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3D Laser Scanning (LiDAR Surveying) and Oblique Photogrammetry Assessment During the 2004 High Flow Test

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U.S. Department of the Interior
U.S. Geological Survey

Evaluation of Mapping Techniques at 30 Mile Sandbar in Grand Canyon

- LiDAR Surveying
  - Nov. 19, 2004 data collection
- Oblique Photogrammetry
  - Nov. 19, 2004 data collection

And compared to

- Conventional Surveying
  - Nov. 16, 2004 data collection

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LiDAR Surveying

- Tripod mounted LiDAR system
- Requires control visible in the scan
- 15-20 minutes per scan
  - Multiple scans may be needed to fill in “shadow zones”
- Scan of 336 degrees
- A maximum of two people needed to run system
- Cost for LiDAR Scanner and Software
  - $50,000 and up

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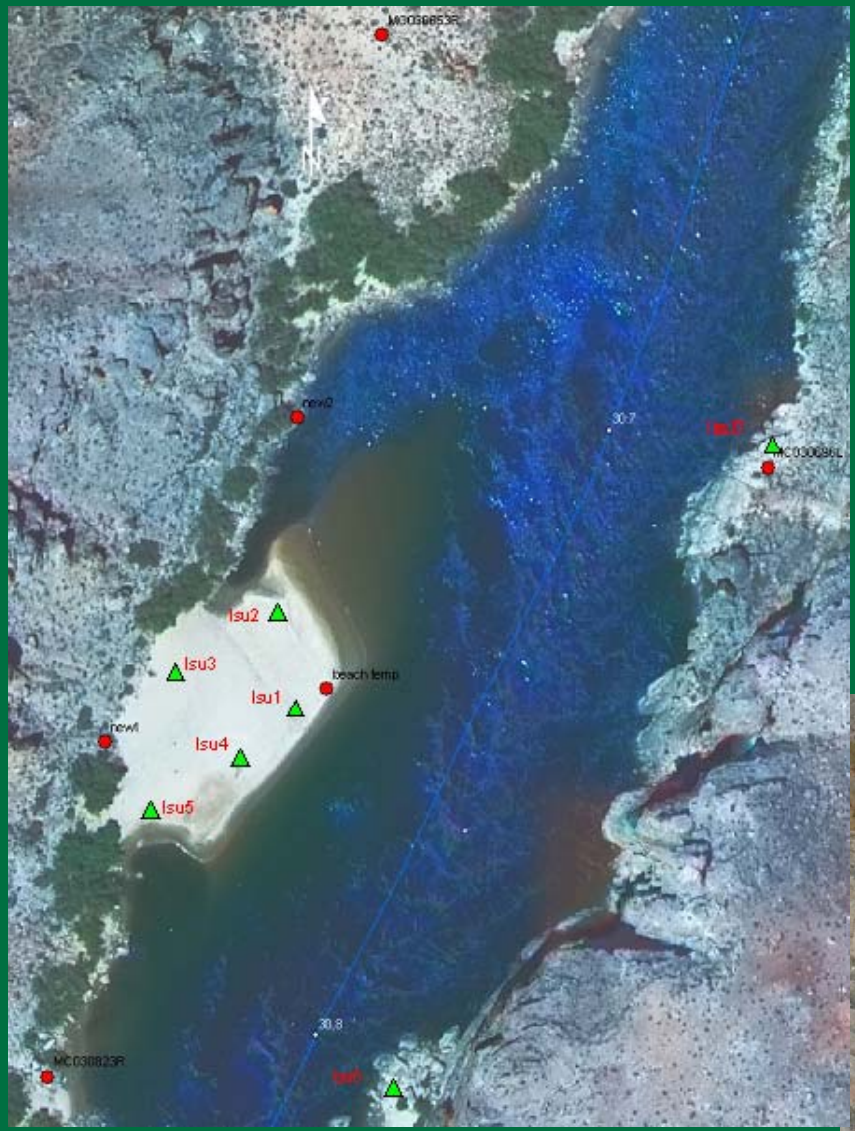
Mile 30 Sand Bar

Locations of laser scans and survey control.



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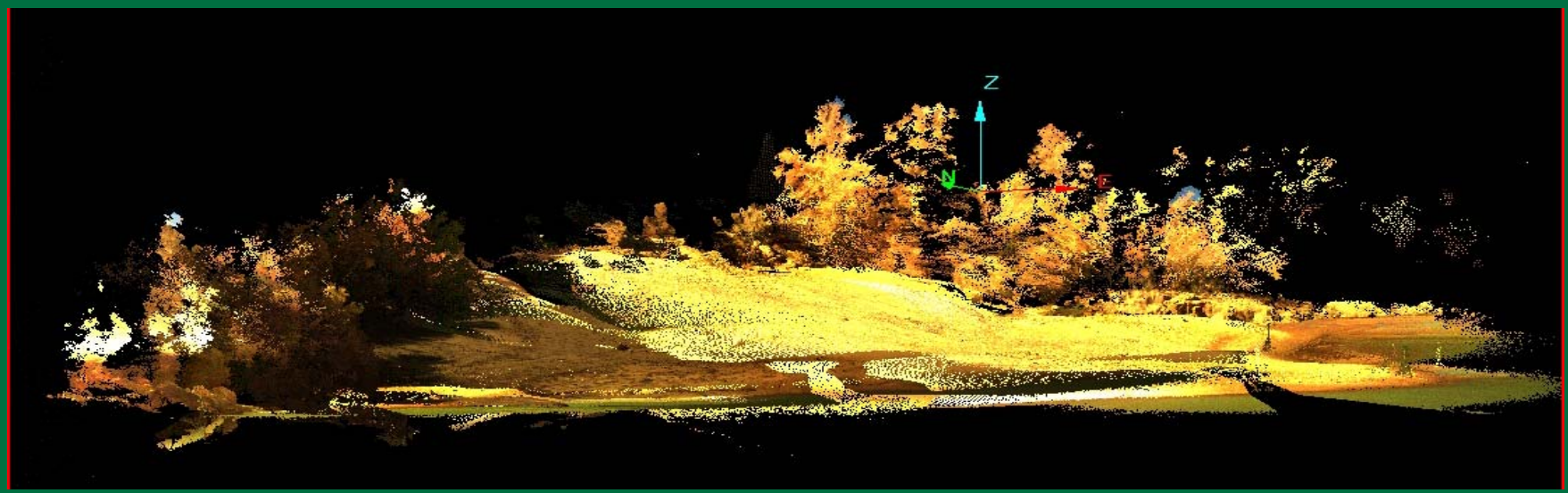
Raw Point Cloud LiDAR Data for 30 Mile Sand Bar



