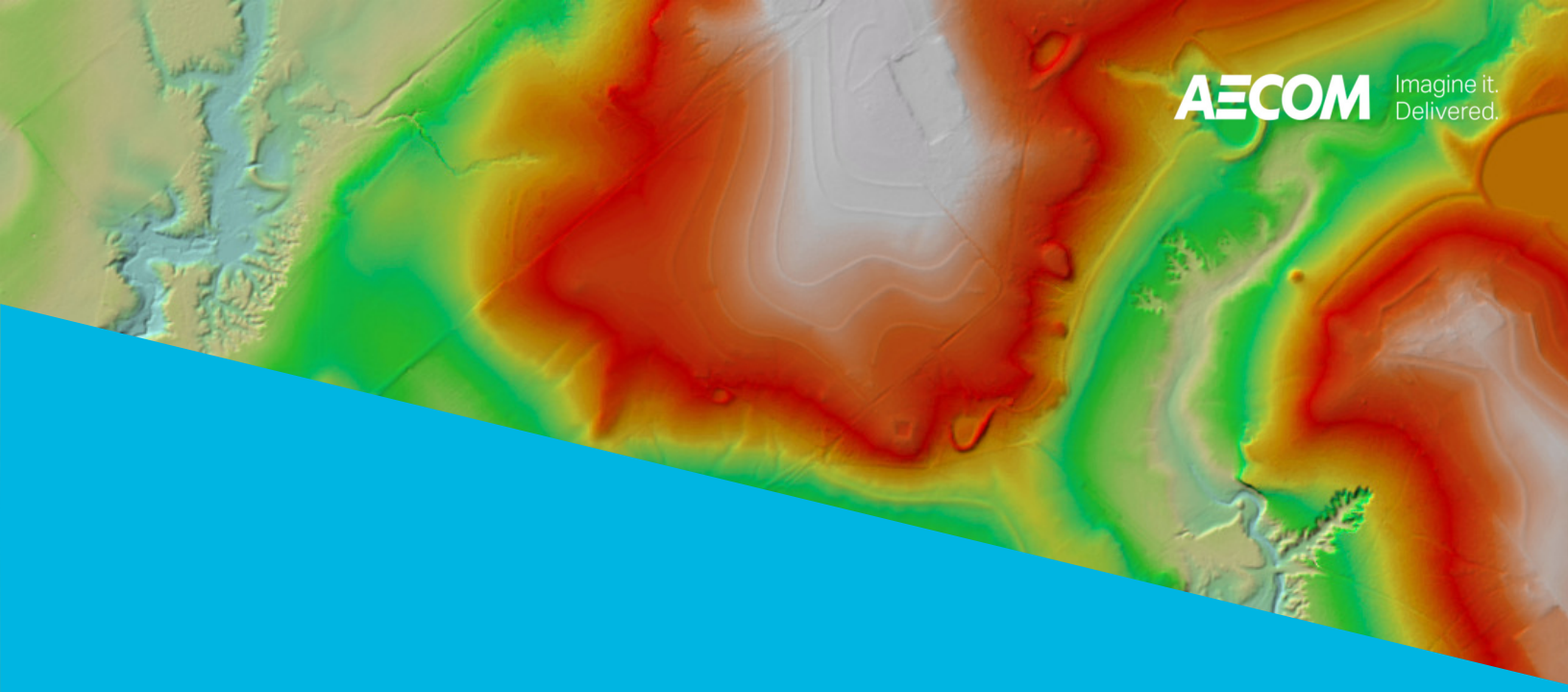

SM580170829
East Texas LiDAR QA/QC
Final QA/QC Report

TEXAS WATER DEVELOPMENT BOARD

September 15, 2017

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1 Overview

AECOM performed an independent Quality Assurance and Quality Control evaluation for Texas Water Development Board (TWDB) Project 580170829 to validate and ensure all LiDAR data and various derivative products meet project specifications, client expectations, and quality criteria.

Project stakeholders included the Texas Natural Resources Information System (TNRIS) and Texas Commission of Environmental Quality (TCEQ).

"The project AOI (~2,763 square miles) is located in East Texas encompassing much of San Jacinto County and the surrounding area. The AOI includes large portions of Lake Livingston and the Sam Houston National Forrest. This region is dominated by dense forest. The data acquired will be used for floodplain planning and management, dam safety, feature extraction, water quality modeling, stream restoration analysis, change detection, wildfire mitigation, and habitat identification/modeling for endangered species. The data acquired will become part of an ongoing geospatial data collection program by the State of Texas to support regional and local mapping needs". - From TWDB Project Solicitation #580170829. An additional 755 mi^2 was appended to the project as part of an optional task award.

USGS Quality Level 2 (QL2) LiDAR specifications were required as a minimum but some aspects of the data exceed these requirements, most notably, LiDAR pulse density of ≥ 4 pts/m^2 having an RMSE vertical accuracy ≤ 10 cm in Non Vegetated Areas.

LiDAR derivative products included Hydro Breaklines, Hydro-flattened DEM Rasters, and Intensity Rasters. These data must be processed to meet or exceed TWDB requirements and the defined ASPRS and USGS specifications.

All raw and derived LiDAR data products were acquired and processed by Fugro Geospatial ("Fugro"). This report references data deliveries prepared and submitted by Fugro from December 2016 to September 2017.

Listed below are the QA/QC elements of the project, some of which were reported upon in preliminary reports during the course of the project and incorporated into this final report for completeness:

- Overview of independent QA/QC scope of work
- Pre-acquisition assessment
- Post-acquisition data assessment
- Vendor production reviews
- QA/QC checkpoint survey data
- Assessment practices and methodologies
- Data accuracy assessment
- Conclusions and lessons learned

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1.1 Independent QA/QC Scope of Work

AECOM completed the following tasks during the course of the project:

Table 1: AECOM – Independent QA/QC Tasks

Phase	Tasks
Phase I **Pre-flight Planning**	1. Participate in Kick-Off Meeting 2. Review timeline and projected milestones 3. Review Fugro's LiDAR flight plans and survey maps 4. Review sensor calibration reports 5. Prepare and submit QA/QC report
Phase II **Data Acquisition**	1. Collect QA/QC checkpoints 2. Review Flight trajectories and associated data acquisition reporting files 3. Review Fugro's survey report and associated reporting files 4. Prepare and submit QA/QC report
Phase III **Data Processing**	1. Review LiDAR and derivative datasets including a. Classified point cloud tiles b. Hydro-flattened breaklines c. Intensity rasters d. Metadata 3. Review revised data 4. Prepare and submit QA/QC report
Phase IV **Product Development**	1. Review Hydro-flattened DEM rasters and metadata 2. Review revised datasets 3. Prepare and submit QA/QC report 3. Prepare and submit final project QA/QC report

1.2 Project Area and Deliverables Received

The project area for this task order consisted of two areas of interest (AOI) covering ~3,501 mi^2 in East Texas.

Northern AOI = “Sulphur” AOI
Southern AOI – “San Jacinto” AOI

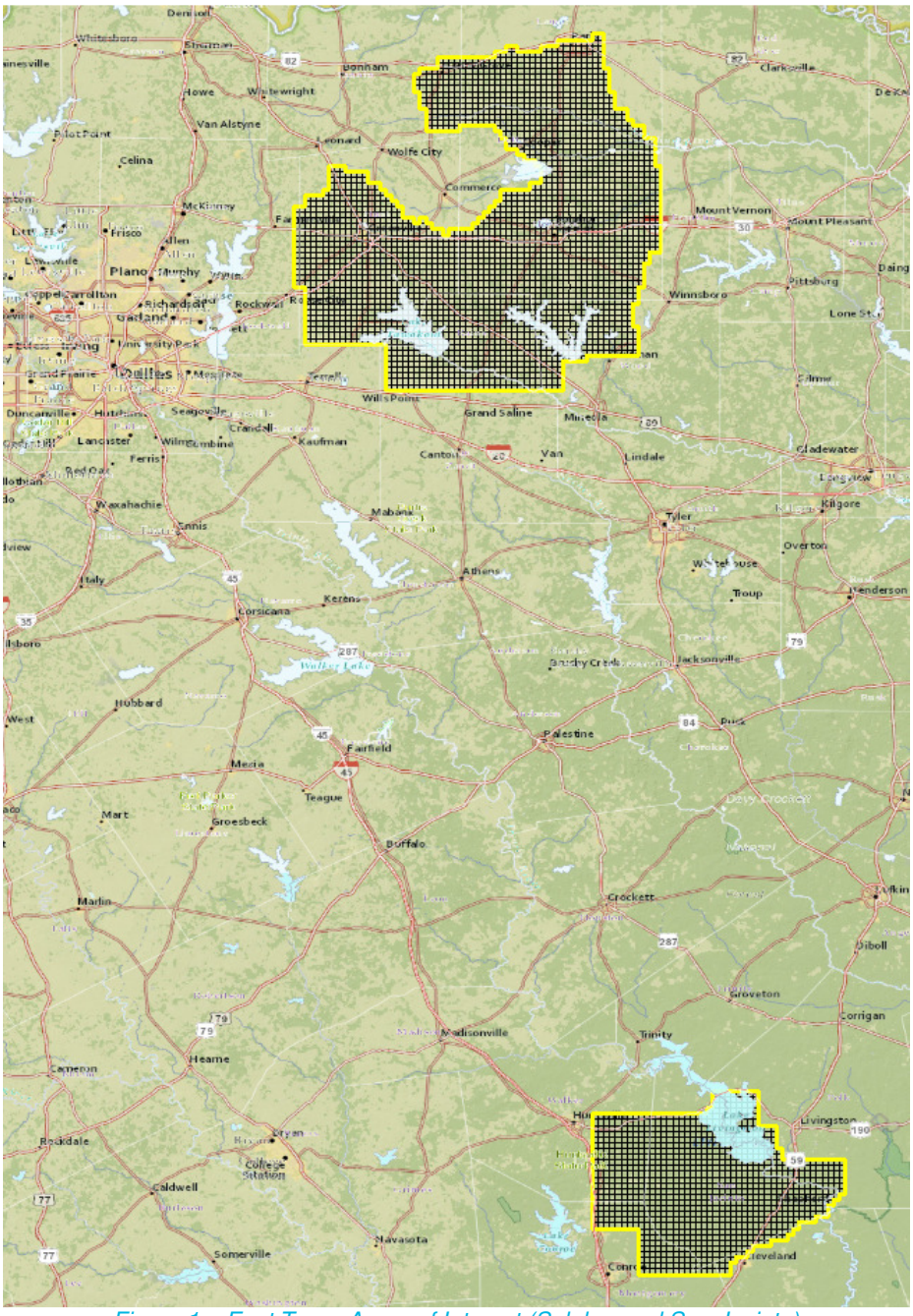


Figure 1 – East Texas Areas of Interest (Sulphur and San Jacinto)

Deliverables were received in the following formats in UTM Zones 14 and 15, NAD83 (2011), NAVD88 (Geoid 12B), Meters.

Table 2: Data Deliverables Received

Deliverable	Sulphur UTM Z14	Sulphur UTM Z15	San Jacinto UTM Z15
LiDAR files in .LAS v1.4 format	Y	Y	Y
Hydro-flattened bare earth DEM files in .IMG format	Y	Y	Y
LiDAR intensity images in GeoTIF/TFW format	Y	Y	Y
LiDAR, DEM-Intensity tile layouts in ESRI SHP format	Y	Y	Y
3D breaklines in ESRI geodatabase format	Y	Y	Y
Project and tile level metadata in XML format	Y	Y	Y

1.3 Applicable Specifications and Guidelines

The following guidelines, specifications, and standards are applicable to AECOM's independent QA/QC evaluation:

A. TWDB/TNRIS SOW - SM_580170829_QAQC_East_Texas.pdf
B. American Society for Photogrammetry and Remote Sensing. 2013. ASPRS Accuracy Standards for Digital Geospatial Data. Photogrammetric Engineering & Remote Sensing 79, no. 12: 1073-1085.
C. American Society for Photogrammetry & Remote Sensing. ASPRS Guidelines Vertical Accuracy Reporting for Lidar Data. 24 May 2004. http://www.asprs.org/a/society/committees/lidar/Downloads/Vertical_Accuracy_Reporting_for_Lidar_Data.pdf
D. American Society for Photogrammetry & Remote Sensing. LAS Specification Version 1.4-R6. 10 June 2012. http://www.asprs.org/a/society/committees/standards/LAS_1_4_r12.pdf
E. Federal Geographic Data Committee. Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy. 1998. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3
F. Maune, David F. Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition. 2007.
G. Maune, David F. FEMA's Mapping and Surveying Guidelines and Specifications. 2003. http://w.psadewberry.com/Libraries/Documents/FEMAs_Mapping_and_Surveying_Guidelines_and_Specifications_ASPRSFall2003.pdf
H. National Digital Elevation Program. Guidelines for Digital Elevations Data (Version 1.0). 10 May 2004. http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf
I. The National Geodetic Survey. The NGS Geoid Page. 11 September 2012. http://www.ngs.noaa.gov/GEOID/

2 Phase I: Pre-flight Planning Review

During the Project Kick-Off Meeting all project stakeholders reviewed and finalized the project QA/QC specifications that would be employed. During Phase I (Pre-Flight Planning), AECOM conducted an independent review of the proposed flight operations and plan files submitted by Fugro prior to the mobilization of data collection flights. These files included, but were not limited to:

- Planned flight lines
- Planned GPS base stations
- Planned airport location
- Calibration plans
- Schedule
- Terrain consideration
- Quality procedures
- Planned scan set (sensor settings)
- Type of aircraft
- Procedure for re-flights
- Land cover considerations

All files and planning documents generated for this phase were reviewed against the defined project specifications and guidelines. Planning documents further facilitated the QA/QC process during the acquisition and processing tasks of the project.

2.1 Aerial Acquisition Pre-flight Planning Review

For the purpose of this review, Fugro provided AECOM with planned flight lines and ground control locations, base station locations, sensor settings, and field calibration plans.

AECOM conducted an initial review to validate aerial acquisition flight planning and reporting requirements in accordance with Project 580170829 SOW. AECOM sent clarifying questions to Fugro, the responses to which were deemed acceptable.

The overall control layout, including QA/QC checkpoints, acquisition base stations, and nearest CORS stations were reviewed by AECOM to ensure adequate project coverage and distribution of points.

The following table reports the results of AECOM's assessment for the pre-flight planning of the aerial acquisition effort:

Table 3: Pre-flight Planning Review

Items Reviewed	Meets Specifications
Planned lines – sufficient coverage, spacing, and length	Yes
Planned GPS stations – at least 2 in range of all missions (baseline 40 km or less)	Yes
Planned ground control – sufficient to control and boresight	Yes
Planned airports – within reasonable distance of AOI	Yes
Schedule	Yes
Quality procedures	Yes
Aircraft utilizes ABGPS at 1 Hz	Yes
Sensor parameters support project design pulse density	Yes
Type of aircraft – supports project design parameters	Yes
Re-flight procedure – tracking, documenting, processing	Yes
Project design supports accuracy requirements of project	Yes
Project design accounts for land cover and terrain types	Yes
Aerial acquisition report	Yes

2.2 QA/QC Checkpoint Survey Plan Review

The ground survey layout for the QA/QC checkpoints was developed by AECOM referencing USGS and ASPRS specifications with respect to distribution and vegetative cover. An accuracy requirement of 1.67 cm $RMSE_z$ (3.3 cm CE95) was applied.

Publically available aerial imagery were referenced to confirm that control point locations were accessible and to ensure that the locations chosen conformed to project specifications and guidelines.

CompassData, working as a subcontractor to AECOM, executed the QA/QC checkpoint field survey.

Figure 2 – AECOM QA/QC Checkpoint Plan
(Sulphur AOI Left, San Jacinto AOI Right)

A total of 137 NVA and 108 VVA checkpoints were established across both AOIs.

- NVA and VVA checkpoints supported the vertical accuracy assessments of the LiDAR and DEM datasets.
- Twenty NVA checkpoints served a dual purpose as horizontal accuracy assessment of the Sulphur AOI. Ten NVA checkpoints served a dual purpose as horizontal accuracy assessment of the San Jacinto AOI.

3 Phase II: Data Acquisition Review

The following QA/QC assessment was performed after the aerial acquisition of the LiDAR data.

3.1 Post-flight Aerial Acquisition Review

Following the aerial acquisition of the LiDAR data, Fugro provided AECOM with trajectory files as well as a variety of other related data files associated with the LiDAR acquisition effort.

The trajectory data captured from the aircraft's GPS, collected at 1 second intervals, were compared against the planned flight plans. A comparison of the planned flight lines and trajectories as they we flown is illustrated below. The as-flown data aligned well with the planned datasets.

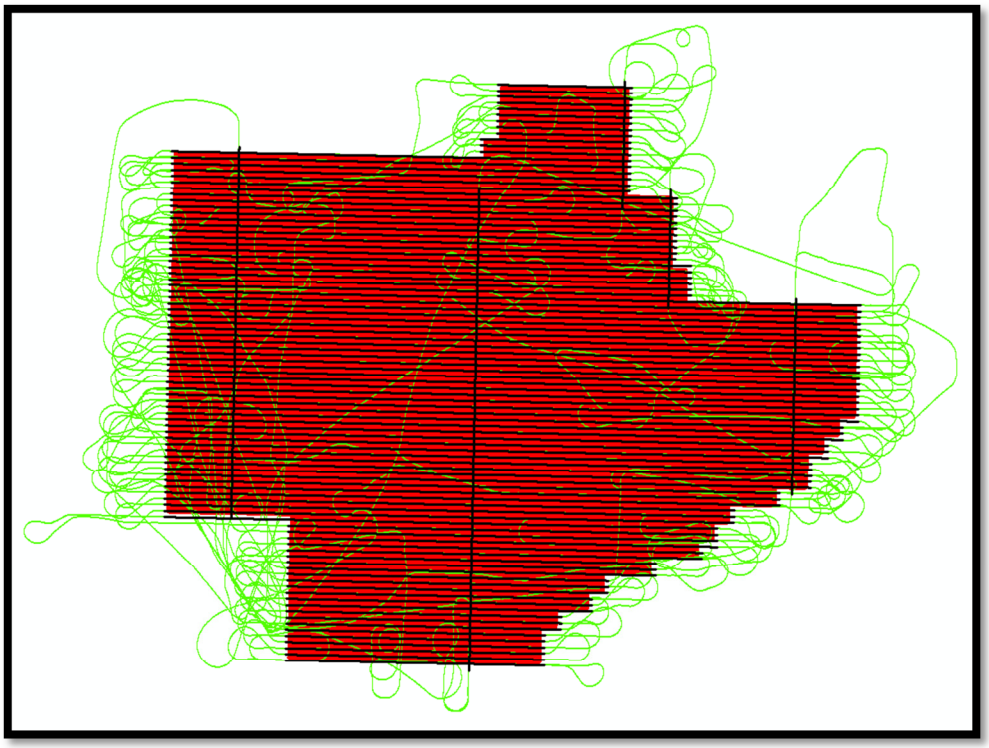


Figure 3 – San Jacinto Block LiDAR Planned Flight lines (Black) and Overlaid Trajectories (Green)

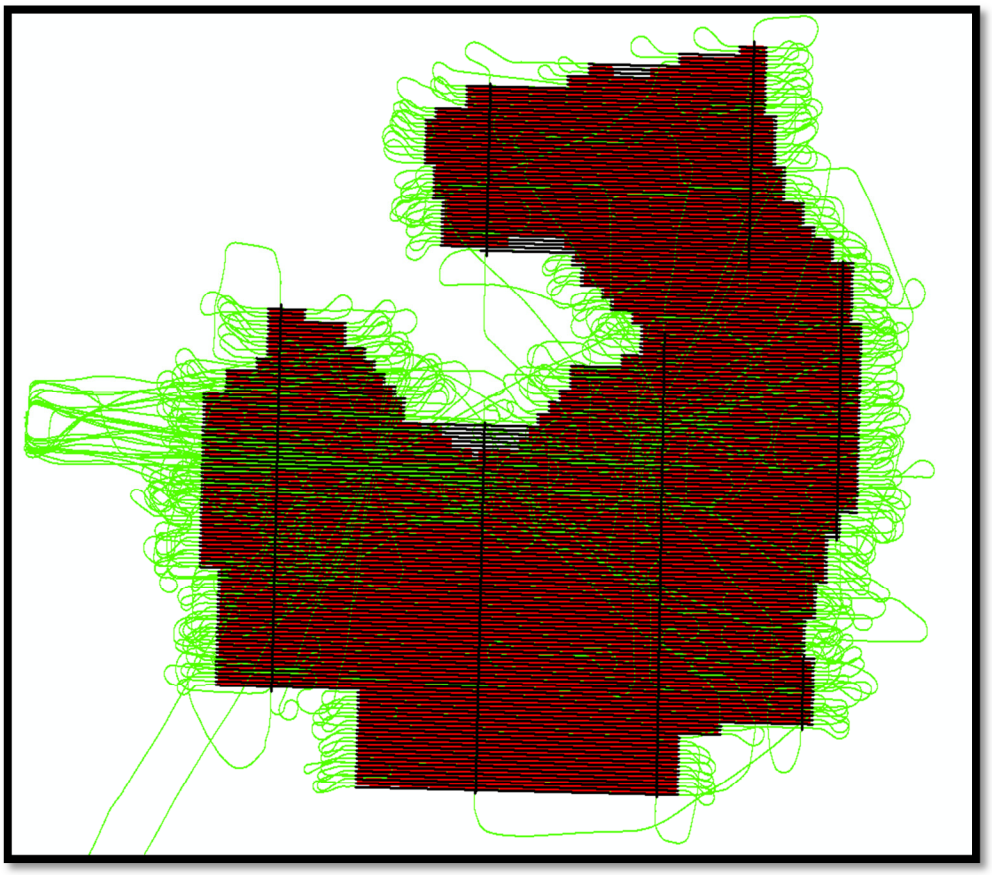


Figure 4 – Sulphur Block LiDAR Planned Flight lines (Black) and Overlaid Trajectories (Green)

GNSS Plot Reviews

- Number of satellites tracked during acquisition altitude exceeded 6 satellites.
- There were instances where PDOP exceeded 4.0 however these instances were outside the on-line data acquisition window.
- Supporting flight logs and ancillary documentation suggests data accuracy meets specifications.

