Collection Report

Goodhue County 3DEP Lidar 2020

Prime Contractor: Ayres

Airborne Lidar Acquisition:
Quantum Spatial, an Nv5 Company

Ingenuity, Integrity, and Intelligence.

www.AyresAssociates.com

AYRES NV5 GEOSPATIAL powered by QUANTUM SPATIAL

Table of Contents

AYRES NV5 GEOSPATIAL powered by QUANTUM SPATIAL

List of Figures

List of Tables

1. Summary / Scope

1.1 Summary

This report contains a summary of the Goodhue County, Minnesota lidar acquisition task order, issued by Ayres Associates Inc. under Task Order 55 that was executed on February 7, 2020. The task order yielded a project area covering approximately 941 square miles over Goodhue County in Minnesota. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

1.2 Scope

Aerial topographic lidar was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned Lidar Specifications

AVERAGE POINT DENSITY	FLIGHT ALTITUDE (AGL)	FIELD OF VIEW	MINIMUM SIDE OVERLAP
30 pts / m²	1200 m	58.5°	60%

1.3 Coverage

The project boundary covers approximately 941 square miles over Goodhue County. Project extents are shown in Figure 1.

1.4 Duration

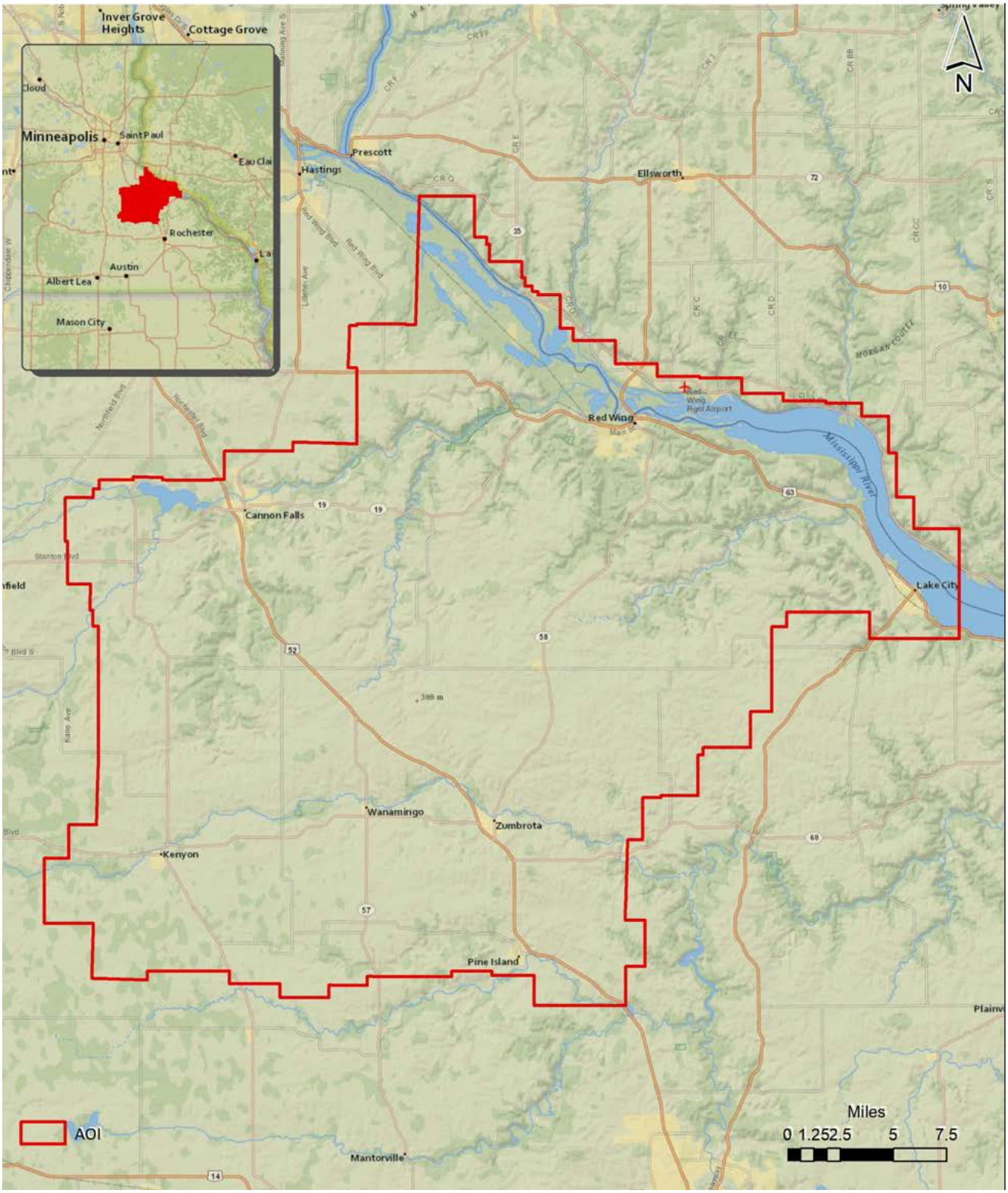
Lidar data was acquired from April 8, 2020, to May 3, 2020, in 13 lifts. See “Section: 2.4. Time Period” for more details.

