

# Maine and Massachusetts 2015 QL1 and QL2 LiDAR Project Report



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Appendix A: GPS / IMU Processing Statistics, Flight Logs, and Base Station Logs

Appendix B: Massachusetts Survey Report

Appendix C: Maine Survey Report

# 1. Summary / Scope

## 1.1. Summary

This report contains a summary of the Maine and Massachusetts 2015 LiDAR acquisition task order, issued by USGS National Geospatial Technical Operations Center, under their Geospatial Product and Services Contract ordered on April 8, 2015. The task order yielded four distinct areas of interest totaling approximately 5,967 square miles. The intent of this document is to only provide specific validation information for the LiDAR data acquisition/collection, processing, and creation of deliverables completed per the task order specifications.

## 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

Quality Level	Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
QL1	8 pts / m <sup>2</sup>	1300 m	28°	50%	≤ 10 cm
QL2	2 pts / m <sup>2</sup>	1500 m	40°	30%	≤ 10 cm

## 1.3. Coverage

The 2,770 square mile Massachusetts project area covers the western and central portions of the state; deliverables for this area are split into UTM 18 and UTM 19 zones, respectively, per the Task Order. The QL1 LiDAR project area also falls within the western part of Massachusetts and totals approximately 815 square miles. The QL2 Maine project area covers approximately 2,882 square miles in central portion of the state. A buffer of 100 meters was applied to the Massachusetts areas, while a buffer of 500 meters was created for Maine. Project extents are shown in Figure 1 through Figure 3 on the following pages.

## 1.4. Duration

LiDAR data was acquired from April 16, 2015 to December 5, 2015 in sixty-one total lifts. See “Section: 2.5. Time Period” for more details.

## 1.5. Issues

Acquisition was not able to be completed in Spring of 2015 due to leaf-out conditions and had to be finished in Fall of 2015. There were also a few drop outs that required re-flights, as well as one lift from Spring that was re-flown in the Fall.

## 1.6. Deliverables

The following products were produced and delivered:

- Raw point cloud data, swath, in LAS in version 1.4 format
- Classified point cloud data, tiled, in LAS in version 1.4 format
- 1-meter hydro-flattened raster DEM, tiled, in ERDAS .IMG format
- Hydro-flattened breaklines, in Esri file geodatabase format
- Control points, in Esri shapefile format
- 1-meter intensity image, in GeoTIFF format
- Control calibration and QC checkpoints, in shapefile format
- Processing boundary, in Esri shapefile format
- Tile indices, in Esri shapefile format
- Project-, deliverable-, and lift-level metadata, in .XML format
- GPS/IMU statistics, flight logs, and base stations report
- Survey report
- Accuracy Assessment in .XLS format

All geospatial deliverables were delivered in the following projections, based on the AOI:

- Western-most contiguous Massachusetts AOI containing both QL1 and QL2 data: NAD83 (2011) UTM Zone 18, meters; NAVD88 (Geoid 12A), meters
- Eastern-most portion of the Massachusetts AOI containing QL2 data: NAD83 (2011) UTM Zone 19, meters; NAVD88 (Geoid 12A), meters
- Maine AOI containing QL2 data: NAD83 (2011) UTM Zone 19, meters; NAVD88, (Geoid 12A), meters

All data will be delivered in orthometric heights. All QL1 tiled deliverables have a tile size of 750 meters x 750 meters. All QL2 tiled deliverables have a tile size of 1,500 meters x 1,500 meters.



Figure 1. Massachusetts QL1 & QL2 Project Boundary (UTM 18)

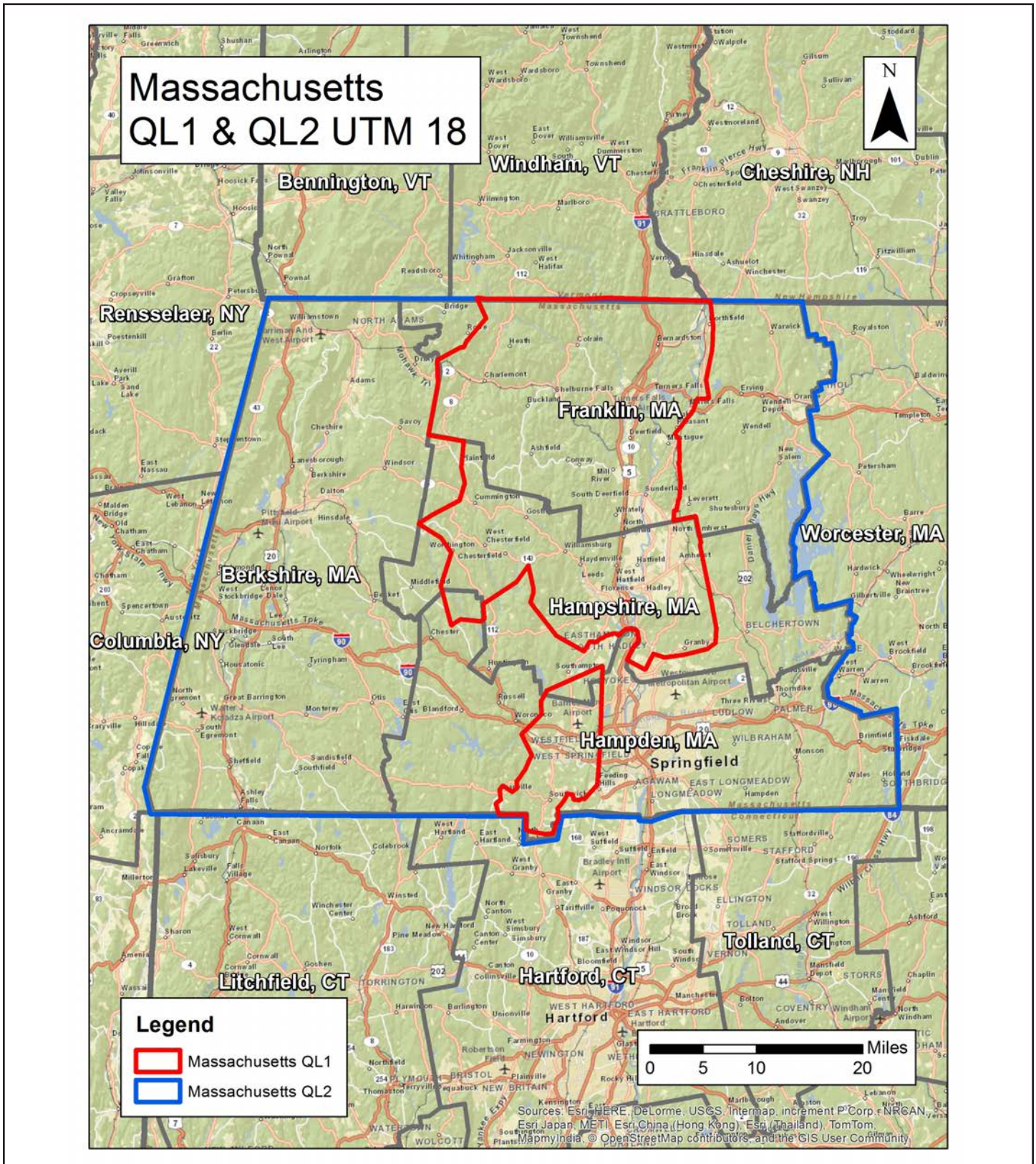




Figure 2. Massachusetts QL2 Project Boundary (UTM 19)

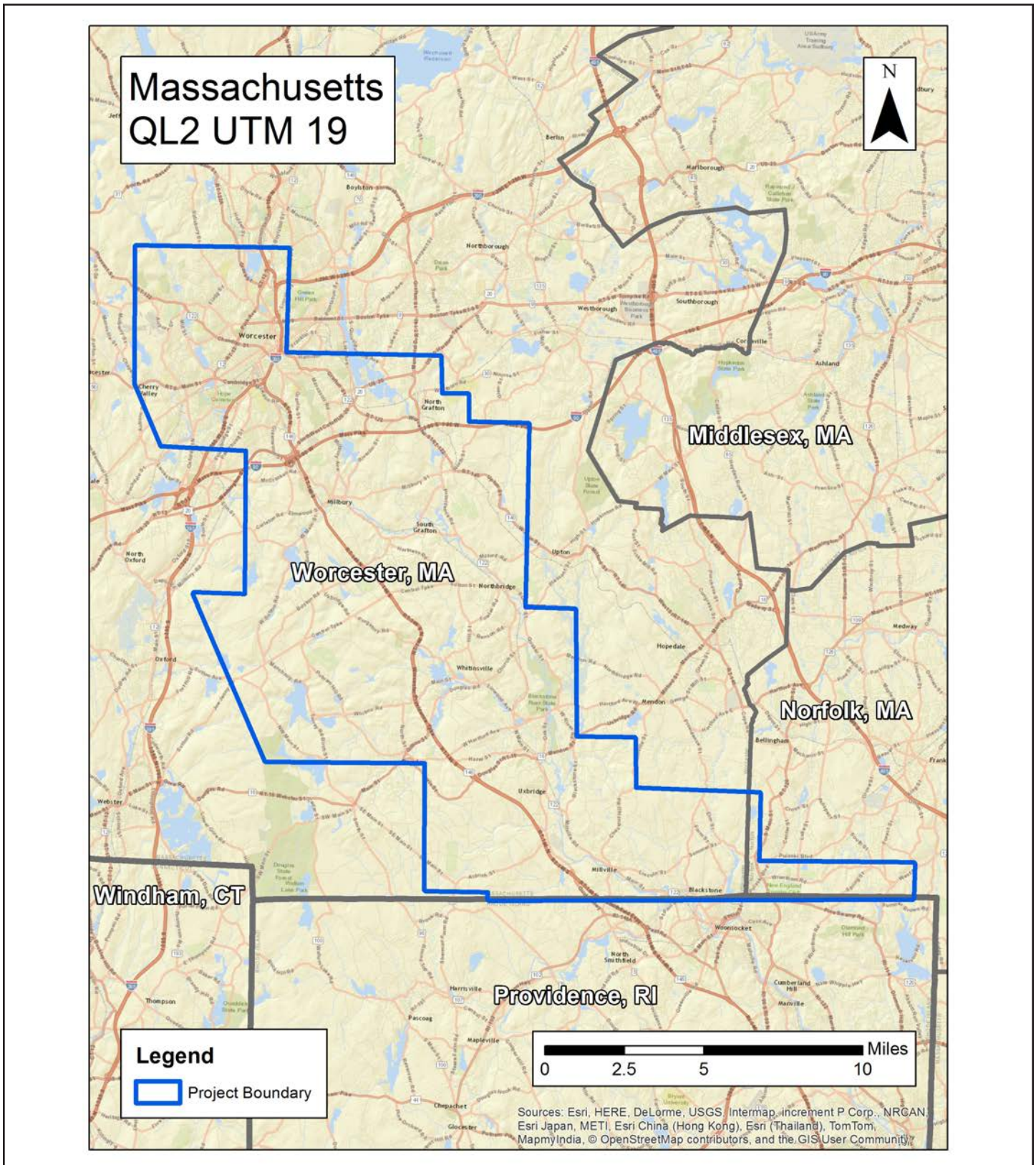
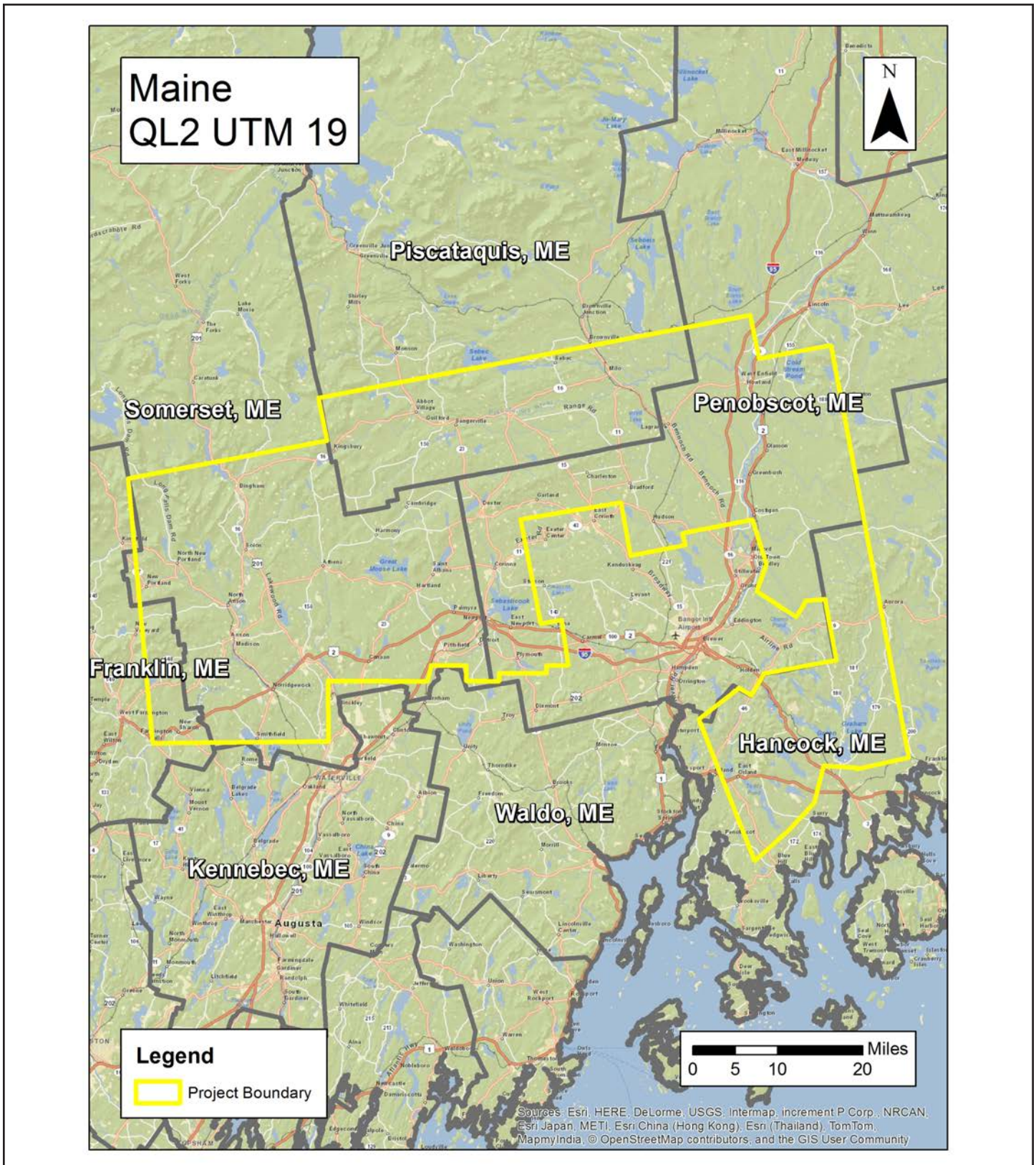




Figure 3. Maine QL2 Project Boundary (UTM 19)



## 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. Please note that certain values in the table below are listed as “Variable” due to the various flight plans used, as described in “Section: “ of this document.

Detailed project flight planning calculations were performed for the project using Leica Mission Pro planning software.

The entire target area was comprised of a total of 660 planned flight lines measuring approximately 17178.3 flight line miles. Listed below is an approximate breakdown of miles per AOI.

- Maine UTM 19 QL2: 248 lines, 7,459.5 miles
- Mass. UTM 18 QL1: 170 lines, 4497 miles
- Mass. UTM 18 QL2: 211 lines, 4742.5 miles
- Mass. UTM 19 QL2: 31 lines, 479.3 miles

Planned flight line layouts can be seen in Figure 4 through Figure 7.

### 2.2. LiDAR Sensor

Quantum Spatial utilized a Leica ALS70 and ALS80 LiDAR sensors (Figure 8 and Figure 9), serial numbers 7108, 7123, 7169, 7178, 7234, and 8239 during the project. These system are capable of collecting data at a maximum frequency of 500 kHz, which affords elevation data collection of up to 500,000 points per second. These systems utilizes a Multi-Pulse in the Air option (MPIA). The sensors are also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd and last returns. The intensity of the returns is also captured during aerial acquisition.

A brief summary of the aerial acquisition parameters for the project are shown in the LiDAR System Specifications in Table 2 through Table 4. Parameters are broken out by acquisition blocks.



