OLC BLM Fires

WSI Applied Remote Sensing and Analysis

Data collected for:

Department of Geology and Mineral Industries

800 NE Oregon Street
Suite 965
Portland, OR 97232

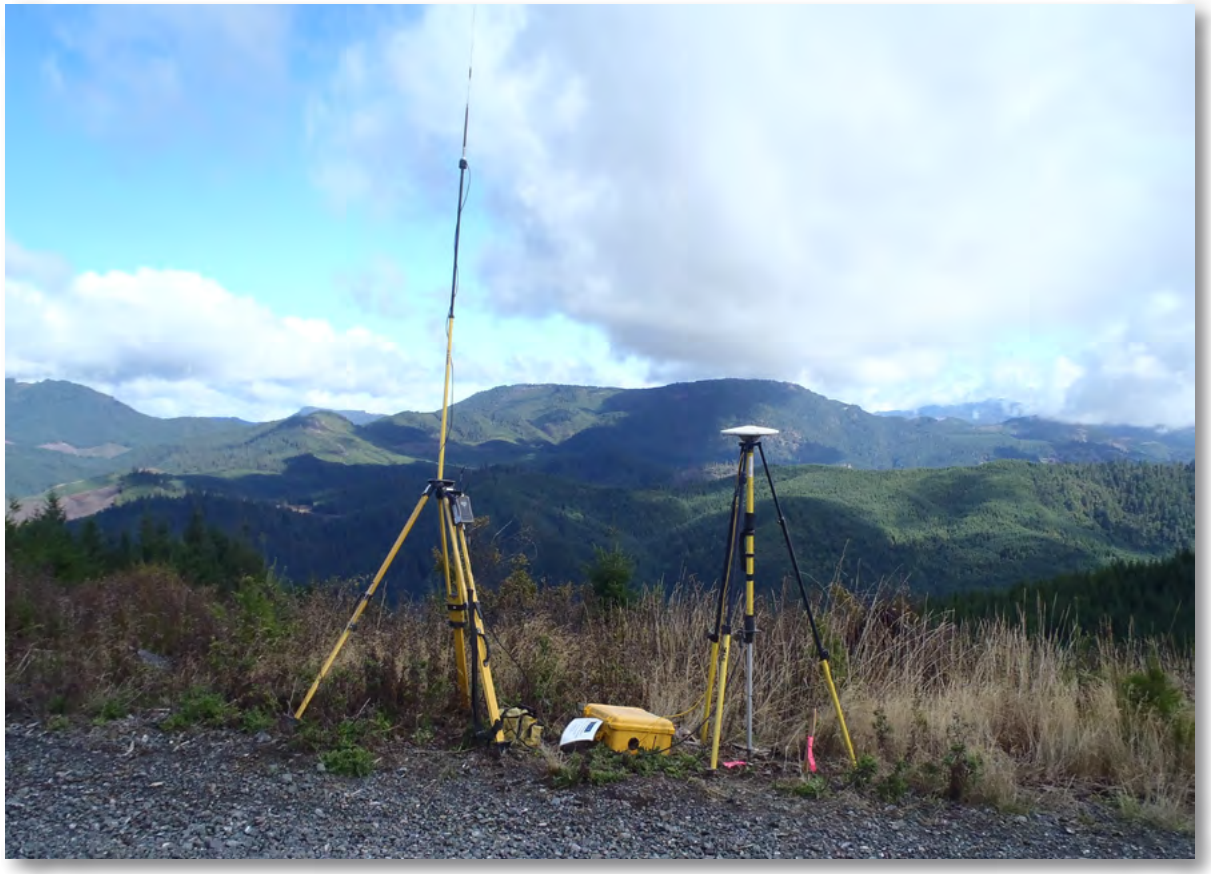
Prepared by:

WSI

421 SW 6th Avenue
Suite 800
Portland, Oregon 97204
phone: (503) 505-5100
fax: (503) 546-6801

517 SW 2nd Street
Suite 400
Corvallis, OR 97333
phone: (541) 752-1204
fax: (541) 752-3770

Contents



Base station and radio unit set up over control BW_02

Project Overview

In July of 2013, lightning strikes ignited three wildfires in southwest Oregon that became known as the Big Windy Complex. The fires were fully contained by the end of September after burning 27,555 acres of land owned by the Bureau of Land Management and protected by the Oregon Department of Forestry.

