Lidar Theory and Application

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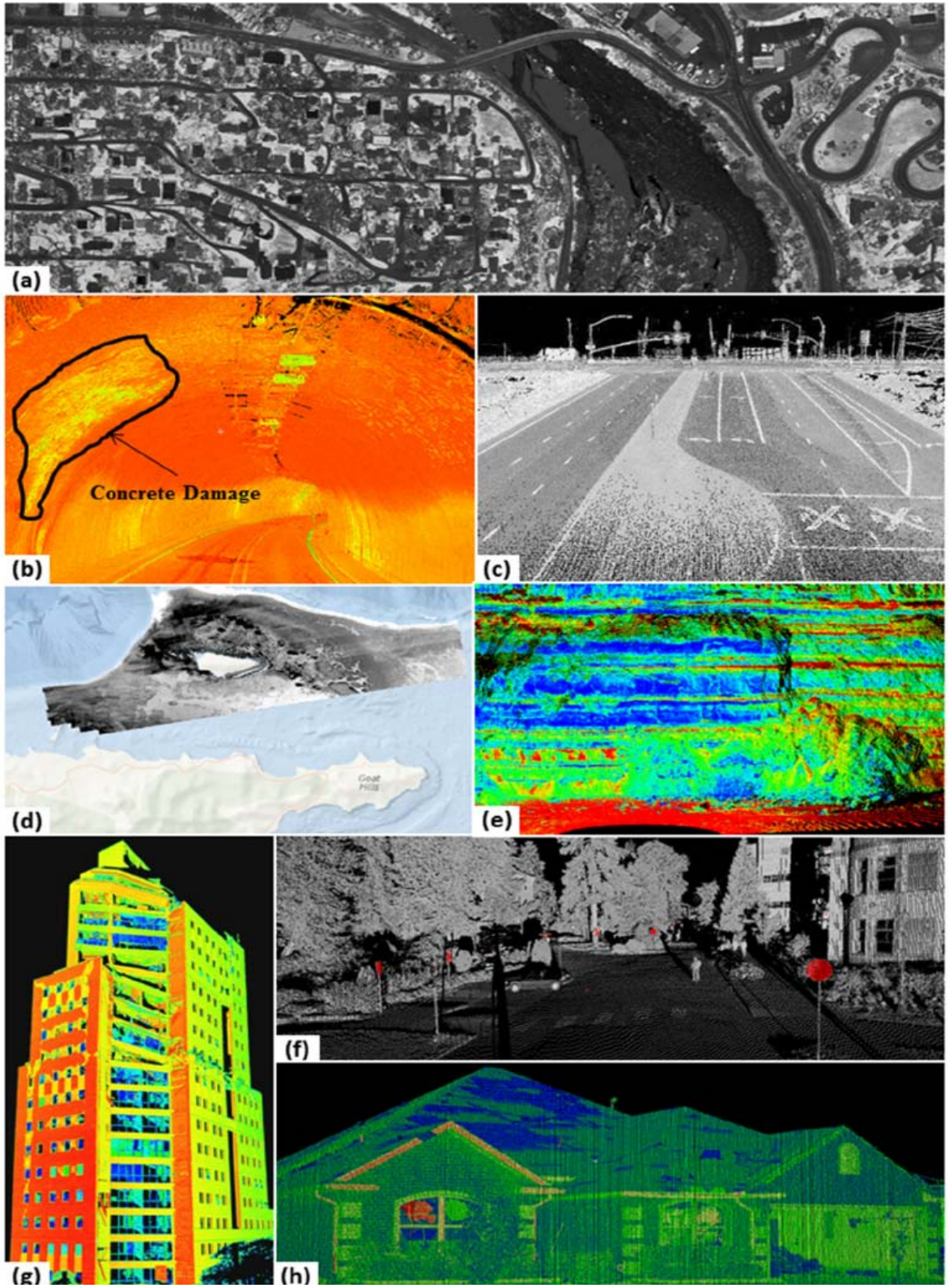
What is LIDAR?

- LIDAR (light detection and ranging) is a method for measuring distances (ranging) by illuminating the target with laser light and measuring the reflection with a sensor.
- Differences in laser return times and wavelengths can then be used to make digital 3-D representations of the target.
- Lidar sometimes is called 3-D laser scanning, a special combination of a 3-D scanning and laser scanning.

LIDAR Application

Lidar is commonly used to make high-resolution maps, with applications in

- Surveying, geodesy, and geomatics,
- archaeology
- Geography, geology, geomorphology, seismology,
- forestry, atmospheric physics,
- laser guidance, airborne laser swath mapping (ALSM), and laser altimetry.



Lidar scanning performed with a multicopter UAV.

How Does LiDAR Work?

- LiDAR is an active remote sensing system that the system itself generates energy - in this case, light - to measure things on the ground.
- In a LiDAR system, light is emitted from a rapidly firing laser. This light travels to the ground and reflects off of things like buildings and tree branches.
- The reflected light energy then returns to the LiDAR sensor where it is recorded.
- A LiDAR system measures the time it takes for emitted light to travel to the ground and back.
- That time is used to calculate distance traveled. Distance traveled is then converted to elevation.
- These measurements are made using the key components of a lidar system including a GPS that identifies the X,Y,Z location of the light energy and an Internal Measurement Unit (IMU) that provides the orientation of the plane in the sky.

LiDAR system components

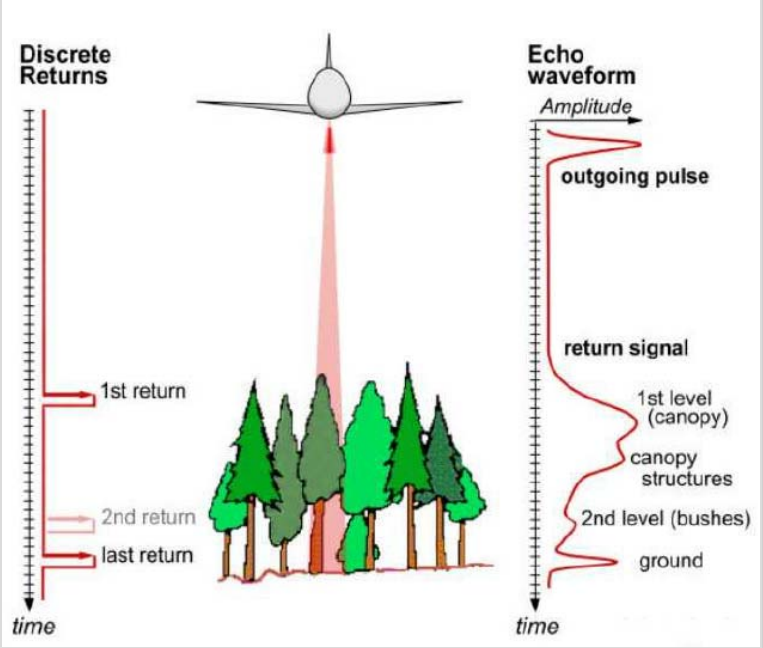
There are 4 main parts of an airborne LiDAR, that work together to produce highly accurate, usable results:

- LiDAR Sensors: As the airplane or Drone travels, sensors scan the ground from side-to-side. The pulses are commonly in green or near-infrared bands.
- GPS Receivers: GPS receivers track the altitude and location of the airplane. These tracks are important for accurate terrain and elevation values.
- Inertial Measurement Units (IMU): As airplanes travel, IMUs tracks its tilt. LiDAR systems use tilt to accurately measure incident angle of the pulse.
- Data Recorders: As LiDAR scans the surface, a computer records all of the pulse returns. Then, these recordings get translated into elevation.

Discrete vs. Full Waveform LiDAR

A waveform or distribution of light energy is what returns to the LiDAR sensor. However, this return may be recorded in two different ways.

- A Discrete Return LiDAR System records individual (discrete) points for the peaks in the waveform curve. Discrete return LiDAR systems identify peaks and record a point at each peak location in the waveform curve. These discrete or individual points are called returns. A discrete system may record 1-4 (and sometimes more) returns from each laser pulse.
- A Full Waveform LiDAR System records a distribution of returned light energy. Full waveform LiDAR data are thus more complex to process however they can often capture more information compared to discrete return LiDAR systems.



https://www.youtube.com/watch?v=q7qZmODh6lI

LiDAR File Formats

- Whether it is collected as discrete points or full waveform, most often LiDAR data are available as discrete points. A collection of discrete return LiDAR points is known as a LiDAR point cloud.
- The commonly used file format to store LIDAR point cloud data is called .las which is a format supported by the American Society of Photogrammetry and Remote Sensing (ASPRS).
- Recently, the .laz format has been developed by Martin Isenberg of LasTools. The differences is that .laz is a highly compressed version of .las.
- Data products derived from LiDAR point cloud data are often raster files that may be in GeoTIFF (.tif) formats.

LiDAR Data Attributes: X, Y, Z, Intensity and Classification

- LiDAR data attributes can vary, depending upon how the data were collected and processed.
- You can determine what attributes are available for each lidar point by looking at the metadata.
- All lidar data points will have an associated X,Y location and Z (elevation) values.
- Most lidar data points will have an intensity value, representing the amount of light energy recorded by the sensor.

