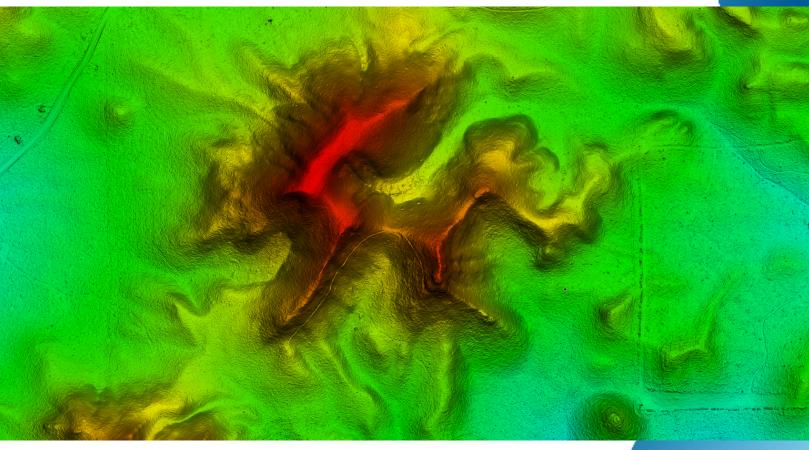
## NV5 GEOSPATIAL



WI 12County B22 Burnett LIDAR PROCESSING REPORT

> Project ID: 230110 Work Unit: 300214

Prepared for:



2023

Submitted: April 20, 2023

Prepared by:

N/V/5 GEOSPATIAL

National Map Help Desk: tnm\_help@usgs.gov



## **Contents**

1. Summary / Scope	1
1.1. Summary	1
1.2. Scope	1
1.3. Coverage	1
1.4. Duration	1
1.5. Issues	1
2. Planning / Equipment	4
2.1. Flight Planning	4
2.2. Lidar Sensor	4
2.3. Aircraft	6
2.4. Time Period	7
3. Processing Summary	8
3.1. Flight Logs	8
3.2. Lidar Processing	9
3.3. LAS Classification Scheme	10
3.4. Classified LAS Processing	11
3.5. Hydro-Flattened Breakline Processing	11
3.6. Hydro-Flattened Raster DEM Processing	12
3.7. Intensity Image Processing	12
3.8. Swath Separation Raster Processing	12
3.9. Maximum Surface Height Raster Processing	13
4. Project Coverage Verification	15
5. Geometric Accuracy	16
5.1. Horizontal Accuracy	16
5.2. Relative Vertical Accuracy	17
Project Report Appendices	xviii
Appendix A	xix
Flight Logs	xix
Appendix B	хх
Survey Report	vv



## **List of Figures**

Figure 1. Work Unit Boundary	
Figure 2. Riegl VQ-1560ii Lidar Sensor	
Figure 3. NV5 Geospatial's Aircraft	
Figure 4. Lidar Tile Layout	
Figure 5. Lidar Coverage	
List of Tables	
Table 1. Originally Planned Lidar Specifications	
Table 2. Lidar System Specifications	5
Table 3. LAS Classifications	

## **List of Appendices**

**Appendix A: Flight Logs** 



## 1. Summary / Scope

## 1.1. Summary

This report contains a summary of the Wisconsin 12 County - Burnett, Work Unit 300214 lidar acquisition task order, issued by USGS under their Contract 140G0221D0012 on 3/25/2022. The task order yielded a work unit area covering 891 square miles over Wisconsin at Quality Level 1. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

## **1.2. Scope**

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

**Table 1. Originally Planned Lidar Specifications** 

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
8 pts / m2	2083 m	58.5°	20%	≤ 10 cm

## 1.3. Coverage

The work unit boundary covers 891 square miles over Burnett County, Wisconsin. Work unit extents are shown in Figure 1.

## 1.4. Duration

Lidar data was acquired from 5/06/2022 to 5/10/2022 in 4 total lifts. See "Section: 2.4. Time Period" for more details.

## 1.5. Issues

No issues were discovered.



## Wisconsin 12 County - Burnett Work Unit 300214 Projected Coordinate System: Wisconsin Coordinate Reference System - Burnett Horizontal Datum: NAD83 (2011) Vertical Datum: NAVD88 (GEOID 18) Units: Survey Feet

Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	<ul> <li>1-foot Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format</li> <li>1-foot Intensity images in GeoTIFF format</li> <li>2-foot Maximum Surface Height Raster in GeoTIFF format</li> <li>2-foot Swath Seperation Images in GeoTIFF format</li> </ul>
Vectors	Shapefiles (*.shp)  Project Boundary  Lidar Tile Index  Geodatabase (*.gdb)  Continuous Hydro-flattened Breaklines  Flightlines Swath
Reports	Reports in PDF format  • Focus on Delivery  • Survey Report  • Processing Report
Metadata	XML Files (*.xml)  • Breaklines  • Classified Point Cloud  • DEM  • Intensity Imagery



## Wisconsin 12 County - Burnett Work Unit 300214 Boundary

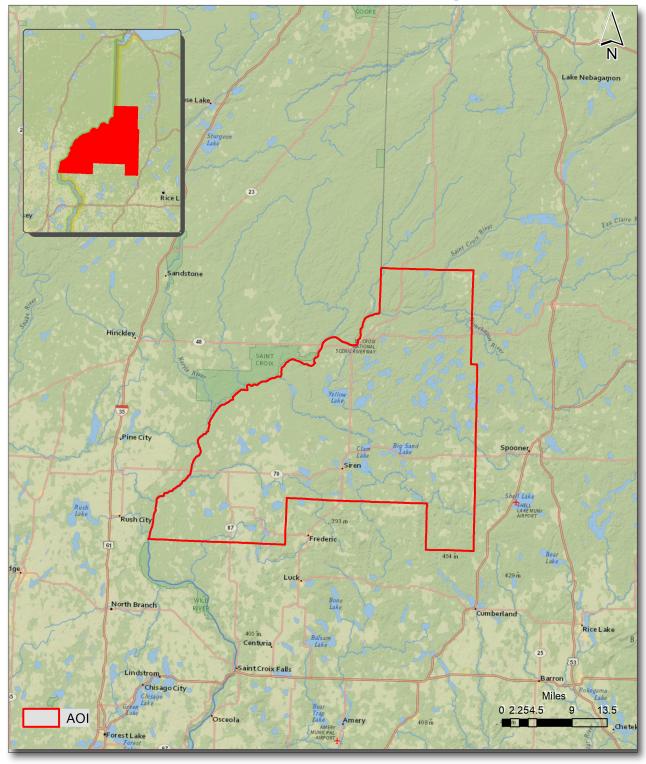


Figure 1. Work Unit Boundary



## 2. Planning / Equipment

## 2.1. Flight Planning

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

Detailed project flight planning calculations were performed for the project using RiPARAMETER planning software.

## 2.2. Lidar Sensor

NV5 Geospatial utilized Riegl VQ-1560ii lidar sensors (Figure 2), serial number(s) 3543 and 3062, for data acquisition.

The Riegl 1560ii system is a dual channel waveform processing airborne scanning system. It has a laser pulse repetition rate of up to 4 MHz resulting in up to 2.66 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA) and an integrated IMU/GNSS unit.

