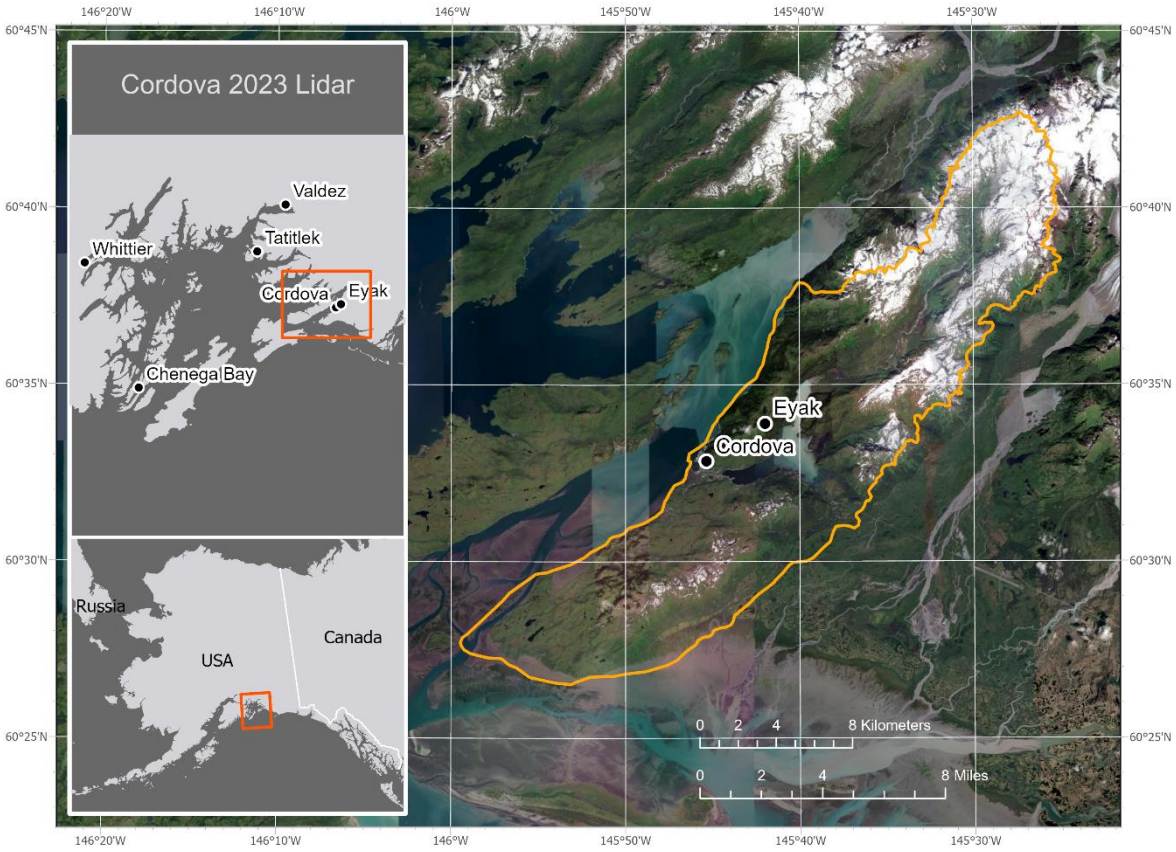
LIDAR-DERIVED ELEVATION DATA FOR CORDOVA, SOUTHCENTRAL ALASKA, COLLECTED AUGUST 18–19, 2023, AND SEPTEMBER 19 AND 22, 2023

Jenna M. Zechmann, Katreen M. Wikstrom Jones, and Gabriel J. Wolken

Raw Data File 2024-6



Location map of survey area.

This report has not been reviewed for technical content or
for conformity to the editorial standards of DGGS.

2024
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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LIDAR-DERIVED ELEVATION DATA FOR CORDOVA, SOUTHCENTRAL ALASKA, COLLECTED AUGUST 18–19, 2023, AND SEPTEMBER 19 AND 22, 2023

Jenna M. Zechmann[1], Katreen M. Wikstrom Jones[1], and Gabriel J. Wolken[1]

INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) used aerial lidar to produce a classified point cloud, digital surface model (DSM), digital terrain model (DTM), and an intensity model of Cordova, Southcentral Alaska, during leaf-on conditions (cover figure). The survey provides snow-free surface elevations for use in landslide and avalanche hazard assessments. Ground control data were collected August 16–17, 2023, and aerial lidar data were collected August 18–19, 2023, and September 19 and 22, 2023, and subsequently merged and processed using a suite of geospatial processing software. This data collection is released as a Raw Data File with an open end-user license. All files are available to download on the DGGS website at https://doi.org/10.14509/31159.