Figure 4. Originally Planned LiDAR Flight Lines for Mass. QL1 (UTM 18)

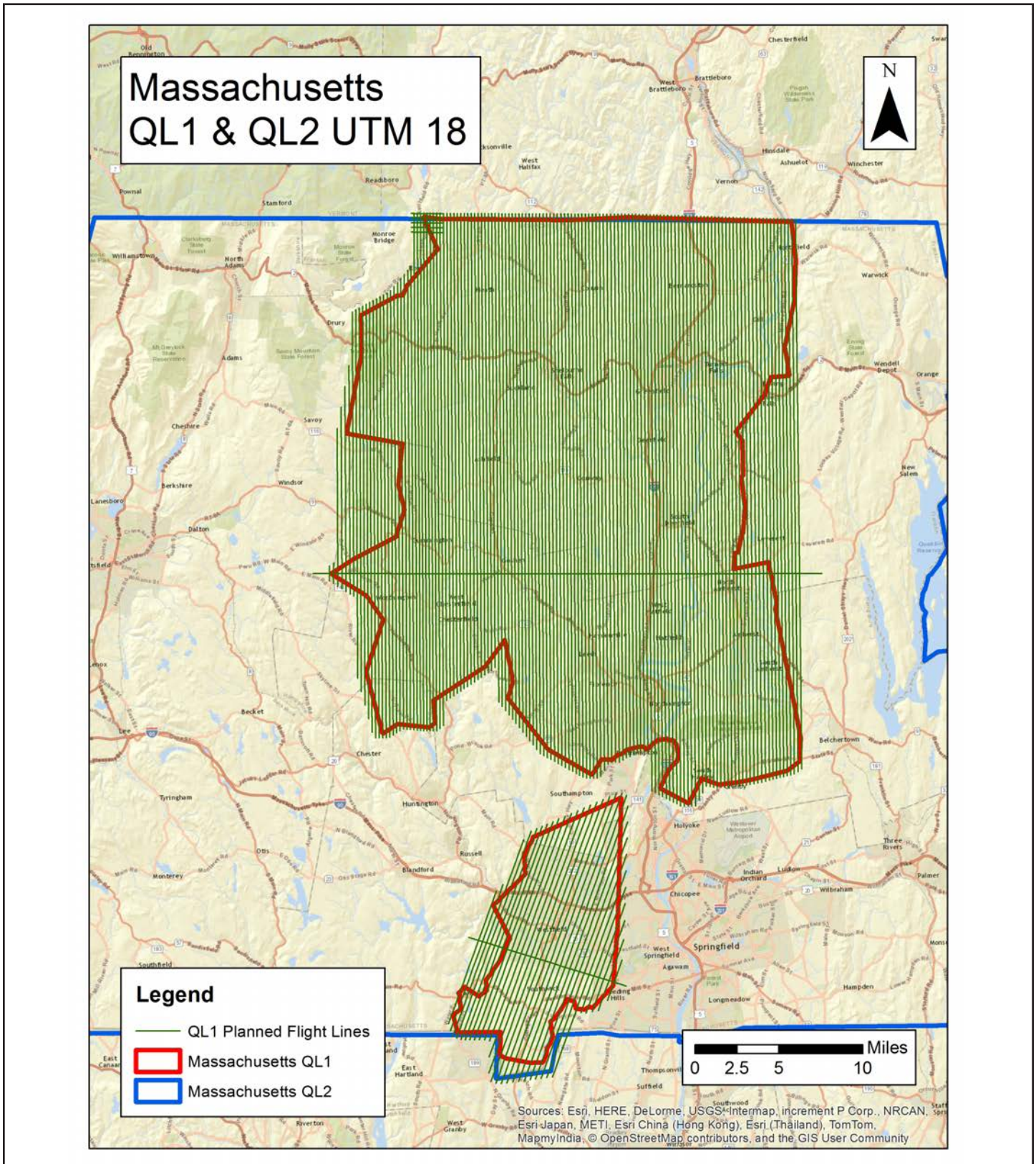




Figure 5. Originally Planned LiDAR Flight Lines for Mass. QL2 (UTM 18)

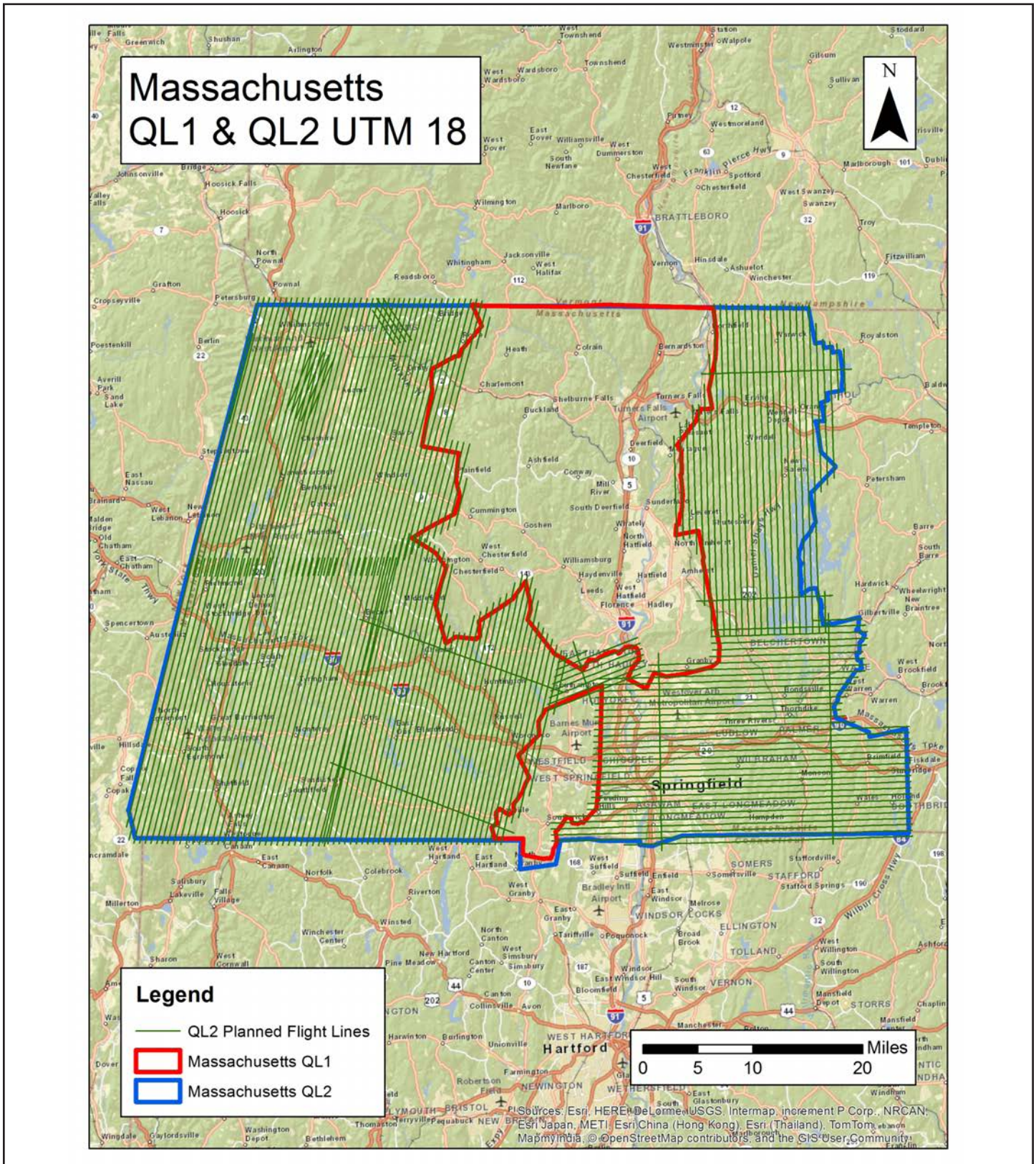




Figure 6. Originally Planned LiDAR Flight Lines for Mass. QL2 (UTM 19)

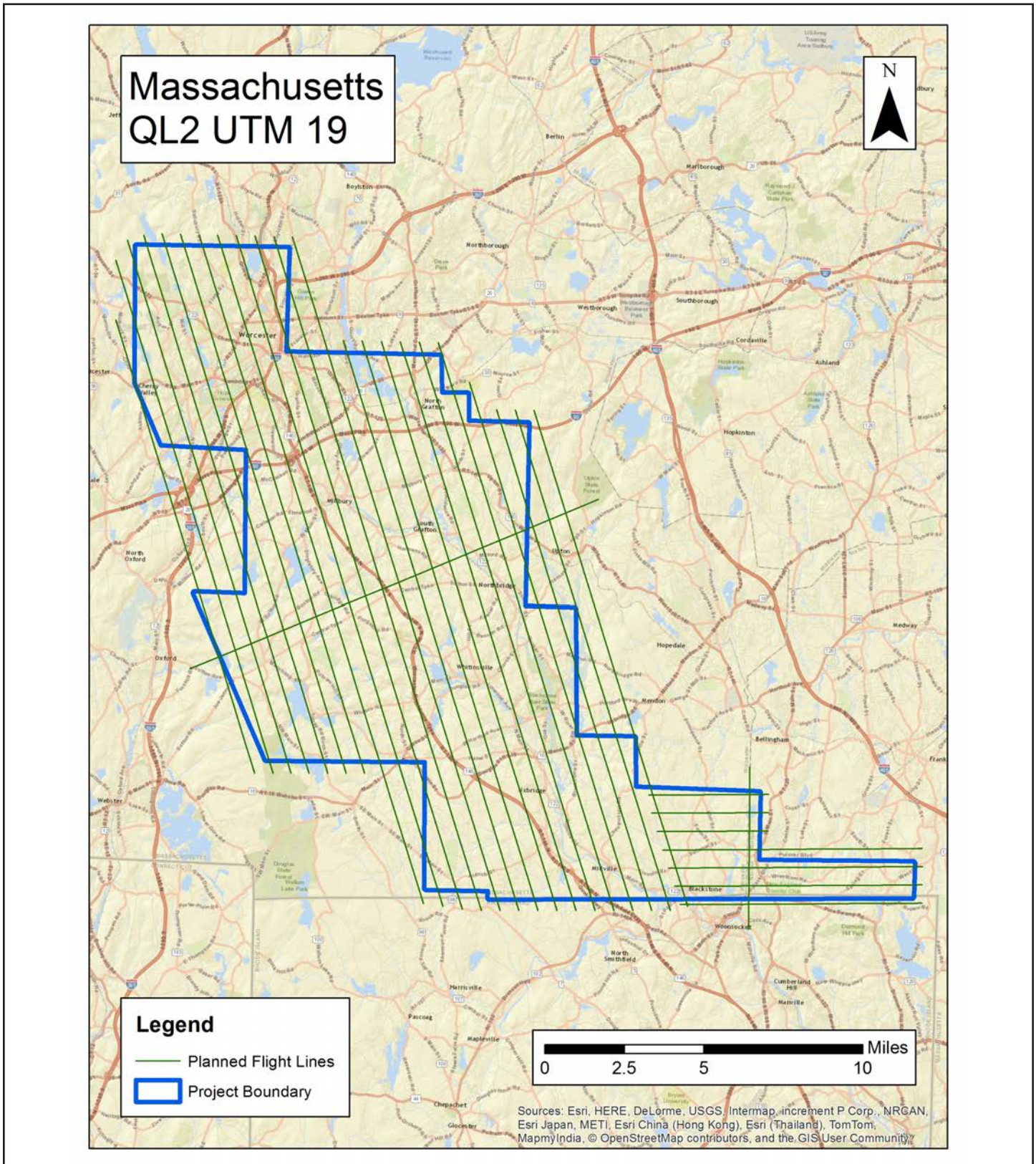
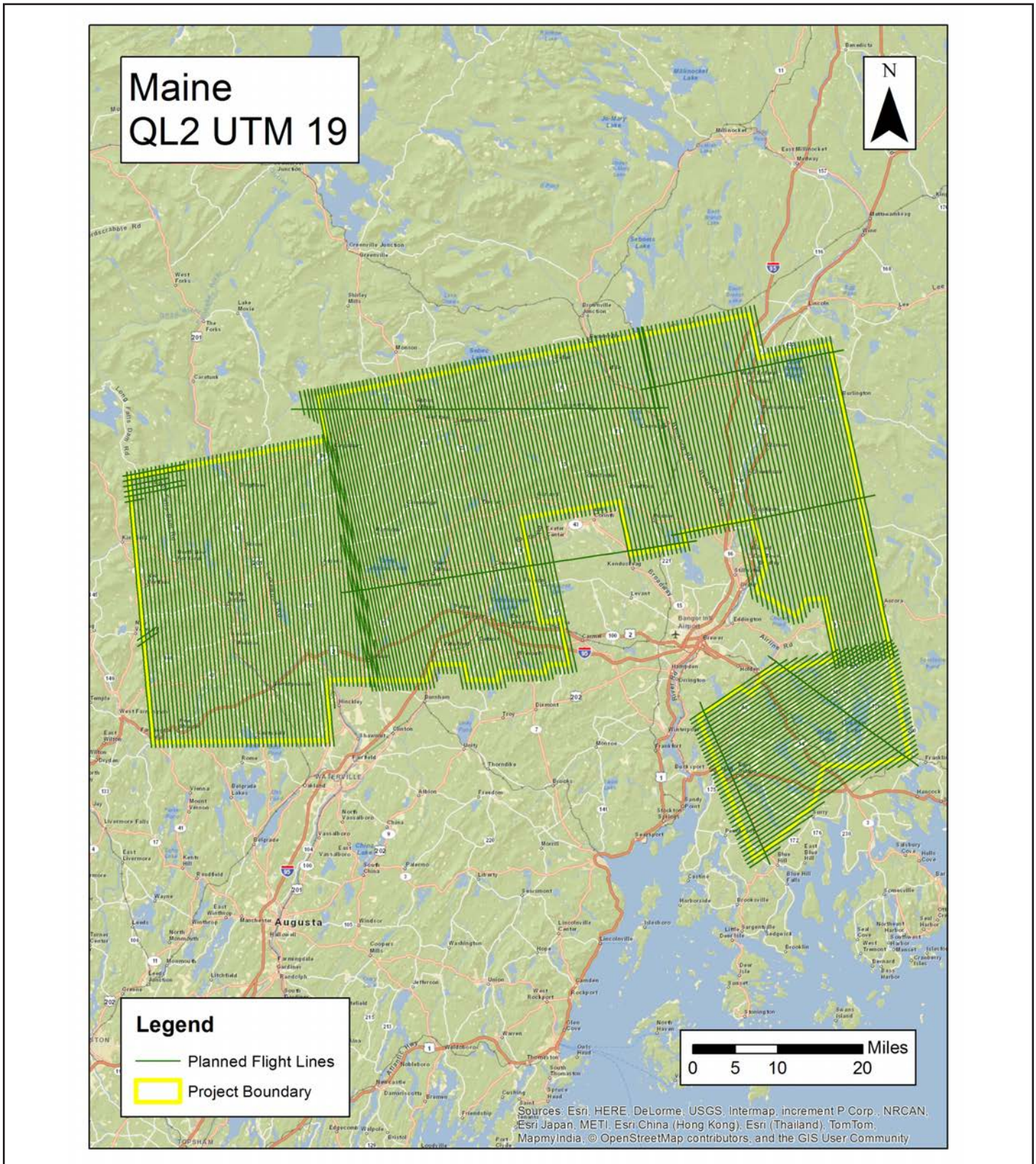




Figure 7. Originally Planned LiDAR Flight Lines for Mass. QL2 (UTM 19)





**Table 2. Lidar System Specifications - QL1 Massachusetts**

		KBAF 7178	Northampton 7178	KBAF ALS80	Northampton 8239
Terrain and Aircraft Scanner	Flying Height (m)	1,100	1,500	772 - 1,100	860 - 1,500
	Recommended Ground Speed (kts)	150	150	150	150
Scanner	Field of View (deg)	37.0	40.0	38.0	40.0
	Scan Rate Setting Used (Hz)	55.3	53.4	35.0	52.0
Laser	Laser Pulse Rate Used (kHz)	491.4	361.2	487.2	358.8
	Multi Pulse in Air Mode	Enabled	Enabled	Enabled	Enabled
Coverage	Full Swath Width (m)	736.11	1,091.91	757.52	1,091.91
	Line Spacing (m)	614.74	952.32	386.64	471.42
Point Spacing and Density	Maximum Point Spacing Across Track (m)	0.37	0.70	0.24	0.69
	Maximum Point Spacing Along Track (m)	1.39	1.44	1.10	1.48
	Average Point Density (pts / m <sup>2</sup> )	8.65	4.29*	8.33	4.26*

\*Northampton 7178 and Northampton 8239 blocks were flown with 50% sidalap to achieve required point density.

