LiDAR Quality Assessment Report

The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset and the Center for LiDAR Information Coordination and Knowledge. The USGS recognizes the complexity of LiDAR collection and processing performed by the data suppliers and has developed this Quality Assessment (QA) procedure to accommodate USGS collection and processing specifications with flexibility. The goal of this process is to assure LiDAR data are of sufficient quality for database population and scientific analysis. Concerns regarding the assessment of these data should be directed to the Chief, Data Operations Branch, 1400 Independence Road, Rolla, Missouri 65401 or NGTOCoperations@usgs.gov.

Materials Received:
3/5/2013

Project ID:
KS_Area2-Lot5_2012

Project Alias(es):
KS_25 COUNTIES LIDAR#1

Project Type: Partnership

Project Description:

USGS partnership, contract # G12PC00012. The purpose of this project is to **acquire detailed surface elevation data for use in conservation planning, design, research, floodplain mapping, dam safety assessments, and hydrologic modeling.** The project is 3 areas consisting of 5 lots: Area 1 as one lot, Area 2 as one lot divided into 6 blocks, and consists of **Ellis, Kingman, Ness, Osborne, Pawnee, Pratt, Reno, Rush, Russell, Smith and Stafford counties.** Area 3 Kansas will consist of the Northeast area including Brown, Doniphan, Jackson, Leavenworth, Nemaha, Pottawatomie, Webaunsee, and Wyandotte counties; the Southeast including Cherokee, Crawford, Linn and Bourbon counties; and Butler County. Areas were defined and supplied by Kansas Department of Administration and includes approximately 9700 square miles for analysis. This report covers Area 2 Lot 5 which is 9932.4 sq. miles.
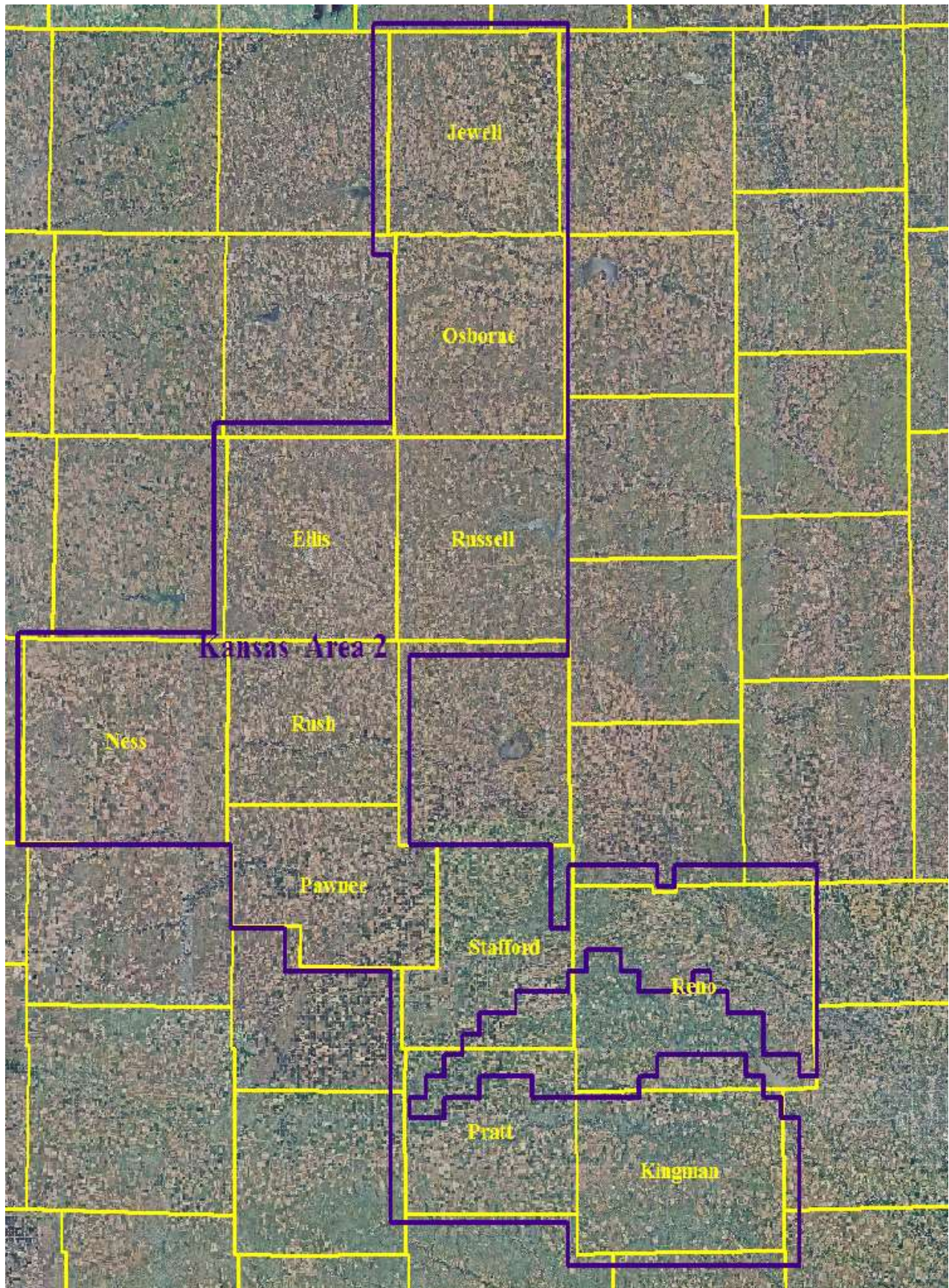
Year of Collection:
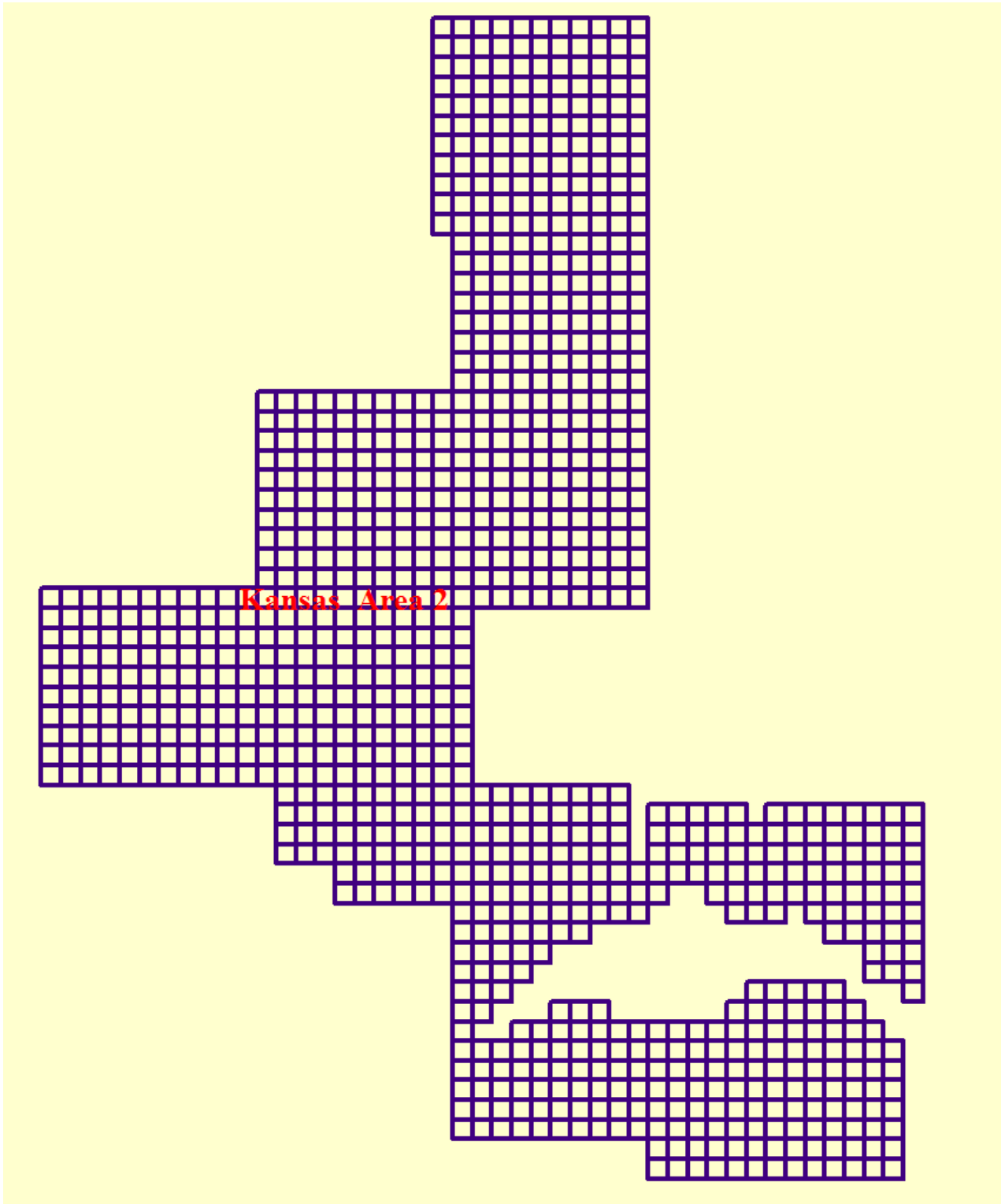January 2nd - April 23, 2012