Data Acquisition Status Updates

- Fugro provided daily acquisition updates via the TNRIS project email thread system from aerial acquisition commencement to completion.

Note: As part of Fugro's internal checks a sensor issue was discovered that resulted in an anomalous point distribution pattern for one lift within the Sulphur AOI. The lift in question (see yellow polygon in graphic below) was reflown by Fugro.

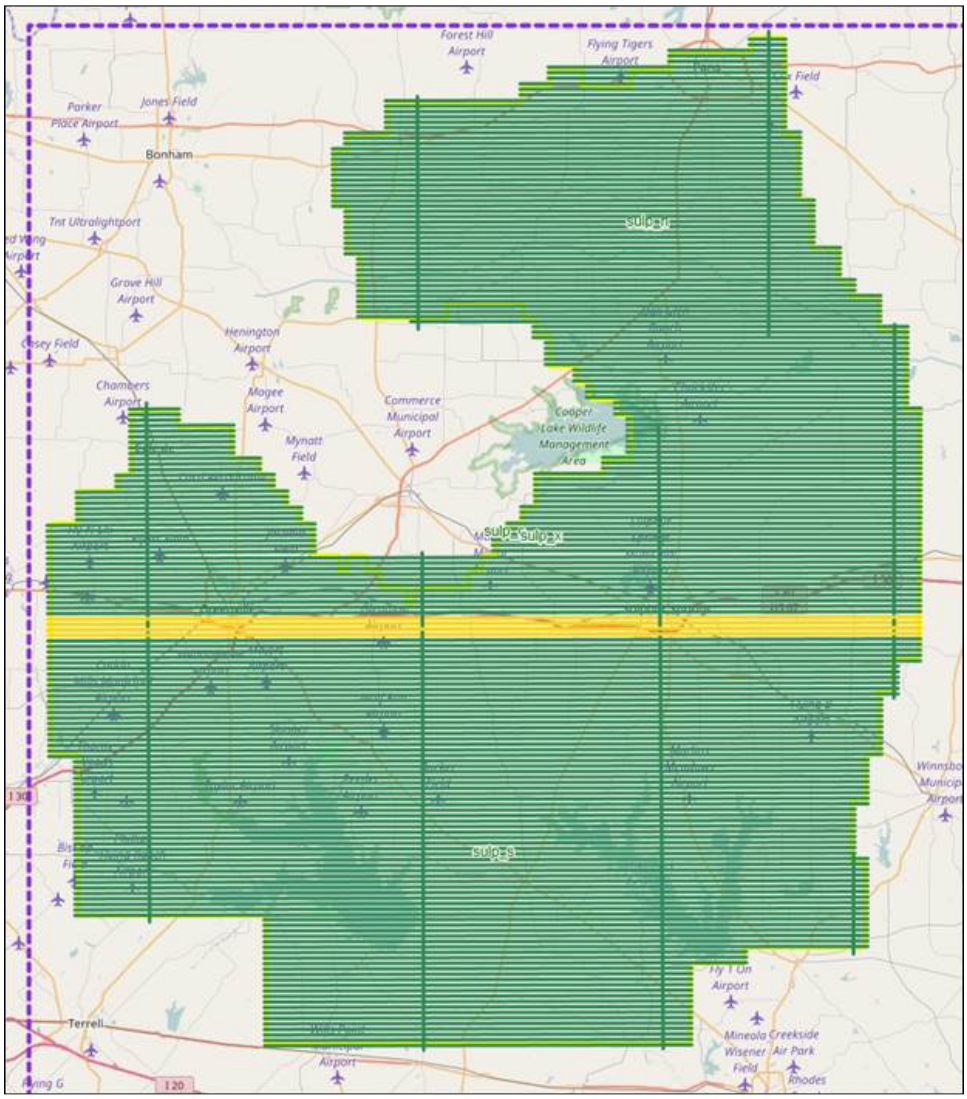


Figure 5 – Reflight Required Due to LiDAR Sensor Malfunction

3.2 Post-flight Ground Control Review

Fugro provided a detailed survey report identifying the control network used and the spatial parameters associated with the control network.

It was noted the baseline distances of the control points exceeded 40 km in some instances. AECOM queried Fugro regarding how frequently Fugro utilized control points with similar baselines. Fugro indicated that utilizing control derived from similar baselines was part of their common procedures and Fugro has not encountered accuracy issues in the past. Fugro sent inquires to Gorondonna if there were any concerns regarding the baseline lengths reported and the control meeting the accuracy of the data. Gorondonna indicated confidence in the accuracy of the data meeting project requirements. The reported estimated accuracy of the adjusted coordinates is ±0.005m at CE95.

Within the GPS Data Processing table, “H. Precision (95%)” and “V. Precision (95%)” refer to the Horizontal and Vertical precision estimates (sphere of uncertainty) of the GPS vectors at a 95% confidence level. The estimate accuracy was generated by Trimble Business Center, the software that was used for processing their survey field data.

Fugro’s control report included tabular data in XLS, CSV, and SHP format containing coordinate and elevation information to 3 decimal places in the project spatial reference framework. Land cover type descriptions were also included for each point, as were images of each survey point.

Survey points were evenly spaced, well dispersed, and closely mimic the planned control point locations, as can be seen in the graphics below.

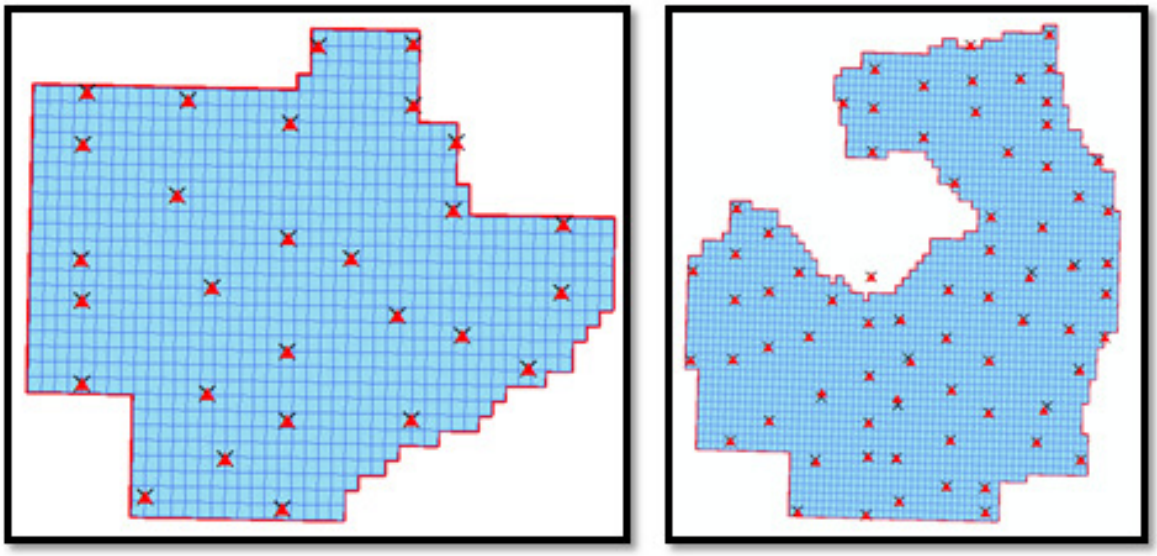


Figure 6 - Fugro LiDAR Planned Control Locations (X) and Actual Control Locations (▲)

3.3 Review and Delivery of QA/QC Checkpoint Survey

During the planning and collection of QA/QC checkpoints, AECOM and CompassData frequently coordinated regarding status. CompassData completed checkpoint survey field work in January 2017.

A total of 137 NVA and 108 VVA checkpoints were established across both AOIs.

- NVA and VVA checkpoints supported the vertical accuracy assessments of the LiDAR and DEM datasets.
- Twenty NVA checkpoints served a dual purpose as horizontal accuracy assessment of the Sulphur AOI. Ten NVA checkpoints served a dual purpose as horizontal accuracy assessment of the San Jacinto AOI.

AECOM reviewed all pertinent documentation submitted by CompassData at the conclusion of the field collection effort. Reported QA/QC checkpoint locations were verified against project specifications and control plan layouts. All survey related documentation was then delivered to TNRIS in February 2017.

Table 4: Vertical Checkpoint Types and Coordinates

AOI	Coordinate Details	Check Point Type	Point_ID	Ground Cover	X	Y	Z
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA001	Gravel/Asphalt	282437.093	3690274.259	130.595
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA002	Asphalt	280374.752	3701106.644	119.092
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA003	Asphalt	275440.929	3702723.891	120.419
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA004	Gravel	275598.635	3707259.784	132.785
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA006	Asphalt	271076.028	3718333.176	140.802
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA007	Asphalt	269380.121	3728192.759	167.626
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA008	Asphalt	260370.932	3727389.045	176.977
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA009	Gravel	252695.676	3723488.586	178.222
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA011	Asphalt	237900.786	3721673.776	195.157
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA012	Asphalt	230028.495	3723671.314	200.778
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA013	Gravel	223025.480	3717926.279	210.657
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA014	Gravel/Asphalt	226603.508	3702604.921	195.784
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA015	Asphalt	235306.782	3703571.000	176.641
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA016	Gravel	246101.967	3698677.941	151.761
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA017	Gravel	242583.977	3706508.099	165.540
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA018	Gravel	249801.608	3694737.218	140.443
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA019_2	Asphalt	257042.618	3688963.052	136.235
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA020	Asphalt	259253.035	3684411.546	156.249
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA021	Gravel	268079.473	3684760.212	144.553
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA022	Asphalt	266997.210	3700087.597	127.022
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA023	Asphalt	260923.765	3712270.641	145.797
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA024	Gravel	250552.655	3720326.933	175.452
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA025	Asphalt	238855.224	3713516.588	160.860
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA026	Gravel/Asphalt	252616.368	3704740.207	157.158
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA027	Gravel	263431.720	3721573.814	158.556
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA028	Asphalt	260905.923	3697835.984	138.589
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA029	Gravel	276921.985	3690750.956	140.237
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA138	Asphalt	263081.029	3725073.113	165.620
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA139	Asphalt	251972.190	3695329.511	135.923
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA030	Asphalt	247089.830	3632294.642	136.767
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA031	Asphalt	256546.582	3631405.289	132.047
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA032	Gravel/Asphalt	263697.274	3634294.438	128.470
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA033	Asphalt	255548.262	3646078.051	142.192
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA034	Asphalt	273072.390	3639662.532	130.406
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA036	Asphalt	276582.290	3657181.349	163.789
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA037	Asphalt	279274.503	3663168.490	153.596
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA038	Asphalt	277546.172	3669024.773	145.063
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA039	Concrete	282883.308	3674146.797	138.826
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA040	Concrete	248236.920	3682844.532	169.156
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA041	Gravel/Asphalt	238097.545	3669450.144	176.717

Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA042	Asphalt	242127.656	3678820.588	173.696
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA043	Asphalt	258501.299	3668622.413	155.848
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA044	Asphalt	275757.640	3671720.205	142.335
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA045	Gravel	252019.369	3653045.794	150.436
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA046	Asphalt	239622.151	3656920.986	152.681
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA047	Asphalt	260476.084	3662895.582	169.285
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA048	Asphalt	267543.884	3664755.743	162.155
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA049	Asphalt	269226.518	3660784.970	164.018
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA050	Asphalt	251208.222	3656751.010	158.769
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA051	Asphalt	253267.552	3631438.273	139.546
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA052	Asphalt	263123.707	3642514.936	126.602
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA053	Asphalt	269171.253	3642814.584	139.968
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA054	Asphalt	260145.468	3675956.054	144.427
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA055	Gravel	250911.520	3671391.880	144.367
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA056	Asphalt	235300.902	3625940.633	130.355
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA057	Asphalt	228817.652	3625541.111	143.677
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA068	Asphalt	223848.726	3675043.037	183.059
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA069	Asphalt	240980.313	3640954.451	138.588
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA074	Asphalt	232272.778	3656964.991	167.822
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA076	Asphalt	225409.201	3666539.766	160.360
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA077	Asphalt	220545.118	3631205.402	133.278
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA078	Asphalt	229669.370	3649475.014	154.618
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA080	Asphalt	236634.869	3643613.884	156.897
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA004	Clover	223048.485	3717918.911	210.631
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA001	Mixed_grass	238897.192	3713526.884	161.172
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA002	Mixed_grass	237943.559	3721691.211	193.801
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA056	Mixed_grass	223877.052	3675074.000	183.110
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA026	Mixed_grass/Trees	250918.732	3671351.777	143.392
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA003	Short_grass	226620.786	3702603.523	196.240
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA008	Short_grass	275587.485	3707278.050	132.855
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA009	Short_grass	276918.636	3690769.460	140.510
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA013	Short_grass	242566.744	3706492.046	165.029
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA014	Short_grass	271053.685	3718323.625	139.962
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA018	Short_grass	249770.127	3694706.107	140.180
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA020	Short_grass	263486.219	3721533.726	158.350
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA021	Short_grass	266973.573	3700108.981	127.010
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA023	Short_grass	247079.786	3632314.928	136.419
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA029	Short_grass	260459.455	3662919.320	169.393
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA039	Short_grass	277539.044	3668962.915	144.274
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA042	Short_grass	279283.822	3663184.230	153.295
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA046	Short_grass	232286.832	3656987.779	167.535
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA048	Short_grass	235288.955	3625974.788	130.102
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA058	Short_grass	225381.416	3666541.827	159.909
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA059	Short_grass	220561.034	3631041.413	131.553
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA064	Short_grass	236610.944	3643603.619	156.378
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA027	Short_grass/Trees	275844.769	3671821.391	139.334
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA032	Short_grass/Trees	276669.304	3657173.975	163.549
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA034	Short_grass/Trees	242129.620	3678731.036	174.199
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA036	Short_grass/Trees	263110.556	3642559.664	127.149
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA038	Short_grass/Trees	263692.977	3634709.910	127.960
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA057	Short_grass/Trees	240942.448	3641054.043	139.168
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA011	Shrub/Trees	257047.438	3688985.446	135.821
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA015	Shrub/Trees	269187.260	3728201.362	173.975
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA022	Shrub/Trees	260913.148	3697873.120	138.355
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA005	Tall_grass	246127.812	3698680.535	151.957
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA007	Tall_grass	252690.489	3723977.816	179.069
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA010	Tall_grass	259225.392	3684425.780	155.831

Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA019	Tall_grass	250763.982	3720349.753	175.459
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA033	Tall_grass/Shrub	237027.651	3669868.709	178.748
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA012	Trees	235286.591	3703545.406	175.996
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA016	Turf	260348.130	3727370.578	176.373
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA024	Turf	251193.984	3656725.117	158.998
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA025	Turf	253254.775	3631456.443	139.483
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA030	Turf	282917.422	3674160.885	139.155
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA031	Turf	269420.980	3638168.943	129.515
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA037	Turf	256520.533	3631358.367	133.611
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA040	Turf	269155.886	3642840.927	139.865
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA041	Turf	269240.785	3660733.100	164.307
Sulphur Z15	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA900	Turf	245827.140	3667800.975	163.828
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA043	Shrub/Trees	772650.267	3662923.724	160.594
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA044	Short_Grass	754999.658	3674305.014	196.130
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA045	Turf	762974.950	3682818.509	192.034
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA047	Trees	778428.076	3670995.121	161.636
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA049	Short_Grass	752879.563	3659911.985	165.061
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA050	Mixed_Grass	764758.501	3670509.496	178.568
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA051	Shrub/Trees	775537.042	3638386.246	139.833
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA052	Mixed_Grass/Trees	778868.562	3628590.164	139.825
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA053	Short_Grass/Trees	756980.176	3646503.845	154.927
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA054	Mixed_Grass/Trees	753327.681	3655871.696	175.042
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA055	Short_Grass	774003.940	3681627.633	181.755
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA060	Short_Grass	768936.047	3646290.882	158.923
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA061	Short_Grass	759894.972	3662977.720	168.512
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA062	Short_Grass	769474.442	3665988.761	169.219
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA063	Short_Grass	766542.447	3638435.230	142.212
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA904	Shrub/Trees	769452.045	3670392.366	167.178
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**VVA**	VVA905	Short/Mixed_Grass	779583.913	3658709.250	147.103
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA058	Asphalt	760311.531	3689735.722	210.878
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA059	Asphalt	754993.396	3674281.007	196.790
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA060	Gravel	752870.216	3659881.690	166.768
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA061	Asphalt	753288.655	3655858.224	176.523
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA062	Gravel	757054.658	3646499.393	155.417
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA063	Asphalt	755222.485	3637867.197	169.074
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA064	Asphalt	766509.791	3638433.413	145.012
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA065	Asphalt	775553.316	3638445.135	137.249
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA066	Asphalt	778844.434	3628615.176	140.692
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA067	Asphalt	773959.153	3681585.261	183.559
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA070	Asphalt	769518.668	3665979.447	168.752
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA071	Gravel	772981.755	3662635.373	162.973
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA072	Gravel	764775.499	3670528.367	178.722
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA073	Asphalt	759928.816	3662998.567	169.384
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA075	Gravel	762996.947	3682797.964	192.396
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA079	Asphalt	768927.168	3646312.706	159.270
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA081	Gravel	778407.567	3671005.110	161.976
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA082	Asphalt	770119.857	3654543.270	151.216
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA146	Asphalt	769386.130	3670441.607	169.311
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA147	Gravel	760859.168	3687273.222	199.781
Sulphur Z14	UTMZ14 NAD83(2011) Geoid12B Meters	**NVA**	NVA149	Gravel/Asphalt	779644.824	3658699.699	146.892
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA083	Asphalt	289862.438	3359217.644	52.292
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA084	Concrete	269766.536	3401968.937	116.301
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA085	Concrete	277563.317	3357941.034	64.497
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA086	Asphalt	261561.525	3380477.999	105.921
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA087	Asphalt	270888.550	3375119.580	123.729
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA088	Asphalt	280370.913	3369728.111	90.945
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA089	Asphalt	275394.748	3369202.664	87.896

San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA090	Asphalt	260809.820	3371366.432	97.169
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA091	Gravel	287180.769	3388405.050	86.440
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA092	Asphalt	289357.020	3374395.598	86.126
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA093	Asphalt	280760.883	3381607.357	72.200
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA094	Gravel	281902.638	3396936.431	113.441
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA095	Asphalt	261167.468	3399571.457	113.883
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA096	Gravel	301175.800	3362513.030	50.241
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA097	Asphalt	283060.091	3357375.444	56.738
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA098	Gravel	286992.680	3379334.919	92.148
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA099	Gravel	270131.208	3380420.975	126.914
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA100	Asphalt	271016.572	3388902.290	92.609
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA101	Asphalt	281363.308	3376515.567	109.860
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA102	Gravel	287879.182	3368065.371	70.638
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA103	Gravel	266533.253	3393686.118	98.005
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA105	Asphalt	294294.405	3377835.311	97.184
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA106	Asphalt	282338.685	3362269.774	67.228
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA107	Gravel	274892.078	3393523.136	116.976
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA108	Asphalt	285560.219	3396166.249	99.883
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA109	Concrete	296726.014	3367766.898	62.054
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA111	Asphalt	273312.934	3357997.564	56.101
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA112	Concrete	291791.332	3356506.078	45.979
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA113	Gravel	270188.064	3403631.947	121.043
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA114	Asphalt	280602.297	3403886.586	92.410
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA115	Asphalt	305113.891	3396750.934	43.964
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA116	Asphalt	320532.444	3377355.606	23.612
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA117	Concrete	313005.579	3372931.289	32.775
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA118	Asphalt	294151.461	3392832.823	81.809
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA119	Gravel/Asphalt	301825.484	3378537.975	78.955
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA120	Asphalt	308330.534	3374300.846	50.868
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA121	Asphalt	291740.511	3398700.369	50.102
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA122	Asphalt	300164.505	3402209.634	44.979
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA123	Asphalt	298452.897	3408923.053	41.314
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA125	Asphalt	322245.483	3385869.448	68.687
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA126	Asphalt	313487.298	3387734.145	35.468
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA127	Asphalt	313032.819	3383520.451	26.267
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA128	Concrete	305058.695	3369930.747	54.127
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA129	Asphalt	301550.530	3374927.125	62.491
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA130	Asphalt	316529.781	3381234.275	28.613
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA131	Asphalt	295988.907	3385485.718	108.570
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA132	Asphalt	303385.760	3388881.127	40.591
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA133	Asphalt	306885.224	3389774.569	27.833
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA134	Gravel	302666.655	3409542.830	64.672
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA135	Asphalt	293277.847	3409174.647	45.169
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA136	Asphalt	315432.771	3370672.137	24.804
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA137	Asphalt	294281.287	3383376.618	103.665
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**NVA**	NVA900	Asphalt	302424.721	3402145.022	47.310
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA077	Mixed/Tall grass	285565.575	3396208.463	98.073
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA068	Mixed_grass	285413.077	3358919.730	53.222
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA069	Mixed_grass	277418.732	3357902.799	64.243
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA070	Mixed_grass	270906.584	3375105.816	123.739
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA075	Mixed_grass	271037.508	3388913.309	92.567
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA089	Mixed_grass	282481.804	3362169.421	66.236
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA111	Mixed_grass	305071.928	3369971.390	54.155
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA084	Mixed_grass/Shrub	283308.052	3357118.151	55.160
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA105	Mixed_grass/shrub	313800.583	3387018.713	33.138
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA094	Mixed_grass/Shrub/Trees	322219.327	3385879.098	68.911
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA083	Mixed_grass/Trees	281464.756	3376615.527	108.775

San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA067	Short_grass	301152.174	3362460.833	50.290
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA073	Short_grass	261549.383	3380433.689	105.182
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA076	Short_grass	276084.107	3392646.559	107.433
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA081	Short_grass	270117.860	3380390.740	125.997
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA087	Short_grass	291766.207	3356528.037	45.669
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA090	Short_grass	280611.300	3403858.922	90.681
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA091	Short_grass	298488.457	3408912.526	41.783
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA096	Short_grass	313105.259	3372301.000	42.132
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA099	Short_grass	306869.075	3389811.934	27.115
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA107	Short_grass	300345.562	3402079.602	47.205
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA112	Short_grass	295984.326	3385463.368	107.970
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA080	Short_grass/Trees	281927.675	3396917.779	112.787
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA102	Short_grass/Trees	293217.350	3409143.182	47.225
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA065	Shrub/Trees	274951.652	3403884.765	119.671
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA082	Shrub/Trees	267115.772	3393043.762	95.515
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA088	Shrub/Trees	270167.802	3403633.160	120.664
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA106	Shrub/Trees	320747.336	3379222.724	24.007
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA066	Turf	285390.892	3403779.084	55.027
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA071	Turf	260784.394	3371331.166	97.144
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA072	Turf	276280.496	3364630.487	87.169
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA079	Turf	277933.707	3368621.031	90.657
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA086	Turf	286004.319	3380557.264	95.221
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA092	Turf	302636.915	3409539.237	63.240
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA093	Turf	305181.757	3396779.878	45.930
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA095	Turf	320637.101	3380648.629	26.010
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA097	Turf	293704.451	3394614.754	60.000
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA098	Turf	303380.194	3388858.534	40.894
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA100	Turf	301705.297	3378417.187	78.130
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA101	Turf	319403.925	3381050.045	26.060
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA103	Turf	291718.804	3398717.568	50.384
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA104	Turf	308308.377	3374275.458	50.381
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA110	Turf	312888.676	3383554.070	23.892
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA078	Turf/Trees	287853.242	3368051.056	70.685
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	**VVA**	VVA109	Turf/Trees	313509.391	3387721.050	35.363

Horizontal Checkpoints - Twenty NVA checkpoints served a dual purpose as horizontal accuracy assessment of the Sulphur AOI. Ten NVA checkpoints served a dual purpose as horizontal accuracy assessment of the San Jacinto AOI.

