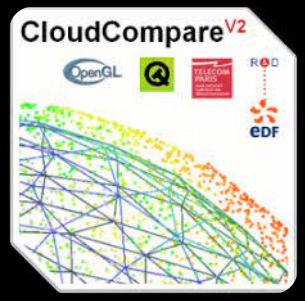
FLYABILITY

Volumes in complex environments and structures - Domes & Silos



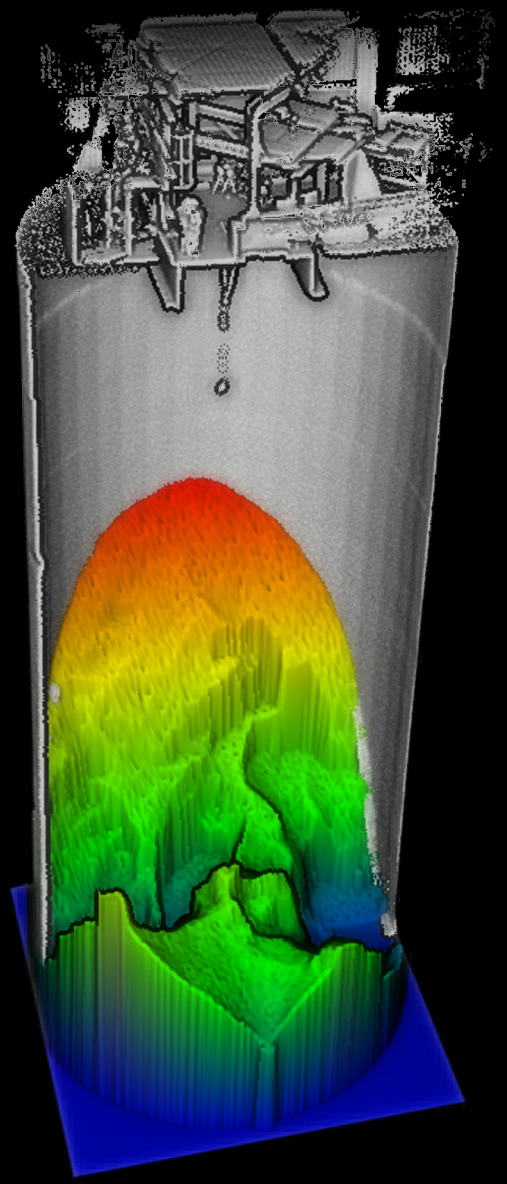


Table of Contents

Volumes in complex environments and structures - Domes & Silos

This document provides a detailed guide for measuring volumes in complex environments and structures. We discuss the use of Flyability's Inspector software alongside CloudCompare. The document is intended to provide information ohn how to do volume calculations with CloudCompare however we offer no support for this software as it is not managed by Flyability.

This volume measurement process is also demonstrated with stockpiles in this YouTube video.

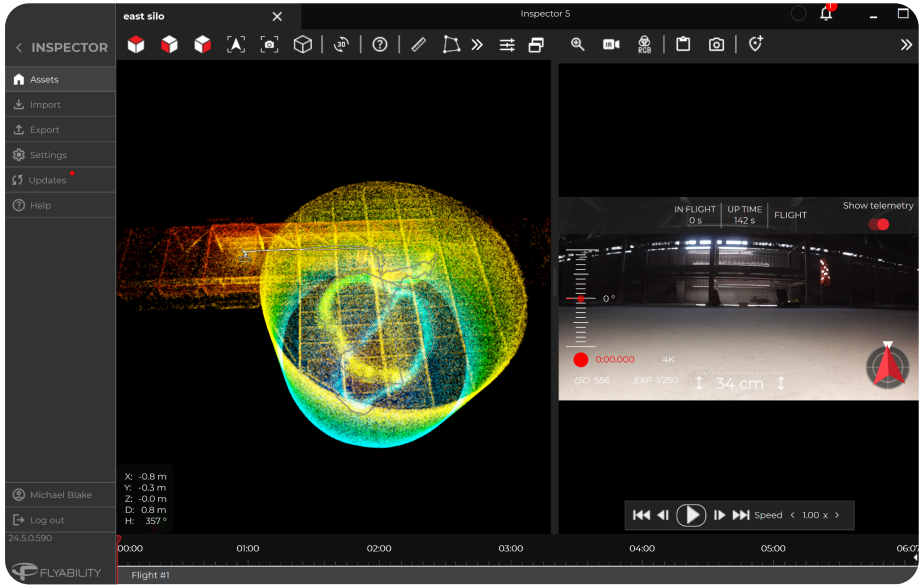
CloudCompare

CloudCompare is used to process the data and compute the volumes

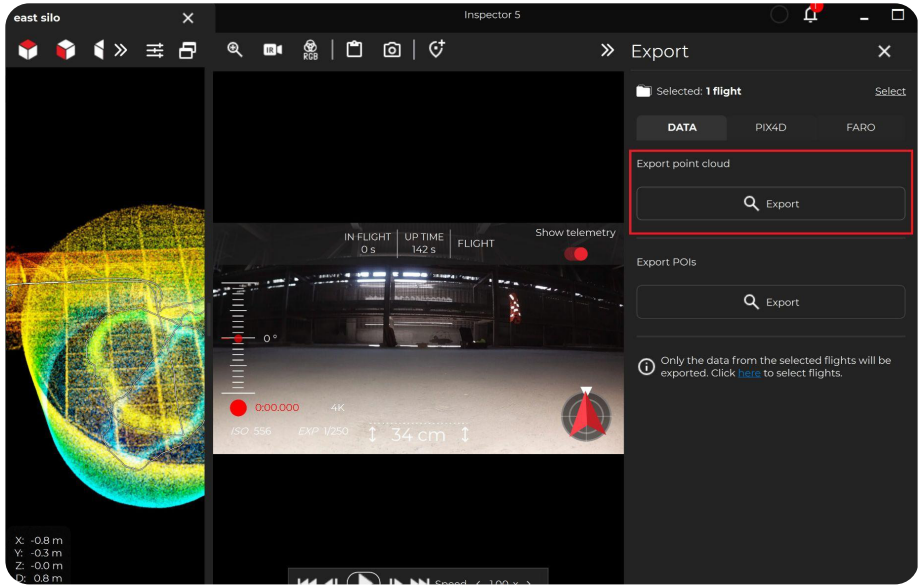
Free download here:
https://www.danielgm.net/cc/

Inspector 5

To export the Point Cloud data from Inspector 5
Open the Asset and the flights in question.



Next: Go to Export tab -> Export Point Cloud
Name and Save to a local drive.



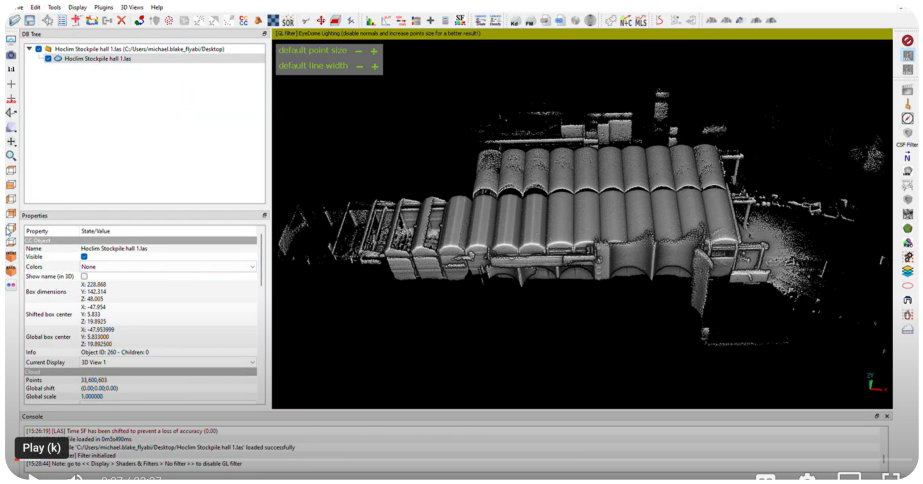
Stockpile Halls

Step 1. Opening the Las File

- Open Cloud Compare
- Drag and Drop the LiveLas file directly from your drive into Cloud Compare
- Click - Apply All