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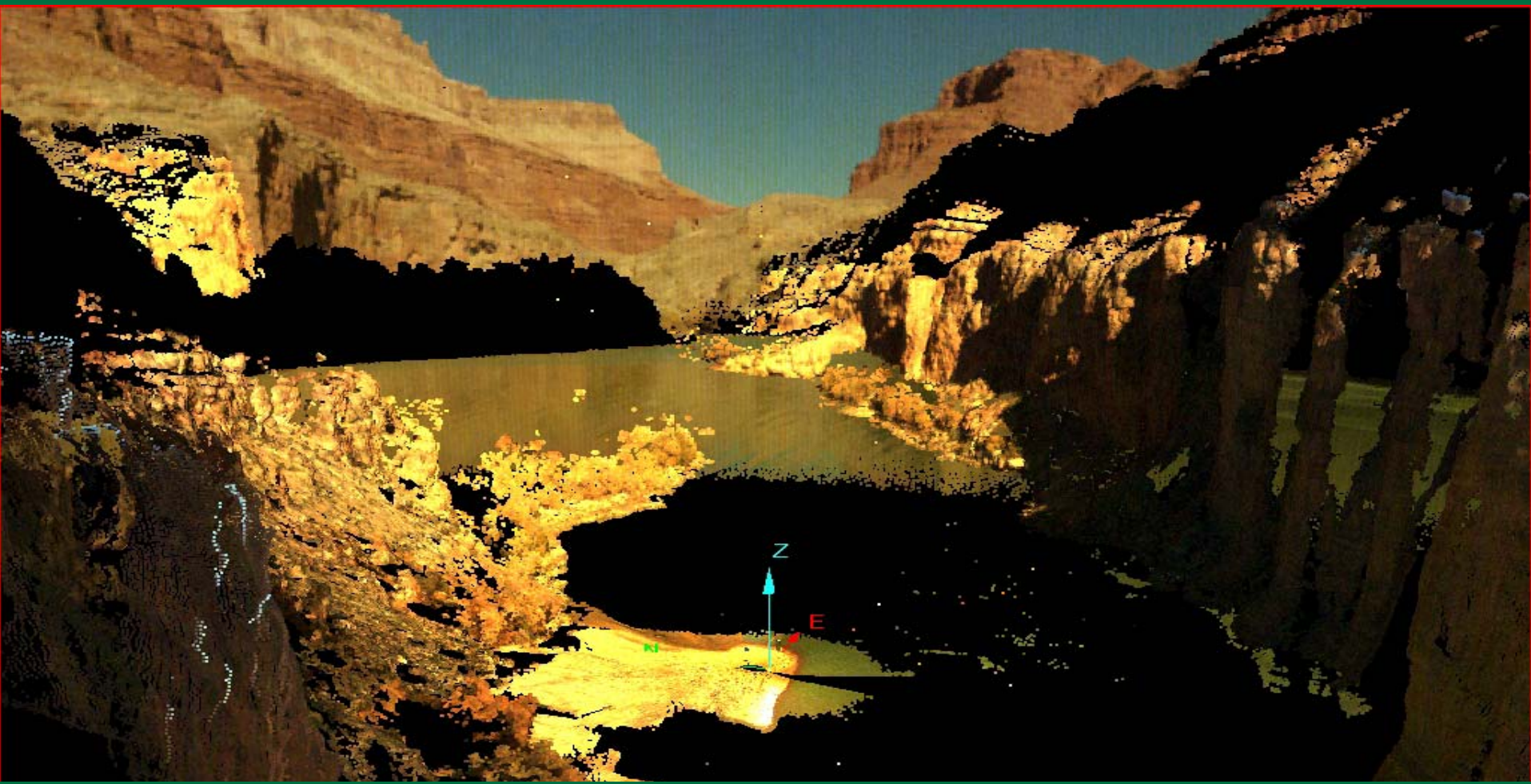
Fly through perspective looking upstream and includes background color data



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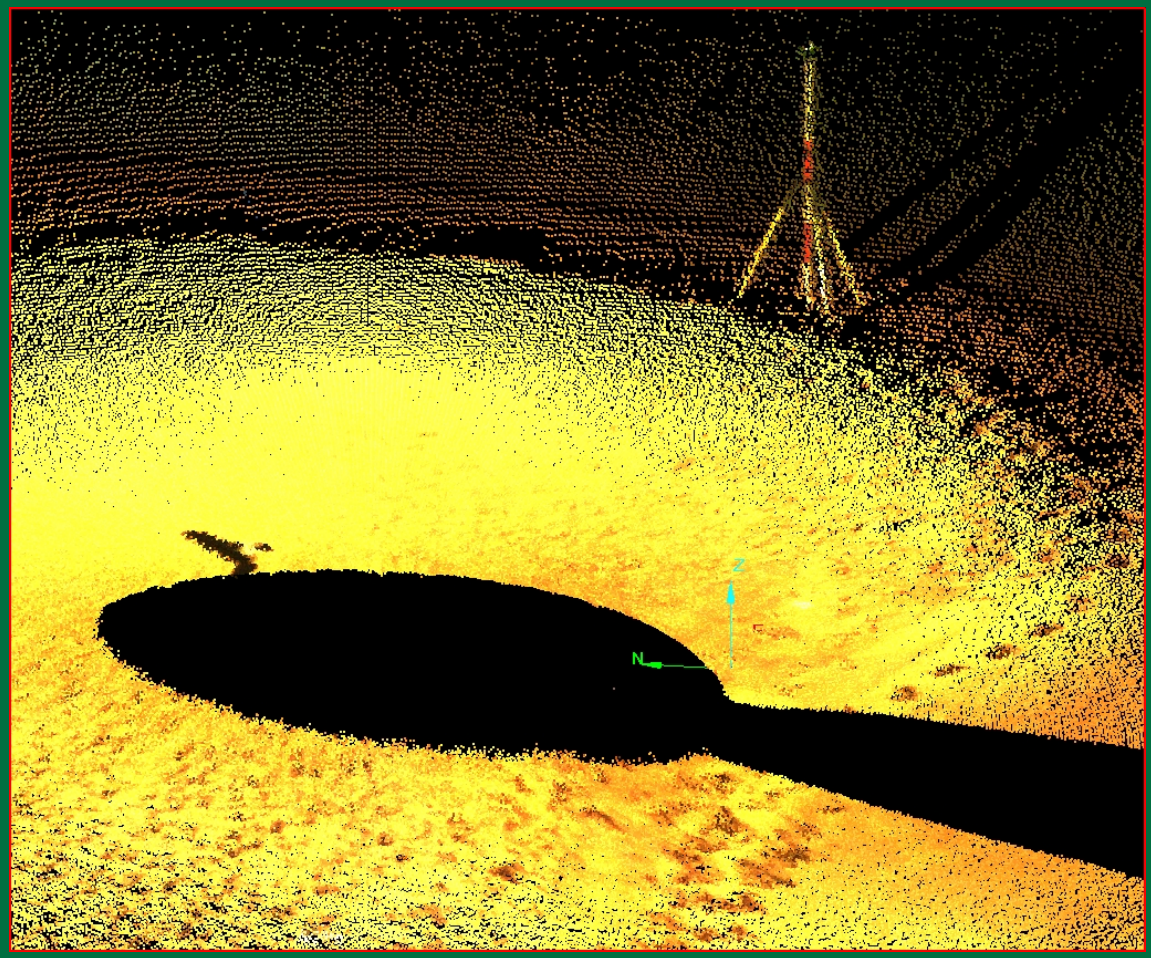
LiDAR Scan captures detail of sand bar surface



