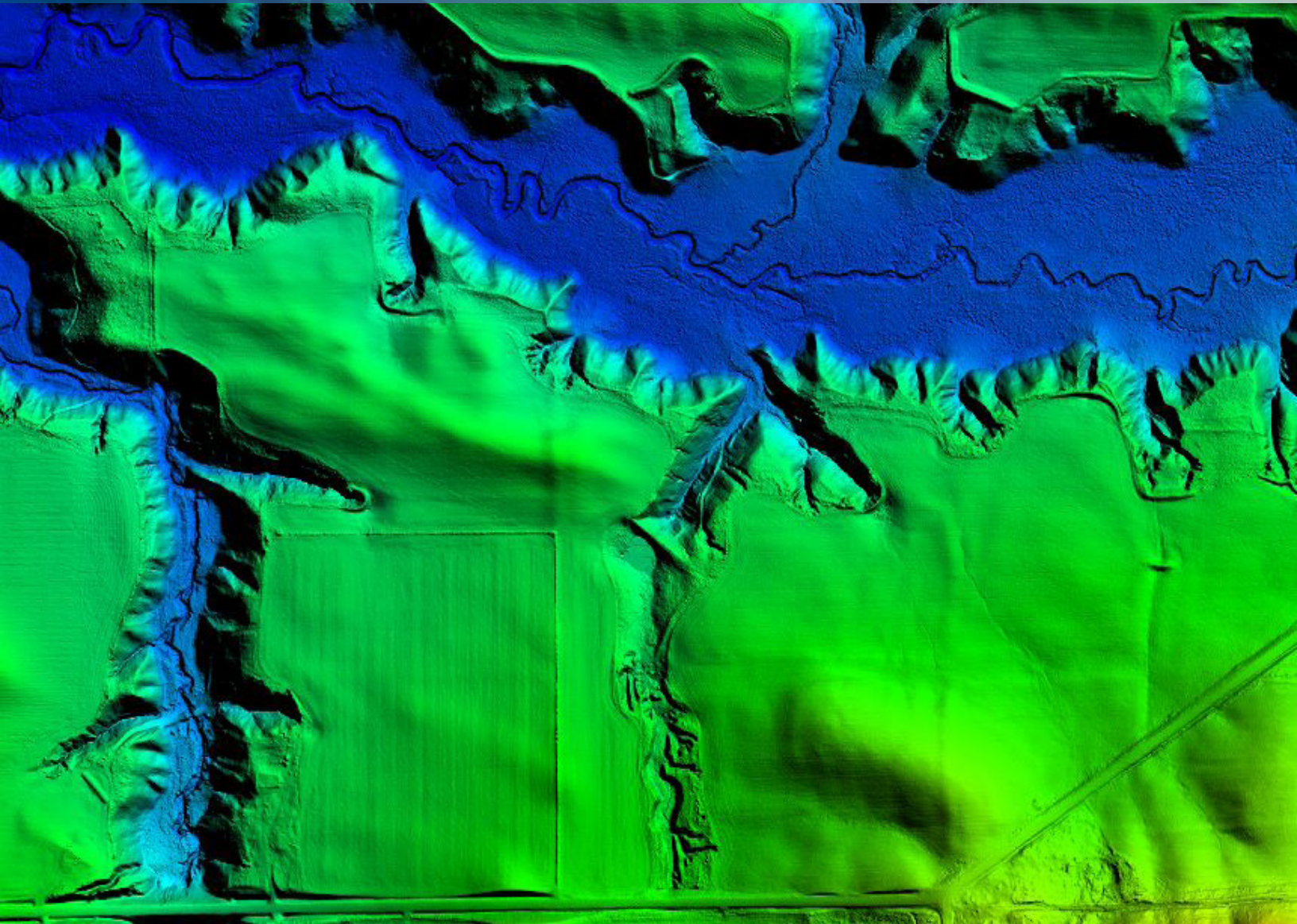


# Calumet County

Wisconsin WROC – 3DEP 2018

Calumet County Lidar

## VERTICAL ACCURACY REPORT



May 2019

## PROJECT INFORMATION

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**Prepared By:** Ayres Associates  
**Project Name:** Wisconsin WROC – 3DEP Calumet County Lidar 2018  
**Sensor Info:** ALS80 SN 8227  
**USGS Quality Level:** 2  
**Required Nominal Pulse Spacing:** 0.7  
**Contractor Name:** Ayres Associates  
**Units:** US Survey Feet  
**Date of Acquisition:** Start: 5/13/2018 Finish: 5/16/2018

## REPORT INFORMATION

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This report documents the absolute vertical accuracy of the lidar data collected for the Calumet County, WI, QL2 lidar project. Independent ground control checkpoints were collected by land surveyors using Trimble GNSS equipment connected to WISCORS base stations. The checkpoints were collected from May 31, 2018, to October 29, 2018.

The checkpoints were collected under various land cover types that are predominant in the County. Each land cover type falls into either the Non-vegetated Vertical Accuracy (NVA) or the Vegetated Vertical Accuracy (VVA) group. For this project, 29 NVA points and 19 VVA points were collected throughout the County.

