Drone Data Collection 2023: Indian Head 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

How to cite this work and report:

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

Executive Summary

The Nova Scotia Community College Applied Geomatics Research Group (NSCC-AGRG) was contracted by Emera Newfoundland & Labrador to collect airborne imagery using drones at the Indian Head, NL grounding site. Survey data were successfully collected on November 6, 2023. Data were required to establish a basis for comparison to historical surveys completed by NSCC-AGRG (longest record 2018) to assess potential deformation of a protective breakwater with a required accuracy of +- 0.30 m and expected accuracy of +- 0.10 m. Quality assurance and control measures have validated that the collected data meet or exceed all project specifications with an accuracy of +- 0.05 m. Comparative analysis has determined that the crest of the breakwater has remained within +-10 cm of the 2018 surveyed position. Results showed that no significant loss had occurred in the breakwater crest elevation as of November 2023.

Table of Contents

Table of Figures

1 Introduction

The Nova Scotia Community College – Applied geomatics Research Group (NSCC-AGRG) was contracted to conduct drone survey activities over Emera Newfoundland & Labrador sites including the Indian Head grounding site in Newfoundland and Labrador, Canada. NSCC-AGRG established a baseline survey in November of 2019 and compared results to a previous survey flown by Emera Newfoundland & Labrador in 2018. Results of the comparison indicated that no significant movement had occurred along the breakwater between 2018 and 2019. Monitoring efforts continued in 2021 when NSCC-AGRG completed a repeat survey of the breakwater on July 14, 2021, and established that no significant change had occurred between 2018 and 2021. The present monitoring survey, 2023, was flown on November 6th, 2023, and survey data were found to exceeded performance expectations set for the project and were determined to be suitable for quantifying the movement of the breakwater material.

2 Data Collection and Processing

Drone survey data were successfully collected on November 6th, 2023. While on site, NSCC-AGRG established GNSS checkpoints using Propeller Aeropoint smart targets designed to provide optimal quality assurance metrics for aerial drone surveys. Checkpoint locations were calculated to have an average vertical variance of 0.00395 m with a maximum vertical variance of 0.0097 m (Appendix A). These points coincided with target centers used to check photo positions during the data quality assessment phase. Attempts were made to locate a survey pin that was established by an unknown party prior to the 2018 survey. The pin was determined to be buried or otherwise removed between 2021 and 2023 (Figure 1, Figure 2, Figure 3). NSCC-AGRG will attempt to establish a new control pin at the time of the next survey and make additional efforts to locate the missing pin.

Figure 1. Indian Head site survey pin observed and positioned in aerial imagery in 2018.

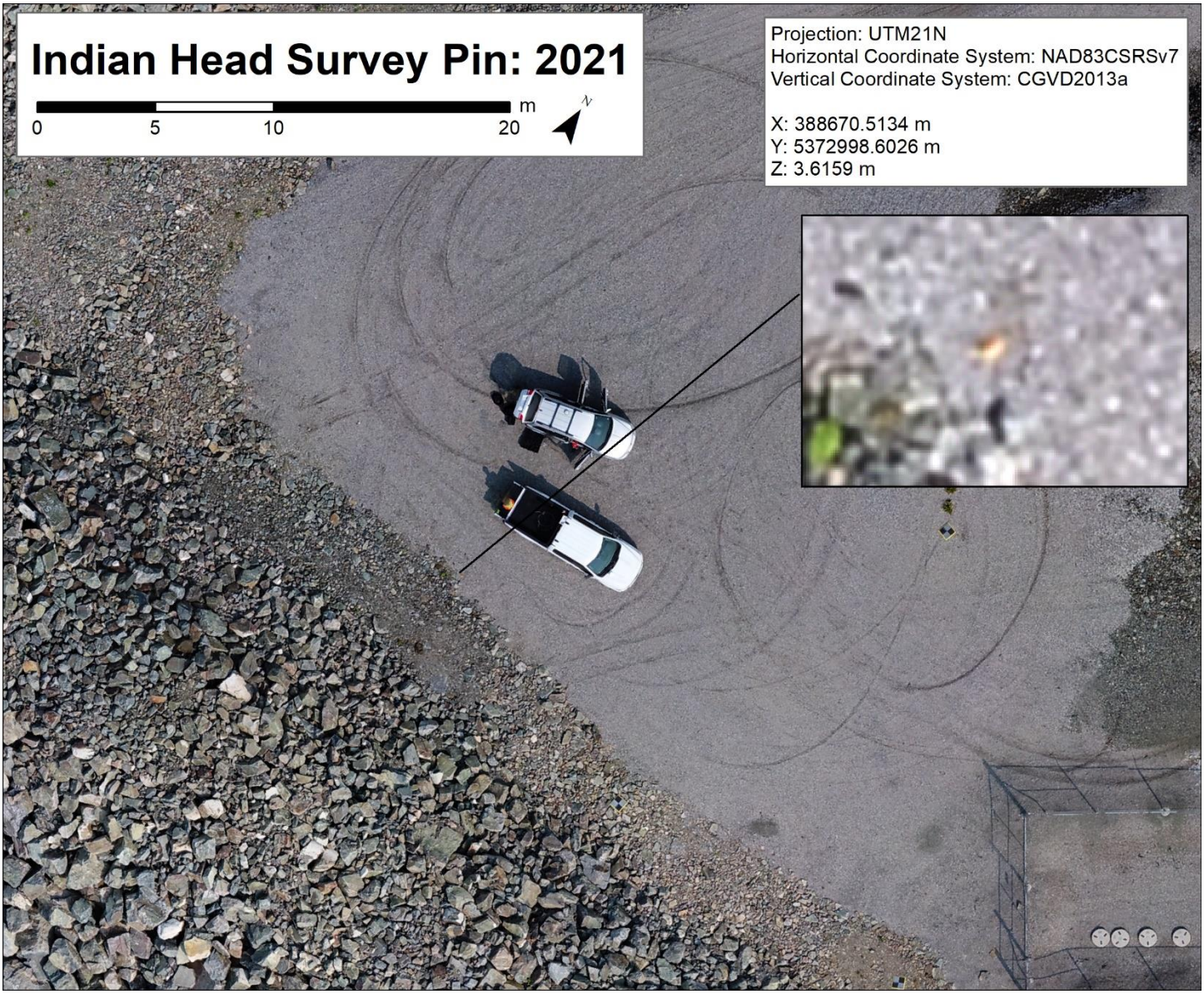


Figure 2. Indian Head site survey pin observed and positioned in aerial imagery in 2021.

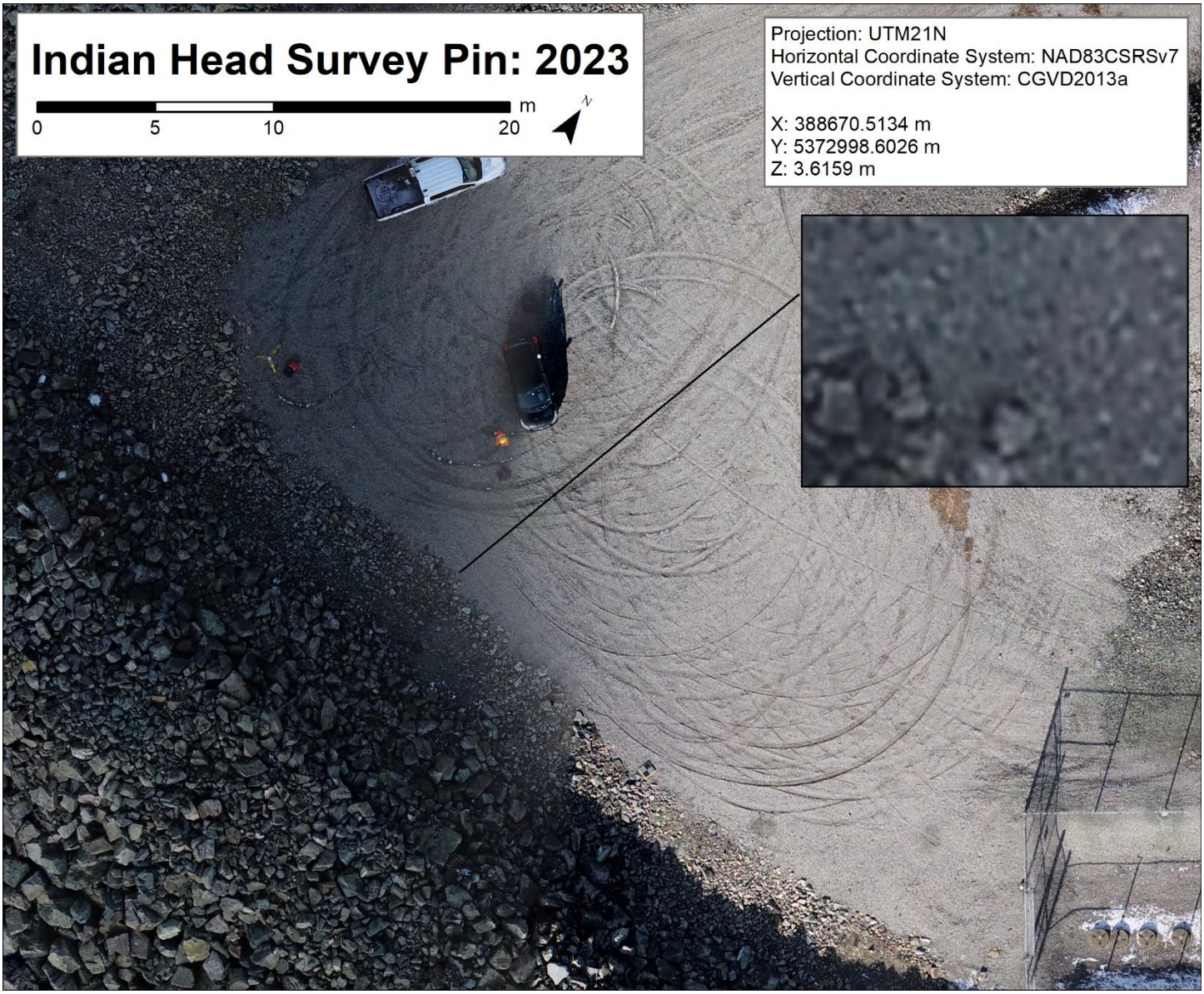


Figure 3. The Indian Head site survey pin was determined to be buried or removed at the time of the 2023 data collection.

