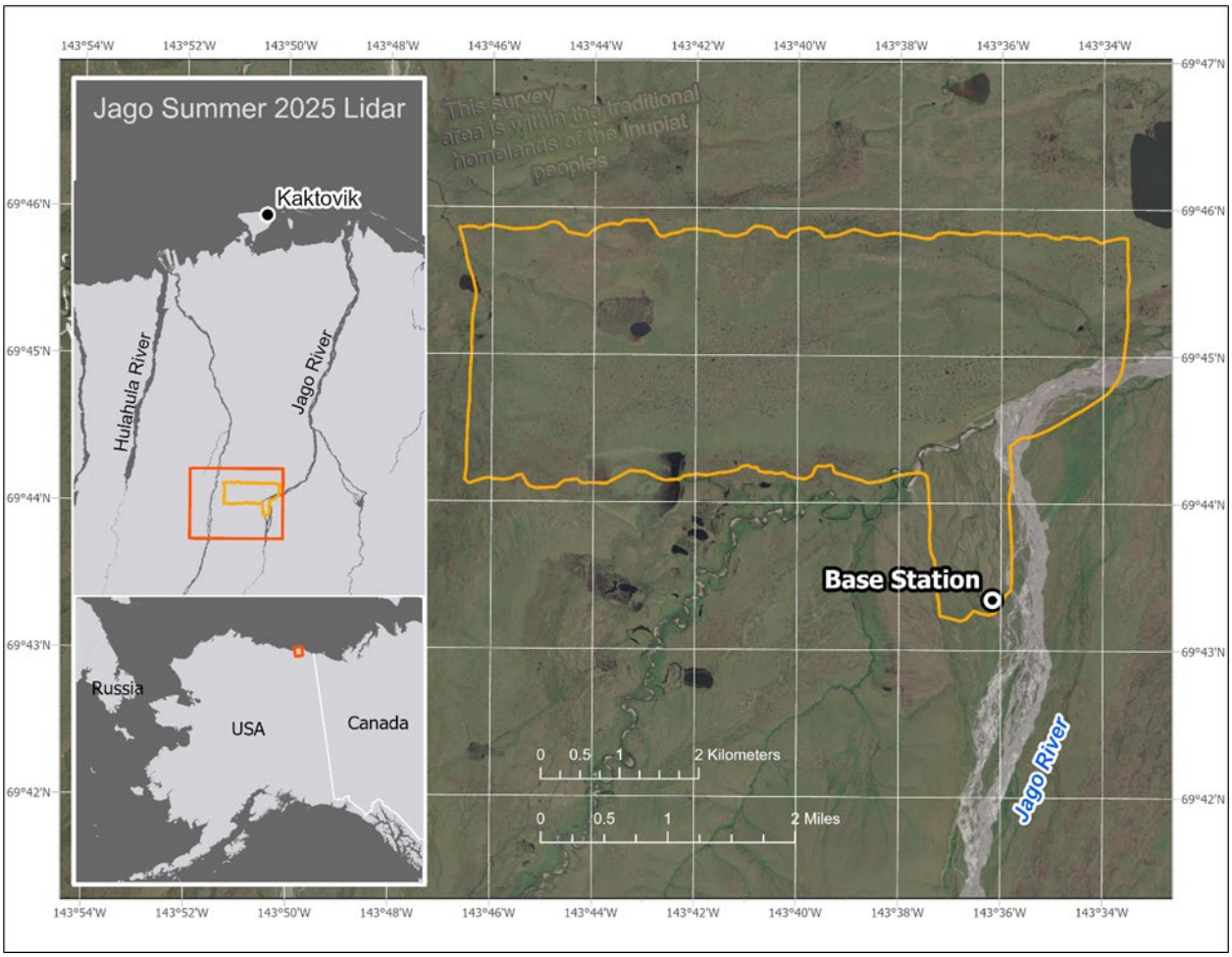
LIDAR-DERIVED ELEVATION DATA FOR JAGO RIVER PERMAFROST RESEARCH SITE, COLLECTED AUGUST 1, 2025

Jenna M. Zechmann, Anna K. Liljedahl, Gabriel J. Wolken, M. Torre Jorgenson, and Chandi Witharana

Raw Data File 2025-30



Location map of the survey area.