**Table 3. Lidar System Specifications - QL2 Massachusetts**

		East Block 7178	KBAF 7178	KCEF 7123	KORE 7123	Pittsfield North/South
Terrain and Aircraft Scanner	Flying Height (m)	1,589 - 1,900	1,272 - 1,900	1,717 - 2,100	1,657 - 2,100	1,981
	Recommended Ground Speed (kts)	170	175	130	130	150
Scanner	Field of View (deg)	40.0	40.0	40.0	40.0	40.0
	Scan Rate Setting Used (Hz)	45.8	46.5	35.9	35.9	41.0
Laser	Laser Pulse Rate Used (kHz)	287.8	287.8	258.0	258.0	272.0
	Multi Pulse in Air Mode	Enabled	Enabled	Enabled	Enabled	Enabled
Coverage	Full Swath Width (m)	1,383.09	1,383.09	1,528.67	1,528.67	1,442.05
	Line Spacing (m)	1,027.06	8,08.75	1,097.99	1,056.67	1,283.57
Point Spacing and Density	Maximum Point Spacing Across Track (m)	0.95	0.97	0.93	0.93	0.94
	Maximum Point Spacing Along Track (m)	0.95	0.97	0.93	0.93	1.88
	Average Point Density (pts / m <sup>2</sup> )	2.38	2.31	2.52	2.52	2.44

**Table 4. Lidar System Specifications - QL2 Maine**

		Norridgewock	Old Town 7169
Terrain and Aircraft Scanner	Flying Height (m)	1,981	1,350 - 1,725
	Recommended Ground Speed (kts)	150	115
Scanner	Field of View (deg)	40.0	40.0
	Scan Rate Setting Used (Hz)	41.0	41.5
Laser	Laser Pulse Rate Used (kHz)	272.0	157.6
	Multi Pulse in Air Mode	Enabled	Disabled
Coverage	Full Swath Width (m)	1,442.05	1,255.70
	Line Spacing (m)	1,283.57	849.02
Point Spacing and Density	Maximum Point Spacing Across Track (m)	0.94	1.44
	Maximum Point Spacing Along Track (m)	1.88	0.71
	Average Point Density (pts / m <sup>2</sup> )	2.44	2.12



Figure 8. Leica ALS 70 LiDAR Sensor



Figure 9. Leica ALS 80 LiDAR Sensor



## 2.3. Aircraft

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

### LiDAR Collection Planes

- Piper Navajo (twin-piston), Tail Numbers: N262AS, N22GE
- VULCANAIR Observer (twin-piston), Tail Number: N775MW
- Cessna Caravan (single-turboprop), Tail Number: N269JE
- Cessna 206 Stationair (piston-single), Tail Number: N799AC

These aircraft provided an ideal, stable aerial base for LiDAR acquisition. These aerial platforms has relatively fast cruise speeds which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which proved ideal for collection of high-density, consistent data posting using a state-of-the-art Leica LiDAR systems. Some of the operating aircraft can be seen in Figure 10 below.

Figure 10. Some of Quantum Spatial's Planes



## 2.4. Base Station Information

GPS base stations were utilized during all phases of flight (Table 5). The base station locations were verified using NGS OPUS service and subsequent surveys. Base station locations are depicted in Figure 12 through Figure 13. Data sheets, graphical depiction of base station locations or log sheets used during station occupation are available in Appendix A.

Table 5. Base Station Locations

Base Station	Latitude	Longitude	Ellipsoid Height (m)
0084	42° 16' 4.13666"	71° 52' 10.73775"	272.303
CTEG	41° 55' 24.34701"	72° 41' 55.88092"	30.293
MASB	42° 6' 41.0811"	72° 5' 13.98571"	159.56
HAMP	42° 19' 3.87277"	72° 38' 22.40329"	42.355
CTWI	41° 53' 51.90745"	73° 4' 10.96846"	192.097
MAWM	42° 33' 40.62121"	71° 55' 59.20783"	317182
MABN	42° 40' 11.99113"	72° 32' 28.64375"	94.89
MASH	42° 8' 25.75395"	73° 21' 51.06343"	175.591
MECC	44° 49' 33.21003"	68° 44' 38.60195"	20.586
PNB6	44° 27' 7.24711"	68° 46' 19.9584"	33.462
AB2640	44° 26' 44.53923"	68° 22' 2.72882"	-2.196
MELI	45° 21' 49.15536"	68° 30' 26.61463"	54.567
XMTS	42° 3' 50.01851"	71° 15' 1.66913"	67.953
Dexter	45° 0' 8.34552"	69° 14' 4.15427"	134.08
MEDX	45° 1' 34.9079"	69° 17' 49.08401"	141.203



Figure 11. Base Station Locations - Massachusetts QL1 and QL2 UTM 18

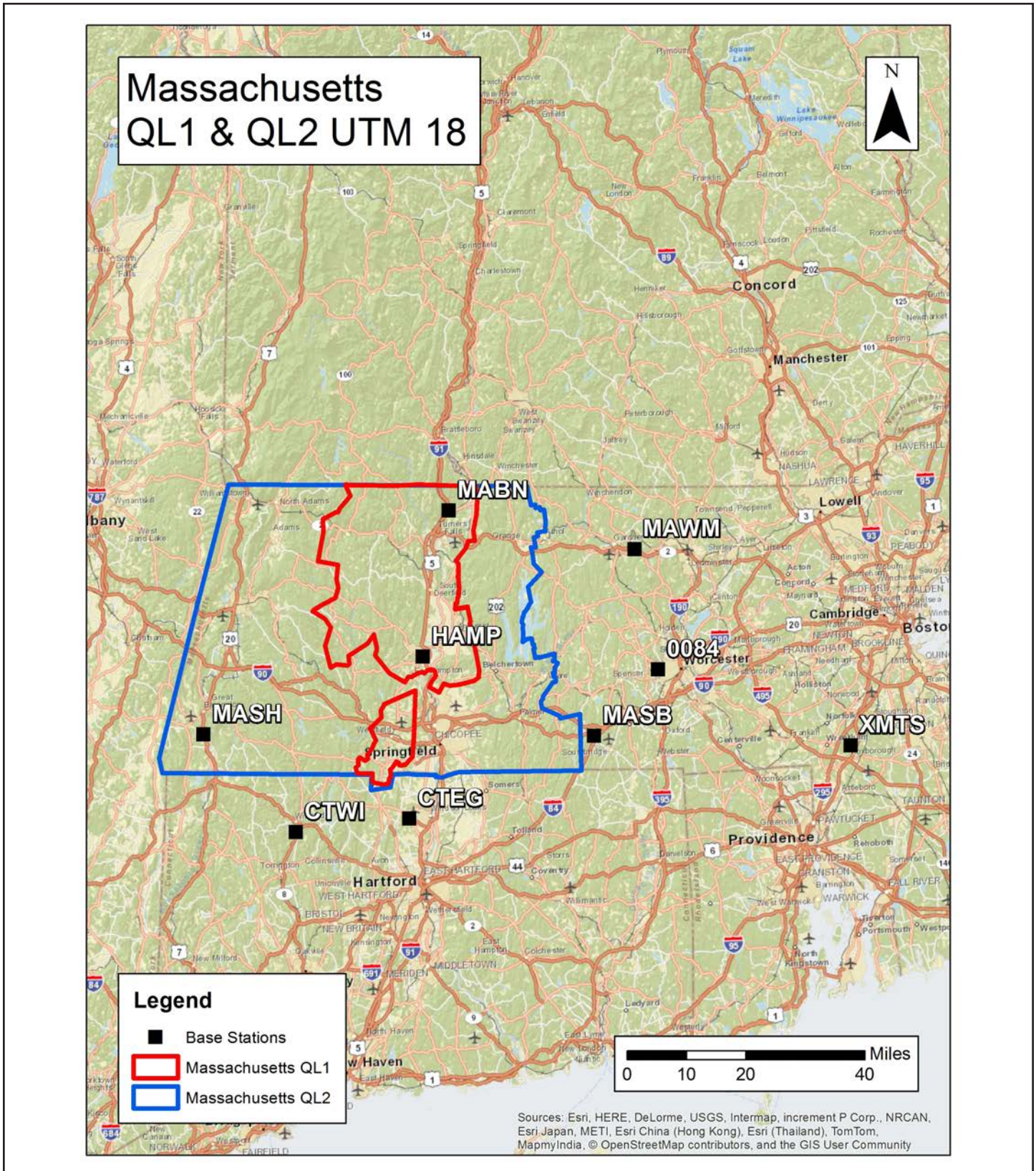




Figure 12. Base Station Locations - Massachusetts QL2 UTM 19

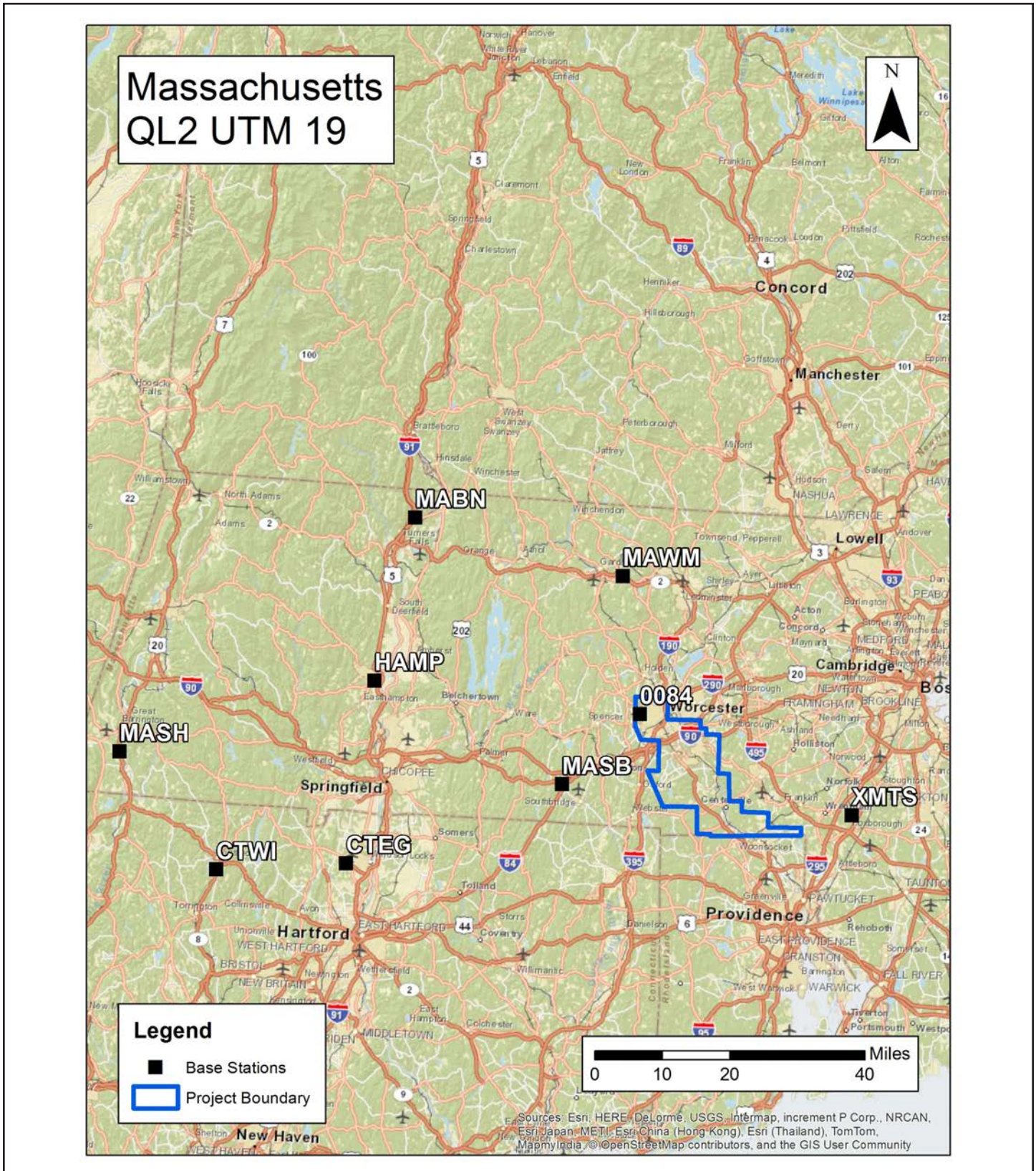
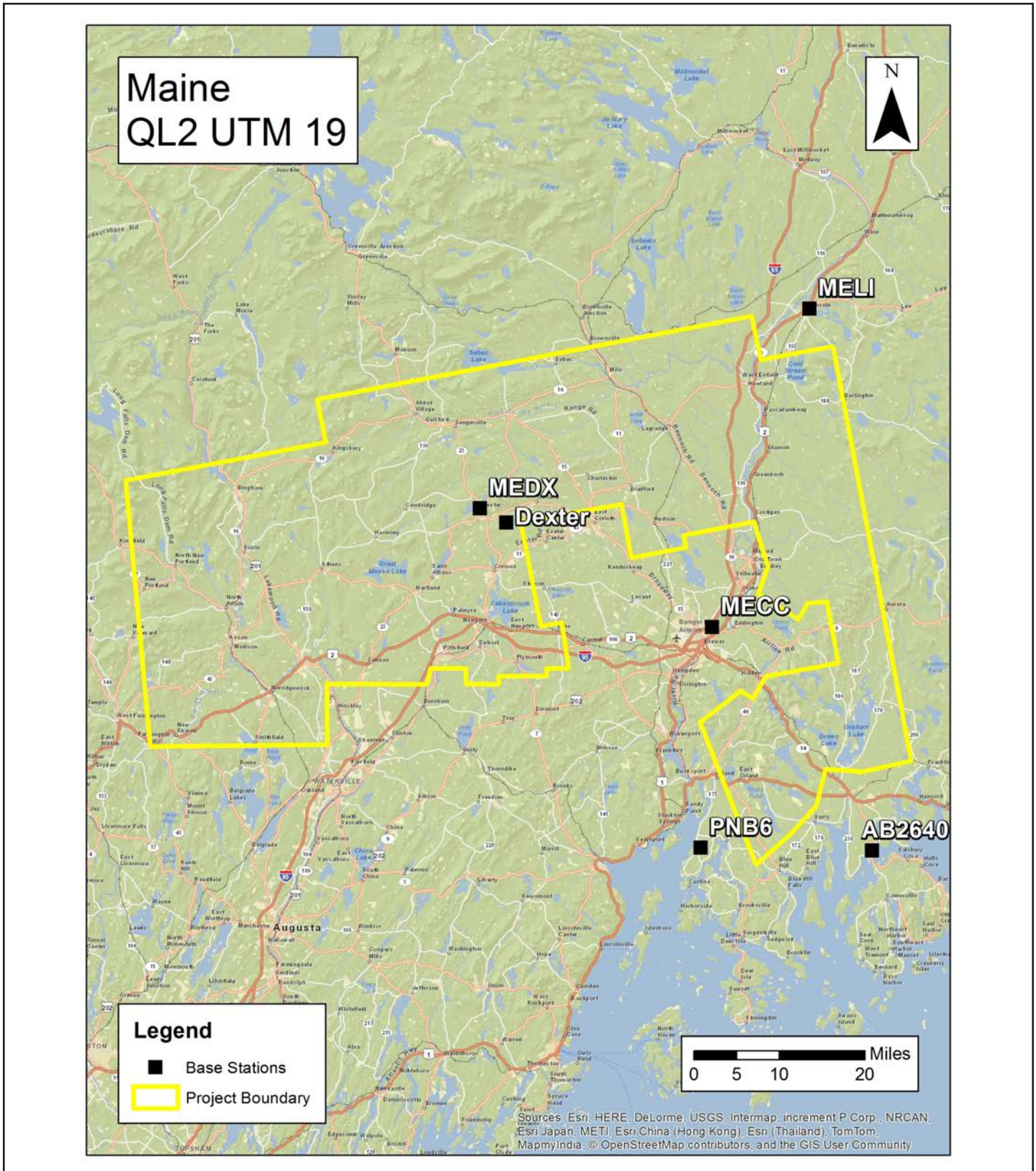




Figure 13. Base Station Locations - Maine QL2 UTM 19







## Maine QL2 UTM 19

- May 04, 2015-A  
(N779AC, SN7169)
- May 04, 2015-B  
(N779AC, SN7169)
- May 04, 2015-C  
(N779AC, SN7169)
- May 05, 2015-A  
(N779AC, SN7169)
- May 06, 2015-A  
(N779AC, SN7169)
- May 07, 2015-A  
(N779AC, SN7169)
- May 08, 2015-A  
(N779AC, SN7169)
- May 09, 2015-A  
(N779AC, SN7169)
- May 07, 2015-A  
(N1107Q, SN7108)
- May 07, 2015-B  
(N1107Q, SN7108)
- May 08, 2015-A  
(N1107Q, SN7108)
- May 08, 2015-B  
(N1107Q, SN7108)
- Nov 04, 2015-A  
(N799AC, SN7169)
- Nov 04, 2015-B  
(N799AC, SN7169)
- Nov 04, 2015-C  
(N799AC, SN7169)
- Nov 08, 2015-A  
(N799AC, SN7169)
- Nov 08, 2015-B  
(N799AC, SN7169)
- Nov 09, 2015-A  
(N799AC, SN7169)
- Nov 09, 2015-B  
(N799AC, SN7169)
- Nov 10, 2015-A  
(N799AC, SN7169)
- Nov 10, 2015-B  
(N799AC, SN7169)



## 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 Mobile Mapping Suite 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. 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 were 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. All relevant graphs produced in the POSPac processing environment for each sortie during the Quantum Spatial project mobilization are available in Appendix A.

