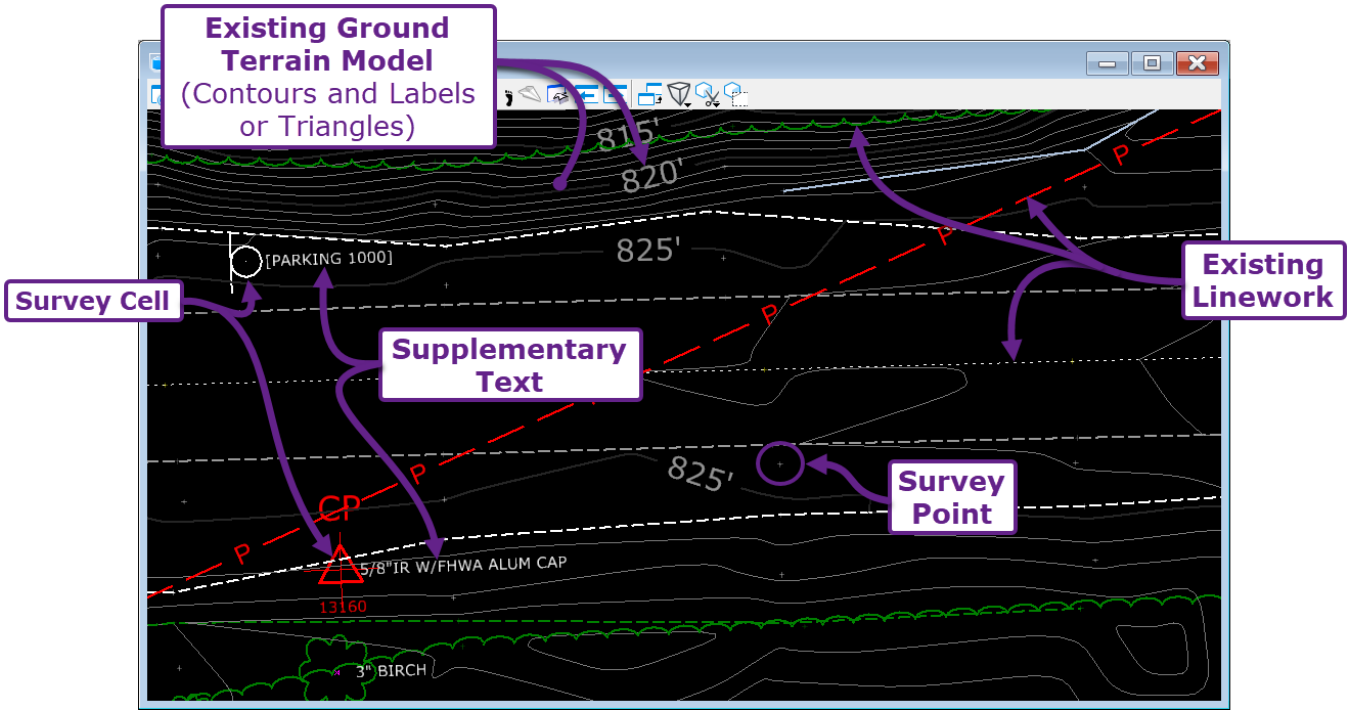
5A – INTRODUCTION TO THE SURVEY ORD FILE

The Survey ORD File contains existing surveyed features that were processed by the project surveyors and map processors.

> ***IMPORTANT:*** The Survey ORD File is a 3D File. It only contains a *3D Design Model*. All elements contained in the Survey ORD File are 3-dimensional. The majority of other ORD Files types originate as 2D Files (meaning they initially only contain a *2D Design Model*). The 3D Survey ORD File is visually flattened when referenced into a 2D File.

The Survey ORD File typically contains the following existing features:



The Existing Ground Terrain Model: The Existing Ground Terrain Model is a 3-dimensional digital surface that characterizes the existing ground elevations in the project area.

From the plan/3D perspective, the Existing Ground Terrain Model displays contours. From a cross sectional perspective (i.e., the *Profile Model*), the Existing Ground Terrain Model displays the existing grade profile. Contour Labels are automatically generated by the Existing Ground Terrain Model.

> ***TIP:*** For analyzation purposes, the appearance of the Existing Ground Terrain Model can be altered by changing the *Feature Definition*. See *5B.1 Feature Definition Settings for the Existing Ground Terrain Model*.

The Existing Ground Terrain Model is used in 3D modeling (i.e., Corridors) and quantity calculations. The proposed 3D model produces cut/fill slopes by seeking out (targeting) the Existing Ground Terrain Model.

Existing Linework: Existing Linework characterizes the layout of existing linear features, such as centerline of road, shoulder of road, toe of slope, edge of water, and utilities lines. Each line vertex represents a Survey Point recorded by a surveyor in the field.

Existing Linework elements are 3-dimensional. Each vertex is set to an elevation. Many types of Existing Linework elements are used as *Break Lines* to create and calibrate the Existing Ground Terrain Model.

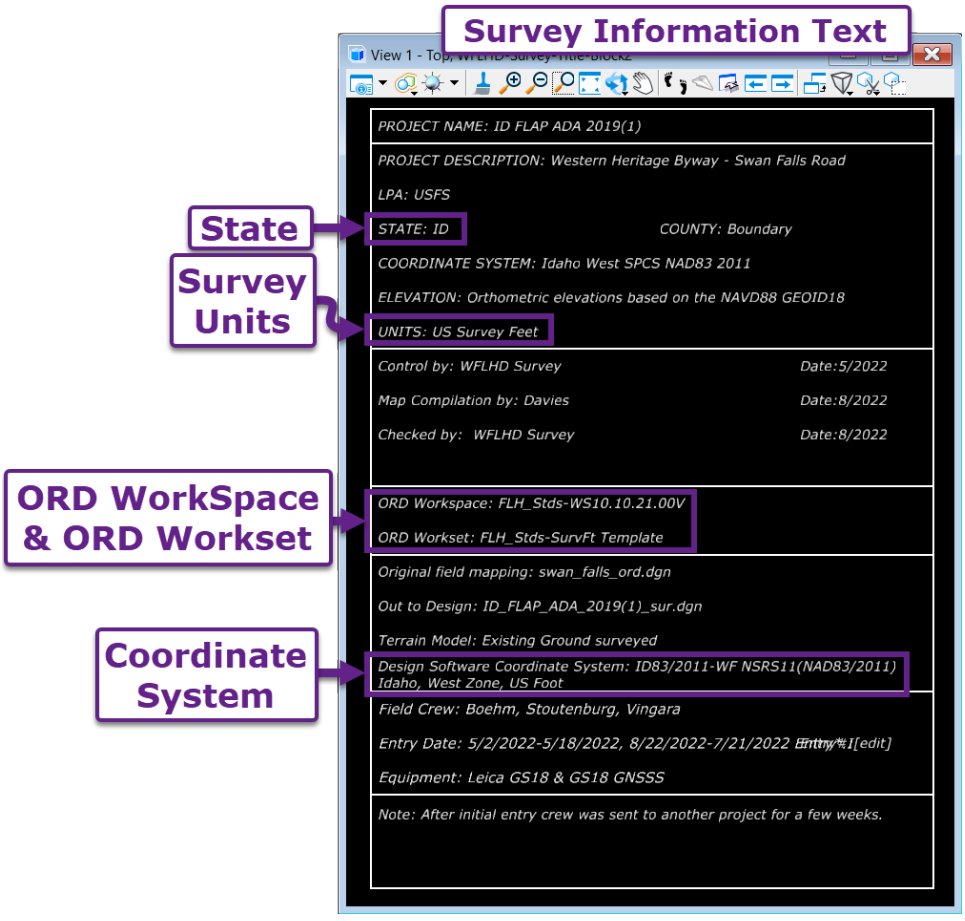
Survey Cells (Symbols): Survey Cells represent non-linear features, such as signs, trees, utility junction boxes, power poles, and water valves. Also, Survey Cells are also used to display Control Points and Benchmarks.

Supplementary Text: Typically, supplementary text is placed next to each Survey Cell to provide a description of the feature. For example, each sign cell contains text that describes the type and message displayed on the sign. Tree cells may contain text that describes the diameter and type of tree (i.e., birch).

Survey Points: A Survey Point typically appears a cross shape or triangle. However, occasionally Survey Points appear as circles or dots, such is the case with culverts. Each point location surveyed in the field has a corresponding Survey Point. Survey Points are located at the vertices of Existing Linework elements. Some Survey Points are NOT associated with Existing Linework and Survey Cells. These points are called Ground Shots and are taken to provide additional data points for the Existing Ground Terrain Model.

Survey Information Text: Information relating to the processing of the Survey ORD File is located off to the side of the graphical elements. The Survey Information Text states the Coordinate System, Survey Units (i.e., US Survey Feet or International Feet), State, datums, surveying agency, and ORD WorkSpace/WorkSet used to create the survey data.

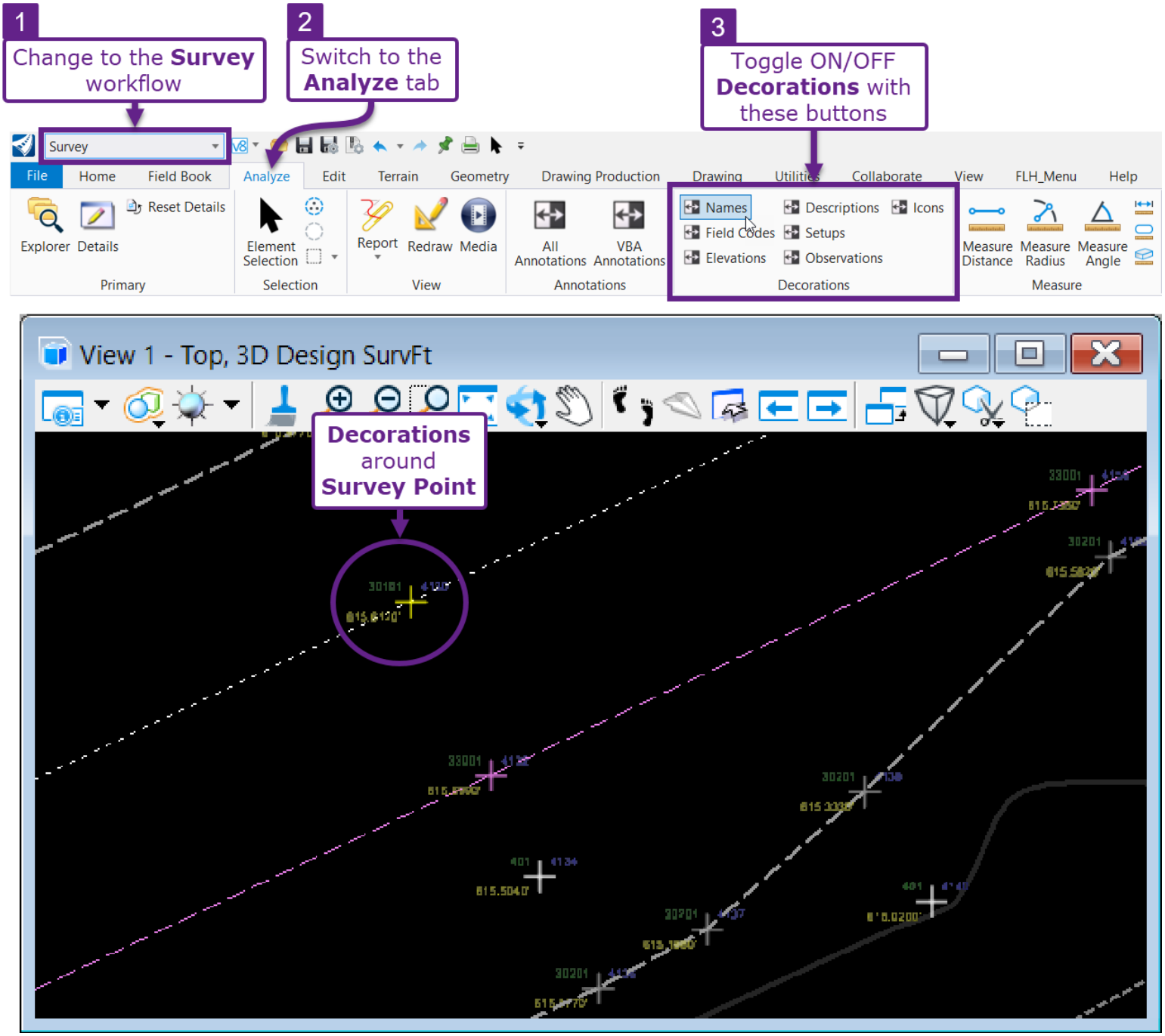
> ***IMPORTANT:*** Knowing the Survey Units for the project is vital. The Survey Units dictates which Seed File is used to create new ORD Files. If the wrong Survey Units Seed File is used, then the graphical elements will be placed in the wrong geographical locations.
>
> ***TIP:*** The following States use **International Feet** units: Oregon, Montana, Arizona, Michigan, North Dakota, and South Carolina. All other States use **US Survey Feet** units.



Decorations (Point Name and Code Information): When accessing the Survey ORD File for the first time, Decorations may be shown in the vicinity of Survey Points. Decorations are Survey Point attributes, such as Point Name, Point Code, and Elevation, and Description.

Decorations are toggled ON/OFF through the Ribbon in the following location:

[***Survey*** → ***Analyze*** → ***Decorations***]



NOTE: Right-of-Way Linework is typically NOT found in the Survey ORD File. Typically, there is a separate ORD File that contains Right-of-Way and Property Boundary linework.

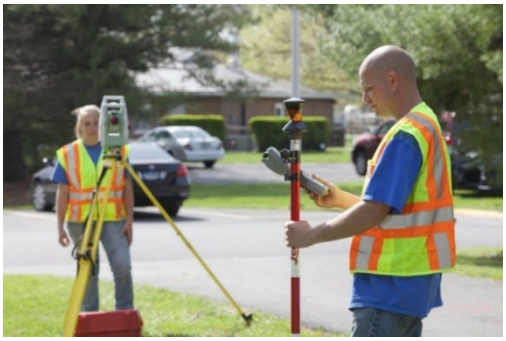
5A.1 Creating the Survey ORD File/Existing Ground Terrain Model

The general process for collecting and processing survey data is as follows:

PROCESS 1 - Determine Survey Requirements: Before visiting the project site, the field staff determines the requirements for the survey. The requirements for the survey are governed by two documents: The Project Scope of Work (SOW) and Chapter 5 (Survey and Mapping) of the PDDM.

The Scope of Work (SOW) for the Project – Each project has a unique Scope of Work document that specifies the requirement for the survey. The following requirements are typically specified in the SOW:

- The exact area(s) to survey. For road projects, the survey boundary is typically specified by a width distance on both sides of the existing centerline of the road for a specified distance (milage) along the route.
- The existing features to survey (i.e., utilities, existing right-of-way, culverts).
- The specific Coordinate Systems, Datums, and Survey Units that must be used.
- Control Point spacing, frequency, and geodetic requirements. The establishment of first order Control Points on a project is critical for maintain accuracy and providing horizontal and vertical reference points for construction layout and quality control.
- Methods for data collection: The most common methods for collecting elevation and survey data include:
  - **Ground Survey:** Ground Surveys are the most traditional type of survey. Teams of survey personnel use Total Stations, GPS, or a mix of these two technologies to collect topographic information. Survey Points are manually recorded by placing the reflector staff or GPS receiver rod at key points within the project limits.



  - **Aerial LiDAR Survey:** Topographic information is collected using manned or Unmanned Aircraft Systems (UAS). A mounted LiDAR sensor is flown over the site to collect 3D information. Elevation data is verified ("truthed") and often supplements Ground Survey data. LiDAR data does NOT provide linework or delineation of individual features – it only provides individual points with minimal associated characteristics.

- **LiDAR Sources:** Agencies such as USGS, NOAA, and USACE may possess high-quality, LiDAR elevation data in the project area. Occasionally, LiDAR data is used to supplement Ground Survey data to create the survey map. In these instances, areas of critical importance (such as the road prism and culverts) are mapped using the Ground Survey method, which provides a higher accuracy for design. LiDAR data is used beyond areas of critical importance.

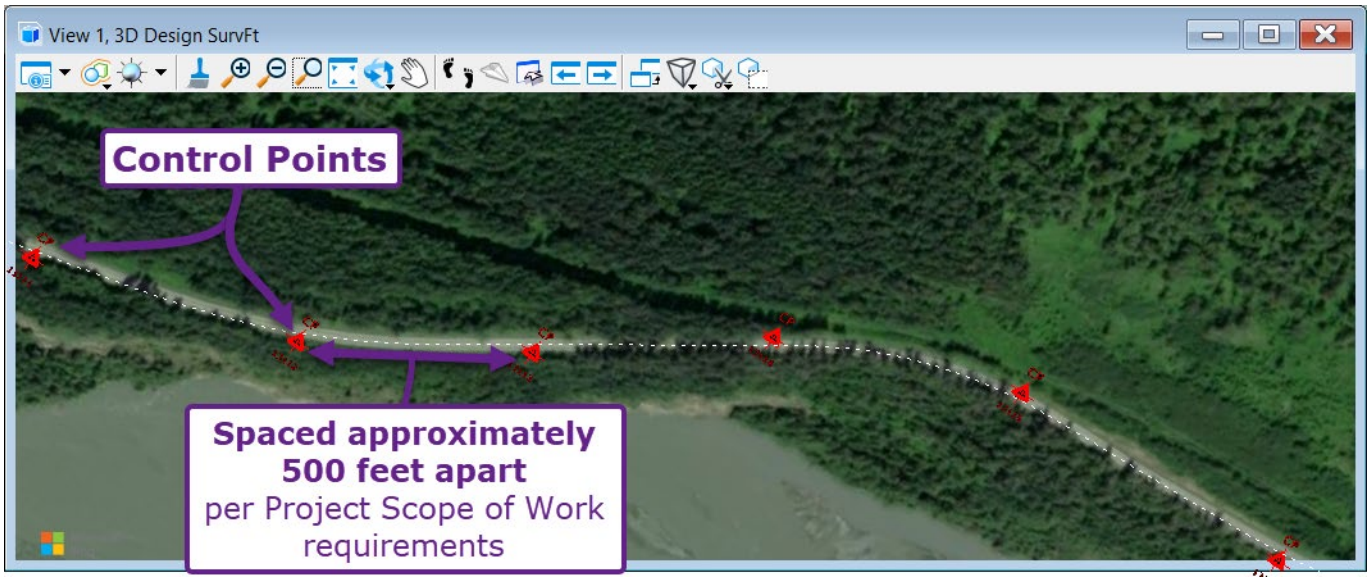
Chapter 5 (Survey and Mapping) of the Project Development and Design Manual (PDDM) – This FLH resource provides standardized practices and requirements for collecting and processing survey data. This document is available on the FHWA website at the following location:

https://highways.dot.gov/federal-lands/pddm/surveying-mapping

PROCESS 2 – On-site Survey Data Collection and Map Processing: The general sequence and process for performing a Control Survey is as follows:

- **Control Points are set:** The first process performed by the field personnel is to set Control Points along the length of the project. A Control Point is a piece of metal rebar set in the ground with an aluminum cap on top. The cap is typically set to just below ground level for protection. Using a GPS receiver, real-world coordinates and elevation is obtained for the Control Point. All survey data to be collected is tied to the known coordinates/elevation of the Control Points. Similarly, in construction, proposed design points are laid out relative to the known coordinates/elevations of the Control Points.

  The spacing of Control Points is specified in the project Scope of Work document.



- **Survey Points are Collected:** The field personnel work down the length of the project to collect Survey Points. When a Survey Point is collected, it is assigned a Point Code that consists of a 3-digit type identifier and a 2-digit line identifier.

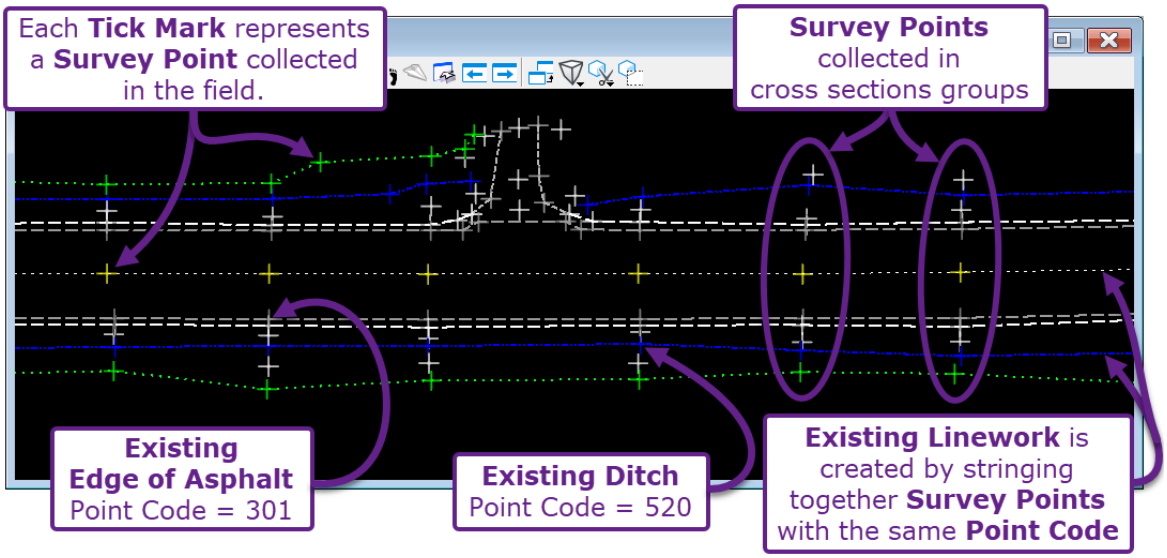
  Example Point Code: 30202

[Type Identifier]	**+**	***[Line Identifier]***
[311]		[02]

  The **Type Identifier** corresponds with the type of existing feature being collected. For example, the Type Identifier for an existing edge of asphalt line is 302.

The **Line Identifier** ensures the correct sequence of points are strung together. For example, there is an existing edge of asphalt line on both sides of the road. The points for the left side of the road are assigned the point code 302**01**. The points for the right side, are assigned 302**02**. In this processing, the Line Identifier ensures that points on the opposite side of the road are NOT erroneously strung together.

TIP: All point codes used in FLH survey are found on the FLH Website in the following location: https://highways.dot.gov/federal-lands/survey/feature-codes-alpha

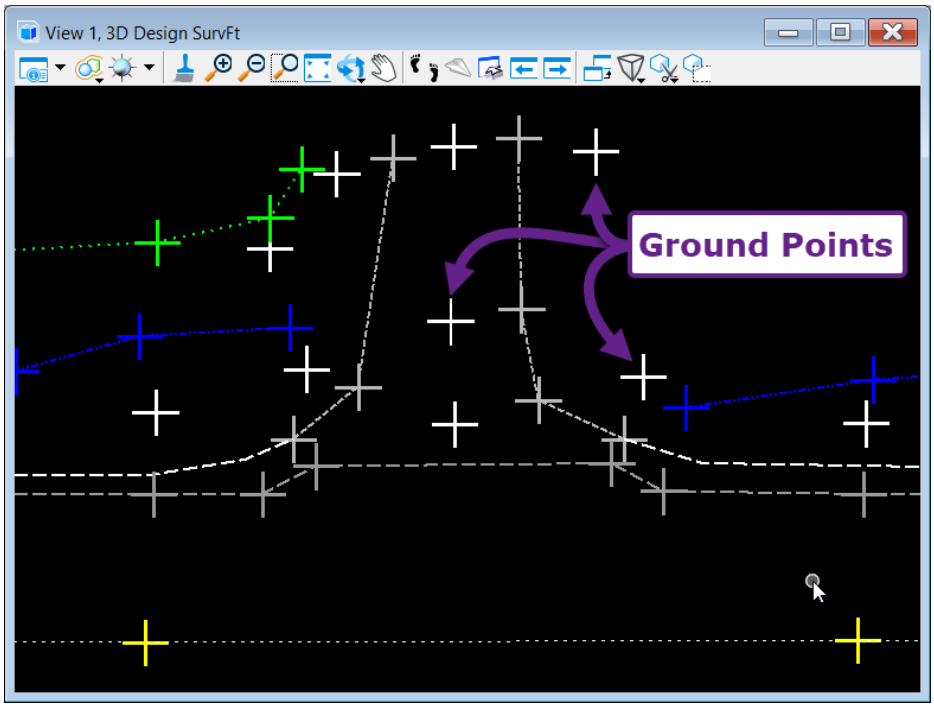


For roadway projects, the field personnel typically collect Survey Points in cross section groups. Typically, cross section groups span the entire width of the existing road embankment. For example, the cross section group might begin at the top of cut, and then move consecutively to the ditch line, edge of shoulder, edge of asphalt, centerline of road, and so on. If necessary, important features outside of the existing road embankment may also be collected in the cross section group.

Typically, cross section groups are spaced at equidistant intervals. However, interval spacing may be decreased around horizontal curves or more complex areas.

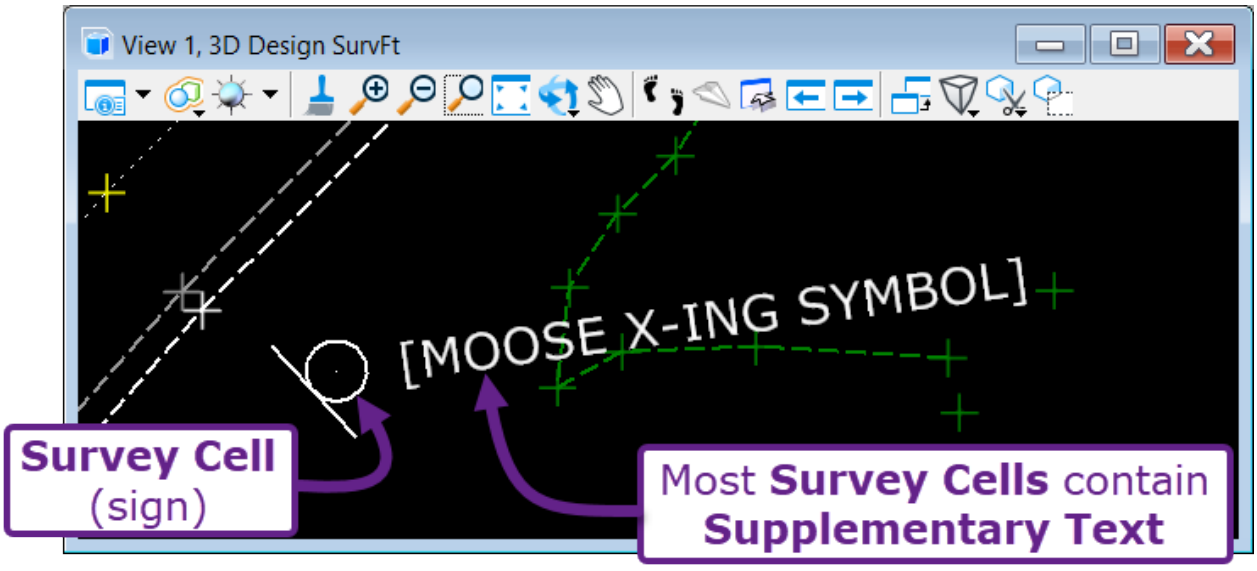
Ground Points are collected at irregular locations to provide additional data points for the Existing Ground Terrain Model. Ground Points may correspond with any type of at-grade features (i.e., asphalt, gravel, bare earth). ***NOTE:*** Since ground points are NOT strung together to form a line, they are only assigned a 3-digit point code. Typically, ground points are assigned to the 401 code.

In the example shown below, Ground Points are collected within and around the approach road to better define this non-linear area in the Existing Ground Terrain Model.



- **Survey Cells: Signs, Trees, and Utility Features:** In processing, Survey Cells are automatically placed at the point locations of non-linear features (i.e., signs, trees, and utility features). Each non-linear point code has a corresponding Survey Cell graphic. For example, the point code for a sign is 232. When a point with the 232 code is imported into ORD, the sign Survey Cell is automatically placed at the point location.

  In field collection of a non-linear point, a description is entered by the surveyor. For example, the message shown on a sign will be recorded as the description. The description is placed as **Supplementary Text** next to the Survey Cell.

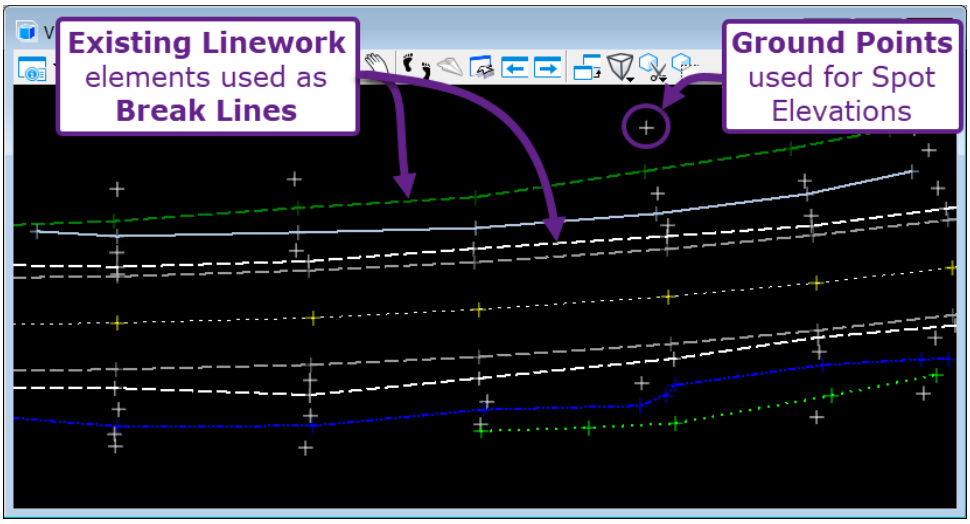


PROCESS 3 – Creating the Existing Ground Terrain Model: Ground Points and select Existing Linework elements form the Existing Ground Terrain Model.

IMPORTANT: Existing Linework elements to be included in the Terrain Model are called **Break Lines**. As discussed on the next page, Break Lines are used to control the triangulation of a Terrain Model.

Only Existing Linework elements that correspond with at-grade features are used as Break Lines. For example, Existing Centerline of Road, Existing Toe of Slope, and Existing Shoulder are used as Break Lines.

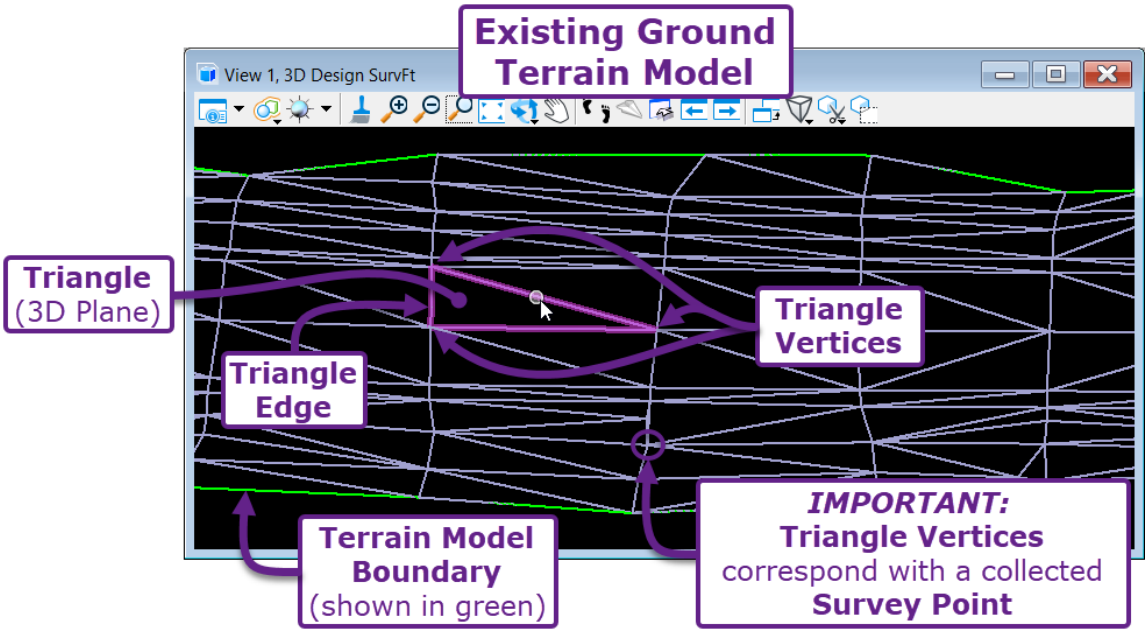
Existing Linework elements that correspond with utilities and features that do NOT lie on the existing ground are NOT used as Break Lines.



As shown below, a Terrain Model is a mesh of **Triangles**. Each **Triangle** is a 3-dimensional plane.
NOTE: A Terrain Model is commonly referred to as a TIN (triangulated irregular network).

Every triangle has three **Triangle Vertices**. A **Triangle Vertex** is created at every Ground Point and Break Line vertex location. In other words, every **Triangle Vertex** corresponds with a Survey Point elevation collected in the field.

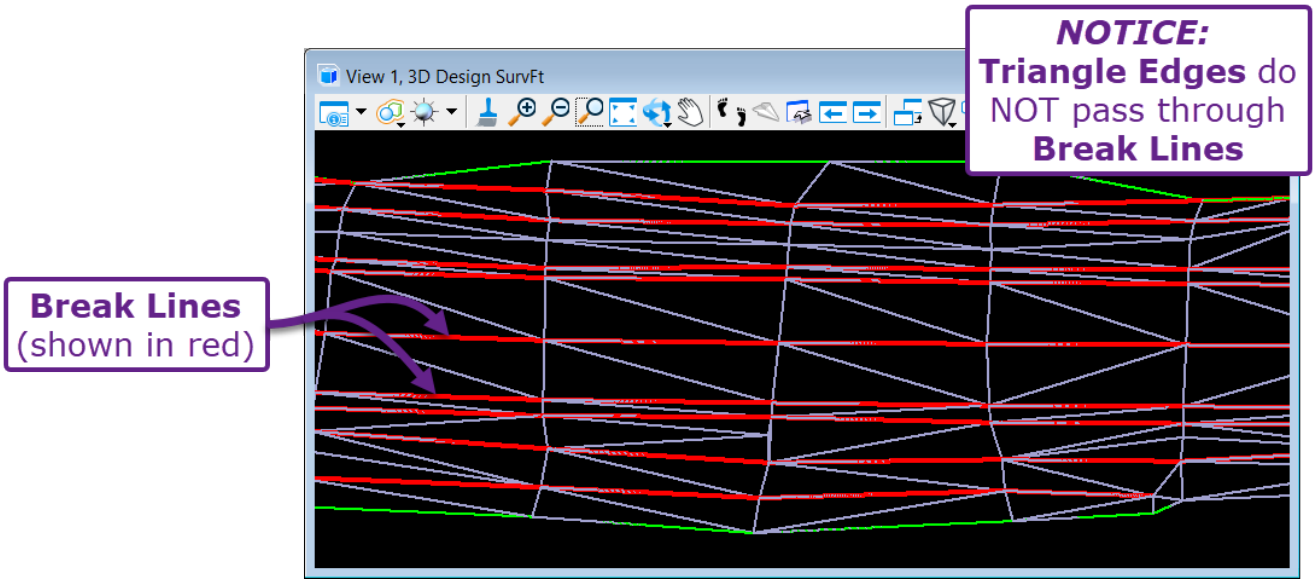
In the areas between **Triangle Vertices**, the Terrain Model elevations are interpolated. Along a **Triangle Edge**, there is a constant slope between the two **Triangle Vertices**.



The term **Triangulation** refers to the configuration and layout of triangles in a Terrain Model.

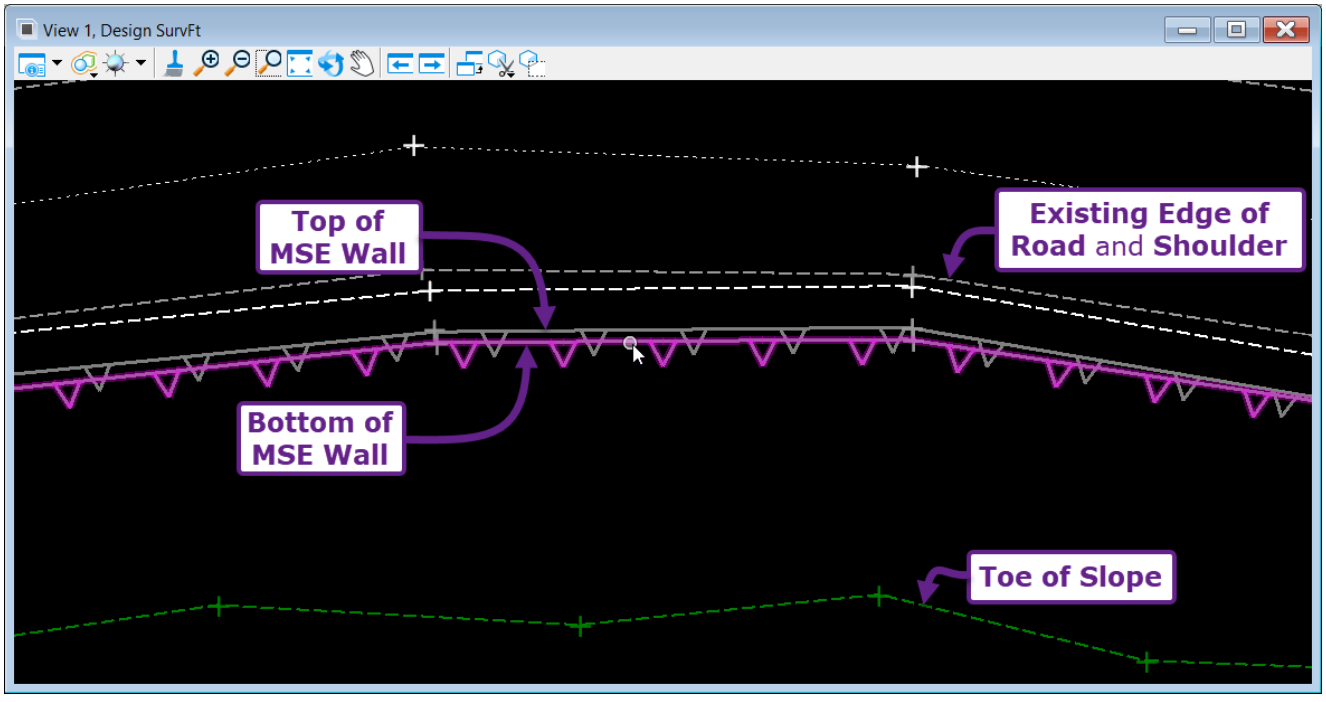
Generally, a triangle is formed between survey points that are in proximity.

Break Lines are used to control the triangulation of a Terrain Model. Triangle Vertices and Triangle Edges are placed along a Break Line. However, Triangle Edges and the interior portions of a Triangle will NEVER pass through a Break Line. Additionally, break lines will NEVER cross each other unless they meet at the same exact horizontal and vertical point.