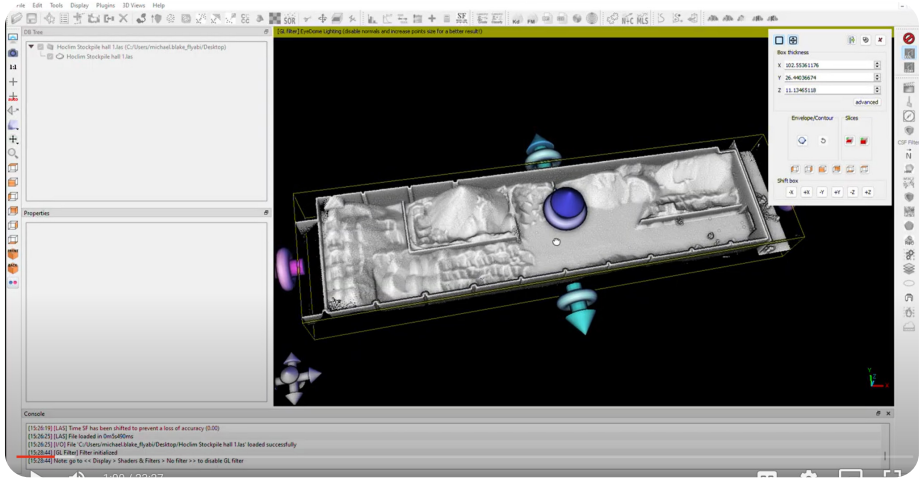
Step 2. Setting Visuals

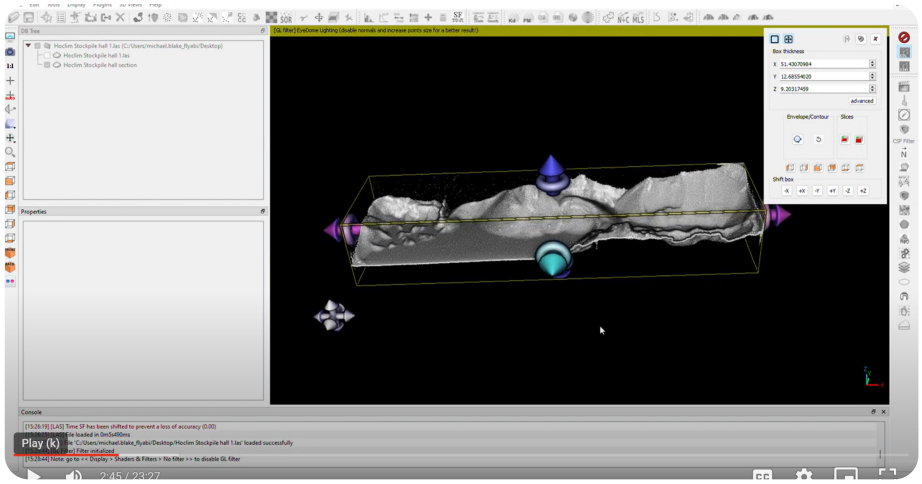
- In the priorities tab:
- Select - Colors - None
- EDL (Eye Dome Lighting) Switched on



Step 3. Section and clippin

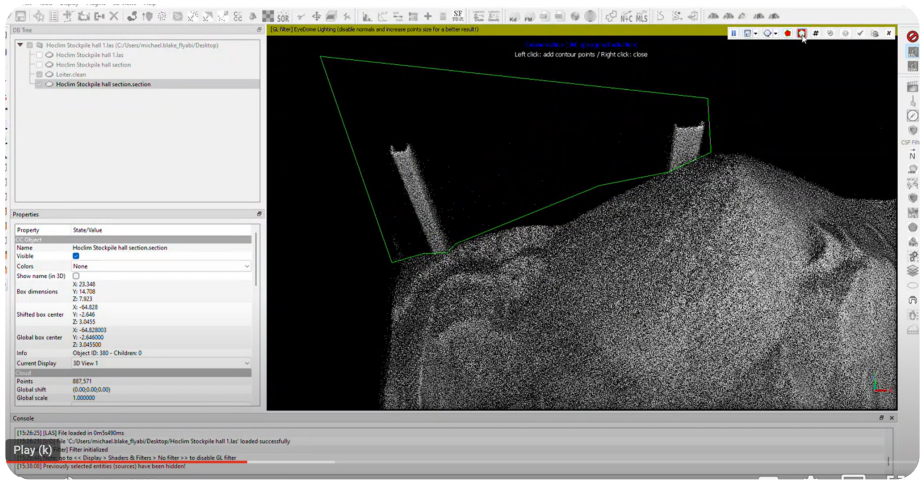
- Section tool - Utilize the section tool to segment the point cloud into separate stockpiles.
- Make sure to remove as much of the vertical retaining walls and structure, only the floor level needs to be maintained.
- Once complete, slice the point cloud to make a copy of the newly segmented section.





If there are some outstanding wall or structural elements remaining, utilize the clipping tool.

- Select the newly segmented point cloud
- Select the clipping tool.
- Manually rotate the point cloud into a viewable position which displays the remaining plant structure.
- Draw and polygon around the point cloud sections that need to be removed.

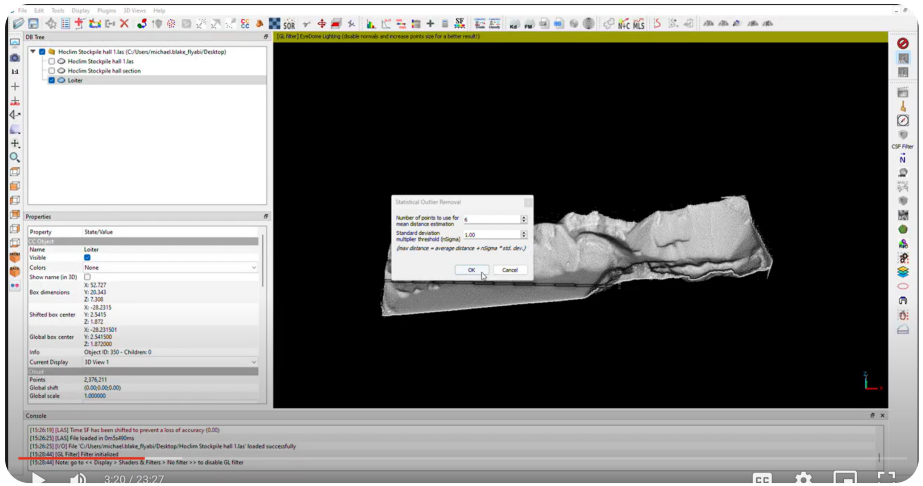


- Use the ‘Segment out’ tool to remove the unwanted points.
- Click the green tick button to split the point clouds and isolate the unwanted points.
- Hide or delete the point cloud with the unwanted points.

Step 4. Point Cloud Cleaning

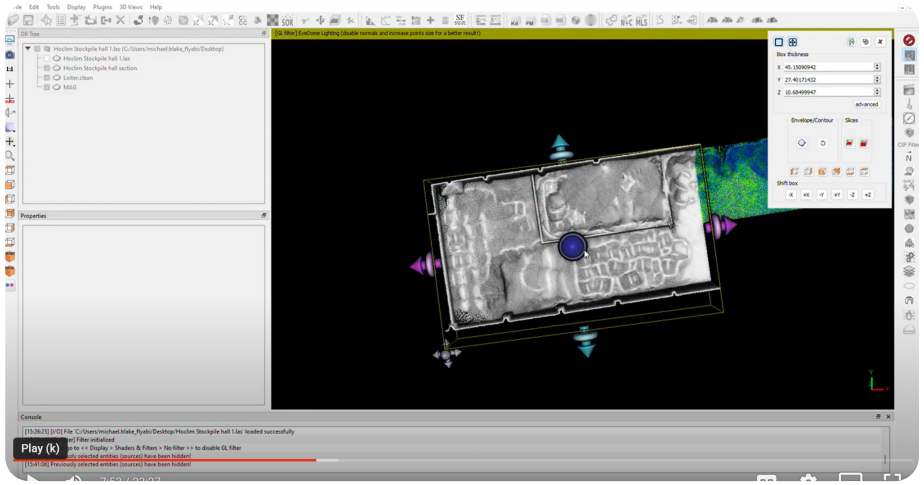
Especially for dusty conditions, it is a good idea to make an additional point cloud cleaning on the final segmented point cloud, before measuring the volumes.

- Go to- Tools -> Clean
- Select - SOR filters
- Set mean distance estimation to **6**. Standard Deviation **2**.

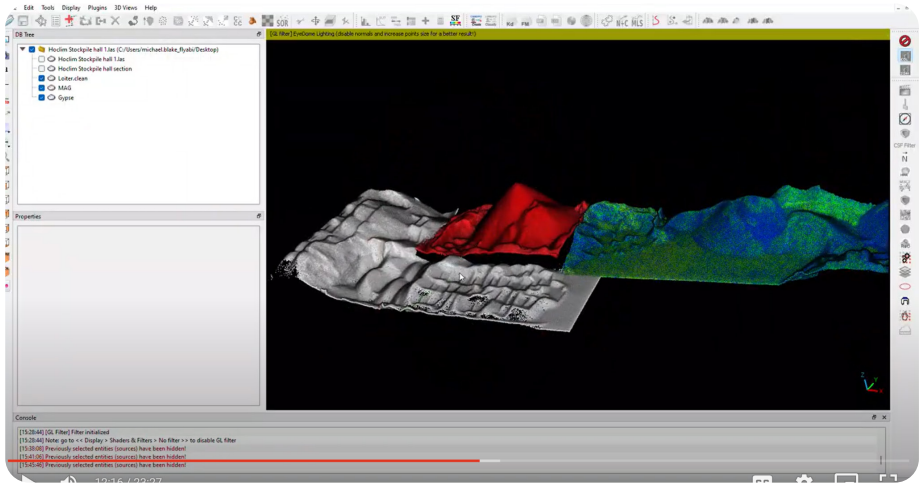


- You will now have a cleaned pointcloud ready for volume measurement.

