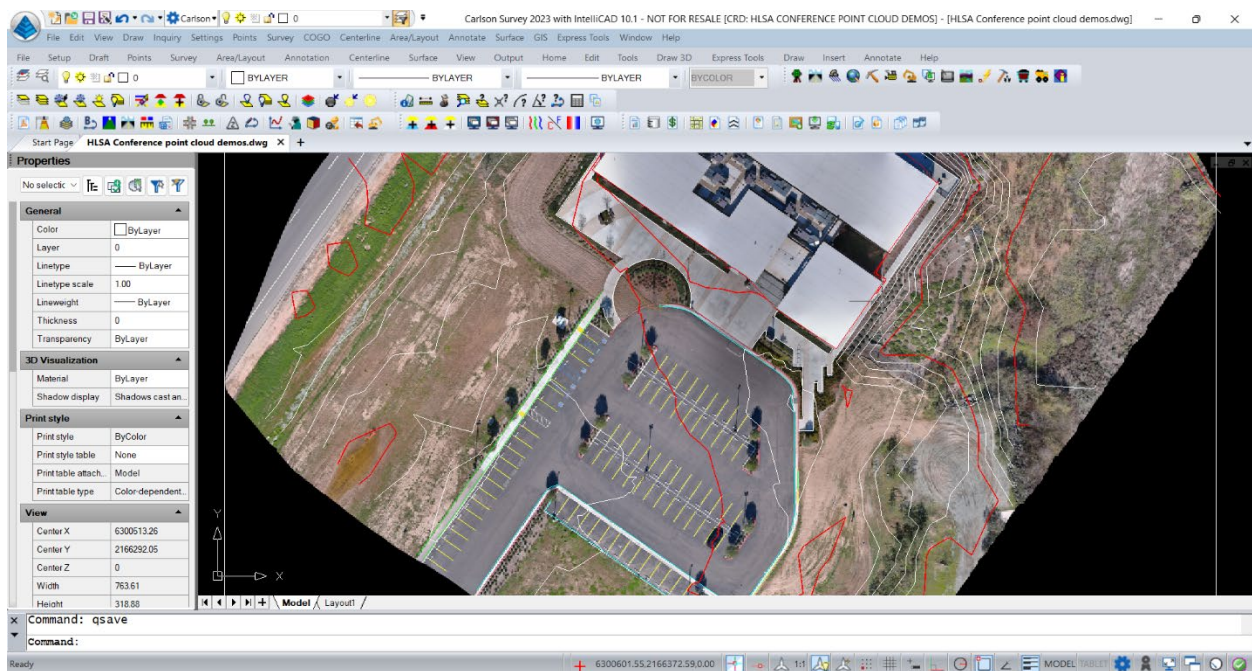


Carlson Point Cloud Advanced Quick Guide

Lesson Objectives

In this class, we will be discussing basic procedures to obtain a representative surface model (TIN) of a project site from a point cloud resulting from LiDAR or areal photogrammetry, including common feature extraction steps and virtual surveying tools. It is important to understand that the lessons through this class are not intended to be fully comprehensive as all point cloud projects pose their own unique set of challenges.

For this lesson, we are going to use a data set collected using an Autel EVO II drone in Southern California. The drone images were processed in Carlson PhotoCapture from which we will utilize the orthoimage as a CAD underlay and then the dense point cloud for feature extraction to create a surface in CAD. See image below.



The objectives for this class are:

- Starting a Point Cloud project
- Import/Export point clouds
- Defining a work zone
- Decimating the point cloud by applying filters (if necessary)
- Automated feature extraction (buildings, parking lines, curbs, sidewalks, edges)
- Drawing polylines to CAD

- Extracting points by grid
- Virtual surveying (field-to-finish)
- Drawing points to CAD
- Creating a surface in CAD

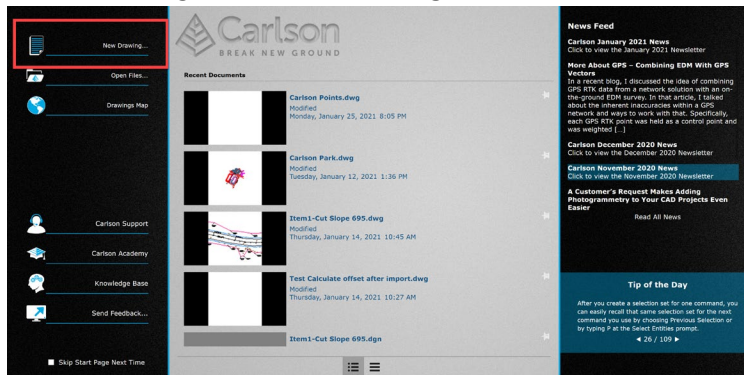
Carlson Point Cloud Advanced Overview

Carlson's Point Cloud Advanced module provides the ability to go from field scan (aerial/terrestrial) to finish plat from large data sets by allowing users to process millions of data points. Filter or decimate points, extract features such as walls, roofs, parking lines, road markings, sidewalks, edges, curbs, field-to-finish, and extract points by grid. With Point Cloud Advanced you can also triangulate from the dense point cloud, calculate volumes, extract profiles, extract trees/poles, cut sections and export solids.

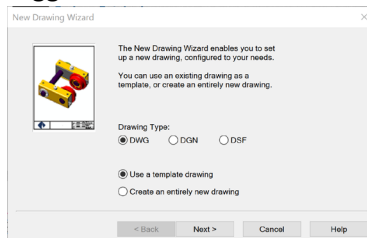
Carlson Project Setup

Begin by creating a new Carlson project.

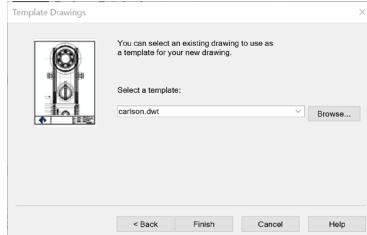
- Open *Carlson* by double-clicking the icon on your desktop.
- In the *Start Page*, click **New Drawing**.



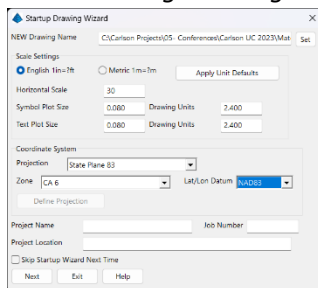
- In the *New Drawing Wizard* dialog, keep *Drawing Type* set to **DWG** and *Use a template drawing* toggled on.



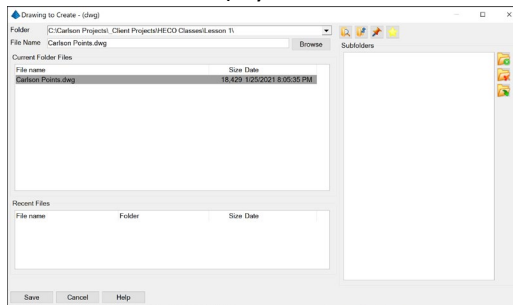
- In the *Template Drawings* dialog, select **carlson.dwt** and click **Finish**.



- In the *Startup Drawing Wizard* dialog, click **Set**.



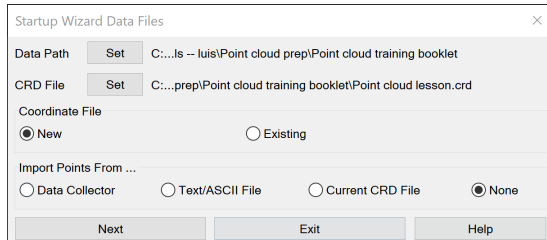
- You will now create a new directory for the project. In the *Drawing to Create* dialog, click **Browse** and then create a new folder under the *Carlson Projects* directory named **Point Cloud Advanced Lesson** (if you haven't done so already).



- In the *File Name* field, type **Point Cloud Advanced Lesson** and then click **Save** to return to the *Drawing to Create* dialog and **Save** again to return to the *Wizard*. It is not necessary to type the file extension.
- Notice the *Scale Settings*, the project scale is used to control the symbol height and the plotted height/printed height of the text. This will set the project default and can be changed later if necessary. We will keep the default value of **20**.
 - As a reminder, if the desired plotted text height is 0.08 inches, at a 1:20 scale this text will need to be 1.6 drawing units.
- The project site is in Southern California therefore you need to set the projection accordingly to place the orthoimage and additional data on the right spot in the drawing. Set the *Projection* to

State Plane 83, Zone to CA 6, and Lat/Lon Datum to NAD83. If you select None, you can change the projection settings later if necessary.

- The *Startup Wizard Data Files* dialog will open.



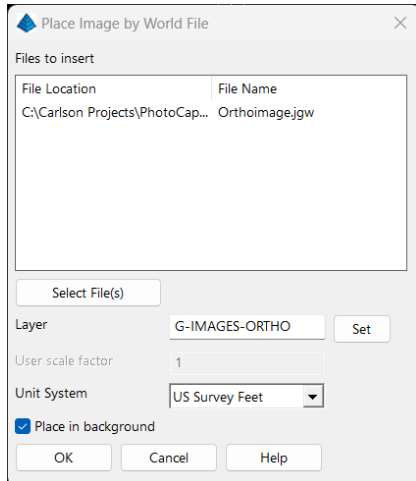
- The *Data Path* allows you to set the location of the different project files if you want to distinguish them.
- The CRD File or Carlson coordinate file is the external file that Carlson uses to store the point data, i.e., point numbers, northings, eastings, elevations and descriptions. Keep the default path and choose **New** to start a new file. CRD files can be used to import the survey data from the field crew using SurvCE/PC.
- Keep *Import Point From* set to **None**.
- Click **Next** to complete the *Wizard*.

