Drone Data Collection 2023: Big Lorraine Technical Report

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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 drones to monitor the position of a critical breakwater at the Big Lorraine, NS grounding site. Drone survey data were successfully collected on October 14th, 2023. Quality assurance and control measures have validated that the collected data meet or exceed all project specifications and were accurate to +-5 cm. Survey results were compared against positions collected by NSCC in August of 2022 to confirm that the breakwater position had remained consistent between surveys. A major storm event, hurricane Fiona, occurred between the two survey dates. While no signs of deformation were observed along the crest of the breakwater, large boulders were shifted, and a significant volume of material was deposited inland at the beach located east of the breakwater. It is possible that marine water was routed inside the control structure at the north tip of the east wall. If incursion is to be prevented, it is advised that the eastern breakwater be extended to the access road.

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1 Introduction

The Nova Scotia Community College – Applied geomatics Research Group (NSCC-AGRG) was contracted to conduct regular drone survey activities over Emera Newfoundland and Labrador sites including the Big Lorraine grounding site in Nova Scotia, Canada. In 2019 NSCC-AGRG agreed to provide Emera Newfoundland and Labrador with a baseline position of engineered breakwaters designed to protect grounding site infrastructure. A baseline was established in 2020 with an accuracy of +- 0.05 m suitable to monitor future movement of the breakwater. Repeat surveys were conducted in 2021 and 2022 to ensure there was no significant movement of breakwater materials. In 2023 NSCC-AGRG continued the monitoring program by resurveyed the area to produce products of similar accuracy.

2 Data Collection and Processing

Drone 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 quality assurance metrics for aerial drone surveys. Checkpoint locations were calculated to have an average vertical variance of +- 0.0036 m with a maximum target variance of 0.0097 m (Appendix A). These points coincided with target centers used to check photo positions during the data quality assessment phase.

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; ~464 M points), a digital elevation model, and an ortho mosaic (Appendix B). Raster data were processed at a native cell resolution of 0.0183 m and down sampled to 0.02 m for ease of delivery.

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_vcsCGVD2013).

3 Results

Image mosaics were found to be of acceptable quality. Shadowing was observed within the site due to the sunrise, but all imagery was found to be suitable for positioning and survey products were not impacted negatively (Figure 1).

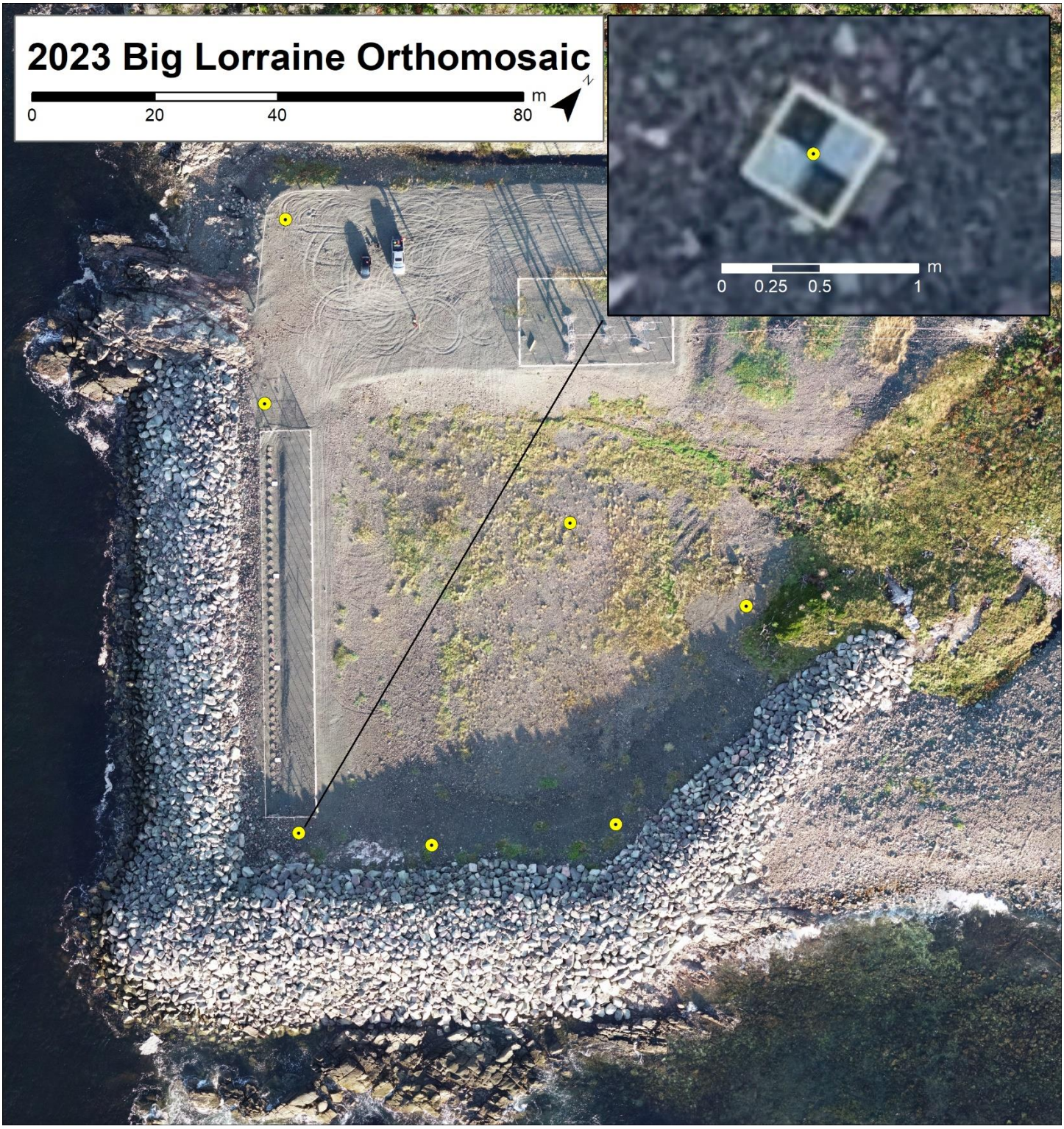


Figure 1. Big Lorraine grounding site photo mosaic demonstrating excellent horizontal alignment over control targets.

A digital surface model was generated by binning dense cloud elevation data at a resolution of 0.02 m. The resulting elevation model ranged from -1.0 m offshore to >10.0 m in elevated area north of the breakwater (Figure 2). Rasterized elevation data were validated using the GNSS control points. Elevation residuals were computed by subtracting the RPAS model elevations from the GNSS checkpoint elevations. Residuals ranged from -0.017 m to 0.042 m with a mean of 0.031 m and standard deviation of 0.008 m (Figure 2). Quality assurance and control measures validated that the collected data exceeded project specifications.