Summary

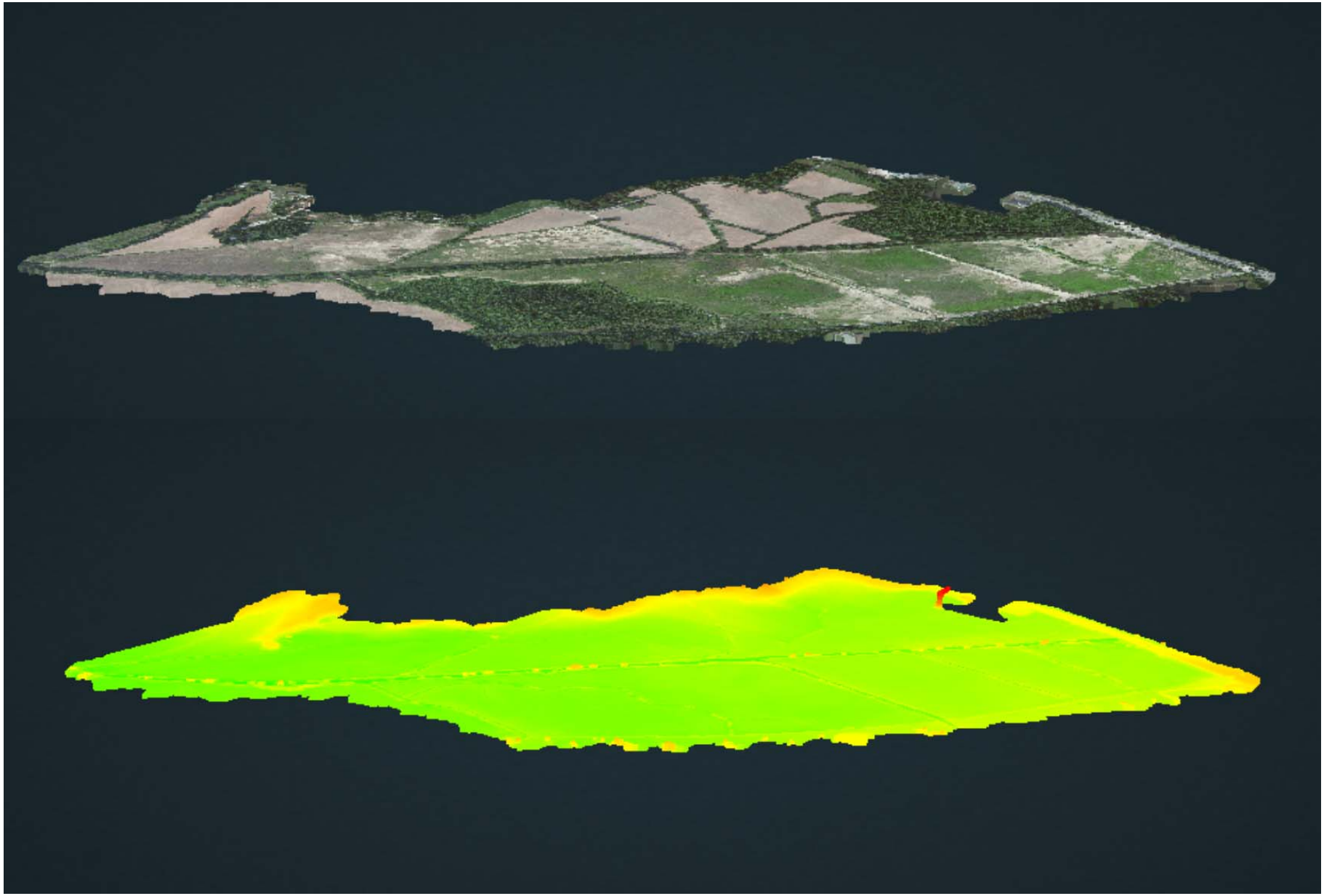
- A LiDAR system uses a laser, a GPS and an IMU to estimate the heights of objects on the ground.
- Discrete LiDAR data are generated from waveforms -- each point represent peak energy points along the returned energy.
- Discrete LiDAR points contain an x, y and z value. The z value is what is used to generate height.
- LiDAR data can be used to estimate tree height and even canopy cover using various methods.

LiDAR Applications

Agriculture

- Agricultural robots have been used for a variety of purposes ranging from seed and fertilizer dispersions, sensing techniques as well as crop scouting for the task of weed control.
- Lidar can help determine where to apply costly fertilizer. It can create a topographical map of the fields and reveal slopes and sun exposure of the farmland.
- Researchers at the Agricultural Research Service used this topographical data with the farmland yield results from previous years, to categorize land into zones of high, medium, or low yield. This indicates where to apply fertilizer to maximize yield.

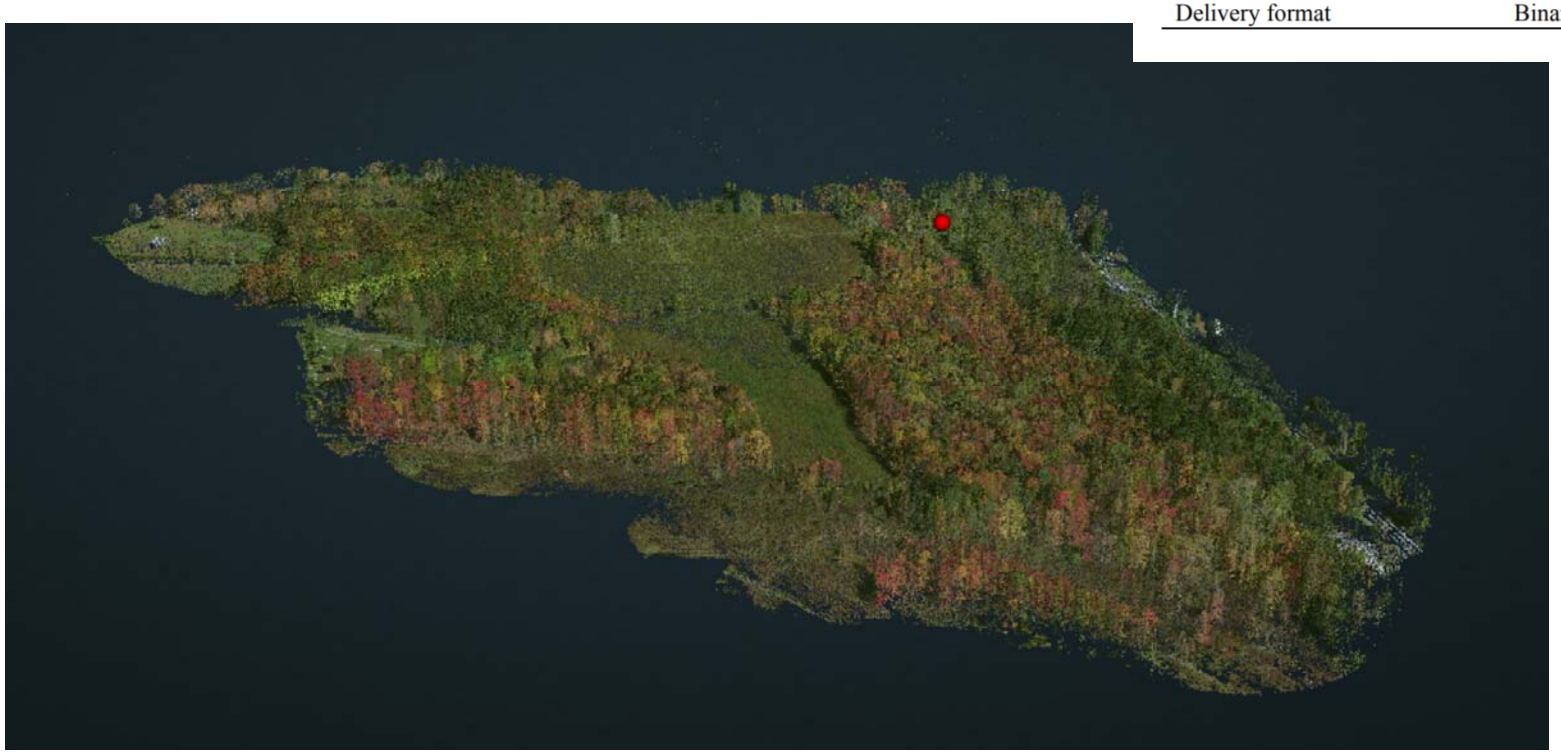
Agriculture



Forest mapping

Table 1. Common lidar sensor parameters for natural resource applications.

Parameter	Value
Wavelength	1.064 µm
Pulse Repetition Rate (PRF)	~50–150 kHz
Returns per pulse	3–4
Pulse width	10 nano-seconds
Beam divergence	10–80 m rad
Scan angle	<15° off-nadir, 30° total look
Scan pattern(s)	Ziz-zag, parallel, elliptical, sinusoidal
GPS frequency	1–2 Hz
INS frequency	50 Hz (200 Hz max)
Operating altitude	100–3,000 m (6,000 m max), average ~2,000 m
Footprint size	0.10–0.30 cm
Pulse Density	> 4 pulse/m^2
Accuracy (Vertical/Elevation)	<0.15 m
Delivery format	Binary lidar exchange format (LAS)