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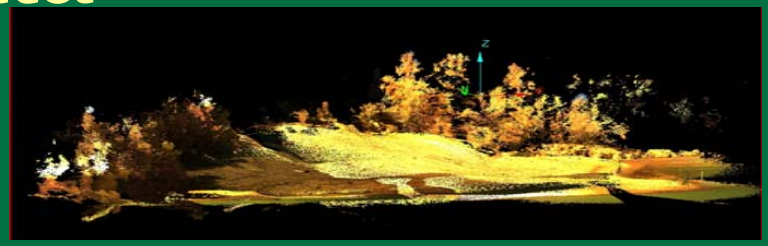
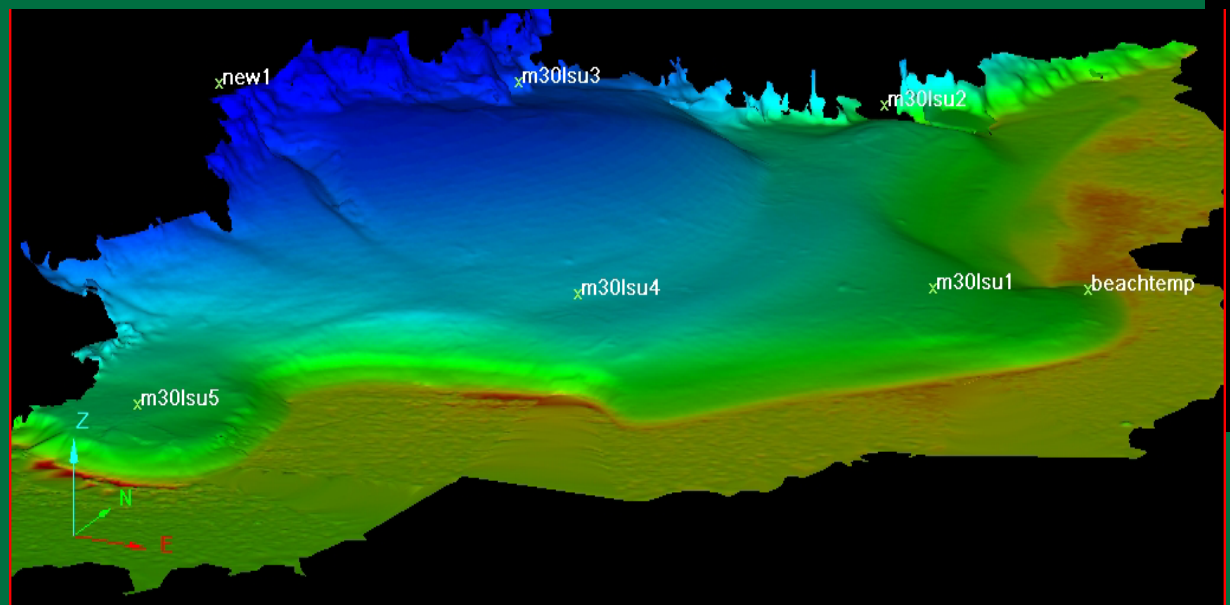
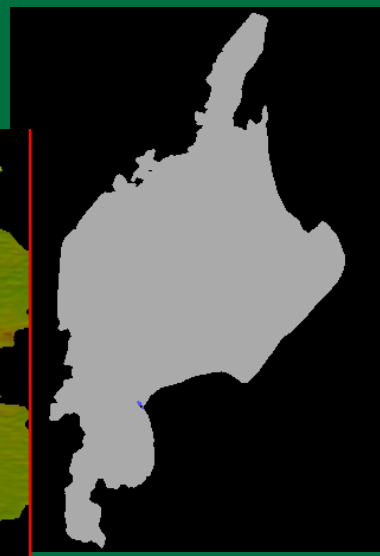
Processing LiDAR Data

- Edit Raw Scan Data
  - Delete vegetation
- Filter Scan Data to desired resolution
- Generate surface for each scan
- Combine surfaces with best fit fusion to generate new surface points







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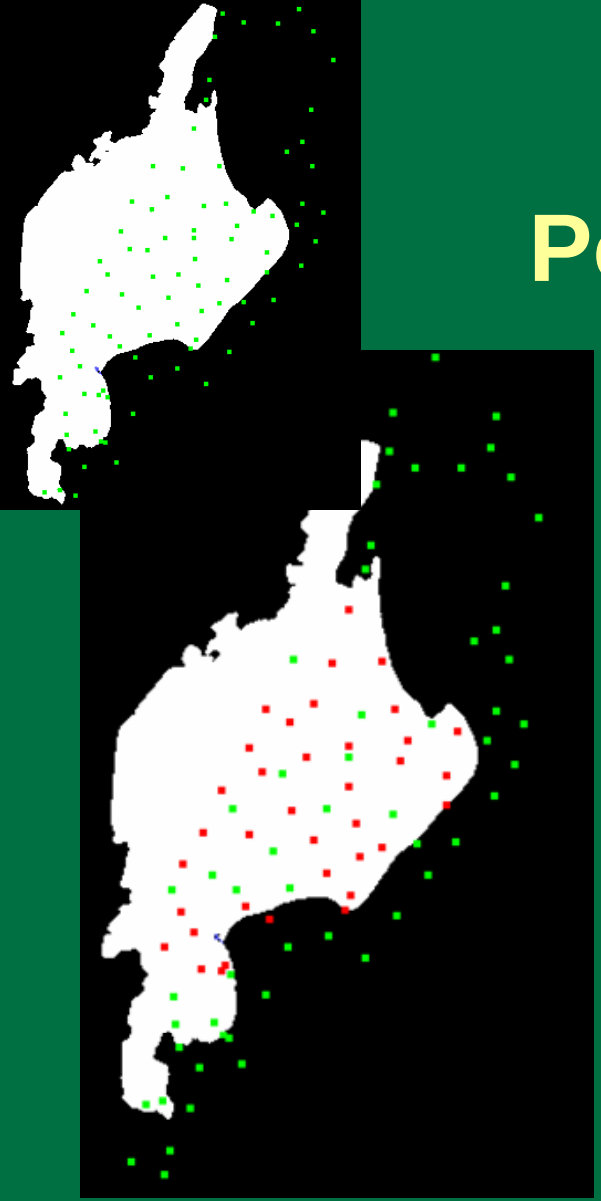