Inserting an Orthoimage

We'll start the CAD drawing by inserting the orthomosaic to give us a reference for the site. The image can be inserted using either the tool found in the Survey or GIS modules. For this lesson, we'll use the Survey menu.

- From the *Settings* menu, select **Carlson Menus → Survey Menu**. Note that you can use the toolbar too.
- In the Survey module find the **GIS** menu → select **Place Image by World File**.
- Browse to the folder where you copied the "Point Cloud Advanced Lesson" data set for this lesson and select **Orthoimage.jgw**. PhotoCapture will generate both a JGW and a TFW files, I

provided you with the smaller jpeg format for simplicity.

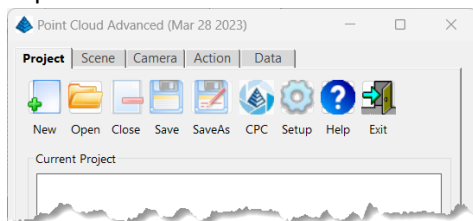


- Check the *Layer* box and verify the layer that the image will be inserted in.
- Make sure **Place in background** is toggled.
- Click **OK**.
- You'll want to **Zoom to Extents** to view the results.

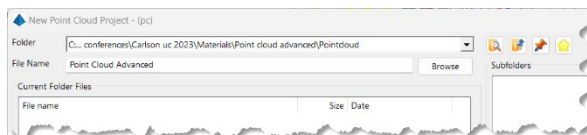
Creating a Point Cloud Project

To provide the ability to work with the large amount of data associated with a point cloud, Carlson's Point Cloud will manage the point cloud data through the Point Cloud Manager. Inside of the Point Cloud Manager you will find all the edit, creation, and extraction tools to work on your projects.

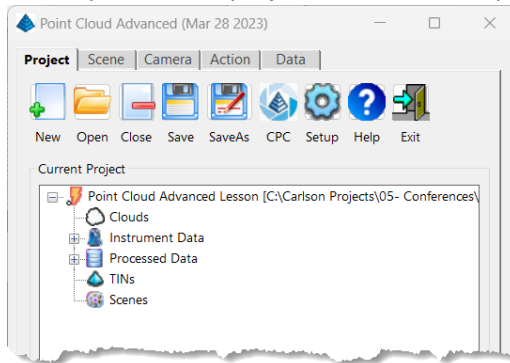
- From *Settings* menu, select **Carlson Menus** → then **Point Clouds Menu**. The *Point Cloud Manager* window will open. If you already had the Point Cloud Menu active, you may need to expand the Point Cloud menu and select Project Manager to open this window.



- Click the **New** button.



- Type **Point Cloud Advanced Lesson** as the file name, then click **Save**.
- You will be prompted if you want to create a new project, click **OK**.
- A new point cloud project tree will be displayed in the *Project* tab.



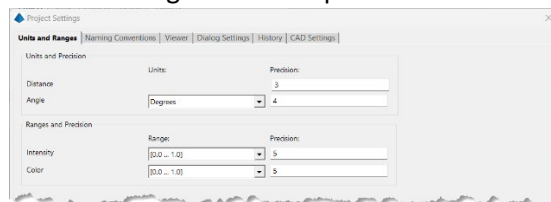
The Point Cloud Manager is also made of five tabs. The Project tab displays the project tree and has the tools to edit settings besides saving and creating point cloud projects. The Scene tab which holds basic display settings including point size and smoothing and, importantly, the tools to control the display of regions/categories in the point cloud. The Camera tab which has the basic display controls (view point, projection style, clipping planes). The Action tab from where you can access all the Selection, Edit, Transform, Create, and Extract tools. The Data tab that displays the coordinate system and object references.

In the Project tab, the project tree displays five main categories: Clouds – this will list the point clouds that you import or you create as you work on the project. Instrument Data – allows you to bring data from ground scanners such as scanner positions and targets. Processed Data – you will find the 3D polylines, coordinate points, and layers. TINs – you will surfaces created directly from the point cloud data or imported from your CAD project. Scenes – scenes are used to display the point clouds and are associated to specific point clouds.

Point Cloud Project Settings

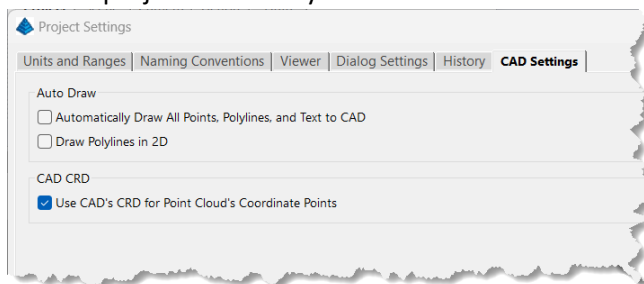
Before we get started, it is good to check the point cloud project settings.

- Click the **Settings** button. (gear icon)
- You can change the *Units'* precision.



- *Naming Conventions*, particularly the number of digits and suffixes used as you apply filters and add data. You can keep defaults.
- *Viewer* settings, from which you can change background and other colors. Importantly though, you can choose to allow to “View Multiple Scenes” and whether or not to “Show Warning” when opening/closing the scene viewer to prevent duplication of view. Having multiple scenes open may be not only confusing but also taxing on your computer’s memory. I recommend having both toggled off.
- You can make changes to these settings per project type and save them as configuration files in the *Dialog Settings* tab. In the *History* tab you can toggle on logging the command history, timestamping command history and object creation, and change the auto-save options.
- Lastly, in the *CAD Settings* tab, you can set auto draw option, which I **do not** recommend turning on as it will slow you down as it will draw the CAD object every time you issue a command. Don’t worry, to draw in CAD only takes one click later.

I recommend turning on *Use CAD’s CRD for PointCloud’s Coordinate Points* as this will keep your Carlson project CRD file synchronized.



- Click **OK** to close and save the changes.

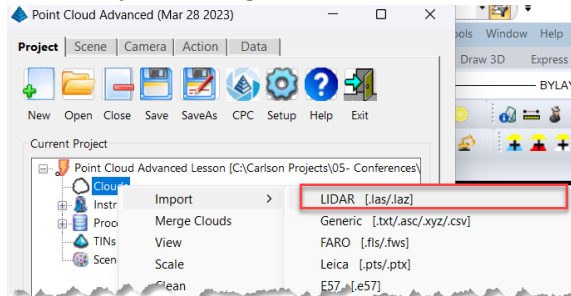
Import the Point Cloud Data

The point cloud data that you will be processing may come from a terrestrial scan, publicly available LiDAR data and aerial photogrammetry data. It is important to know that when working from ground scans, Point Cloud can handle different scanner setups which will allow you to get a true 3D representation of the site. Once these ground scans are registered, they would have obtained a coordinate system and Point Cloud can be used to merge this data.

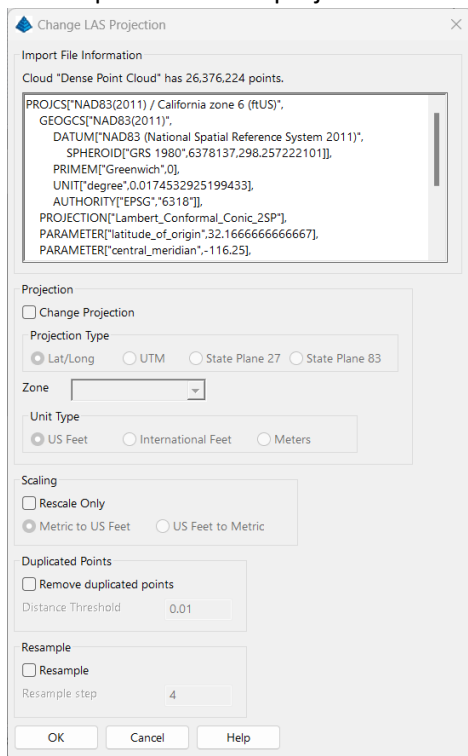
For this lesson we will be using a point cloud obtained from an aerial survey using an unmanned aerial vehicle (UAV). It is important to note that the flight was done with the objective to optimize feature extraction and therefore a low altitude flight was done (130’ AGL) with rendered a low 0.03’ ground sampling distance (GSD) horizontally and 0.12’ vertical GSD on average.

Let’s import the dense point cloud resulting from the photogrammetry process in Carlson PhotoCapture.

- In the *Project* tab, **right-click** on **Clouds**. Then select **Import**, and **LiDAR (.las/.laz)**



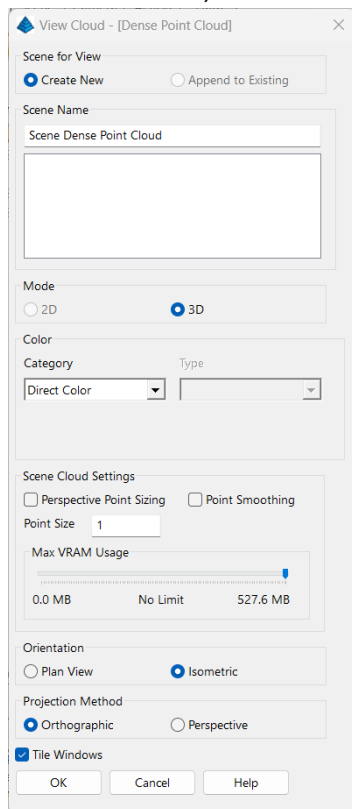
- Select the **dense_point_cloud** file provided in the compressed *Point Cloud Advanced Lesson.zip* file. This will open the *Change LAS Projection* window in which you can see the number of points that will be imported as well as confirm the projection. For this lesson, the point cloud has 26 million points and the projection is NAD83 (2011) / California Zone 6 (EPSG: 6426).