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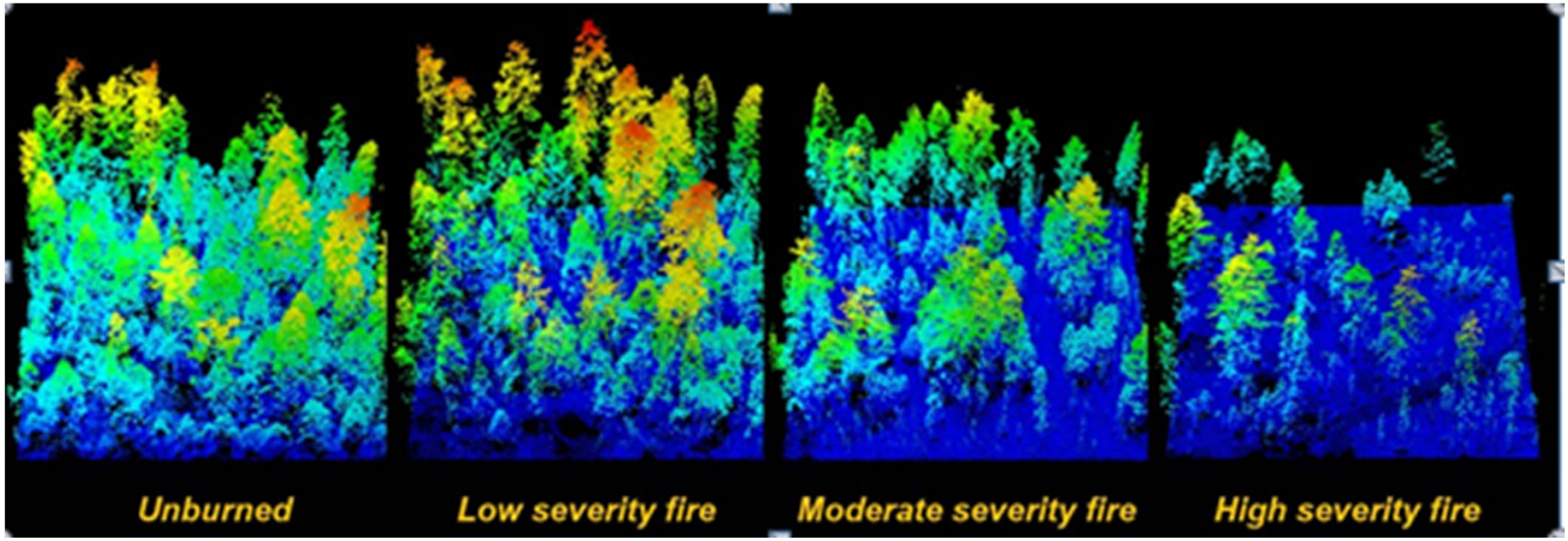
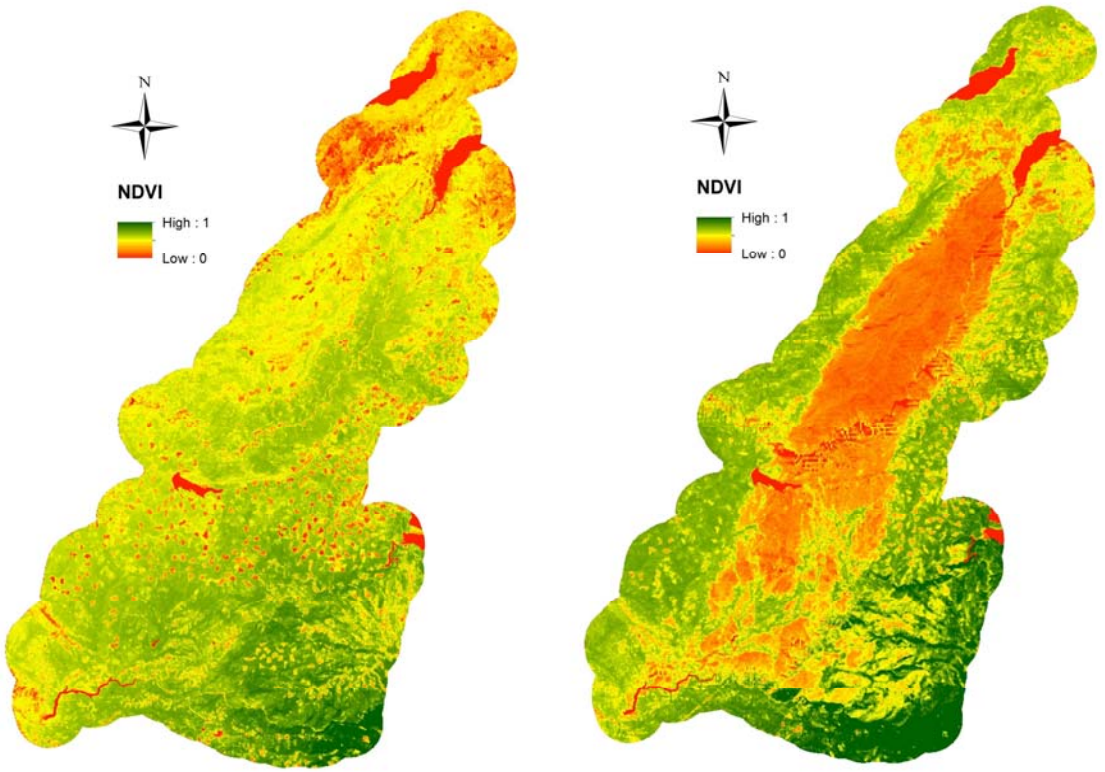

Unburned
Low severity fire
Moderate severity fire
High severity fire

Forest Fire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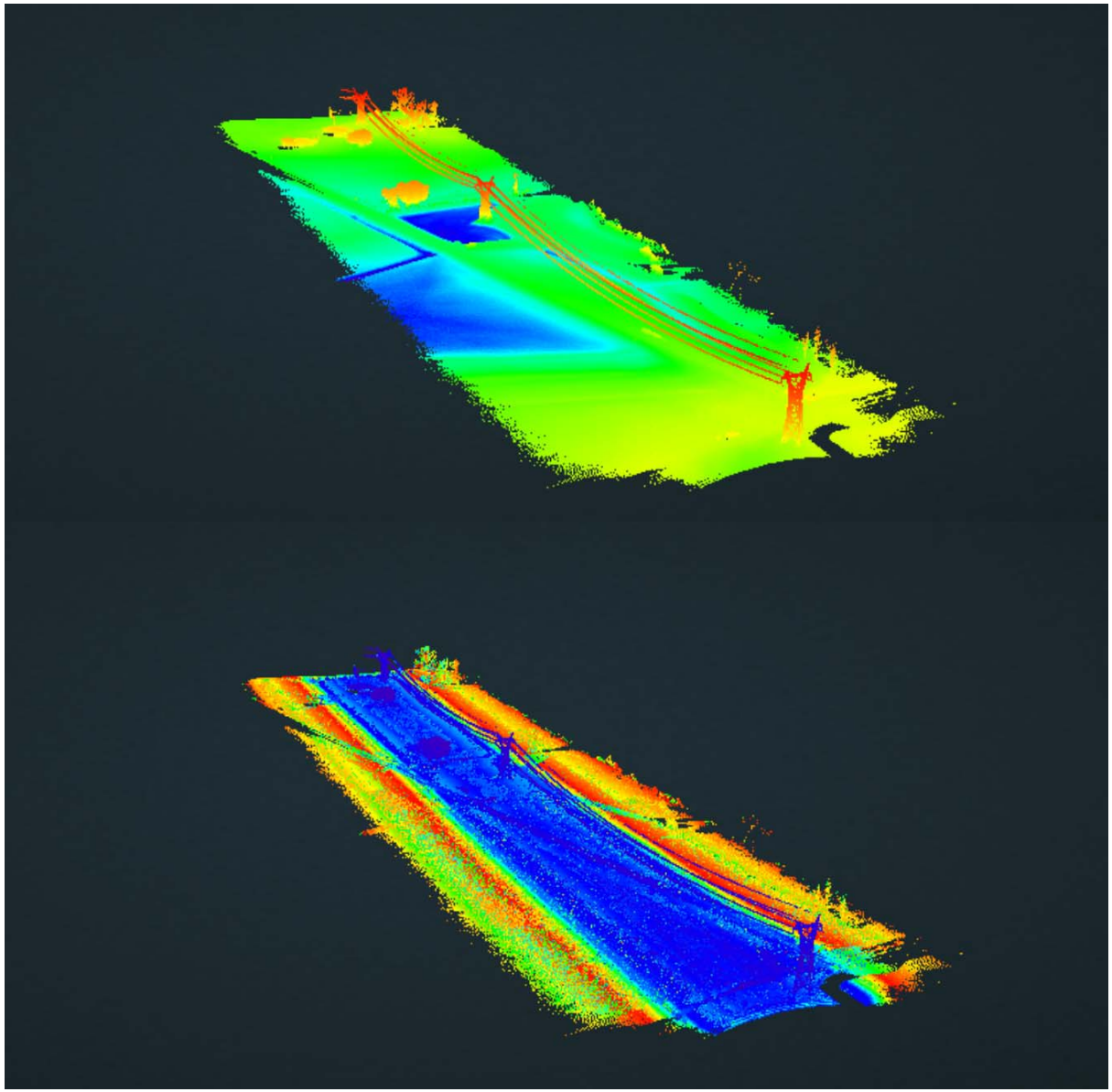
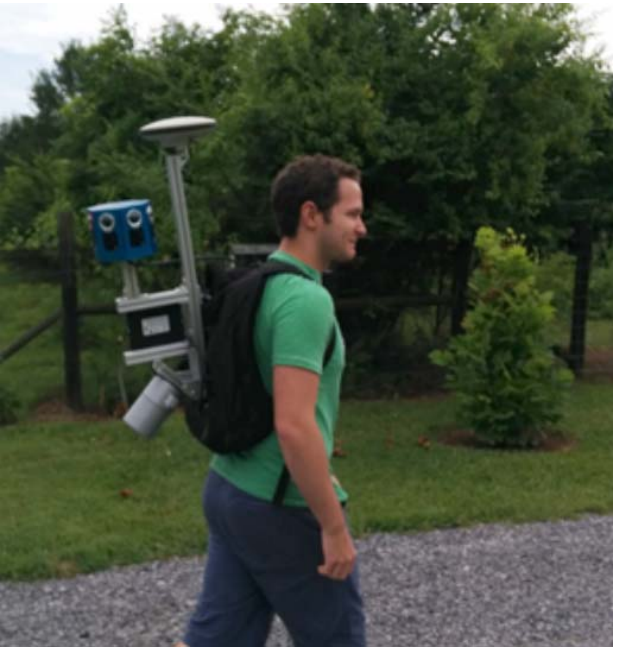
NDVI
High : 1
Low : 0
N
NDVI
High : 1
Low : 0

