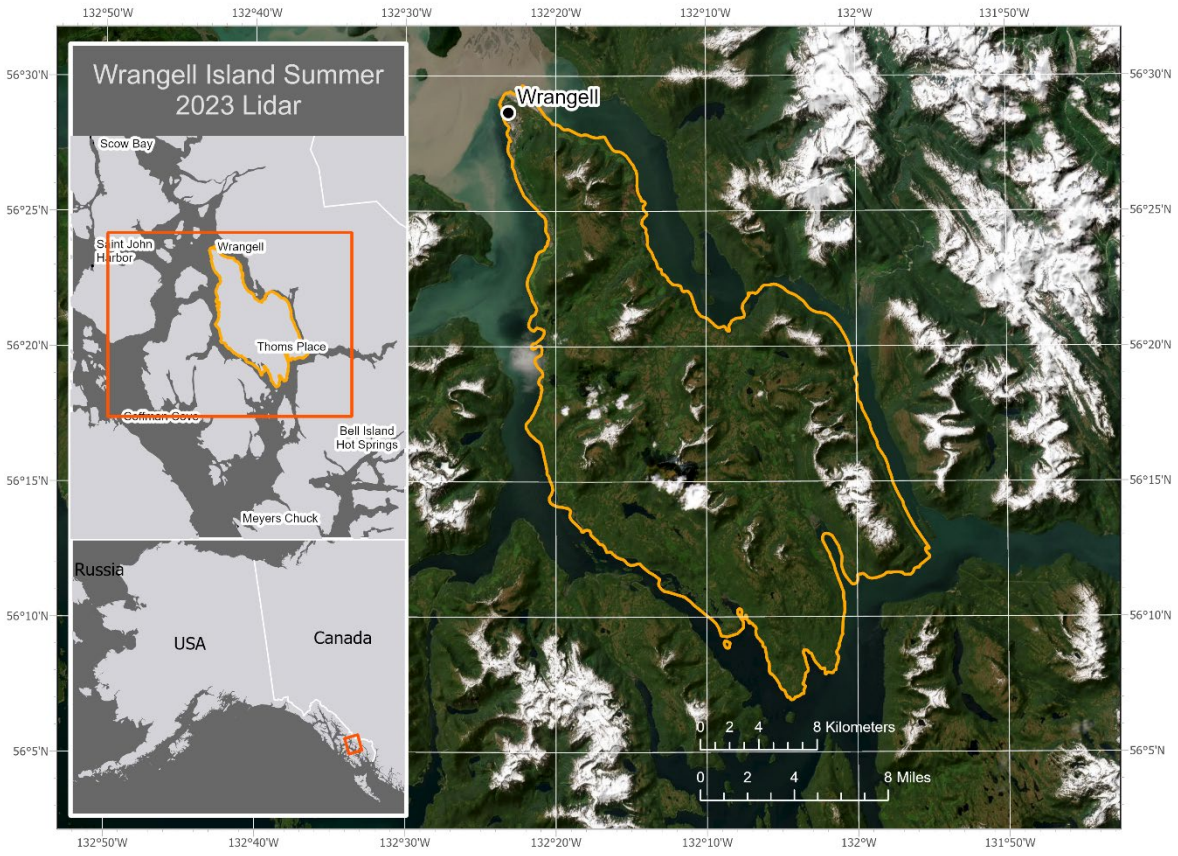
LIDAR-DERIVED ELEVATION DATA FOR WRANGELL ISLAND, SOUTHEAST ALASKA, COLLECTED JULY 2023

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

Raw Data File 2023-28



Location map of survey area.

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

2023
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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LIDAR-DERIVED ELEVATION DATA FOR WRANGELL ISLAND, SOUTHEAST ALASKA, COLLECTED JULY 2023

Jenna M. Zechmann[1], Katreen M. Wikstrom Jones[1], 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 Wrangell Island, Southeast Alaska, during leaf-on ground conditions (cover figure). The survey provides snow-free surface elevations for use in shoreline development, resource quantification, hydrographic mapping, and slope stability modeling. Ground control data were collected June 26–30, 2023, and aerial lidar data were collected July 7–11, 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/10.14509/31098.