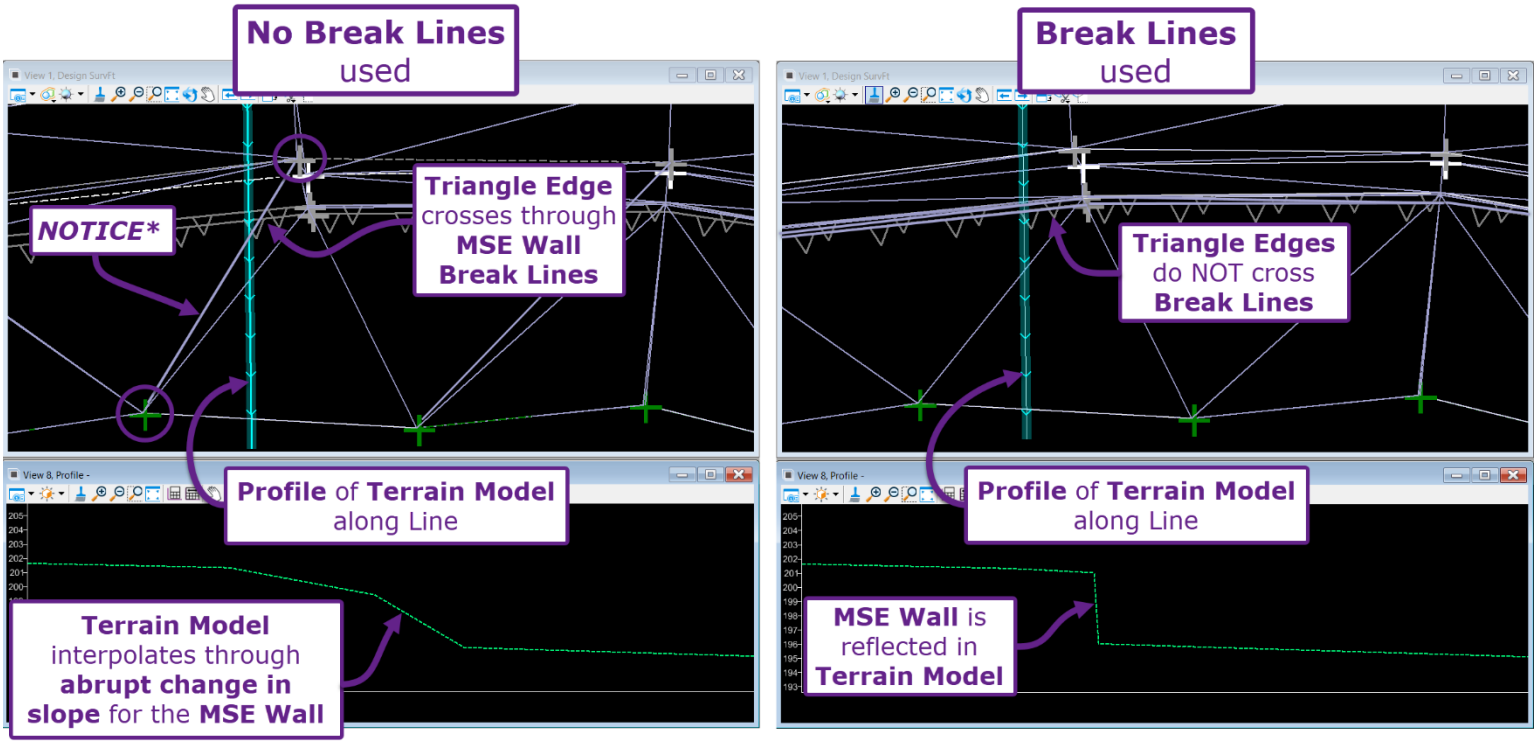
Break Lines are necessary to capture abrupt changes in slope and deflections in a surface (i.e., a sharp ridge). If Break Lines are NOT used, then the Terrain Model may interpolate through important deflection areas.

The scenario below demonstrates the necessity for Break Lines. To capture the abrupt change in slope due to a MSE Wall, a series of points must be surveyed along the **Top of the MSE Wall** and **Bottom of the MSE Wall**. The top and bottom points must be strung together and added to the Terrain Model as Break Lines.



Shown below on the left is how the Terrain Model would look if NO Break Lines were used. In this case, the Terrain Model is created from Survey Points ONLY. As shown in the Profile view, the abrupt change from the MSE wall is NOT captured.

NOTICE*: A Triangle Edge extends from a Existing Edge of Pavement point to a Toe of Slope point (both circled in purple). Along this Traingle Edge line, the Terrain Model reflects a constant slope between the two point elevations.



Shown above on the right is how the Terrain Model looks when Break Lines are used to control triangulation. In this case, the Triangle Edges NEVER cross through the Top and Bottom of MSE Wall Break Lines. The abrupt changes in slope that the Break Lines correspond to are reflected in the Terrain Model.

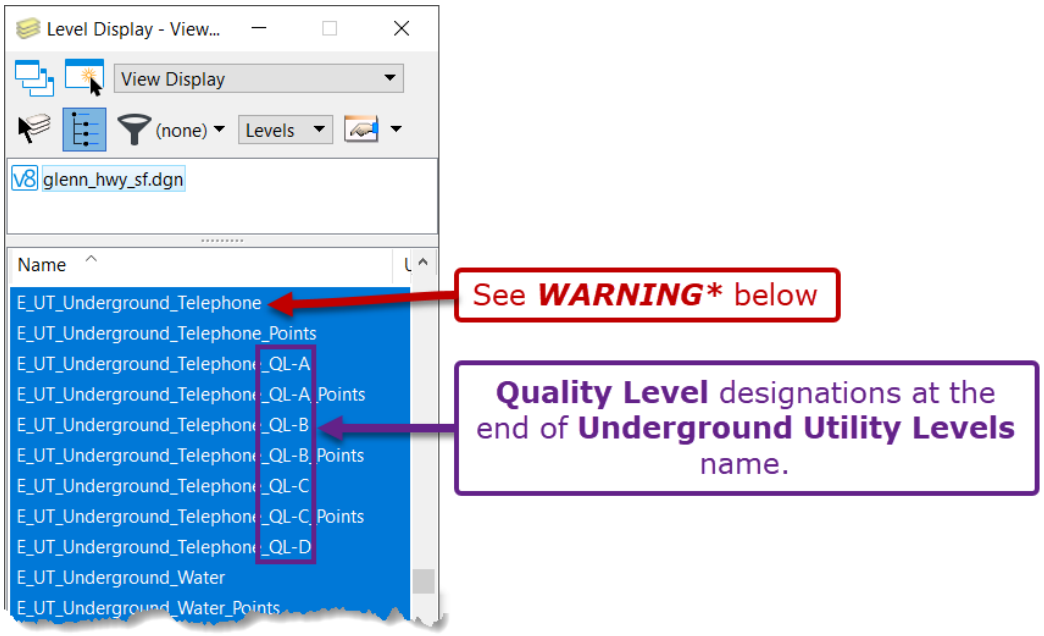
Process 4 – Quality Control and Data Distribution: For all but the simplest projects, the person who completed the mapping will send the Survey ORD File and mapping to another survey staff member for review. The review will check the Survey Linework, Survey Cells, Description labels, and the Existing Ground Terrain Model for any omissions, irregularities, and errors.

5A.1.a Mapping Underground Utilities and Quality Levels (Accuracy)

Determining the location of underground utility lines and facilities is a challenge in the surveying process.

In the Survey ORD File, the accuracy of underground utilities is designated by the **Quality Level –** which is shown at the end of the Level name for underground utilities.

TIP: All underground utilities Levels begin with the prefix: "E_UT_Underground_…".



Quality Level ratings range from QL-A (most accurate) to QL-D (least accurate).

Quality Level ratings are based on the methods and sources used to map and collect the underground utilities data. In summation, the **Quality Level** ratings are as follows:

QL-D: Underground utility information is mapped from as-built plan records and/or verbal information obtained from a source familiar with the project area. With this designation, there is a possibility that some underground utilities are absent from the Survey ORD File.

QL-C: The location of underground utilities is determined from a combination of as-built plan records and surveying visible utilities facilities (i.e., manholes, utility boxes, valve boxes). The survey processors manually draw underground utility lines to connect the visible utilities facilities. With this designation, there is a possibility that some underground utilities are absent from the Survey ORD File.

QL-B: Using sensors that penetrate the existing ground surface and other sophisticated techniques, a precise horizontal location is determined for ALL underground utilities in the project area. With this designation, it is safe to assume that ALL utilities are shown in the Survey ORD File.

QL-A: Similar to QL-B, all utilities are located using sensors. However, the utility data provided for QL-A is comprehensive and includes the size, condition, and material of the underground utilities. Also, the profile and elevations of the underground utilities are provided. With this designation, it is safe to assume that ALL utilities are shown in the Survey ORD File.

More detailed information on Quality Level ratings is found on the FHWA website at the following location: https://www.fhwa.dot.gov/programadmin/sueindex.cfm

WARNING*: If the underground utility Level does NOT designate a Quality Level rating (i.e., E_UT_Underground_Telephone), then a Quality Level is NOT assigned. In this case, the location of the underground utility lines should be considered an approximation.

TIP: Most FLH projects require a Utility Report that assesses the accuracy of underground utility data.

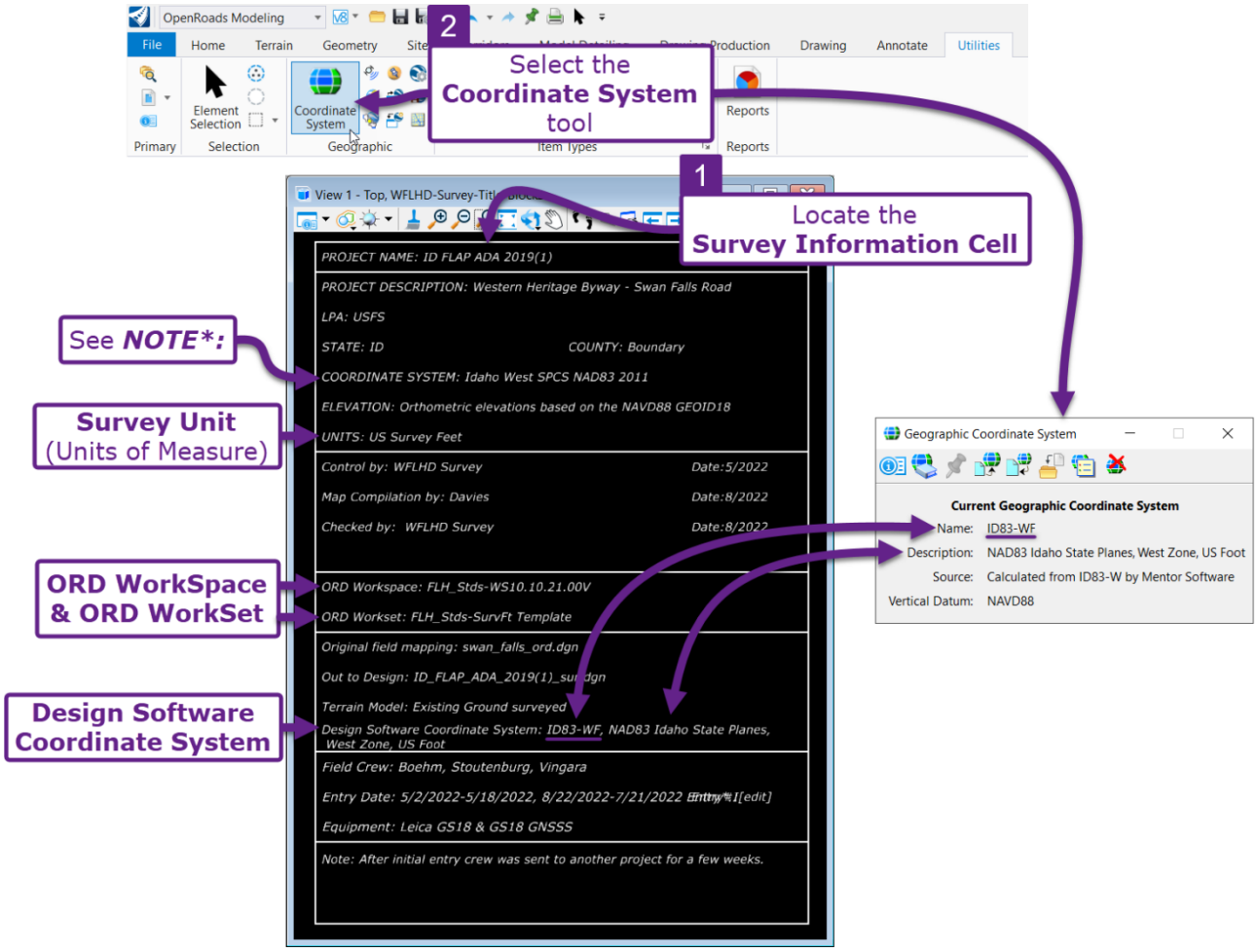
5A.2 Review the Survey ORD File before Designing

Both the Survey ORD File and Existing Ground Terrain Model must be reviewed for discrepancies before designing and plan production. If a problematic area is identified, then consult the project surveyor.

The flowing list provides guidance for reviewing survey data from the perspective of a design engineer:

Ensure the Survey ORD File is set to the appropriate Coordinate System and Survey Units: The appropriate Coordinate System and Survey Units (i.e., Survey Feet or International Feet) must be set to ensure that the Survey ORD File and all new ORD Files to be created are in the correct geographical location. Contact the project surveyor with any questions about the Coordinate System and Survey Units.

1	Locate the Survey Information Cell text. Every Survey ORD File will have a text box that states the Coordinate System, Survey Unit, and surveying agency. To locate the Survey Information Cell text, zoom out so that all survey data is shown. ***TIP:*** Double-Click the Mouse Scroll Wheel to fit all elements in the ORD File into the View window.
2	Use the *Coordinate System* tool to reveal the Coordinate System and Survey Units set in the Survey ORD File. From the Ribbon, select the *Coordinate System* tool: [***OpenRoads Modeling*** → ***Utilities*** → ***Geographics*** → ***Coordinate System***].
3	Compare the **Name** and **Description** (shown in the *Coordinate System* tool) with the **Design Software Coordinate System** information (shown in the Survey Information Cell text).

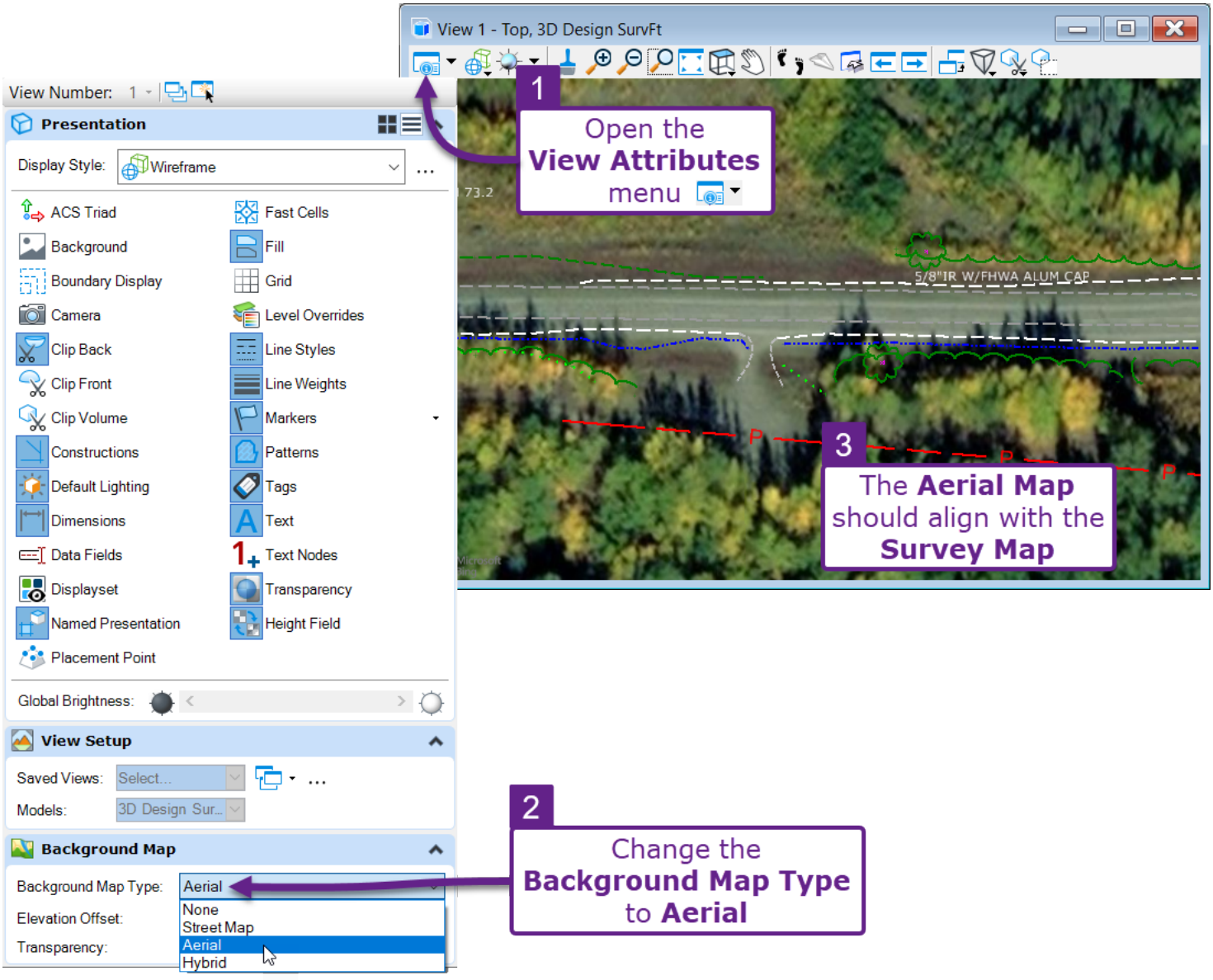


***NOTE*:** In the Survey Information Cell, there is an entry for the **Coordinate System** and the **Design Coordinate System**. These names may slightly differ, but they should satisfy the same geospatial requirements. In ORD, the survey mappers must select a **Design Coordinate System** from the ORD Coordinate System Library. The **Coordinate System** corresponds with the common real-world name for the coordinate system. The ORD Coordinate System Library name may differ from the real-world name.

ORD WorkSpace and WorkSet: The Survey Information Cell states the ORD WorkSpace and WorkSet used to create the Survey ORD File. All ORD Files to be created for the project must use the corresponding WorkSpace.

Alternate Methods for checking the Coordinate System using Aerial Map Overlays tools:

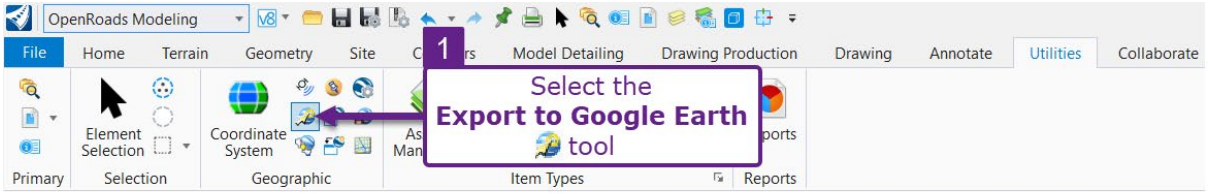
The *Background Map* can be turned ON to overlay an aerial map onto the ORD graphics. The *Background Map* option is found in *View Attributes Menu*. If the Coordinate System is set correctly, then the survey mapping elements and *Background Map* aerial should align.

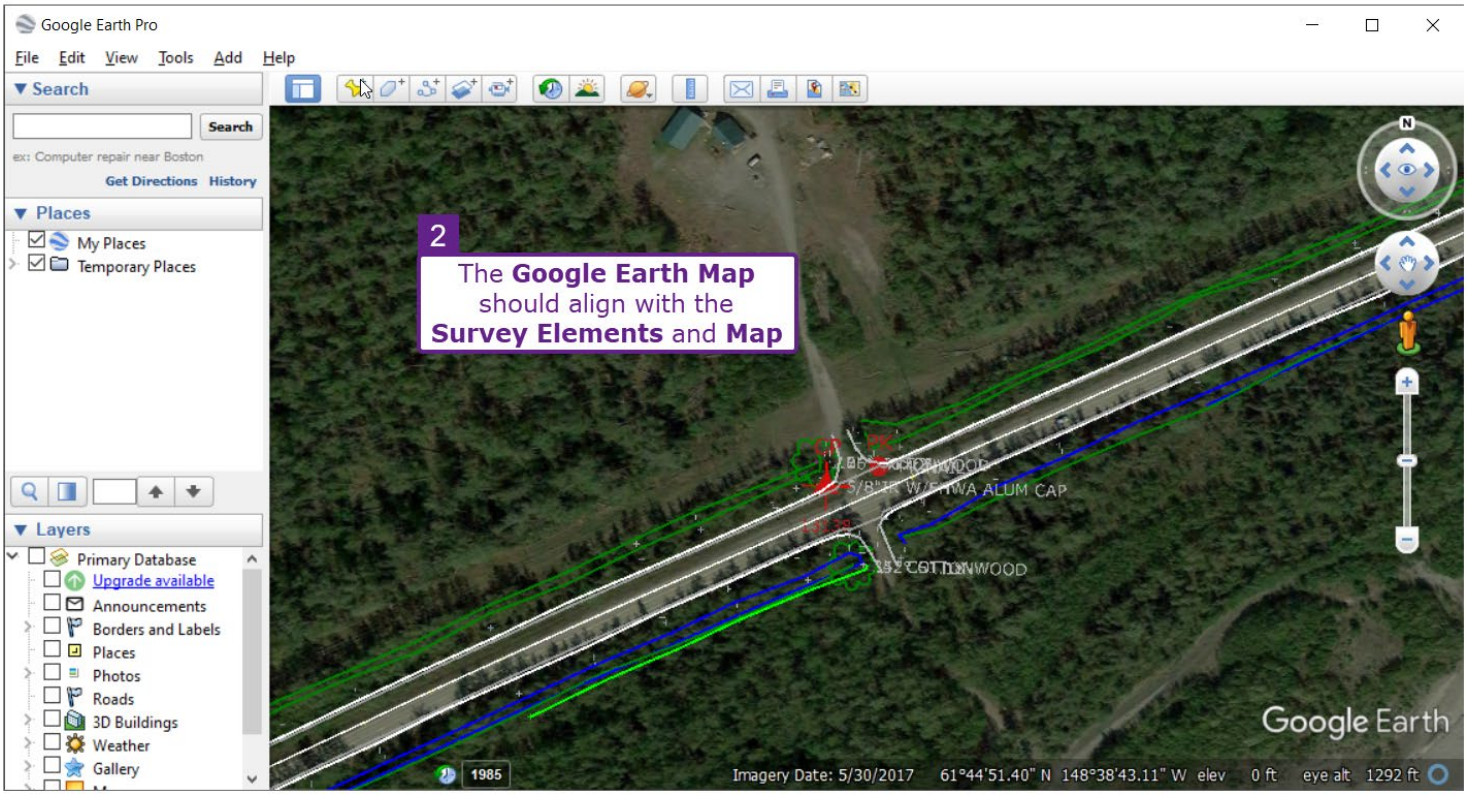


NOTE: The *Background Map* may NOT exactly overlay onto the survey mapping elements. In general, the *Background Map* should overlay within a few feet of the survey elements. If there is a major discrepancy between the *Background Map* and survey elements, then the Coordinate System is probably set incorrectly.

Method #2: Another map overlay method of checking the Coordinate System is to use the *Export a Google Earth File* tool to create a KMZ of the Survey ORD File. When this tool is selected, all elements currently displayed are exported to Google Earth. If the Coordinate System is set correctly, then the survey mapping linework should be shown in the correct geographical location in Google Earth.

TIP: When the *Export a Google Earth File* tool is used, only the currently displayed Levels will be exported. Turn OFF the Existing Ground Terrain Model level (E_TER_Existing_Ground_Surface), because the Terrain Model is graphically complex and greatly increases the export processing time.

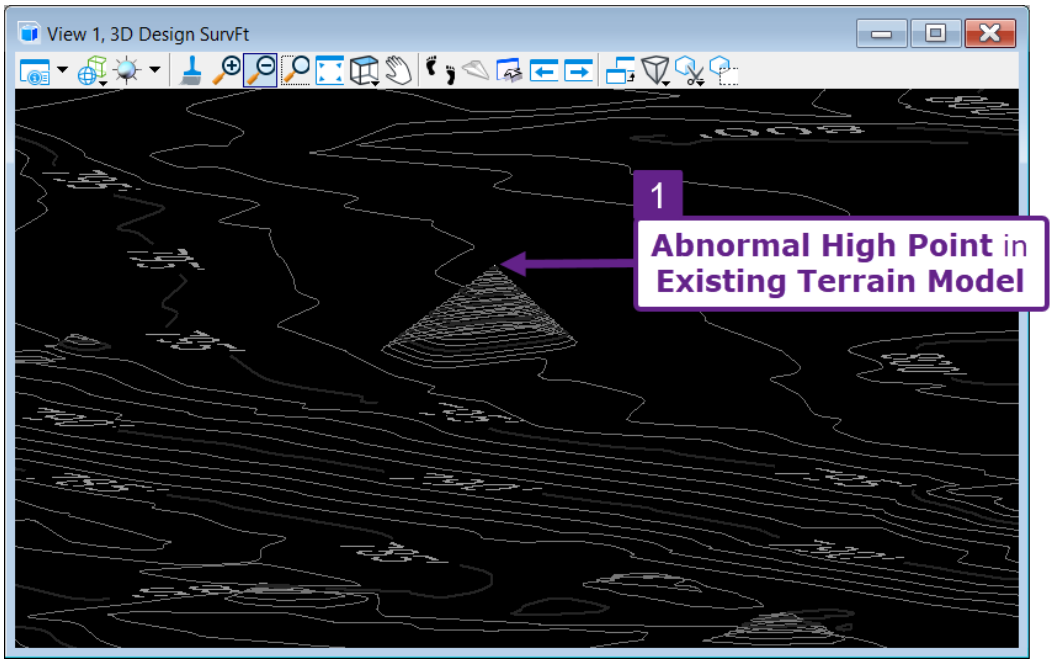




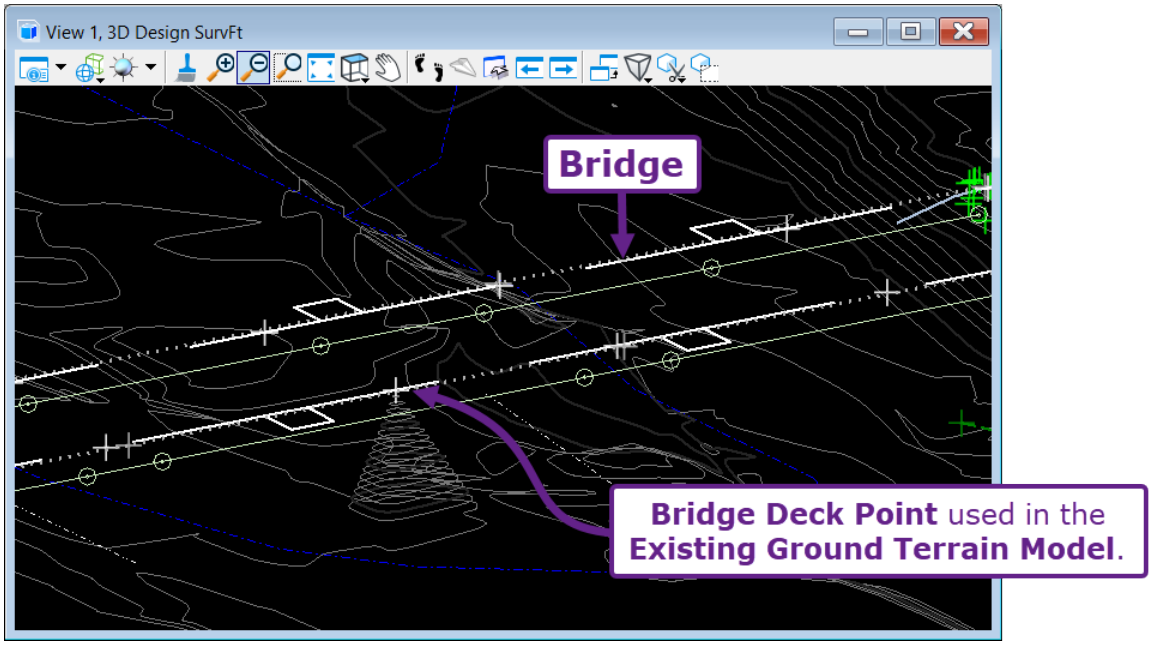
Review the Existing Ground Terrain Model for Elevation Busts: By rotating and orbiting the Terrain Model from a 3D perspective, faulty elevation points (busts) and triangulation issues may be identified. If problems are found with the Existing Ground Terrain Model, then contact the project surveyor for repair.

Tips and tricks for moving around and orbiting from a 3D perspective is shown in *1A.3.b.i Move Around and Orbit in the 3D Design Model*.

1	Examine the Existing Ground Terrain Model from the sides and isometric perspectives. Look for abnormal spikes or dips in the Terrain Model.



2	Elevation busts are more likely to happen in the vicinity of culverts, bridges, and other complex areas. Examine these complex areas for faulty elevations points. In the example shown below, a Bridge Deck Point shot is included in the Existing Ground Terrain Model. Bridge points do NOT represent the Existing Ground elevation and should NOT be included in the Terrain Model.



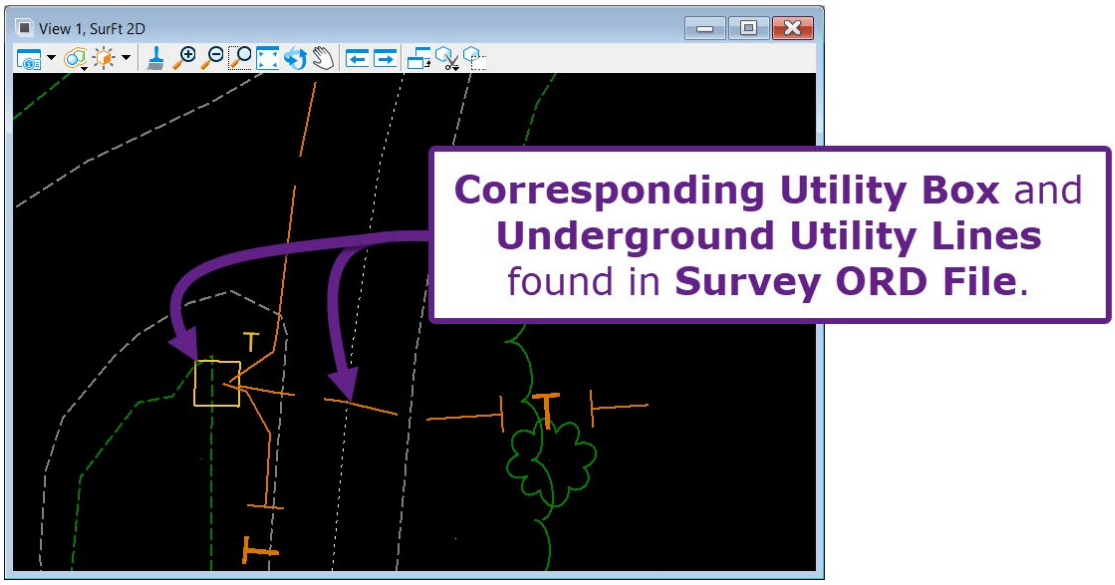
Inspect Utilities Linework for Completeness: The presence or overhead or underground utilities must be considered in civil design. Using background knowledge of the project site, check to see if the appropriate utilities are represented in the Survey ORD File.

For example, a project in an urban setting is likely to have more utilities than a rural setting. In an urban setting, utilities may include: water, sewage, storm, fiber optic, power, natural gas, and telephone.

In rural settings, it is less likely to encounter water, sewage, and storm utilities.

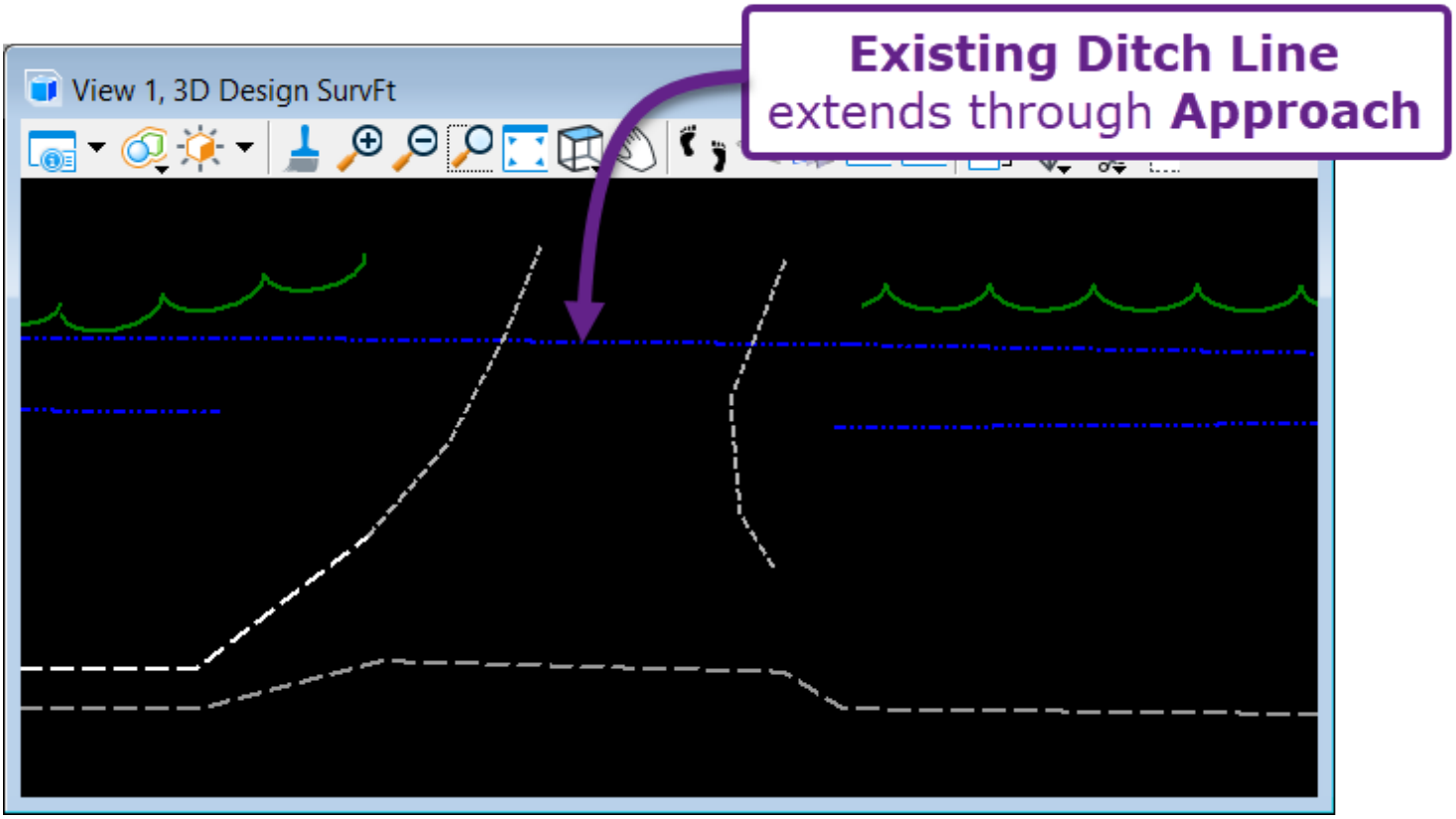
TIP: Use project site photos and Google Street View to look for evidence of utilities. Overhead utilities can be easily verified by the presence of power poles.

Underground utilities are likely present if the photos or Google Street View shows manholes, valve boxes, utility junction boxes, power transformer boxes, and storm inlets.

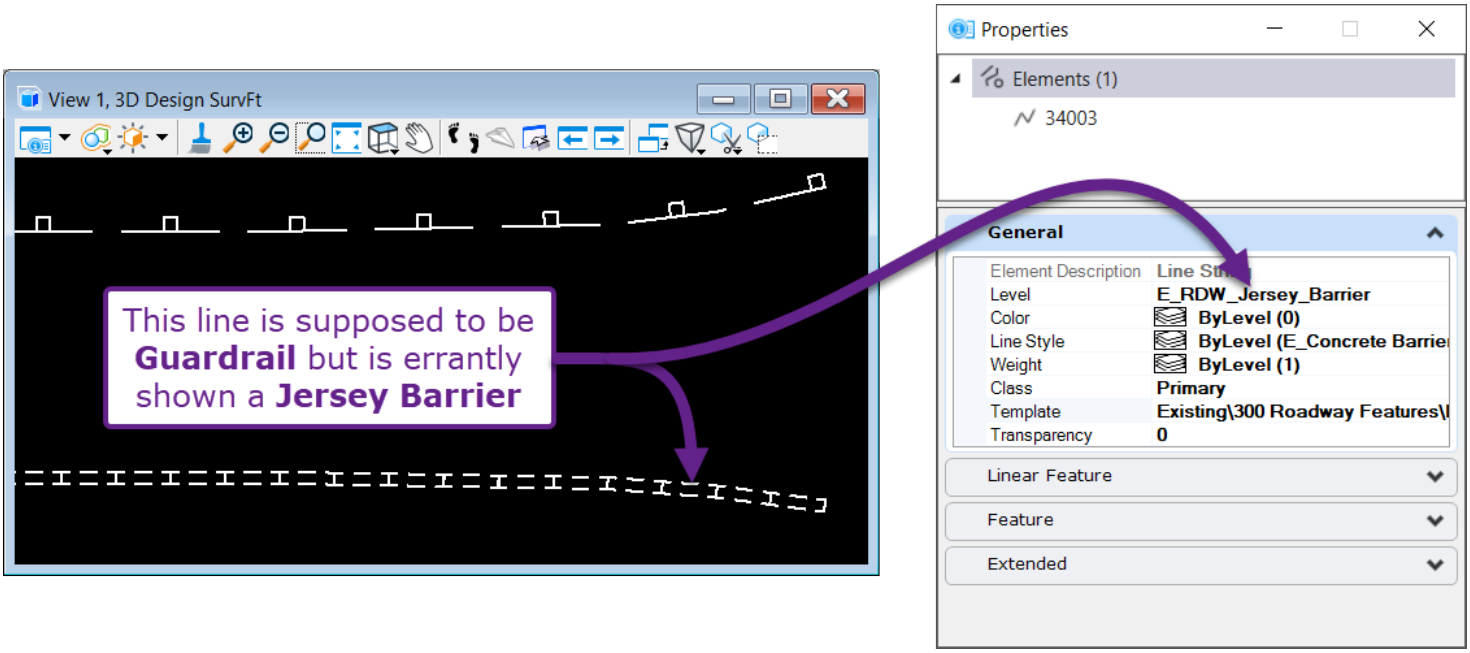


Examine Existing Linework for Discrepancies: Ensure that Existing Linework is joined together or segmented appropriately.

As shown below, the Existing Ditch line errantly passes through the approach area:



Also, ensure that Existing Linework reflects the correct feature. As an example, the line on the bottom is depicted and set to the Jersey Barrier level; but this feature is a guardrail in the field.