1.5 Issues

There were no major issues to report for this project.

GOODHUE COUNTY, MINNESOTA – DELIVERABLES PROJECTED COORDINATE SYSTEM: GOODHUE COUNTY HORIZONTAL DATUM: NAD83 (HARN) VERTICAL DATUM: NAVD88 (GEOID 12B) UNITS: US SURVEY FEET
• One copy of lidar tiled point cloud data in LAS format on external hard drive
• All flight mission parameters appropriate for inclusion in FGDC/USGS compliant metadata

Figure 1. Goodhue County Project Boundary



2. Planning / Equipment

2.1 Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount/type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using Leica MissionPro, RiPARAMETER, and TrackAir SnapPLAN planning software. The entire target area was comprised of 132 planned flight lines (Figure 2).

2.2 Lidar Sensor

Quantum Spatial used a Riegl VQ1560i lidar sensor (Figure 3), serial number 4040 for lidar collection.

The Riegl 1560i system has a laser pulse repetition rate of up to 2 MHz resulting in more than 1.3 million measurements per second. The system uses a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to an unlimited number of targets per pulse from the laser.

A brief summary of the aerial acquisition parameters for the project are shown in the Lidar System Specifications in Table 2.

Figure 2. Goodhue County Planned Flight Lines

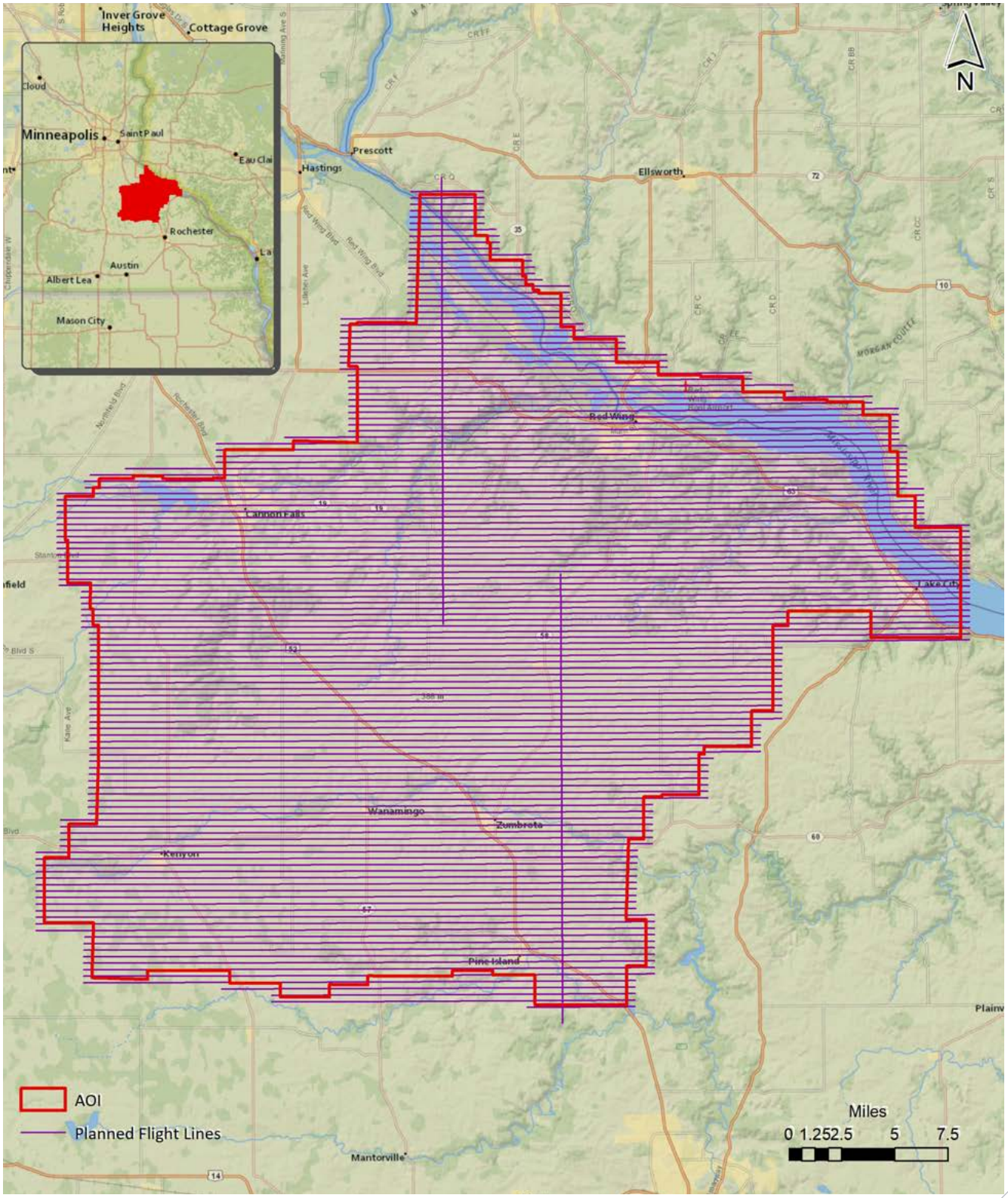


Table 2. Lidar System Specifications

		RIEGL VQ1560I
Terrain and Aircraft Scanner	Flying Height	1200 m
	Recommended Ground Speed	180 kts
Scanner	Field of View	58.5°
	Scan Rate Setting Used	2 x 276 lps
Laser	Laser Pulse Rate Used	2 x 1740 kHz
	Multi Pulse in Air Mode	1
Coverage	Full Swath Width	1344 m
	Line Spacing	1050.53 m
Point Spacing and Density	Average Point Spacing	0.335 m
	Average Point Density	2 x 9.31 pts/m²

Figure 3. Riegl VQ1560i Lidar Sensor

2.3 Aircraft

All flights for the project were accomplished through the use of a customized plane. The plane type and tail number are listed below.

Lidar Collection Planes

- Piper Navajo (twin-piston), Tail Number(s): N22GE

This aircraft provided an ideal, stable aerial base for lidar acquisition. This aerial platform has relatively fast cruise speeds, which are beneficial for project mobilization/demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art Riegl VQ1560i lidar system. Some of Quantum Spatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of Quantum Spatial's Planes

2.4 Time Period

Project-specific flights were conducted between April and May of 2020. Thirteen aircraft lifts were completed. The accomplished lifts are listed below.