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

2025
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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Suggested citation:
Zechmann, J.M., Liljedahl, A.K., Wolken, G.J., Jorgenson, M.T., and Witharana, Chandi, 2025, Lidar-derived elevation data for Jago River permafrost research site, collected August 1, 2025: Alaska Division of Geological & Geophysical Surveys Raw Data File 2025-30, 15 p. https://doi.org/10.14509/31748

LIDAR-DERIVED ELEVATION DATA FOR JAGO RIVER PERMAFROST RESEARCH SITE, COLLECTED AUGUST 1, 2025

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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 a permafrost study area adjacent to the Jago River, Northern Alaska, during snow-free conditions (cover figure). Surface elevations were acquired for permafrost evolution studies. Aerial lidar data were collected on August 1, 2025, and ground control data were collected August 1–3, 2025. These datasets were merged and processed using geospatial 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/10.14509/31748.

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 with a global navigation satellite system (GNSS) and a Northrop Grumman LN-200C inertial measurement unit (IMU) integrated by Phoenix LiDAR Systems. The sensor can collect up to 1,500,000 points per second at a range of 230 m, or a minimum of 50,000 points per second at 1,000 m (ranges assume ≥ 20 percent natural reflectance). The scanner operated with a pulse refresh rate of 1,500,000 pulses per second at a scan rate of 200 revolutions per second. We used a Robinson R44 helicopter to survey from an elevation of approximately 100–150 m above ground level, at a ground speed of approximately 30 m/s, and with a scan angle set from 120 to 240 degrees. The total survey area covers approximately 26.3 km^2 (cover figure).

Weather Conditions and Flight Times

The survey area was accessed by air (fig. 1) from Toolik Field Station. Data were collected from 1:05 pm to 3:55 pm (AKST). The weather throughout the survey was clear with no wind.

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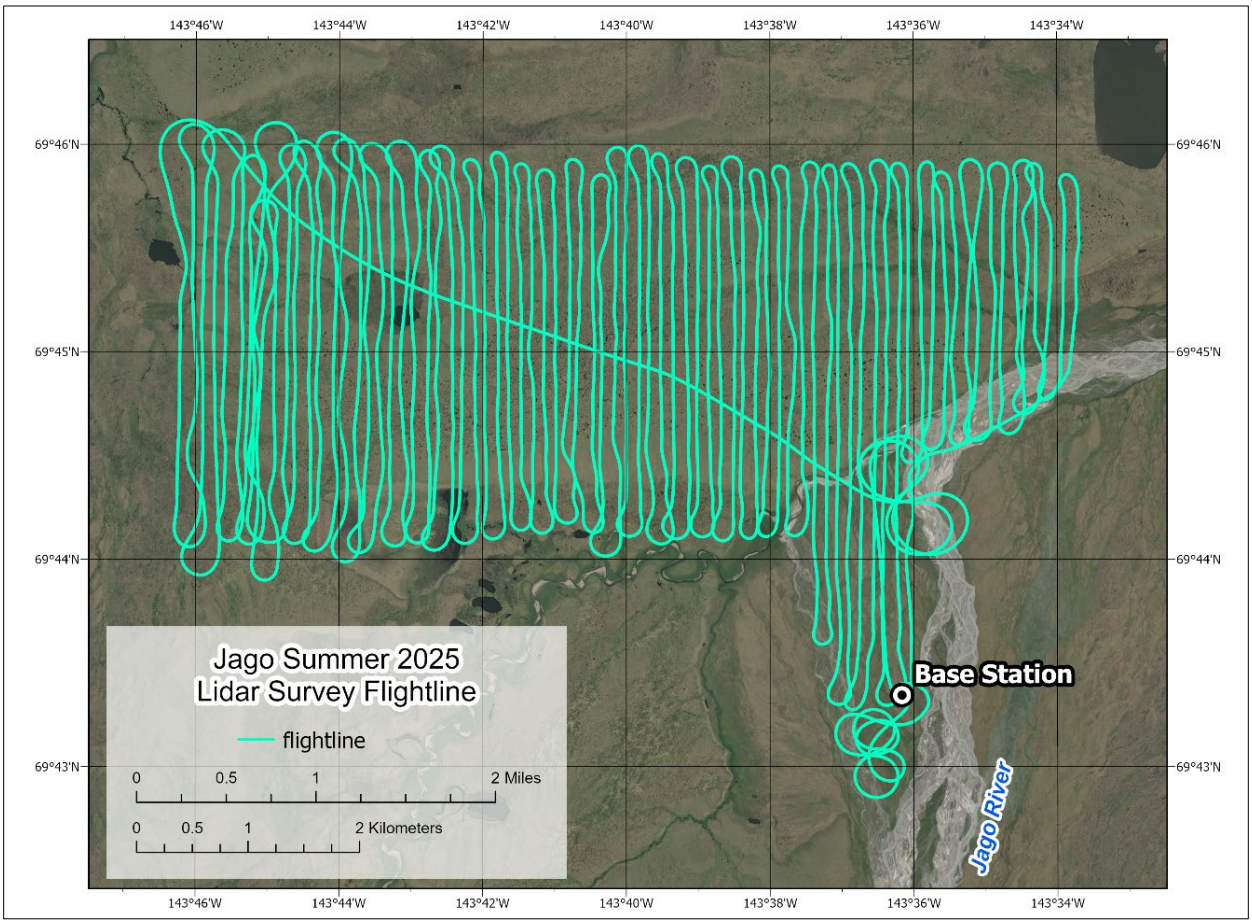