Lot 5 of 6 lots.

Project Extent:
☑ Project Extent image?

Kansas Area 2

☑ Project Tiling Scheme image?

Kansas Area 2

Contractor: Applicable Specification:

Kucera International Inc.	V13

Licensing Restrictions:

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Ingrid Landgraf	NSDI Liaison	785-832-3566	imlandgraf@usgs.gov

Project Deliverables

All project deliverables must be supplied according to collection and processing specifications. The USGS will postpone the QA process when any of the required deliverables are missing. When deliverables are missing, the Contracting Officer Technical Representative (COTR) will be contacted by the Elevation/Orthoimagery Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

☑ Collection Report
☑ Survey Report
☑ Processing Report
☑ QA/QC Report
☑ Control and Calibration Points

☑ Project Shapefile/Geodatabase
☑ Project Tiling Scheme Shapefile/Gdb
☑ Control Point Shapefile/Gdb
☑ Breakline Shapefile/Gdb
☑ Project XML Metadata

Multi-File Deliverables

File Type	Quantity
☑ Swath LAS Files ☑ Required? ☐ XML Metadata?	457
☑ Intensity Image Files ☑ Required?	1029
☑ Tiled LAS Files ☑ Required? ☑ XML Metadata?	1029
☑ Breakline Files ☑ Required? ☑ XML Metadata?	6
☑ Bare-Earth DEM Files ☑ Required? ☑ XML Metadata?	1029

First Return DEM

Errors, Anomalies, Other Issues to document?	◉ Yes ○ No

missing swath metadata. blind points missing

Project Geographic Information

Areal Extent:

9932.4

Sq Mi
Grid Size:

1

meters
Tile Size:

5000 x 5000

 meters

Nominal Pulse Spacing: 1.4 meters
Vertical Datum: NAVD88 meters
Horizontal Datum: NAD83_HARN meters

Project Projection/Coordinate Reference System: UTM Zone 14/NAD83 HARN meters.