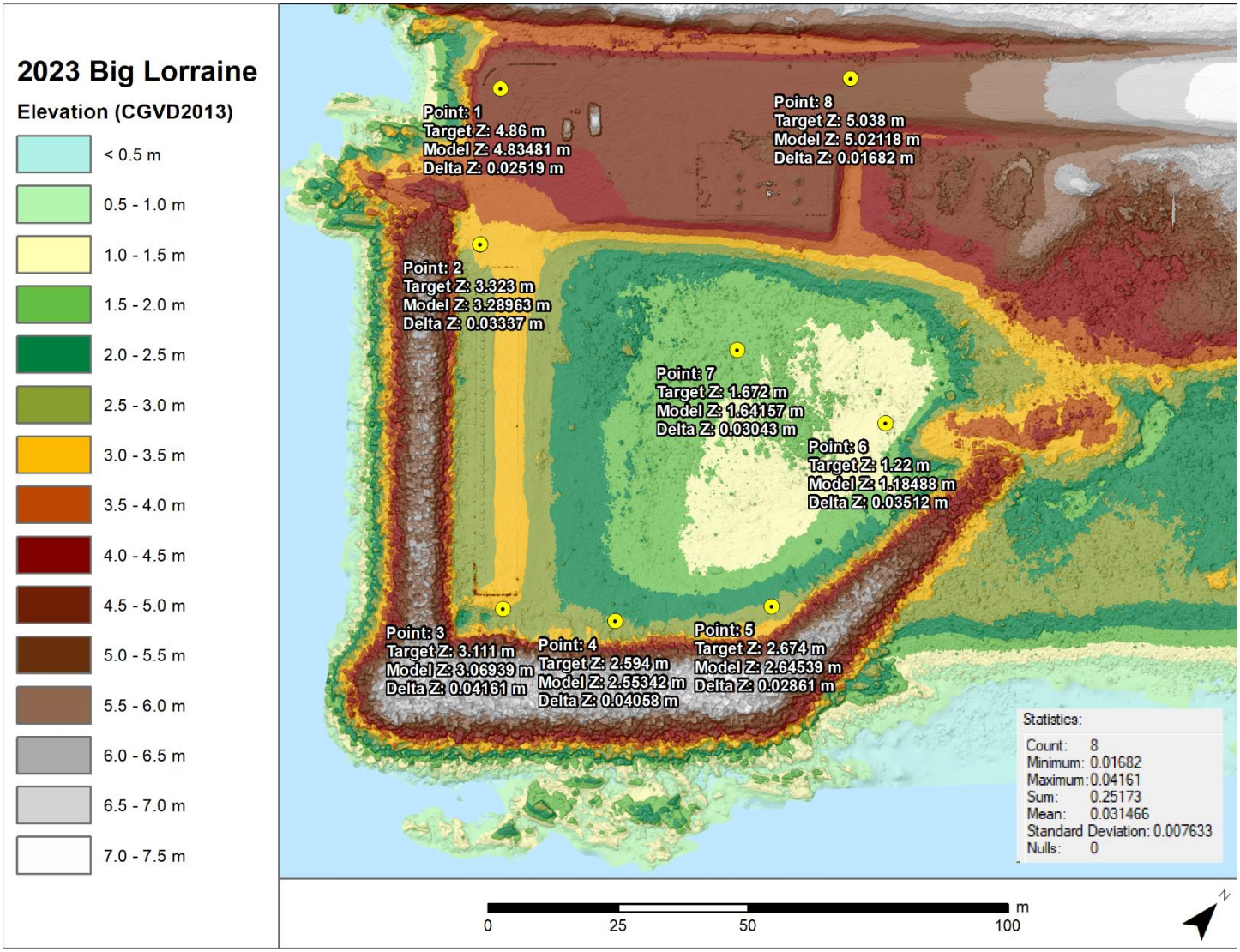


Figure 2. Colour graduated elevation model of the Big Lorraine site survey showing elevations along the extent of the breakwater structure and agreement with established checkpoints.

A baseline position of the Big Lorraine breakwater was successfully established during the 2022 survey. 2023 survey elevations were produced and assessed to determine if the breakwater position had changed between 2022 and 2023. Direct comparison of accurately georeferenced elevations demonstrated that no significant portion of the breakwater had shifted more than 10 cm between 2022 and 2023 (Figure 3).