LIST OF DELIVERABLES

Classified Points
DSM and DTM
Intensity Image
Metadata

MISSION PLAN

Aerial Lidar Survey Details

DGGS used a Riegl VUX1-LR[22] laser scanner integrated with a global navigation satellite system (GNSS) and Northrop Grumman LN-200C inertial measurement unit (IMU) designed by Phoenix LiDAR Systems. The sensor can collect a maximum of 1,500,000 points per second at a range of 230 m, or a minimum of 50,000 points per second at a range of 1,000 m (ranges assume ≥ 20 percent natural reflectance). The scanner operated with a pulse refresh rate of 200,000 pulses per second over alpine terrain and 400,000–600,000 pulses per second over forested terrain, with a scan rate of 65-195 revolutions per second. We used a Cessna 180 Skywagon fixed-wing platform to survey from an elevation of approximately 230–390 m above ground level, at a ground speed of approximately 40 m/s, with a scan angle set from 80 to 280 degrees. The total survey area covers approximately 298 km^2.

Weather Conditions and Flight Times

The survey area was accessed by air from Cordova Municipal Airport and Merle K. (Mudhole) Smith Airport. Flightlines are shown in figure 1. See table 1 for data collection start and end times and weather conditions.

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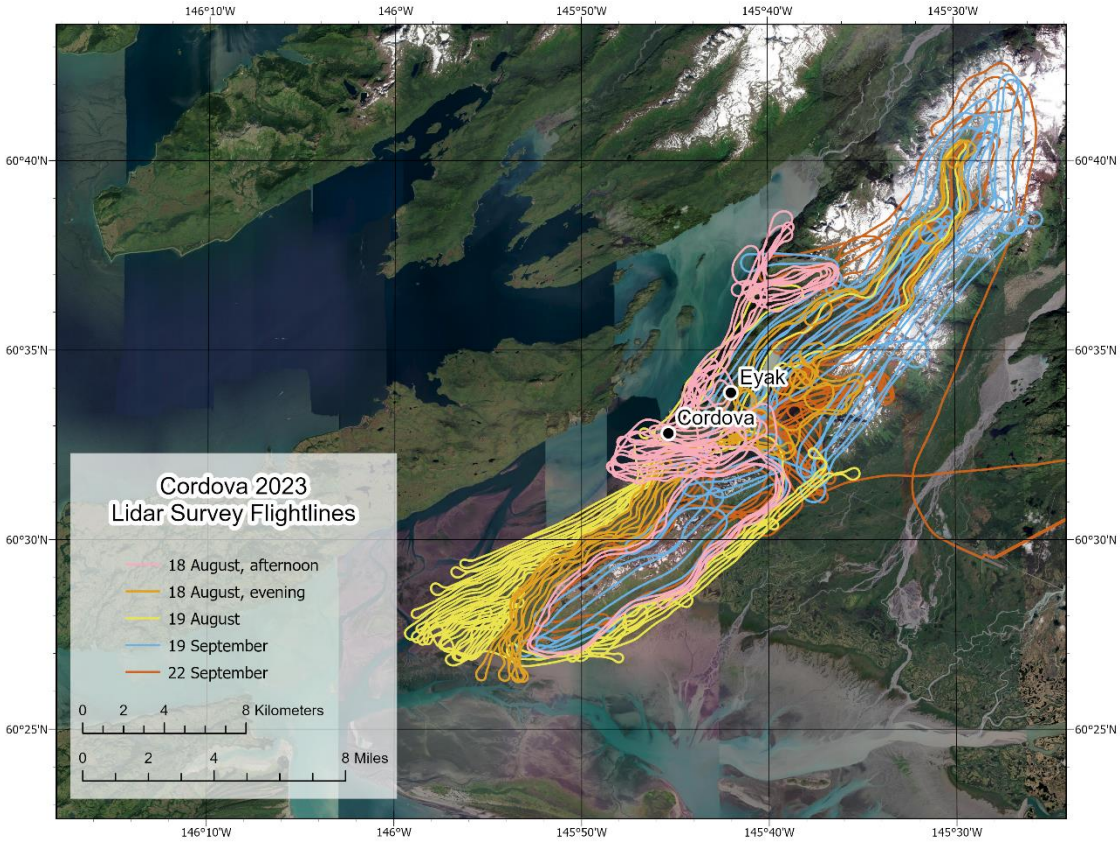

Figure 1. Lidar data collection flightlines.