This Projection Coordinate Reference System is consistent across the following deliverables:
- ☑ Project Shapefile/Geodatabase
- ☑ Project Tiling Scheme Shapefile/Gdb
- ☑ Checkpoints Shapefile/Geodatabase
- ☑ Project XML Metadata File
- ☑ Swath LAS XML Metadata File
- ☑ Classified LAS XML Metadata File
- ☑ Breaklines XML Metadata File
- ☑ Bare-Earth DEM XML Metadata File
- ☑ Swath LAS Files
- ☑ Classified LAS Files
- ☑ Breaklines Files
- ☑ Bare-Earth DEM Files

Review Cycle

This section documents who performed the QA Review on a project as well as when QA reviews were started, actions passed, received, and completed.

Review Start Date:
5/1/2014

Action to Contractor Date	Issue Description	Return Date
5/7/2014	KS Area2 Blocks 1-6 Review DEM errors: 1 artifact on road 1 missing ground points on road 1 vegetation 1 floating water 1 processing error 2 flatten water 2 areas with spikes 7 areas not water 36 bridges 41 culverts 273 hydro elevation errors See shapefile for all DEM errors Metadata were not re-delivered All metadata have the same information. The swath metadata does not report the FVA for swath. Classified LAS and Swath were not re-delivered. See LAS and Swath section for errors	

Review Complete: 5/7/2014

Metadata Review

Provided metadata files have been parsed using 'mp' metadata parser. Any errors generated by the parser are documented below for reference and/or corrective action.

The Project XML Metadata file parsed without errors.

The Classified LAS XML Metadata file parsed without errors.

The Breakline XML Metadata file parsed without errors.

The Bare-Earth DEM XML Metadata file parsed without errors.

Project QA/QC Report Review

ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the dataset. National Standards for Spatial Data Accuracy (NSSDA) guidance states that checkpoints may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. Checkpoints should be distributed so that points are spaced at intervals of at least ten percent of the diagonal distance across the dataset and at least twenty percent of the points are located in each quadrant of the dataset.

NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be selected near severe breaks in slope, such as bridge abutments, edges of roads, or near river bluffs. Checkpoints are an important component of the USGS QA process. There is the presumption that the checkpoint surveys are error free and the discrepancies are attributable to the LiDAR dataset supplied.

For this dataset, USGS checked the spatial distribution of checkpoints with an emphasis on the bare-earth (open terrain) points; the number of points per class; the methodology used to collect these points; and the relationship between the data supplier and checkpoint collector. When independent control data are available, USGS has incorporated this into the analysis.