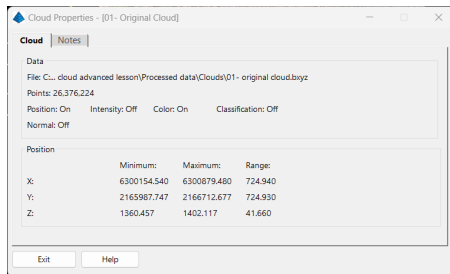
In this case, the projection and units are correct therefore there is no need to apply any transformation during the import process. In addition, because this data is coming from a photogrammetry process, there isn't a need to decimate the point cloud either. Keep in mind that for data coming from other sources, it may be recommendable to apply some filters during import. For example, data collected with a ground scanner may have a high density of points in and around 20' from the scanner that can be

decimated reducing the number of points that you will need to deal with later. Also good to know, if your data was classified during the registration process, an additional window will open prompting to if you want to keep the classifications – if you accept Carlson Point Cloud will convert into Regions which can be used to turn on/off their visibility and for selection sets.

- Click **OK**. The import time will vary depending on the size of the cloud data.
- Once completed, you will be prompted if you want to view a scene with the new cloud data, click **Yes**. The create new scene window will open. I recommend toggling off *Perspective Point Sizing* and *Point Smoothing* for clear initial display. Also, make the *Point Size* of 1. For this lesson's data set, Direct Color is recommended but know that there are other options.



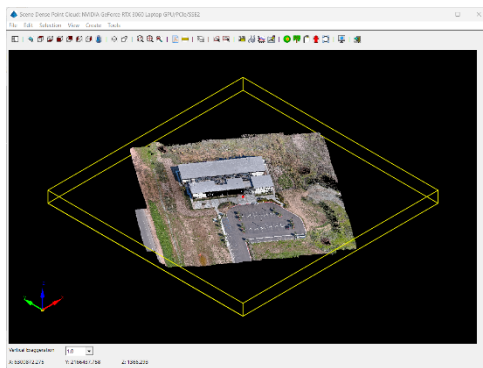
- Notice that the point cloud listed in the Project Manager displays the .las file name and will be sorted in alphanumeric order. You can rename and simplify. **Right-click** on the point cloud, then select **Rename**. Name it **01- Original Cloud**.
- At any time, you can check the point cloud properties to get an idea of number of points, position ranges and whether it contains classifications. To do this, **right-click** on the point cloud name and select **Properties**.



- Click **OK** to close.

Navigating the Scene(s)

As mentioned earlier, as you work with the data, you may develop one or more point clouds which will be associated with their individual scenes.



You can navigate the point cloud in the scene window in multiple ways. You can zoom in and out using the middle-button wheel in your mouse. Pressing the middle-button will behave as panning. And, left clicking will allow you to rotate the view just as when you work with Carlson's 3D Viewer. In the toolbar you will find helpful shortcuts to set the view to top, front, perspective, etc. Take a moment to review these tools.

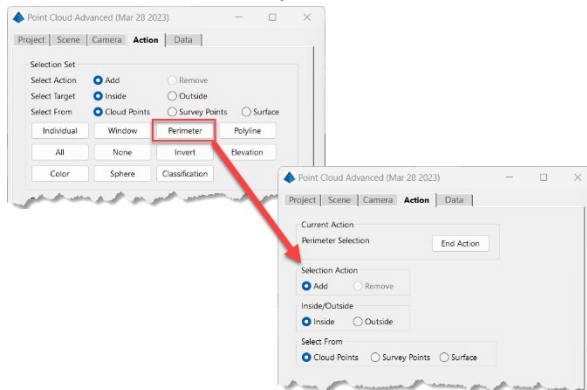


Defining the Working Area

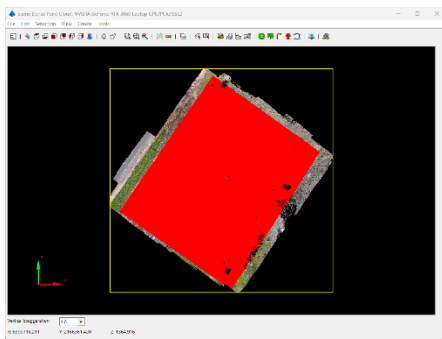
As mentioned at the beginning, the goal for this lesson and for many projects is to obtain a representative surface model (TIN) of the project site from the point cloud data. With that in mind, it is a good practice to isolate or create a point cloud that is sub-set of the complete project. For this lesson, and to illustrate the steps, we will remove the street and shoulder areas on the west side.

- Start by changing the scene view to Top.

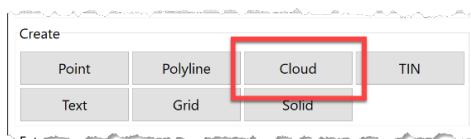
- In the *Project Manager*, open the **Action** tab. In this tab, we will use the **Perimeter** tool under *Selection Set*. Using Perimeter Inside, we can draw a boundary to select all the points we are interested for our study.



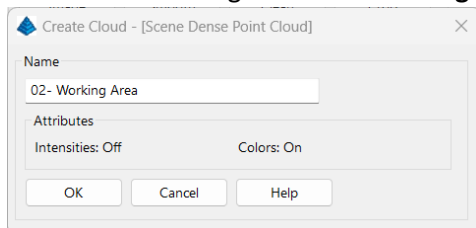
- Select an area similar to the image below that will include only the park and streets we are interested in.



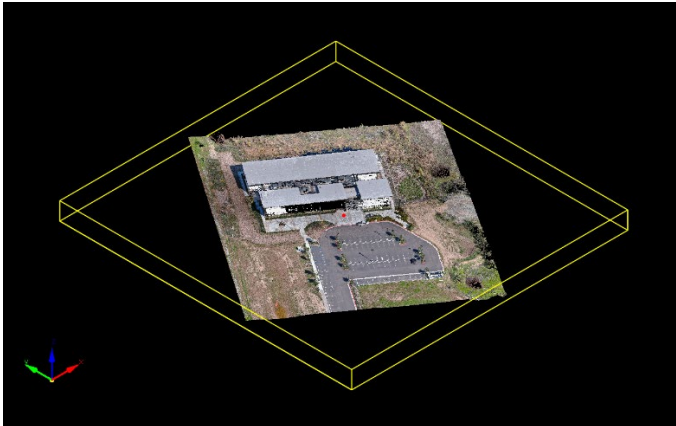
- To create the isolated, work area, from the *Action* tab, click the **Cloud** button in the *Create* section.



- Name the resulting cloud **02- Working Area**. And click **OK**.



- You will be prompted “*Would you like to view the new cloud?*”, click **Yes**. This will close the current scene and create a new scene associated with the newly created point cloud. The software will remember the settings you used last when the first scene was created. The resulting view will look similar to the image below.



Clean the Point Cloud Data

In this case, the resulting working area cloud is still over 20 million points which isn't an issue for Carlson Point Cloud. In addition, and to reiterate, this data set came from aerial photogrammetry using a UAV, therefore the point density is good for our intended feature extraction. Therefore, I wouldn't necessarily recommend decimating or thinning down this cloud. But you may encounter projects with larger data sets or clouds from aerial or terrestrial LiDAR sensors in which case it is good to mention some of the tools.

Let's start with the simplest *Clean Cloud* filters which can be easily accessed by right-clicking on the point cloud that you want to decimate. The *Clean Cloud* window offers the following:

Duplicated Points – this method searches for two or more points that are within the *Distance Threshold* and then will remove them. This method is typically fast and helps reduce much of the redundancy in the data. For example, data collected with a ground scanner will have more points than necessary right next to the scanner.

Isolated Points – searches for points that have less than *Minimum Neighbor Counts* within the threshold and delete them.

Redundant Points – this parametric method is more useful when needing to reduce the flat areas down to one point. It will create a user-defined box and check how the points inside of it fit the plane and/or have a color match.

If you are looking to decimate a point cloud with these filters, I recommend applying the Duplicated and Isolated Points filter first. Then, apply the Redundant Points second. For the redundant point

parameters, I recommend small sampling boxes, thus a *Box Length and Width* of 0.5, a *Box Height* of 0.25, and a *Residual Tolerance* of 0.03 will render good results. Note that after applying the filter(s) the result will be viewed as a new point cloud. Following the naming convention proposed earlier, you could name this cloud “03- Working Area Cleaned” and so on.

Resampling the Cloud Data

Resampling provides two additional methods to decimate the point cloud data which can be somewhat more aggressive than those found in the Clean window. The two methods:

Step – this method reduces the cloud to 1/Step it’s current size. It is fast but at the cost of being less intelligent.

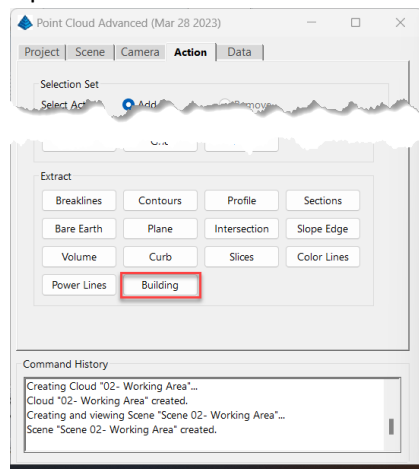
OC-Tree – analyzes the data by using user-defined bounding boxes to search for minimum and maximum numbers of points within the ranges and deleting points. This method may take a few minutes to complete depending on the number of points in your point cloud data.

