Detecting Geomorphic Changes - Applying Innovations to Spatial Data Gathering

Using Strucutre-from-Motion Photogrammetry (SfM)

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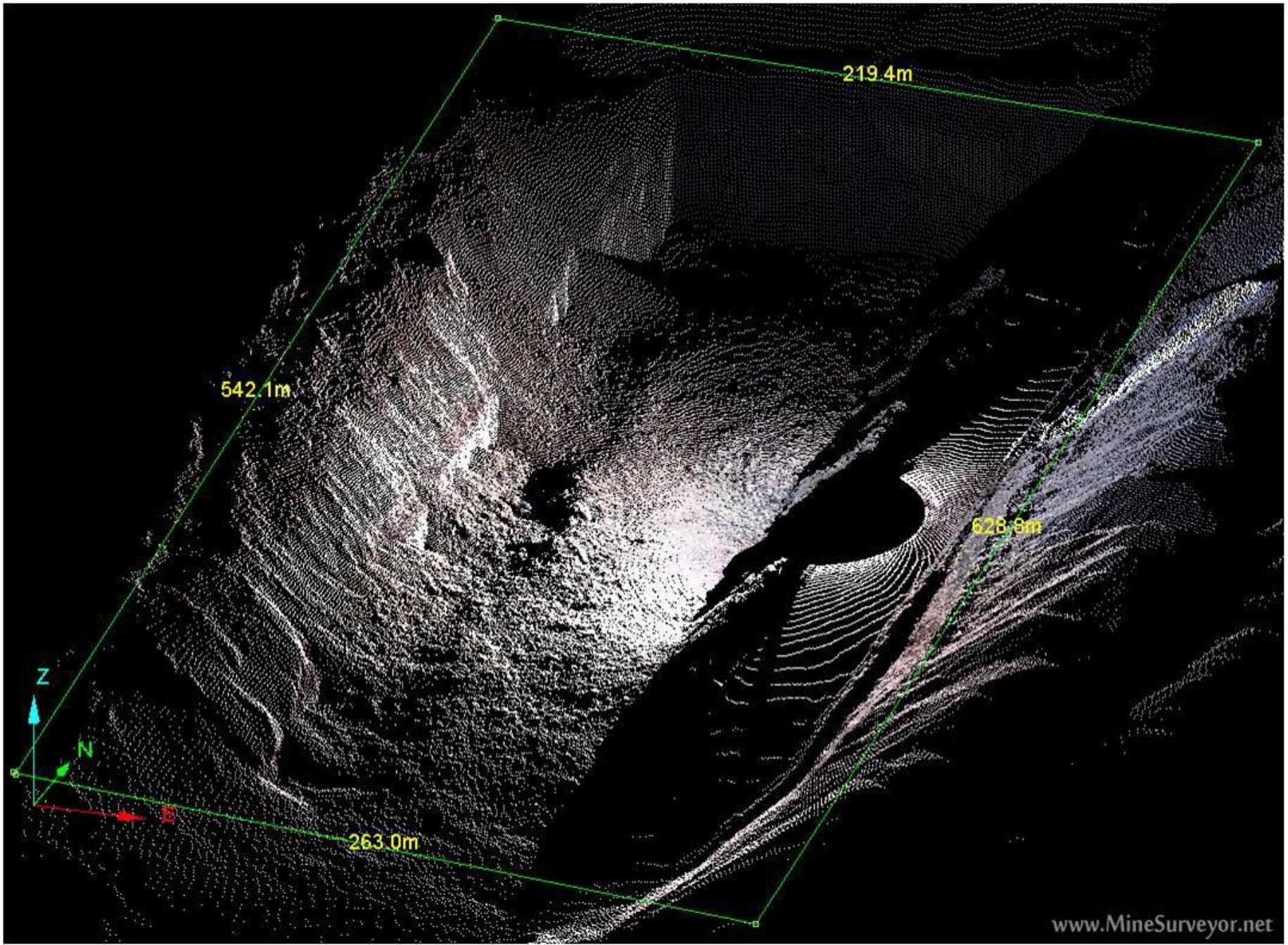
New Hampshire Geological Survey

Why Measure Geomorphic Changes?

Measurements speak louder than words

Tradition low-cost monitoring method:

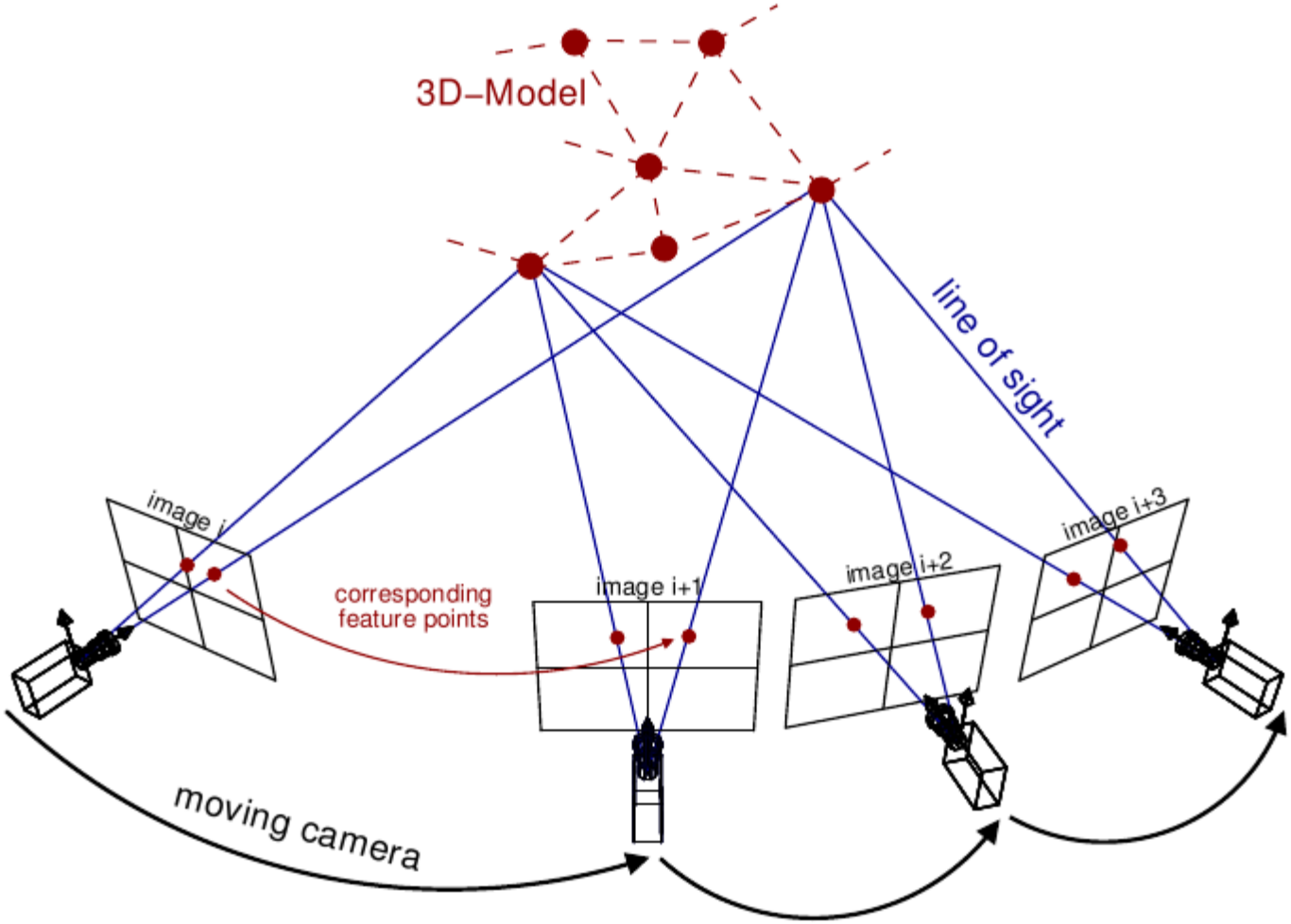
Cutting-edge, High-Cost Monitoring Method: Terrestrial LiDAR



Structure-from-Motion Photogrammetry (SfM)

http://blogs.msdn.com/b/photosynth/archive/2009/02/06/photosynth-update-new-features-improvements.aspx

SfM



http://www.tnt.uni-hannover.de/project/motionestimation/


http://topofly.blogspot.com

http://topofly.blogspot.com

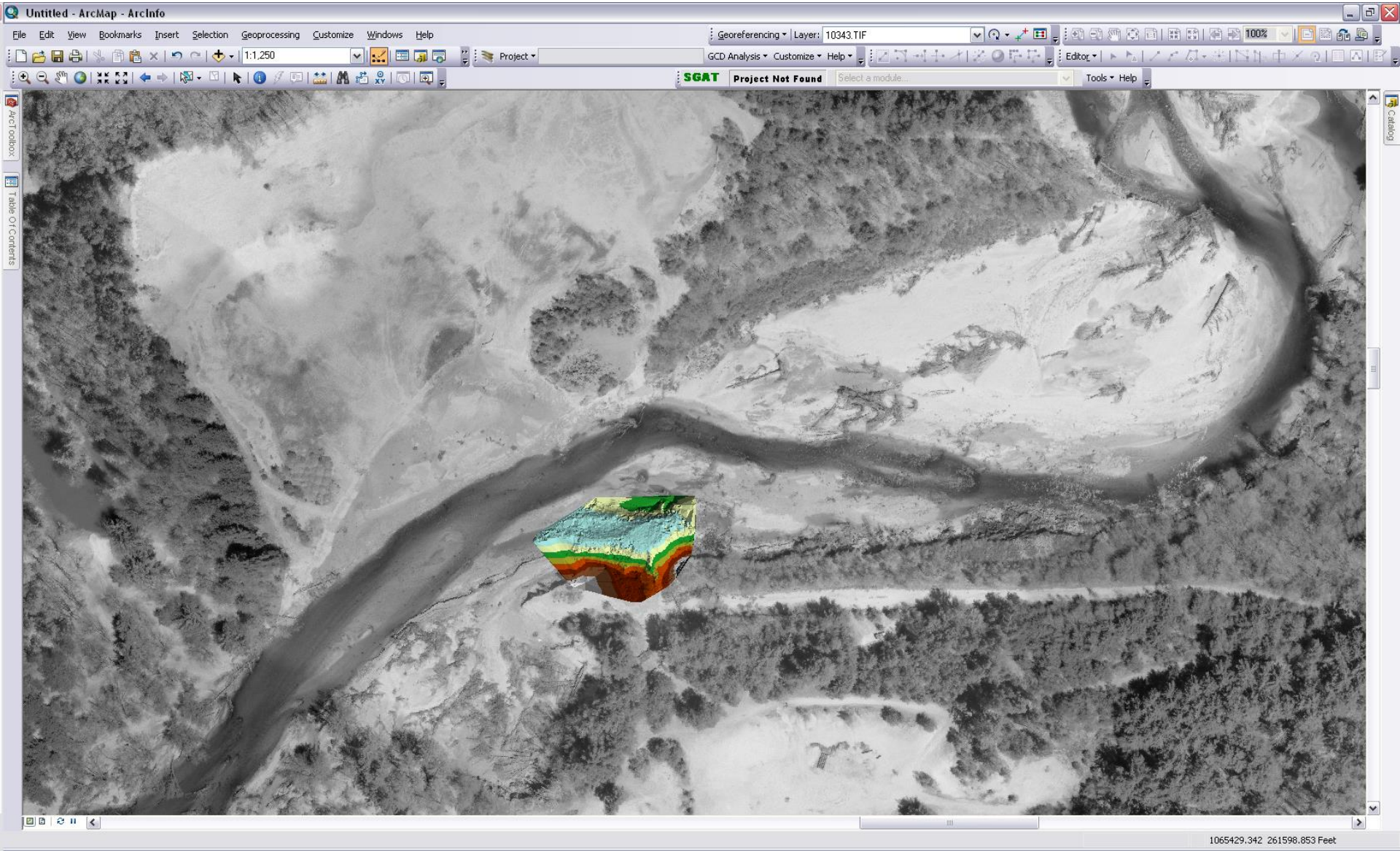
Free Software!