Figure 1. Lidar data collection flightline.

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 150.3 pulses/m^2, and the average pulse spacing is 8.2 cm.

We created a macro (an ordered list of point classification commands tailored to this dataset) in Terrasolid software and classified points in accordance with the American Society for Photogrammetry & Remote Sensing (ASPRS) 2025 guidelines (ASPRS, 2025). 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 10-cm DSM was interpolated from ground and vegetation classes using a binning method and maximum values. A 10-cm DTM was interpolated from all ground-class returns using a binning method and minimum values. We also produced a 10-cm intensity image using average binning in ArcGIS Pro, with no normalization or corrections applied.

Classified Point Cloud

Classified point cloud data are provided in LAZ format. Classification follows ASPRS 2025 standards (table 1) with return and intensity values. Ground-classified points have a mean density of 41.1 pts/m² (fig. 2) and an average spacing of 15.6 cm.

Table 1. Point cloud class code definitions.

Class Code	Description
1	Unclassified
2	Ground
3	Low Vegetation, ≥0.0m, <0.2m
4	Medium Vegetation, ≥0.2m, <0.6m
5	High Vegetation, ≥0.6m, ≤10m
6	Structure (tents, barrels)
7	Low Noise
12	Wide Angle Points, ≤-45° or ≥45°
18	High Noise
30	Noise (manually classified)

Digital Surface Model

The DSM represents surface elevations, including heights of vegetation and structures. The DSM is a single-band, 32-bit tiled GeoTIFF dataset of 10-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 and structures. The DTM is a single-band, 32-bit tiled GeoTIFF dataset of 10-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 tiled GeoTIFF dataset of 10-cm resolution. No Data value is set to -3.40282306074e+38.

