



10/03/0001

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## **Montana Aerial LiDAR 2021 Ground Control Survey Report**

**For**

**Dewberry Engineers Inc.**

**November 2021**

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# 1. Introduction

## 1.1 Project Summary:

Aero-Graphics Inc. is under contract to Dewberry Engineers to provide surveyed ground control points to support the acquisition of aerial lidar for 4,470 sq. miles in eastern Montana. The survey field work was conducted August 20, 2021, thru October 4, 2021. The ground control point locations were distributed across the project areas as evenly as the terrain would allow.

Existing NGS control points were located and surveyed as part of the field work to verify the accuracy of survey. The results are shown in section 2.4 of this report.

The final horizontal coordinates are referenced to NAD83(2011) Montana State Plane meters. The final vertical elevations are referenced to NAVD88 meters using Geoid model 2018 (Geoid18).

## 1.2 Surveyor:

Questions regarding this report can be addressed to:

Karl Jensen, PLS, CP  
Surveying Manager  
Aero-Graphics, Inc  
40 W Oakland Ave  
Salt Lake City, Utah 84115  
801-487-3273  
801-891-2779 direct



Utah Licensed Professional Land Surveyor #7643406, exp date 3/31/2023

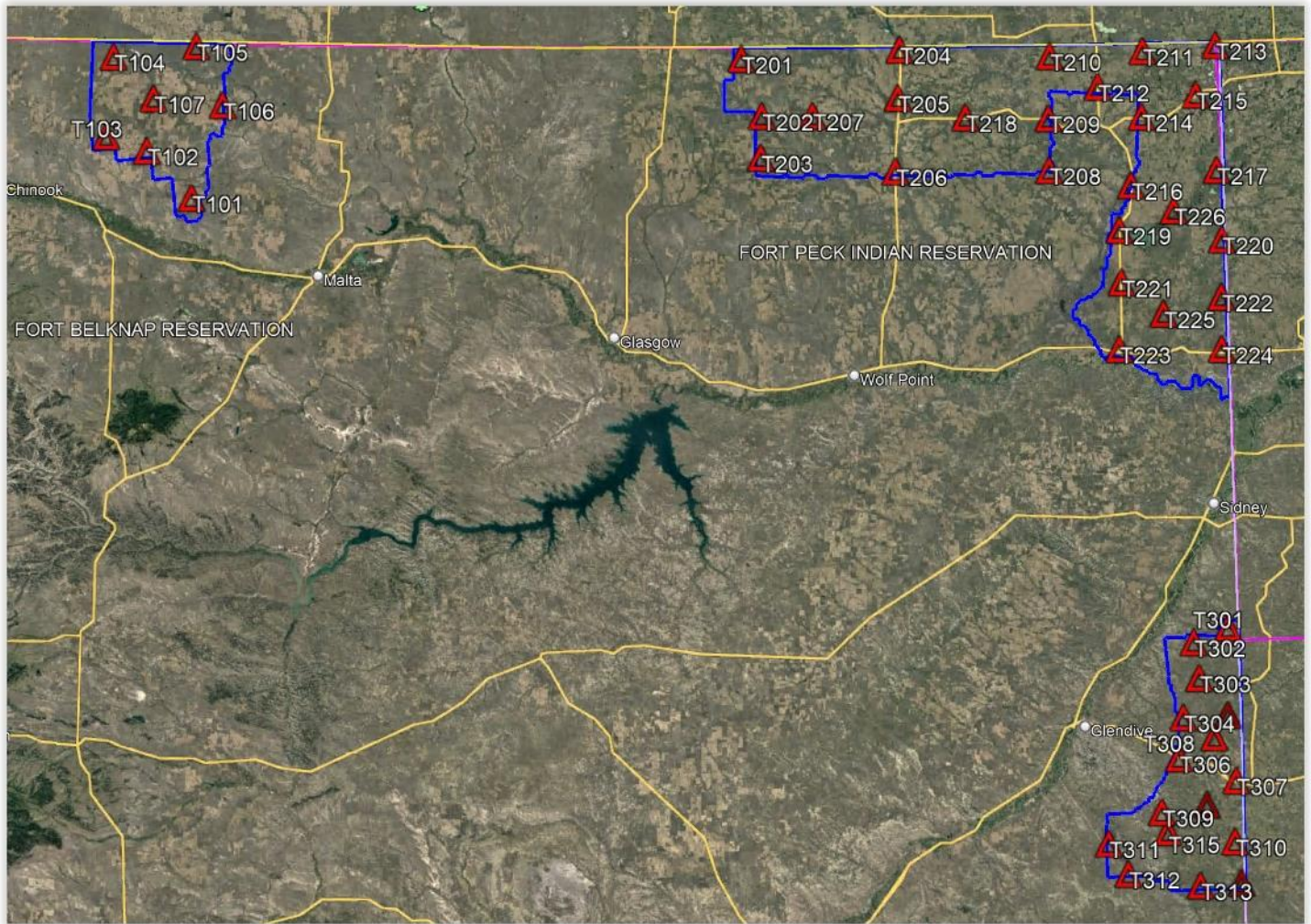
Colorado Licensed Professional Land Surveyor #PLS-0038527, exp date 10/31/2023