Point to Point Comparison

Difference (cm) n=37	Northing	Easting	Elevation
Average	2.9	1.9	4.6
Maximum	44.5	43.2	49.0
Minimum	-13.5	-12.3	-31.0
Range	58.0	55.5	80.0
Standard Deviation	10.5	9.6	17.6
Median	1.9	-0.1	1.0

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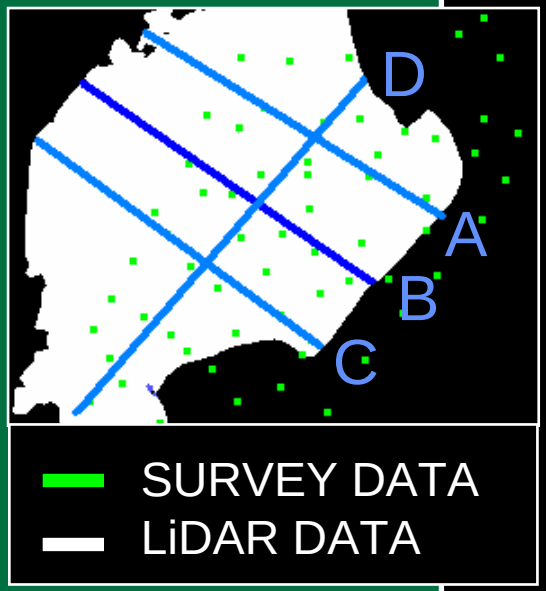
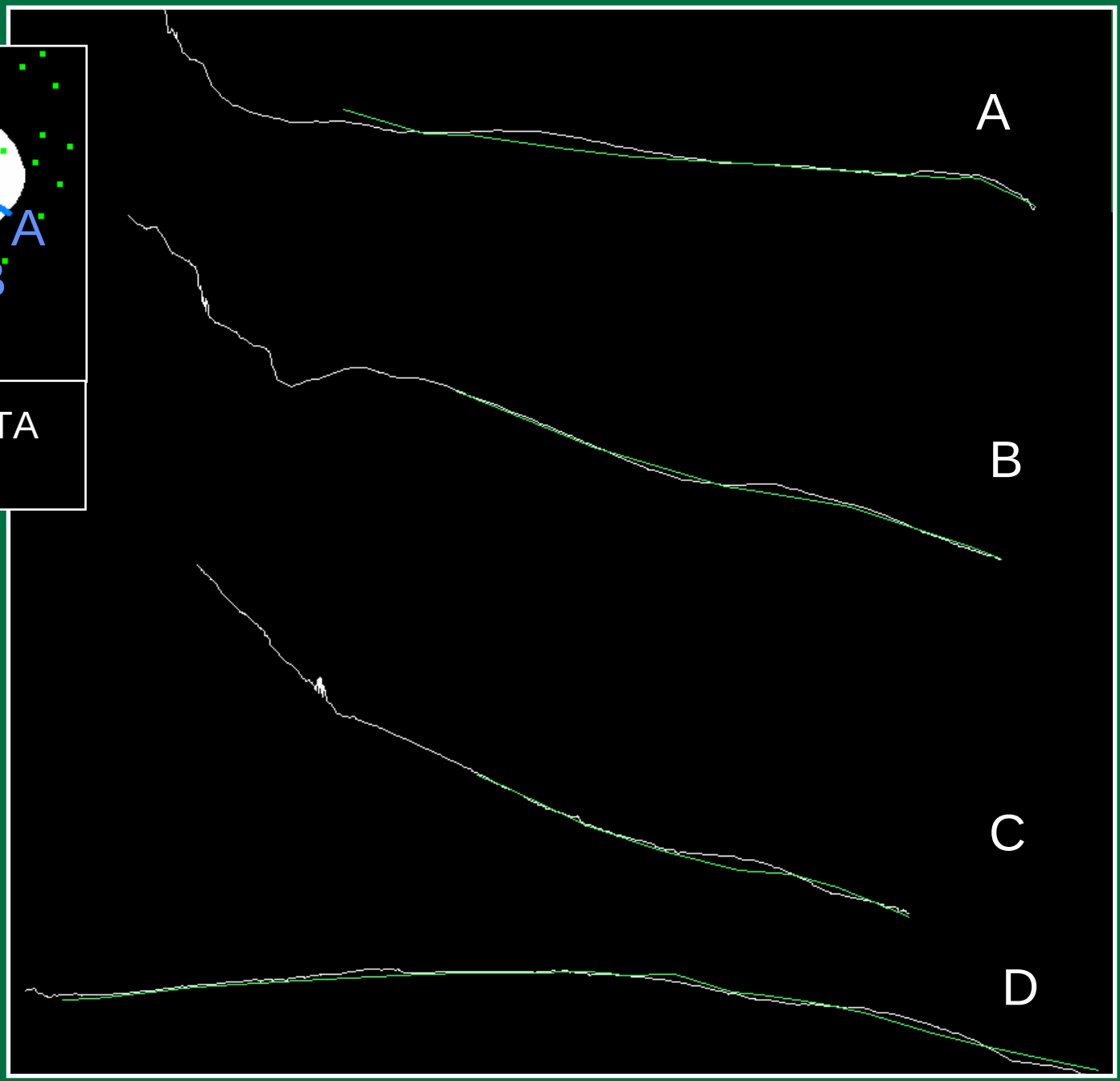