The remaining presentation is a SfM Methods and Applications Walk-through

- Study Area Overview
- Data Gathering
- Data Processing
- Data Density, Accuracy, Precision
- Data Application
- 3D Modeling and Visualization
- Conclusions

Study Area:
Suncook River Valley, Epsom NH

Colored Area = Study Site



Seasonal Variability: July 2013


November 2013

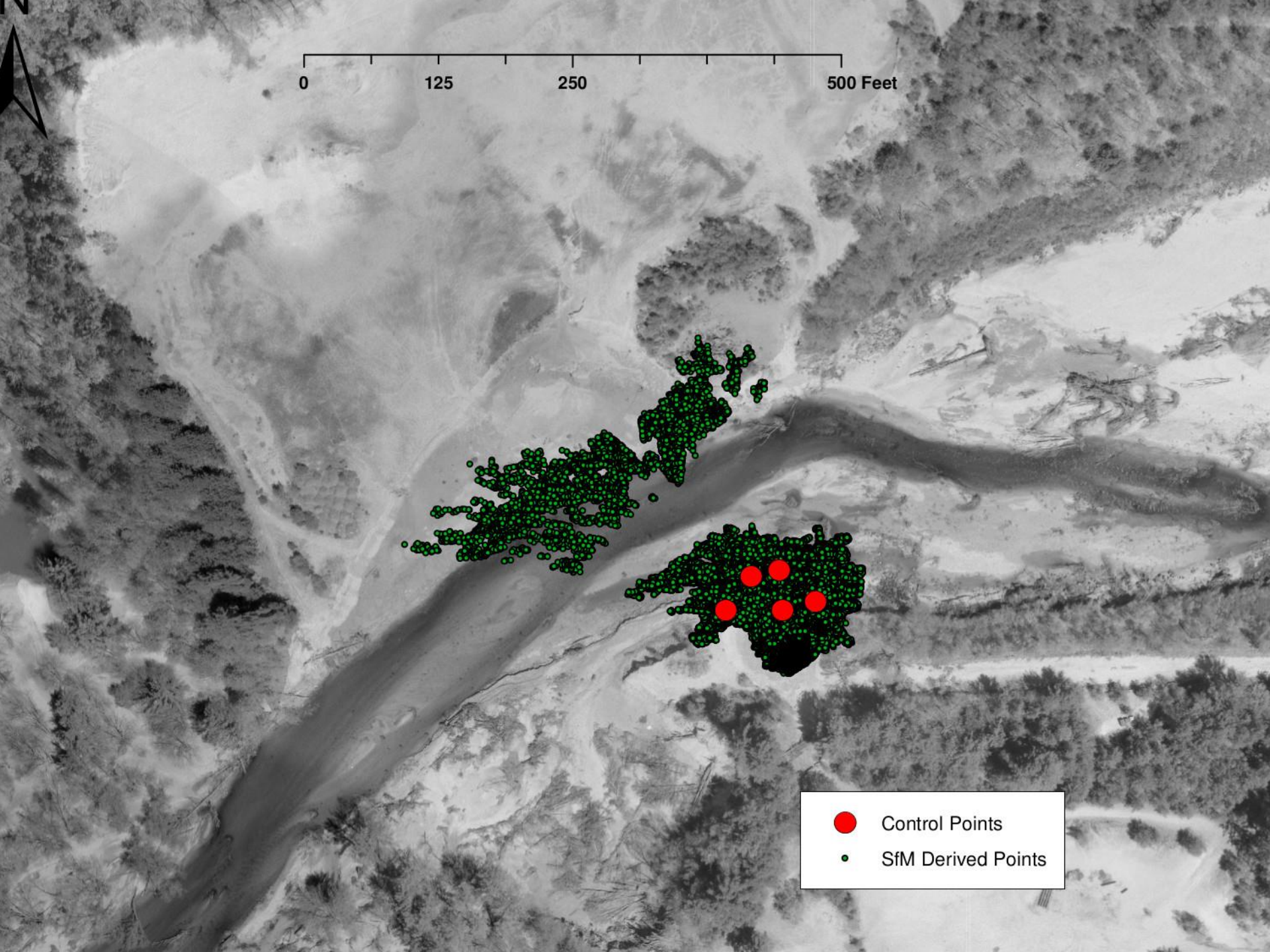
Developing Gully:

Gathering Data

Field Data Gathering: Creating Monuments

- These are created in the same manner as any other monument
- They need to be highly visible
- Seen here: Stake Skirt
- Stake deepness reduces stake abduction

Measurements are needed for scale


N
0
125
250
500 Feet
Control Points
SfM Derived Points

Then snap lots of photos...






Very rapid. ~15 to 30 minutes

Data Gathering Review

Gathering Datasets:

15 to 30 min.

Establishing Monuments:

30 minutes to1hr.

Data Processing

Shortcut to ppt_gui_start.bat

```
C:\Python26\ArcGIS10.0>File ôppt_gui_start.batö:
'File' is not recognized as an internal or external command,
operable program or batch file.

C:\Python26\ArcGIS10.0>PATH=C:\Program Files\ImageMagick-6.8.6-Q16;C:\Python26\
rcGIS10.0\Lib\site-packages\PyQt4;C:\oracle\ora81\bin;C:\Program Files\Oracle\j
e\1.1.7\bin;c:\oracle\orant\bin;C:\oracle\ora80\bin;C:\WINDOWS\system32;C:\WIND
WS;C:\WINDOWS\System32\Wbem;C:\Program Files\Intel\DMIX;C:\Program Files\ATI Te
hnologies\ATI.ACE\Core-Static;C:\Program Files\Common Files\Roxio Shared\DLLSha
ed\;C:\Program Files\Common Files\Roxio Shared\9.0\DLLShared\;c:\oracle\orant\j
k\bin;C:\Program Files\ZipGenius 6\;C:\cygwin\bin;C:\Program Files\MATLAB\MATLA
 Compiler Runtime\v714\runtime\win32;C:\Program Files\Microsoft SQL Server\80\T
ols\Binn\;C:\Program Files\Microsoft SQL Server\100\Tools\Binn\;C:\Program File
\Microsoft SQL Server\100\DTS\Binn\;C:\Python26;"C:\Python26\ArcGIS10.0"

C:\Python26\ArcGIS10.0>python ppt_gui.py
Working directory created: c:\temp\osm-bundler-jif1zm
BundlerMatching executable path: C:\Python26\ArcGIS10.0\software\bundler/bin/Ke
MatchFull.exe
Sift executable path: C:\Python26\ArcGIS10.0\software\vlfeat/bin/w32/sift.exe

Processing photo 'P1060065.JPG':
        Copy of the photo has been scaled down to 1200x801
        Extracting features with the SIFT method from VLFeat library...
        Found 10428 features

Processing photo 'P1060066.JPG':
        Copy of the photo has been scaled down to 1200x801
        Extracting features with the SIFT method from VLFeat library...
        Found 13304 features

Processing photo 'P1060067.JPG':
        Copy of the photo has been scaled down to 1200x801
        Extracting features with the SIFT method from VLFeat library...
```

There are plenty of SfM software suites out there:

(Most are not free, especially the nicer ones)

PIX4D Freedom to map

Microsoft Photosynth

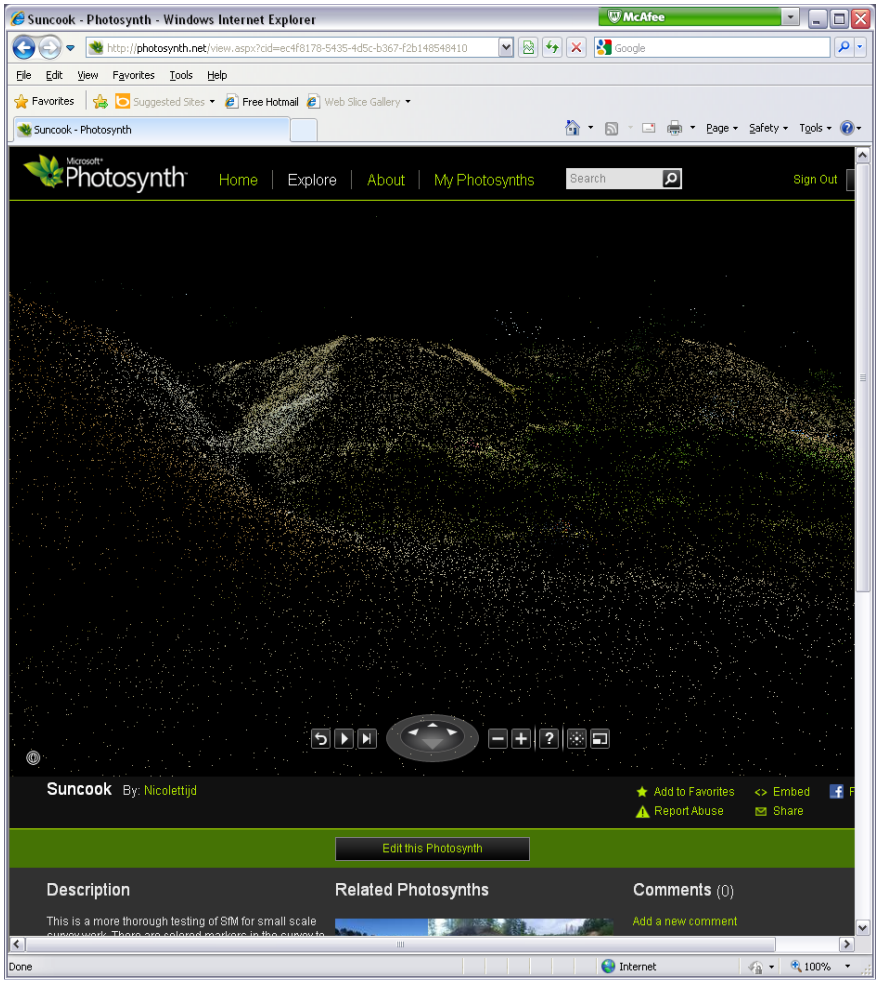
simactive
CUTTING-EDGE PHOTOGRAMMETRY SOFTWARE