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 < 0.02 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; ~1.068 billion points), a digital elevation model, and an ortho mosaic (Appendix B). Raster data were processed at a native cell resolution of 0.0126 m and sampled down to 0.02 m for ease of delivery. Image mosaics were found to be of acceptable quality with intermittent light levels fluctuations experienced during the collection period (Figure 4). Light level differences between flight lines did not impact survey results. Rasterized elevation data were validated using the GNSS control points. Elevation residuals were computed by subtracting the RPAS model elevations from the GNSS target elevations. Residuals ranged from -0.016 m to 0.002 m with a mean of -0.007 m and standard deviation of 0.005 m (Figure 5). Quality assurance and control measures validated that the collected data exceeded all project specifications.

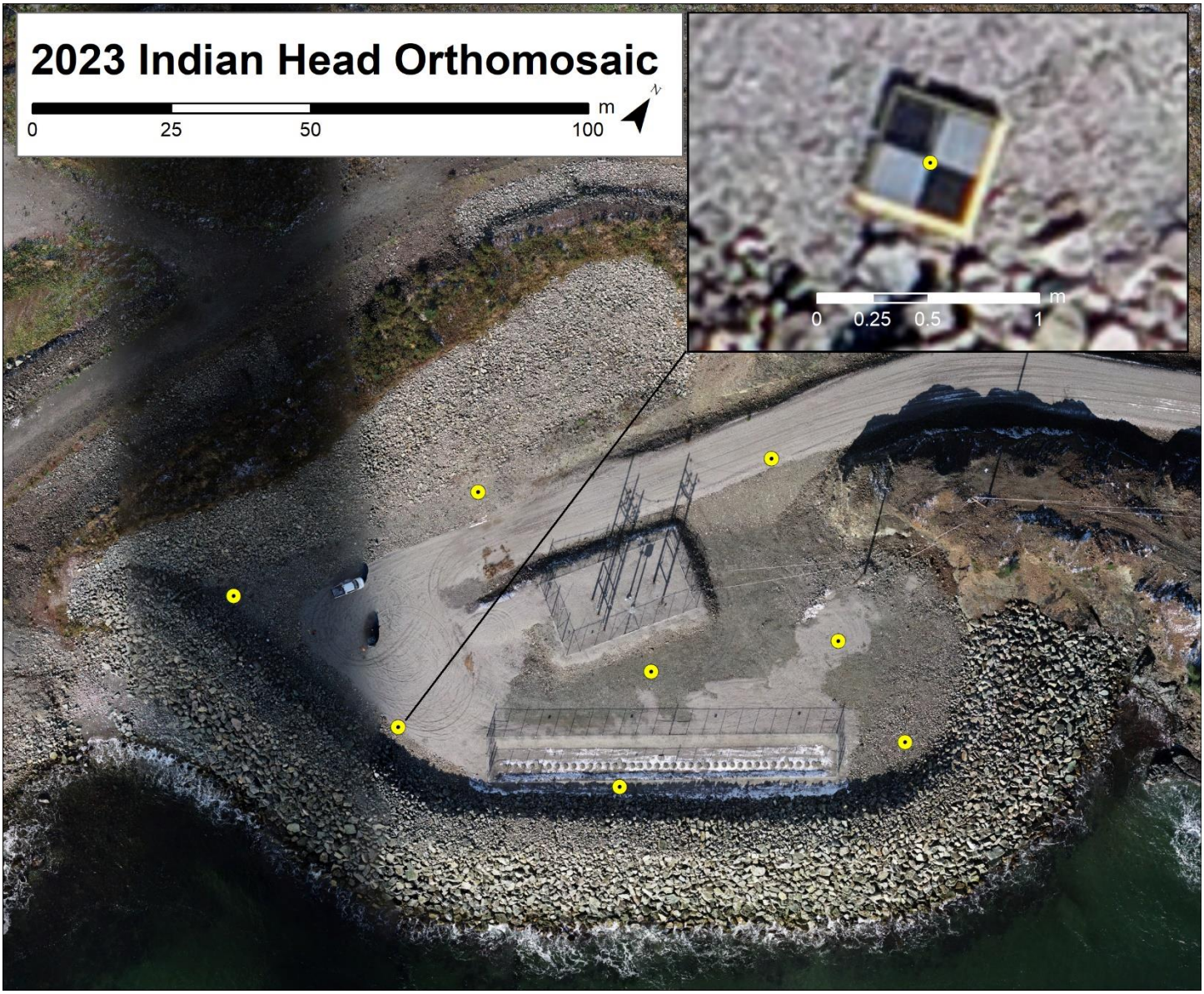


Figure 4. Indian Head grounding site photo mosaic showing good horizontal alignment with checkpoint targets.

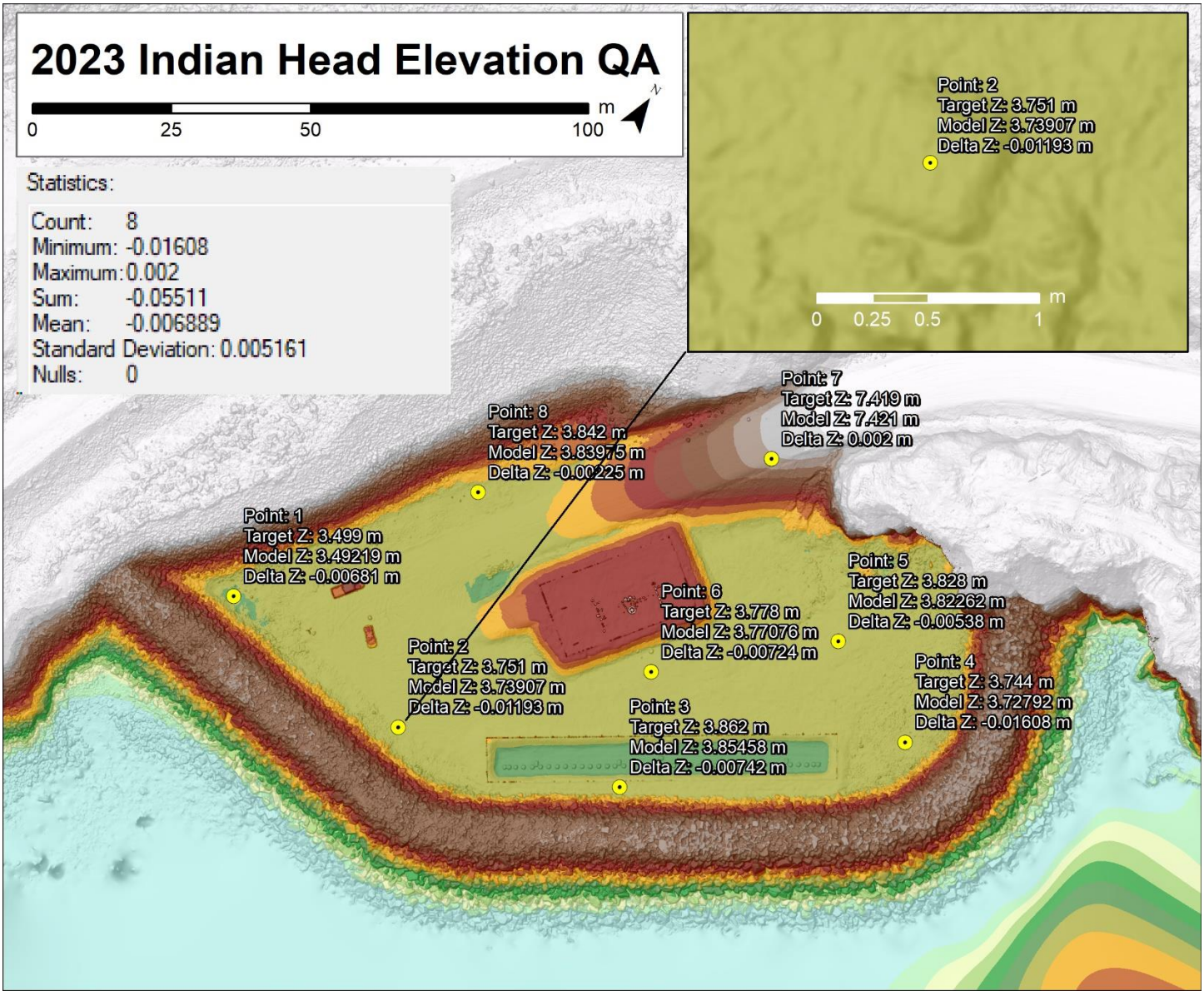


Figure 5. RPAS elevation model and validation point comparison showing excellent agreement between drone survey elevations and checkpoint target positions.

3 Data Delivery and Storage

NSCC-AGRG has agreed to persist a copy of Emera Newfoundland & Labrador's survey data on their secured central server. This persistence will ensure that additional copies can be provided in varying formats and datums 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_vcsCGVD2013).

4 Breakwater Positioning

Breakwater movement was assessed by comparing surveys flown in 2018, 2019, 2021, and 2023. Elevation maps generated for each of the years shows that the breakwater has been stable since 2018. Qualitative assessments were done by examining colour graduated elevation models for the three survey dates. The crest of the breakwater exhibited a consistent elevation between 6.5 and 7.5 m with few gaps below 6.5 m along the length of the crest (Figure 6, Figure 7, Figure 8, Figure 9). No discernable breakwater deformation can be observed between survey elevation models.