Continue to segment the main point cloud into individual point cloud stockpiles so that each stockpile is represented by an individual point cloud and can be independently measured.



Example below of the segmented and separated stockpiles for Gypse, MAG and Laiter.



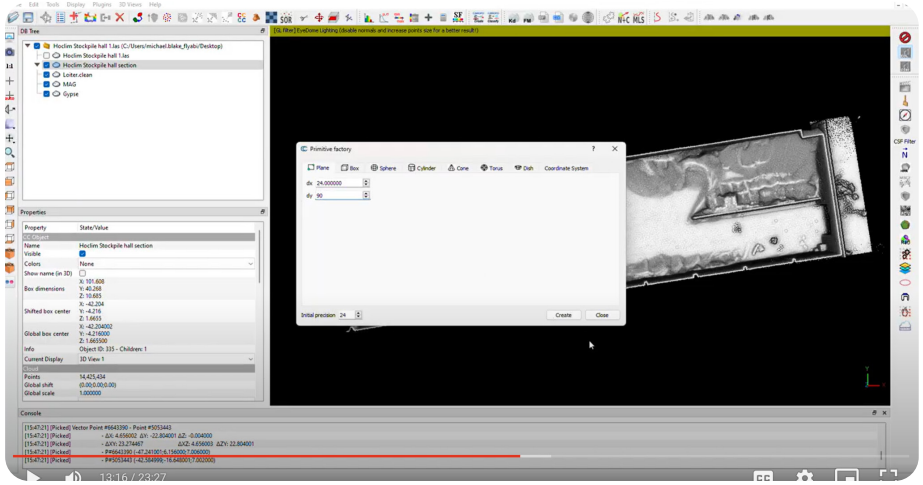
Step 5. Setting the reference

Before making the volume computation, a floor or reference level needs to be set.

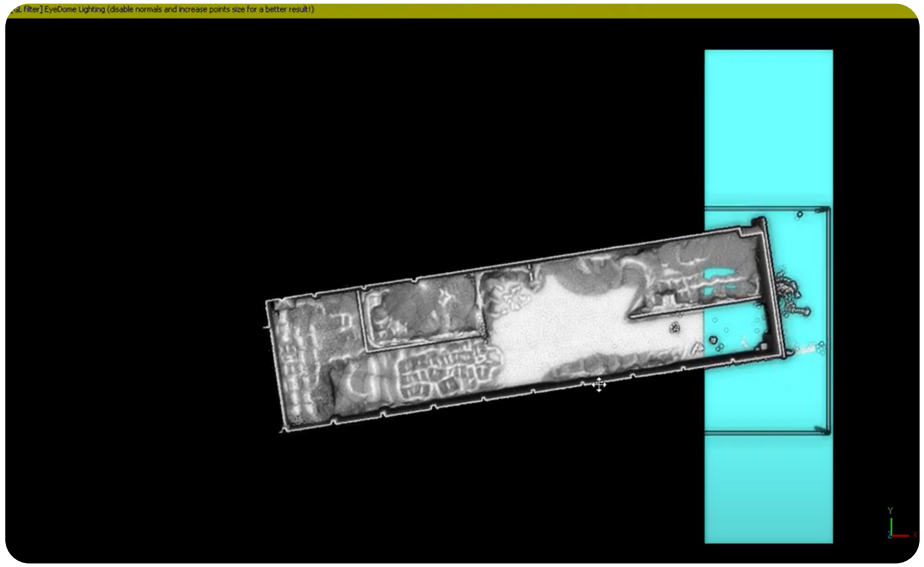
To do this, we will use the Primitive Factory tool to set a plane as the reference level.

Go to:

- Primitive factory tool
- Select Plane - Set the length and width of the floor plane (The measurement can be taken from the point cloud but it does not have to be precise)



- This will add a 3D Plane mesh into the viewer.



To Align the floor plane to the pointcloud.

Go to:

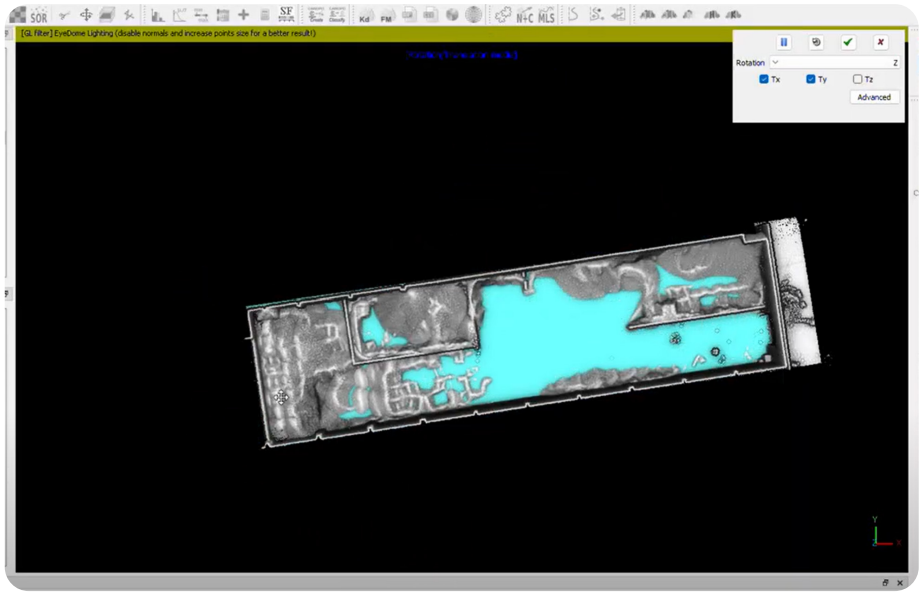
Select the Plane layer on the left hand side.

Choose the Translation tool feature

For rotation - Set to Z only.

For translation, select X & Y only.

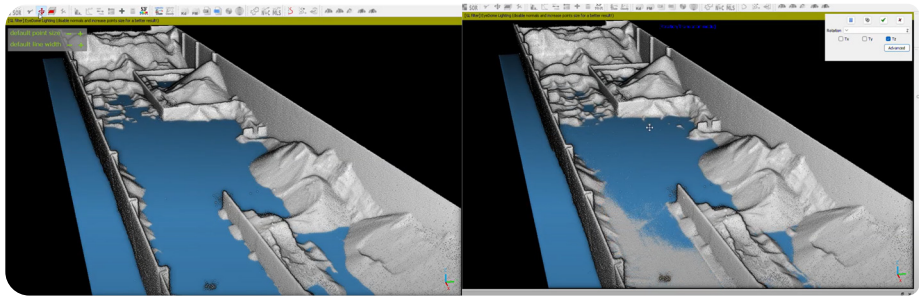
Rotate and translate the floor plane into the correct position on the X, Y axis.



To set the floor level:

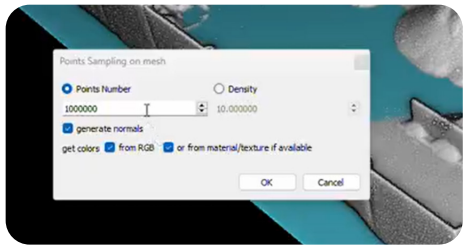
- Select the Plane layer on the left hand side.
- Choose the Translation tool feature
- For rotation - Set to Z only.
- For translation, select Z only.

Adjust the height of the floor plane on the Z axis so that the plane aligns with the top surface of the pointcloud as per the images below.

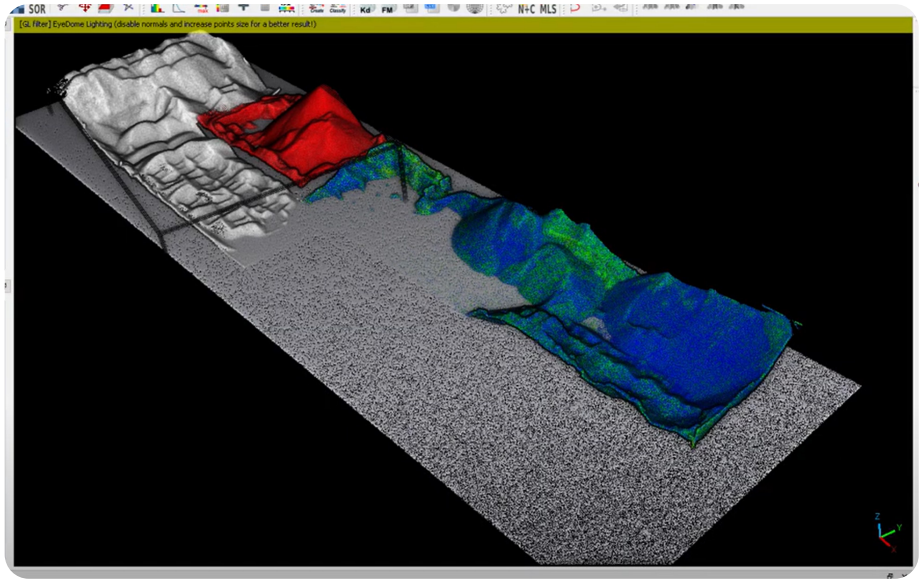


The last item in the step before computing the volume is to convert the Floor Plane 3D mesh into a sampled Point cloud.