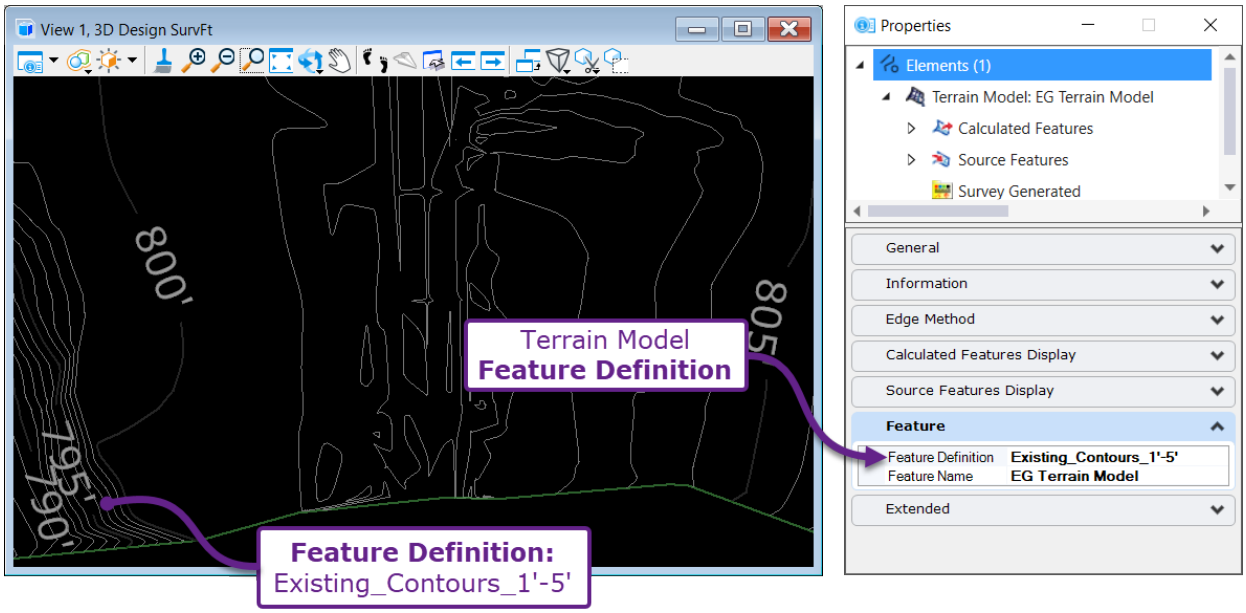
5B – MANIPULATE THE APPEARANCE OF THE TERRAIN MODEL

The visual appearance of the Existing Ground Terrain Model is manipulated by three settings:

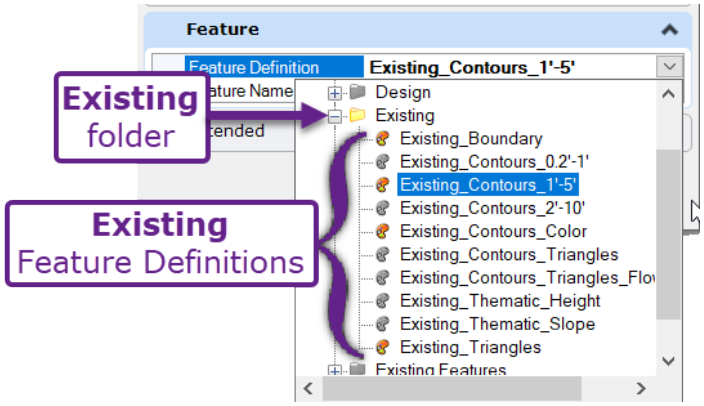
- **Feature Definition:** The Feature Definition setting is used to change the overall display style for the Existing Ground Terrain Model.
- **Properties Features:** When the Existing Ground Terrain Model is selected, individual Features can be toggled ON/OFF in the Properties box. Some examples of Properties Features include Major/Minor contours, Triangles, Boundary, Flow Arrows, High/Low Points, and Break Lines.
- **Override Element Template (In Reference File ONLY):** When the Terrain Model is referenced into a different ORD File, an Override Element Template can be specified to change the display style.
- **Levels:** Each Property Component has a corresponding Level that can be toggled ON/OFF. Also, the entire Terrain Model and all Property Components can be toggled ON/OFF through the Master Level. For Existing Terrain Models, the Master Level is "E_TER_Existing_Ground_Surface".

5B.1 Feature Definition Settings for the Existing Ground Terrain Model

The Feature Definition sets the overall display style for Existing Ground Terrain Model. The Feature Definition setting is shown in the Properties box when the Terrain Model is selected.

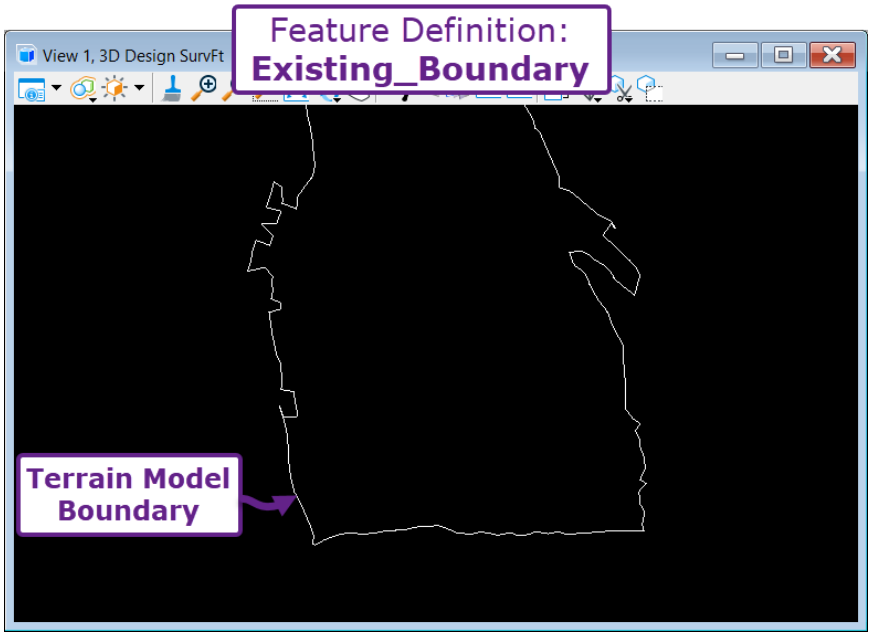


IMPORTANT: For Existing Ground Terrain Models, ONLY select Feature Definitions from the **Existing** folder.

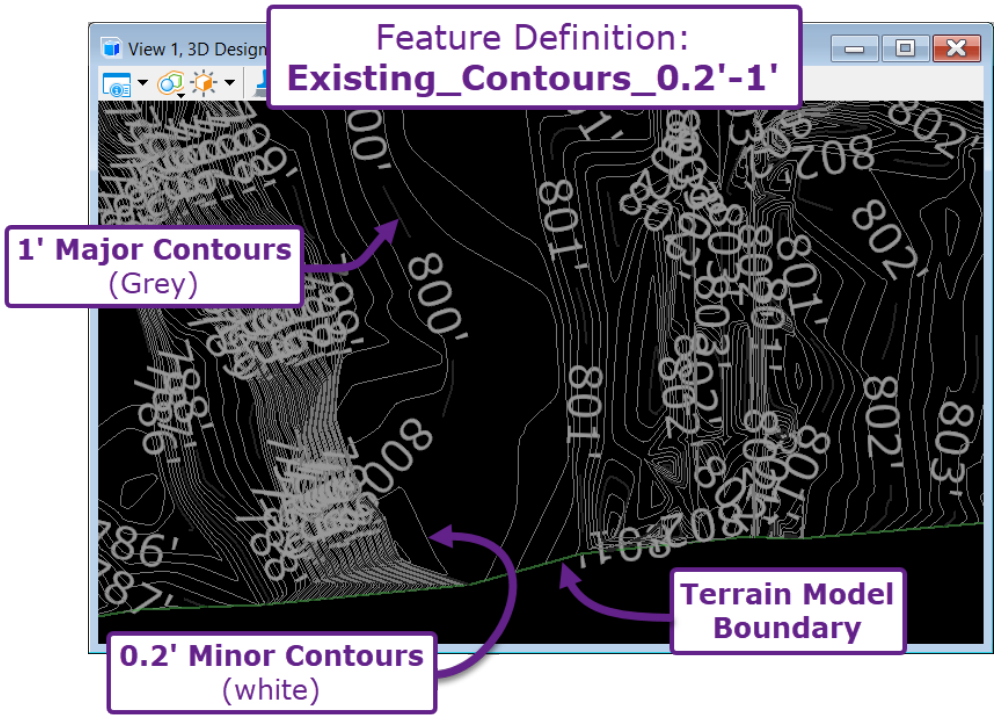


The available Feature Definition settings include:

Existing_Boundary: ONLY the Boundary of the Terrain Model is displayed. All other Property Components (i.e., contours, triangles, flow arrows) are toggled OFF.

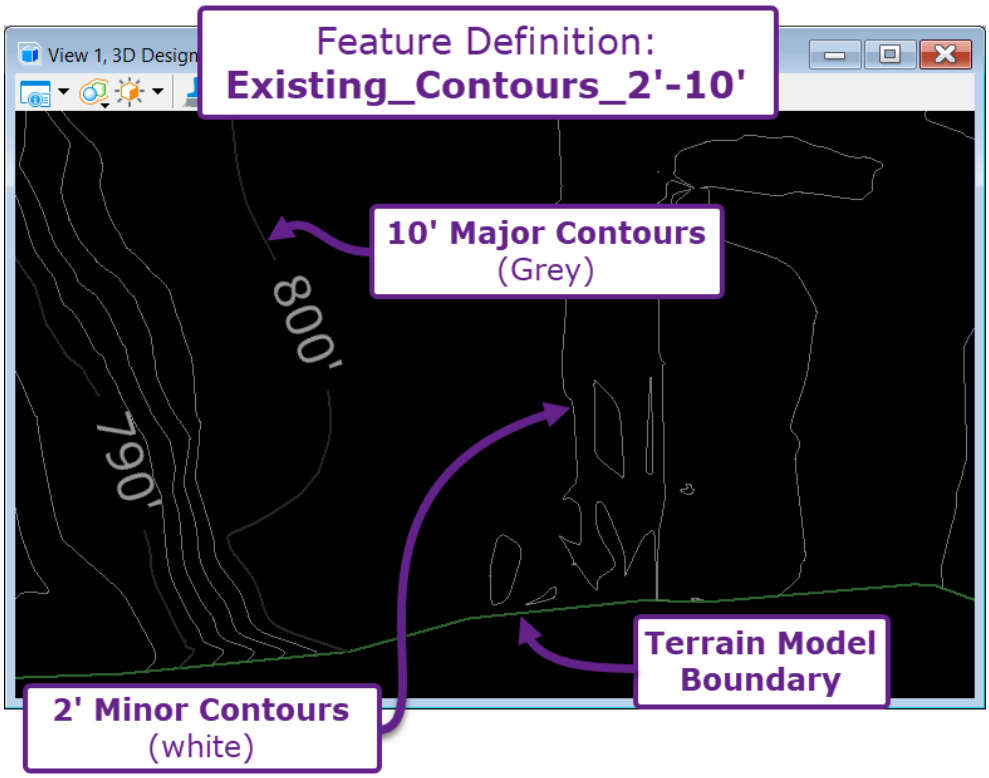


Existing_Contours_0.2'-1': The Boundary and Contours of the Terrain Model are displayed. Instead of the conventional 1' minor and 5' major contour interval, the contours are shown at 0.2' minor and 1' major. This Feature Definition is useful for analyzing very flat areas.

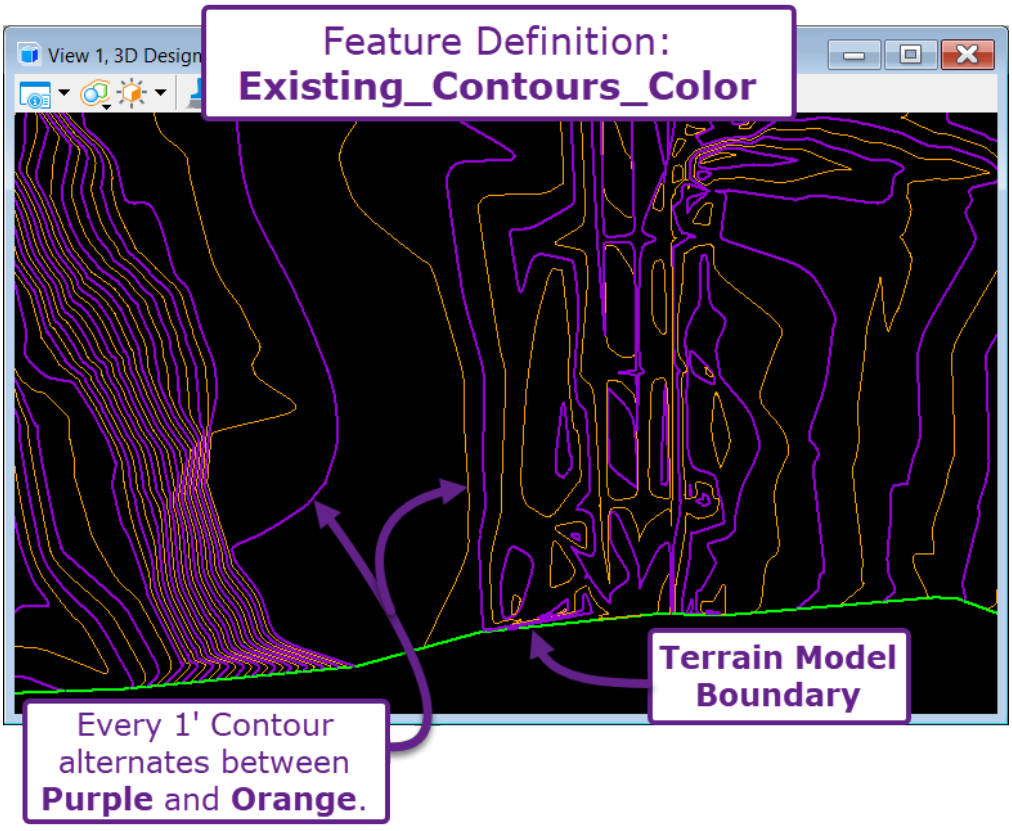


Existing_Contours_1'-5': This is the most used Feature Definition. The Boundary and Contours of the Terrain Model are displayed. The contour interval is set to 1' minor and 5' major. See the previous page for a graphic of this Feature Definition style.

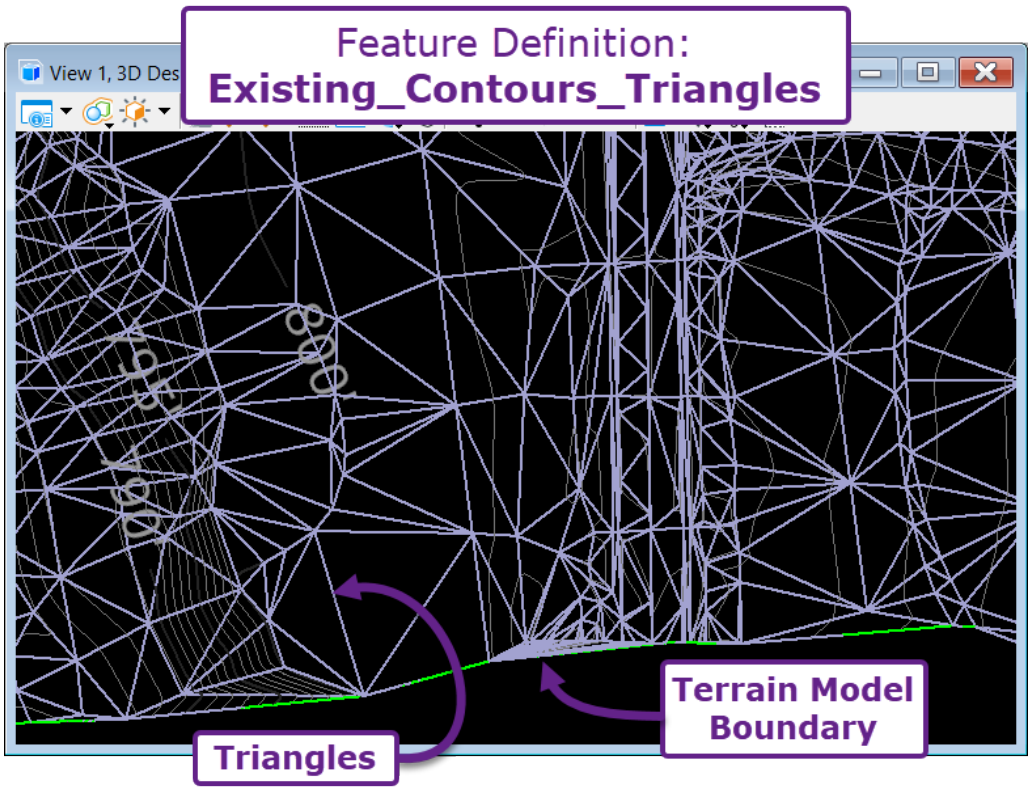
Existing_Contours_2’-10’: The Boundary and Contours of the Terrain Model are displayed. Instead of the conventional 1’ minor and 5’ major contour interval, the contours are shown at 2’ minor and 10’ major. For larger maps, this Feature Definition is useful for decluttering contours by increasing the interval.



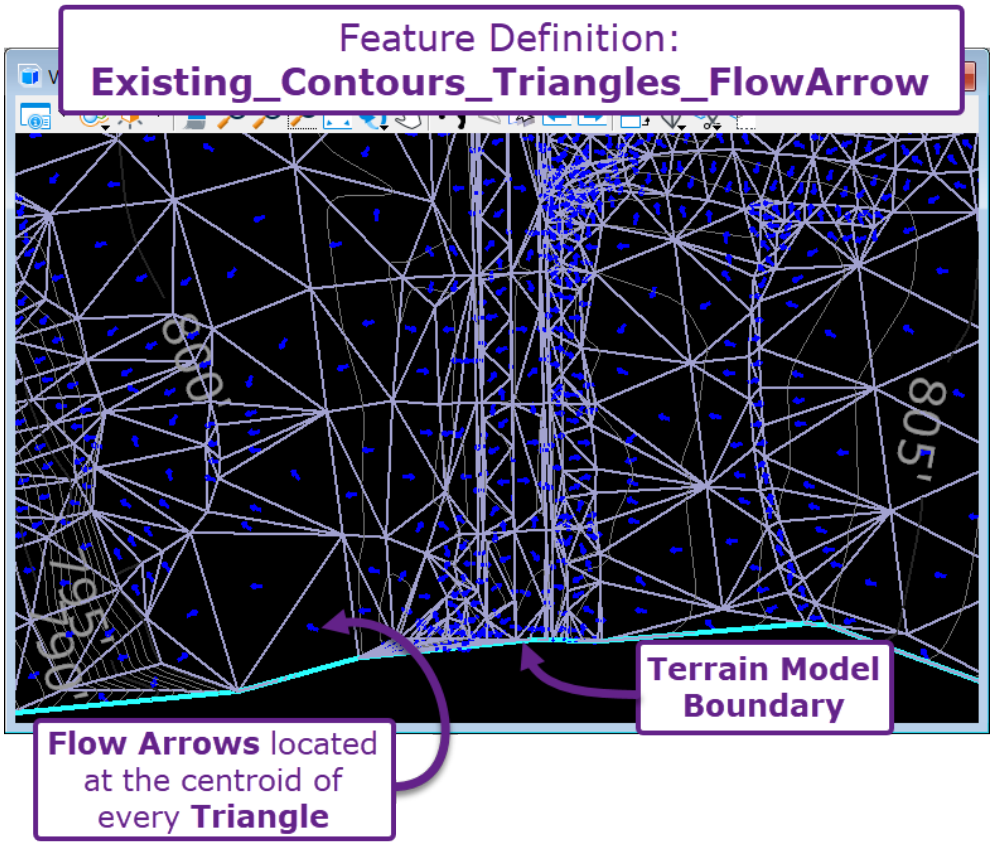
Existing_Contours_Color: The Boundary and Contours of the Terrain Model are displayed. Traditional contour intervals are NOT used. Instead, the color for every 1’ contour alternates between purple and orange.



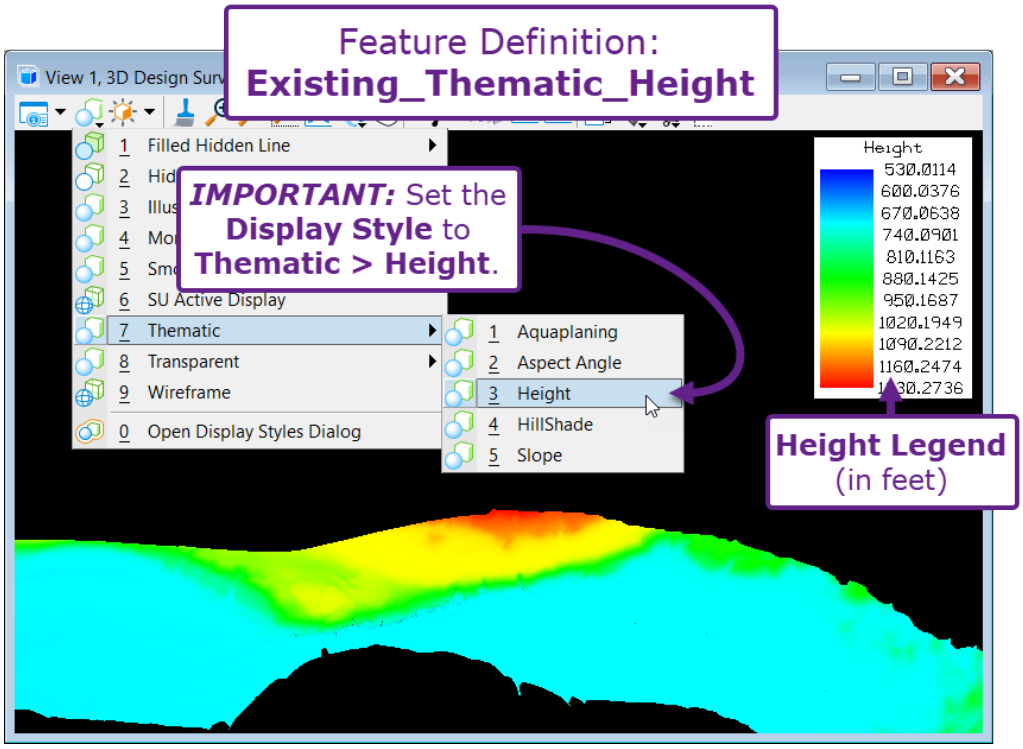
Existing_Contours_Triangles: The Boundary, Contours, and Triangles of the Terrain Model are displayed. The contour interval is set to 1’ minor and 5’ major.



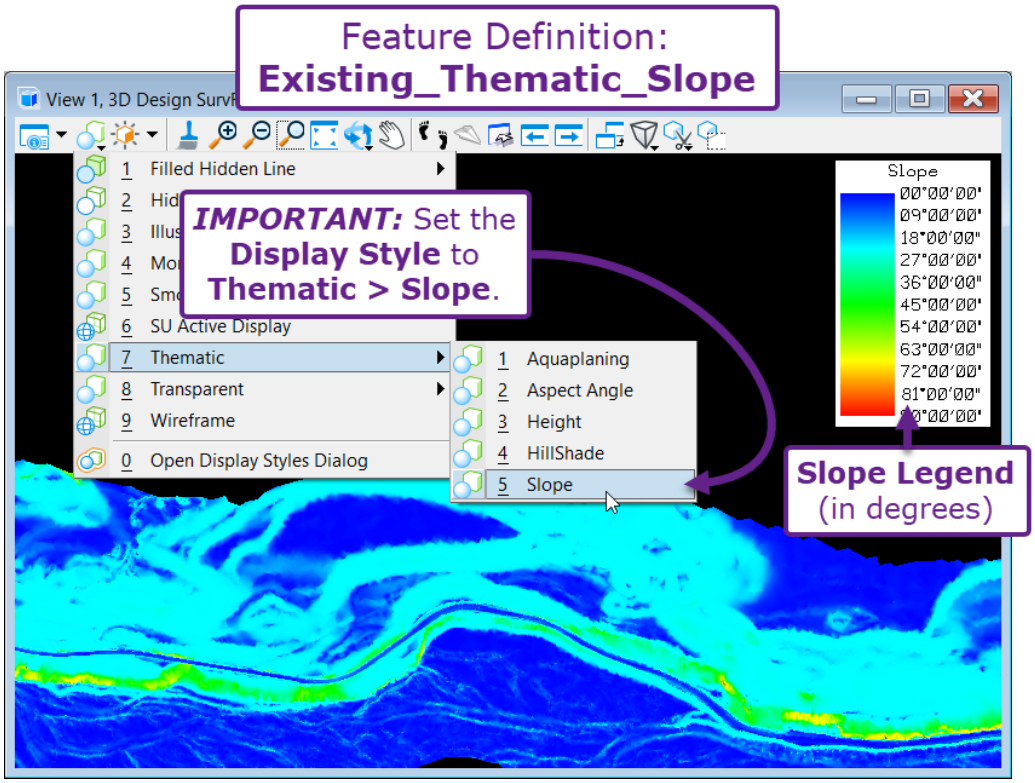
Existing_Contours_Traingles_FlowArrows: The Boundary, Contours, Triangles, and Flow Arrows are shown. Each Triangle displays a Flow Arrow, which denotes the sloping direction of the Triangle.



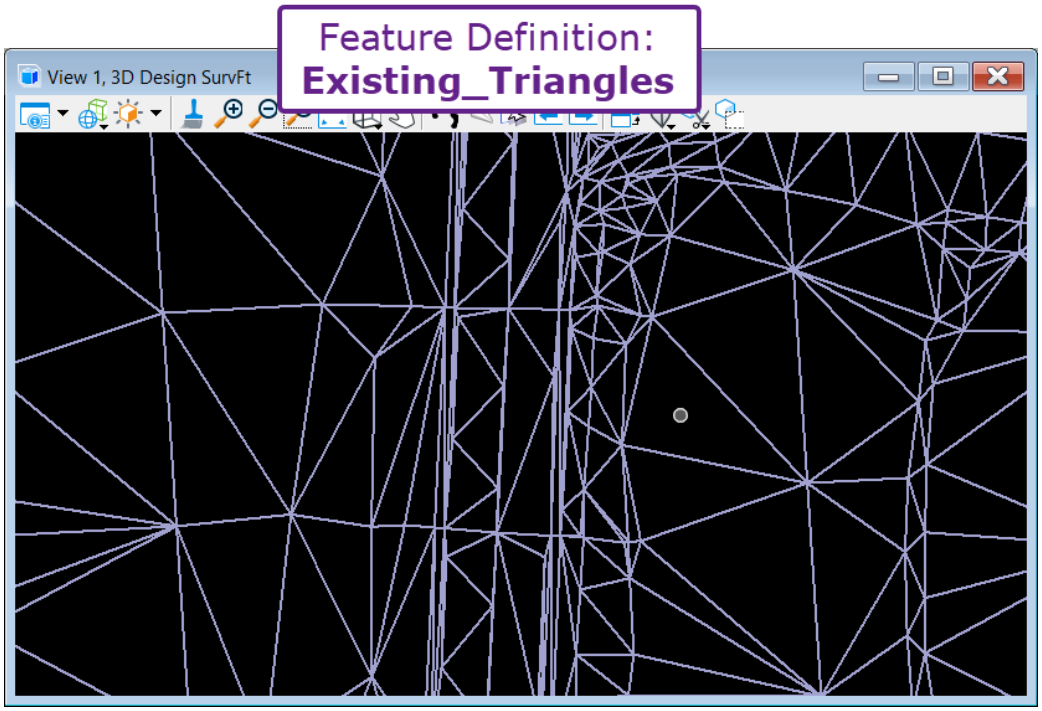
Existing_Thematic_Height: The Display Style must be set to "Thematic → Height" for this Feature Definition to display correctly. The Terrain Model is color-graded to depict changes in elevation. The "Thematic → Height" Display Style provides a legend to analyze elevation based on color. The legend elevation units are in feet.



Existing_Thematic_Slope: The Display Style must be set to "Thematic → Slope" for this Feature Definition to display correctly. The Terrain Model is color-graded to depict changes in slopes. The "Thematic → Slope" Display Style provides a legend to analyze slope angle based on color. The legend slope units are in degrees.



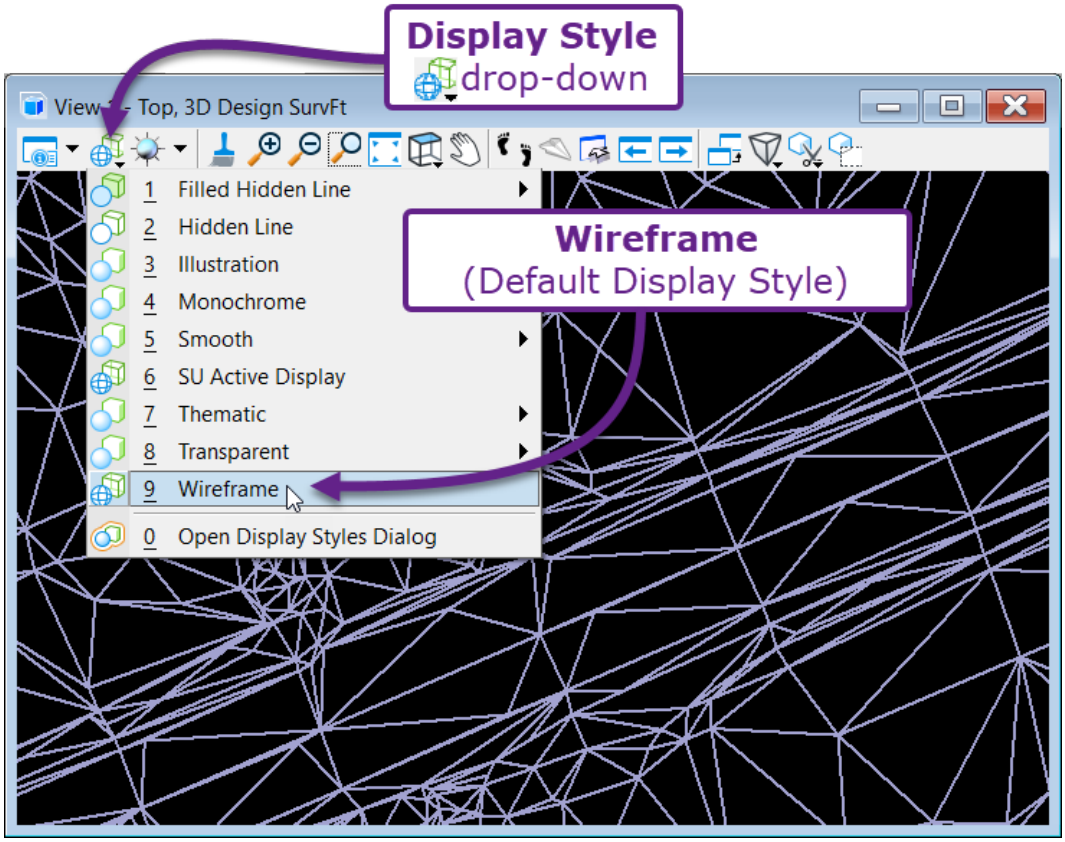
Existing_Triangles: Only the Boundary and Triangles of the Terrain Model are displayed.



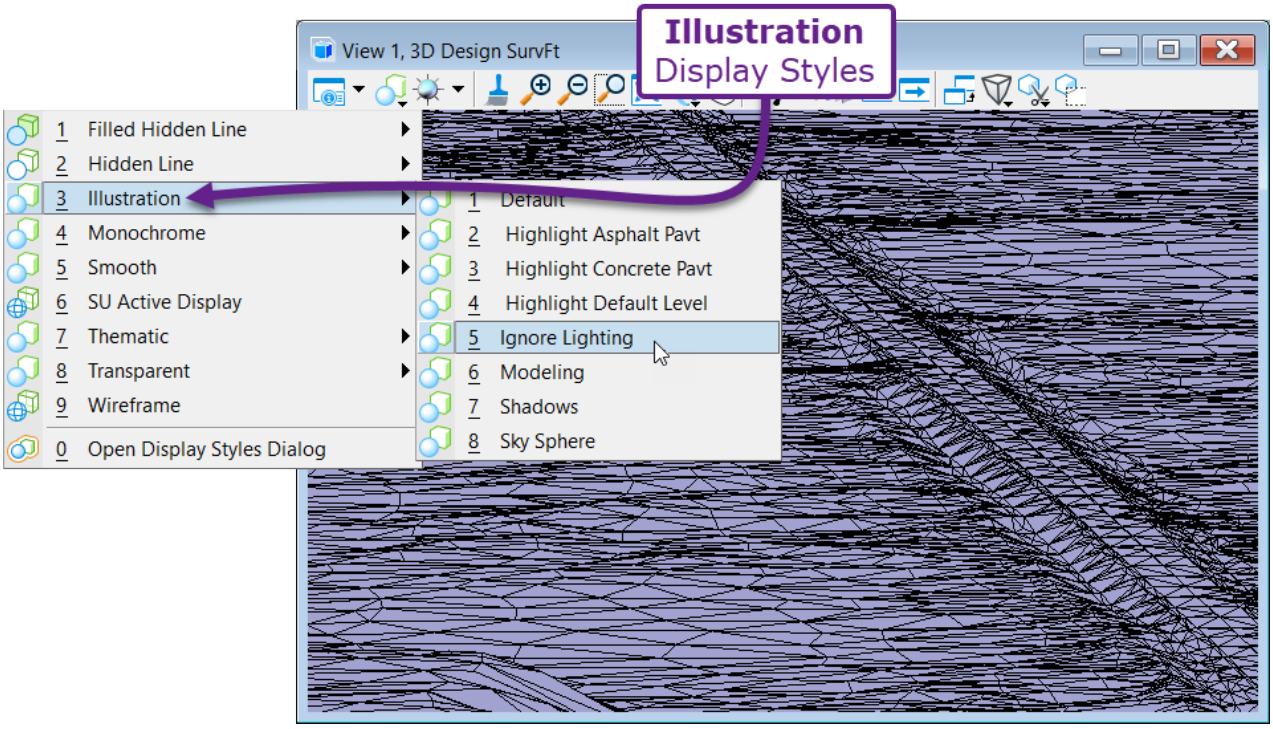
5B.2 Alter Terrain Model Triangles Appearance with Display Styles

When the Triangles of a Terrain Model are shown, the Display Style sets the appearance of the Triangles.

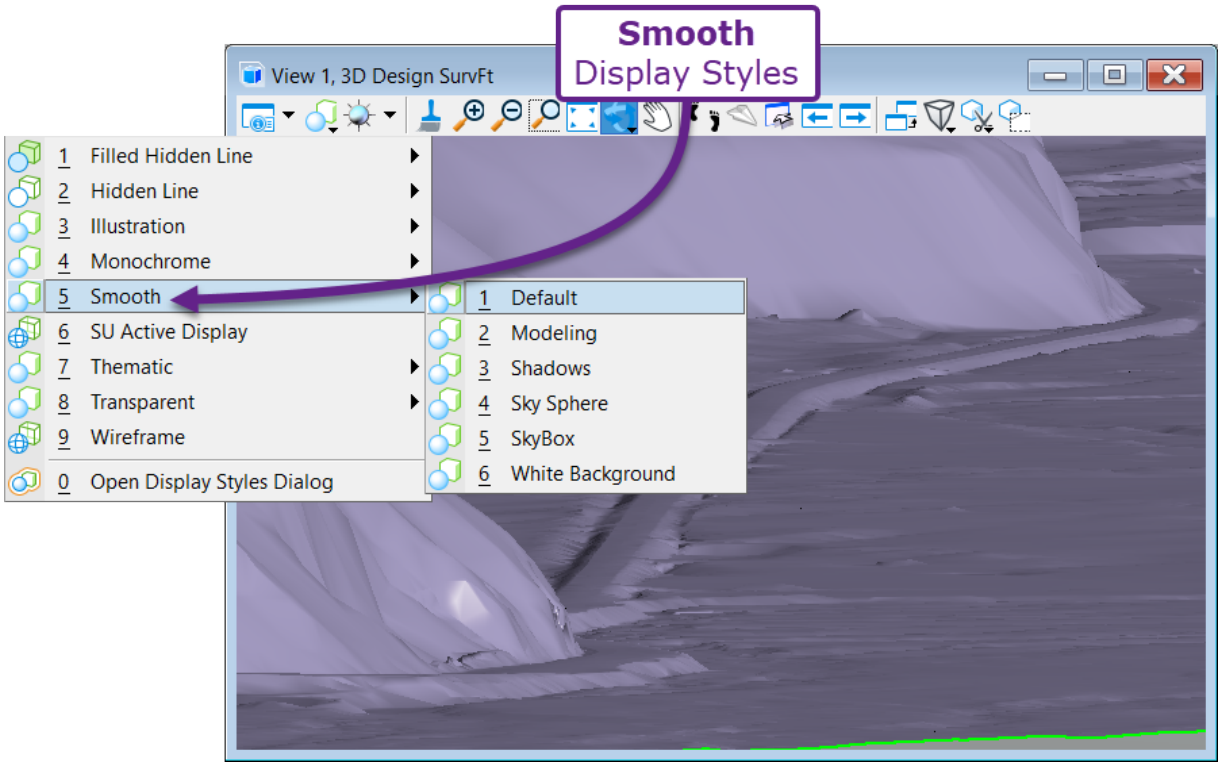
By default, the Display Style is set to **Wireframe**, which only shows the edges of the Terrain Model triangles.



Changing the Display Style to an **Illustration** style will show the triangles as solid mesh. The edges of the triangles are shown.

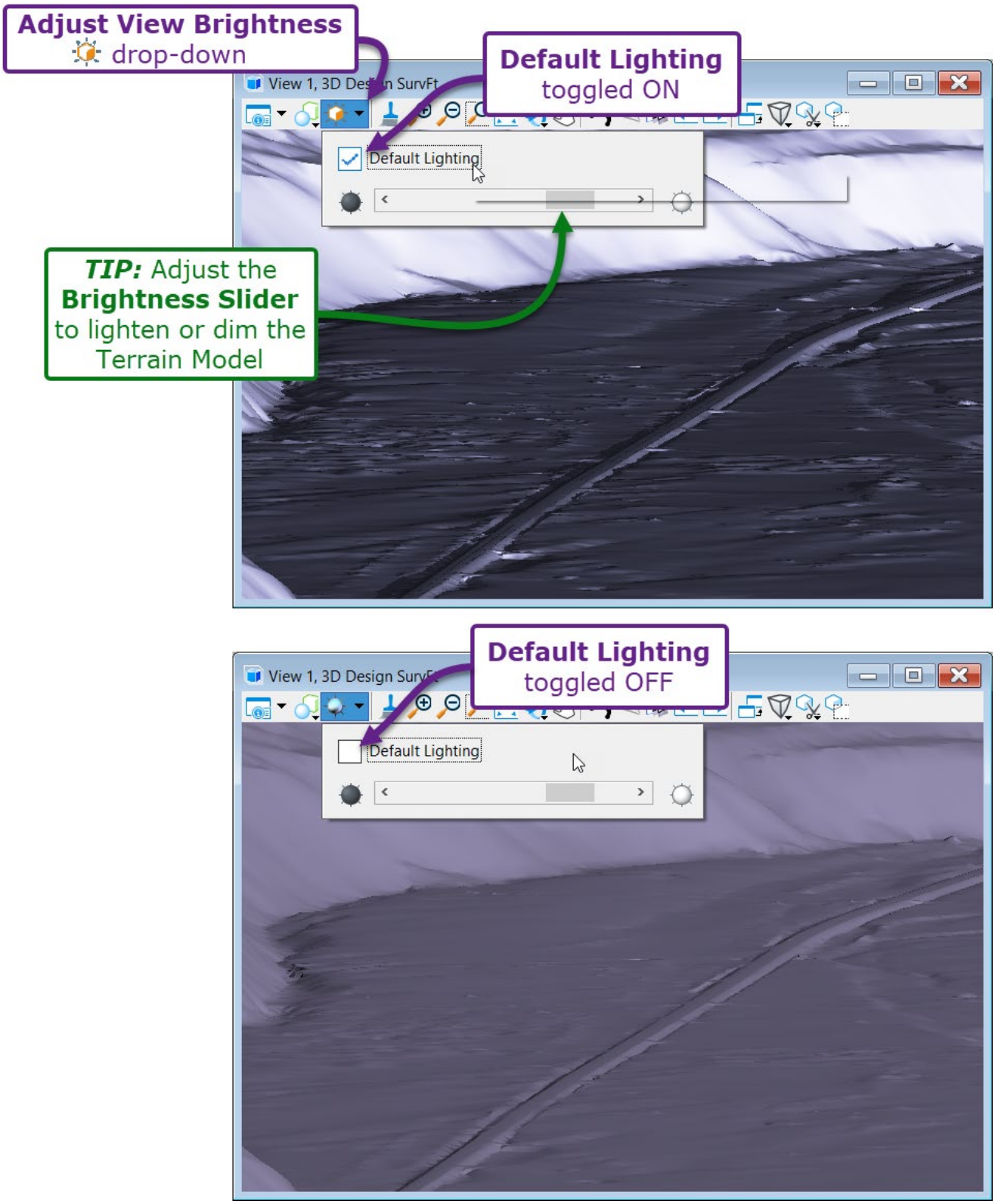


Changing the Display Style to a **Smooth** style shows the Terrain Model with smoothed over, solid triangles. To provide an increased sense of realism, the triangle edges are NOT shown.