AUTODESK 123D

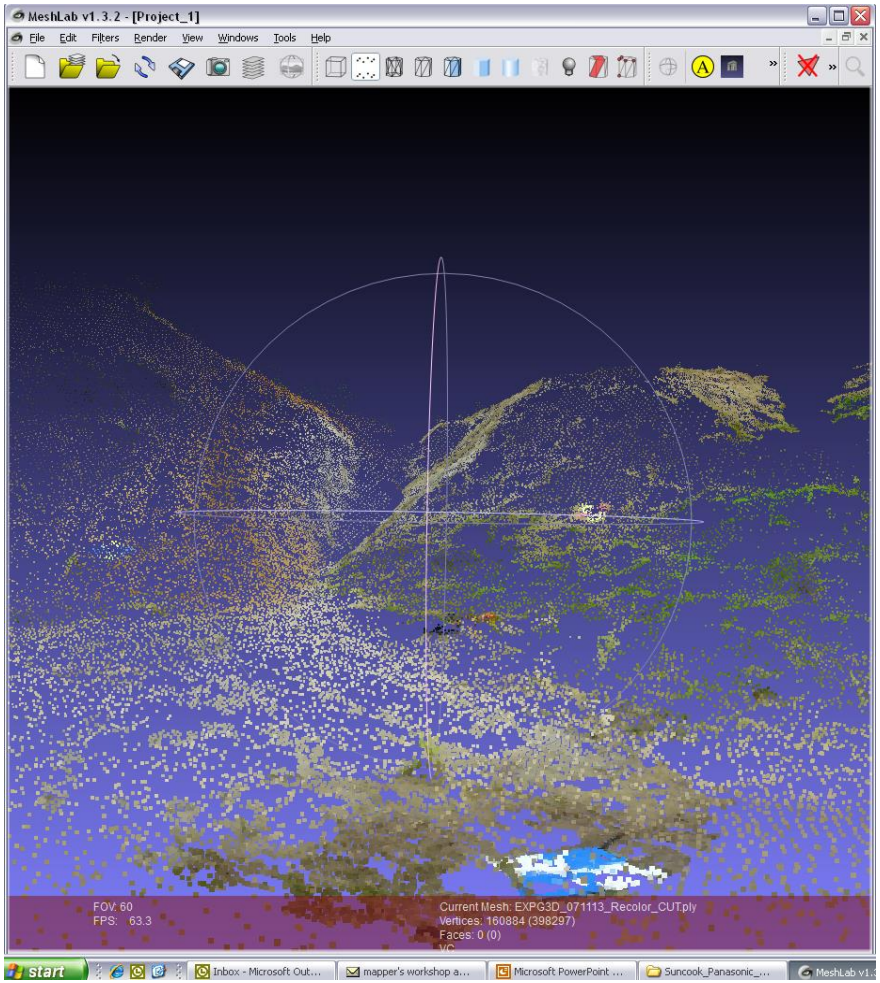
- when it has to be right

Leica Geosystems

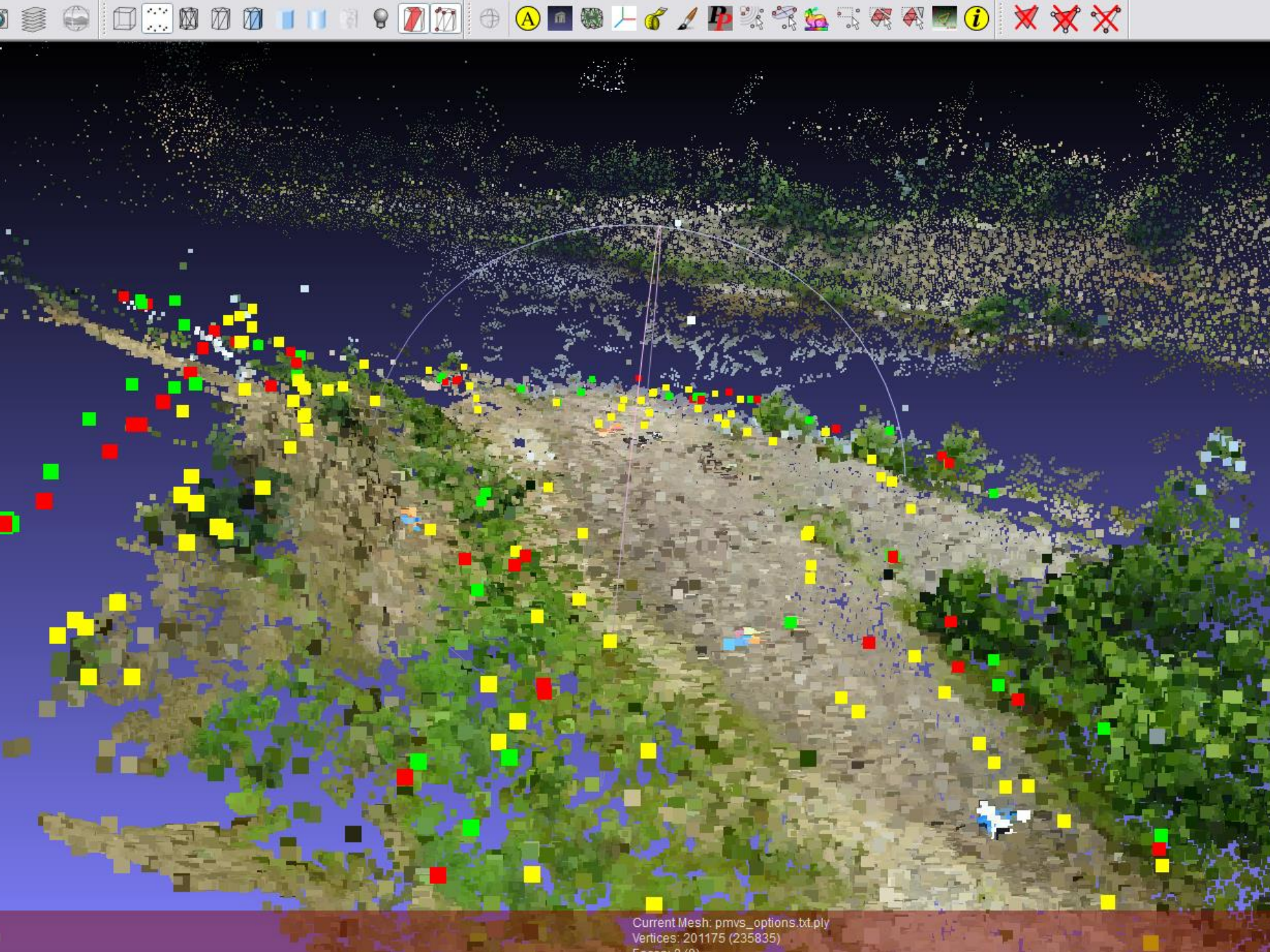
What you choose will depend on your needs and budget:



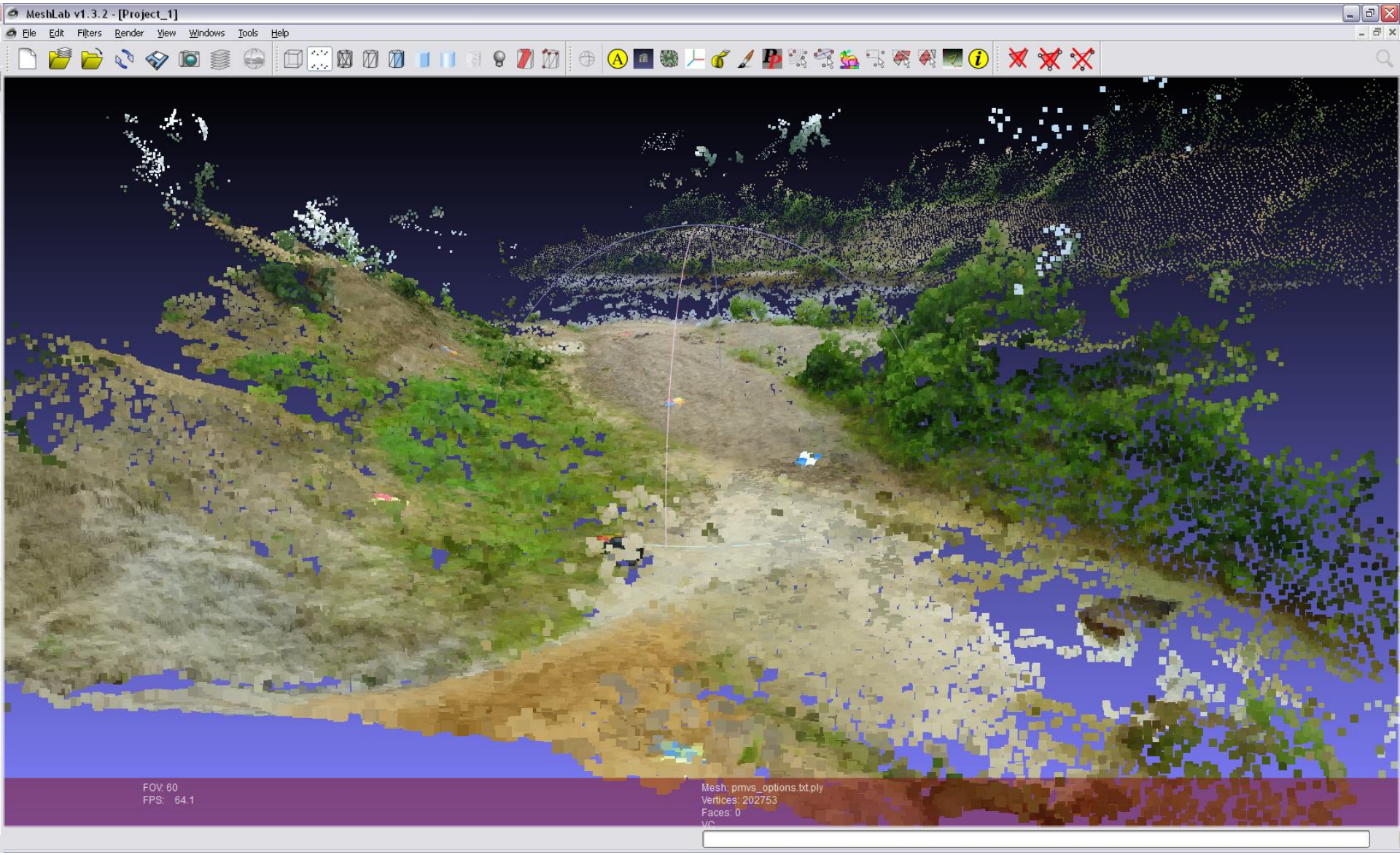
Photosynth: <15min. to create ~60k points



Bundler/PVMS: >10hrs. to create ~100k points


Current Mesh: pmvs_options.txt.ply
Vertices: 201175 (235835)

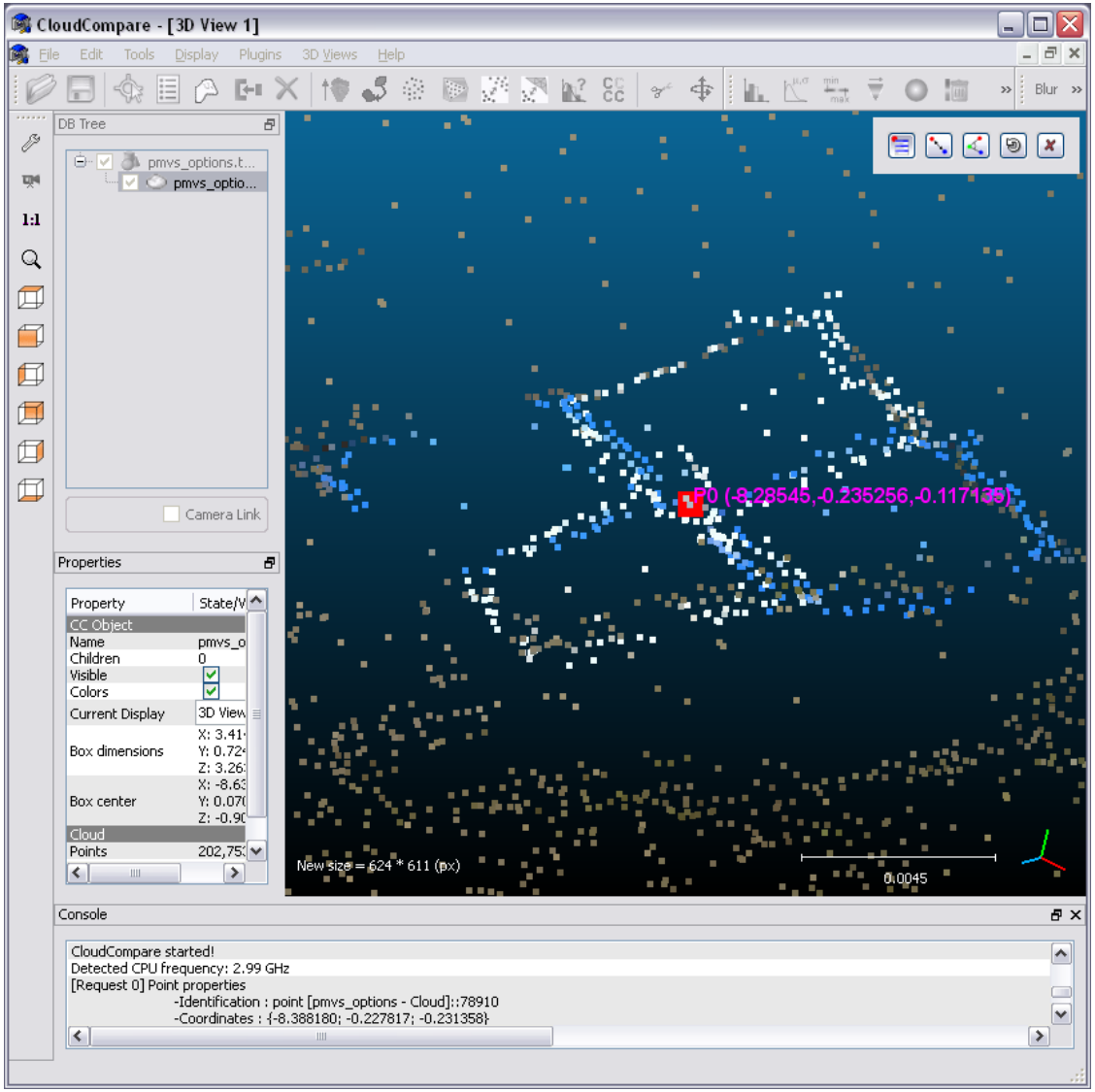
Data Cleaning



expect about an hour of cleaning per 100,000 points

Projecting Point Clouds

- New point clouds are not located in their real-word locations
- They need to be projected into a real scale or coordinate system
- ~1 hour to project a point cloud