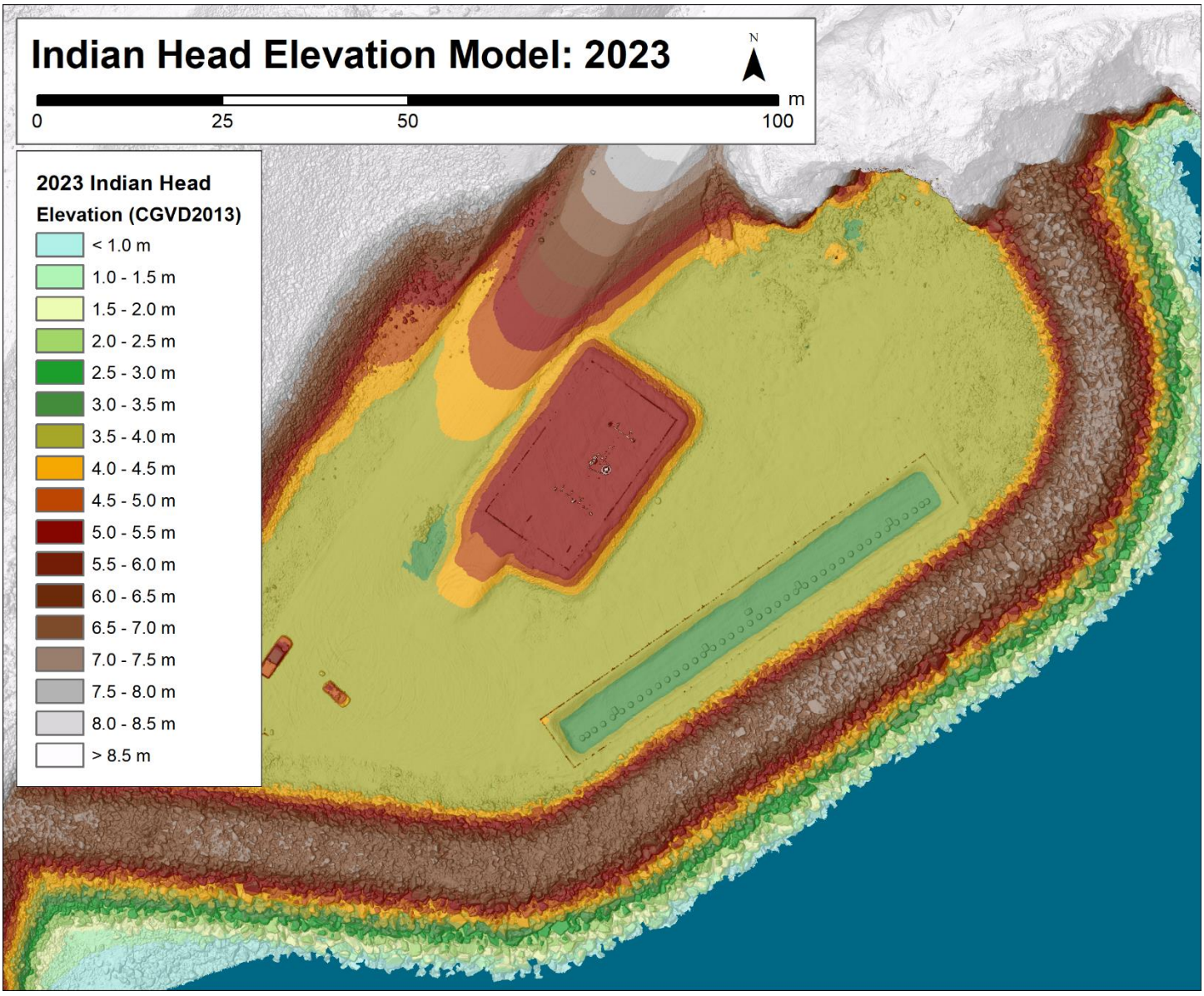


Figure 6. Colour shaded relief of the of the 2023 elevation model.

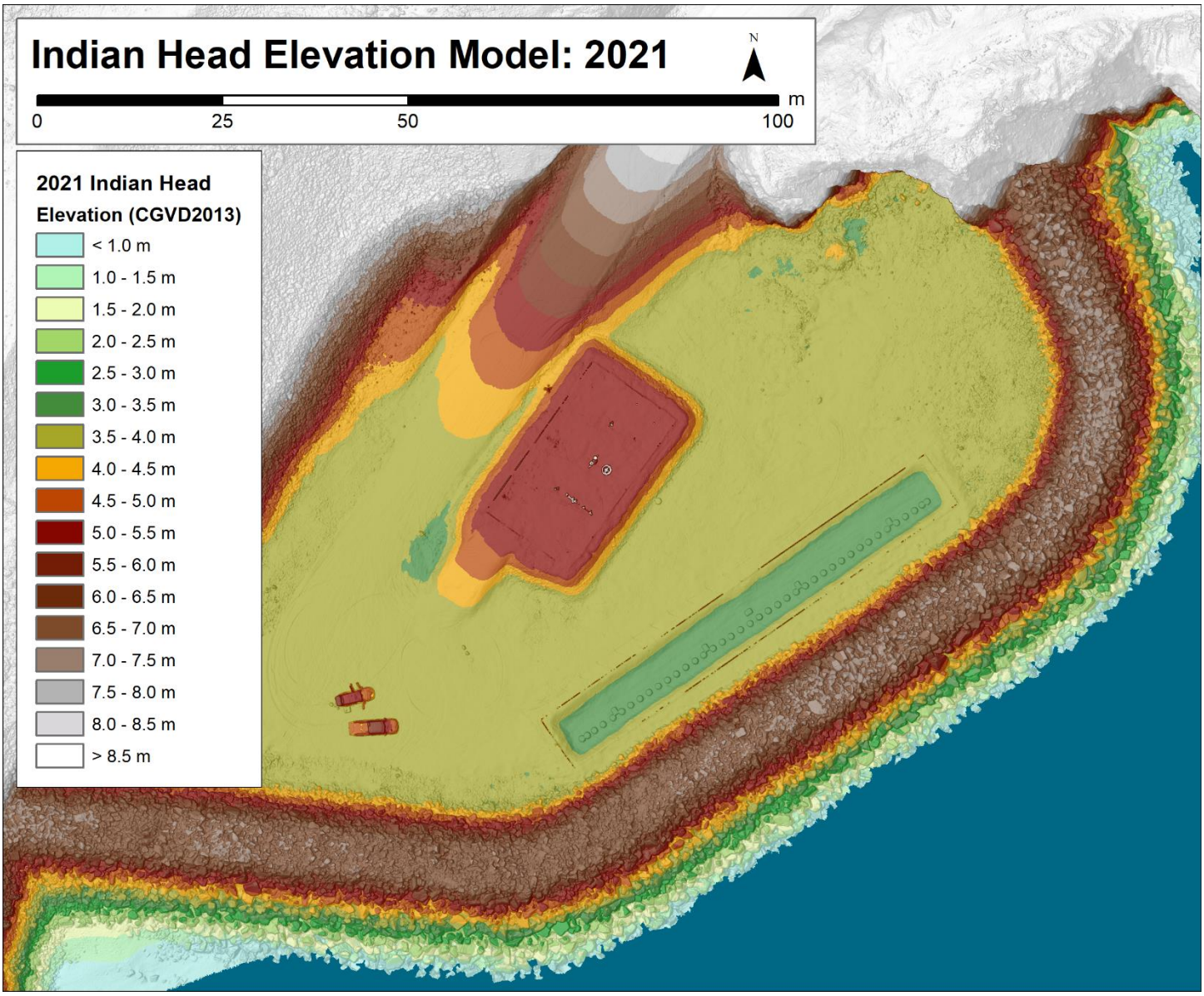


Figure 7. Colour shaded relief of the of the 2021 elevation model.

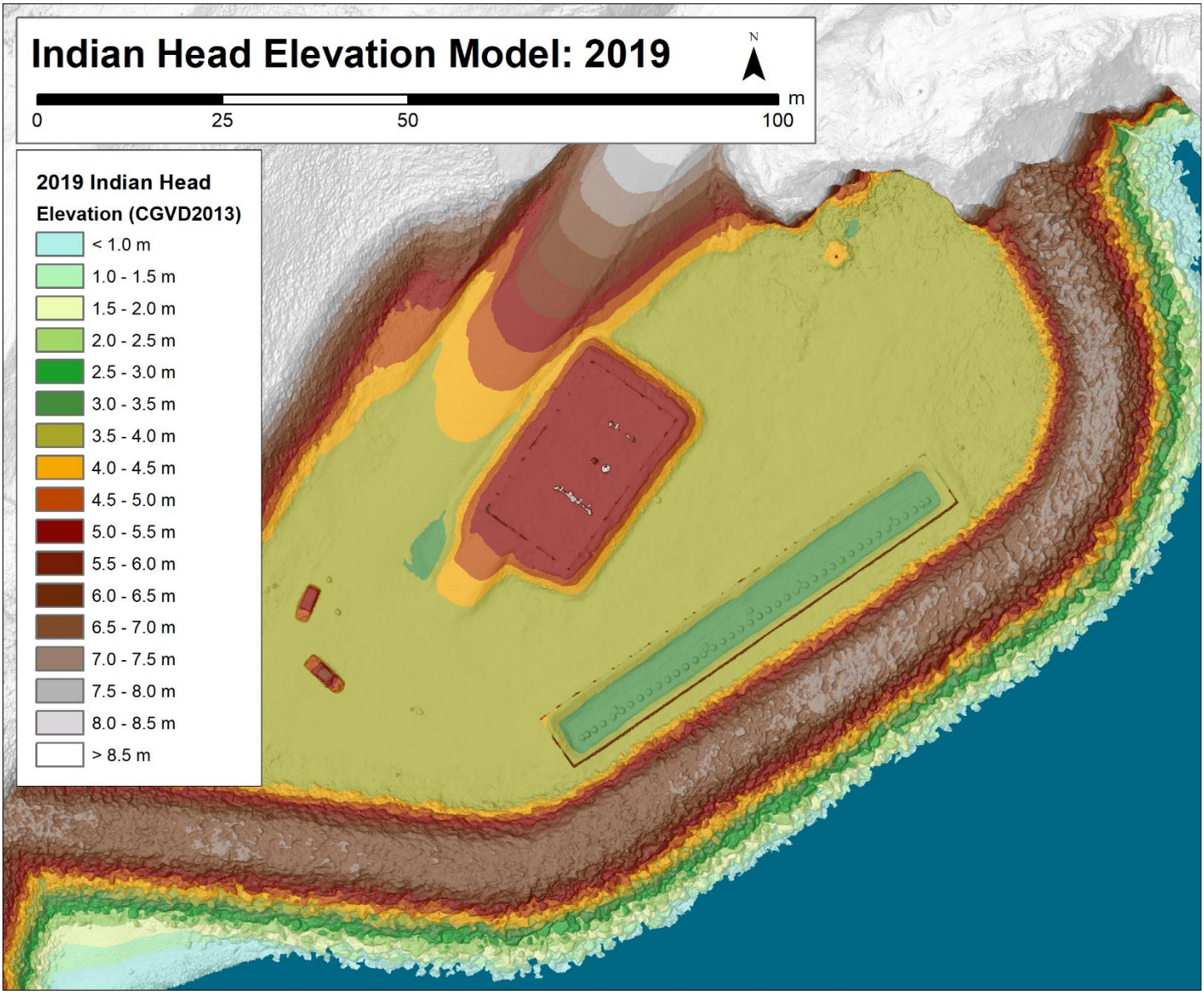


Figure 8. Colour shaded relief of the of the 2019 elevation model.