Checkpoint Shapefile or Geodatabase:
☑ Checkpoint Distribution Image?
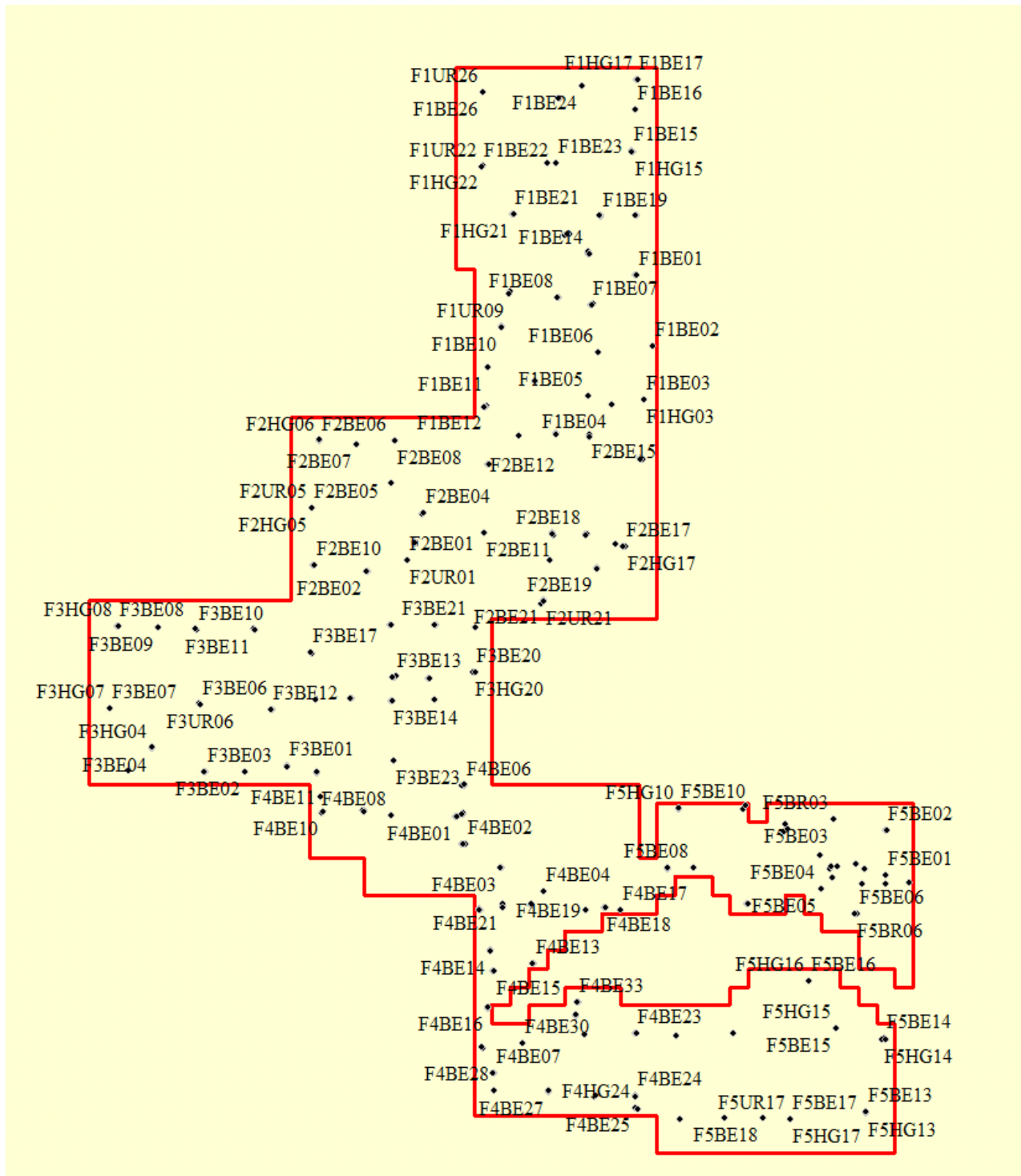
The following land cover classes are represented in this dataset (uncheck any that do not apply):

☑ Bare Earth

☑ Tall Weeds and Crops

☐ Brush Lands and Low Trees

☐ Forested Areas Fully Covered by Trees

☑ Urban Areas with Dense Man-Made Structures

There are a minimum of 20 checkpoints for each land cover class represented. Points within each class are uniformly distributed throughout the dataset. USGS was notable to locate independent checkpoints for this analysis. USGS acceptsthe quality of the checkpoint data for these LiDAR datasets.

○ Yes ⦿ No

Accuracy values are reported in terms of Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy(s) (SVA), and Consolidated Vertical Accuracy (CVA).

Accuracy values are reported in: centimeters

Required FVA Value is 24.5 centimeters or less.
Target SVA Value is 36.3 centimeters or less.
Required CVA Value is 36.3 centimeters or less.

The reported FVA of the LAS Swath data is centimeters .

The reported FVA of the Bare-Earth DEM data is 11.52 centimeters .
SVA are required for each land cover type present in the data set with the exception of bare-earth. SVA is calculated and reported as a 95th Percentile Error.

Land Cover Type	SVA Value	Units
Tall Weeds and Crops	23.10	centimeters
Brush Lands and Low Trees		N/A
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structu...	10.84	centimeters

The reported CVA of this data set is: 17.81 centimeters .