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

**Table 2. Lidar System Specifications** 

		Riegl VQ1560ii (SN3062)	Riegl VQ1560ii (SN3543)
Terrain and	Flying Height	1767 m	1767 m
Aircraft Scanner	Recommended Ground Speed	160 kts	160 kts
	Field of View	60°	60°
Scanner	Scan Rate Setting Used	177 Hz	191 Hz
Laser	Laser Pulse Rate Used	1100 kHz	1200 kHz
Laser	Multi Pulse in Air Mode	YES	YES
Carraga	Full Swath Width	2040 m	2040 m
Coverage	Line Spacing	1632 m	1632 m
Point Spacing	Average Point Spacing	0.35 m	0.35 m
and Density	Average Point Density	8 pts / m²	8 pts / m²

Figure 2. Riegl VQ-1560ii Lidar Sensor



## 2.3. Aircraft

All flights for the project were accomplished through the use of customized aircraft. Plane type and tail numbers are listed below.

## **Lidar Collection Planes**

- Piper PA-31, Tail Number(s): C-FFRY
- Piper PA-31, Tail Number(s): C-GAYY

These aircraft provided an ideal, stable aerial base for lidar acquisition. These aerial platforms have relatively fast cruise speeds, which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art lidar system. NV5 Geospatial's operating aircraft can be seen in Figure 3 below.

Figure 3. NV5 Geospatial's Aircraft





## 2.4. Time Period

Project specific flights were conducted between 5/06/2022 and 5/10/2022. Four aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
05062022A (SN3543, C-FFRY) 5/06/2022 UTC	5/06/2022 12:08:18 PM	5/06/2022 1:38:42 PM
05072022A (SN3543, C-FFRY) 5/07/2022 UTC	5/07/2022 4:30:32 PM	5/07/2022 4:42:04 PM
05102022A (SN3062, C-GAYY) 5/10/2022 UTC	5/10/2022 3:47:00 PM	5/10/2022 9:01:50 PM
05102022A (SN3543, C-FFRY) 5/10/2022 UTC	5/10/2022 2:47:22 PM	5/10/2022 7:30:43 PM



## 3. Processing Summary

## 3.1. Flight Logs

Flight logs were completed by Lidar sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.



## 3.2. Lidar Processing

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

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

Point clouds in flightline swath format were created using the RiPROCESS software. The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Each flightline swath point cloud was calibrated using Strip Align software that corrects systematic geometric errors and improves the relative and absolute accuracy of the flightline swath point cloud. The calibrated point cloud swaths were imported into GeoCue distributive processing software and the imported data was then tiled so further processing could take place in TerraScan software. Using TerraScan, the vertical accuracy of the surveyed ground control was tested and any vertical bias was removed from the data. TerraScan and TerraModeler software packages were then used for automated data classification and manual cleanup. The data were manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

DEMs and Intensity Images are then generated using proprietary software. In the bare earth surface model, above-ground features are excluded from the data set. Global Mapper is used as a final check of the bare earth dataset.

Finally, proprietary software is used to perform statistical analysis of the LAS files.

Software	Version
Applanix + POSPac	8.6
RiPROCESS	1.8.6
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
Microstation Connect	10.16.02.34
TerraModeler	21.008
TerraScan	21.016
StripAlign	2.21



## 3.3. LAS Classification Scheme

The classification classes are determined by Lidar Base Specifications 2021, Revision A and are an industry standard for the classification of lidar point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

**Table 3. LAS Classifications** 

	Classification Name	Description
1	Processed, but Unclassified	Laser returns that are not included in the bare earth class, or any other project classification
2	Bare earth	Laser returns that are determined to be bare earth using automated and manual cleaning algorithms
7	Low Noise	Laser returns that are often associated with scattering from reflective surfaces, or artificial points below the bare earth surface
9	Water	Laser returns that are found inside of hydro features
17	Bridge Deck	Laser returns falling on bridge decks
18	High Noise	Laser returns that are often associated with birds or artificial points above the bare earth surface
20	Ignored Ground	Bare earth points that fall within the given threshold of a collected hydro feature.
21	Snow	Bare earth points that fall on snow, where identifiable
22	Temporal Exclusion	Points that are excluded due to differences in collection dates



## 3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare-earth surface is finalized, it is then used to generate all hydro-breaklines through headsup digitization.

All ground (ASPRS Class 2) lidar data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using proprietary tools. A buffer of 1.5 feet/0.5 meter was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 20). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 2) points were reclassified to the correct classification after the automated classification was completed.

Any noise that was identified either through manual review or automated routines was classified to the appropriate class (ASPRS Class 7 and/or ASPRS Class 18) followed by flagging with the withheld bit.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. NV5 Geospatial's proprietary software was then used to create the deliverable industry-standard LAS files for all point cloud data and to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

## 3.5. Hydro-Flattened Breakline Processing

Using heads-up digitization, all Lake-Ponds, Double Line Drains, and Islands are manually collected that are within the project size specification. This includes Lake-Ponds greater than 2 acres in size, Double Line Drains with greater than a 100 foot nominal width, and Islands greater than 1 acre in size within a collected hydro feature. Lidar intensity imagery and bare-earth surface models are used to ensure appropriate and complete collection of these features.

Elevation values are assigned to all collected hydro features via NV5 Geospatial's proprietary software. This software sets Lake-Ponds to an appropriate, single elevation to allow for the generation of hydro-flattened digital elevation models (DEM). Double Line Drain elevations are assigned based on lidar elevations and surrounding terrain feature to ensure all breaklines match the lidar within acceptable tolerances. Some deviation is expected between breakline and lidar elevations due to monotonicity, connectivity, and flattening rules that are enforced on the breaklines. Once complete, horizontal placement, and vertical variances are reviewed, all breaklines are evaluated for topological consistency and data integrity using a combination of proprietary tools and manual review of hydro-flattened DEMs.

Breaklines are combined into one seamless shapefile, clipped to the project boundary, and imported into an Esri file geodatabase for delivery.



## 3.6. Hydro-Flattened Raster DEM Processing

Hydro-Flattened DEMs (topographic) represent a lidar-derived product illustrating the grounded terrain and associated breaklines (as described above) in raster form. NV5 Geospatial's proprietary software was used to take all input sources (bare earth lidar points, bridge and hydro breaklines, etc.) and create a Triangulated Irregular Network (TIN) on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper triangulation can occur. From the TIN, linear interpolation is used to calculate the cell values for the raster product. The raster product is then clipped back to the tile edge so that no overlapping cells remain across the project area. A 32-bit floating point GeoTIFF DEM was generated for each tile with a pixel size of 1-foot. NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each DEM is reviewed in Global Mapper to check for any surface anomalies and to ensure a seamless dataset. NV5 Geospatial ensures there are no void or no-data values (-999999) in each derived DEM. This is achieved by using propriety software checking all cell values that fall within the project boundary. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.

## 3.7. Intensity Image Processing

Intensity images represent reflectivity values collected by the lidar sensor during acquisition. Proprietary software generates intensity images using first returns and excluding those flagged with a withheld bit. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written during product generation.

## 3.8. Swath Separation Raster Processing

Swath Separation Images are rasters that represent the interswath alignment between flight lines and provide a qualitative evaluation of the positional quality of the point cloud. NV5 Geospatial proprietary software generated 2-foot cell size raster images in GeoTIFF format using last returns, excluding points flagged with the withheld bit, and using a point-in-cell algorithm. Images are generated with a 75% intensity opacity and (4) absolute 8-cm intervals, see below for interval coloring. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written to the file during product generation. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the images against what is required before final delivery.