Table 5: Horizontal Checkpoint Types and Coordinates

AOI	Coordinate Details	Check Point Type	Point_ID	X	Y
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA010	242914.402	3724186.444
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA022	266997.210	3700087.597
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA023	260923.765	3712270.641
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA026	252616.368	3704740.207
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA140	247042.350	3715192.970
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA141	269003.680	3687419.500
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA034	273072.390	3639662.532
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA035	276668.234	3645691.211
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA042	242127.656	3678820.588
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA053	269171.253	3642814.584

Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA054	260145.468	3675956.054
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA142	245846.656	3667788.284
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA144	267311.111	3670385.429
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA145	257364.084	3654122.513
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA057	228817.652	3625541.111
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA076	225409.201	3666539.766
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA077	220545.118	3631205.402
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA003	275440.93	3702723.89
Sulphur Z 15	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA011	237900.79	3721673.78
Sulphur Z 14	UTMZ14 NAD83(2011) Geoid12B Meters	Horizontal	NVA066	778844.43	3628615.18
Sulphur Z 14	UTMZ14 NAD83(2011) Geoid12B Meters	Horizontal	NVA146	769386.13	3670441.61
Sulphur Z 14	UTMZ14 NAD83(2011) Geoid12B Meters	Horizontal	NVA147	760859.17	3687273.22
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA095	261167.468	3399571.457
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA101	281363.308	3376515.567
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA150	265819.546	3398544.866
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA151	299617.101	3359650.627
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA152	285155.386	3383074.889
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA120	308330.534	3374300.846
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA126	313487.298	3387734.145
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA130	316529.781	3381234.275
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA137	294281.287	3383376.618
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA155	299760.337	3407569.611
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA156	308596.705	3392433.265
San Jacinto	UTMZ15 NAD83(2011) Geoid12B Meters	Horizontal	NVA900	302424.721	3402145.022

4 Phase III: Data Processing

The following QA/QC reviews were conducted during the Data Processing and Final Product Development phases.

4.1 Quality Assessment

This section describes the QA/QC specifications checked, the methods and tools applied, and the results of the Phase III evaluation.

4.1.1 Software

Primary software programs used by AECOM in performing the quality assessment are highlighted below:

- *TerraScan* - used for point classification checks and point file generation
- *ESRI ArcMap/ArcCatalog* - general GIS analysis software used to run automated QA/QC models and support manual data review
- *LP360 standalone and ArcGIS extension* – LiDAR specific software used to run automated QA/QC processes and support manual data review
- *FugroViewer* – used for data visualization and manual data assessments
- *Proprietary tools* - developed in-house to conduct a statistical analysis of .LAS files

4.1.2 Quality Assessment Process

The following systematic Macro and Micro QA/QC approach was applied to perform quantitative and qualitative assessments. A complete list of QA/QC checks for each dataset type is presented in the following sections.

Macro Reviews

- Deliveries were reviewed for completeness of content
- Performed coverage/gap check to ensure proper coverage of the tiles submitted
    - Created a spatial distribution raster to check that delivery meets data distribution requirements
    - Conducted a statistical analysis of delivery to check point classifications, variable-length record values, and maximum/minimum XYZ ranges
    - QA/QC processing models were run on the DEM files to isolate data voids, pits, and spikes
    - QA/QC processing of breaklines to ensure closed polygon vertices were consistent and direction of flow was accurate

Micro Reviews

- Performed tile-by-tile analysis
    - Verified that tile naming conventions were followed
    - Verified that deliverable formats were correct
    - Using FugroViewer and LP360, checked for errors in profile mode (noise, high and low points)
    - Conducted measurements to determine if delivery met applicable specifications outlined in acquisition specifications (overlap, gaps, etc.)
    - Reviewed hydro-breakline data for accuracy and completeness
    - Reviewed each tile for anomalies; if problems were found, the areas were identified using polygons in ESRI SHP format and accompanied by comments and relevant screenshots in the report

- Reports prepared and submitted to TNRIS and Fugro

4.1.3 Sulphur UTM Zone 15 Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Classified LiDAR Point Cloud

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets Specifications	
Verify readability of media	Meets Specifications	
Coverage/Gap check	Meets Specifications	
No tile/data overlap	Meets Specifications	
Tile Naming Convention		
Tile name match index	Meets Specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
LAS Header Check		
LAS format (LAS 1.4)	Meets Specifications	
GPS Times is Adjusted GPS time	Meets Specifications	
GPS times (0.01 m)	Meets Specifications	
LAS X,Y,Z scale factors 0.01 precision	Meets Specifications	
File source ID assigned	Meets Specifications	
LAS Number Variable Length Records Present	Meets Specifications	
Point Source ID equal to the File Source ID	Meets Specifications	
LAS Point Data Record Format - 6	Meets Specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets Specifications	
At least 3 returns per pulse	Meets Specifications	
Acceptable classes - 1,2,3,4,5,6,7,9,10,13,14	Meets Specifications	
Analysis		
LAS Overlap Flag - Overage points flagged as Overlap in Classified point clouds Class 12 should NOT be used	Meets Specifications	1,093,385,152 points tagged as Overlap
LAS Withheld Flag - Geometrically unreliable points flagged as Withheld in Classified point clouds	Meets Specifications	No points tagged as Withheld
Horizontal Accuracy Check - RMSE ≤ 0.25 m	Meets Specifications	

Vertical Accuracy Check - NVA (RMSE ≤ 0.1 m, 95% CI ≤ 0.196 m)	Meets Specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets Specifications	
Intra-swath Accuracy (≤ 0.06 m)	Meets Specifications	
Inter-swath Accuracy (≤ 0.08 m, MAX +/- 0.16 m)	Meets Specifications	
ANPS ≤ 0.5 m ***OR*** ANPD ≥ 4.0 pts/m^2	Meets Specifications	
Spatial Distribution and Uniformity (At least 90 percent of the cells in a 1.0 m grid contain at least one single swath, FR lidar point)	Meets Specifications	
Duplicate Points (X, Y, Z, AND TIME)	Meets Specifications	Observation – 389,567 points have repeating XYZ values. Random sampling suggests time is unique
Gross Anomaly Check		
Extreme intensity values	Meets Specifications	
Systematic data dropouts	Meets Specifications	
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Classification Review (1=unclassified, 2=bare earth ground, 3=low vegetation, 4=medium vegetation, 5=high vegetation, 6=buildings, 7=low point/noise, 9=water, 10=ignored ground ((1*NPS) near BL), 13=bridges, 14=culverts)		
Consistency in filtering	Meets Specifications	
Classification accuracy (misclassification)	Meets Specifications	
Building facades are primarily C6, not veg	Meets Specifications	
Data voids/gaps ≥ $(4x\ ANPS)^2$ = 4.0 m^2	Meets Specifications	
Ridges/steps	Meets Specifications	
Cornrows	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	
No LiDAR shadowing (sliver gaps) around taller structures	Meets Specifications	

Intensity Rasters

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
50 meter tile overlap with 90 degree corners	Meets specifications	
Tile Naming Convention		
Tile name match index	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Tile Level metadata - Content check	Meets specifications	

USGS metadata parser check	Meets specifications	
INTENSITY Header Check		
GeoTIFF format, 16bit U	Meets specifications	
Resolution ≤ 0.5 m	Meets specifications	
Geoid 12B, NAD83(2011), UTM Z15, meters	Meets specifications	
Analysis		
NODATA value set to 0	Meets specifications	
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Uniformity/consistency across swath	Meets specifications	
No over or under saturation/Extreme intensity values	Meets specifications	

Hydro-flattened Breaklines

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
Breaklines can extend just beyond AOI limits	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Tile Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Breakline Header Checks		
Seamless or Tile based PolylineZ or PolygonZ GDB format v10.3	Meets specifications	
.PRJ file present	NA, GDB provided	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets specifications	
Analysis		
No duplicate features	Meets specifications	
No topology issues (overlapping features, snapping issues, or open polygons)	Meets specifications	
Expresses monotonicity	Meets specifications	
Relative Vertical Accuracy Check	Meets specifications	AECOM reviewed 26,634 breakline vertices and found them to be equal to or just beneath the surrounding surface. A number of the vertices with relatively high deltas were reviewed and explainable or were

		in areas of significant slope along the river bank or near breaks in the river breakline having vegetative overgrowth.
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Streams/Rivers break at culverts	Meets specifications	
Streams/Rivers continuous at bridges	Meets specifications	
All inland streams and rivers should have been captured and flattened that have a 15.25 m nominal width	Meets specifications	
Water bodies greater than 10,000 m^2 collected	Meets specifications	
Islands greater than 5,000 m^2 collected	Meets specifications	
Breaklines extend just PAST project limits	Meets specifications	
Other Requirements		
Hydro will be split and delivered per UTM zones	Meets specifications	

4.1.3.1 Vertical Accuracy Assessments

4.1.3.1.1 Relative Vertical Accuracy

Intraswath Relative Accuracy – Intraswath vertical relative accuracy was tested using 598 points on a 1m grid residing in an airport tarmac setting. As the AOI was exceptionally rural and/or heavily forested in nature there were limited locations that were suitable to perform this test. First Return, Single Swath points tested having a Z delta of less than 6cm. For the sake of brevity a table has not be included in this report.

Interswath Relative Accuracy - Measuring 62,731 interswath points, and excluding 356 points that exceeded 0.16 m that resided in vegetation areas, an RMSEz = 0.03m was calculated. For the sake of brevity a table has not be included in this report.

4.1.3.1.2 Absolute Vertical Accuracy

Vertical accuracy of LiDAR data will be achieved by comparing the elevation of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as per ASPRS/NSSDA guidelines.

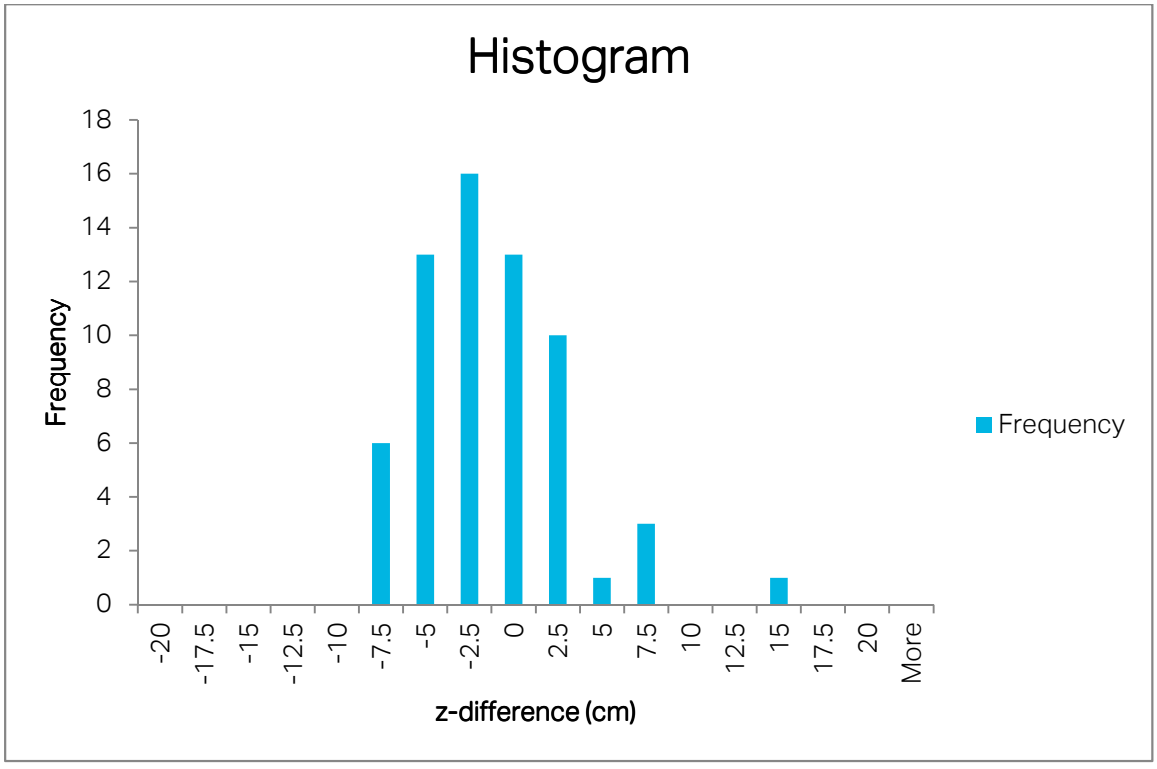
Table 6: LiDAR NVA Assessment
(UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA001	130.595	130.64	0.045
NVA002	119.092	119.085	-0.007
NVA003	120.419	120.44	0.021
NVA004	132.785	132.723	-0.062
NVA006	140.802	140.732	-0.070
NVA007	167.626	167.556	-0.070
NVA008	176.977	176.922	-0.055
NVA009	178.222	178.21	-0.012
NVA011	195.157	195.112	-0.045
NVA012	200.778	200.715	-0.063

NVA013	210.657	210.625	-0.032
NVA014	195.784	195.745	-0.039
NVA015	176.641	176.547	-0.094
NVA016	151.761	151.727	-0.034
NVA017	165.54	165.487	-0.053
NVA018	140.443	140.449	0.006
NVA019_2	136.235	136.177	-0.058
NVA020	156.249	156.306	0.057
NVA021	144.553	144.536	-0.017
NVA022	127.022	126.988	-0.034
NVA023	145.797	145.781	-0.016
NVA024	175.452	175.429	-0.023
NVA025	160.86	160.775	-0.085
NVA026	157.158	157.103	-0.055
NVA027	158.556	158.464	-0.092
NVA028	138.589	138.546	-0.043
NVA029	140.237	140.237	0.000
NVA138	165.62	165.616	-0.004
NVA139	135.923	135.903	-0.020
NVA030	136.767	136.709	-0.058
NVA031	132.047	132.015	-0.032
NVA032	128.47	128.442	-0.028
NVA033	142.192	142.193	0.001
NVA034	130.406	130.426	0.020
NVA036	163.789	163.775	-0.014
NVA037	153.596	153.505	-0.091
NVA038	145.063	145.064	0.001
NVA039	138.826	138.793	-0.033
NVA040	169.156	169.176	0.020
NVA041	176.717	176.689	-0.028
NVA042	173.696	173.675	-0.021
NVA043	155.848	155.791	-0.057
NVA044	142.335	142.304	-0.031
NVA045	150.436	150.409	-0.027
NVA046	152.681	152.66	-0.021
NVA047	169.285	169.223	-0.062
NVA048	162.155	162.11	-0.045
NVA049	164.018	163.95	-0.068
NVA050	158.769	158.692	-0.077
NVA051	139.546	139.507	-0.039
NVA052	126.602	126.665	0.063
NVA053	139.968	140.02	0.052
NVA054	144.427	144.39	-0.037

NVA055	144.367	144.346	-0.021
NVA056	130.355	130.496	0.141
NVA057	143.677	143.586	-0.091
NVA068	183.059	183.071	0.012
NVA069	138.588	138.549	-0.039
NVA074	167.822	167.825	0.003
NVA076	160.36	160.372	0.012
NVA077	133.278	133.3	0.022
NVA078	154.618	154.618	0.000
NVA080	156.897	156.839	-0.058

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	63	4.927	4.270	-2.516	3.100	-1.081	-9.400	14.100
Accuracy Assessment Results								
PASS	Tested 9.657cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600							



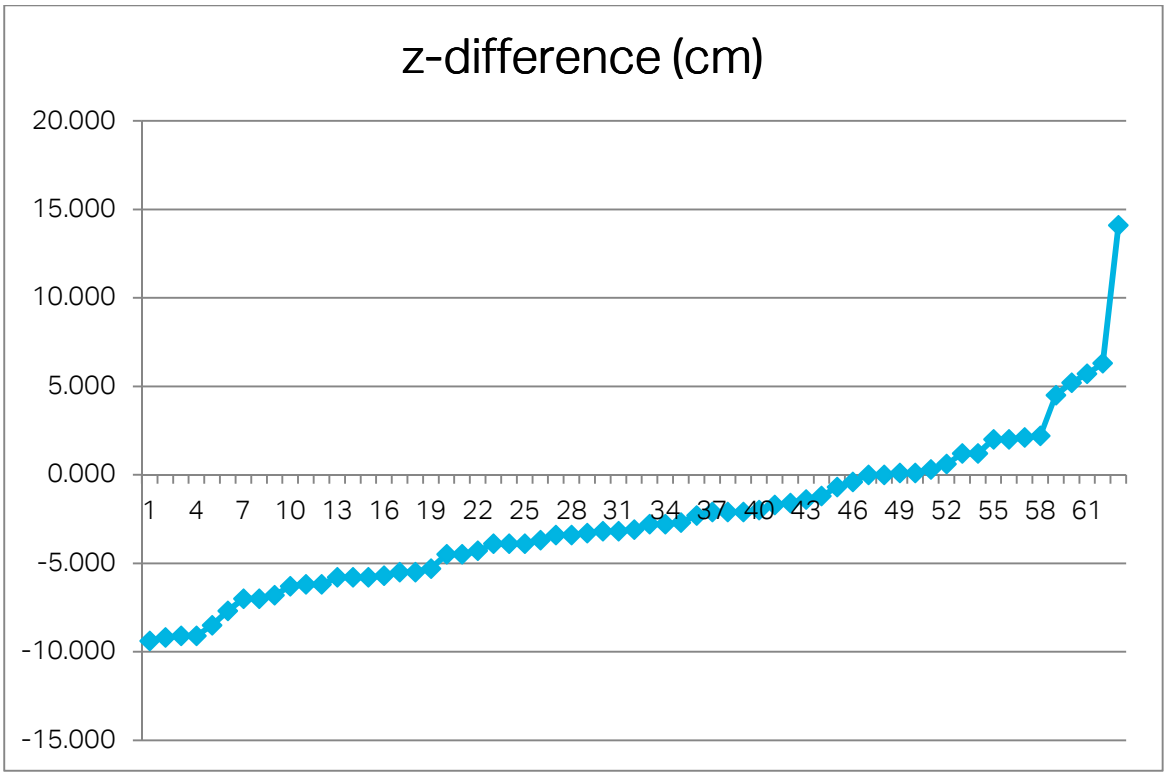


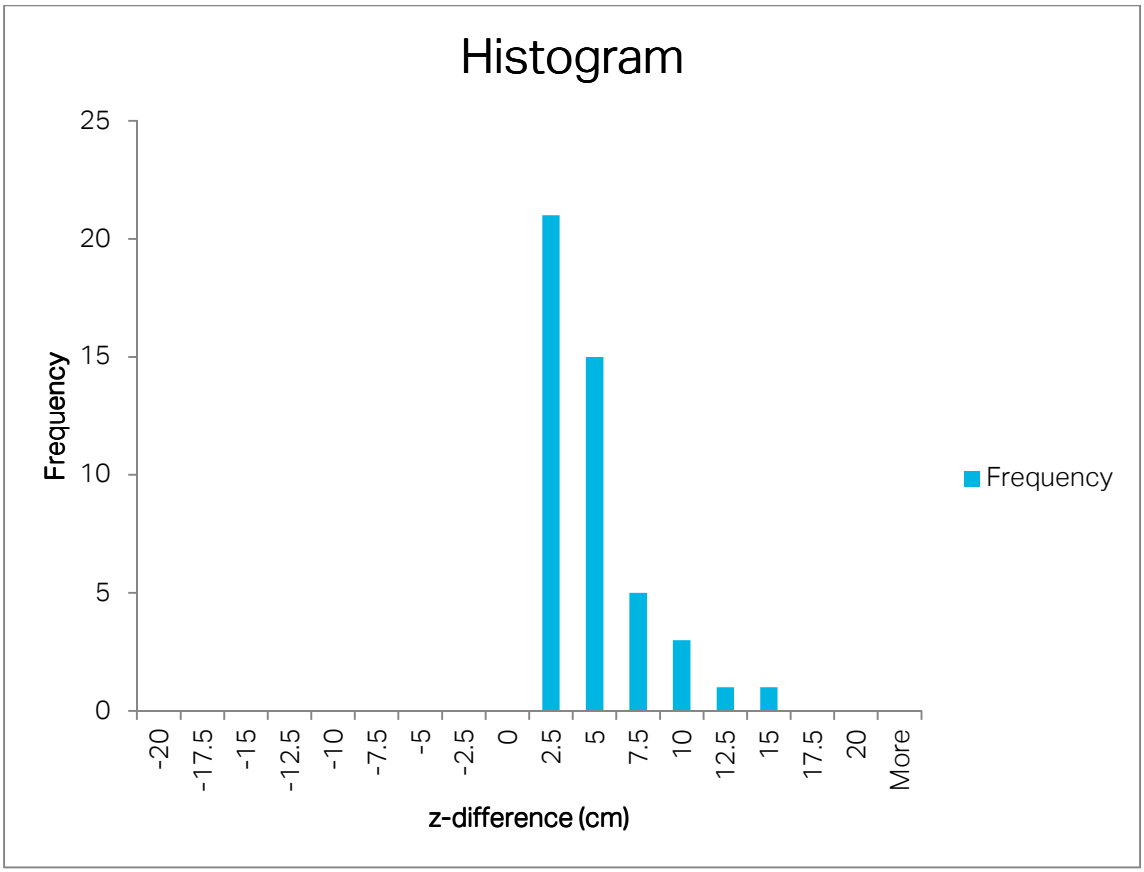
Table 7: LiDAR VVA Assessment
(UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA057	139.168	139.071	0.097
VVA012	175.996	175.921	0.075
VVA008	132.855	132.803	0.052
VVA013	165.029	164.981	0.048
VVA024	158.998	158.954	0.044
VVA001	161.172	161.129	0.043
VVA037	133.611	133.572	0.039
VVA004	210.631	210.595	0.036
VVA016	176.373	176.34	0.033
VVA900	163.828	163.796	0.032
VVA014	139.962	139.936	0.026
VVA064	156.378	156.354	0.024
VVA038	127.96	127.937	0.023
VVA029	169.393	169.379	0.014
VVA026	143.392	143.383	0.009
VVA023	136.419	136.411	0.008
VVA025	139.483	139.475	0.008
VVA041	164.307	164.301	0.006
VVA034	174.199	174.195	0.004