Rural Transmission Line

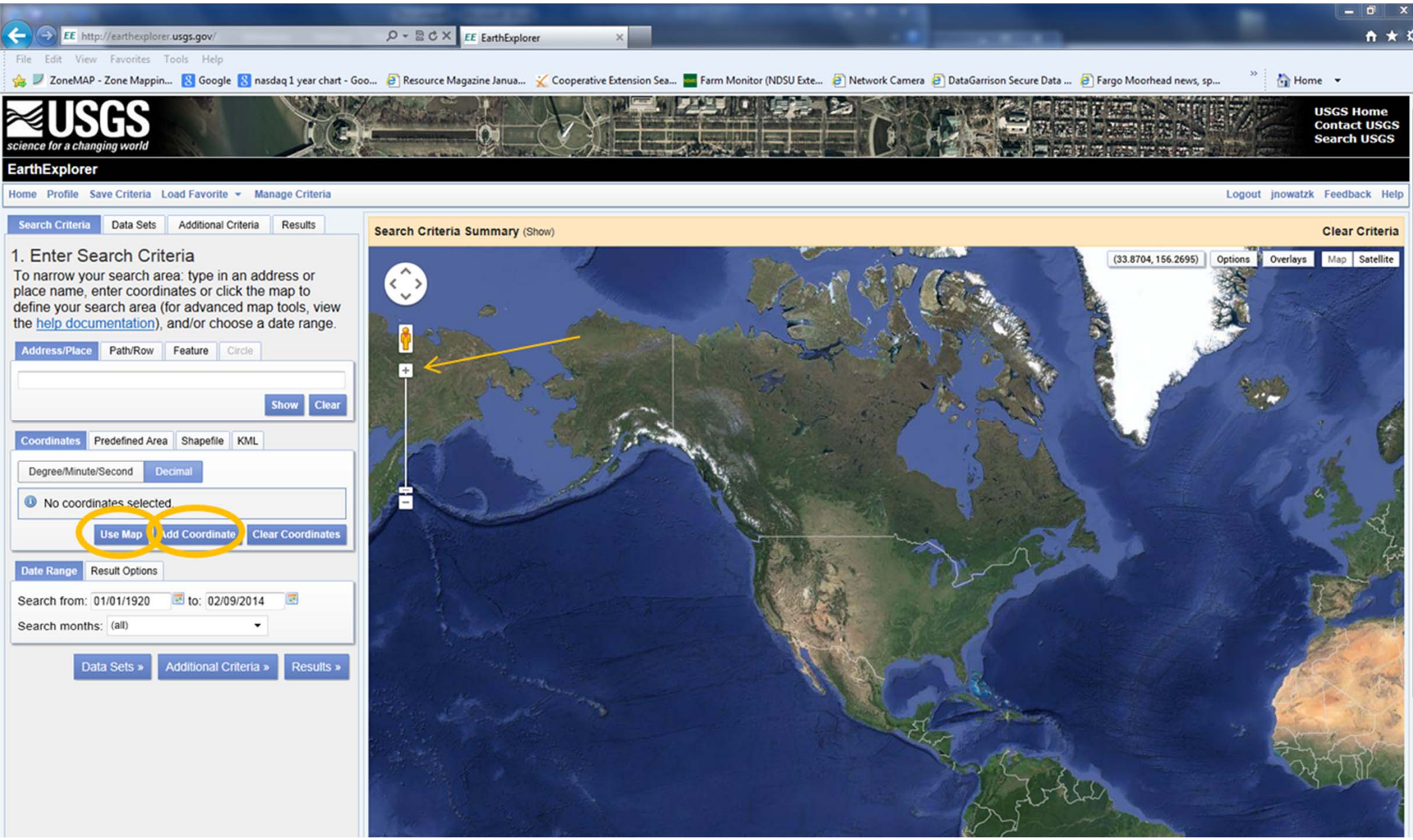



NIWA
Taihoro Nukurangi


LIDAR USA

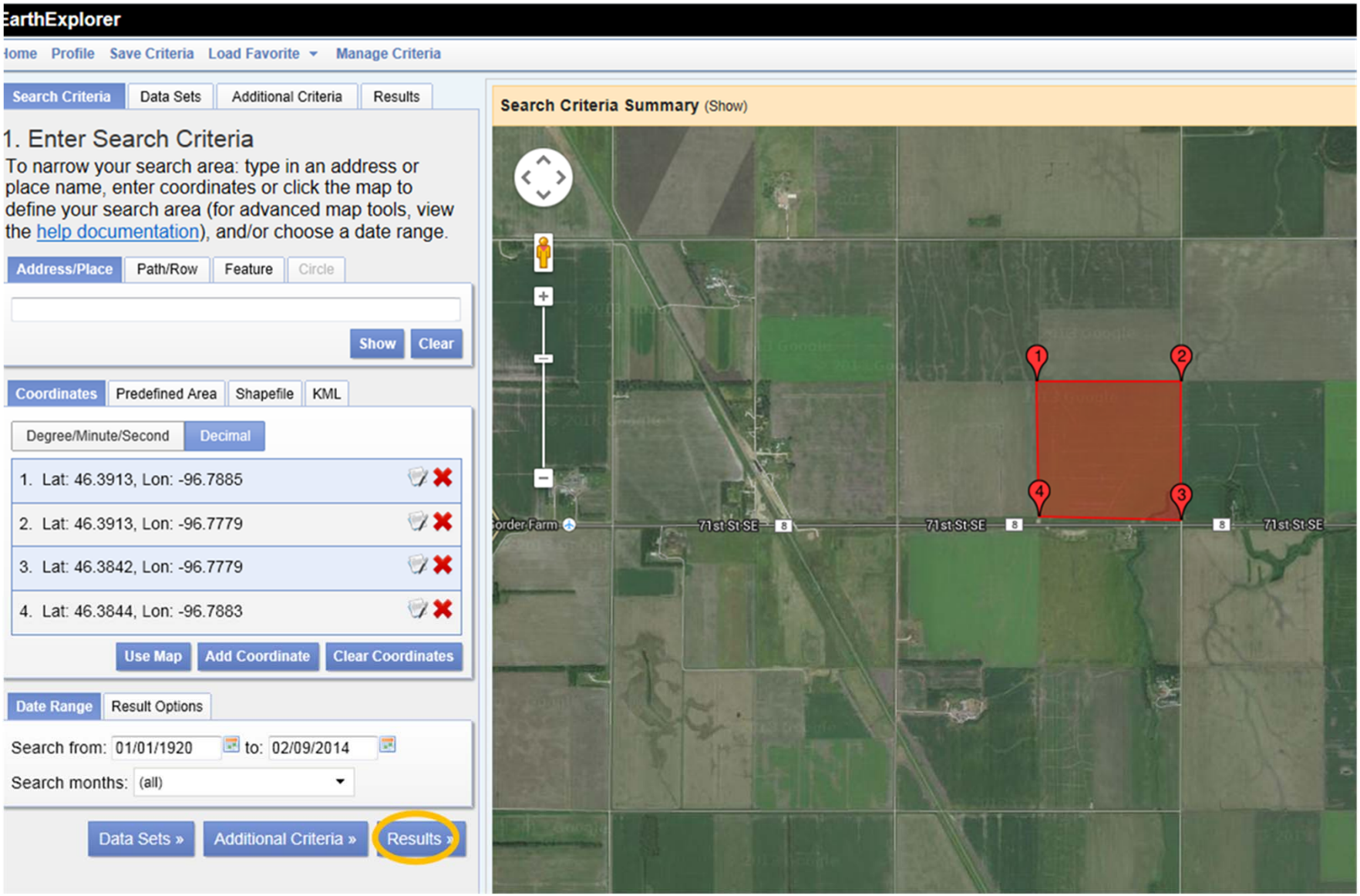


Data Availability



Downloading LiDAR Data

http://earthexplorer.usgs.gov/


EarthExplorer
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Search Criteria Data Sets Additional Criteria Results
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To narrow your search area: type in an address or place name, enter coordinates or click the map to define your search area (for advanced map tools, view the help documentation), and/or choose a date range.
Address/Place Path/Row Feature Circle
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2. Lat: 46.3913, Lon: -96.7779