Relative Cross Section Comparison



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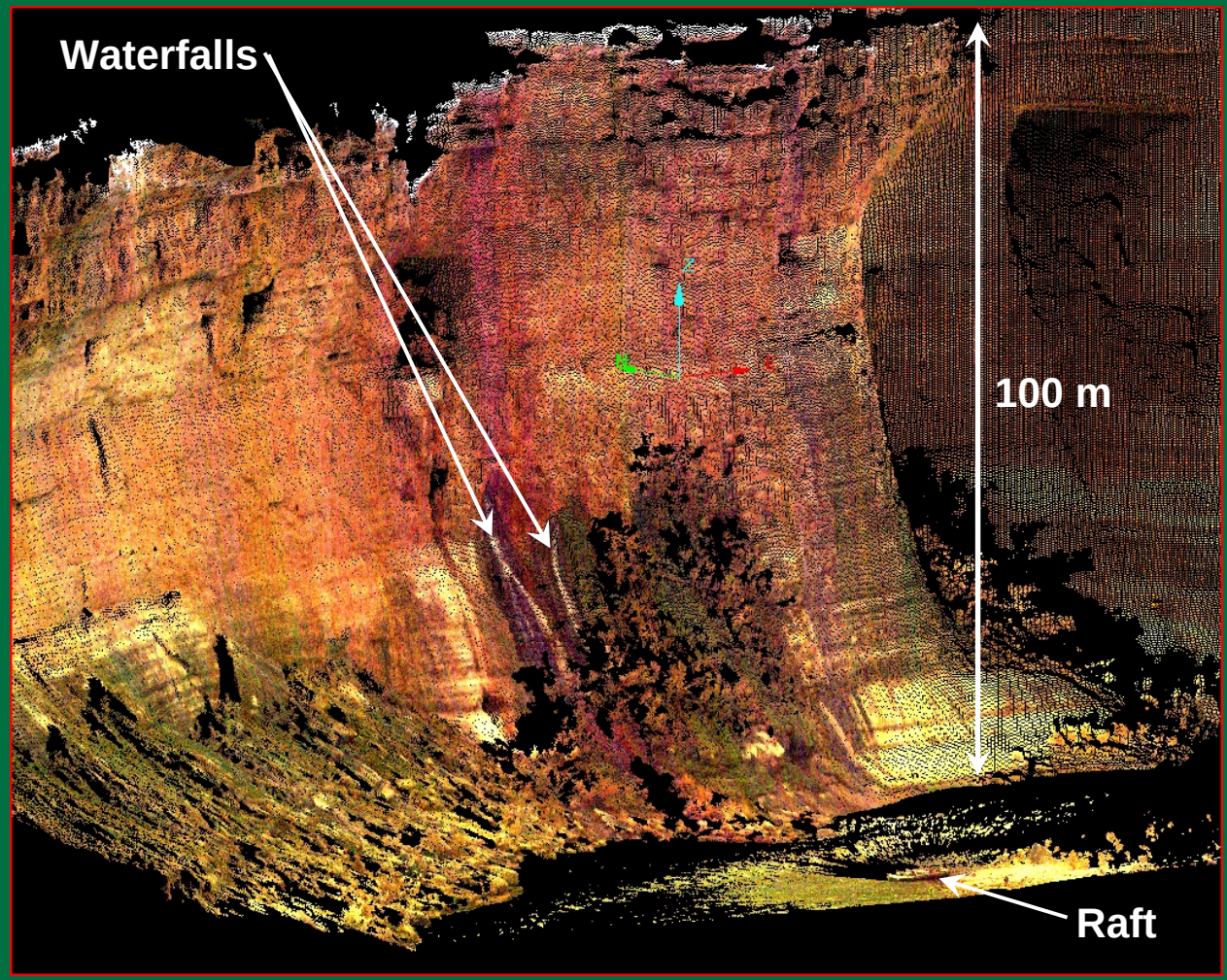
LiDAR Surveying at Vasey's Paradise



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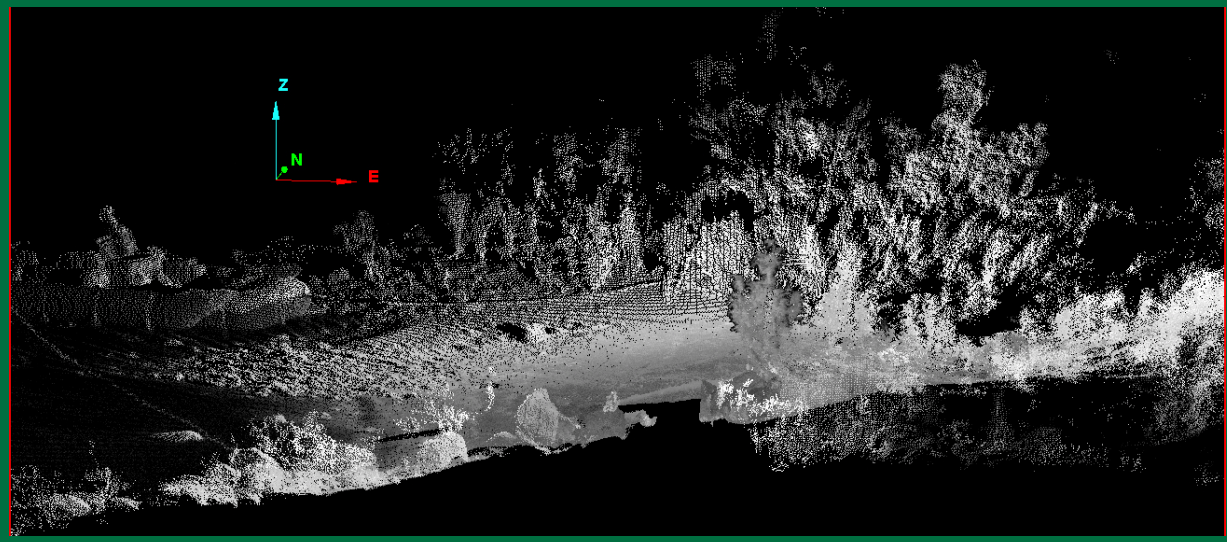
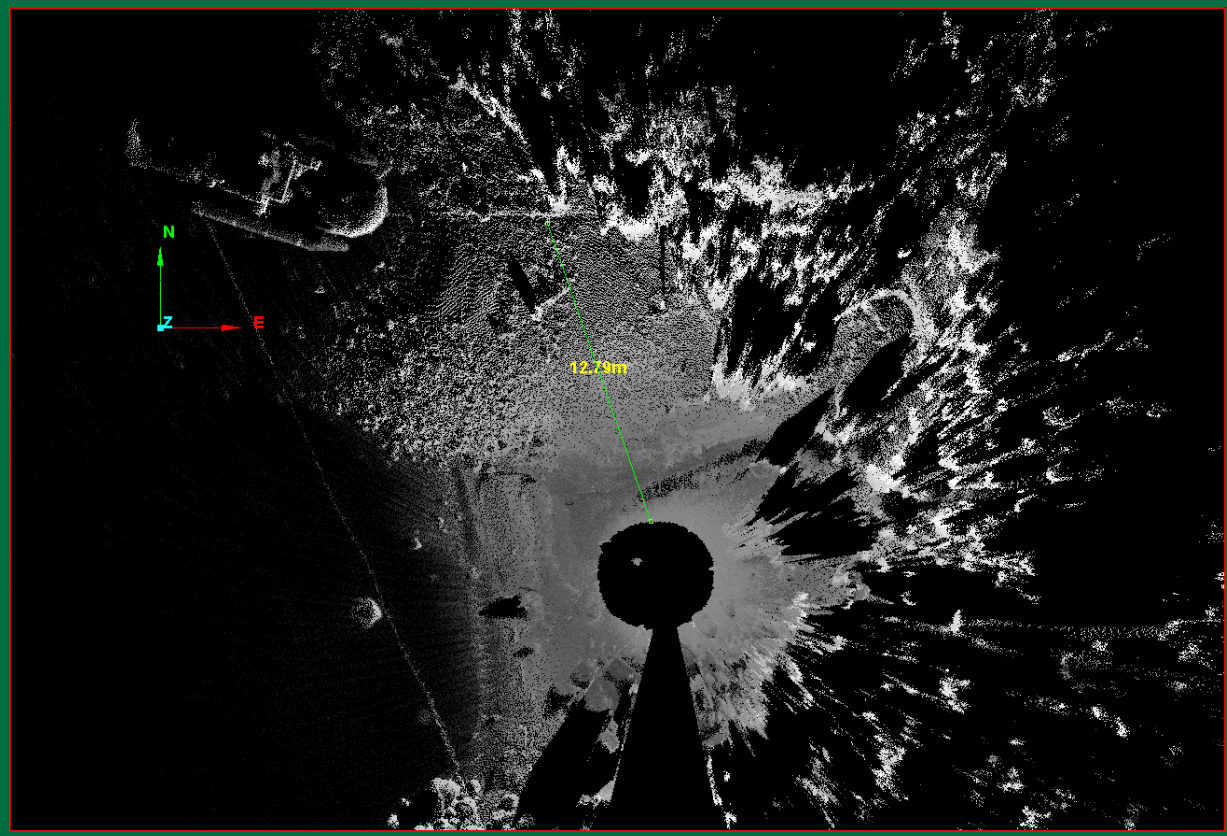
Palisades Raw LiDAR Data

