WSI Applied Remote Sensing and Analysis

OLC Lane County: Delivery 5

Data collected for:
Oregon Department of Geology and Mineral Industries

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“Lane 17” and “Lane 19” survey caps.

Project Overview

WSI has completed the acquisition and processing of Light Detection and Ranging (LiDAR) data and Four-Band Radio Metric Image Enhanced Survey (FRIES) of the OLC Lane County Delivery Area Five, for the Oregon Department of Geology and Mineral Industries (DOGAMI). The Oregon LiDAR Consortium's Lane County project area of interest (AOI) encompasses 1,640,978 acres. Delivery Area Five encompasses 68,155.1 acres.

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.

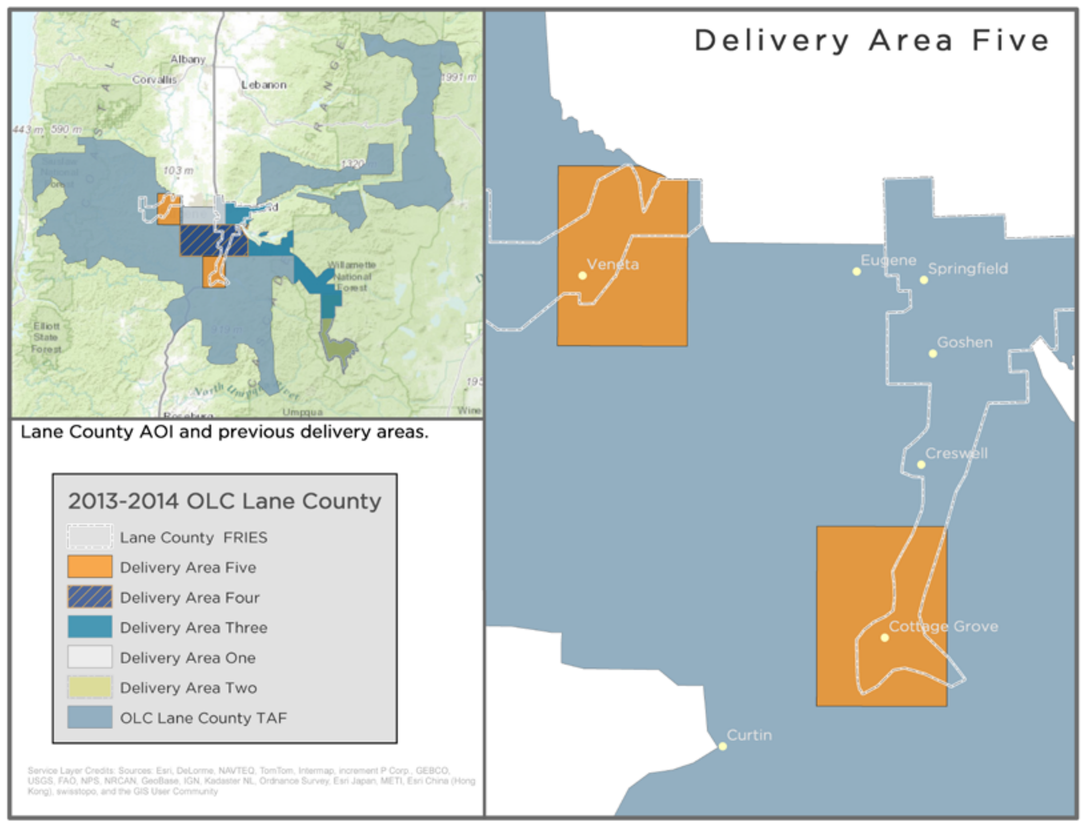
WSI began data collection on September 5, 2013 for the Lane County project and collection is currently ongoing contingent upon weather. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

Final products created include LiDAR point cloud data, three-foot digital elevation models of bare earth ground model and highest-hit returns, 1.5-foot intensity rasters, 3-inch orthophotos, ground density rasters, study area vector shapes, and corresponding statistical data.

WSI acquires and processes data in the most current, NGS-approved datums and geoid. For OLC Lane county, all final deliverables are projected in Oregon Lambert, endorsed by the Oregon Geographic Information Council (OGIC),[1] using the NAD83(2011) horizontal datum and the NAVD88 (Geoid 12a) vertical datum, with units in international feet.

OLC Lane County AOI Data Delivered November 18, 2014	
Acquisition Dates	September 10 - 13, 2013, November 27 - 28, 2013 December 4, 2013 January 25 - 26, 2014 April 7 - 8, 2014 June 4- 7, 2014
Delivery Area Five Area of Interest	68,155.1 acres
Projection	Oregon Lambert
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	International Feet

Study Area



Lane County AOI and previous delivery areas.

1 http://www.oregon.gov/DAS/EISPD/GEO/pages/coordination/projections/projections.aspx