The following report shows the final statistics for the NVA checkpoints compared against the raw swath point cloud and the bare earth DEM, and the VVA statistics compared against the DEM. Statistics are reported for LAS and DEM by NVA and VVA categories and by land cover type.

Vertical Accuracy Specifications per USGS QL2 level:

**LAS:**

NVA equates to 10 cm RMSEz, or 19.6 cm (0.64 ft) at the 95% confidence level.

**DEM:**

NVA equates to 10 cm RMSEz, or 19.6 cm (0.64 ft) at the 95% confidence level.

VVA equates to 29.4 cm (0.96 ft) at the 95th percentile.

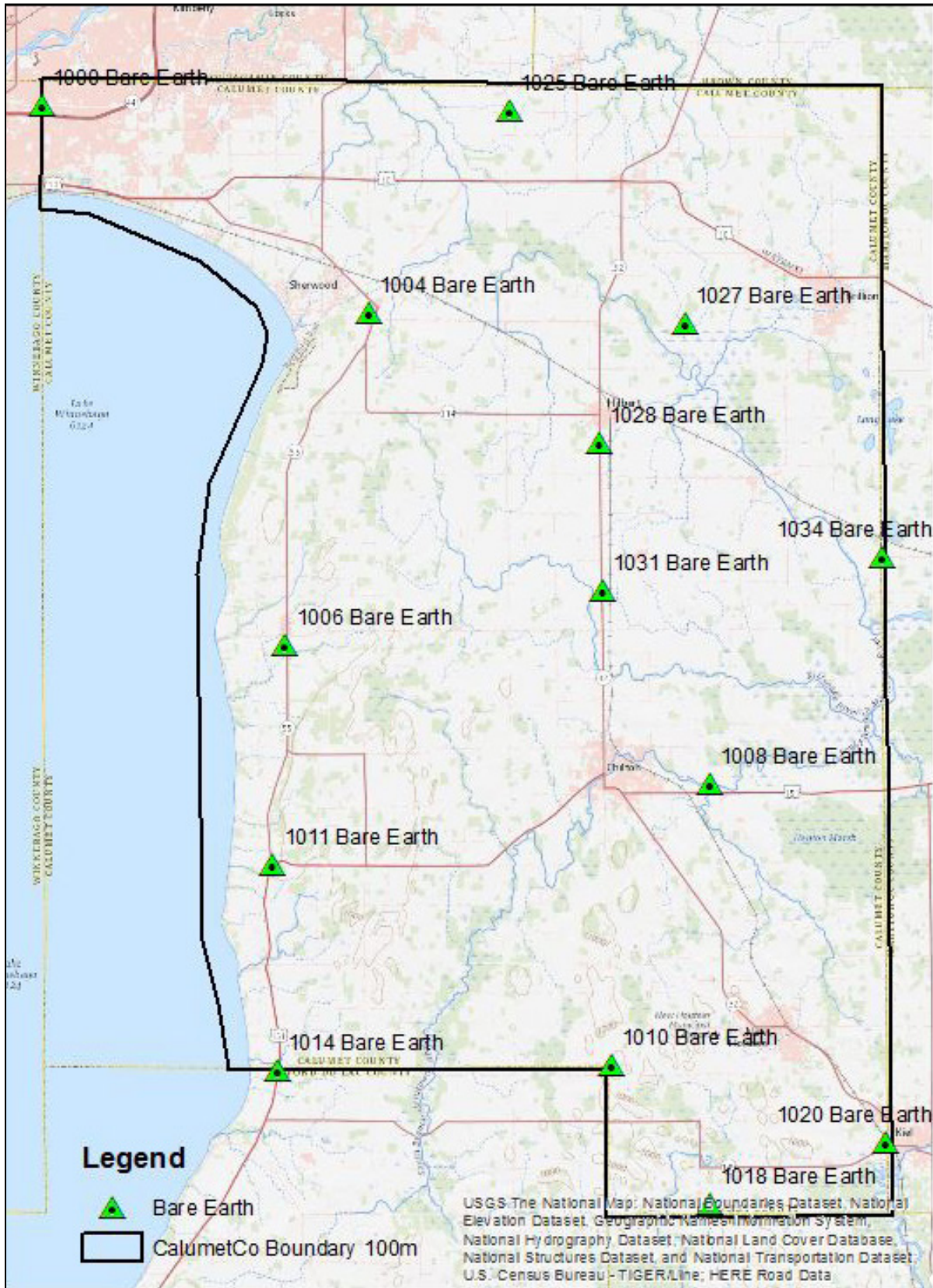
The NVA and VVA statistics for this project are within the above stated specifications.