- 04082020C (SN 4040, N22GE)
- 04082020C (SN 4040, N22GE)
- 04102020B (SN 4040, N22GE)
- 04102020C (SN 4040, N22GE)
- 04112020B (SN 4040, N22GE)
- 04222020A (SN 4040, N22GE)
- 04242020A (SN 4040, N22GE)
- 04252020A (SN 4040, N22GE)
- 04262020B (SN 4040, N22GE)
- 04302020A (SN 4040, N22GE)
- 04302020B (SN 4040, N22GE)
- 05022020B (SN 4040, N22GE)
- 05032020A (SN 4040, N22GE)

3. Processing Summary

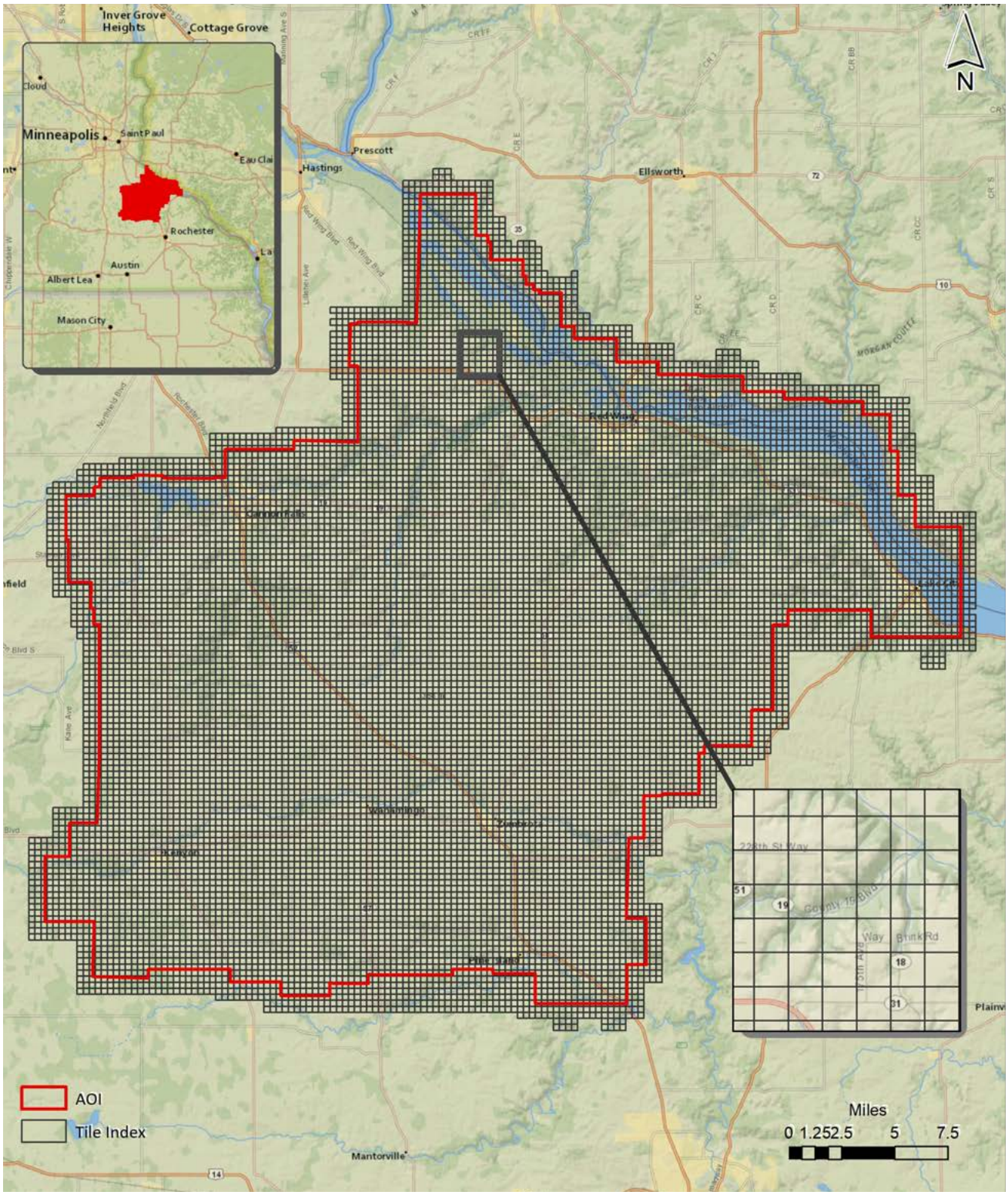
3.1 Lidar Processing

Applanix + POSPac software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the lidar sensor during all flights. Applanix POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a “Smoothed Best Estimate Trajectory” (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the lidar missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix + POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: Max horizontal/vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