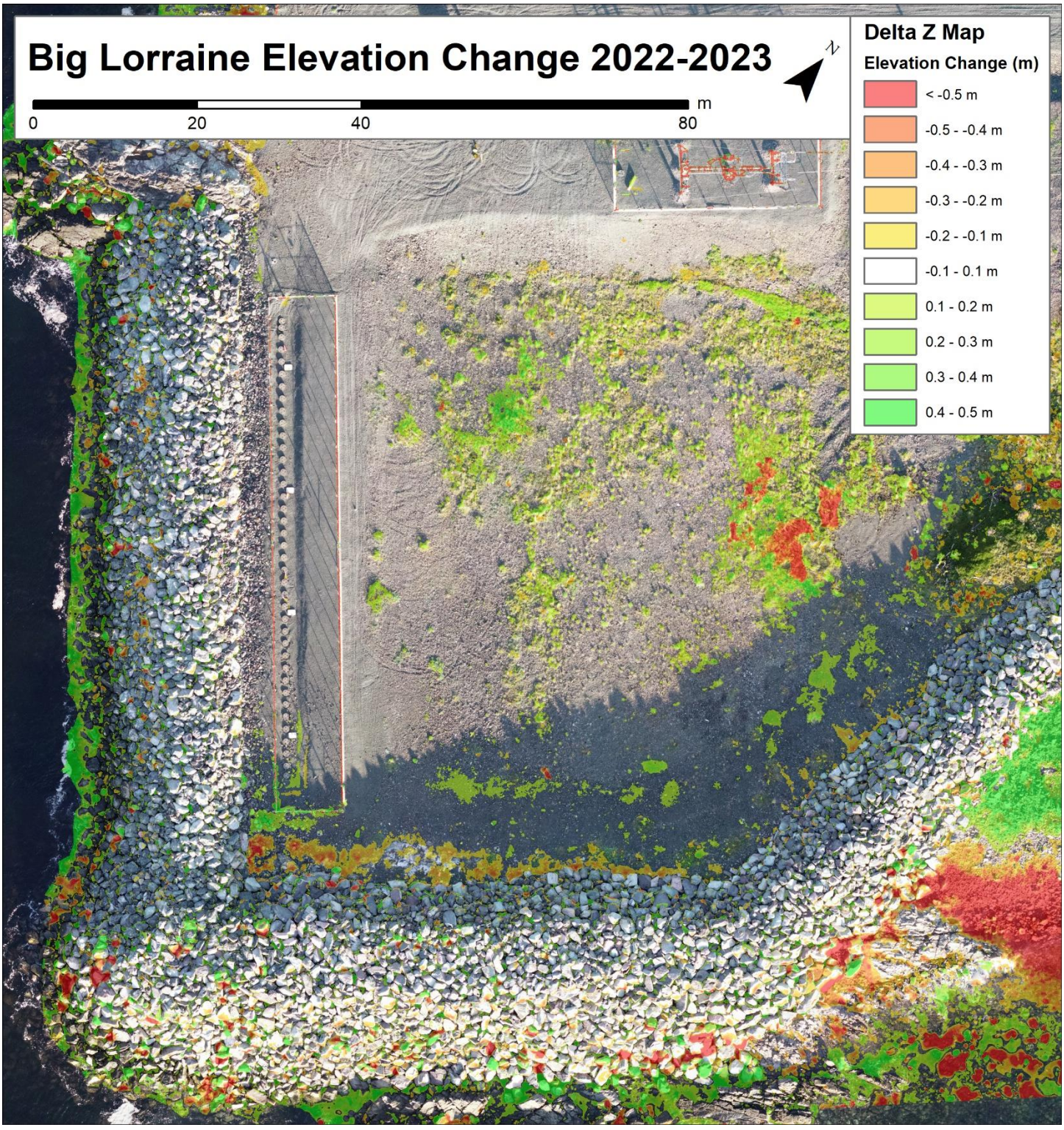


Figure 3. Comparison of 2022 and 2023 survey elevations. Negative values (red scale) denote a loss of material.

Large boulders were observed to have shifted between the 2022 and 2023 surveys. These shifts occurred primarily on the south corner of the breakwater with other scattered movements observed on the southeast wall, oceanward of the crest (Figure 4).

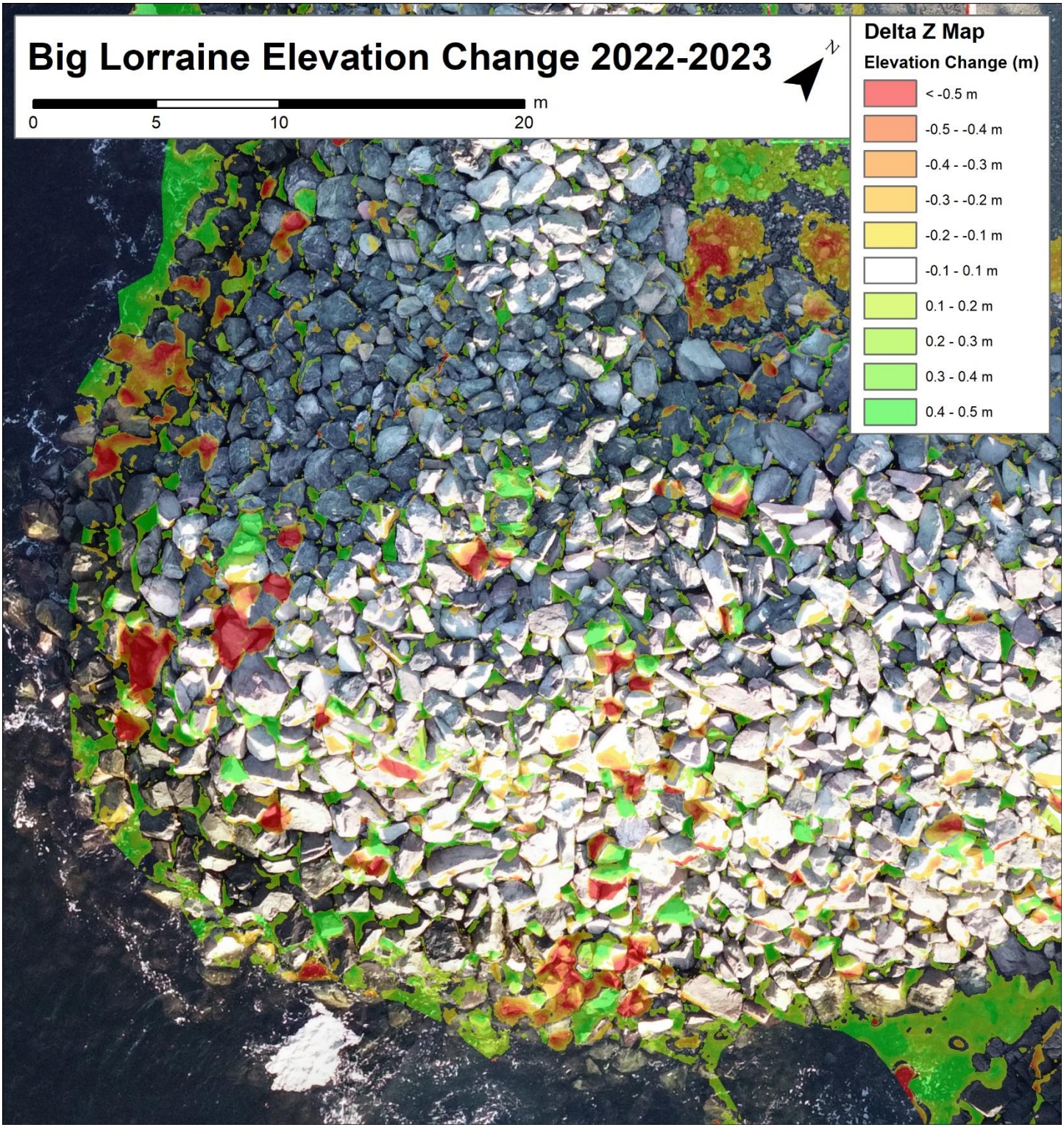


Figure 4. Close comparison of elevation changes between 2022 and 2023 demonstrates shifts in boulder positions localized primarily on the oceanward of the breakwater crest.

A significant change in beach morphology was observed east of the breakwater where a large volume of material was pushed inland between August 31, 2022 (Figure 5) and October 14, 2023 (Figure 6). It is likely that these significant movements were a result of hurricane Fiona which occurred in late September of 2022.

Figure 5. Imagery of highly vegetated beach material east of the Big Lorraine breakwater prior to hurraine Fiona.

Figure 6. Imagery of raised inland beach area void of vegetation east of the Big Lorraine breakwater post hurraine Fiona.