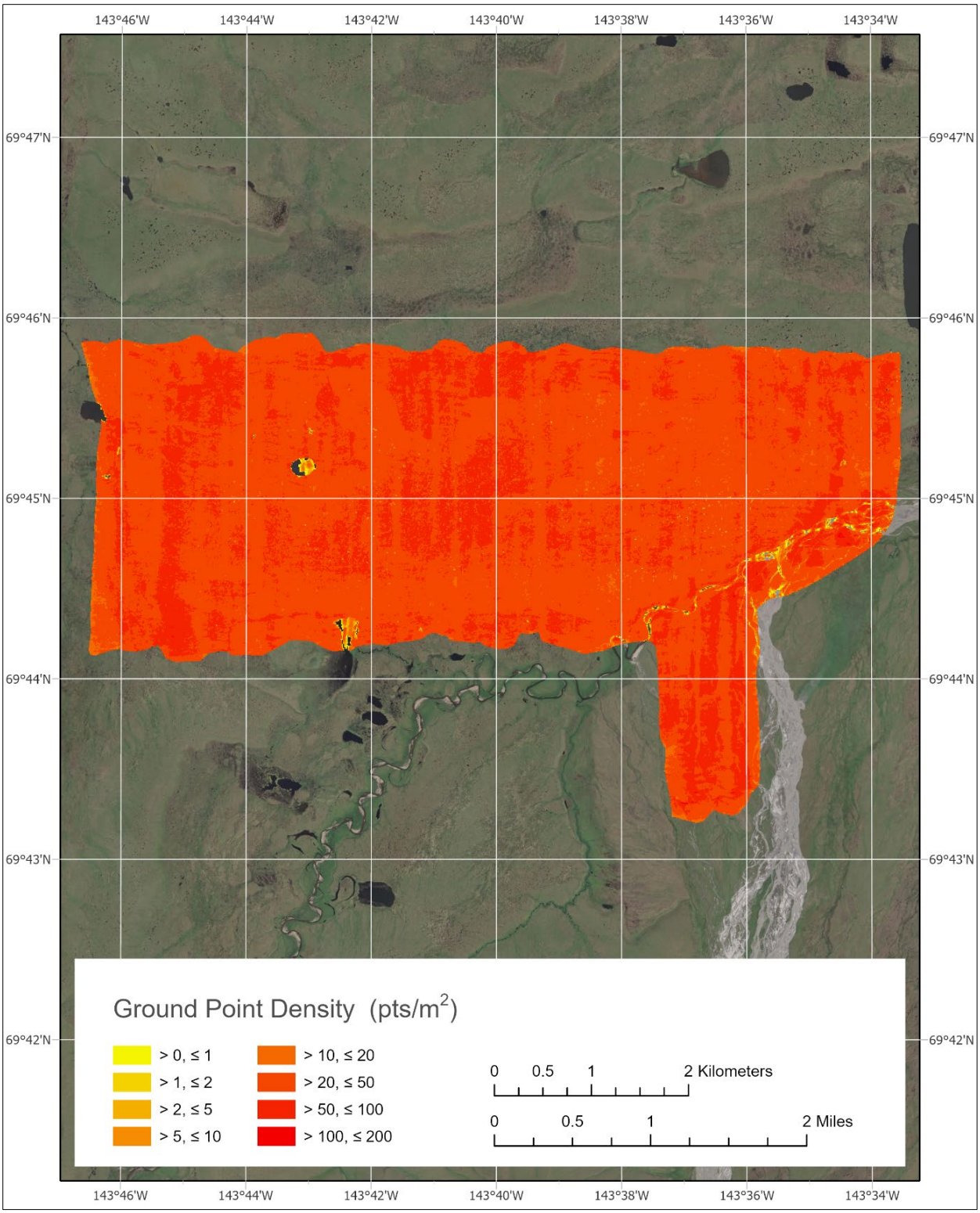

Figure 2. Ground point density for the survey, displayed as a raster.

SURVEY REPORT

Ground Survey Details

On August 1, 2025, we established a GNSS base station at the field camp using a Trimble R12i (fig. 1) to support subsequent correction of lidar survey flightlines. This location also served as the base station for ground control point collection. Ground control points were collected on August 1-3, 2025. We deployed a Trimble R12i GNSS base receiver and surveyed points with a rover Trimble R12i GNSS receiver/Mesa3 controller within the survey area. We collected 157 ground control points and checkpoints; ground control points were collected on bare earth (gravel), and checkpoints were taken in areas of bare earth, tundra vegetation, reeds, shrubs, and tussocks. Where possible, we surveyed existing markers (rock piles, tents, and barrels) to determine horizontal accuracy later.

Coordinate System and Datum

Data were processed and are provided in NAD83(2011) UTM Zone 7 North, with vertical referencing to the NAVD88 (GEOID12B) datum.

Horizontal Accuracy

The offset between the pointcloud (visualized as a DSM hillshade or intensity image) and 20 ground control points was 2.2 cm measured west to east and 3.7 cm measured south to north (app. 1). This was changed to -4.4 cm and +0.7 cm, respectively, by applying a constant horizontal correction (app. 2). We used 17 checkpoints to determine the horizontal accuracy of the corrected point cloud by measuring the offset between checkpoints and their respective locations in the dsm and/or intensity image produced from the corrected point cloud. The project's horizontal accuracy has a root-mean-square error (RMSE) of 10.5 cm in the east-west direction and 8.3 cm in the north-south direction (app. 2).