Point clouds were created using the RiPROCESS software. The generated point cloud is the mathematical three-dimensional composite of all returns from all laser pulses as determined from the aerial mission. The point cloud is imported into GeoCue distributive processing software. Imported data is tiled and then calibrated using TerraMatch and proprietary software. Using TerraScan, the vertical accuracy of the surveyed ground control is tested, and any bias is removed from the data.

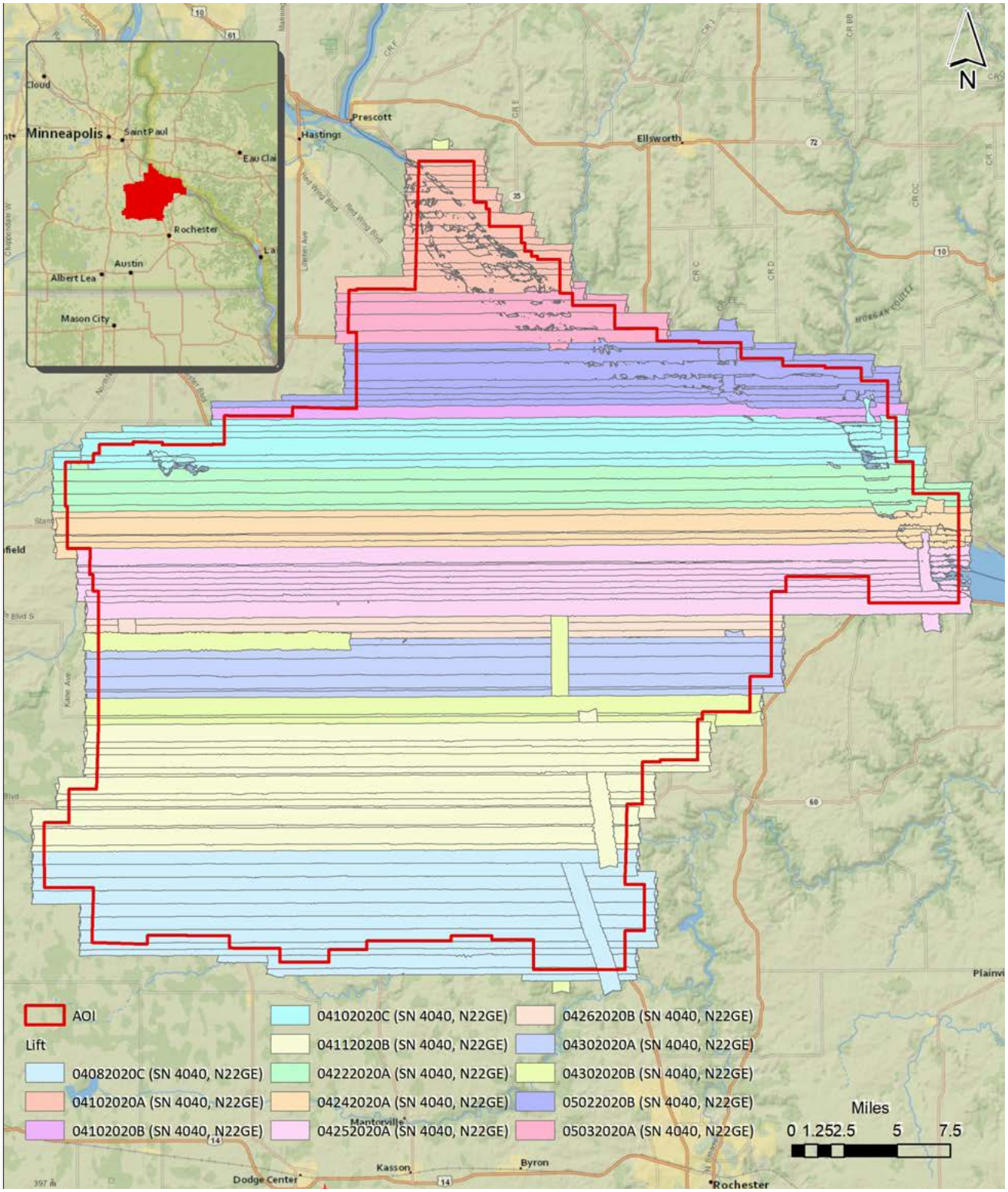
Figure 5. Lidar Tile Layout



4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 6.

Figure 6. Lidar Flight Line Coverage



5. Ground Control and Check Point Collection

Quantum Spatial used 43 ground control (calibration) points collected by Goodhue County.

5.1 Calibration Control Point Testing

Figure 7 shows the location of each bare earth calibration point for the project area. TerraScan was used to perform a quality assurance check using the lidar bare earth calibration points. The results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