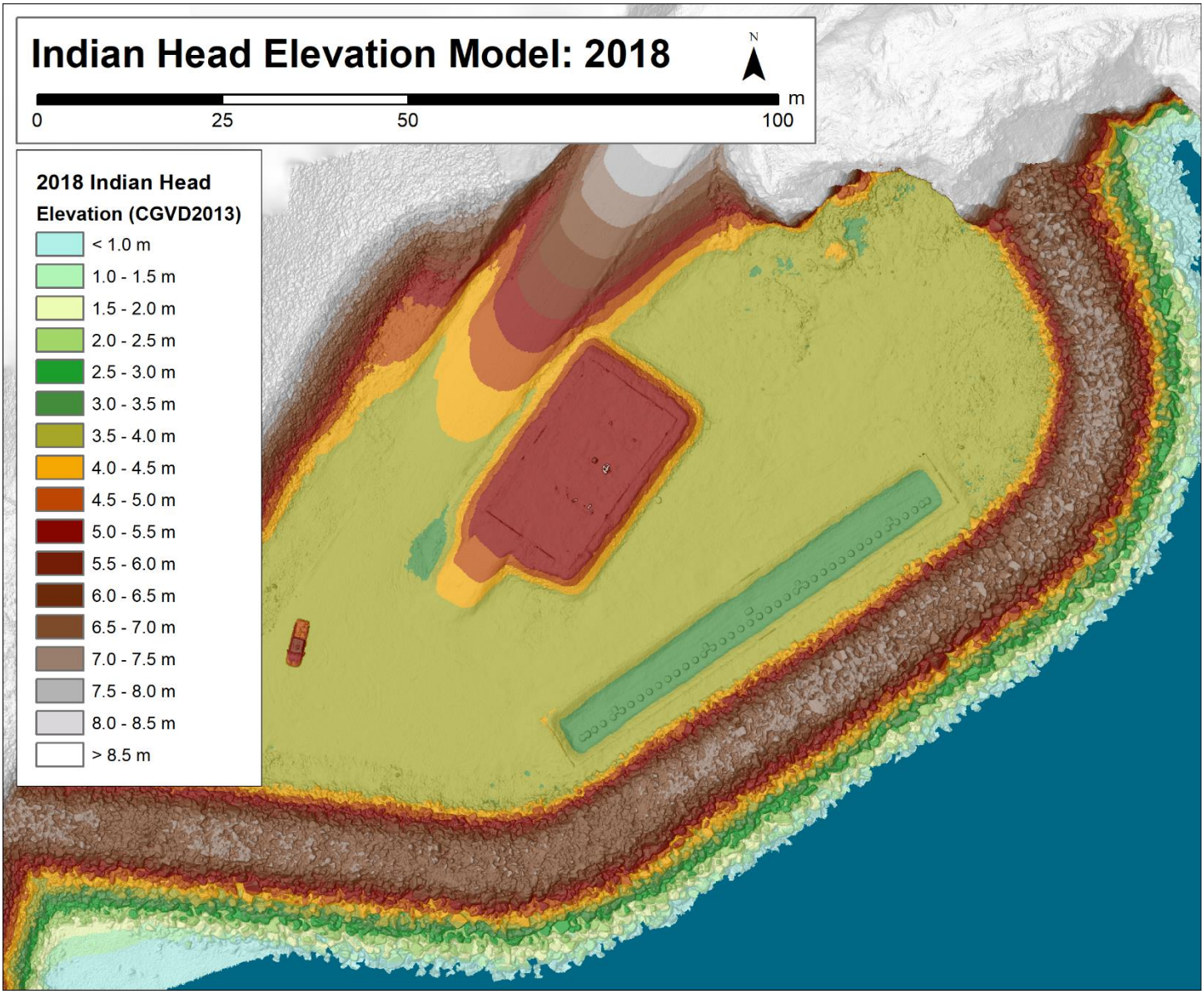


Figure 9. Colour shaded relief of the of the 2018 elevation model.

Quantitative comparisons between breakwater positions were generated by differencing the photogrammetric elevation models to produce elevation difference grids (Delta Z) of the Indian Head site where negative values represented a loss of material between survey dates (Figure 10). Between 2018 and 2023 elevation gains of roughly 0.5 m were noted to be consistent along the outer perimeter of the breakwater. This observation agrees with comparisons generated in the 2021 survey between 2018 and the 2021 survey (Figure 11). The most likely cause of this discrepancy is positioning error that was uncorrected outside of the survey control points which were distributed within the breakwater boundary. In 2018, drone positions were not real-time corrected or post-processed due to limitations in the hardware. Survey data were precisely positioned using the control points. RPAS advances in 2021 and 2023 allowed NSCC-AGRG to develop updated workflows which used both control point and RPAS positions to correct survey data in 2021 and only RPAS positioning to precisely position survey data in 2023. In 2023, the deployed targets were referred to as “checkpoints” rather than “control points” to reinforce this update to usage. In 2023, targets were no longer being used to correct survey data and were simply being used to generate accuracy metrics. The newly developed workflows enabled accurate positioning outside of the checkpoint distribution area as the targets were not influential in survey positioning and were used only to establish the accuracy of the collected drone data. The result of this workflow can be observed when comparing the 2023 and 2021 data (Figure 12) where large magnitude elevation differences outside the target distribution area were not observed.

In all cases, the crest of the breakwater was surveyed to be stationary and remained within +-10 cm of the 2018 surveyed position and survey results showed that no significant loss had occurred in the breakwater crest elevation as of November 2023 (Figure 12).

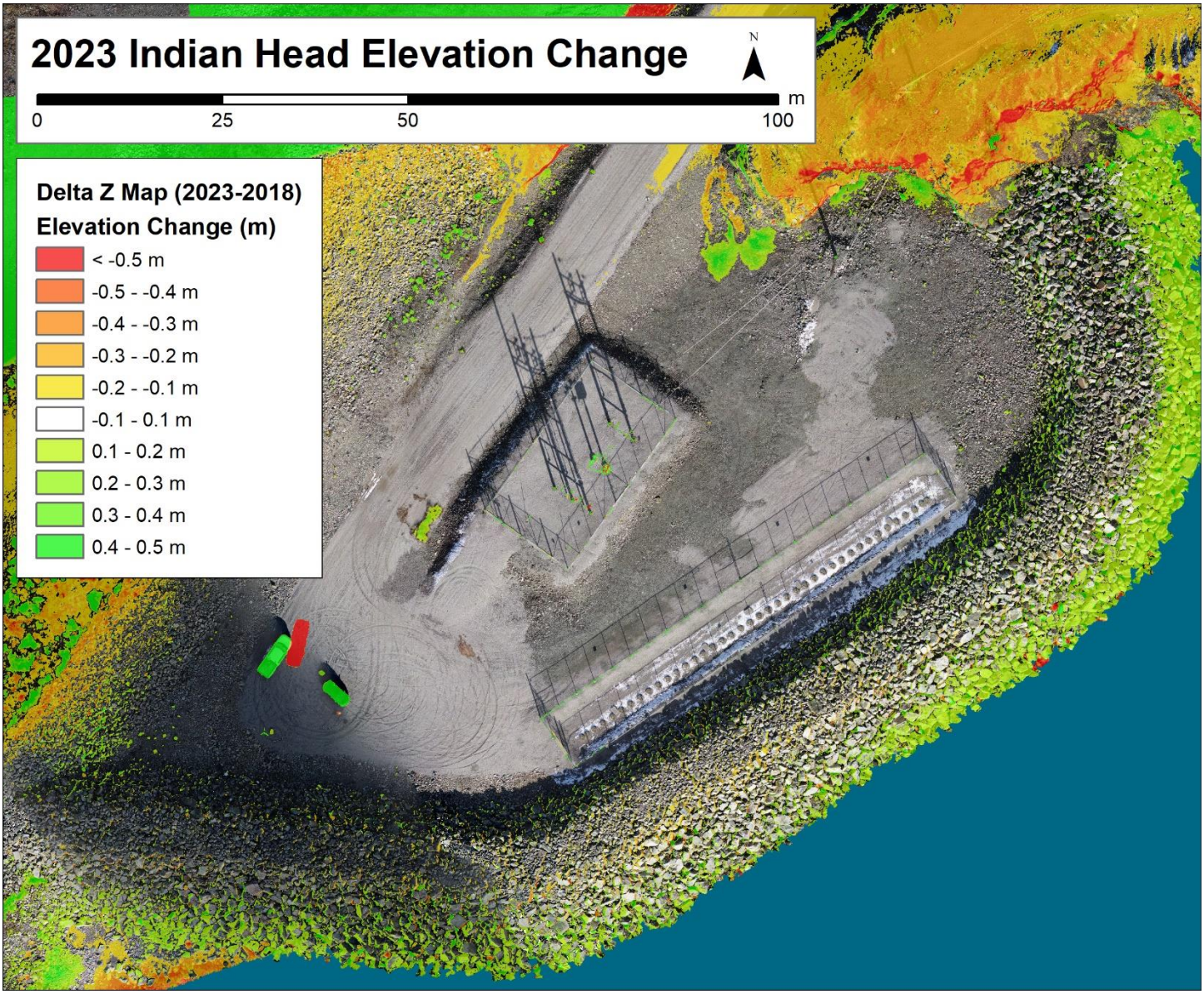


Figure 10. 2023 elevation difference map showing an increase in material elevation (green) for the oceanward portion of the breakwater. Material appears to have been lost in the softer cliff areas north of the breakwater (orange). Elevations that were within 10 cm of their 2018 measures remain transparent and represent the landward area of the grounding site along with the crest of the breakwater.