Vertical Accuracy

We measured a mean elevation offset of -1.5 cm between 37 control points and the point cloud (app. 3). This offset was changed to +1.8 cm in non-vegetated areas (app. 4) and +13.1 cm in vegetated areas (app. 5) by applying a constant vertical correction of +1.5 cm to the lidar point data. We used 37 non-vegetated and 67 vegetated checkpoints to determine the vertical accuracy of the point cloud ground class using a Triangulated Irregular Network (TIN) approach. The project's vertical accuracy has an RMSE of 8.7 cm in non-vegetated areas (app. 4) and 18.6 cm in vegetated areas (app. 5). We evaluated the relative accuracy of this dataset using interswath overlap consistency and found a 5.7 cm RMSE.

Data Consistency and Completeness

This is a full-release dataset. There was no over-collect. Data quality is consistent throughout the survey, save for gaps over bodies of water.

ACKNOWLEDGMENTS

A subaward from the National Science Foundation, grant number 2234117, funded this work. We thank Alpine Air Alaska for their aviation expertise and for their contributions to these data products, and Toolik Field Station and Battelle ARO for providing logistical support. 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), 2025, LAS Specification 1.4 - R16. https://publicdocuments.asprs.org/las-v14-r16-2025

APPENDIX 1: HORIZONTAL GROUND CONTROL POINTS

GCP	Easting (m)	Northing (m)	Point Cloud Easting (m)	Point Cloud Northing (m)	Easting Offset (Point Cloud X – GCP X) (m)	Northing Offset (Point Cloud Y – GCP Y) (m)
4	399424.555	7737054.449	399424.708	7737054.633	0.153	0.183
5	399425.388	7737054.249	399425.476	7737054.302	0.088	0.053
7	399424.760	7737055.224	399424.910	7737055.360	0.150	0.136
9	399423.375	7737066.565	399423.491	7737066.714	0.116	0.148
16	399215.171	7737112.899	399215.321	7737112.814	0.149	-0.085
18	399211.266	7737105.646	399211.410	7737105.564	0.144	-0.081
20	399211.717	7737104.597	399211.773	7737104.611	0.057	0.014
21	399212.033	7737105.296	399212.024	7737105.273	-0.009	-0.022
27	399305.676	7737053.900	399305.566	7737053.865	-0.110	-0.035
28	399305.847	7737054.702	399305.858	7737054.670	0.011	-0.032
29	399348.794	7737046.451	399348.719	7737046.466	-0.075	0.015
31	399351.162	7737044.912	399351.183	7737044.883	0.020	-0.030
32	399348.779	7737044.796	399348.784	7737044.753	0.005	-0.042
36	399334.751	7737059.579	399334.554	7737059.635	-0.197	0.057
37	399332.899	7737060.611	399332.917	7737060.858	0.019	0.247
38	399333.292	7737062.908	399333.351	7737062.850	0.059	-0.058
49	399316.422	7737158.803	399316.435	7737158.691	0.013	-0.112
87	399313.180	7737064.426	399313.176	7737064.617	-0.004	0.191
88	399313.860	7737063.616	399313.766	7737063.583	-0.095	-0.033
89	399314.734	7737064.314	399314.792	7737064.456	0.058	0.142
126	400241.972	7739843.441	400241.882	7739843.570	-0.090	0.129
				Average Offset (m)	0.022	0.037
				Minimum Offset (m)	-0.197	-0.112
				Maximum Offset (m)	0.153	0.247
				Average Magnitude Error (m)	0.077	0.088
				Root Mean Square Error (m)	0.096	0.109
				Standard Deviation (m)	0.096	0.105