Figure 7. Calibration Control Point Locations

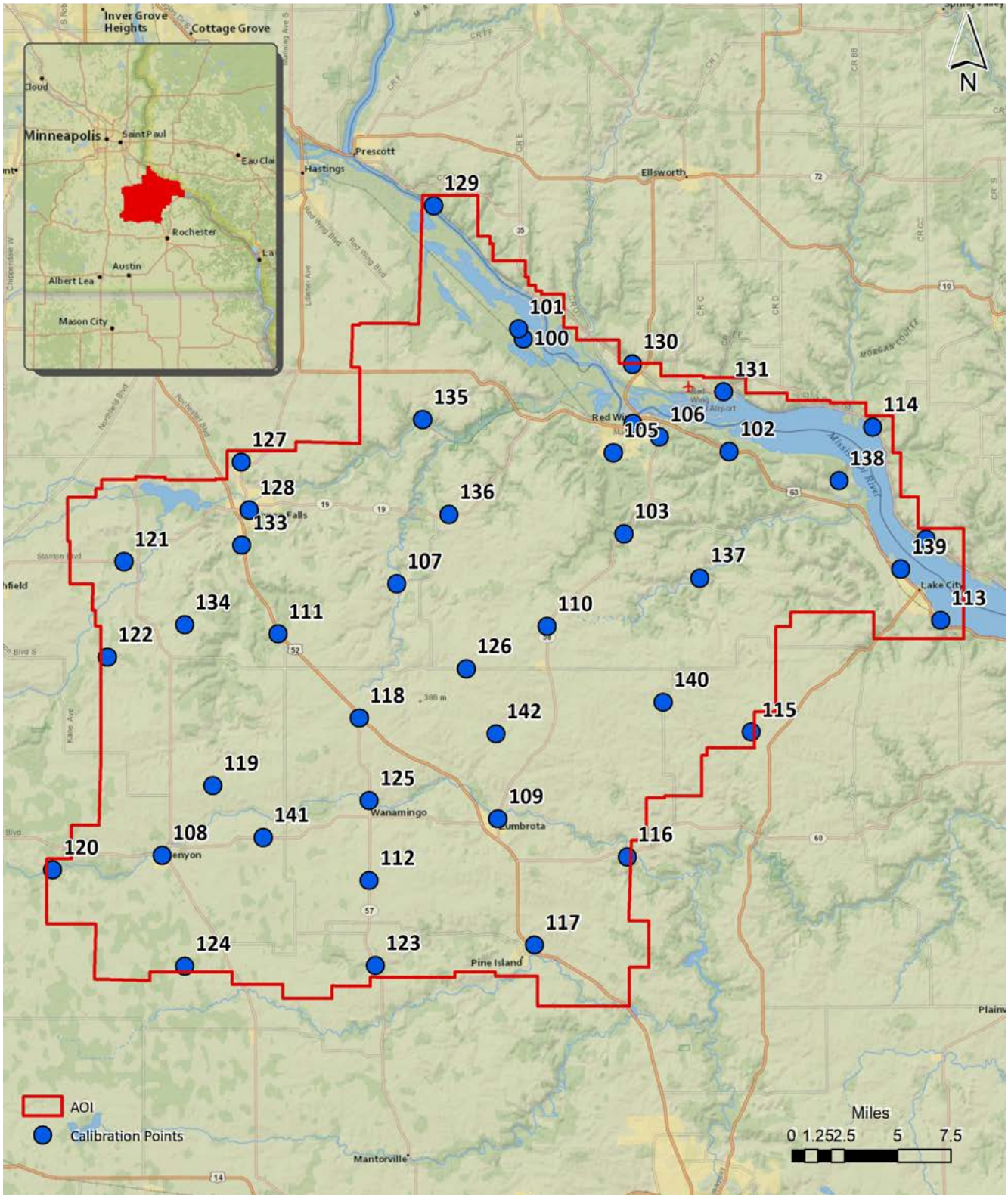


Table 3. Calibration Control Point Report
Units = US survey feet

NUMBER	EASTING	NORTHING	KNOWN Z	LASER Z	DZ
100	627902.992	256452.856	695.589	695.52	-0.069
101	626735.716	258835.733	691.074	691.17	0.096
102	679074.225	228385.929	720.254	720.22	-0.034
103	652847.645	207963.376	826.953	826.91	-0.043
104	655133.22	235424.481	711.697	711.71	0.013
105	650219.892	228093.57	815.155	815.13	-0.025
106	661692.195	232035.999	831.506	831.5	-0.006
107	596436.154	195649.358	942.095	942.22	0.125
108	538197.269	128169.16	1151.481	1151.55	0.069
109	621572.55	137213.741	977.493	977.45	-0.043
110	633781.076	185107.136	1111.618	1111.64	0.022
111	566981.528	183173.205	1187.339	1187.35	0.011
112	589612.814	121891.874	1244.124	1244.16	0.036
113	731569.381	186524.766	695.817	695.73	-0.087
114	714683.896	234519.654	688.688	688.85	0.162
115	684483.178	158799.708	1112.215	1112.22	0.005
116	653768.354	127815.662	936.172	936.3	0.128
117	630727.603	105922.28	1096.559	1096.57	0.011
118	587128.136	162290.97	1191.883	1191.88	-0.003
119	550807.238	145510.786	1190.202	1190.18	-0.022
120	511003.609	124516.483	1119.447	1119.53	0.083