The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set. Point clouds were created using the Leica ALS Post Processor software. GeoCue distributive processing software was used in the creation of some files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. TerraScan and TerraModeler software packages were then used for the automated data classification, manual cleanup, and bare earth generation. Project specific macros were developed to classify the ground and remove side overlap between parallel flight lines.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper was used as a final check of the bare earth dataset. GeoCue was used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files.



### 3.3. LAS Classification Scheme

The classification classes are determined by the USGS Version 1.2 specifications 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:

- Class 1 – Processed, but Unclassified – These points would be the catch all for points that do not fit any of the other deliverable classes. This would cover features such as vegetation, cars, etc.
- Class 2 – Bare Earth Ground – This is the bare earth surface
- Class 7 – Low Noise – Low points, manually identified below the surface that could be noise points in point cloud.
- Class 8 – Model Key Point
- Class 9 – In-land Water – Points found inside of inland lake/ponds
- Class 10 – Ignored Ground – Points found to be close to breakline features. Points are moved to this class from the Class 2 dataset. This class is ignored during the DEM creation process in order to provide smooth transition between the ground surface and hydro flattened surface.
- Class 17 – Bridge Decks – Points falling on bridge decks
- Class 18 – High Noise – High points, manually identified above the surface that could be noise points in point cloud.

### 3.4. Classified LAS Processing

The bare earth surface was 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 heads-up 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 TerraScan macro functionality. A buffer of 1 meter was also used around each hydro-flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 10). 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. All bridge decks were classified to Class 17.

All overlap data was processed through automated functionality provided by TerraScan to classify the overlapping flight line data to approved classes by USGS. The overlap data was identified using the Overlap Flag, per LAS 1.4 specifications.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. Quantum Spatial proprietary software was

used 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.

Per the Task order, elevation data for the Maine AOI was matched to existing Maine datasets. Data was matched vertically to the highest level of accuracy allowable, allowing for temporal changes between the two datasets.

### 3.5. Hydro-Flattening Breakline Creation

Class 2 LiDAR was used to create a bare earth surface model. The surface model was then used to heads-up digitize 2D breaklines of inland streams and rivers with a 30 meter nominal width and Inland Ponds and Lakes of 2 acres or greater surface area.

Elevation values were assigned to all Inland Ponds and Lakes, Inland Pond and Lake Islands, Inland Stream and River Islands, using TerraModeler functionality.

Elevation values were assigned to all Inland streams and rivers using Quantum Spatial proprietary software.

All ground (ASPRS Class 2) LiDAR data inside of the collected inland breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 1 meter was also used around each hydro-flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 10).

The breakline files were then translated to ESRI File-Geodatabase format using ESRI conversion tools.

### 3.6. Hydro-Flattening Raster DEM Creation

Class 2 LiDAR in conjunction with the hydro breaklines were used to create a 1 meter Raster DEM. Using automated scripting routines within ArcMap, an ERDAS Imagine IMG file was created for each tile. Each surface was reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

### 3.7. Intensity Image Creation

GeoCue software was used to create the deliverable Intensity Images with a 1 meter cell size. All overlap classes were ignored during this process. This helps to ensure a more aesthetically pleasing image.

The GeoCue software was then used to verify full project coverage as well. TIF/TWF files were then provided as the deliverable for this dataset requirement.



# 4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 14 through Figure 17.

Figure 14. Flightline Swath LAS File Coverage MA QL1 UTM 18

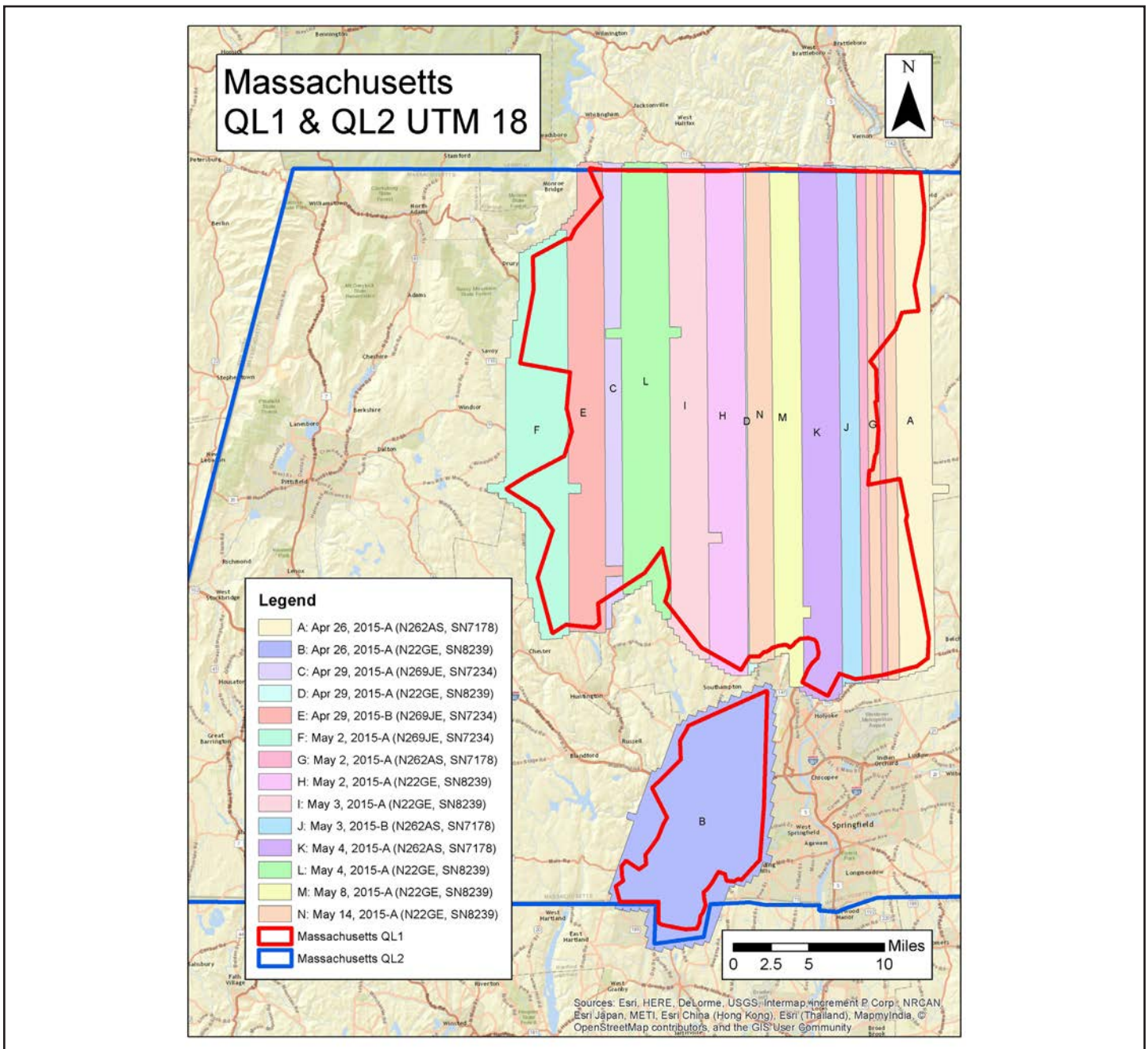


Figure 15. Flightline Swath LAS File Coverage MA QL2 UTM 18

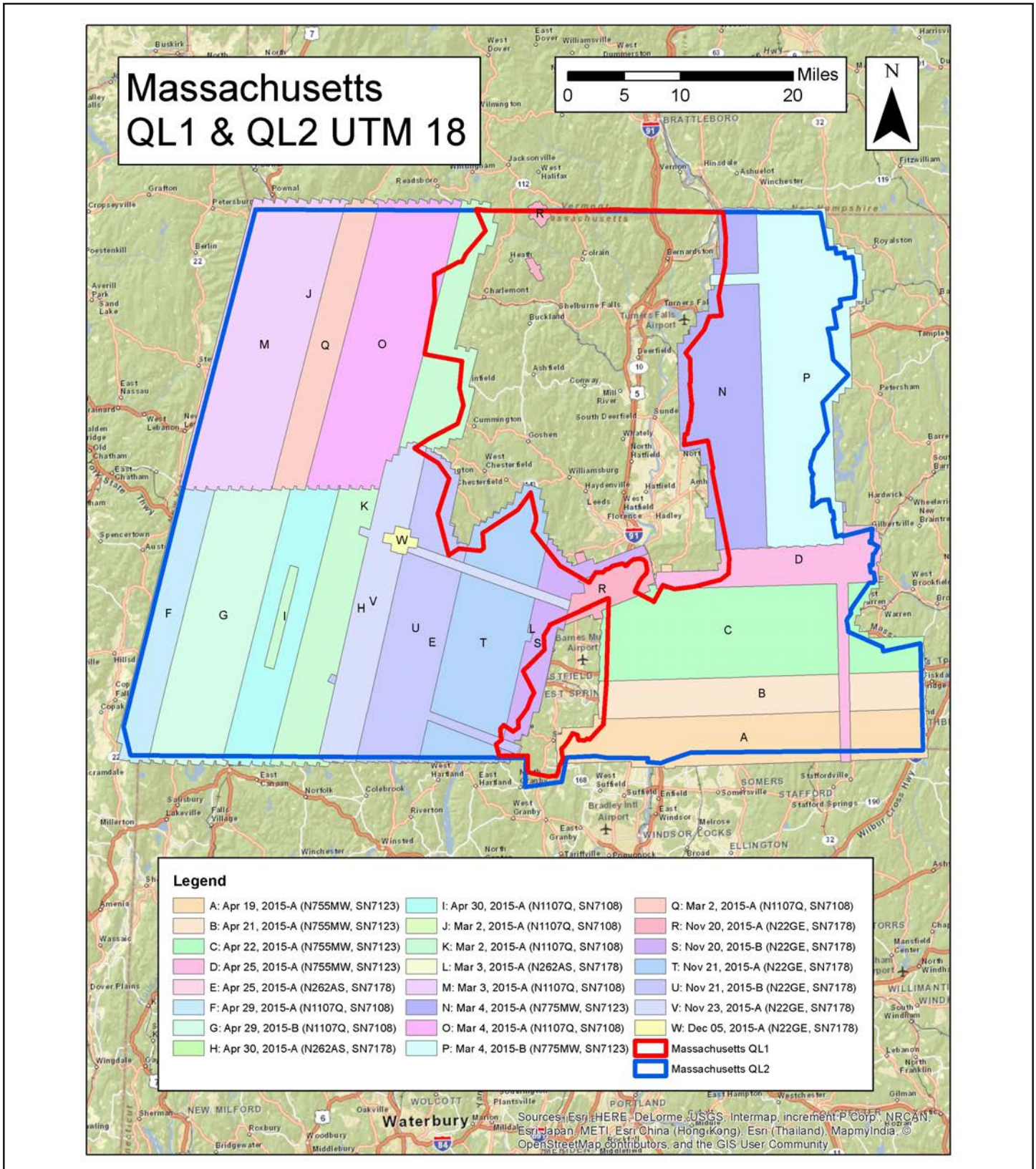




Figure 16. Flightline Swath LAS File Coverage MA QL2 UTM 19

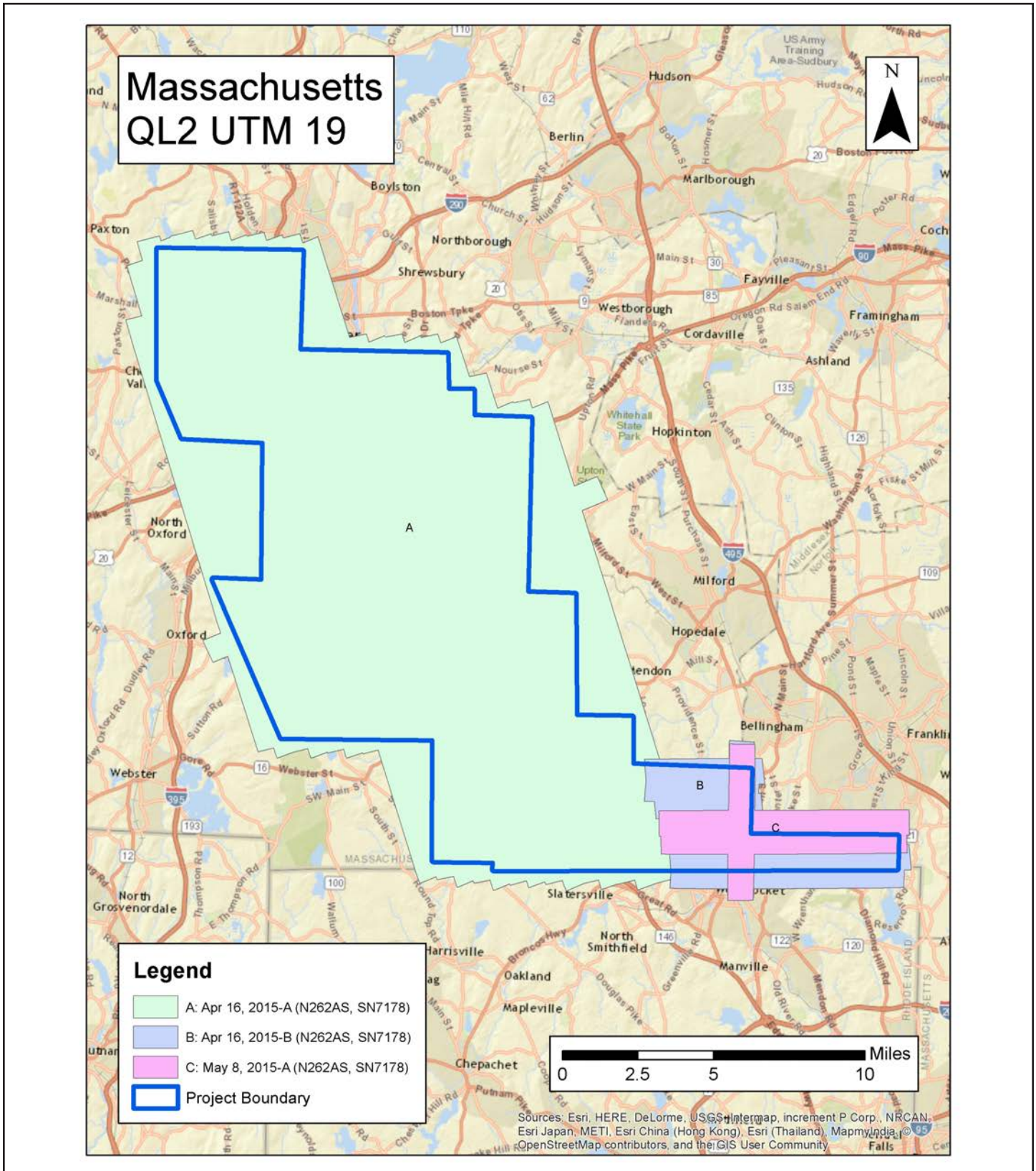
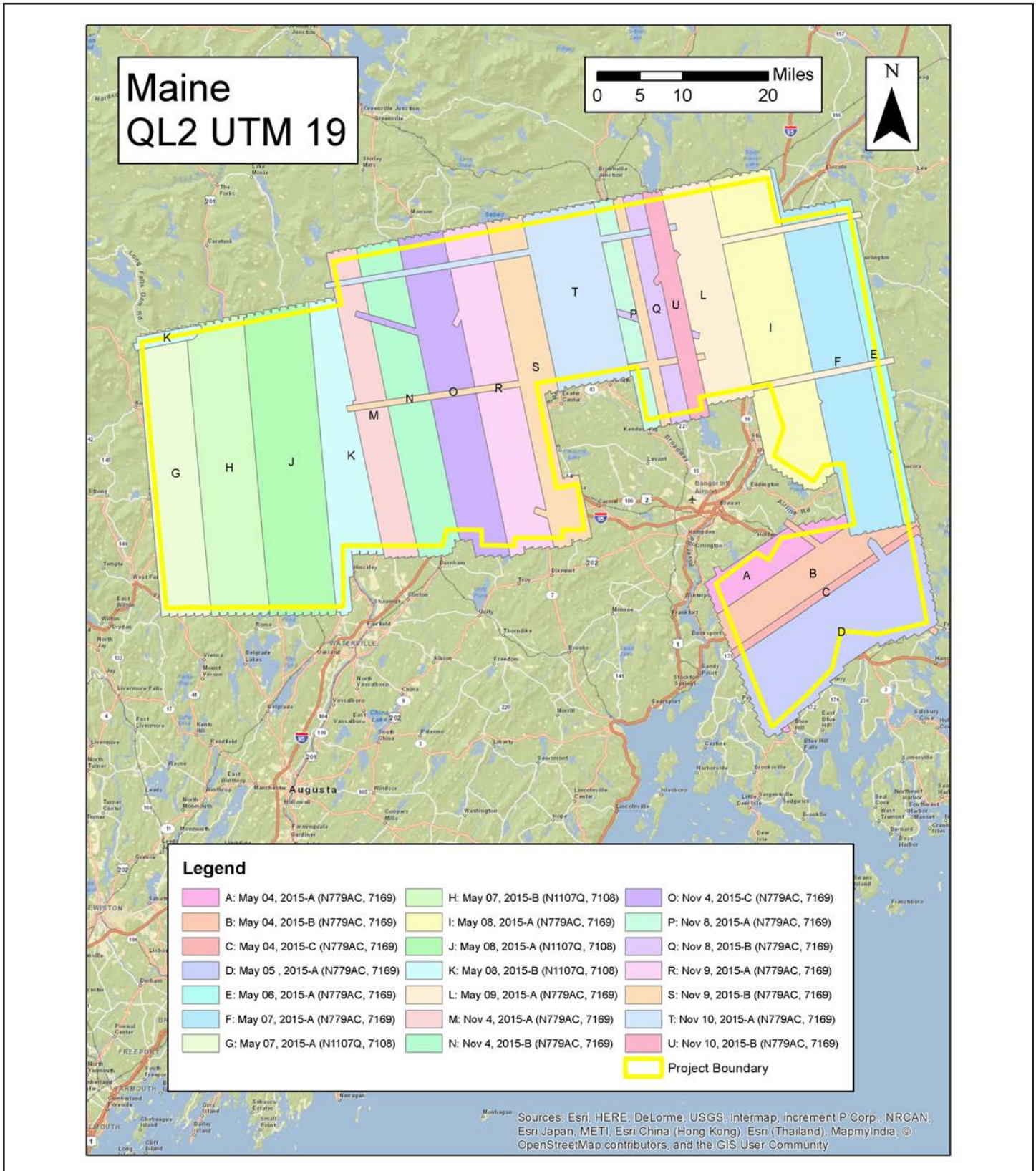




