Drone Data Collection 2023: Point Aconi Technical Report

Prepared by

Nathan Crowell, M.Sc.
Research Specialist, NSCC Applied Geomatics Research Group
Tel. 902 824 3953
Email: Nathan.Crowell@nscc.ca

Submitted to

James Dyson, P.Eng.
HVDC Engineer, Emera Newfoundland & Labrador
Tel. 902 222 1445
Email: James.Dyson@emera.com

January 31, 2024

nscc | Applied Research | AGRG Applied Geomatics Research Group

How to cite this work and report:

Crowell, Nathan. 2023. Drone Data Collection 2023: Point Aconi Technical Report, Applied Geomatics Research Group, NSCC Middleton, NS.

Copyright and Acknowledgement

Executive Summary

The Nova Scotia Community College Applied Geomatics Research Group (NSCC-AGRG) was contracted by Emera Newfoundland and Labrador to collect airborne imagery using a drone to establish a baseline position of an area of eroding coastline near Point Aconi infrastructure. Data were successfully collected on August 31st of 2022, and on October 14, 2023, using a DJI Matrice 300 RTK drone equipped with an L1 survey grade lidar and camera system. Quality assurance and control measures have validated that the collected image data met or exceeded project specifications and were accurate to +-5 cm. Survey results were determined to be of high quality and are suitable for use in future monitoring of bank erosion. In 2023, the crest of the eroding bank position remained stable when compared to measurements obtained in 2022. However, a large volume of material was removed from the toe of the bank which resulted in a more vertical face along the elevated areas to the north and east of the HDD pad. It is expected that stability in these areas will fail and result in a slump of the face and setback (estimated at 1.5 m) of the crest toward the HDD pad.

Table of Contents

Table of Figures

1 Introduction

The Nova Scotia Community College – Applied geomatics Research Group (NSCC-AGRG) was contracted to survey an area of eroding coastline in proximity to infrastructure located at the Point Aconi site, NS. NSCC-AGRG established baseline positions for several Emera Newfoundland and Labrador sites in 2019 and have been providing repeat surveys and monitoring services to identify any critical movements in these areas. In 2022, NSCC-AGRG used similar methodologies to establish a baseline position of the Point Aconi coastline position with an accuracy of better than +- 0.05 m and produced data that were suitable for monitoring future movement of the eroding coastline. In 2023, NSCC-AGRG returned to the Point Aconi site to measure any erosion or deformation.

2 Methods

Data were successfully collected on October 14, 2023. While on site, NSCC-AGRG established GNSS checkpoints using Propeller Aeropoint smart targets designed to provide optimal positioning metrics for aerial surveys. Checkpoint positions were calculated to have an average vertical variance of +- 0.014 m with a maximum variance of 0.026 m (Appendix A). These points coincided with target centers that were used to establish photo position accuracies for data validation.

NSCC-AGRG collected aerial imagery using a DJI Matrice 300 RTK equipped with a differential GNSS survey grade receiver. Flights were planned at above ground altitudes which yielded imagery with a 0.0195 m ground pixel resolution with an image overlap of 70% along and across flight lines. Lines were planned in an East-West orientation, followed by a North-South orientation to ensure all surfaces were captured in several overlapping images at varying angles. Images were processed using Agisoft Metashape to produce elevation models and photo mosaics. With accurate positioning established, the model was used to generate a dense point cloud (LAS; ~419 M points), a digital elevation model, and an ortho mosaic (Appendix B). Raster data were processed at a native cell resolution of 0.0195 m and sampled down to 0.02 m for ease of delivery.

The NSCC-AGRG has agreed to persist a copy of Emera Newfoundland and Labrador's survey data on their secured central server. This persistence will ensure that additional copies in varying formats and datums can be requested as required. For delivery, map data have been projected to the Universal Transverse Mercator Zone 21 North, following the North American Datum of 1983 Canadian Spatial Reference System Version 7 horizontal coordinate system, and the Canadian Geodetic Vertical Datum of 2013 vertical coordinate system (prjUTM21N_hcsNAD83CSRSv7_vcsCGVD2013a).

3 Results

Image mosaics were found to be of high quality due to consistent light levels experienced during the collection period (Figure 1).

Figure 1. Point Aconi site photo mosaic showing good horizontal alignment over checkpoint targets.

Rasterized elevation data were generated by binning dense cloud elevation values at a resolution of 0.02 m. Elevations ranged from roughly 0.0 m offshore to >20.0 m in the wooded areas with the main pad at about 8.5 - 8.6 m CGVD2013 (Figure 2). Quality assurance and control measures validated that the collected data exceeded project specifications with a maximum error < 0.05 m.

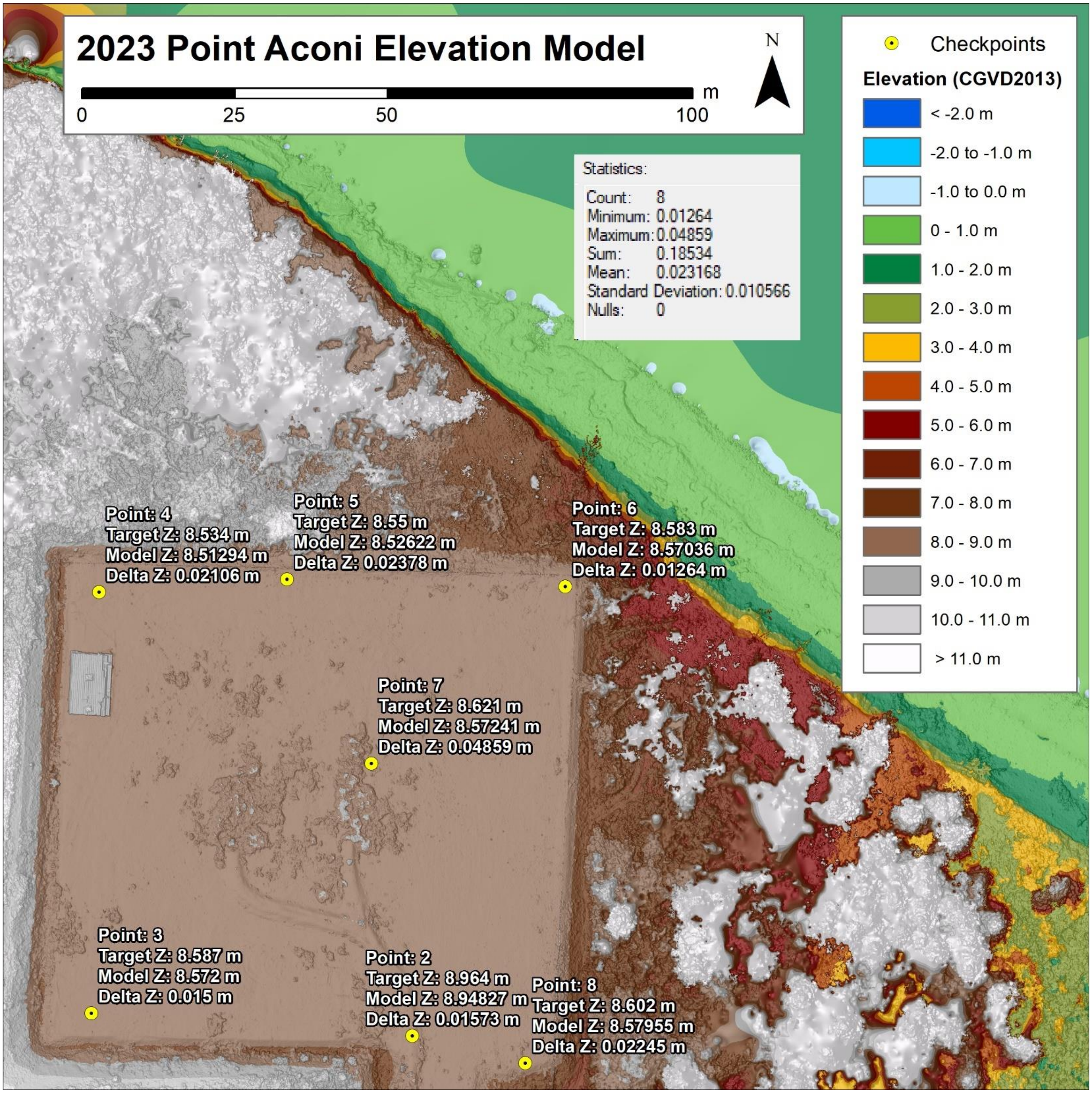


Figure 2. Elevation model and control point comparison showing good agreement between drone survey elevations and control target positions.

Traditional top-down measurement of elevation differences between data surveyed in 2022 and 2023 showed no definitive movement of the bank position or the horizontal directional drilling (HDD) pad between the two surveys (Figure 3). Note that material loss was noted at the toe of the cliff north and east of the HDD pad. Vegetation growth was also observed on the pad with most of the growth localized north of the raised lines.