Aerial Acquisition

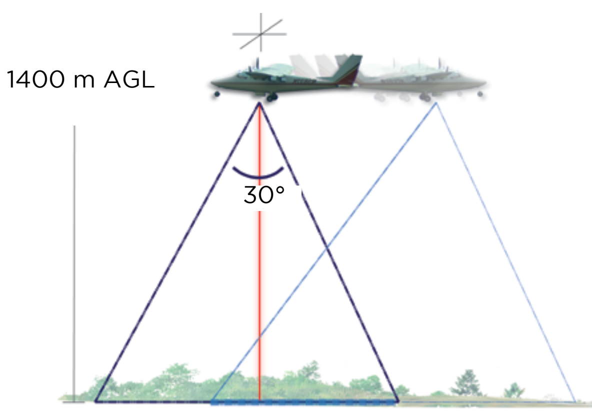
Cessna Caravan

LiDAR Survey

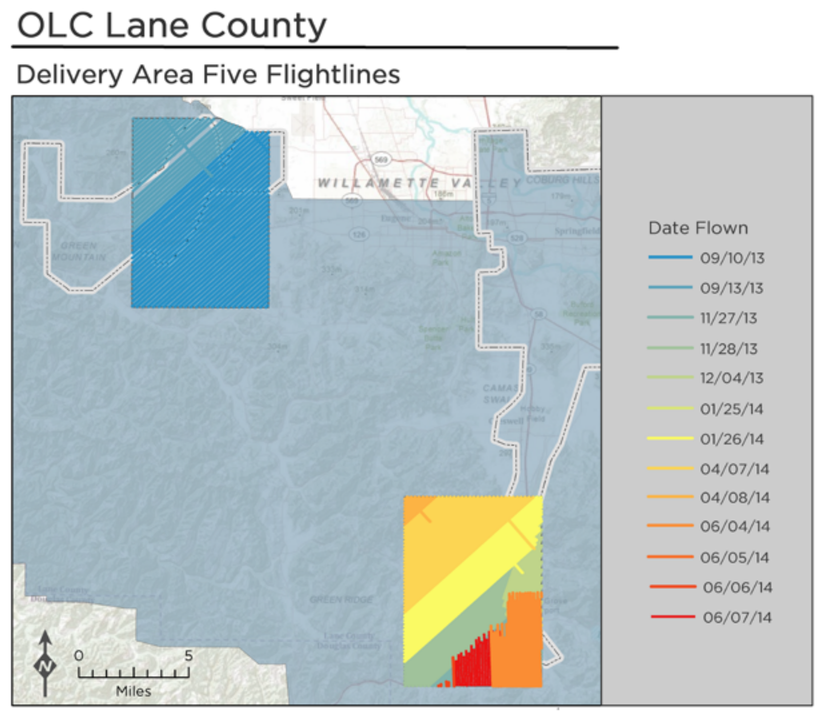
The LiDAR survey utilized both Leica ALS70 and ALS50 sensors mounted in a Cessna Caravan 208B and Piper PA-31 respectively. The systems were programmed to emit single pulses at a rate of 190 to 198 kilohertz, and flown at 1,400 meters or 900 meters above ground level (AGL), capturing a scan angle of +/-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.

The native pulse density is the number of pulses emitted by the LiDAR system. Some types of surfaces such as dense vegetation or water may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and lightly vary according to distributions of terrain, land cover, and water bodies. The study area was surveyed with opposing flight line side-lap of greater than 65 percent with at least 100 percent overlap to reduce laser shadowing and increase surface laser painting. The system allows up to four range measurements per pulse, and all discernible laser returns were processed for the output dataset.

To solve for laser point position, it is vital to have an accurate description of aircraft position and attitude. Aircraft position is described as x, y, and z and measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is measured 200 times per second (200 hertz) as pitch, roll, and yaw (heading) from an onboard inertial measurement unit (IMU). As illustrated in the accompanying map, 572 flightlines provide coverage of the study area.



Project Flightlines



Lane County Acquisition Specifications	
Sensors Deployed	Leica ALS 50 and Leica ALS 70
Aircraft	Cessna Caravan 208B, Piper-PA
Survey Altitude (AGL)	1400 m / 900 m
Pulse Rate	190-198 kHz
Pulse Mode	Single (SPiA)
Field of View (FOV)	30°
Roll Compensated	Yes
Overlap	100% overlap with 65% sidelap
Pulse Emission Density	≥ 8 pulses per square meter

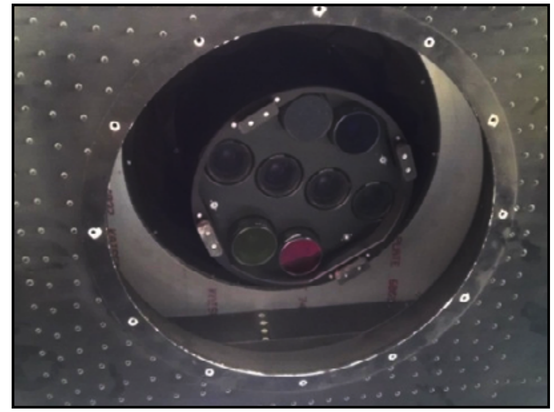
Aerial Acquisition

Photography

The photography or Four-Band Radio Metric Image Enhanced Survey (FRIES) utilized an UltraCam Eagle 260 megapixel camera mounted in a Cessna 208B Caravan. The UltraCam Eagle is an 80 mm, 260 megapixel large format digital aerial camera manufactured by the Microsoft Corporation. The system is gyro-stabilized and contains a fully integrated UltraNav flight management system with a POS-AV 510 IMU embedded within the body of the camera unit.

The Eagle was designed with high efficiency, high resolution, and high accuracy in mind. With a physical pixel size of 5.2 microns, the Eagle captures a 6.5 cm ground sample distance (GSD) at a flying height of 1,000 meters AGL. This sensor size of the camera is 20,010 x 13,080 pixels in size, which allows for total ground coverage of 1300 x 850 meters within a single captured image frame at 1,000 meters AGL. This large footprint coupled with a fast frame rate (1.8 seconds per frame) allows for highly efficient acquisition. The precise integrated UltraNav system is accurate enough for direct georeferencing in many applications.

The UltraCam Eagle simultaneously collects panchromatic and multispectral (RGB, NIR) imagery in 14 bit format. The spectral sensitivity of the panchromatic charged coupled device (CCD) array ranges from 400-720 nm, with 16,000 grey values per pixel. Four separate 27 mm lenses collect red (590-720 nm), green (490-660 nm), blue (410-590 nm) and near infrared (690-990 nm) light. Panchromatic lenses collect high resolution imagery by illuminating nine CCD arrays, writing nine raw image files. RGB and NIR lenses collect lower resolution imagery, written as four individual raw image files. Level 2 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 3 pan-sharpened TIFFs in either 8 bit format.



Above: UltraCam Eagle lens configuration as viewed from the Cessna Caravan.

Above: A Cessna Grand Caravan 208B was employed in the collection of all orthoimagery.

Below: UltraCam Eagle installed in the aircraft.

Orthophoto Processing

Within the UltraMap software suite, raw acquired images are radiometrically and geometrically corrected using the camera's calibration files and output as Level 2 images. The resulting radiometry is then manually edited to ensure each image has the appropriate tone, no pixels are clipped, and to blend each image with its neighbors. Once radiometry has been edited, separate RGBI and panchromatic images are blended together to form single level 3 pan-sharpened 4 band TIFF images.