APPENDIX 2: HORIZONTAL CHECKPOINTS

Check Point Name	Easting (m)	Northing (m)	Corrected Point Cloud Easting (m)	Corrected Point Cloud Northing (m)	Easting Offset (Corrected Point Cloud X – GCP X) (m)	Northing Offset (Corrected Point Cloud Y – GCP Y) (m)
6	399425.606	7737055.058	399425.528	7737055.035	-0.078	-0.023
8	399426.523	7737066.161	399426.550	7737066.127	0.027	-0.033
17	399212.952	7737113.351	399212.864	7737113.390	-0.089	0.039
19	399211.019	7737104.919	399211.093	7737104.981	0.074	0.061
25	399304.838	7737054.814	399304.860	7737054.897	0.021	0.082
26	399304.827	7737054.042	399304.812	7737054.041	-0.015	-0.001
30	399351.041	7737046.579	399351.074	7737046.645	0.033	0.066
34	399349.880	7737047.278	399349.762	7737047.294	-0.119	0.015
35	399338.716	7737059.664	399338.481	7737059.526	-0.235	-0.138
39	399335.085	7737064.168	399334.863	7737064.049	-0.222	-0.119
40	399338.974	7737063.726	399338.781	7737063.861	-0.194	0.134
48	399316.313	7737157.845	399316.342	7737157.750	0.029	-0.095
86	399314.087	7737065.639	399314.026	7737065.495	-0.061	-0.144
124	400240.663	7739843.681	400240.665	7739843.758	0.003	0.077
125	400241.332	7739842.882	400241.375	7739842.942	0.043	0.061
127	400241.375	7739844.212	400241.350	7739844.267	-0.025	0.055
Base	399354.811	7737066.353	399354.866	7737066.435	0.055	0.082
				Average Offset (m)	-0.044	0.007
				Minimum Offset (m)	-0.235	-0.144
				Maximum Offset (m)	0.074	0.134
				Average Magnitude Error (m)	0.078	0.072
				Root Mean Square Error (m)	0.105	0.083
				Standard Deviation (m)	0.098	0.086

APPENDIX 3: VERTICAL GROUND CONTROL POINTS

GCP	Easting (m)	Northing (m)	GCP Z (m)	Point Cloud Z (m)	Elevation Difference (Point Cloud Z – GCP Z) (m)
1	**399357.471**	**7737065.337**	**150.055**	**150.047**	**-0.008**
3	399401.035	7737053.953	150.526	150.447	-0.079
4	399424.555	7737054.449	150.334	150.329	-0.005
7	399424.760	7737055.224	150.318	150.327	0.009
8	399426.523	7737066.161	150.549	150.486	-0.063
9	399423.375	7737066.565	150.512	150.459	-0.053
12	399301.239	7737090.319	150.026	149.982	-0.044
15	399227.012	7737102.710	149.707	149.628	-0.079
16	399215.171	7737112.899	149.619	149.562	-0.057
19	399211.019	7737104.919	149.582	149.511	-0.071
20	399211.717	7737104.597	149.581	149.514	-0.067
22	399214.100	7737104.579	149.620	149.554	-0.066
23	399214.665	7737105.187	149.638	149.553	-0.085
27	399305.676	7737053.900	150.096	150.099	0.003
44	399318.859	7737060.580	150.193	150.164	-0.029
46	399338.972	7737106.070	150.108	150.069	-0.039
47	399319.472	7737144.491	149.972	149.945	-0.027
48	399316.313	7737157.845	149.822	149.818	-0.004
49	399316.422	7737158.803	149.832	149.741	-0.091
50	399315.379	7737158.855	149.816	149.762	-0.054
67	399348.264	7737399.709	148.569	148.517	-0.052
73	399328.735	7737275.582	149.189	149.117	-0.072
75	399272.028	7737195.121	149.625	149.540	-0.085
76	399281.237	7737186.753	149.679	149.625	-0.054
85	399311.407	7737070.708	149.908	149.887	-0.021
90	399359.939	7737060.292	150.277	150.229	-0.048
91	399323.510	7737311.939	149.064	148.987	-0.077
97	399395.993	7737834.126	145.476	145.432	-0.044
100	399412.948	7738314.657	142.626	142.584	-0.042
104	399412.563	7738737.711	140.473	140.514	0.041
105	399372.004	7738867.169	139.804	139.886	0.082
106	399369.101	7739002.371	139.051	139.088	0.037
108	399326.948	7739150.945	138.244	138.313	0.069
110	399281.223	7739288.726	137.691	137.778	0.087
124	400240.663	7739843.681	133.532	133.719	0.187
126	400241.972	7739843.441	133.555	133.742	0.187
130	400175.467	7739793.898	133.750	133.896	0.146