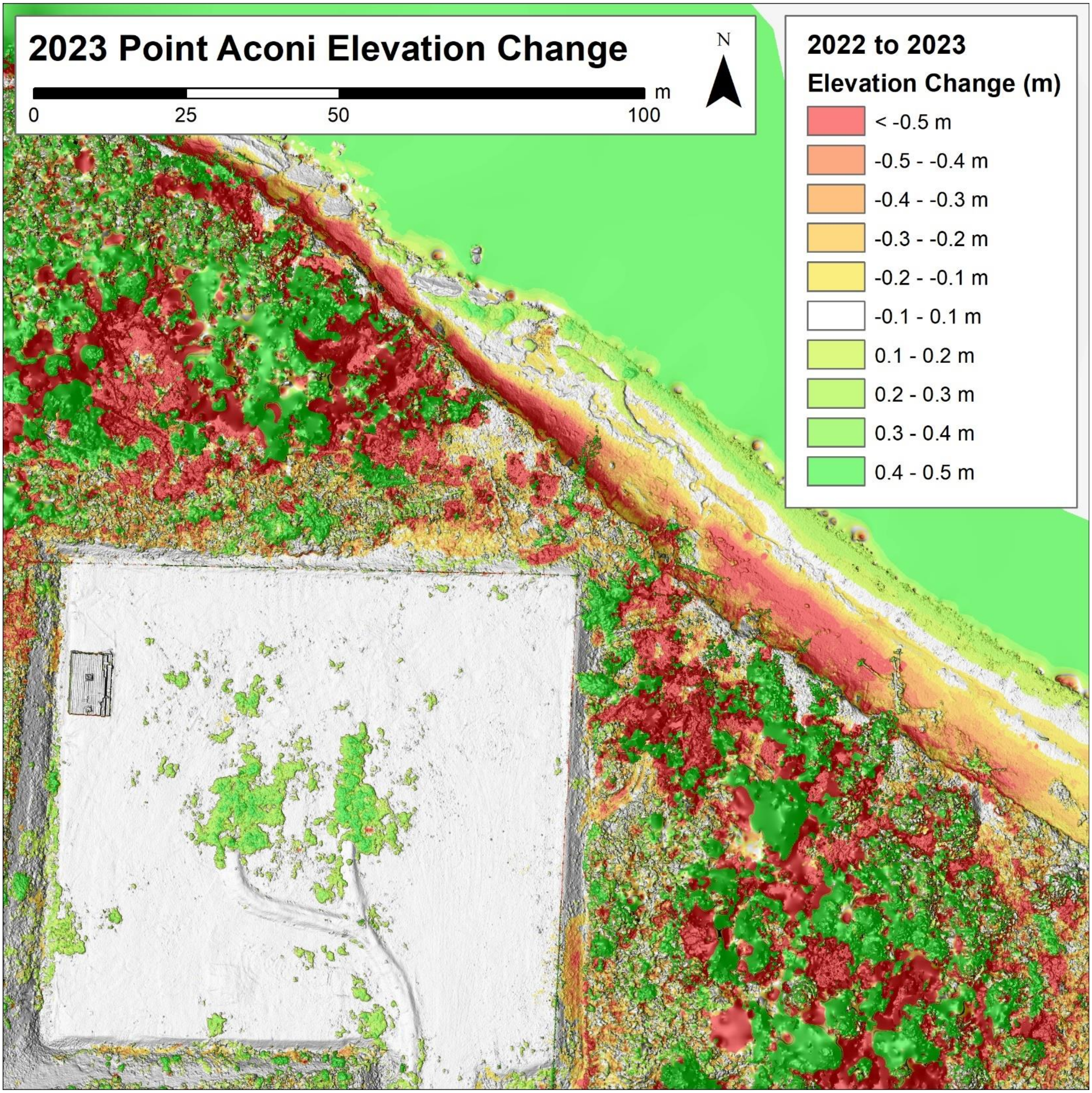


Figure 3. Model of elevation differences between 2022 and 2023 showing stability along the cliff ridge and HDD pad. Material was lost in the beach area at the toe of the cliff. Large differences in elevation were observed in the forested areas.

This type of analysis, elevation model differencing, is best suited for quantifying shifts in objects based on elevation and works optimally for unobstructed hard targets, such as breakwaters, with no tree canopy or interspersed vegetation. This limitation is examined further in the discussion section.

Image point cloud data (pixel matches) were further examined in cross-sections drawn perpendicular to the eroding bank. Closer inspection confirmed trends observed in the top-down elevation model differencing. Between 2022 and 2023 the bank crest remained nearly stationary; however, a large volume of material was removed from the bank toe (Figure 4). This removal of material is consistent with marine erosion in areas exposed to wave action. While the crest of the bank remained stable between 2022 and 2023, the bank material will become less stable as the ocean continues to remove toe material to create a vertical face. The crest will set back at the next slump event when the material fails and re-fills the toe.

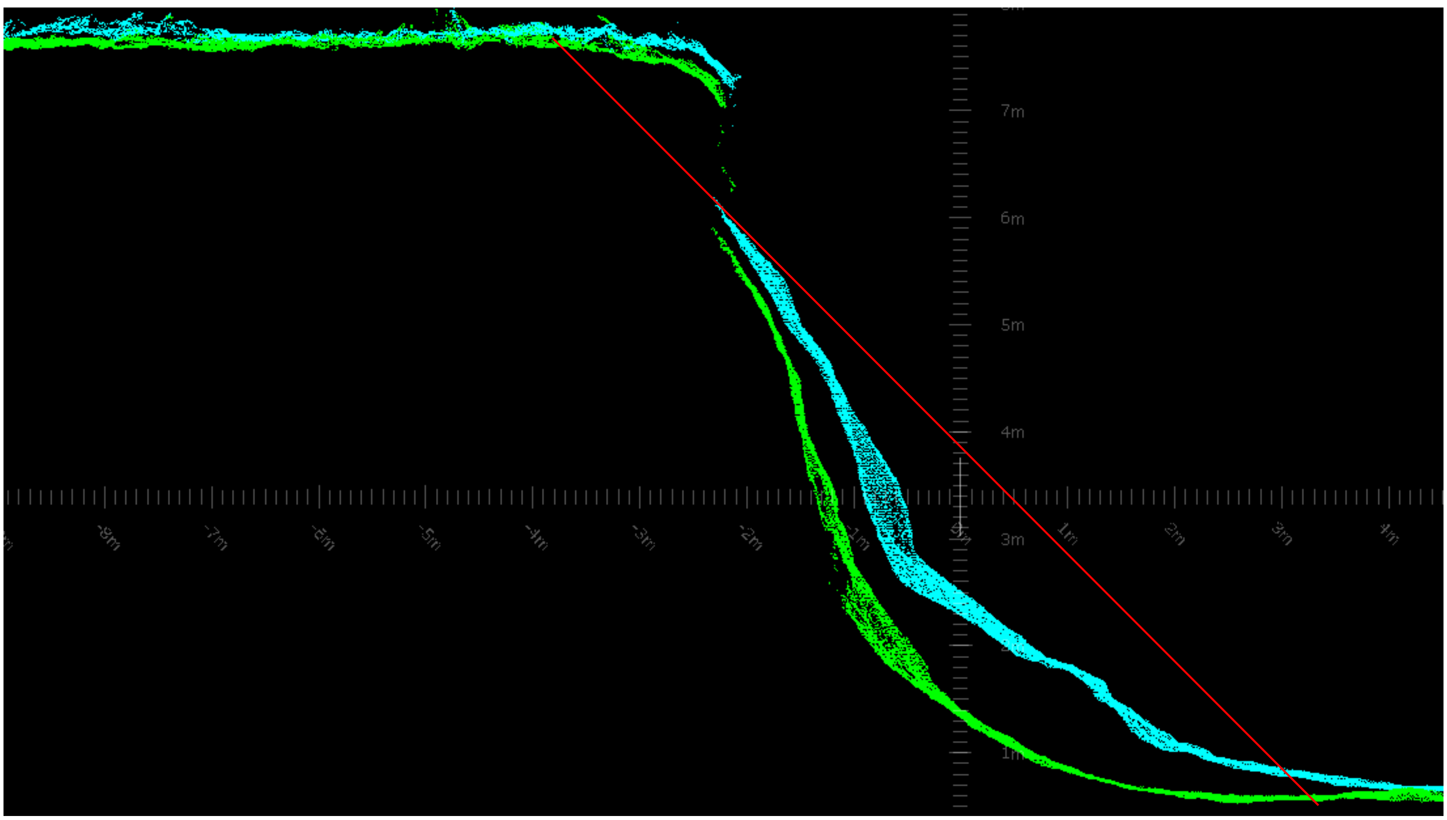


Figure 4. Cross-section (1 m width) of image point cloud data drawn perpendicular to the eroding cliff face. A large volume of material was removed from the toe of the bank between the 2022 (blue) and 2023 (green) surveys. 1:1 slope line imposed in red to demonstrate potential setback of 1.5 m.

4 Discussion

Camera imagery is unable to penetrate vegetation and only provides surface measurements for objects within the survey area. To date, NSCC-AGRG have generated digital surface models (DSM) using these surface measurements captured in imagery. This image-based method has several strengths including very high accuracies and resolutions required to position data in compliance with Emera Newfoundland and Labrador's specifications. The primary shortcoming of image-based modelling is the inability to measure objects below vegetation. This limitation is simply caused by the inability of the camera to *see* through those materials. A second limitation is the inability to resolve objects which are not stationary between camera exposures. Image modelling works on the principle of pixel matching where positions are generated by matching multiple observations of the same object in frames with different perspectives. Camera positions and parallax are calculated to resolve pixel positions in a three-dimensional space. While this method works very well for hard and stationary materials, the movement of objects between camera exposure produces erroneous results by either artificially diminishing or exaggerating the impact of parallax resulting in large elevation fluctuations. These fluctuations are filtered out of the data in the processing workflow in normal areas but can often be observed in areas with very little stationary material, such as forested areas and water. Additional processing can be implemented to further clean the data by classifying points into groups, such as ground, vegetation, buildings, powerlines, etc. based on their geometry. Survey products can then be generated which only include a limited number of classes. For example, the standard digital surface model (DSM) for Point Aconi includes all classes captured in the image pixel-match point cloud (Figure 5). The same area can be gridded to generate a digital terrain model (DTM) using only ground-classified points (Figure 6). While the DTM data appeared cleaner than the DSM, several details were lost around the cliff edge. This oversimplification of the data occurred because there were too few points observed under the tree canopy to confidently classify the cliff edge as ground in the point data.