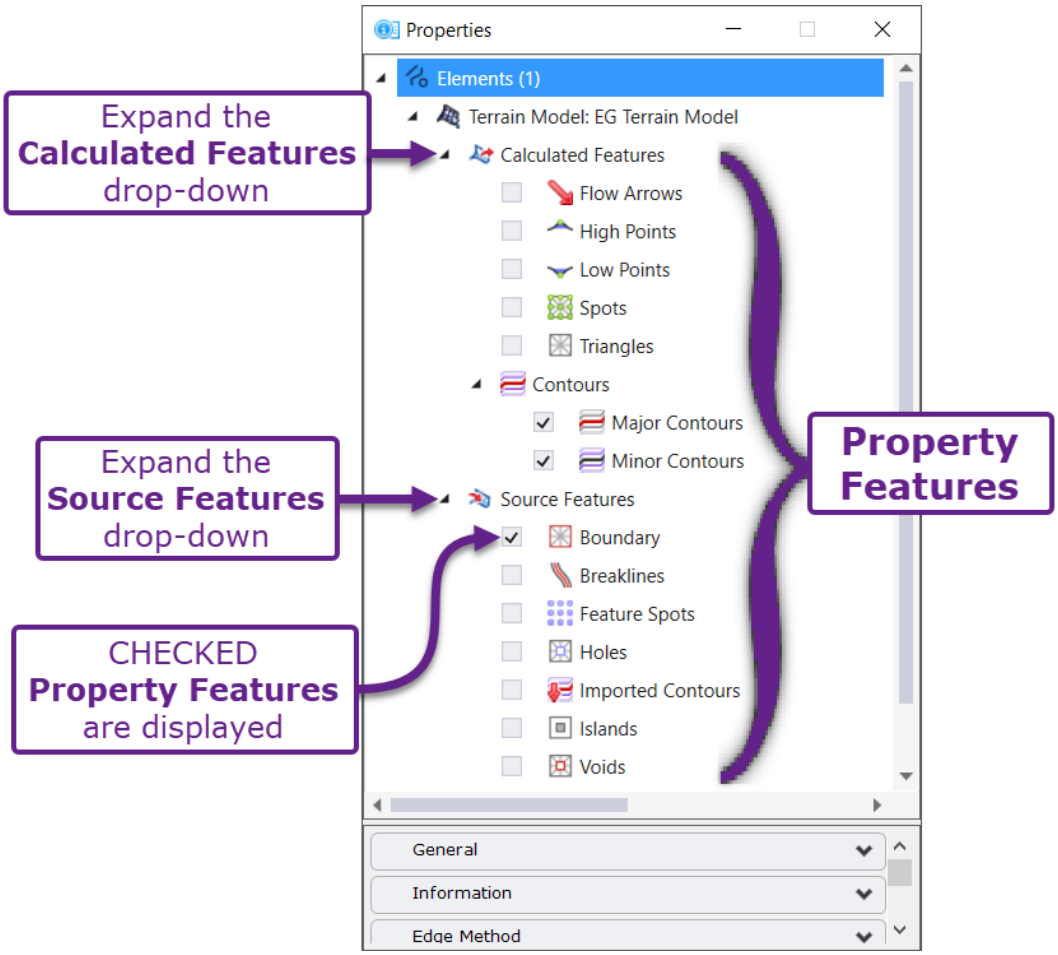
TIP: When using a **Smooth** Display Style, toggle ON/OFF the **Default Lighting** option to change the shadow/lighting effects on the Terrain Model. The Default Lighting option is found under the **Adjust View Brightness** drop-down.

Also, adjust the **Brightness Slider**, to lighten or dim the Terrain Model.



5B.3 Properties Features

In the Properties box, individual Property Features can be toggled ON and OFF.



Calculated Features: Calculated Features are automatically generated by the Terrain Model. For example, Contours are calculated through interpolation based on the Break Lines and Ground Points elevations used to create the Terrain Model.

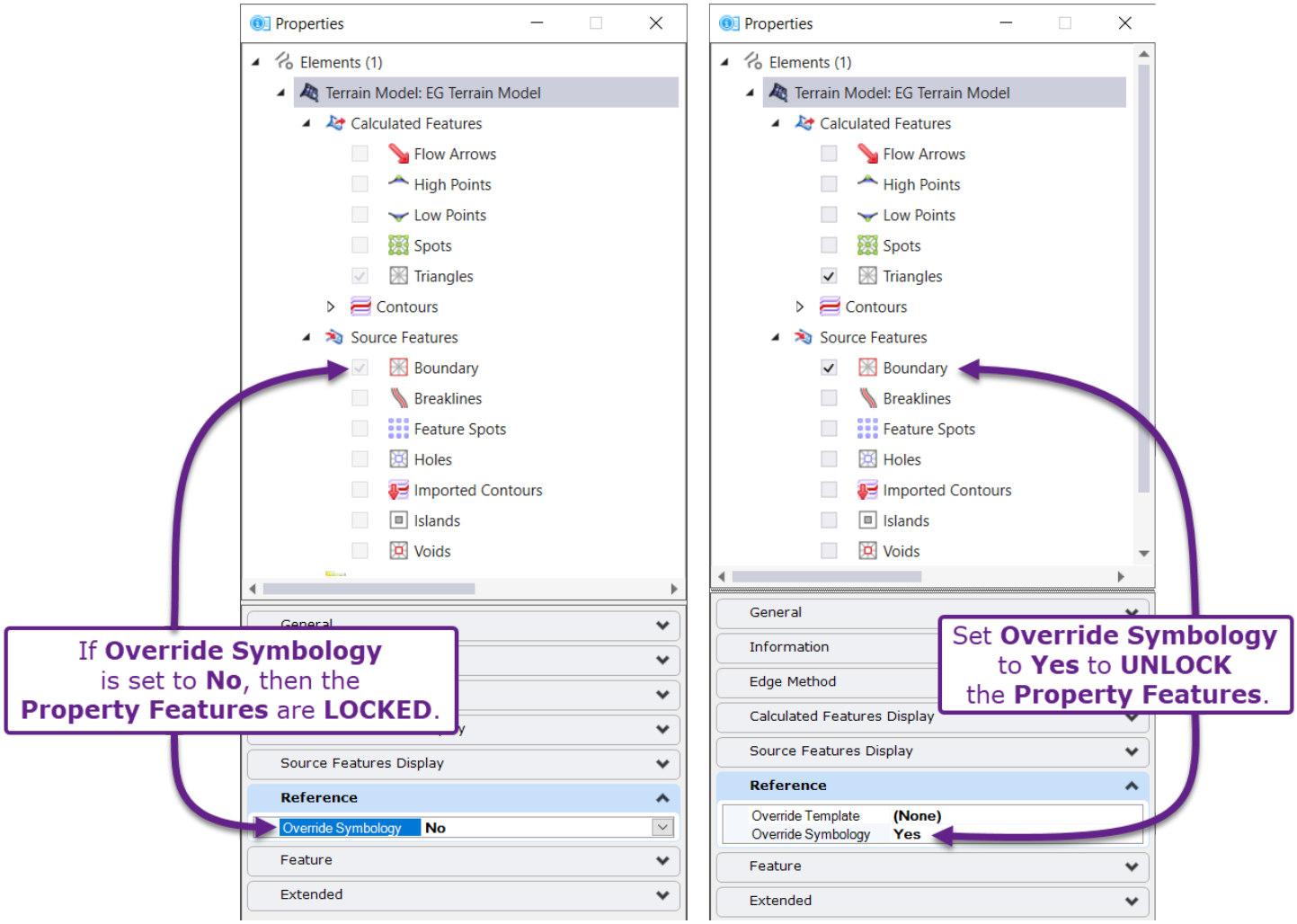
Source Features: Source Features are elements used to create and form the Terrain Model. For example, checking ON the Breaklines box will display all Break Lines used triangulate the Terrain Model.

> ***NOTE:*** The display of the Major and Minor Contours may be toggled ON/OFF with the Property Features checkboxes. However, the display of Contour Labels is controlled by the "E_GEO_Contour_Index_Labels" Level.

TIP: When the Terrain Model is referenced into a different ORD File, the Property Component boxes are greyed out and locked. To unlock and toggle ON/OFF Property Component boxes from a Reference File: change the **Override Symbology** setting to **Yes**.

NOTE: Changing the Property Component configuration from a Reference File does NOT affect the Property Component configuration in the Survey ORD File or other Reference Files. The overrides are ONLY shown in the active Reference File.

IMPORTANT: The **Override Symbology** setting is ONLY displayed when the Terrain Model is **referenced** into another ORD File.



5B.4 Override Element Template (References ONLY)

If the **Override Symbology** property is set to **Yes** (see the previous page), then the **Element Template** style for the Terrain Model can be modified.

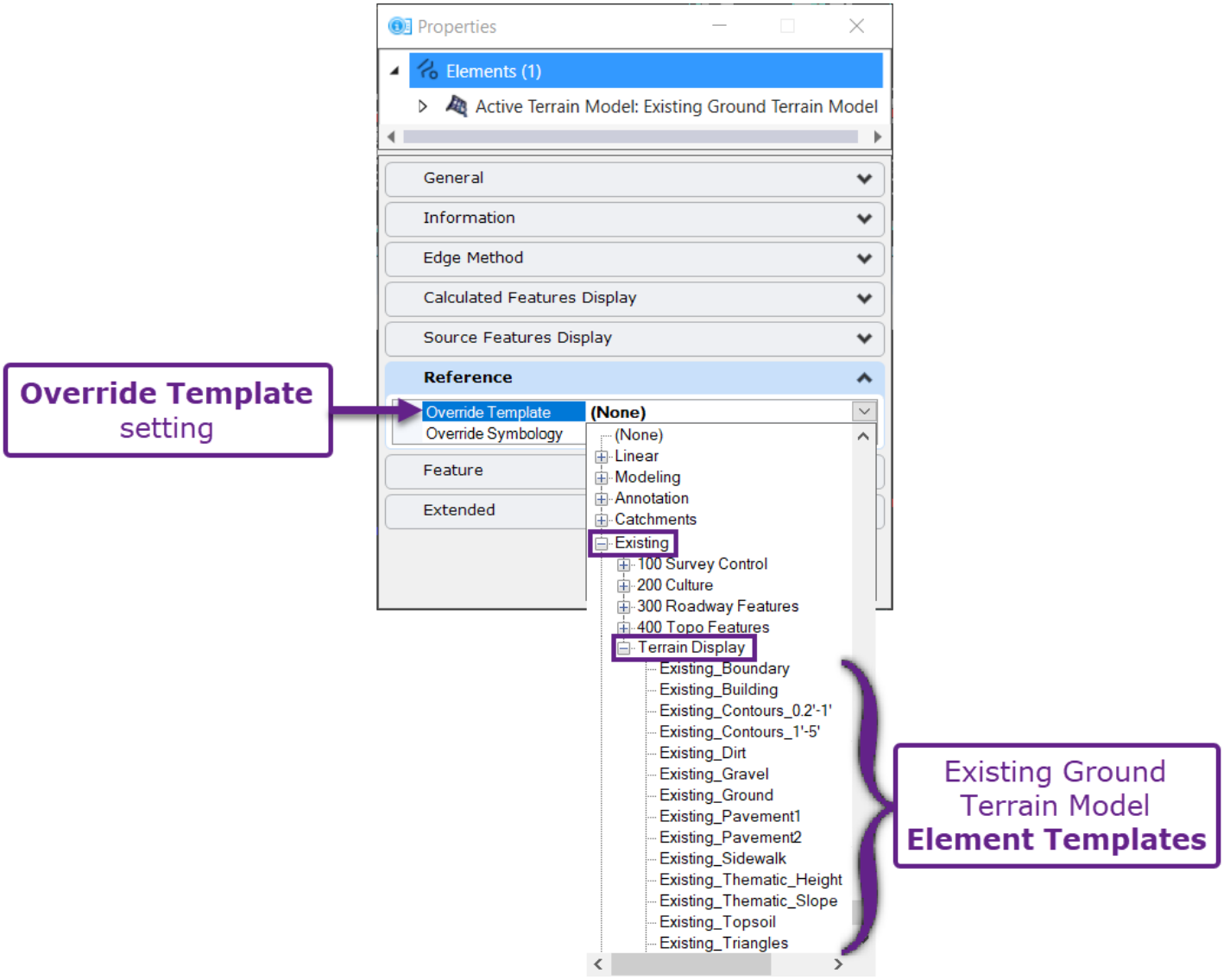
NOTE: The **Override Symbology** and **Override Template** settings are ONLY shown when a Terrain Model is referenced into a different ORD File.

The available Element Templates styles match the "Existing" Feature Definitions in both name and function. Changing the Element Template will change the appearance of the Terrain Model.

BEST PRACTICE: ONLY change the Element Template if the desire is to show the Contour interval different for a particular Reference ORD File. For displaying Triangles, Flow Arrows, or High/Low Points, CHECK the appropriate **Properties Features** boxes. See *5B.3 Properties Features*.

Within the **Override Template** drop-down, Existing Element Template Styles are found under:

Existing → Terrain Display.



WARNING: Do NOT use Element Templates that correspond with materials (i.e., Existing_Building, Existing_Dirt, Existing_Gravel, etc…)

5B.5 Levels for the Existing Ground Terrain Model

The Existing Ground Terrain Model has a **Master Level** and a set of **Component Sub-Levels**.

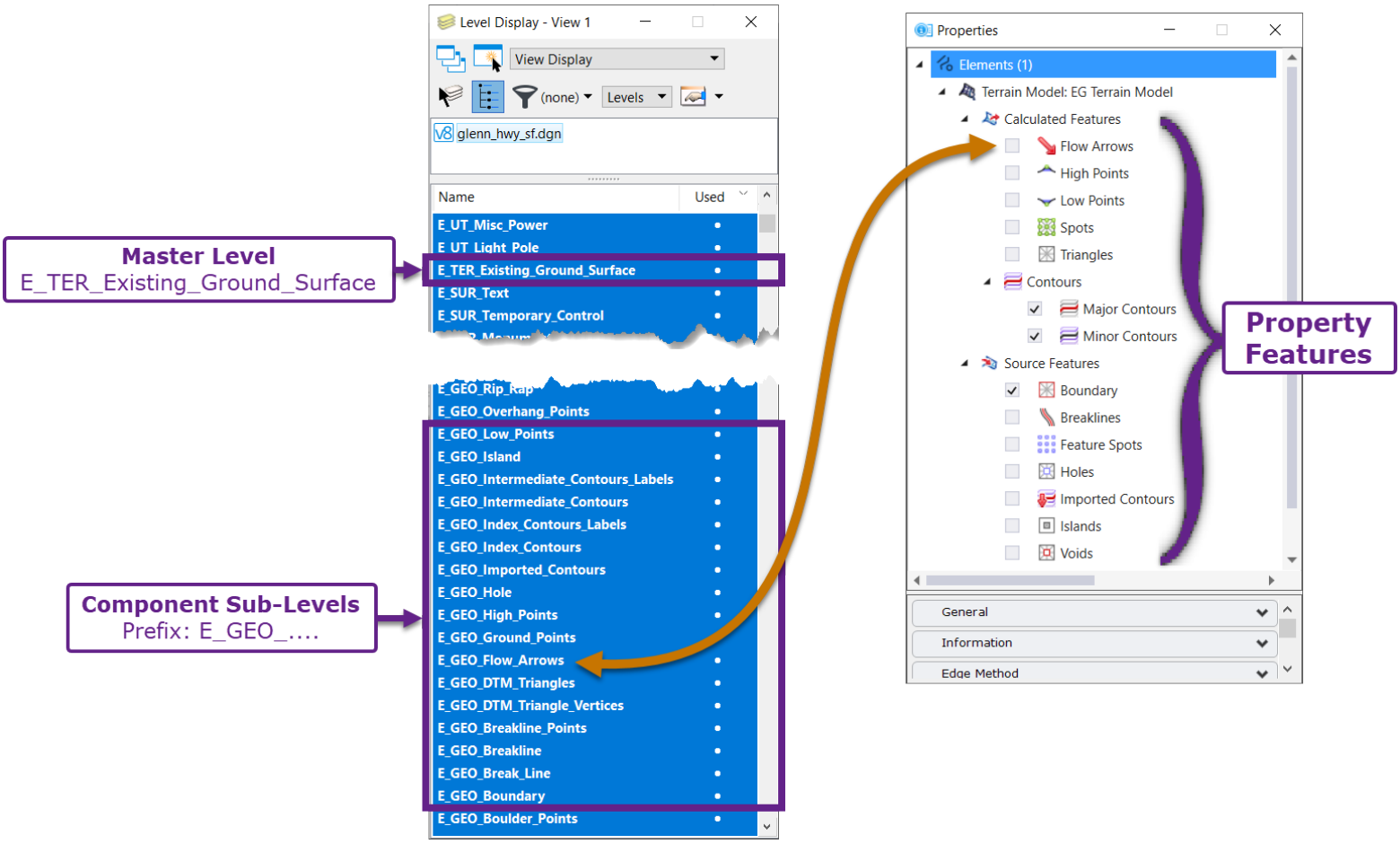
Master Level: The Master Level must be toggled ON to display any graphical component of the Existing Ground Terrain Model. Toggling OFF the Master Level turns off ALL Existing Ground Terrain Model graphics and components.

The Master Level for the Existing Ground Terrain Model is: "E_TER_Existing_Ground_Surface".

Component Sub-Levels: Properties Features (i.e., Triangles, Flow Arrows, Major/Minor Contours) all have a corresponding Levels.

Component Sub-Levels all begin with the prefix: "E_GEO_...".

TIP: Major Contour Labels can be toggled ON/OFF with the "E_GEO_Index_Contours_Labels" Level.



For example, the display of the Boundary element can be toggled OFF with the "E_GEO_Boundary" Level.

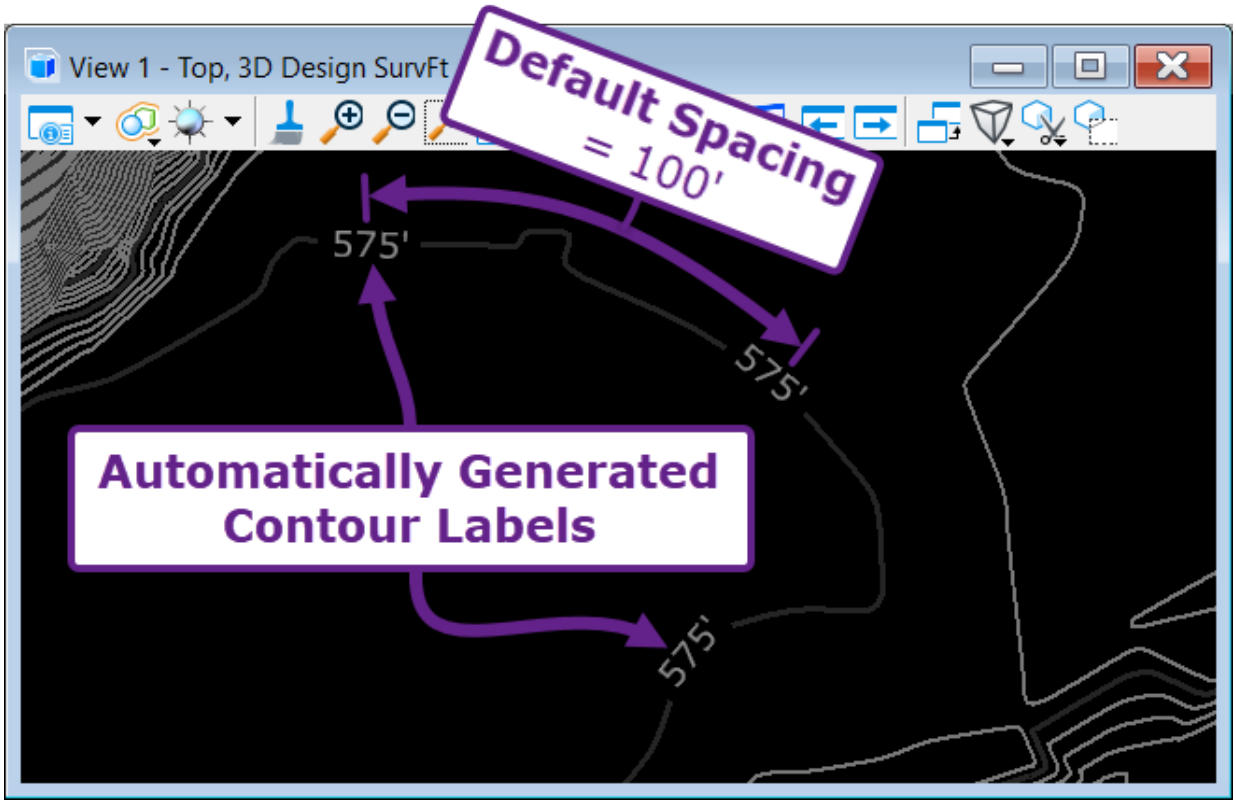
IMPORTANT: For the Boundary element to display, the following conditions must be met:

- The **Property Feature** box for the **Boundary** must be CHECKED.
- The **Master Level** ("E_TER_Existing_Ground_Surface") must be toggled ON.
- The **Component Sub-Level** for the Boundary ("E_GEO_Boundary") must be toggled ON.

5B.6 Contour Labels

By default, Major Contour Labels are automatically generated by the Terrain Model. Automatically generated Contour Labels are placed 100 feet apart, as measured along the length of the Contour.

Automatically generated Contour Labels change position as the *View* window is panned and rotated.

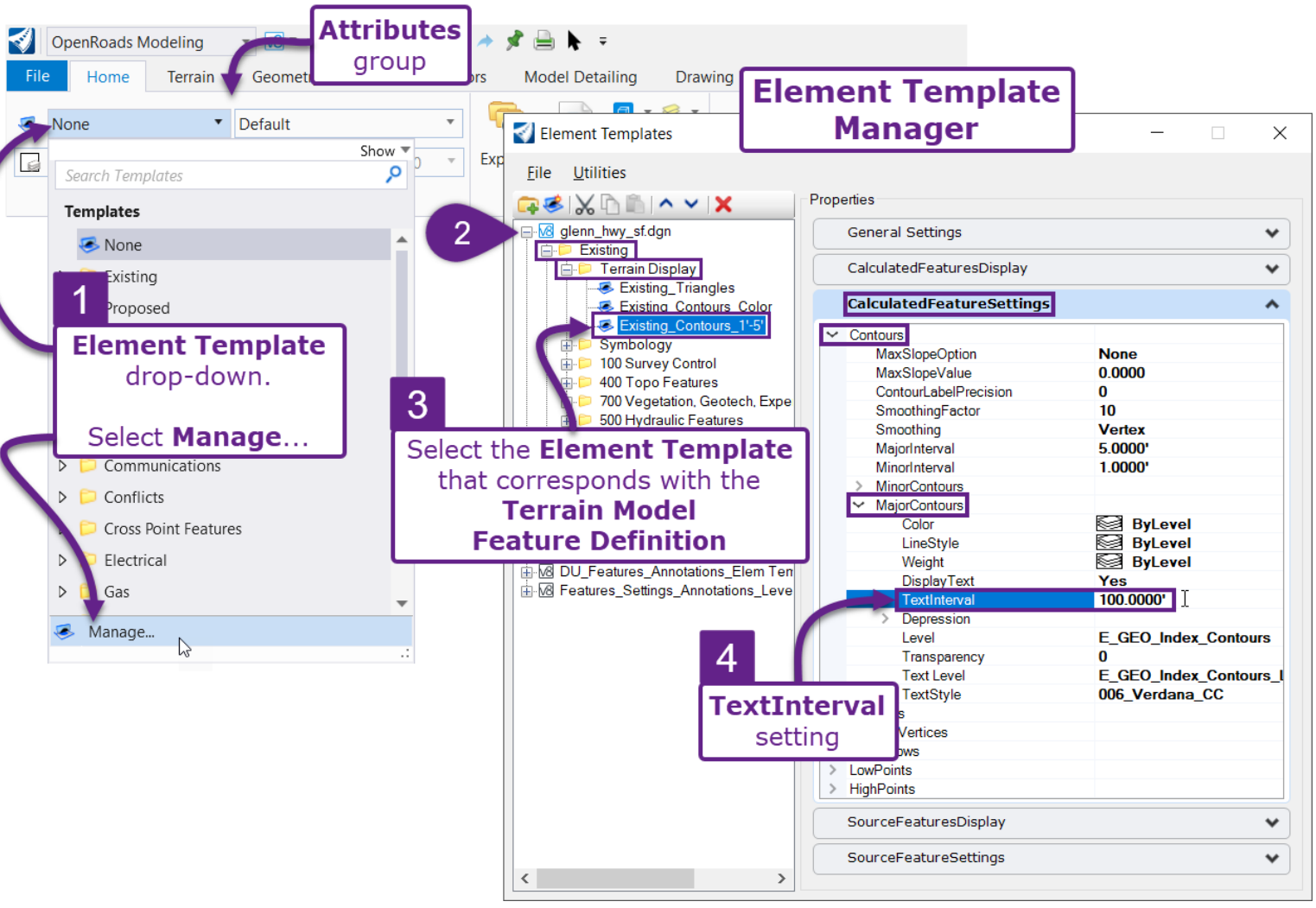


TIP: Contour Labels can be created and placed at a fixed location with the *Label Terrain Contours* tool. See *5B.7 Label Terrain Contours tool*.

The default spacing for automatically generated Contour Labels is set and modified through the Element Template for the Terrain Model. The **TextInterval** setting controls the Contour Label spacing.

To access the Element Template and **TextInterval** setting:

1	In the Ribbon, locate the **Attributes** group. Expand the **Element Template** drop-down and select **Manage...** The **Attributes** group can be found in the following location: [***OpenRoads Modeling*** → ***Home*** → ***Attributes***]
2	Expand the drop-down that corresponds with the active ORD File.
3	Element Templates for Existing Terrain Models are found under: [***Existing*** → ***Terrain Display***]. Select the Element Template that corresponds with the currently set Feature Definition. In this case, **Existing_Contours_1'-5'** is selected.
4	Locate the **TextInterval** setting under: [***CalculatedFeatureSettings*** → ***Contours*** → ***MajorCoutours*** → ***TextInterval***] Change the Contour Label spacing to the desired value.

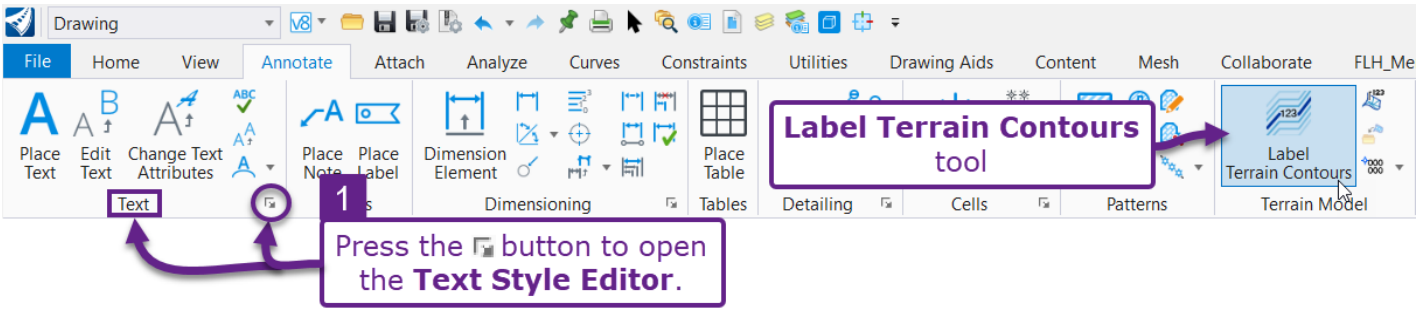


5B.7 Label Terrain Contours tool

As discussed in *5B.6 Contour Labels*, a Terrain Model will automatically produce contour labels that are spaced at a fixed interval distance. The *Label Terrain Contours* tool is used to manually place contour labels at any location on the Terrain Model.

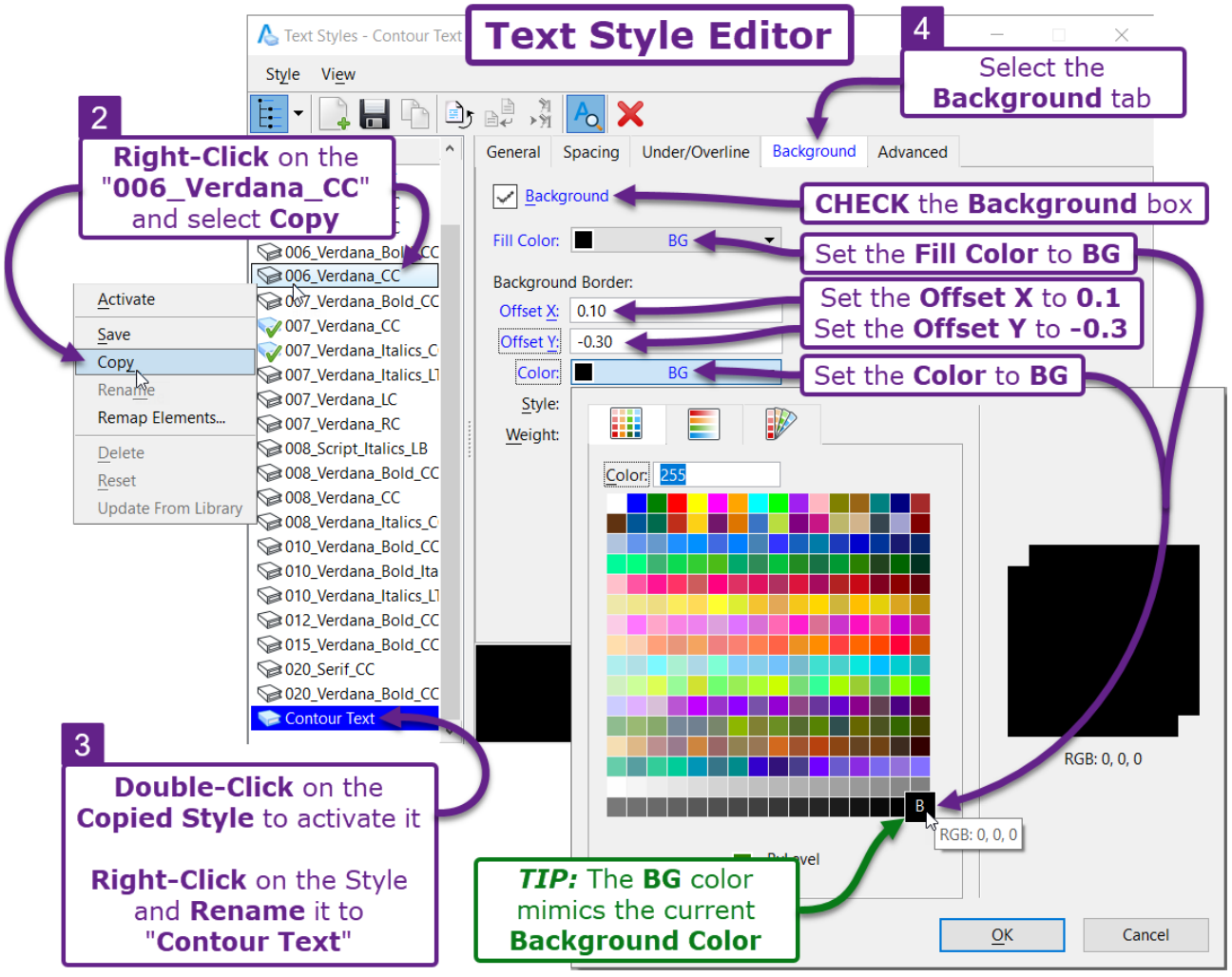
The *Label Terrain Contours* tool is found in the following Ribbon location:

[***Drawing*** → ***Annotate*** → ***Terrain Model***]

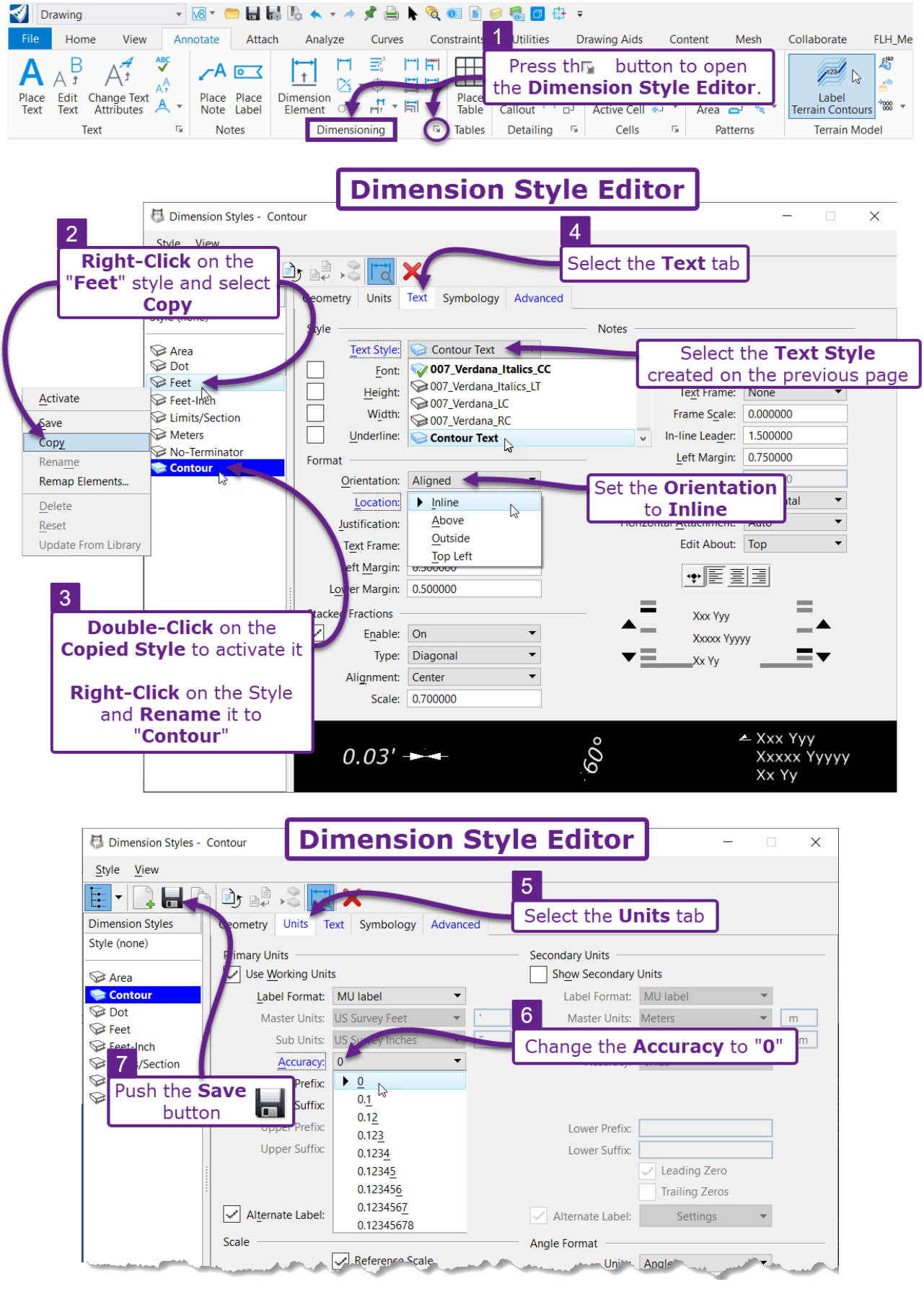


IMPORTANT: Before using this tool, a custom **Text Style** and **Dimension Style** must be created. The FLH WorkSpace does NOT contain **Text/Dimension Styles** that are appropriate for contour labels.

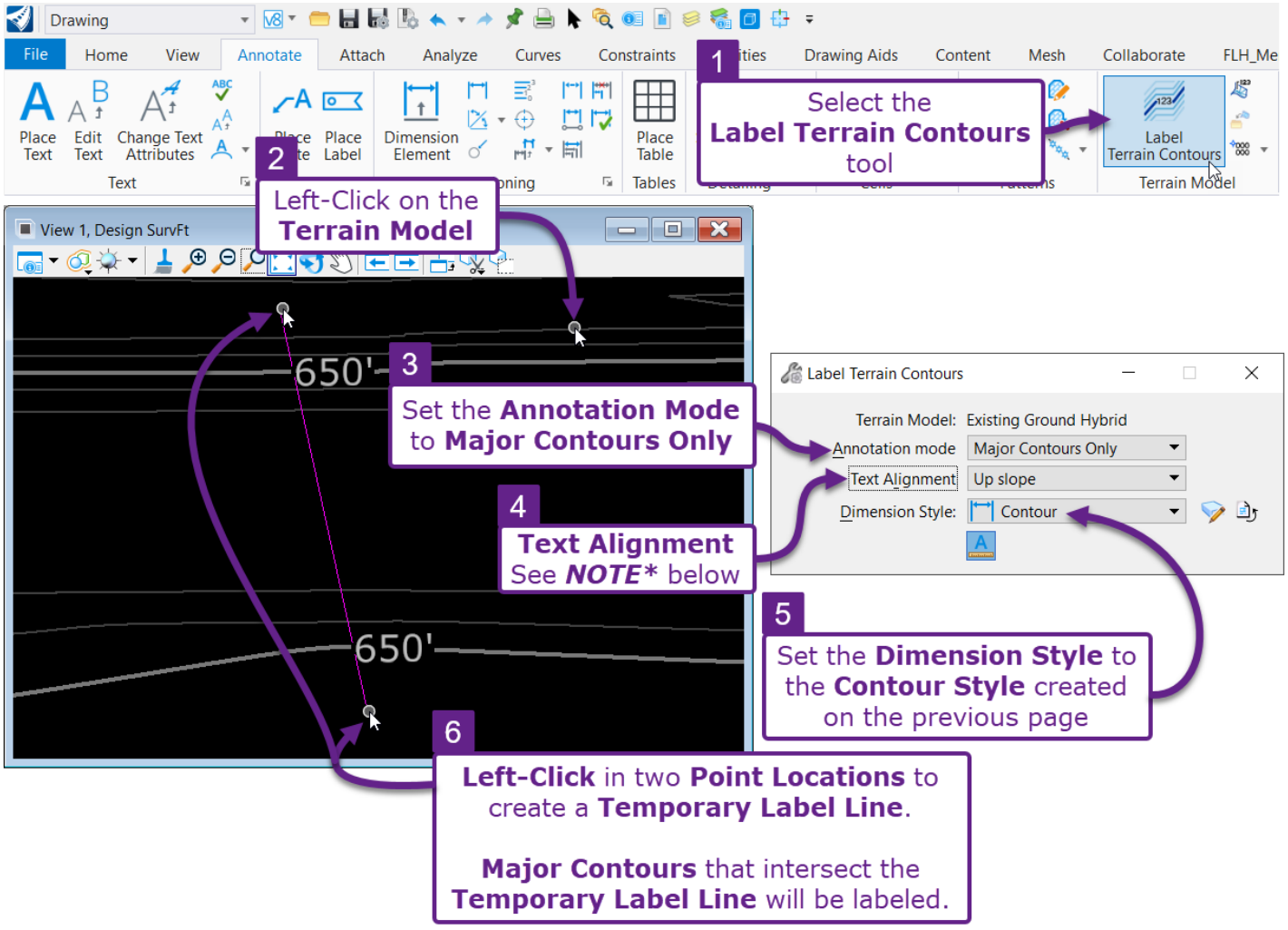
The graphic below shows the appropriate settings for the contour label **Text Style**. To create the contour label Text Style, the "006_Verdana_CC" style must be copied and a Background Mask must be applied to the copied style.