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 150 m, or a minimum of 50,000 points per second at a range of 640 m. The scanner operated with a pulse refresh rate of 600,000 pulses per second over forested terrain, and 200,000 pulses per second over alpine terrain, with a scan rate between 50 and 200 lines per second. We used a Cessna 180 fixed-wing platform to survey from an elevation of approximately 150–350 m above ground level, at a ground speed of approximately 40 m/s, and with a scan angle set from 80 to 280 degrees. The total survey area covers approximately 565 km^2.

Weather Conditions and Flight Times

The survey area was accessed by air from Wrangell Airport (fig. 1). See table 1 for data collection start and end times, and weather conditions.

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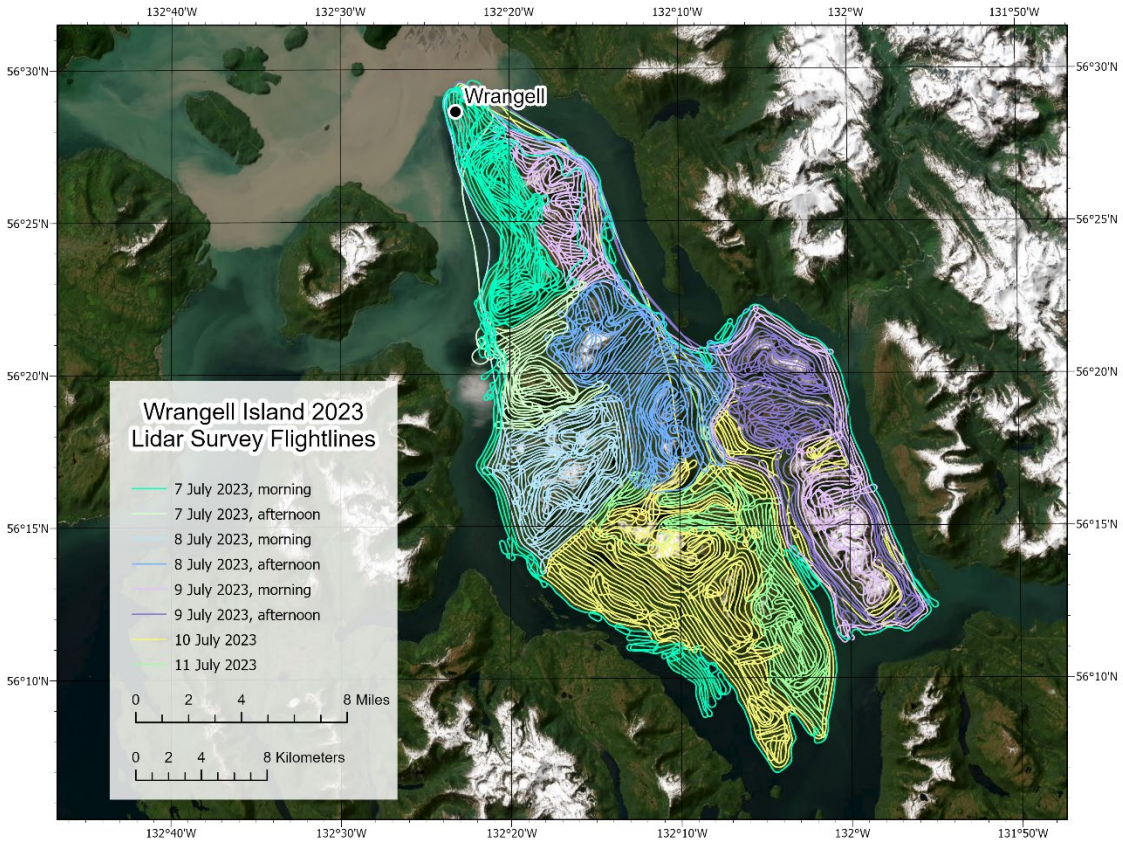

Figure 1. Lidar data collection flightlines.