Table 1. Data collection start and end times and weather conditions for the lidar collection survey.

Date	Start time (AKST)	End time (AKST)	Weather conditions
18 August 2023	1:00 PM	4:00 PM	Overcast with wind
18 August 2023	5:00 PM	7:10 PM	Partly cloudy with wind
19 August 2023	1:50 PM	5:10 PM	Partly cloudy
19 September 2023	1:10 PM	4:00 PM	Scattered clouds
22 September 2023	10:10 AM	1:30 PM	Partly cloudy

PROCESSING REPORT

Lidar Dataset Processing

We processed point data in Spatial Explorer for initial filtering and multiple-time-around (MTA) disambiguation. MTA errors, corrected in this process, result from ambiguous interpretations of received pulse time intervals and occur more frequently with higher pulse refresh rates. IMU and GNSS data were processed in Inertial Explorer, and flightline information was integrated with the point cloud in Spatial Explorer. We calibrated the point data at an incrementally precise scale of

sensor movement and behavior, incorporating sensor velocity, roll, pitch, and yaw fluctuations throughout the survey. For the lidar data collection, the average pulse density is 23.0 pulses/m^2 and the average pulse spacing is 20.8 cm.

We created macros in Terrasolid software and classified points in accordance with the American Society for Photogrammetry & Remote Sensing (ASPRS) 2019 guidelines (ASPRS, 2019). Once classified, we applied a geometric transformation and converted the points from ellipsoidal heights to GEOID12B (Alaska) orthometric heights.

Raster products were derived from the point cloud in ArcGIS Pro. A 50-cm DSM was interpolated from ground, vegetation, bridge deck, and building classes using a binning method and maximum values. A 50-cm DTM was interpolated from all ground class returns using a binning method and minimum values. We also produced a 50-cm intensity image for the entire area using average binning in ArcGIS Pro, with no normalization or corrections applied.

Classified Point Cloud

Classified point cloud data are provided in LAZ format. Data are classified following ASPRS 2019 guidelines (table 2) and contain return and intensity information. For classified ground points (fig. 2), the average point density is 2.84 pts/m^2, and the average spacing is 59.3 cm.

Table 2. Point cloud class code definitions.

Class Code	Description
1	Unclassified
2	Ground
3	Low Vegetation, ≥0.0m, <0.5m
4	Medium Vegetation, ≥0.5m, <3m
5	High Vegetation, ≥3m, ≤60m
6	Building
7	Low Noise
17	Bridge Deck
18	High Noise
30	Noise (manually classified)

Digital Surface Model

The DSM represents surface elevations, including heights of vegetation, buildings, powerlines, bridge decks, etc. The DSM is a single-band, 32-bit GeoTIFF file of 50-cm resolution. No Data value is set to -3.40282306074e+38 (32-bit, floating-point minimum).

Digital Terrain Model

The DTM represents bare earth elevations, excluding vegetation, bridge decks, buildings, etc. The DTM is a single-band, 32-bit GeoTIFF file of 50-cm resolution. No Data value is set to -3.40282306074e+38.

Lidar Intensity Image

The lidar intensity image describes the relative amplitude of reflected signals contributing to the point cloud. Lidar intensity is (1) primarily a function of scanned object reflectance in relation to the signal frequency, (2) dependent on ambient conditions, and (3) not necessarily consistent between separate scans. The intensity image is a single-band, 32-bit GeoTIFF file of 50-cm resolution. No Data value is set to -3.40282306074e+38.

SURVEY REPORT

Ground Survey Details

The State of Alaska, Division of Mining, Land, and Water (DMLW) collected ground control points on August 16 and 17, 2023. They deployed a Trimble R12 GNSS receiver to provide a base station occupation and real-time kinematic (RTK) corrections to points they surveyed with a rover Trimble R12 GNSS receiver/TSC5 controller. A brass disk with designation 945 4050 H and PID BBGS17, located along Orca Inlet Road 0.5 km south of Cordova Ferry Terminal, served as a base station location. One hundred fifty-one ground control points and checkpoints were collected for calibration and to assess the vertical accuracy of the point cloud. Checkpoints were collected on bare earth, and in low vegetation, shrubland, and forest.

