GEM4D DOCUMENTATION

Reconstructing a Surface from a Point Cloud

User Manual

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This manual shows you how to turn a scanned point cloud into a triangulated surface in GEM4D. The scan can be LiDAR or photogrammetry of a drive, a stope, a face or a stockpile. You can paint the scan's own colours onto the surface, or leave it plain.

> **Accuracy.** A reconstructed surface is an interpolation of the points, not a survey. It follows the points to within about one grid cell (about 0.2 m at the default settings). It smooths out detail smaller than the voxel cell (§3.1). It also adds new geometry wherever **Repair surface** or **Cap openings** fills a gap. Compare the surface with the cloud before you use it for volumes, profiles or stability analysis.

How to use this manual

If you want to…	Read
Get a surface from a scan quickly	§2 Quick start
Understand the few ideas that matter	§3 Key ideas
Load a LAS/LAZ file and choose how many points to keep	§4
Cut part of a cloud away, or split it off and save it as LAS/LAZ	§4.5
Clean stray points out of a cloud	§5
Look up a setting in the reconstruction dialog	§6
Know what happens when you press OK, and keep the result	§7
Find settings for a particular job	§8 Recipes
Fix a poor result or understand a message	§9 Troubleshooting
Check a default or a range	§10 Reference

1. What this covers

Two tools work together, and stray points are removed by themselves on the way (§5):

Tool	Where	What it does
Reduce point cloud dialog	Opens every time you load a LAS/LAZ file	Thins the cloud as it loads. Also asks whether you want to keep the points or go straight to a surface.
Reconstruct surface from points	**Toolbox 1**	Builds the surface.

Toolbox 1 is a drop-down button on the scene toolbar. It shows an icon only; hover over it to see its name.

The result is either a **mesh** (one plain colour) or an **Image**. An Image is a surface with the scan's colours painted on as a picture (a *texture*). Images are managed in the Image panel, which is described in `Image_Objects_Manual.md`.

This manual is the only one that covers loading LAS/LAZ files. It does not cover mapping joints from a cloud (**Map Discs ▸ Auto mapping from points**, see `Wedge_Facet_Mapping_Manual.md`; **Map Discs ▸ Best fit disc on point cloud** fits one mapping disc to the points under a rubber band) or saving a cloud in a project file (see `Project_File_Manual.md`).

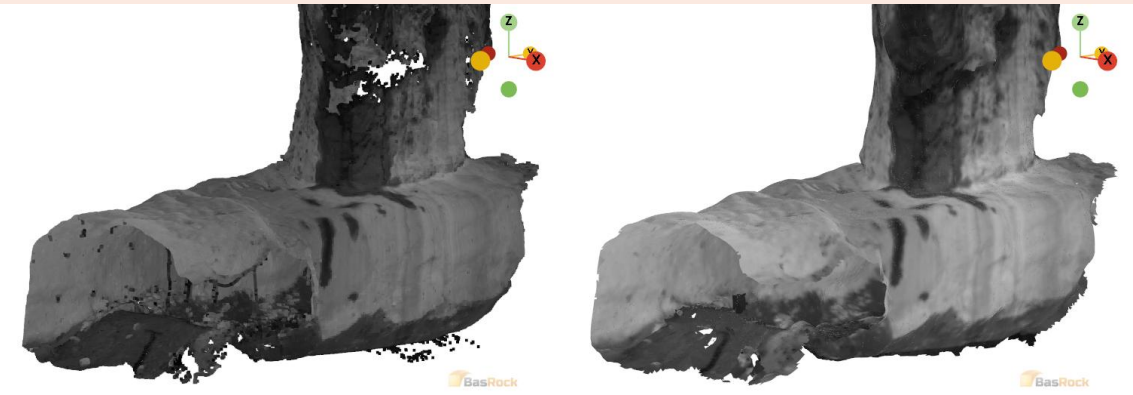


Figure 1 — A shaft scan shown as a coloured point cloud (left) and the textured surface reconstruction (right).

2. Quick start

Route A — straight from a file to a surface

Use this route when you only want the surface, not the points.

1. Click **Mesh** ▸ **Load other formats** ▸ **Other formats** ▸ **Point cloud (LAS/LAZ)** and choose the file. You can also drag the file onto the scene.
2. In the **Reduce point cloud** dialog, select **Create a mesh surface from the points, after which the points are removed**. GEM4D selects **Voxel downsample** for you. Click **OK**.
3. The **Reconstruct surface from points** dialog opens on **Auto (recommended)**, or on the preset you chose last unless that was Custom. Click **OK**.
4. A progress window shows each stage. **Cancel** stops the run.
5. Save the result:
   - **Without colour,** a Save dialog asks for a DXF file name. **Save the file. If you cancel this dialog, the new surface is deleted.**
   - **With colour,** GEM4D asks whether to save the surface as a textured OBJ. **Yes** writes an `.obj`, an `.mtl` and one or more `.png` files. **No** keeps the surface in the scene, unsaved.
6. Only the surface is shown; the points are released. If you cancel a later step, or the run fails, the points are added to the scene instead, and the Info panel says so.

Route B — keep the cloud and build the surface later

1. Load the file as in Route A, but keep the default choice, **Load the points cloud into the scene using the reduction options below**.
2. Hide every object you do not want in the surface. Reconstruction uses **all** visible meshes and clouds (§3.4).
3. Click **Toolbox 1** ▸ **Reconstruct surface from points**, then **OK**.
4. Save the result as in Route A, step 5.

3. Key ideas

3.1 The voxel cell sets the detail

A **voxel** is a small cube of space. *Voxel downsampling* keeps one point for each cube that contains points. That point sits at the average position of the points in the cube and carries their average colour. The result has an even density, which is the best input for building a surface.

In the reconstruction dialog, **Voxel downsample cell (m; 0 = use all)** is the main control. The finished surface shows detail of about this size. The Auto preset uses **0.25 m**. Underground excavation scans are rough and noisy, and below about 0.25 m most of what you see is scanner noise. A larger cell gives a smoother surface and a faster run. A smaller cell gives finer detail, but the run is slower and the surface is noisier.