## 3.9. Maximum Surface Height Raster Processing

Maximum Surface Height rasters (topographic) represent a lidar-derived product illustrating natural and built-up features. NV5 Geospatial's proprietary software was used to take all first-return classified lidar points, excluding those flagged with a withheld bit, and create a raster on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper gridding can occur. The raster product is then clipped back to the tile edge so that no overlapping cells remain across the project area. A 32-bit floating point GeoTIFF was generated for each tile with a pixel size of 2-foot cell size. NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each maximum surface height raster is reviewed in Global Mapper to check for any anomalies and to ensure a seamless dataset. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.



## Wisconsin 12 County - Burnett Work Unit 300214 Tile Layout

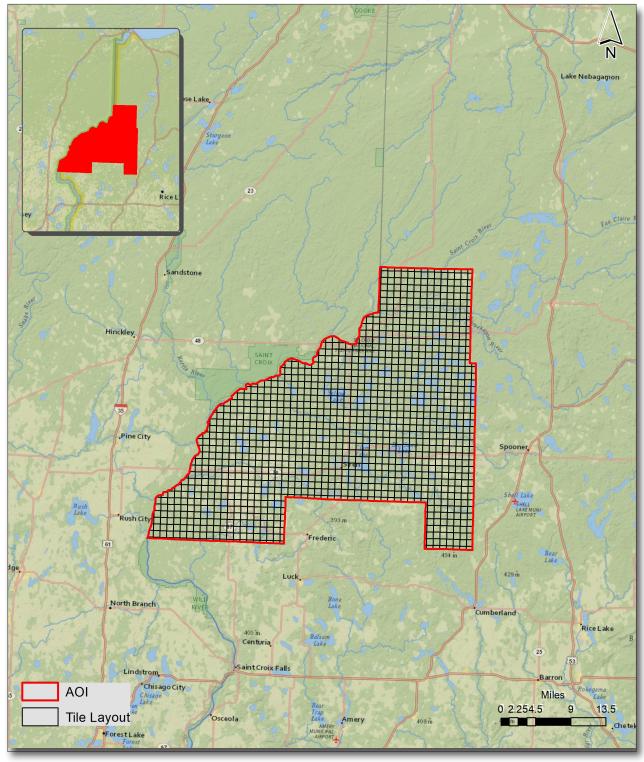


Figure 4. Lidar Tile Layout



## 4. Project Coverage Verification

A proprietary tool (FOCUS on Flight) produces grid-based polygons of each flightline, depicting exactly where lidar points exist. These swath polygons are reviewed against the project boundary to verify adequate project coverage. Please refer to Figure 5.

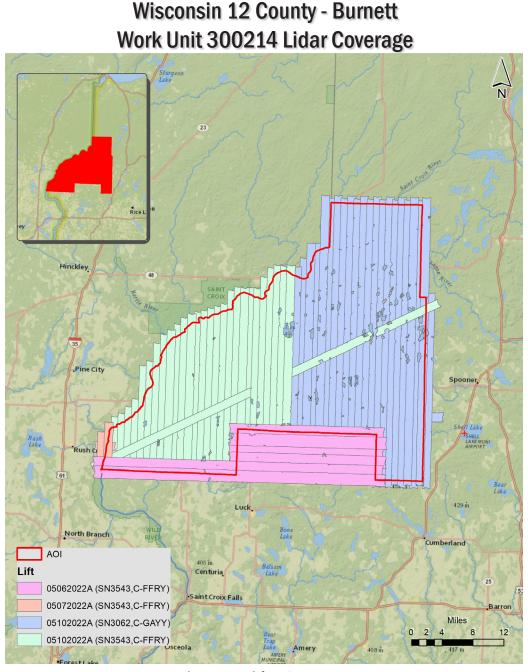


Figure 5. Lidar Coverage



## **5. Geometric Accuracy**

## 5.1. Horizontal Accuracy

Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained RMSE<sub>r</sub> value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial Data Accuracy (NSSDA) reporting standard where a theoretical point will fall within the obtained radius 95% of the time. Based on a flying altitude of 1767 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.19 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

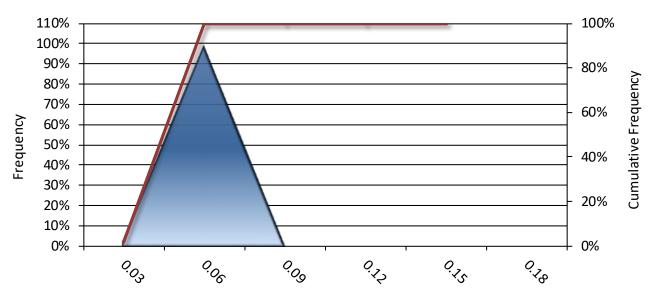
Horizonta	l Accuracy
DMCE	0.37 ft
RMSE <sub>r</sub>	0.11 m
ACC	0.63 ft
ACC <sub>r</sub>	0.19 m



## 5.2. Relative Vertical Accuracy

Relative vertical accuracy refers to the internal consistency of the data set as a whole: the ability to place an object in the same location given multiple flight lines, GPS conditions, and aircraft attitudes. When the lidar system is well calibrated, the swath-to-swath vertical divergence is low (<0.10 meters). The relative vertical accuracy was computed by comparing the ground surface model of each individual flight line with its neighbors in overlapping regions. The average (mean) line to line relative vertical accuracy for the Wisconsin 12 County - Burnett project was 0.041 feet (0.013 meters). A summary is shown below.

Relative Vertical Accuracy	
Sample	52 flight line surfaces
Average	.047 ft
Average	.014 m
Madian	.046 ft
Median	.014 m
DNACE	.046 ft
RMSE	.014 m
Standard Deviation (1g)	.007 ft
Standard Deviation ( $1\sigma$ )	.002 m
1.000	.013 ft
1.96σ	.004 m



Wisconsin 12 County - Burnett, Wisconsin Relative Vertical Accuracy (ft)
Total Compared Points (n = 9,705,001,569)



## **Project Report Appendices**

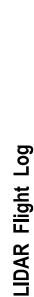
The following section contains the appendices as listed in the Wisconsin 12 County - Burnett Lidar Project Report.

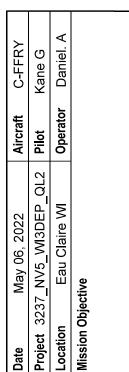


## Appendix A

**Flight Logs** 

ght A
Flight
126
Day
Julian





System	Riegl VQ-1560ii
Unit	43
NM	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	1 Drive
Scanner 2 Drive	2 Drive

System	Riegl VQ-1560ii		Ă
Unit	43		_
NMI	Applanix AP60		
GPS Rx	Trimble GNSS17		⋖
Scanner 1 Drive	1 Drive		ㅗ
Scanner 2 Drive	2 Drive		•
		•	l

ompany

Additional Notes	Si	4	AIRBORN
T-8C			A Clean Harbors Compa
H- 71%			
AMLS-278m			
Hpa-1013			
Time to next maintenance:		<b>©</b> 50 hr O 100 hr	<u>.</u>
	Static	49	GPS Time
500khz/ch	Alignment	Start	End
100hz/ch	Pre Mission	1134	1139
eo degs	Post Mission	1813	1818