Coordinate System and Datum

We processed and delivered all data in NAD83 (2011) UTM6N and vertical datum NAVD88 GEOID12B.

Horizontal Accuracy

Horizontal accuracy was not measured for this collection.

Vertical Accuracy

We measured a mean offset of -164.1 cm between 25 control points and the point cloud (app. 1). This offset was reduced to -0.7 cm in non-vegetated areas (app. 2) by applying a constant vertical correction to the lidar point data. In vegetated areas, checkpoints show the average offset to be +16.3 cm (app. 3). We used 57 non-vegetated and 69 vegetated checkpoints to determine the vertical accuracy of the point cloud ground class using a Triangulated Irregular Network (TIN) approach. The project vertical accuracy has a root mean square error (RMSE) of 7.8 cm in non-vegetated areas (app. 2) and 26.6 cm in vegetated areas (app. 3). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 7.7 cm RMSE.

Data Consistency and Completeness

This is a full-release dataset. There was no over-collect. Data quality is consistent throughout the survey, except for high-elevation glaciated areas where few laser returns resulted in interpolated areas.

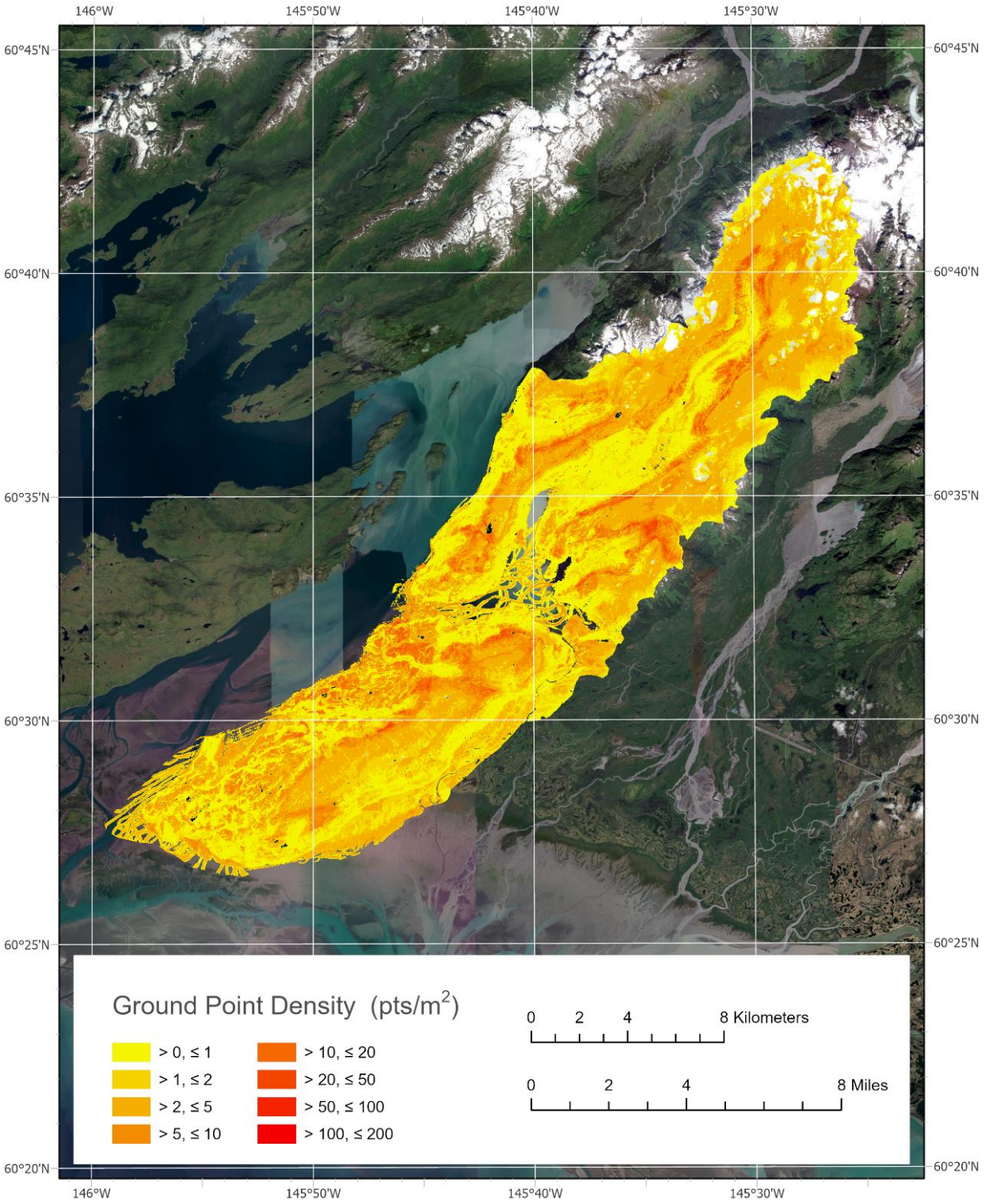

Figure 2. Ground point density for the survey displayed as a raster.

ACKNOWLEDGMENTS

This survey area is on the traditional homelands of the Eyak peoples. This work was funded by a Federal Emergency Management Agency (FEMA) grant number EMS-2021-CA-00014. We thank Clearwater Air for their aviation expertise and contribution to these data products and the DMLW for providing ground control points and checkpoints. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

REFERENCES