The kinematic GPS positional data is post-processed in office, using static monument coordinates from base stations that were occupied for a minimum of 6 hours, and were running during the time of acquisition. Photo position and orientation are calculated by linking the time of image capture, the corresponding aircraft position and attitude, and the smoothed best estimate of trajectory (SBET) data in POSPac MMS, and outputting an initial Exterior Orientations (EO) file.

The EO file is combined with level 3 TIFFs within the Inpho software suite to place the images frames spatially. Aerial triangulation is performed to tie the image frames to each other, and to align them with surveyed ground control coordinates. A point cloud ground model is generated from the image frames by finding matching pixels between images and calculating the coordinates of each extracted point. Triangulated image frames are then draped onto a DEM, derived from the extracted point cloud and orthorectified. Individual orthorectified tiffs are blended together to remove seams and corrected for any remaining radiometric differences between images using Inpho's OrthoVista. The 4-Band image mosaic is tiled to create a usable GeoTIFF raster product.

The 4-band GeoTIFF format allows for flexibility in image analysis and display. By adjusting the image band setup to display the near infrared spectral band as red (this display is known as color-infrared), vegetation stands out extremely vividly in the orthophoto mosaic.

Digital Orthophotography Survey Specifications	
Aircraft	Cessna 208-B Grand Caravan
Sensor	UltraCam Eagle
Altitude	1,846 m AGL
GPS Satellite Constellation	6
GPS PDOP	3.0
GPS Baselines	≤ 13 nm
Image	8-bit GeoTIFF
Along Track Overlap	60%
Spectral Bands	Red, Green, Blue, NIR
Resolution	3 in. pixel size

Below: Trimble R7 set up over Lane_19.

Aerial Targets

Prior to photo acquisition, permanent and temporary aerial photo targets were located and installed throughout the study area. The air targets were set within two miles of a GPS base location and target control points (TCPs) were collected at each corner of the target, as well as the center point, for utilization in the processing and quality control of the orthophoto deliverables.

Because temporary air targets are subject to possible outside influences (e.g., weather, curious public, wildlife), WSI identifies locations adequate for collection of TCPs that are on permanent features. Selected locations include existing aerial targets, turn-arrows, STOP bars, etc. that are visible from the aircraft. WSI also paints permanent targets in appropriate locations when necessary. Additional permanent air targets were identified in the field and used for processing orthophotos.

All TCPs were acquired using one of two methods. The air targets that were set within two miles of a GPS base location had TCPs collected at each corner of the target as well as the center point. In order to increase TCP sample size for data quality, WSI also used a Fast-Static (FS) survey technique by baseline post-processing. For the air targets that were set this way, WSI collected a single static session with the R8 rover set over the center point of the target. The FS sessions lasted 15-30 minutes, depending on the distance from the air target to the base station. The static sessions and the concurrent R7 base session data were later processed in Trimble Business Center software. The use of post processing eliminates the need to deal with radio link issues, and fast static methodology generally results in precision equal to or better than full RTK collection on each target.

Examples of permanent air targets.

Ground Survey

During the LiDAR survey, static (one hertz recording frequency) ground surveys were conducted over five monuments with known coordinates. After the airborne survey, the static GPS data were processed using triangulation with CORS stations and using the Online Positioning User Service (OPUS) to quantify daily variance. Multiple sessions were processed over the same monument to confirm antenna height measurements and reported position accuracy.

Instrumentation

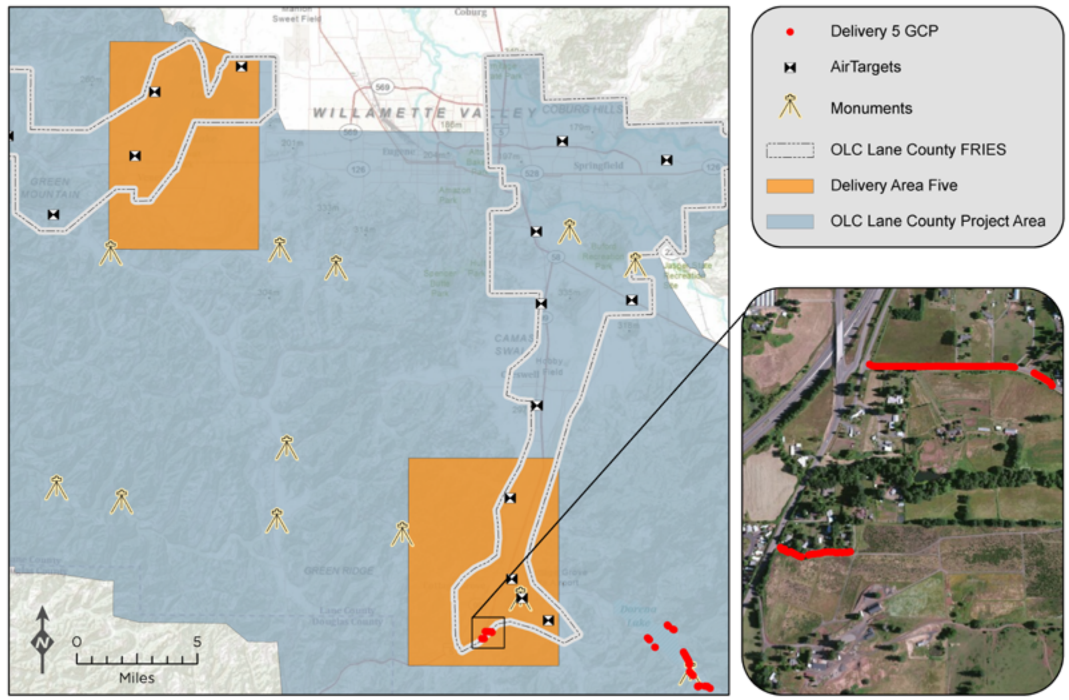
For this study area all Global Navigation Satellite System (GNSS) survey work utilizes a Trimble GNSS receiver model R7 with a Zephyr Geodetic Antenna Model 2 for static control points. The Trimble GNSS R8 unit is used primarily for real time kinematic (RTK) work but can also be used as a static receiver. 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 two-inch diameter aluminum cap stamped “Watershed Sciences, Inc. Control.” One new monument was established and occupied for the Lane County study area. See Appendix B for a list of monuments placed within the whole OLC Lane County Study Area.