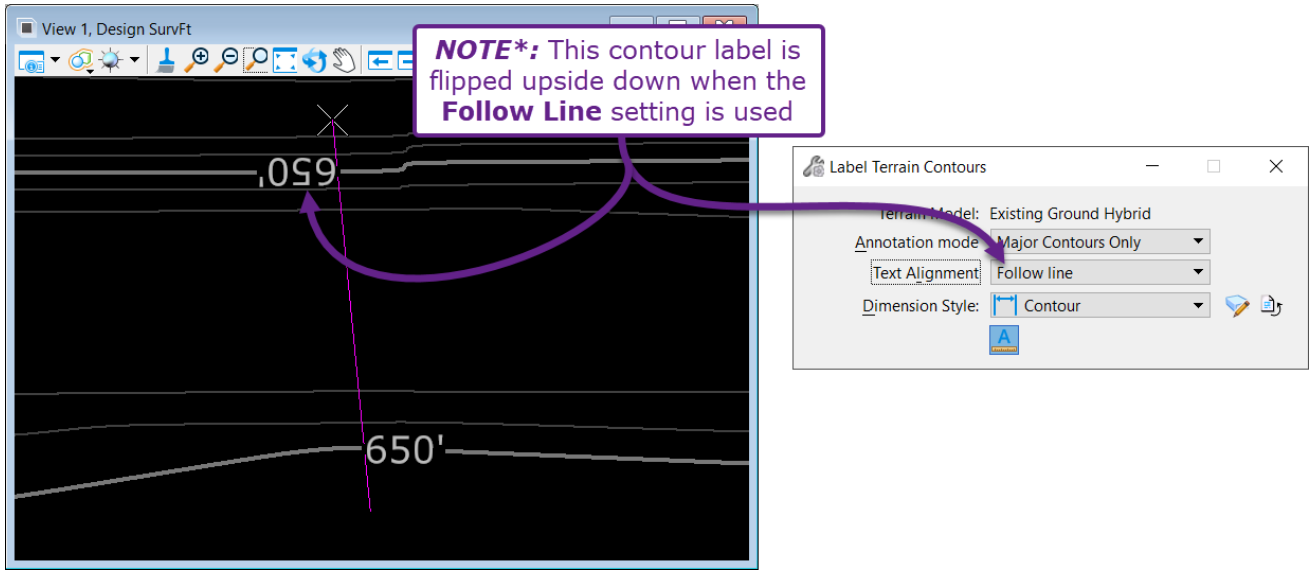
The graphic below shows the appropriate settings for the contour label **Dimension Style**. To create the contour label Dimension Style, the "Feet" style must be copied.



After creating the contour label **Text** and **Dimension Styles**, the *Label Terrain Contour* tool can be used. In step 5, select the contour label style created on the previous page.



NOTE*: There are two **Text Alignment** (step 4) settings: "Up Slope" and "Follow Line". This setting affects the orientation of the contour labels. The User may need to experiment with both settings to show the label right-side up. In the graphic above, the Text Alignment is set to "Up Slope" and both labels are shown correctly. In the graphic below, the Text Alignment is set to "Follow Line" and the top label is shown upside-down.

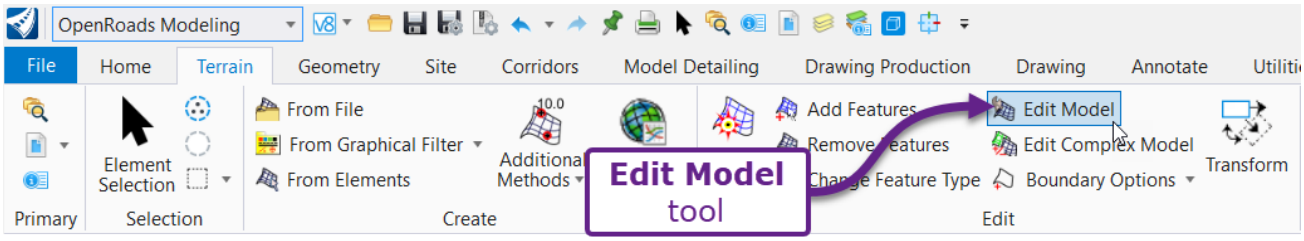


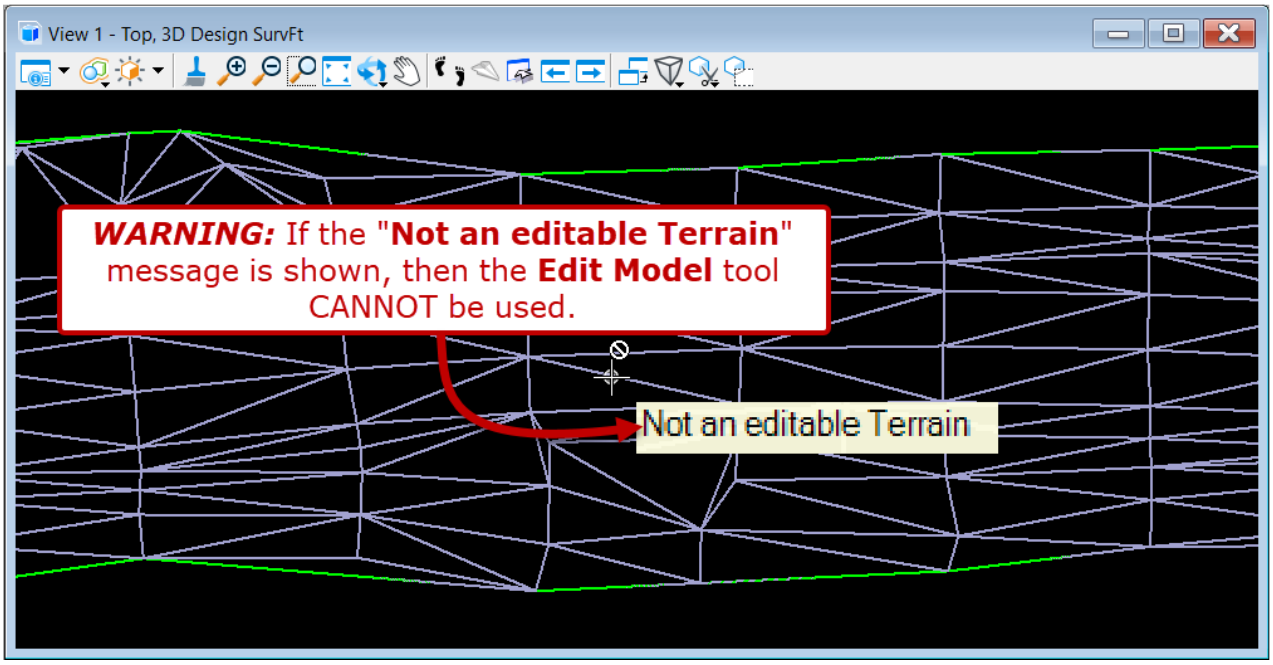
5B.8 Edit Model tool

The *Edit Model* tool is used to modify the triangulation of a Terrain Model. This tool can delete a triangle vertex, delete triangle edges, swap triangle edges to reconfigure triangulation, insert an interpolated triangle vertex, and move a triangle vertex.

WARNING: Editing the triangulation of the Existing Ground Terrain Model should ONLY be done by the project surveyor. If faulty or unappropriated triangulation is found, contact the project surveyor for revision.

The *Edit Model* tool is NOT compatible with Terrain Models that are *ruled* to graphical elements. If a Terrain Model contains graphical element *rules*, then the error message "Not an editable Terrain" is shown when the *Edit Model* tool is used.





Rules dynamically link a Terrain Model to the graphical elements that were used to create it. If a graphical element is manipulated, then the Terrain Model will automatically update due to the *rule* relationship.

It's possible to remove all graphical element *rules* for a Terrain Model, but the Terrain Model becomes mostly static. The ONLY method for editing a Terrain Model after removing *rules* is the *Edit Model* tool.

Existing Ground Terrain Models made in ORD are created with a graphical filter. The graphical filter selects the appropriate element types (i.e., existing edge of road and shoulder) to form the Terrain Model. The Terrain Model is *ruled* to the elements selected by the graphical filter. The ONLY way to remove *rules* is to export the Terrain Model as a .tin or .xml file, delete the Terrain Model, and then import the .tin or .xml file to create a new Terrain Model. The new Terrain Model will NOT contain rules and is compatible with the *Edit Model* tool. **The new Terrain Model will NOT be linked (*ruled*) to the survey breaklines and points**, which can be a problem if edits are made to the Terrain Model in the future.

5C – IMPORT LIDAR DATA INTO ORD

This section demonstrates several processes for importing LiDAR data into ORD as a Terrain Model. LiDAR data is generally used for conceptual design or to fill a gap in an Existing Ground Terrain Model.

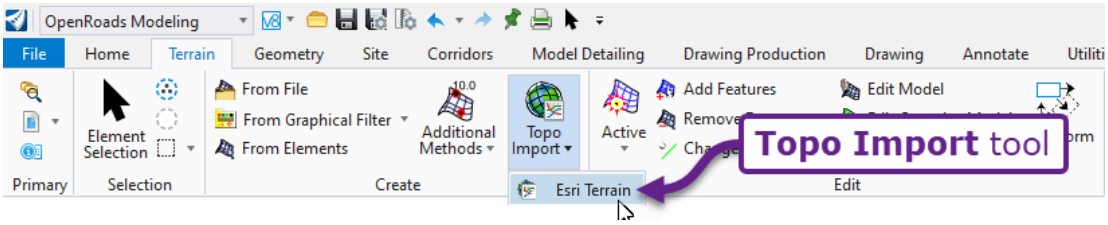
The LiDAR import procedures shown in this section will be exclusively done by Survey and Mapping staff, with very few exceptions.

WARNING: The quality and accuracy of LiDAR depends on the available datasets available for the project location. Some project locations may NOT have adequate LiDAR datasets. The accuracy of LiDAR data is presented when downloading/acquiring the data. Assessing the accuracy of LiDAR data is discussed in each subsequent workflow.

WARNING: For engineering design, LiDAR data should always be considered an approximation. Commonly, there will be discrepancies between LiDAR data and ground surveyed elevations. The elevation discrepancies may be minor or severe depending on the accuracy of the LiDAR data source.

In this section, two methods for acquiring LiDAR data are discussed:

METHOD 1 – Topo Import tool: The *Topo Import* tool directly imports LiDAR data from an ESRI base map and automatically creates a Terrain Model. This is the easiest and most stream-lined method for acquiring LiDAR data. This tool is demonstrated in *5C.2.a Topo Import tool*. ***NOTE:*** The *Topo Import* tool requires an ESRI subscription and login.



METHOD 2 – Acquire LiDAR data from an External Website: This process involves downloading LiDAR data from the National Oceanic and Atmospheric Administration (NOAA) website or the US Geological Survey (USGS) website.

> **NOAA (National Oceanic and Atmospheric Administration) – Data Access Viewer:** In general, the elevation data found on the NOAA website is of high-quality, refined, and easy to import into ORD. NOAA data coverage is plentiful near coastal regions, but sparse in the middle regions of the country. https://coast.noaa.gov/dataviewer/#/lidar/search/
>
> **USGS (The U.S. Geological Survey) – The National Map:** The USGS website has larger data coverage span than NOAA. However, some of the elevation data found in the USGS National Map is of poor quality/resolution and may NOT be appropriate for engineering applications. https://apps.nationalmap.gov/viewer/

The NOAA and USGS websites are specifically prescribed because these websites will automatically process the LiDAR data. These websites project the LiDAR data to the desired Coordinate System. Also, the data is clipped to an area set by the User.

NOTE: Many Federal, State, and Local agencies provide LiDAR data. However, the data is typically in bulk format.

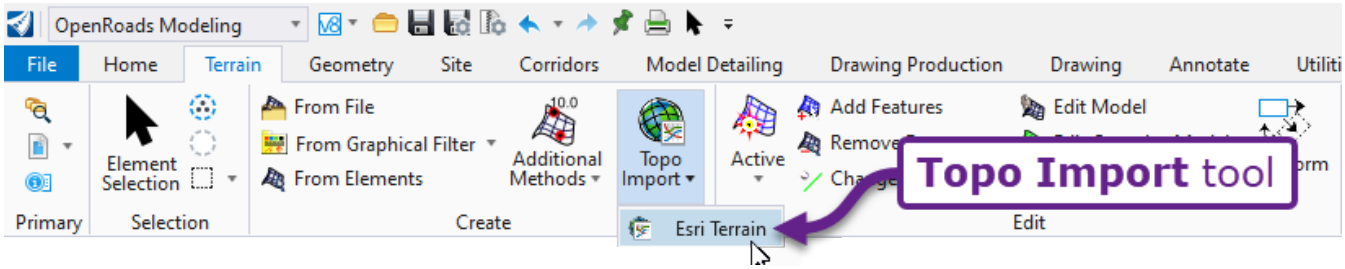
Bulk LiDAR data is typically NOT assigned to the same Coordinate System or units (i.e., meters) used in the Survey ORD File. It is NOT possible to convert LiDAR data to the desired Coordinate System and units using the ORD software. Specialized software is required for the conversion.

Also, bulk LiDAR data typically covers a large area. It is possible to clip LiDAR data in ORD. However, bulk LiDAR data sets will likely crash the ORD software due to the large file size. Bulk LiDAR data sets may have to be clipped down to the appropriate area using specialized software. Contact survey staff to address this issue if it arises.

5C.1 Acquire LiDAR Data with the Topo Import tool

This tool automatically acquires elevation data from an ESRI base map* to create a Terrain Model. The resulting, imported Terrain Model can be merged with the Existing Ground Terrain Model to fill in gaps.

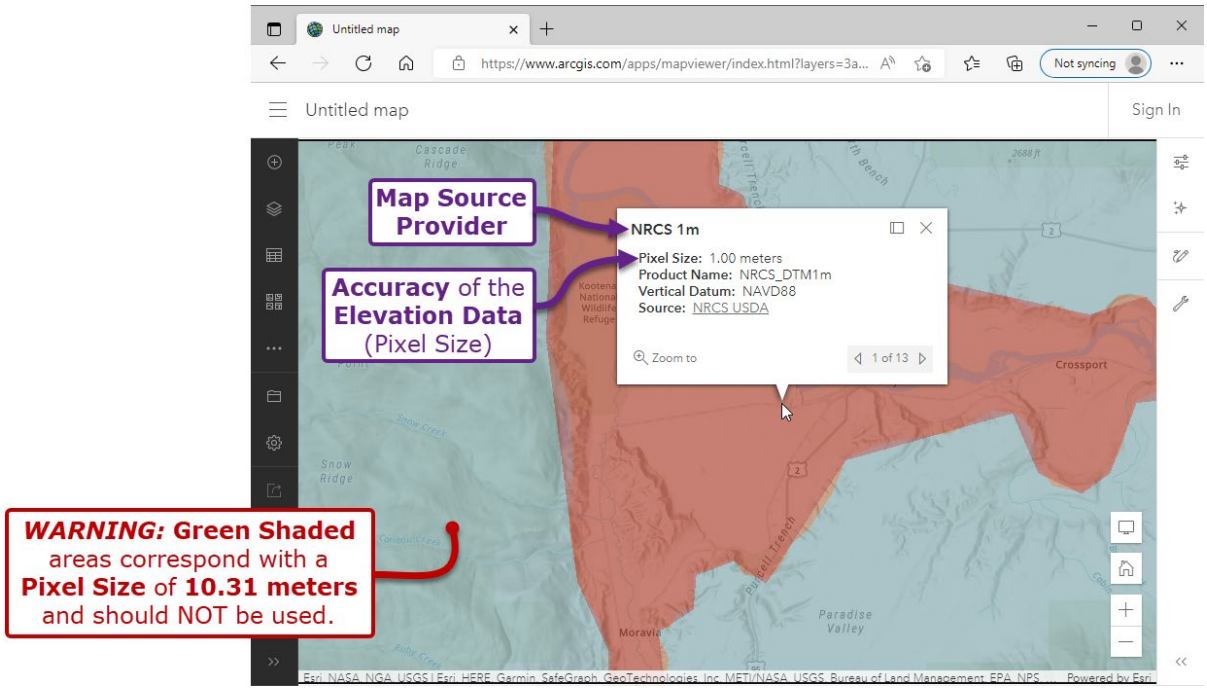
NOTE: The *Topo Import* tool requires an ESRI subscription and login.



***NOTE*:** This tool is powered by the ESRI World Elevation map. The source and accuracy of the imported Terrain Model depends on the selected area. Before using this tool, the ESRI World Elevation map can be accessed through the following website:

https://www.arcgis.com/apps/mapviewer/index.html?layers=3af669838f594b378f90c10f98e46a7f

In the web map, locate the project area and click at any point to reveal the Map Source Provider and Accuracy of the Elevation Data (Pixel Size):



The **Pixel Size** corresponds with the accuracy of the elevation data in the area.

IMPORTANT: In general, elevation data with a **Pixel Size** of 3.44 meters or less is acceptable for engineering applications. The smaller the Pixel Size, the more accurate the elevation data will be. A Pixel Size of 1.00 meters is considered high quality elevation data.

The most common Pixel Sizes available in the ESRI World Elevation map include 1.00 (shown in red shading), 3.00 (orange shading), 3.44 (orange shading), and 10.31 meters (green shading).

WARNING: Green shaded areas (10.31 meters Pixel Size) correspond with 1/3 arc-second maps and are NOT accurate enough for engineering applications.

Topo Import tool – Workflow:

The *Topo Import* tool should be operated from an ORD File created with a 3D Seed File. ORD Files created with a 3D Seed ONLY contain a *3D Design Model*. They will NOT contain a *2D Design Model*.

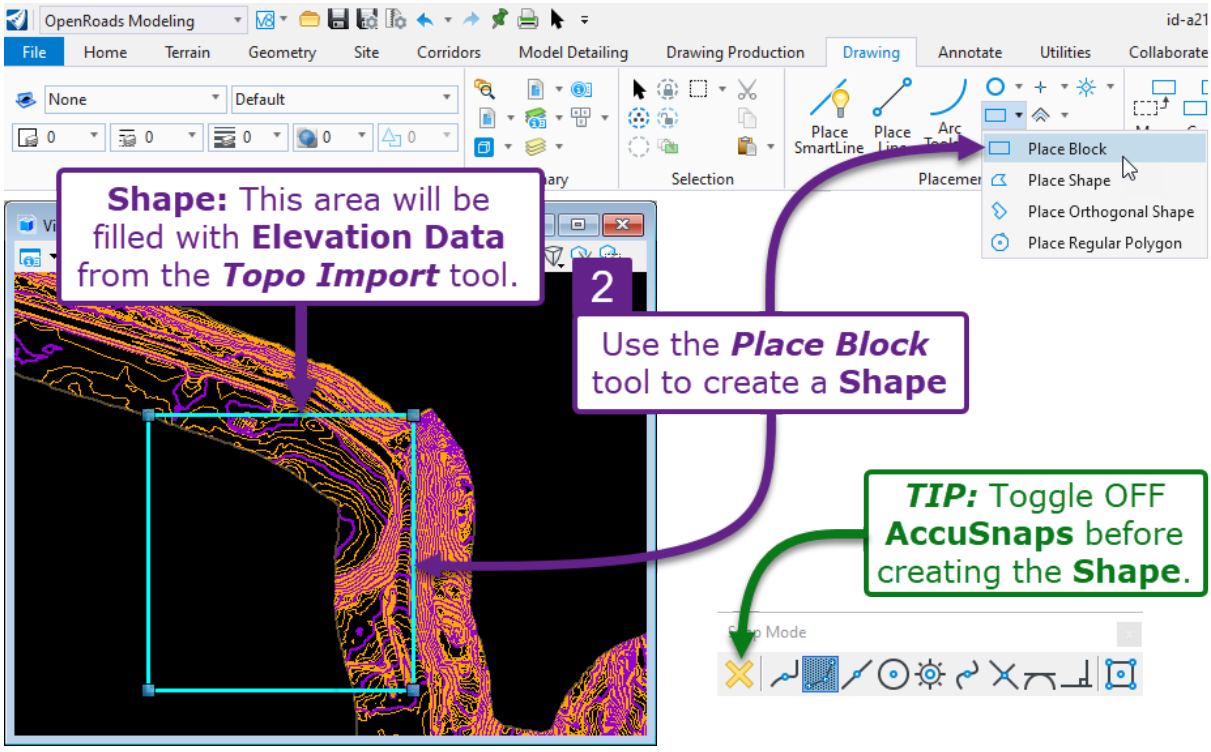
To create a New ORD File with a 3D Seed File, see *3B – Create a New ORD File*. In step 5 of that workflow, select a 3D Seed File instead of a 2D Seed File.

IMPORTANT: A Coordinate System must be set in the current ORD File for the *Topo Import* tool to function. See *3D.1 Set the Coordinate System*.

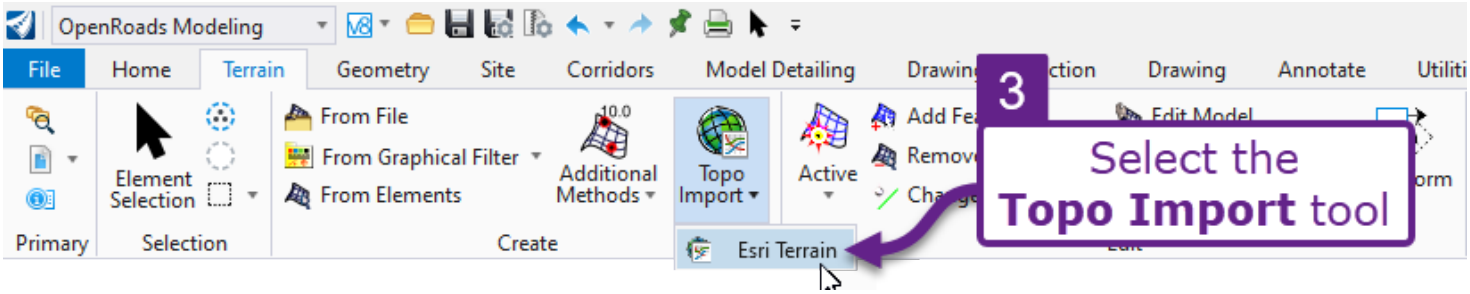
1	Open the copied version of the Survey ORD File (see ***BEST PRACTICE*** below). OR Create a new ORD File using a 3D seed File. Set the Coordinate System for the new ORD File.

BEST PRACTICE: If the need is to fill in a Gap in the Existing Ground Terrain Model, then create a copy of the Survey ORD File and use the *Topo Import* tool within the copied ORD File. If the results are acceptable after merging the two Terrain Models, then replace the Survey ORD File with the copied File.

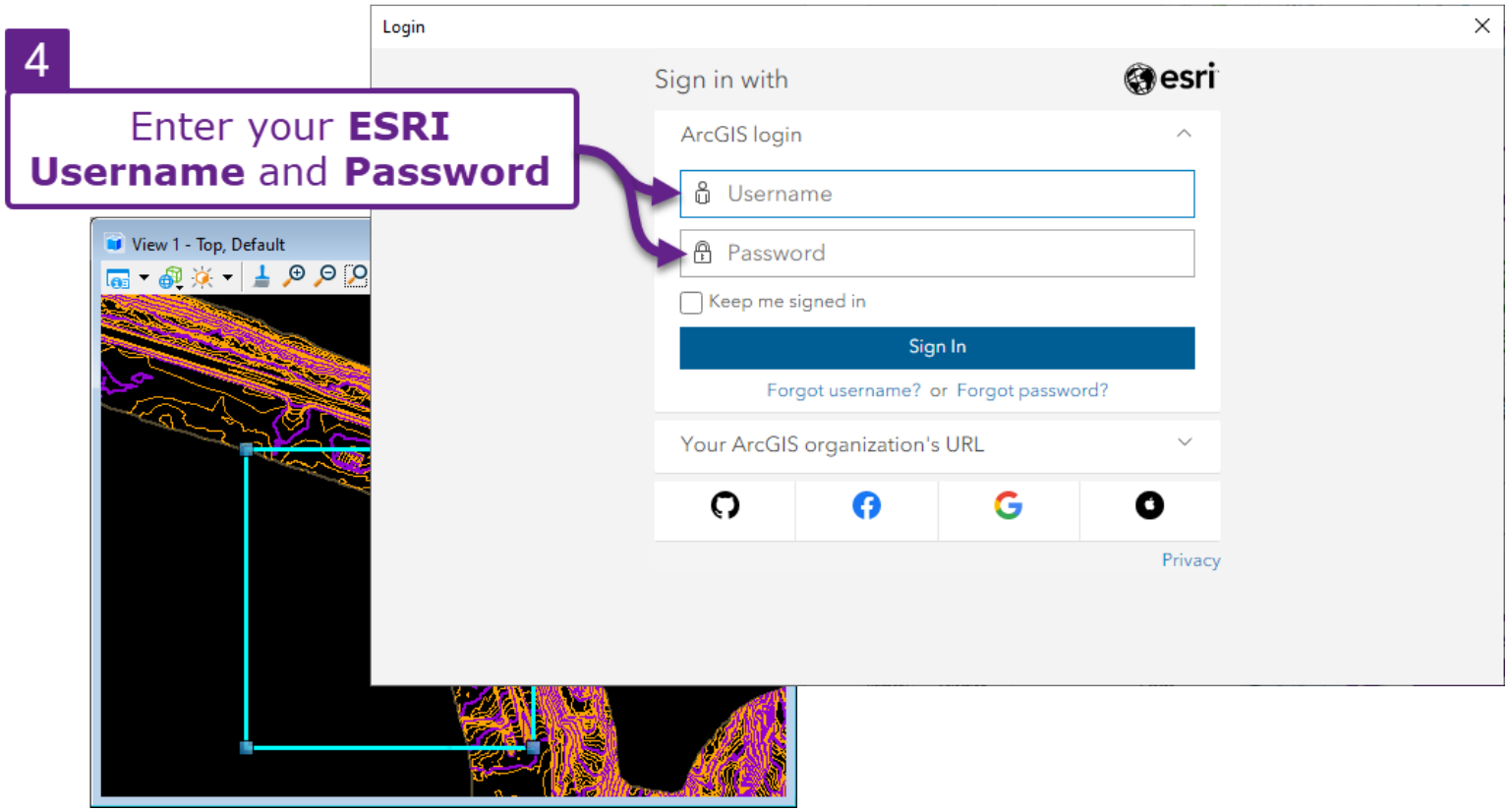
2	Create a **Closed Shape Element** that represents the desired area for the *Topo Import* tool. Use the *Place Block* or *Place Shape* tool to create the Closed Shape. ***TIP:*** Before creating the shape element, set the *View Rotation* to **Top View**. This ensures that the shape is drawn from the top-down (plan) perspective. ***TIP:*** Before creating the shape element, turn OFF the AccuSnap function. This ensures that the shape does NOT snap to a contour or other survey linework. ***TIP:*** Ensure the Shape overlaps with the Existing Ground Terrain Model. Overlap is needed for merging the *Topo Import* Terrain Model with the Existing Ground Terrain Model. Also, the overlapping areas can be used to compare the accuracy of the Imported Terrain Model with the Existing Ground Terrain Model.



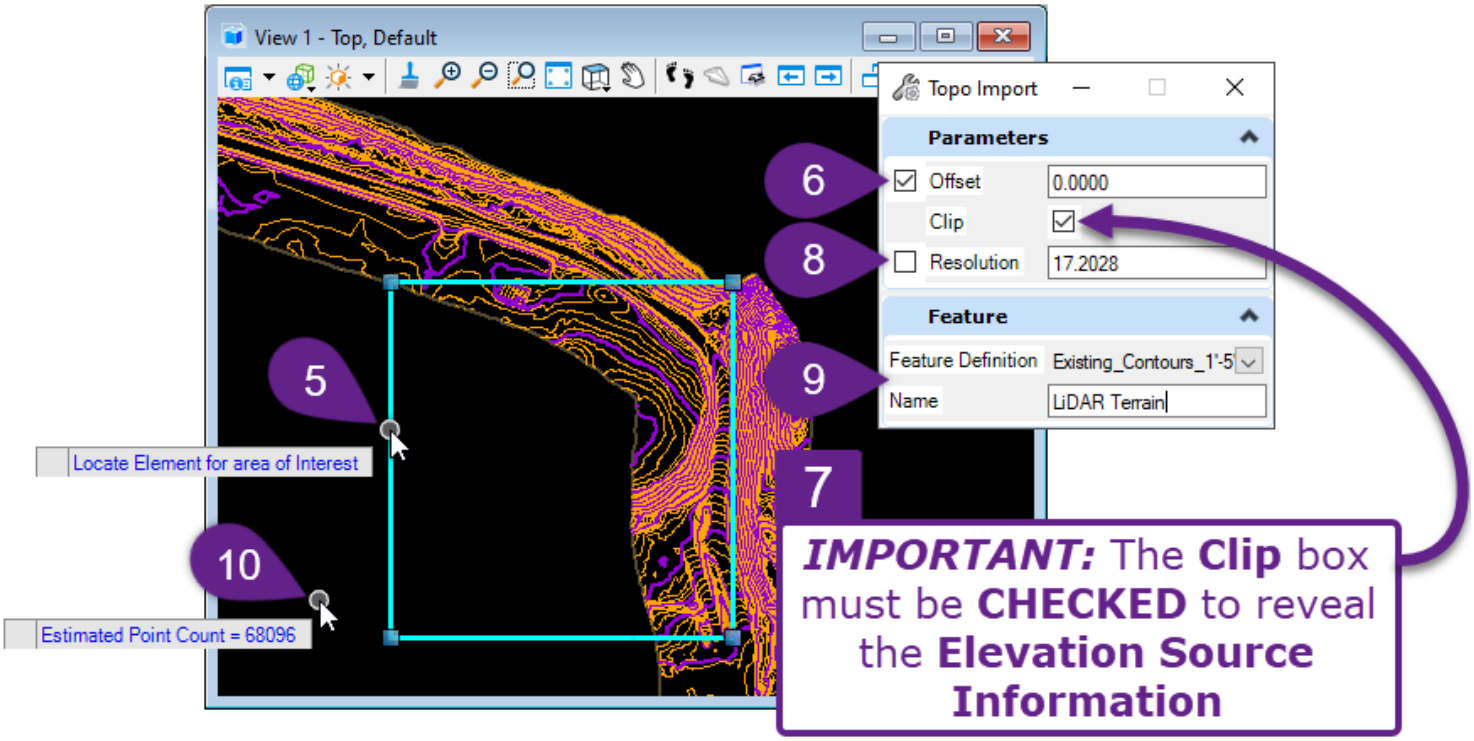
3	From the Ribbon, select the *Topo Import* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Create*** → ***Topo Import***].



4	After the *Topo Import* tool is executed, the ESRI Login window will be shown. Enter your ESRI Login credentials. ***NOTE:*** The ESRI Login window will NOT instantaneously pop-up. It may take 30-60 seconds to load. ***WARNING:*** The ESRI Login Window may need to be exited out of and reattempted multiple times before the Username and Password Login is shown. If the ESRI Login window appears blank or does NOT load, then exit out of the *Topo Import* tool and try again. If the ESRI Login window does NOT load after a few reattempts, then close the ORD software, re-open it, and retry the *Topo Import* tool.



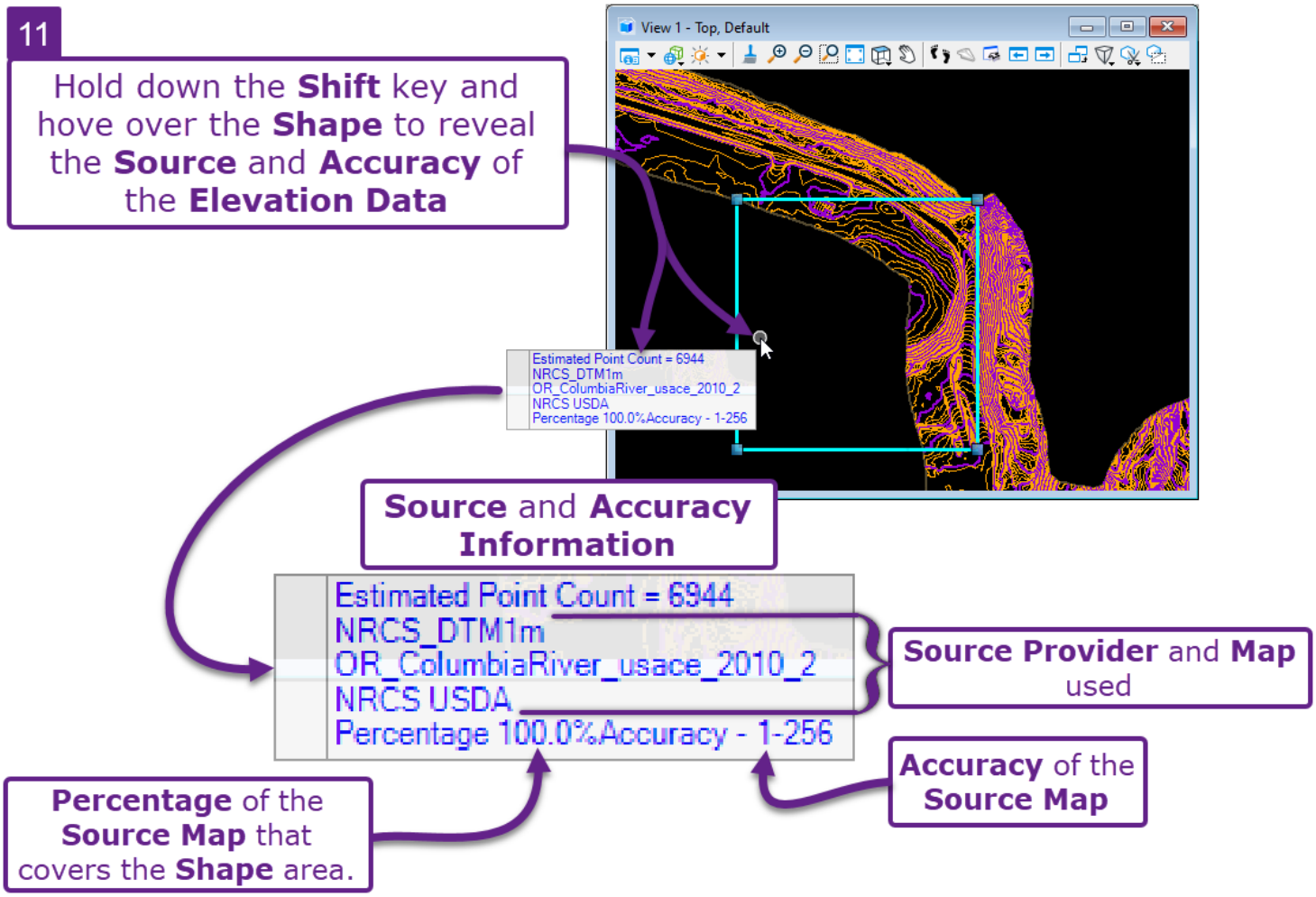
5	*Prompt: Locate Element for area of Interest* – Select the **Shape** element created in step 2.
6	In the Dialogue Box, set the **Offset** value to 0.0000 and LOCK it. ***NOTE:*** If an Offset value is greater than 0 is used, then the imported Terrain Model will extend past the selected Shape element.
7	In the Dialogue Box, CHECK the **Clip** box. If the selected **Shape** element is non-rectangular, then the imported Terrain Model is clipped around the boundary of the Shape. ***IMPORTANT:*** The **Clip** box must to be CHECKED to reveal the elevation source information that is used to create the imported Terrain Model. ALWAYS keep this box CHECKED.
8	In the Dialogue Box, set the **Resolution** if desired. If the Resolution is INCREASED, then the **Estimated Point Count** will DECREASE. ***BEST PRACTICE:*** Keep this box UNCHECKED and a default Resolution is calculated when the Shape element is selected. ***TIP:*** In general, the default Resolution should ONLY be changed for quality maps (3.44m Pixel Size accuracy or less). Increasing the Resolution will smooth contours because fewer Points will contribute to the Terrain Model.
9	In the Dialogue Box, assign the imported Terrain Model an appropriate **Feature Definition** and **Name**.
10	*Prompt: Estimated Point Count = X* – The Estimated Point Count corresponds with the **Resolution** and accuracy of the elevation source data. The **Estimated Point Count** signifies the amount of data points that will be used to create the imported Terrain Model. Left-Click anywhere in the *View* window to advance to the next prompt and reveal the Source Information



After step 10, the source provider and accuracy of the elevation data is shown in the Floating Dialogue Box.

WARNING: If the **Clip** box is UNCHECKED, then the source information is NOT shown.

10	Hold down the **Shift** key and hover the mouse cursor over the Shape to reveal the Source and Accuracy of the Elevation Data.



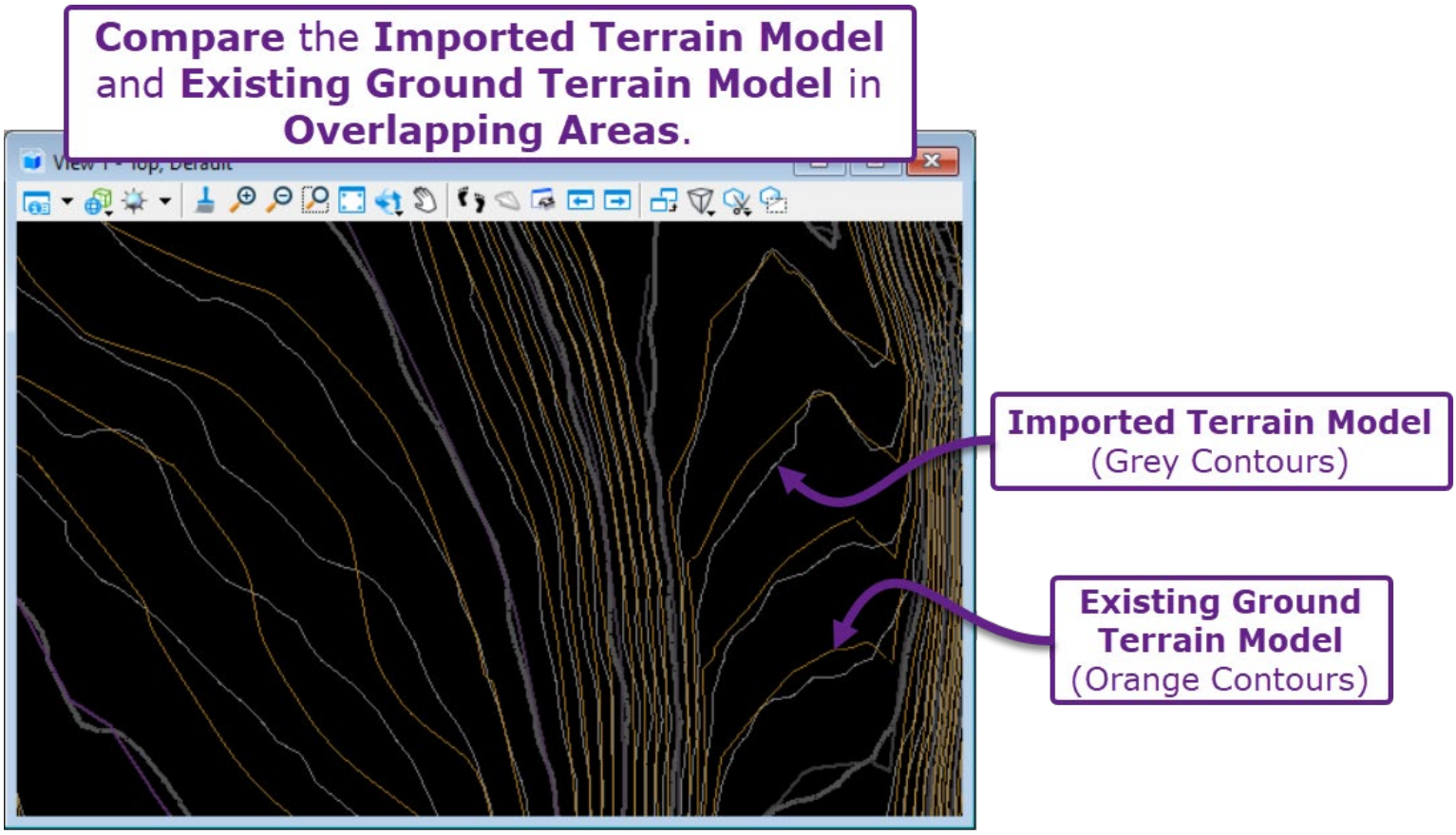
Source Provider and Map: This information designates the providing agency and map used for the elevation data.

Percentage: This value represents the amount of the Shape area within the Source Map. If this value is less than 100%, then portions of the Shape area will NOT be included in the imported Terrain Model. Ideally, this value should be 100.0%

Accuracy: The first value shown represents the **Pixel Size** (in meter units) for the Source Map. In the example above, the Pixel Size is 1.00 meters. Pixel Size is discussed at the beginning of this section.