The American Society for Photogrammetry & Remote Sensing (ASPRS), 2019, LAS Specification 1.4 - R15. https://www.asprs.org/wp-content/uploads/2019/07/ LAS_1_4_r15.pdf

APPENDIX 1: GROUND CONTROL POINTS

GCP	Easting (m)	Northing (m)	GCP Z (m)	Pointcloud Z (m)	Elevation difference (Pointcloud Z – GCP Z) (m)
1001	568149.096	6713581.575	8.876	7.166	-1.710
1008	568825.676	6715076.046	5.668	3.984	-1.684
1013	570117.784	6716579.411	5.730	4.063	-1.667
1018	570093.872	6716559.387	5.333	3.583	-1.750
1021	568395.194	6712095.807	14.329	12.536	-1.793
1027	567021.050	6711289.028	12.015	10.282	-1.733
1036	565875.730	6709814.469	18.071	16.375	-1.696
1038	564042.678	6709082.123	24.074	22.551	-1.523
1048	562533.517	6708035.357	13.429	11.852	-1.577
1054	561693.512	6706460.307	29.792	28.155	-1.637
1056	560889.301	6705744.465	21.635	20.104	-1.531
1064	570994.446	6712107.392	7.996	6.348	-1.648
1073	572969.853	6712422.213	17.688	16.103	-1.585
1075	574544.070	6711272.591	9.356	7.711	-1.645
1083	575288.108	6710949.182	8.123	6.508	-1.615
1087	570209.888	6712705.997	6.838	5.162	-1.676
1097	571769.246	6713701.056	10.658	9.023	-1.635
1098	572814.868	6715197.980	9.517	8.003	-1.514
1104	572898.948	6716773.211	9.613	8.093	-1.520
1114	574268.383	6717761.698	6.682	5.049	-1.633
1120	575061.537	6717975.860	11.483	9.934	-1.549
1121	576461.191	6717776.970	34.688	32.884	-1.804
1138	574626.687	6710697.587	23.387	21.809	-1.578
1144	568595.085	6713259.904	123.630	121.950	-1.680
1154	569474.240	6713685.244	382.957	381.321	-1.636
Average elevation difference (dZ) (m)	-1.641				
Minimum dZ (m)	-1.804				
Maximum dZ (m)	-1.514				
Average magnitude error (m)	1.641				
Root mean square error (m)	1.643				
Standard deviation (m)	0.082				