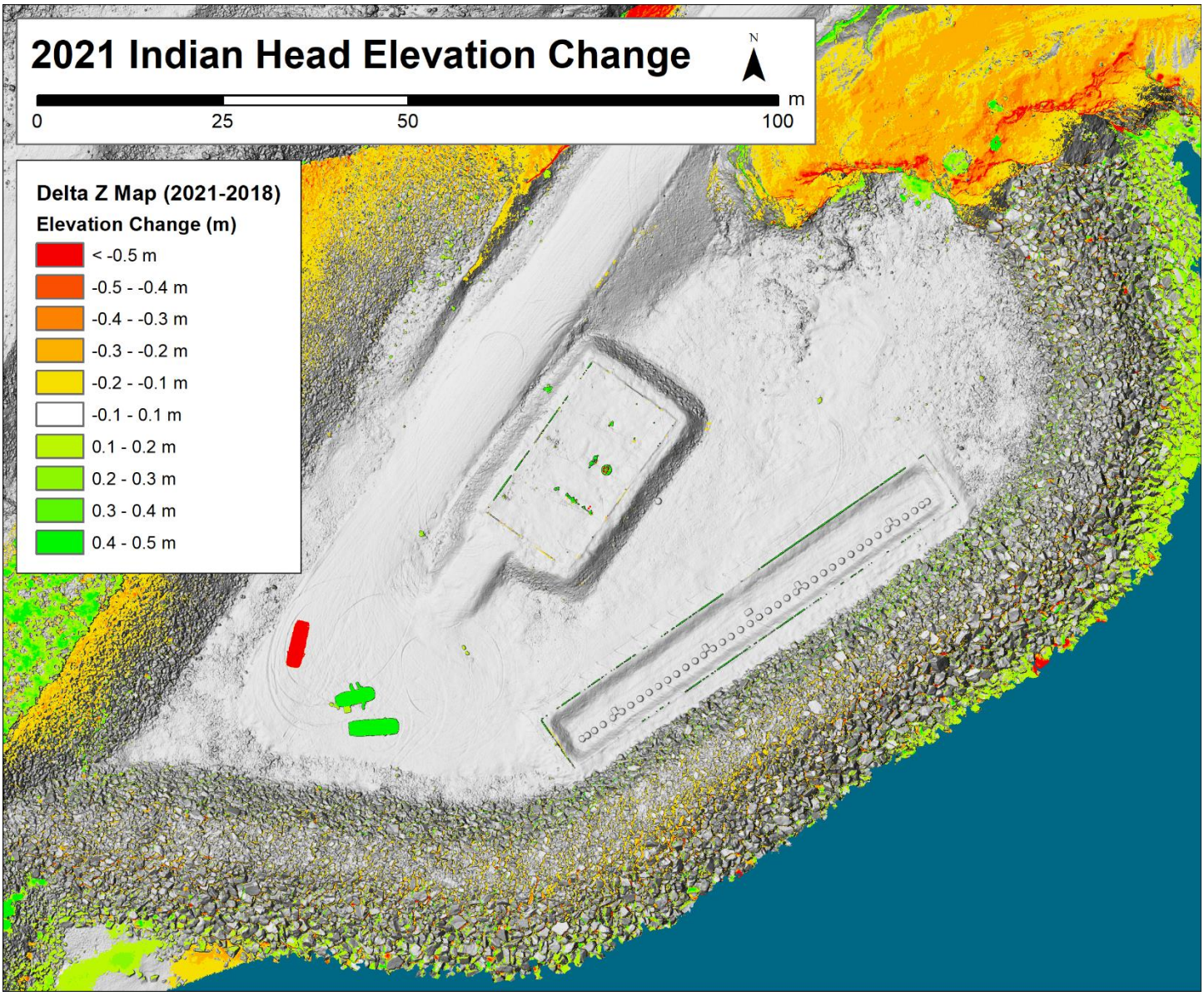


Figure 11. 2021 elevation difference map showing an increase in material elevation (green) for the oceanward portion of the breakwater. Material appears to have been lost in the softer cliff areas north of the breakwater (orange). Elevations that were within 10 cm of their 2018 measures remain transparent and represent the landward area of the grounding site along with the crest of the breakwater.

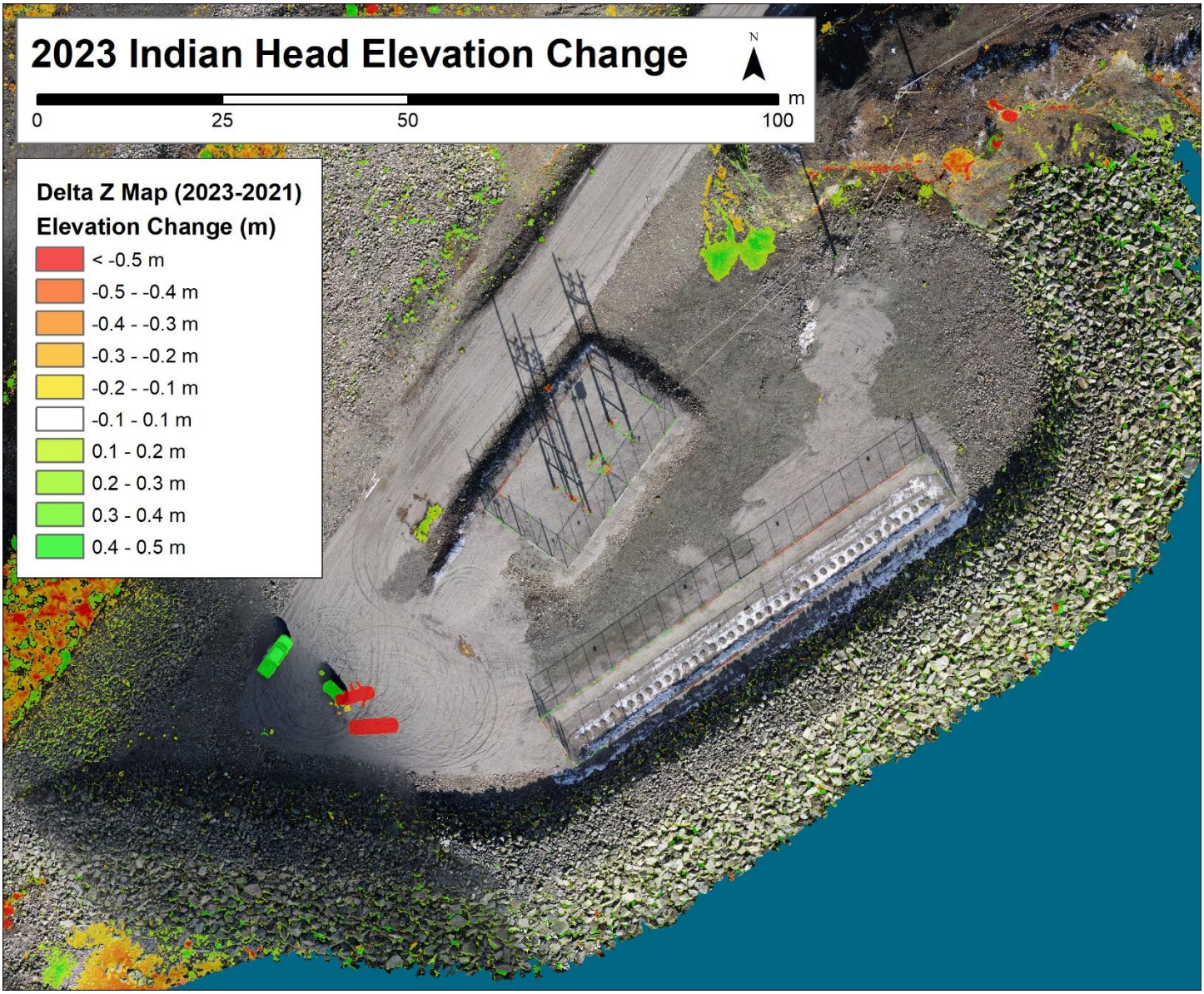


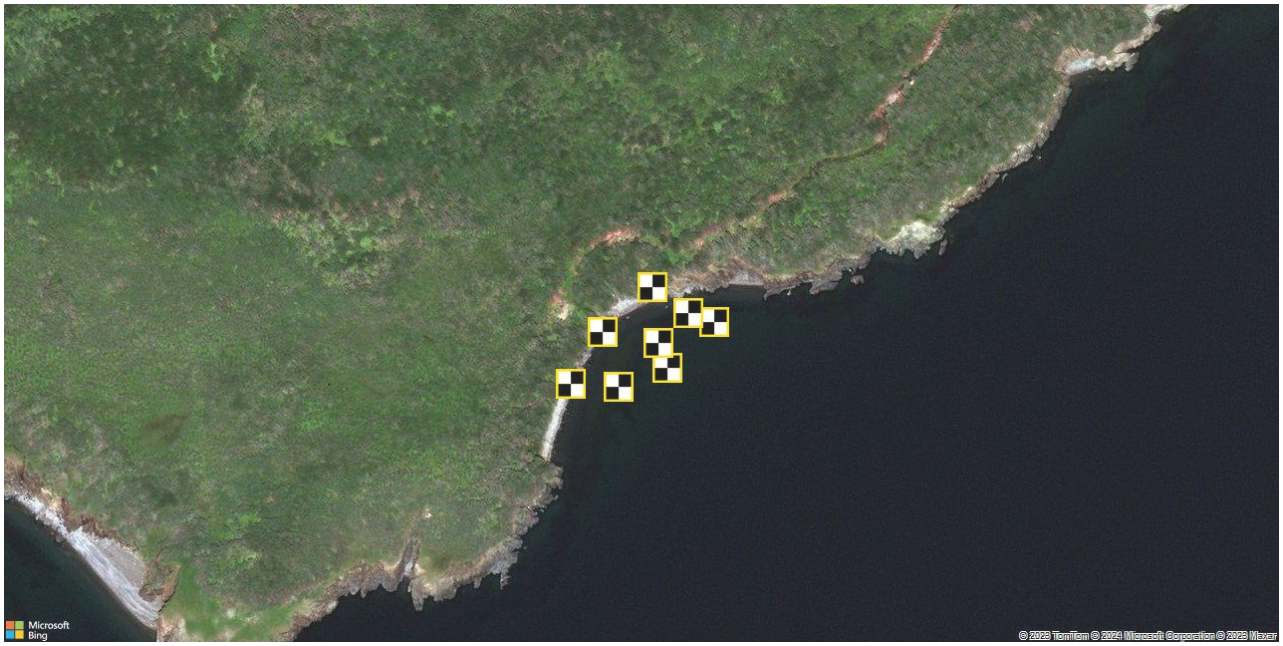
Figure 12. 2023 elevation difference map showing an increase in material (green) localized mainly around the ditch outflow, south of the entrance road. Material appears to have been lost in the softer cliff areas, north of the breakwater (orange). Elevations that were within 10 cm of their 2021 position remain transparent. Measured differences in elevation were minimal outside the breakwater area due to RPAS positioning improvements.