Once again, OC-Tree is my recommended filter and it’s application should be in small boxed areas.

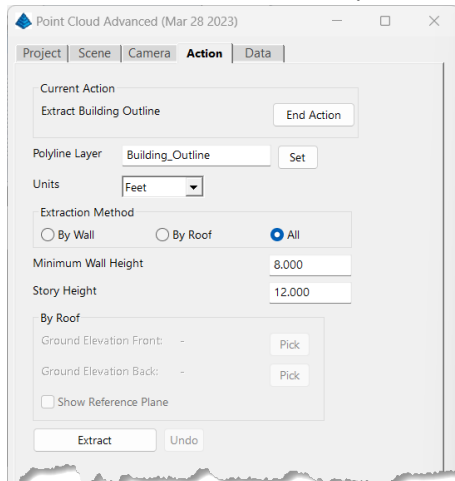
Extracting Roofs/Walls

To reiterate, for this type of photogrammetry data set, there isn’t a need to decimate the cloud to begin feature extraction. So, let’s start by finding the buildings before we bare-earth the cloud.

- Open the **Action** tab. And click on **Building** in the *Extract* frame.



- There are three extraction methods, but we will go for the simplest, click on **All**. This will allow the software to scan the complete cloud looking for roofs.



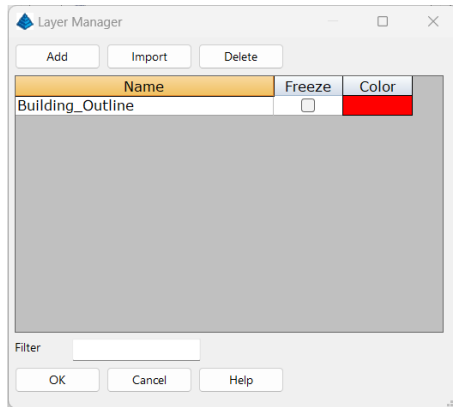
- The *Minimum Wall Height* will help filter out walls of less than that height. For example, this will prevent the software from resolving a small landscaping wall or fence as a building wall. The *Story Height* is used as reference to determine that 'planes' found at different elevations may be building roofs. Keep the default values and click **OK**.
Depending on the point cloud size (and your computer), this process may take a few minutes. For this data set, it will be less than a minute to resolve you will see a 3D polyline drawn around the building.
- Click **End Action** to close the panel once the process is finished.

Editing Layers

In the previous step a 3D polyline was created and drawn in the default *Building_Outline* layer. Great opportunity to familiarize you with the *Layer Manager*.

- Open the *Project* tab.
- You will see that now the *Processed Data* tree has been expanded to show the newly created polyline in the *Polylines* branch and that a new layer was added.
- Right-click on *Layers*, then click on **Edit**.
- You can import layers from the project's CAD drawing by clicking the Add button – great if you are working from a template. Or import a layer standard file by clicking Import.

- For this lesson, we'll simply change the color for the Building_Outline layer by clicking on the **Color** field on the list.



- Choose red and click **OK**.
- Click **OK** to close the *Layer Manager*.

The building outline polyline will be displayed in red.



Applying Bare-Earth Filter

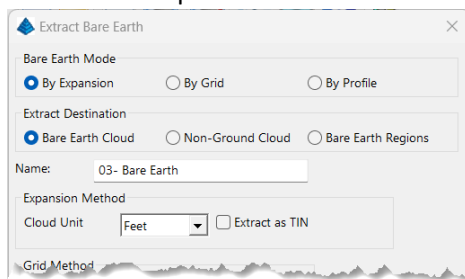
Now that we have the building outline, let's go ahead and remove the building, vehicle(s), trees and other non-ground points from the data set. We can automate the removal of these data by applying one of the three bare-earth filters.

By Expansion (recommended) – the program will determine ground the ground plane in an area and then expand the solved ground plan by proximity until it has resolved the complete site. There are no parameters to worry about and you can select to also create a TIN from the resulting data.

By Profile – this method works by drawing a 3D line away from the selected position and seeing if it slopes too sharply, removing any vertical segments and keeping any flat segments.

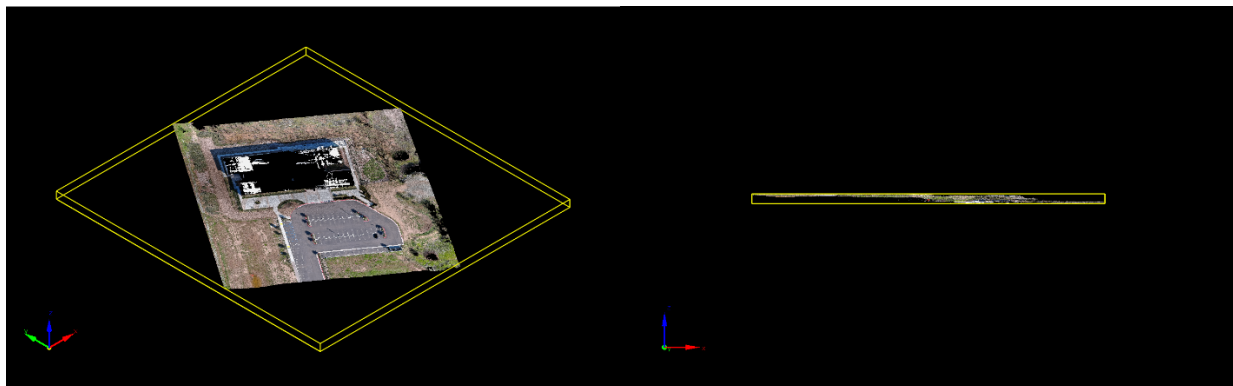
By Grid – works by inspecting the cloud as a grid to find the lowest valid points in each grid cell and keeping only those points.

- From the *Project Tree*, **right-click** on the *02- Working Area* point cloud and select **Bare Earth**. You can also open the Action tab and click Bare Earth button.



- Name the new cloud **03- Bare Earth**. Make sure **By Expansion** is selected. We want the result to be a new bare earthed cloud, so make sure **Bare Earth Cloud** is selected. There are no parameters to worry about, click **OK**.
 Note that there are a *Non-Ground Cloud* and *Bare Earth Regions* options, the later of which will classify the current cloud into two regions of ground and not ground.

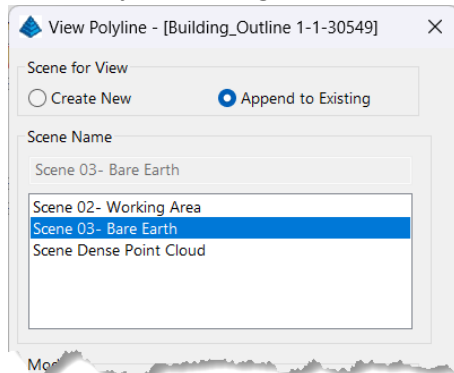
The process will take a few minutes depending on the size of the cloud (and your computer). Once finished, the program will suggest creating and opening a new scene to view the results. Use the display tools to see the resulting cloud from different angles



Using Polylines

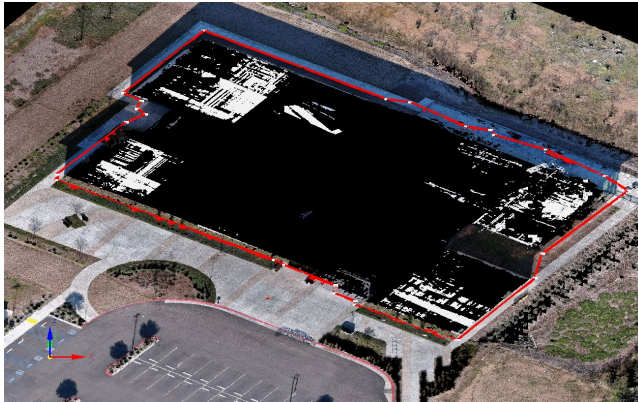
Let's take advantage of the fact that in this data set the roof is white and, since the flight was done at noon, there is still some noise in the building area to illustrate how to view a polyline in a different scene.

- In the *Project Tree*, right-click on the **Building_Outline 1-1-####** polyline and select **View**.



- Select **Append to Existing** under the *Scene for View* frame. Then highlight the target scene, in our case **Scene 03 – Bare Earth** and click **OK**.

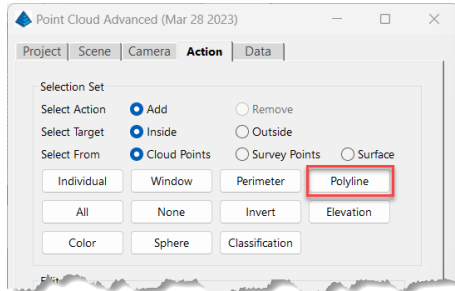
The polyline will be added to the current bare earth scene, and it can be used for selections and other features.



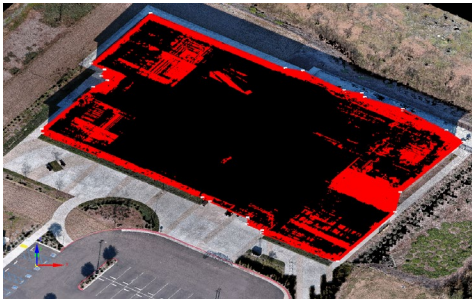
Delete Points

Now that we have the building outline added to the current scene, we can use it to delete the 'noise' left over from the roof.