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
7 July 2023	9:20 am	2:50 pm	Clear
7 July 2023	3:50 pm	5:50 pm	Haze
8 July 2023	9:50 am	1:10 pm	Haze
8 July 2023	2:30 pm	6:20 pm	Haze and wind
9 July 2023	9:50 am	2:20 pm	Haze
9 July 2023	3:20 pm	6:30 pm	Scattered clouds
10 July 2023	11:30 am	4:00 pm	Overcast
10 July 2023	4:40 pm	6:40 pm	Overcast
11 July 2023	3:50 pm	6:40 pm	Overcast

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. We processed IMU and GNSS data 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.

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.

We used ArcGIS Pro to derive raster products from the point cloud. A 50-cm DSM was interpolated from maximum return values 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 an 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 LASer (LAS) format. Data are classified following ASPRS 2019 guidelines (table 2) and contain return and intensity information. For all ground points, the average point spacing is 54.6 cm, and the average density is 3.35 pts/m^2 (fig. 2).

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 -9999.

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 -9999.

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, 16-bit unsigned GeoTIFF file of 50-cm resolution. No Data value is set to 0.

SURVEY REPORT

Ground Survey Details

Ground control points were collected June 26–30, 2023, by the Alaska Division of Mining, Land and Water (DMLW). 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 R12i GNSS receiver/TSC5 controller. Benchmark HH-2 (PID BBDX58), located on the Heritage Harbor breakwater in Wrangell, served as the base station location. DMLW collected 43 ground control points and 214 checkpoints to use for calibration and assess the vertical accuracy of the point cloud. Checkpoints were collected in forest, shrubland, grassland, sphagnum bog, bare earth, and paved surfaces.

Coordinate System and Datum

We processed and delivered all data in NAD83 (2011) UTM8N and vertical datum NAVD88 GEOID12B.

Horizontal Accuracy

Horizontal accuracy was not measured for this collection.

Vertical Accuracy

We measured a mean offset of +94.3 cm between 43 control points and the point cloud (app. 1). This offset was reduced to +0.9 cm in non-vegetated areas (app. 2) and +10.5 cm in vegetated areas (app. 3) by applying a rubber-sheet vertical correction to the lidar point data. We used 214 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 5.3 cm in non-vegetated areas (app. 2) and 17.4 cm in vegetated areas (app. 3). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 6.4 cm RMSE.