LAS Swath File Review

LAS swath files or raw unclassified LiDAR data are reviewed to assess the quality control used by the data supplier during collection. Furthermore, LAS swath data are checked for positional accuracy. The data supplier should have calculated the Fundamental Vertical Accuracy using ground control checkpoints measured in clear open terrain. The following was determined for LAS swath data for this project:

LAS Version
◉ LAS 1.2   ○ LAS1.3   ○ LAS 1.4

Swath File Characteristics
☑ Separate folder for LAS swath files
☑ Each swath files <= 2GB
☐ *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is ‖ centimeters .

Based on this review, the USGS does not accept at this time the LAS swath file data.

‖ ◉ Yes ○ No

☑ Image?

1.4 Standard Specifications for LiDAR

Acquisition		
Requirement	Description	
Returns per pulse	LiDAR sensor shall be capable of recording up to 3 (or more) returns per pulse, including 1st and last returns	
Scan angle	±17	
Swath overlap	30%	
Design pulse density (nominal)	1.4m	
GPS procedures	At least 2 GPS reference stations in operation during all missions, sampling positions at 1 Hz or higher frequently. Differential GPS baseline lengths shall not exceed 30 km. Differential GPS unit in aircraft shall sample position at 2 Hz or higher. LiDAR data shall only be acquired when GPS PDOP is ≤ 3.5 and at least 6 satellites are in view.	
Coverage	No voids between Swaths or due to cloud cover or instrument failure	

The LiDAR Final Report specifies standard specifications for LiDAR on page 5, Scan Angle, + or - 17 degrees on each side of Nadir. All swath extremely exceeds these scan angles.

☑ Image?

Table 1 shows the planned LiDAR acquisition parameters with a flying height of 2,673-3,000 meters above ground level (AGL) for the Leica ALS-50 on a mission to mission basis.

Table 1: LiDAR Leica Acquisition Parameters

Average Altitude	2673-3000 Meters AGL
Airspeed	~170 Knots
Scan Frequency	35.8 Hertz
Scan Width Half Angle	17 Degrees
Pulse Rate	82700 Hertz

Preliminary data processing was performed in the field immediately following the missions for quality control of GPS data and to ensure sufficient overlap between flight lines. Any problematic data could then be re-flown immediately as required. Final data processing was completed in the Colorado Springs office.

Table 1: LiDAR Leica Acquisition Parameters, pg 8 LiDAR Final Report, also verifies scan angle as 17 degrees on each side of Nadir. Please explain Scan Angles found in Swath data.

☐ Image?

The LiDAR Final Report specifies the Leica ALS-50 system was used to collect LiDAR for KS Area 2. KS Area 2 consists of 6 blocks. The maximum capability Field of View (FOV) at an altitude of 3000m is 75 degrees, + or - 37.5 degrees on each side of nadir for the Leica ALS-50.   LP360 stats extractor indicates 8 swath files exceed -37.5 MIN Scan Angle (SAMN) and 11 swath files exceed MAX Scan Angle (SAMX) 37.5. Those files listed by block are:

Block 1 Minimum Scan Angle (SAMN) exceeding -37.5 & Maximum Scan Angle (SAMX) exceeding 37.5:

SAMN   SAMX
RPC_1031-31302N = -40   RPC_1020-31501S = 43

RPC_1028-31305S = 41

Block 2 exceeding MIN/MAX Scan Angles:

SAMN   SAMX
RPC_2028-3204 = -44   RPC_2017-32106W = 41
RPC_2014-32103W = -43   RPC_2003-31903W = 41
                                    RPC_2019-32201W = 39
RPC_2015-32104W = -40min & 60max

Block 3 exceeding MIN/MAX Scan Angles:

SAMN   SAMX
                                    RPC_3064-33301 = 38
RPC_3057-33308 = -39min & 41max

Block 4 exceeding MIN/MAX Scan Angles:

SAMN   SAMX
RPC_4114-33001 = -62   RPC_4089-32706 = 52
                                    RPC_4107-32904W = 42

Block 5 has 0 flightlines exceeding + or - 37.5 degrees

Block 6 exceeding MIN/MAX Scan Angles:

SAMN   SAMX
RPC_6008-30302 = -46   RPC_6011-30213 = 41
RPC_6025-30110 = -38

All swath exceeds the scan angle specified in the LiDAR Final Report. Flightlines
listed above exceed FOV capability of the Leica ALS-50 system.
Please verify and explain.