- Select the Floor plane on the left hand side layers
- Go to - Point Sampling on Mesh tool.
- Set point numbers to 1000000 (Usually more than enough)
- Press ok.



The floor plane has now been subsampled into a point cloud and is ready for Volume computation.



Step 6. Measuring the volumes

To measure the volumes of each individual stockpile:

Firstly select the floor plane pointcloud and the point cloud volume to be measured.

Next go to:

- Tool-> Volume -> Compute 2.5D volumes
- The Volumes Computation tab will open as below.

To calculate the volume of the Stock in the dome, utilize the Volume Calculation 2.5D tool

Presets:

Ground /Before

- Source - Floor Plane
- Cells - Interpolate

Ciel/After

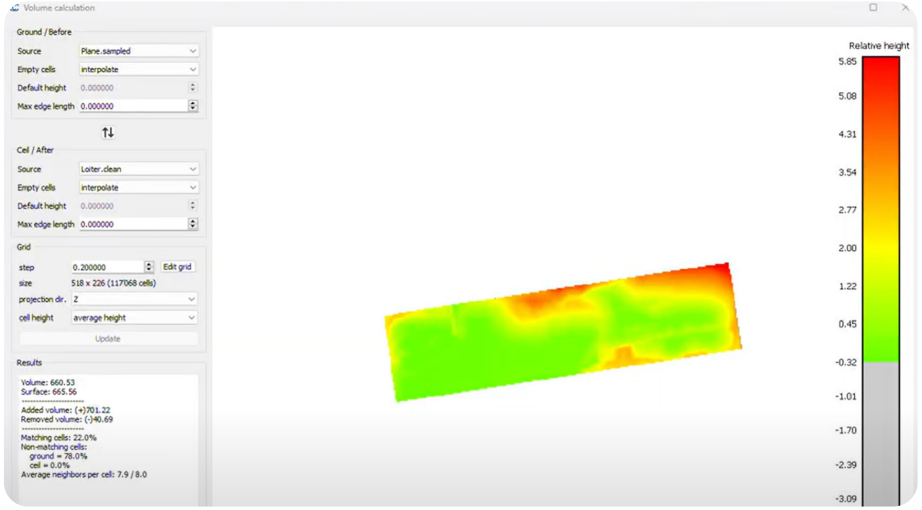
- Source - Pointcloud of Volume
- Cell -Interpolate
- Default Height - 0.0000

Grid

- Step - 0.200m
- Projection -Z axis
- Ceil Height - Set to Average height

Num Precision - Set to 1 or 2

Press -Update



Total volume in this example is **701m³.**

Do the same for each individual stockpile to complete.

Volumes in Silos

Step 1. Flight Plan

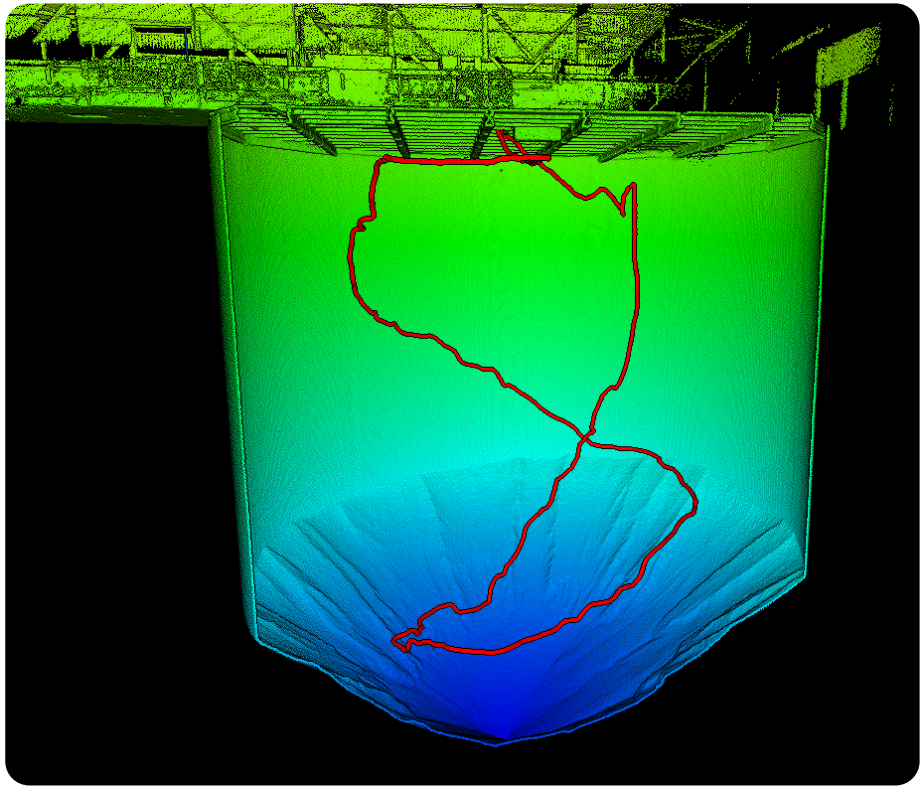
When flying inside a Silo, it is really important to achieve 100% coverage.
Due to the amount of suspended dust inside the silo, some simple produces can be followed:

- Only use the Rev 7 Survey Lidar, the Rev 6 may not be able to penetrate the dust.
- When entering the silo, fly close to the room until you meet the silo wall.
- Once you meet the silo wall, descend in a spiraling pattern along the wall, down to the actual dead stock material. This is to maintain lidar assist during the flight and avoid the drone losing lidar fix and switching to Atti mode.
- The front facing camera may be blocked from view due to the dust. Switch to the Lidar map on Cockpit and use the map to Navigate.
- Once the stock is reached, continue to fly in a spiral pattern until all of the deadstock is covered on the live map.
- To ascend out of silo, continue to use the spiral method and maintain a few meters distance from the wall.

Please follow the steps as per the Flyability training video on safe operation inside a silo

Cement inspection tutorial: Silo Preparation and Inspection

Example below

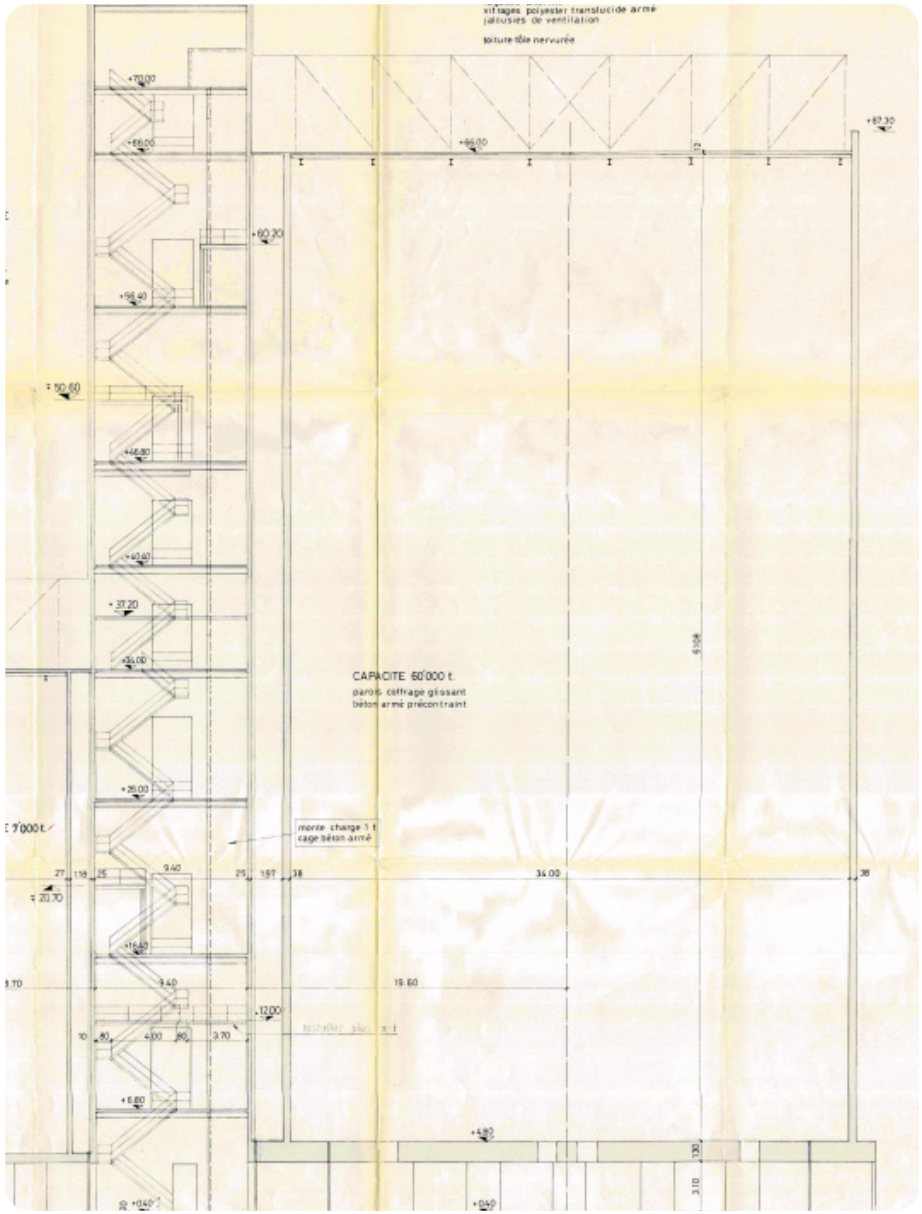


Step 2. Silo empty volume computation

To calculate the ‘Dead Stock’ volume remaining in the Silo, use the inverse volume method.