WSI has collected Light Detection and Ranging (LiDAR) data for the BLM Fires study area for the Oregon Department of Geology and Mineral Industries (DOGAMI). The Oregon LiDAR Consortium's BLM Fires area of interest (AOI) encompasses approximately 123,340 acres in Curry, Douglas and Jefferson counties in Oregon. The entire AOI lies within the Rogue River LiDAR dataset collected in 2012.

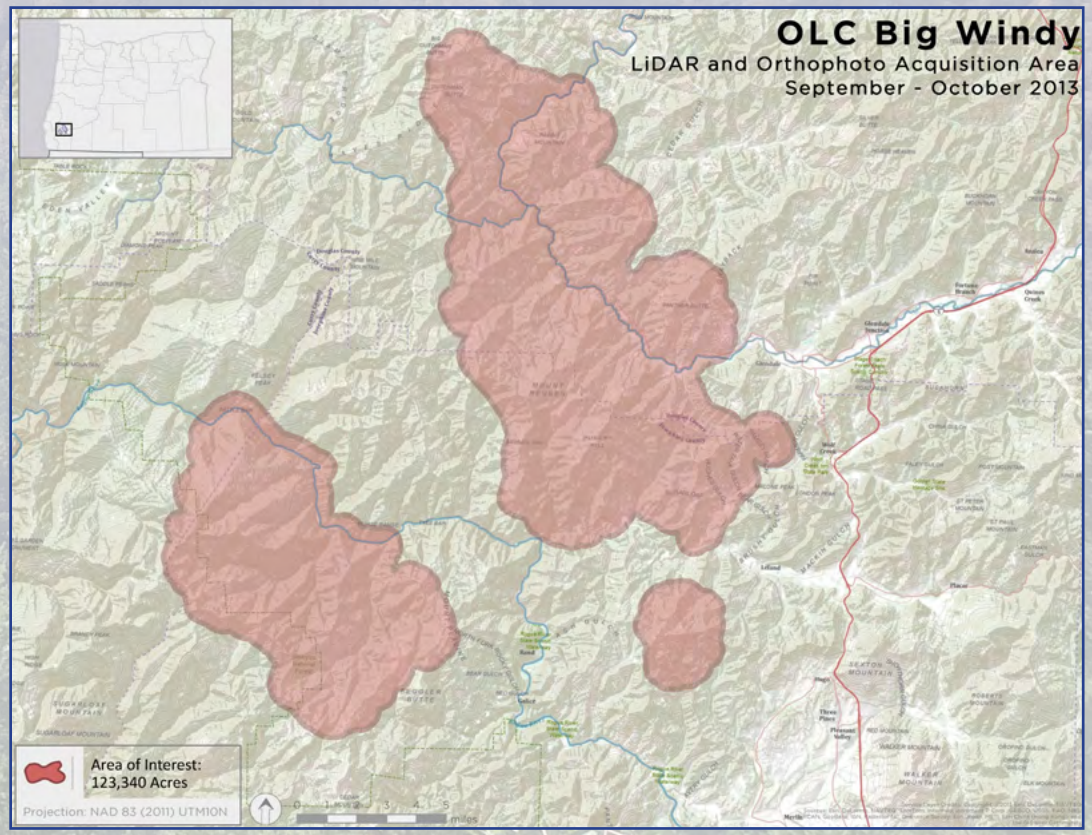
The collection of high resolution geographic data is part of an ongoing pursuit to amass a library of information accessible to government agencies as well as the general public.

Between September 26 and October 23, 2013, WSI employed remote-sensing lasers in order to obtain a total area flown of 127,340 acres. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

Final products created include LiDAR point cloud data, one meter digital elevation models of bare earth ground model and highest-hit returns, intensity rasters, ground density rasters, orthophotos, study area vector shapes, and corresponding statistical data.

BLM Fires Data Delivered November 22, 2013	
Acquisition Dates	9/26-9/27, 10/4-10/6, 10/9, 10/14, 10/17, 10/20-10/23/2013
Area of Interest	123,340 acres
Total Area Flown	127,559 acres
Data	OGIC HARN
Projection	Oregon Statewide Lambert Conformal Conic
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	International Feet

Study Area



Aerial Acquisition

LiDAR Survey

The LiDAR survey occurred in September and October 2013, utilizing a Leica ALS50 sensor mounted in a Cessna Caravan. The system was programmed to emit single pulses at a rate of 96 to 105 kilohertz, and flown at 900 meters above ground level (AGL), capturing a scan angle of 15 degrees from nadir (field of view equal to 30 degrees). These settings are developed to yield points with an average native density of greater than eight pulses per square meter over terrestrial surfaces.