VVA002	193.801	193.798	0.003
VVA021	127.01	127.008	0.002
VVA003	196.24	196.239	0.001
VVA032	163.549	163.548	0.001
VVA020	158.35	158.357	0.007
VVA039	144.274	144.285	0.011
VVA022	138.355	138.369	0.014
VVA015	173.975	173.989	0.014
VVA030	139.155	139.17	0.015
VVA027	139.334	139.352	0.018
VVA059	131.553	131.575	0.022
VVA033	178.748	178.771	0.023
VVA019	175.459	175.484	0.025
VVA031	129.515	129.542	0.027
VVA009	140.51	140.539	0.029
VVA058	159.909	159.94	0.031
VVA042	153.295	153.328	0.033
VVA011	135.821	135.855	0.034
VVA056	183.11	183.146	0.036
VVA040	139.865	139.914	0.049
VVA036	127.149	127.215	0.066
VVA046	167.535	167.601	0.066
VVA018	140.18	140.249	0.069
VVA007	179.069	179.153	0.084
VVA010	155.831	155.918	0.087
VVA005	151.957	152.06	0.103
VVA048	130.102	130.23	0.128

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	46	4.600	2.994	3.520	-2.800	-1.230	0.100	12.800

Accuracy Assessment Results	
PASS	Tested 9.45cm vertical accuracy at 95th percentile in vegetated areas


Histogram
Frequency
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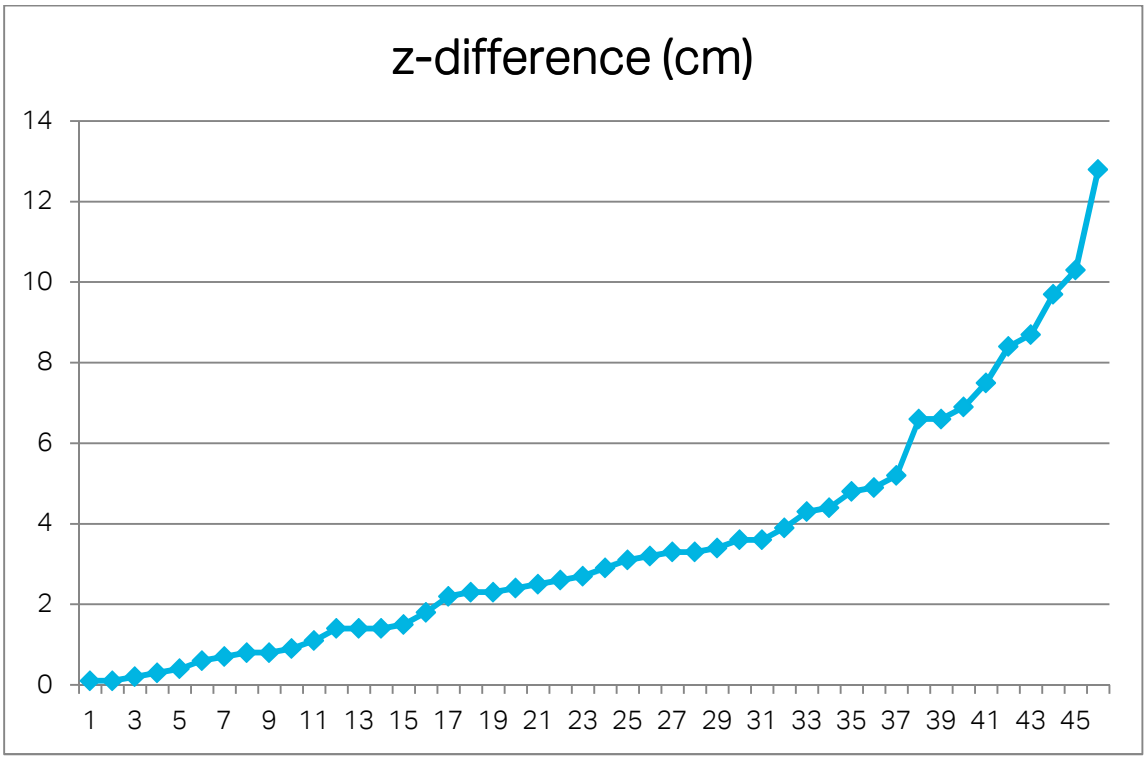
20
15
10
5
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency


z-difference (cm)
14
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45

4.1.3.2 Point Density and Spatial Distribution Analysis

Table 8: Aggregated Nominal Point Density (ANPD) / Aggregated Nominal Point Spacing (ANPS) Check (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	5,024,680,319.52	
Number of First Return(FR), Single Swath(SS) Points	20,229,952,019	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
Number of FR, SS Points/m^2 ≥ 4	4.03 pts/m^2	**PASS**

ANPD = 4.03pts/m^2 or ANPS = 0.50 m

Project area had two very large waterbodies. Had the waterbodies not been present the ANPD/ANPS would be higher (better).

Table 9: Spatial Distribution of Points (Uniformity Grid Analysis) (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	5,024,680,319.52	
# 1m X 1m cells in project AOI with ≥ 1 FR, SS point	4,804,238,735	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
≥90% of 1m X 1m cells contain at least one single swath, FR point	95.60%	**PASS**

Project area had two very large waterbodies. Had the waterbodies not been present the Uniformity Grid Analysis would be higher (better).

4.1.3.3 LiDAR Horizontal Accuracy Assessment

Horizontal accuracy of LiDAR data is achieved by identifying coincident locations between the Intensity rasters and the horizontal checkpoints. Deviations exhibited by the LiDAR Intensity rasters relative to the checkpoints were reported as an RMSE. The Sulphur AOI intersected UTM Zone 14 and Zone 15. The RMSE reported below reflects an accuracy assessment for both zones. Shaded points below reside in Zone 14.

Table 10: LiDAR Horizontal Accuracy Assessment
(UTM Z14N & Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

POINT ID	CHK PT X	CHK PT Y	INTENSITY X	INTENSITY Y	X DELTA	Y DELTA
NVA066	778844.43	3628615.18	778843.89	3628614.69	-0.55	-0.49
NVA146	769386.13	3670441.61	769386.13	3670441.61	0.00	0.00
NVA147	760859.17	3687273.22	760859.17	3687273.22	0.00	0.00
NVA003	275440.93	3702723.89	275440.86	3702723.75	-0.07	-0.14
NVA011	237900.79	3721673.78	237900.79	3721673.73	0.00	-0.05
NVA022	266997.21	3700087.60	266996.94	3700087.74	-0.27	0.14
NVA023	260923.77	3712270.64	260923.74	3712270.89	-0.02	0.25
NVA026	252616.37	3704740.21	252616.38	3704740.06	0.01	-0.15
NVA140	247042.35	3715192.97	247042.13	3715192.87	-0.22	-0.10

NVA141	269003.68	3687419.50	269003.41	3687419.59	-0.27	0.09
NVA034	273072.39	3639662.53	273072.49	3639662.48	0.10	-0.05
NVA042	242127.66	3678820.59	242127.76	3678820.56	0.10	-0.02
NVA053	269171.25	3642814.58	269171.28	3642814.63	0.02	0.05
NVA054	260145.47	3675956.05	260145.04	3675956.18	-0.42	0.12
NVA142	245846.66	3667788.28	245846.79	3667788.64	0.14	0.35
NVA144	267311.11	3670385.43	267310.69	3670385.38	-0.42	-0.05
NVA145	257364.08	3654122.51	257363.76	3654122.39	-0.32	-0.12
NVA057	228817.65	3625541.11	228817.70	3625541.04	0.05	-0.07
NVA076	225409.20	3666539.77	225408.90	3666539.44	-0.30	-0.32
NVA077	220545.12	3631205.40	220545.02	3631205.43	-0.10	0.02
Specification Acceptance						
Specification Threshold	Calculated Result	Status				
$RMSE_x \leq 0.25$ m	0.24 m	**PASS**				
RMSEy ≤ 0.25 m	0.18 m	**PASS**				

4.1.4 Sulphur UTM Zone 14 Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Classified LiDAR Point Cloud

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
No tile/data overlap	Meets specifications	
Tile Naming Convention		
Tile name match index	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
LAS Header Check		
LAS format (LAS 1.4)	Meets specifications	
GPS Times is Adjusted GPS time	Meets specifications	

GPS times (0.01 m)	Meets specifications	
LAS X,Y,Z scale factors 0.01 precision	Meets specifications	
File source ID assigned	Meets specifications	
LAS Number Variable Length Records Present	Meets specifications	
Point Source ID equal to the File Source ID	Meets specifications	
LAS Point Data Record Format - 6	Meets specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15 meters	Meets specifications	
At least 3 returns per pulse	Meets specifications	
Acceptable classes - 1,2,3,4,5,6,7,9,10,13,14	Meets specifications	
Analysis		
LAS Overlap Flag - Overage points flagged as Overlap in Classified point clouds Class 12 should NOT be used	Meets specifications	1,037,027,359 tagged as Overlap
LAS Withheld Flag - Geometrically unreliable points flagged as Withheld in Classified point clouds	Meets specifications	No points are tagged as Withheld
Horizontal Accuracy Check - RMSE ≤ 0.25 m	Meets specifications	
Vertical Accuracy Check - NVA (RMSE ≤ 0.1 m, 95% CI ≤ 0.196 m)	Meets specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets specifications	
Intra-swath Accuracy (≤ 0.06 m)	Meets Specifications	
Inter-swath Accuracy (≤ 0.08 m, MAX +/- 0.16 m)	Meets specifications	
ANPS ≤ 0.5 m ***OR*** ANPD ≥ 4.0 pts/m^2	Meets specifications	
Spatial Distribution and Uniformity (At least 90 percent of the cells in a 1.0m grid contain at least one single swath, FR lidar point)	Meets specifications	
Duplicate Points (X, Y, Z, AND TIME)	Meets specifications	Observation – 115,288 points have repeating XYZ values. Random sampling suggests time is unique.
Gross Anomaly Check		
Extreme intensity values	Meets specifications	
Systematic data dropouts	Meets specifications	

Micro QA/QC Checks

	Review Status	Comments to Fugro & TNRIS
Classification Review (1=unclassified, 2=bare earth ground, 3=low vegetation, 4=medium vegetation, 5=high vegetation, 6=buildings, 7=low point/noise, 9=water, 10=ignored ground (near BL), 13=bridges, 14=culverts)		
Consistency in filtering	Meets Specifications	
Classification accuracy (misclassification)	Meets Specifications	
Building facades are primarily C6, not veg	Meets Specifications	
Data voids/gaps ≥ $(4x\ ANPS)^2 = 4.0\ m^2$	Meets Specifications	
Ridges/steps	Meets Specifications	
Cornrows	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	
No LiDAR shadowing (sliver gaps) around taller structures	Meets Specifications	

Intensity Rasters

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
50 meter tile overlap with 90 degree corners	Meets specifications	
Tile Naming Convention		
Tile name match index	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
INTENSITY Header Check		
GeoTIFF format, 16bit U	Meets specifications	
Resolution ≤ 0.5 m	Meets specifications	
Geoid 12B, NAD83(2011), UTM Z15 meters	Meets specifications	
Analysis		
NODATA set to 0	Meets specifications	
Micro QA Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Uniformity/consistency across swath	Meets specifications	
No over or under saturation/Extreme intensity values	Meets specifications	

Hydro-flattened Breaklines

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
Breaklines can extend just beyond AOI limits	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Breakline Header Checks		

Seamless or Tile based PolylineZ or PolygonZ GDB format v10.3	Meets specifications	
.PRJ file present	NA, GDB provided	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15 meters	Meets specifications	
Analysis		
No duplicate features	Meets specifications	
No topology issues (overlapping features, snapping issues, or open polygons)	Meets specifications	
Expresses monotonicity	Meets specifications	
Relative Vertical Accuracy Check	Meets specifications	AECOM reviewed 125,367 breakline vertices and found them to be equal to or just beneath the surrounding surface. A number of the vertices with relatively high deltas were reviewed and explainable or were in areas of significant slope along the river bank or near breaks in the river breakline having vegetative overgrowth.
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Streams/Rivers break at culverts	Meets specifications	
Streams/Rivers continuous at bridges	Meets specifications	
All inland streams and rivers should have been captured and flattened that have a 15.25 m nominal width	Meets specifications	
Water bodies greater than 10,000 m^2 collected	Meets specifications	
Islands greater than 5,000 m^2 collected	Meets specifications	
Breaklines extend just PAST project limits	Meets specifications	
Other Requirements		
Hydro will be split and delivered per UTM zones	Meets specifications	

Note: Five sliver voids were detected on the south facing façade of several larger airport hangers. Three were very narrow. Due to the exceptionally engineered flat terrain in and around the hangers, not having C2 points in these areas has no negative impact on the underling bare earth surface accuracy.

4.1.4.1 Vertical Accuracy Assessments

4.1.4.1.1 Relative Vertical Accuracy

Intraswath Relative Accuracy – Intraswath vertical relative accuracy was tested using 978 points on a 1m grid residing in an airport tarmac setting. As the AOI was exceptionally rural and/or heavily forested in nature there were limited locations that were suitable to perform this test. Ninety percent of First Return, Single Swath points tested ≤ 6 cm. Points having delta above 6 cm deemed isolated noise and discarded. For the sake of brevity a table has not be included in this report.

Interswath Relative Accuracy - Measuring 62,375 interswath points, and excluding 98 points that exceeded 0.16 m that resided in vegetation areas, an RMSEz = 0.03m was calculated. For the sake of brevity a table has not be included in this report.

4.1.4.1.2 Absolute Vertical Accuracy

Vertical accuracy of LiDAR data will be achieved by comparing the elevation of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE for NVA assessments and @ 95th Percentile for VVA assessments.

Table 11: LiDAR NVA Assessment
(UTM Z14N, NAVD88, Geoid 12B, NAD83(2011), Meters)

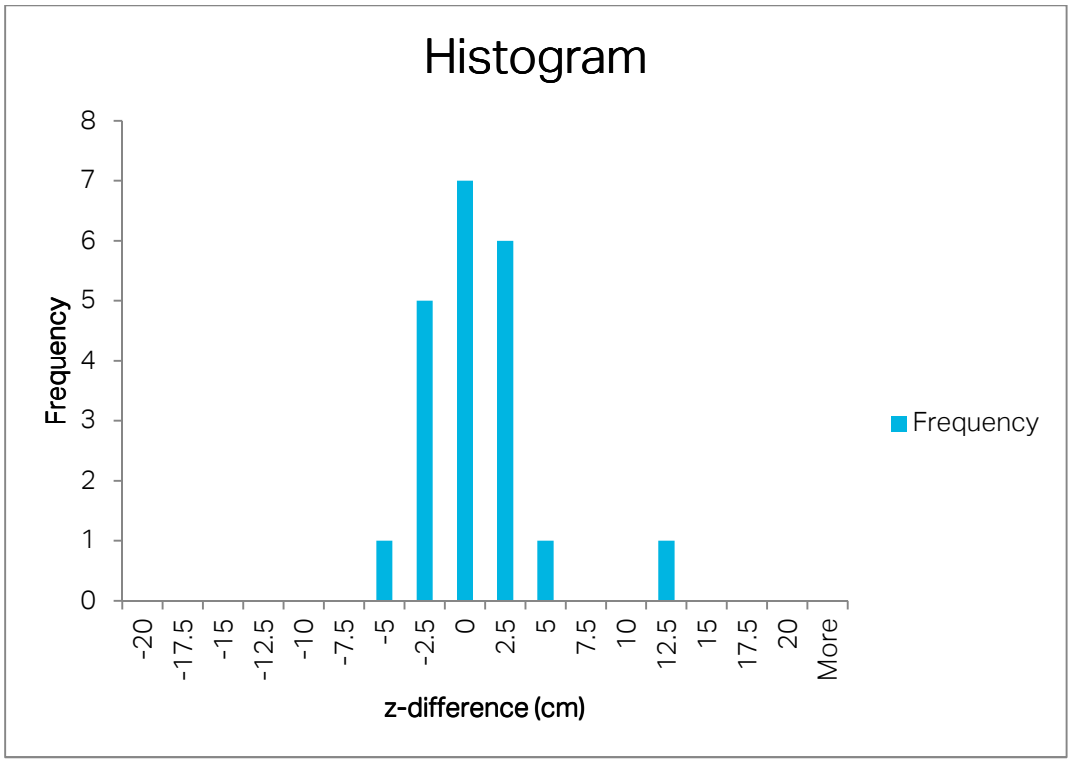
GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA058	210.878	210.843	-0.035
NVA059	196.79	196.768	-0.022
NVA060	166.768	166.78	0.012
NVA061	176.523	176.521	-0.002
NVA062	155.417	155.377	-0.040
NVA063	169.074	169.023	-0.051
NVA064	145.012	145.117	0.105
NVA065	137.249	137.261	0.012
NVA066	140.692	140.66	-0.032
NVA067	183.559	183.564	0.005
NVA070	168.752	168.744	-0.008
NVA071	162.973	162.99	0.017
NVA072	178.722	178.714	-0.008
NVA073	169.384	169.383	-0.001
NVA075	192.396	192.38	-0.016
NVA079	159.27	159.27	0.000
NVA081	161.976	161.995	0.019
NVA082	151.216	151.171	-0.045
NVA146	169.311	169.34	0.029
NVA147	199.781	199.74	-0.041
NVA149	146.892	146.899	0.007

Vertical Accuracy Statistics - NSSDA

Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	21	3.374	3.426	-0.452	0.200	-1.470	-5.100	10.500

Accuracy Assessment Results

PASS	Tested 6.613cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600


Histogram
Frequency
8
7
6
5
4
3
2
1
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency