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4. Lat: 46.3844, Lon: -96.7883
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Search Criteria Summary (Show)
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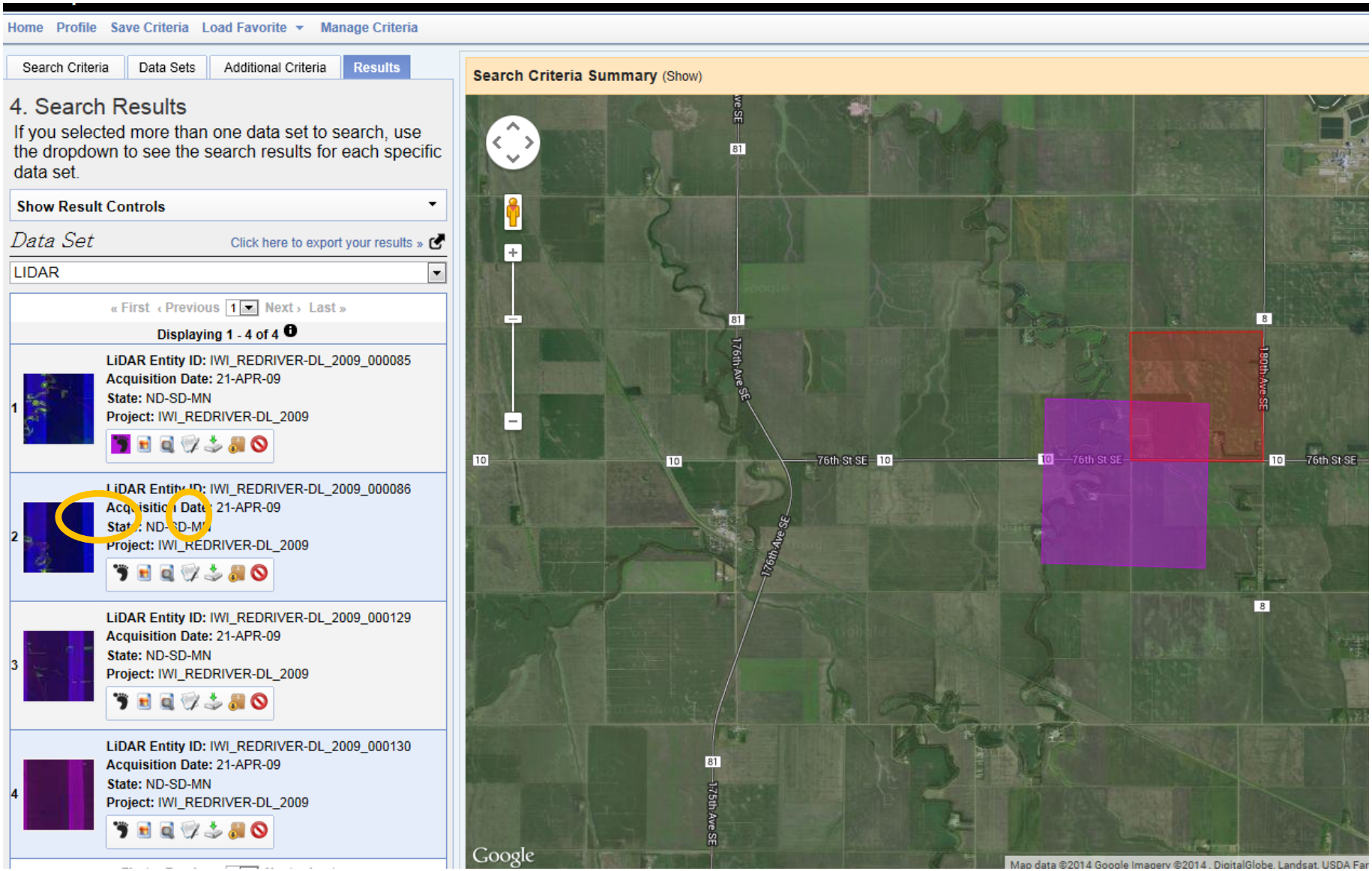
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Profile
Save Criteria
Load Favorite
Manage Criteria
Search Criteria
Data Sets
Additional Criteria
Results
4. Search Results
If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.
Show Result Controls
Data Set
Click here to export your results »
LIDAR
« First ‹ Previous 1 Next › Last »
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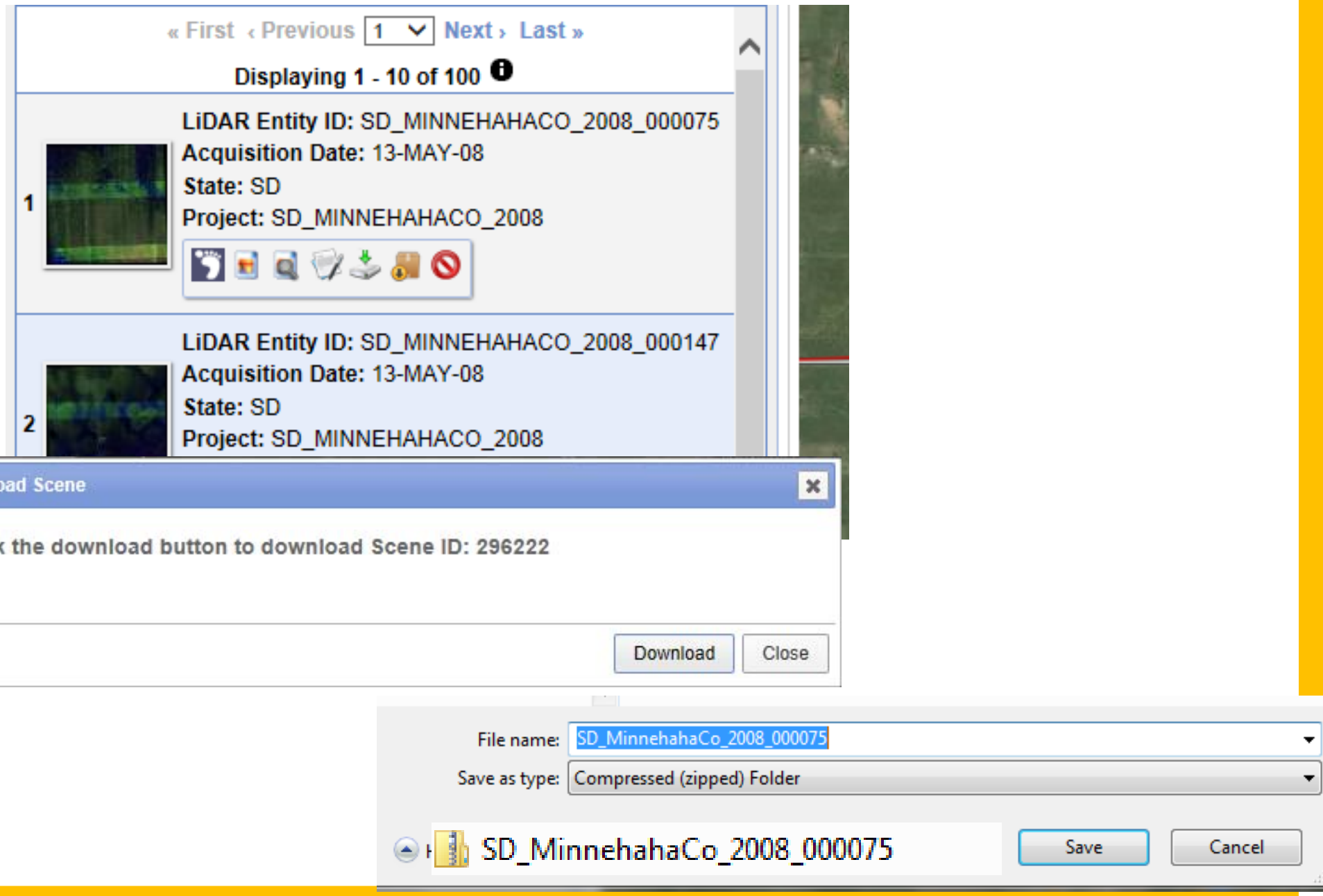
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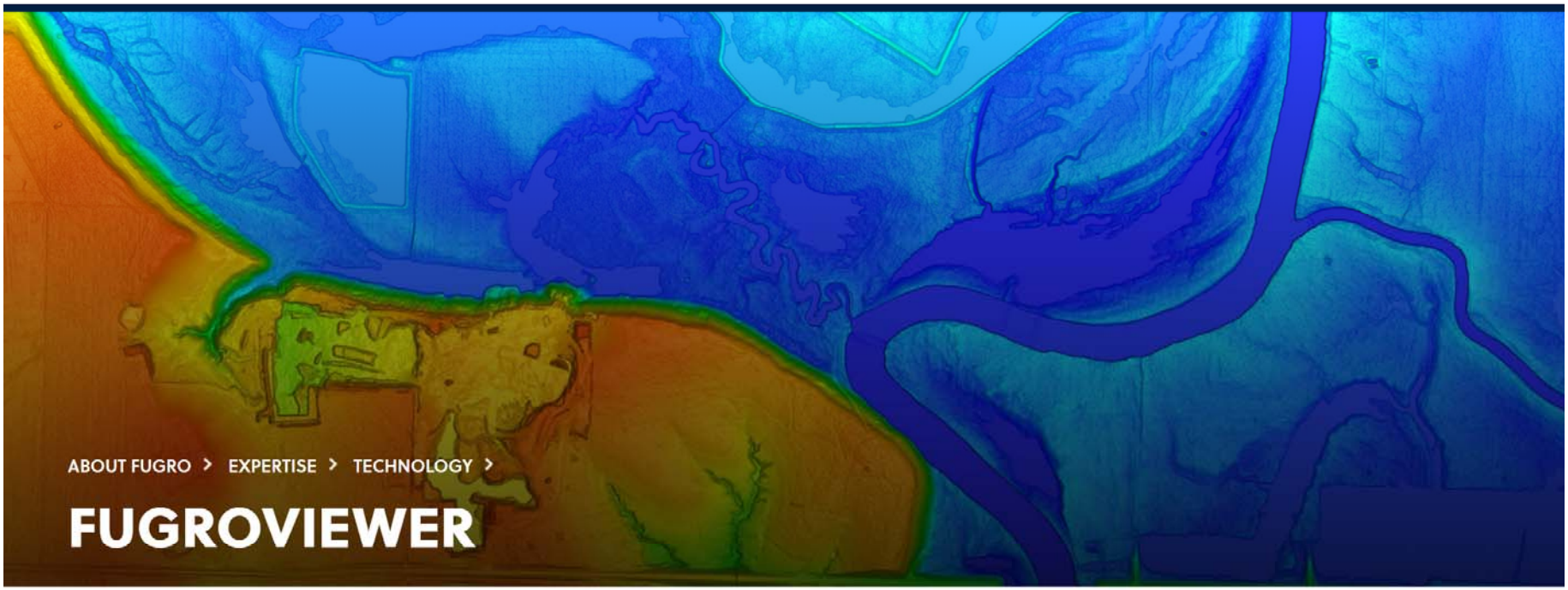
Software