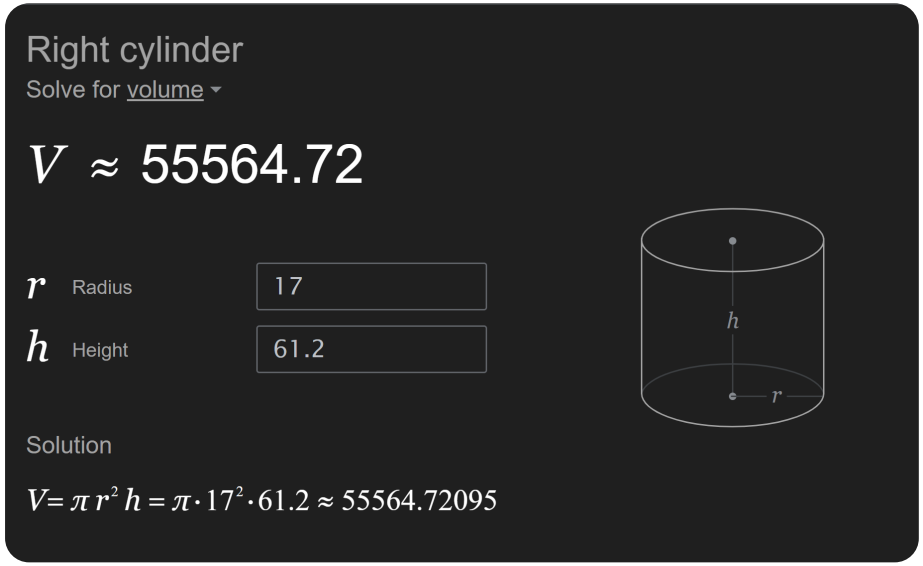
For this, we will need to understand the total volume of the silo and take away the empty volume of the silo from the total volume.

It is important to be able to understand the entire volume of the silo. For this, usually, there are some old construction drawings of the silo with the radius and height.



Simple trigonometry is used to work out the total volume of the right cylinder.

Total volume is as follows in this example.

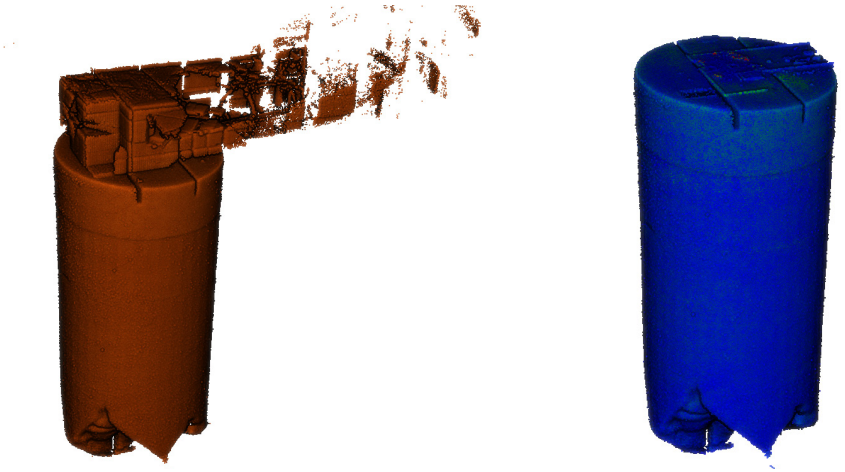


Step 3. Editing the Point cloud

Step 1

Import Flight into Cloud Compare.

Trim the unnecessary elements of the structure (Galleries and rooms) from the Silo itself so just the silo structure remains.



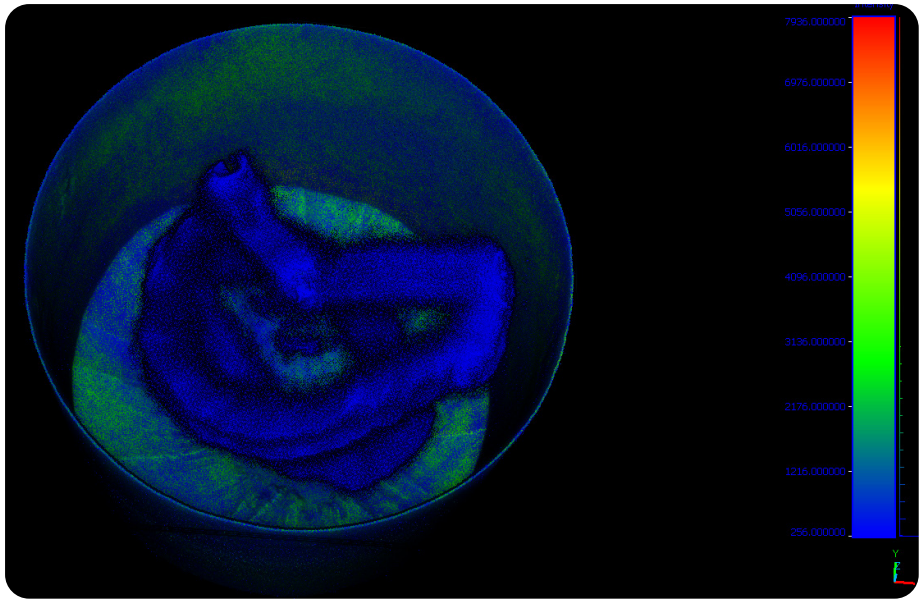
Step 2

Due to the amount of suspended dust inside the silos, this causes a large amount of transient dust which follows the trajectory of the drone. This dust snake will need to be removed so it does not affect the overall volume computation.

Below is an example of the high intensity dust trail in the silo caused by the drone.

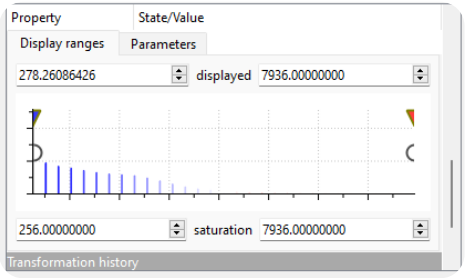
In the property tab go to:

- CC Object - Colors - select Scalar field
- In the Colour Scale tab, Select - Blue>Green>Yellow>Red
- Steps -256 by default.

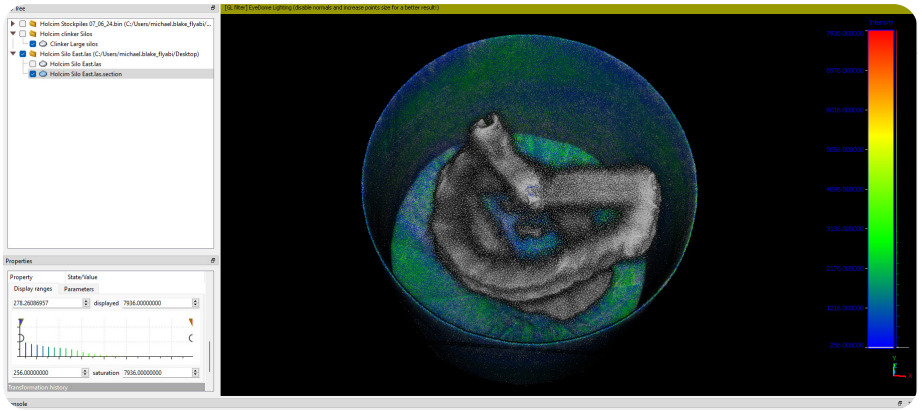


In the property tab on the left hand side:

- Adjust the top display range from 256.00 to 270-280



This will select the high intensity points caused by the drone's dust trail.