## LIDAR ACCURACY ASSESSMENT SUMMARY

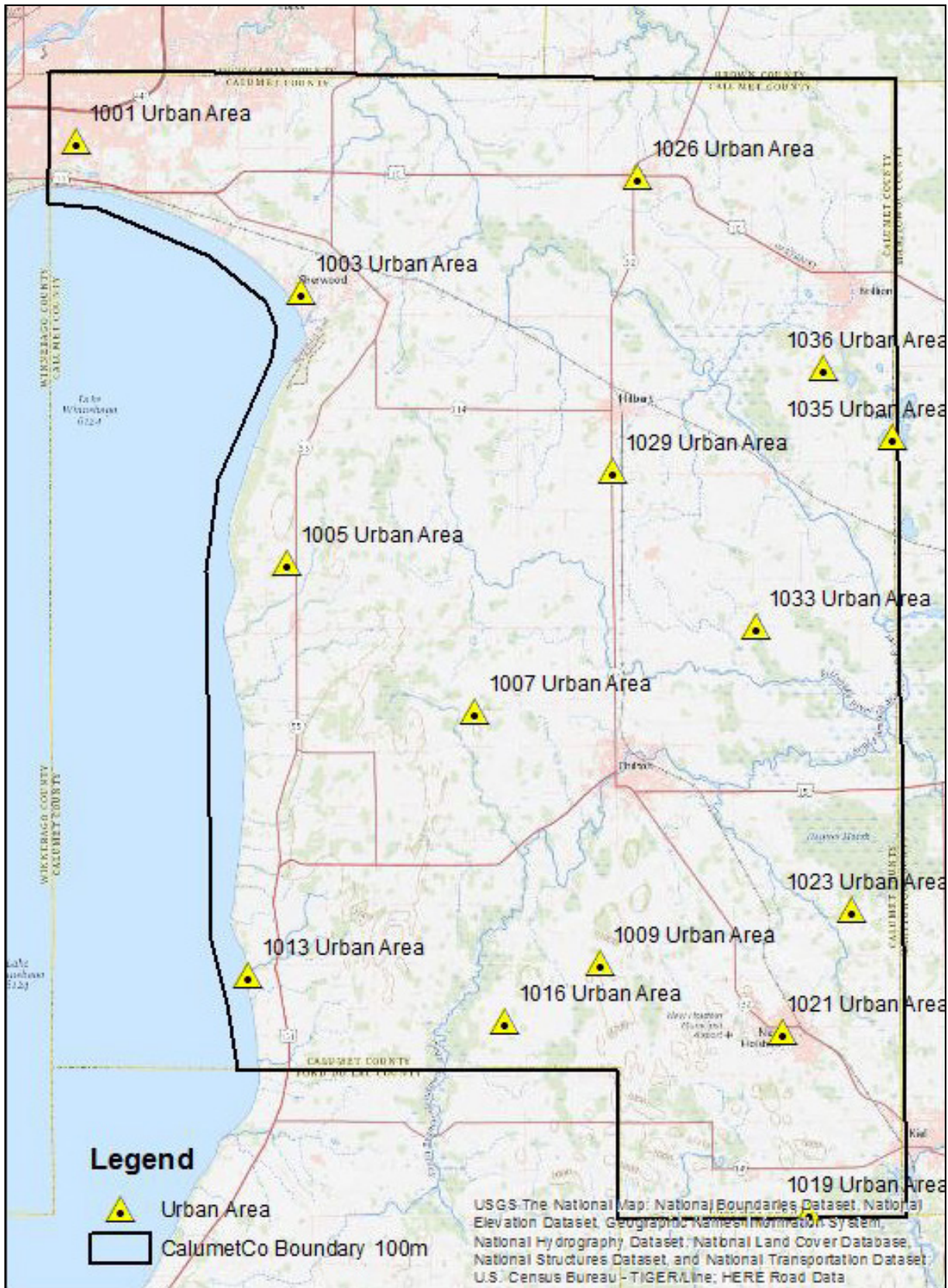
| LAND COVER TYPE | # OF POINTS | NVA                  | VVA             |
|-----------------|-------------|----------------------|-----------------|
| <b>LAS</b>      |             | 95% confidence level | N/A             |
| 1. Bare Earth   | 14          | 0.192                | N/A             |
| 2. Urban Areas  | 15          | 0.193                | N/A             |
| 3. Tall Weeds   | 9           | N/A                  | N/A             |
| 5. Forest       | 10          | N/A                  | N/A             |
| <b>TOTAL</b>    | <b>29</b>   | <b>0.193</b>         | N/A             |
| <b>DEM</b>      |             |                      |                 |
|                 |             | 95% confidence level | 95th percentile |
| 1. Bare Earth   | 14          | 0.217                | N/A             |
| 2. Urban Areas  | 15          | 0.184                | N/A             |
| 3. Tall Weeds   | 9           | N/A                  | 0.554           |
| 5. Forest       | 10          | N/A                  | 0.501           |
| <b>TOTAL</b>    | <b>19</b>   | <b>0.201</b>         | <b>0.501</b>    |