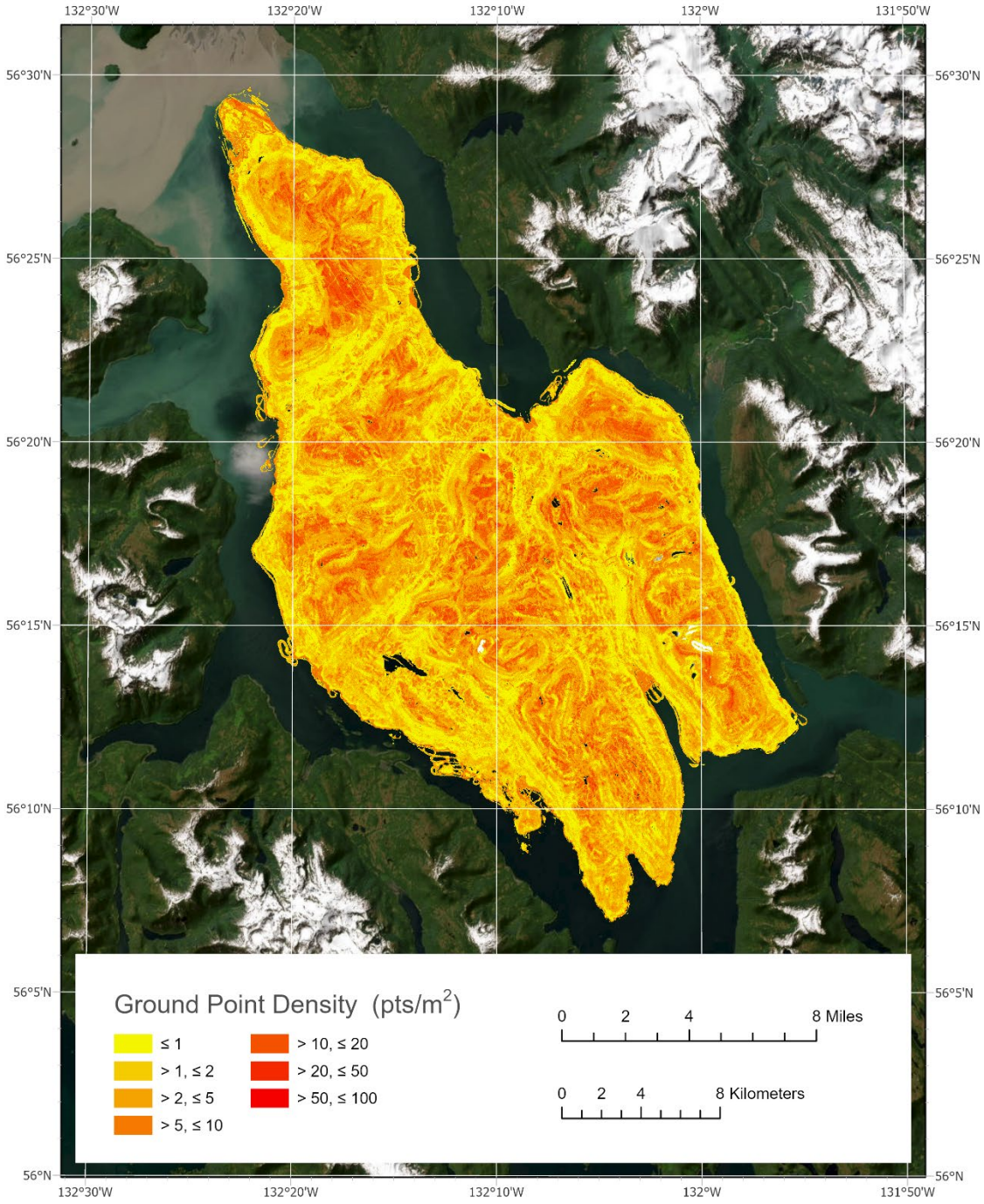

Figure 2. Ground point density for the survey displayed as a raster.

Data Consistency and Completeness

This is a full-release dataset. There was no over-collect. Data quality is consistent throughout the survey.

ACKNOWLEDGMENTS

This survey area is on the traditional homelands of the Stikine Tlingit people. For this project, we partnered with the U.S. Forest Service to cost-share the acquisition of lidar data in an area of mutual interest. We thank Clearwater Air for their aviation expertise and contribution to these data products, Dustin Wittwer and Joe Delabrue of the U.S. Forest Service for logistical help, and David Ciampa and Amy Helkenn of the Alaska Division of Mining, Land and Water for providing ground control points. 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)	Dz (m)
1	661190.532	6259765.520	6.434	6.970	0.536
2	664332.874	6247664.636	32.768	33.610	0.842
3	662822.893	6250829.371	8.649	9.361	0.712
4	664416.102	6253386.508	15.501	16.169	0.668
5	663609.366	6255696.322	6.591	7.130	0.539
6	661661.855	6258454.968	7.872	8.425	0.553
7	661373.432	6263085.991	10.815	11.166	0.351
8	662475.216	6261963.199	23.650	24.034	0.384
9	660621.749	6262528.912	17.110	17.468	0.358
10	661045.076	6261645.231	6.531	6.926	0.395
11	670890.621	6252124.398	263.047	263.774	0.727
12	670783.779	6252509.201	110.447	111.152	0.705
13	671174.808	6251343.656	200.202	200.906	0.704
14	667940.027	6250173.837	70.887	71.657	0.770
15	668032.794	6245300.403	480.108	481.121	1.013
16	667665.815	6248020.426	469.791	470.609	0.818
17	664272.969	6241405.650	198.923	200.108	1.185
18	665719.644	6238988.115	147.613	148.778	1.165
19	665709.867	6238976.308	147.910	149.006	1.096
20	666410.038	6235901.755	71.650	72.955	1.305
21	664772.463	6243871.224	40.469	41.549	1.080
22	670355.135	6244896.394	201.302	202.270	0.968
23	668180.546	6242702.264	413.298	414.358	1.060
24	672139.788	6240729.080	168.767	169.863	1.096
25	670621.772	6238019.367	78.775	79.997	1.222
26	668782.469	6236896.416	85.239	86.433	1.194
27	673138.756	6246082.658	127.778	128.736	0.958
28	672074.023	6247032.550	66.461	67.314	0.853
29	674730.264	6247658.775	108.308	109.195	0.887
30	674795.096	6247600.741	111.440	112.367	0.927
31	676619.894	6244823.871	99.810	100.752	0.942
32	677162.358	6248767.059	6.374	7.123	0.749
33	679682.224	6246624.064	192.457	193.276	0.819
34	677154.324	6241794.677	218.441	219.587	1.146
35	677222.865	6241742.561	219.637	220.730	1.093
36	681463.242	6238819.982	89.382	90.562	1.180
37	680087.065	6237172.281	92.341	93.656	1.315
38	677935.652	6235417.342	216.511	217.809	1.298
39	676209.210	6233336.801	159.520	160.797	1.277
40	675142.417	6231121.626	72.192	73.778	1.586
41	672977.887	6233708.887	150.768	152.150	1.382
42	681162.969	6235091.111	175.553	176.784	1.231