<u></u> %

100 160

Laser Current **Target Speed AGL Height** 

m Pulse Rate

2300

Mission Plan

Aircraft Block Time

Takeoff 11:46 **Landing** 18:10 Total 6.4 hrs

Engine Off 18:20 Engine On 11:28

hrs

6.9

Tota

kts | Scan Rate

	Comments														
Mission ID	Time Stamp		120817	122753	123815	124859	125955	132517	132517	134214	131833	141833	143410	145054	
Line Aborted	nmi to End														
Line	Time														
Time	End	1202	1220	1234	1245	1255	1306	1322	1338	1354	1411	1430	1447	1503	
GPS T	Start	1157	1208	1227	1238	1248	1259	1309	1325	1342	1358	1418	1434	1450	
Flight	Direction														
LiDAR	File Name		432212601	432212602	432212603	432212604	432212605	432212606	432212607	432212608	432212609	432212610	432212611	432212612	
	Flight Line	F8	2032	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	

TCP Error media disconnected

152231 150838

6.3nm

1530

1519 1529

1508 1522

432212613 432212614

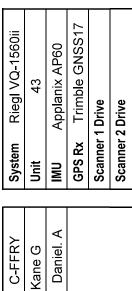
2012 2013

Flight
126
Julian Day

⋖

# LIDAR Flight Log





Kane G

Project 3237\_NV5\_WI3DEP\_QL2

Aircraft Pilot

May 06, 2022

Date

Operator

Eau Claire WI

Location

Mission Objective

Riegl VQ-1560ii	Addi
43	- -
Applanix AP60	±
Trimble GNSS17	AM
nner 1 Drive	Нра
nner 2 Drive	Tim

ditional Notes	Si		A .	AIRBORNE
8 C			A Clez	A Clean Harbors Company
. 71%				
<b>JLS-278m</b>				
oa-1013				
me to next maintenance:	aint		<b>©</b> 50 hr O 100 hr	
		Static	49 	GPS Time
0khz/ch		Alignment	Start	End
0hz/ch		Pre Mission	1134	1139
sbəp		Post Mission	1813	1818

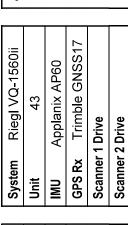
n P	S	, F	
	kt	%	
2300	160	100	
AGL Height	Target Speed	Laser Current	
1:46	8:10	hrs	
# 1	ng 1	6.4	
Takeo	Landii	Total	
11:28	18:20	hrs	
00	Off	6.9	
gine	ngine	otal	
	Engine On         11:28         Takeoff         11:46         AGL Height         2300         m         P	AGL Height Target Speed	AGL Height         2300           Target Speed         160 k           Laser Current         100 '

AGL Height         2300         m         Pulse Rate         500khz/ch         Alig           Target Speed         160         kts         Scan Rate         100hz/ch         Pre Mis           Laser Current         100         %         FOV         60         degs         Post Mis		Σ	issio	Mission Plan		<u>ಸ</u>
Rate 100hz/ch 60 degs	AGL Height	2300	Ε	Pulse Rate	500khz/ch	Align
sbap 09		160	kts		100hz/ch	Pre Miss
	Laser Current	100	%	FOV		Post Mis

	Comments		Refly 6.3nm from the W EOL												
Mission ID	Time Stamp	153328	153601	154906	160216	161520	162810	164102	170014	171209	172408	173620			
Line Aborted	nmi to End														
Line	Time														
Time	End	1533	1541	1559	1611	1624	1637	1649	1709	1721	1733	1745	1751		
GPS Time	Start	1533	1536	1549	1602	1615	1628	1641	1700	1712	1724	1736	1746		
Flight	Direction														
LiDAR	File Name		432212615	432212616	432212617	432212618	432212619	432212620	432212621	432212622	432212623	432212624			
	Flight Line	Test Strip	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	F8		

ht A

## LIDAR Flight Log



Daniel. A

Operator

Eau Claire WI

Location

Mission Objective

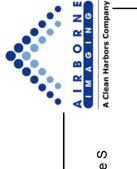
Project 3237\_NV5\_WI3DEP\_QL2

C-FFRY Kake G

Aircraft Pilot

May 07, 2022

Date



T-7 C W-34Knt gusting from the S Time to next maintenance: **Additional Notes** AMLS-278m Hpa-1015 %<del>2</del>2 -Н

	<b>⊙</b> 50 hr <b>O</b> 100 hr		GPS Time	Start End	1122   1127
aint			Static		Pre Mission
	lain	1			

1724

1719

**Post Mission** 

Aircraft Block Time	Engine On 11:16 Takeoff 11:32	Engine Off 17:28   Landing 17:16	Total 6.2 hrs Total 5.7 hrs
	Engine 0	Engine O	Total 6

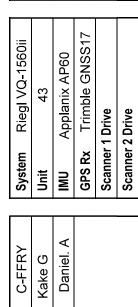
AGL Height	2300	Ε	Pulse Rate	500 khz/ch
Target Speed	160	kts	Scan Rate	100 hz/ch
Laser Current	100	%	FOV	e00 degs

	Comments															
Mission ID	Time Stamp		140436	141711	142934	144315	145635	151039	152359	153740	155043	160652		163031	163541	164111
Line Aborted	nmi to End															
Line	Time															
GPS Time	End	1359	1413	1426	1439	1443	1507	1520	1534	1547	1601	1611	1624	1632	1638	1642
GPS	Start	1345	1404	1417	1429	1443	1456	1510	1523	1537	1550	1606	1619	1630	1635	1641
Flight	Direction															
LiDAR	File Name		432212711	432212712	432212713	432212714	432212715	432212716	432212717	432212718	432212719	432212721		432212723	432212724	432212725
	Flight Line	F8	2023	2024	2025	2026	2027	2028	2029	2030	2031	Xtie	F8	3122	3123	Xtie

Flight /
127
Julian Day

<

## LIDAR Flight Log



Operator

Eau Claire WI

Location

Mission Objective

Project 3237\_NV5\_WI3DEP\_QL2

Aircraft Pilot

May 07, 2022

Date

A I R	
gusting from the S	

T- 7 C W-34Knt g H- 75% AMLS-278m Additional Notes

Hpa-1015

**⊙** 50 hr **O** 100 hr Time to next maintenance:

	ш	<u>}</u>
	ZO	l pa
	œ <sup>z</sup>	5
	0	pors
	m A	Far
	~ ≥	a a
	4	A Clean Harbors Company
Ī		

	Aircraft Block Time	
Engine On 11:16   Takeoff 11:32	Takeoff 11:32	AGL Height
Engine Off 17:28   Landing 17:16	Landing 17:16	Target Speed
Total 6.2 hrs	Total 5.7 hrs	Laser Curren

AGL Height	2300	Ε	m Pulse Rate	500 khz/ch
Target Speed	160	kts	Scan Rate	100 hz/ch
Laser Current	100	%	% FOV	s69 09

	Static	В	GPS Time
	Alignment	Start	End
	Pre Mission	1122	1127
gs	Post Mission	1719	1724

	Comments								
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
GPS Time	End	1647							
GPS	Start	1642							
Flight	Direction								
LiDAR	File Name								
	Flight Line	F8							

Page 2 of 5

Flight A
130
Julian Day



System	Riegi VQ-1560II
Unit	43
NMI	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	1 Drive
Scanner 2 Drive	2 Drive

Daniel. A

Operator

Eau Claire WI

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_V3

C-FFRY Kane G

Aircraft Pilot

May 10, 2022

Date

Time to n	2 Drive
Hpa-101	1 Drive
AMLS-2	Trimble GNSS17
H- 82%	Applanix AP60
T- 16C	43
Additiona	Riegl VQ-1560ii