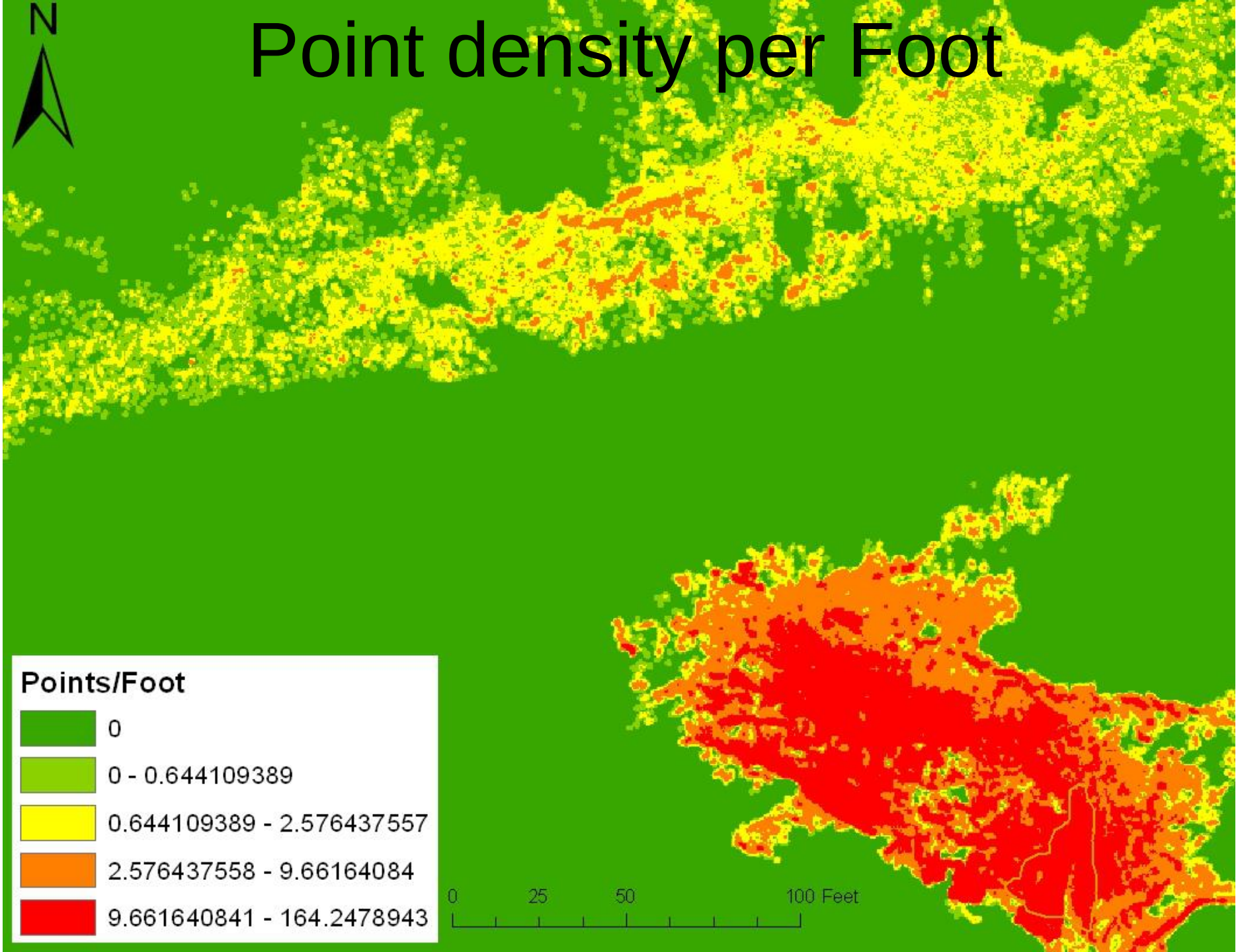
Control Points need to be visible

Post-Processing Review

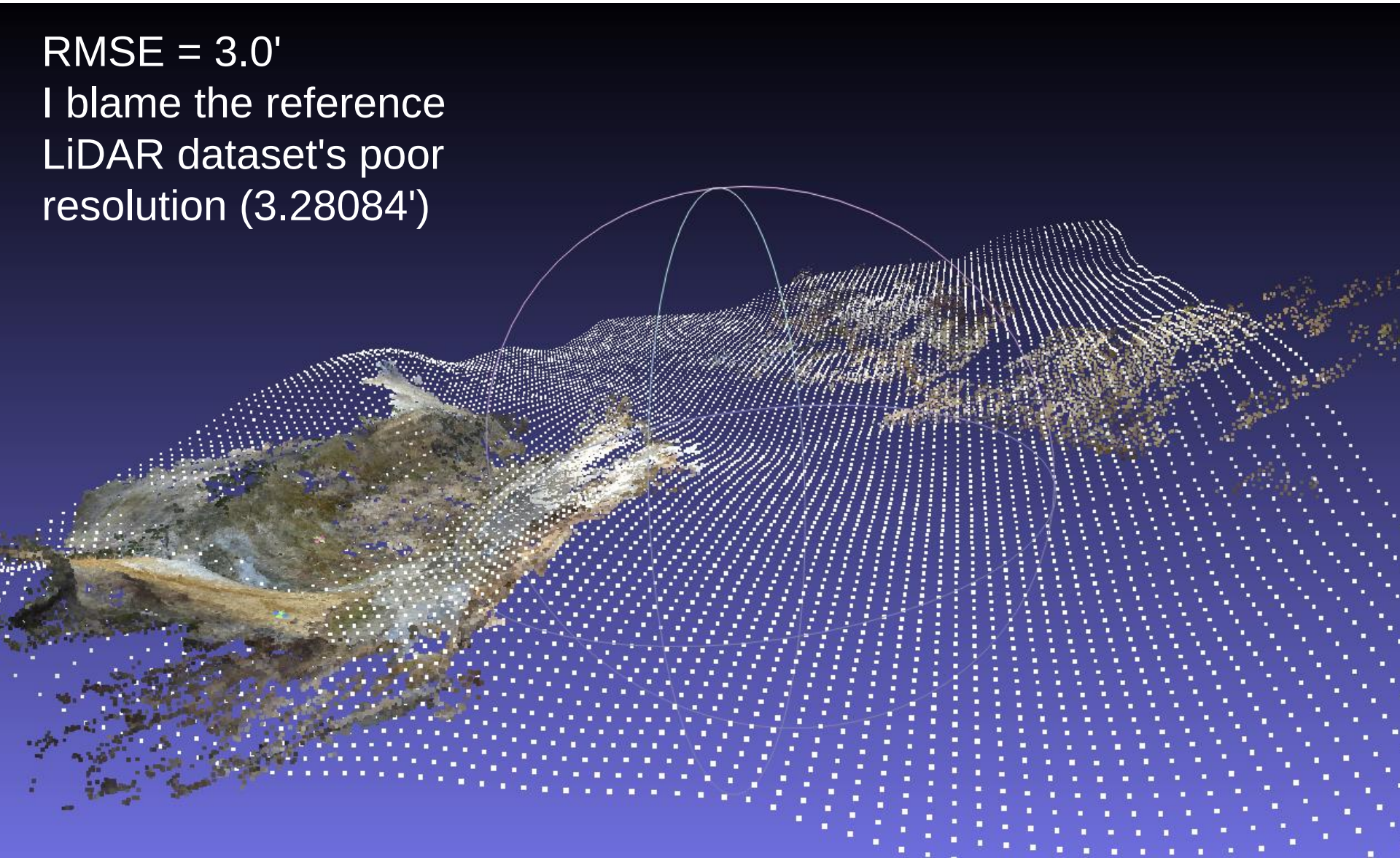
- 1-16 hrs. of processing time (passive)
- 3-5 hrs. of data editing and transformation