GCP	Easting (m)	Northing (m)	GCP Z (m)	Pointcloud Z (m)	Dz (m)
43	683483.622	6232487.681	95.389	96.846	1.457
Average dz (m)	0.943				
Minimum dz (m)	0.351				
Maximum dz (m)	1.586				
Average magnitude error (m)	0.943				
Root mean square error (m)	0.992				
Standard deviation	0.313				

APPENDIX 2: NONVEGETATED CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
7	661175.208	6259760.100	6.281	6.312	0.031
2	664420.405	6247819.743	45.273	45.223	-0.050
3	664416.482	6247829.808	45.556	45.533	-0.023
4	676626.036	6244828.453	99.389	99.468	0.079
5	676636.493	6244827.368	98.967	99.024	0.057
6	671727.046	6243382.839	130.662	130.726	0.064
7	676200.465	6233331.487	158.348	158.393	0.045
8	661175.216	6259760.100	6.276	6.312	0.036
9	661167.455	6259713.129	4.129	4.128	-0.001
10	661144.506	6259801.022	5.564	5.570	0.006
11	661134.744	6259835.947	2.681	2.673	-0.008
12	664420.390	6247819.736	45.281	45.222	-0.059
13	664416.478	6247829.805	45.561	45.532	-0.029
14	664344.257	6247675.496	34.129	34.141	0.012
15	664292.853	6247665.676	30.964	30.973	0.009
16	662835.592	6250884.603	8.720	8.684	-0.036
17	662807.692	6250848.927	3.826	3.788	-0.038
18	664412.276	6253401.050	14.869	14.872	0.003
19	664436.244	6253416.538	15.871	15.892	0.021
20	663586.549	6255632.696	7.545	7.529	-0.016
21	663583.244	6255606.885	7.120	7.084	-0.036
22	661668.493	6258460.207	8.506	8.482	-0.024
23	661607.287	6258478.990	2.703	2.645	-0.058
24	661394.518	6263081.294	10.818	10.833	0.015
25	662472.957	6261957.106	23.530	23.528	-0.002
26	664727.693	6261103.835	23.574	23.543	-0.031
27	665368.096	6260737.408	76.505	76.446	-0.059
28	665951.913	6260796.046	29.183	29.135	-0.048
29	660625.520	6262483.390	15.877	15.901	0.024
30	660615.507	6262516.874	16.039	16.048	0.009
31	661120.484	6261629.044	6.609	6.613	0.004
32	661085.998	6261688.336	8.839	8.832	-0.007
33	661175.206	6259760.092	6.267	6.311	0.044
34	664416.479	6247829.795	45.557	45.532	-0.025
35	670900.190	6252124.669	262.742	262.805	0.063
36	669001.551	6256004.242	155.984	156.006	0.022
37	669357.080	6254376.678	139.148	139.150	0.002
38	669921.974	6252660.947	39.750	39.719	-0.031
39	664416.486	6247829.801	45.557	45.533	-0.024
40	664416.490	6247829.812	45.558	45.533	-0.025
41	671671.453	6250235.282	190.219	190.248	0.029
42	670967.804	6250712.484	400.318	400.433	0.115