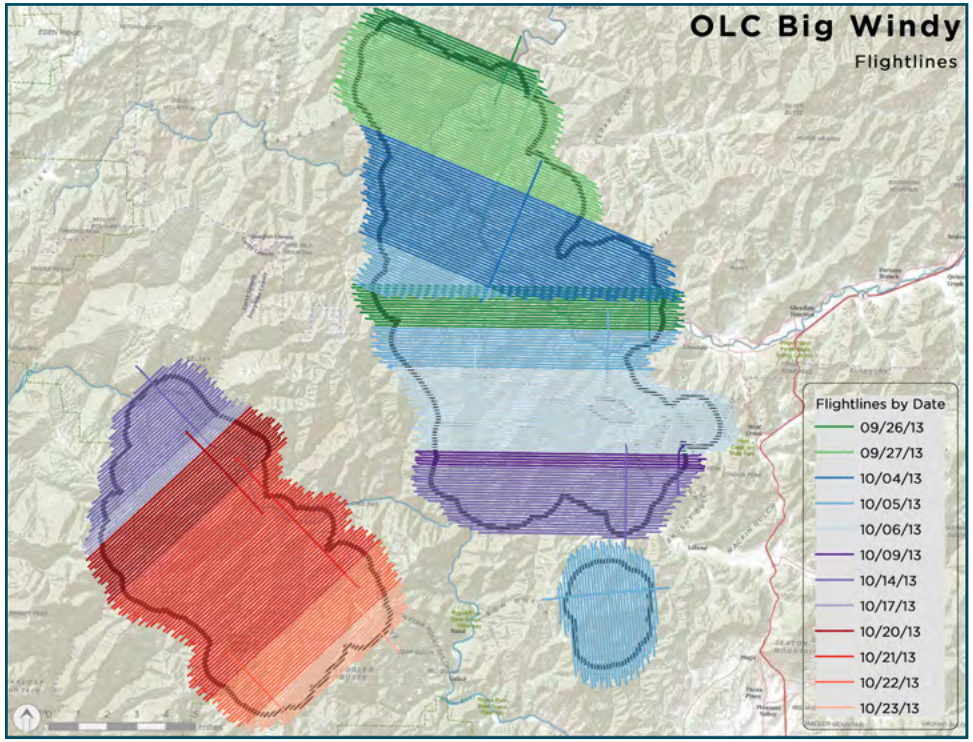
To solve for laser point position, an accurate description of aircraft position and attitude is vital. Aircraft position is described as x, y, and z and was measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is described as pitch, roll, and yaw (heading) and was measured 200 times per second (200 hertz) from an onboard inertial measurement unit (IMU).

The LiDAR sensor operators constantly monitored the data collection settings during acquisition of the data, including pulse rate, power setting, scan rate, gain, field of view, and pulse mode. For each flight, the crew performed airborne calibration maneuvers designed to improve the calibration results during the data processing stage. They were also in constant communication with the ground crew to ensure proper ground GPS coverage for data quality. The LiDAR coverage was completed with no data gaps or voids, barring non-reflective surfaces (e.g., open water, wet asphalt). All necessary measures were taken to acquire data under good conditions (e.g., minimum cloud decks) and in a manner (e.g., adherence to flight plans) that prevented the possibility of data gaps. All WSI LIDAR systems are calibrated per the manufacturer and our own specifications, and tested by WSI for internal consistency for every mission using proprietary methods.

Cessna Caravan

BLM Fires LiDAR Acquisition Specs	
Aircraft	Cessna Caravan 208B
Sensor	Leica ALS 50
Survey Altitude (AGL)	900 m
Targeted Aircraft Speed	105 knots
Coverage	100% Overlap with 65% Sidelap
Field of View (FOV)	30°
Laser Pulse Rate	96,000 - 105,900 Hz
Planned Swath Width	482 meters
Targeted Pulse Density	≥ 8 pulses per square meter

Project Flightlines



Aerial Acquisition

Photography

Orthophoto acquisition was conducted between October 15 and October 17, 2013.

The photography survey utilized an UltraCam Eagle 260 megapixel camera mounted in a Cessna 208-B Grand Caravan. The UltraCam-Eagle is a large format digital aerial camera manufactured by the Microsoft Corporation. The system is gyro-stabilized and simultaneously collects panchromatic and multispectral (RGB, NIR) imagery. Panchromatic lenses collect high resolution imagery by illuminating nine CCD (charged coupled device) arrays, writing nine raw image files. RGB and NIR lenses collect lower resolution imagery, written as four individual raw image files. Level 02 images are created by stitching together raw image data from the nine panchromatic CCDs, and ultimately combined with the multispectral image data to yield Level 03 pan-sharpened tiffs.