- Vegetation and flat terrain impaired LiDAR data acquisition





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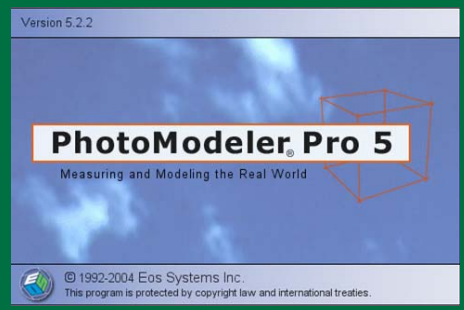
Oblique Photogrammetry

Equipment

- Digital Camera - 6 Megapixel or better
- Control Points, targets and objects of known length
- Software – PhotoModeler, Z/I Imaging ImagineStation



The Process

- Camera Calibration
- Visible control for georeferencing
- Targets or natural reference points visible on multiple photographs
- Series of “orientation” or “survey” photographs
- Series of “stereo photographs

Cost for camera set-up, hardware, and software – up to $5,000 to $50,000

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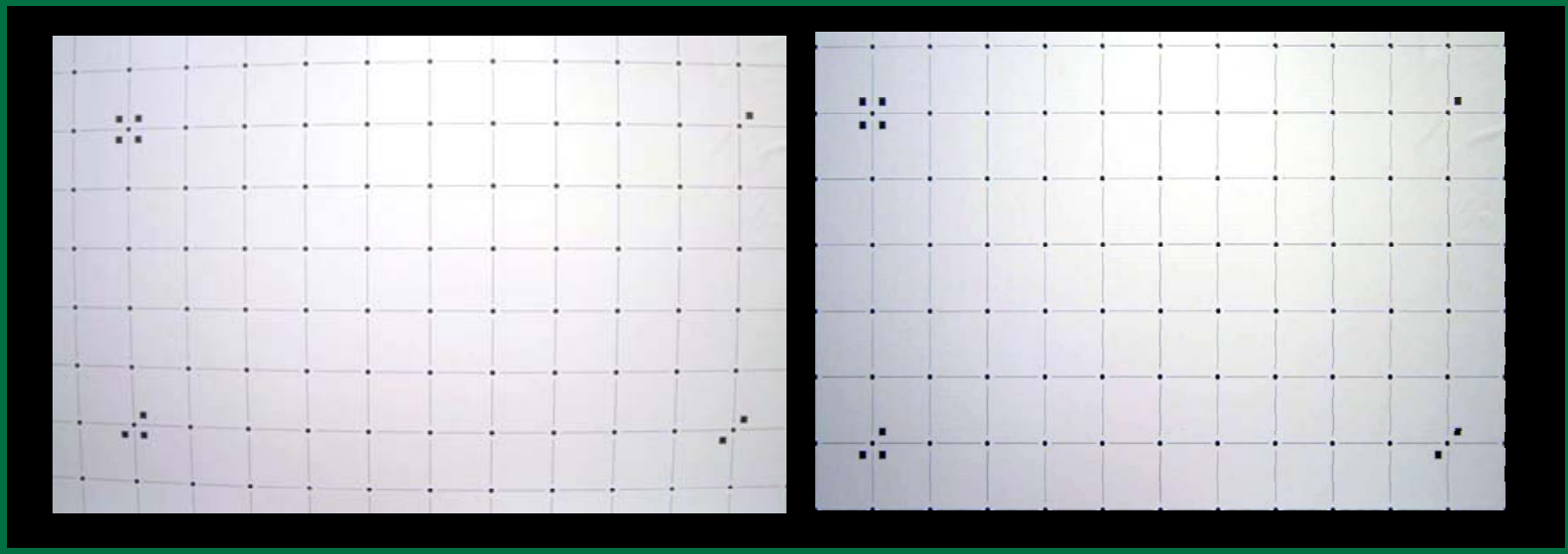
Camera Calibration



The following parameters are provided from completing the camera calibration process:

- format size
- focal length
- principal point
- distortion coefficients

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Field Set-up for Oblique Photogrammetry Work

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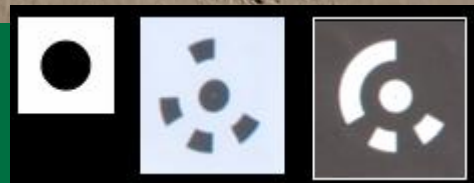
TARGETS