Appendix A

propeller aeropoints

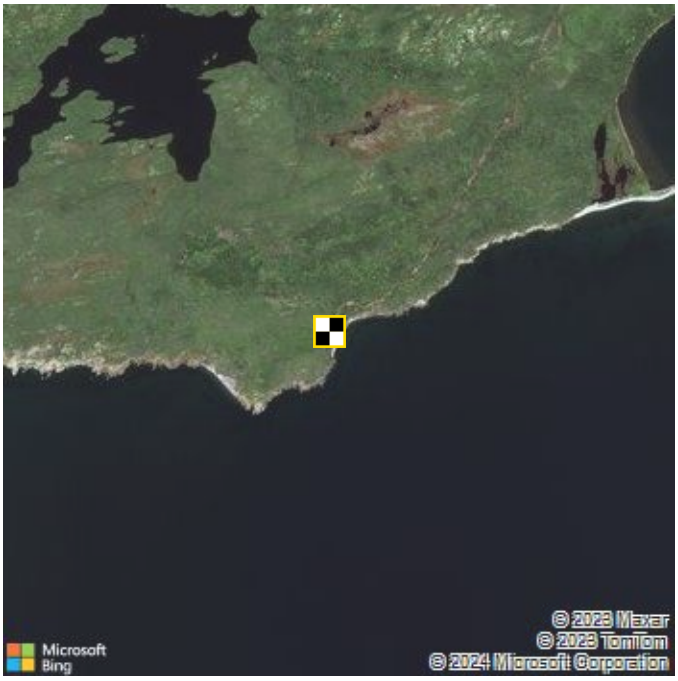
Ground Control Report

Stephenville Crossing, NL copy



Survey ID	asa65205cc
Aeropoint Set	
Date captured	06 Nov 2023 10:10 AM NST
Points captured	8
Processing method	User supplied base station correction
Document generated	22 Jan 2024 11:10 AM NST

Point 1



Point Number	1	**Capture start**	06 Nov 2023 10:10 AM NST
Global ID	acac5f8567	**Capture end**	06 Nov 2023 11:29 AM NST
AeroPoint ID	07286423	**Duration**	1:18
		Uploaded	06 Nov 2023 11:44 AM NST

NAD83(CSRS)

Latitude	48.50023677° (48° 30' 0.85238" N)
Longitude	-58.50745112° (58° 30' 26.82404" W)
Ellipsoid height (NAD83(CSRS))	-1.494 m

NAD83(CSRS) / UTM zone 21N

Easting	388643.865 m
Northing	5372999.156 m

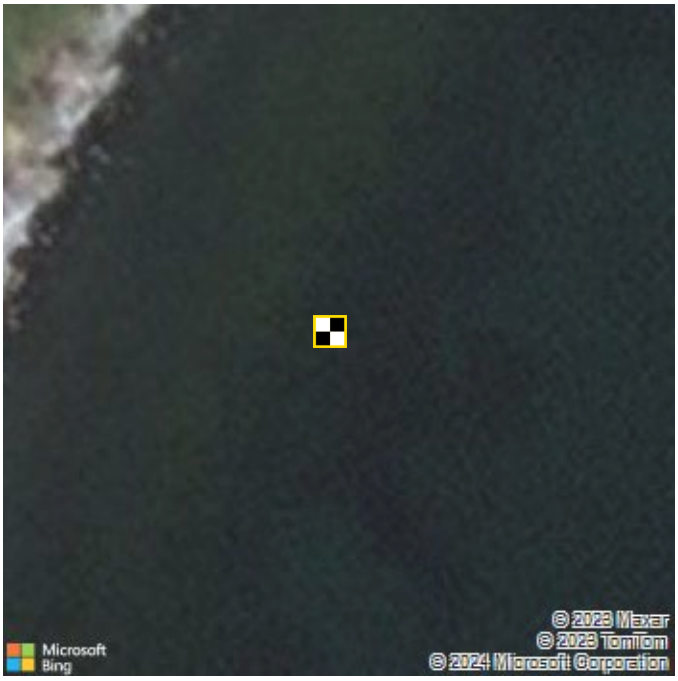
CGVD2013 height

Height	3.499 m

Quality

Data points	470
Points used	452 (96.2%)
Baseline distance	0.10 km
Data variance	1.4 mm / 0.7 mm / 2.8 mm

Point 2



Point Number	2	**Capture start**	06 Nov 2023 10:10 AM NST
Global ID	ac9e317e46	**Capture end**	06 Nov 2023 11:30 AM NST
AeroPoint ID	07284587	**Duration**	1:19
		Uploaded	06 Nov 2023 11:45 AM NST

NAD83(CSRS)

Latitude	48.50021644° (48° 30' 0.77919" N)
Longitude	-58.50693958° (58° 30' 24.98248" W)
Ellipsoid height (NAD83(CSRS))	-1.239 m

NAD83(CSRS) / UTM zone 21N

Easting	388681.608 m
Northing	5372996.152 m

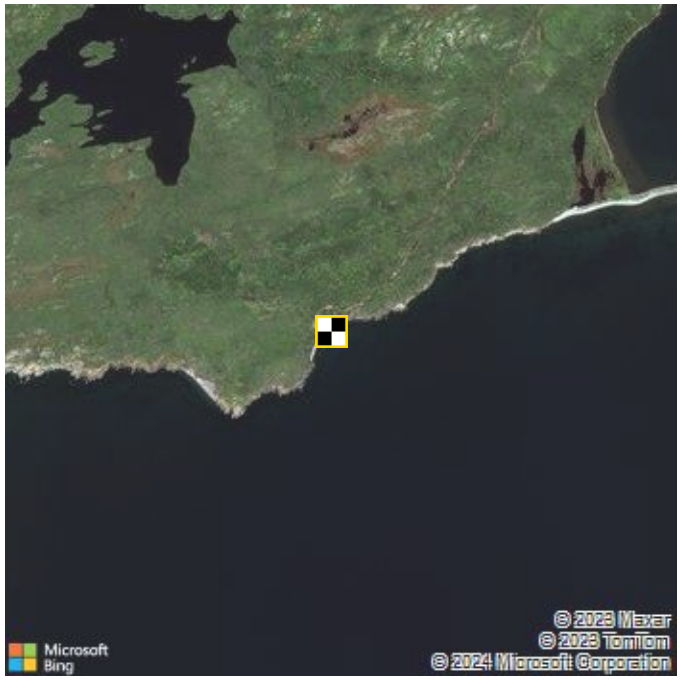
CGVD2013 height

Height	3.751 m

Quality

Data points	476
Points used	458 (96.2%)
Baseline distance	0.08 km
Data variance	0.7 mm / 1.9 mm / 2.4 mm

Point 3



Point Number	3	**Capture start**	06 Nov 2023 10:11 AM NST
Global ID	ac91d5ee51	**Capture end**	06 Nov 2023 11:31 AM NST
AeroPoint ID	07284730	**Duration**	1:19
		Uploaded	06 Nov 2023 11:45 AM NST

NAD83(CSRS)

Latitude	48.50034341° (48° 30' 1.23628" N)
Longitude	-58.50641385° (58° 30' 23.08985" W)
Ellipsoid height (NAD83(CSRS))	-1.125 m

NAD83(CSRS) / UTM zone 21N

Easting	388720.721 m
Northing	5373009.5 m

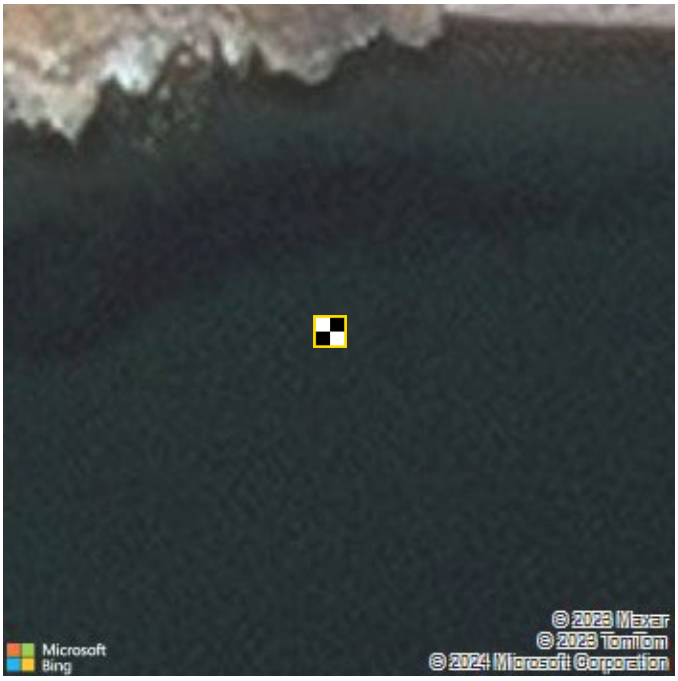
CGVD2013 height

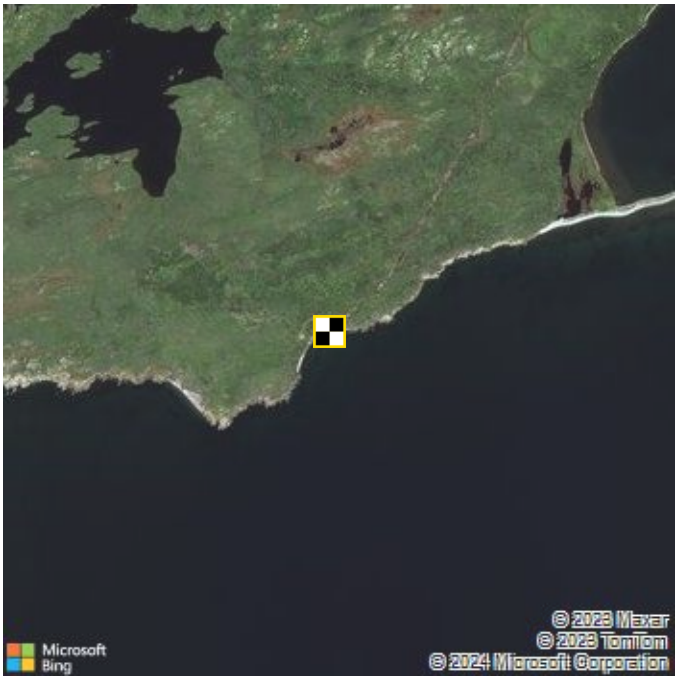
Height	3.862 m

Quality

Data points	477
Points used	463 (97.1%)
Baseline distance	0.07 km
Data variance	4.5 mm / 4.6 mm / 9.7 mm

Point 4





Point Number	4	**Capture start**	06 Nov 2023 10:12 AM NST
Global ID	acf0b0f9a3	**Capture end**	06 Nov 2023 11:32 AM NST
AeroPoint ID	07287283	**Duration**	1:20
		Uploaded	06 Nov 2023 11:45 AM NST

NAD83(CSRS)

Latitude	48.50066899° (48° 30' 2.40838" N)
Longitude	-58.50590779° (58° 30' 21.26803" W)
Ellipsoid height (NAD83(CSRS))	-1.239 m

NAD83(CSRS) / UTM zone 21N

Easting	388758.815 m
Northing	5373044.952 m

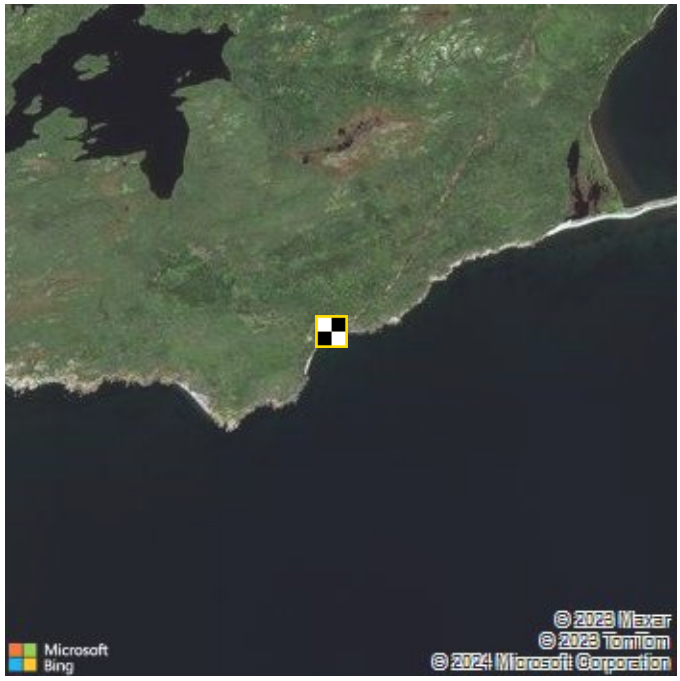
CGVD2013 height

Height	3.744 m

Quality

Data points	480
Points used	469 (97.7%)
Baseline distance	0.06 km
Data variance	1.2 mm / 2.0 mm / 6.0 mm