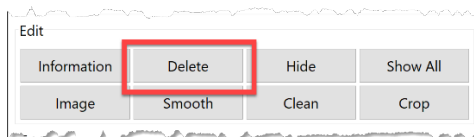
- In the *Action* tab, under *Selection Set*, click the **Polyline** button.



- You will be prompted in the scene to select building outline polyline. The program will select all the cloud points inside the polyline.



- Now, in the *Edit* frame, click **Delete**.



- Accept the prompt.



There are other tools in the *Selection Set* area allow you to select points individually, by window selection, perimeter, elevation range, color, sphere and classification. You can also invert selection set, select all points or clear the selection (none).

Point Cloud Topo Best Practices

You now have a point cloud that is ready to develop a topo and thus the question is what the best practice is. As every project is different or has it's own challenges/nuances, let's briefly touch on different techniques.

- Decimation – As discussed earlier, the point cloud can be decimated using the Clean and Resampling filters such that you end with a few thousand points from which you can create a TIN surface. Now then, in doing this you risk thinning the cloud to a point that you may lose defining features, but this may work well for earthwork/volume calculations if your tolerances allow.
- Direct TIN – Point Cloud Advanced offers a TIN command (Action tab > Create > TIN) which allow you to set limits on the triangle side lengths, number of triangulation vertices and density limits. The caveat is that the algorithm will decide how to filter data to match the number of vertices and point density limit criteria. Not as much or not any point cloud thinning for this but again you may lose defining features but this is a quick and easy method that is very appropriate for earthwork/volume calculations.
- Feature Extraction – By extracting features such as building walls/roofs, curbs, road markings, parking stripes, sidewalks, edges, general topo points, and other features, you will be able to define breaklines and place points that may give you a better representation of your site. In addition, by creating the polylines and points, you can quickly develop the plan and create a surface in CAD. I recommend this method for sites such as the one being used in this lesson as it is an ideal complement to data measured with traditional instruments.

This said, we will go down the feature extraction path for this lesson as we will be able to extract parking lines, curbs, sidewalks, and other edges both automatically and through field-to-finish tools (virtual surveying) to add to the building outline that we already have. Then we will draw the resulting 3D polylines to CAD and create the surface in Carlson Survey/Civil.

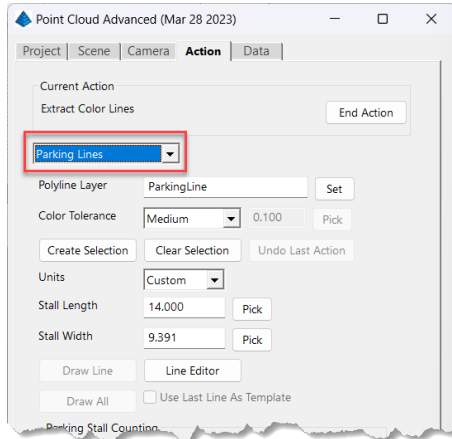
Lastly, before we begin, note that the following steps in this lesson can be applied in any order as they have no pre-requisites. Keep in mind that in your projects you may not be able to use all of these tools.

Extract Parking Lines and Count Stalls

Let's start by extracting parking lines as the results can be used for ALTA surveys.

- In the *Scene Viewer*, change to a top view and zoom around the parking lot area.
- Open the *Action* tab.

- From the *Extract* frame, click **Color Lines**.

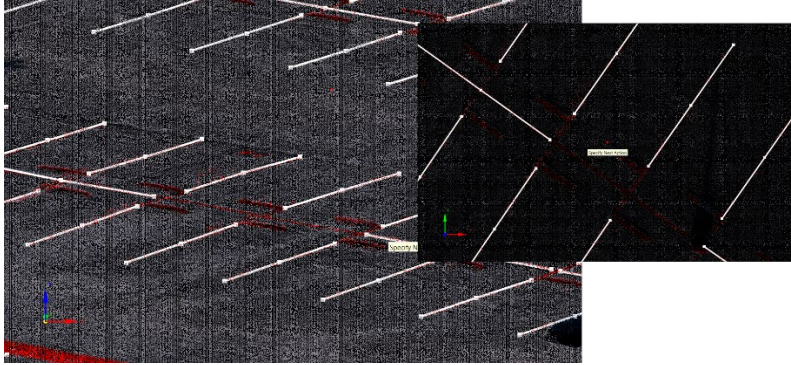


- From the drop-down list, select **Parking Lines**.
- We'll keep the default *Layer* and *Color Tolerance* settings.
- Click **Create Selection**, in the *Scene Viewer*, click on a point on a parking stripe. The program will find points with the similar RGB values (within tolerance)

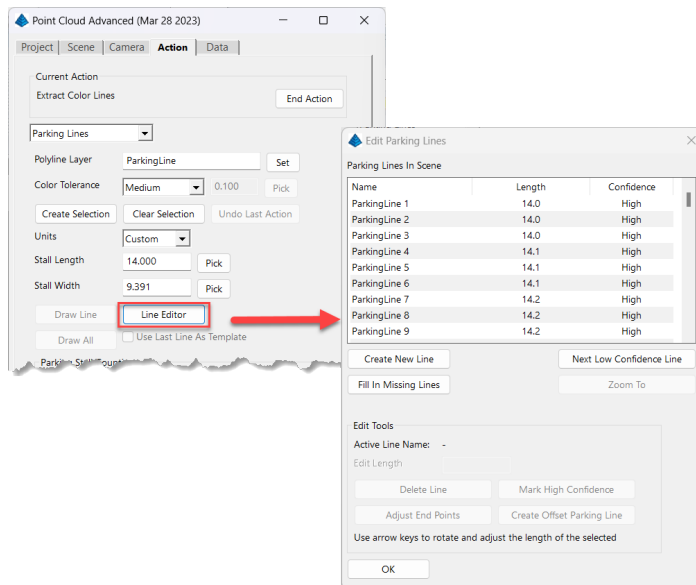


- The *Stall Length* is an approximation of the parking stripe lines, for this example, use **14** (feet). You can click Pick to measure if you prefer.
- Similarly *Stall Width* is an approximation of the stall width, use **9** (feet). Similarly, you can click Pick to measure if you prefer.
- Click **Draw All**. The software will analyze the selected data (RGB and clustering) and then trace the 3D polylines. The elevation on the polylines is measure from the cloud points on the end points and in the middle. Depending on your site (and computer) this will take a few minutes.

In the example below, notice how there are some extra lines resolved in the divider. You will need to do some editing as not all the lines might have been picked up (faded paint) or extra lines added (RGB and clustering similarity) because we are aiming to do a stall count for ALTA purpose.



- Click the **Line Editor** button.



- Once the editor is open, you can select any parking line in the *Scene Viewer* and, right-clicking will open an actions menu. You will see a listing of all the parking lines that the program created followed with their length and a high/low confidence value. You can sort the list and then press **Zoom To** to check the specific lines.

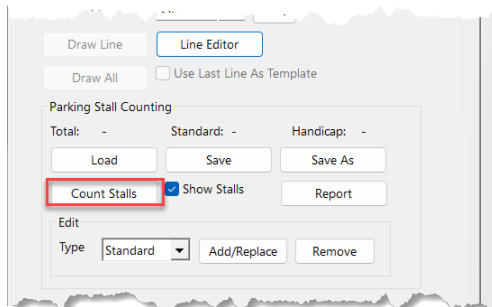
Some of the actions that you can apply:

- Create New Line – pick points to draw a new parking stripe.
- Create Offset Parking Line – allows you to copy and offset any parking line. Once you drop the new line in place, the program will obtain the elevation for the line reading the cloud points on the new position.
- Fill in Missing Lines – allows to select to parking lines and then it will suggest the in between lines based on the Stall Width parameter.
- Adjust End Points – allows you to adjust the position of parking line endpoints.
- Delete Line – deletes the selected line.

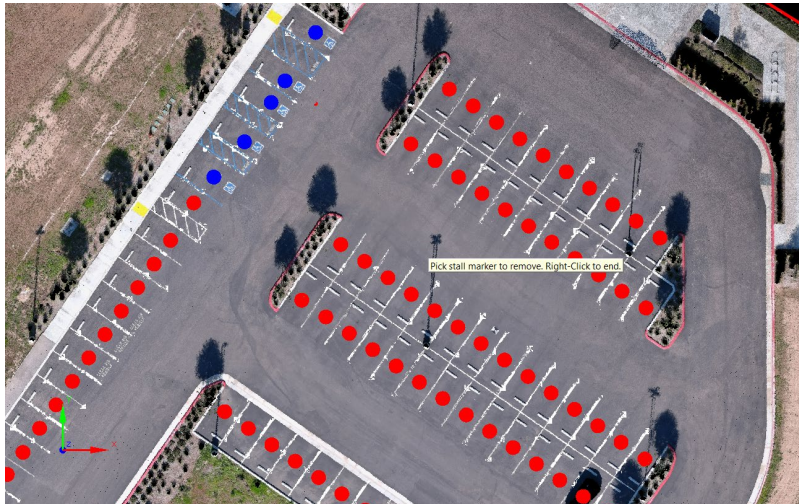
- For this data set, you will want to delete all the parking lines that are incorrect and may need to offset and fill in others. Note that you picked white lines, so none of the handicap blue stalls were drawn, you can use the offset parking line command to create them. The reason to do this cleanup is that we are going to use the stall counting tool which uses the drawn lines to place markers.

Click **OK** when you are done editing the lines.

- Now, let's count the stalls, click **Count Stalls** in the *Parking Stall Counting* frame.



- Use the **Remove** button to delete any unwanted markers. Then, use the **Add/Replace** button to add missing standard missing markers and then select **Handicap** under type to add the handicap blue markers. The result should be similar to the image below.