Average Elevation Difference (Dz) (M)	-0.015				
Minimum Dz (M)	-0.091				
Maximum Dz (M)	0.187				
Average Magnitude Error (M)	0.061				
Root Mean Square Error (M)	0.074				
Standard Deviation (M)	0.074				

APPENDIX 4: NONVEGETATED VERTICAL CHECK POINTS

Check Point Name	Easting (m)	Northing (m)	Check Point Z (m)	Corrected Point Cloud Z (m)	Elevation Difference (Corrected Point Cloud Z –Check Point Z) (m)
2	399377.680	7737047.308	150.385	150.335	-0.050
5	399425.388	7737054.249	150.341	150.336	-0.005
6	399425.606	7737055.058	150.338	150.331	-0.007
10	399353.169	7737077.929	150.311	150.270	-0.041
11	399319.705	7737085.268	150.078	150.087	0.009
13	399285.823	7737093.927	149.986	149.943	-0.043
14	399250.349	7737100.825	149.692	149.647	-0.045
17	399212.952	7737113.351	149.601	149.541	-0.060
18	399211.266	7737105.646	149.594	149.538	-0.056
21	399212.033	7737105.296	149.597	149.510	-0.087
24	399267.701	7737069.822	149.953	149.863	-0.090
25	399304.838	7737054.814	150.107	150.096	-0.011
26	399304.827	7737054.042	150.119	150.123	0.004
28	399305.847	7737054.702	150.080	150.089	0.009
45	399336.178	7737083.588	150.232	150.217	-0.015
51	399315.327	7737157.924	149.805	149.809	0.004
64	399307.636	7737450.118	148.326	148.253	-0.073
65	399328.654	7737440.694	148.363	148.296	-0.067
66	399337.785	7737407.494	148.505	148.475	-0.030
68	399351.387	7737384.452	148.738	148.696	-0.042
74	399327.509	7737266.533	149.236	149.193	-0.043
77	399267.656	7737156.665	149.748	149.704	-0.044
92	399356.810	7737426.611	148.228	148.191	-0.037
98	399416.533	7737889.798	145.236	145.217	-0.019
99	399389.208	7738069.148	143.744	143.759	0.015
101	399428.003	7738381.067	142.276	142.297	0.021
102	399467.559	7738463.985	141.969	141.984	0.015
103	399451.846	7738586.798	141.065	141.134	0.069
107	399348.936	7739063.739	138.787	138.857	0.070
109	399279.697	7739253.747	137.388	137.506	0.118
125	400241.332	7739842.882	133.568	133.759	0.191
127	400241.375	7739844.212	133.540	133.737	0.197
128	400241.314	7739843.565	133.606	133.787	0.181
129	400229.374	7739830.846	133.805	133.965	0.160
131	400224.481	7739802.504	133.566	133.721	0.155
132	400233.115	7739806.633	133.486	133.650	0.164

133	400248.695	7739811.171	133.447	133.603	0.156
Average Elevation Difference (Dz) (m)	0.018				
Minimum Dz (m)	-0.090				
Maximum Dz (m)	0.197				
Average Magnitude Error (m)	0.065				
Root Mean Square Error (m)	0.087				
Standard Deviation (m)	0.087				