Below: LiDAR point cloud with RGB extraction from orthophotos. 5 miles southwest of Glendale.

BLM Fires Orthophoto Acquisition Specs	
Aircraft	Cessna 208-B Grand Caravan
Sensor	UltraCam Eagle
Survey Altitude (AGL)	924 m
GPS Satellite Constellation	6
GPS PDOP	3.0
GPS Baselines	≤ 13nm
Image	8-bit GeoTIFF
Along Track Overlap	60%
Spectral Bands	Red, Green, Blue, NIR
Resolution	3 in. pixel size

Orthophoto Horizontal Accuracy (n=16)	WSI Achieved (ft.)
RMSE	0.482
1 Sigma	0.511
2 Sigma	0.739

Below: UltraCam Eagle installed in the aircraft.

Ground Survey

During the LiDAR survey, static (one hertz recording frequency) ground surveys were conducted over nine monuments with known coordinates. GPS data was uploaded to WSI cloud resources for WSI PLS QA/QC and oversight. OPUS processing triangulated the position of each monument using three CORS stations, resulting in a fully adjusted position. After multiple sessions of data collection at each monument, accuracy was calculated. During the US government shutdown from October 1 to October 16, 2013, our typical workflow of processing GPS data through OPUS was not possible. After research and testing of OPUS alternatives, we found that Trimble RTX gave us consistent, accurate solutions when comparing to past sessions holding OPUS as the standard. Blue Marble Geographics Calculator 2013 SP1 software was used to convert the geodetic positions from the RTX and OPUS reports.

Instrumentation

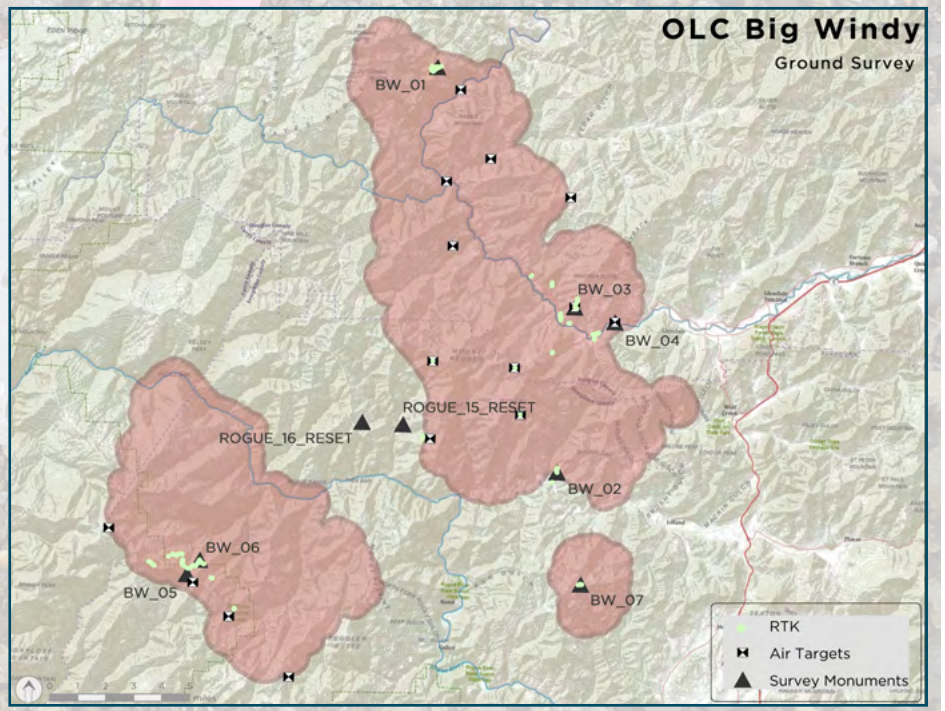
For this study area all Global Navigation Satellite System (GNSS) survey work utilizes a Trimble GNSS receiver model R7 with a Zephyr Geodetic Antenna Model 2 for static control points. The Trimble GPS R8 unit is used primarily for real time kinematic (RTK) work but can also be used as a static receiver. For RTK data, the collector begins recording after remaining stationary for five seconds then calculating the pseudo range position from at least three epochs with the relative error under 1.5 centimeters horizontal and 2.0 centimeters vertical. All GPS measurements are made with dual frequency L1-L2 receivers with carrier-phase correction.