APPENDIX 2: NON-VEGETATED CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Elevation difference (Corrected pointcloud Z-Checkpoint Z) (m)
101	568137.464	6713569.598	8.880	8.849	-0.031
102	573648.115	6717479.712	6.718	6.663	-0.055
1002	568160.706	6713594.388	8.747	8.616	-0.131
1004	568161.119	6713640.323	8.351	8.301	-0.050
1007	568837.682	6715080.978	5.559	5.508	-0.051
1011	568823.717	6715014.560	5.960	5.920	-0.040
1014	570105.915	6716574.128	5.396	5.373	-0.023
1017	570151.463	6716608.271	6.738	6.745	0.007
1020	568391.986	6712102.847	13.985	13.834	-0.151
1024	568393.310	6712074.213	14.962	14.824	-0.138
1026	567017.545	6711286.037	12.074	11.991	-0.083
1030	567030.127	6711322.687	10.993	10.937	-0.056
1032	565920.789	6709812.538	18.945	18.879	-0.066
1034	565910.731	6709810.452	18.857	18.688	-0.169
1041	564066.015	6709091.357	24.098	24.264	0.166
1042	564084.118	6709093.839	24.477	24.672	0.195
1044	562525.695	6708041.208	14.336	14.399	0.063
1049	562518.923	6708014.838	12.156	12.213	0.057
1050	561698.048	6706476.504	29.311	29.327	0.016
1057	560901.973	6705746.600	21.598	21.679	0.081
1060	560916.263	6705757.324	21.428	21.497	0.069
1062	570989.137	6712092.913	7.958	7.926	-0.032
1067	571002.248	6712114.980	7.977	7.965	-0.012
1068	572982.054	6712420.465	17.952	17.965	0.013
1069	572990.473	6712432.908	18.010	18.033	0.023
1074	574540.182	6711264.445	9.151	9.095	-0.056
1078	574531.561	6711268.709	8.991	9.046	0.055
1080	575291.761	6710939.656	8.040	8.043	0.003
1081	575289.219	6710935.080	7.834	7.830	-0.004
1086	570207.962	6712693.363	6.398	6.360	-0.038
1090	570255.291	6712732.295	6.941	6.888	-0.053
1092	571757.558	6713675.245	11.084	11.088	0.004
1094	571770.043	6713687.817	10.779	10.671	-0.108
1100	572809.759	6715184.191	9.519	9.532	0.013
1105	572905.916	6716780.963	9.726	9.818	0.092
1108	572904.888	6716793.023	9.534	9.665	0.131
1109	574257.843	6717752.688	6.593	6.666	0.073
1113	574259.094	6717755.991	6.679	6.695	0.016
1115	575076.275	6717970.711	11.641	11.707	0.066
1116	575085.726	6717977.838	11.240	11.333	0.093

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Elevation difference (Corrected pointcloud Z-Checkpoint Z) (m)
1122	576492.881	6717777.250	36.368	36.267	-0.101
1125	576510.058	6717768.850	36.585	36.653	0.068
1126	577018.628	6717914.956	63.667	63.612	-0.055
1131	573646.820	6717479.402	6.713	6.597	-0.116
1132	568137.460	6713569.597	8.889	8.848	-0.041
1133	568137.462	6713569.590	8.891	8.848	-0.043
1134	574660.734	6710862.042	25.735	25.913	0.178
1135	574661.245	6710858.912	25.715	25.778	0.063
1141	573977.364	6709807.127	5.668	5.625	-0.043
1142	568137.476	6713569.594	8.911	8.849	-0.062
1143	568137.465	6713569.592	8.887	8.848	-0.039
1146	568599.995	6713288.237	123.897	123.870	-0.027
1148	568597.884	6713312.942	124.747	124.718	-0.029
1150	569461.118	6713676.157	383.524	383.528	0.004
1152	569465.696	6713664.707	385.641	385.673	0.032
1156	568137.455	6713569.598	8.883	8.848	-0.035
102 STATIC	573648.113	6717479.707	6.712	6.663	-0.049
Average elevation difference (dZ) (m)	-0.007				
Minimum dZ (m)	-0.169				
Maximum dZ (m)	0.195				
Average magnitude error (m)	0.063				
Root mean square error (m)	0.078				
Standard deviation (m)	0.079				