ASPRS Certified Photogrammetrist, exp date 9/17/2023



### 1.3 Project Areas:

#### Montana Highline (QL2)



## **2. Project Details**

### **2.1 Survey Equipment**

The equipment listed below was used to survey the ground points for this LiDAR project.

TOPCON Dual Frequency/ Dual Constellation GNSS Receivers:

HiPER Ga, S/N: 498-00418	HiPER Ga, S/N: 457-02513
HiPER SR, S/N: 1064-16270	HiPER SR, S/N: 1209-11478
HiPER SR, S/N: 1209-10832	HiPER SR, S/N: 1209-14758
HiPER SR, S/N: 1209-18284	HiPER SR, S/N: 1209-18273

Two meter fixed height range pole for each Topcon GNSS HiPER receiver with attached bipod legs for stability.

### **2.2 Surveyed Point Details**

The ground control points were well distributed throughout the project areas. Five (5) photographs were taken of each point, looking north, east, south, west, and close on the point/monument. A mag nail or spike was set at each location where possible. Some points were surveyed at photo\lidar identifiable locations.

Control point locations are detailed in the “Control Point Documentation Report” sheets attached to this report.

### **2.3 Surveyed Point Network**

Static GNSS survey methods were used during the ground survey to observe the control points. The process for this method is detailed below.

LiDAR identifiable features or surveyor set\painted targets were used as control points.

## **STATIC:**

Static (or Rapid-Static) Surveying is a method that Aero-Graphics has employed for many years to collect ground control points. A base station location is selected, usually at one or more control locations, and a GNSS receiver is left there for the duration of the day to complete the survey. The other GNSS receivers are then used as rovers to survey the other point locations.

The duration of the rover receivers will vary depending upon the distance from the base receiver. Normally the rover will not be further than 10 km from the base. The greater the distance the rover is from the base receiver, the longer the recording duration of the rover needs to be. Each rover location is surveyed for a minimum of 20 minutes or greater.

Static Surveying was used to collect control points.

The individual point locations are post-processed after the field survey is completed. The GNSS data collected by the receivers is downloaded and processed in NovaTel's Waypoint GravNET software. The base station coordinates are used to differentially correct the other point's locations.

The NGS Online Positioning User Service (OPUS) was used to process the base station location data. A minimum of 2+ hours of GNSS data was collected for base stations to be processed through OPUS.

## **2.4 Field Procedures and Analysis**

All control points were surveyed one. Each observation for static surveying occupied the point for a minimum of 20 minutes in duration