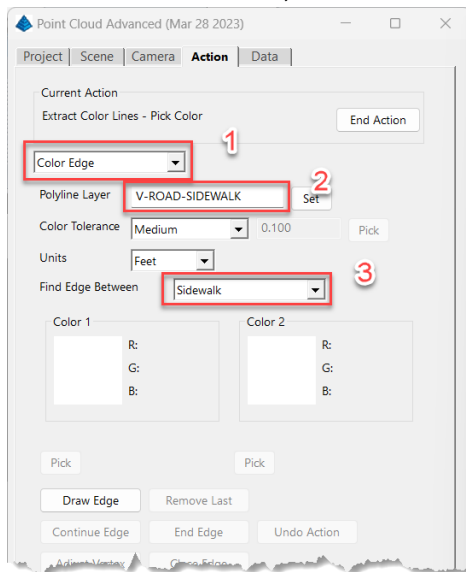


- Click the **Report** button to save/export the stall count. Then, click the **Save** button to save the parking data.
- Click **End Action** to close the action panel.

Extract Sidewalks

The sidewalk extraction tool is also found in the Color Lines tool

- In the *Scene Viewer*, change to a top view and zoom around the sidewalk on the west end of the lot.
- Open the *Action* tab.
- From the *Extract* frame, click **Color Lines**. Then select **Color Edge** from the drop-down list.



- Name the *Polyline Layer* as **Sidewalk**.
- Select **Sidewalk** from the *Find Edge Between* drop-down list.
- Click **Draw Edge** then zoom close the sidewalk that you want to extract and pick a point on the sidewalk.



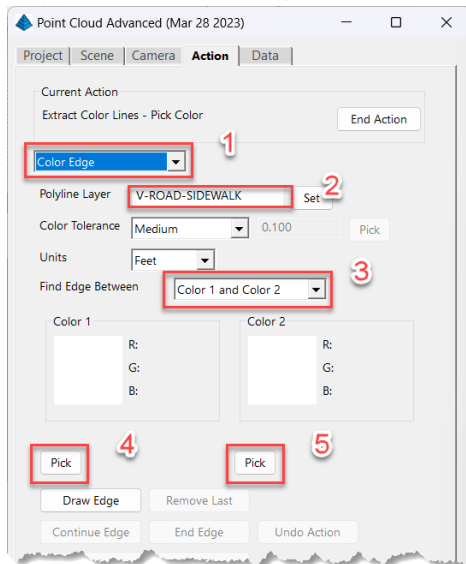
- The program will find and follow the edge as best it can. Note that you have a few actions to correct or continue the edge extraction:
 - Adjust Vertex – allows you to graphically correct the position of endpoints.
 - Manual Pick Edge – allows you to manually pick the next point along the edge.
 - Continue Edge – allows you pick another point to continue the edge, the software will continue tracing the edge.
 - Trim Edge – will trim the edge line to the selected point.
 - Close Edge – will close the edge.
 - End Edge – completes the tracing of the edge so you can start a new one.

- You may need to adjust and continue the edge to complete the sidewalk. When done, click **End Edge** and then click **End Action**.

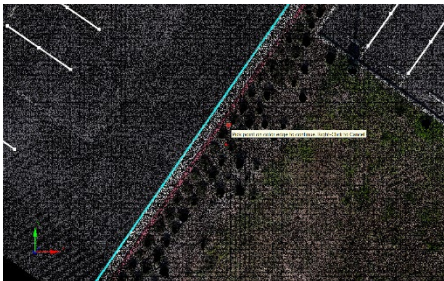
Extract Edge by Colors

Similar to sidewalk extraction, in that the program is using RGB values to find the edges, the next tool we will use allows you to select two points and read their RGB values to extract the colored edges.

- In the *Scene Viewer*, change to a top view and zoom around the valley gutter on the south of the lot.
- Open the *Action* tab.
- From the *Extract* frame, click **Color Lines**. Then select **Color Edge** from the drop-down list.



- Name the *Polyline Layer* as **Drain**.
- Select **Color 1 and Color 2** from the *Find Edge Between* drop-down list.
- Click the **Pick** button under the *Color 1* swath. Pick a point on the asphalt.
- Click the **Pick** button under the *Color 2* swath. Pick a point on the valley gutter.
- Click **Draw Edge** then zoom close the sidewalk that you want to extract and pick a point on the sidewalk.



- The program will find and follow the edge as best it can. Note that you have a few actions to correct or continue the edge extraction:
 - Adjust Vertex – allows you to graphically correct the position of endpoints.
 - Manual Pick Edge – allows you to manually pick the next point along the edge.
 - Continue Edge – allows you pick another point to continue the edge, the software will continue tracing the edge.
 - Trim Edge – will trim the edge line to the selected point.
 - Close Edge – will close the edge.
 - End Edge – completes the tracing of the edge so you can start a new one.
- You may need to adjust and continue the edge to complete the sidewalk. When done, click **End Edge** and then click **End Action**.
- Open the **Project** tab and click **Save**.

Editing Layers

Now that you have added a few more layers and polylines, good time to change layer colors as necessary. Note that you can *Add* new layers and *Import* layers by reading the layer names in the current drawing or from a layer standards file.

- Open the *Project* tab.
- You will see that now the *Processed Data* tree has been expanded to show the newly created polyline in the *Polylines* branch and that a new layer was added.
- Right-click on *Layers*, then click on **Edit**.
- Review the current layers and edit the colors as desired by clicking on the **Color** field on the list. Choose the color and click **OK**.
- Click **OK** to close the *Layer Manager*.

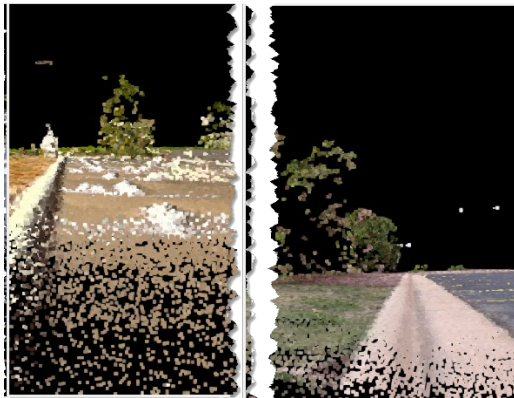
Your scene may look similar to the one below.



Will Curb Extraction work?

It is important to note that every project is different, and you may not be able to automatically extract the curb lines, in which case, follow the steps in the “Create Polylines” section next in the lesson.

Let’s refresh on how this particular data set was created: drone flight at a low altitude above ground level (AGL), specifically 130’. Sweet spot is between 120’ – 130’ which renders a low ground sampling distance (GSD) of 0.03’. Lower AGL will result in lower GSD value and possibly better results but there is a point of diminishing returns when too many pictures will cause longer processing times, larger data sets, etc. As an example, in the image below, the point cloud on the left was capture with an AGL of 180’ versus the cloud on the right which was captured at an AGL of 120’. Please note that an Autel EVO II RTK drone with a 20 MP (1” CMOS sensor) was used. Drones with higher end cameras will result with similar GSD values at higher altitudes.



Ground scanner data will work but keep in mind that you will want to decimate the point cloud such that the data doesn’t overwhelm the extraction algorithm.

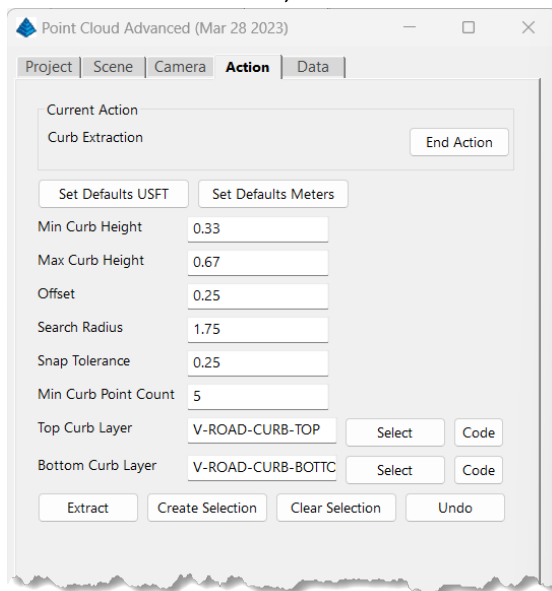
Extract Curbs

Alright, with that preamble, let’s extract a curb for this project – note that it is possible that in your project curb extraction won’t work on all curbs.

- In the *Scene Viewer*, change to a top view and zoom around the curb on the south side of the lot by the valley gutter.



- Open the *Action* tab.
- From the *Extract* frame, click the **Curb** button.

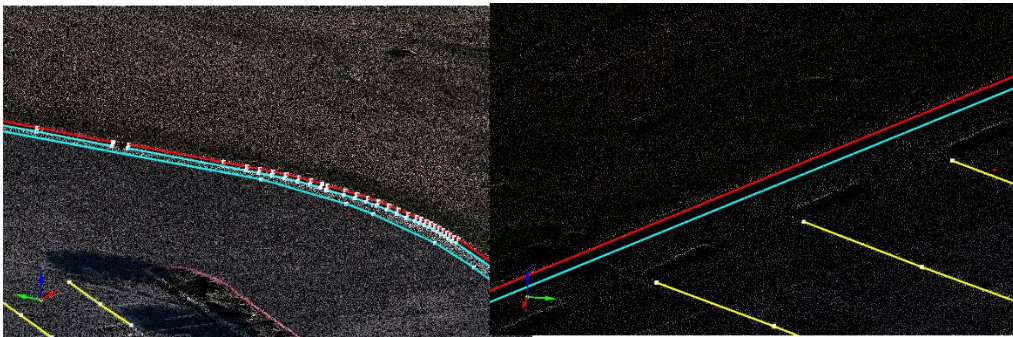


- The parameters in the image above are good starting point. Min/Max curb height of 0.033/0.67, offset of 0.25, search radius of 1.75, snap tolerance of 0.25, and min curb point count of 5.
- Click the **Create Selection** button, this will allow you to create a selection set where to focus the curb extraction algorithm.
- You will be prompted for the first point, click close the curb on the southern most end (see image below). Then, pick a second point on the other end (see image below). Then right-click to

complete the process.