Photographs are taken from several locations

“Orientation” Photographs (yellow)

“Stereo” Photographs (pink)

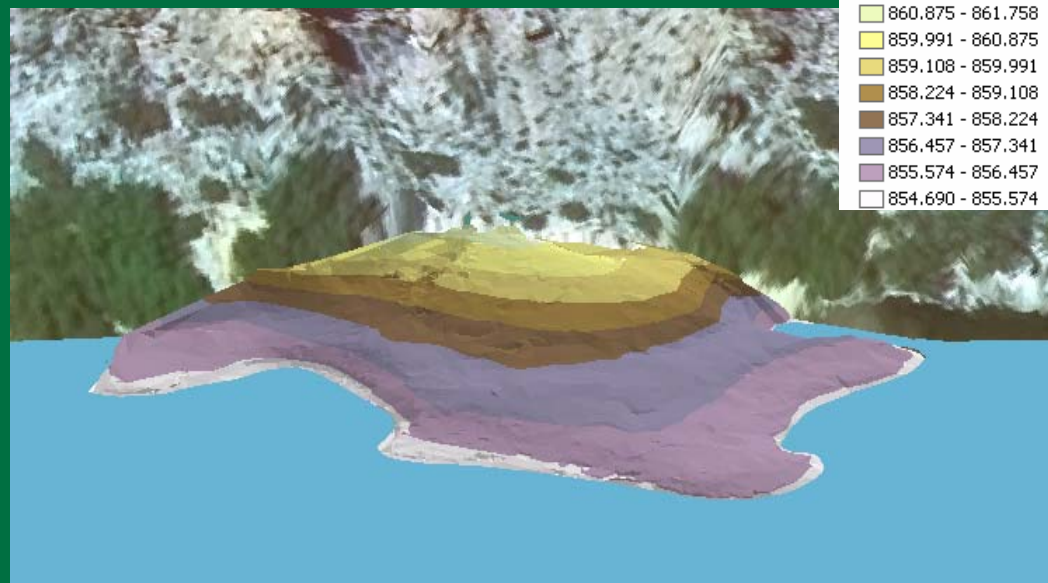
Both “Orientation” Photographs and “Stereo” Photographs are included in a PhotoModeler project

- To georeference project
- To determine position and rotations of camera for all photographs

Softcopy Photogrammetry Workstation

- Define breaklines and select common points between photographs
- Perform Image matching

Points are generated from image matching or manually selected in the photogrammetry software (2411 pts)



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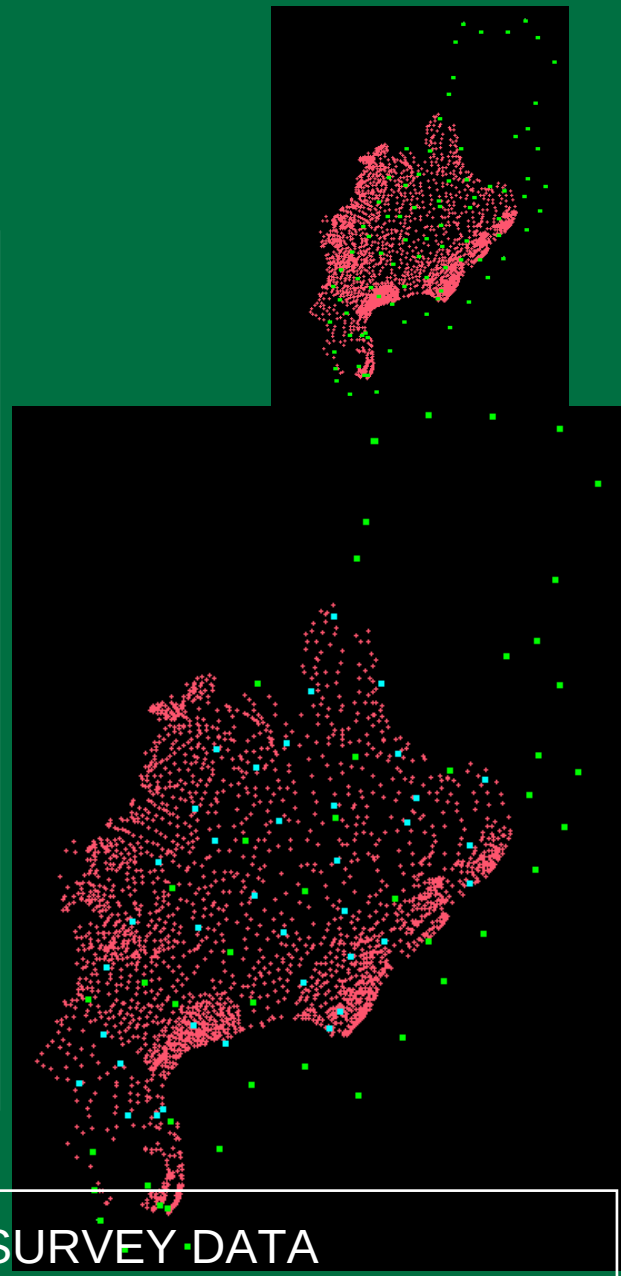
Point to Point Comparison

Difference (cm) n=38	Northing	Easting	Elevation
Average	0.5	5.8	-38.8
Minimum	-66.6	-86.6	-92.0
Maximum	49.8	72.0	15.0
Range	116.4	158.6	107.0
Standard Deviation	29.2	41.2	26.9
Median	4.1	12.9	-38.0



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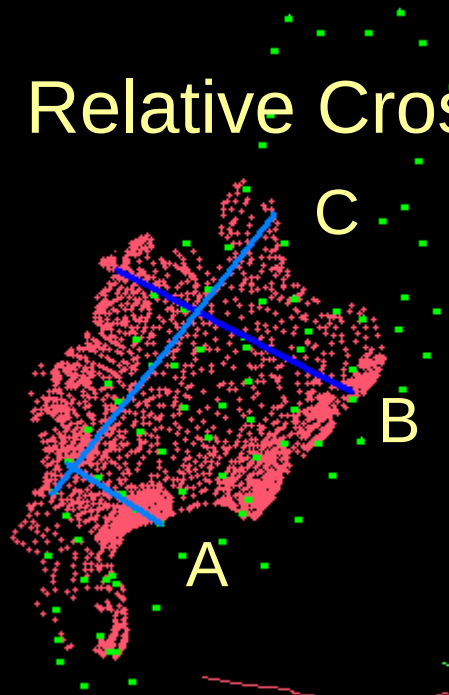
Relative Cross Section Comparison