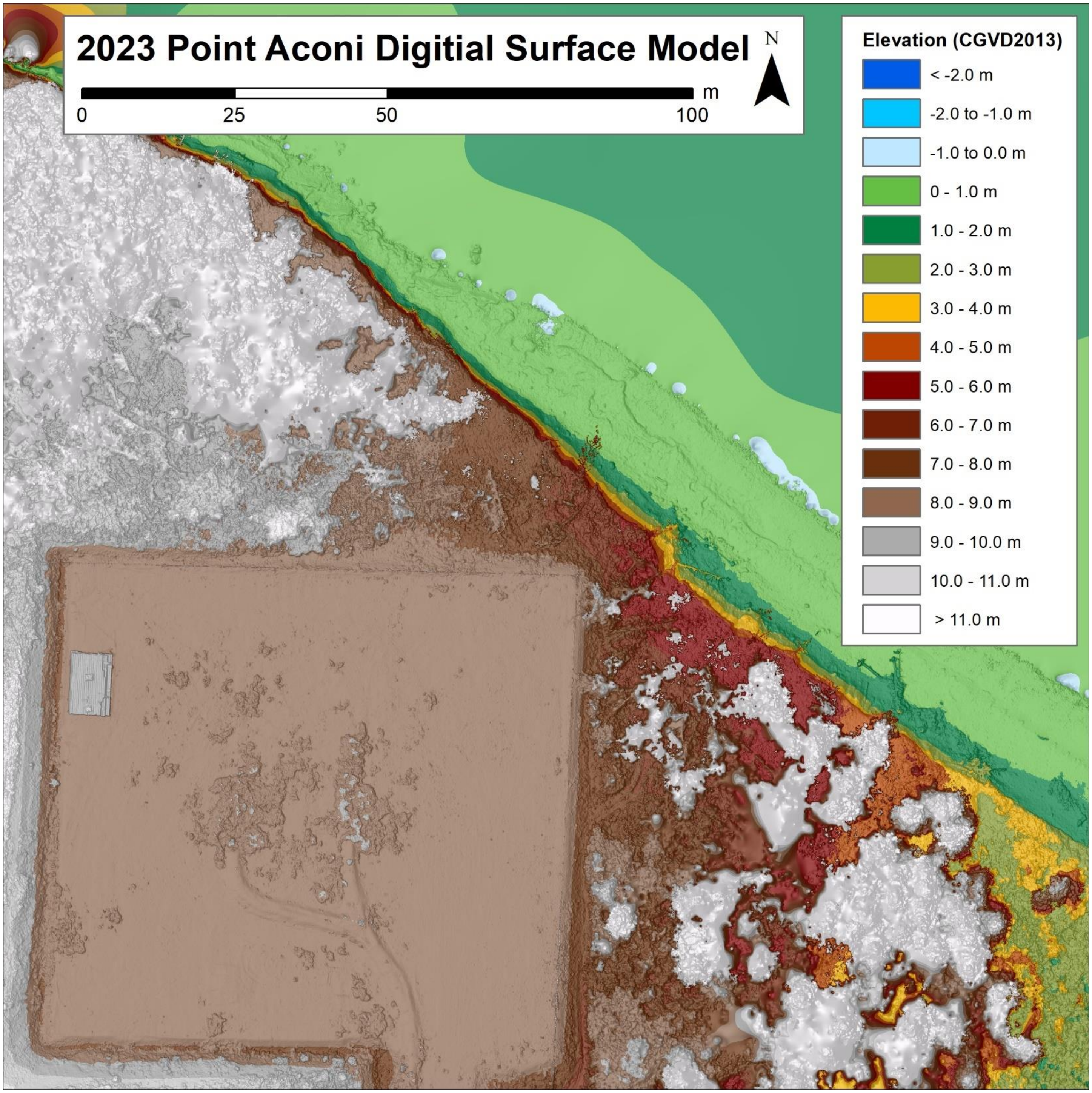


Figure 5. Digital surface model of the Point Aconi site using all point classes captured in the image point cloud.

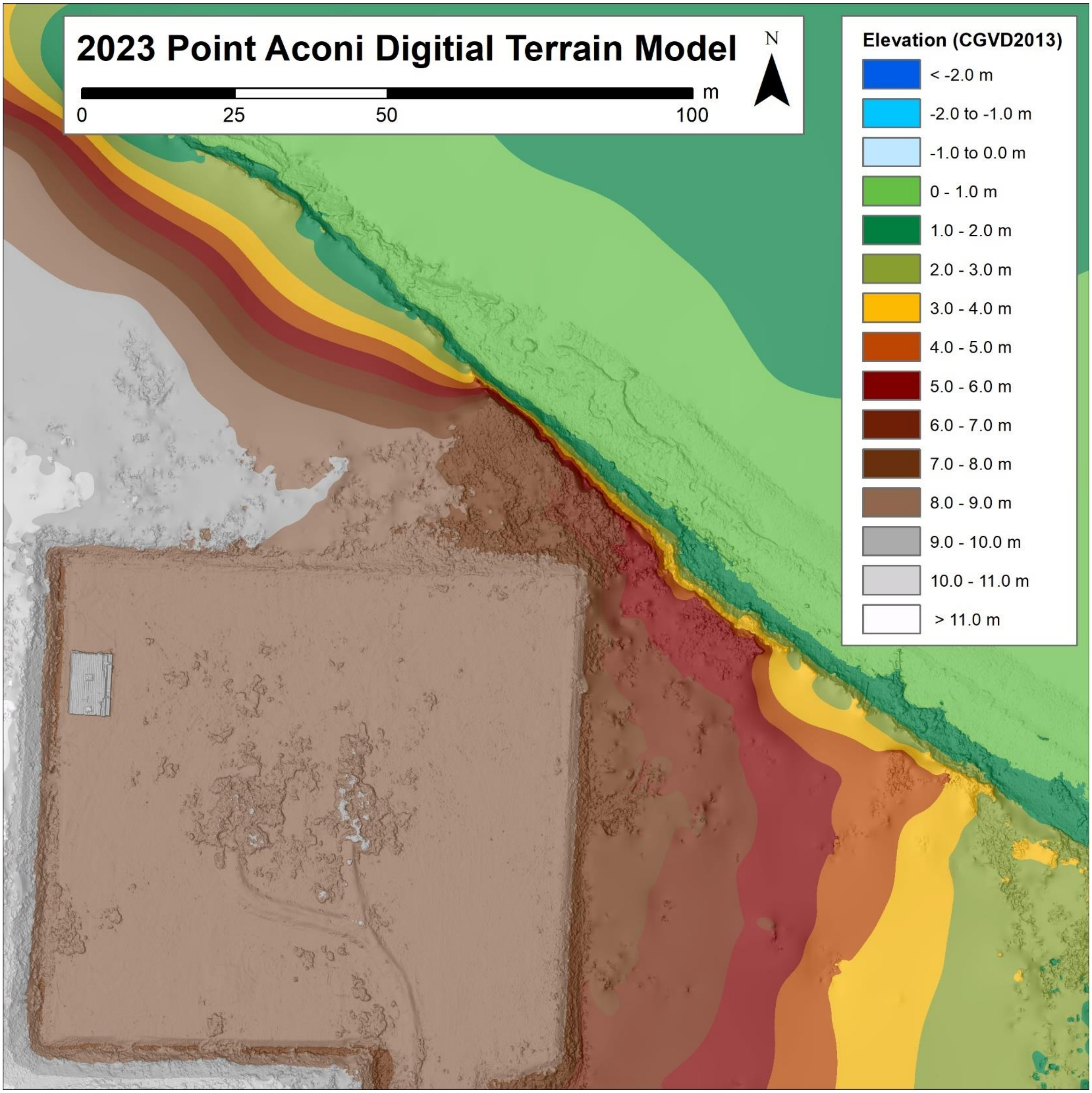


Figure 6. Digital surface model of the Point Aconi site using all point classes captured in the image point cloud.

Advances in drone and sensor technology have led to the development of affordable light detection and ranging (lidar) capture devices that can be mounted on drones. Lidar measures multiple objects struck by each emitted laser pulse by resolving the return time of reflected light. In this way, a single laser shot can illuminate and reflect light off a tree branch followed by the forest floor. Each reflection is discretized to resolve the range and plotted in a three—dimensional space based on the position of the sensor and angle of emission. The primary advantage of lidar over imagery is its ability to penetrate vegetation to measure objects with a single pulse of light.

NSCC-AGRG captured data with a DJI L1 lidar and camera unit in 2022 and 2023. Current processing workflows are unable to generate lidar products that are as dense or as accurate an imagery, but lidar data provide additional detail in areas that containing vegetation (Figure 7, Figure 8).