Figure 17. Flightline Swath LAS File Coverage ME QL2 UTM 19



## 5. Ground Control and Check Point Collection

Quantum Spatial completed a field survey of 275 ground control (calibration) points along with 305 blind QA points in Vegetated and Non-Vegetated land cover classifications (total of 580 points) as an independent test of the accuracy of this project. Quantum Spatial partnered with Sewall to complete the field survey in the Maine AOI.

A combination of precise GPS surveying methods, including static and RTK observations were used to establish the 3D position of ground calibration points and QA points for the point classes above. GPS was not an appropriate methodology for surveying in the forested areas during the leaf-on conditions for the actual field survey (which was accomplished after the LiDAR acquisition). Therefore the 3D positions for the forested points were acquired using a GPS-derived offset point located out in the open near the forested area, and using precise offset surveying techniques to derive the 3D position of the forested point from the open control point. The explicit goal for these surveys was to develop 3D positions that were three times greater than the accuracy requirement for the elevation surface. In this case of the blind QA points the goal was a positional accuracy of 5 cm in terms of the RMSE.

For more information, see the Survey Reports in Appendix B and Appendix C.

In this document, horizontal coordinates for ground control and QA points for all LiDAR classes are reported in NAD83 (2011) UTM Zone 18 or 19, Meters; NAVD88 (Geoid 12A), Meters based on the AOI's deliverable requirements.

The required accuracy testing was performed on the LiDAR dataset (both the LiDAR point cloud and derived DEM's) according to the USGS LiDAR Base Specification Version 1.2 (2014).

The results of the Calibration Control Point Report for the LiDAR bare earth calibration points are shown Table 6 below. Note that these results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

Table 6. Calculated Calibration Control Point Accuracy

AOI	RMSEz	St. Dev.	Table	Figure
Mass. UTM 18	0.052 m	0.052 m	Table 10	Figure 18
Mass. UTM 19	0.027 m	0.028 m	Table 11	Figure 19
Maine UTM 19	0.043 m	0.042 m	Table 12	Figure 20



## 5.1. Point Cloud Testing

The Raw Non-Vegetated Vertical Accuracy (Raw NVA) for the dataset based on TINs derived from the final calibrated and controlled LiDAR swath data is stated in terms of the RMSEz and the 95% confidence level (RMSEz x 1.96) in Table 9 below. This dataset meets the required NVA of  $\leq 19.6$  cm at the 95% confidence level (according to the National Standard for Spatial Database Accuracy (NSSDA)).

Table 7. Calculated Raw Nonvegetated Vertical Accuracy

AOI	RMSEz	95% CL	Table	Figure
Mass. UTM 18	0.071 m	0.138 m	Table 13	Figure 21
Mass. UTM 19	0.023 m	0.045 m	Table 14	Figure 22
Maine UTM 19	0.039 m	0.076 m	Table 15	Figure 23

## 5.2. Digital Elevation Model (DEM) Testing

The tested Non-Vegetated Vertical Accuracy (NVA) for the dataset captured from the DEM using bi-linear interpolation to derive the DEM elevations is stated in terms of the RMSEz as well as the 95% confidence level (RMSEz x 1.96) are listed in Table 8 below. This dataset meets the required NVA of  $\leq 19.6$  cm at the 95% confidence level (based on NSSDA). Please note that Point UA02 of the MA 18 AOI was not used in these calculations. See for more information.

Table 8. Calculated Nonvegetated Vertical Accuracy

AOI	RMSEz	95% CL	Table	Figure
Mass. UTM 18	0.070 m	0.138 m	Table 16	Figure 24
Mass. UTM 19	0.026 m	0.050 m	Table 17	Figure 25
Maine UTM 19	0.038 m	0.075 m	Table 18	Figure 25

The tested Vegetated Vertical Accuracy (VVA) for the dataset captured from the DEM using bi-linear interpolation for all classes (including the bare earth class) is stated in terms of the 95th percentile error are listed in Table 9 below. The data meets the required VVA of  $\leq 29.4$  cm. Please note that points SW05 and SW08 were not used in the MA UTM 18 calculations. See Table 17 for more information.

Table 9. Calculated Vegetated Vertical Accuracy

AOI	RMSEz	95th Percentile	Table	Figure
Mass. UTM 18	0.155 m	0.287 m	Table 19	Figure 27
Mass. UTM 19	0.064 m	0.107 m	Table 20	Figure 28
Maine UTM 19	0.145 m	0.286 m	Table 21	Figure 29

**Table 10. Control Calibration Point Report - MA UTM 18**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
CP001	646791.672	4732941.056	187.67	187.76	0.09
CP002	648364.550	4729766.698	191.70	191.71	0.01
CP003	656973.731	4730847.836	285.76	285.82	0.06
CP004	667076.080	4733105.544	594.89	594.87	-0.02
CP005	673694.050	4733322.884	584.35	584.32	-0.03
CP006	690491.967	4724664.447	295.68	295.76	0.08
CP007	691911.857	4730912.712	262.99	262.95	-0.04
CP008	699469.989	4730836.105	133.57	133.60	0.03
CP009	708928.121	4733305.360	78.61	78.59	-0.02
CP010	718085.627	4729006.257	285.48	285.48	0.00
CP012	654290.322	4720618.597	242.18	242.20	0.02
CP013	662705.368	4726238.412	572.76	572.72	-0.04
CP014	666125.553	4722150.266	304.45	304.40	-0.05
CP015	669895.481	4729793.976	488.12	488.10	-0.02
CP016	677195.420	4729393.539	442.44	442.42	-0.02
CP017	694868.994	4726537.638	214.63	214.48	-0.15
CP018	708123.453	4726452.058	83.17	83.18	0.01
CP019	711709.979	4725956.471	350.10	350.08	-0.02
CP020	727537.325	4723182.401	184.14	184.12	-0.02
CP021	645021.503	4719387.672	349.52	349.55	0.04
CP022	649208.411	4711161.278	297.53	297.67	0.14
CP024	663350.078	4713443.879	541.75	541.74	-0.01
CP025	674242.435	4721615.528	167.80	167.89	0.09
CP029	696359.472	4716914.481	81.10	81.06	-0.04
CP030	697242.094	4718876.583	76.83	76.79	-0.04
CP031	705329.843	4716614.382	99.40	99.44	0.04
CP032	718923.489	4718036.885	179.30	179.31	0.01
CP033	636512.628	4710977.691	298.87	298.84	-0.03
CP034	644811.613	4706851.845	339.05	339.08	0.03
CP035	696625.751	4705249.590	61.43	61.32	-0.11
CP036	668818.177	4705864.984	345.94	345.86	-0.08
CP037	671435.935	4709221.375	504.26	504.28	0.02

Number	Easting	Northing	Known Z	Laser Z	Dz
CP041	699384.286	4704671.915	42.16	42.17	0.01
CP042	703963.452	4707391.915	120.44	120.47	0.03
CP043	707114.748	4708545.790	165.89	165.87	-0.02
CP044	712961.790	4703245.474	373.27	373.25	-0.02
CP045	724767.590	4710735.799	172.63	172.64	0.01
CP046	633519.050	4699823.408	436.77	436.72	-0.04
CP047	638601.047	4702072.975	356.09	356.04	-0.05
CP048	648904.771	4701248.346	323.41	323.35	-0.06
CP049	659338.887	4697334.251	559.91	559.85	-0.06
CP049A	660978.115	4700232.225	611.60	611.55	-0.05
CP050	678332.098	4720784.043	161.91	161.87	-0.04
CP051	666600.474	4682901.247	183.22	183.19	-0.03
CP052	676930.749	4696869.192	427.18	427.22	0.04
CP053	687270.947	4695596.178	156.13	156.19	0.06
CP054	698094.492	4698172.349	39.55	39.49	-0.06
CP055	706590.348	4701271.976	106.36	106.34	-0.02
CP056	713640.901	4697574.392	348.29	348.24	-0.05
CP057	634369.513	4692708.031	318.06	318.17	0.12
CP058	642589.639	4696307.798	347.33	347.45	0.12
CP061	681410.407	4711853.403	373.22	373.22	0.00
CP065	694742.056	4690036.599	44.41	44.33	-0.08
CP066	701931.003	4692107.763	49.34	49.40	0.06
CP067	727052.982	4692548.215	238.55	outside	*
CP068	644194.361	4685168.565	269.78	269.86	0.09
CP069	658373.115	4680228.989	534.14	534.10	-0.04
CP074	675493.123	4678126.914	113.68	113.63	-0.05
CP076	692136.151	4682486.656	55.09	55.09	0.00
CP077	697684.483	4685233.355	41.02	40.97	-0.05
CP078	700328.774	4680720.888	63.54	63.53	-0.01
CP079	708248.203	4691306.501	117.63	117.66	0.03
CP080	709688.867	4687128.288	106.43	106.40	-0.03
CP081	715038.297	4687387.058	263.30	263.31	0.01
CP082	726910.308	4686935.269	170.72	170.71	-0.01
CP083	730127.413	4688249.633	166.31	166.29	-0.02
CP084	637697.397	4678654.742	264.03	264.05	0.02