OLC Lane County

Delivery Area Five Ground Control



Methodology

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

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.

The ground crew uploads the GPS data to the Dropbox website on a daily basis to be returned to the office for Professional Land Surveyor (PLS) oversight, Quality Assurance/Quality Control (QA/QC) review, and processing. OPUS processing triangulates the monument position using three CORS stations resulting in a fully adjusted position. Blue Marble Geographics Calculator 2013 SP1 is used to convert the geodetic positions from the OPUS reports. After multiple days of data have been collected at each monument, accuracy and error ellipses are calculated. This information leads to a rating of the monument based on FGDC-STD-007.2-1998 Part 2 at the 95 percent confidence level (see monument accuracy table).

All Ground Check Point (GCP) 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. For collecting GCPs, WSI uses two methods; Real Time Kinematic (RTK) and Post Processed Kinematic (PPK). GCP 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.


Ground professional collecting RTK

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).

LiDAR Accuracy

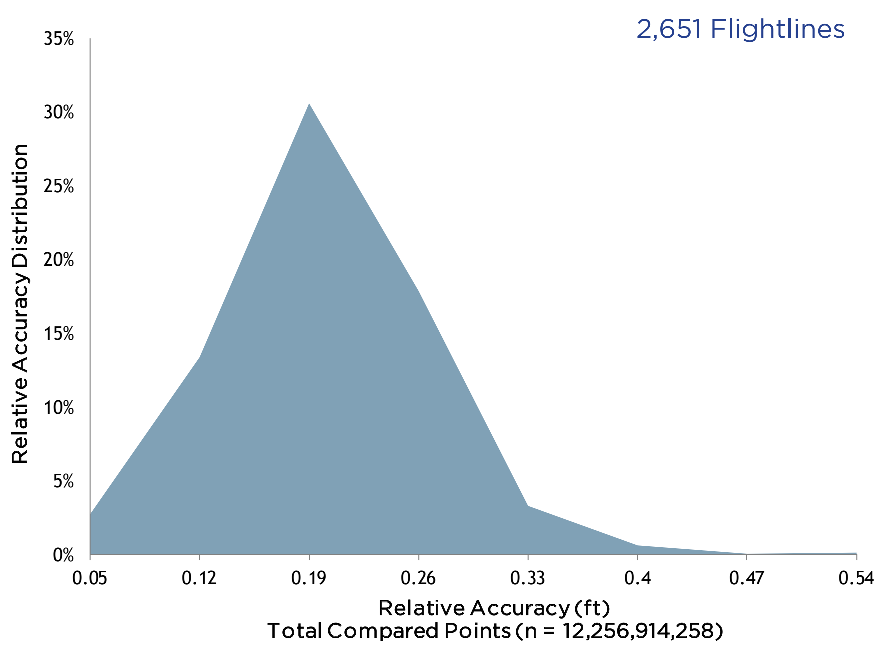
Relative Accuracy

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 2,651 full and partial flightlines (1,207 full and partial flightlines from Delivery Area Five) and over 12 billion points. Relative accuracy is reported for the cumulative delivered portions of the study area.

Relative Accuracy Calibration Results N = 2,651 flightlines	
Project Average	0.17 ft. (0.05 m)
Median Relative Accuracy	0.17 ft. (0.05 m)
1σ Relative Accuracy	0.19 ft. (0.06m)
2σ Relative Accuracy	0.27 ft. (0.08 m)

Relative Accuracy Distribution



R7 Receiver

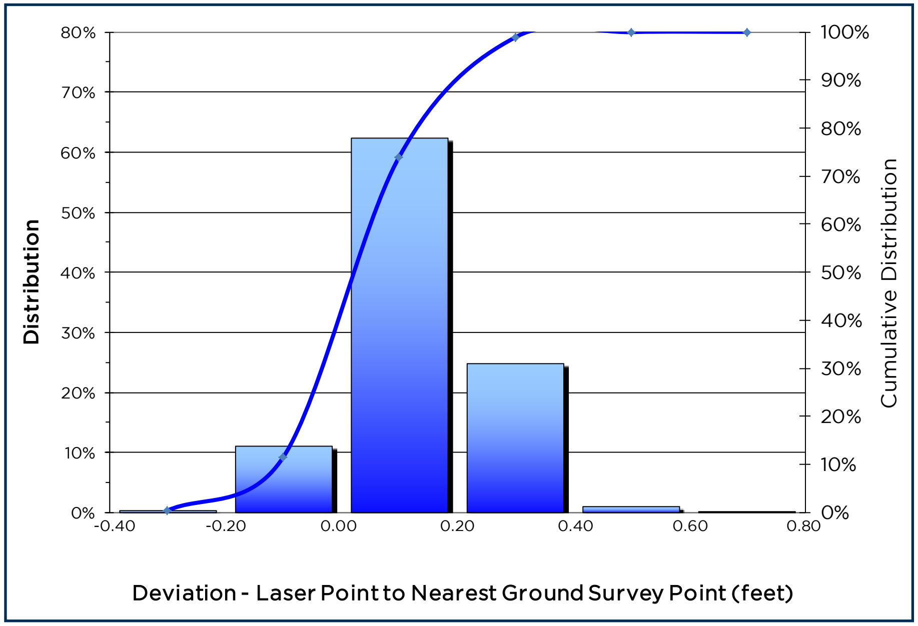
Vertical Accuracy

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 ground check points to the triangulated LiDAR surface. 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 Lane County Delivery Five study area, 2,607 GCPs were collected. Statistics are shown for Delivery Area Five.