A I R B O R N G I M A O I N O A Clean Harbors Company A Clean Harbors Company Control of the company A Clean Harbors Company
Lime
GPS Time
50 hr O 100 hr
A Clean Harbors Company
AIRBORNEIMAGING

,	Aircraft Block Time		Missic	Aission Plan
Engine On 13:57 Takeoff 14:12	Takeoff 14:12	AGL Height	1584 m <b>Pulse R</b>	Pulse R
<b>Engine Off</b> 20:23   <b>Landing</b> 20:11	Landing 20:11	Target Speed 160 kts Scan Ra	160 <b>kts</b>	Scan Ra
Total         6.4         hrs         Total         6.0         hrs	Total 6.0 hrs	Laser Current 100 % FOV	100 %	FOV

	Z	issio	Mission Plan		Static
AGL Height	1584	ш	Pulse Rate	1584 m <b>Pulse Rate</b> 1200 khz/ch	Alignme
Target Speed 160 kts Scan Rate 186 hz/ch	160	kts	Scan Rate	186 hz/ch	Pre Mission
Laser Current 100 % FOV	100	%	FOV	e0 degs	Post Missio

	Lidar	Fliaht	GPS Time	Time	Line	Line Aborted	Mission ID	
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp	Comments
F8			1437	1442				
3173	432213001		1447	1504			144722	
3124	432213002		1508	1510			150814	
3125	432213003		1513	1516			151349	
3126	432213004		1519	1522			151942	
3127	432213005		1526	1529			152613	
3128	432213006		1532	1537			153246	
3129	432213007		1541	1546			154101	
3130	432213008		1549	1555			154914	
3131	432213009		1558	1604			155805	
3132	432213010		1607	1614			160729	
3133	432213011		1619	1626			161958	
3134	432213012		1629	1636			162943	
3135	432213013		1644	1651			164433	
3136	432213014		1654	1701			165445	

Flight
130
Day
Julian

⋖

## LIDAR Flight Log





Operator

3238\_NV5\_WI3DEP\_V3

May 10, 2022

Date

Eau Claire WI

Location Project

Mission Objective

Aircraft Pilot Pilot

System	Riegl VQ-1560ii	⋖
Unit	43	•
IMU	Applanix AP60	
GPS Rx	Trimble GNSS17	_
Scanner 1 Drive	1 Drive	_
Scanner 2 Drive	2 Drive	

A Clean Harbors Company

e Rate 1200 khz/ch I Rate 186 hz/ch Pre Mission Poet Mission			Time to next maintenance:		<b>©</b> 50 hr O 100 hr	
Alignment Pre Mission	s	n Plan		Static	99 6P	GPS Time
Pre Mission	E	Pulse Rate	1200 khz/ch	Alignment	Start	End
SO Doct Mission	kts	Scan Rate	186 hz/ch	Pre Mission	1403	1408
liniesimi ten l	%	% FOV	e0 degs	Post Mission	1914	1919

Mission Plan

Aircraft Block Time **Takeoff** 14:12

1584

100 160

Laser Current **Target Speed AGL Height** 

> Total 6.0 hrs **Landing** 20:11

> > hrs

6.4

Total

Engine Off 20:23

Engine On 13:57

	Comments													
Mission ID	Time Stamp	170512	171530	172604	173645	174831	175942	181108	182259	183234	18157	185151	190204	191248
Line Aborted	nmi to End													
Lin	Time													
Time	End	1712	1722	1733	1744	1756	1807	1819	1829	1838	1848	1858	1909	1919
GPS	Start	1705	1715	1726	1736	1748	1759	1811	1822	1832	1841	1851	1902	1912
Fliaht	Direction													
LiDAR	File Name	432213014	432213015	432213017	432213018	432213019	432213020	432213021	432213022	432213023	432213024	432213025	432213026	432213027
	Flight Line	3137	3138	3139	3140	3141	3142	3143	3144	3145	3146	3147	3148	3149

192315

1930 1937

1923

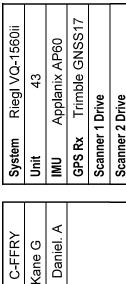
432213028

3150 8 E

1932

Flight A
134
Julian Day





Time to ne	er 2 Drive	er
Hpa-101	ler 1 Drive	er
AMLS-27	Trimble GNSS17	×
H- 71%	Applanix AP60	
T-11C 30	43	
Additional	Riegl VQ-1560ii	ш

Additional Notes T-11C 30Kt Wind/ Moderate to Severe H- 71% Turbulence AMLS-278m Hpa-1012
---

•	-	É -
	20	ם
	œ <sup>™</sup>	A Clean Harbors Company
	0	I.S
	ω o	<u>و</u>
	- ✓	표
	Z	a
	_	l e
	$\triangleleft$	<

**⊙** 50 hr **O** 100 hr next maintenance:

Date May	May 14, 2022	Aircraft	C-FFRY		System
ect 3238_NV5	Project 3238_NV5_WI3DEP_QL1	Pilot	Kane G		Unit
Location D	Duluth MI	Operator	Daniel. A		IMU
Mission Objective					GPS Rx
					Scanner 1
					Scanner 2
				- 	
1	Aircraft Block Time	ле			
Engine On 11:58	<b>Takeoff</b> 12:15			AGL	AGL Height
gine Off 17:58	Engine Off 17:58   Landing 17:47			Tarç	Target Speed
Total 6.0 hrs	Total 5.5 hrs			Lase	Laser Current

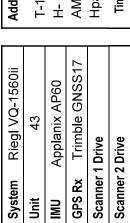
	2	issio	Mission Plan	
AGL Height	1584	Ε	m Pulse Rate	1200 khz/ch
Target Speed	160	kts	Scan Rate	188 hz/ch
Laser Current	100	%	100 % <b>FOV</b>	e0 degs

Total

	Comments															Aborted Rain 3237_NV5_QL1
Mission ID	Time Stamp		125801	131909	134041	140416	142544	144656	150759	152948	154920	161028	163007			173024
Line Aborted	nmi to End															
Line	Time															1732
Time	End	1250	1315	1337	1358	1421	1443	1504	1526	1546	1607	1626	1635	1640	1721	1732
GPS Tim	Start	1245	1258	1319	1340	1404	1425	1446	1507	1529	1549	1610	1630	1635	1716	1730
Flight	Direction															
LiDAR	File Name		432213401	432213402	432213403	432213404	432213405	432213406	432213407	432213408	432213409	432213410	432213411			
	Flight Line	F8	3007	3008	3009	3010	3011	3012	3013	3014	3019	3020	Xtie	F8	F8	1001

$\triangleleft$
Flight
134
Julian Day





Daniel. A

Operator

Duluth MI

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_QL1

C-FFRY Kane G

Aircraft Pilot

May 14, 2022

Date

Additional No	T-11C 30K	H- 71%	AMLS-278	Hpa-1012	Time to next
n Riegl VQ-1560ii	43	Applanix AP60	x Trimble GNSS17	er 1 Drive	er 2 Drive

Additional Notes	AIRBORNE
T-11C 30Kt Wind/ Moderate to Severe	A Clean Harbors Company
H- 71% Turbulence	
AMLS-278m	
Hpa-1012	
Time to next maintenance: © 50 hr O 100 hr	) 100 hr