4 Discussion

No significant elevation changes of the breakwater crest were observed between 2022 and 2023. Elevation differences were observed for individual boulders primarily located on the oceanward of the breakwater, and a large portion of the beach east of the breakwater. It is possible that water was routed behind the breakwater at the lowest points on the north corner of the east wall. In 2022, this unfortified area contained a natural high point > 4 m in elevation with lower sections located to the north and south at elevations of 3.0 - 3.5 m and 3.5 – 4.0 m respectively (Figure 7). In 2023, material loss was measured in the low section on the northern tip of the east wall, south of the natural high point, where the elevation was lowered by roughly 0.8 m. The material may have been removed by water entering the controlled area during the event that caused the beach movement, likely Fiona (Figure 8). Additional protection may be required in the low sections identified north of the breakwater to prevent incursion of water during storm events.

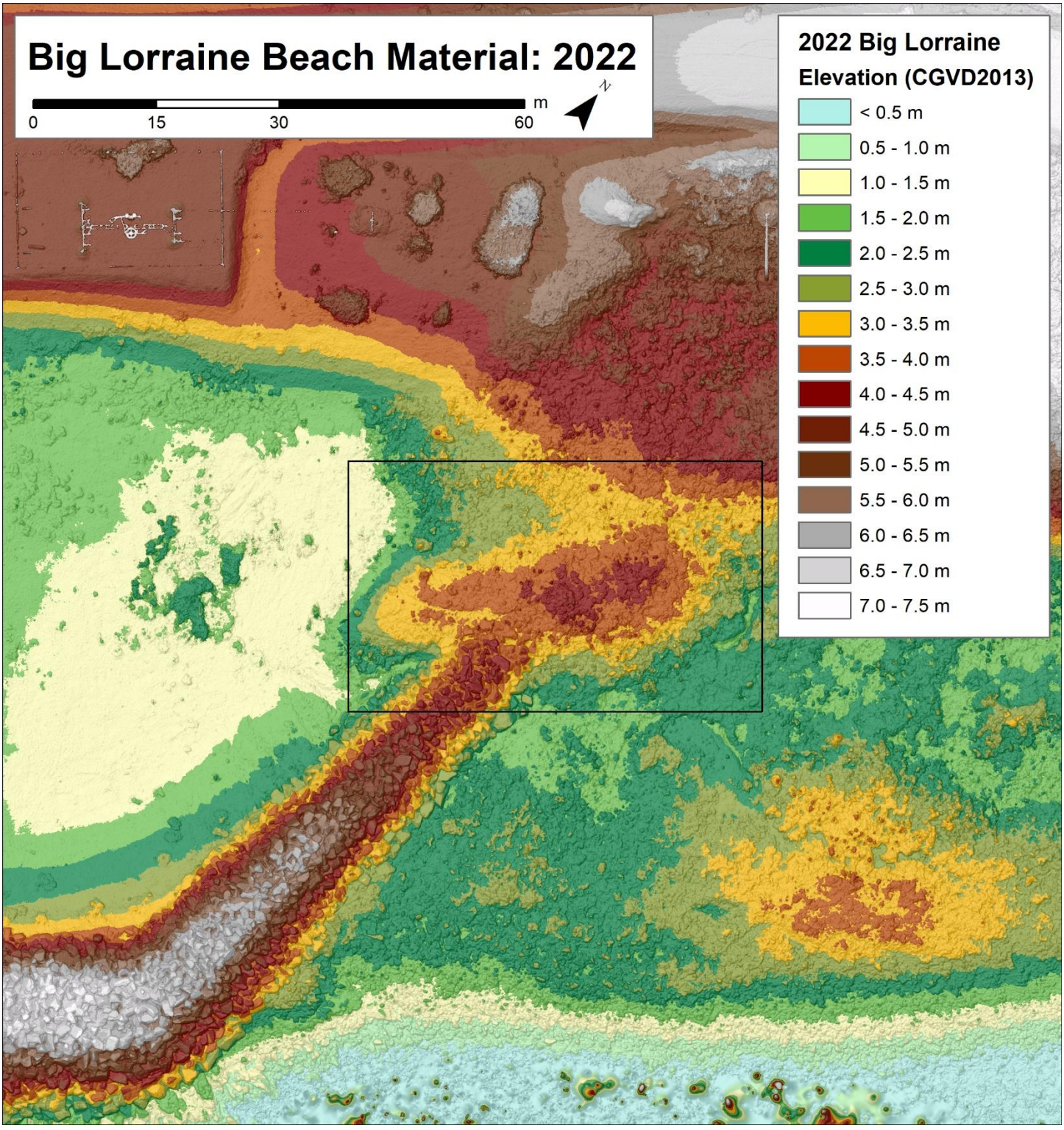


Figure 7. Colour shaded relief model of the beach elevations in 2022 highlighting the lowest portion of the protective breakwater.