The load dialog also has a voxel option (§4). It controls how many points come into GEM4D. **The surface detail follows whichever of the two voxel cells is coarser.** For example, if you load at 0.5 m, the reconstruction's 0.25 m cell removes almost nothing and the surface has about 0.5 m detail.

3.2 Open surface or watertight solid

	Open surface (default)	Watertight solid
Use it for	Anything open-ended or scanned from one side: drives, tunnel networks, walls, faces, benches	A cloud that completely surrounds an object: a stockpile or muck pile scanned all the way round, an ore block
What you get	A skin that stops at the edge of the data	A closed solid
How to choose it	Leave **Watertight solid** unticked	Tick **Watertight solid** (under **Show advanced settings**)

If you tick **Watertight solid** for an open scan, the run stops with the message *"Watertight not suitable"*. To get a closed solid of a development, build an open surface first. Then run **Toolbox 1** ▸ **Prepare meshes for BEM** ▸ **Remesh for BEM analysis** on it.

3.3 Settings measured in "× point spacing"

The **point spacing** is the typical gap between neighbouring points. GEM4D measures it during the run, after the voxel step.

Two advanced settings, **Cell size** and **Influence radius**, are multiples of the point spacing, not metres. A Cell size of 0.8 means 0.8 × the point spacing. This lets the same values work on fine and coarse clouds. The two voxel cells are the only settings in metres.

3.4 What goes into the surface

- **Every visible mesh and point cloud contributes its points**, including the corner points of ordinary meshes. Hide everything you do not want included. Images are never used.
- **In clipping mode, only the clipped part is used.** You can use this to rebuild one section of a large scan.
- **One surface or one per object.** The **TOGGLE: Single Delaunay Object** item in Toolbox 1 controls this. Ticked (the default), GEM4D builds one surface from all visible objects together. Unticked, it builds a separate surface for each visible object. The item's name mentions Delaunay, but it applies to reconstruction too. Route A always builds one surface from the file.
- An object with fewer than 10 points produces no surface.

3.5 Mesh or Image

You asked for	You get
No texture (or the texture failed)	A **mesh**. It takes the colour and name of its source: the first visible object in single mode, or each source object in per-object mode. Route A uses the file name.
A texture, and the cloud has colour	An **Image**: the surface with the scan colours painted on.

Saving, and what is hidden afterwards: §7.3 (mesh), §7.4 (Image).

An Image is for viewing. It is not in the Mesh lists, so tools that work on meshes (Remesh for BEM analysis and the BEM model, for example) do not see it. If you need both, reconstruct twice: once with texture and once without.

4. Loading and cutting a LAS/LAZ cloud

Click **Mesh** ▸ **Load other formats** ▸ **Other formats** ▸ **Point cloud (LAS/LAZ)**. You can select several files. You can also drag `.las` or `.laz` files onto the scene. Compressed LAZ files, including Deswik Suite exports, load the same way as LAS.

Before the dialog opens, GEM4D reads the file's header (to get the point count) and decodes the first million points (to measure the density). The dialog then opens for every file, whatever its size.

A file far from the scene. If the scene already holds objects and the header places the file 1,000 km or more from the scene's coordinate offset, GEM4D asks first, with *"Load it here anyway?"*. This usually means two coordinate systems, or two sites: the scene keeps coordinates in steps that grow with the distance, 6 cm at 1,000 km and 0.5 m at 6,000 km, so the points and any surface made from them come out coarser than the file. **No** loads nothing; use **Scene** ▸ **Reset all** and load the file on its own, or check its coordinate system. **Yes** loads it there. If the header has no box or a wrong one, a notice says the same once the points have been read.

Measured on a 109-million-point scan at the 0.25 m voxel: about 10 % fewer triangles at 1,500 km, a quarter to a half fewer from 3,000 km, and two to four times the run time from 1,500 km. A finer voxel is likely to feel it sooner.

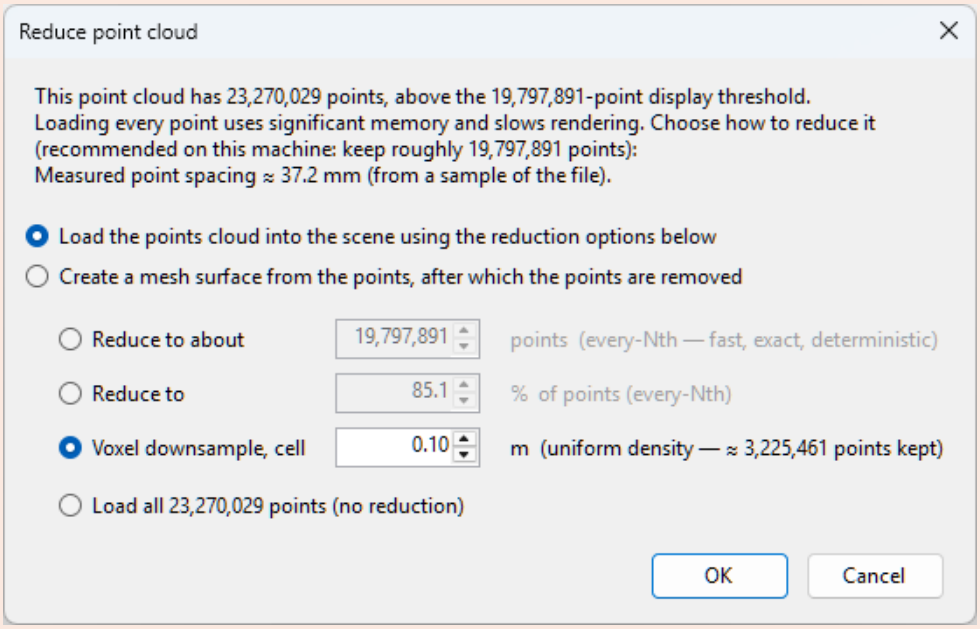


Figure 2 — The Reduce point cloud dialog for a large file: the header with the recommended point count and the measured spacing, the two purpose choices, and the four reduction options with Voxel downsample selected and its "≈ N points kept" estimate.