Point 5



Point Number	5	**Capture start**	06 Nov 2023 10:12 AM NST
Global ID	ac2f8e7c49	**Capture end**	06 Nov 2023 11:32 AM NST
AeroPoint ID	07283903	**Duration**	1:20
		Uploaded	06 Nov 2023 11:48 AM NST

NAD83(CSRS)

Latitude	48.50074025° (48° 30' 2.66491" N)
Longitude	-58.50618248° (58° 30' 22.25693" W)
Ellipsoid height (NAD83(CSRS))	-1.157 m

NAD83(CSRS) / UTM zone 21N

Easting	388738.68 m
Northing	5373053.272 m

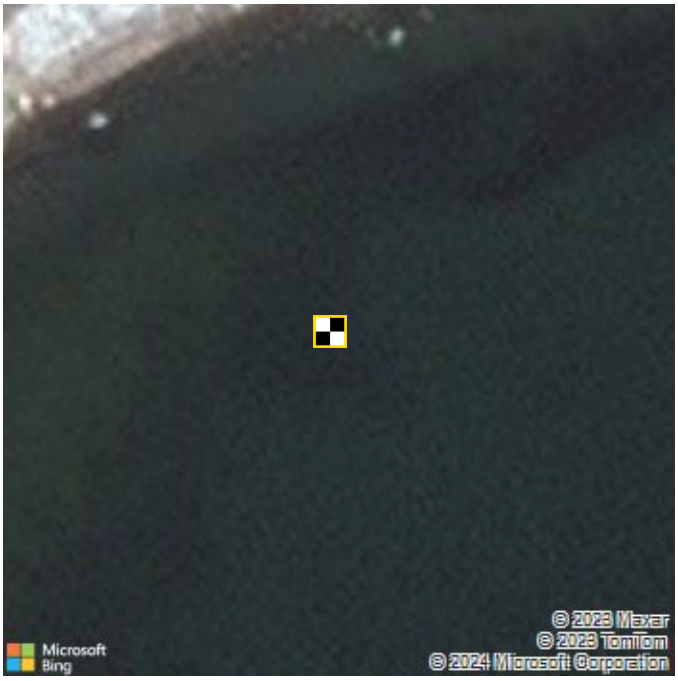
CGVD2013 height

Height	3.828 m

Quality

Data points	480
Points used	474 (98.8%)
Baseline distance	0.04 km
Data variance	1.4 mm / 1.1 mm / 0.8 mm

Point 6



Point Number	6	**Capture start**	06 Nov 2023 10:14 AM NST
Global ID	ac6d5a47c0	**Capture end**	06 Nov 2023 11:37 AM NST
AeroPoint ID	07287239	**Duration**	1:23
		Uploaded	06 Nov 2023 11:59 AM NST

NAD83(CSRS)

Latitude	48.50052524° (48° 30' 1.89086" N)
Longitude	-58.50651234° (58° 30' 23.44441" W)
Ellipsoid height (NAD83(CSRS))	-1.21 m

NAD83(CSRS) / UTM zone 21N

Easting	388713.844 m
Northing	5373029.853 m

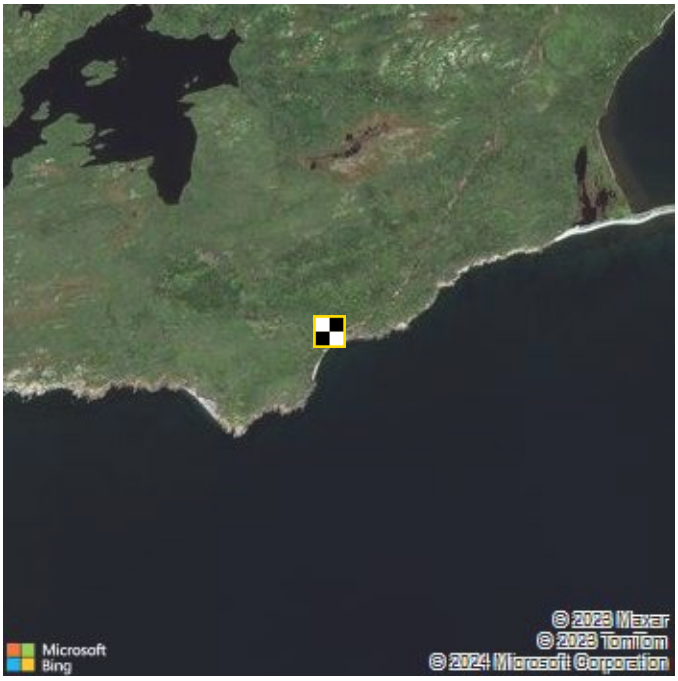
CGVD2013 height

Height	3.778 m

Quality

Data points	499
Points used	484 (97.0%)
Baseline distance	0.04 km
Data variance	1.2 mm / 1.8 mm / 5.2 mm

Point 7



Point Number	7	**Capture start**	06 Nov 2023 10:14 AM NST
Global ID	ac69d97fb4	**Capture end**	06 Nov 2023 11:34 AM NST
AeroPoint ID	07284369	**Duration**	1:20
		Uploaded	06 Nov 2023 11:59 AM NST

NAD83(CSRS)

Latitude	48.50091979° (48° 30' 3.31125" N)
Longitude	-58.50657149° (58° 30' 23.65736" W)
Ellipsoid height (NAD83(CSRS))	2.432 m

NAD83(CSRS) / UTM zone 21N

Easting	388710.338 m
Northing	5373073.794 m

CGVD2013 height

Height	7.419 m

Quality

Data points	481
Points used	481 (100.0%)
Baseline distance	0.09 km
Data variance	2.2 mm / 1.4 mm / 2.8 mm

Point 8

Point Number	8	**Capture start**	06 Nov 2023 10:14 AM NST
Global ID	ac08d31835	**Capture end**	06 Nov 2023 11:36 AM NST
AeroPoint ID	07286502	**Duration**	1:21
		Uploaded	06 Nov 2023 11:58 AM NST

NAD83(CSRS)

Latitude	48.50060192° (48° 30' 2.16692" N)
Longitude	-58.50710916° (58° 30' 25.59298" W)
Ellipsoid height (NAD83(CSRS))	-1.149 m

NAD83(CSRS) / UTM zone 21N

Easting	388669.925 m
Northing	5373039.245 m

CGVD2013 height

Height	3.842 m

Quality

Data points	489
Points used	483 (98.8%)
Baseline distance	0.05 km
Data variance	1.0 mm / 1.1 mm / 1.9 mm

Appendix B

2023 Indian Head Drone Survey

DJI Matrice 300 RTK L1 RGB Processing Report
22 January 2024

Survey Data

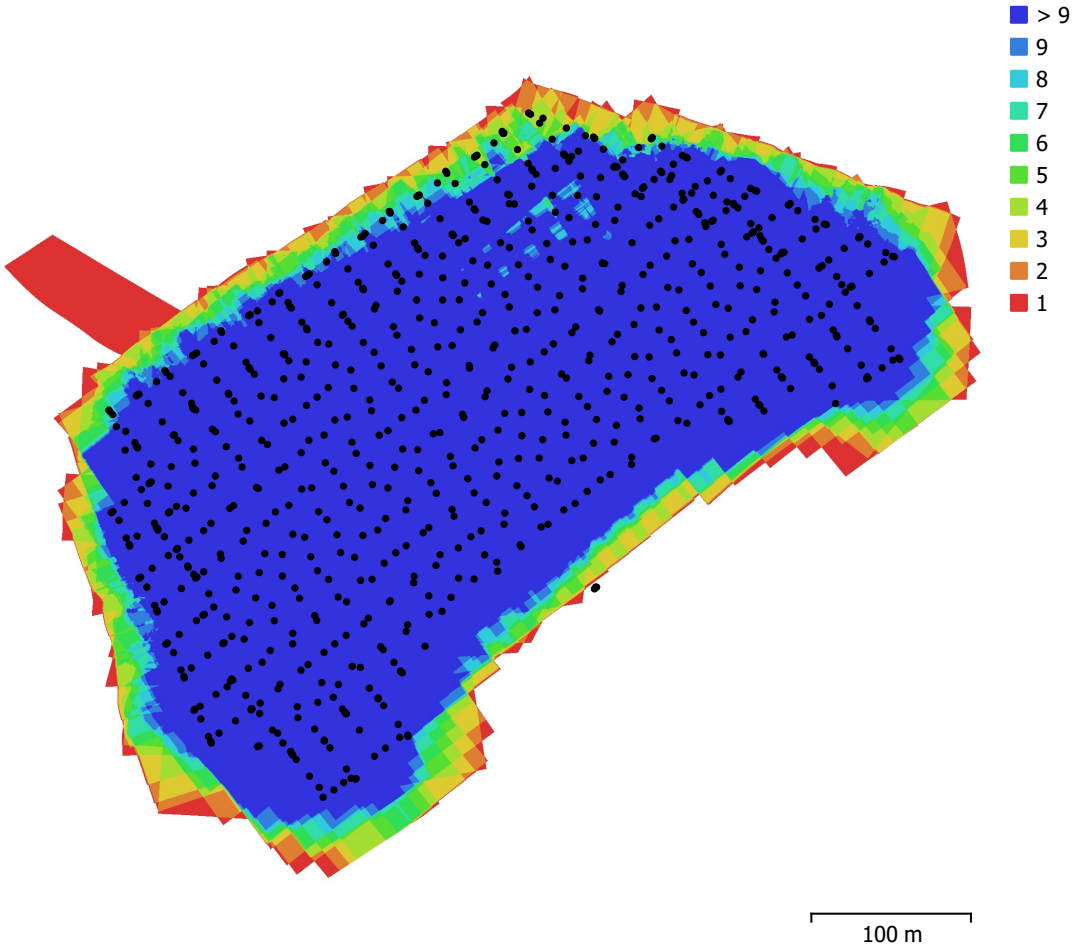


Fig. 1. Camera locations and image overlap.