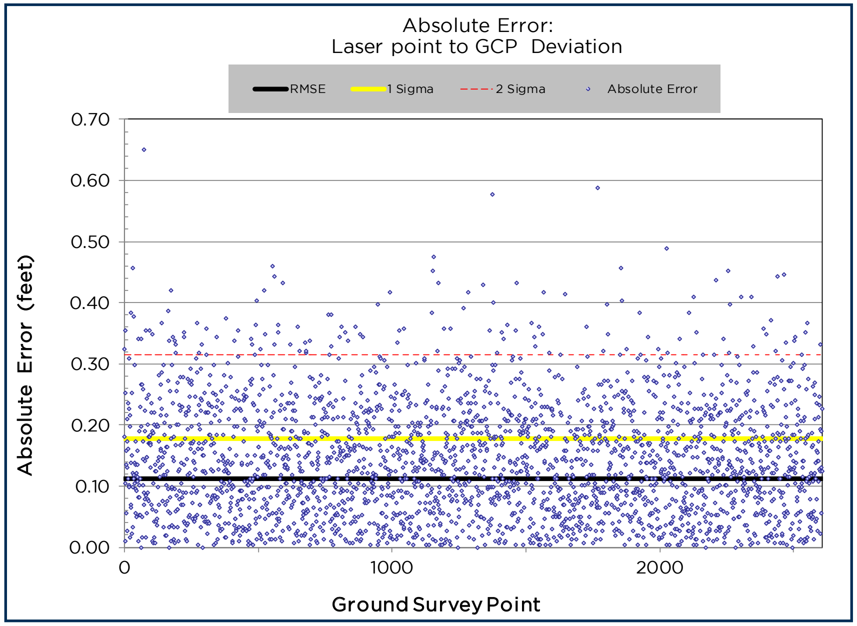
For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as "Compiled to Meet." Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation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

Vertical Accuracy Results		
	Delivery Area Five	Cumulative
Sample Size (n)	2,607 Ground check points	7,062 Ground check points
Root Mean Square Error	0.11 ft. (0.03 m)	0.09 ft. (0.03 m)
1 Standard Deviation	0.18 ft. (0.05 m)	0.09 ft. (0.03 m)
2 Standard Deviation	0.31 ft. (0.10 m)	0.18 ft. (0.06 m)
Average Deviation	-0.13 ft. (0.04m)	-0.02 ft. (0.00 m)
Minimum Deviation	-0.37 ft. (-0.11 m)	-0.55 ft. (-0.17 m)
Maximum Deviation	0.65 ft. (0.20 m)	0.42 ft. (0.13 m)