Data Density, Accuracy, and Precision

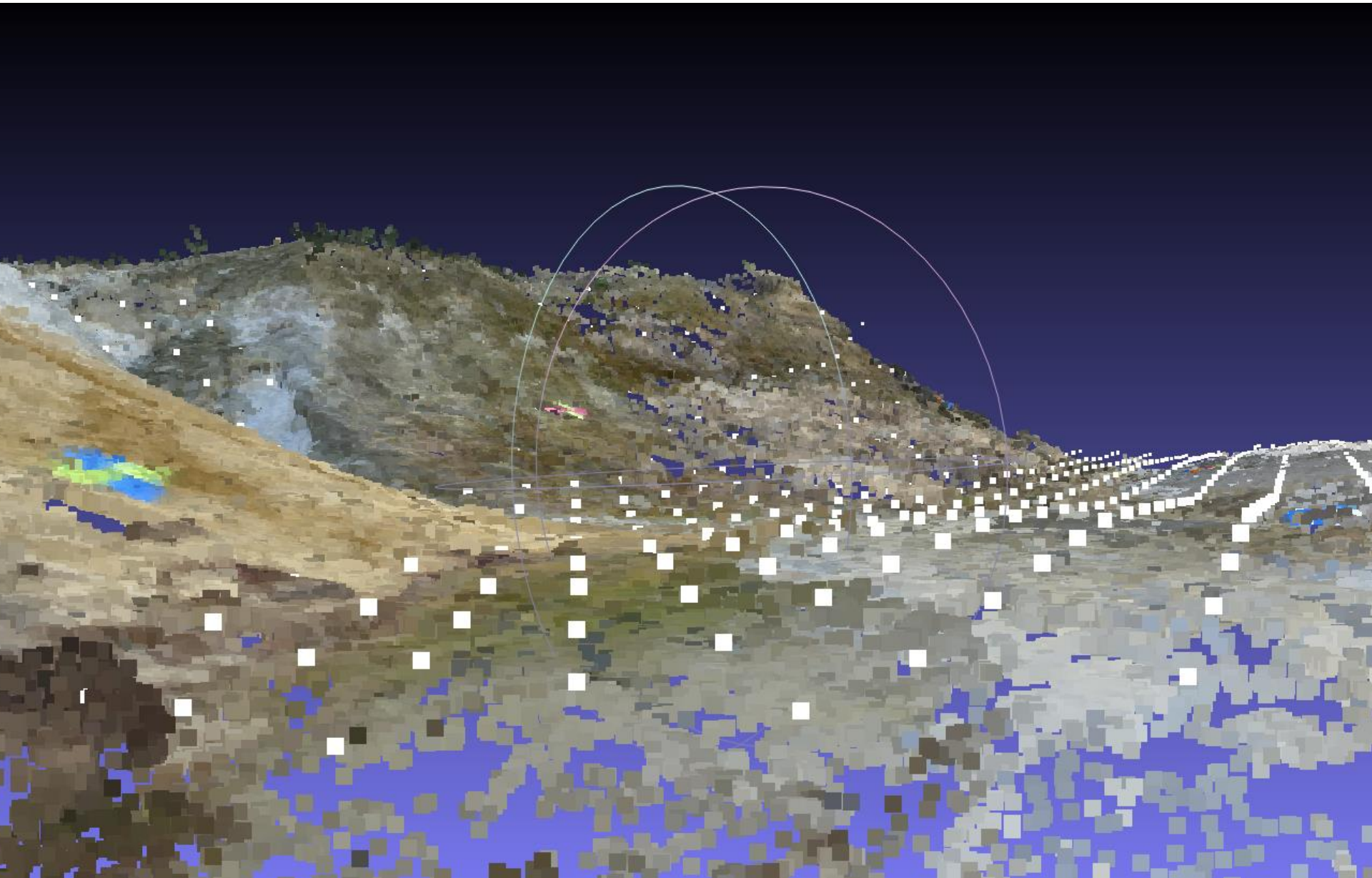
Point density per Foot

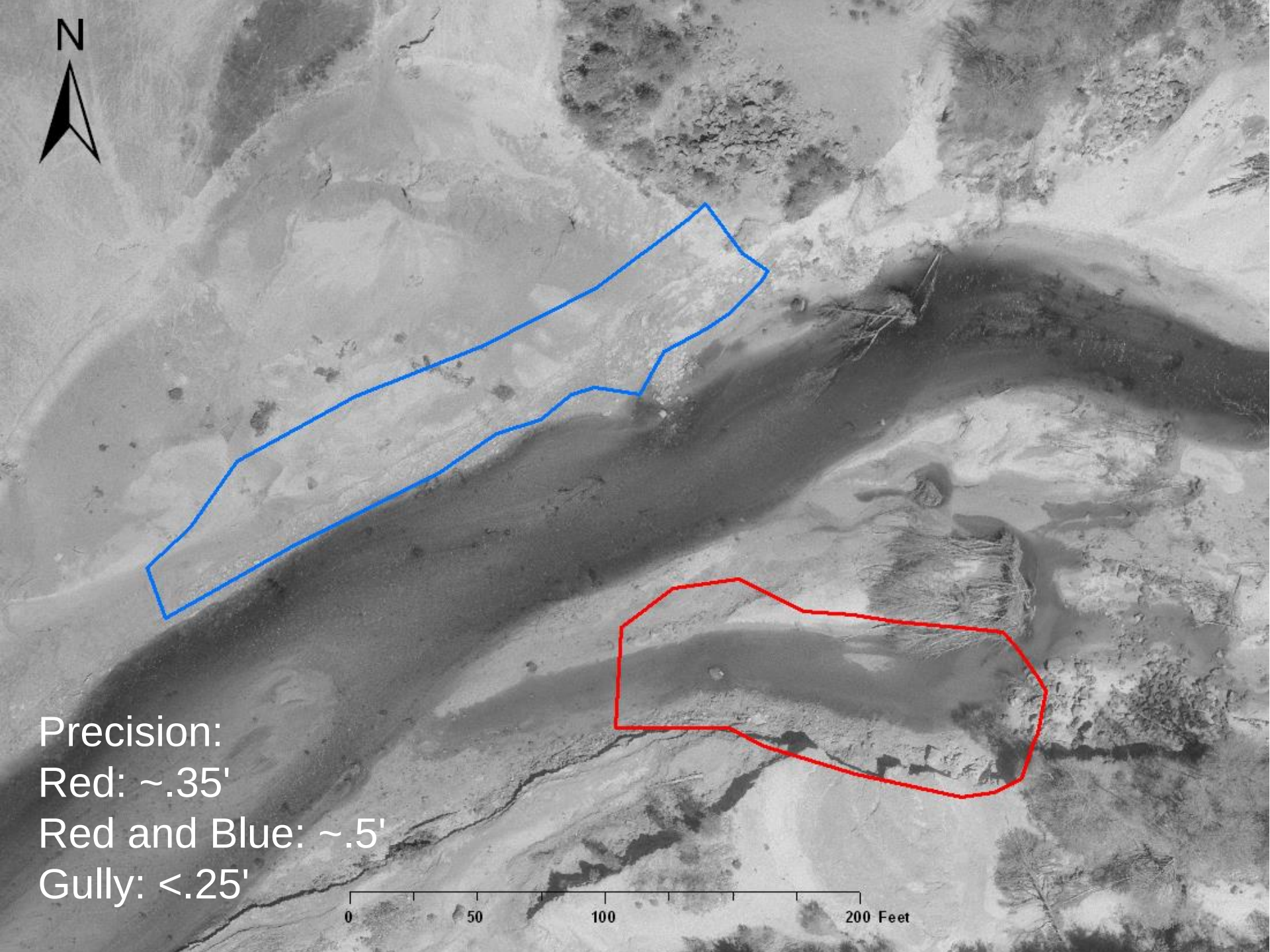


LiDAR(white) vs. SfM (color)



Result? Smaller Survey = >Detail



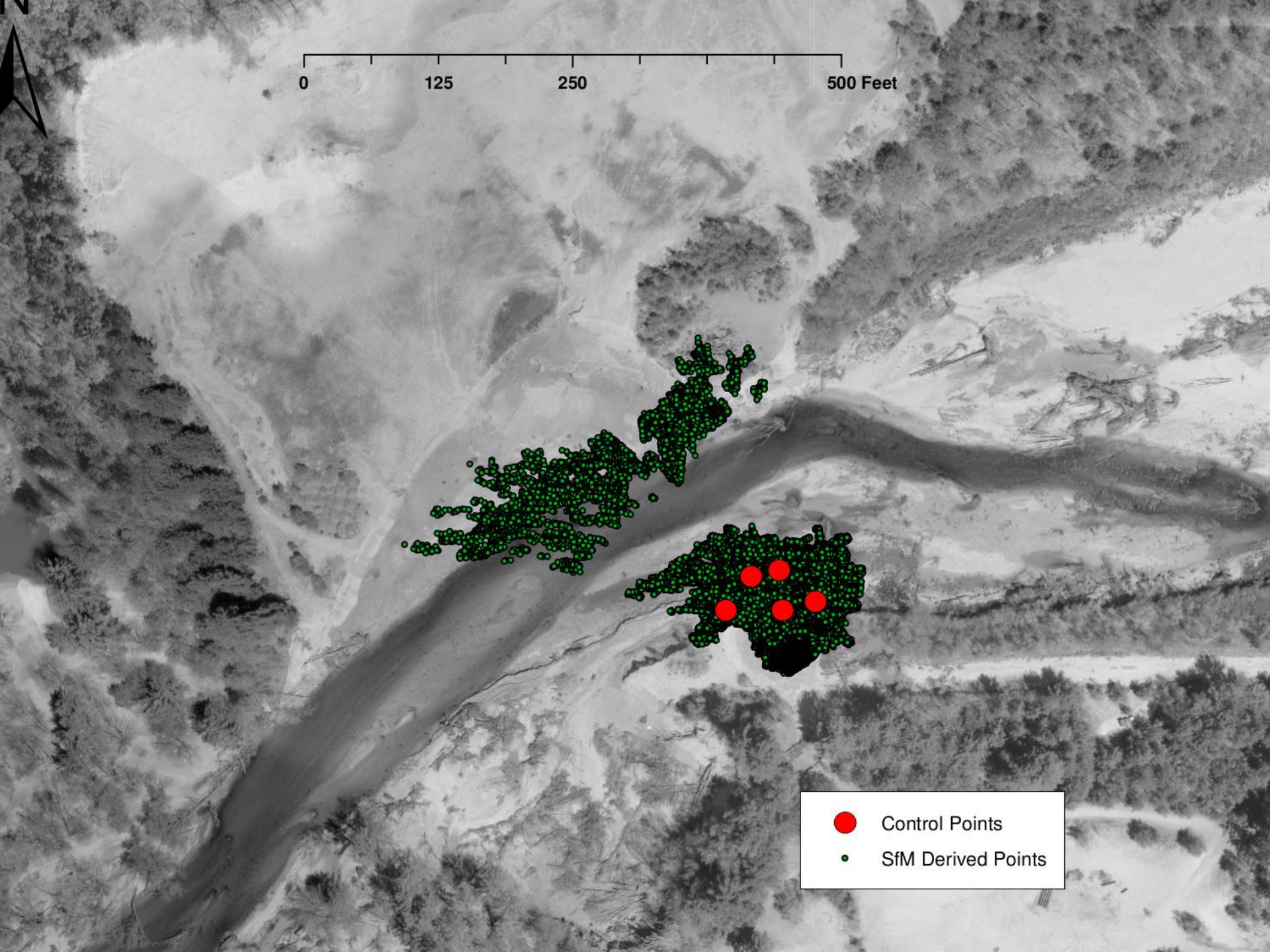

N
Precision:
Red: ~.35'
Red and Blue: ~.5'
Gully: <.25'
0
50
100
200 Feet

Precision suffers from:

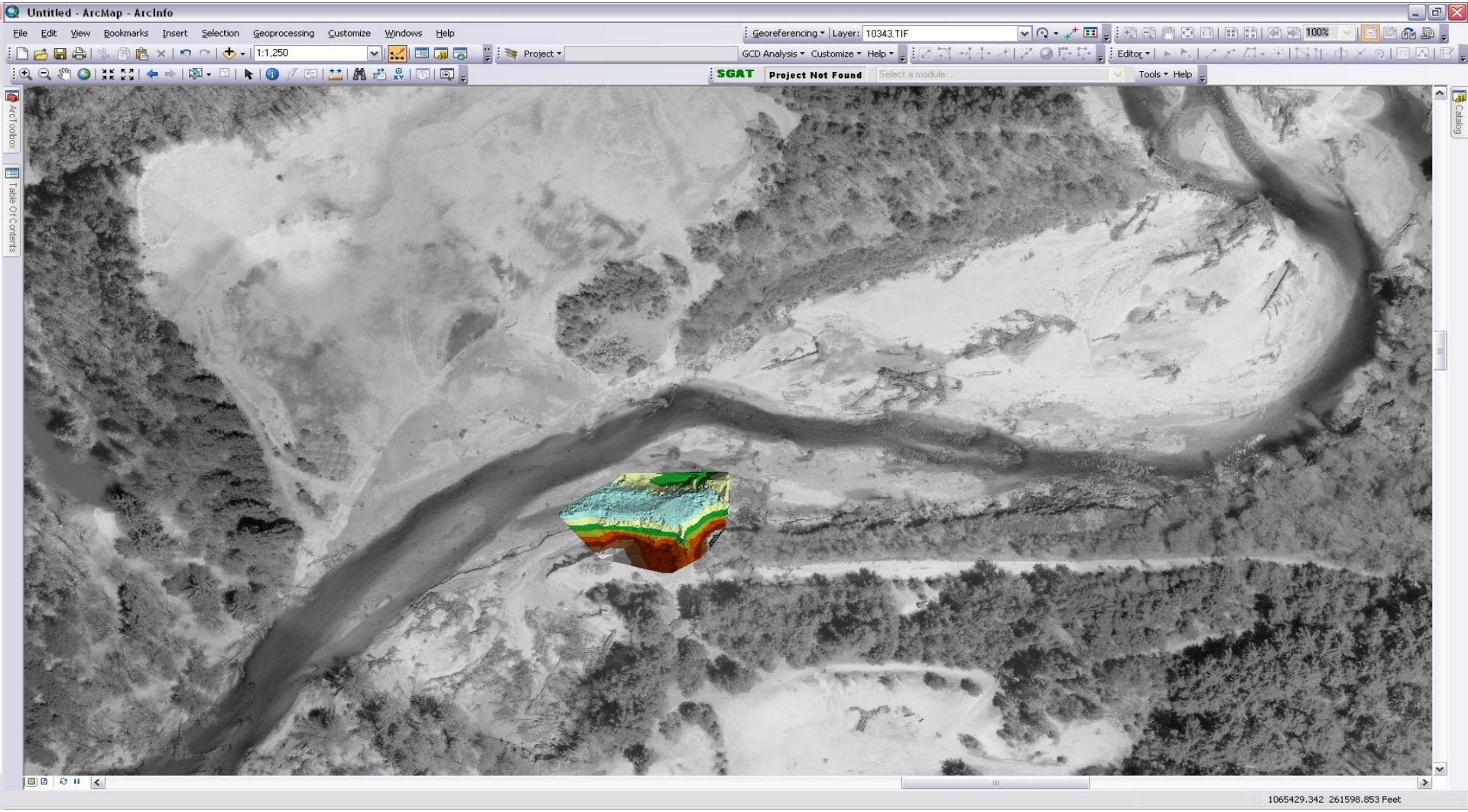
- Distance from camera
- Surface roughness
- Vegetation
- Slope (when converted to raster format)
- Water (Never use SfM on water)