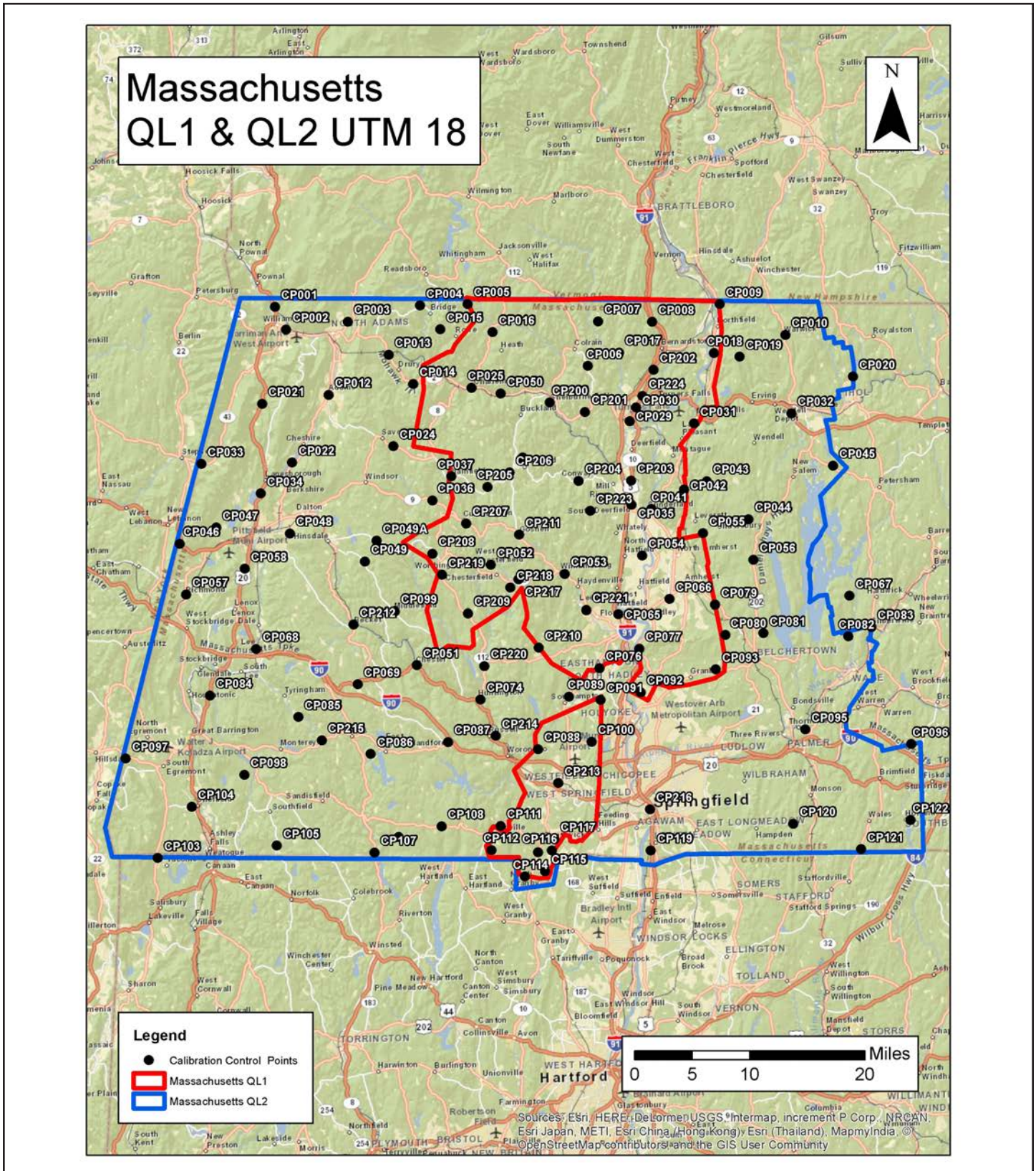


Number	Easting	Northing	Known Z	Laser Z	Dz
CP085	650076.384	4675663.172	286.48	286.55	0.07
CP086	660176.347	4670505.716	444.71	444.72	0.01
CP087	670964.931	4672153.640	453.73	453.72	-0.01
CP088	683544.680	4671160.355	111.904	111.91	0.01
CP089	687877.441	4678510.410	84.92	84.92	0.00
CP091	692290.746	4678071.633	79.66	79.67	0.01
CP092	697883.589	4679123.889	72.66	72.64	-0.02
CP093	708391.729	4682314.749	83.61	83.69	0.08
CP095	720874.864	4673920.394	109.85	109.86	0.01
CP096	735655.016	4671901.700	247.60	247.60	0.00
CP097	625970.011	4669857.840	311.06	311.15	0.09
CP098	642532.294	4667591.810	306.08	306.09	0.01
CP099	663548.940	4690398.280	512.13	512.20	0.07
CP100	691025.492	4672206.281	82.45	82.49	0.04
CP103	630435.292	4655960.188	230.11	outside	*
CP104	635158.807	4663127.487	207.15	207.25	0.10
CP105	647073.781	4657699.022	389.84	389.96	0.12
CP106	664089.588	4658913.585	412.41	412.40	-0.01
CP107	660694.703	4656731.588	238.58	238.61	0.03
CP108	670083.494	4660403.010	359.71	359.73	0.02
CP111	678324.356	4660437.930	178.38	178.37	-0.01
CP112	677015.938	4657079.608	202.48	202.49	0.01
CP113	683551.734	4656764.873	71.68	71.70	0.02
CP114	681715.890	4653380.020	118.47	118.43	-0.04
CP115	684533.020	4654093.287	71.26	71.22	-0.03
CP116	685464.559	4656996.659	73.76	73.74	-0.02
CP117	685814.437	4658618.185	70.99	70.99	0.00
CP119	699306.848	4657018.604	15.856	15.82	-0.04
CP120	719214.373	4660743.569	214.093	214.14	0.05
CP121	728655.996	4657185.207	260.696	260.74	0.04
CP122	735585.396	4661271.519	209.556	209.58	0.02
CP200	685162.990	4719554.291	149.262	149.31	0.05
CP201	690121.511	4718240.241	203.16	203.14	-0.02
CP202	699694.665	4724123.930	105.742	105.8	0.06
CP203	696532.127	4708651.620	69.376	69.41	0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
CP204	689226.916	4708599.692	168.83	168.91	0.08
CP205	676505.678	4707752.091	393.997	394.04	0.04
CP206	679592.310	4709781.364	499.474	499.44	-0.03
CP207	673493.627	4702638.646	304.331	304.34	0.01
CP208	668803.814	4698421.942	502.675	502.6	-0.07
CP209	673741.369	4690120.180	288.946	288.97	0.02
CP210	683658.010	4685342.121	188.646	188.67	0.02
CP211	680915.688	4701094.863	443.654	443.6	-0.05
CP212	657785.646	4688567.812	366.842	366.98	0.14
CP213	686381.386	4666428.176	42.496	42.51	0.01
CP214	677653.325	4673030.126	82.869	82.88	0.01
CP215	653341.908	4672413.741	445.676	445.81	0.13
CP216	699200.235	4662772.058	17.001	16.99	-0.01
CP217	680831.038	4694853.643	376.847	376.85	0.00
CP218	679656.651	4693708.067	339.82	339.74	-0.08
CP219	670112.730	4695463.911	430.031	430.02	-0.01
CP220	676068.961	4682784.122	138.408	138.38	-0.03
CP221	690301.830	4690587.554	81.353	81.36	0.01
CP223	690837.815	4704415.880	232.733	232.73	0.00
CP224	698125.428	4720479.107	81.56	81.54	-0.02
Average Dz		0.01 m			
Minimum Dz		-0.148 m			
Maximum Dz		0.138 m			
Root Mean Square		0.052 m			
Std. Deviation		0.052 m			



Figure 18. Calibration Control Points - MA UTM 18

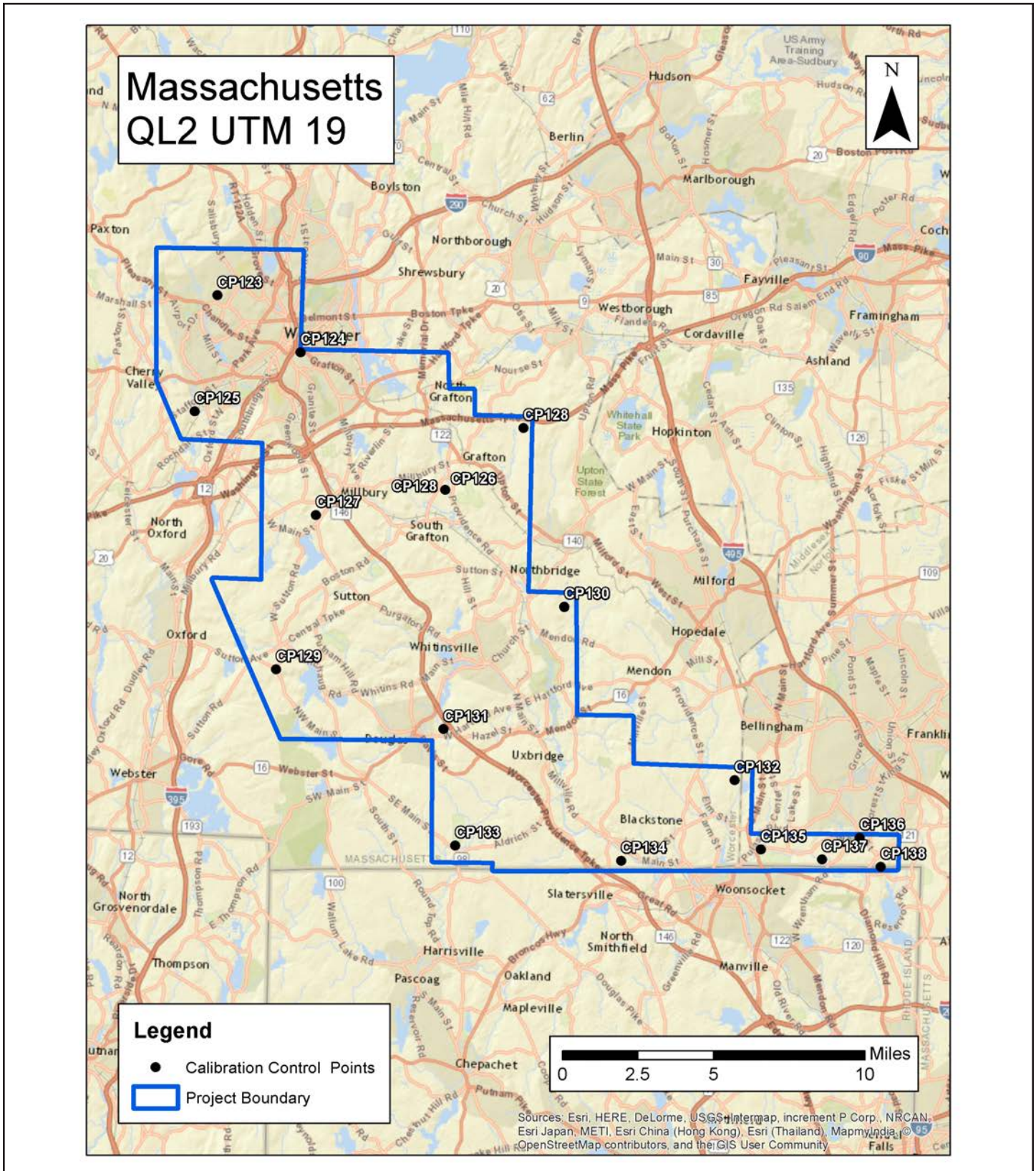




**Table 11. Control Calibration Point Report - MA UTM 19**
**Units = Meters**

Number	Easting	Northing	Known Z	Laser Z	Dz
CP123	265428.326	4685053.631	251.86	251.90	0.05
CP124	269850.045	4682016.482	155.66	155.67	0.01
CP125	264209.039	4678877.807	203.66	203.65	0.00
CP126	277539.125	4674703.342	92.28	92.26	-0.02
CP127	270667.293	4673362.543	162.60	162.57	-0.03
CP128	277539.119	4674703.341	92.28	92.26	-0.02
CP128	281706.516	4677996.385	160.02	160.05	0.03
CP129	268548.057	4665182.329	235.99	235.95	-0.04
CP130	283875.342	4668491.245	86.08	86.08	0.00
CP131	277453.589	4661992.271	106.50	106.49	-0.01
CP132	292917.837	4659281.590	78.90	78.92	0.02
CP133	278062.520	4655810.749	162.15	162.12	-0.03
CP134	286895.631	4654987.654	81.99	81.97	-0.02
CP135	294331.263	4655596.220	58.16	58.21	0.05
CP136	299581.587	4656224.493	92.47	92.49	0.02
CP137	297582.139	4655068.163	84.87	84.90	0.03
CP138	300695.328	4654668.318	119.63	119.62	-0.01
Average Dz		0.00 m			
Minimum Dz		-0.043 m			
Maximum Dz		0.055 m			
Root Mean Square		0.027 m			
Std. Deviation		0.028 m			

Figure 19. Calibration Control Points - MA UTM 19



**Table 12. Control Calibration Point Report - ME UTM 19**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
CAL10A	530547.837	4918537.332	47.97	outside	*
CAL11A	557806.821	4938129.632	30.19	30.15	-0.04
CAL12A	555569.796	4948641.050	87.79	87.84	0.05
CAL12B	555569.813	4948641.065	87.77	87.85	0.08
CAL13A	553045.339	4966953.141	106.82	106.74	-0.08
CAL13B	553045.352	4966953.147	106.77	106.74	-0.03
CAL14A	549635.524	4981266.175	103.07	103.13	0.07
CAL15A	543998.821	4964387.659	172.71	172.70	-0.01
CAL15B	543998.803	4964387.646	172.72	172.70	-0.02
CAL16A	525921.968	4946424.271	48.00	48.02	0.02
CAL16B	525921.972	4946424.274	48.01	48.02	0.02
CAL17A	530741.074	4931041.868	85.90	85.92	0.03
CAL17B	530741.063	4931041.862	85.89	85.92	0.03
CAL18A	544883.535	4937167.324	32.73	32.71	-0.02
CAL18B	544883.546	4937167.327	32.72	32.71	-0.01
CAL19A	542235.879	4949662.156	90.45	90.41	-0.04
CAL19B	542235.876	4949662.156	90.46	90.41	-0.05
CAL1A	452701.406	4991623.419	329.73	329.73	0.00
CAL1B	452701.405	4991623.417	329.71	329.73	0.03
CAL20A	542549.362	4955644.621	131.29	131.26	-0.03
CAL20B	542549.356	4955644.609	131.26	131.26	0.00
CAL21A	542860.482	5016263.710	108.59	108.59	0.00
CAL21B	542860.484	5016263.717	108.59	108.59	0.00
CAL22A	530558.535	5024788.560	60.41	outside	*
CAL22B	530558.537	5024788.563	60.39	outside	*
CAL23A	445073.723	5004608.940	389.12	outside	*
CAL24A	463566.079	5011549.774	240.50	outside	*
CAL24B	463566.078	5011549.774	240.49	outside	*
CAL25A	481059.031	5013210.611	149.00	148.99	-0.01
CAL25B	481059.032	5013210.608	148.99	148.99	0.00
CAL26A	496792.835	5016828.338	135.57	135.57	0.00
CAL26B	496792.845	5016828.341	135.57	135.57	0.00



Number	Easting	Northing	Known Z	Laser Z	Dz
CAL27A	516792.678	5020624.240	103.35	outside	*
CAL27B	516792.677	5020624.240	103.34	outside	*
CAL28A	537301.836	4962748.618	78.19	outside	*
CAL28B	537301.839	4962748.621	78.19	outside	*
CAL29A	529299.164	4969605.345	44.88	44.83	-0.05
CAL29B	529299.168	4969605.342	44.89	44.83	-0.06
CAL2A	462847.376	4961997.281	123.10	123.08	-0.02
CAL2B	462847.378	4961997.275	123.10	123.08	-0.02
CAL30A	516267.163	4981362.943	37.04	37.00	-0.04
CAL30B	516267.160	4981362.940	37.05	37.00	-0.05
CAL31A	504017.660	4977651.932	62.53	62.59	0.06
CAL31B	504017.662	4977651.944	62.51	62.59	0.08
CAL32A	494059.779	4984296.856	99.22	outside	*
CAL32B	494059.777	4984296.863	99.21	outside	*
CAL33A	522610.569	4981816.231	42.43	42.41	-0.02
CAL33B	522610.569	4981816.237	42.42	42.41	-0.01
CAL34A	458408.839	4971180.984	86.26	86.25	-0.01
CAL34B	458408.834	4971180.988	86.27	86.25	-0.02
CAL35A	470817.001	4972574.124	135.97	135.97	0.00
CAL35B	470816.992	4972574.134	135.98	135.97	-0.01
CAL36A	481939.791	4975714.747	117.95	117.94	-0.01
CAL36B	481939.808	4975714.732	117.93	117.94	0.01
CAL37A	446049.086	4984218.261	252.09	252.05	-0.04
CAL37B	446049.088	4984218.267	252.11	252.05	-0.06
CAL38A	461139.377	4994076.183	258.81	258.80	-0.01
CAL38B	461139.374	4994076.171	258.84	258.80	-0.04
CAL39A	474362.167	4989110.734	196.26	196.30	0.04
CAL39B	474362.155	4989110.740	196.28	196.30	0.03
CAL3A	476524.646	4963962.254	76.34	76.35	0.01
CAL3B	476524.649	4963962.242	76.35	76.35	0.00
CAL40A	485443.809	4997272.877	148.05	147.98	-0.07
CAL40B	485443.810	4997272.880	148.05	147.98	-0.07
CAL41A	495414.540	5004299.695	108.53	108.56	0.03
CAL41B	495414.535	5004299.710	108.50	108.56	0.06
CAL42A	502893.786	4997510.795	102.13	102.16	0.03