FUGROVIEWER

FugroViewer™ is a robust, easy-to-use freeware designed to help users make the most of their geospatial data. We have developed it for use with various types of raster- and vector-based geospatial datasets, including data from photogrammetric, lidar, and IFSAR sources

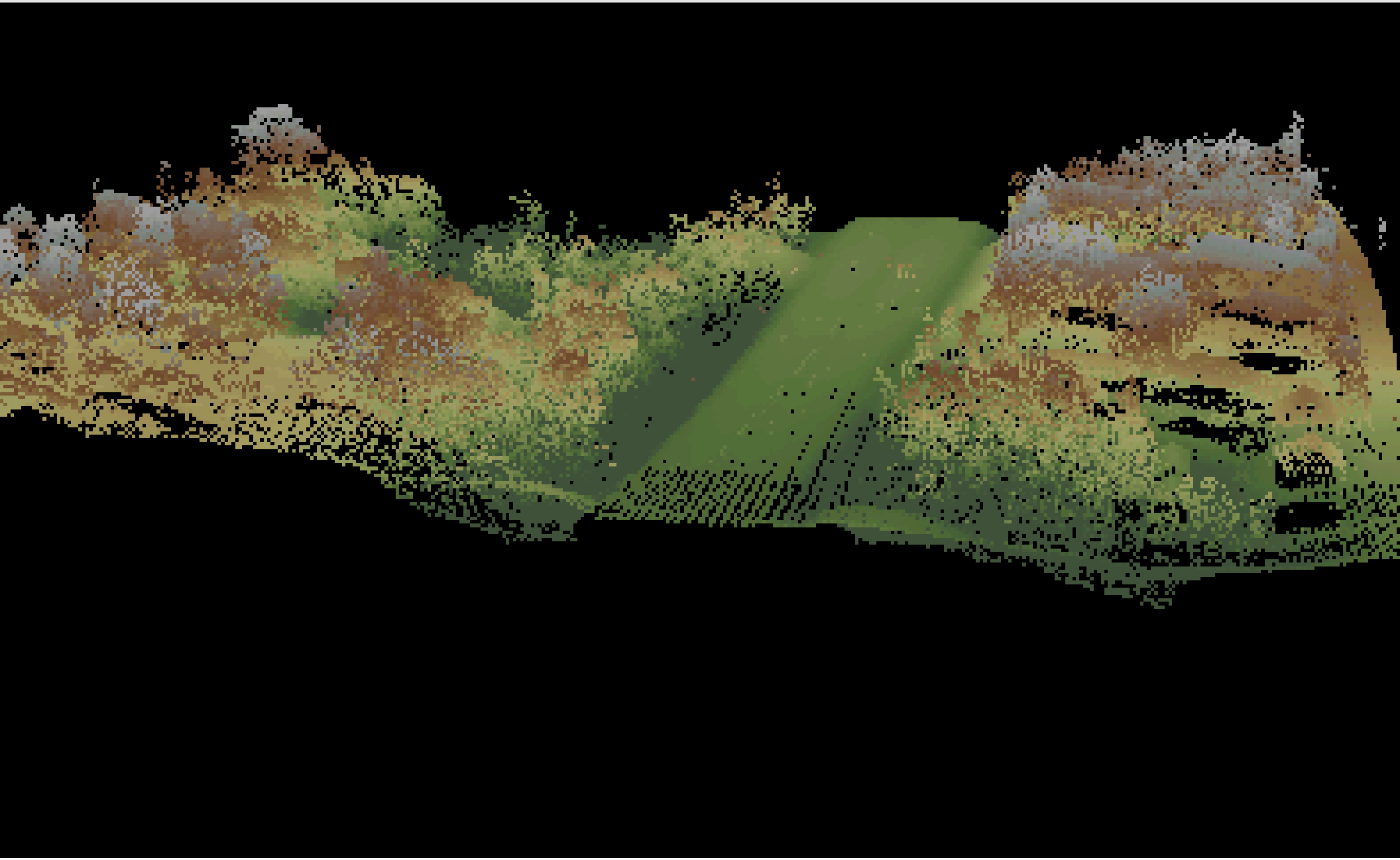
TECHNOLOGY

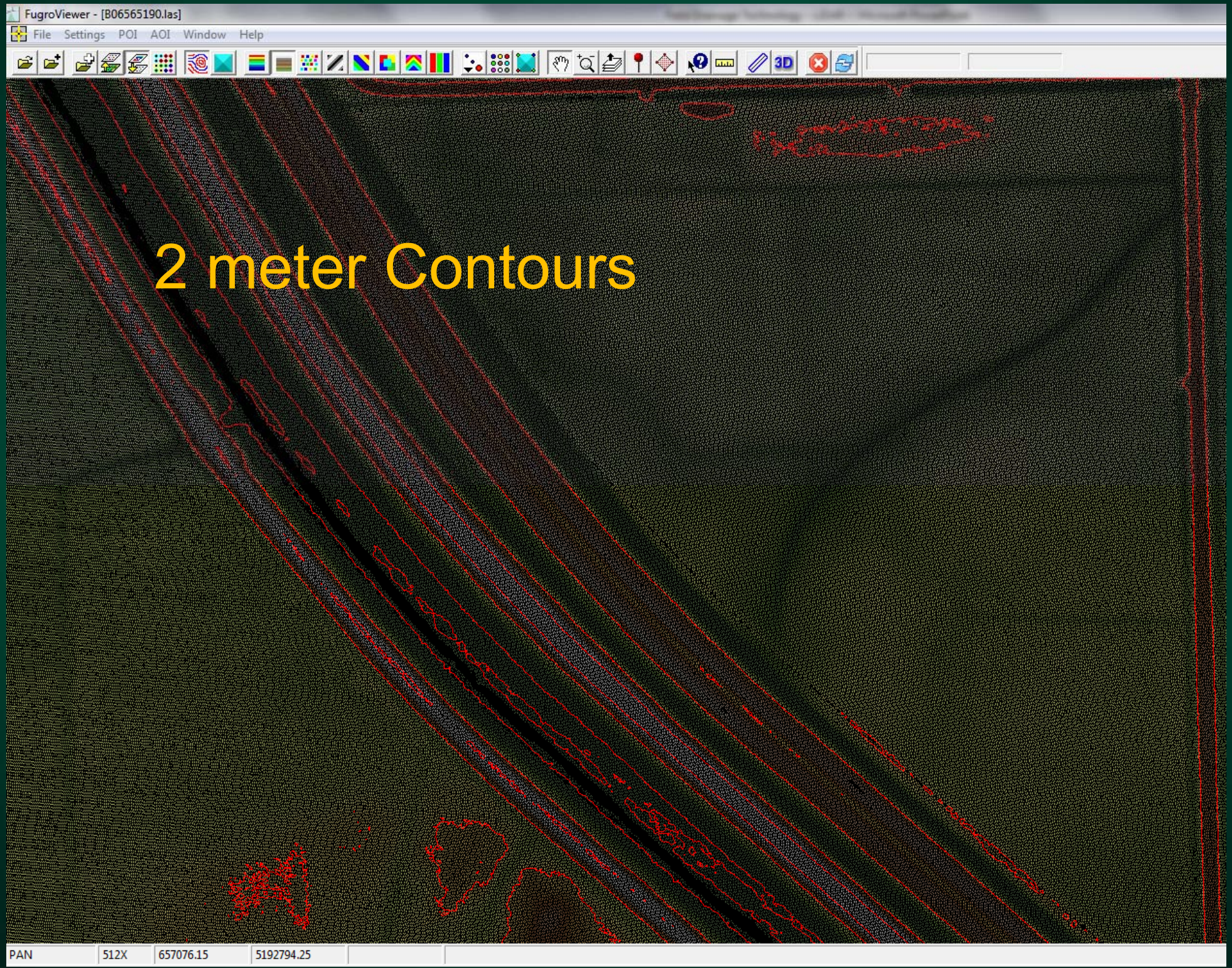
Autonomous underwater vehicle (AUV)