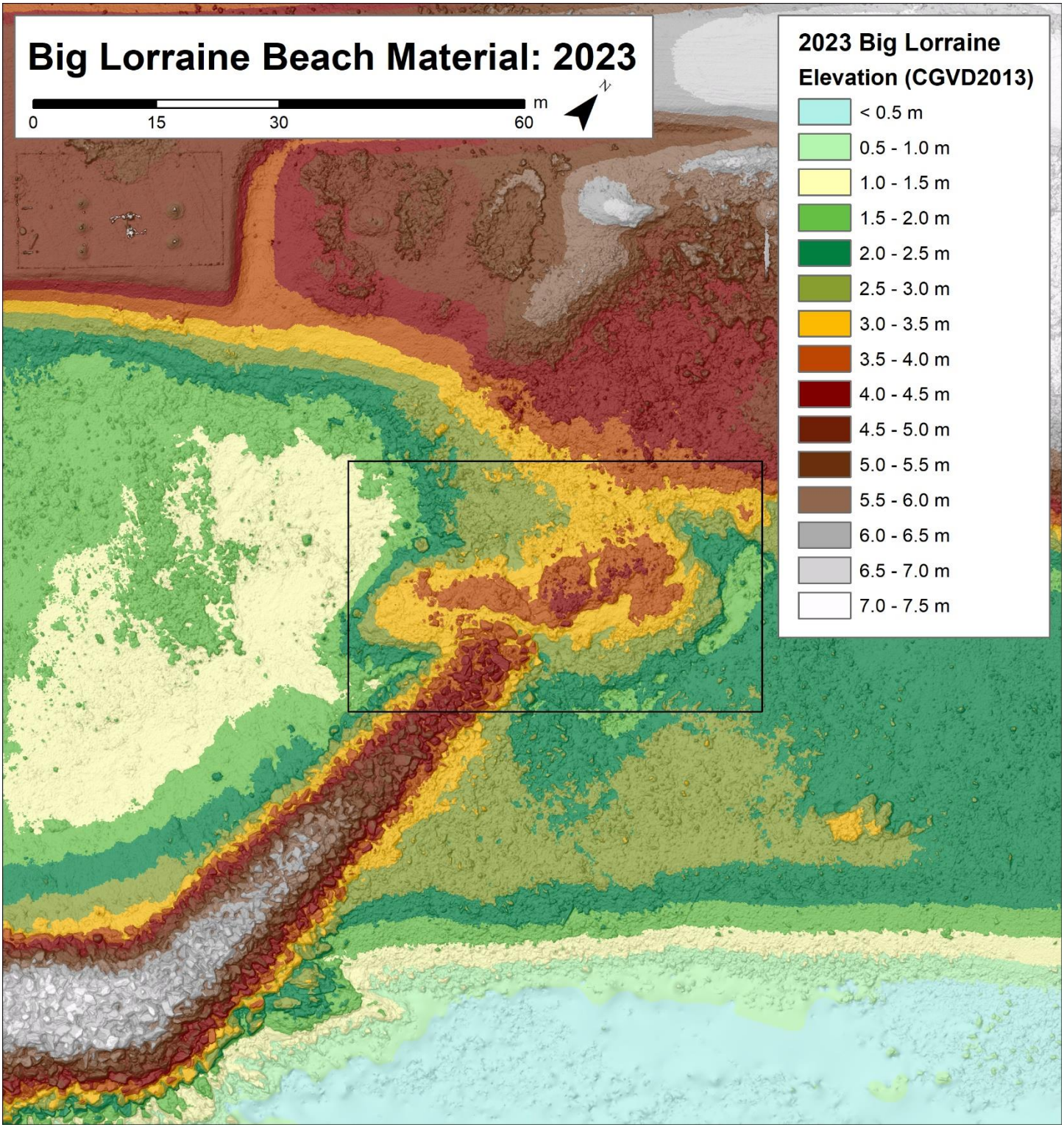


Figure 8. Colour shaded relief model of the beach elevations in 2023 highlighting a loss of material in the channel located at the northern tip of the breakwater.

Appendix A

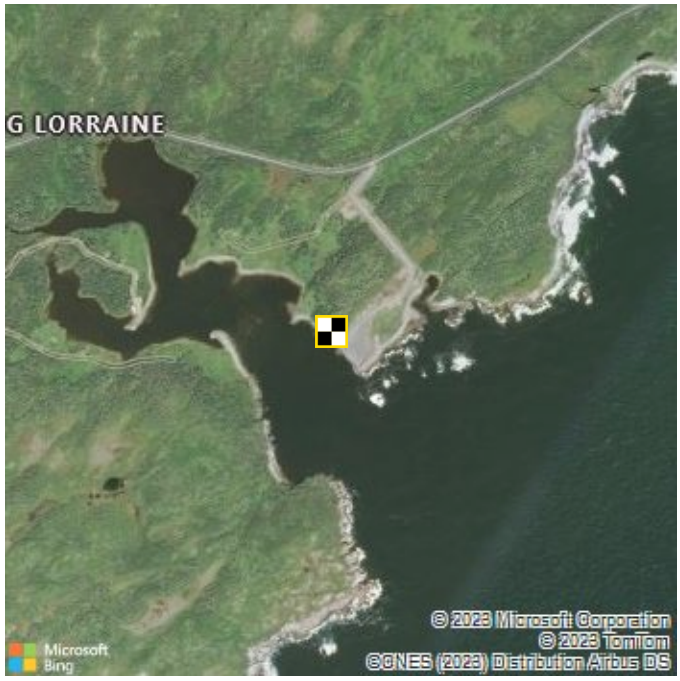
propeller aeropoints

Ground Control Report

Cape Breton, NS

Survey ID	as395b6a75
Aeropoint Set	
Date captured	14 Oct 2023 7:32 AM ADT
Points captured	8
Processing method	Propeller network correction
Document generated	17 Oct 2023 4:34 PM ADT

Point 1



Point Number	1	**Capture start**	14 Oct 2023 7:32 AM ADT
Global ID	acbddc05e5	**Capture end**	14 Oct 2023 8:32 AM ADT
AeroPoint ID	7283903	**Duration**	1:00
		Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	45.92792332° (45° 55' 40.52396" N)
Longitude	-59.91863469° (59° 55' 7.08488" W)
Ellipsoid height (NAD83(CSRS))	-6.748 m

NAD83(CSRS) / UTM zone 21N

Easting	273713.152 m
Northing	5090181.978 m

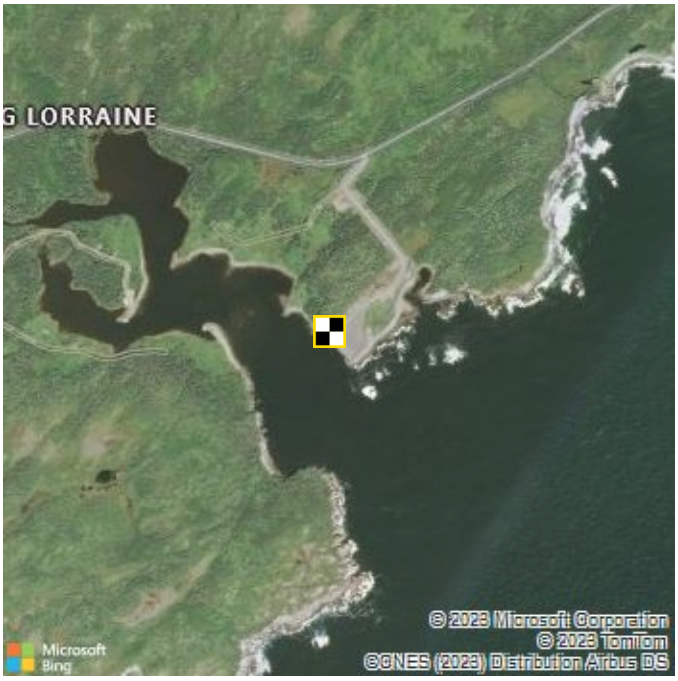
CGVD2013 height

Height	4.86 m

Quality

Data points	360
Points used	305 (84.7%)
Baseline distance	0.07 km
Data variance	0.4 mm / 0.1 mm / 0.2 mm

Point 2



Point Number	2
Global ID	aca1c505e8
AeroPoint ID	7284369

Capture start	14 Oct 2023 7:32 AM ADT
Capture end	14 Oct 2023 8:32 AM ADT
Duration	0:59
Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	45.92770252° (45° 55' 39.72907" N)
Longitude	-59.91840798° (59° 55' 6.26873" W)
Ellipsoid height (NAD83(CSRS))	-8.286 m

NAD83(CSRS) / UTM zone 21N

Easting	273729.83 m
Northing	5090156.803 m

CGVD2013 height

Height	3.323 m

Quality

Data points	358
Points used	308 (86.0%)
Baseline distance	0.08 km
Data variance	0.4 mm / 0.1 mm / 1.4 mm