Vertical Accuracy Distribution



GCP Absolute Error



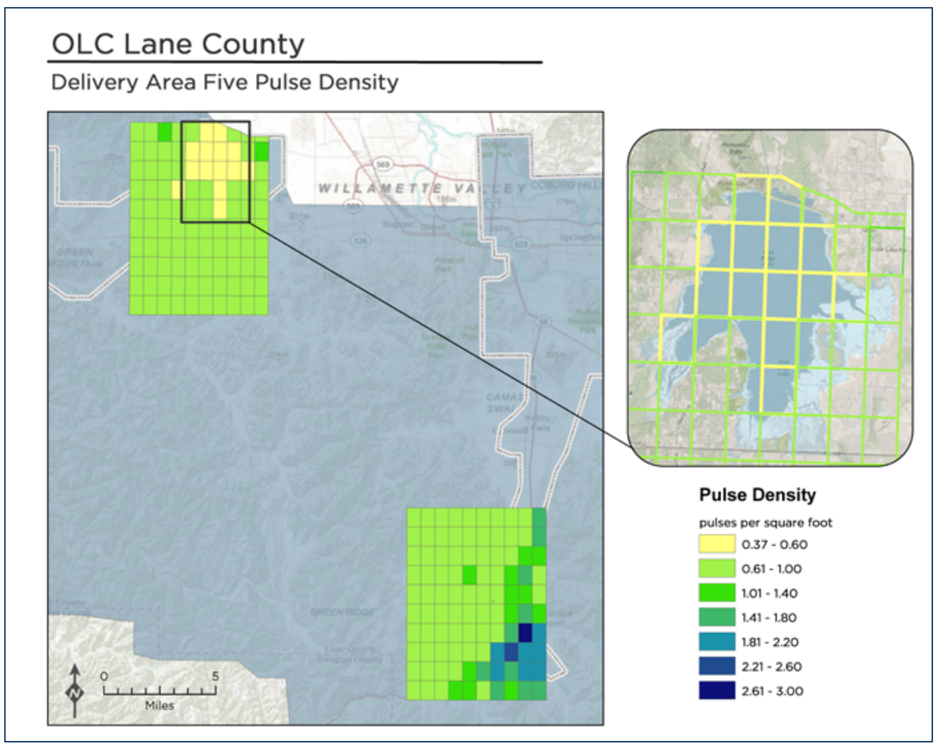
Density

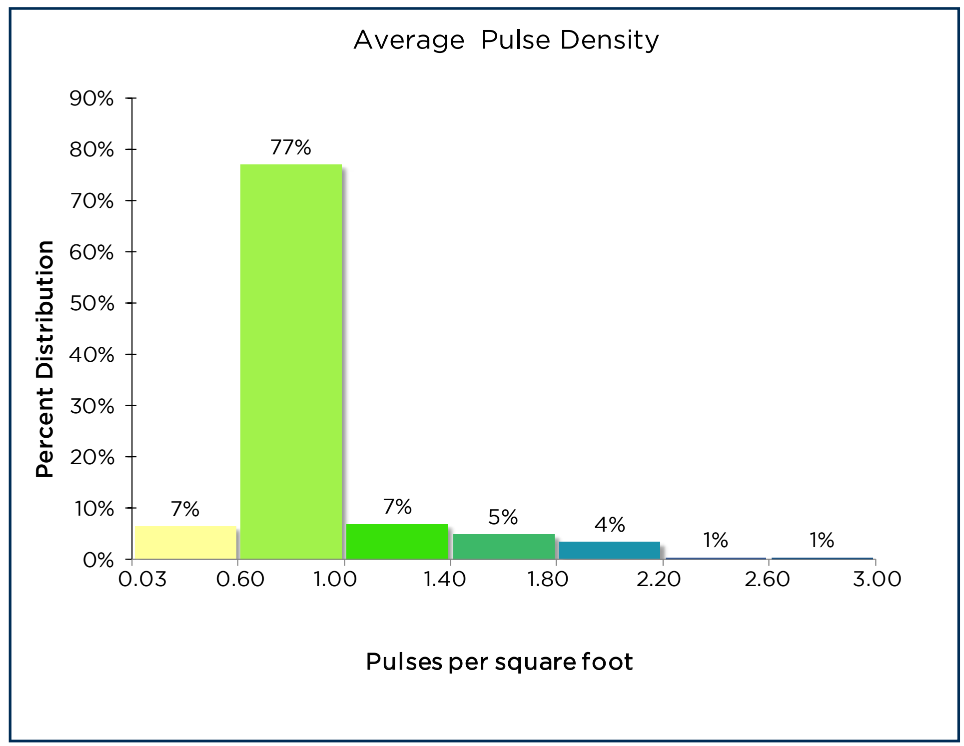
Pulse Density

Final pulse density is calculated after processing and is a measure of first returns per sampled area. 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. Densities are reported for delivery area.

Average Pulse Density	pulses per square meter	pulses per square foot
	9.90	0.92

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



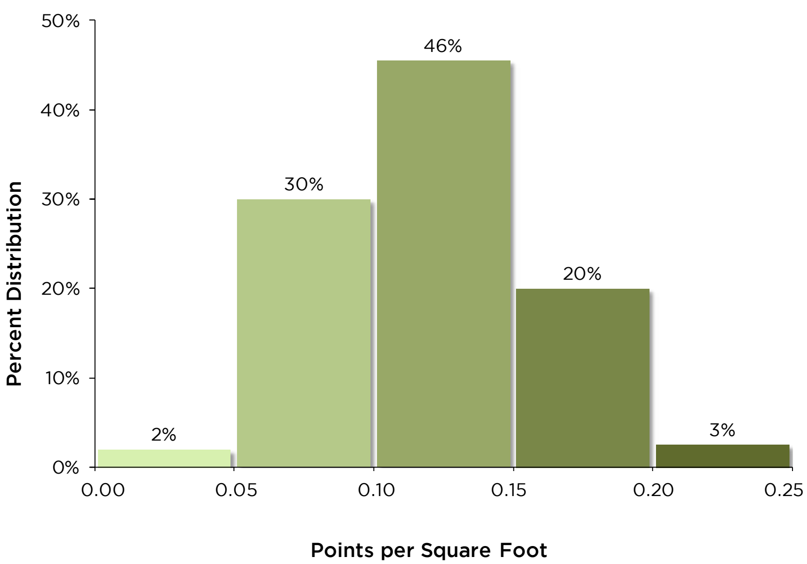


Ground Density

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. The classifications are influenced by terrain and grounding parameters that are adjusted for the dataset. The reported ground density is a measure of ground-classified point data for the delivery area.

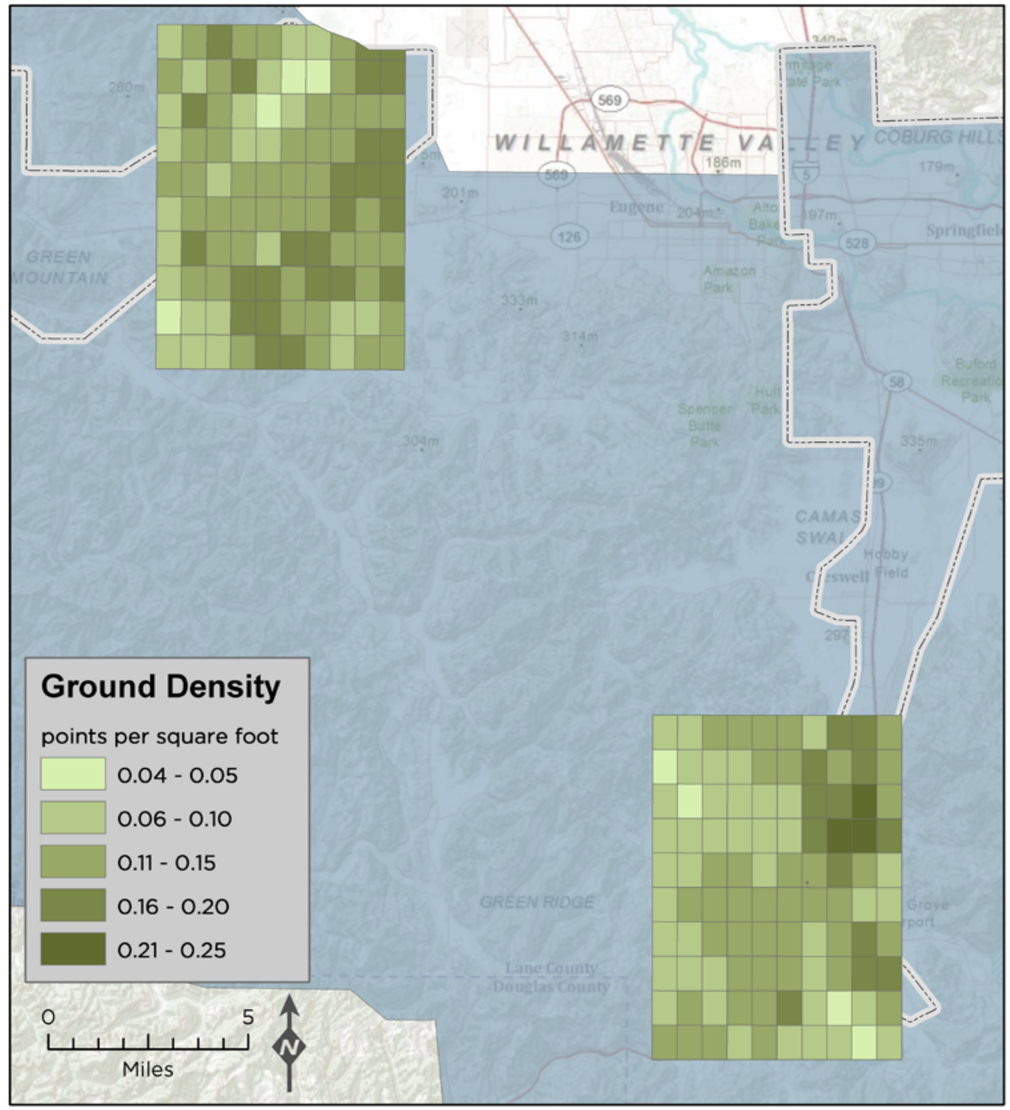
	points per square meter	points per square foot
Ground Density	1.33	0.12