Static	49 CF	GPS Time
Alignment	Start	End
Pre Mission	1203	1208
Post Mission	6441	1757

m Pulse Rate 1200 khz/ch kts | Scan Rate 188 hz/ch

1584 160

**AGL Height** 

**Target Speed** 

Landing 17:47

**Engine On 11:58** Engine Off 17:58

Mission Plan

Aircraft Block Time **Takeoff** 12:15

	1 11	-		i						
•										
sbep (	<b>FOV</b> 60	%	100	Laser Current	hrs	5.5	Total	hrs	<b>Total</b> 6.0 h	<b>Total</b> 6.0 h

	Comments								
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
Time	End								
GPS Time	Start								
Fliaht	Direction								
LiDAR	File Name								
	Flight Line								

$\triangleleft$
Flight
134
Julian Day

Scanner 2 Drive Scanner ' **GPS Rx** System ₽ Unit Daniel. A C-FFRY Kane G Operator Aircraft Pilot Project 3238\_NV5\_WI3DEP\_QL1 May 14, 2022 Duluth MI Mission Objective

Location

Date

	43 Annlanix AP60	T-11C
--	---------------------	-------

Notes	
Additiona	

C 30Kt 1% S-278m 1012

Time to next

ıal Notes	S		AIRBORNE IMAGING
30Kt V	30Kt Wind/ Moderate to Severe		A Clean Harbors Company
г %	Turbulence		
.278m			
112			
next ma	next maintenance:	<b>©</b> 50 hr <b>O</b> 100 hr	
	Static	ъ	GPS Time
z/ch	Alignment	Start	End
ch	Pre Mission	1203	1208
degs	Post Mission	1752	1221

m Pulse Rate 1200 khz/ch kts | Scan Rate 188 hz/ch

1584 160

**AGL Height** 

Target Speed

Mission Plan

Aircraft Block Time

**Takeoff** 12:15

Engine On 11:58

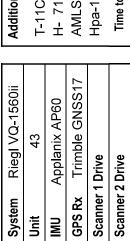
Engine Off 17:58 | Landing 17:47

Mission ID	Mis	F	Line Aborted	Line		GPS Time	d9	Fliaht	LiDAR			
							-					
gs Post N	degs	90	, FOV	%	100	Laser Current		hrs	<b>Total</b> 5.5	hrs	0.9	Total

	Comments								
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
GPS Time	End								
	Start								
Flight	Direction								
LiDAR	File Name								
	Flight Line								

$\triangleleft$
Flight
134
Julian Day





Daniel. A

Operator

Duluth MI

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_QL1

C-FFRY Kane G

Aircraft Pilot

May 14, 2022

Date

iegl VQ-1560ii 43 planix AP60	Additional Notes T-11C 30Kt Wind/ I H- 71% Turbul
rimble GNSS17	AMLS-278m
ive	Hpa-1012
ive	Time to next maintenar

BORNE	A Clean Harbors Company		
A P	A Clean		
	erate to Severe		

Modera

**⊙** 50 hr **O** 100 hr ince:

		Scanner 2 Dr	٥
Ai	Aircraft Block Time		
Engine On 11:58 Takeoff 12:15	Takeoff 12:15	AGL Height	15
Engine Off 17:58   Landing 17:47	Landing 17:47	Target Speed 16	16
Total 6.0 hrs Total 5.5 hrs	Total 5.5 hrs	Laser Current	1

	2	issio	Mission Plan	
AGL Height	1584	Ε	Pulse Rate	m Pulse Rate 1200 khz/ch
Target Speed	160	kts	kts   Scan Rate	188 hz/ch
Laser Current	100	%	FOV	60 degs

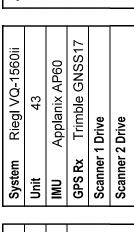
	Static	19	GPS Time
200 khz/ch	Alignment	Start	End
188 hz/ch	Pre Mission	1203	1208
so degs	Post Mission	1752	1757

	Comments								
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
Time	End								
GPS Time	Start								
Fliaht	Direction								
LiDAR	File Name								
	Flight Line								

Page 4 of 5

Flight /
134
Julian Day





Daniel. A

Operator

Duluth MI

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_QL1

C-FFRY Kane G

Aircraft Pilot

May 14, 2022

Date

stem	Riegl VQ-1560ii	Additio
<u>#</u>	43	T-11C
n	Applanix AP60	H- 71
S Rx	Trimble GNSS17	AMLS
anner	anner 1 Drive	Hpa-1
anner	anner 2 Drive	Time to
I		

Additional Notes	AIRBORNE
T-11C 30Kt Wind/ Moderate to Severe	A Clean Harbors Company
H- 71% Turbulence	
AMLS-278m	
Hpa-1012	
Time to next maintenance: © 50 hr O 100 hr	) 100 hr

GPS Time	End	1208	1757
99	Start	1203	1752
Static	Alignment	Pre Mission	Post Mission
	z/ch	,ch	degs

m Pulse Rate 1200 khz/ch kts | Scan Rate 188 hz/ch

1584

Mission Plan

Aircraft Block Time **Takeoff** 12:15 Landing 17:47 Total 5.5 hrs

> **Engine On 11:58** Engine Off 17:58

hrs

0.9

Total

9

₽ 2

%

100 160

Laser Current **Target Speed AGL Height** 

	Comments								
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
GPS Time	End								
GPS	Start								
Flight	Direction								
LiDAR	File Name								
	Flight Line								

Flight
135
Day
Julian

<

## LIDAR Flight Log



System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	1 Drive
Scanner 2 Drive	2 Drive

Daniel. A

Operator

Duluth MI

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_2022

C-FFRY Kane G

Aircraft Pilot

May 15, 2022

Date

אופטן אייט אייט אייט אייט אייט אייט אייט אי	43   T- 8C I		Trimble GNSS17   AMLS-	Hpa-10	Time to	
יובאו אים	43	Applanix AP60	Trimble GN	er 1 Drive	er 2 Drive	
=			×	er	er.	

Additional Notes  T- 8C Moderate to Severe Turbulence H- 76% AMLS-435m Hpa-1012 Time to next maintenance:	AP60 GNSS17
Tpa=1012	
Hpp 1012	
AMI S-435m	CNSS17
	))
78%	APGO
וויסמקומום וס ספעקום וחוממוקווסם	
T= 8C. Moderate to Severe Turbulence	
Additional Notes	4-1000II
Additional Notes	1560;;

AIRBORNEIMAGING A Clean Harbors Company

GPS Time	End	1205	1752
9	Start	1200	1747
Static	Alignment	Pre Mission	Post Mission
	z/ch	ch	sbep

m Pulse Rate 1200 khz/ch kts | Scan Rate 186hz/ch

1584

Mission Plan

Aircraft Block Time

**Takeoff** 12:12

Landing 17:44 Total 5.5 hrs

Engine Off 17:56 Engine On 11:55

hrs

0.9

Total

9

₽ 2 %

100 160

Laser Current **Target Speed AGL Height** 

O 50 hr **O** 100 hr

LiDAR	Flight	GPS	GPS Time	Line	Line Aborted	Mission ID	
	Direction	Start	End	Time	nmi to End	Time Stamp	Comments
		1245	1250				
		1255	1311			125511	
		1314	1332			131459	
		1335	1351			135443	
432213504		1355	1412			135541	
432213505		1416	1432			141621	Laser did not stop after fiish the line
432213506		1439	1456			143958	
432213507		1503	1519			150329	
432213508		1523	1539			152311	
432213509		1542	1545			154212	
		1550	1555				
		1630	1631				
432213510		1644	1656			164415	3237_NV5_QL1_2022
432213511		1659	1611			165916	
432213512		1714	1726			171414	