4.1 The dialog, top to bottom

The header states the number of points in the file. Above the *display threshold* (§4.3), it recommends reducing the cloud and gives the recommended number of points for your computer. Below the

threshold, it says the file is small enough to load in full. If the density sample worked, a last line gives *"Measured point spacing ≈ …"*.

Two choices: keep the points, or make a surface.

Choice	What happens
Load the points cloud into the scene using the reduction options below (default)	The cloud is loaded and kept. Build a surface from it later with Toolbox 1.
Create a mesh surface from the points, after which the points are removed	The points are loaded only as input, and the reconstruction dialog opens straight away (§6). On success, only the surface is shown and the Info panel reads *"Surface created from \<file\> — the temporary point cloud was released."* If you cancel any later step (the reconstruction dialog, the progress window or the save dialog), or the run fails, the points are added to the scene after all: *"Surface not created — the loaded point cloud was kept: \<file\>"*.

GEM4D remembers your choice for the rest of the session.

Four ways to reduce the points. Choose one:

Option	Value box	What it keeps
Reduce to about *N* points	1 up to the file's total. Starts at the recommended count.	Every *N*th point in file order, ending close to the count you set. Dense areas stay dense and sparse areas stay sparse.
Reduce to *N* % of points	1–100 %. Starts at the percentage that gives the recommended count.	The same every-*N*th thinning, set as a percentage. The row shows *"≈ N points kept"*.
Voxel downsample, cell *N* m	0.10–10 m	One point for each cube of that size (§3.1). Gives an even density everywhere. If the density sample worked, the row shows *"≈ N points kept"*. Selected at the start for files above the display threshold, and whenever you choose **Create a mesh surface**.
Load all *N* points (no reduction)	—	Every point. Selected at the start for files below the display threshold, when you keep the points.

All four options keep the points' colours.

The suggested voxel cell. For a file above the recommended count, GEM4D suggests the cell that brings the kept count down to about that number. For a smaller file, it suggests the measured spacing, which evens out the density with almost no loss. The suggestion is never below 0.10 m, the smallest value the box accepts. If the density sample could not be read, a file above the display threshold gets a suggestion from its bounding box, and a smaller file gets 0.10 m. The voxel row then shows no *"≈ N points kept"* figure. The bounding-box estimate tends to remove too many points from a long tunnel network, so check the kept count in the Info panel after loading (§4.4), or use **Reduce to about *N* points**.

4.2 Which option to choose

- **To build a surface, choose Voxel downsample. Create a mesh surface** selects it for you, and you can still choose another option. The every-*N*th options keep the scanner's uneven density and thin the sparse patches even further, and those patches become holes in the surface. Voxel downsampling evens the density out.

- **Voxel downsampling makes a textured surface much quicker and softer.** Colours are painted from the points you load, so a 0.10 m cell gives colour detail of about 10 cm. With **Load all**, Auto often chooses the High texture too, when it sharpens the colours and the computer has 12 GB of RAM or more. On a 23-million-point scan, the run took about 32 seconds with the voxel and 6½ minutes with **Load all**. Choose **Load all** when you will inspect the colours close-up.
- **To keep the cloud for viewing or joint mapping,** any option that brings the count near the recommendation is fine. Voxel downsampling still gives the most even result.
- **For a small file, Load all** is fine. The reconstruction's own 0.25 m voxel cell thins the points before the surface is built.

4.3 The recommended point count

The recommendation depends on your computer's memory (RAM):

RAM	4 GB	8 GB	16 GB	32 GB	64 GB	128 GB or more
Recommended points	2 million	4 million	8 million	20 million	45 million	90 million

Between these values, GEM4D interpolates. The **display threshold**, above which the dialog recommends reducing, is the recommended count or 10 million points, whichever is larger.

4.4 After loading

- The Info panel reports the result, for example *"Point cloud loaded: kept 4,812,330 of 61,507,442 points (voxel 0.1 m)"*.
- A cloud with colours shows them. A cloud without colours, or with colours that are all zero, shows in white. You can change its colour in the Objects list.
- The cloud is listed in the Mesh Files and Objects lists, like a mesh.
- If you selected several files, the dialog opens for each file in turn. It keeps your choice between loading the points and making a surface; the reduction option and its values are set afresh for each file.

4.5 Cutting a cloud with a rubber band

Four tools in the scene toolbar's rubber-band drop-down cut a loaded cloud as well as meshes: **Split selection out by rubberband**, **Split polys out by rubberband**, **Delete polys inside rubberband** and **Delete polys outside rubberband**. Draw the band with two clicks (see `Scene_Navigation_and_Picking_Manual.md`, §8). The band reaches through the whole depth of the scene, so every point under it is taken, including points behind a wall.

- **What it works on:** every visible object made only of points: a LAS/LAZ cloud, or a point set from DXF, Deswik or Surpac. Meshes in the same band are cut as before.
- **Delete inside / Delete outside** remove the points inside or outside the band. The cloud keeps its name, colours and place in the lists. The file on disk is not changed.
- **Split** (either of the two) takes the points inside the band out of the cloud. A Save dialog asks for a file name, and you choose **LAZ** (compressed) or **LAS**. The piece is written with its colours and appears straight away as a new object, named after its cloud.
  - Pieces collected with **Shift** are saved together, as one cloud in one file.
  - If meshes were split too, their pieces are saved first, as a DXF, in a dialog of their own.
  - **Cancel** in the Save dialog drops the piece. The points stay out of the cloud, as they do when you cancel a mesh split, but the file on disk still holds them.
  - **If the file cannot be written** (a full disk, a lost network drive), GEM4D says why and the Save dialog comes back in the same folder with your file name and type, so you can choose another drive or name. **Cancel** there drops the piece. No part-written file is left, and a file

you chose to replace stays as it was. Saving over a file needs room for the old and the new file for a moment.