Point 3

Point Number	3	**Capture start**	14 Oct 2023 7:34 AM ADT
Global ID	acf5d8b7e9	**Capture end**	14 Oct 2023 8:33 AM ADT
AeroPoint ID	7286502	**Duration**	0:59
		Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	45.9272694° (45° 55' 38.16983" N)
Longitude	-59.91774978° (59° 55' 3.89922" W)
Ellipsoid height (NAD83(CSRS))	-8.498 m

NAD83(CSRS) / UTM zone 21N

Easting	273779.098 m
Northing	5090106.814 m

CGVD2013 height

Height	3.111 m

Quality

Data points	355
Points used	314 (88.5%)
Baseline distance	0.12 km
Data variance	3.4 mm / 2.2 mm / 8.0 mm

Point 4

Point Number	4
Global ID	ac7c5d008c
AeroPoint ID	7286423

Capture start	14 Oct 2023 7:35 AM ADT
Capture end	14 Oct 2023 8:34 AM ADT
Duration	0:59
Uploaded	14 Oct 2023 12:14 PM ADT

NAD83(CSRS)

Latitude	45.92738704° (45° 55' 38.59333" N)
Longitude	-59.91752578° (59° 55' 3.09281" W)
Ellipsoid height (NAD83(CSRS))	-9.014 m

NAD83(CSRS) / UTM zone 21N

Easting	273796.944 m
Northing	5090119.248 m

CGVD2013 height

Height	2.594 m

Quality

Data points	357
Points used	320 (89.6%)
Baseline distance	0.11 km
Data variance	5.2 mm / 1.1 mm / 9.7 mm

Point 5

Point Number	5	**Capture start**	14 Oct 2023 7:36 AM ADT
Global ID	ac6666547c	**Capture end**	14 Oct 2023 8:35 AM ADT
AeroPoint ID	7287239	**Duration**	0:59
		Uploaded	14 Oct 2023 12:15 PM ADT

NAD83(CSRS)

Latitude	45.92759061° (45° 55' 39.32620" N)
Longitude	-59.91726799° (59° 55' 2.16477" W)
Ellipsoid height (NAD83(CSRS))	-8.934 m

NAD83(CSRS) / UTM zone 21N

Easting	273817.759 m
Northing	5090141.134 m

CGVD2013 height

Height	2.674 m

Quality

Data points	353
Points used	322 (91.2%)
Baseline distance	0.10 km
Data variance	0.7 mm / 0.1 mm / 0.3 mm

Point 6

Point Number	6	**Capture start**	14 Oct 2023 7:37 AM ADT
Global ID	ac5ee92ec8	**Capture end**	14 Oct 2023 8:36 AM ADT
AeroPoint ID	7284587	**Duration**	0:59
		Uploaded	14 Oct 2023 12:14 PM ADT

NAD83(CSRS)

Latitude	45.92795612° (45° 55' 40.64202" N)
Longitude	-59.91737249° (59° 55' 2.54097" W)
Ellipsoid height (NAD83(CSRS))	-10.387 m

NAD83(CSRS) / UTM zone 21N

Easting	273811.143 m
Northing	5090182.038 m

CGVD2013 height

Height	1.22 m

Quality

Data points	354
Points used	329 (92.9%)
Baseline distance	0.07 km
Data variance	0.2 mm / 0.2 mm / 1.9 mm

Point 7

Point Number	7
Global ID	ac3e22705e
AeroPoint ID	7287283

Capture start	14 Oct 2023 7:38 AM ADT
Capture end	14 Oct 2023 8:36 AM ADT
Duration	0:58
Uploaded	14 Oct 2023 12:14 PM ADT

NAD83(CSRS)

Latitude	45.92787345° (45° 55' 40.34442" N)
Longitude	-59.91776424° (59° 55' 3.95126" W)
Ellipsoid height (NAD83(CSRS))	-9.936 m

NAD83(CSRS) / UTM zone 21N

Easting	273780.435 m
Northing	5090173.966 m

CGVD2013 height

Height	1.672 m

Quality

Data points	349
Points used	332 (95.1%)
Baseline distance	0.06 km
Data variance	0.0 mm / 0.0 mm / 0.4 mm

Point 8

Point Number	8	**Capture start**	14 Oct 2023 7:41 AM ADT
Global ID	accf83b09e	**Capture end**	14 Oct 2023 8:37 AM ADT
AeroPoint ID	7284730	**Duration**	0:56
		Uploaded	14 Oct 2023 12:13 PM ADT

NAD83(CSRS)

Latitude	45.92834991° (45° 55' 42.05967" N)
Longitude	-59.91801853° (59° 55' 4.86670" W)
Ellipsoid height (NAD83(CSRS))	-6.569 m

NAD83(CSRS) / UTM zone 21N

Easting	273762.659 m
Northing	5090227.623 m

CGVD2013 height

Height	5.038 m

Quality

Data points	341
Points used	340 (99.7%)
Baseline distance	6.41 km
Data variance	5.5 mm / 2.0 mm / 6.7 mm