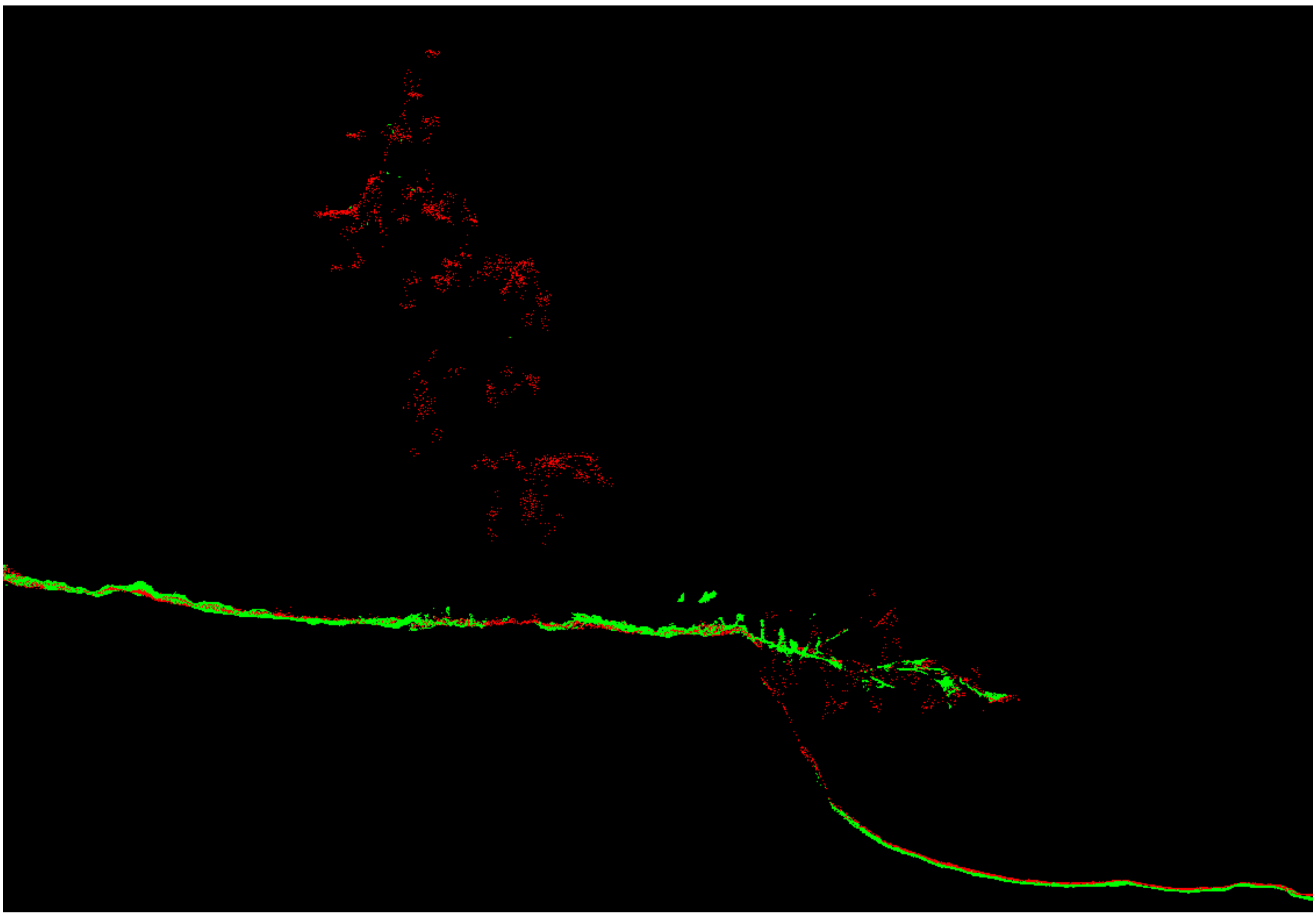


Figure 7. Point cloud data cross-section (1 m width) of the Point Aconi cliff northeast of the HDD pad with lidar data in red and image data in green. The lidar sensor was able to capture tree boughs inland and fine branches and cliff structure around a fallen tree on the cliff face.

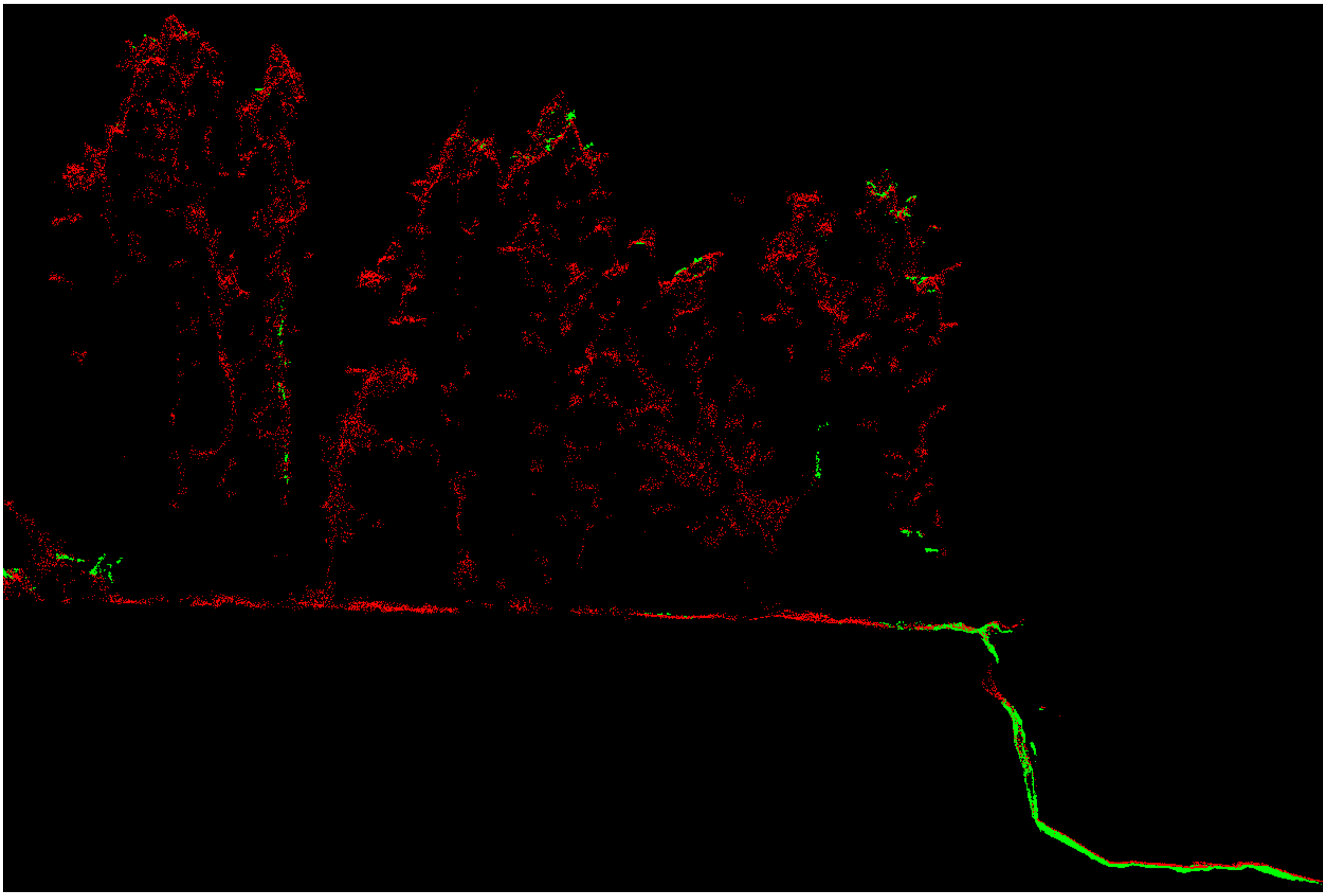


Figure 8. Point cloud data cross-section (1 m width) of the Point Aconi cliff north of the HDD pad with lidar data in red and image data in green. The lidar sensor was able to capture tree boughs and forest floor data where the imagery was unable to resolve points. Additional cliff structure was also captured by the lidar sensor.

NSCC-AGRG is presently investigating the merger of these data sources to improve point classification routines. Additional lidar measurements of the forest floor will improve the ground classification confidence, especially in complex areas such as cliffs under canopy, and will improve the quality of rasterized DTM products. Generation of accurate DTMs will allow NSCC-AGRG to provide metrics for material loss and cliff setback for the entire site without the need for inspection via cross-sections.

Cross-section inspection determined that the crest of the eroding bank remained stable when compared to measurements obtained in 2022. However, a large volume of material was removed from the toe of the bank which resulted in a more vertical face along the elevated areas to the north and east of the HDD pad. It is expected that stability in these areas will fail and result in a slump of the face and setback (estimated at 1.5 m) of the crest toward the HDD pad.