BEST PRACTICE: Examine overlapping areas between the imported Terrain Model and the Existing Ground Terrain Model. Assess the contour alignment between the two Terrain Models. Pay close attention to the contour alignment in critical areas, such as the roadway.

If the contours generally agree, then proceed to merge the imported Terrain Model into the Existing Ground Terrain Model. See *5C.3 Combine Imported Terrain Model with Existing Ground Terrain Model*.



5C.2 Acquire and Process LiDAR Data from NOAA or USGS

Survey will acquire and incorporate LiDAR data into the Terrain Model when available. Necessary datum conversions will be performed by Survey staff.

5C.2.a LiDAR File Type Formats

Generally, LiDAR data is provided in either **Point Cloud** or **DEM (Digital Elevation Model)** file type format.

Point Clouds: Point Cloud data comes in ".las" or ".laz" file types. The .laz file type is simply a compressed .las. The .las file type is too bulky for quick transfer/download, so the provider compresses the .las file into a .laz file. However, both ".las" and ".laz" file types can be imported into ORD.

Compared to DEMs, Point Clouds require additionally processing in the ORD software. In the ORD Software, the Point Cloud must be processed to filter out points that correspond with non-ground features (i.e., vegetation, buildings, water surface).

DEM (Digital Elevation Model): A DEM is a raster image. DEMs originate from Point Cloud data. Point Clouds are processed into a DEM raster image to significantly reduce the file size. DEMs are the final, processed product of a Point Cloud. The file types for DEMs are ".dem" or ".tif" (commonly referred to as a GeoTIFF).

DEMS are considered equally accurate to Point Clouds.

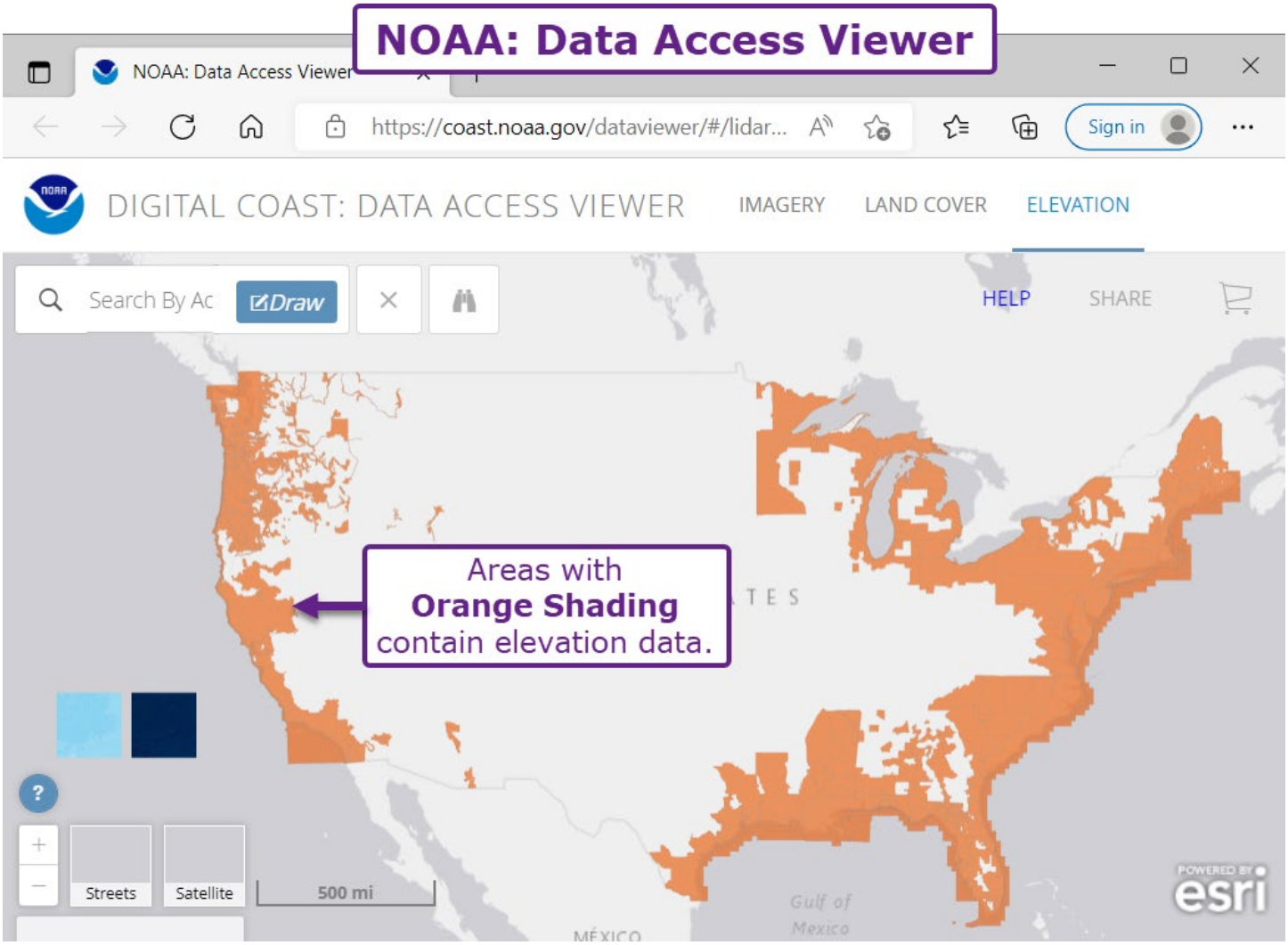
DEM files do NOT require processing in the ORD software. DEMs can be directly imported into ORD as a Terrain Model.

> ***NOTE:*** The **USGS** provides both Point Cloud and DEM data. However, the USGS website does NOT provide a service for projecting **DEM** files into the project Coordinate System or clipping the DEM. **Point Cloud** data should be acquired from the USGS website because DEMs acquired will be unprocessed.

5C.2.b Import LiDAR data from NOAA

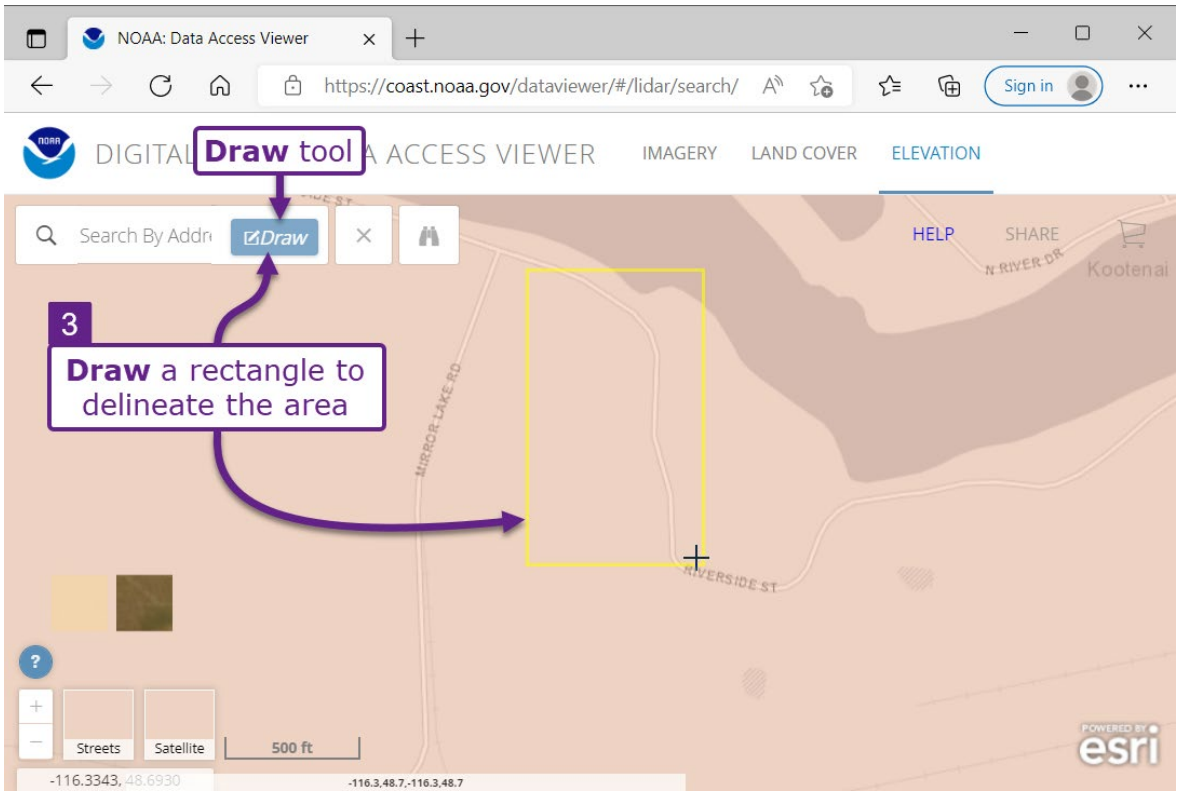
The National Oceanic and Atmospheric Association (NOAA) provides elevation data in Point Cloud (.las or .laz) and DEM format (.tiff or .dem) formats. Most LiDAR data provided by NOAA is high quality. However, the nation-wide coverage is focused primarily in coastal areas.

1	Open the NOAA Data Access Viewer through the weblink below: https://coast.noaa.gov/dataviewer/#/lidar/search/ Elevation data is available in areas with orange shading.

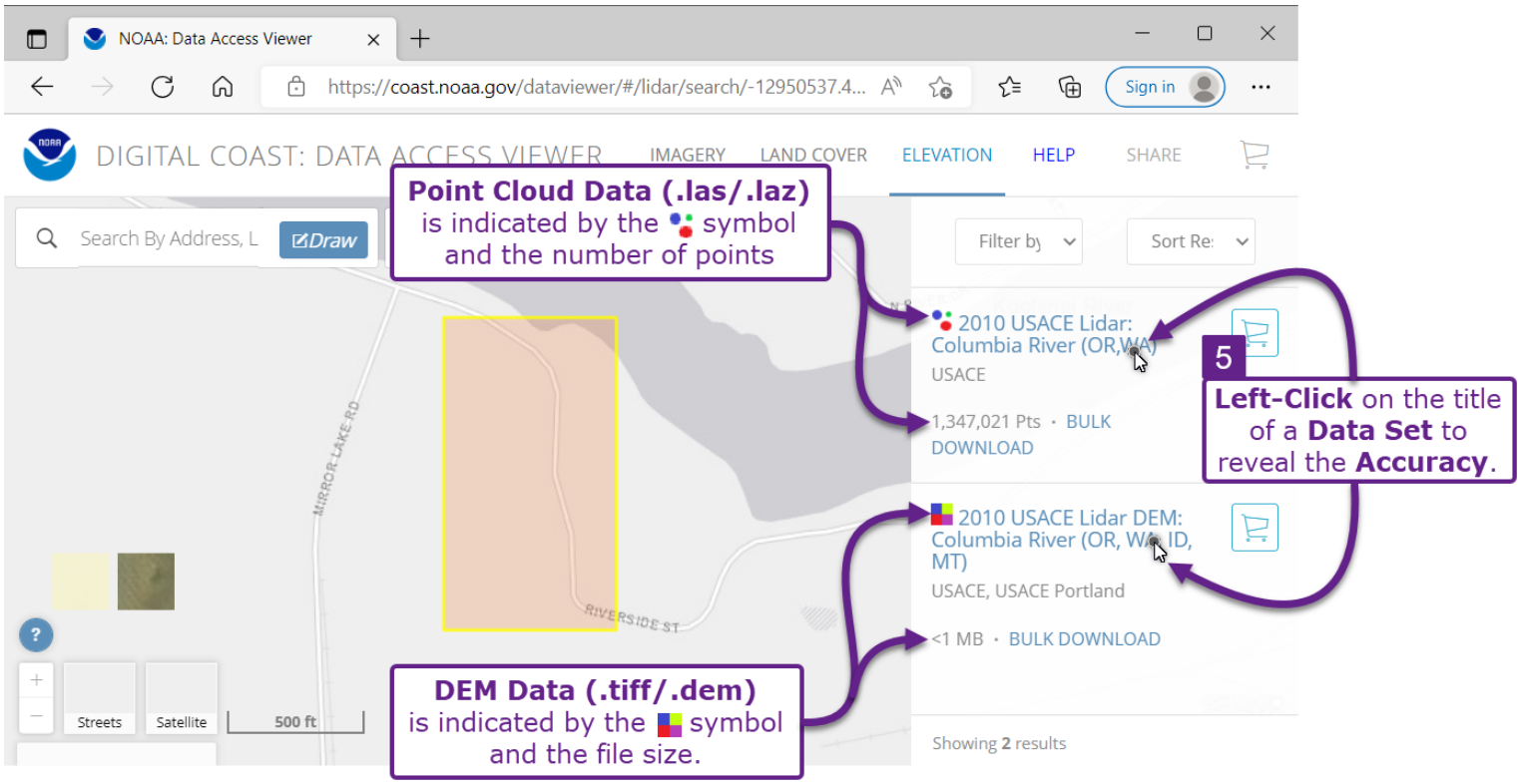


TIP: If the elevation data is NOT available for the desired area through NOAA, then try the *Topo Import* tool or acquiring LiDAR data from the USGS website. See *5C.1 Acquire LiDAR Data with the Topo Import tool* or *5C.2.c Import LiDAR data from the USGS*.

2	Locate and zoom-in on the desired area for elevation data acquisition.
3	Press the **Draw** button to create a rectangular shape. Left-Click and hold to draw the rectangle. The elevation data will be clipped to this area.



After the rectangle is drawn, the available data sets are shown on the right-side of the map.

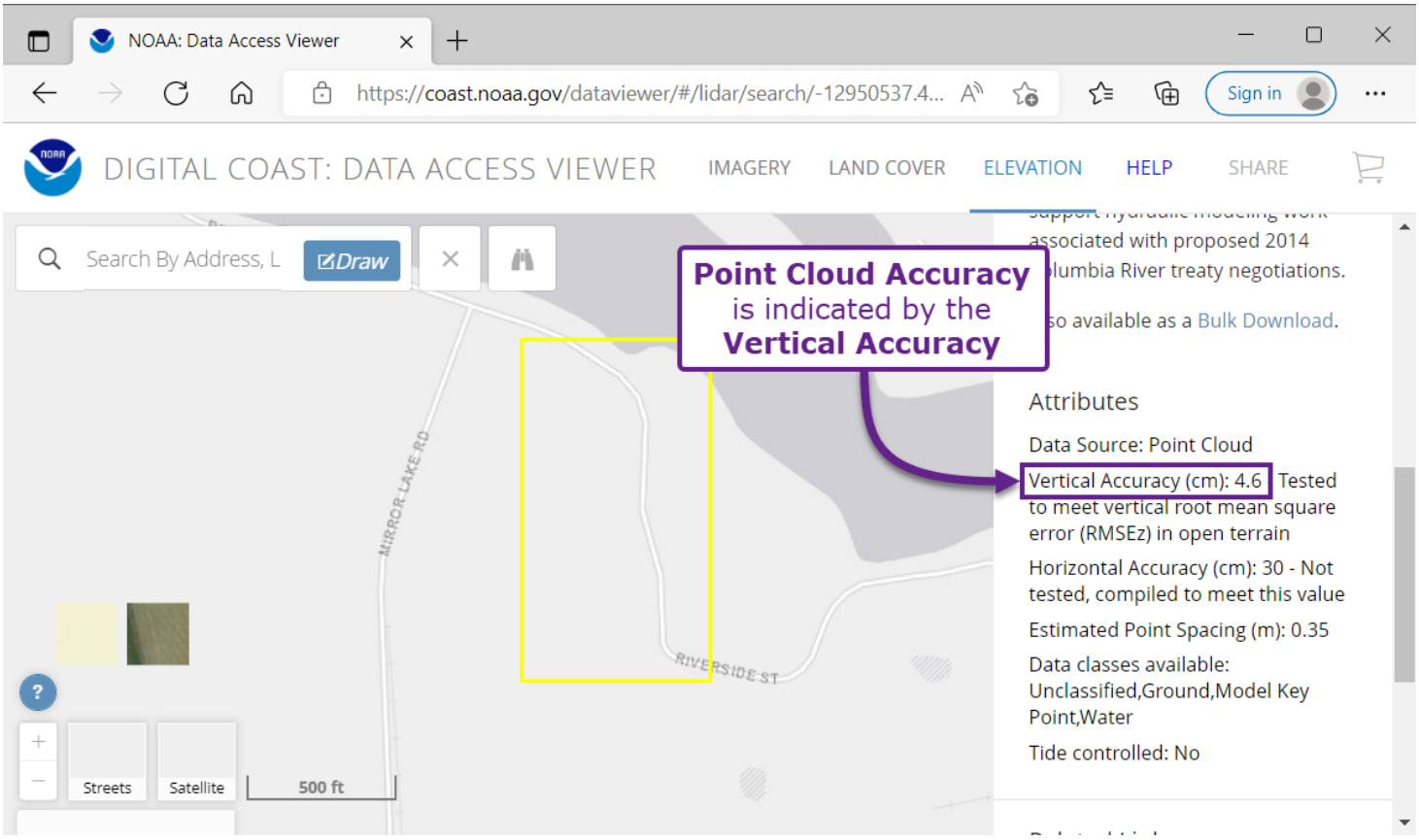


BEST PRACTICE: If both Point Cloud and DEM data are available, then use the DEM data. DEM use smaller file sizes and require very little processing for Terrain Model creation. Point Clouds require more processing within the ORD software. DEMs are derived from Point Clouds and are considered equally accurate. For more information on Point Clouds vs DEMs, see *5C.2.a LiDAR File Type Formats*.

5	Determine the accuracy of the Point Cloud or DEM data set by clicking on the title.

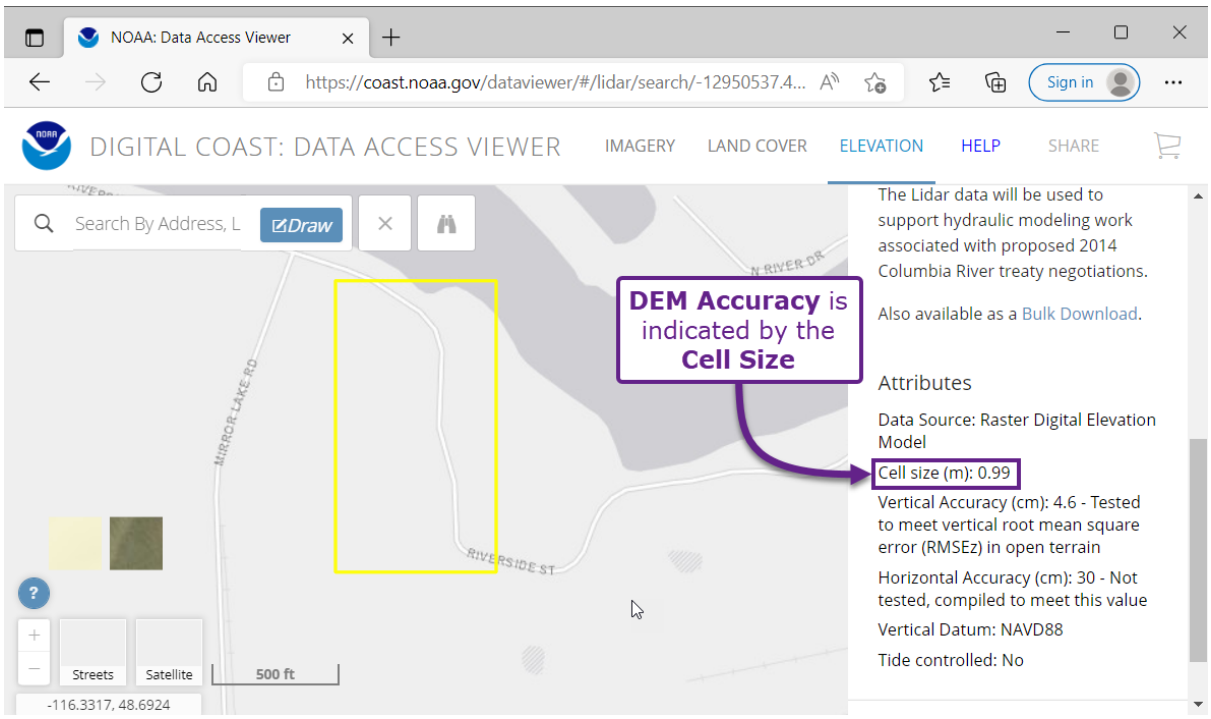
Point Cloud Accuracy: Click on a Point Cloud data set and scroll down to the **Attributes** information. The **Vertical Accuracy** denotes the overall accuracy of the Point Cloud.

TIP: 5 cm or less is considered excellent quality. Between 5-10 cm is good quality. Between 10-20 cm is adequate. Do NOT use Point Cloud data with Vertical Accuracy greater than 20 cm.

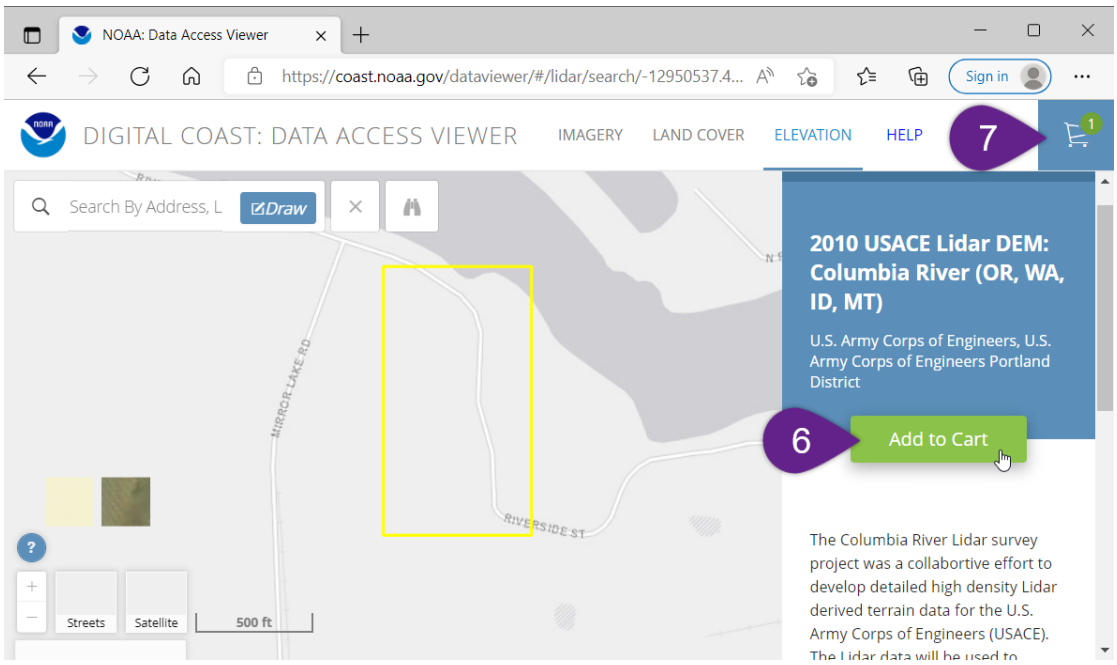


DEM Accuracy: Click on a DEM data set and scroll down to the **Attributes** information. The **Cell Sizes** denotes the overall accuracy of the DEM.

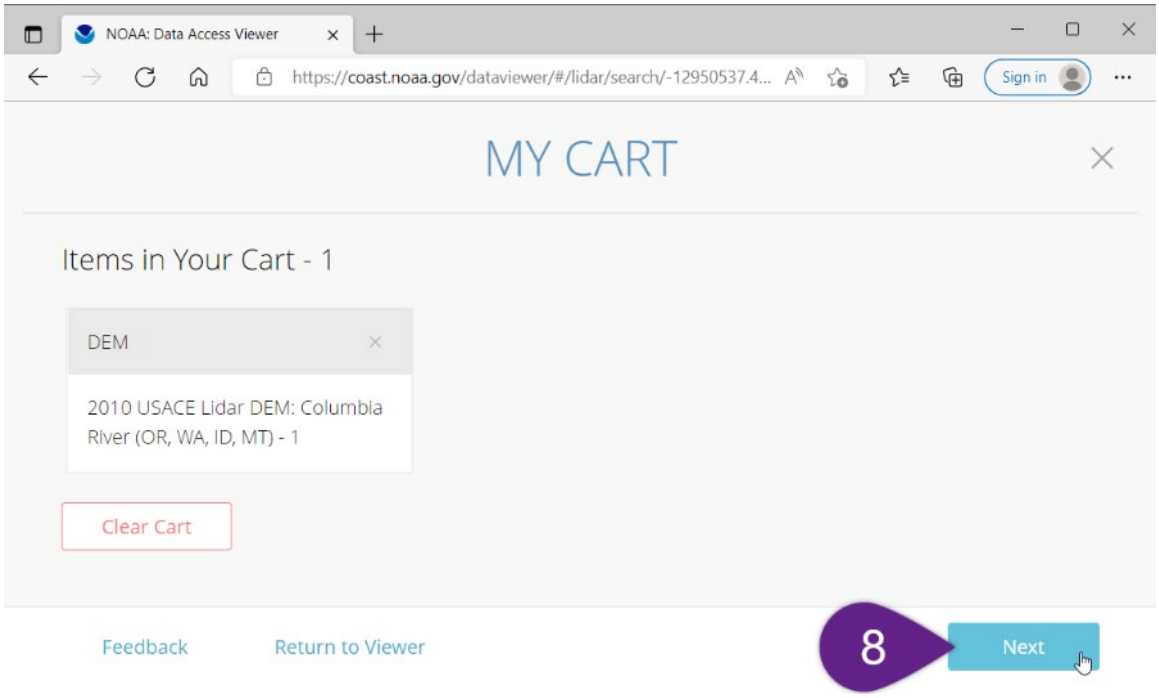
TIP: 1 meter or less is considered excellent quality. Between 1-3.44 meter is good quality. Do NOT use DEM data with a Cell Size greater than 5 meters.



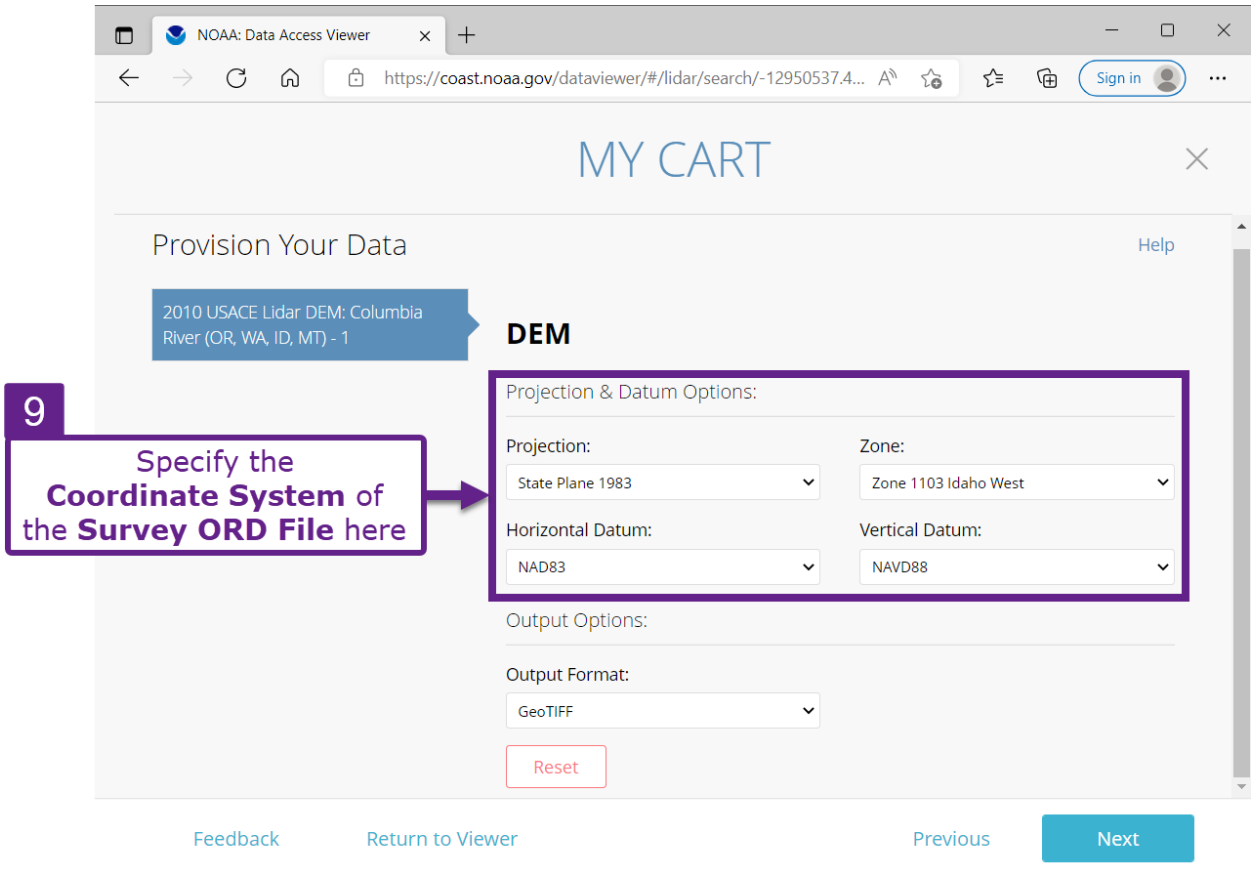
6	After the elevation data set has been accessed, scroll up and select **Add to Cart**. ***NOTE:*** This service does NOT charge money. However, it is necessary to add the data set to the cart to request processing.
7	Select the **Cart** symbol.



8	Select **Next**.

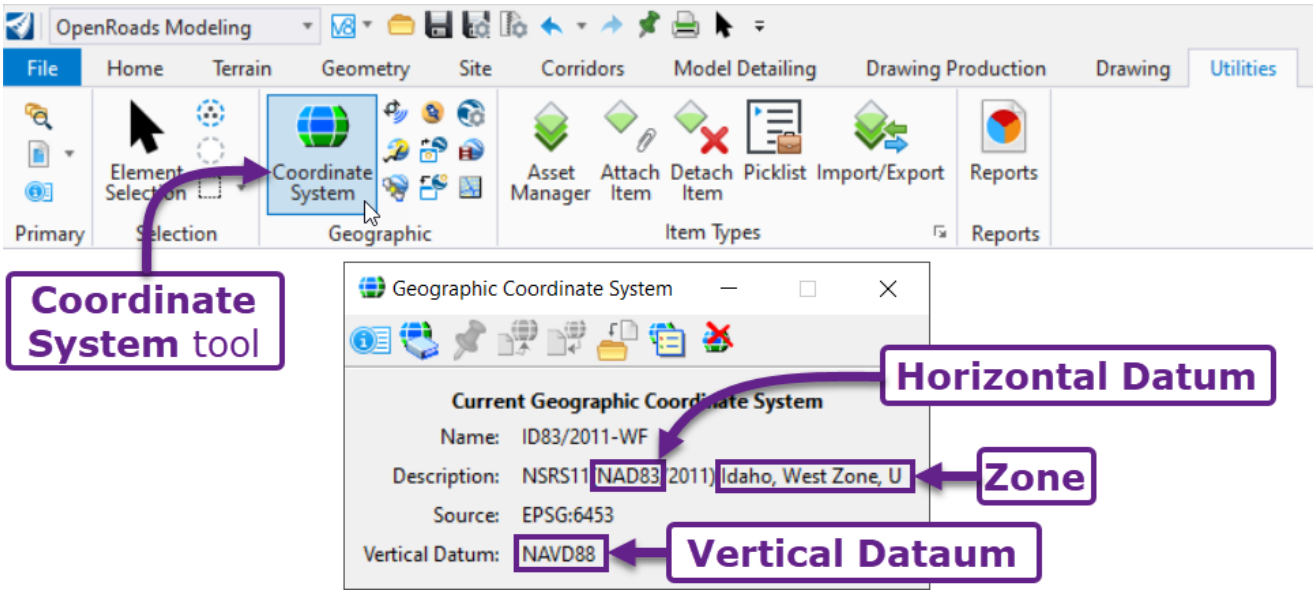


9	In this step, the **Coordinate System** and **Datums** for the data set to be projected into must be specified. Select the **Coordinate System** used in the Survey ORD File.



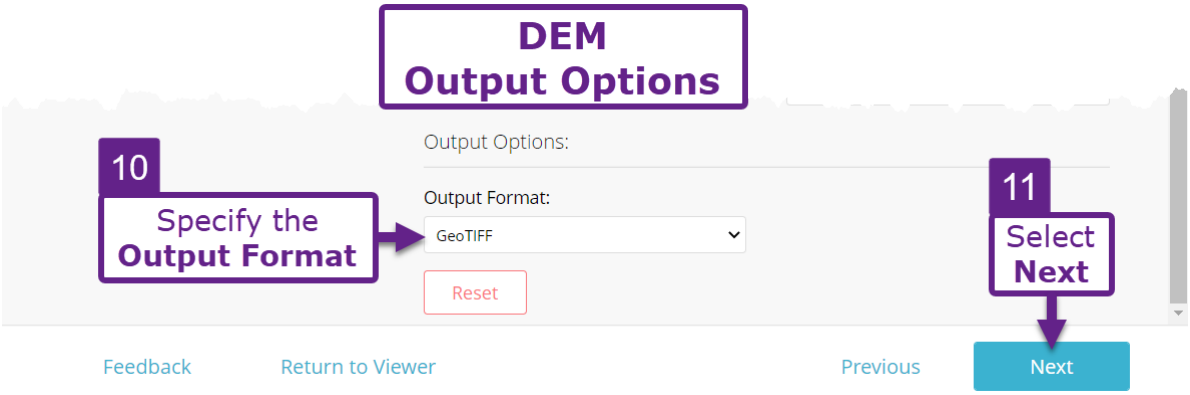
TIP: In the Survey ORD File, select the *Coordinate System* tool. This tool is found in the following location [***OpenRoads Modeling*** → ***Utilities*** → ***Geographic***]

TIP: For FLH projects, the **Projection** is commonly **State Plane 1983**. The **Horizontal Datum** is commonly **NAD 83**. The **Vertical Datum** is commonly **NAVD88**. The **Zone** can be determined with the *Coordinate System* tool.



10	In this step, the **Output Format** is specified.

DEM: If a DEM was selected, then the Output option should be set to **GeoTIFF**, **DEM**, or any other Raster format.



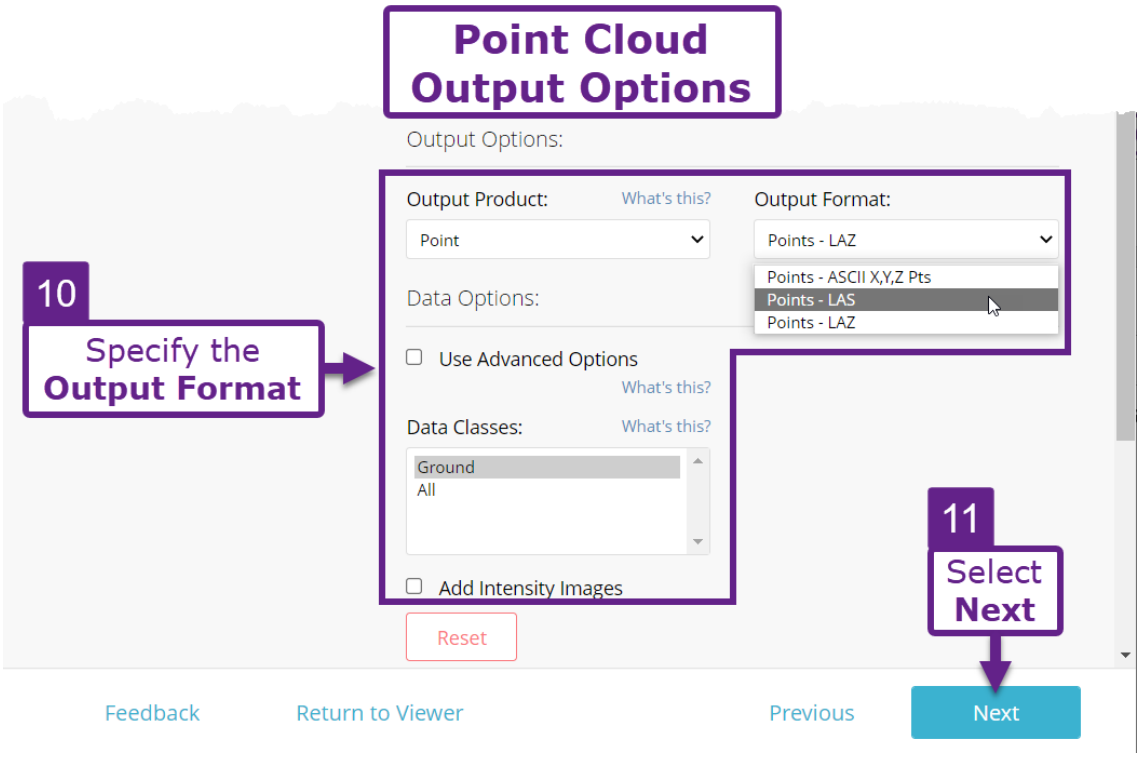
Point Cloud: If a Point Cloud was selected, then consider the following options:

Output Product: To obtain a LiDAR Point Cloud, select **Point**.

Output Format: Select either **Points – LAS** or **Points - LAZ**. Both options provide the same data set. However, the **LAZ** option is compressed and has a smaller file size. The **LAS** option is uncompressed and has a larger file size, but requires less processing in the ORD Software. The **LAZ** option should be used for large areas.

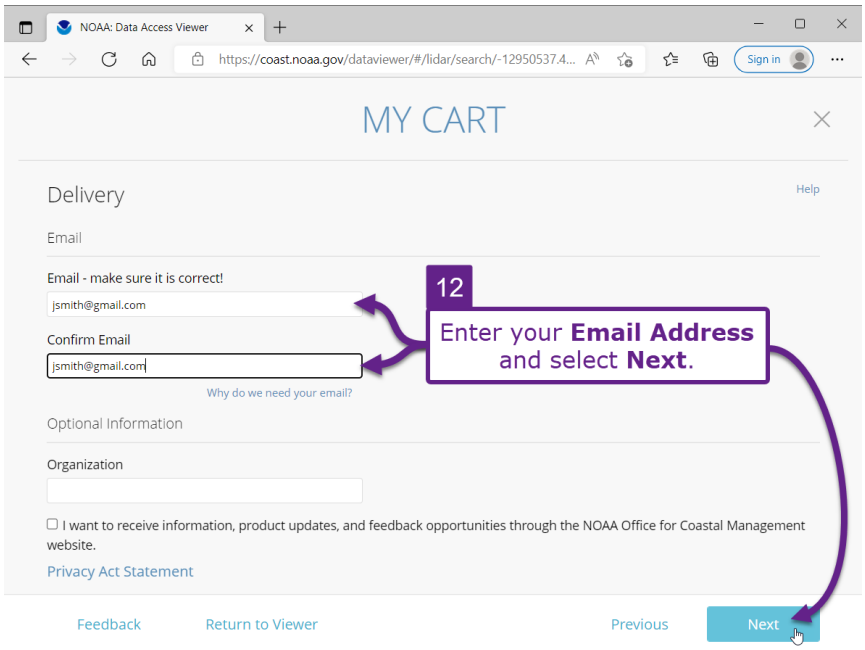
Data Classes: This option is used to specify which types of Points are included in the data set. Typically, only the **Ground** points are required to create a Terrain Model. The **All** option includes points that correspond with extraneous features (i.e., vegetation, buildings, water surface). If the **All** option is selected, extraneous points can be filtered out in ORD.