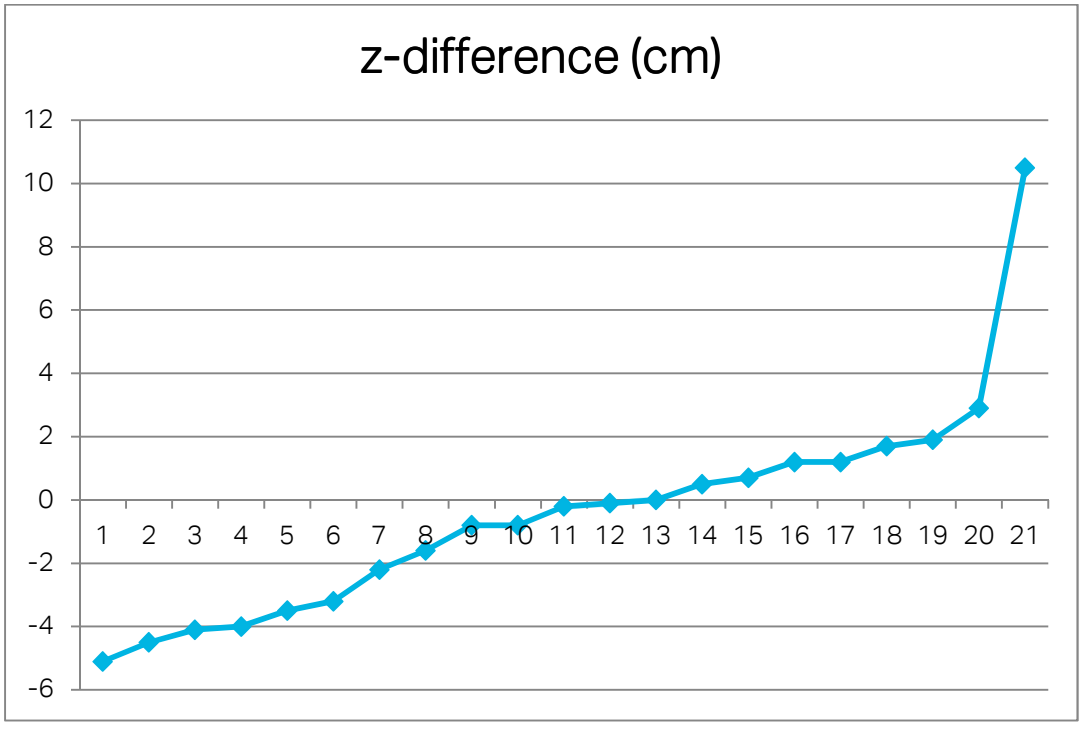
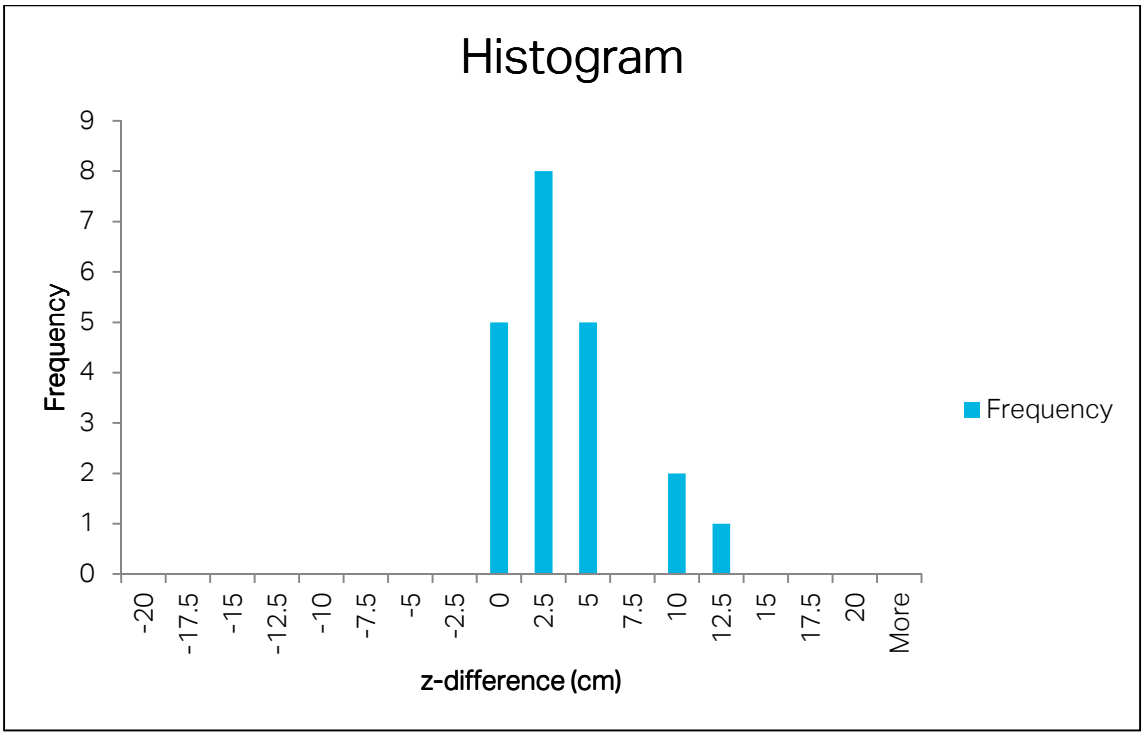
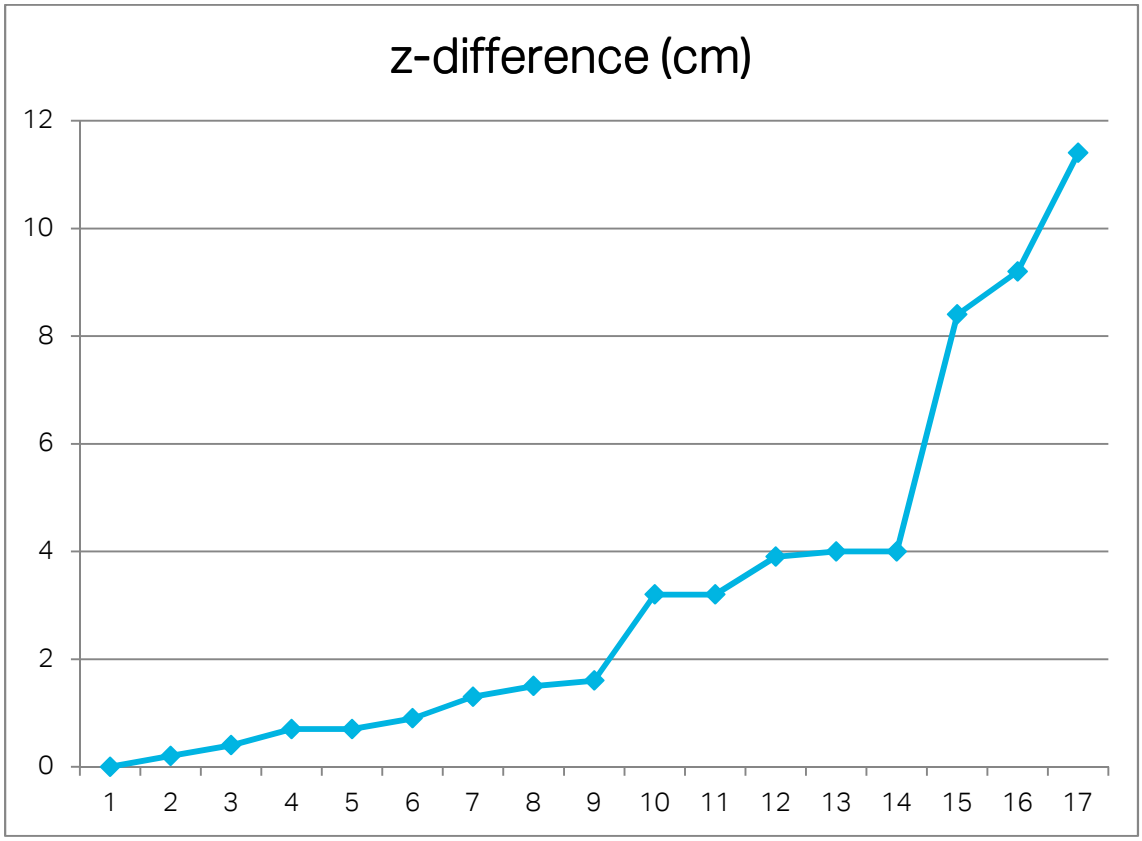

z-difference (cm)
12
10
8
6
4
2
0
-2
-4
-6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Table 12: LiDAR VVA Assessment (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)			
GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA043	160.594	160.626	0.032
VVA044	196.130	196.130	0.000
VVA045	192.034	192.043	0.009
VVA047	161.636	161.634	0.002
VVA049	165.061	165.100	0.039
VVA050	178.568	178.652	0.084
VVA051	139.833	139.837	0.004
VVA052	139.825	139.785	0.040
VVA053	154.927	154.943	0.016
VVA054	175.042	175.082	0.040
VVA055	181.755	181.847	0.092
VVA060	158.923	158.955	0.032
VVA061	168.512	168.505	0.007
VVA062	169.219	169.234	0.015
VVA063	142.212	142.326	0.114
VVA904	167.178	167.191	0.013
VVA905	147.103	147.096	0.007

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	17	4.610	3.409	3.212	-1.600	-1.362	0.000	11.400

Accuracy Assessment Results	
PASS	Tested 9.640cm vertical accuracy at 95th percentile in vegetated areas


Histogram
Frequency
9
8
7
6
5
4
3
2
1
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency


z-difference (cm)
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

4.1.4.2 Point Density and Spatial Distribution Analysis

Table 13: Aggregated Nominal Point Density (ANPD) / Aggregated Nominal Point Spacing (ANPS) Check (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	1,413,097,453.80	
Number of First Return(FR), Single Swath(SS) Points	5,894,792,485	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
Number of FR, SS Points/m^2 ≥ 4	4.17 pts/m^2	**PASS**

ANPD = 4.17pts/m^2 or ANPS = 0.49 m

Project area had large waterbodies. Had the waterbodies not been present the ANPD/ANPS would be higher (better).

Table 14: Spatial Distribution of Points (Uniformity Grid Analysis) (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	1,413,097,453.80	
# 1m X 1m cells in project AOI with ≥ 1 FR, SS point	1,362,346,671	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
≥90% of 1m X 1m cells contain at least one single swath, FR point	96.4%	**PASS**

Project area had large waterbodies. Had the waterbodies not been present the Uniformity Grid Analysis would be higher (better).

4.1.4.3 LiDAR Horizontal Accuracy Assessment

Please see 4.1.3.3 LiDAR Horizontal Accuracy Assessment for description.

4.1.5 San Jacinto Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Classified LiDAR Point Cloud

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets Specifications	
Verify readability of media	Meets Specifications	
Coverage/Gap check	Meets Specifications	
No tile/data overlap	Meets Specifications	
Tile Naming Convention		
Tile name match index	Meets Specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
USGS Lidar tags present	Meets Specifications	
LAS Header Check		
LAS format (LAS 1.4)	Meets Specifications	
GPS Times is Adjusted GPS time	Meets Specifications	
GPS times (0.01 m)	Meets Specifications	
LAS X,Y,Z scale factors 0.01 precision	Meets Specifications	
File source ID assigned	Meets Specifications	
LAS Number Variable Length Records Present	Meets Specifications	
Point Source ID equal to the File Source ID	Meets Specifications	
LAS Point Data Record Format - 6	Meets Specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets Specifications	
At least 3 returns per pulse	Meets Specifications	
Acceptable classes - 1,2,3,4,5,6,7,9,10,13,14	Meets Specifications	
Analysis		
LAS Overlap Flag - Overage points flagged as Overlap in Classified point clouds Class 12 should NOT be used	Meets Specifications	946,177,491 points tagged as Overlap
LAS Withheld Flag - Geometrically unreliable points flagged as Withheld in Classified point	Meets Specifications	No points tagged as Withheld

clouds		
Horizontal Accuracy Check - RMSE ≤ 0.25 m	Meets Specifications	
Vertical Accuracy Check - NVA (RMSE ≤ 0.1 m, 95% CI ≤ 0.196 m)	Meets Specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets Specifications	
Intra-swath Accuracy (≤ 0.06 m)	Meets Specifications	.
Inter-swath Accuracy (≤ 0.08 m, MAX +/- 0.16 m)	Meets Specifications	
ANPS ≤ 0.5 m ***OR*** ANPD ≥ 4.0 pts/m^2	Meets Specifications	
Spatial Distribution and Uniformity (At least 90 percent of the cells in a 1.0 m grid contain at least one single swath, FR lidar point)	Meets Specifications	
Duplicate Points (X, Y, Z, AND TIME)	Meets Specifications	Observation – 215,274 points have repeating XYZ values. Random sampling suggests time is unique
Gross Anomaly Check		
Extreme intensity values	Meets Specifications	
Systematic data dropouts	Meets Specifications	
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Classification Review (1=unclassified, 2=bare earth ground, 3=low vegetation, 4=medium vegetation, 5=high vegetation, 6=buildings, 7=low point/noise, 9=water, 10=ignored ground ((1*NPS) near BL), 13=bridges, 14=culverts)		
Consistency in filtering	Meets Specifications	
Classification accuracy (misclassification)	Meets Specifications	
Building facades are primarily C6, not veg	Meets Specifications	
Data voids/gaps ≥ $(4x\ ANPS)^2$ = 4.0 m^2	Meets Specifications	
Ridges/steps	Meets Specifications	
Cornrows	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	
No LiDAR shadowing (sliver gaps) around taller structures	Meets Specifications	

Intensity Rasters

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
50 meter tile overlap with 90 degree corners	Meets specifications	
Tile Naming Convention		
Tile name match index	Meets specifications	

Metadata Review		
Project Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Tile Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
INTENSITY Header Check		
GeoTIFF format, 16bit U	Meets specifications	
Resolution ≤ 0.5 m	Meets specifications	
Geoid 12B, NAD83(2011), UTM Z15, meters	Meets specifications	
Analysis		
NODATA value set to 0	Meets specifications	

Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Uniformity/consistency across swath	Meets specifications	
No over or under saturation/Extreme intensity values	Meets specifications	

Hydro-flattened Breaklines

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
Breaklines can extend just beyond AOI limits	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Tile Level metadata - Content check	Meets specifications	
USGS metadata parser check	Meets specifications	
Breakline Header Checks		
Seamless or Tile based PolylineZ or PolygonZ GDB format v10.3	Meets specifications	
.PRJ file present	NA, GDB provided	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets specifications	
Analysis		
No duplicate features	Meets specifications	
No topology issues (overlapping features, snapping issues, or open polygons)	Meets specifications	
Expresses monotonicity	Meets specifications	

Relative Vertical Accuracy Check	Meets specifications	AECOM reviewed 21,136 breakline vertices. A number of the vertices with relatively high deltas were reviewed and explainable or were in areas of significant slope along the river bank or near breaks in the river breakline having vegetative overgrowth.
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Streams/Rivers break at culverts	Meets specifications	
Streams/Rivers continuous at bridges	Meets specifications	
All inland streams and rivers should have been captured and flattened that have a 15.25 m nominal width	Meets specifications	
Water bodies greater than 10,000 m^2 collected	Meets Specifications	
Islands greater than 5,000 m^2 collected	Meets specifications	
Breaklines extend just PAST project limits	Meets specifications	
Other Requirements		
Hydro will be split and delivered per UTM zones	N/A	

4.1.5.1 Vertical Accuracy Assessments

4.1.5.1.1 Relative Vertical Accuracy

Intraswath Relative Accuracy – Intraswath vertical relative accuracy was tested using 664 points on a 1m grid residing in an airport tarmac setting. All First Return, Single Swath points tested ≤ 6 cm. For the sake of brevity a table has not be included in this report.

Interswath Relative Accuracy - Measuring 42,324 interswath points, and excluding 718 points that exceeded 0.16 m that resided in vegetation areas, an RMSEz = 0.04m was calculated. For the sake of brevity a table has not be included in this report.

4.1.5.1.2 Absolute Vertical Accuracy

Vertical accuracy of LiDAR data will be achieved by comparing the elevation of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE for NVA assessments and @ 95^{th} Percentile for VVA assessments.

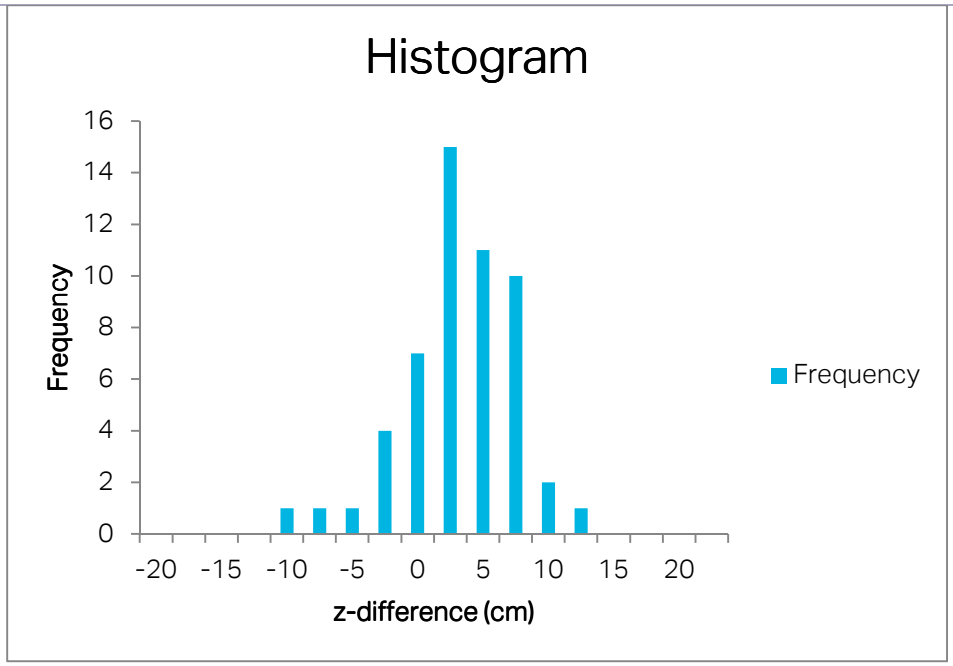
Table 15: LiDAR NVA Assessment
(UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA083	52.292	52.410	0.118
NVA084	116.301	116.323	0.022
NVA085	64.497	64.573	0.076
NVA086	105.921	105.945	0.024
NVA087	123.729	123.730	0.001

NVA088	90.945	90.934	-0.011
NVA089	87.896	87.920	0.024
NVA090	97.169	97.238	0.069
NVA091	86.440	86.463	0.023
NVA092	86.126	86.117	-0.009
NVA093	72.200	72.238	0.038
NVA094	113.441	113.414	-0.027
NVA095	113.883	113.865	-0.018
NVA096	50.241	50.309	0.068
NVA097	56.738	56.763	0.025
NVA098	92.148	92.158	0.010
NVA099	126.914	126.959	0.045
NVA100	92.609	92.617	0.008
NVA101	109.860	109.916	0.056
NVA102	70.638	70.640	0.002
NVA103	98.005	97.911	-0.095
NVA105	97.184	97.076	-0.108
NVA106	67.228	67.260	0.032
NVA107	116.976	116.928	-0.048
NVA108	99.883	99.896	0.013
NVA109	62.054	62.024	-0.030
NVA111	56.101	56.151	0.050
NVA112	45.979	46.028	0.049
NVA113	121.043	121.107	0.064
NVA114	92.410	92.447	0.037
NVA115	43.964	44.012	0.048
NVA116	23.612	23.608	-0.004
NVA117	32.775	32.751	-0.024
NVA118	81.809	81.780	-0.029
NVA119	78.955	78.971	0.016
NVA120	50.868	50.894	0.026
NVA121	50.102	50.079	-0.023
NVA122	44.979	45.042	0.063
NVA123	41.314	41.346	0.032
NVA125	68.687	68.705	0.018
NVA126	35.468	35.477	0.009
NVA127	26.267	26.319	0.052
NVA128	54.127	54.170	0.043
NVA129	62.491	62.549	0.058
NVA130	28.613	28.640	0.027
NVA131	108.570	108.629	0.059
NVA132	40.591	40.581	-0.010
NVA133	27.833	27.781	-0.053
NVA134	64.672	64.742	0.070
NVA135	45.169	45.239	0.070
NVA136	24.804	24.811	0.007
NVA137	103.665	103.670	0.005
NVA900	47.310	47.395	0.085

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	53	4.720	4.323	1.987	-2.400	0.649	-10.800	11.800

Accuracy Assessment Results	
PASS	Tested 9.252cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600



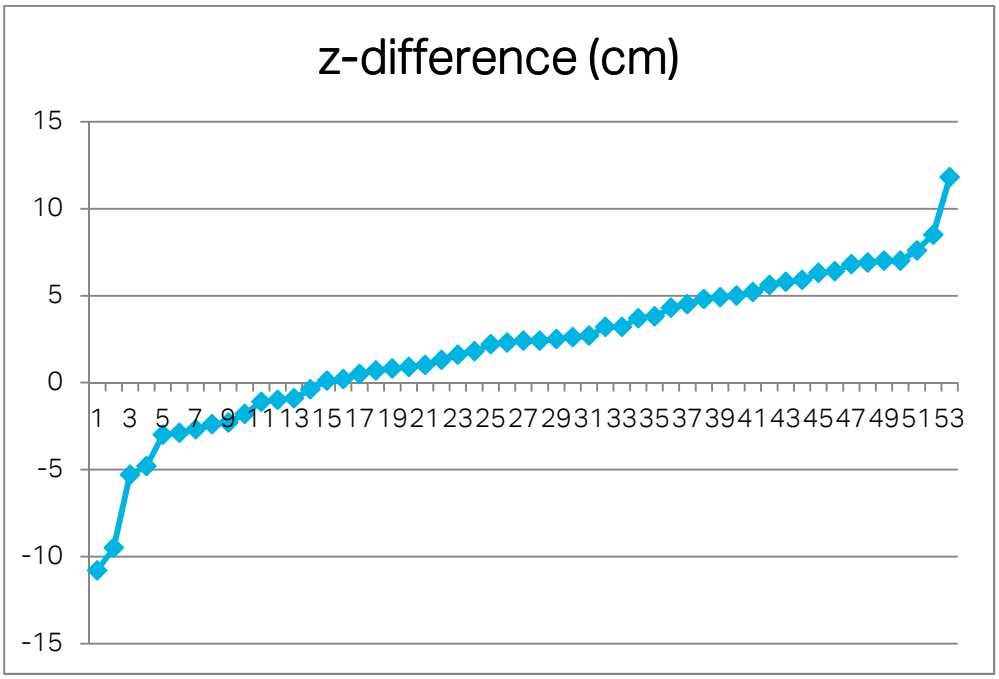
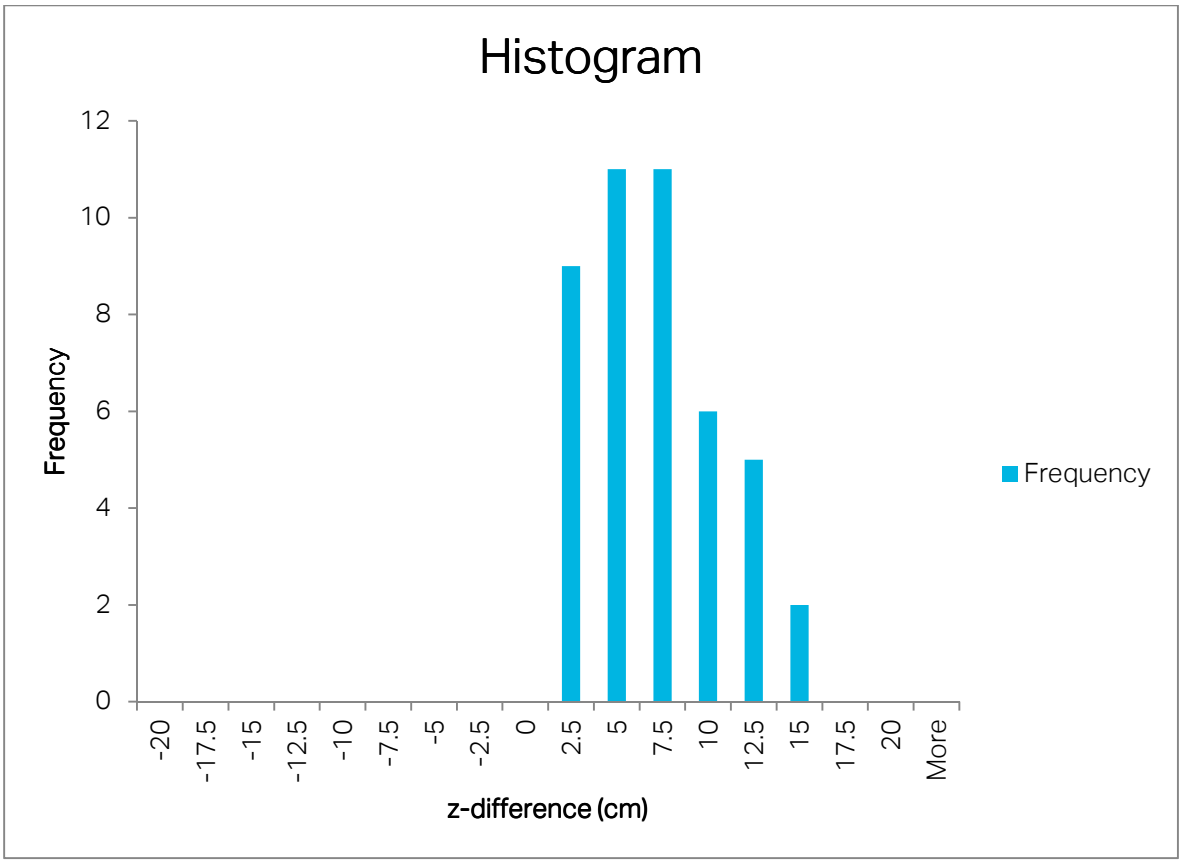