Monumentation

Existing and established survey benchmarks serve as control points during LiDAR acquisition including those previously set by WSI. NGS benchmarks are preferred for control points; however, in the absence of NGS benchmarks, WSI produces our own monuments. These monuments are spaced at a minimum of one mile and every effort is made to keep them within the public right of way or on public lands. If monuments are necessary on private property, consent from the owner is required. All monumentation is done with 5/8" x 30" rebar topped with a 2 inch diameter aluminum cap stamped "Watershed Sciences, Inc. Control." Seven new monuments were established and occupied for the BLM Fires study area (see Monument table at bottom left).

Monument Accuracy	
FGDC-STD-007.2-1998 Rating	
St Dev NE	0.020 m
St Dev z	0.050 m

Monuments			
	Datum NAD 83 (2011)		
Name	Latitude	Longitute	Ellipsoid Height (m)
BW_01	42° 52' 16.18555"	-123° 36' 40.48343"	843.489
BW_02	42° 39' 48.51008"	-123° 31' 04.99973"	338.235
BW_03	42° 44' 57.03697"	-123° 30' 33.55483"	746.193
BW_04	42° 44' 31.35062"	-123° 28' 50.74246"	390.363
BW_05	42° 36' 15.95668"	-123° 46' 30.78800"	1132.792
BW_06	42° 36' 43.47390"	-123° 45' 59.37129"	984.428
BW_07	42° 36' 21.06403"	-123° 29' 56.66432"	938.421
ROGUE_15_RESET	42° 41' 08.89031"	-123° 37' 37.94635"	428.227
ROGUE_16_RESET	42° 41' 10.82713"	-123° 39' 21.18355"	772.840



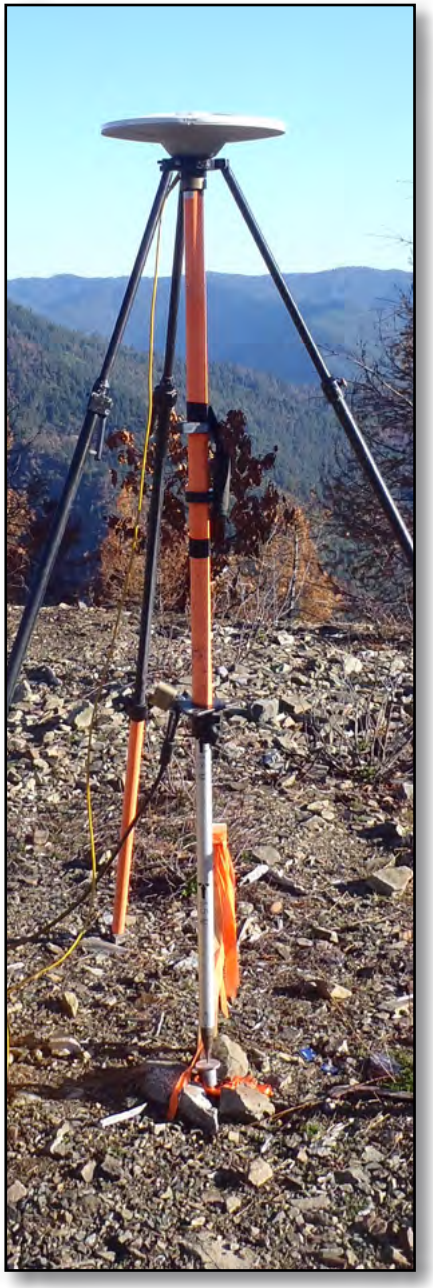
Methodology

Each aircraft is assigned a ground crew member with two R7 receivers and an R8 receiver. The ground crew vehicles are equipped with standard field survey supplies and equipment including safety materials. All control points are observed for a minimum of two survey sessions lasting no fewer than two hours. At the beginning of every session the tripod and antenna are reset, resulting in two independent instrument heights and data files. Data are collected at a rate of one hertz, using a 10 degree mask on the antenna.