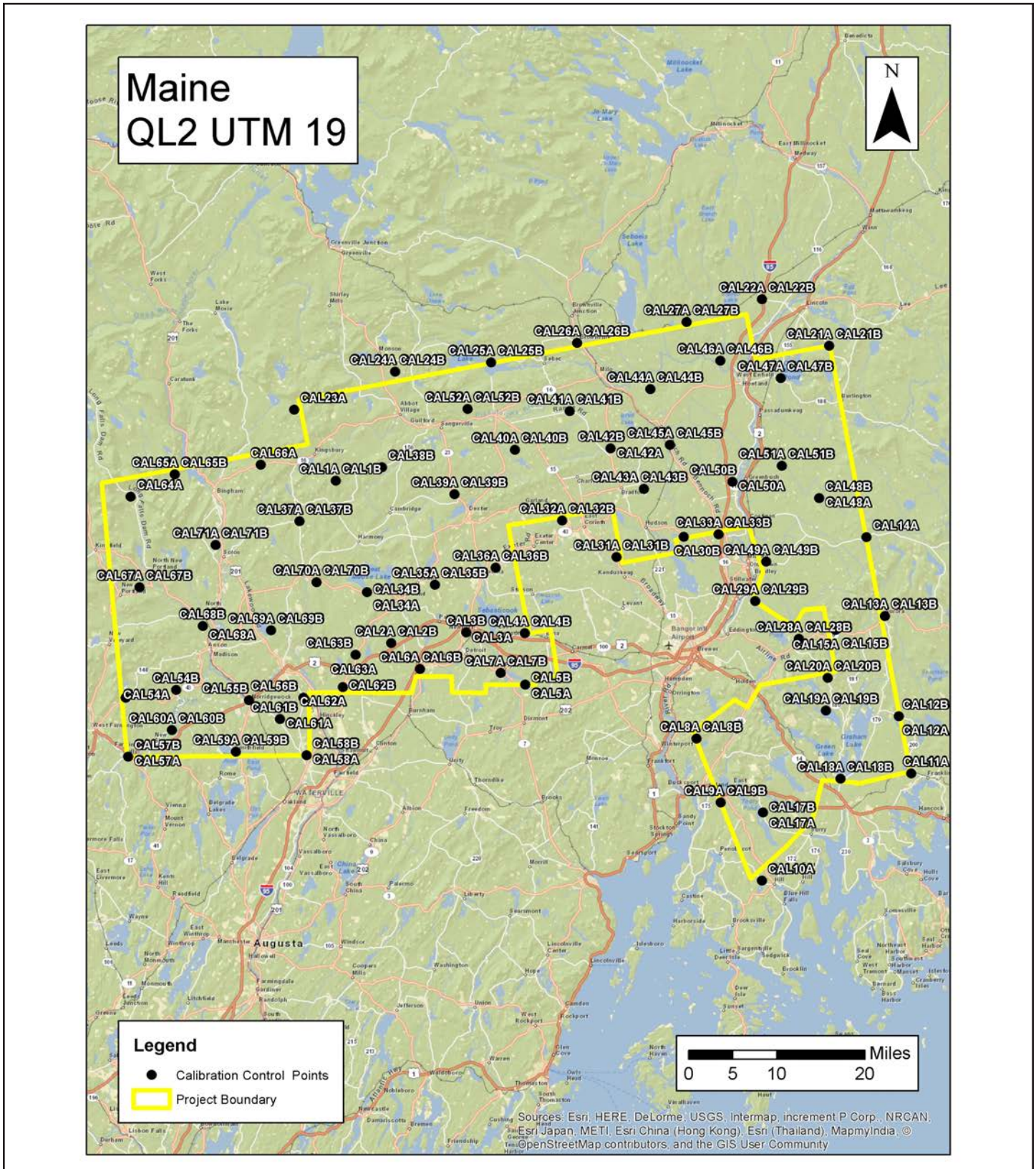
Number	Easting	Northing	Known Z	Laser Z	Dz
CAL42B	502893.788	4997510.795	102.14	102.16	0.02
CAL43A	509021.372	4990094.813	75.55	75.55	0.00
CAL43B	509021.378	4990094.807	75.55	75.55	0.00
CAL44A	510161.936	5008322.673	143.665	143.65	-0.02
CAL44B	510161.959	5008322.691	143.65	143.65	0.00
CAL45A	513728.204	4998156.027	79.82	79.81	-0.01
CAL45B	513728.204	4998156.034	79.83	79.81	-0.02
CAL46A	522992.172	5013529.719	55.00	55.03	0.03
CAL46B	522992.176	5013529.716	55.00	55.03	0.03
CAL47A	534028.981	5010379.007	58.83	58.90	0.07
CAL47B	534028.979	5010379.010	58.84	58.90	0.06
CAL48A	540990.879	4988447.049	125.13	125.16	0.03
CAL48B	540990.884	4988447.037	125.15	125.16	0.02
CAL49A	531320.754	4976796.829	34.29	34.26	-0.03
CAL49B	531320.754	4976796.829	34.29	34.26	-0.03
CAL4A	487267.025	4963831.187	76.06	76.12	0.06
CAL4B	487267.011	4963831.184	76.08	76.12	0.04
CAL50A	525148.120	4991432.495	43.01	42.94	-0.07
CAL50B	525148.114	4991432.528	42.94	42.94	0.00
CAL51A	534170.792	4994328.439	47.65	47.60	-0.05
CAL51B	534170.816	4994328.424	47.63	47.60	-0.03
CAL52A	476775.036	5004704.699	175.20	175.22	0.02
CAL52B	476775.034	5004704.705	175.22	175.22	0.01
CAL53A	414348.729	4951960.435	171.62	171.61	-0.01
CAL53B	414348.727	4951960.426	171.61	171.61	0.00
CAL54A	423533.058	4953412.157	84.42	84.44	0.02
CAL54B	423533.060	4953412.151	84.40	84.44	0.04
CAL55A	436844.214	4951551.200	68.856	68.82	-0.04
CAL55B	436844.205	4951551.210	68.902	68.82	-0.08
CAL56A	446790.016	4951966.692	99.188	99.2	0.01
CAL56B	446790.020	4951966.677	99.192	99.2	0.01
CAL57A	414791.743	4941226.086	104.865	104.83	-0.04
CAL57B	414791.735	4941226.080	104.853	104.83	-0.02
CAL58A	447354.419	4941485.386	105.387	105.34	-0.05
CAL58B	447354.418	4941485.386	105.377	105.34	-0.04

Number	Easting	Northing	Known Z	Laser Z	Dz
CAL59A	434448.130	4942104.131	83.003	83.01	0.01
CAL59B	434448.136	4942104.128	82.993	83.01	0.02
CAL5A	487304.744	4954389.793	97.452	97.41	-0.04
CAL5B	487304.740	4954389.796	97.451	97.41	-0.04
CAL60A	422734.127	4946062.723	98.248	98.21	-0.04
CAL60B	422734.128	4946062.729	98.221	98.21	-0.01
CAL61A	442477.616	4948119.158	69.727	69.67	-0.06
CAL61B	442477.622	4948119.152	69.723	69.67	-0.05
CAL62A	453991.707	4953966.334	49.607	49.57	-0.04
CAL62B	453991.698	4953966.334	49.605	49.57	-0.04
CAL63A	456353.391	4959846.709	93.725	93.8	0.08
CAL63B	456353.383	4959846.718	93.726	93.8	0.07
CAL64A	415242.359	4988673.290	201.619	201.62	0.00
CAL65A	423259.451	4992769.667	343.993	344.15	0.16
CAL65B	423259.447	4992769.679	343.997	344.15	0.15
CAL66A	439024.764	4994551.431	416.569	416.59	0.02
CAL67A	416825.675	4972130.240	130.989	130.98	-0.01
CAL67B	416825.688	4972130.246	130.988	130.98	-0.01
CAL68A	428401.025	4965129.632	126.925	126.94	0.02
CAL68B	428401.023	4965129.626	126.897	126.94	0.04
CAL69A	440860.865	4964304.750	122.107	122.06	-0.05
CAL69B	440860.865	4964304.744	122.112	122.06	-0.05
CAL6A	468121.100	4957267.800	60.15	60.17	0.02
CAL6B	468121.102	4957267.809	60.19	60.17	-0.02
CAL70A	449218.578	4973028.421	124.362	124.34	-0.02
CAL70B	449218.586	4973028.418	124.348	124.34	-0.01
CAL71A	430719.082	4979830.442	122.855	122.85	-0.01
CAL71B	430719.080	4979830.436	122.86	122.85	-0.01
CAL7A	482861.023	4956510.873	130.982	130.93	-0.05
CAL7B	482861.031	4956510.861	130.97	130.93	-0.04
CAL8A	518587.650	4944504.969	126.814	126.82	0.01
CAL8B	518587.644	4944504.969	126.83	126.82	-0.01
CAL9A	523006.732	4932811.276	25.589	25.69	0.10
CAL9B	523006.727	4932811.269	25.599	25.69	0.09



Number	Easting	Northing	Known Z	Laser Z	Dz
	Average Dz	0.00 m			
	Minimum Dz	-0.082 m			
	Maximum Dz	0.157 m			
	Root Mean Square	0.042 m			
	Std. Deviation	0.043 m			

Figure 20. Calibration Control Points - ME UTM 19



**Table 13. QA Checkpoint Report: Raw NVA - MA UTM 18**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
BE002	706840.732	4722087.332	59.55	59.59	0.042
BE3	655926.808	4692107.374	406.22	406.45	0.230
BE5	651386.954	4667666.388	523.06	523.26	0.204
BE004	708277.690	4691340.649	118.59	118.59	-0.002
BE006	711410.582	4666772.270	79.22	79.25	0.029
BE13	658547.589	4720109.323	632.31	632.35	0.040
BE317	696283.977	4667869.041	18.49	18.51	0.024
BE320	676059.029	4682862.507	138.96	138.94	-0.023
UA01	644372.331	4728824.014	368.48	368.59	0.113
UA02	652175.503	4729036.119	198.48	removed	*
UA03	662077.410	4728349.051	669.07	slope	*
UA04	672233.673	4729071.171	409.29	409.24	-0.050
UA05	678948.280	4731537.106	417.02	416.99	-0.025
UA06	688086.027	4731061.784	221.42	221.45	0.035
UA07	694010.726	4730337.923	300.50	300.40	-0.104
UA08	700924.473	4729053.759	111.72	111.77	0.048
UA09	708462.451	4730326.273	94.54	94.64	0.096
UA10	719886.005	4730894.658	310.87	310.84	-0.027
UA11	641044.932	4720825.529	325.36	325.37	0.013
UA12	653742.930	4720003.018	252.16	252.14	-0.020
UA13	660314.805	4719131.381	633.06	633.14	0.082
UA14	669354.058	4717407.329	293.57	293.54	-0.025
UA15	674750.615	4722088.443	198.42	198.43	0.011
UA17	696365.353	4717039.740	80.22	80.21	-0.009
UA18	701663.048	4720281.681	58.31	58.39	0.084
UA19	713151.966	4719650.672	142.42	142.42	0.005
UA20	720575.026	4719573.703	204.95	204.91	-0.038
UA21	638150.002	4711399.856	316.42	316.41	-0.014
UA22	648133.302	4707869.199	301.84	302.06	0.221
UA24	667283.469	4711631.639	521.72	521.70	-0.020
UA27	696670.307	4705326.196	61.54	61.53	-0.013
UA28	699992.302	4706474.358	49.15	49.23	0.080

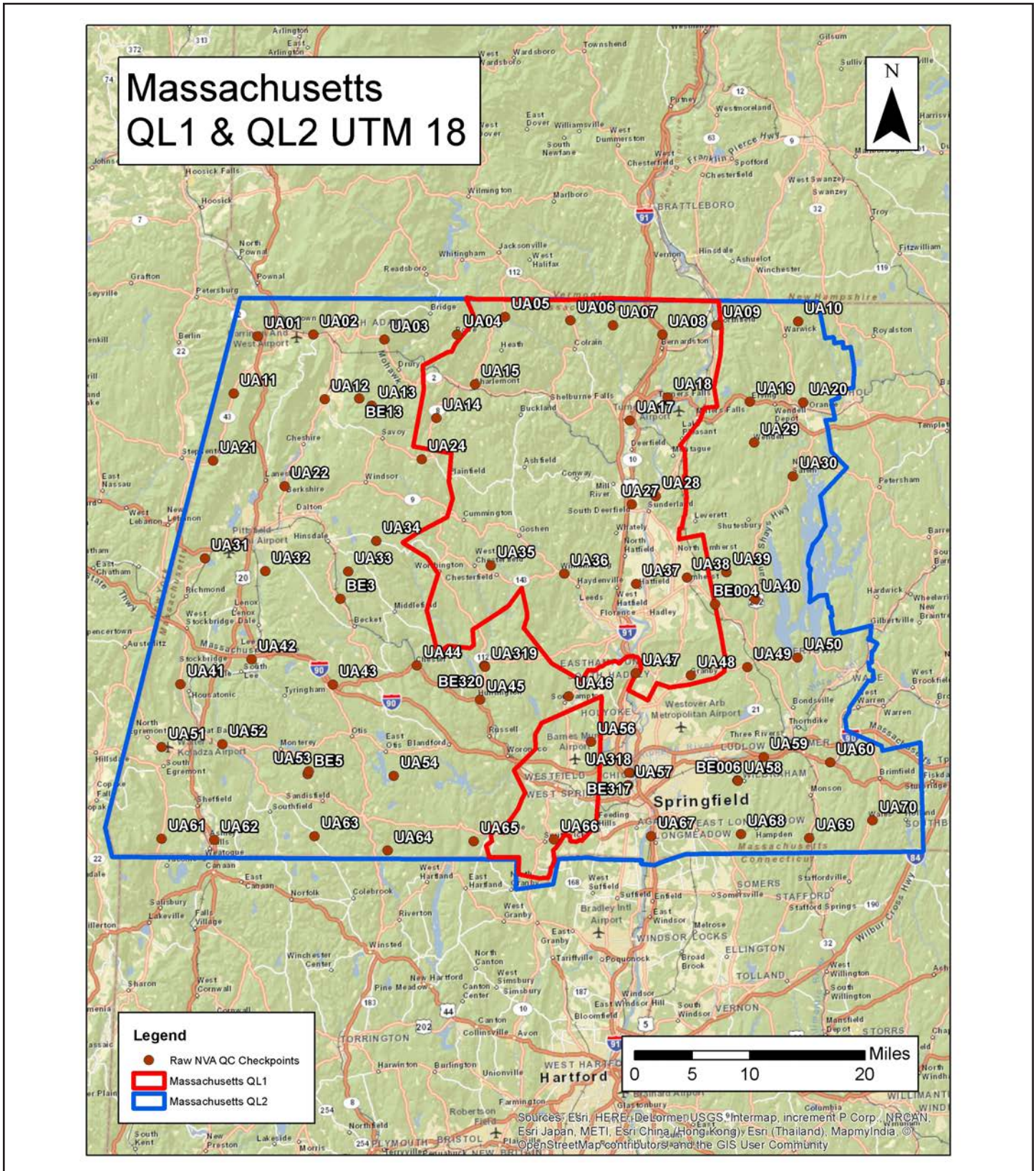


Number	Easting	Northing	Known Z	Laser Z	Dz
UA29	713742.676	4713965.443	354.98	354.98	-0.002
UA30	719147.402	4709253.992	312.66	312.68	0.022
UA31	637010.059	4697784.394	347.11	347.11	0.004
UA318	696249.397	4667861.513	18.80	18.85	0.055
UA319	676168.176	4682700.981	139.59	139.55	-0.036
UA32	645455.413	4695966.313	300.05	300.21	0.165
UA33	657025.593	4695956.620	487.70	487.73	0.027
UA34	660929.653	4700201.997	612.87	612.84	-0.029
UA35	676938.156	4696770.154	425.68	425.69	0.009
UA36	687196.206	4695624.633	156.41	156.44	0.030
UA37	697239.159	4694192.378	42.78	42.75	-0.028
UA38	704328.394	4695097.669	86.92	86.95	0.035
UA39	709873.362	4695816.517	172.68	172.61	-0.070
UA40	713884.412	4692081.796	288.31	288.32	0.007
UA41	633608.579	4680242.213	231.48	231.54	0.065
UA42	643540.603	4683714.327	276.55	276.62	0.066
UA43	654870.782	4680214.430	448.92	449.02	0.102
UA44	666617.263	4682868.227	182.34	182.38	0.042
UA45	675461.873	4678089.066	114.92	114.90	-0.015
UA46	687830.804	4678559.430	86.01	86.02	0.008
UA47	697179.939	4681796.655	40.82	40.78	-0.044
UA48	704905.513	4681496.001	102.26	102.33	0.067
UA49	712775.729	4682648.281	148.50	148.56	0.056
UA50	719799.509	4683956.653	120.93	120.96	0.032
UA51	630979.582	4671469.459	227.85	227.93	0.080
UA52	639454.734	4671865.099	298.47	298.54	0.066
UA53	651504.003	4668064.548	515.21	515.37	0.157
UA54	663388.698	4667445.904	444.60	444.65	0.049
UA56	690950.627	4672198.174	81.93	81.93	0.005
UA57	696179.450	4666156.523	22.59	22.61	0.022
UA58	711434.563	4666757.120	78.98	79.00	0.016
UA59	715049.537	4670063.678	107.65	107.70	0.049
UA60	724353.259	4669339.427	120.07	120.12	0.055
UA61	630973.453	4658649.130	230.07	230.15	0.084
UA62	638306.262	4658482.634	206.27	206.38	0.106

Number	Easting	Northing	Known Z	Laser Z	Dz
UA63	652321.113	4658969.740	429.52	429.55	0.032
UA64	662555.030	4656999.135	278.79	278.70	-0.086
UA65	674579.181	4658277.408	345.86	345.89	0.032
UA66	685786.385	4658529.738	72.11	72.15	0.037
UA67	699343.241	4659004.463	17.15	17.16	0.015
UA68	711869.632	4659303.925	76.14	76.18	0.044
UA69	721450.372	4658735.784	198.39	198.34	-0.045
UA70	730288.864	4661235.379	282.84	282.85	0.014
Average Dz		0.03 m			
Minimum Dz		-0.104 m			
Maximum Dz		0.230 m			
Root Mean Square		0.071 m			
95% Confidence Level		0.138 m			

Point UA02 was removed due to a man-made obstruction at the point location.