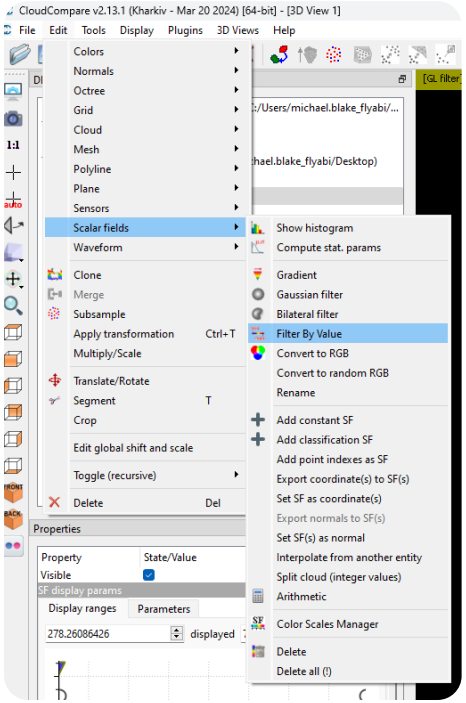


To remove the dust trail go to:

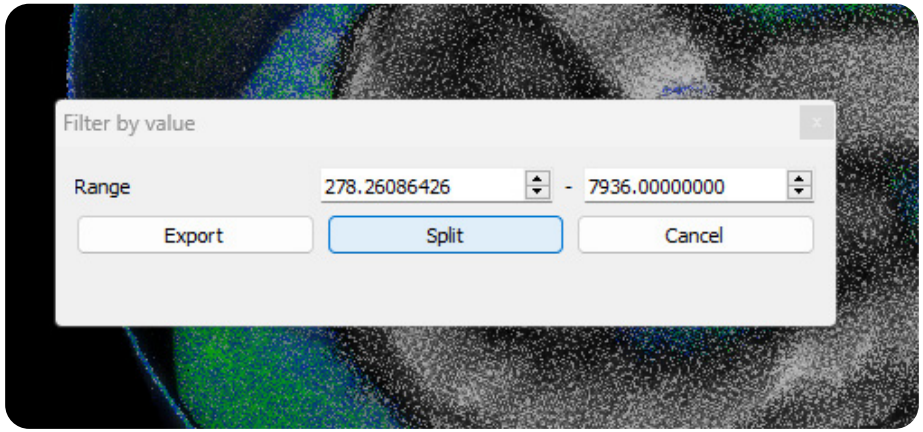
GO to the Edit tab:

- Scalar fields - Filter by Value.
- The range will already be selected previously
- Select - Split.

This will create a new point cloud, without the dust trail of the drone.

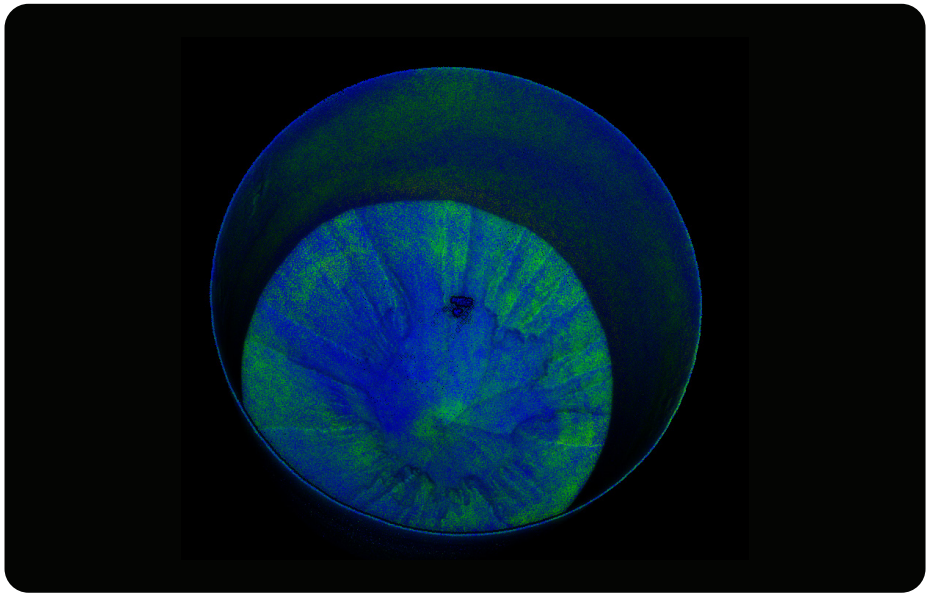


Split the point cloud



Delete the unwanted point cloud and only retain the cleaned point cloud.

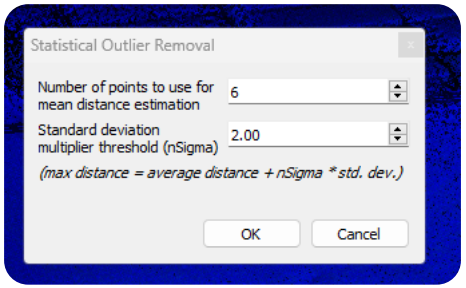
- Las.extract.inside



If there is still some excess noise or dust in the pointcloud.

Use the SOR filter:

- Neighbors set to - 6
- Standard Deviation - 2



Step 4. Calculate Volume

To calculate the volume of the Stock in the dome, utilize the Volume Calculation 2.5D tool

Presets:

Ground /Before

- Source - Constant
- Default Hiehgt - 0.000

Ciel/After

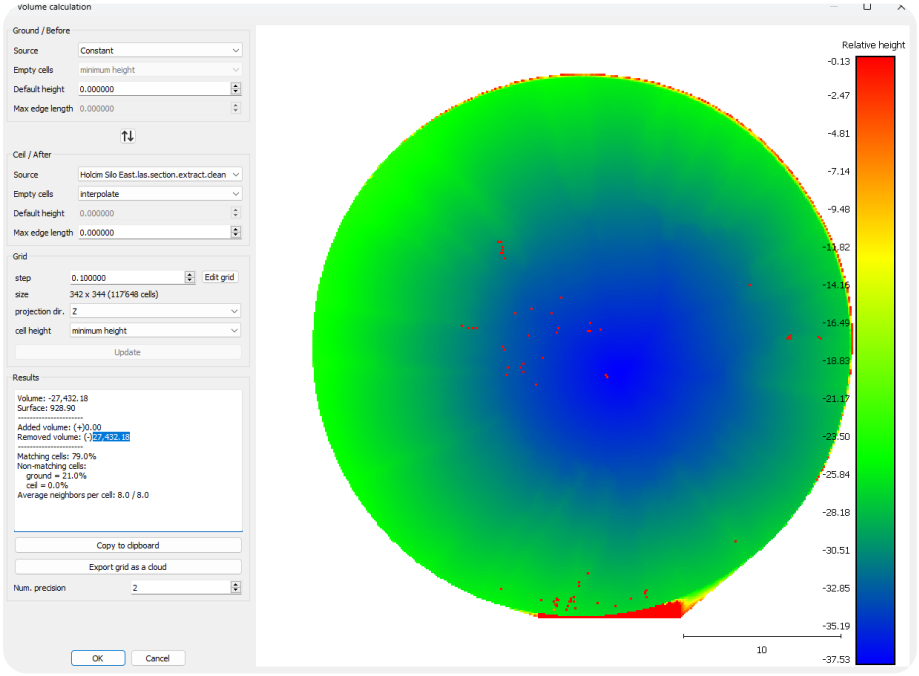
- Source - Pointcloud of Flight volume section
- Cell -Interpolate
- Default Height

Grid

- Step - 0.1m
- Projection -Z-axis
- Ceil Height - Set to Minimum to reference the lowest level of the empty volume.

Num Precision - Set to 1 or 2

Press -Update



Removed Volume = **27,422m³**

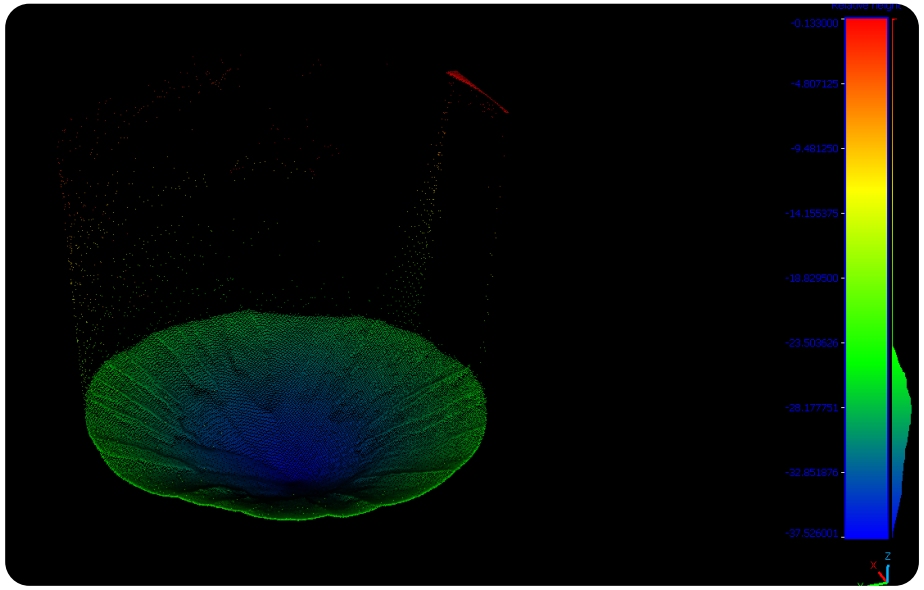
Step 5. Dead Stock volume

Total volume of the **dead stock.**

55565m³ - 27,422m³ = <u>28,143m³</u>

Export grid as a cloud.