All RTK measurements are made during periods with a Position Dilution of Precision (PDOP) of less than 3.0 and in view of at least six satellites by the stationary reference and roving receiver. RTK positions are collected on 20 percent of the flight lines and on bare earth locations such as paved, gravel or stable dirt roads, and other locations where the ground is clearly visible (and is likely to remain visible) from the sky during the data acquisition and RTK measurement period(s). In order to facilitate comparisons with LiDAR survey points, RTK measurements are not taken on highly reflective surfaces such as center line stripes or lane markings on roads. RTK points are taken no closer than one meter to any nearby terrain breaks such as road edges or drop offs. Examples of identifiable locations would include manhole and other flat utility structures that have clearly indicated center points or other measurement locations.

Multiple differential GPS units are used in the ground based real-time kinematic portion of the survey. To collect accurate ground surveyed points, a GPS base unit is set up over monuments to broadcast a kinematic correction to a roving GPS unit. The ground crew uses a roving unit to receive radio-relayed kinematic corrected positions from the base unit. This RTK survey allows precise location measurement (≤1.5 centimeters).

R7 Receiver



Accuracy

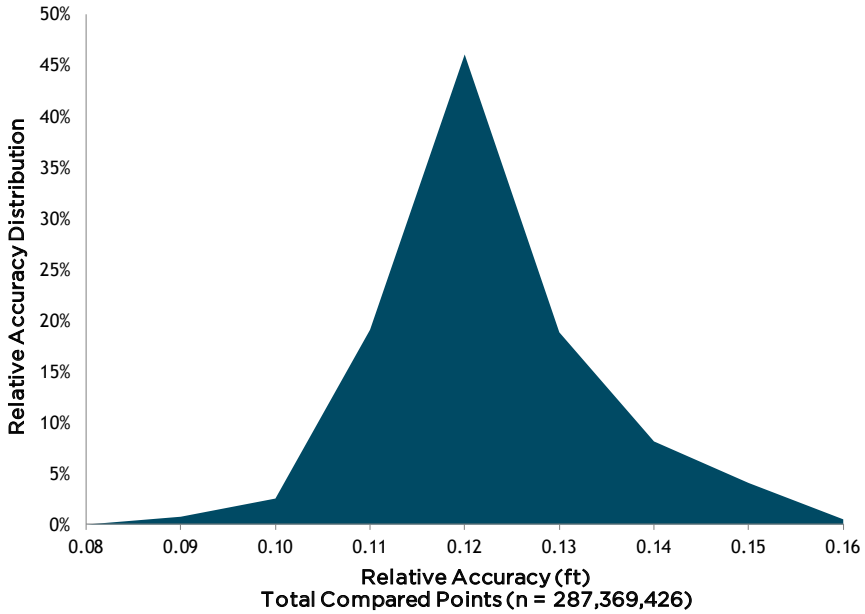
Relative Accuracy

Relative accuracy refers to the internal consistency of the data set and is measured as the divergence between points from different flightlines within an overlapping area. Divergence is most apparent when flightlines are opposing. When the LiDAR system is well calibrated the line to line divergence is low (<10 centimeters). Internal consistency is affected by system attitude offsets (pitch, roll, and heading), mirror flex (scale), and GPS/IMU drift.

Relative accuracy statistics are based on the comparison of 393 flightlines and over 287 million points. Relative accuracy is reported for the entire study area.

Relative Accuracy Calibration Results	
Project Average	0.12 ft. (0.04 m)
Median Relative Accuracy	0.11 ft. (0.03 m)
1σ Relative Accuracy	0.12 ft. (0.04 m)
2σ Relative Accuracy	0.14 ft. (0.04 m)

Relative Accuracy Distribution



Below: LiDAR point cloud with RGB extraction from orthophotos. 4 miles northwest of Glendale.