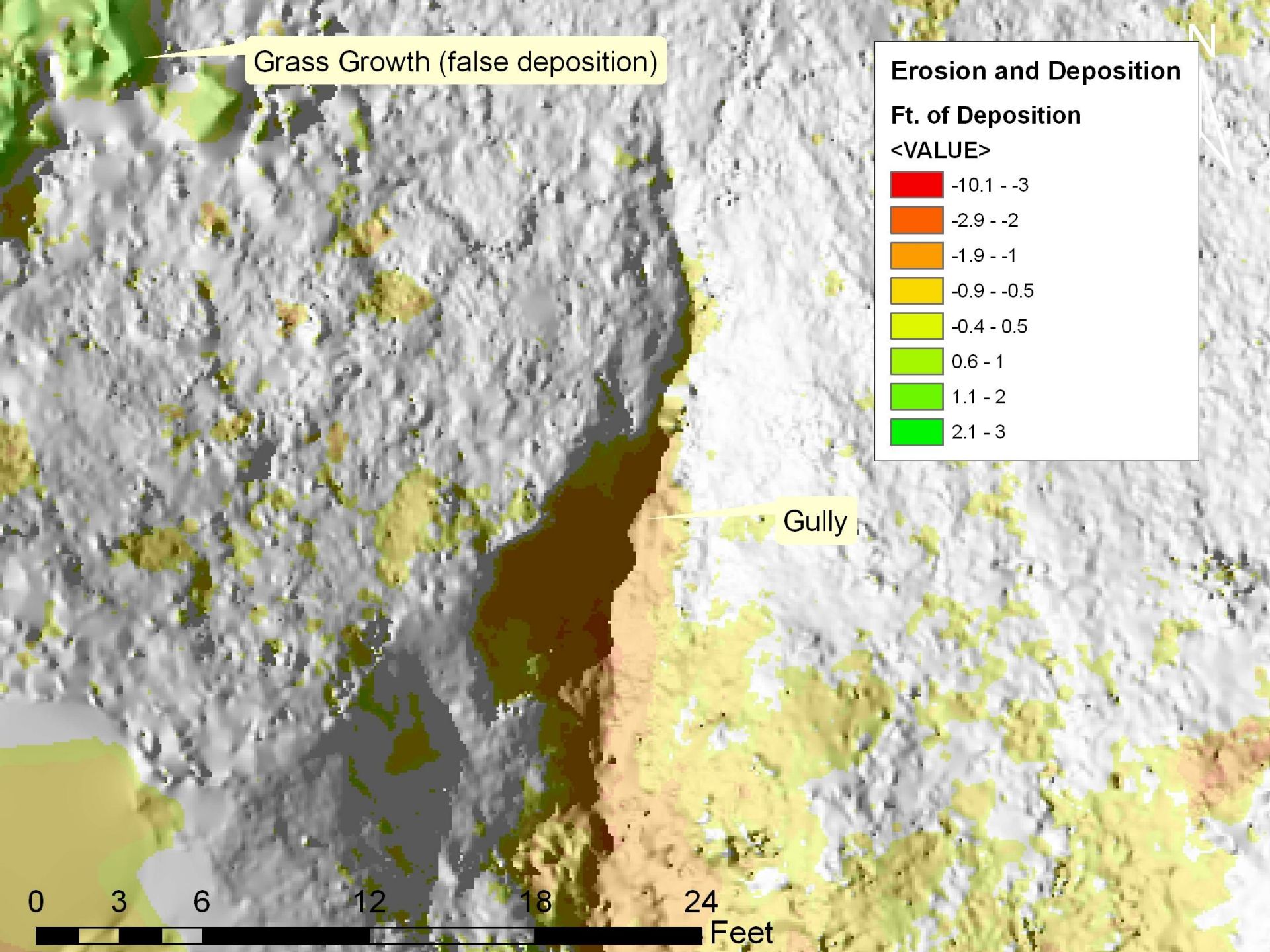
Data Applications

Wheaton, 2008

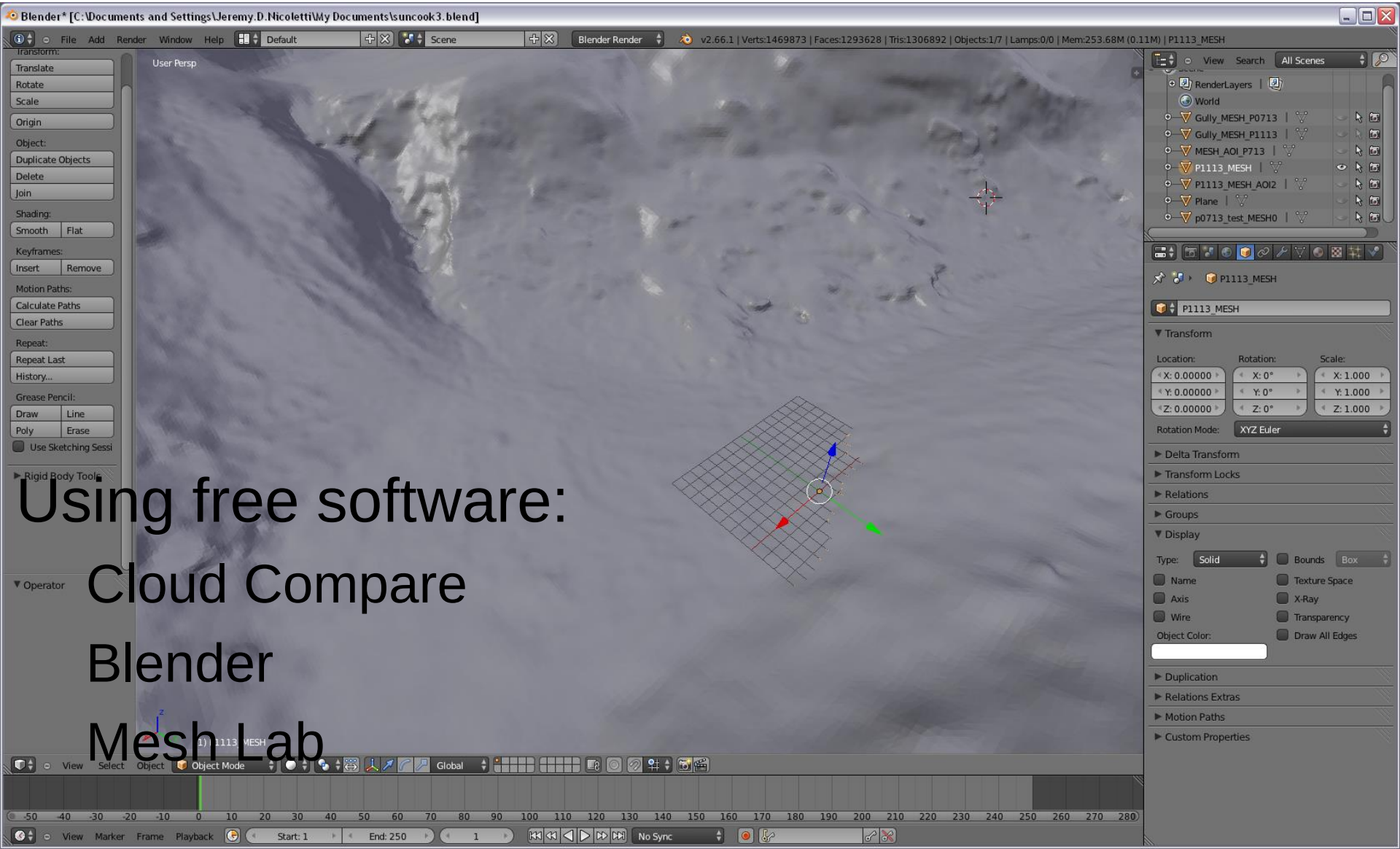

N
0
125
250
500 Feet
Control Points
SfM Derived Points

Arc GIS: Converting/Analysis




Grass Growth (false deposition)
Gully
Erosion and Deposition
Ft. of Deposition
<VALUE>
-10.1 - -3
-2.9 - -2
-1.9 - -1
-0.9 - -0.5
-0.4 - 0.5
0.6 - 1
1.1 - 2
2.1 - 3
N
0
3
6
12
18
24
Feet

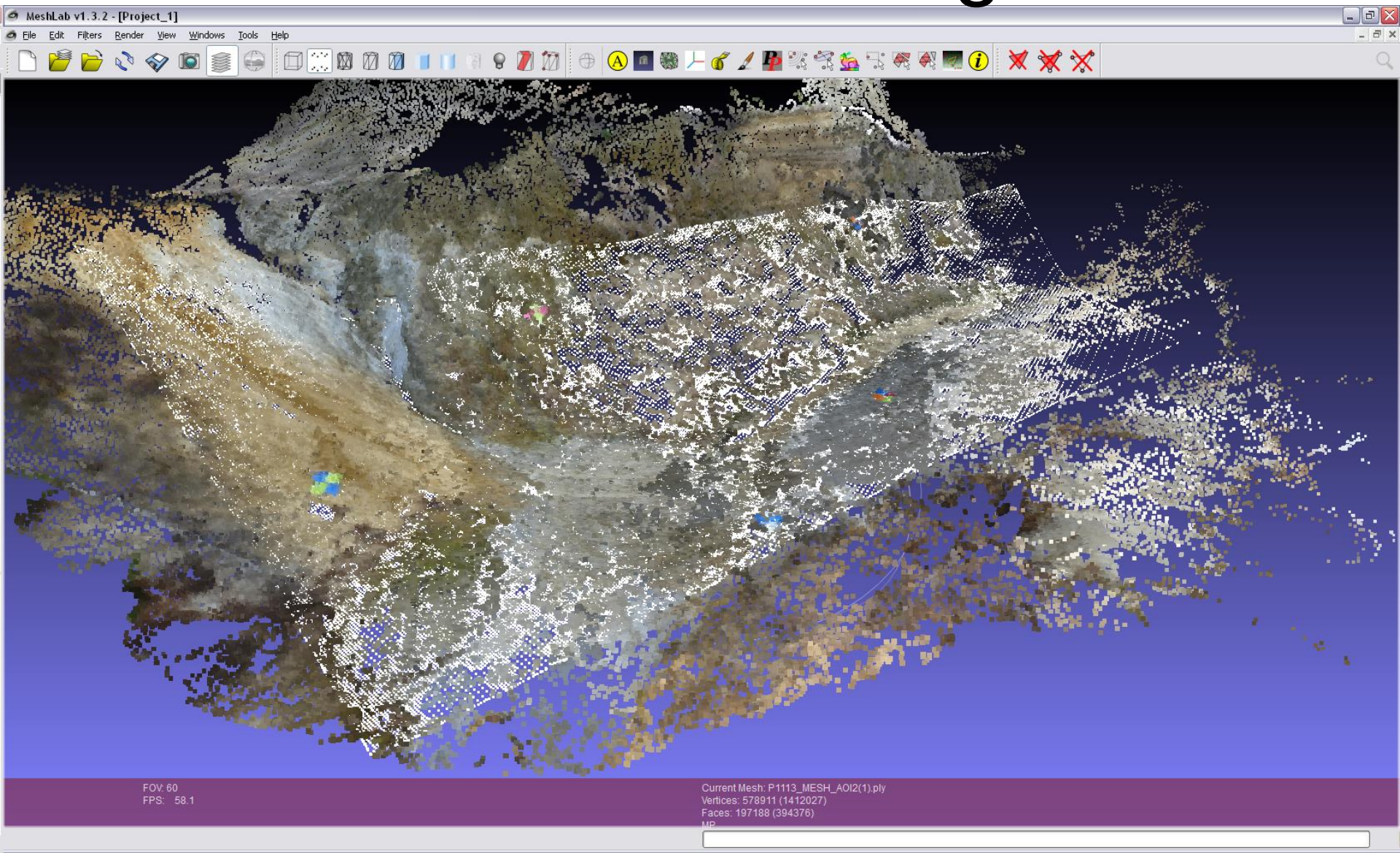
3D Models and Measurements



Using free software:

- Cloud Compare
- Blender
- Mesh Lab

We can target sections of a survey for 3D modeling



d Settings\Jeremy.D.Nicoletti\My Documents\suncook1.blend]

Window Help Default Scene Blender Render v2.66.1 | Verts:641431 | Faces:1270251 | Tris:1282842 | Objects:1/5 | Lamps:0/0 | Mem:440.66M (0.11M) | Plane

ser Persp

View

Scene

Render

World

Gully_

P1113

Plane

gully_n

p0713

Plane

Transform

Location:

4.584

18.04

28.80

Rotation M

Delta Transfo

Transform Lo

Relations

Groups

Display

Type: Solid

Name

Axis

Wire

Object Color:

Duplication

Relations Ext

Motion Paths

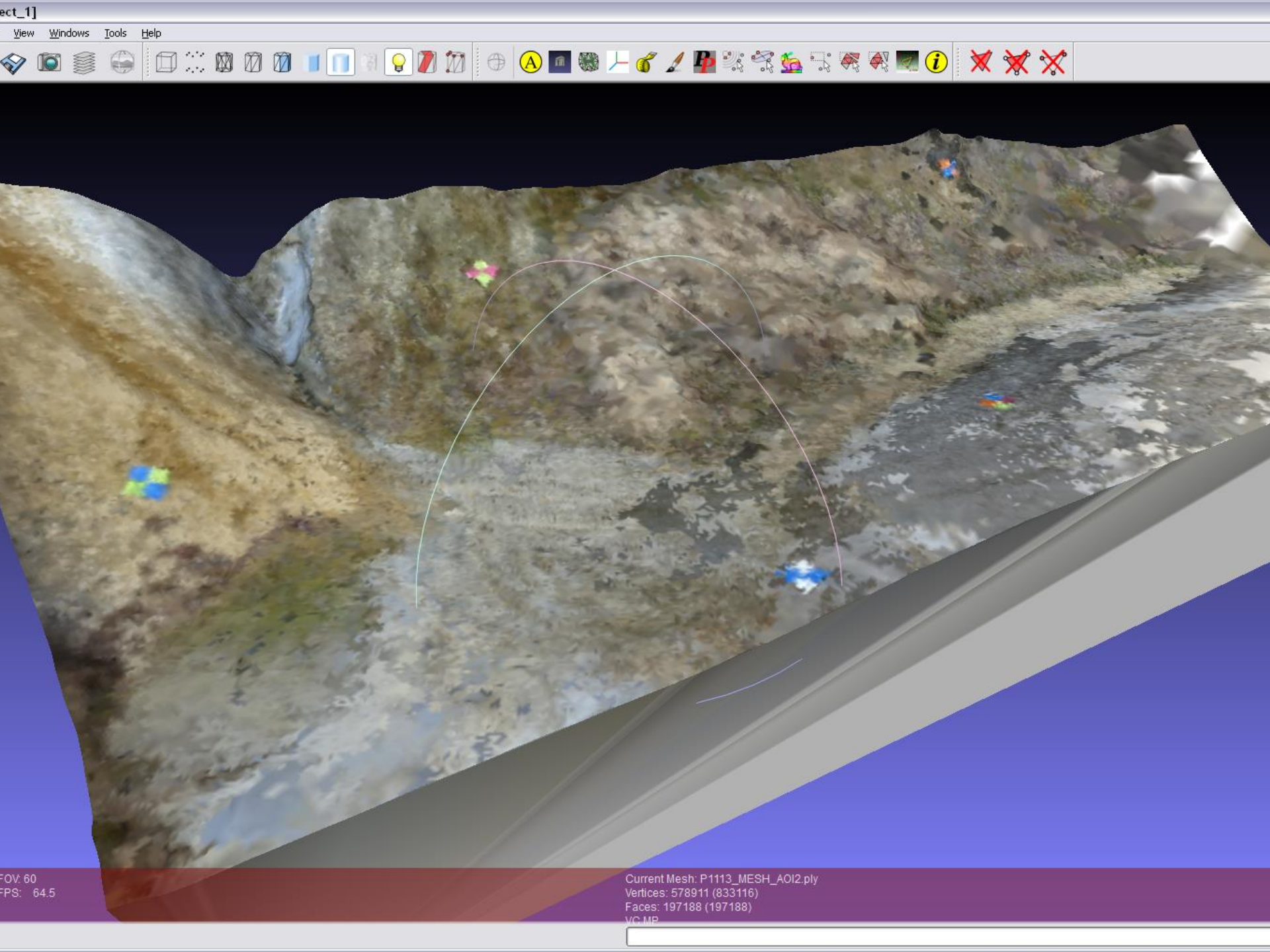
Custom Prop

(1) Plane

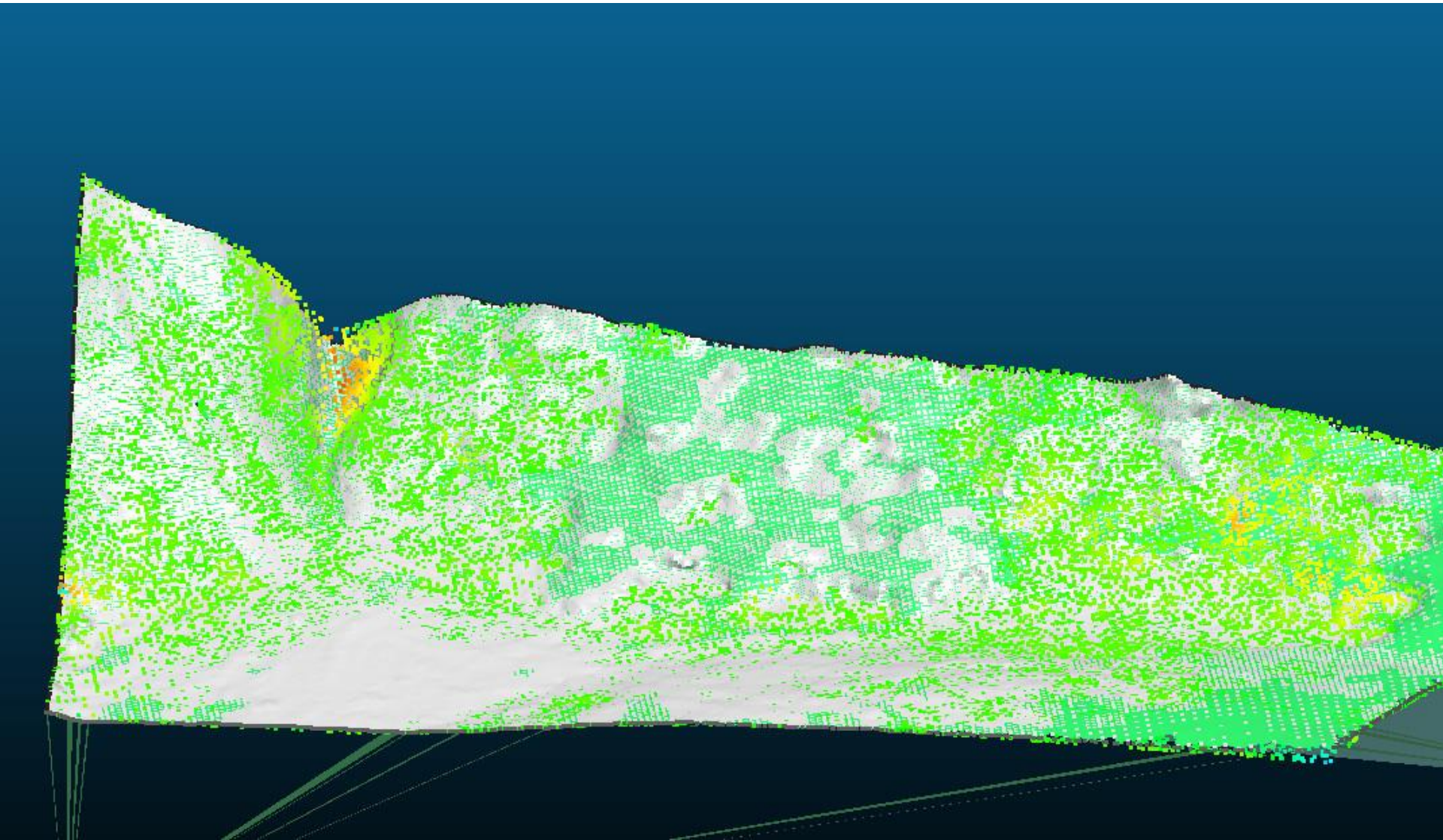
Object Mode Global

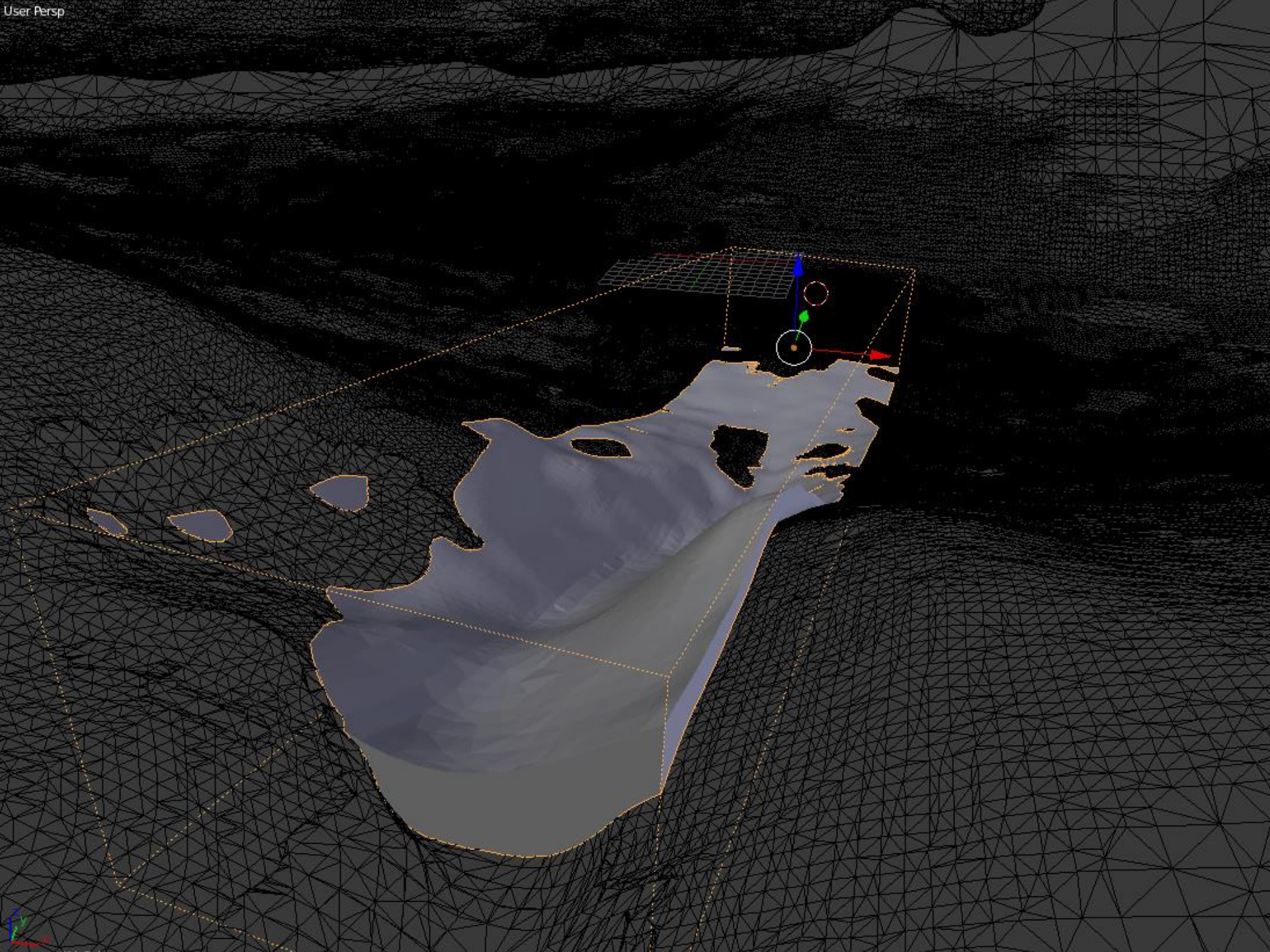
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280