- **What the saved file holds:** the points in mine coordinates at 1 mm, and their colours if the piece has any. A cloud loaded without colours, or shown under a mesh colouring such as Elevation, is saved without them, and the Info panel says so after the save. Intensity, classification and the source file's coordinate-system record are not kept, because GEM4D does not keep them after loading.
- **Time:** a cut takes about a second, even on clouds of tens of millions of points.

Delete single mesh triangle is a mesh tool. On a cloud it still breaks the cloud into single points and switches its colours off.

5. Removing stray points

Stray points, also called *fliers*, are dust, water drops and stray laser returns. They grow spikes and bumps on a reconstructed surface. **GEM4D removes them by itself before it builds a surface.** There is nothing to run. The cloud in the scene and the file on disk do not change.

- **When it runs:** whenever every visible object is made only of points, in both routes (§2). With a mesh visible it is off, because the corner points of a mesh are spread unevenly and would read as stray points.
- **How it decides.** GEM4D looks at the cloud thinned to one point per 0.10 m cube, so the result depends little on how densely you loaded it. A cube much farther from its neighbours than is usual for this cloud goes, with all its points. A patchy cloud is treated more gently, so sparse but real patches survive.
- **Safety limit.** It never removes more than 20 % of the cubes, unless the cubes with almost no neighbours (fewer than 3 nearby), which always go, exceed that on their own.
- **What it costs.** It can also take real surface where the scan is thin. On two real underground scans loaded through the voxel, it took about 1–2 % of the surface, in connected patches up to about 5 m long, and shortened the open edges by about 30 %. If a surface is missing a patch where the scan has points, untick **Remove outliers before reconstruction (statistical)** under **Show advanced settings** (§6.5) and run again.
- **Time.** A few seconds at most, however densely the cloud was loaded (about 4 s on 23 million points).
- **How many went.** The Info panel gives the count once the surface is in the scene, for example *"Stray points removed: 2,971 of 117,166 (2.5 %)"*. The count is in points as loaded, added up over the objects in per-object mode (§3.4). The check judges each cloud against itself, so it takes something from almost any cloud, mostly at the edge of the scan: a perfectly clean test surface lost up to 8 % of its cubes. The figure is therefore not a measure of noise. *"Stray points removed: none of …"* means the check ran and took nothing; *"Stray points not removed: Remove outliers was off"* means it did not run (a mesh was visible, or the box was unticked).

It does not remove a dense clump that looks like a real surface, such as a parked vehicle, vegetation or standing water. To take those out, or to clean a cloud you keep, use the rubber-band **Delete** tools (§4.5).

6. The Reconstruct surface from points dialog

When you click **Reconstruct surface from points**, GEM4D first measures the visible points. This takes a second or two on a large cloud. The dialog then opens in its **compact** view. Tick **Show advanced settings** to see seven more settings.

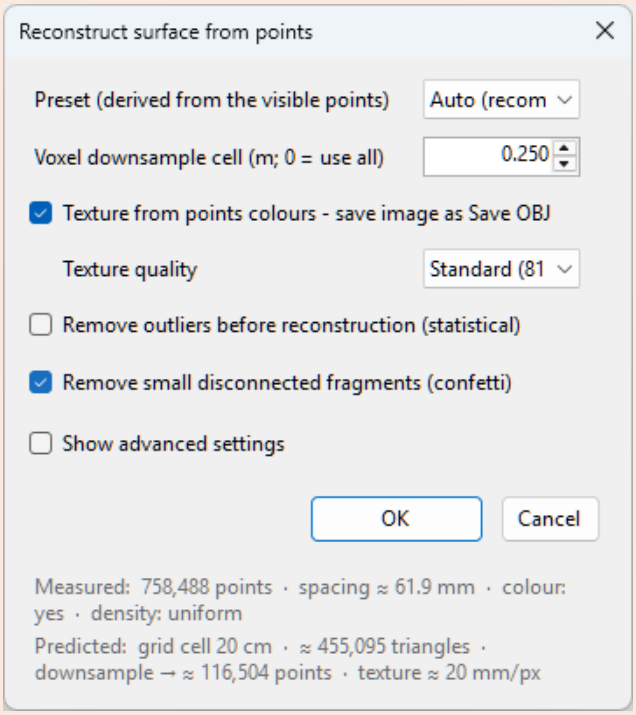


Figure 3 — The Reconstruct surface from points dialog in its compact view, Auto preset, a coloured cloud: Texture ticked, with the Measured and Predicted lines filled in.

The settings, in order on screen:

1. **Preset (derived from the visible points)** — §6.1
2. **Voxel downsample cell (m; 0 = use all)** — §6.2
3. **Texture from points colours - save image as Save OBJ** — §6.3
4. **Texture quality** — §6.4
5. **Remove outliers before reconstruction (statistical)** — §6.5 *(shown with the advanced settings)*
6. **Remove small disconnected fragments (confetti)** — §6.6
7. **Show advanced settings** — §6.7

Advanced settings:

8. **Watertight solid (closed surface — wraps a volume)** — §6.8
9. **Cell size (× point spacing; lower = finer)** — §6.9
10. **Normal estimation neighbours (kNN)** — §6.10
11. **Influence radius (× spacing) — open only** — §6.11
12. **Cap openings (open only; close tunnel ends / scan edges)** — §6.12
13. **Repair surface (fill holes; genuine openings stay open)** — §6.13

The **Measured** and **Predicted** lines at the bottom are described in §6.14. Defaults and ranges for every setting are listed together in §10.2.