Table 16: LiDAR VVA Assessment (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)			
GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA098	40.894	40.861	0.033
VVA079	90.657	90.629	0.028
VVA096	42.132	42.122	0.010
VVA086	95.221	95.212	0.009
VVA082	95.515	95.510	0.005
VVA099	27.115	27.116	0.001
VVA097	60.000	60.002	0.002
VVA078	70.685	70.689	0.004
VVA100	78.130	78.135	0.005
VVA103	50.384	50.406	0.022
VVA104	50.381	50.406	0.024
VVA106	24.007	24.037	0.030
VVA070	123.739	123.770	0.031
VVA072	87.169	87.202	0.033
VVA110	23.892	23.931	0.038
VVA102	47.225	47.271	0.046
VVA066	55.027	55.074	0.047
VVA089	66.236	66.283	0.047
VVA073	105.182	105.230	0.048
VVA112	107.970	108.020	0.050
VVA092	63.240	63.291	0.051
VVA090	90.681	90.736	0.055
VVA080	112.787	112.844	0.057
VVA109	35.363	35.422	0.059
VVA091	41.783	41.842	0.059
VVA101	26.060	26.122	0.062
VVA081	125.997	126.060	0.063
VVA095	26.010	26.074	0.064
VVA076	107.433	107.499	0.066
VVA094	68.911	68.980	0.069
VVA068	53.222	53.292	0.070
VVA107	47.205	47.285	0.080
VVA075	92.567	92.647	0.080
VVA083	108.775	108.864	0.089
VVA093	45.930	46.024	0.094
VVA069	64.243	64.340	0.097
VVA084	55.160	55.259	0.099
VVA105	33.138	33.240	0.102
VVA087	45.669	45.772	0.103
VVA065	119.671	119.774	0.103
VVA071	97.144	97.249	0.105
VVA088	120.664	120.789	0.125
VVA067	50.290	50.422	0.132
VVA111	54.155	54.303	0.148

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	46	6.709	3.837	5.533	-5.300	-0.384	0.000	14.800

Accuracy Assessment Results	
PASS	Tested 12.200cm vertical accuracy at 95th percentile in vegetated areas


Histogram
Frequency
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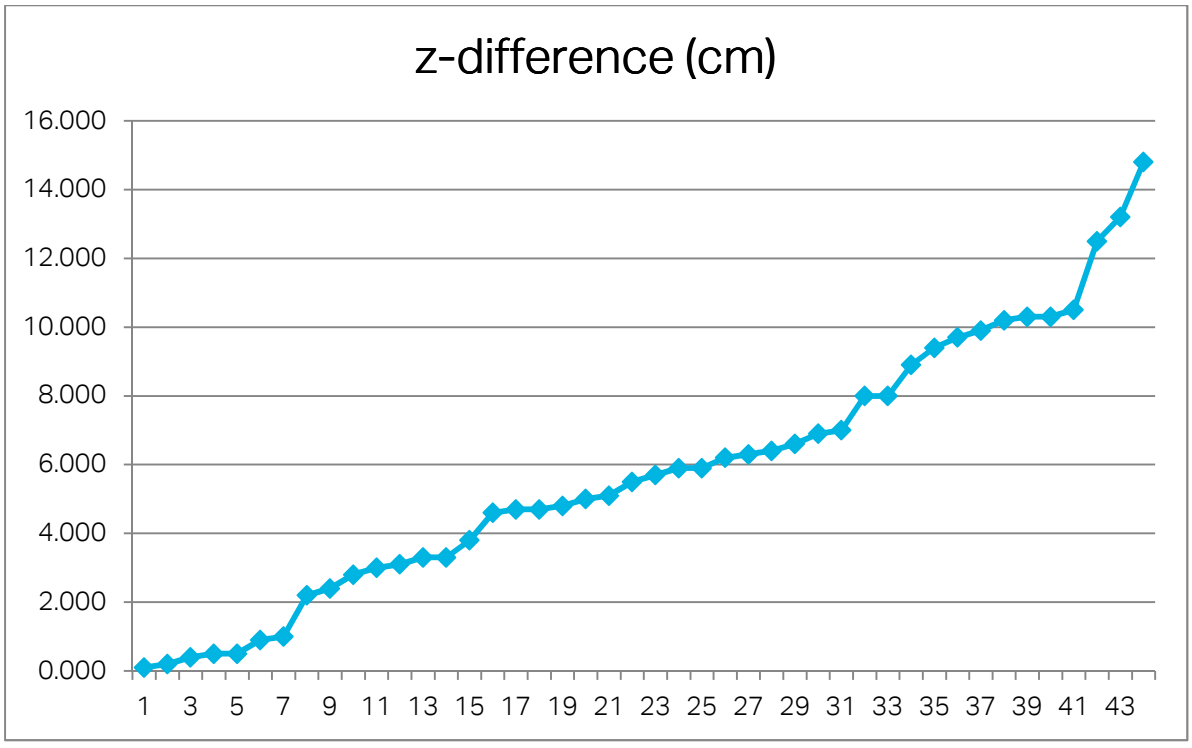
8
6
4
2
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency


z-difference (cm)
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43

4.1.5.2 Point Density and Spatial Distribution Analysis

Table 17: Aggregated Nominal Point Density (ANPD) / Aggregated Nominal Point Spacing (ANPS) Check (UTM Z15, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	2,480,695,194.28	
Number of First Return(FR), Single Swath(SS) Points	10,923,364,765	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
Number of FR, SS Points/m^2 ≥ 4	4.40 pts/m^2	**PASS**

ANPD = 4.4 pts/m^2 or ANPS = 0.48 m

Project area had one large waterbody. Had the waterbody not been present the ANPD/ANPS would be higher (better).

Table 18: Spatial Distribution of Points (Uniformity Grid Analysis) (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)		
Project AOI M^2	2,480,695,194.28	
# 1m X 1m cells in project AOI with ≥ 1 FR, SS point	2,345,755,661	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
≥90% of 1m X 1m cells contain at least one single swath, FR point	94.6%	**PASS**

Project area had one large waterbody. Had the waterbody not been present the Uniformity Grid Analysis would be higher (better).

4.1.5.3 LiDAR Horizontal Accuracy Assessment

Horizontal accuracy of LiDAR data is achieved by identifying coincident locations between the Intensity rasters and the horizontal checkpoints. Deviations exhibited by the LiDAR Intensity rasters relative to the checkpoints were reported as an RMSE.

Table 19: LiDAR Horizontal Accuracy Assessment
(UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

POINT ID	CHK PT X	CHK PT Y	INTENSITY X	INTENSITY Y	X DELTA	Y DELTA
NVA095	261167.468	3399571.46	261167.51	3399571.41	-0.04	0.05
NVA101	281363.308	3376515.57	281363.20	3376515.71	0.11	-0.15
NVA150	265819.546	3398544.87	265819.47	3398544.94	0.07	-0.07
NVA152	285155.386	3383074.89	285155.42	3383074.89	-0.04	0.00
NVA120	308330.534	3374300.85	308330.61	3374300.59	-0.07	0.25

NVA126	313487.298	3387734.15	313487.23	3387734.18	0.07	-0.04
NVA130	316529.781	3381234.28	316529.96	3381234.20	-0.18	0.07
NVA137	294281.287	3383376.62	294281.32	3383376.55	-0.04	0.07
NVA155	299760.337	3407569.61	299760.35	3407569.60	-0.01	0.01
NVA156	308596.705	3392433.27	308596.74	3392433.20	-0.03	0.07
NVA900	302424.721	3402145.02	302424.59	3402144.89	0.13	0.13
Specification Acceptance						
Specification Threshold	Calculated Result	Status				
$RMSE_x \leq 0.25$ m	0.09 m	**PASS**				
RMSEy ≤ 0.25 m	0.11 m	**PASS**				

5 Phase IV: Product Development

5.1.1 Sulphur UTM Zone 15 DEM Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets specifications	
Verify readability of media	Meets specifications	
Coverage/Gap check	Meets specifications	
50 meter tile overlap with 90 degree corners	Meets specifications	
Tile Naming Convention		
Tile name match index	Meets specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
DEM Header Check		
.IMG format, 32bit U	Meets specifications	
Resolution ≤ 1.0 m	Meets specifications	
X,Y,Z 0.01 meter precision	Meets specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets specifications	
Analysis		
NODATA value = -9999	Meets specifications	
Vertical Accuracy Check - NVA (RMSE ≤ 0.10 m, 95% CI ≤ 0.196 m)	Meets specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets specifications	

Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Bridges not in DEM (Culverts in DEM bare earth surface)	Meets specifications	
Extreme elevation values	Meets specifications	
No floating or sunken waterbodies	Meets specifications	
Water bodies greater than 10,000m^2 flattened	Meets specifications	
Islands greater than 5,000 m^2 collected	Meets specifications	
Data voids/gaps	Meets specifications	
Ridges/steps between tiles	Meets specifications	Stepping observable in DEM but

		minimal
Over or Under aggressive filtering anomalies	Meets specifications	
Spikes/Divots (noise)	Meets specifications	

5.1.1.1 Vertical Accuracy Assessments

5.1.1.1.1 Absolute Vertical Accuracy

Vertical accuracy of DEM raster data is achieved by comparing the rasterized version of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE for NVA assessments and @ 95th Percentile for VVA assessments.

Table 20: DEM NVA Assessment
(UTM Z14N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA001	130.595	130.629	-0.034
NVA002	119.092	119.087	0.005
NVA003	120.419	120.430	-0.011
NVA004	132.785	132.728	0.057
NVA006	140.802	140.711	0.091
NVA007	167.626	167.585	0.041
NVA008	176.977	176.896	0.081
NVA009	178.222	178.197	0.025
NVA011	195.157	195.106	0.051
NVA012	200.778	200.711	0.067
NVA013	210.657	210.625	0.032
NVA014	195.784	195.726	0.058
NVA015	176.641	176.549	0.092
NVA016	151.761	151.728	0.033
NVA017	165.540	165.496	0.044
NVA018	140.443	140.443	0.000
NVA019_2	136.235	136.185	0.050
NVA020	156.249	156.315	-0.066
NVA021	144.553	144.542	0.011
NVA022	127.022	126.987	0.035
NVA023	145.797	145.778	0.019
NVA024	175.452	175.424	0.028
NVA025	160.860	160.771	0.089
NVA026	157.158	157.103	0.055
NVA027	158.556	158.474	0.082
NVA028	138.589	138.546	0.043
NVA029	140.237	140.239	-0.002
NVA138	165.620	165.616	0.004
NVA139	135.923	135.910	0.013
NVA030	136.767	136.711	0.056
NVA031	132.047	132.019	0.028
NVA032	128.470	128.444	0.026
NVA033	142.192	142.206	-0.014
NVA034	130.406	130.426	-0.020
NVA036	163.789	163.766	0.023
NVA037	153.596	153.494	0.102
NVA038	145.063	145.068	-0.005
NVA039	138.826	138.793	0.033
NVA040	169.156	169.178	-0.022

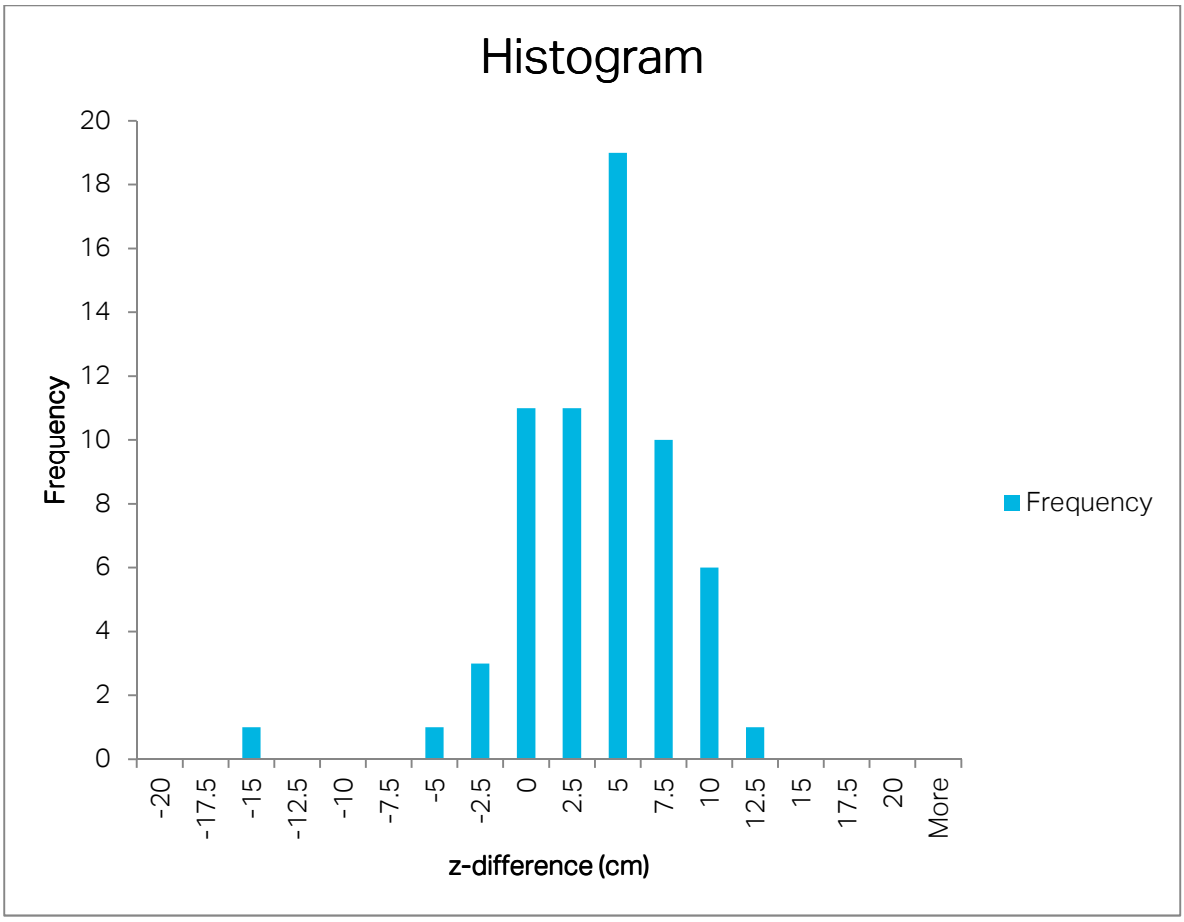
NVA041	176.717	176.691	0.026
NVA042	173.696	173.667	0.029
NVA043	155.848	155.780	0.068
NVA044	142.335	142.307	0.028
NVA045	150.436	150.400	0.036
NVA046	152.681	152.660	0.021
NVA047	169.285	169.223	0.062
NVA048	162.155	162.117	0.038
NVA049	164.018	163.950	0.068
NVA050	158.769	158.699	0.070
NVA051	139.546	139.515	0.031
NVA052	126.602	126.650	-0.048
NVA053	139.968	140.000	-0.032
NVA054	144.427	144.404	0.023
NVA055	144.367	144.351	0.016
NVA056	130.355	130.506	-0.151
NVA057	143.677	143.588	0.089
NVA068	183.059	183.075	-0.016
NVA069	138.588	138.549	0.039
NVA074	167.822	167.828	-0.006
NVA076	160.360	160.371	-0.011
NVA077	133.278	133.289	-0.011
NVA078	154.618	154.602	0.016
NVA080	156.897	156.869	0.028

Vertical Accuracy Statistics - NSSDA

Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	63	4.941	4.260	2.560	-2.800	1.137	-15.100	10.200

Accuracy Assessment Results

PASS	Tested 9.684cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600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14
12
10
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6
4
2
0
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-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency

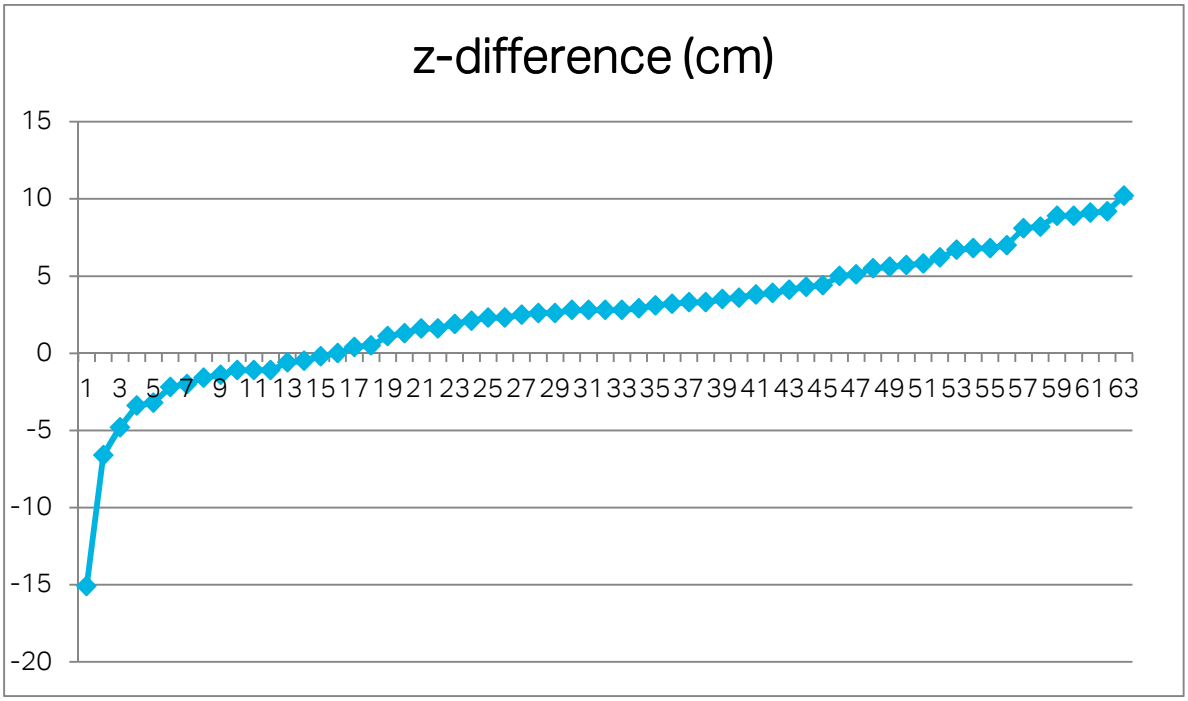
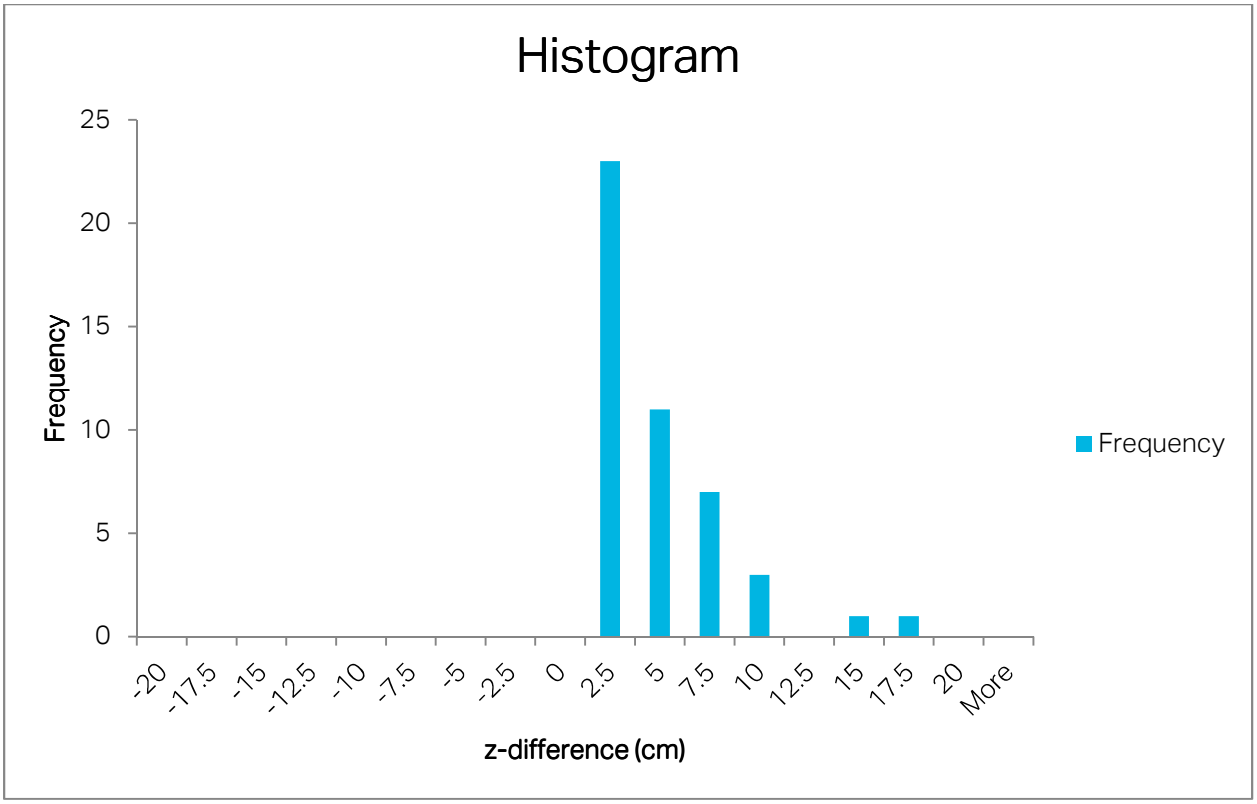
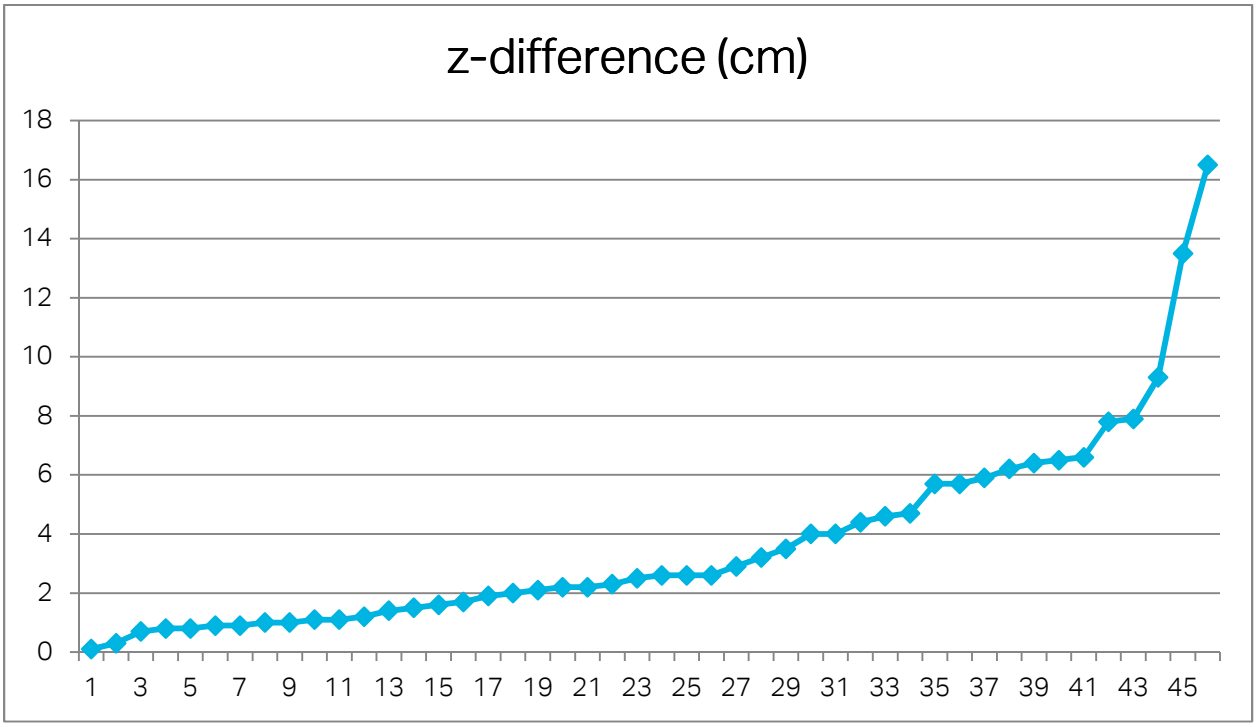

z-difference (cm)
15
10
5
0
-5
-10
-15
-20
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63

Table 21: DEM VVA Assessment (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)			
GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA001	161.172	161.197	0.025
VVA002	193.801	193.811	0.010
VVA003	196.240	196.226	0.014
VVA004	210.631	210.591	0.040
VVA005	151.957	152.122	0.165
VVA007	179.069	179.147	0.078
VVA008	132.855	132.798	0.057
VVA009	140.510	140.536	0.026
VVA010	155.831	155.910	0.079
VVA011	135.821	135.853	0.032
VVA012	175.996	175.930	0.066
VVA013	165.029	164.983	0.046
VVA014	139.962	139.942	0.020
VVA015	173.975	173.997	0.022
VVA016	176.373	176.309	0.064
VVA018	140.180	140.273	0.093
VVA019	175.459	175.476	0.017
VVA020	158.350	158.366	0.016
VVA021	127.010	126.998	0.012
VVA022	138.355	138.346	0.009
VVA023	136.419	136.408	0.011
VVA024	158.998	158.954	0.044
VVA025	139.483	139.472	0.011
VVA026	143.392	143.400	0.008
VVA027	139.334	139.353	0.019
VVA029	169.393	169.378	0.015
VVA030	139.155	139.165	0.010
VVA031	129.515	129.541	0.026
VVA032	163.549	163.557	0.008
VVA033	178.748	178.795	0.047
VVA034	174.199	174.200	0.001
VVA036	127.149	127.206	0.057
VVA037	133.611	133.571	0.040
VVA038	127.960	127.951	0.009
VVA039	144.274	144.277	0.003
VVA040	139.865	139.886	0.021
VVA041	164.307	164.300	0.007
VVA042	153.295	153.321	0.026
VVA900	163.828	163.766	0.062
VVA046	167.535	167.594	0.059
VVA048	130.102	130.237	0.135
VVA056	183.110	183.145	0.035
VVA057	139.168	139.103	0.065
VVA058	159.909	159.931	0.022
VVA059	131.553	131.582	0.029
VVA064	156.378	156.401	0.023

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	46	4.950	3.369	3.661	-2.550	-1.920	0.100	16.500

Accuracy Assessment Results	
PASS	Tested 8.950cm vertical accuracy at 95th percentile in vegetated areas





5.1.2 Sulphur UTM Zone 14 DEM Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets Specifications	
Verify readability of media	Meets Specifications	
Coverage/Gap check	Meets Specifications	
50 meter tile overlap with 90 degree corners	Meets Specifications	
Tile Naming Convention		
Tile name match index	Meets Specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
DEM Header Check		
.IMG format, 32bit U	Meets Specifications	
Resolution ≤ 1.0 m	Meets Specifications	
X,Y,Z 0.01 meter precision	Meets Specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z14, meters	Meets Specifications	
Analysis		
NODATA value = -9999	Meets Specifications	
Vertical Accuracy Check - NVA (RMSE ≤ 0.1 m, 95% CI ≤ 0.196 m)	Meets Specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets Specifications	

Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Bridges not in DEM (Culverts in DEM bare earth surface)	Meets Specifications	
Extreme elevation values	Meets Specifications	
No floating or sunken waterbodies	Meets Specifications	
Water bodies greater than 10,000m^2 flattened	Meets Specifications	
Islands greater than 5,000 m^2 collected	Meets Specifications	
Data voids/gaps	Meets Specifications	
Ridges/steps between tiles	Meets Specifications	Stepping observable in DEM but minimal
Over or Under aggressive filtering anomalies	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	

5.1.2.1 Vertical Accuracy Assessments

5.1.2.1.1 Absolute Vertical Accuracy

Vertical accuracy of DEM raster data will be achieved by comparing the rasterized version of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE for NVA assessments and @ 95th Percentile for VVA assessments.

Table 22: DEM NVA Assessment
(UTM Z14N, NAVD88, Geoid 12B, NAD83(2011), Meters)

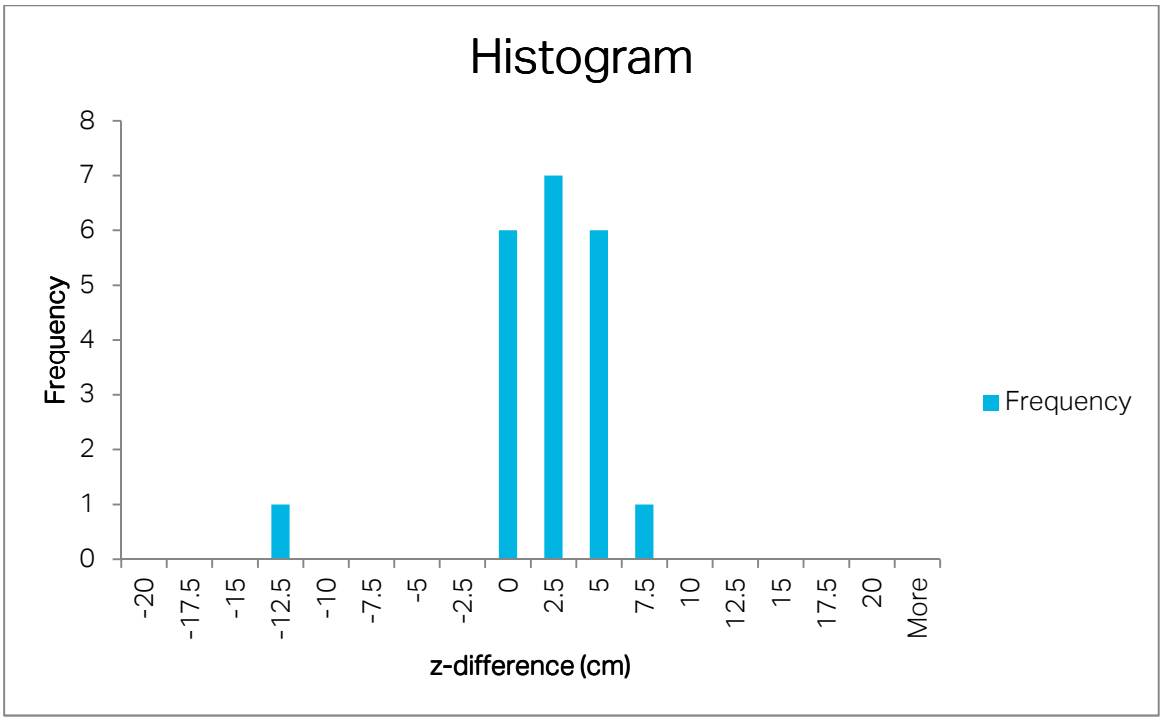
GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA058	210.878	210.843	0.035
NVA147	199.781	199.746	0.035
NVA075	192.396	192.372	0.024
NVA067	183.559	183.556	0.003
NVA059	196.79	196.763	0.027
NVA081	161.976	161.988	-0.012
NVA072	178.722	178.717	0.005
NVA146	169.311	169.327	-0.016
NVA070	168.752	168.747	0.005
NVA073	169.384	169.373	0.011
NVA071	162.973	162.979	-0.006
NVA060	166.768	166.771	-0.003
NVA149	146.892	146.9	-0.008
NVA061	176.523	176.544	-0.021
NVA082	151.216	151.164	0.052
NVA062	155.417	155.37	0.047
NVA079	159.27	159.265	0.005
NVA064	145.012	145.148	-0.136
NVA065	137.249	137.247	0.002
NVA063	169.074	169.036	0.038
NVA066	140.692	140.642	0.05

Vertical Accuracy Statistics - NSSDA

Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	21	3.92	3.961	0.652	-0.5	2.318	-13.6	5.2

Accuracy Assessment Results

PASS	Tested 7.683cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600


Histogram
Frequency
8
7
6
5
4
3
2
1
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency

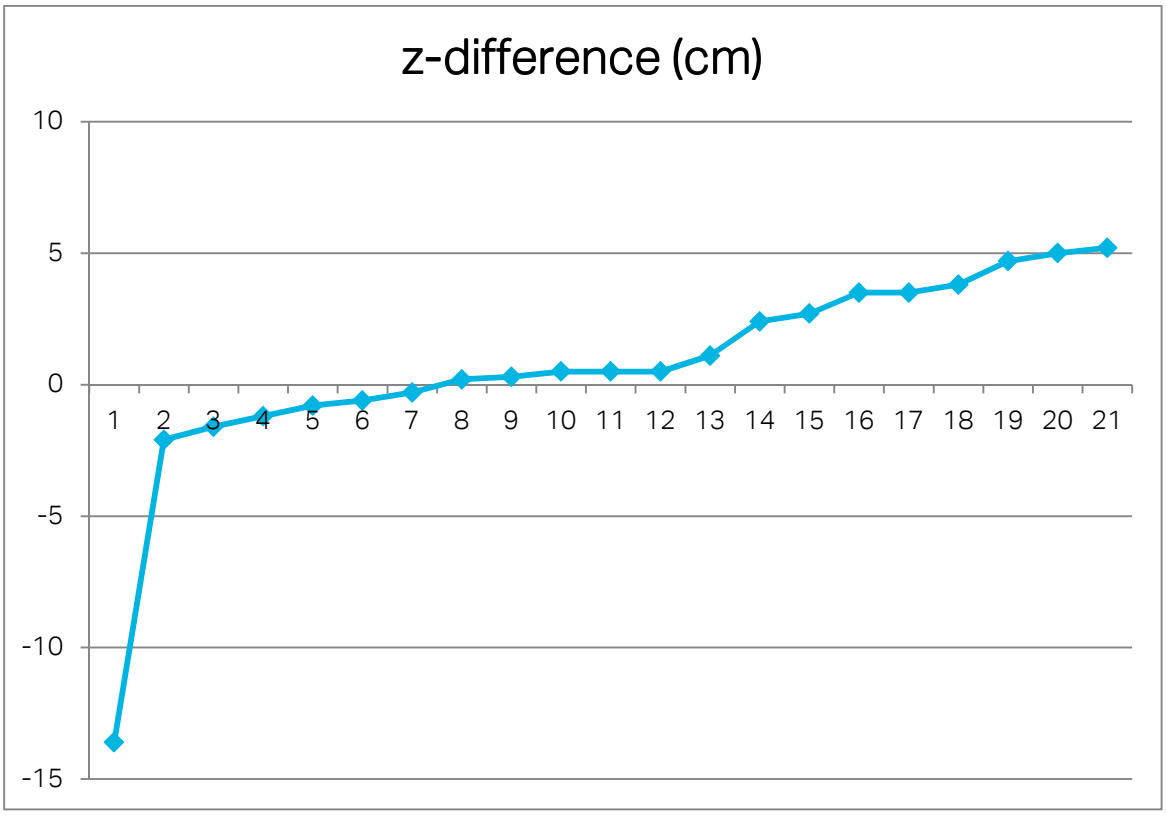
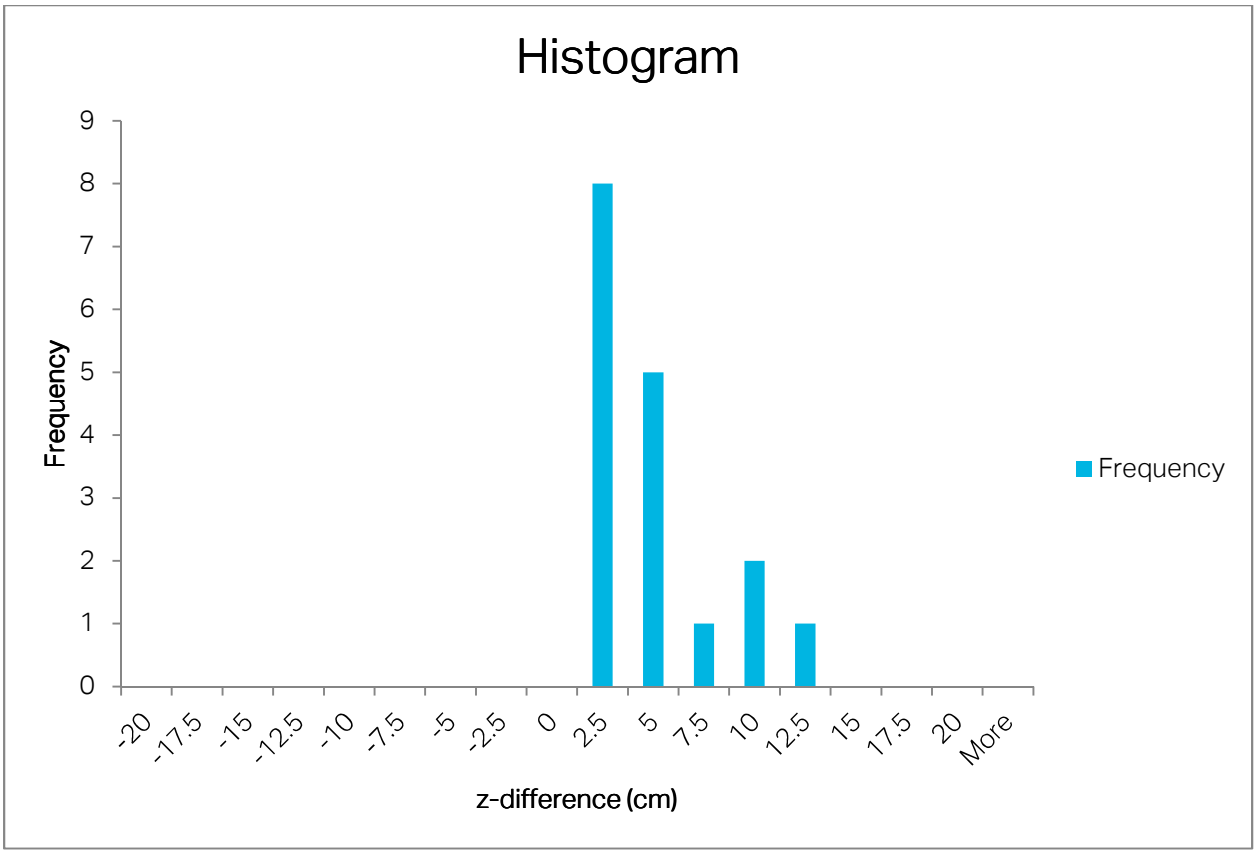
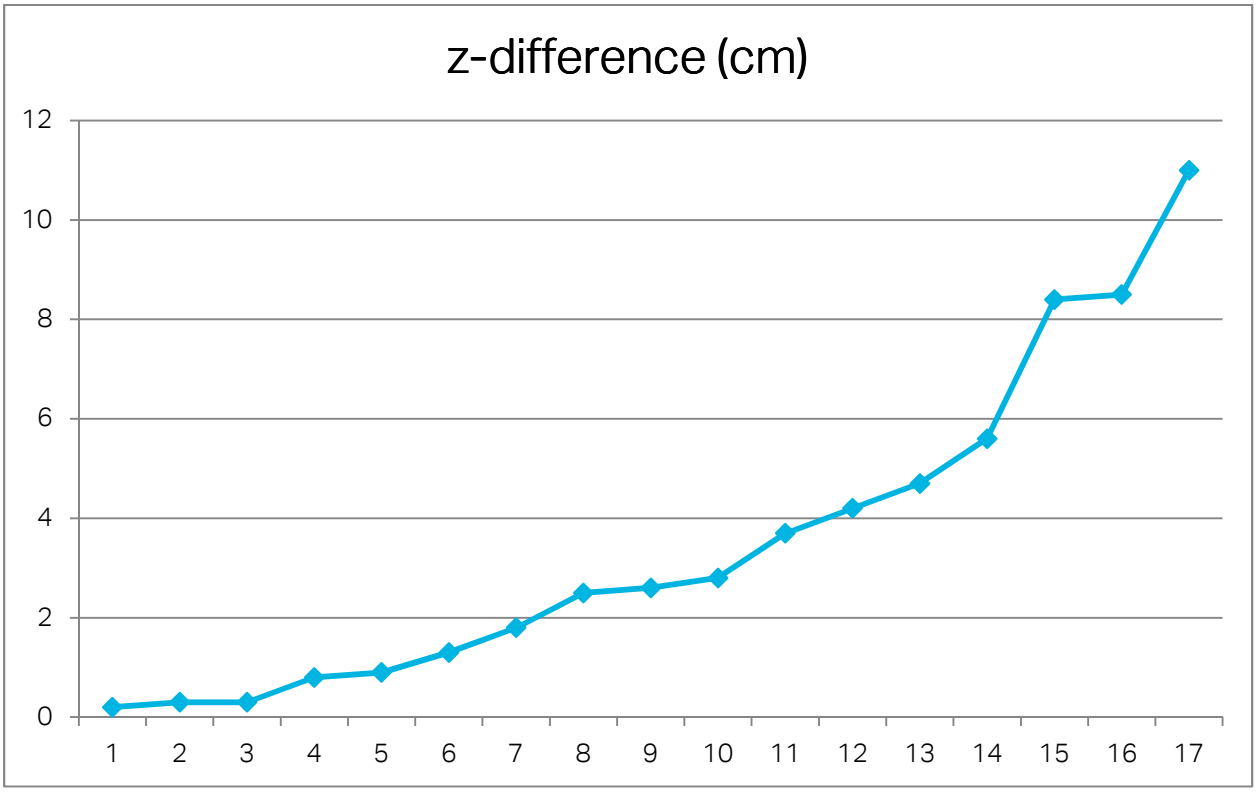

z-difference (cm)
10
5
0
-5
-10
-15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Table 23: DEM VVA Assessment (UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)			
GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA045	192.034	192.026	0.008
VVA055	181.755	181.840	0.085
VVA044	196.130	196.105	0.025
VVA047	161.636	161.633	0.003
VVA050	178.568	178.652	0.084
VVA904	167.178	167.234	0.056
VVA062	169.219	169.216	0.003
VVA043	160.594	160.620	0.026
VVA061	168.512	168.499	0.013
VVA049	165.061	165.089	0.028
VVA905	147.103	147.101	0.002
VVA054	175.042	175.079	0.037
VVA053	154.927	154.936	0.009
VVA060	158.923	158.970	0.047
VVA051	139.833	139.815	0.018
VVA063	142.212	142.322	0.110
VVA052	139.825	139.783	0.042

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	46	2.859	2.577	1.296	0.000	-2.369	0.000	11.000

Accuracy Assessment Results	
PASS	Tested 9.000cm vertical accuracy at 95th percentile in vegetated areas


Histogram
Frequency
9
8
7
6
5
4
3
2
1
0
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
More
z-difference (cm)
Frequency


z-difference (cm)
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

5.1.3 San Jacinto DEM Macro and Micro Review Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for evaluation and final verification.