Flight A
135
Julian Day

C-FFRY Kane G

Aircraft Pilot

May 15, 2022

Date

LIDAR Flight Log

Scanner **GPS Rx** Scanner System <u>N</u> Unit Daniel. A

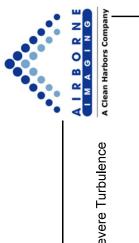
Operator

**Duluth MI** 

Location

Mission Objective

Project 3238\_NV5\_WI3DEP\_2022



Additional	T- 8C Mo	%9/ -H	AMLS-43	Hpa-1012	Time to ney
Riegl VQ-1560ii	43	Applanix AP60	Trimble GNSS17	r 1 Drive	r 2 Drive

GPS Time	End	1205	1752
9	Start	1200	1747
Static	Alignment	Pre Mission	Post Mission
	z/ch	ch	sbap

m Pulse Rate 1200 khz/ch kts | Scan Rate 186hz/ch

1584

**AGL Height** 

Mission Plan

Aircraft Block Time

**Takeoff** 12:12

Engine On 11:55 Engine Off 17:56

Landing 17:44 Total 5.5 hrs

hrs

0.9

Total

9

₽ 2

%

100 160

Laser Current

**Target Speed** 

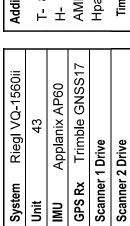
**⊙** 50 hr **O** 100 hr

	Comments		do not process							
Mission ID	Time Stamp	172855	173039							
Line Aborted	nmi to End									
Line	Time									
<b>Time</b>	End	1730	1731	1736						
GPS Time	Start	1728	1730	1731						
Flight	Direction									
LiDAR	File Name	432213513								
	Flight Line	Xtie	Test Strip	F8						

Page 2 of 5

Flight /
136
Julian Day

Log	
Flight	
DAR	
_	



Daniel. A

Operator

3237\_NV5\_QL1\_2022 May 16, 2022

Date

**Duluth MN** 

Location Project

Mission Objective

C-FFRY Kane G

Aircraft Pilot

Additional No	T- 8C	H- 71%	AMLS-435	Hpa-1010	Time to next
iegl VQ-1560ii	43	planix AP60	rimble GNSS17	ive	ive

Notes	A I R B O R N E I M A G I N G A Clean Harbors Company
35m 10	
ext maintenance:	● 50 hr O 100 hr

4	Aircraft Block Time		
Engine On 11:35   Takeoff 11:54	Takeoff 11:54	AGL Height	16(
<b>Engine Off</b> 14:15   <b>Landing</b> 14:06	Landing 14:06	Target Speed	16
Total         2.7         hrs         Total         2.2         hrs	Total 2.2 hrs	Laser Current	1(

			5	
AGL Height	1600	ш	m Pulse Rate	1000 khz/ch
Target Speed	160	kts	kts Scan Rate	295 hz/ch
Laser Current	100	%	% FOV	sbap 09

Static	GP	GPS Time
Alignment	Start	End
Pre Mission	1141	1146
Post Mission	1408	1413

Comments						Possible cloud						
Mission ID	Time Stamp		121332	122902	124822	130505	133216					
Line Aborted	nmi to End											
Line	Time											
GPS Time	End	1210	1225	1243	1301	1320	1333					
GPS	Start	1205	1213	1229	1248	1305	1332					
Flight	Direction											
LiDAR	File Name		432213601	432213602	432213603	432213604	432213605					
	Flight Line	F8	1004	1005	1006	1007	Xtie					

Flight
137
Day
Julian

⋖



GPS Scan Scan Syste

Daniel. A

Operator

3237\_NV5\_QL1\_2022 May 17, 2022

**Duluth MN** 

Location Project Date

Mission Objective

C-FFRY Kane G

Aircraft Pilot

tem	Riegl VQ-1560ii		Addit
ب ا	43		T- 5
	Applanix AP60		H- 7
s Rx	Trimble GNSS17		AML
nner	nner 1 Drive		Нра
nner ;	nner 2 Drive		ij
		_	

nal Notes	
Addition	

A Clean Harbors Company AIRBORN IMAGING

5C 75% ILS-435m a-1017

**⊙** 50 hr **O** 100 hr ne to next maintenance:

			Aircraft Block Time	Bloc	sk Time	
<b>Engine On</b> 10:46	o	10:46	<b>Takeoff</b> 11:07	<b>f</b> 1.	1:07	
Engine	Off	Engine Off 16:28	Landing 16:16	16 16	3:16	
Total 5.7 hrs	5.7	hrs	<b>Total</b> 5.2 hrs	5.2	hrs	

	N	ISSIO	Mission Plan	
AGL Height	1600	ш	Pulse Rate	1100 khz/ch
Target Speed	160	kts	Scan Rate	177hz/ch
Laser Current	100	%	% FOV	ego degs

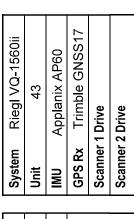
Static	_	GPS Time
,	Start	End
Pre Mission	1052	1057
Post Mission	1622	1627

e         Direction         Start         End         Time Start         Inmit o End         Time Start           01         1110         1115         1116         Image         Image		LiDAR	Flight	GPS Tim	Time	Line	Line Aborted	Mission ID	
432213701       1110       1115       6         432213702       1134       1148       6         432213703       1151       1205       6         432213704       1209       1223       6         432213705       1226       1241       6         432213706       1244       1259       6         432213707       1302       1334       6         432213709       1320       1334       6         432213711       1412       1426       6         432213712       1426       1443       6         432213713       1446       1459       6         432213714       1502       1516       6	ght Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp	Comments
432213701       1117       1131       6         432213702       1134       1148       6         432213703       1151       1205       6         432213704       1226       1223       6         432213705       1226       1241       6         432213707       1302       1316       6         432213709       1338       1351       6         432213710       1355       1409       6         432213712       1446       1459       6         432213713       1446       1459       6         432213714       1502       1516       6	F8			1110	1115				
432213702       1134       1148       6         432213703       1151       1205       6         432213704       1226       1241       6         432213705       1226       1241       6         432213707       1302       1316       6         432213708       1320       1334       6         432213710       1355       1409       6         432213712       1426       7443       6         432213713       1446       1459       6         432213714       1502       1516       6	1008	432213701		1117	1131			111745	
432213703       1151       1205       1223         432213704       1209       1223       6         432213705       1244       1269       6         432213707       1302       1316       6         432213708       1320       1334       6         432213710       1355       1409       6         432213712       1412       1426       6         432213713       1446       1459       6         432213714       1466       1459       6         432213714       1502       1516       6	1009	432213702		1134	1148			113424	
432213704       1209       1223       8         432213705       1226       1241       8         432213707       1302       1316       8         432213708       1320       1334       8         432213709       1355       1409       8         432213710       1355       1409       8         432213712       1446       1459       8         432213713       1446       1459       8         432213714       1502       1516       8	1010	432213703		1151	1205			115155	
432213705       1226       1241       6         432213706       1244       1259       6         432213707       1302       1316       6         432213708       1320       1334       6         432213710       1355       1409       6         432213711       1412       1426       6         432213713       1446       1459       6         432213714       1502       1516       6	1011	432213704		1209	1223			120903	
432213706       1244       1259       8         432213708       1320       1334       8         432213709       1338       1351       8         432213710       1355       1409       8         432213711       1412       1426       8         432213712       1429       1443       8         432213713       1446       1459       8         432213714       1502       1516       8	1012	432213705		1226	1241			122658	
432213707       1302       1316       6         432213708       1320       1334       6         432213710       1355       1409       6         432213711       1412       1426       6         432213712       1446       1459       6         432213713       1446       1459       6         432213714       1502       1516       6	1013	432213706		1244	1259			124424	
432213708       1320       1334       6         432213710       1355       1409       6         432213711       1412       1426       6         432213712       1429       1443       6         432213713       1446       1459       6         432213714       1502       1516       6	1014	432213707		1302	1316			130223	
432213709       1338       1351       8         432213710       1412       1426       8         432213712       1429       1443       8         432213713       1446       1459       8         432213714       1502       1516       8	1015	432213708		1320	1334			132006	
432213710       1355       1409       6         432213712       1429       1443       6         432213713       1446       1459       6         432213714       1502       1516       6	016	432213709		1338	1351			133804	
432213711       1412       1426         432213712       1429       1443         432213713       1446       1459         432213714       1502       1516	017	432213710		1355	1409			135512	
432213712     1429     1443       432213713     1446     1459       432213714     1502     1516	1018	432213711		1412	1426			141251	
432213713     1446     1459       432213714     1502     1516	1019	432213712		1429	1443			142934	
432213714 1502 1516	020	432213713		1446	1459			144626	
	1021	432213714		1502	1516			150247	