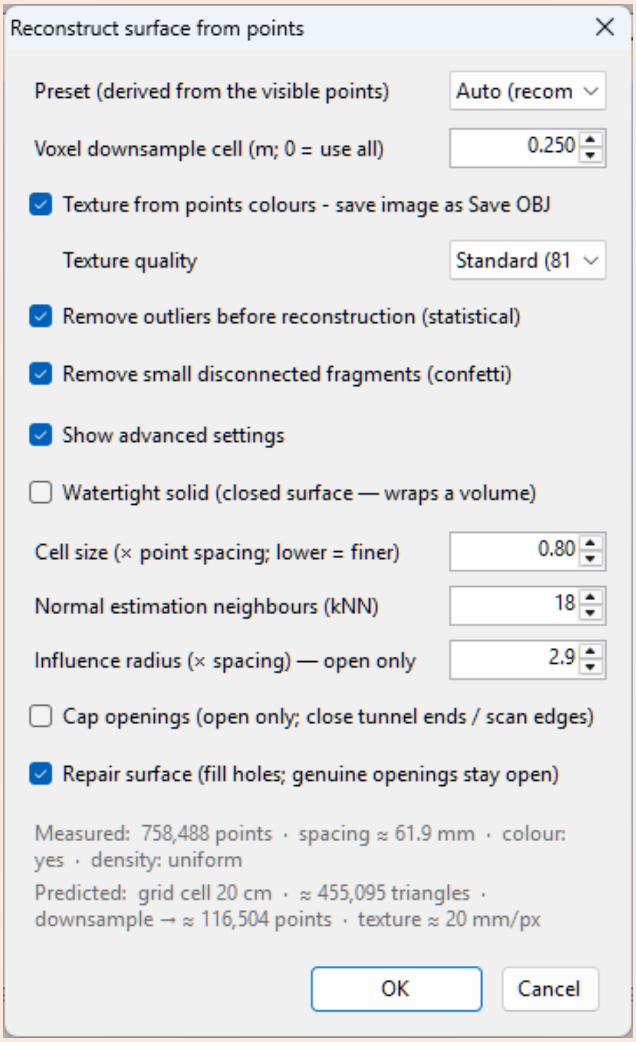


Figure 4 — The same dialog with Show advanced settings ticked, showing the six advanced rows.

6.1 Preset

The preset fills in every setting for you, based on what GEM4D measured.

Preset	What it sets
Auto (recommended)	Voxel cell 0.25 m. Influence radius twice the density spread (the 90th-percentile gap over the median gap), kept between 2.0 and 4.0: 2.0 for a perfectly even cloud, up to 3.2 for one the Measured line still calls uniform, up to 4.0 for a patchy one. Texture ticked if the cloud has colour. High texture quality only when it will visibly sharpen the colours and the computer has at least 12 GB of RAM. Every other setting at its default.
Textured photo mesh	As Auto, but with Texture always ticked.
Clean analysis mesh	As Auto, but with no texture and Cell size 1.0 (slightly coarser and cleaner). This is a starting point for a surface you will analyse. It is still an open surface: run **Remesh for BEM analysis** on it before using it in BEM.
Quick draft	Voxel cell 0.5 m, Cell size 1.5, no Repair, no texture. Fast and rough, for a first look.
Custom	Your own settings. Changing any setting switches the preset to Custom and keeps the values you set.

Every preset except Custom builds an open surface. GEM4D remembers the preset for the session. Choosing **Custom** from the list loads the settings of your last **Toolbox 1** run. Before the first such run, and always when the dialog opens during a load (Route A), Custom holds plain defaults with the voxel cell at 0 (every point), so set the voxel cell if you choose it there (§7.1). During a load the dialog opens on Auto if you last used Custom.

6.2 Voxel downsample cell (m; 0 = use all)

This is the main control (§3.1). Just before building, GEM4D thins the points to one per cube of this size.

- **0.3–0.5 m:** a smoother surface and a faster run.
- **0.1 m:** finer detail on a clean scan. The run is slower and the surface noisier.
- **0:** uses every point. Use it only for a small, clean cloud, or for a cloud you already voxel-reduced to the detail you want when you loaded it.
- A cell smaller than the cloud's own spacing changes little or nothing.

The Predicted line shows *"downsample → ≈ N points"*.

6.3 Texture from points colours - save image as Save OBJ

Tick this to paint the points' colours onto the surface. The result is an Image (§3.5), which you save through the Save OBJ prompt (§7.4). Auto ticks it when a visible point object has its own colours.

- **How the colour is made.** Each pixel of the texture blends the colours of the nearby points. Where no points are close, the colour is filled in from the surrounding pixels, so the surface has no grey patches. If more than 5 % of the surface had to be filled in this way (for example, holes closed by Repair), a *"Texture coverage"* message gives the percentage.
- **Colour detail comes from the loaded points.** GEM4D takes the colours from all visible coloured point objects, at the density they were loaded with, not from the thinned copy used to build the surface. A cloud loaded with more points gives sharper colour.
- **Large surfaces** are spread over several texture images, up to 12. They behave as one object, and Save OBJ writes them all together. At Standard quality, above about 50 million triangles, the texture is refused.
- **If the texture cannot be made** (no visible point object, no colours, or too many triangles), a *"Texture not applied"* message gives the reason. The surface is then created as a plain mesh.

Texturing adds time to the run.

6.4 Texture quality

This setting is greyed out unless **Texture** is ticked.

Choice	Effect
Standard (8192 px)	Each texture image is up to 8192 × 8192 pixels. Sharp enough for most work.
High (16384 px, ~1 GB RAM)	Each image is up to 16384 × 16384 pixels, with up to twice as many pixels along each triangle edge. Each image takes about 1 GB of memory, and the run and the saved `.png` files are slower and larger.

Choose **High** when you will inspect the surface close-up and Standard looks soft. Auto chooses High itself when it will help and the computer has enough memory.

6.5 Remove outliers before reconstruction (statistical)

On by itself when every visible object is made only of points, and off when a mesh is visible. This is the cleaning described in §5, run on the working copy of the points before the voxel step. The cloud in the scene does not change.

Untick it if the surface is missing a patch where the scan has points. If you tick it with a mesh visible, the mesh's corner points are judged as well, and many of them can go.