Number of images:	897	Camera stations:	783
Flying altitude:	48.6 m	Tie points:	3,216,830
Ground resolution:	1.26 cm/pix	Projections:	10,053,944
Coverage area:	0.164 km²	Reprojection error:	0.649 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

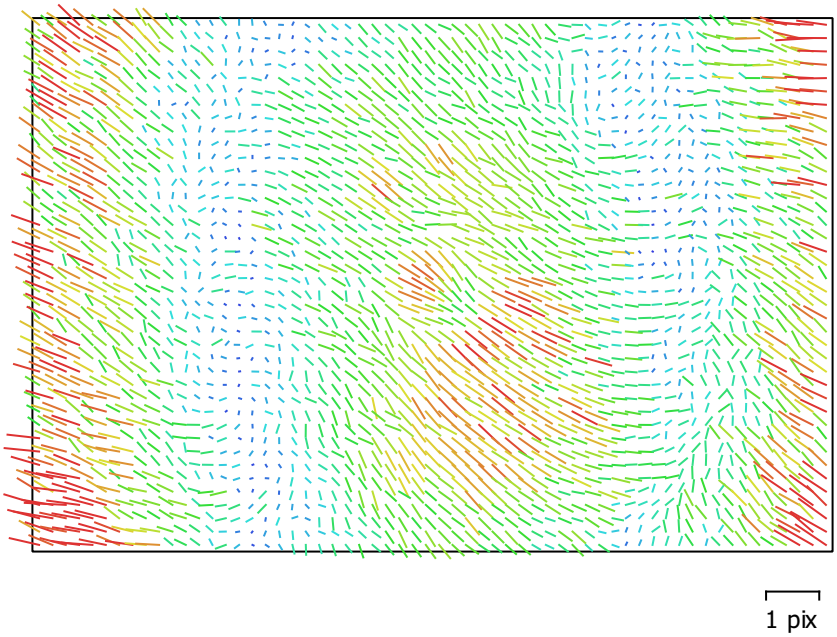


Fig. 2. Image residuals for EP800 (8.8mm).

EP800 (8.8mm)

897 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

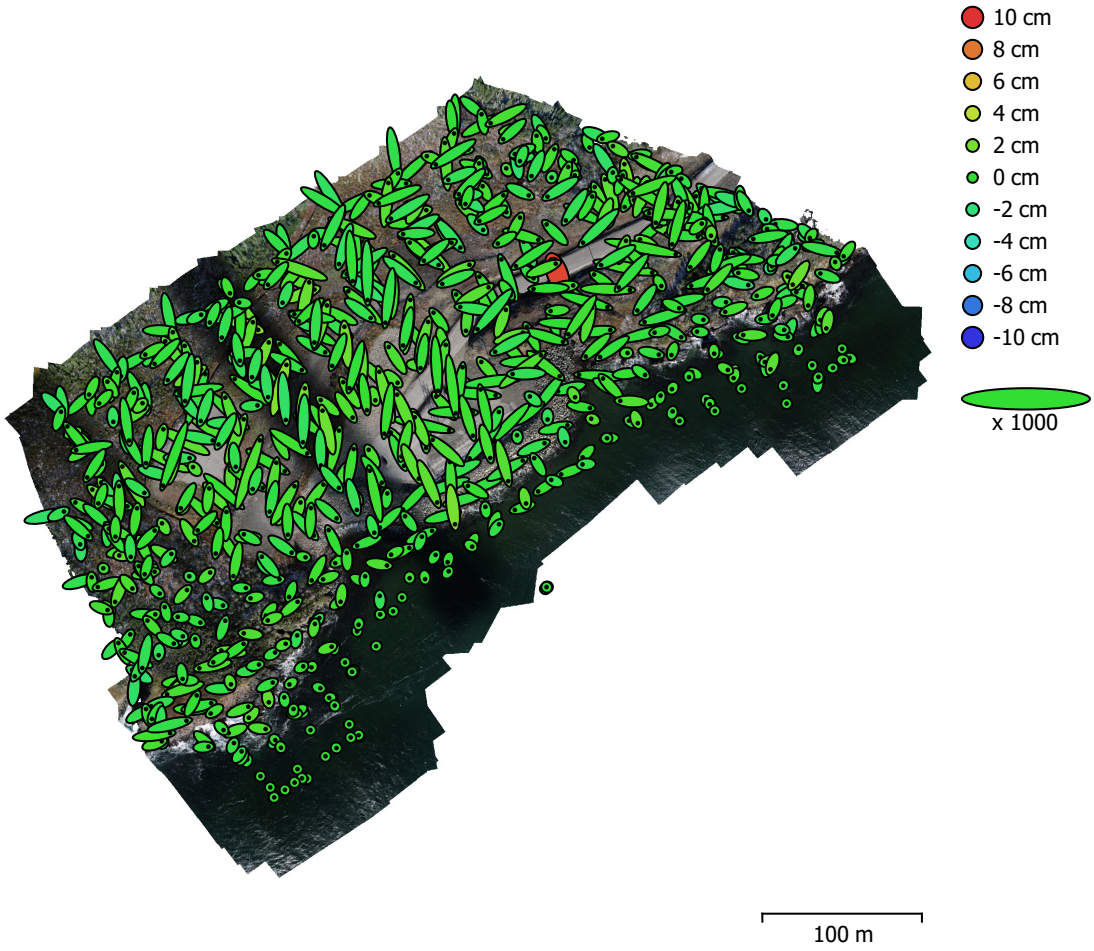


Fig. 3. Camera locations and error estimates.
Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
Estimated camera locations are marked with a black dot.

X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total error (cm)
1.02269	1.08863	0.790368	1.49365	1.68988

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

Digital Elevation Model

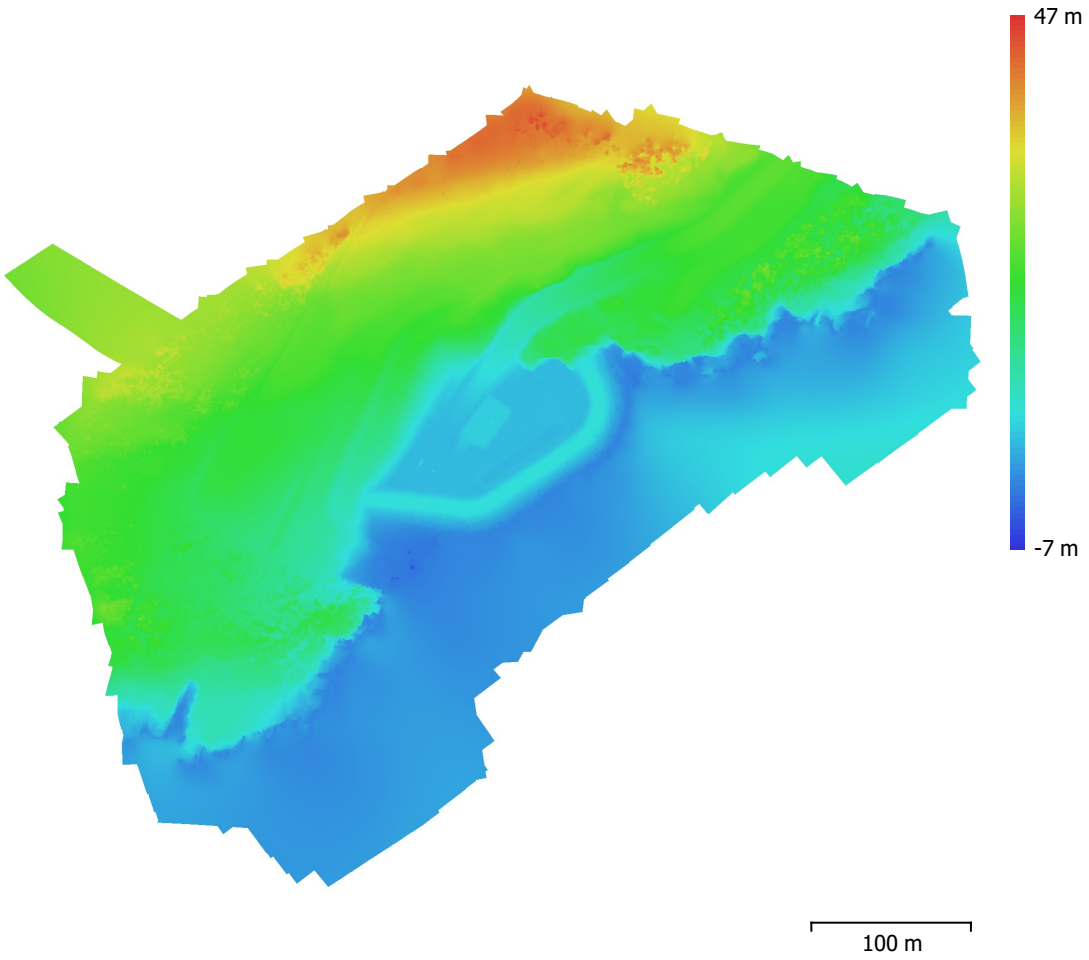


Fig. 4. Reconstructed digital elevation model.

Resolution:	1.26 cm/pix
Point density:	0.625 points/cm²

Processing Parameters

General	
Cameras	897
Aligned cameras	783
Markers	48
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Rotation angles	Yaw, Pitch, Roll
Point Cloud	
Points	3,216,830 of 4,086,485
RMS reprojection error	0.184042 (0.649304 pix)
Max reprojection error	0.783912 (36.9504 pix)
Mean key point size	3.27991 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	3.1076
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	10 minutes 45 seconds
Matching memory usage	1.19 GB
Alignment time	1 hours 16 minutes
Alignment memory usage	2.63 GB
Date created	2024:01:22 01:10:36
Software version	1.8.3.14331
File size	375.98 MB
Depth Maps	
Count	776
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 26 minutes
Memory usage	18.38 GB
Date created	2024:01:22 05:09:47
Software version	1.8.3.14331
File size	16.72 GB
Dense Point Cloud	
Points	1,068,180,033
Point colors	3 bands, uint8
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 26 minutes

Memory usage	18.38 GB
Dense cloud generation parameters	
Processing time	4 hours 19 minutes
Memory usage	47.28 GB
Date created	2024:01:22 09:30:18
Software version	1.8.3.14331
File size	14.96 GB
DEM	
Size	72,692 x 63,863
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Reconstruction parameters	
Source data	Dense cloud
Interpolation	Extrapolated
Processing time	15 minutes 36 seconds
Memory usage	343.14 MB
Date created	2024:01:22 18:08:13
Software version	1.8.3.14331
File size	9.37 GB
Orthomosaic	
Size	48,895 x 40,191
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	33 minutes 41 seconds
Memory usage	2.95 GB
Date created	2024:01:22 18:45:41
Software version	1.8.3.14331
File size	13.67 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