- This is to check whether the reference was correctly selected



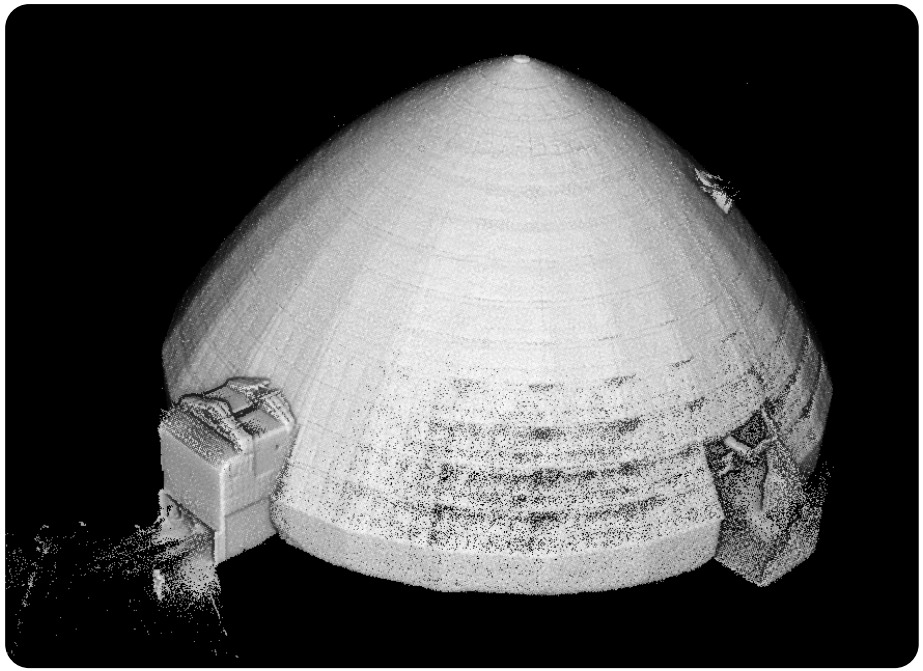
The export grid to cloud tool is useful to visually check if the volume has been computed from the lowest point of the flight, which represents the top surface level of the stock.

Dome Structure

For Dome structures, either the stockpile methodology can be used (removing the building structure and adding a floor as a reference plane) or the Silo inverse volume method can be used. Which one is more suitable depends on the size of the Dome and how much capacity is currently inside (the floor is totally covered and no location to take a floor plane reference from)

Step 1. Opening the Las File

- Open Cloud Compare
- Drag and Drop the LiveLas file directly from your drive into Cloud Compare
- Click - Apply All



Step 2. Section and clipping

Use the clipping tool to remove all of the surrounding dome structure so as to only reveal the stockpile material. This is the exact same procedure as the stockpile clipping workflow.

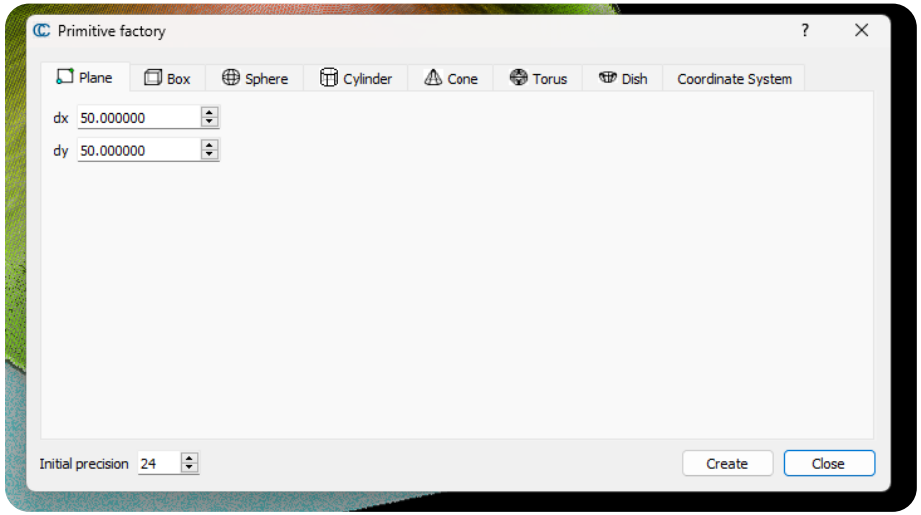
Especially for dusty conditions, it is a good idea to make an additional point cloud cleaning on the final segmented point cloud, before measuring the volumes.

- Go to- Tools -> Clean
- Select - SOR filters
- Set mean distance estimation to **6**. Standard Deviation **2**.

Step 3. Setting the reference

The Primitive factory tool to add a floor plane.

- Primitive factory - Plane
- Select the size of the floor plane

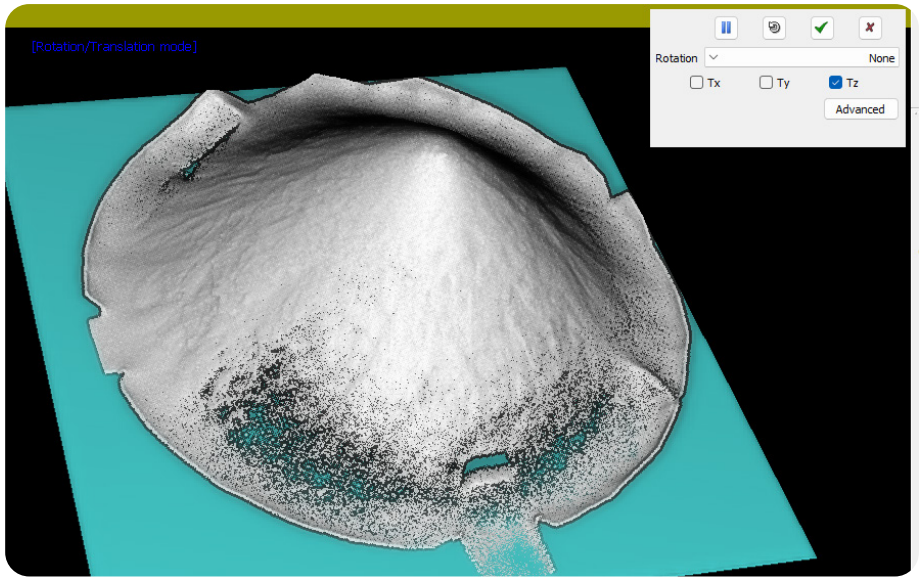


To Align the floor plane to the pointcloud.

Go to:

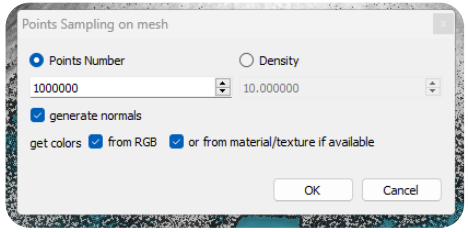
- Select the Plane layer on the left hand side.
- Choose the Translation tool feature
- For rotation - Set to Z only.
- For translation, select X & Y only.

Rotate and translate the floor plane into the correct position on the X,Y axis.



In this case, the floor reference was taken from the entrance to the stockpile dome as the internal floor was completely covered.

The last item in the step before computing the volume is to convert the Floor Plane 3D mesh into a sampled Point cloud.



- Select the Floor plane on the left hand side layers
- Go to - Point Sampling on Mesh tool.
- Set point numbers to 1000000 (Usually more than enough)
- Press ok.

Step 4. Measuring the volumes

To measure the volume of the internal dome stock,
Firstly select the floor plane pointcloud and the point cloud volume to be measured.

Next go to:

- Tool-> Volume -> Compute 2.5D volumes
- The Volumes Computation tab will open as below.

To calculate the volume of the Stock in the dome, utilize the Volume Calculation 2.5D tool.