Appendix A

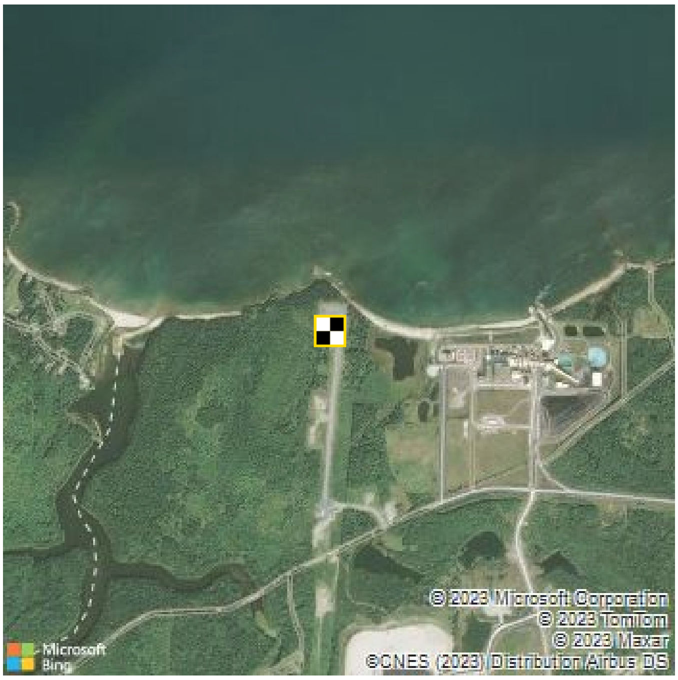
propeller aeropoints

Ground Control Report

Cape Breton, NS

Survey ID	as096b2f7f
Aeropoint Set	
Date captured	14 Oct 2023 11:20 AM ADT
Points captured	8
Processing method	Propeller network correction
Document generated	17 Oct 2023 4:34 PM ADT

Point 1



Point Number	1
Global ID	ac902f013a
AeroPoint ID	7283903

Capture start	14 Oct 2023 11:20 AM ADT
Capture end	14 Oct 2023 12:03 PM ADT
Duration	0:43
Uploaded	14 Oct 2023 12:17 PM ADT

NAD83(CSRS)

Latitude	46.32245452° (46° 19' 20.83626" N)
Longitude	-60.33699281° (60° 20' 13.17412" W)
Ellipsoid height (NAD83(CSRS))	-3.566 m

NAD83(CSRS) / UTM zone 20N

Easting	704998.384 m
Northing	5133322.127 m

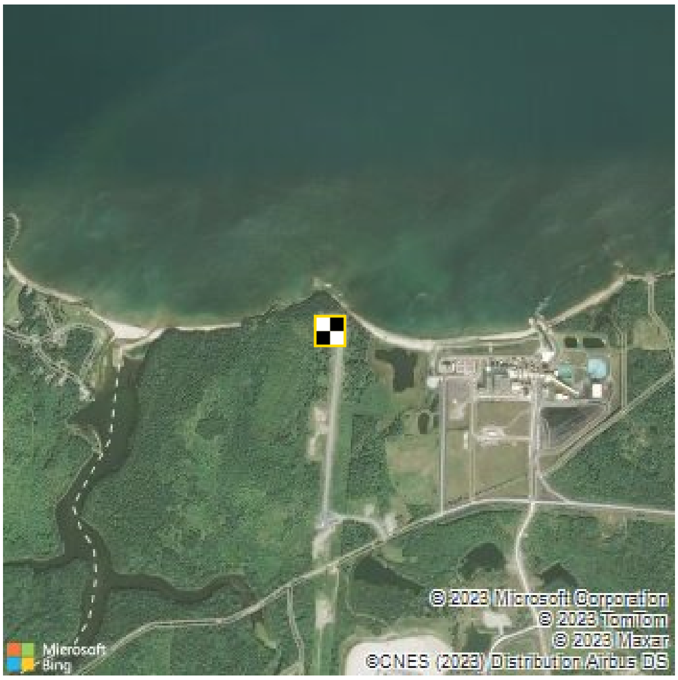
CGVD2013 height

Height	8.381 m

Quality

Data points	259
Points used	258 (99.6%)
Baseline distance	21.29 km
Data variance	14.4 mm / 16.1 mm / 28.7 mm

Point 2



Point Number	2
Global ID	ac7d7cbdd4
AeroPoint ID	7287239

Capture start	14 Oct 2023 11:22 AM ADT
Capture end	14 Oct 2023 12:06 PM ADT
Duration	0:44
Uploaded	14 Oct 2023 12:16 PM ADT

NAD83(CSRS)

Latitude	46.32278835° (46° 19' 22.03806" N)
Longitude	-60.33702839° (60° 20' 13.30222" W)
Ellipsoid height (NAD83(CSRS))	-2.983 m

NAD83(CSRS) / UTM zone 20N

Easting	704994.397 m
Northing	5133359.126 m

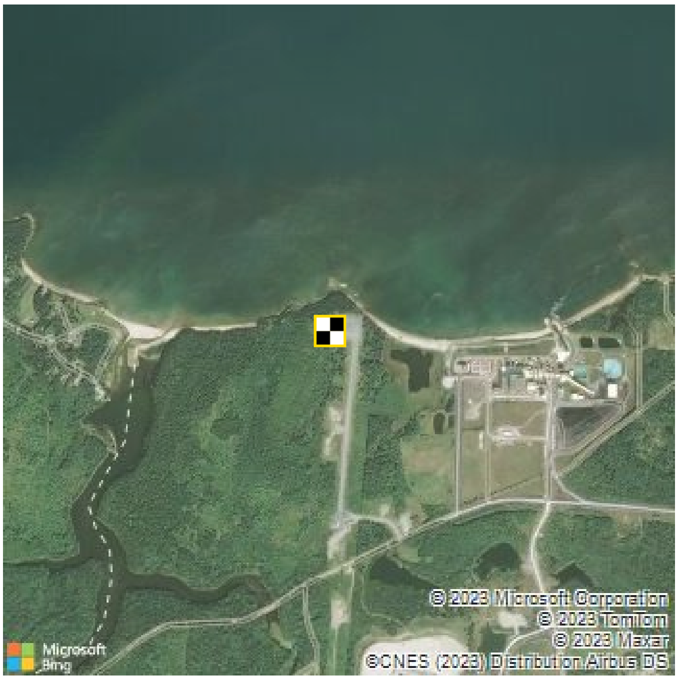
CGVD2013 height

Height	8.964 m

Quality

Data points	265
Points used	262 (98.9%)
Baseline distance	21.33 km
Data variance	2.7 mm / 6.0 mm / 10.4 mm

Point 3



Point Number	3
Global ID	acd21d667a
AeroPoint ID	7284587

Capture start	14 Oct 2023 11:23 AM ADT
Capture end	14 Oct 2023 12:07 PM ADT
Duration	0:44
Uploaded	14 Oct 2023 12:14 PM ADT

NAD83(CSRS)

Latitude	46.32283728° (46° 19' 22.21423" N)
Longitude	-60.33770863° (60° 20' 15.75108" W)
Ellipsoid height (NAD83(CSRS))	-3.36 m

NAD83(CSRS) / UTM zone 20N

Easting	704941.851 m
Northing	5133362.802 m

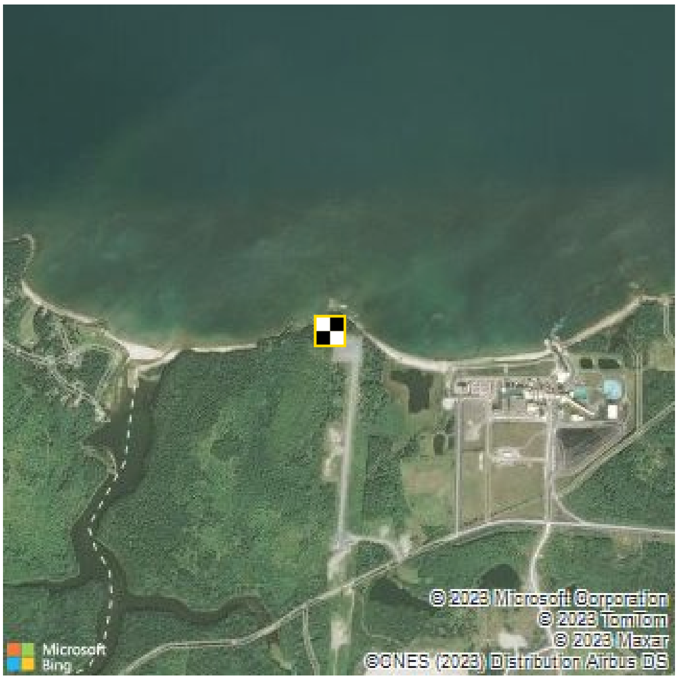
CGVD2013 height

Height	8.587 m

Quality

Data points	263
Points used	259 (98.5%)
Baseline distance	0.05 km
Data variance	6.0 mm / 3.5 mm / 2.0 mm

Point 4



Point Number	4
Global ID	ac3b923bbe
AeroPoint ID	7284730

Capture start	14 Oct 2023 11:23 AM ADT
Capture end	14 Oct 2023 12:08 PM ADT
Duration	0:44
Uploaded	14 Oct 2023 12:13 PM ADT

NAD83(CSRS)

Latitude	46.32345756° (46° 19' 24.44721" N)
Longitude	-60.33766256° (60° 20' 15.58522" W)
Ellipsoid height (NAD83(CSRS))	-3.413 m