Units: US Survey Feet

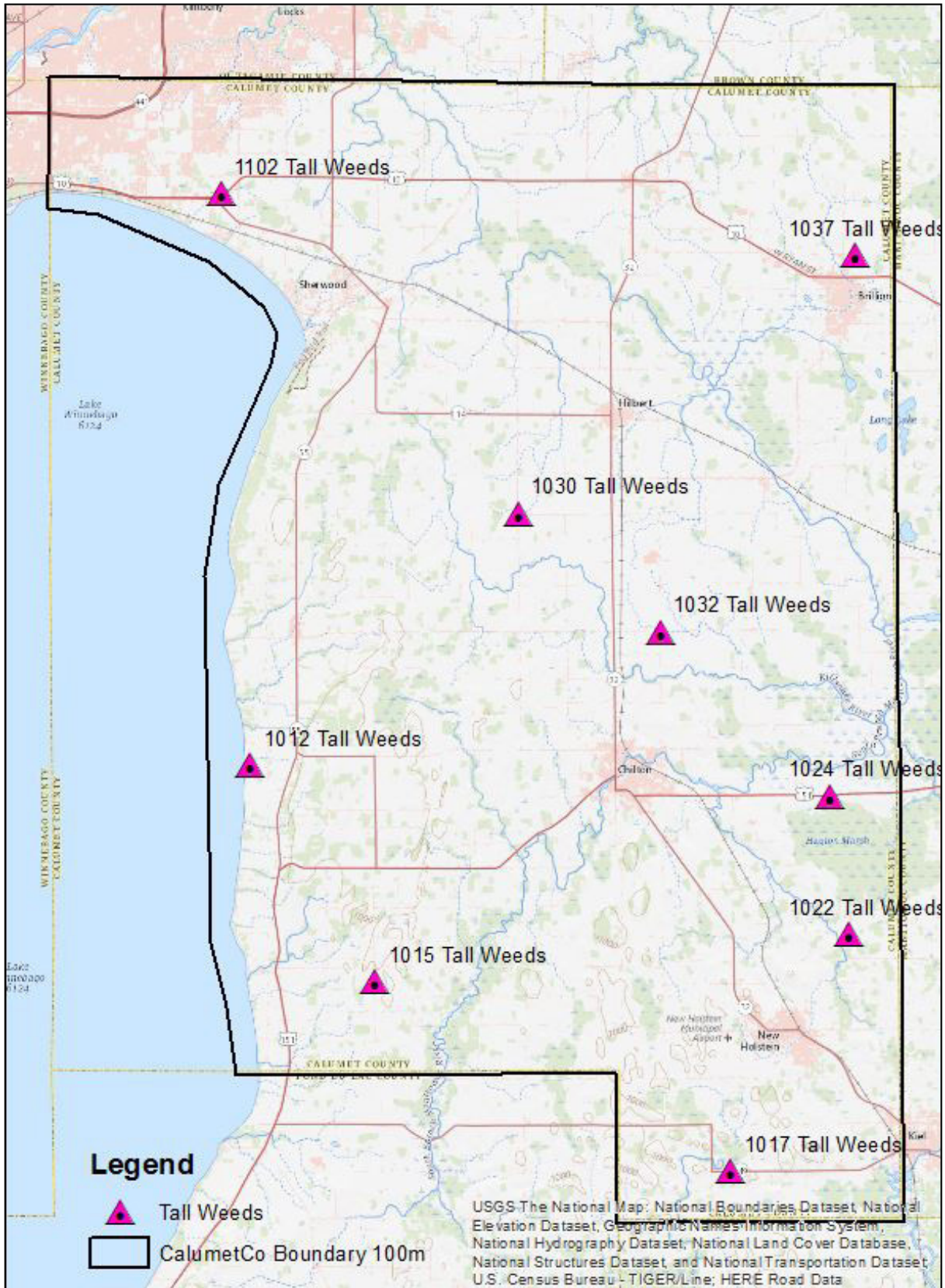
**MAP OF NVA CHECKPOINT LOCATIONS - 1. BARE EARTH**



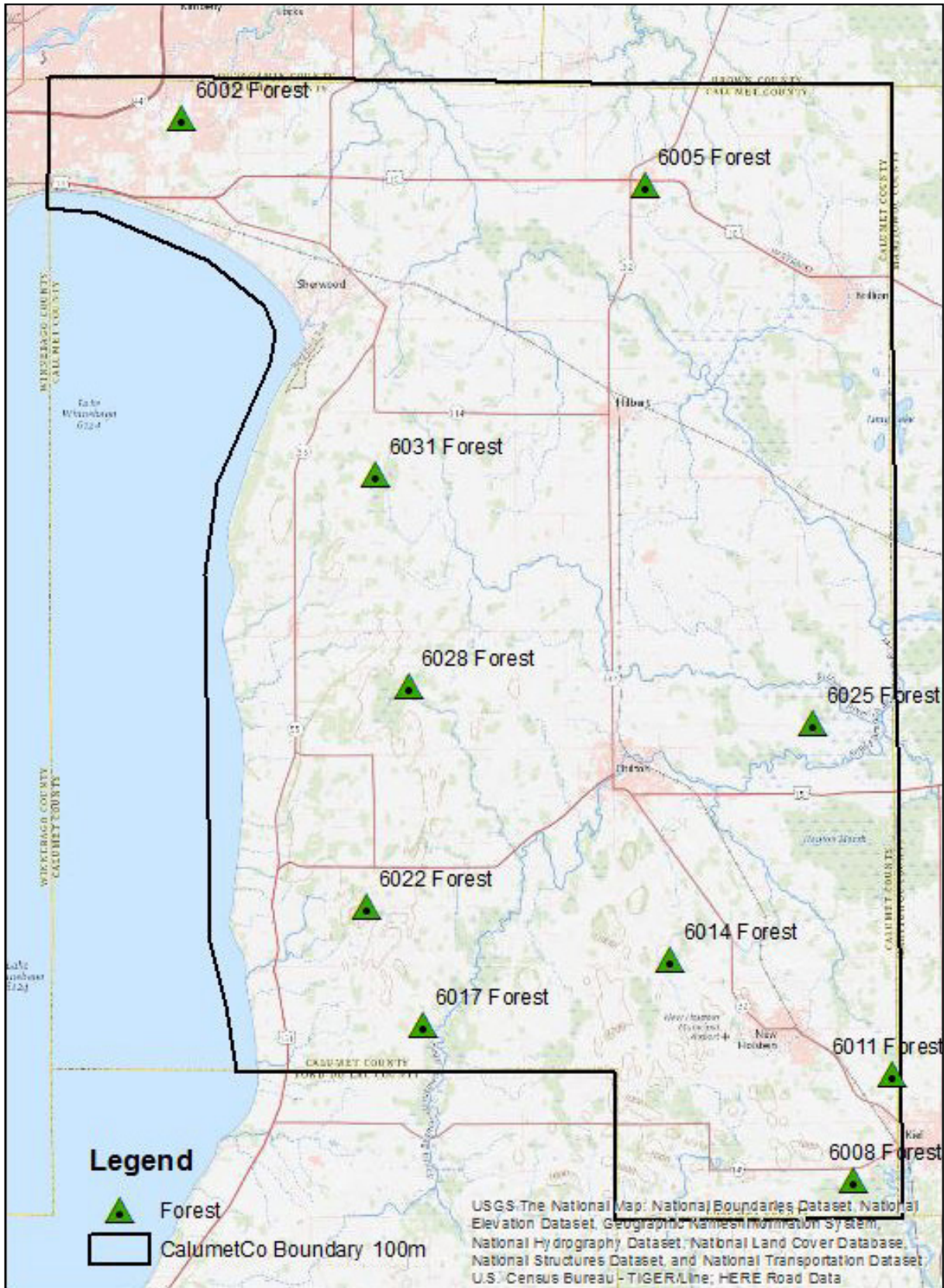
## MAP OF NVA CHECKPOINT LOCATIONS - 2. URBAN AREA