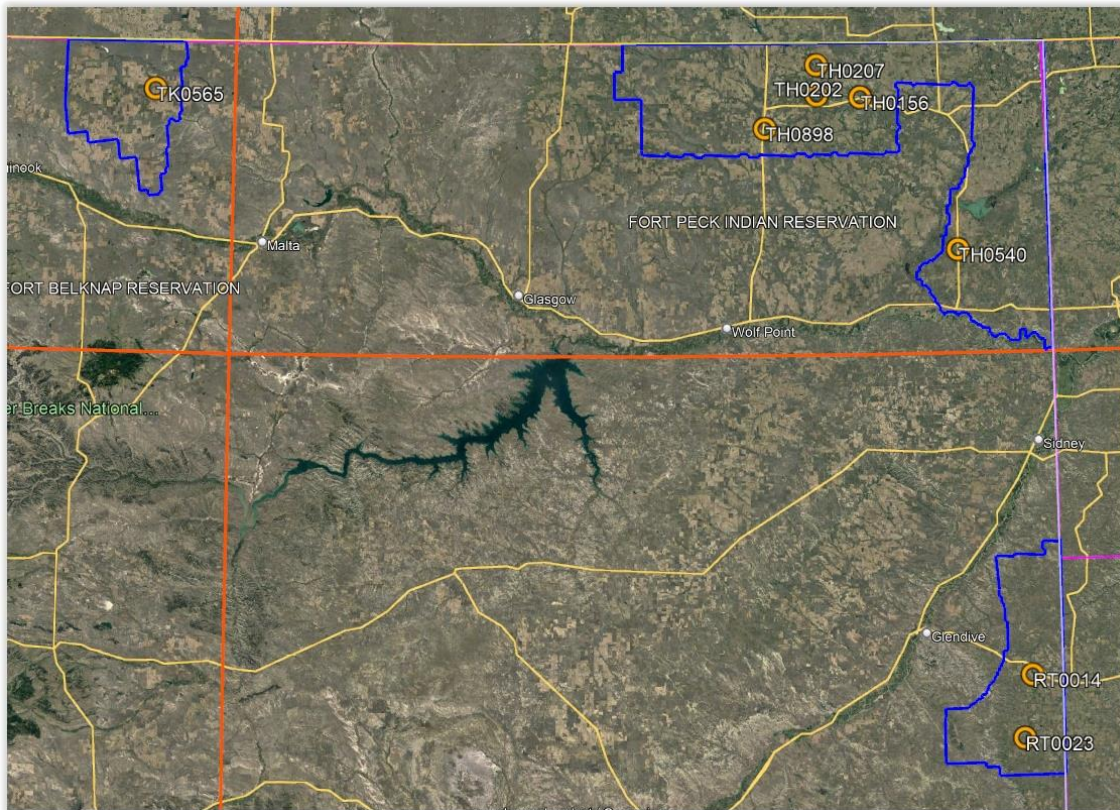
Eight (8) NGS monuments were surveyed as part of the field procedures. Monuments were researched and located prior to field work commencing. Monuments that were surveyed were chosen for accessibility. Although all results are shown below, some are less than desirable due to imprecise data from the NGS datasheets.

The NGS monuments were occupied to provide a QC/QA for the survey methods used. Each of the monuments was surveyed once. The observed values and data sheet values are shown below along with the differences. The latitude and longitude from the data sheets were converted to Montana State Plane meters.



# NGS Monuments

POINT		OBSERVED VALUES			DATASHEETS VALUES			DIFFERENCE		
ID	NGS PID	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	VERTICAL
V 207	RT0014	315032.361	1003560.418	816.652	315032.243	1003560.211	816.628	0.118	0.207	0.024
D 208	RT0023	292342.331	1001831.905	875.507	292342.062	1001830.820	875.470	0.269	1.085	0.037
E 64	TH0156	517963.139	933402.314	644.262	517965.366	933402.421	644.276	-2.227	-0.107	-0.014
W 269	TH0202	517886.504	917768.636	823.904	517886.182	917768.532	823.872	0.322	0.104	0.032
C 270	TH0207	528739.894	917262.532	814.247	528738.409	917261.719	814.234	1.485	0.813	0.013
K 545	TH0540	465315.199	970523.386	615.058	465304.555	970541.552	615.054	10.644	-18.166	0.004
Q 46	TH0898	505183.643	899769.289	704.152	505154.221	899790.749	704.180	29.422	-21.460	-0.028
39 REB	TK0565	511302.673	681433.717	925.219	511300.435	681420.076	924.914	2.238	13.641	0.305



## 2.5 Data Processing Procedures

The data from the static GNSS receivers was downloaded each day and a copy was uploaded to the office FTP server.

Base station observations were uploaded to OPUS only after the rapid or precise ephemeris was available for processing. Whether the base station was located on an NGS monument or at a new point location, all GNSS data sets with a duration longer than two (2) hours were processed through OPUS.

The static surveyed points were post-processed using NovaTel's Waypoint software. Some of the static control point observations of less than two (2) hours in duration were processed with OPUS Rapid Static (OPUS-RS) as a QA\QC on the static post processing.