APPENDIX 5: VEGETATED VERTICAL CHECK POINTS

Check Point Name	Easting (m)	Northing (m)	Check Point Z (m)	Corrected Point Cloud Z (m)	Elevation Difference (Corrected Point Cloud Z – Check Point Z) (m)
Reeds					
41	399319.880	7737035.952	149.560	149.610	0.050
42	399307.874	7737038.335	149.578	149.664	0.086
43	399291.061	7737039.715	149.592	149.639	0.047
69	399347.472	7737352.708	148.179	148.179	0.000
70	399332.764	7737330.701	148.306	148.309	0.003
71	399330.928	7737319.215	148.231	148.238	0.007
72	399337.211	7737297.902	148.322	148.346	0.024
95	399423.548	7737652.111	145.903	145.965	0.062
116	399512.773	7739586.688	152.099	152.320	0.221
117	399573.815	7739626.639	151.469	151.656	0.187
118	399680.967	7739636.774	150.229	150.454	0.225
119	399728.011	7739667.326	149.129	149.351	0.222
136	399894.467	7739962.230	146.326	146.608	0.282
138	399838.791	7739996.615	146.834	147.126	0.292
141	399598.997	7740001.360	149.678	149.973	0.295
142	399530.299	7740024.895	150.222	150.608	0.386
144	399447.722	7740051.575	151.549	151.831	0.282
149	399205.460	7739969.412	153.008	153.208	0.200
151	399181.866	7739917.170	153.085	153.310	0.225
154	399152.794	7739846.359	153.643	153.852	0.209
Shrubs					
56	399320.732	7737245.305	149.302	149.356	0.054
82	399232.413	7737070.186	149.473	149.485	0.012
83	399254.288	7737060.859	149.538	149.596	0.058
84	399272.215	7737057.421	149.515	149.650	0.135
120	399798.573	7739685.596	146.488	146.893	0.405
121	399817.693	7739696.233	145.669	145.876	0.207
122	399894.506	7739710.099	146.629	146.918	0.289
137	399862.184	7739978.206	146.808	147.099	0.291
139	399786.063	7740013.454	147.953	148.247	0.294
Tundra Vegetation					
52	399311.737	7737171.128	149.755	149.720	-0.035
53	399313.645	7737196.615	149.590	149.533	-0.057
54	399311.785	7737209.338	149.529	149.466	-0.063

55	399309.208	7737221.638	149.370	149.328	-0.042
57	399322.770	7737257.007	149.039	149.044	0.005
58	399306.634	7737283.831	149.131	149.077	-0.054
59	399288.999	7737310.888	148.921	148.883	-0.038
60	399280.191	7737352.668	148.857	148.825	-0.032
61	399272.566	7737386.626	148.674	148.638	-0.036
62	399278.994	7737418.158	148.505	148.485	-0.020
63	399295.629	7737437.698	147.752	147.718	-0.034
78	399211.122	7737151.957	149.504	149.468	-0.036
79	399219.087	7737138.690	149.558	149.500	-0.058
80	399238.121	7737123.465	149.544	149.518	-0.026
81	399238.936	7737085.612	149.661	149.589	-0.072
93	399384.930	7737521.101	147.298	147.297	-0.001
94	399385.499	7737577.303	146.888	146.882	-0.006
96	399444.365	7737761.188	145.535	145.525	-0.010
145	399397.655	7740024.249	152.142	152.364	0.222
146	399367.339	7740028.054	152.481	152.705	0.224
147	399317.783	7740017.222	153.142	153.305	0.163
148	399276.020	7740000.915	152.866	153.089	0.223
153	399171.775	7739835.263	153.788	154.026	0.238
155	399123.334	7739874.740	153.739	153.952	0.213
156	399115.347	7739900.811	153.855	154.112	0.257
157	399097.840	7739910.255	153.908	154.159	0.251
BaseStation	399354.811	7737066.353	150.036	150.030	-0.006
Tussocks					
111	399284.836	7739496.492	153.373	153.579	0.206
112	399317.793	7739505.759	153.280	153.511	0.231
113	399388.015	7739521.919	153.079	153.329	0.250
114	399430.820	7739519.233	152.685	152.843	0.158
115	399466.102	7739544.490	152.697	152.868	0.171
123	400011.626	7739774.274	146.032	146.278	0.246
134	399993.414	7739919.279	145.122	145.357	0.235
135	399924.305	7739954.562	145.998	146.263	0.265
140	399681.469	7740002.177	149.209	149.435	0.226
143	399516.598	7740031.482	150.519	150.776	0.257
150	399183.593	7739951.670	153.516	153.721	0.205
152	399195.977	7739833.024	153.990	154.215	0.225

	Overall	Reeds	Shrubs	Tundra Veg	Tussocks
Average Elevation Difference (Dz) (m)	0.131	0.165	0.194	0.043	0.223
Minimum Dz (m)	-0.072	0.000	0.012	-0.072	0.158
Maximum Dz (m)	0.405	0.386	0.405	0.257	0.265
Average Magnitude Error (m)	0.149	0.165	0.194	0.090	0.223
Root Mean Square Error (m)	0.186	0.202	0.232	0.127	0.225
Standard Deviation (m)	0.133	0.119	0.136	0.122	0.033