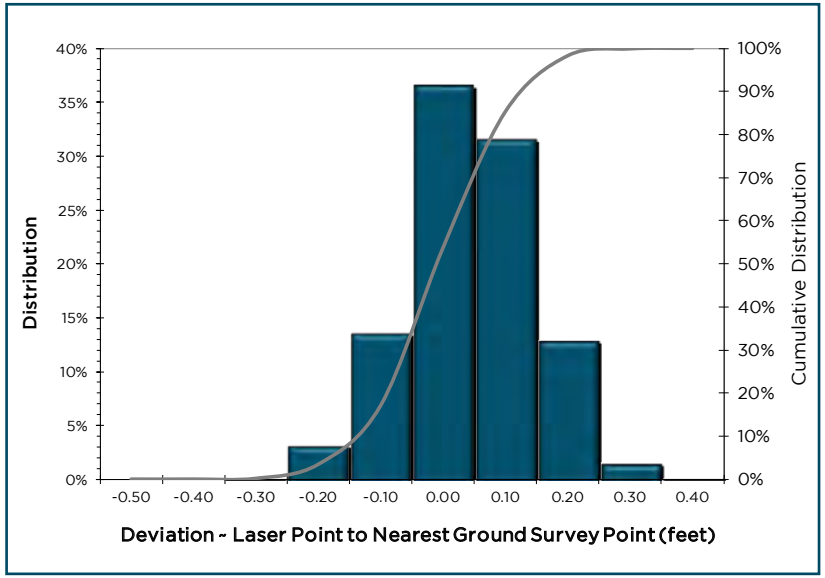
Vertical Accuracy

Vertical Accuracy reporting is designed to meet guidelines presented in the National Standard for Spatial Data Accuracy (NSSDA) (FGDC, 1998) and the ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data V1.0 (ASPRS, 2004). The statistical model compares known RTK ground survey points to the closest laser point. Vertical accuracy statistical analysis uses ground control points in open areas where the LiDAR system has a "very high probability" that the sensor will measure the ground surface and is evaluated at the 95th percentile. For the BLM Fires study area, 1,744 RTK points were collected.

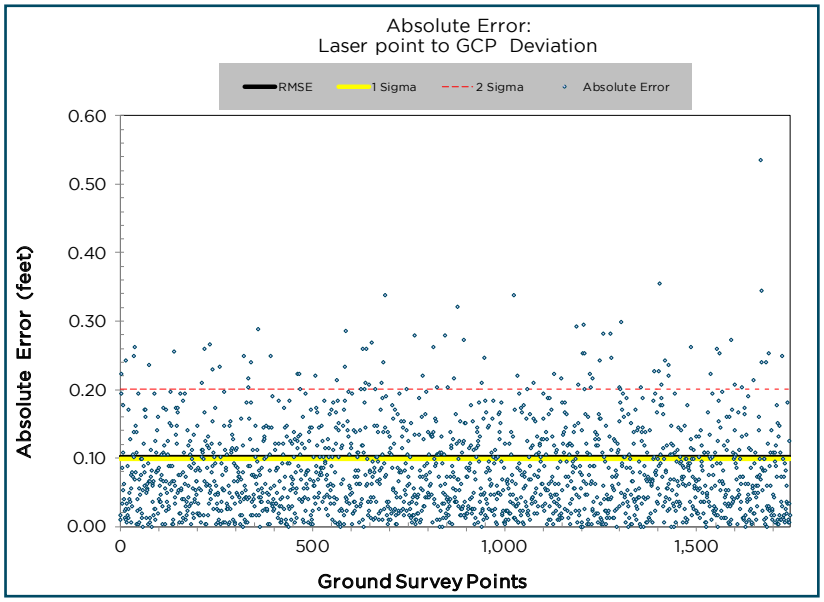
For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as "Compiled to Meet." Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation statistics displayed to the right.

Vertical Accuracy Results	
Sample Size (n)	1,744
Root Mean Square Error	0.10 ft (0.03 m)
1 Standard Deviation	0.10 ft (0.03 m)
2 Standard Deviations	0.20 ft (0.06 m)
Average Deviation	-0.01 ft (0.00 m)
Minimum Deviation	-0.53 ft (-0.16 m)
Maximum Deviation	0.35 ft (0.11 m)

Vertical Accuracy Distribution



RTK Absolute Error



Density

Pulse Density

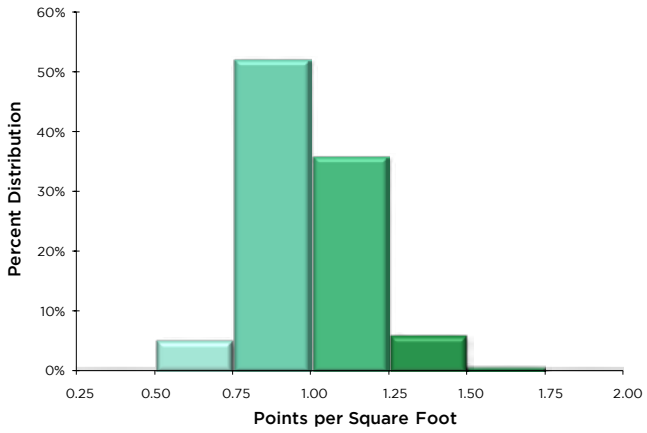
Some types of surfaces (e.g., dense vegetation, water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according to terrain, land cover, and water bodies. Density histograms and maps have been calculated based on first return laser pulse density and ground-classified laser point density.