Seafloor Drills

ROTV – Acoustic pipeline

3D View in Fugro Viewer

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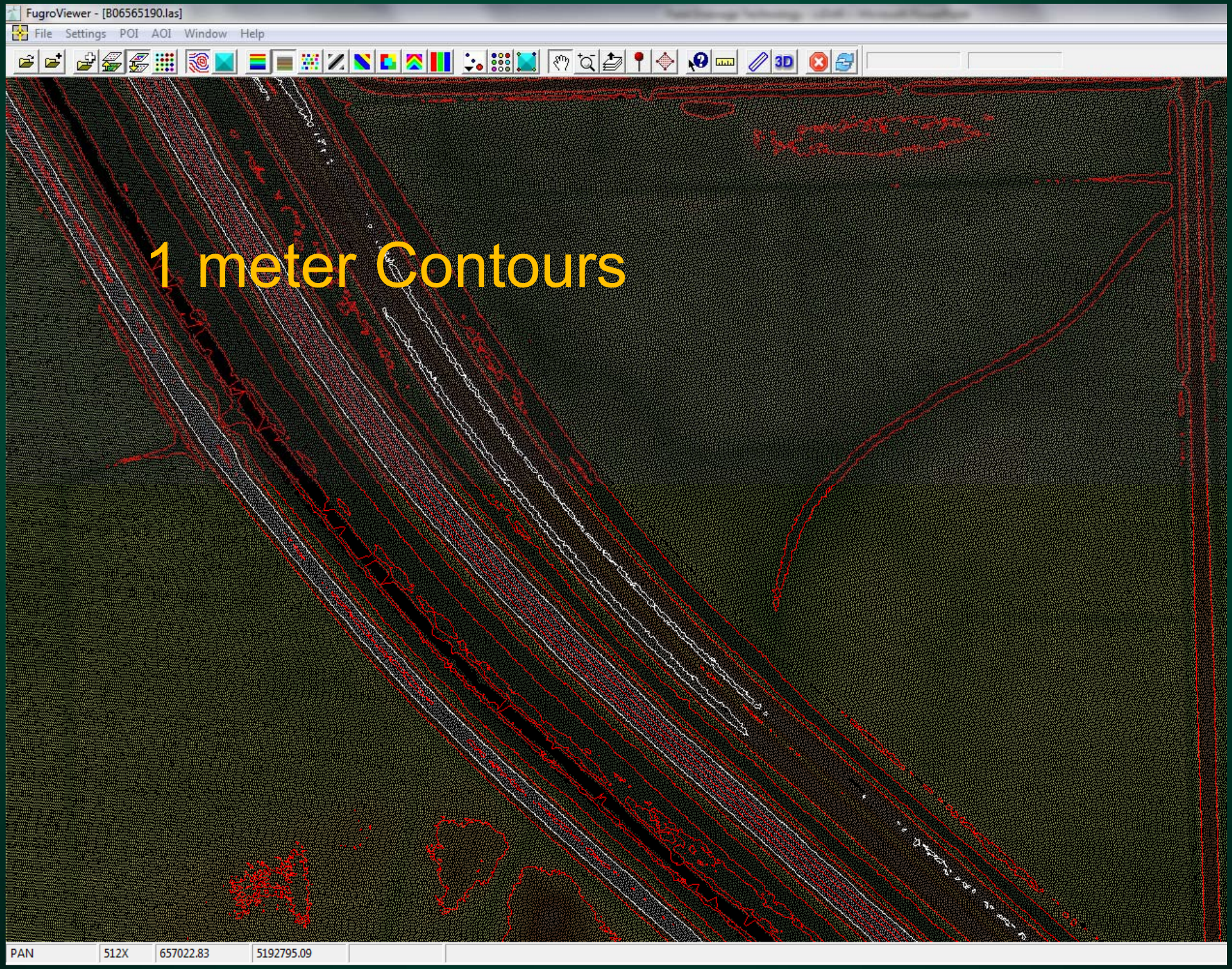
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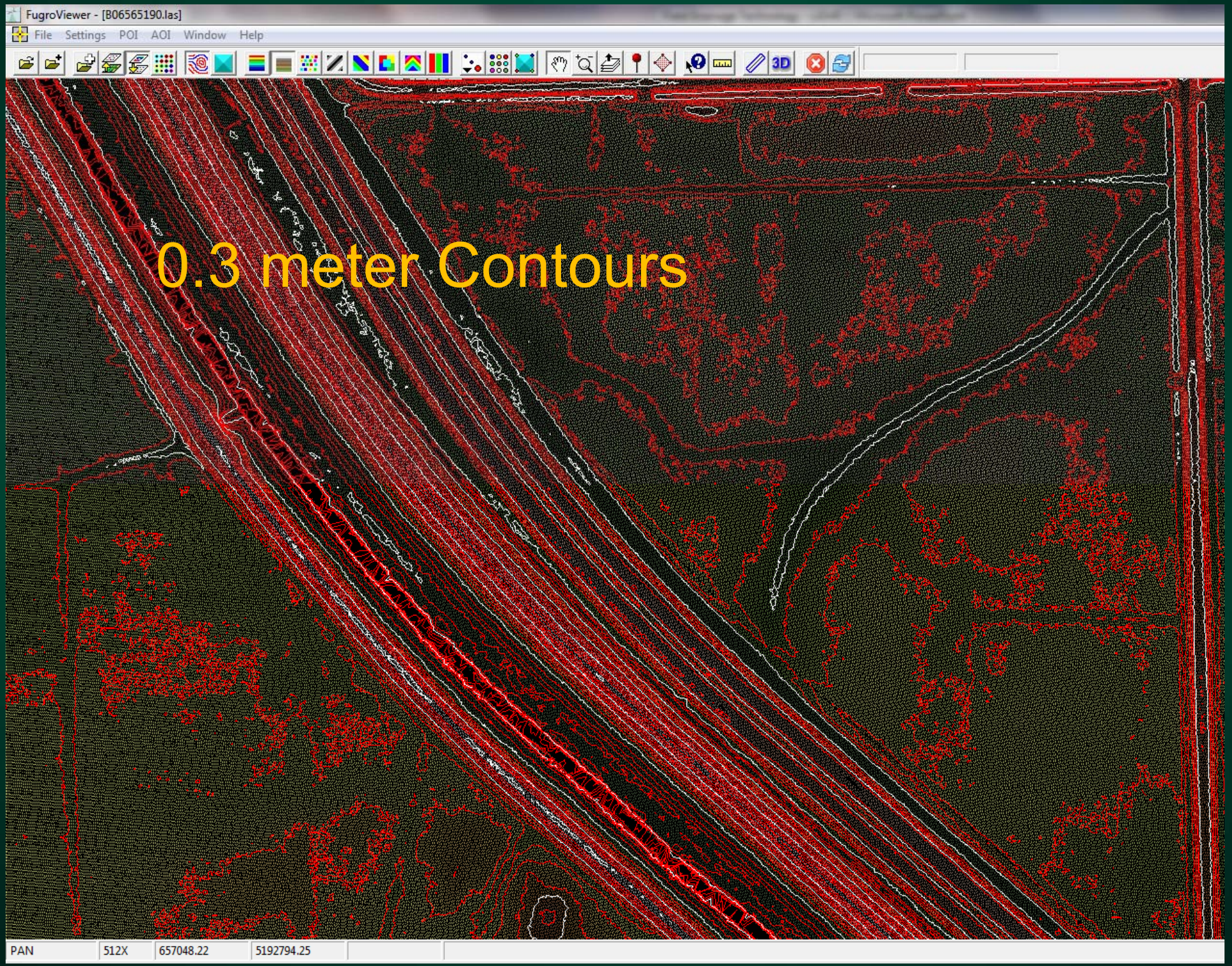
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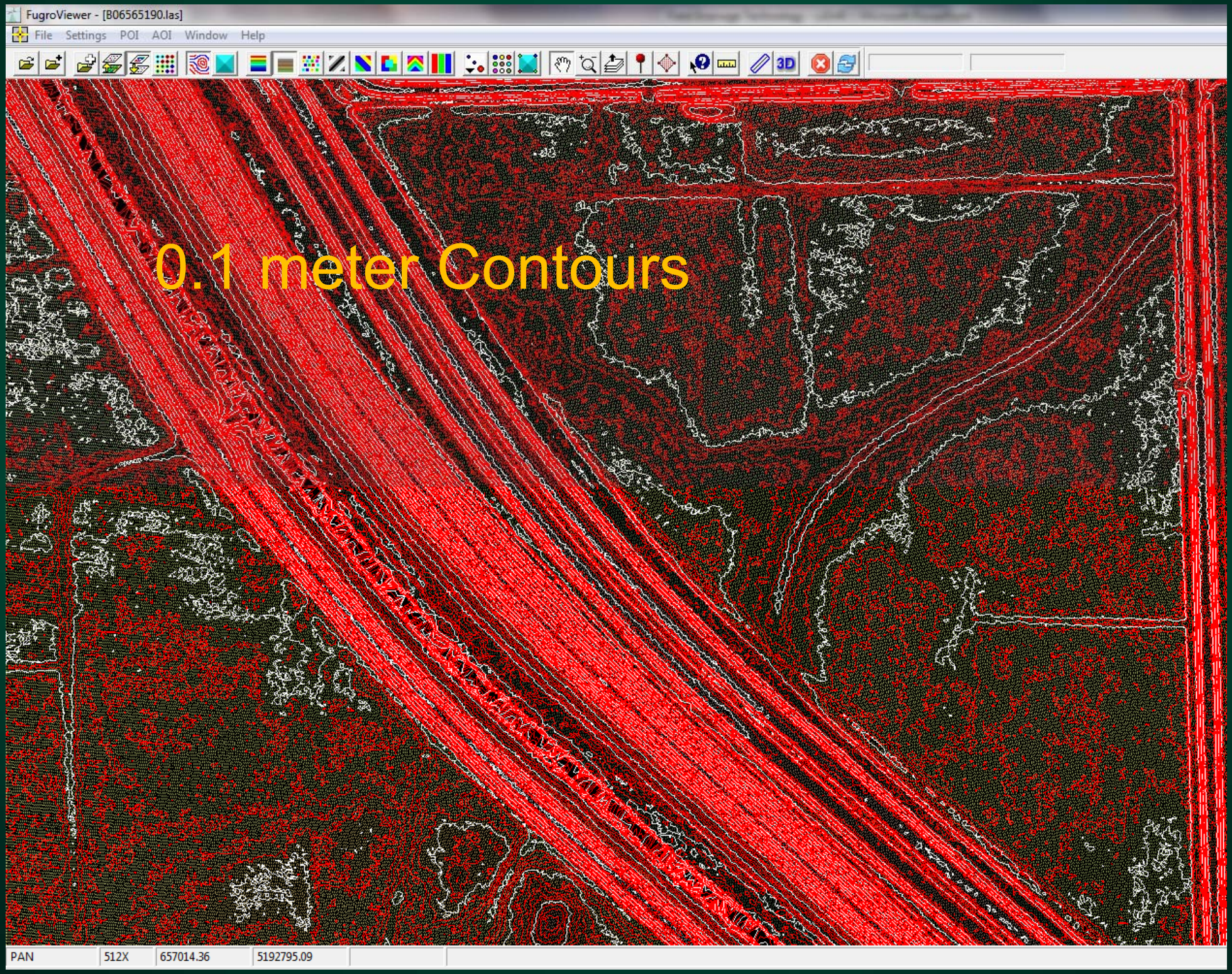
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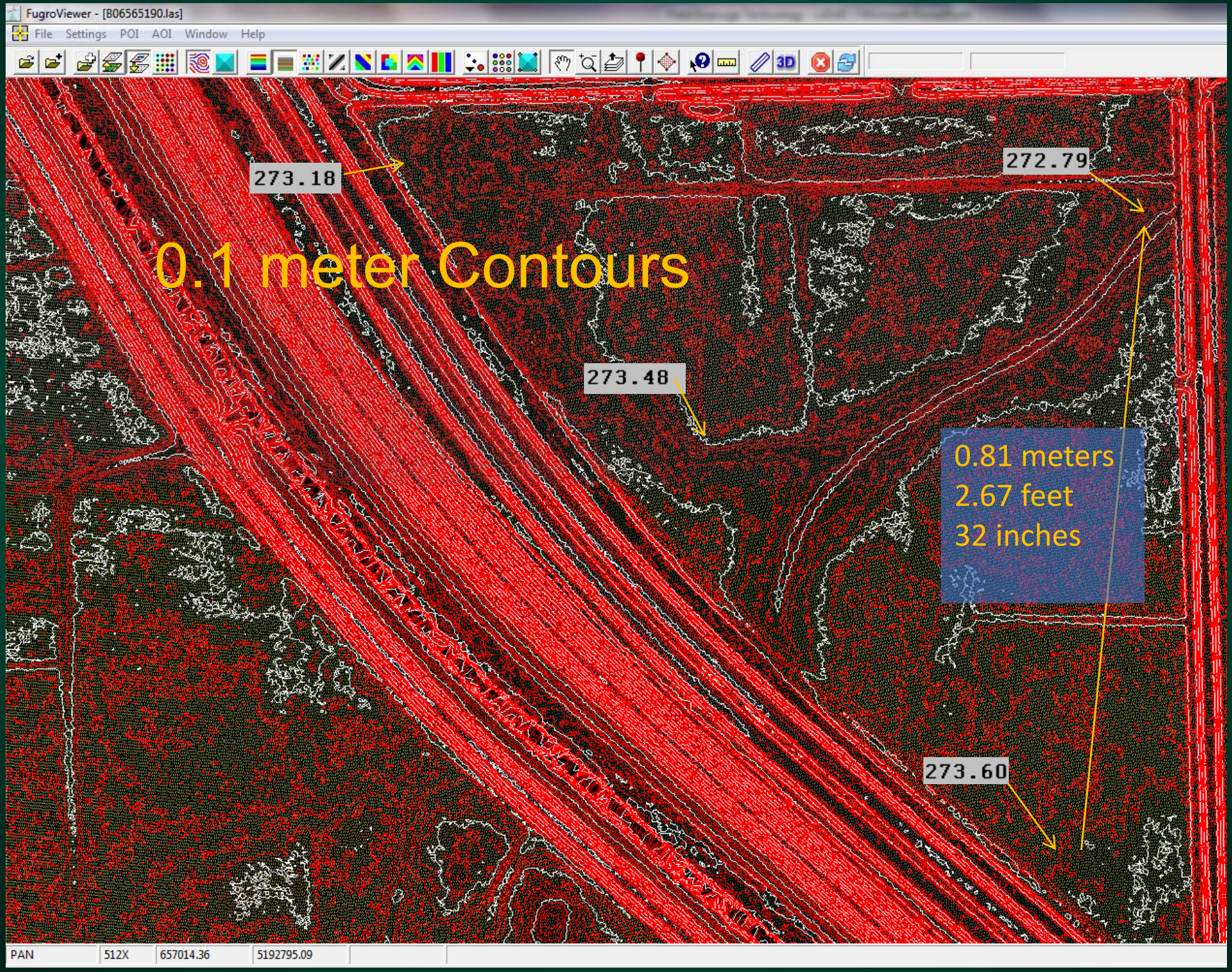
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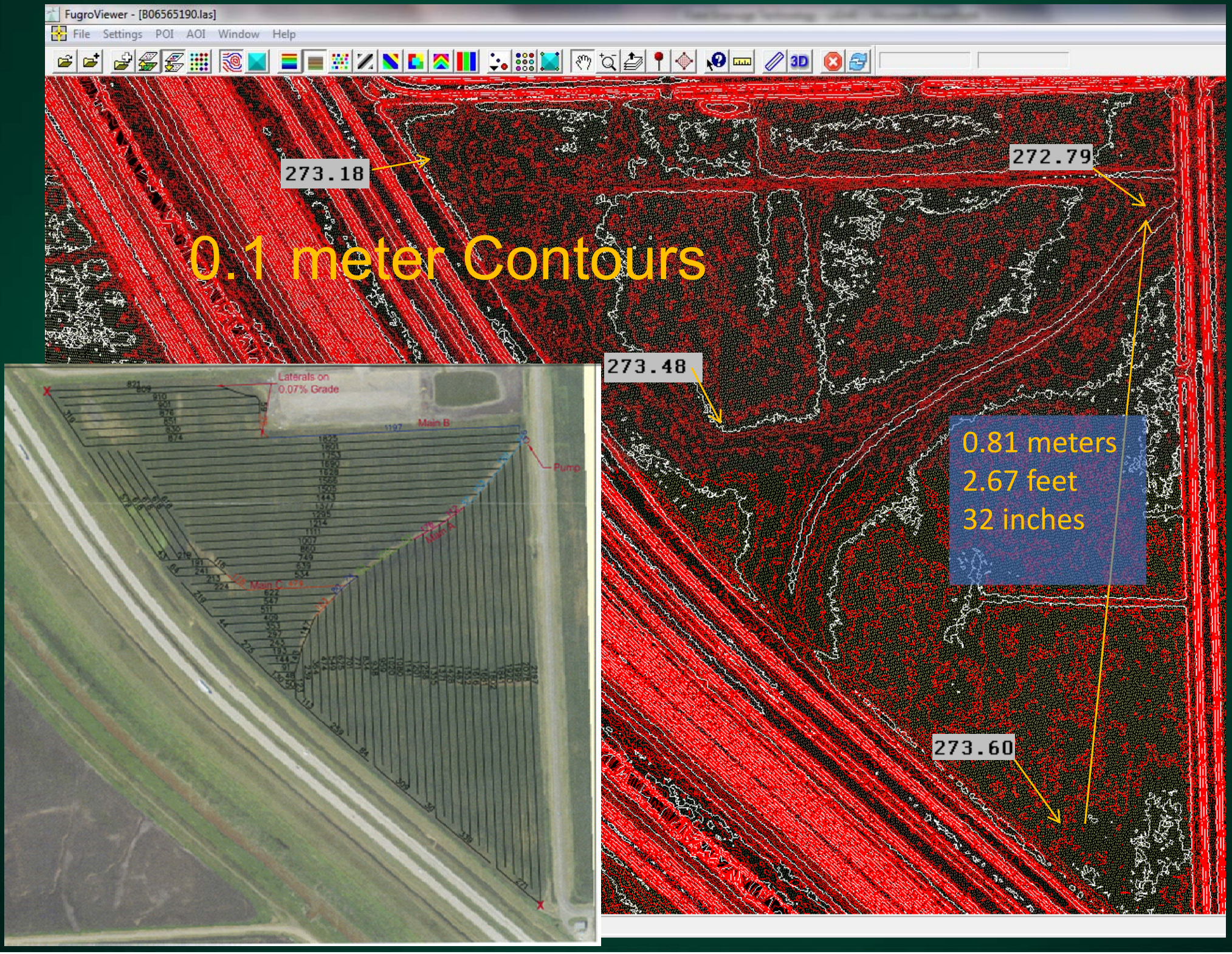
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3D
273.18
272.79
0.1 meter Contours
273.48
0.81 meters
2.67 feet
32 inches
273.60
Laterals on
0.07% Grade
Main B
Pump
Main A
Main C

Summary

- Light Detection and Ranging (LiDAR) uses lasers to measure the elevation of features.
- It’s a distance technology that samples with an incredible amount of accuracy and points.
- It’s similar to sonar (sound waves) or radar (radio waves) because it sends a pulse and measures the time it takes to return. But LiDAR is different than sonar and radar because it uses light.

Readings

- LiDAR - Introduction to Light Detection and Ranging

https://www.youtube.com/watch?v=m7SXoFv6Sdc

- How Does LiDAR Remote Sensing Work? Light Detection and Ranging https://youtu.be/EYbhNSUnIdU