## MAP OF VVA CHECKPOINT LOCATIONS - 3. TALL WEEDS



## MAP OF VVA CHECKPOINT LOCATIONS - 5. FORESTED AREAS



## LAS

| <b>NONVEGETATED VERTICAL ACCURACY – OVERALL</b> |                              |
|---|------------------------------|
| Land Cover Type                                 | 1. Bare Earth, 2 Urban Areas |
| Minimum DZ                                      | -0.223                       |
| Maximum DZ                                      | 0.308                        |
| Mean DZ   | -0.02                        |
| Mean Magnitude DZ                               | 0.274                        |
| Number Observations                             | 29                           |
| Standard Deviation DZ                           | 0.098                        |
| RMSE Z  | 0.098                        |
| 95% Confidence Level Z                          | 0.193                        |
| Units   | US Survey Feet               |

## DEM

| <b>NONVEGETATED VERTICAL ACCURACY – OVERALL</b> |                              |
|---|------------------------------|
| Land Cover Type                                 | 1. Bare Earth, 2. Urban Area |
| Minimum DZ                                      | -0.247                       |
| Maximum DZ                                      | 0.334                        |
| Mean DZ   | -0.01                        |
| Mean Magnitude DZ                               | 0.276                        |
| Number Observations                             | 29                           |
| Standard Deviation DZ                           | 0.104                        |
| RMSE Z  | 0.102                        |
| 95% Confidence Level Z                          | 0.201                        |
| Units   | US Survey Feet               |



## DEM (CONTINUED)

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| <b>VEGETATED VERTICAL ACCURACY</b> |                |
|------------------------------------|----------------|
| Land Cover Type                    | 3. Tall Weeds  |
| Minimum DZ                         | -0.007         |
| Maximum DZ                         | 0.554          |
| Mean DZ                            | 0.212          |
| Mean Magnitude DZ                  | 0.462          |
| Number Observations                | 9              |
| Standard Deviation DZ              | 0.176          |
| RMSE Z                             | 0.269          |
| 95th Percentile                    | 0.554          |
| Units                              | US Survey Feet |

## DEM (CONTINUED)

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| <b>VEGETATED VERTICAL ACCURACY</b> |                |
|------------------------------------|----------------|
| Land Cover Type                    | 5. Forest      |
| Minimum DZ                         | -0.025         |
| Maximum DZ                         | 0.501          |
| Mean DZ                            | 0.284          |
| Mean Magnitude DZ                  | 0.537          |
| Number Observations                | 10             |
| Standard Deviation DZ              | 0.159          |
| RMSE Z                             | 0.321          |
| 95th Percentile                    | 0.501          |
| Units                              | US Survey Feet |

## Point: 1000 Bare Earth

Survey X: 827873.62, Survey Y: 552998.54, Z1: 803.53, Z DEM: 803.53, Z LAS: 803.55, LC Type: 1, ΔZ DEM: 0, ΔZ LAS: 0.02



**North**



**South**



**East**



**West**

## Point: 1001 Urban Area

Survey X: 830824.5, Survey Y: 548308.52, Z1: 793.58, Z DEM: 793.48, Z LAS: 793.45, LC Type: 2, ΔZ DEM: -0.09, ΔZ LAS: -0.13