Average Ground Point Density



OLC Lane County

Delivery Area Five Ground Density



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

Orthophoto Accuracy

Orthophoto Accuracy Assessment

To assess the spatial accuracy of the orthophotographs, artificial check points were established. Thirteen target control points, distributed evenly across the total acquired area, were generated on permanent air target surface features, such as painted road lines and fixed high-contrast objects or on temporary air targets. They were then compared against check points identified from the LiDAR intensity images. The accuracy of the final mosaic was calculated in relation to the LiDAR-derived check points and is listed below.

Above: Example of co-registration of color images with LiDAR intensity images. **Below:** Examples of permanent air targets located within Lane County project area.

Orthophoto horizontal accuracy results.

Orthophoto Horizontal Accuracy (n=13)	WSI Achieved (m)	WSI Achieved (ft.)
RMSE	0.110	0.360
1 Sigma	0.118	0.388
2 Sigma	0.187	0.612

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Appendix A : PLS Certification

WSI provided LiDAR services for the OLC Lane County Delivery 5 project as described in this report.

I, Evon P. Silvia, being duly registered as a Professional Land Surveyor in and by the state of Oregon, hereby certify that the methodologies, static GNSS occupations used during airborne flights, and ground survey point collection were performed using commonly accepted Standard Practices. Field work conducted for this report was conducted between September 3, 2013, and November 10, 2014.

Accuracy statistics shown in the Accuracy Section of this Report have been reviewed by me and found to meet the "National Standard for Spatial Data Accuracy".

11/17/2014

Evon P. Silvia, PLS Oregon
WSI, a Quantum Spatial Company
Corvallis, OR 97333

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JUNE 10, 2014
EVON P. SILVIA
81104LS

EXPIRES: 6/30/2014

Appendix B : GPS Monument Table

List of GPS monuments used in Lane County Survey Area.

Lane County GPS Monuments			
PID	Latitude	Longitude	Ellipse
LANE_01	44 13 34.22103	-123 55 25.99216	487.832
LANE_02	44 11 04.59366	-123 51 03.90195	104.844
LANE_05	44 16 43.86859	-124 02 41.13217	458.248
LANE_11	44 04 08.74341	-122 48 06.59661	161.587
LANE_13	44 00 41.08475	-122 59 27.48519	119.047
LANE_15	43 59 28.97732	-122 56 10.19436	139.378
AI1995	44 01 06.96543	-123 51 37.53642	-15.700
LANE_07	43 59 52.25896	-123 22 23.48186	143.322
LANE_09	44 04 26.42150	-123 30 21.24330	133.059
LANE_17	43 59 22.07068	-123 11 07.80197	111.693
LANE_19	44 00 01.44296	-123 13 56.62771	104.781
LANE_14	43 50 13.64839	-123 14 03.11154	175.699
LANE_16	43 49 45.78726	-123 07 47.74145	212.747
LANE_06	44 12 10.80761	-123 30 31.42667	196.503
LANE_08	44 08 23.10388	-123 35 55.56664	168.733
LANE_22	43 52 51.72856	-123 13 33.92296	147.785
LANE_23	43 47 25.93196	-123 01 54.25135	176.209
LANE_24	43 42 26.18996	-122 25 40.56001	450.794
LANE_25	43 42 51.38283	-122 23 45.43363	792.318
LANE_26	43 33 00.45694	-122 28 22.66794	815.341
LANE_27	43 31 20.08417	-122 20 15.46234	1080.075
LANE_30	43 37 14.50986	-123 05 19.83916	253.542
LANE_31	43 45 16.82389	-122 26 41.15314	492.053
LANE_32	43 47 33.82161	-122 25 40.76291	677.205
LANE_29	43 52 12.08177	-122 47 18.45224	420.380
LANE_28	43 53 58.92454	-122 48 59.17889	194.478