Macro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Inventory Assessment		
Conduct file inventory	Meets Specifications	
Verify readability of media	Meets Specifications	
Coverage/Gap check	Meets Specifications	
50 meter tile overlap with 90 degree corners	Meets Specifications	
Tile Naming Convention		
Tile name match index	Meets Specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
DEM Header Check		
.IMG format, 32bit U	Meets Specifications	
Resolution ≤ 1.0 m	Meets Specifications	
X,Y,Z 0.01 meter precision	Meets Specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15, meters	Meets Specifications	
Analysis		
NODATA value = -9999	Meets Specifications	
Vertical Accuracy Check - NVA (RMSE ≤ 0.1 m, 95% CI ≤ 0.196 m)	Meets Specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets Specifications	
Micro QA/QC Checks		
	Review Status	**Comments to Fugro & TNRIS**
Micro Review		
Bridges not in DEM (Culverts in DEM bare earth surface)	Meets Specifications	
Extreme elevation values	Meets Specifications	
No floating or sunken waterbodies	Meets Specifications	
Water bodies greater than 10,000m^2 flattened	Meets Specifications	
Islands greater than 5,000 m^2 collected	Meets Specifications	
Data voids/gaps	Meets Specifications	
Ridges/steps between tiles	Meets Specifications	
Over or Under aggressive filtering anomalies	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	

5.1.3.1 Vertical Accuracy Assessments

5.1.3.1.1 Absolute Vertical Accuracy

Vertical accuracy of DEM raster data will be achieved by comparing the rasterized version of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE for NVA assessments and @ 95th Percentile for VVA assessments.

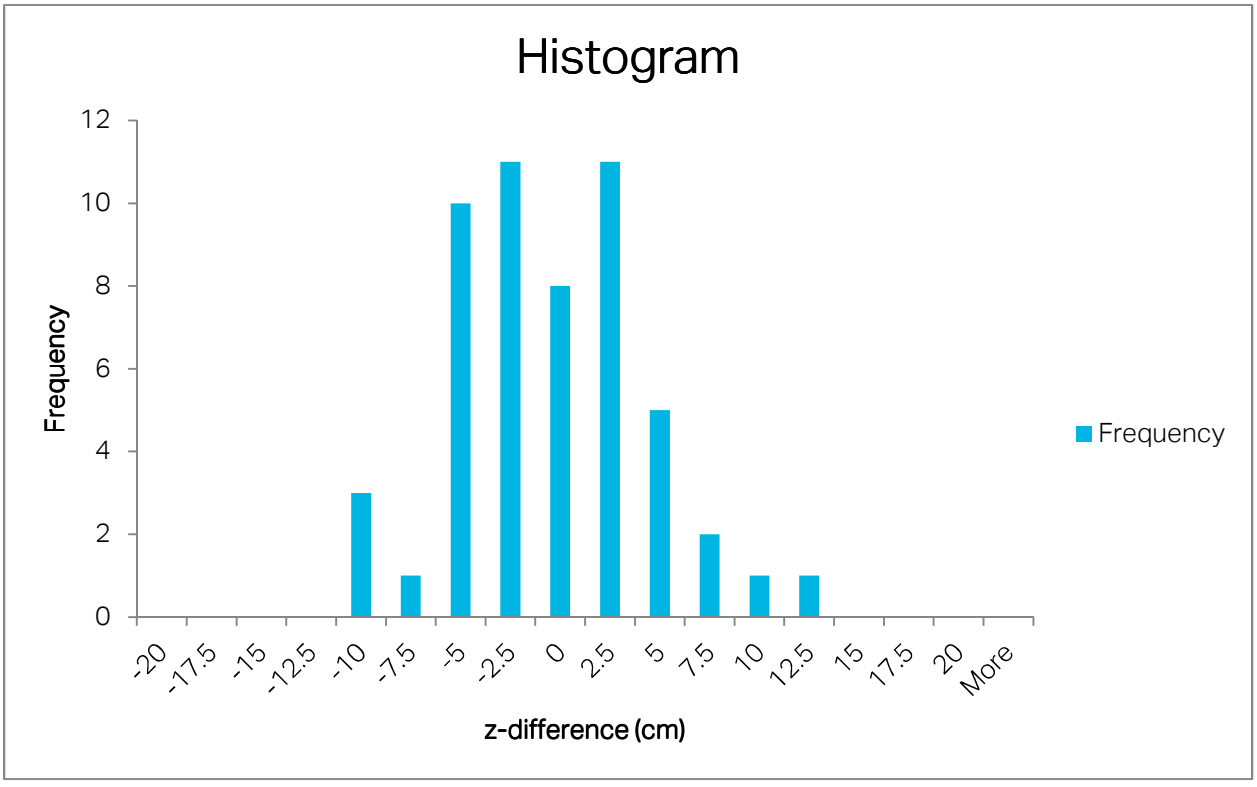
Table 24: DEM NVA Assessment
(UTM Z14N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Difference
NVA134	64.672	64.744	-0.072
NVA135	45.169	45.268	-0.099
NVA123	41.314	41.350	-0.036
NVA114	92.410	92.445	-0.035
NVA113	121.043	121.144	-0.101
NVA122	44.979	45.042	-0.063
NVA084	116.301	116.300	0.001
NVA900	47.310	47.379	-0.069
NVA095	113.883	113.866	0.017
NVA121	50.102	50.080	0.022
NVA094	113.441	113.347	0.094
NVA115	43.964	44.080	-0.116
NVA108	99.883	99.848	0.035
NVA103	98.005	97.931	0.074
NVA107	116.976	116.911	0.065
NVA118	81.809	81.769	0.040
NVA133	27.833	27.783	0.050
NVA100	92.609	92.620	-0.011
NVA132	40.591	40.576	0.015
NVA091	86.440	86.469	-0.029
NVA126	35.468	35.480	-0.012
NVA125	68.687	68.670	0.017
NVA131	108.570	108.614	-0.044
NVA127	26.267	26.316	-0.049
NVA137	103.665	103.679	-0.014
NVA093	72.200	72.210	-0.010
NVA130	28.613	28.641	-0.028
NVA086	105.921	105.951	-0.030
NVA099	126.914	126.938	-0.024
NVA098	92.148	92.125	0.023
NVA119	78.955	79.010	-0.055
NVA105	97.184	97.066	0.118
NVA116	23.612	23.609	0.003
NVA101	109.860	109.913	-0.053
NVA087	123.729	123.727	0.002
NVA129	62.491	62.552	-0.061
NVA092	86.126	86.110	0.016
NVA120	50.868	50.881	-0.013
NVA117	32.775	32.735	0.040
NVA090	97.169	97.235	-0.066
NVA136	24.804	24.816	-0.012
NVA088	90.945	90.912	0.033
NVA128	54.127	54.172	-0.045
NVA089	87.896	87.938	-0.042

NVA102	70.638	70.627	0.011
NVA109	62.054	62.035	0.019
NVA096	50.241	50.300	-0.059
NVA106	67.228	67.255	-0.027
NVA083	52.292	52.410	-0.118
NVA085	64.497	64.563	-0.066
NVA111	56.101	56.155	-0.054
NVA097	56.738	56.769	-0.031
NVA112	45.979	46.002	-0.023

Vertical Accuracy Statistics - NSSDA								
Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	53	5.246	5.029	-1.645	2.300	-0.315	-11.800	11.800

Accuracy Assessment Results	
PASS	Tested 10.282cm vertical accuracy at 95 percent confidence level in bare earth using RMSEz x 1.9600



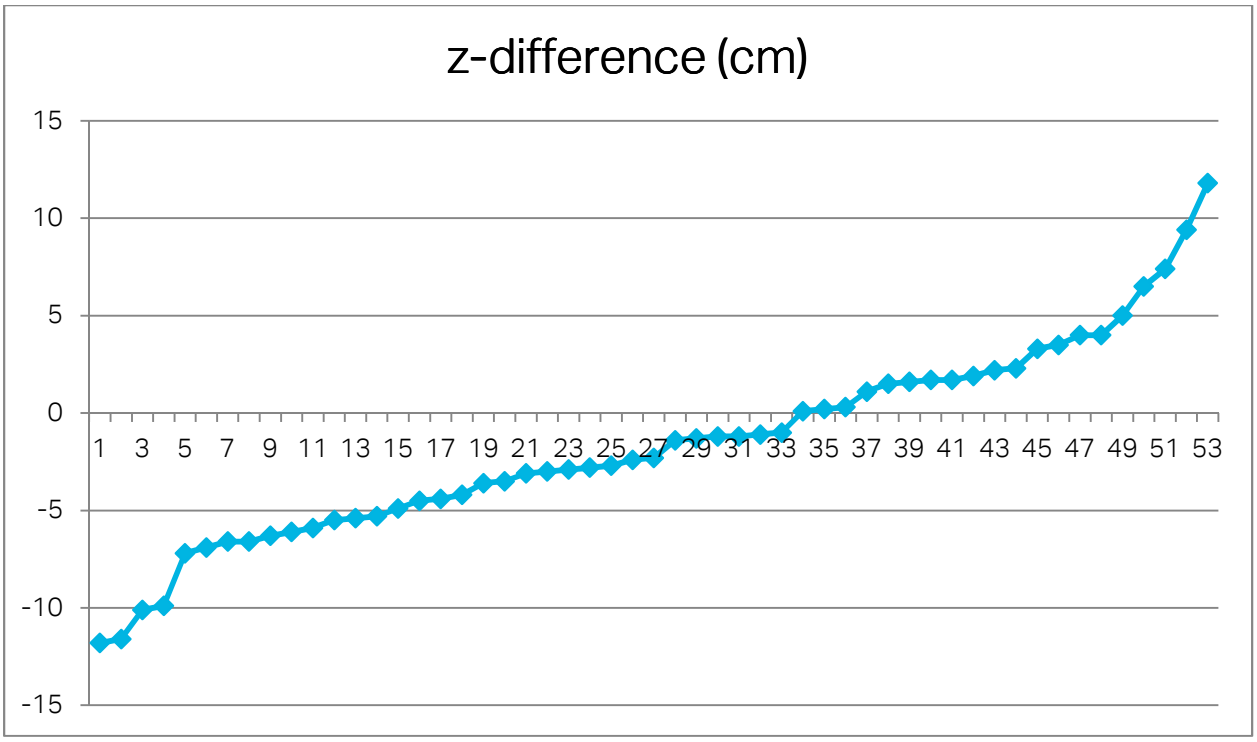


Table 25: DEM VVA Assessment
(UTM Z15N, NAVD88, Geoid 12B, NAD83(2011), Meters)

GPS Point Name	Survey Elevation	LiDAR Elevation	Absolute Difference
VVA092	63.240	63.271	0.031
VVA102	47.225	47.317	0.092
VVA091	41.783	41.839	0.056
VVA090	90.681	90.747	0.066
VVA065	119.671	119.789	0.118
VVA066	55.027	55.059	0.032
VVA088	120.664	120.888	0.224
VVA107	47.205	47.283	0.078
VVA103	50.384	50.430	0.046
VVA080	112.787	112.868	0.081
VVA093	45.930	46.015	0.085
VVA077	98.073	98.098	0.025
VVA097	60.000	60.013	0.013
VVA082	95.515	95.515	0.000
VVA076	107.433	107.512	0.079
VVA099	27.115	27.085	0.030
VVA075	92.567	92.694	0.127
VVA098	40.894	40.870	0.024
VVA109	35.363	35.420	0.057
VVA105	33.138	33.259	0.121
VVA094	68.911	68.992	0.081
VVA112	107.970	108.011	0.041
VVA110	23.892	23.915	0.023
VVA101	26.060	26.130	0.070
VVA073	105.182	105.230	0.048

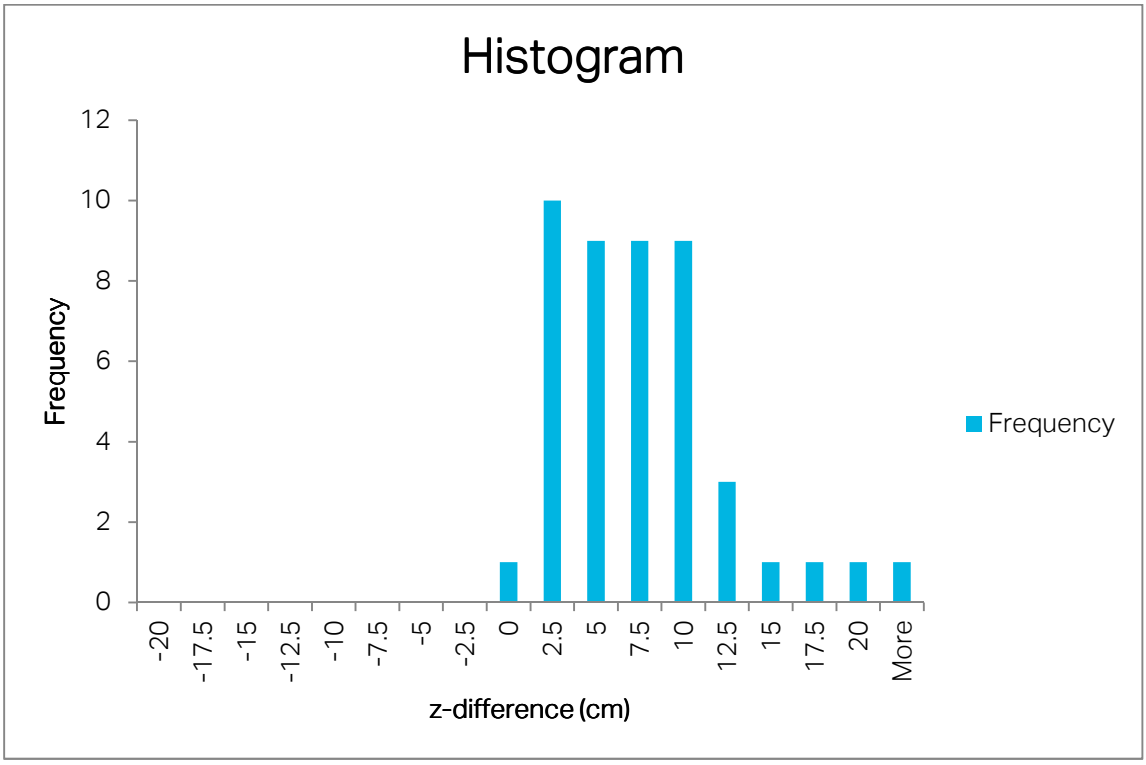
VVA086	95.221	95.205	0.016
VVA095	26.010	26.084	0.074
VVA081	125.997	126.055	0.058
VVA106	24.007	24.013	0.006
VVA100	78.130	78.144	0.014
VVA083	108.775	108.857	0.082
VVA070	123.739	123.752	0.013
VVA104	50.381	50.413	0.032
VVA096	42.132	42.120	0.012
VVA071	97.144	97.209	0.065
VVA111	54.155	54.338	0.183
VVA079	90.657	90.625	0.032
VVA078	70.685	70.691	0.006
VVA072	87.169	87.213	0.044
VVA067	50.290	50.453	0.163
VVA089	66.236	66.305	0.069
VVA068	53.222	53.281	0.059
VVA069	64.243	64.334	0.091
VVA084	55.160	55.277	0.117
VVA087	45.669	45.754	0.085

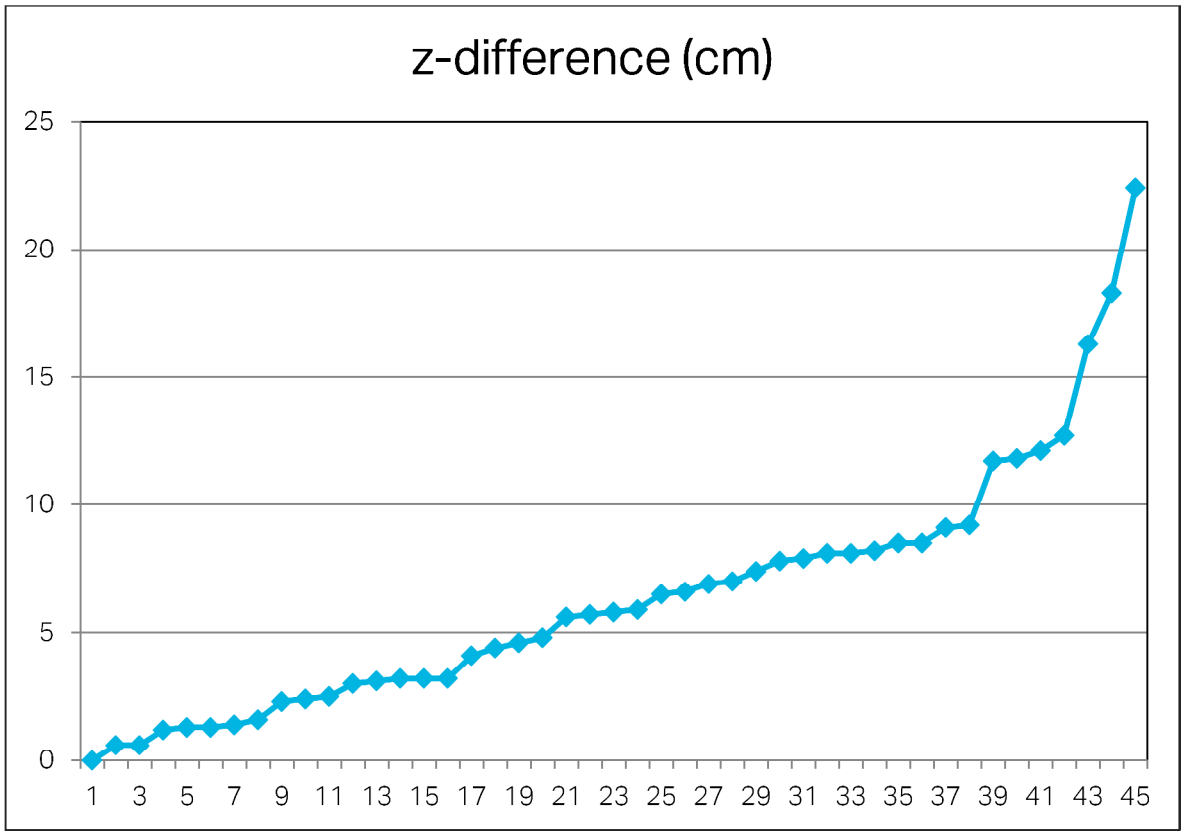
Vertical Accuracy Statistics - NSSDA

Land Cover	# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew (cm)	Min (cm)	Max (cm)
Bare Earth	45	7.953	4.808	6.376	-5.800	-1.275	0.000	22.400

Accuracy Assessment Results

PASS	Tested 15.580cm vertical accuracy at 95th percentile in vegetated areas




z-difference (cm)
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45

5.1.4 Credits

Organizations involved in the procurement, acquisition, processing, and quality assessment of this project are identified below.

Table 26: Project Stakeholders

Project Function	Stakeholder
LiDAR procurement	Texas Natural Resources Information System (TNRIS) Texas Water Development Board (TWDB) Texas Commission of Environmental Quality (TCEQ)
LiDAR acquisition and processing	Fugro
QA/QC checkpoint ground survey	AECOM subcontractor - CompassData & Associates, L.P.
Accuracy assessment and QA/QC review and reporting	AECOM Technical Services, Inc.

6 Conclusions

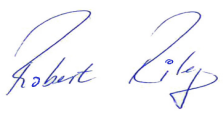
The East Texas LiDAR project was a relatively large project with standard TNRIS and USGS QL2 specifications and deliverable requirements. The primary challenge associated with project was the very narrow window within which to acquire, process, validate, and finalize the data. All deadlines were achieved and the data produced was found to be of high quality.

A sensor issue was detected by Fugro which resulted in reacquiring a single lift encompassing several flightlines across the Sulphur AOI. Five very small LiDAR shadows were detected as part of the QA/QC process. AECOM estimates that the size and location of the LiDAR shadows had no impact on the derived terrain surface. The LiDAR shadows were the result of very tall structures near the edge of LiDAR swaths. Despite the laborious flight planning steps utilizing the LiDAR manufacturer's planning software, and the numerous subsequent internal checks performed by Fugro, these anomalies sometimes present themselves. AECOM's take away from the project is to elevate the communication of this and similar issues as part of the pre-flight planning process in future projects.

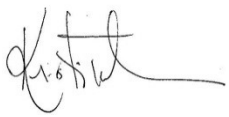
All QA/QC issues reported by AECOM were satisfactorily addressed by Fugro or deemed insignificant and acceptable by TNRIS. Fugro is responsible for preparation and final delivery of the completed, accepted datasets to TNRIS and TCEQ via mobile drive.

The final data sets reviewed by AECOM meet all contractual expectations and should be a valuable resource for all project stakeholders.

Geospatial Quality Assessment conducted by:



Robert T. Riley, PMP, ASPRS CP
AECOM Geospatial QA/QC Manager



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