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
43	667934.323	6250146.822	70.997	71.051	0.054
44	668006.298	6245294.236	481.614	481.613	-0.001
45	667637.360	6248034.404	467.415	467.462	0.047
46	667020.557	6243889.116	136.283	136.118	-0.165
47	667029.719	6243895.763	136.084	135.972	-0.112
48	664274.473	6241425.309	199.619	199.518	-0.101
49	666419.711	6235902.943	72.542	72.550	0.008
50	664785.334	6243866.375	41.161	41.185	0.024
51	664802.357	6243886.354	40.949	40.930	-0.019
52	664416.486	6247829.807	45.539	45.533	-0.006
53	670377.251	6244893.258	200.669	200.680	0.011
54	668171.726	6242726.262	410.901	410.892	-0.009
55	672128.478	6240709.683	168.697	168.724	0.027
56	670596.343	6237993.443	76.189	76.211	0.022
57	668826.144	6236911.651	85.900	85.996	0.096
58	673151.973	6246111.433	127.513	127.518	0.005
59	672054.886	6247069.761	69.964	69.972	0.008
60	676636.506	6244827.394	98.975	99.021	0.046
61	676626.051	6244828.469	99.396	99.464	0.068
62	676647.301	6244788.606	99.220	99.251	0.031
63	677128.514	6248715.140	10.718	10.619	-0.099
64	677129.380	6248756.756	5.896	5.905	0.009
65	679659.391	6246608.433	191.960	191.946	-0.014
66	676626.037	6244828.460	99.378	99.467	0.089
67	679839.773	6241211.790	150.097	150.205	0.108
68	679895.717	6241208.244	148.543	148.632	0.089
69	681468.702	6238853.044	90.424	90.517	0.093
70	680070.583	6237199.925	90.402	90.412	0.010
71	678001.114	6235450.152	220.818	220.808	-0.010
72	676194.555	6233293.980	154.388	154.435	0.047
73	675131.070	6231133.974	71.209	71.309	0.100
74	672992.193	6233706.759	149.709	149.689	-0.020
75	681197.889	6235069.597	173.395	173.481	0.086
76	683466.990	6232491.925	95.911	95.896	-0.015
77	676626.044	6244828.452	99.376	99.469	0.093
Average dz (m)	0.009				
Minimum dz (m)	-0.165				
Maximum dz (m)	0.115				
Average magnitude error (m)	0.040				

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
Root mean square error (m)	0.053				
Standard deviation (m)	0.052				