Flight /
137
ılian Day
Jul

4





Daniel. A

Operator

3237\_NV5\_QL1\_2022 May 17, 2022

**Duluth MN** 

Location Project Date

Mission Objective

C-FFRY Kane G

Aircraft Pilot

ystem	Riegl VQ-1560ii		Ad
Init	43		Ļ
ΩM	Applanix AP60		İ
PS Rx	Trimble GNSS17		₹
canner 1 Drive	1 Drive		芏
canner 2 Drive	2 Drive		F
		_	I

Additional Notes	AIRBORNE
T- 5C	A Clean Harbors Company
H- 75%	
AMLS-435m	
Hpa-1017	
Time to next maintenance:	O 50 hr <b>O</b> 100 hr

O 50 hr <b>©</b>
ext maintenance:
ime to next

	AGL Height	Target Spee	Laser Curre
Aircraft Block Time	11:07	16:16	2 hrs
Aircraft Bl	Engine On 10:46   Takeoff 11:07	Engine Off 16:28   Landing 16:16	Total 5.2 hrs
	10:46	16:28	
	o o	) Off	5.7
	Engine	Engine	Total 5.7 hrs

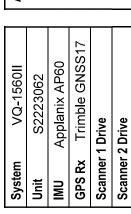
	<b>A</b>	INISSIM	וו בו	
AGL Height	1600	ш	Pulse Rate	1100 khz/ch
Target Speed	160	kts	Scan Rate	177hz/ch
Laser Current	100	%	FOV	e0 degs

	Static	45 15	GPS Time
hz/ch	Alignment	Start	pu∃
z/ch	Pre Mission	1052	1057
sbep	Post Mission	1622	1627

	Comments										
Mission ID	Time Stamp	151934	153555	155317							
Line Aborted	nmi to End										
Line	Time										
Time	End	1532	1548	1557	1605						
GPS Time	Start	1519	1535	1553	1600						
Fliaht	Direction										
LiDAR	File Name	432213715	432213716	432213717							
	Flight Line	1022	1023	Xtie	F8						

⋖
Flight
130
lian Day
3





B.Eisenbart

Operator

Eau Claire, Wisconsin 3238\_NV5\_QL1 April 10, 2022

Location **Project** Date

Mission Objective

C-GAYY A. Hering

Aircraft Pilot

 Additional Notes

**⊙** 50 hr **O** 100 hr Time to next maintenance:

Ð			
ock Tim	15:18	21:29	2 hrs
Aircraft Block Time	Takeoff	Landing 21:29	Total 6.2 hrs
	Engine On 15:05	Engine Off 21:38	Total 6.6 hrs
	e On	e Off	6.6
	Engin	Engin	Total

	2	MISSION	n Plan	
AGL Height	1584	ш	Pulse Rate	1200 khz/ch
Target Speed	160	kts	Scan Rate	191 lps/ch
Laser Current	100	- %	FOV	s6ep 09

Static	5	GPS Time
Alignment	Start	Pug
Pre Mission	15:08	15:13
Post Mission	21:31	21:36

	-																I
	Comments																
Mission ID	Time Stamp 220510	-	154659	155811	160913	161959	163152	164309	165707	171031	172354	173704	175037	180353	181659	183217	
Line Aborted	nmi to End																
Lin	Time																
lime .	End	15:42	15:53	16:05	16:17	16:28	16:40	16:54	17:07	17:21	17:34	17:47	18:01	18:14	18:27	18:44	
GPS Tim	Start	15:38	15:46	15:58	16:09	16:19	16:31	16:43	16:57	17:10	17:23	17:37	17:50	18:03	18:16	18:32	
Flight	Direction	-	273°	001°	181°	001°	181°	001°	181°	001°	181°	001°	181°	001°	181°	001°	
LiDAR	File Name		622213030	622213031	622213032	622213033	622213034	622213035	622213036	622213037	622213038	622213039	622213040	622213041	622213042	622213043	
	Flight Line	figure 8	X-TIE	3151	3152	3153	3154	3155	3156	3157	3158	3159	3160	3161	3162	3163	

Flight ,	
130	
Julian Day	

<

## LIDAR Flight Log

VQ-1560II Applanix AP6 Trimble GN S2223062 Scanner 1 Drive **Scanner 2 Drive GPS Rx** System Unit  $\frac{1}{8}$ 

B Eisenbart

Operator

Eau Claire, Wisconsin 3238\_NV5\_QL1 April 10, 2022

Location **Project** Date

Mission Objective

C-GAYY A. Hering

Aircraft Pilot

AIR	A Clean			<b>●</b> 50 hr <b>O</b> 100 hr
Additional Notes				Time to next maintenance:
OII	2	.60	<b>18817</b>	

A Clean Harbors Company AIRBORN IMAGING

			Aircra	ft Bi	lock	Aircraft Block Time	
Engine	On	Engine On 15:05	<b>Takeoff</b> 15:18	off	15	18	
Engine	Off	Engine Off 21:38	<b>Landing</b> 21:29	ing	21	.29	
Total 6.6 hrs	9.9	hrs	<b>Total</b> 6.2 hrs	9	2	hrs	

	2	MISSION	ושוו	
AGL Height	1584	Ε	m Pulse Rate	1200 khz/ch
Target Speed	160	kts	Scan Rate	kts Scan Rate 191 lps/ch
Laser Current	100	%	% FOV	sbap 09

Static	₽Đ	GPS Time
Alignment	Start	End
Pre Mission	15:08	15:13
Post Mission	21:31	21:36

	Linar	Flight	GPS	GPS Time	Line	Line Aborted	Mission ID	
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp 220510	Comments
3164	622213044	181°	18:47	18:59			184733	
3165	622213045	001°	19:03	19:15			190306	
3166	622213046	181°	19:18	19:30			191816	
3167	622213047	001°	19:33	19:45			193332	
3168	622213048	181°	19:48	20:01			194852	
3169	622213049	001°	20:04	20:16			200409	
3170	622213050	181°	20:19	20:31			201930	
3171	622213051	001°	20:34	20:47			203456	
3172	622213052	181°	20:53	21:01			205306	
figure 8		-	21:02	21:06			-	