**North**



**South**



**East**



**West**

## Point: 1102 Tall Weeds

Survey X: 847367.49, Survey Y: 542922.06, Z1: 793.52, Z DEM: 793.55, Z LAS: 793.56, LC Type: 3, ΔZ DEM: 0.04, ΔZ LAS: 0.04



**North**



**South**



**East**



**West**

## Point: 1003 Urban Area

Survey X: 856144.33, Survey Y: 531424.27, Z1: 778.84, Z DEM: 778.79, Z LAS: 778.78, LC Type: 2, ΔZ DEM: -0.04, ΔZ LAS: -0.06



**North**



**South**



**East**



**West**

## Point: 1004 Bare Earth

Survey X: 864868.37, Survey Y: 529658.63, Z1: 908.62, Z DEM: 908.68, Z LAS: 908.66, LC Type: 1, ΔZ DEM: 0.06, ΔZ LAS: 0.04



**North**



**South**



**East**



**West**

## Point: 1005 Urban Area

Survey X: 854536.69, Survey Y: 500856.31, Z1: 960.48, Z DEM: 960.44, Z LAS: 960.41, LC Type: 2, ΔZ DEM: -0.03, ΔZ LAS: -0.06



**North**



**South**



**East**



**West**

## Point: 1006 Bare Earth

Survey X: 855472.11, Survey Y: 491964.2, Z1: 815.92, Z DEM: 816.26, Z LAS: 816.23, LC Type: 1, ΔZ DEM: 0.33, ΔZ LAS: 0.31



**North**



**South**



**East**



**West**



## Point: 1007 Urban Area

Survey X: 875692.93, Survey Y: 484259.25, Z1: 997.06, Z DEM: 996.98, Z LAS: 996.98, LC Type: 2, ΔZ DEM: -0.08, ΔZ LAS: -0.08



**North**



**South**



**East**



**West**

## Point: 1008 Bare Earth

Survey X: 903487.46, Survey Y: 476184.9, Z1: 814.9, Z DEM: 814.92, Z LAS: 814.88, LC Type: 1, ΔZ DEM: 0.03, ΔZ LAS: -0.01



**North**



**South**



**East**



**West**

## Point: 1009 Urban Area

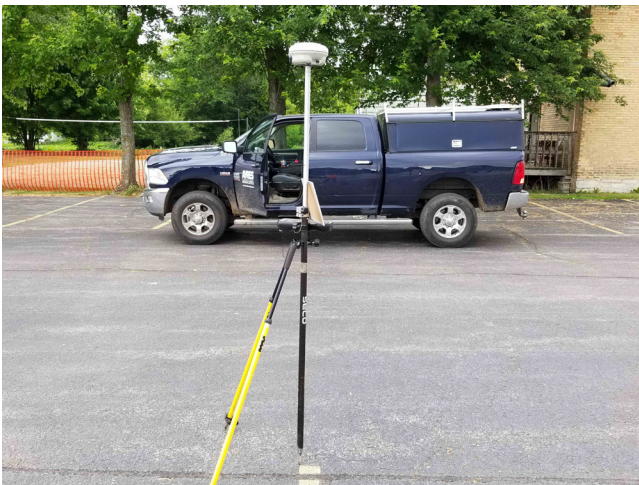
Survey X: 889687.49, Survey Y: 456061.69, Z1: 984.32, Z DEM: 984.26, Z LAS: 984.25, LC Type: 2, ΔZ DEM: -0.06, ΔZ LAS: -0.07



**North**



**South**



**East**



**West**

## Point: 1010 Bare Earth

Survey X: 892312.86, Survey Y: 444447.36, Z1: 995.01, Z DEM: 994.92, Z LAS: 994.92, LC Type: 1, ΔZ DEM: -0.09, ΔZ LAS: -0.09



**North**



**South**



**East**



**West**

## Point: 1011 Bare Earth

Survey X: 853990.63, Survey Y: 467142.51, Z1: 902.75, Z DEM: 902.82, Z LAS: 902.73, LC Type: 1, ΔZ DEM: 0.08, ΔZ LAS: -0.01



**North**



**South**



**East**



**West**

## Point: 1012 Tall Weeds

Survey X: 850612.1, Survey Y: 478555.46, Z1: 764.92, Z DEM: 764.91, Z LAS: 765.02, LC Type: 3, ΔZ DEM: -0.01, ΔZ LAS: 0.1



**North**



**South**



**East**



**West**

## Point: 1013 Urban Area

Survey X: 850281.28, Survey Y: 454582.38, Z1: 749.63, Z DEM: 749.54, Z LAS: 749.54, LC Type: 2, ΔZ DEM: -0.09, ΔZ LAS: -0.1



**North**



**South**



**East**



**West**

## Point: 1014 Bare Earth

Survey X: 854570.31, Survey Y: 443816.85, Z1: 791.58, Z DEM: 791.54, Z LAS: 791.55, LC Type: 1, ΔZ DEM: -0.04, ΔZ LAS: -0.03



**North**



**South**



**East**



**West**



## Point: 1015 Tall Weeds

Survey X: 864624.42, Survey Y: 454184.15, Z1: 983.23, Z DEM: 983.46, Z LAS: 983.43, LC Type: 3, ΔZ DEM: 0.23, ΔZ LAS: 0.2