- Click the **Extract** button.



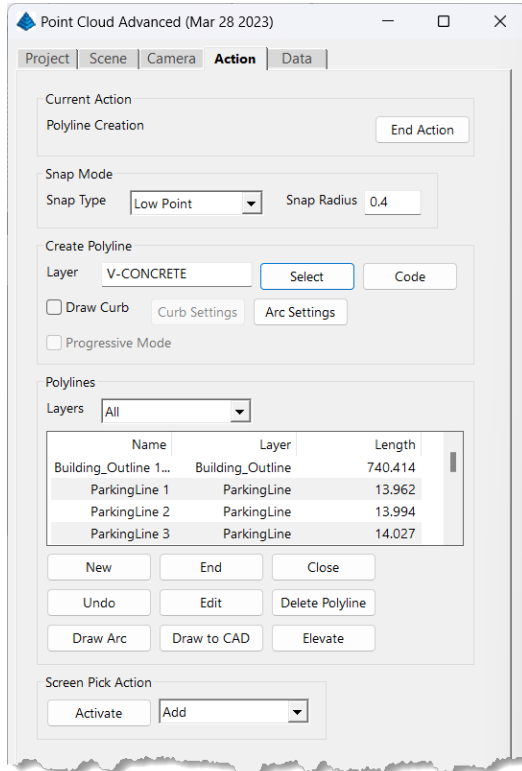
- Once finished, click **End Action**.
- Save the project.

Create Polylines

As mentioned, you will have challenging areas for automated extraction but the program has a few more tools. Let's start with creating polylines that behaves similar to creating a 3D polyline and includes a curb template tool. Note that, if you want to place points and generate linework, you can use the field-to-finish tools in Create Points (skip to the Field-to-Finish section next). For our lesson, we will add some linework around the concrete floor at the building entrance.

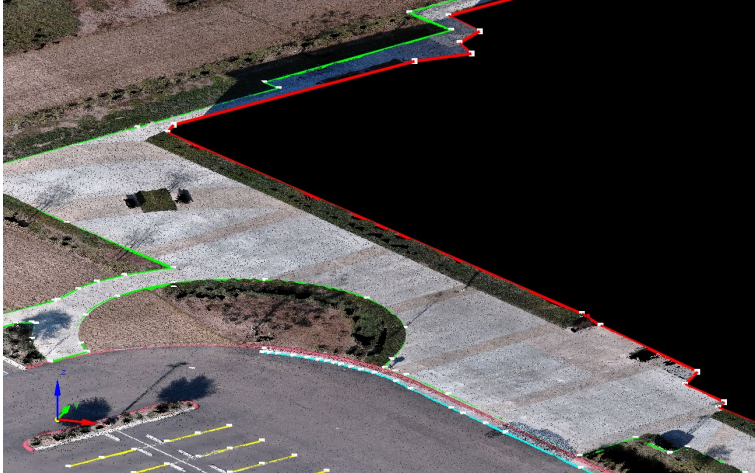
- Zoom around the building area.

- Open the *Action* tab, from the *Create* frame, click **Polyline**.



- Select **Low Point** from the *Snap Type* pull-down list. Note that there are multiple other options to choose from.
- Make the layer **Concrete**.
- Note that the *Screen Pick Action* is set to **Add**, which means that you will be creating new lines. Once again there are several other actions that will allow you to edit the polylines that you draw.
- Click **New** and now select points around the concrete patio. Note that there are options to draw arcs and that you can change the snap type to settings including endpoint to snap to other

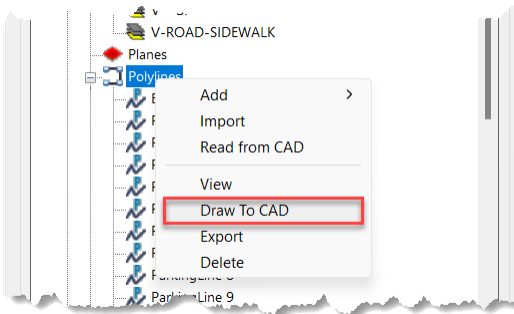
polylines. The image below is an example of the concrete patio drawn.



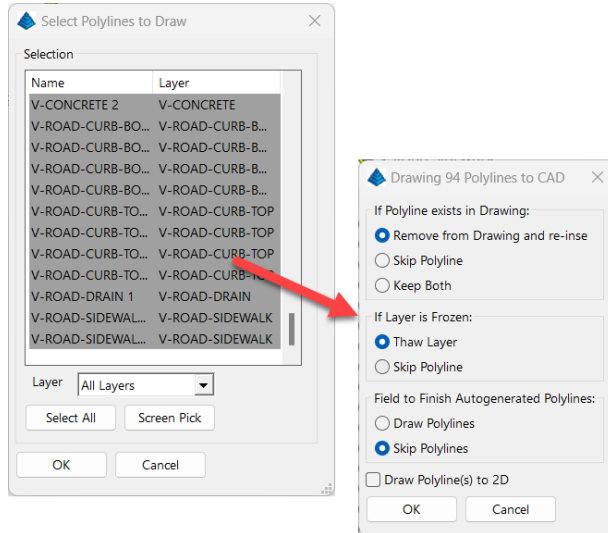
Draw Polylines to CAD

In so far, we have extracted or drawn multiple polylines, as you have realized a few more minutes of work will allow you to trace most of the linework necessary to complete the drawing. So, time to show you how to transfer the polylines from the point cloud manager to the drawing.

- Open the *Project* tab, in the *Project Tree*, right-click on **Polylines** and select **Draw to CAD**.

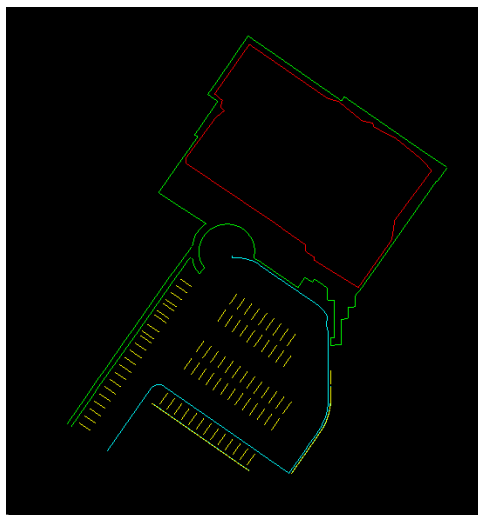


- In the *Select Polylines to Draw* window, click on **Select All** and then **OK**.



- Click **OK**.
- Click **OK** to the window confirming the lines were drawn.
- Minimize the *Point Cloud Manager* and zoom extents the CAD drawing.

The image below is an example after both extracting and drawing a good amount of linework.

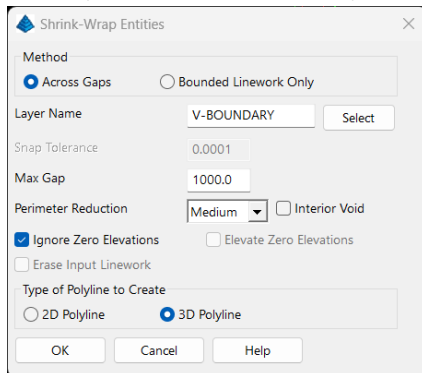


Creating an Exclusion Boundary

As we continue extracting data from the point cloud to create the topo for the project, we will create an exclusion boundary. The concept is that we have plenty of data from the 3D polylines so far to create a good model of the paved area of the parking lot and the building patio. To complete the data, we can extract points for the rest of the site. From a workflow point of view, you may also consider projects in

which you may want to mix data collected with a total station or GNSS receiver with data from the point cloud.

- In CAD, from the *Draw* menu, select **Shrink-Wrap Entities**.

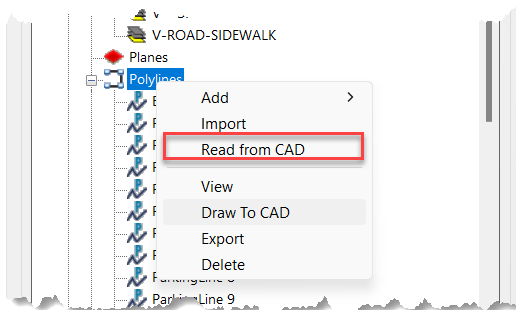


- Change the *Layer Name* to **Boundary**.
- The *Perimeter Reduction* can remain as **Medium**.
- For our purpose, it doesn't matter if the resulting polyline is in 2D or 3D. choose **3D Polyline** for simplicity and then click **OK**.
- Once prompted in CAD, select all the 3D polylines created so far and press ENTER.
- The software will create the enveloping 3D polyline.

Adding a Polyline from CAD

Now, let's add the exclusion boundary to our point cloud scene to illustrate how to you can bring data from your CAD drawing into your point cloud project.