☐ Image?

FVA for swath was not reported in the Swath metadata or the Final LiDAR Report for
Area 2

☐ Image?

NGTOC reports FVA accuracy on swath = 5.4cm

LAS Tile File Review

Classified LAS tile files are used to build digital terrain models using the points classified as ground. Therefore, it is important that the classified LAS are of sufficient quality to ensure that the derivative product accurately represents the landscape that was measured. The following was determined for classified LAS files for this project:

Classified LAS Tile File Characteristics
- ☑ Separate folder for Classified LAS tile files
- ☑ Classified LAS tile files conform to Project Tiling Scheme
- ☑ Quantity of Classified LAS tile files conforms to Project Tiling Scheme
- ☑ Classified LAS tile files do not overlap
- ☑ Classified LAS tile files are uniform in size
- ☑ Classified LAS tile files have no points classified as '12'

- ☐ Point classifications are limited to the standard values listed below:

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored ground (breakline proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

- ☑ Buy up?

Based on this review, the USGS does not accept at this time the classified LAS tile file data.

○ Yes ○ No

☐ Image?

> Classified LAS are not accepted due to scan angle, breakline and culvert/bridge errors
> .
> Note***classes in LAS other than the standard values are
> 17, 18, 24 and 25 which are identified as overlap.
>
> ***Class 31 exists in blocks 1 and 2 and is not described in the SOW***

Breakline File Review

Breaklines are vector feature classes that are used to hydro-flatten the bare earth Digital Elevation Models.

Breakline File Characteristics
☑ Separate folder for breakline files
☑ All breaklines captured as PolylineZ or PolygonZ features
☑ No missing or misplaced breaklines

Based on this review, the USGS does not accept at this time the breakline files.

Errors, Anomalies, Other Issues to document? ● Yes ○ No

☐ Image for error?

> Breaklines still have errors within causing banks to be too steep on some water bodies.

Bare-Earth DEM Tile File Review

The derived bare-earth DEM file receives a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by USGS using supplied and independent checkpoints, and a manual check of the appearance of the DEM layer.

Bare-Earth DEM files provided in the following format: Erdas Imagine *.img

Bare-Earth DEM Tile File Characteristics
☑ Separate folder for bare-earth DEM files
☑ DEM files conform to Project Tiling Scheme
☑ Quantity of DEM files conforms to Project Tiling Scheme
☑ DEM files do not overlap
☑ DEM files are uniform in size
☑ DEM files properly edge match
☑ Independent check points are well distributed

All accuracy values reported in centimeters .

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy$_z$) Required FVA = 24.5 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	124	11.52		
Tall Weeds and Crops	121		23.10	
Brush Lands and Low Trees				

Land Cover Category	# of Points	Fundamental Vertical Accuracy	Supplemental Vertical Accuracy	Consolidated Vertical Accuracy
Forested Areas Fully Covered by Trees	⌷		⌷	
Urban Areas with Dense Man-Made Structures	127		10.84	
Consolidated	372			17.81

☑ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy$_z$) Required FVA = 24.5 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	124	11.3		
Tall Weeds and Crops	121		22.9	
Brush Lands and Low Trees	⌷		⌷	
Forested Areas Fully Covered by Trees	⌷		⌷	
Urban Areas with Dense Man-Made Structures	127		11	
Consolidated	372			18.4

Based on this review, the USGS <u>does not recommend</u> the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

Based on this review, the USGS <u>does not accept at this time</u> the bare-earth DEM files.

Bare-Earth DEM Anomalies, Errors, Other Issues

Errors, Anomalies, Other Issues to document? ⦿ Yes ○ No

☐ Image?

Culvert, Bridge, water and misc errors still extist in the DEM
See error shape file for all errors.

This is the end of the report.