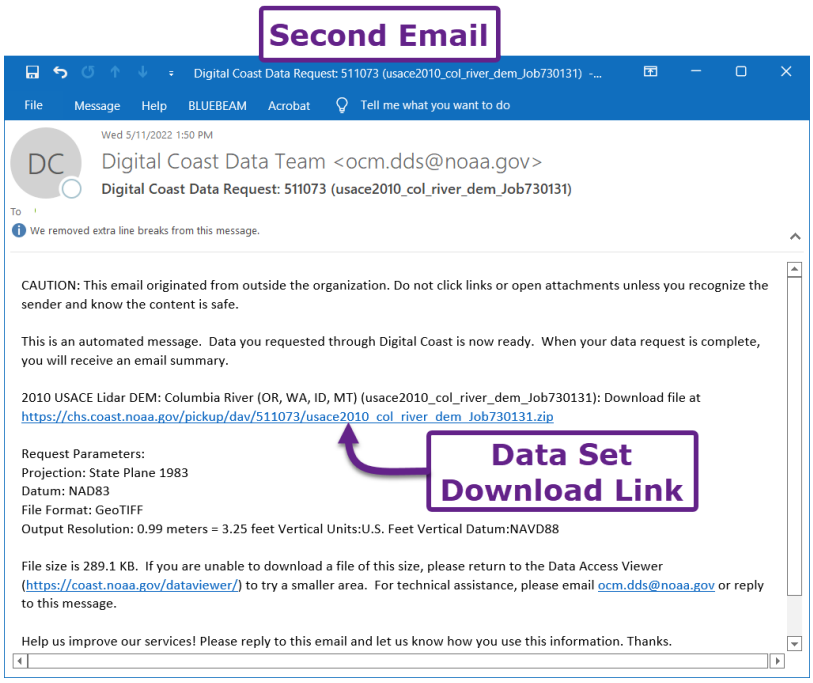
TIP: Select the **Ground** option for streamlined processing in ORD.



12	Enter your **Email Address** and select **Next**. ***NOTE:*** The data set is clipped, projected, and processed by an automated service. The data set will be emailed in approximately 5 minutes. There will be 3 emails sent after the data processing request is submitted. The second email will contain the download link for the data set (as shown below). ***TIP:*** If a **DEM** was selected, then it will be packaged it a .ZIP file. Unzip this file before importing into the ORD Software.

Creating a Terrain Model from a DEM is shown in *5C.2.d Create the Terrain Model from a DEM file*.
Creating a Terrain Model from a Point Cloud is shown in *5C.2.e Process the LAS or LAZ File and Create a Terrain Model*.



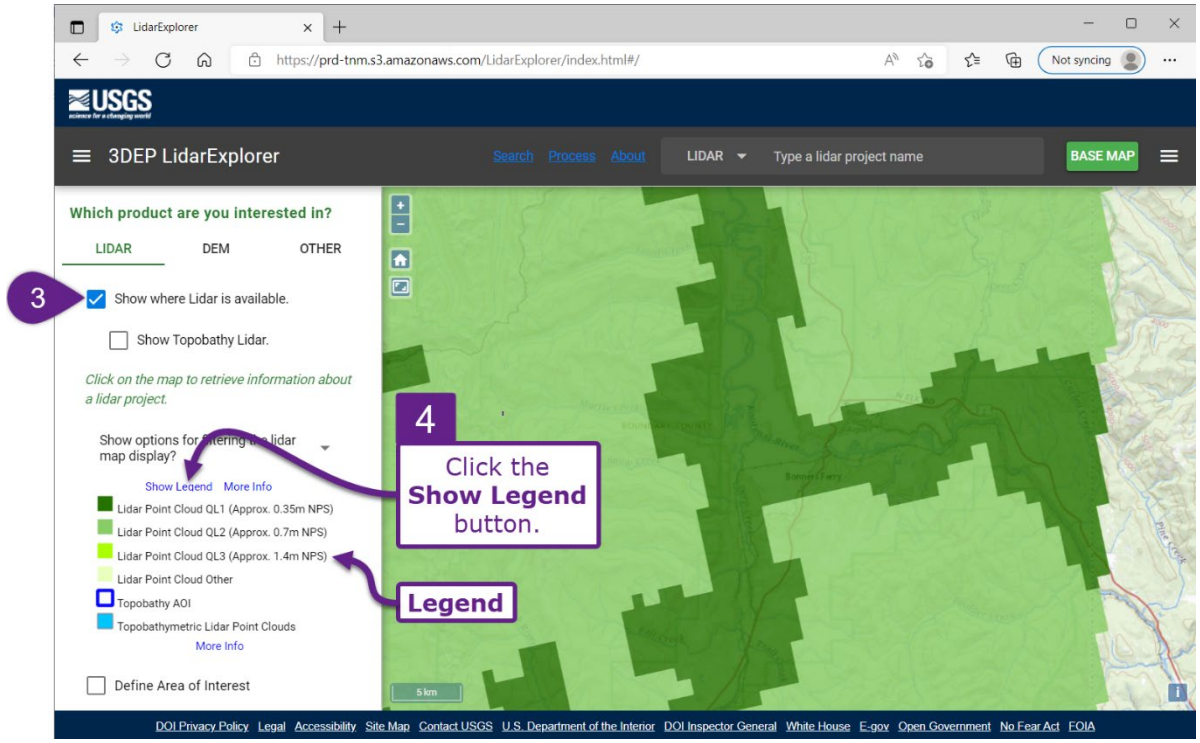


5C.2.c Import LiDAR data from USGS

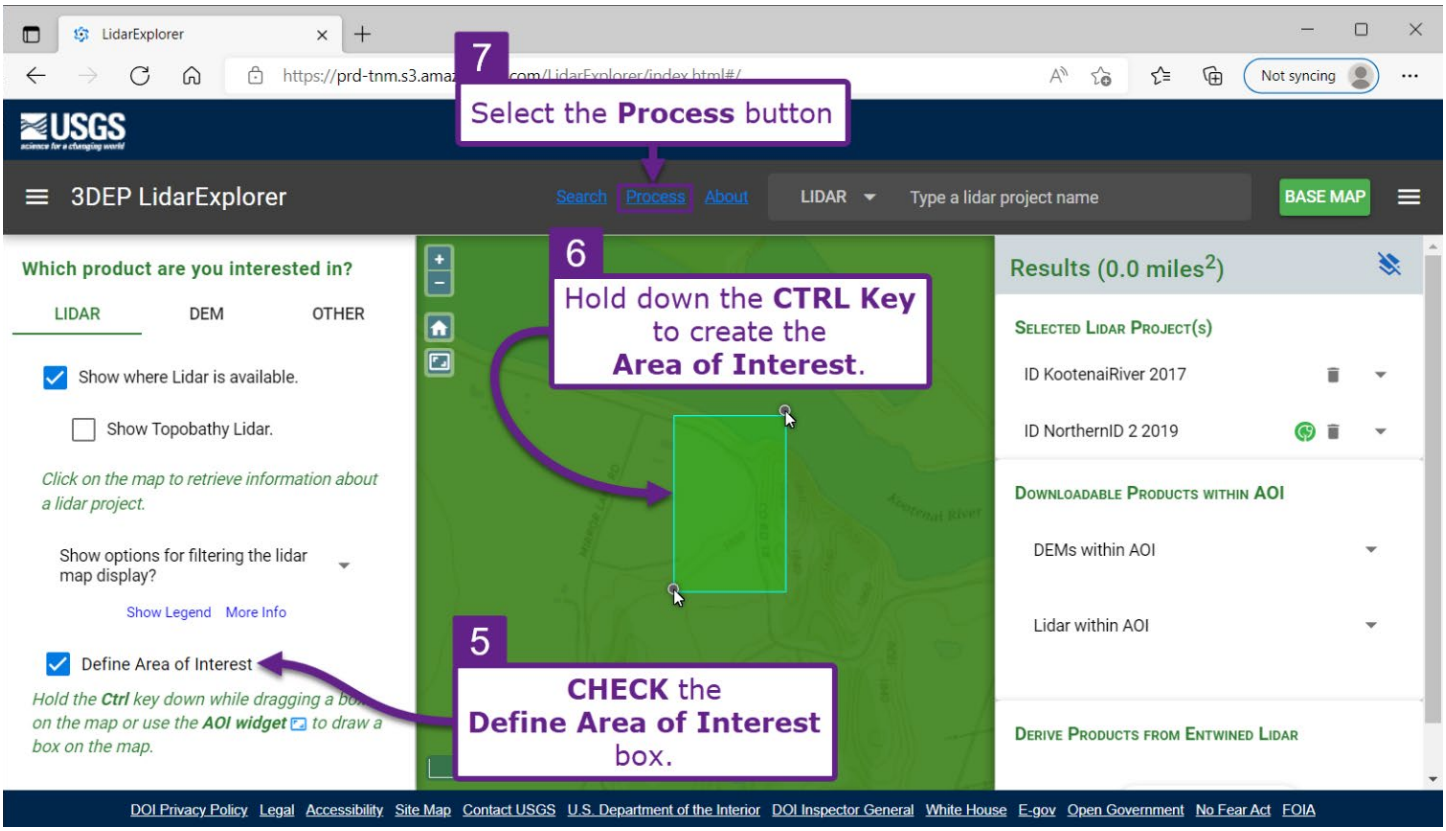
In this workflow, Point Cloud (.las or .laz) data is acquired from the US Geological Survey (USGS) Lidar Explorer map. The USGS website provides an automated service for clipping and processing the Point Cloud data to the project Coordinate System.

WARNING: DEM data can be acquired from the USGS LiDAR Explorer Map. However, the USGS website does NOT provide an automated service for processing the DEM data to the project Coordinate System. If the DEM is NOT processed to the project Coordinate System, then it will be placed in the wrong geographical location.

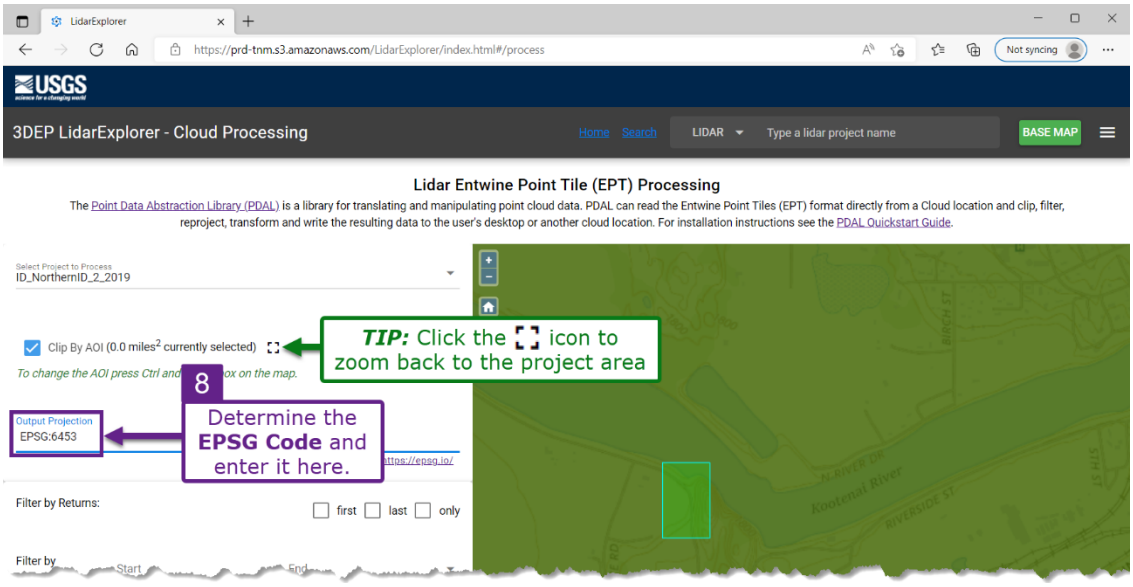
1	Open the USGS LidarExplorer map through the weblink below: https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/
2	Zoom to the project area.
3	In the menu on the left, CHECK the **Show where Lidar is available** box.
4	In the menu on the left, click on the **Show Legend** button. In the map, the shades of green correspond with the accuracy of the LiDAR data – which is shown in the legend. Hide Legend Lidar Point Cloud QL1 (Approx. 0.35m NPS) Lidar Point Cloud QL2 (Approx. 0.7m NPS) Lidar Point Cloud QL3 (Approx. 1.4m NPS) Lidar Point Cloud Other Topobathy AOI Topobathymetric Lidar Point Clouds QL 1 data (dark green) is the most accurate form of LiDAR data. QL2 data (light green) is typically acceptable accuracy, but should be analyzed in the ORD software for acceptance. QL3 data (lime green) is too poor of quality for engineering applications.

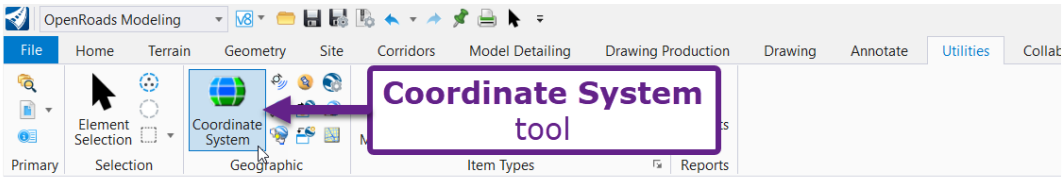


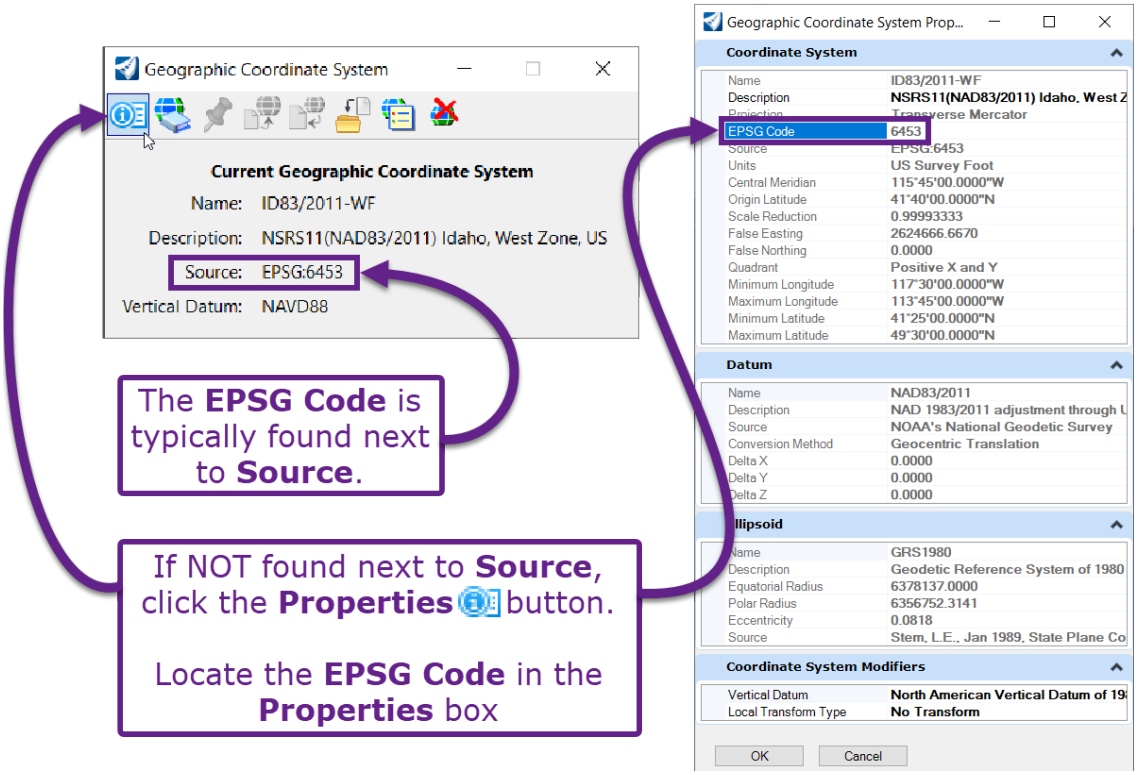
5	In the menu on the left, CHECK the **Define Area of Interest** box.
6	To define the area of interest: hold down the **CTRL key** and left-click/drag to create the rectangular box.
7	In the top banner, select the **Process** button.



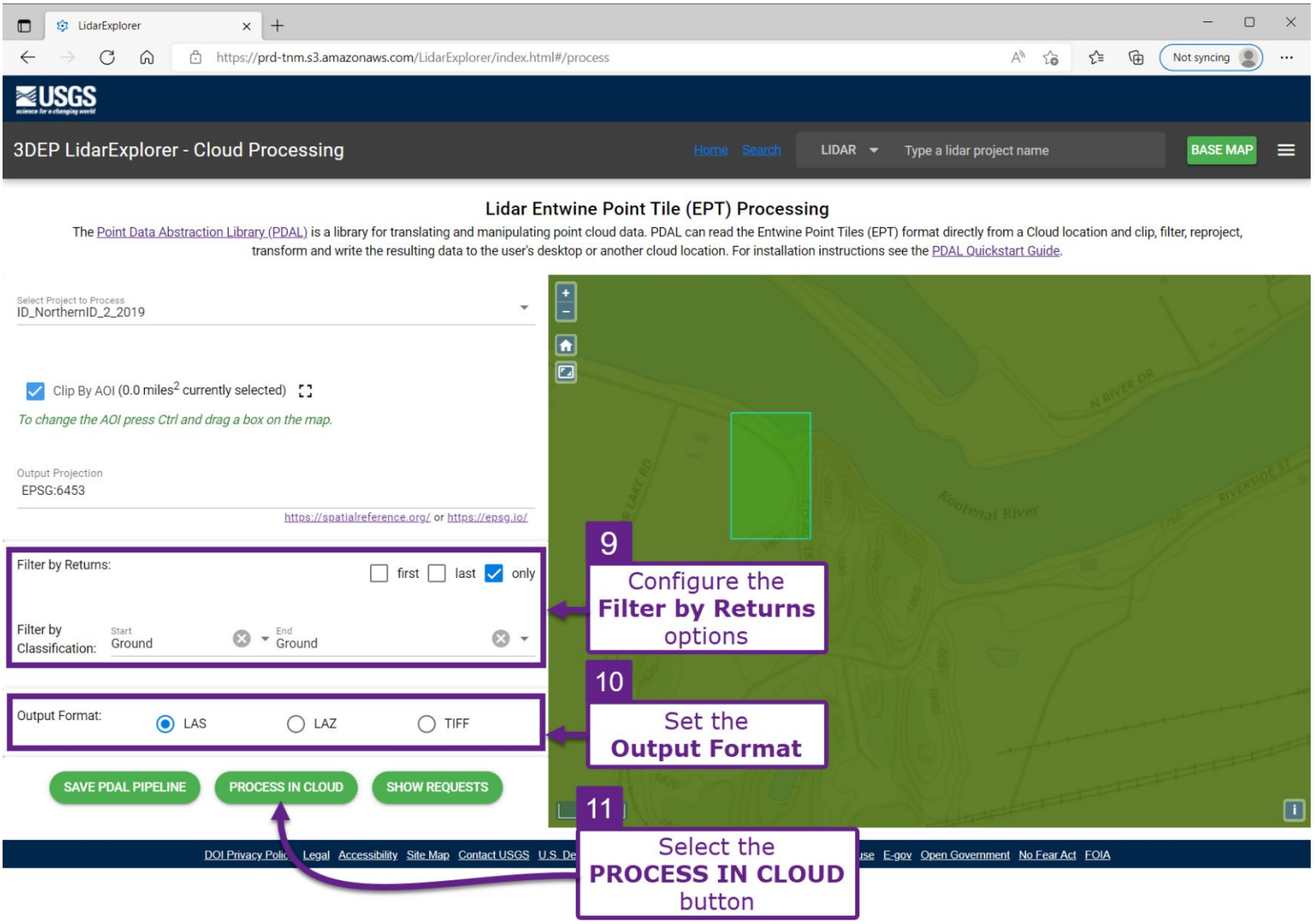
8	Determine the **EPSG Code** (Output Projection). Every standardized Coordinate System has an EPSG Code. The EPSG Code entered in the USGS website should correspond with the Coordinate System set in the Survey ORD File. To determine the EPSG Code, use the *Coordinate System* tool in the Survey ORD File. The EPSG Code is found next to **Source**. Alternatively, the EPSG Code is revealed by pushing the Properties button.





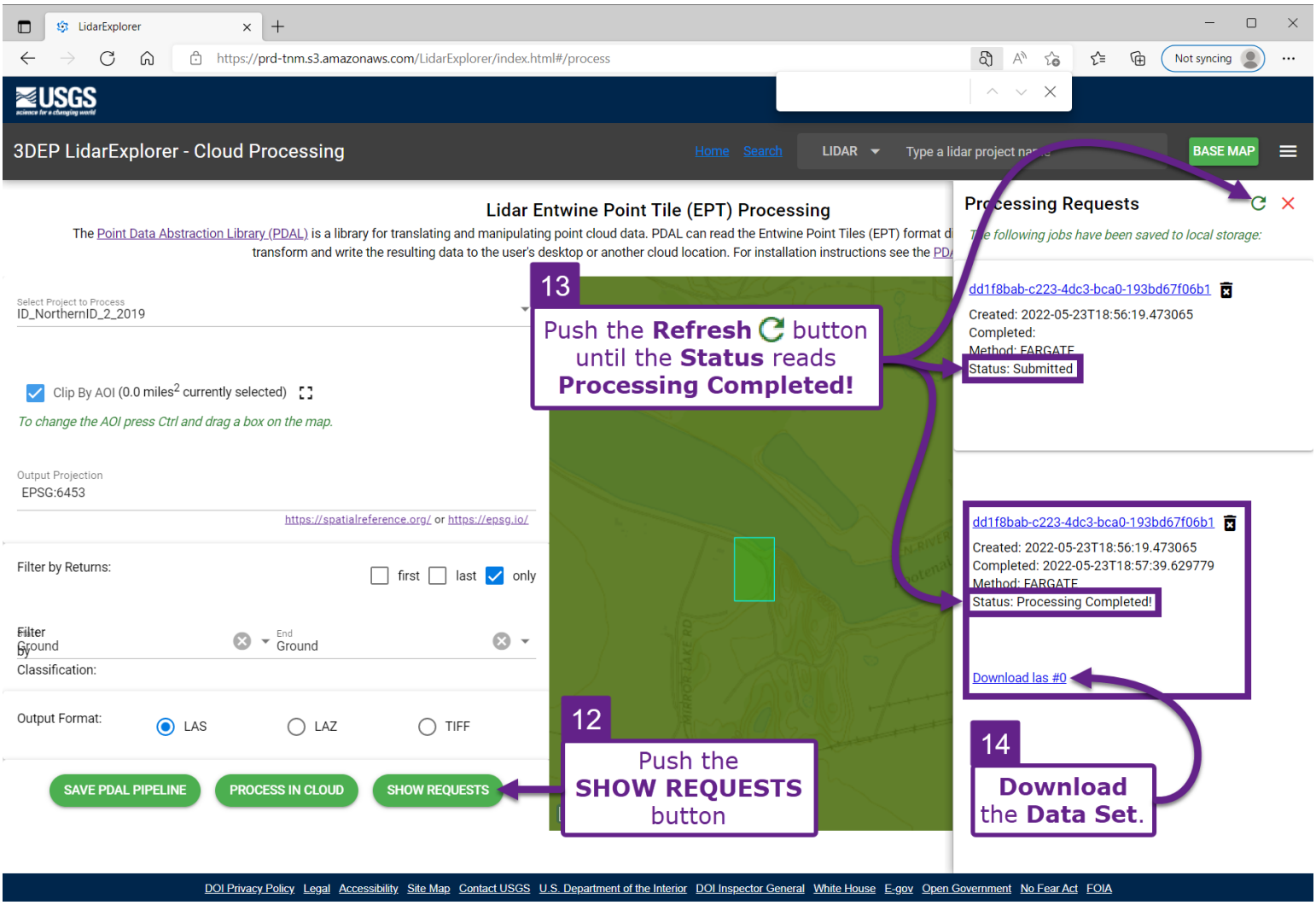


9	Configure the **Filter by Returns** option. If the default options are used, then ALL points in the Point Cloud are used. The data set will include extraneous points that correspond to vegetation, buildings, water surface, and other miscellaneous features. Miscellaneous points can be filtered out when the Point Cloud is imported into ORD. Ideally, the **only** box should be CHECKED, and both the **Start** and **End** set to **Ground**. If this configuration is used, then the data set will ONLY contain points that correspond with the ground elevation. This configuration requires less processing in ORD.
10	Specify the **Output Format**. Select either **LAS** or **LAZ**. The **LAS** option is an uncompressed Point Cloud. The download size will be larger, but requires less processing in ORD. The **LAZ** option is a compressed Point Cloud. Either option can be imported into ORD. ***WARNING:*** Do NOT select **TIFF**. The automatic processing service will attempt to compile a DEM type file. However, the resulting TIFF file results in an error when importing into ORD.
11	Push the **PROCESS IN CLOUD** button.



12	Push the **SHOW REQUESTS** button. The **Processing Requests** menu will be shown on the right-side of the web window.
13	Push the **Refresh** button until the **Status** reads **Processing Completed!** ***NOTE:*** The processing time depends on the size of the selected area and quality of the LiDAR data.
14	Download the data set from the provided link.

Creating a Terrain Model from the Point Cloud file is shown in *5C.2.e Process the LAS or LAZ File and Create a Terrain Model*.



5C.2.d Create the Terrain Model from a DEM File

After a DEM has been acquired, it can be imported and converted into a Terrain Model in the ORD Software.

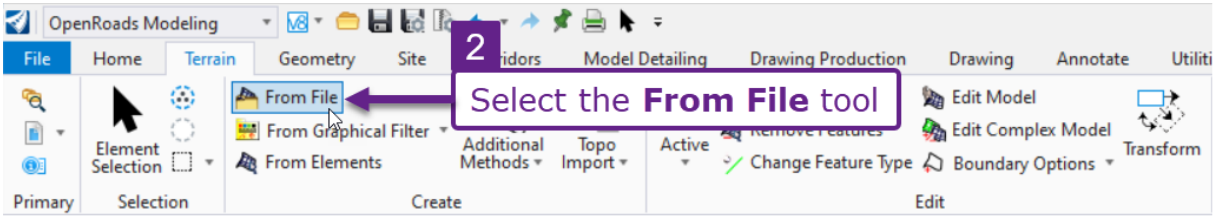
NOTE: DEMs come in a variety of raster file types. The most common file types are .tiff (GeoTIFF), .img, and .dem.

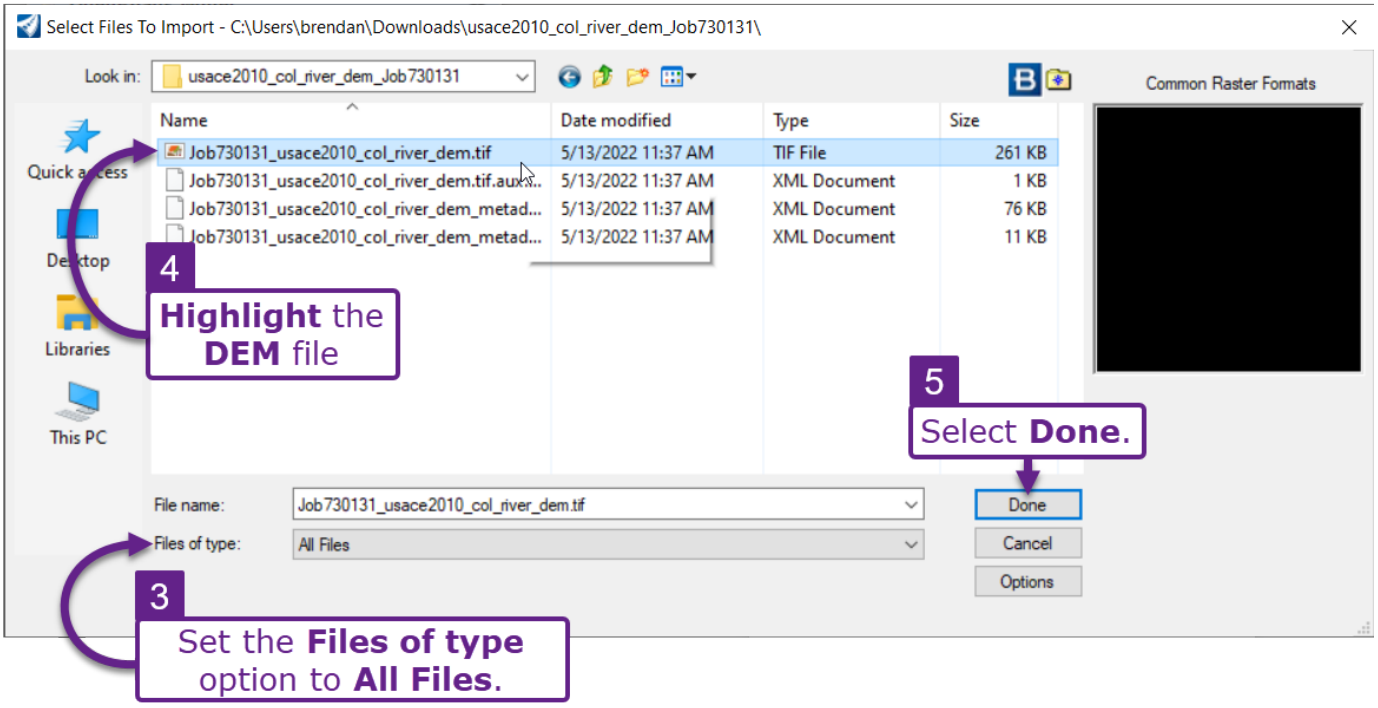
WARNING: Unzip the file folder that DEM was packaged in before importing into ORD.

1	Open the copied version of the Survey ORD File (see ***BEST PRACTICE*** below). OR Create a new ORD File using a 3D seed File. Set the Coordinate System for the new ORD File.

BEST PRACTICE: If the need is to fill in a Gap in the Existing Ground Terrain Model, then create a copy of the Survey ORD File and import the DEM file in the copied ORD File. If the results are acceptable after merging the two Terrain Models, then replace the Survey ORD File with the copied File.

2	From the Ribbon, select the *From File* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Create*** → ***From File***].
3	Ensure the **Files of Type:** option is set to **All Files**.
4	Locate and highlight the DEM file. See ***NOTE*** above.
5	Select **Done**.



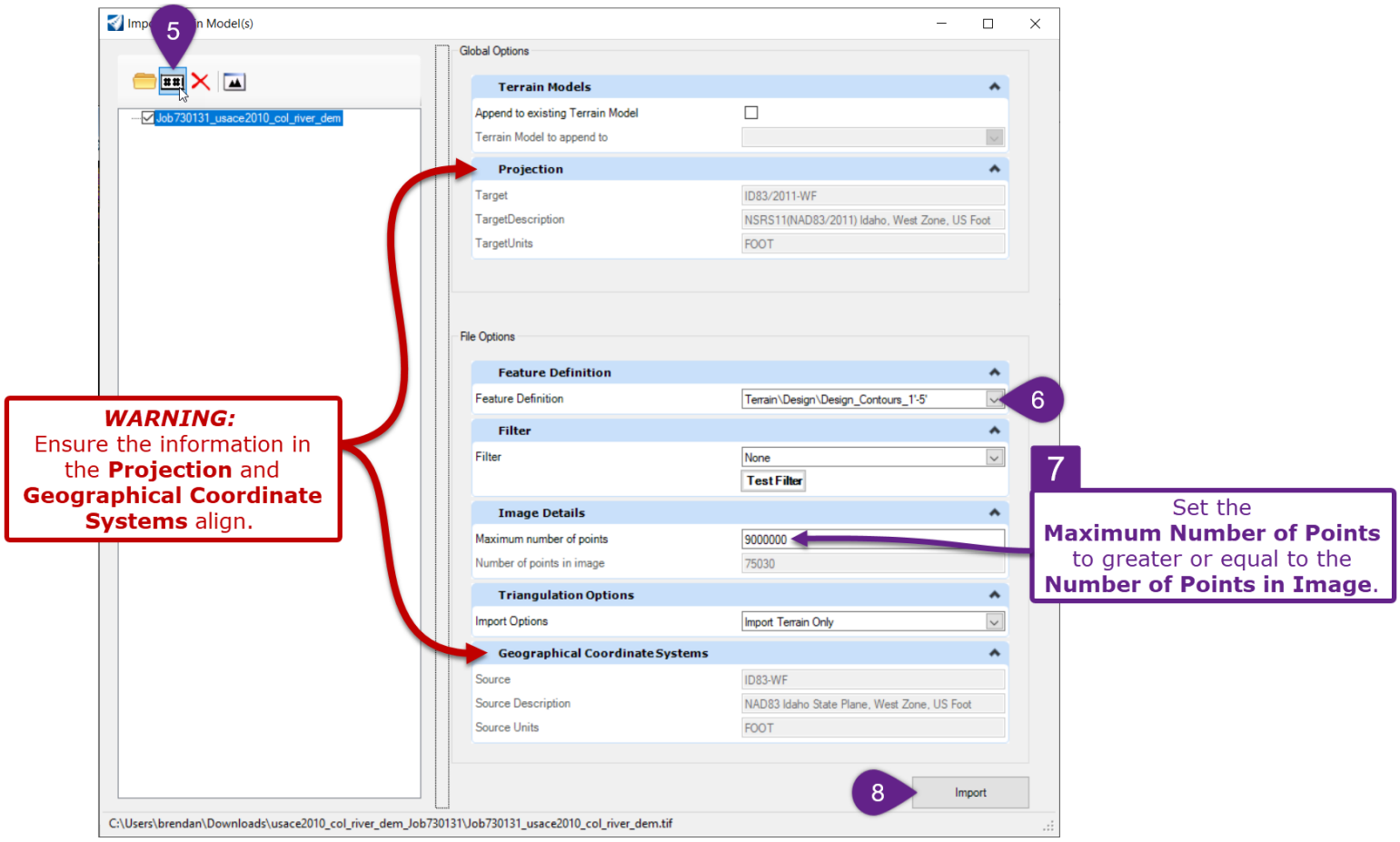


WARNING: Before importing the DEM as a Terrain Model, ensure that the **Projection** and **Geographical Coordinate System** information agree. In these two locations, there may be slight terminology discrepancies. However, this is acceptable if the information generally aligns.

> **Projection:** This information corresponds with the Coordinate System that is set in the current ORD File. If the current ORD File has a set Coordinate System, then these options will be greyed out. If NO Coordinate System is set, then one can be selected through the **Target** drop-down.
>
> **Geographical Coordinate System:** Typically, a DEM has an associated Coordinate System stored within the file – which is shown in this location.

The remaining import options should remain in their default configuration.

5	If desired, use the button to rename the Imported Terrain Model.
6	Set a **Feature Definition** for the Imported Terrain Model.
7	Ensure that the **Maximum Number of Points** exceeds the **Number of Points in Image**. If this value is less, then the DEM will be compressed and elevation data may be lost.
8	Select **Import** to create the Terrain Model.



After the **Import** button is pushed, the Imported Terrain Model is created. To combine the Imported Terrain Model with the Existing Ground Terrain Model, see *5C.3 Combine Imported Terrain Model with Existing Ground Terrain Model*.

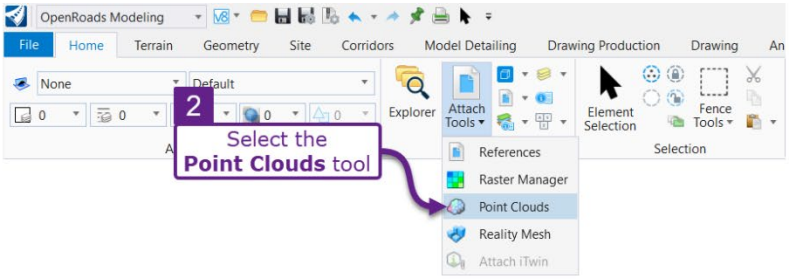
5C.2.e Process the LAS or LAZ File and Create a Terrain Model

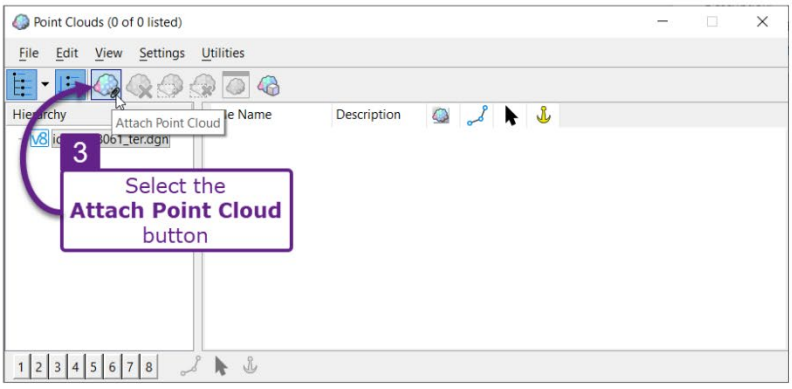
In this workflow, a Point Cloud file (.las or .laz) is imported, processed, and converted to a Terrain Model.

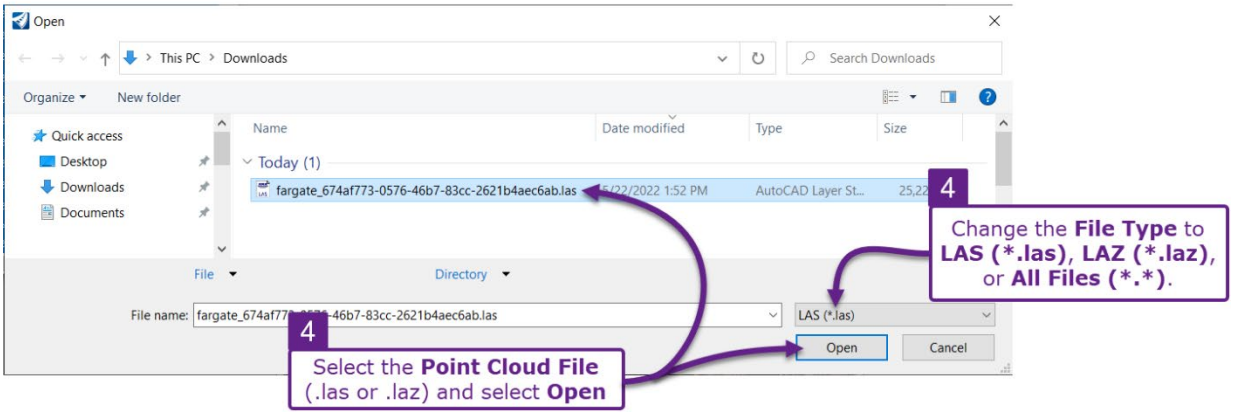
1	Open the copied version of the Survey ORD File (see ***BEST PRACTICE*** below). OR Create a new ORD File using a 3D seed File. Set the Coordinate System for the new ORD File.

BEST PRACTICE: If the need is to fill in a Gap in the Existing Ground Terrain Model, then create a copy of the Survey ORD File and import the Point Cloud file within the copied ORD File. If the results are acceptable after merging the two Terrain Models, then replace the Survey ORD File with the copied File.