Appendix B

2023 Big Lorraine Drone Survey

DJI Matrice 300 RTK L1 RGB Processing Report

22 January 2024

Survey Data

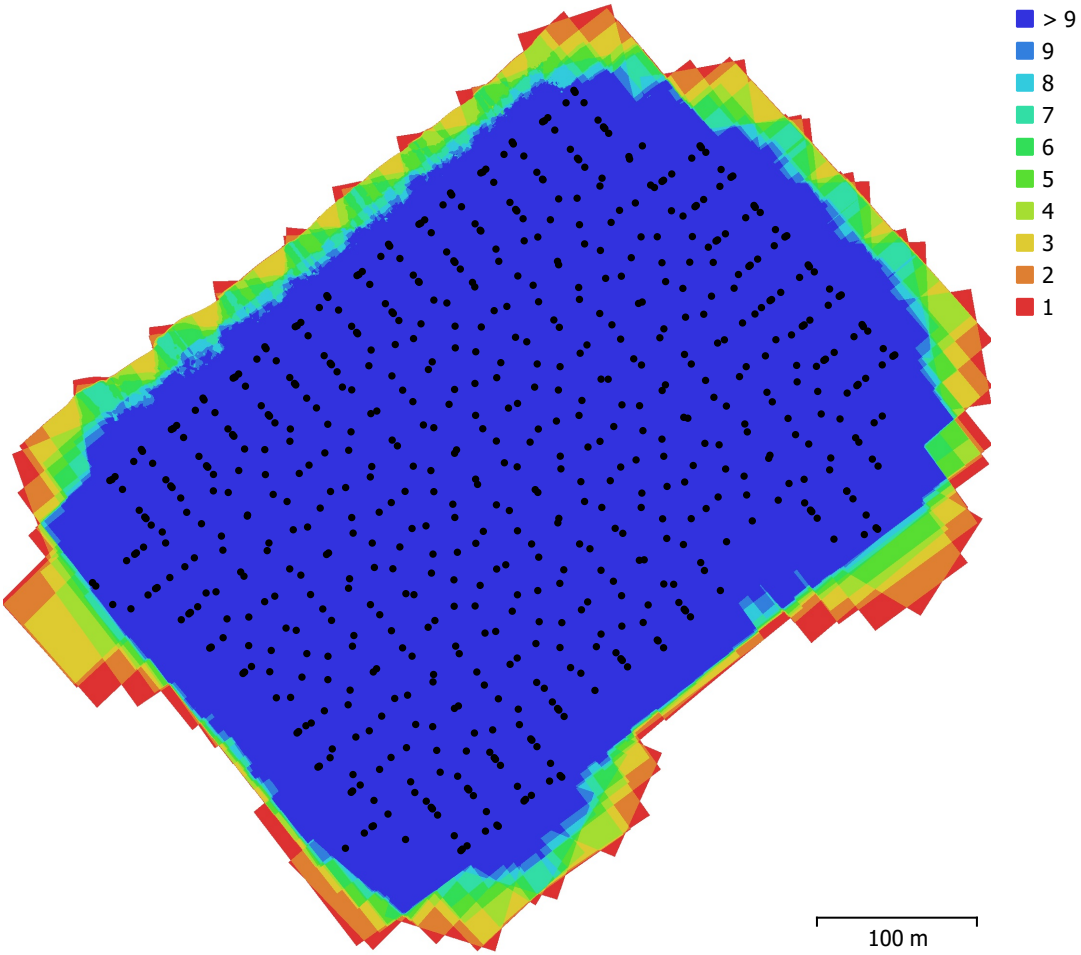


Fig. 1. Camera locations and image overlap.

Number of images:	749	Camera stations:	657
Flying altitude:	73.8 m	Tie points:	2,047,436
Ground resolution:	1.83 cm/pix	Projections:	7,071,586
Coverage area:	0.215 km²	Reprojection error:	1.12 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

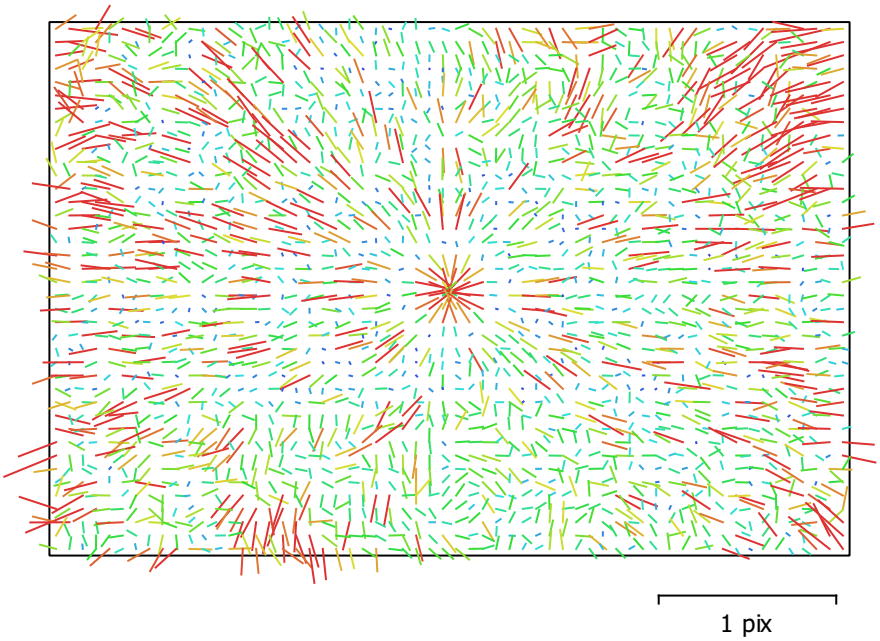


Fig. 2. Image residuals for EP800 (8.8mm).

EP800 (8.8mm)