**North**



**South**



**East**



**West**

## Point: 1016 Urban Area

Survey X: 879118.97, Survey Y: 449468.97, Z1: 958.48, Z DEM: 958.37, Z LAS: 958.34, LC Type: 2, ΔZ DEM: -0.11, ΔZ LAS: -0.14



**North**



**South**



**East**



**West**

## Point: 1017 Tall Weeds

Survey X: 904681.36, Survey Y: 432894.08, Z1: 955.98, Z DEM: 956.21, Z LAS: 956.2, LC Type: 3, ΔZ DEM: 0.23, ΔZ LAS: 0.22



**North**



**South**



**East**



**West**

## Point: 1018 Bare Earth

Survey X: 903446.27, Survey Y: 428709.96, Z1: 981.68, Z DEM: 981.65, Z LAS: 981.67, LC Type: 1, ΔZ DEM: -0.03, ΔZ LAS: -0.01



**North**



**South**



**East**



**West**

## Point: 1019 Urban Area

Survey X: 913163.08, Survey Y: 427914.39, Z1: 949.4, Z DEM: 949.27, Z LAS: 949.29, LC Type: 2, ΔZ DEM: -0.13, ΔZ LAS: -0.11



North



South



East



West

## Point: 1020 Bare Earth

Survey X: 923392.7, Survey Y: 435779.45, Z1: 924.04, Z DEM: 924.03, Z LAS: 924.03, LC Type: 1,  $\Delta Z$  DEM: -0.01,  $\Delta Z$  LAS: 0



North



South



East



West

## Point: 1021 Urban Area

Survey X: 910243.32, Survey Y: 448155.7, Z1: 981.88, Z DEM: 981.95, Z LAS: 981.96, LC Type: 2, ΔZ DEM: 0.07, ΔZ LAS: 0.08



**North**



**South**



**East**



**West**

## Point: 1022 Tall Weeds

Survey X: 917887.29, Survey Y: 459557.83, Z1: 861.3, Z DEM: 861.57, Z LAS: 861.52, LC Type: 3, ΔZ DEM: 0.26, ΔZ LAS: 0.21



**North**



**South**



**East**



**West**



## Point: 1023 Urban Area

Survey X: 917991.06, Survey Y: 462029.95, Z1: 875.18, Z DEM: 874.93, Z LAS: 874.96, LC Type: 2, ΔZ DEM: -0.25, ΔZ LAS: -0.22



**North**



**South**



**East**



**West**

## Point: 1024 Tall Weeds

Survey X: 915728, Survey Y: 475066.18, Z1: 817.03, Z DEM: 817.41, Z LAS: 817.44, LC Type: 3, ΔZ DEM: 0.38, ΔZ LAS: 0.41



**North**



**South**



**East**



**West**

## Point: 1025 Bare Earth

Survey X: 880827.05, Survey Y: 552414.98, Z1: 808.27, Z DEM: 808.38, Z LAS: 808.34, LC Type: 1, ΔZ DEM: 0.11, ΔZ LAS: 0.07



**North**



**South**



**East**



**West**

## Point: 1026 Urban Area

Survey X: 893962.96, Survey Y: 544328, Z1: 834.59, Z DEM: 834.65, Z LAS: 834.65, LC Type: 2, ΔZ DEM: 0.06, ΔZ LAS: 0.06



**North**



**South**



**East**



**West**

## Point: 1027 Bare Earth

Survey X: 900664.51, Survey Y: 528431.28, Z1: 814.12, Z DEM: 814.04, Z LAS: 814.05, LC Type: 1, ΔZ DEM: -0.08, ΔZ LAS: -0.07



North



South



East



West

## Point: 1028 Bare Earth

Survey X: 890991.63, Survey Y: 514951.04, Z1: 851.94, Z DEM: 851.98, Z LAS: 851.98, LC Type: 1, ΔZ DEM: 0.04, ΔZ LAS: 0.05



**North**



**South**



**East**



**West**

## Point: 1029 Urban Area

Survey X: 891122.36, Survey Y: 511315.08, Z1: 866.56, Z DEM: 866.55, Z LAS: 866.54, LC Type: 2, ΔZ DEM: -0.01, ΔZ LAS: -0.02



**North**



**South**



**East**



**West**

## Point: 1030 Tall Weeds

Survey X: 880748.06, Survey Y: 506910.3, Z1: 900.94, Z DEM: 901.07, Z LAS: 901.11, LC Type: 3, ΔZ DEM: 0.12, ΔZ LAS: 0.17



**North**



**South**



**East**



**West**



## Point: 1031 Bare Earth

Survey X: 891442.69, Survey Y: 498233.65, Z1: 889.42, Z DEM: 889.33, Z LAS: 889.33, LC Type: 1, ΔZ DEM: -0.08, ΔZ LAS: -0.09



**North**



**South**



**East**



**West**

## Point: 1032 Tall Weeds

Survey X: 896745.24, Survey Y: 493603.05, Z1: 842.83, Z DEM: 843.38, Z LAS: 843.4, LC Type: 3, ΔZ DEM: 0.55, ΔZ LAS: 0.57