### 3. Final Coordinates

	MT SP NAD83(2011) NORTHING	MT SP NAD83(2011) EASTING	ORTHO HGT (Geoid18)	
Point ID	Meter	Meter	Meter	TYPE
T101	480493.768	681839.337	876.868	Control
T102	494586.993	667254.582	976.633	Control
T103	498644.585	654381.918	993.315	Control
T104	523390.172	655516.606	959.832	Control
T105	527532.177	681207.610	910.278	Control
T106	509545.161	690289.318	923.467	Control
T107	510870.064	668611.277	944.778	Control
T201	529843.535	850349.122	935.101	Control
T202	512434.155	857324.478	835.563	Control
T203	499577.084	857554.584	884.944	Control
T204	534836.460	899217.472	748.351	Control
T205	519812.730	899194.020	725.215	Control
T206	497103.793	899322.132	735.848	Control
T207	513147.478	873015.518	842.847	Control
T208	499491.748	946975.235	714.444	Control
T209	515546.439	946216.946	628.550	Control
T210	534797.616	945924.738	753.447	Control
T211	537691.887	974787.019	683.766	Control
T212	525954.595	961185.635	702.902	Control
T213	540579.357	997581.457	658.147	Control
T214	517287.572	975178.777	721.300	Control
T215	524903.227	991947.971	681.300	Control
T216	495928.399	972680.022	612.346	Control
T217	501847.430	999231.783	622.435	Control
T218	514671.673	920374.116	813.603	Control
T219	481952.306	969489.895	592.760	Control
T220	480390.804	1001624.750	675.470	Control
T221	465772.464	970752.490	618.237	Control
T222	462619.495	1002094.432	745.284	Control
T223	445171.245	970820.833	590.119	Control
T224	446485.527	1002786.794	643.278	Control
T225	456657.457	984209.835	657.342	Control
T226	488694.922	986261.538	614.713	Control
T301	360652.379	1008152.241	682.634	Control
T302	355686.377	997584.813	693.320	Control
T303	344677.808	999740.494	748.626	Control
T304	332345.023	995295.127	767.011	Control
T305	333624.252	1009180.215	766.993	Control

T306	319650.133	994494.815	861.287	Control
T307	313414.845	1012672.212	857.986	Control
T308	326535.635	1005308.554	777.068	Control
T309	302791.687	989888.011	818.320	Control
T310	294520.359	1013139.861	903.396	Control
T311	292550.066	973760.884	840.704	Control
T312	283335.902	980290.974	804.253	Control
T313	280495.710	1002986.441	931.321	Control
T314	281803.566	1015802.946	961.301	Control
T315	296762.892	992081.835	904.829	Control
T316	305667.287	1003854.030	869.234	Control

## 4. GNSS Observations

	DATE	JULIAN		
Point ID	SURVEYED	DATE	SURVEY METHOD	TYPE
T101	August 27, 2021	239	Static	Control
T102	August 28, 2021	240	Static	Control
T103	August 27, 2021	239	Static	Control
T104	August 27, 2021	239	Static	Control
T105	August 28, 2021	240	Static	Control
T106	August 28, 2021	240	Static	Control
T107	August 27, 2021	239	Static	Control
T201	August 26, 2021	238	Static	Control
T202	August 26, 2021	238	Static	Control
T203	August 26, 2021	238	Static	Control
T204	August 25, 2021	237	Static	Control
T205	August 25, 2021	237	Static	Control
T206	August 25, 2021	237	Static	Control
T207	August 26, 2021	238	Static	Control
T208	August 25, 2021	237	Static	Control
T209	August 25, 2021	237	Static	Control
T210	August 25, 2021	237	Static	Control
T211	August 24, 2021	236	Static	Control
T212	August 24, 2021	236	Static	Control
T213	August 24, 2021	236	Static	Control
T214	August 24, 2021	236	Static	Control
T215	August 24, 2021	236	Static	Control
T216	August 24, 2021	236	Static	Control
T217	August 23, 2021	235	Static	Control
T218	August 25, 2021	237	Static	Control
T219	August 23, 2021	235	Static	Control
T220	August 23, 2021	235	Static	Control
T221	August 22, 2021	234	Static	Control
T222	August 22, 2021	234	Static	Control
T223	August 22, 2021	234	Static	Control
T224	August 22, 2021	234	Static	Control
T225	August 22, 2021	234	Static	Control
T226	August 23, 2021	235	Static	Control
T301	August 20, 2021	232	Static	Control
T302	August 20, 2021	232	Static	Control
T303	August 20, 2021	232	Static	Control
T304	August 20, 2021	232	Static	Control
T305	August 20, 2021	232	Static	Control
T306	August 21, 2021	233	Static	Control



T307	August 21, 2021	233	Static	Control
T308	August 21, 2021	233	Static	Control
T309	August 21, 2021	233	Static	Control
T310	August 21, 2021	233	Static	Control
T311	August 21, 2021	233	Static	Control
T312	August 21, 2021	233	Static	Control
T313	August 21, 2021	233	Static	Control
T314	August 21, 2021	233	Static	Control
T315	August 21, 2021	233	Static	Control
T316	August 21, 2021	233	Static	Control

## 5. Deliverables

Along with this report, the deliverables to Dewberry Engineers includes the Control Point Documentation Report sheets and an Excel Spreadsheet including all control point data.