6.6 Remove small disconnected fragments (confetti)

On by default. After the surface is built, GEM4D finds the pieces that are not joined to each other. It removes **every piece smaller than 100 triangles or 0.5 % of the largest piece, whichever is larger.** The largest piece is always kept.

For example, if the main surface has 1,000,000 triangles, every separate piece under 5,000 triangles is removed. That clears the floating specks that dust and stray points create. It can also remove a genuine small object built in the same run, such as a short, separate drive. If that matters, untick this setting, or untick **TOGGLE: Single Delaunay Object** so that each object gets its own surface and is judged on its own.

Only detached pieces are removed. A spike still joined to the surface stays; **Remove outliers** (§6.5) deals with those.

6.7 Show advanced settings

Shows or hides setting 5 and settings 8–13. It does not change any value. GEM4D remembers, for the session, whether you left it open.

6.8 Watertight solid (closed surface — wraps a volume)

Off by default. See §3.2 for when to use it.

When it is ticked, **Influence radius**, **Cap openings** and **Repair surface** are greyed out, because the watertight method always closes and repairs its own result.

The watertight method samples one grid over the whole cloud, with at most 600 cells along each axis. For a long or large cloud, the cells are therefore coarser than **Cell size** asks for; the Predicted line shows the cell actually used. The run time grows with the size of this grid, not with the number of points.

6.9 Cell size (× point spacing; lower = finer)

GEM4D builds the surface on an invisible 3D grid. This setting is the size of a grid cell, as a multiple of the point spacing (§3.3).

- **Lower:** finer detail, but slower and more memory. Going far below 1 gains little, because the surface cannot show detail finer than the points.
- **Higher:** smoother and faster, but small features are lost.

For an open surface, GEM4D samples the grid only around the points, so a long drive does not coarsen the cells. If the total surface is very large, GEM4D coarsens the cells to stay within its processing budget. The Predicted line then says *"auto-coarsened to fit the processing budget — Cell size has little effect"*. In that case, raise the voxel cell instead.

6.10 Normal estimation neighbours (kNN)

Before building, GEM4D works out which way the surface faces at each point (the point's *normal*). It does this by fitting a plane through the nearest points. This setting is how many points it uses.

- **More (for example 30):** steadier on noisy scans, but sharp edges get rounded.
- **Fewer (for example 8):** keeps sharp detail, but noise affects it more.

6.11 Influence radius (× spacing) — open only

How far each point reaches to join up with its neighbours into a continuous skin, as a multiple of the point spacing.

- **Too small:** the skin cannot bridge the gaps between points, which leaves holes and slits.
- **Too large:** the skin bridges gaps it should not. A narrow drive can fill in solid.

Raise it if the surface has holes. Lower it if a drive has filled in.

6.12 Cap openings (open only; close tunnel ends / scan edges)

Off by default. When it is on, GEM4D also closes the genuine openings, such as drive ends and the edges of the scan, sealing the surface.

Tiny slits between points are always closed, whatever this setting.

6.13 Repair surface (fill holes; genuine openings stay open)

On by default. After an open surface is built, Repair fills the holes left where the scanner saw nothing, such as shadows behind equipment or gaps between scan passes.

Repair only fills holes up to a size limit, measured across the hole's bounding box. The limit is the larger of 10 × **Influence radius** and 25 × **Cell size**, counted in point spacings: 20 spacings at Influence radius 2.0 and Cell size 0.8 (**roughly 5 m at the default 0.25 m voxel cell**), up to 40 when Auto sets Influence radius to 4.0, and at least 25 with **Clean analysis mesh**. Larger openings stay open.

An opening smaller than the limit is closed even if it is real, for example the end of a narrow raise. Untick Repair if such an opening must stay open. Unticking it also makes the run faster.

6.14 The Measured and Predicted lines

These two grey lines update as you change settings.

Measured describes the visible points: *"Measured: N points · spacing ≈ … · colour: yes/no · density: uniform"* (or *"uneven (spread ×N)"*).

- The point count includes every visible object.
- *Spacing* is the median gap between neighbouring points, before any voxel step. It can be much smaller than the load dialog's *"Measured point spacing"*, because scanners place points close together along each scan line but further apart between lines, and the two dialogs measure differently. Neither figure changes the result directly; the run measures the spacing again after the voxel step.
- *Uneven* means the larger gaps (the 90th percentile) are more than 1.6 times the median gap.

Predicted shows what the current settings will produce: the grid cell size, an estimated triangle count (accurate to within about ±50 %), the point count after the voxel step and, with Texture ticked, the texture detail per pixel.

If the surface would need more than 12 texture images, a second line warns *"Too many triangles to texture — increase Cell size or Voxel downsample."* That happens above about 50 million predicted triangles at Standard quality, the same limit at which the texture is refused (§6.3). Because the estimate is only accurate to about ±50 %, treat a surface close to the limit with care.

If the visible points cannot be measured (a single point, or more than about 700 million), the Measured line reads *"(no visible point data)"* and the presets fall back to plain defaults.

7. Running the reconstruction and keeping the result

7.1 Before the run

If more than 250,000 points are visible and the voxel cell is 0, a *"Large input"* message warns that the run can take minutes and a lot of memory. **Yes** runs anyway. **No** cancels the run (on Route A the points are kept in the scene); start again with a voxel cell set.

7.2 While it runs

A *"Reconstructing surface"* window shows a progress bar and the current stage:

- **Open surface:** *Reading points… · Measuring point spacing… · Removing outliers… · Voxel-downsampling the cloud… · Estimating point normals… · Building surface — block N of M… · Merging blocks… · Closing small slits… · Building the mesh… · Filling coverage holes…*
- **Watertight solid:** *… · Estimating point normals… · Sampling the winding field… · Extracting the isosurface… · Polishing the solid…*
- **With Texture:** *Baking the texture…*

Stages for settings you switched off are skipped, and a stage that takes under a quarter of a second may not show. In per-object mode, each stage adds *"[surface i of N]"*.