749 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

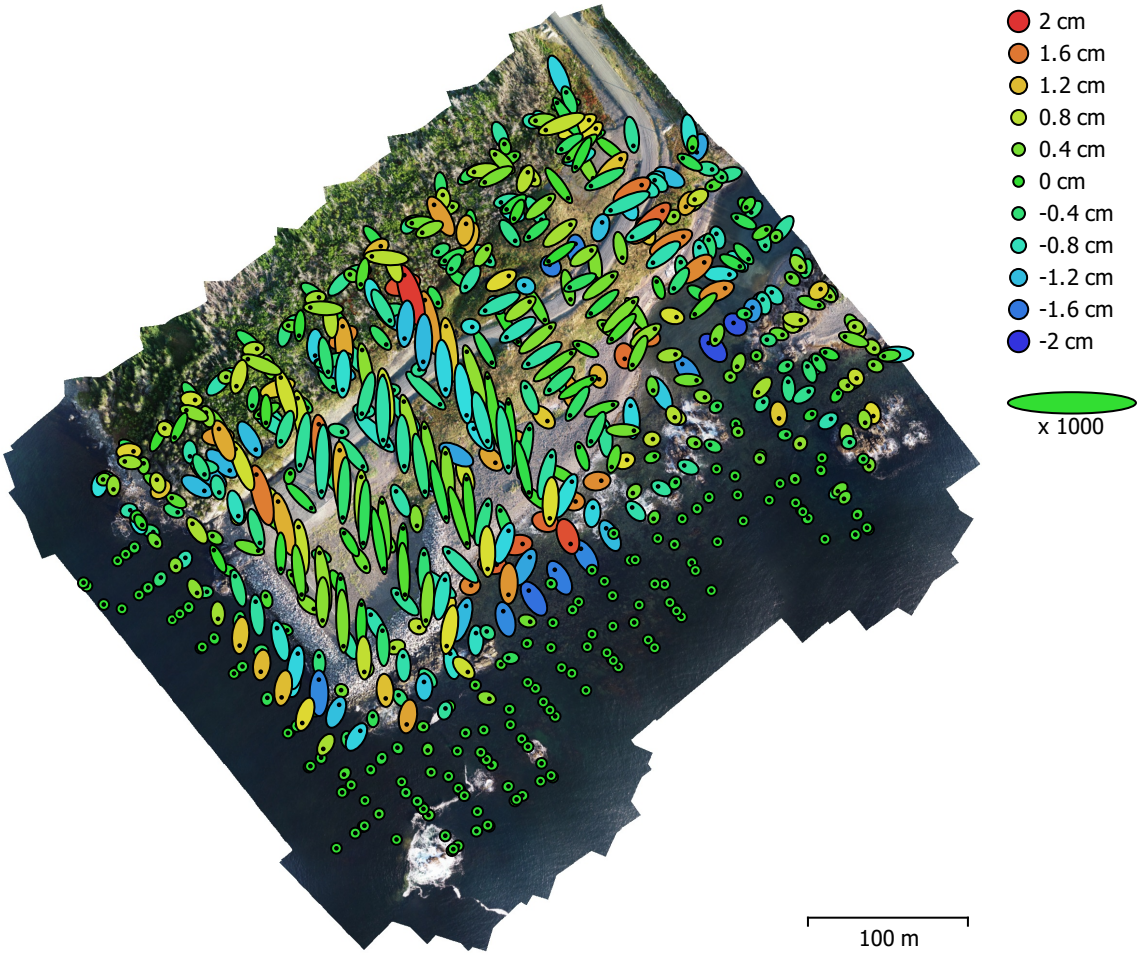


Fig. 3. Camera locations and error estimates.
Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
Estimated camera locations are marked with a black dot.

X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total error (cm)
0.593715	1.07684	0.658133	1.22967	1.39471

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

Digital Elevation Model

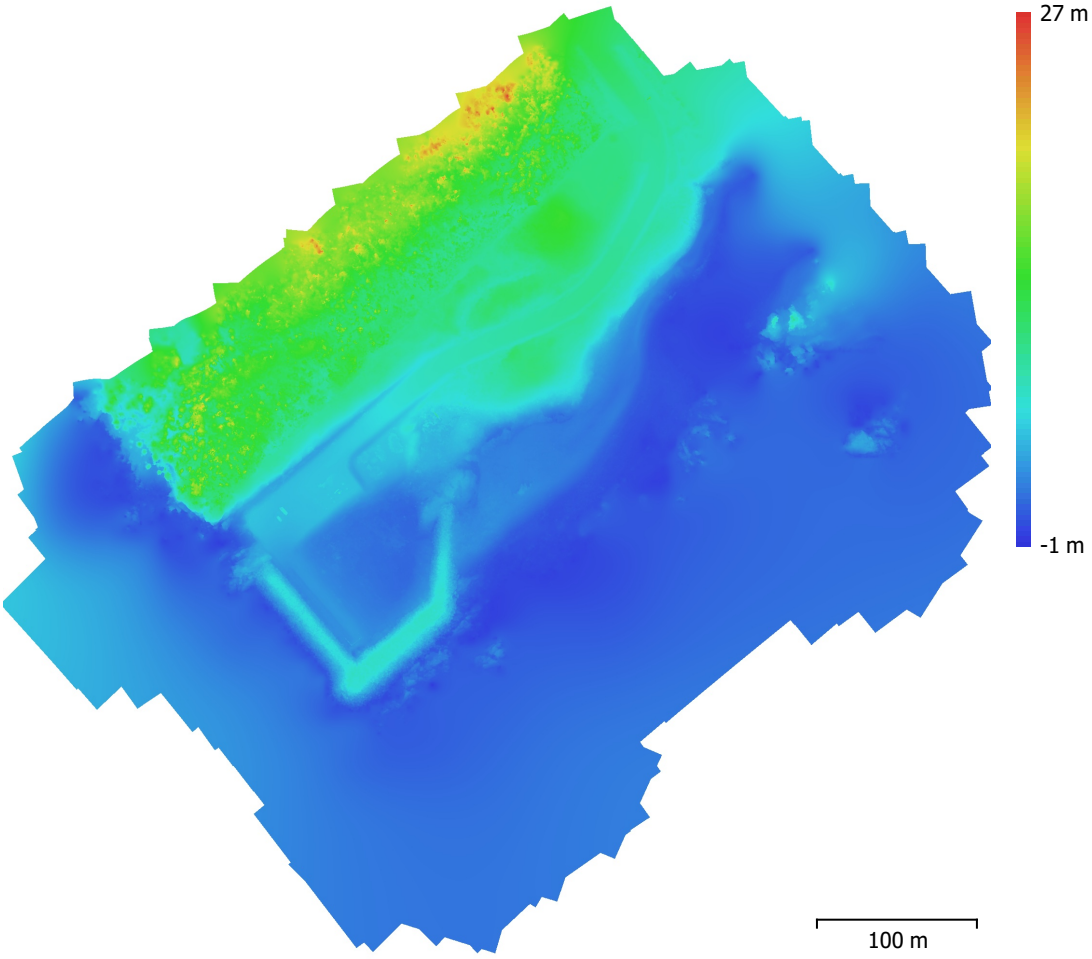


Fig. 4. Reconstructed digital elevation model.

Resolution:	1.83 cm/pix
Point density:	0.3 points/cm²

Processing Parameters

General	
Cameras	749
Aligned cameras	657
Markers	55
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Rotation angles	Yaw, Pitch, Roll
Point Cloud	
Points	2,047,436 of 2,664,716
RMS reprojection error	0.175459 (1.11845 pix)
Max reprojection error	0.530438 (50.9913 pix)
Mean key point size	5.25402 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	3.45612
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 51 seconds
Matching memory usage	9.78 GB
Alignment time	36 minutes 31 seconds
Alignment memory usage	2.77 GB
Date created	2024:01:21 19:03:27
Software version	1.8.3.14331
File size	195.11 MB
Depth Maps	
Count	344
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	1 hours 47 minutes
Memory usage	14.54 GB
Date created	2024:01:22 04:14:05
Software version	1.8.3.14331
File size	6.24 GB
Dense Point Cloud	
Points	464,158,692
Point colors	3 bands, uint8
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	1 hours 47 minutes

Memory usage	14.54 GB
Dense cloud generation parameters	
Processing time	2 hours 57 minutes
Memory usage	35.87 GB
Date created	2024:01:22 07:11:39
Software version	1.8.3.14331
File size	6.51 GB
DEM	
Size	50,190 x 48,865
Coordinate system	NAD83(CSRS) / UTM zone 21N + CGVD2013 height (EPSG::6664)
Reconstruction parameters	
Source data	Dense cloud
Interpolation	Extrapolated
Processing time	6 minutes 49 seconds
Memory usage	396.81 MB
Date created	2024:01:22 17:30:36
Software version	1.8.3.14331
File size	5.44 GB
Orthomosaic	
Size	33,791 x 32,767
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	18 minutes 21 seconds
Memory usage	2.42 GB
Date created	2024:01:22 17:53:59
Software version	1.8.3.14331
File size	9.93 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