APPENDIX 3: VEGETATED CHECK POINTS

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
78	661188.843	6259745.231	5.008	5.221	0.213
79	661163.712	6259737.654	4.853	4.966	0.113
80	661229.031	6259732.045	6.101	6.187	0.086
81	664352.603	6247692.345	34.429	34.720	0.291
82	662822.302	6250873.882	6.582	6.714	0.132
83	662811.910	6250830.328	5.176	5.164	-0.012
84	664414.593	6253407.873	14.504	14.687	0.183
85	664435.208	6253398.200	15.985	16.217	0.232
86	664409.924	6253376.571	15.289	15.343	0.054
87	664421.350	6253430.110	11.619	11.544	-0.075
88	663596.420	6255676.882	7.020	7.194	0.174
89	663595.073	6255692.526	7.048	7.304	0.256
90	663604.848	6255691.940	6.455	6.533	0.078
91	663585.595	6255590.480	6.728	6.776	0.048
92	661672.989	6258464.789	7.492	7.595	0.103
93	661609.035	6258499.075	4.084	4.141	0.057
94	661380.940	6263092.953	10.618	10.708	0.090
95	662449.873	6261956.781	22.616	22.646	0.030
96	662460.247	6261952.096	21.964	22.289	0.325
97	662468.880	6261942.576	22.189	22.274	0.085
98	664728.244	6261093.984	24.221	24.370	0.149
99	664716.982	6261104.641	25.923	26.014	0.091
100	665367.794	6260731.277	75.365	75.490	0.125
101	665361.510	6260723.879	81.126	81.157	0.031
102	665349.600	6260708.462	84.203	84.239	0.036
103	665371.992	6260745.513	75.525	75.404	-0.121
104	665952.162	6260790.081	28.654	28.775	0.121
105	665957.982	6260781.841	31.389	31.438	0.049
106	665905.640	6260774.997	26.984	26.715	-0.269
107	670901.427	6252137.770	262.991	262.989	-0.002
108	670908.154	6252140.817	263.922	263.906	-0.016
109	670893.384	6252112.821	262.576	262.841	0.265
110	670770.333	6252516.469	108.803	108.598	-0.205
111	670777.939	6252508.904	109.768	109.855	0.087

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
112	670774.425	6252502.264	112.819	112.854	0.035
113	670792.416	6252512.114	109.278	109.239	-0.039
114	668986.517	6256002.228	158.780	158.765	-0.015
115	668981.297	6255997.123	161.381	161.587	0.206
116	669019.548	6255917.733	155.937	155.805	-0.132
117	669032.874	6255915.708	154.273	154.653	0.380
118	669363.557	6254378.675	137.890	137.680	-0.210
119	669374.664	6254377.232	135.587	135.584	-0.003
120	669367.664	6254383.520	136.782	136.990	0.208
121	669375.242	6254393.878	135.385	135.646	0.261
122	669344.300	6254374.459	141.050	141.125	0.075
123	669924.863	6252657.564	39.760	39.868	0.108
124	669932.496	6252646.015	40.185	40.387	0.202
125	669918.644	6252682.824	37.789	37.883	0.094
126	671677.908	6250230.967	191.234	191.319	0.085
127	671666.580	6250239.488	189.391	189.457	0.066
128	671656.061	6250239.417	188.478	188.256	-0.222
129	671168.923	6251345.160	199.583	199.648	0.065
130	671165.803	6251337.915	202.067	201.966	-0.101
131	671182.865	6251341.915	199.135	199.289	0.154
132	670973.793	6250706.598	398.209	398.612	0.403
133	670955.960	6250702.016	403.694	403.843	0.149
134	670953.692	6250705.942	404.246	404.394	0.148
135	667935.278	6250169.121	70.516	70.682	0.166
136	667942.531	6250159.169	70.855	71.065	0.210
137	667940.291	6250144.796	70.701	70.816	0.115
138	668012.083	6245306.414	482.476	482.545	0.069
139	668021.276	6245309.133	482.181	482.311	0.130
140	668029.062	6245314.052	481.633	481.773	0.140
141	667645.707	6248035.767	467.181	467.327	0.146
142	667661.106	6248033.429	468.326	468.792	0.466
143	667663.571	6248041.391	467.803	467.904	0.101
144	667020.607	6243895.720	135.989	136.044	0.055
145	667009.195	6243892.348	135.626	135.661	0.035
146	667014.526	6243896.003	135.925	136.027	0.102
147	664276.574	6241399.478	198.848	198.676	-0.172
148	664281.331	6241411.365	199.752	199.732	-0.020
149	664288.241	6241394.159	202.305	202.384	0.079
150	665726.058	6238992.547	146.606	146.757	0.151
151	665723.467	6238976.888	148.208	148.468	0.260
152	665735.305	6238973.016	150.221	150.341	0.120
153	666407.587	6235902.031	71.373	71.480	0.107
154	666426.665	6235898.651	72.173	72.531	0.358