Average Point Densities			
Pulse Density (sq ft)	Pulse Density (sq m)	Ground Density (sq ft)	Ground Density (sq m)
0.99	10.68	0.10	1.03

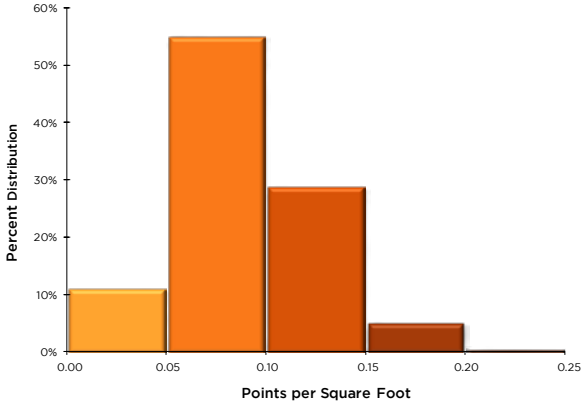
Ground Density

Ground classifications were derived from ground surface modeling. Further classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes, and at tile boundaries.

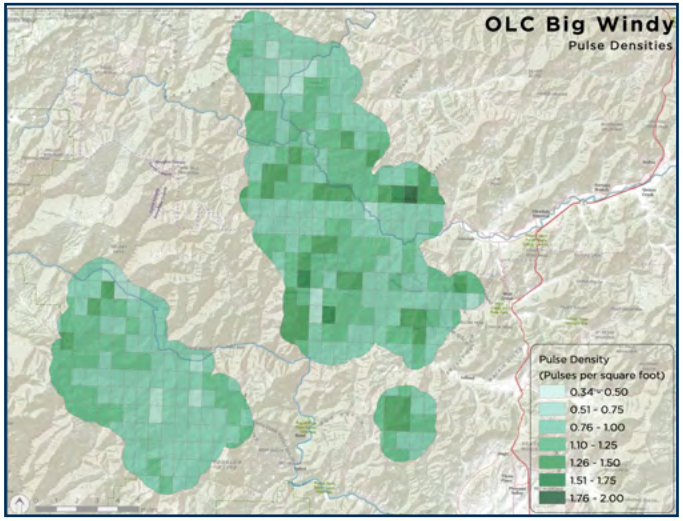
Pulse Density Distribution



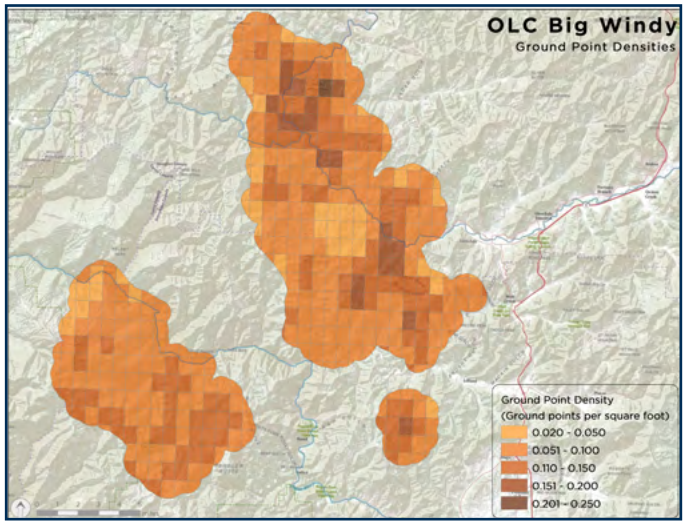
Ground Density Distribution



Average Pulse Density per 0.75' USGS Quad
(color scheme aligns with density chart)



Average Ground Point Density per 0.75' USGS Quad
(color scheme aligns with density chart)



[Page Intentionally Blank]

Certification

Watershed Sciences provided LiDAR services for the OLC BLM Fires study area as described in this report.

I, Mathew Boyd, have reviewed the attached report for completeness and hereby state that it is a complete and accurate report of this project.

Mathew Boyd
Principal
Watershed Sciences, Inc.

I, Christopher W. Yotter-Brown, being first duly sworn, say that as described in the Ground Survey subsection of the Acquisition section of this report was completed by me or under my direct supervision and was completed using commonly accepted standard practices. Accuracy statistics shown in the Accuracy Section have been reviewed by me to meet National Standard for Spatial Data Accuracy.

Christopher W. Yotter-Brown, PLS Oregon & Washington
WSI
Portland, OR 97204