Lane County GPS Monuments

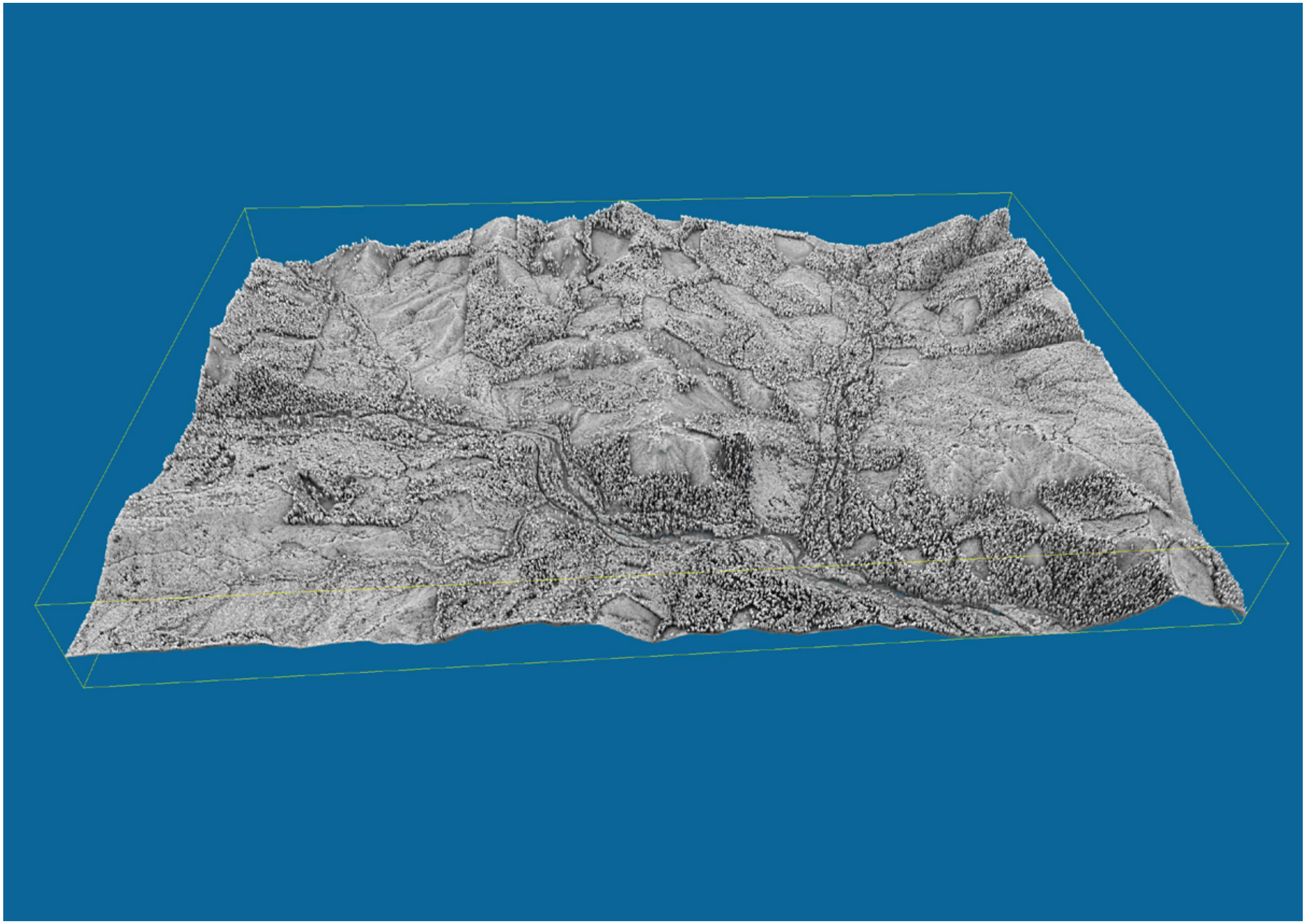
PID	Latitude	Longitude	Ellipse
LANE_34	43 45 30.54400	-122 29 48.47559	308.081
LANE_29A	43 52 12.08161	-122 47 18.45256	420.361
AI2001	43 55 19.20493	-122 47 41.08223	195.963
LANE_35	43 48 11.57911	-122 42 37.56859	1041.596
LANE_36	43 50 54.28025	-123 21 47.73924	229.292
LANE_37	43 51 23.46541	-123 25 02.19196	197.776
LANE_20	43 53 27.38516	-123 28 30.83622	153.934
LANE_18	43 55 40.86962	-123 37 20.35729	178.186
LANE_38	43 58 54.14928	-123 41 53.55130	424.298
LANE_10	44 00 11.70302	-123 59 45.31927	-21.486
LANE_46	43 38 28.84405	-123 12 52.40829	104.565
LANE_47	43 35 46.97747	-123 15 08.04840	105.980
LANE_33	43 36 30.58173	-123 01 40.84386	471.540
RP_265+4988	43 25 06.36155	-123 09 01.37675	201.245
LANE_43	43 21 17.49608	-122 44 41.88280	524.594
LANE_39	43 42 19.93987	-122 57 05.04012	456.450
LANE_40	43 35 23.35579	-123 00 04.90380	479.127
LANE_41	43 44 45.10607	-122 53 27.75969	236.302
LANE_42	43 40 03.45665	-122 48 42.76721	311.004
LANE_49	43 41 54.47511	-122 46 16.97790	331.018
LANE_45	43 30 26.64379	-122 50 42.75367	1160.885
LANE_06	44 12 10.80764	-123 30 31.42667	196.522
LANE_12	44 05 44.71178	-123 43 49.91180	63.439
LANE_06A	44 14 32.55999	-123 24 47.48386	336.456
LANE_03	44 17 35.16542	-123 41 42.13047	69.602
LANE_51	44 05 39.63958	-122 47 04.98635	545.973

Lane County GPS Monuments

PID	Latitude	Longitude	Ellipse
AI1987	44 12 27.42931	-122 49 49.03656	157.321
LANE_04	44 19 30.86443	-123 39 58.03953	230.843
LANE_53	44 11 00.46734	-121 55 12.33453	1466.849
LANE_54	44 10 41.98041	-121 57 40.08010	1208.453
LANE_55	44 14 58.44023	-121 49 52.63978	1558.758
LANE_56	44 15 38.38604	-121 48 09.68817	1601.779
AJ8191	44 39 23.18028	-121 41 33.57573	1983.063
LANE_59	44 42 09.70199	-122 04 57.99867	497.773
LANE_69	44 42 36.07455	-122 06 34.98373	463.920
WRM_SP_01	44 39 22.75371	-121 41 33.13407	1981.876
LANE_57	44 25 19.90234	-121 51 23.67546	1434.237
LANE_58	44 26 11.01683	-121 56 36.51882	1117.648
LANE_63	44 15 13.30087	-122 07 55.02809	1377.917
LANE_64	44 13 05.95603	-122 06 13.58282	1482.944
LANE_67	44 09 58.41010	-122 40 34.96786	736.802
LANE_68	44 12 06.66895	-122 39 43.82798	699.408
LANE_60	44 40 38.57139	-121 54 04.98722	1281.918
LANE_70	44 07 45.63642	-122 26 24.72517	543.955
BLUE_RIV_04	44 19 45.50913	-122 06 01.51323	1412.718
LANE_71	44 10 24.58901	-122 32 25.77843	536.990
LANE_74	44 04 58.19343	-122 21 53.66019	715.086

Appendix C : Selected Imagery

Orthophotos: **Top Left:** Main Street Bridge, Springfield, Oregon. **Top Right:** McKenzie View Drive, south of Coburg, Oregon. **Bottom Left:** Kellogg Road, Springfield, Oregon **Bottom Right:** Island Park along the Willamette River, Spring-field, Oregon.



Highest Hit DEM of section of Delivery Area Two.

LiDAR derived DEM's: **Above** highest hit DEM and **Below:** bare earth DEM. Both areas depicted are within delivery area three.