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
155	666428.525	6235900.016	72.673	72.957	0.284
156	664787.500	6243872.030	40.720	40.765	0.045
157	664810.891	6243888.221	40.399	40.561	0.162
158	670370.013	6244883.021	201.717	201.815	0.098
159	670372.790	6244867.779	203.984	204.147	0.163
160	670383.792	6244877.956	201.344	201.404	0.060
161	668172.474	6242710.994	412.846	412.999	0.153
162	668191.391	6242711.336	412.884	413.103	0.219
163	668164.475	6242725.249	411.330	411.384	0.054
164	672159.455	6240707.974	168.260	168.261	0.001
165	672155.307	6240686.603	167.996	168.137	0.141
166	672157.369	6240731.169	168.078	168.199	0.121
167	670595.870	6237984.724	76.319	76.038	-0.281
168	670613.002	6238017.327	76.938	77.378	0.440
169	668813.874	6236914.087	86.068	86.324	0.256
170	668795.466	6236895.338	85.236	84.976	-0.260
171	668848.299	6236915.662	84.754	85.010	0.256
172	673154.524	6246090.582	130.029	130.100	0.071
173	673156.952	6246095.001	129.827	129.969	0.142
174	673127.542	6246075.768	125.694	125.968	0.274
175	672065.733	6247033.049	66.106	66.227	0.121
176	672063.304	6247028.019	67.273	67.146	-0.127
177	672065.084	6247062.446	67.479	67.477	-0.002
178	674739.870	6247638.802	109.329	109.389	0.060
179	674764.933	6247627.731	109.704	110.062	0.358
180	674799.108	6247605.910	110.949	111.159	0.210
181	676597.354	6244807.854	101.686	101.817	0.131
182	676611.306	6244788.839	102.356	102.390	0.034
183	676655.697	6244800.606	98.316	98.206	-0.110
184	677173.913	6248761.831	6.220	6.273	0.053
185	677154.901	6248743.154	6.461	6.712	0.251
186	677123.018	6248716.394	9.895	10.119	0.224
187	679687.762	6246631.805	193.042	193.064	0.022
188	679698.850	6246623.741	191.290	191.291	0.001
189	679626.223	6246604.558	190.659	190.787	0.128
190	677163.467	6241793.320	218.159	218.391	0.232
191	677177.621	6241765.371	218.938	219.104	0.166
192	677211.951	6241742.524	219.871	219.946	0.075
193	679862.810	6241222.953	148.937	149.004	0.067
194	679868.039	6241205.819	148.737	148.917	0.180
195	679885.413	6241217.134	148.594	148.820	0.226
196	681456.445	6238820.773	88.148	88.506	0.358
197	681472.021	6238838.010	88.774	89.002	0.228

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Dz (m)
198	680100.309	6237159.879	91.822	92.018	0.196
199	680119.440	6237173.836	91.409	91.484	0.075
200	680078.621	6237203.447	89.197	89.350	0.153
201	677952.772	6235418.239	216.402	216.607	0.205
202	677948.431	6235433.405	219.062	218.984	-0.078
203	677991.478	6235456.734	221.712	221.760	0.048
204	676203.039	6233336.592	159.008	159.012	0.004
205	676188.193	6233294.644	152.639	152.852	0.213
206	675132.066	6231124.663	71.533	71.483	-0.050
207	675139.271	6231133.092	71.476	71.491	0.015
208	672969.949	6233710.833	151.018	150.920	-0.098
209	672961.100	6233700.947	152.328	152.484	0.156
210	681172.838	6235090.447	174.265	174.524	0.259
211	681191.043	6235079.508	172.804	172.944	0.140
212	683458.480	6232489.363	96.658	96.895	0.237
213	683463.759	6232456.394	99.709	99.850	0.141
214	683464.003	6232471.027	98.314	98.521	0.207
Average dz (m)	0.105				
Minimum dz (m)	-0.281				
Maximum dz (m)	0.466				
Average magnitude error (m)	0.144				
Root mean square error (m)	0.174				
Standard deviation (m)	0.139				