- Restore or reopen the *Point Cloud Manager*.
- From the *Project* tab, in the *Project Tree*, right click on **Polylines**, and select **Read from CAD**.



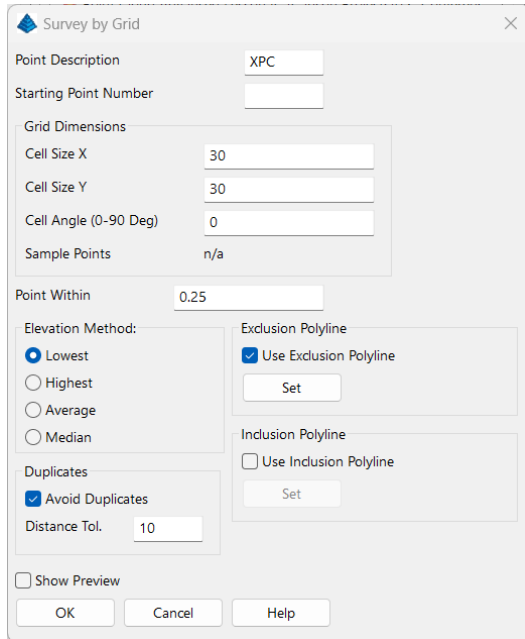
- Select the polyline we just drew and accept the warning message.

You will see the exclusion boundary now in the scene viewer.

Survey by Grid Points

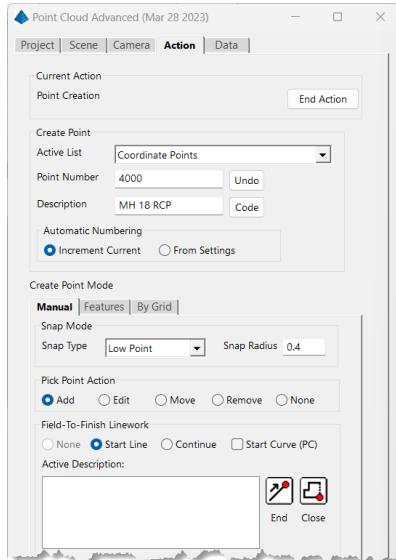
Alright, for the most we are only missing topo shots in the unpaved areas. We can get them extracted easily.

- From the *Project* tab, in the *Project Tree*, right click on the **03- Bare Earth** cloud under *Clouds*, then select **Survey by Grid**. Note that you can also access this command from the *Action* tab, *Create* then **Points**.



- Type a point description, I like a point code that distinguishes point cloud extracted points from regular measurements, for example XPC. X regular ground shot, XPC point cloud ground shot.
- For the starting point number, I also prefer a high number to differentiate from regular shots again. For example, 5000.
- As for grid dimension, this is computer time but for the lesson use 30 by 30 cells.
- Cell Angle* allows you to rotate/orient the grid to best fit the project. In this case we won't worry about this.
- Point Within* is a tolerance to resolve the grid point, keep the default value.
- Choose the *Elevation Method*, I recommend Lowest.
- Make sure *Avoid Duplicates* is on.
- Toggle on **Use Exclusion Polyline** and then click **Set**. Select the exclusion boundary polyline that we brought in from CAD.
- In this case we are not setting an *Inclusion Polyline* but you could use to extract points from a smaller area.
- Show Preview* will display the grid points allowing you to verify that you are getting the results you are looking for.
- Click **OK**.

- From the *Action* tab, *Create* frame click the **Point**.



- The *Active List* is set to **Coordinate Points**. Remember, we configured the point cloud manager to use the CAD project CRD file.
- Once again, I prefer a high point number to differentiate point cloud points from traditional instrument. For example, 4000.
- Code*, this allows you to tap into your field code table file (FLD) that you use in Carlson Survey and SurvPC for field-to-finish! To select a field code table (or find a code) click on **Code**.

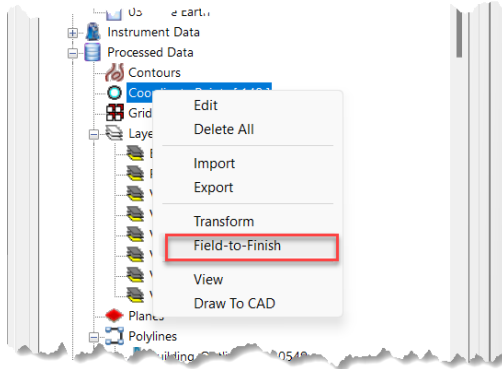
Note that you have tools to start line, add a curve (PC), end the line, and close the line. Which means that you could use this tool to place points and draw linework automatically as you are used in SurvPC.

- For this lesson, we will assume that the field code table includes a manhole code (MH). And, if the Pipe Feature is configured, we can add more descriptors. Type **MH 18 RCP** to field-to-finish placing a manhole symbol, draw and label that it is an 18" RCP pipe.
- The *Action* is set to **Add**, therefore you are ready to start placing points. Place the two manhole points one on the center of the road at the entrance and one further along in the parking lot.
- Right-click and select **End Current Linework**.
- Click **End Action**.
- Save the project.

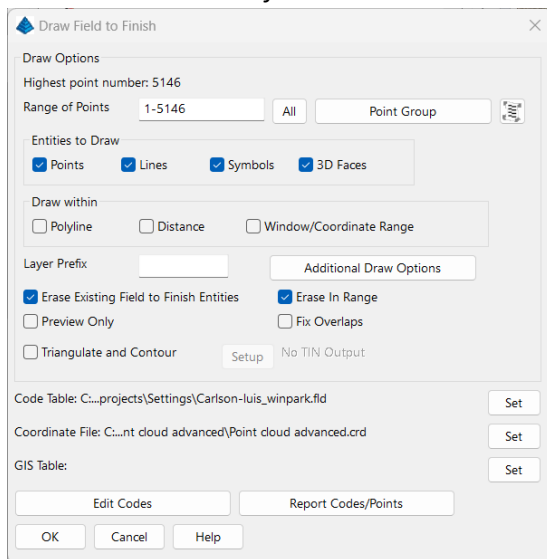
Drawing the Points to CAD

As we have already placed the lines in CAD, we just need to draw the point.

- In the *Project* tab, **right-click** on *Coordinate Points* and select **Field-to-Finish**

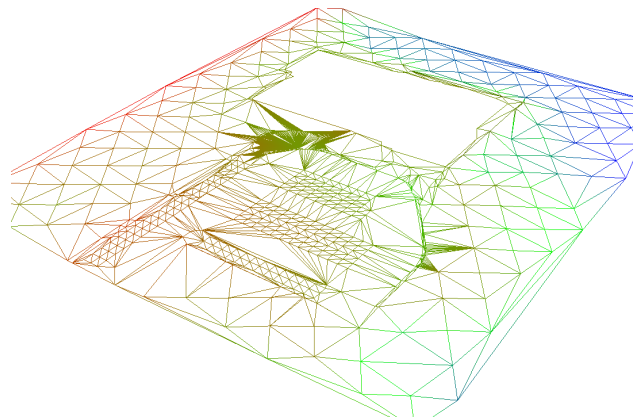
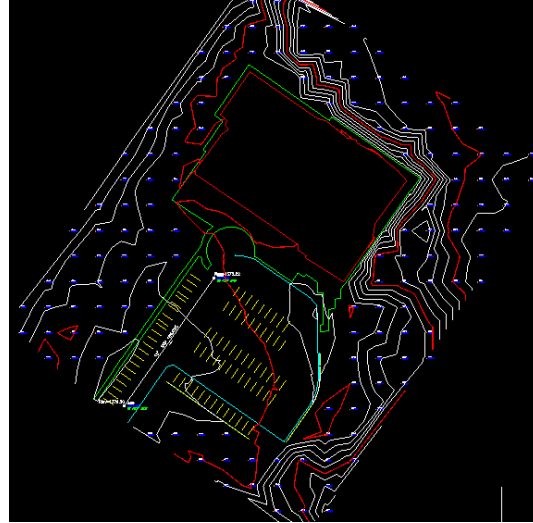
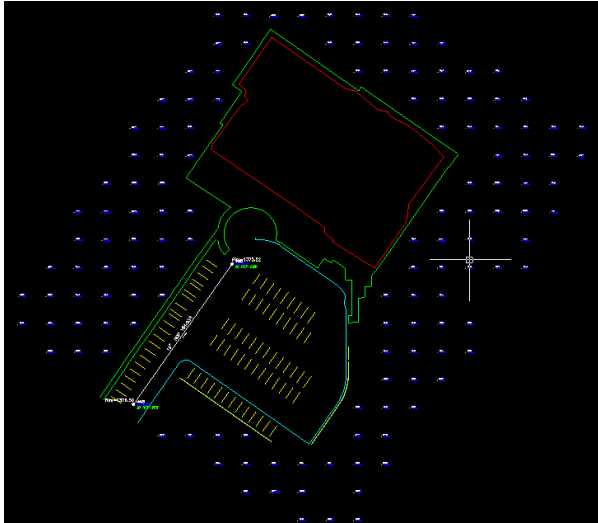


- In the *Draw Field to Finish* window, verify the field code table selected. For our lesson, this would be the *Carlson.fld* code table.



- Click **OK** and the points and lines will be processed in CAD.
- Save the project.

At this time, you can close the *Point Cloud Manager*. The drawing will look like the image below with all the linework and points that have been extracted. For this lesson, we will assume that you are already familiar with creating surfaces with Carlson. For reference, the contours and triangulation will look like the remaining images.



Other Tools

Lastly, and for reference, it is good to know that you can also extract powerlines, extract profiles, calculate volumes, create features such as poles and trees.