NAD83(CSRS) / UTM zone 20N

Easting	704943.08 m
Northing	5133431.838 m

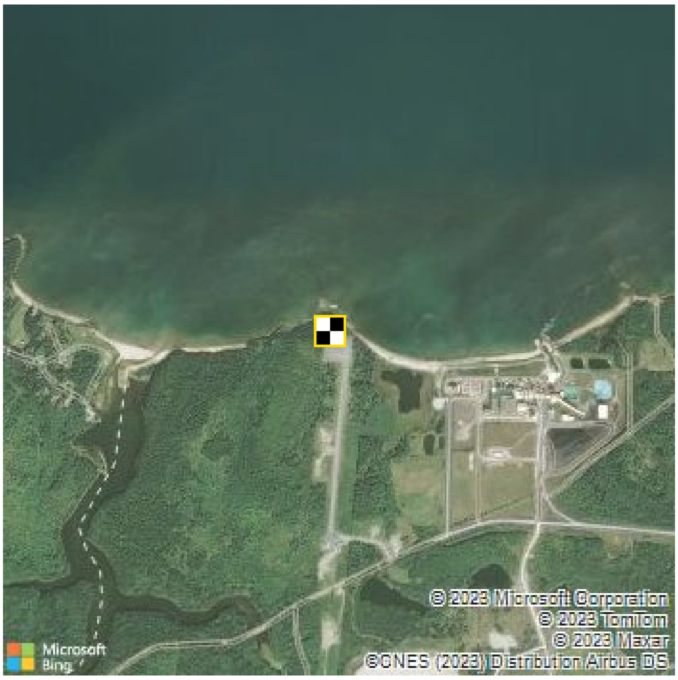
CGVD2013 height

Height	8.534 m

Quality

Data points	266
Points used	256 (96.2%)
Baseline distance	0.09 km
Data variance	0.8 mm / 0.5 mm / 1.4 mm

Point 5



Point Number	5
Global ID	acd465bdca
AeroPoint ID	7287283
Capture start	14 Oct 2023 11:25 AM ADT
Capture end	14 Oct 2023 12:08 PM ADT
Duration	0:43
Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	46.32346718° (46° 19' 24.48183" N)
Longitude	-60.33726163° (60° 20' 14.14188" W)
Ellipsoid height (NAD83(CSRS))	-3.397 m

NAD83(CSRS) / UTM zone 20N

Easting	704973.906 m
Northing	5133433.945 m

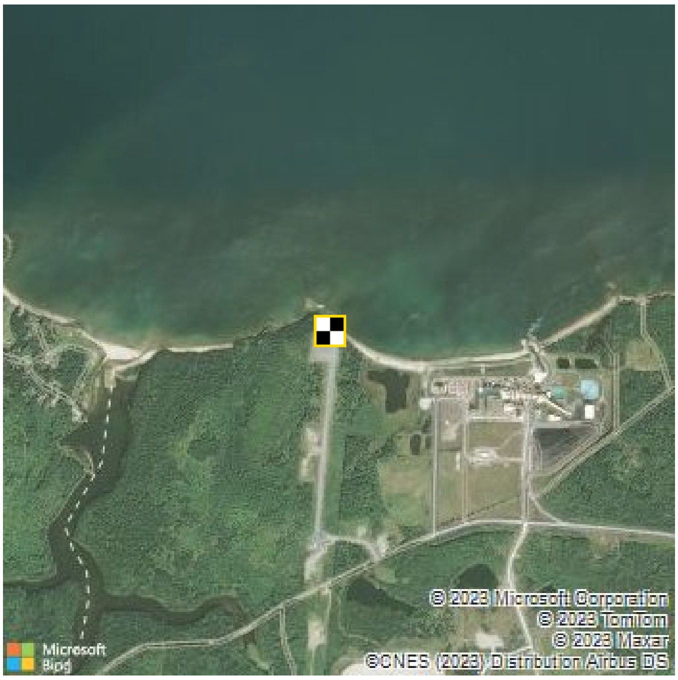
CGVD2013 height

Height	8.55 m

Quality

Data points	262
Points used	260 (99.2%)
Baseline distance	21.40 km
Data variance	17.3 mm / 6.7 mm / 26.4 mm

Point 6



Point Number	6
Global ID	acd0d95f8c
AeroPoint ID	7286423

Capture start	14 Oct 2023 11:26 AM ADT
Capture end	14 Oct 2023 12:09 PM ADT
Duration	0:43
Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	46.32344258° (46° 19' 24.39329" N)
Longitude	-60.33667071° (60° 20' 12.01457" W)
Ellipsoid height (NAD83(CSRS))	-3.364 m

NAD83(CSRS) / UTM zone 20N

Easting	705019.484 m
Northing	5133432.743 m

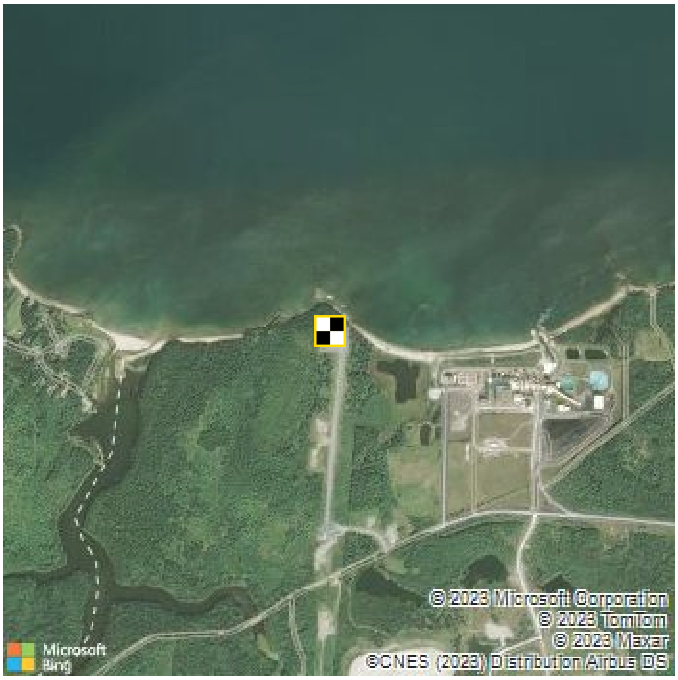
CGVD2013 height

Height	8.583 m

Quality

Data points	261
Points used	245 (93.9%)
Baseline distance	0.08 km
Data variance	3.0 mm / 4.2 mm / 10.1 mm

Point 7



Point Number	7
Global ID	acb4aebaad
AeroPoint ID	7286502
Capture start	14 Oct 2023 11:27 AM ADT
Capture end	14 Oct 2023 12:10 PM ADT
Duration	0:43
Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	46.3231914° (46° 19' 23.48903" N)
Longitude	-60.33709573° (60° 20' 13.54465" W)
Ellipsoid height (NAD83(CSRS))	-3.325 m

NAD83(CSRS) / UTM zone 20N

Easting	704987.707 m
Northing	5133403.734 m

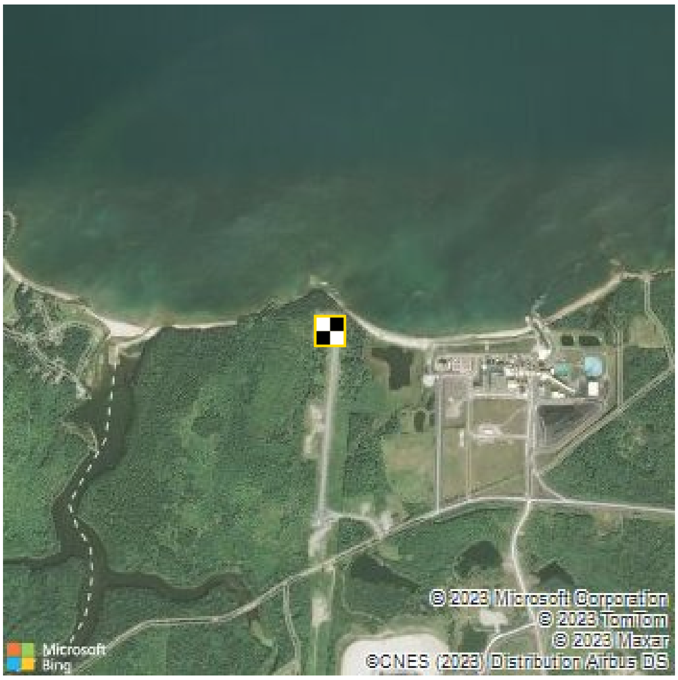
CGVD2013 height

Height	8.621 m

Quality

Data points	260
Points used	258 (99.2%)
Baseline distance	21.37 km
Data variance	2.3 mm / 1.7 mm / 11.9 mm

Point 8



Point Number	8
Global ID	ac474e5a61
AeroPoint ID	7284369

Capture start	14 Oct 2023 11:28 AM ADT
Capture end	14 Oct 2023 12:11 PM ADT
Duration	0:42
Uploaded	14 Oct 2023 12:16 PM ADT

NAD83(CSRS)

Latitude	46.32274273° (46° 19' 21.87384" N)
Longitude	-60.3367896° (60° 20' 12.44256" W)
Ellipsoid height (NAD83(CSRS))	-3.345 m