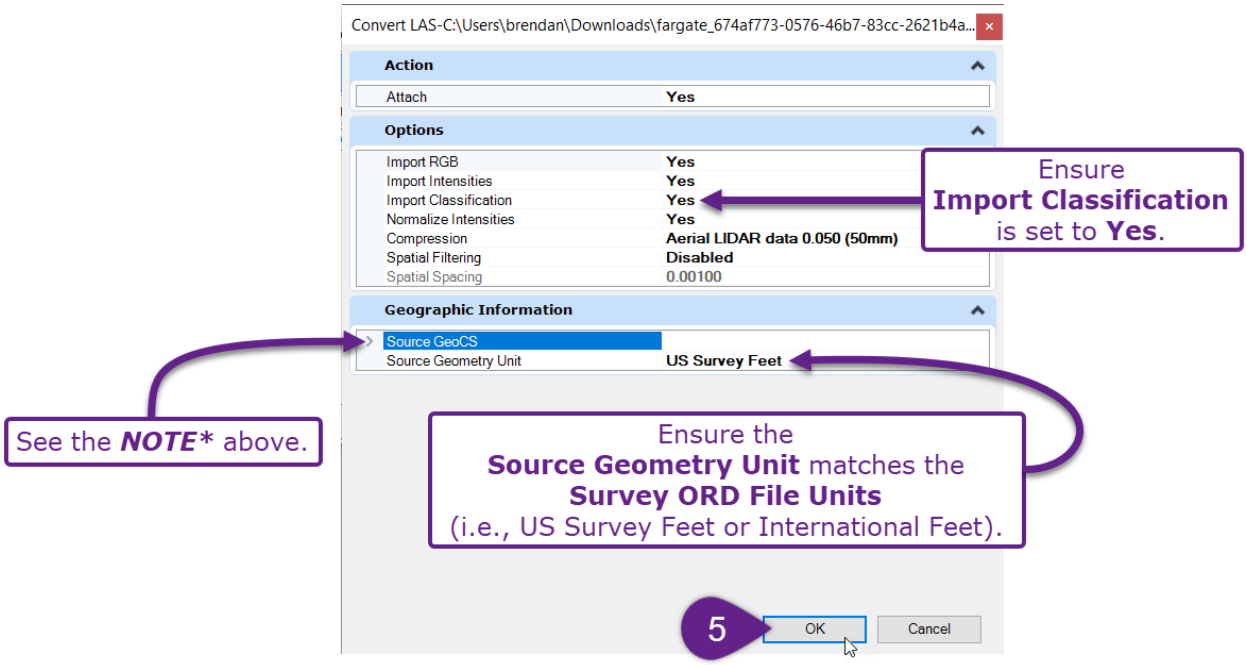
2	From the Ribbon, select the *Point Cloud* tool: [***OpenRoads Modeling*** → ***Home*** → ***Primary*** → ***Attach Tools***].
3	Select the **Attach Point Cloud** button.
4	When locating the **Point Cloud File** in the **Open** box, the **File Type** must be set to **LAS (*.las)**, **LAZ (*.laz)**, or **All Files (*.*)**. Select the **Point Cloud File** and select **Open**.



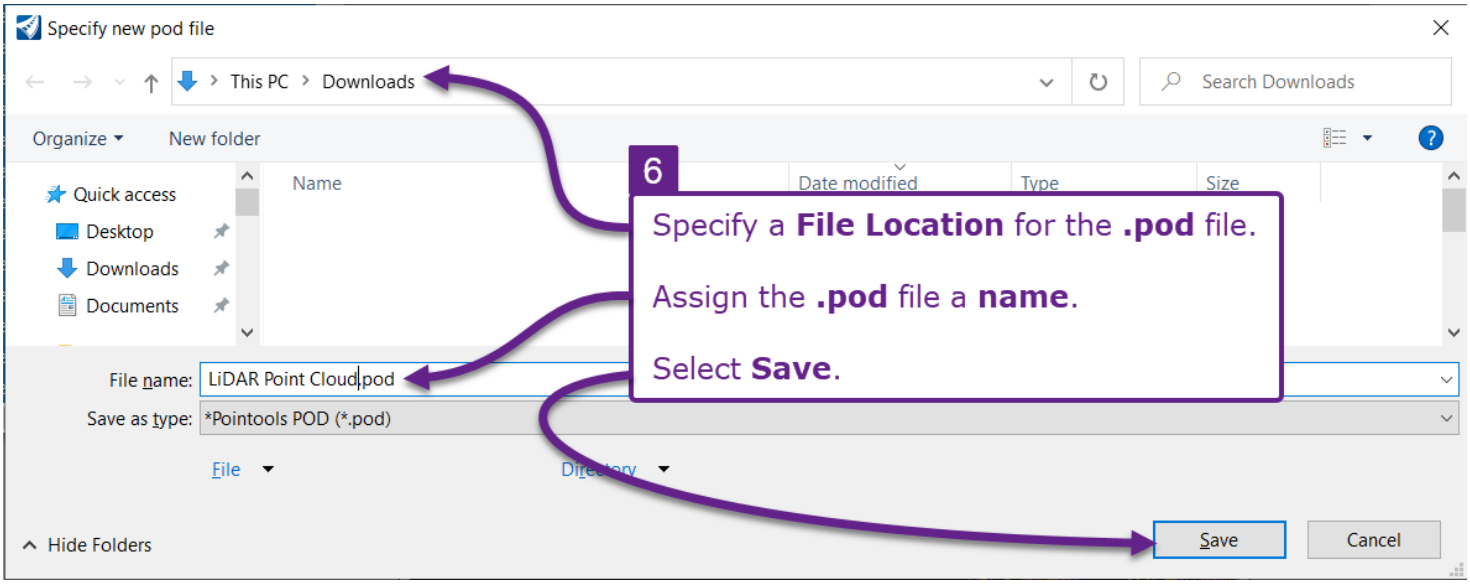




5	Typically, the default options are appropriate for importing the Point Cloud data. However, review the following options: **Import Classification:** Ensure this option is set to **Yes**. **Source Geometry Unit:** Ensure this option matches the units used in the Survey ORD File (i.e., US Survey Feet or International Feet). ***NOTE*:** The **Source GeoCS** is determined from the Coordinate System specified when the data was downloaded (i.e., EPSG Code). This setting CANNOT be edited. Select **OK**.

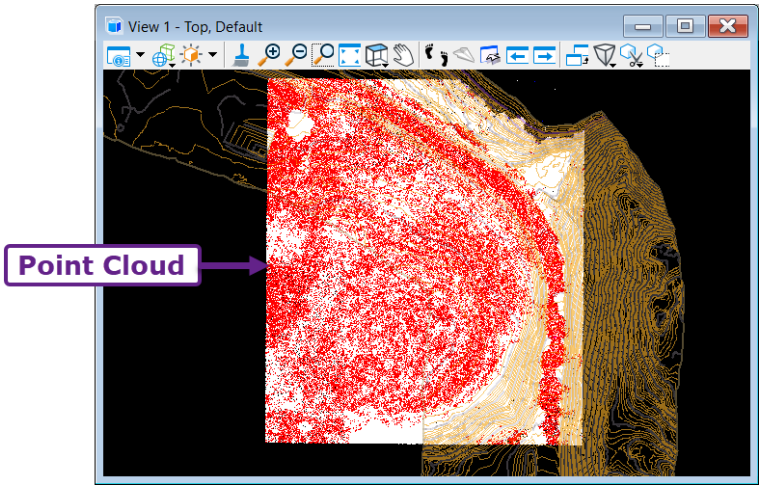


6	In this step, the .las or .laz is converted in to a **.pod** file. The **.pod** file is needed for the ORD Software to display the Point Cloud graphics.



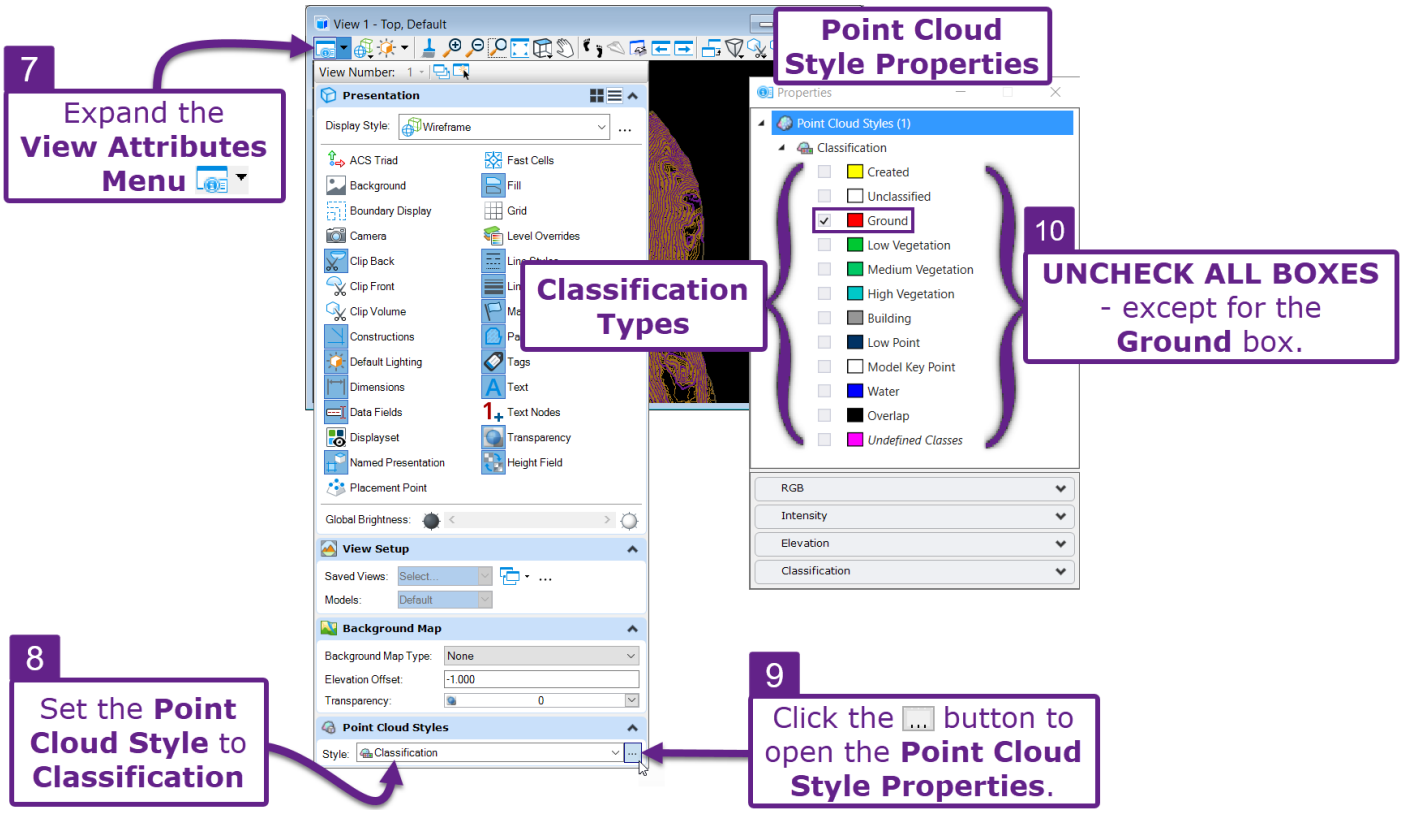
After step 6, the Point Cloud is shown in the ORD File. Points in the Point Cloud are color-coded according to Classification. Each Point is given a Classification based on the feature that it represents.

TIP: The Point Cloud area can be clipped to reduce the area. See *5C.2.e.i Clip the Point Cloud area*.



All points that DON'T represent the Ground must be toggled OFF before creating a Terrain Model. Through the **Point Cloud Style Properties** box, points can be toggled OFF by Classification:

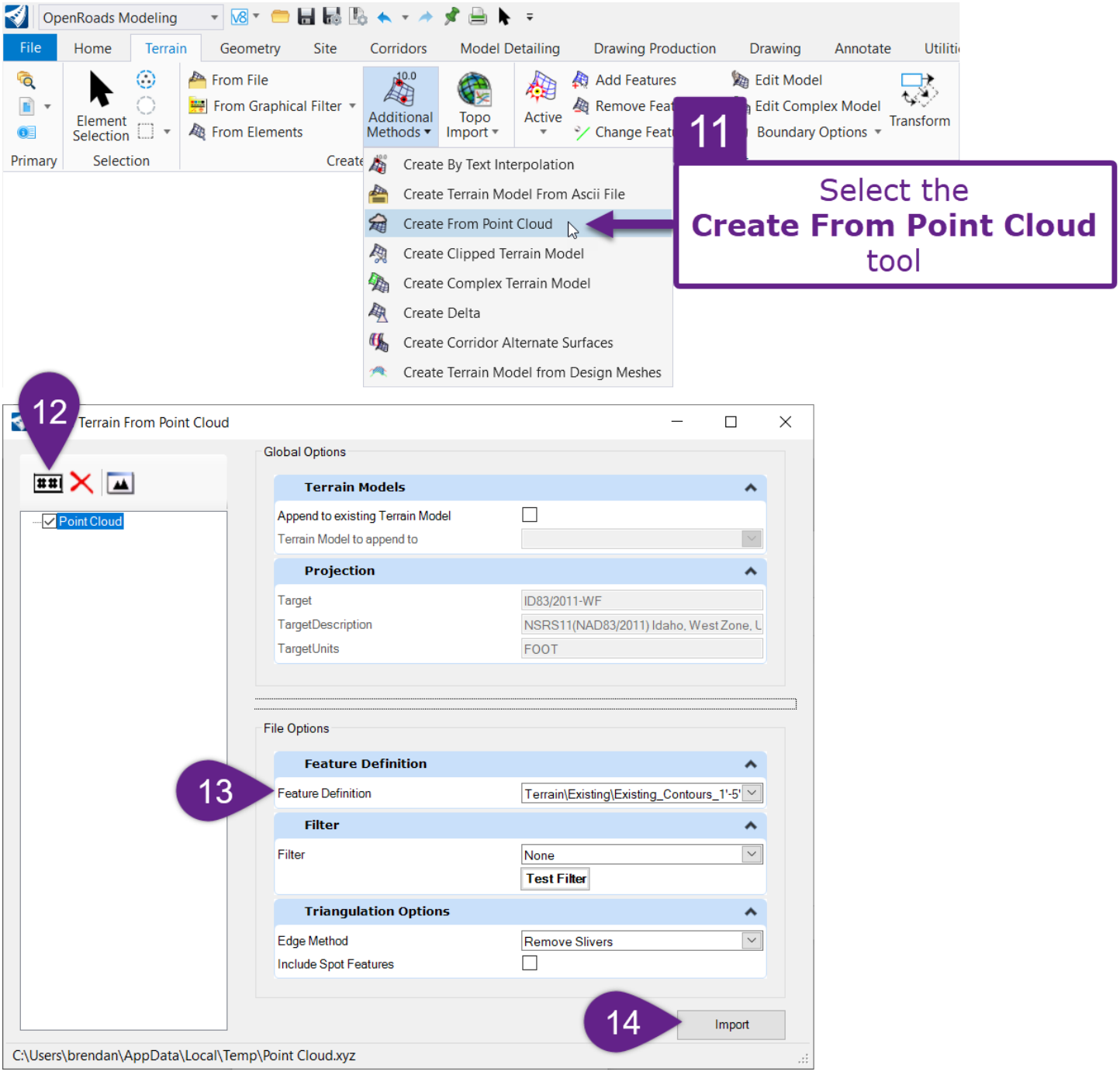
7	Open the **View Attributes Menu** .
8	At the bottom of the View Attributes Menu, set the **Point Cloud Style** to **Classification**.
9	Open the **Point Cloud Style Properties** box through the ... button.
10	In the Point Cloud Style Properties, UNCHECK all boxes – except for the **Ground** box.



With ONLY the Ground points displayed, the Terrain Model can be created. The *Create From Point Cloud* tool is used to convert the Point Cloud into a Terrain Model.

Use the default options to create the Terrain Model creation.

11	From the Ribbon, select the *Create From Point Cloud* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Create*** → ***Additional Methods***].
12	If desired, use the button to rename the Imported Terrain Model.
13	Set a **Feature Definition** for the Imported Terrain Model.
14	Select **Import**.

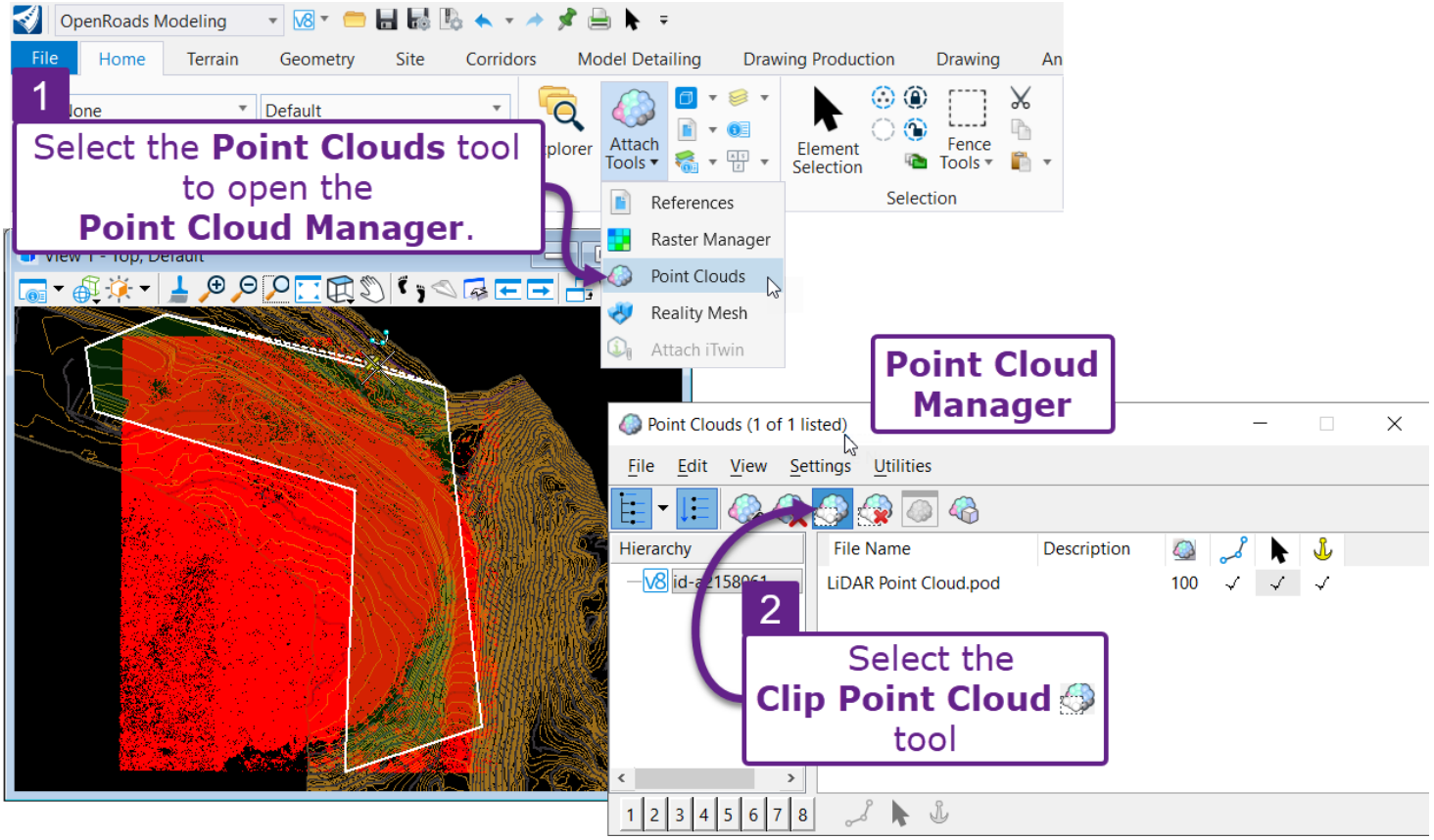


5C.2.e.i Clip the Point Cloud Area

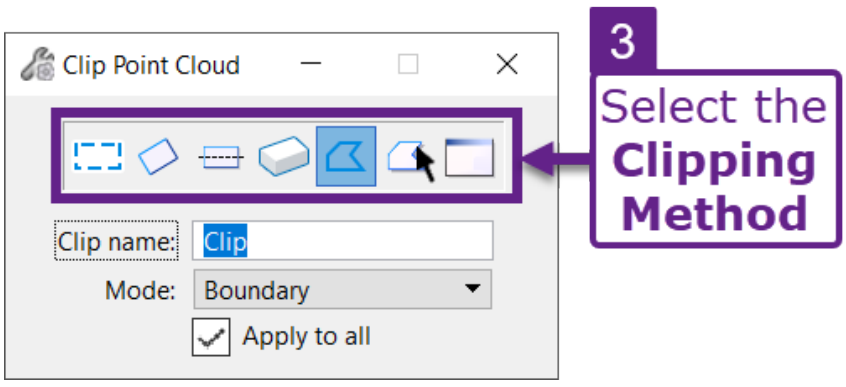
Using the *Clip Point Cloud* tool, the Point Cloud can be trimmed down to the desired area. This tool is found in the **Point Cloud Manager**.

TIP: Always leave some overlap between the Point Cloud and Existing Ground Terrain Model. Overlap is needed to merge the Point Cloud Terrain Model with the Existing Ground Terrain Model.

1	The **Point Cloud Manager** is opened with the *Point Clouds* tool. From the Ribbon, select the *Point Cloud* tool: [***OpenRoads Modeling*** → ***Home*** → ***Primary*** → ***Attach Tools***].
2	Select the *Clip Point Cloud*  tool.

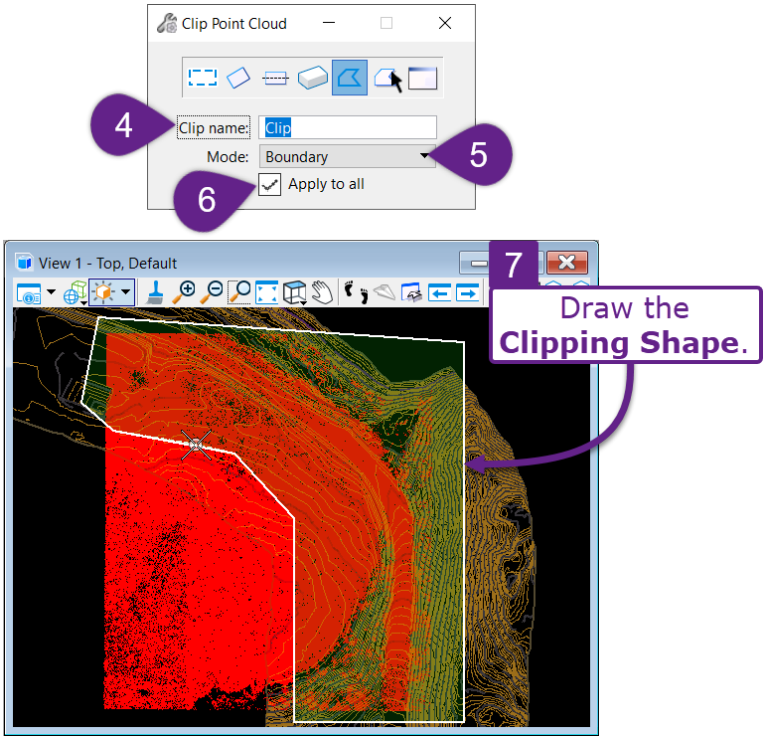


3	In the *Dialogue Box*, select the **Method** for clipping.



Clipping Methods		
Method:		**Description:**
Block		A rectangular clipping shape is defined by clicking in two locations. The rectangle is perpendicular with the *View* window rotation.
Oriented Block		A rectangular clipping shape is used. The rectangle can be orientated to any rotational angle.
Oriented Block by Axis		A rectangular clipping shape is used. First, the length and rotation of the rectangle's center axis is defined by clicking two locations. Next, the width of the rectangle is the rectangle is defined by clicking in a third location.
Slab		A 3-dimensional rectangular prism is used as a clipping volume. This method could be used to clip points above or below a specified elevation.
Shape		A custom polygon clipping shape is defined by clicking in multiple locations.
Element		Any closed shape element can be selected for the clipping shape. Draw the closed shape element before using this tool.
View		The Point Cloud is clipped around the current zoom limits of the *View* window.

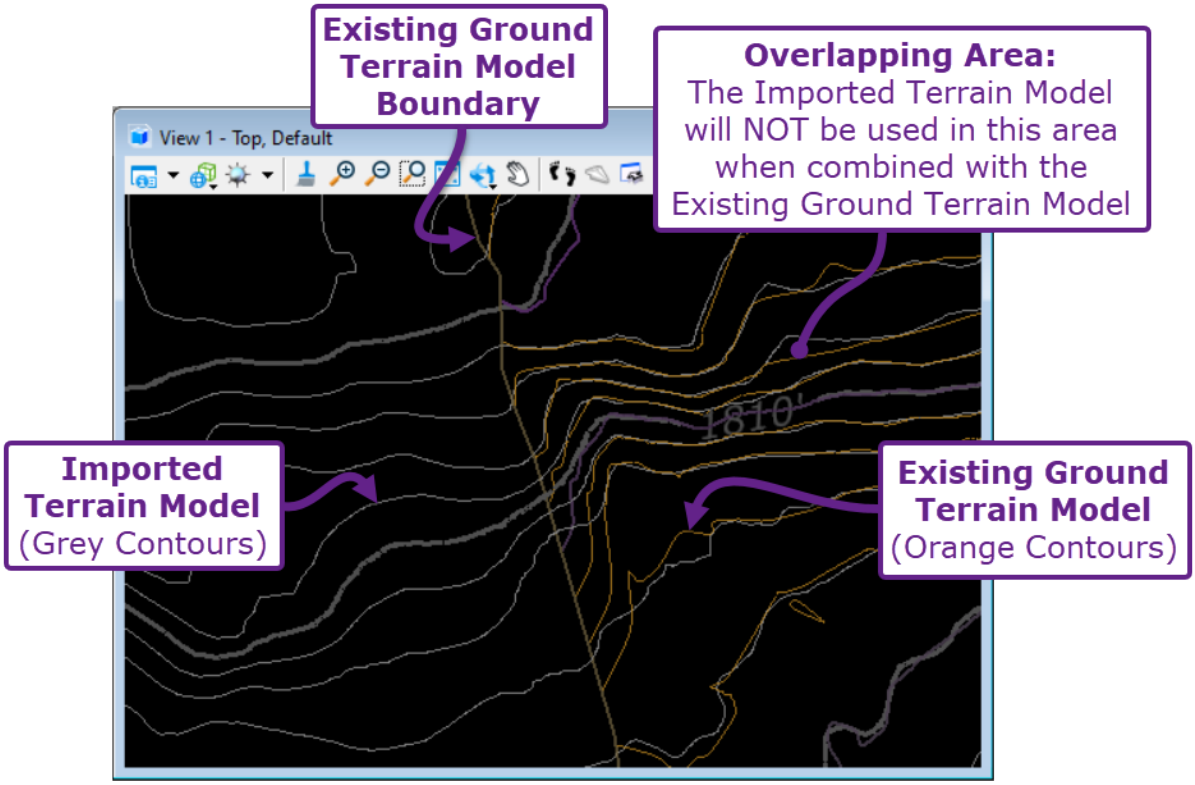
4	If desired give the clip a **Clip Name**.
5	Select the **Mode**. If **Boundary** is selected, then Point Cloud data outside of the clipping shape is deleted. If **Mask** is selected, then Point Cloud data inside of the clipping shape is deleted. Typically, **Boundary** mode is used.
6	The **Apply to all** option is ONLY applicable if multiple Point Clouds are found in the current ORD File. If only one Point Cloud is used, then keep this box CHECKED.
7	Draw the **Clipping Shape**.



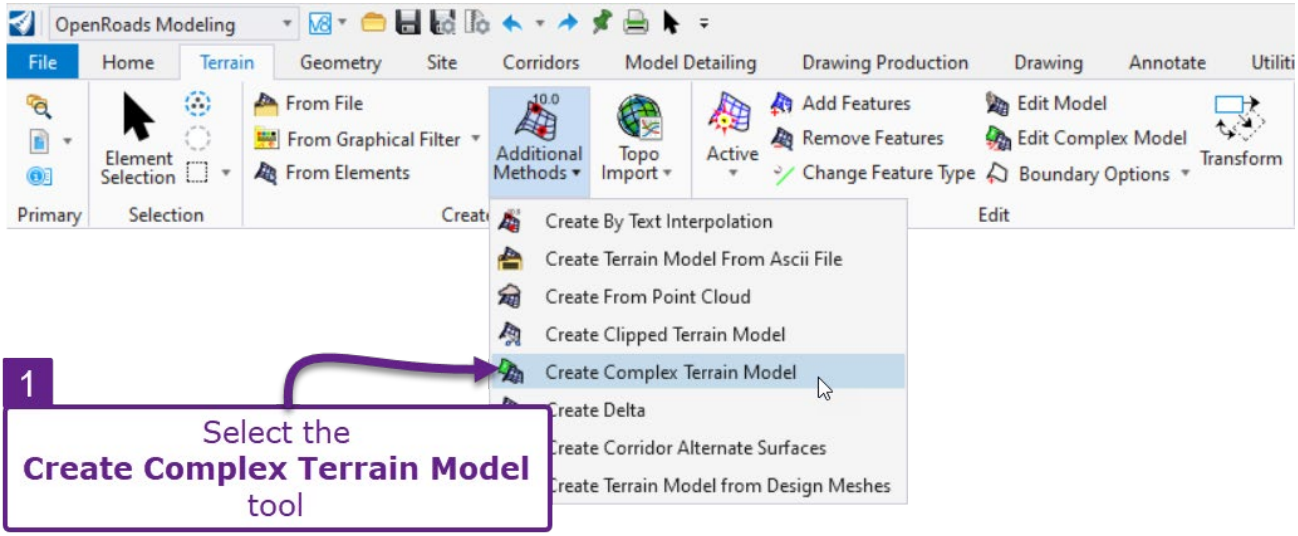
5C.3 Combine Imported Terrain with Existing Ground Terrain Model

After an Imported Terrain Model has been created and assessed for agreeability with the Existing Ground Terrain Model, then they can be combined.

For this workflow, the two Terrain Models should overlap along the boundary of the Existing Ground Terrain Model. When the two Terrain Models are combined, the Imported Terrain Model will be ignored in the areas of overlap.



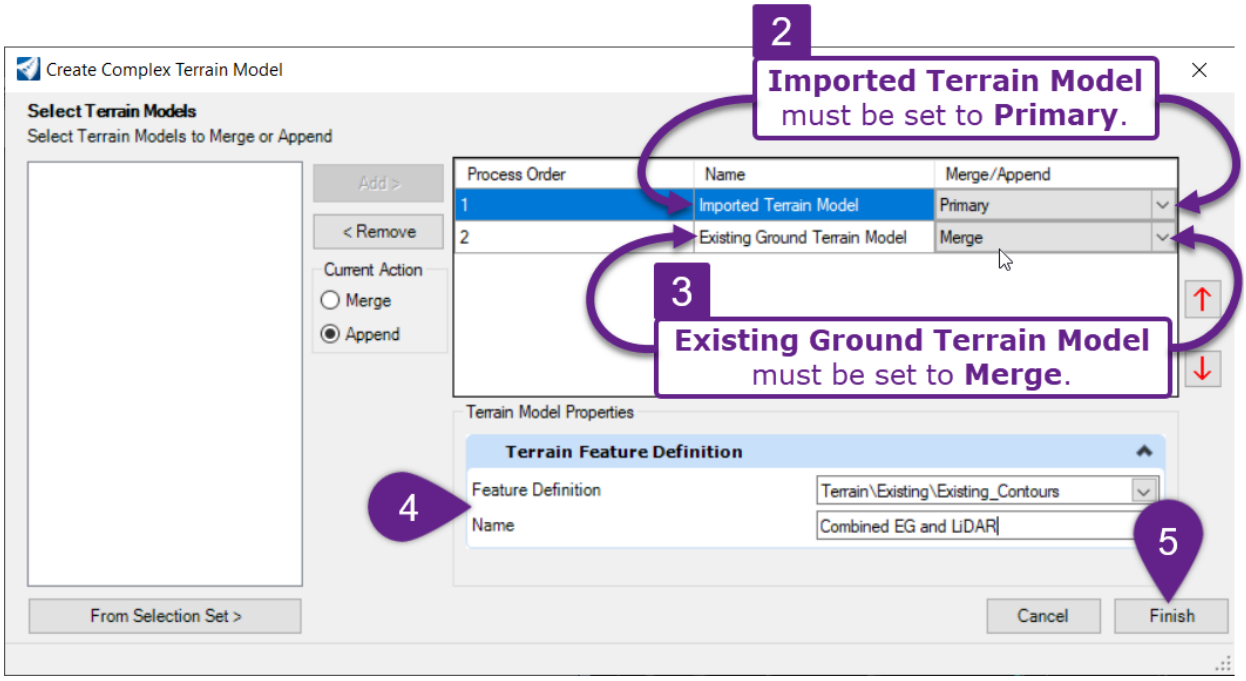
Combining Terrain Models is performed with the *Create Complex Terrain Model* tool. This tool is discussed in greater detail in *22E – Merge Terrain Models*.

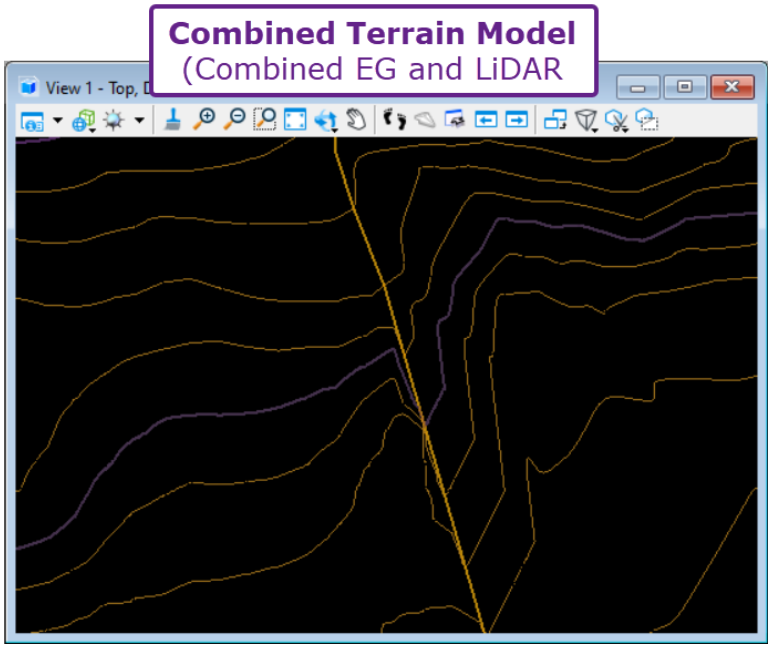


1	From the Ribbon, select the *Create Complex Terrain Model* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Create*** → ***Additional Methods***].

IMPORTANT: The Imported Terrain Model must be set as the **Primary**. The Existing Ground Terrain Model must be set to **Merge**. This configuration is necessary to ignore the Imported Terrain Model in areas of overlap with the Existing Ground Terrain Model.

2	Add the **Imported Terrain Model** as the **Primary**.
3	Add the **Existing Ground Terrain Model** and set the Merge/Append option to **Merge**. ***WARNING:*** Do NOT set the Existing Ground Terrain Model to **Append**. This will result in erroneous triangulation for the combined Terrain Model.
4	Assign the resulting, combined Terrain Model a **Feature Definition** and **Name**.
5	Select **Finish** to combine the two Terrain Models.





OPTIONAL - Delete the Extraneous Terrain Models in the Survey ORD File: After combining, there are THREE Terrain Models in the Survey ORD File:

- The Existing Ground Terrain Model (original)
- The Imported Terrain Model (LiDAR)
- and the Combined Terrain Model

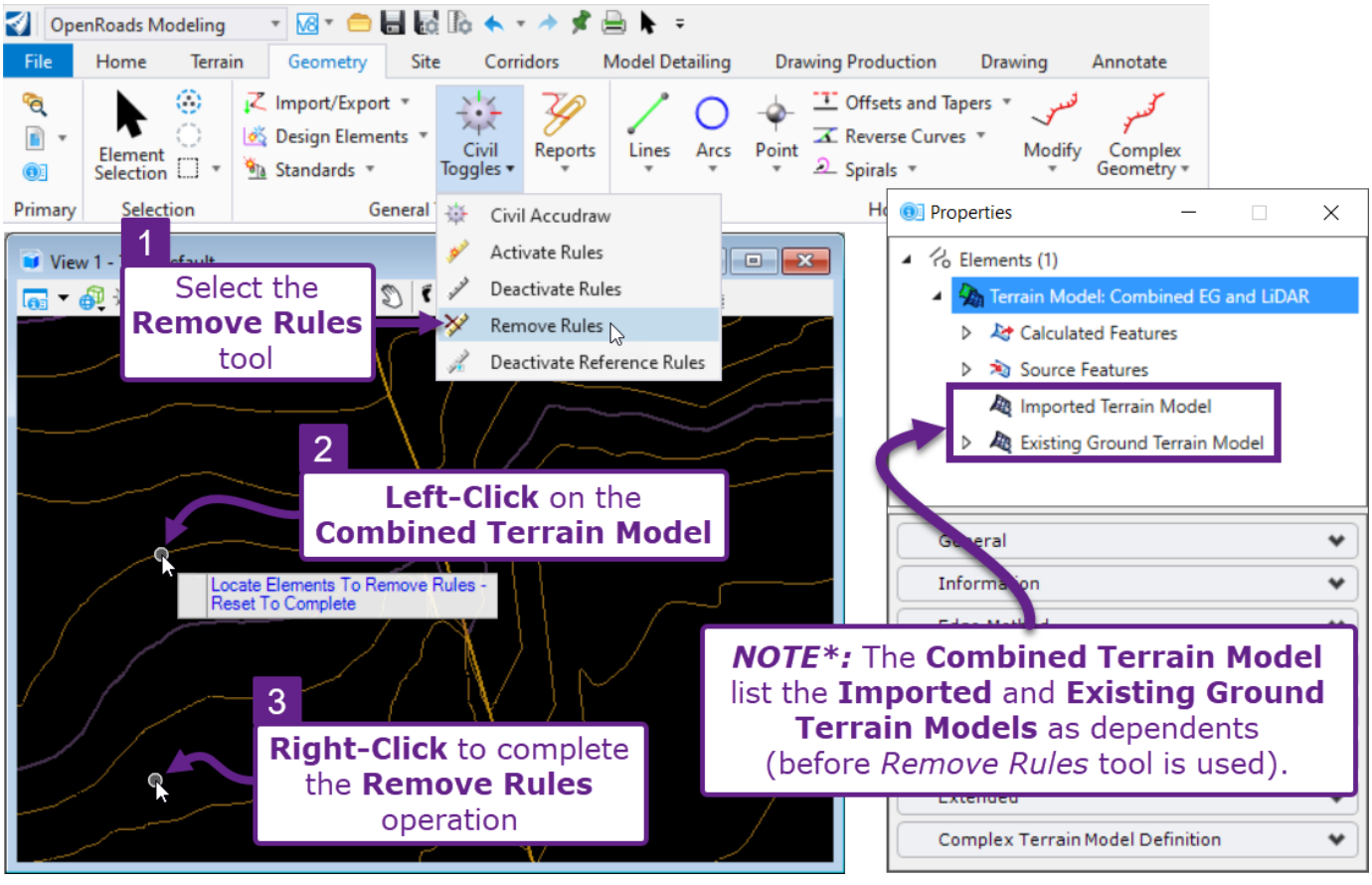
To reduce data clutter, the Existing Ground Terrain Model and Imported Terrain Model can be deleted.

> ***WARNING:*** Ensure a copy or backup of the Survey ORD File has been created before deleting the Existing Ground Terrain Model.

The Existing Ground and Imported Terrain Models CANNOT be deleted until the *Remove Rules* tool has been used on the Combined Terrain Model.

NOTE*: Before the *Remove Rules* tool is used, the Combined Terrain Model is dependent on the Existing Ground and Imported Terrain Models. Deleting the contributing Terrain Models would also delete the Combined Terrain Model. The dependency relationship is shown in the Properties box when the Combined Terrain Model is selected. After the *Remove Rules* tool is used, the contributing Terrain Models can be deleted without affecting the Combined Terrain Model.

1	From the Ribbon, select the *Remove Rules* tool: [***OpenRoads Modeling*** → ***Geometry*** → ***General*** → ***Civil Toggles***].
2	*Prompt: Locate Elements To Remove Rules – Reset To Complete* – Left-Click on the Combined Terrain Model.
3	*Prompt: Locate Elements To Remove Rules – Reset To Complete* – Right-Click anywhere in the *View* window to complete the operation.



To delete the Imported and Existing Ground Terrain Models, open the **Explorer** and open the **OpenRoads Model** drop-down. Locate the Terrain Models to delete under the **Terrain Models** drop-down.

WARNING: After the Existing Ground Terrain Model is deleted, all Corridors and Linear Template that are targeting it will need to be re-processed. The Combined Terrain Model must be set as the *Active Terrain* in all Design ORD Files and Corridors/Linear Templates must be re-processed.