**North**



**South**



**East**



**West**

## Point: 1033 Urban Area

Survey X: 907219.51, Survey Y: 493840.78, Z1: 835.52, Z DEM: 835.49, Z LAS: 835.45, LC Type: 2, ΔZ DEM: -0.03, ΔZ LAS: -0.07



**North**



**South**



**East**



**West**

## Point: 1034 Bare Earth

Survey X: 922980.16, Survey Y: 501984.95, Z1: 836.98, Z DEM: 837.09, Z LAS: 837.07, LC Type: 1, ΔZ DEM: 0.12, ΔZ LAS: 0.09



**North**



**South**



**East**



**West**

## Point: 1035 Urban Area

Survey X: 922594.16, Survey Y: 515095.79, Z1: 860.41, Z DEM: 860.45, Z LAS: 860.45, LC Type: 2, ΔZ DEM: 0.04, ΔZ LAS: 0.03



**North**



**South**



**East**



**West**

## Point: 1036 Urban Area

Survey X: 914908.42, Survey Y: 522921.78, Z1: 826.14, Z DEM: 826.16, Z LAS: 826.19, LC Type: 2, ΔZ DEM: 0.02, ΔZ LAS: 0.05



**North**



**South**



**East**



**West**

## Point: 1037 Tall Weeds

Survey X: 918642.47, Survey Y: 536025.92, Z1: 901.34, Z DEM: 901.44, Z LAS: 901.38, LC Type: 3, ΔZ DEM: 0.1, ΔZ LAS: 0.03



North



South



East



West

## Point: 6002 Forest

Survey X: 842915.4, Survey Y: 551370.25, Z1: 811.15, Z DEM: 811.33, Z LAS: 811.43, LC Type: 5, ΔZ DEM: 0.18, ΔZ LAS: 0.28



North



South



East



West



## Point: 6005 Forest

Survey X: 895143.55, Survey Y: 543942.18, Z1: 832.28, Z DEM: 832.26, Z LAS: 832.3, LC Type: 5, ΔZ DEM: -0.03, ΔZ LAS: 0.01



North



South



East



West

## Point: 6008 Forest

Survey X: 918672.27, Survey Y: 431634.95, Z1: 896.89, Z DEM: 897.14, Z LAS: 897.19, LC Type: 5, ΔZ DEM: 0.25, ΔZ LAS: 0.3



**North**



**South**



**East**



**West**

## Point: 6011 Forest

Survey X: 923060.45, Survey Y: 443673.26, Z1: 904.54, Z DEM: 905.04, Z LAS: 905.04, LC Type: 5, ΔZ DEM: 0.5, ΔZ LAS: 0.5



North



South



East



West

## Point: 6014 Forest

Survey X: 898022.29, Survey Y: 456529.92, Z1: 955.97, Z DEM: 956.19, Z LAS: 956.19, LC Type: 5, ΔZ DEM: 0.22, ΔZ LAS: 0.23



North



South



East



West

## Point: 6017 Forest

Survey X: 870053.02, Survey Y: 449192.55, Z1: 932.72, Z DEM: 933.15, Z LAS: 933.15, LC Type: 5, ΔZ DEM: 0.43, ΔZ LAS: 0.43



North



South



East



West

## Point: 6022 Forest

Survey X: 863633.44, Survey Y: 462582.87, Z1: 989.69, Z DEM: 990.07, Z LAS: 990.17, LC Type: 5, ΔZ DEM: 0.38, ΔZ LAS: 0.48



North



South



East



West

## Point: 6025 Forest

Survey X: 914139.27, Survey Y: 483339.09, Z1: 803.74, Z DEM: 804.06, Z LAS: 804.05, LC Type: 5, ΔZ DEM: 0.32, ΔZ LAS: 0.32



North



South



East



West

## Point: 6028 Forest

Survey X: 868563.36, Survey Y: 487416.47, Z1: 967.94, Z DEM: 968.35, Z LAS: 968.27, LC Type: 5, ΔZ DEM: 0.42, ΔZ LAS: 0.33



North



South



East

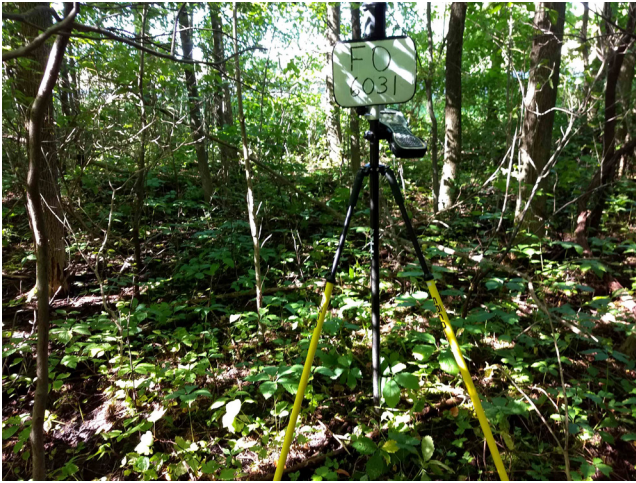


West



## Point: 6031 Forest

Survey X: 864809.58, Survey Y: 511361.84, Z1: 939.07, Z DEM: 939.22, Z LAS: 939.22, LC Type: 5, ΔZ DEM: 0.15, ΔZ LAS: 0.15



North



South



East



West