NAD83(CSRS) / UTM zone 20N

Easting	705012.949 m
Northing	5133354.676 m

CGVD2013 height

Height	8.602 m

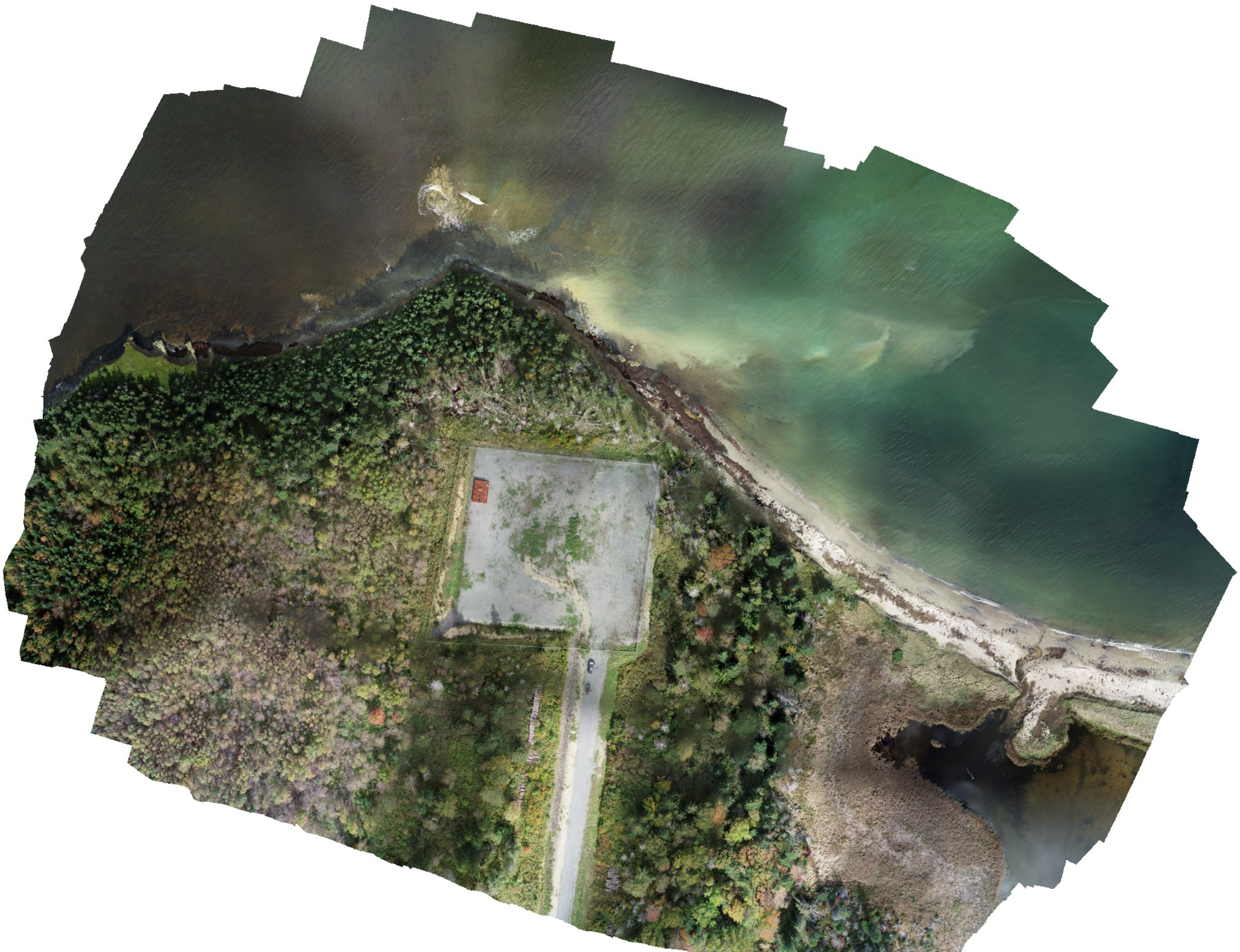
Quality

Data points	257
Points used	250 (97.3%)
Baseline distance	21.31 km
Data variance	7.5 mm / 13.3 mm / 20.3 mm

Appendix B

2023 Point Aconi Drone Survey

DJI Matrice 300 RTK L1 RGB Processing Report
22 January 2024



Survey Data

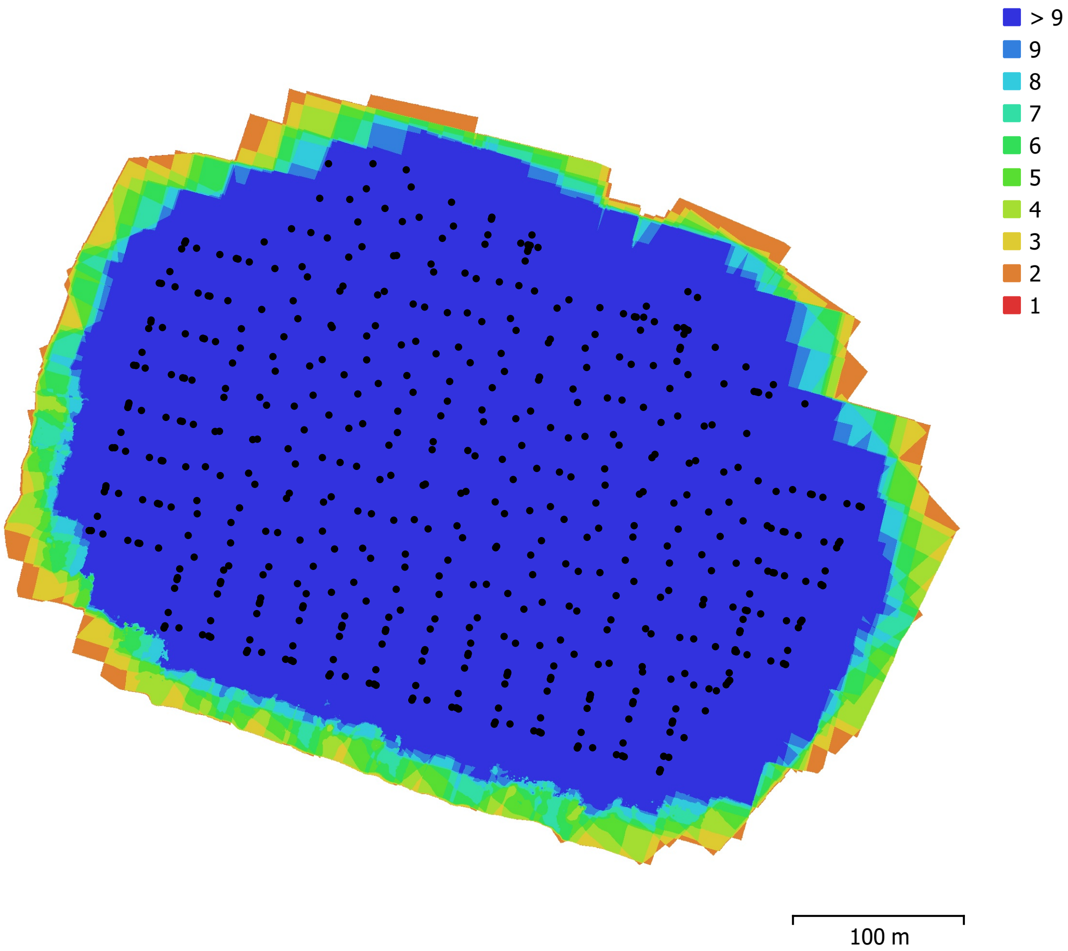


Fig. 1. Camera locations and image overlap.

Number of images:	666	Camera stations:	530
Flying altitude:	76.6 m	Tie points:	1,063,881
Ground resolution:	1.95 cm/pix	Projections:	3,606,913
Coverage area:	0.175 km²	Reprojection error:	0.964 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
EP800 (8.8mm)	5472 x 3648	8.8 mm	2.41 x 2.41 μm	Yes

Table 1. Cameras.

Camera Calibration

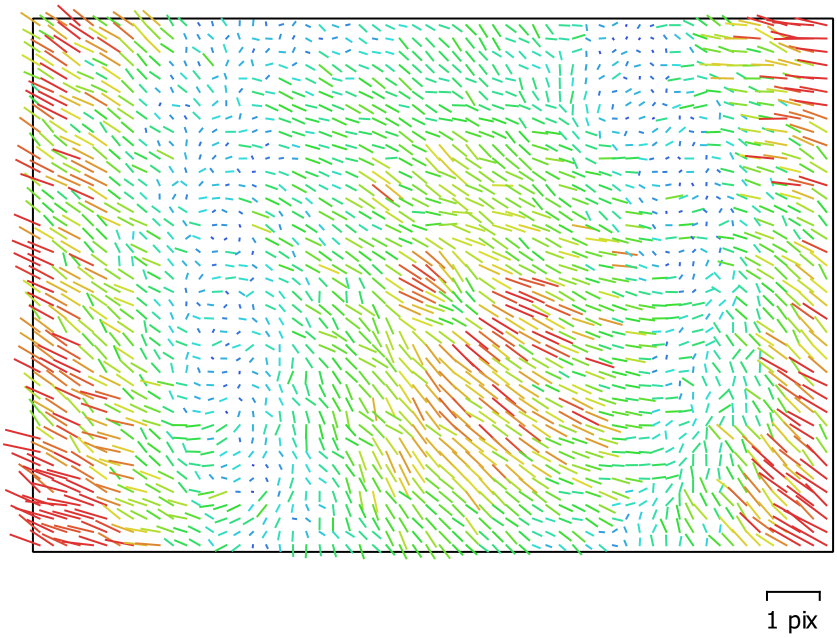


Fig. 2. Image residuals for EP800 (8.8mm).