The scene cannot be used during the run. **Cancel** discards the run and the Info panel reads *"Surface reconstruction cancelled"*.

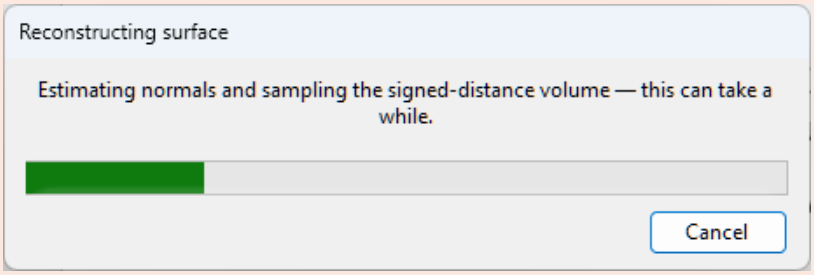


Figure 5 — The Reconstructing surface progress window part-way through the "Building surface — block N of M" stage, with its Cancel button.

7.3 A plain (untextured) surface is saved as DXF

1. A Save dialog asks for a DXF file name. **Cancelling it deletes the new surface** (*"Saving was cancelled and the created objects deleted"*). If the name is already in the Files list, GEM4D asks again.
2. The surface is listed under that DXF in the Mesh Files and Objects lists, with its source's name and colour (§3.5).
3. On Route B, every mesh and point cloud that was shown is hidden, so you see the new surface on its own: they are the objects it was built from. Show them again in the Objects list. On Route A nothing else is hidden; the cloud itself was never in the scene.

7.4 A textured surface becomes an Image

1. The Image is listed in the Image panel under its source's name (or *"Textured surface"*).
2. GEM4D asks *"Save it now as a textured OBJ (.obj + .mtl + .png)?"*
   - **Yes** opens a Save dialog and writes the `.obj`, the `.mtl` and one `.png` per texture image.
   - **No** leaves the Image in the scene, unsaved. You can save it later with **Image ▸ Save and export files ▸ Textured OBJ**, once every other object is hidden — the source cloud

included — or GEM4D refuses with *"Hide or delete all visible objects except the transformed OBJ-object"*. An unsaved Image is lost when you close GEM4D, unless you save a project.

3. The source cloud stays visible and may cover the Image. Hide the cloud to see the Image.

7.5 Keeping everything together

A GEM4D project file (`.gem4d`) saves point clouds, meshes and Images together in one file. See `Project_File_Manual.md`.

8. Recipes

You have, or want…	Do this
A drive or stope scan; you need only the surface	Route A (§2) with the Auto preset.
The cloud **and** a surface	Route B (§2).
A coloured photogrammetry scan with a realistic look	Preset **Textured photo mesh**, then **Yes** to the Save OBJ prompt. For close-up mapping, choose **High** texture quality and load the cloud with more points (a smaller load voxel cell), because the colour detail comes from the loaded points.
A surface for BEM or other analysis	Preset **Clean analysis mesh**, then **Toolbox 1 ▸ Prepare meshes for BEM ▸ Remesh for BEM analysis** to close it.
A stockpile or muck pile scanned all the way round	Tick **Watertight solid** (advanced).
Only part of a large scan	Switch on clipping, then reconstruct. Only the clipped part is used.
Several objects as separate surfaces	Untick **TOGGLE: Single Delaunay Object** in Toolbox 1, and show only those objects.
A dense cloud to inspect, but a light surface	Load at a fine voxel cell, then reconstruct with the 0.25 m default. The cloud in the scene keeps its detail.

For a slow run, or a spiky or bumpy surface, see §9.1.

9. Troubleshooting

9.1 The result looks wrong

What you see	Likely cause	What to do
Holes or missing patches	Sparse patches in the cloud, often from an every-*N*th reduction on load. Or the influence radius is too small. Or outlier removal took a thin patch (§5).	Load with **Voxel downsample**. Raise **Influence radius**. Keep **Repair surface** on. If the scan has points there, untick **Remove outliers** (advanced settings).
A drive has filled in solid, or the surface is a blob	**Influence radius** is too large and bridged the drive.	Lower **Influence radius**, and/or **Cell size**.
No surface, *"Watertight not suitable"*	**Watertight solid** was ticked for an open scan.	Untick it (§3.2).
Spikes and bumps	Fliers in the cloud.	Check that **Remove outliers** is ticked (advanced settings). It is off when a mesh is visible, so hide the mesh. Raise **Normal estimation neighbours**.

What you see	Likely cause	What to do
Small floating specks remain	Specks larger than the confetti limit (100 triangles when the main surface is small), or confetti removal is off.	Tick **Remove small disconnected fragments**. Check that **Remove outliers** is ticked (advanced settings).
A small separate surface is missing	Confetti removal judged it a speck (§6.6).	Untick confetti removal, or build one surface per object.
A real opening, such as a raise end, was closed	**Repair surface** fills openings up to 20–40 point spacings (§6.13).	Untick **Repair surface**.
Sharp edges are rounded	Too many neighbours, or the cells or voxels are too large.	Lower **Normal estimation neighbours**, the voxel cell or **Cell size**.
An unexpected shape is part of the surface	Another visible mesh or cloud was included (§3.4).	Hide everything except the cloud, and run again.
The run is very slow or runs out of memory	Too many points or too fine a grid.	Raise the voxel cell to 0.4–0.5 m, or reduce harder when loading. Untick **Repair** and **Texture** while you try settings. Use **Standard** texture quality.
The surface is rough or stepped, and the run was slower than usual	The cloud lies far from the scene's coordinate offset (§4).	**Scene ▸ Reset all**, load the file on its own, and run again.
The surface is plain when you wanted colour	The texture could not be made. The *"Texture not applied"* message gives the reason.	See §9.2.
The texture looks soft close-up	Not enough texture pixels or colour points.	Choose **High** texture quality. Load the cloud with more points.
The textured surface is not visible	The source cloud is still shown on top of it.	Hide the cloud.
The surface disappeared after the run	The DXF Save dialog was cancelled, which deletes the surface.	Run again and save the file.