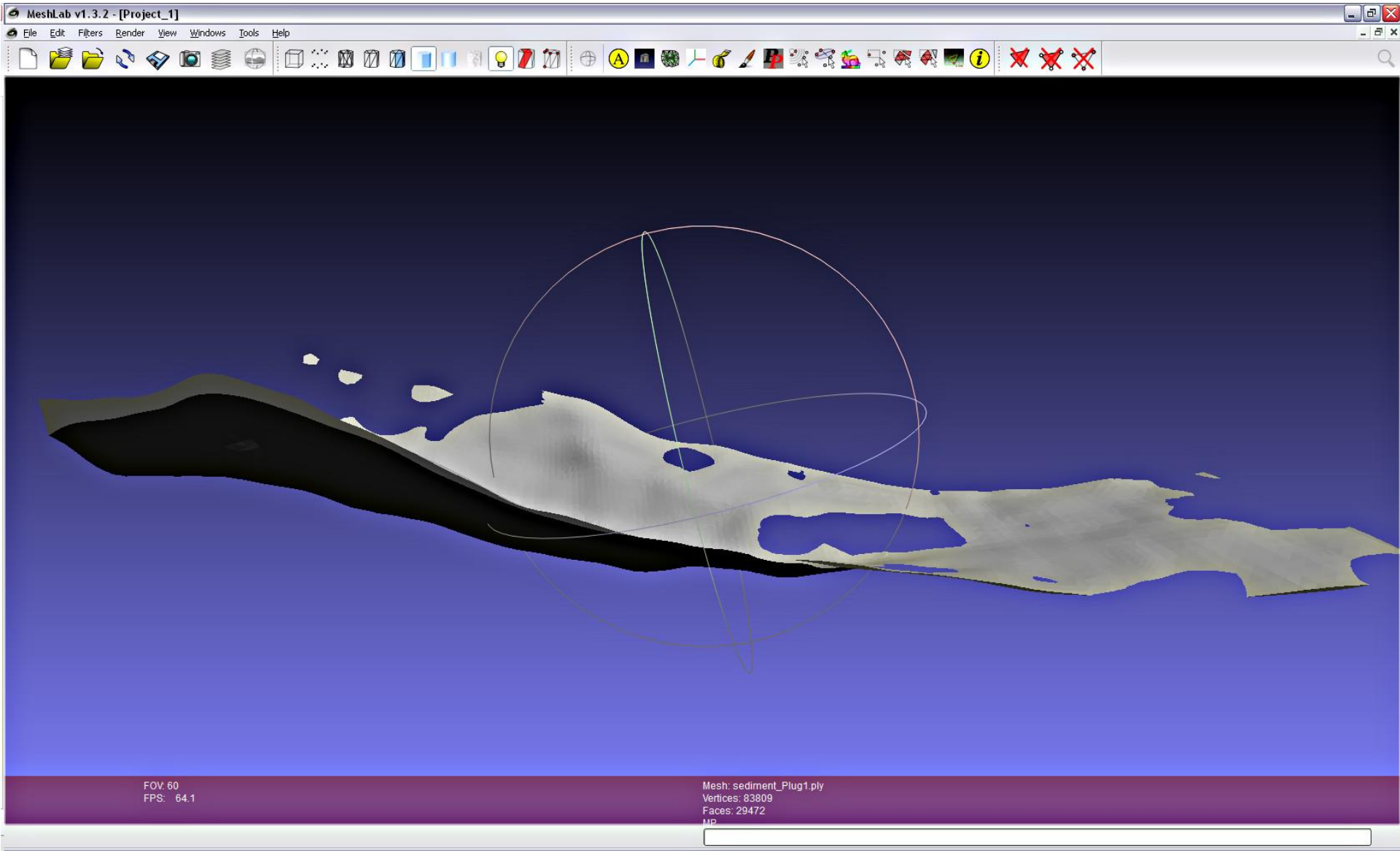
Playback Start: 1 End: 250 1 No Sync

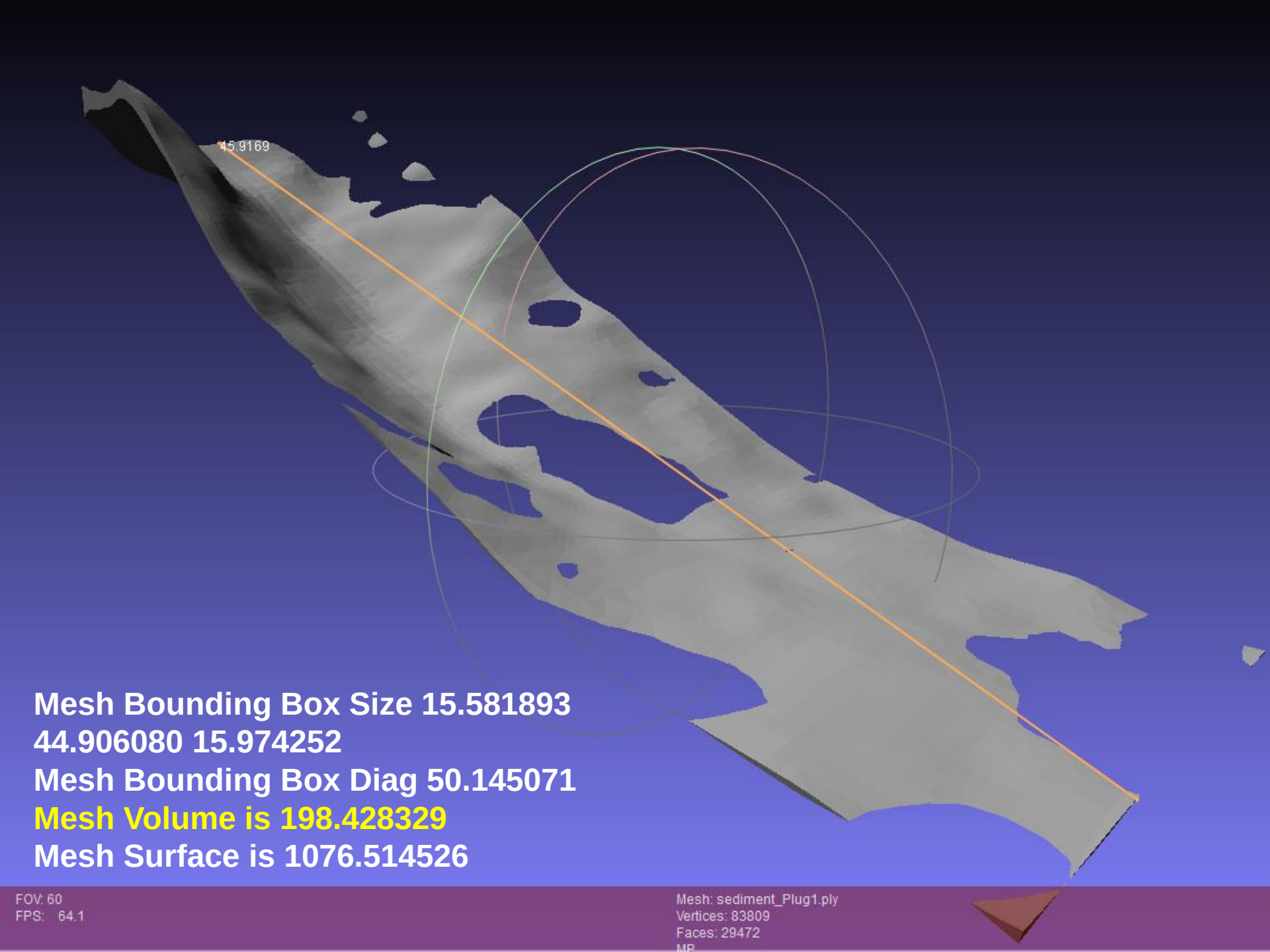

ect_1]
View
Windows
Tools
Help
FOV: 60
FPS: 64.5
Current Mesh: P1113_MESH_AOI2.ply
Vertices: 578911 (833116)
Faces: 197188 (197188)
VC MP

Point Cloud to Mesh Distance:



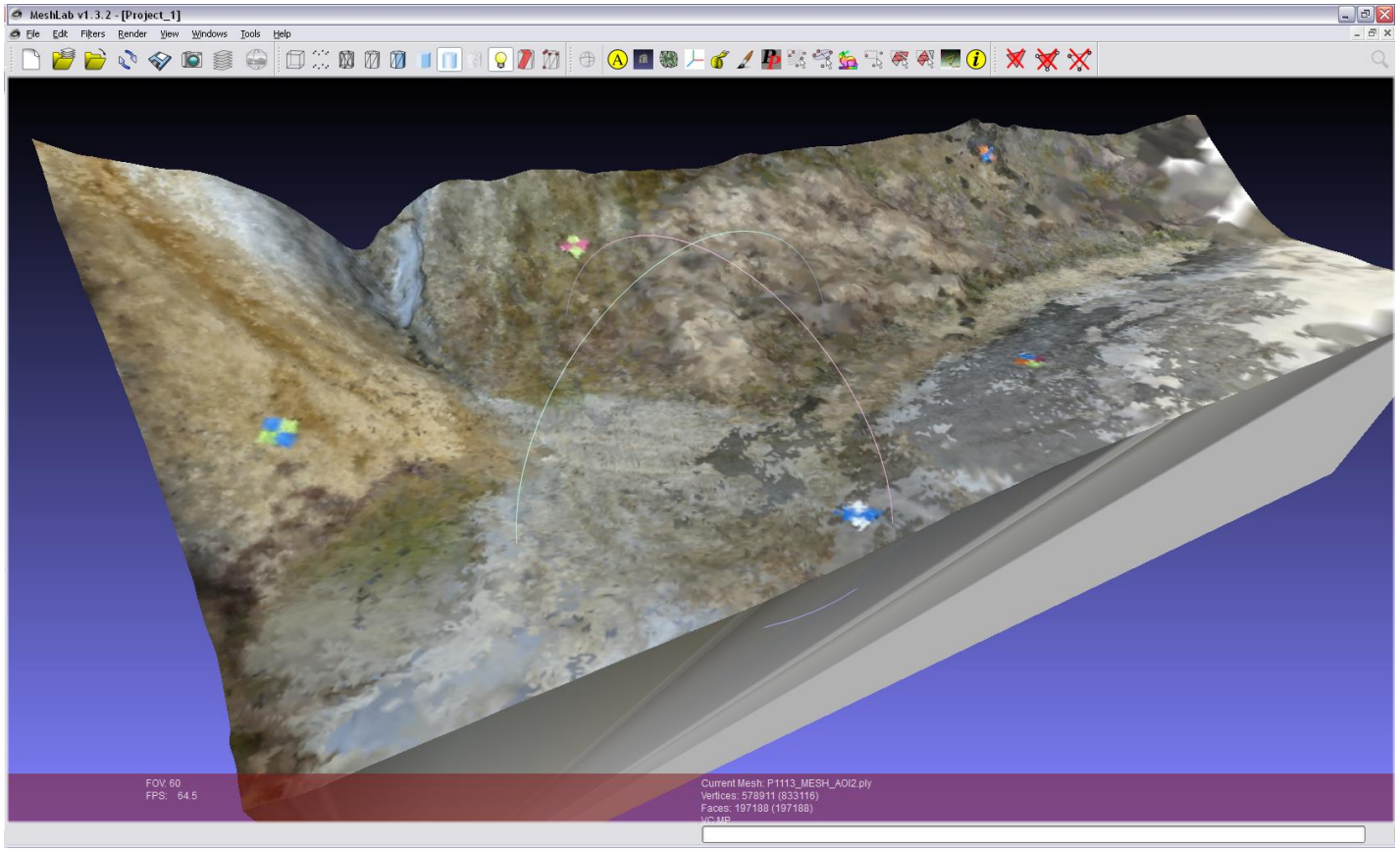

User Persp


MeshLab v1.3.2 - [Project_1]
File Edit Filters Render View Windows Tools Help
FOV: 60
FPS: 64.1
Mesh: sediment_Plug1.ply
Vertices: 83809
Faces: 29472


45.9169
Mesh Bounding Box Size 15.581893
44.906080 15.974252
Mesh Bounding Box Diag 50.145071
Mesh Volume is 198.428329
Mesh Surface is 1076.514526
FOV: 60
FPS: 64.1
Mesh: sediment_Plug1.ply
Vertices: 83809
Faces: 29472

General Conclusion

SfM is an excellent tool for building robust spatial models of eroding stream banks on a budget, but requires time to learn.



Conclusions

- Field surveys are much faster than most traditional bank monitoring methods
  - A minimalist survey can be completed with Camera, Stakes, Skirts, Measuring Tape, and Clinometer
- Post-Processing times are highly variable depending on work flow, and generally time-consuming
- Datasets are dense and useful for detecting small changes over a large area

Minimal Field Gear:

First Site Visit:

-Camera

-Stakes

-Colored Stake Skirts

-Hammer

Second Site Visit:

-Above Equipment

-Surveying Gear

Point Cloud Examples:

http://photosynth.net/view.aspx?cid=bcc308a3-06d8-41c3-88f7-340c29b8ce1d

Early spring ^

http://photosynth.net/view.aspx?cid=f56509e1-aedf-4a6d-bc45-89a1a41f9cd6

Summer ^

Works Cited

Wheaton JM. 2008. Uncertainty in Morphological Sediment Budgeting of Rivers. Unpublished PhD Thesis, University of Southampton, Southampton, 412 pp.

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