EP800 (8.8mm)

666 images, precalibrated, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5472 x 3648**	**8.8 mm**	**2.41 x 2.41 μm**

F:	3688.87		
Cx:	-25.4144	B1:	0
Cy:	-30.9689	B2:	0
K1:	-0.0186257	P1:	-0.00190621
K2:	0.0244866	P2:	-0.00385085
K3:	-0.0168014	P3:	0
K4:	0	P4:	0

Fixed parameters: All

Camera Locations

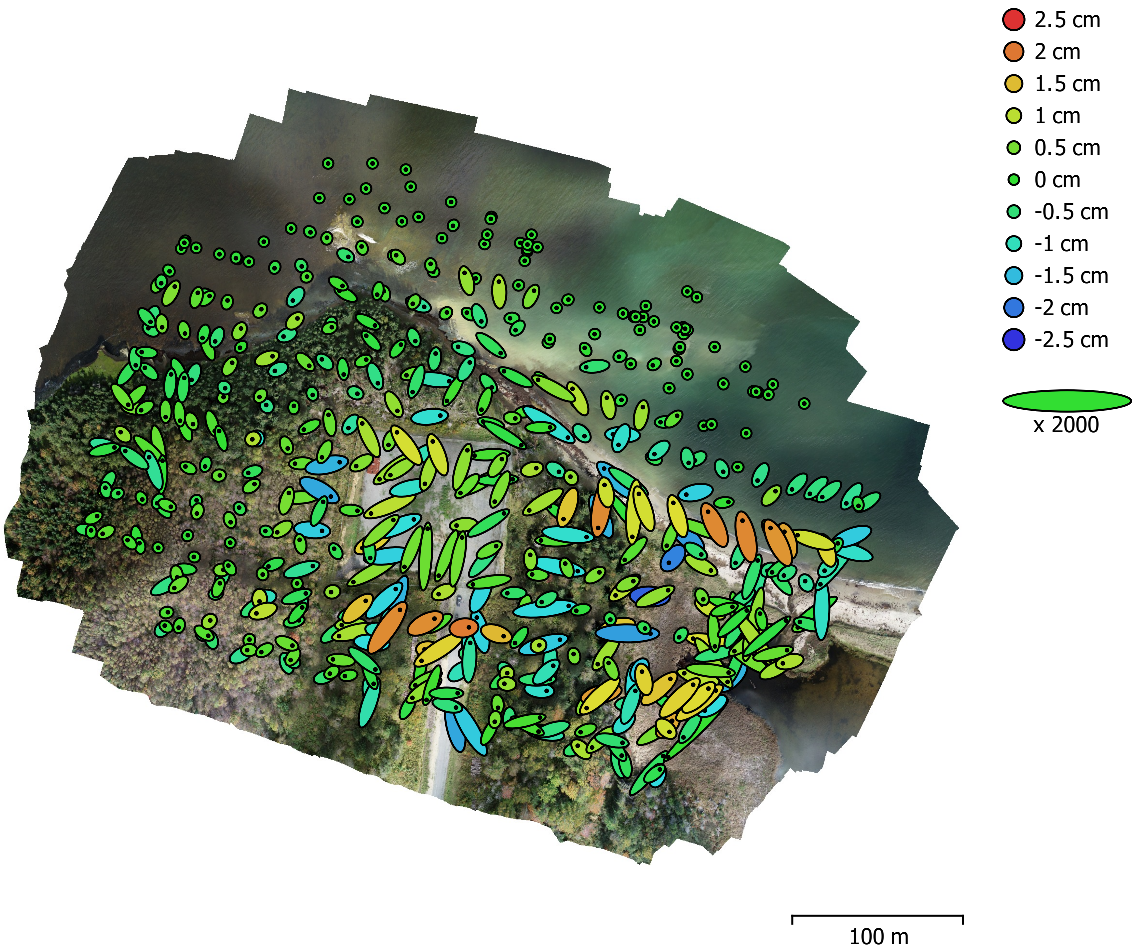


Fig. 3. Camera locations and error estimates.
Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
Estimated camera locations are marked with a black dot.

X error (mm)	Y error (mm)	Z error (mm)	XY error (mm)	Total error (mm)
4.03181	4.08602	6.68586	5.7403	8.81202

Table 2. Average camera location error.
X - Easting, Y - Northing, Z - Altitude.

Digital Elevation Model

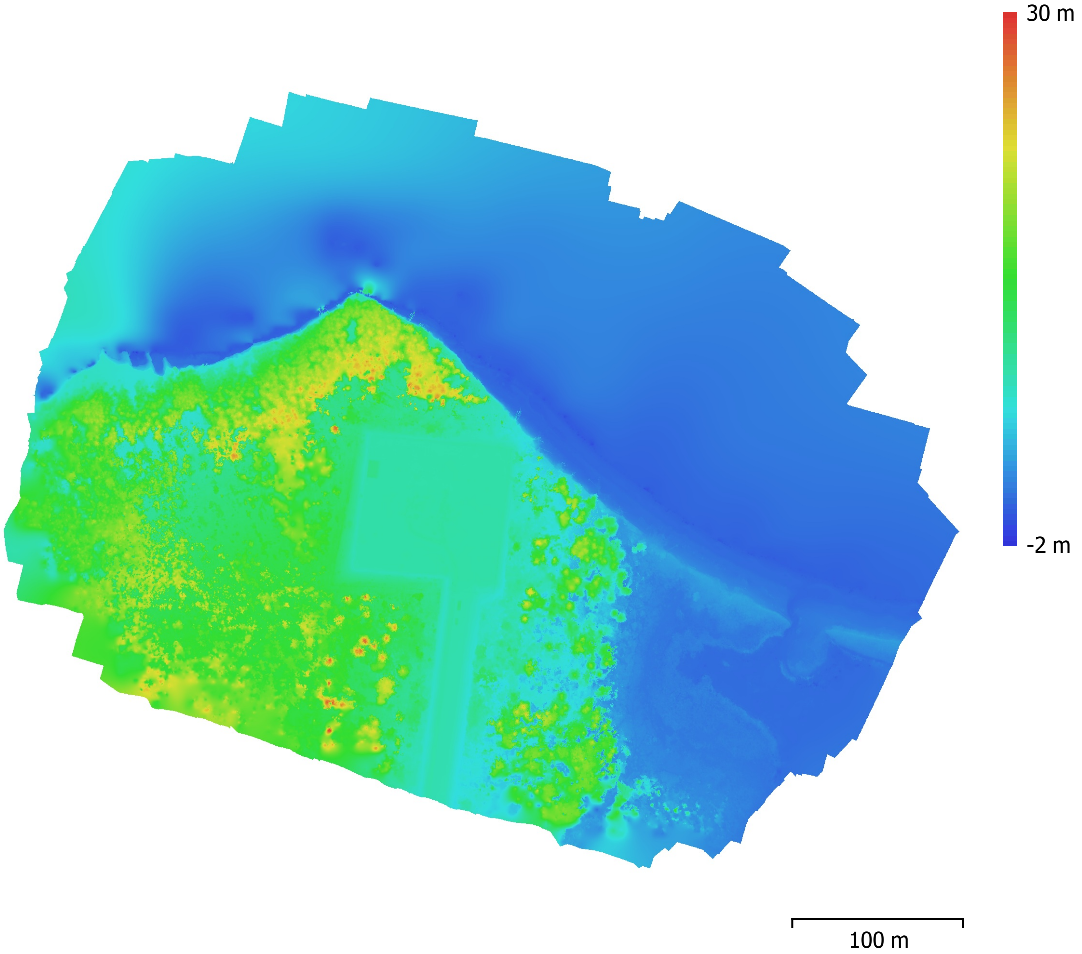


Fig. 4. Reconstructed digital elevation model.

Resolution:	1.95 cm/pix
Point density:	0.264 points/cm²

Processing Parameters

General	
Cameras	666
Aligned cameras	530
Markers	44
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Rotation angles	Yaw, Pitch, Roll
Point Cloud	
Points	1,063,881 of 1,620,508
RMS reprojection error	0.197123 (0.964357 pix)
Max reprojection error	0.801703 (51.0683 pix)
Mean key point size	4.29462 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	3.20027
Alignment parameters	
Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	80,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	5 minutes 57 seconds
Matching memory usage	1.15 GB
Alignment time	30 minutes 37 seconds
Alignment memory usage	1.84 GB
Date created	2024:01:21 23:43:43
Software version	1.8.3.14331
File size	108.20 MB
Depth Maps	
Count	482
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 17 minutes
Memory usage	17.34 GB
Date created	2024:01:22 04:43:31
Software version	1.8.3.14331
File size	7.19 GB
Dense Point Cloud	
Points	419,657,211
Point colors	3 bands, uint8
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 17 minutes

Memory usage	17.34 GB
Dense cloud generation parameters	
Processing time	3 hours 30 minutes
Memory usage	47.36 GB
Ground points classification parameters	
Max angle (°)	13
Max distance (m)	0.2
Cell size (m)	30
Classification time	59 minutes 22 seconds
Classification memory usage	16.93 GB
Date created	2024:01:22 08:13:50
Software version	1.8.3.14331
File size	5.91 GB
DEM	
Size	43,726 x 36,683
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Reconstruction parameters	
Source data	Dense cloud
Interpolation	Enabled
Processing time	6 minutes 31 seconds
Memory usage	336.37 MB
Date created	2024:01:22 22:33:07
Software version	1.8.3.14331
File size	2.18 GB
Orthomosaic	
Size	29,695 x 24,575
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Colors	3 bands, uint8
Reconstruction parameters	
Blending mode	Mosaic
Surface	DEM
Enable hole filling	Yes
Enable ghosting filter	No
Processing time	10 minutes 40 seconds
Memory usage	2.19 GB
Date created	2024:01:22 21:52:42
Software version	1.8.3.14331
File size	13.01 GB
System	
Software name	Agisoft Metashape Professional
Software version	1.8.3 build 14331
OS	Windows 64 bit
RAM	127.73 GB
CPU	12th Gen Intel(R) Core(TM) i9-12900K
GPU(s)	NVIDIA GeForce RTX 3090