9.2 Messages

Title	Message (start)	What to do
Large input	*"The visible data has N points…"* (Route B) or *"This cloud has N points and no voxel downsample is set…"* (Route A)	**Yes** to continue, or **No** to cancel and run again with a voxel cell (§7.1).
No surface produced	*"Could not reconstruct a surface from the visible points…"*	Check that a point cloud is visible. Try a smaller **Cell size** or a larger **Influence radius**.
Watertight not suitable	*"Could not build a watertight solid from the visible points…"*	Untick **Watertight solid**. For a closed development, use **Remesh for BEM analysis** on the open result.
Texture not applied	*"No point object is visible to take colour from…"*	Show the coloured cloud as well as anything else you are reconstructing.
Texture not applied	*"The visible point object has no per-point RGB colour…"*	The scan holds no colour (intensity or classification only). Untick **Texture**.
Texture not applied	*"The surface has too many triangles to texture…"*	Raise the voxel cell or **Cell size**, or reduce the triangle count with **Toolbox 1 ▸ Reduce polygon count**, then try again.

Title	Message (start)	What to do
Texture too large	*"One or more surfaces had too many triangles to texture at full resolution and were skipped…"*	As above, for the surfaces that were skipped.
Texture coverage	*"About N% of the textured surface had no cloud colour within the search band…"*	For information. Those areas were coloured from their surroundings.
Save textured OBJ	*"Textured surface created (a GEM4D "Image")…"*	§7.4.
Warning	*"Saving was cancelled and the created objects deleted"*	Run again and save the DXF (§7.3).
Empty point cloud	*"No points found in …"*	The file contains no points.
Error reading LAS/LAZ file	The reader's own error text	The file could not be read. Check that it is a complete, valid LAS or LAZ file.
Error reconstructing surface	The error text	Route A only. The points are kept in the scene; try again from **Toolbox 1**.
Large coordinate system	*"… lies N km from the scene's coordinate offset…"*	The file is far from the objects already loaded (§4). **No**, then **Scene ▸ Reset all** and load it on its own, or check its coordinate system.
Save point cloud	*"The points split out of the cloud could not be saved…"*	If it goes on *"The Save dialog comes back…"*, the disk or folder refused the file (full, read-only, drive lost): choose another drive or name, or **Cancel** to drop the points (§4.5). Otherwise the piece is dropped, as with **Cancel**.
Save point cloud	*"… already exists. Choose another name."*	GEM4D added `.laz` or `.las` to the name you typed, and that file exists. Choose another name.

For support, the file `%LOCALAPPDATA%\GEM4D\GEM4D_diag.log` records what each run did. Look for lines starting `LAS import:` (what was kept, seconds to read), `recon build:` (the points after each step, the settings, seconds per stage), `recon run:` (the texture quality, seconds to build and to bake), `recon merge input:` (the points going into *Merging blocks*, and their bounds), `confetti cull:`, `recon outlier removal:` and `Far from the scene:` (the distance, and the answer given). Past 1 MB the log moves to `GEM4D_diag.old.log` beside it, so send both files.

10. Reference

10.1 Reduce point cloud dialog

Setting	Default	Range
Load the points / Create a mesh surface	Load the points (remembered for the session)	one or the other
Reduce to about *N* points	The recommended count (§4.3), or the file's total if smaller	1 to the file's total
Reduce to *N* % of points	The percentage that gives the recommended count (100 % for a smaller file)	1–100 %
Voxel downsample, cell	Measured suggestion (§4.1)	0.10–10 m
Load all points	—	—

Setting	Default	Range
Option selected at the start	**Voxel downsample** above the display threshold; **Load all** below it	—

10.2 Reconstruct surface from points dialog

Setting	Default (Auto)	Range	Applies to
Preset	Auto (recommended)	Auto / Textured photo mesh / Clean analysis mesh / Quick draft / Custom	both
Voxel downsample cell (m)	0.25 m (Quick draft 0.5 m)	0–100 m (0 = use every point)	both
Texture from points colours	Ticked if the cloud has colour	on / off	both
Texture quality	Standard (8192 px); High when Auto judges it worthwhile	Standard / High	both, with Texture
Remove outliers before reconstruction *(advanced)*	On when every visible object is made only of points, otherwise off	on / off	both
Remove small disconnected fragments	On	on / off	both
Show advanced settings	Off (remembered for the session)	on / off	—
Watertight solid *(advanced)*	Off	on / off	—
Cell size *(advanced)*	0.8 (Clean analysis 1.0, Quick draft 1.5)	0.25–4.0 × spacing	both
Normal estimation neighbours *(advanced)*	18	4–100	both
Influence radius *(advanced)*	2 × the density spread, 2.0–4.0 (§6.1)	0.5–20 × spacing	open only
Cap openings *(advanced)*	Off	on / off	open only
Repair surface *(advanced)*	On (Quick draft off)	on / off	open only

10.3 What happens in a run, in order

1. Read the points of every visible object (or the clipped part), and measure their spacing.
2. **Remove outliers**, if ticked: judge the points thinned to one per 0.10 m cube, and drop all the points of each cube that is rejected.
3. **Voxel downsample** to the voxel cell, then measure the spacing again.
4. Estimate the normal at each point, using **Normal estimation neighbours**.
5. Build the surface:
   - **Open:** sample the grid in blocks around the points, using **Cell size** and **Influence radius**. Join the blocks. Close tiny slits, or every opening if **Cap openings** is on. Then **Repair surface**, if ticked.
   - **Watertight:** sample one grid over the whole cloud, extract the closed solid and repair it.
6. **Remove small disconnected fragments**, if ticked.

7. With **Texture**: paint the colours on and create an Image (§7.4). Otherwise: save the mesh as DXF (§7.3).