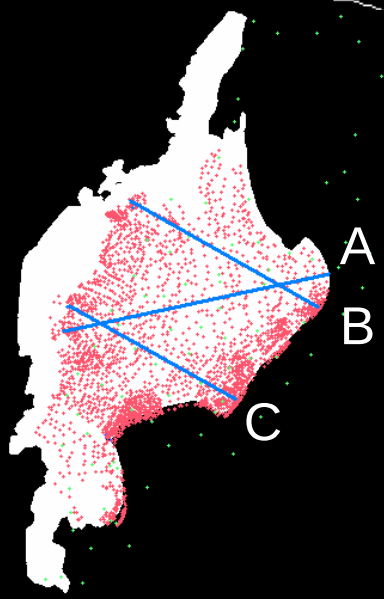
A

B

C

SURVEY DATA
PHOTOGRAMMETRY DATA

Relative Cross Section Comparison



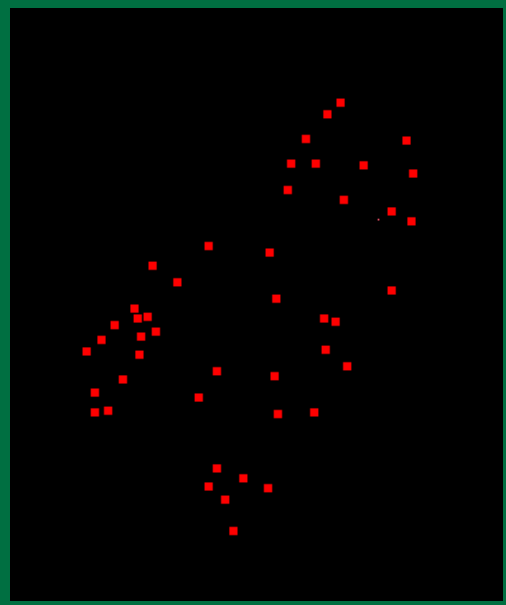
A

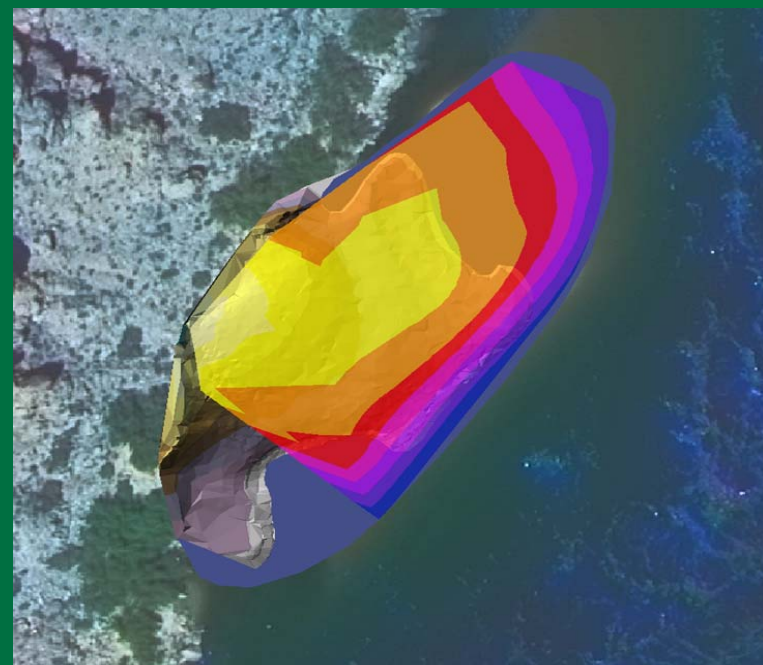
B

C

SURVEY DATA
LiDAR DATA
PHOTOGRAMMETRY DATA

Post Flood Photographs to Generate Terrain Models





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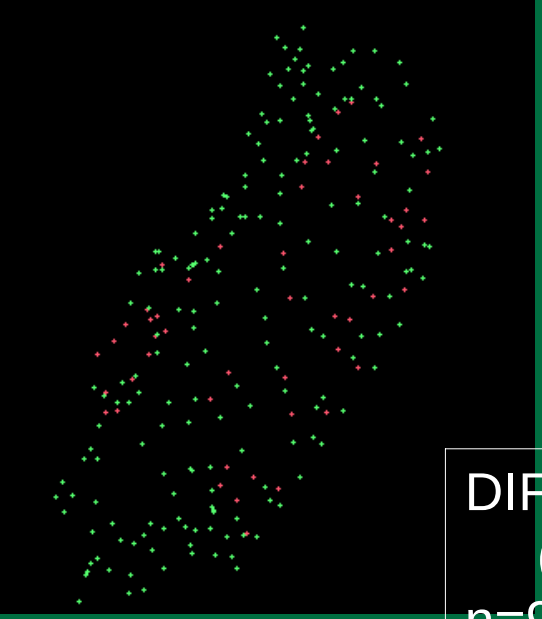

Point to Point Comparison

DIFFERENCE (cm) n=9	NORTHING	EASTING	ELEVATION
AVERAGE	-13.0	6.2	-31.9
MAXIMUM	84.0	66.0	26.0
MINIMUM	-83.0	-72.0	-70.0
RANGE	167.0	138.0	96.0
STANDARD DEVIATION	60.0	47.0	36.8
MEDIAN	-22.0	16.0	-37.0

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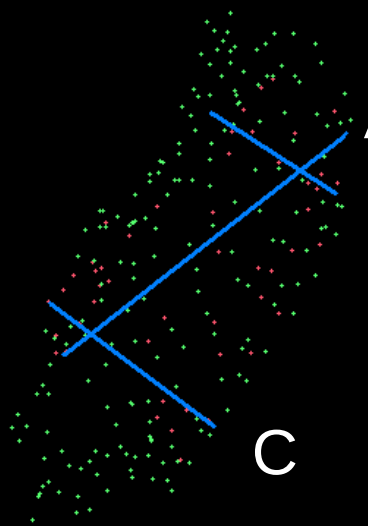
Relative Cross Section Comparison



A

B

C

SURVEY DATA
PHOTOGRAMMETRY DATA

Conclusions

- **Vertical Error Assessment (Std value)**
  - **LiDAR – 18 cm and an average of 5 cm**
  - **Photogrammetry – 27 cm and an average of 38 cm**

Benefits of LiDAR Surveying and Oblique Photogrammetry

- **Applicable to research that will tolerate the error**
- **Increased point density**
- **Applicable to monitor small features**
- **Efficient mapping methods**
- **Collect data for inaccessible sites**
- **Remote data acquisition (Photogrammetry)**

Shortcomings

- **Require exposed ground, topographic relief, and minimal vegetation**
- **Trouble in complicated terrain - arroyos**

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Thanks!

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