121	528648.722	201057.047	923.667	923.7	0.033
122	524588.26	177412.377	969.014	969.06	0.046
123	591152.436	100770.804	1087.003	1087.02	0.017
124	543845.275	100614.485	1225.213	1225.26	0.047
125	589649.247	141737.646	1021.282	1021.3	0.018
126	613762.731	174555.772	1199.762	1199.81	0.048
127	557852.211	225793.741	871.543	871.57	0.027

NUMBER	EASTING	NORTHING	KNOWN Z	LASER Z	DZ
128	559804.297	213925.322	848.878	848.78	-0.098
129	605579.608	289583.835	785.249	785.23	-0.019
130	655003.816	250184.763	716.912	716.91	-0.002
131	677639.4	243260.472	688.928	689.04	0.112
132	727972.56	206614.586	755.382	755.35	-0.032
133	558001.812	205099.038	931.508	931.58	0.072
134	543809.038	185443.206	1086.122	1086.1	-0.022
135	602912.682	236409.44	720.257	720.27	0.013
136	609428.394	212800.768	1079.26	1079.3	0.04
137	671800.601	197081.603	848.086	848.06	-0.026
138	706300.083	221162.489	795.624	795.58	-0.044
139	721698.728	199186.058	680.995	680.94	-0.055
140	662646.214	166238.178	1113.561	1113.55	-0.011
141	563288.409	132582.91	1178.997	1179	0.003
142	621111.444	158382.393	1140.049	1139.97	-0.079

Average Dz	0.012
Minimum Dz	-0.098
Maximum Dz	0.162
Average Magnitude	0.046
Root Mean Square	0.059
Std Deviation	0.059