APPENDIX 3: VEGETATED CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Elevation difference (Corrected Pointcloud Z - Checkpoint Z) (m)
1005	568148.585	6713609.580	8.412	8.297	-0.115
1006	568134.960	6713561.578	8.892	9.034	0.142
1009	568815.922	6715074.410	5.202	5.214	0.012
1010	568816.048	6715031.167	5.795	5.797	0.002
1012	568837.716	6715043.302	4.749	4.731	-0.018
1015	570143.586	6716608.219	6.534	6.633	0.099
1016	570205.262	6716576.796	10.940	11.089	0.149
1019	570027.794	6716475.883	5.134	4.698	-0.436
1022	568375.131	6712067.906	15.702	15.710	0.008
1023	568369.225	6712079.741	15.070	14.997	-0.073
1025	568401.210	6712079.580	14.798	14.748	-0.050
1028	567030.000	6711286.752	11.966	12.304	0.338
1029	567021.804	6711322.219	11.035	11.010	-0.025
1033	565917.295	6709816.446	19.281	19.309	0.028
1035	565891.120	6709822.907	18.542	18.675	0.133
1037	565898.593	6709805.609	18.180	18.169	-0.011
1039	564042.972	6709090.216	23.798	24.590	0.792
1040	564053.729	6709080.140	23.688	24.426	0.738
1043	564093.024	6709117.428	23.538	24.169	0.631
1045	562524.560	6708048.122	14.790	14.921	0.131
1046	562514.428	6708025.796	14.105	14.385	0.280
1047	562496.125	6708031.289	13.435	13.621	0.186
1051	561704.114	6706484.387	28.393	28.632	0.239
1052	561714.946	6706469.062	29.333	29.447	0.114
1053	561703.794	6706456.942	29.383	29.730	0.347
1055	561667.400	6706444.287	27.969	28.246	0.277
1058	560889.859	6705755.159	21.150	21.304	0.154
1059	560907.359	6705763.493	21.043	21.069	0.026
1061	560935.975	6705782.717	20.957	21.012	0.055
1063	571000.462	6712097.420	7.716	7.980	0.264
1065	570972.453	6712109.465	7.548	7.910	0.362
1066	570988.124	6712122.168	8.050	8.112	0.062
1070	572985.622	6712433.640	17.662	18.120	0.458
1071	573006.486	6712421.161	17.865	18.085	0.220
1072	573003.957	6712433.012	17.888	18.083	0.195
1076	574538.230	6711283.889	7.532	7.716	0.184
1077	574535.280	6711287.284	6.795	7.034	0.239
1079	574544.312	6711256.166	8.278	8.342	0.064
1082	575284.726	6710940.672	7.080	7.740	0.660
1084	575292.654	6710930.385	7.603	7.815	0.212
1085	575289.659	6710923.647	7.701	7.790	0.089

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Elevation difference (Corrected Pointcloud Z - Checkpoint Z) (m)
1088	570235.684	6712710.260	6.131	6.303	0.172
1089	570254.294	6712723.953	6.148	6.133	-0.015
1091	570270.652	6712770.560	8.446	8.420	-0.026
1093	571759.307	6713683.474	10.611	10.976	0.365
1099	572815.684	6715190.141	9.094	9.130	0.036
1101	572808.509	6715165.329	9.601	9.390	-0.211
1102	572802.768	6715170.627	9.519	9.721	0.202
1107	572894.093	6716766.707	9.284	9.816	0.532
1110	574255.139	6717745.105	6.357	6.436	0.079
1111	574250.782	6717750.297	6.697	6.894	0.197
1112	574258.127	6717748.162	6.379	6.403	0.024
1117	575103.474	6717984.170	9.739	10.229	0.490
1118	575097.915	6717989.513	10.240	10.453	0.213
1119	575090.897	6717985.922	10.414	10.409	-0.005
1123	576489.705	6717765.780	36.159	36.060	-0.099
1127	577018.562	6717906.729	63.875	63.917	0.042
1128	577010.976	6717896.425	63.955	64.066	0.111
1130	576974.492	6717899.734	63.789	64.199	0.410
1136	574649.866	6710833.992	24.868	25.097	0.229
1137	574642.592	6710811.909	24.648	24.942	0.294
1139	574625.968	6710705.716	23.136	23.360	0.224
1140	573983.874	6709821.817	5.440	5.509	0.069
1145	568612.680	6713268.735	122.765	122.746	-0.019
1147	568601.734	6713310.817	125.260	125.390	0.130
1149	568554.501	6713290.115	123.301	123.457	0.156
1151	569456.854	6713670.223	382.678	382.944	0.266
1153	569476.871	6713697.222	382.065	382.206	0.141
1155	569450.009	6713676.249	381.373	381.447	0.074
Average elevation difference (dZ) (m)	0.163				
Minimum dZ(m)	-0.436				
Maximum dZ (m)	0.792				
Average magnitude error (m)	0.195				
Root mean square error (m)	0.266				
Standard deviation (m)	0.211				