Presets:

Ground /Before

- Source - Floor Plane
- Cells - Interpolate

Ciel/After

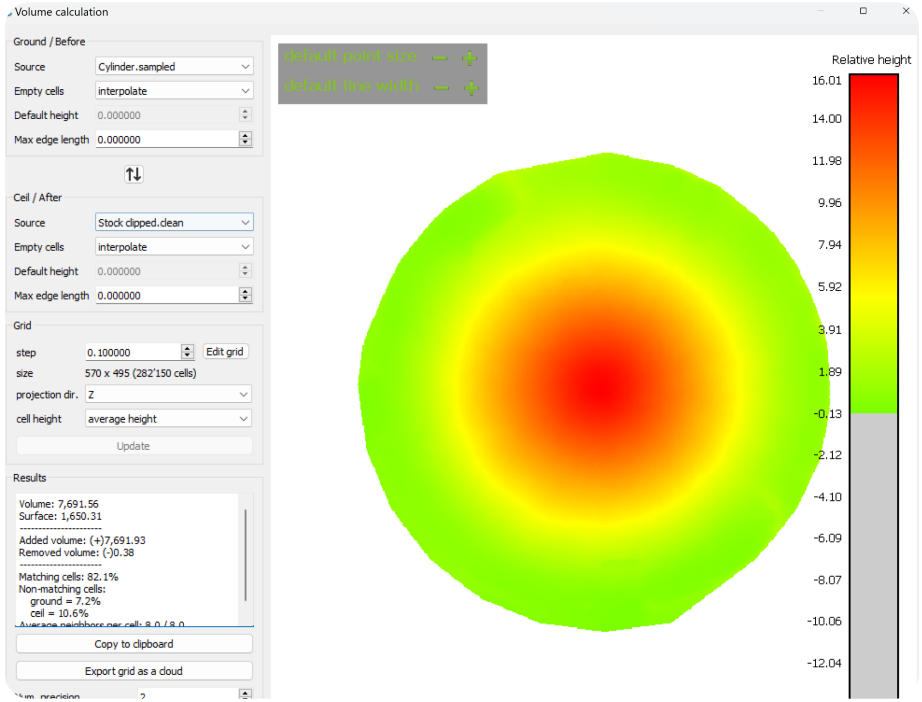
- Source - Pointcloud of Volume
- Cell -Interpolate
- Default Height - 0.0000

Grid

- Step - 0.200m
- Projection -Z axis
- Ceil Height - Set to Average height

Num Precision - Set to 1 or 2

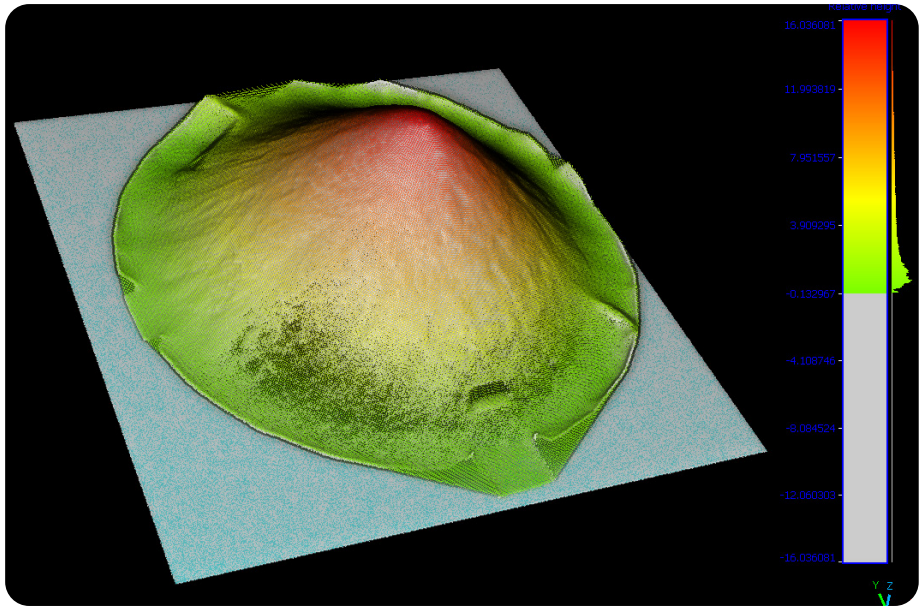
Press -Update



Total volume in this example is **7691m³**.

Export grid as cloud.

- This is to check whether the reference was correctly selected



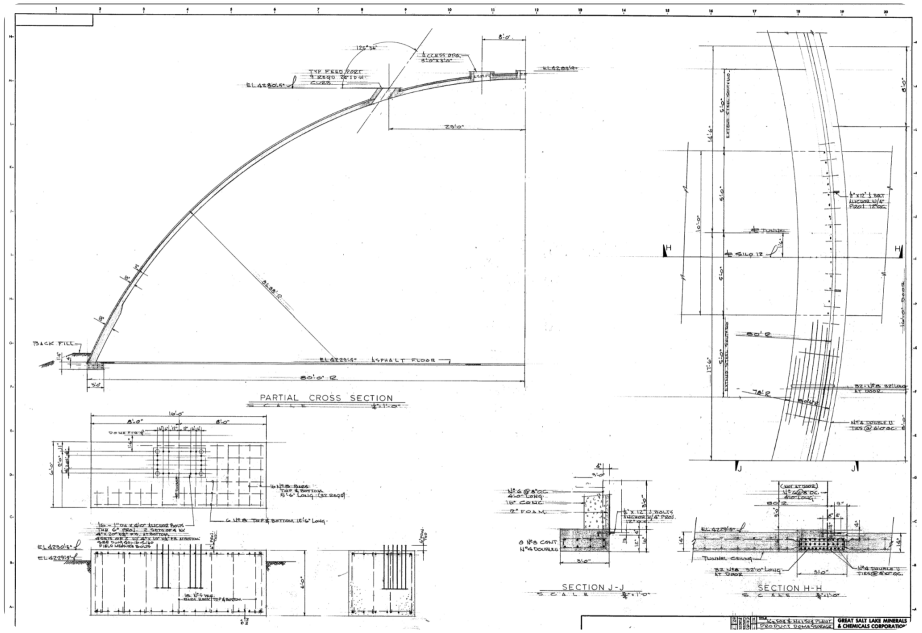
Dome Inverse Volumes method

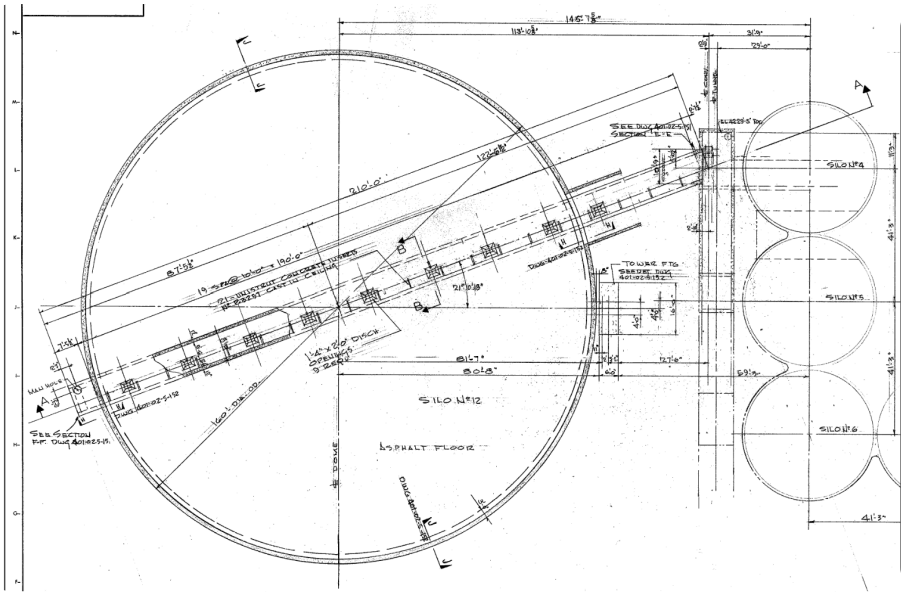
To calculate the ‘Dead Stock’ volume remaining in the Dome, it is possible to use the inverse volume method, similar to computing the volume in a silo.

For this, we will need to understand the total volume of the Dome and take away the empty volume of the Dome from the total volume.

It is important to be able to understand the entire volume of the volume. For this, usually, there are some old construction drawings of the silo with the radius and height.

Example below.

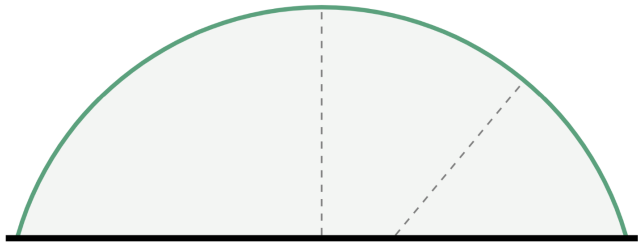




Spherical Dome Calculator

BY DAVE SOUTH UPDATED 11 APR 2023 CALCULATORS »

Diameter	Height	Stem Wall	Level	Overlay	Units	
80	30	0	0	none	ft	Go



Floor: 80.00 ft diameter		Dome: 30.00 ft height	
Radius	40.00 ft	Radius of Curvature	41.67 ft
Circumference	251.33 ft	Surface Distance	53.63 ft
Area	5,026.55 ft^2	Surface Area	7,853.98 ft^2
		Volume	89,535.39 ft^3

The 2D as built drawings will have enough information to be able to calculate the dome volume. The main measurements needed are the overlap height and diameter of the internal surface of the dome.

Follow the Silo workflow to compute the Inverse Volume of the Dome.

FLYABILITY

Check out our case studies to discover other ways to use the Elios