Figure 21. QA Checkpoints: Raw NVA - MA UTM 18



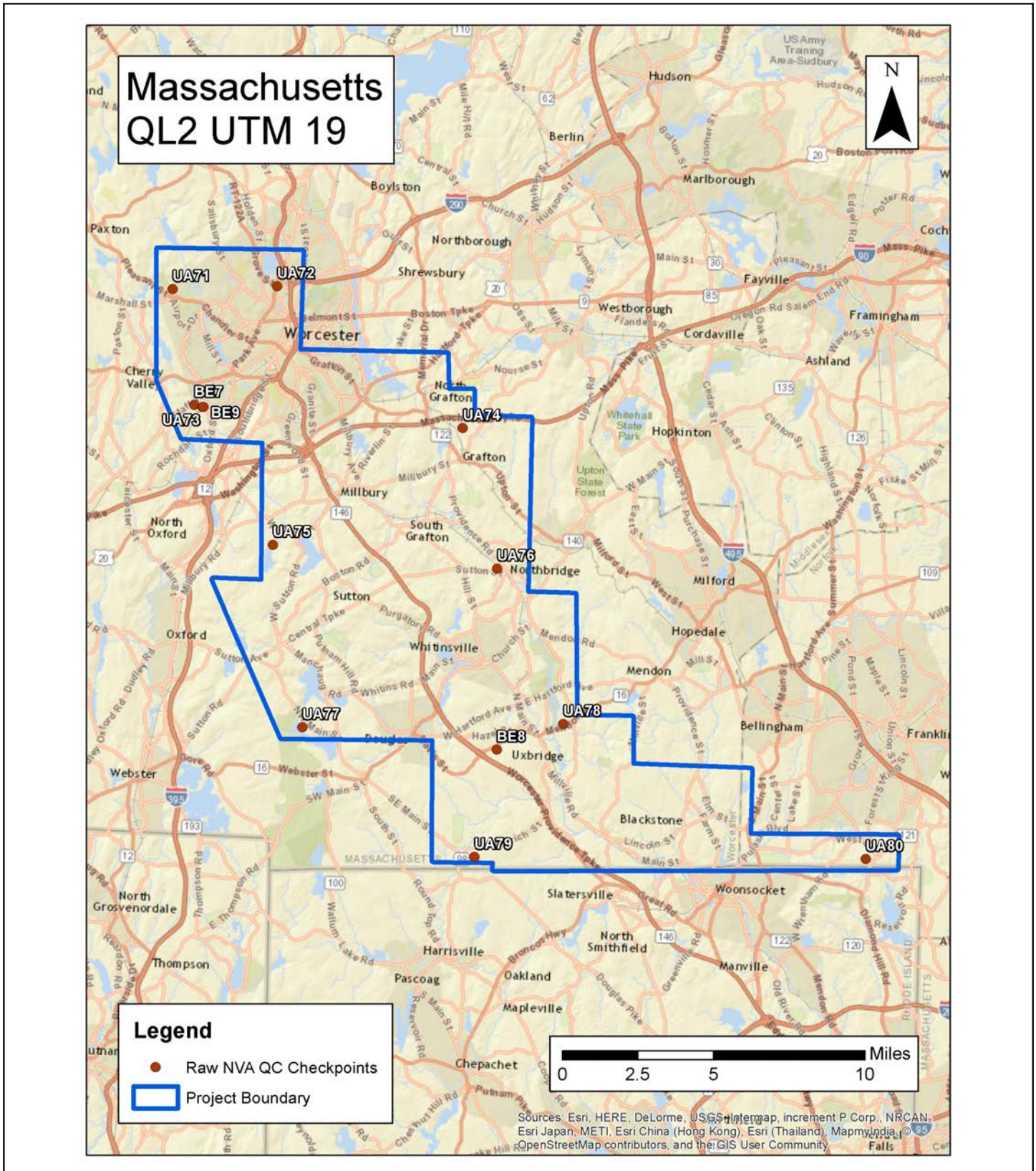


**Table 14. QA Checkpoint Report: Raw NVA - MA UTM 19**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
BE7	264202.073	4679218.207	208.16	208.21	0.05
BE8	280280.977	4660899.971	116.73	116.74	0.014
BE9	264656.328	4679110.422	163.17	163.2	0.026
UA71	263039.209	4685378.152	291.61	291.59	-0.02
UA72	268593.241	4685542.311	155.35	155.35	0
UA73	264671.918	4679117.091	163.55	163.55	0.004
UA74	278475.939	4677985.004	134.79	134.82	0.034
UA75	268364.845	4671782.339	194.12	194.13	0.014
UA76	280301.411	4670508.694	95.98	95.98	0.001
UA77	269936.046	4662093.626	202.19	202.15	-0.037
UA78	283823.850	4662273.982	73.79	73.78	-0.013
UA79	279094.110	4655199.967	170.47	170.48	0.015
UA80	299897.103	4655089.210	120.65	120.64	-0.008
Average Dz		0.023 m			
Minimum Dz		-0.037 m			
Maximum Dz		0.050 m			
Root Mean Square		0.023 m			
95% Confidence Level		0.045 m			

Figure 22. QA Checkpoints: Raw NVA - MA UTM 19



**Table 15. QA Checkpoint Report: Raw NVA - ME UTM 19**

Units = Meters

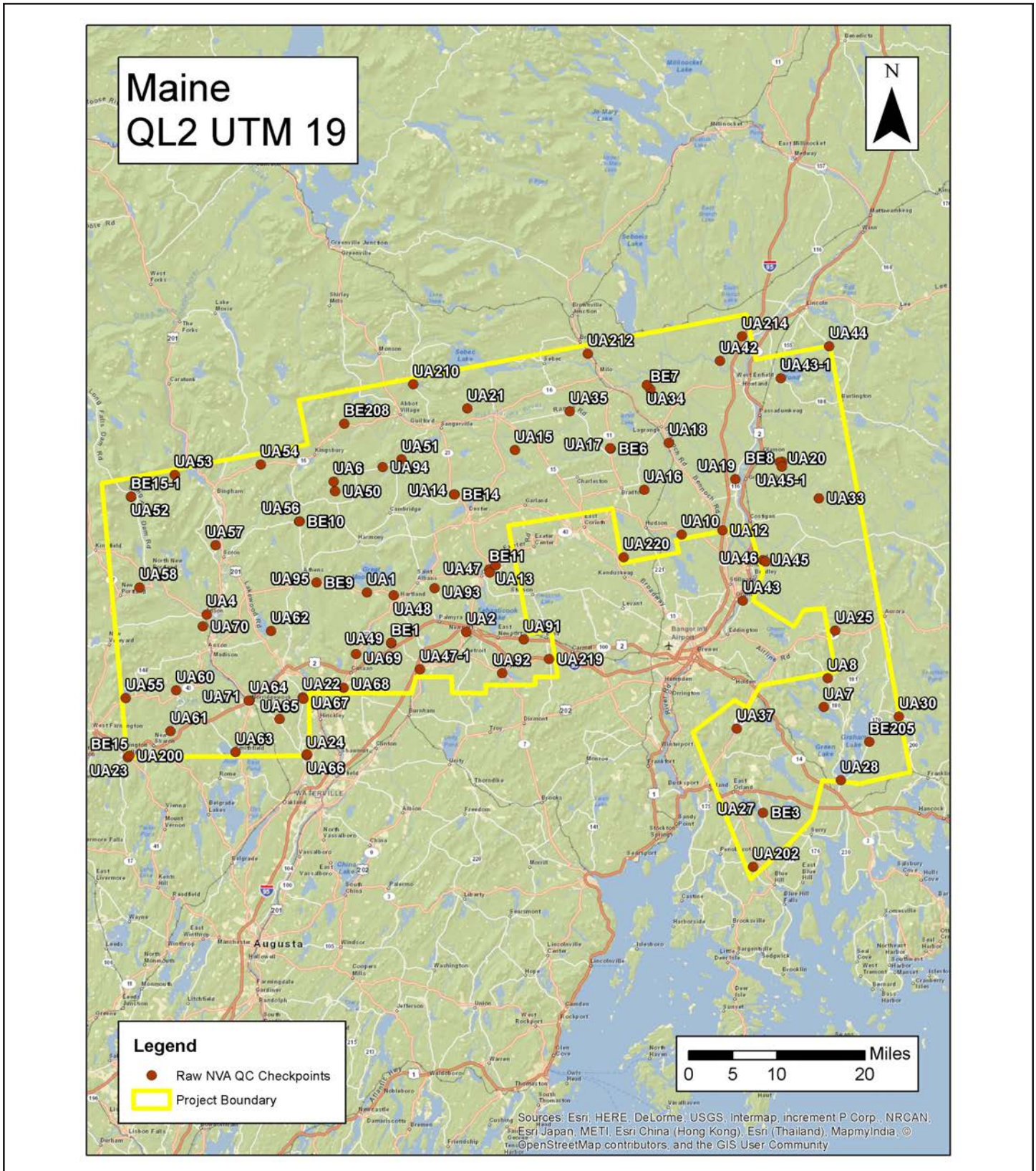
Number	Easting	Northing	Known Z	Laser Z	Dz
BE1	462846.94	4962014.01	123.25	123.35	0.1
BE3	530758.01	4931040.76	86.24	86.32	0.08
BE6	502902.23	4997482.44	102.08	102.13	0.05
BE7	510154.45	5008332.25	143.27	143.24	-0.03
BE8	534284.29	4995078.48	46.25	46.23	-0.02
BE9	449219.69	4973009.53	123.71	123.7	-0.01
BE10	446032.52	4984217.74	251.56	251.55	-0.01
BE11	480768.42	4975451.36	80.65	80.6	-0.05
BE14	474344.78	4989145.29	195.97	195.94	-0.03
BE15	414702.35	4941153.23	105.66	105.66	0
BE15-1	415270.94	4988683.49	202.04	202.03	-0.01
BE205	550164.036	4944008.133	41.67	41.73	0.065
BE208	454257.989	5002084.904	290.04	290.04	-0.001
UA1	458396.02	4971209.74	85.33	85.32	-0.01
UA2	476544.12	4964054.71	75.45	75.41	-0.04
UA4	429111.54	4967252.51	91.43	91.41	-0.02
UA6	452285.67	4991452.37	338.53	338.5	-0.03
UA7	541856.08	4950337.5	102.22	102.19	-0.03
UA8	542566.37	4955617.3	130.99	130.98	-0.01
UA10	515911.99	4981779.02	41.09	41.06	-0.03
UA12	523329.39	4982574.47	43.14	43.09	-0.05
UA13	481895.77	4976157.5	114.56	114.52	-0.04
UA14	474370.7	4989163.74	196.69	196.67	-0.02
UA15	485443.81	4997272.88	148.05	147.98	-0.07
UA16	509049.15	4989959.15	74.51	74.48	-0.03
UA17	502863.55	4997548.2	102.16	102.16	0
UA18	513533.47	4998530.72	80.32	80.32	0
UA19	525677.88	4991925.74	38.8	38.74	-0.06
UA20	533822.15	4995033.29	56.67	56.7	0.03
UA21	476740.9	5004824.99	175.99	176.01	0.02
UA22	446672.45	4952142.99	103.13	103.15	0.02
UA23	414692.53	4941159.37	105.35	105.34	-0.01



Number	Easting	Northing	Known Z	Laser Z	Dz
UA24	447350.01	4941502.04	105.58	105.56	-0.02
UA25	543944.52	4964348.44	173.79	173.81	0.02
UA27	530732.9	4931031.56	86.21	86.25	0.04
UA28	544980.28	4936994.61	31.3	31.35	0.05
UA30	555556.36	4948638.62	87.54	87.55	0.01
UA33	540982.17	4988447.7	124.92	124.98	0.06
UA34	509498.64	5009130.01	166.56	166.54	-0.02
UA35	495419.48	5004309.37	108.52	108.49	-0.03
UA37	525950.5	4946411.77	47.21	47.18	-0.03
UA42	522899.54	5013576.6	56.24	56.24	0
UA43	527026.65	4969745.93	22.47	outside	*
UA43-1	534022.45	5010394.92	59.24	59.22	-0.02
UA44	542867.24	5016241.16	108.51	108.47	-0.04
UA45	530727.34	4977148.56	34.61	34.62	0.01
UA45-1	534182.91	4994186.86	41.7	41.73	0.03
UA46	531236.26	4976834.07	34.04	33.98	-0.06
UA47	480792.72	4974871.33	84.27	84.26	-0.01
UA47-1	468114.53	4957242.21	60.38	60.36	-0.02
UA48	463287.65	4970714.05	99.55	99.51	-0.04
UA49	462838.28	4962135.81	123.32	123.29	-0.03
UA50	452588.01	4989721.7	274.99	274.95	-0.04
UA51	464709.43	4995531.12	164.34	164.3	-0.04
UA52	415280.75	4988721.84	204.09	204.06	-0.03
UA53	423302.66	4992724.74	339.01	339	-0.01
UA54	439015.1	4994582.62	415.94	415.96	0.02
UA55	414329.81	4951976.6	171.75	171.75	0
UA56	446061.6	4984219.3	252.41	252.42	0.01
UA57	430720.5	4979841.39	122.77	122.73	-0.04
UA58	416827.75	4972145.29	131.18	131.14	-0.04
UA60	423571.68	4953423.05	85.14	85.12	-0.02
UA61	422513.19	4945936.12	95.42	95.34	-0.08
UA62	440872.22	4964283.09	122.21	122.2	-0.01
UA63	434415.67	4942112.89	83.19	83.2	0.01
UA64	436918.46	4951531.16	69.05	69.03	-0.02
UA65	442456.16	4948131.31	69.84	69.75	-0.09

Number	Easting	Northing	Known Z	Laser Z	Dz
UA66	447470.77	4941726.39	106.86	106.85	-0.01
UA67	446811.81	4951867.59	98.4	98.43	0.03
UA68	454124.21	4953863.93	56.08	56.1	0.02
UA69	456376.28	4960049.01	96.42	96.45	0.03
UA70	428391.35	4965113.31	127.1	127.09	-0.01
UA71	436806.48	4951559.35	69.03	68.96	-0.07
UA91	487025.36	4962710.21	78.41	78.45	0.04
UA92	483113.13	4956549.83	104.82	104.72	-0.1
UA93	470734.74	4972004.28	147.88	147.85	-0.03
UA94	461302.01	4994134.33	265.75	265.76	0.01
UA95	449220.83	4973001.88	123.62	123.63	0.01
UA200	414940.014	4941485.056	105.81	105.75	-0.057
UA202	528924.951	4921140.891	109.04	109.1	0.064
UA210	466836.38	5009236.629	151.86	151.91	0.048
UA212	498750.795	5014859.191	139.43	139.47	0.044
UA214	526945.522	5017999.736	71.31	71.29	-0.018
UA219	491668.768	4959153.124	91.96	91.95	-0.006
UA220	505271.998	4977651.999	55.09	55.13	0.036
Average Dz		-0.01 m			
Minimum Dz		-0.100 m			
Maximum Dz		0.100 m			
Root Mean Square		0.039 m			
95% Confidence Level		0.076 m			

Figure 23. QA Checkpoints: Raw NVA - ME UTM 19





**Table 16. QA Checkpoint Report: NVA - MA UTM 18**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
BE002	706840.73	4722087.33	59.55	59.58	0.03
BE3	655926.81	4692107.37	406.22	406.44	0.22
BE5	651386.95	4667666.39	523.06	523.28	0.22
BE004	708277.69	4691340.65	118.59	118.58	-0.01
BE006	711410.58	4666772.27	79.22	79.25	0.03
BE13	658547.59	4720109.32	632.31	632.35	0.04
BE317	696283.98	4667869.04	18.49	18.54	0.05
BE320	676059.03	4682862.51	138.96	138.93	-0.03
UA01	644372.33	4728824.01	368.48	368.6	0.13
UA02	652175.5	4729036.12	198.48	*	*
UA03	662077.41	4728349.05	669.07	669.09	0.02
UA04	672233.67	4729071.17	409.29	409.25	-0.04
UA05	678948.28	4731537.1	417.02	416.99	-0.02
UA06	688086.03	4731061.78	221.41	221.44	0.03
UA07	694010.73	4730337.92	300.5	300.4	-0.1
UA08	700924.47	4729053.76	111.72	111.79	0.06
UA09	708462.45	4730326.27	94.54	94.63	0.09
UA10	719886.01	4730894.66	310.87	310.83	-0.03
UA11	641044.93	4720825.53	325.36	325.36	0.01
UA12	653742.93	4720003.02	252.16	252.14	-0.02
UA13	660314.81	4719131.38	633.06	633.14	0.09
UA14	669354.06	4717407.33	293.57	293.54	-0.02
UA15	674750.62	4722088.44	198.42	198.41	-0.01
UA17	696365.35	4717039.74	80.22	80.21	-0.01
UA18	701663.05	4720281.68	58.31	58.36	0.06
UA19	713151.97	4719650.67	142.41	142.43	0.02
UA20	720575.03	4719573.7	204.95	204.9	-0.05
UA21	638150	4711399.86	316.42	316.42	0
UA22	648133.3	4707869.2	301.84	302.04	0.2
UA24	667283.47	4711631.64	521.72	521.7	-0.02
UA27	696670.31	4705326.2	61.54	61.55	0.01
UA28	699992.3	4706474.36	49.15	49.24	0.09

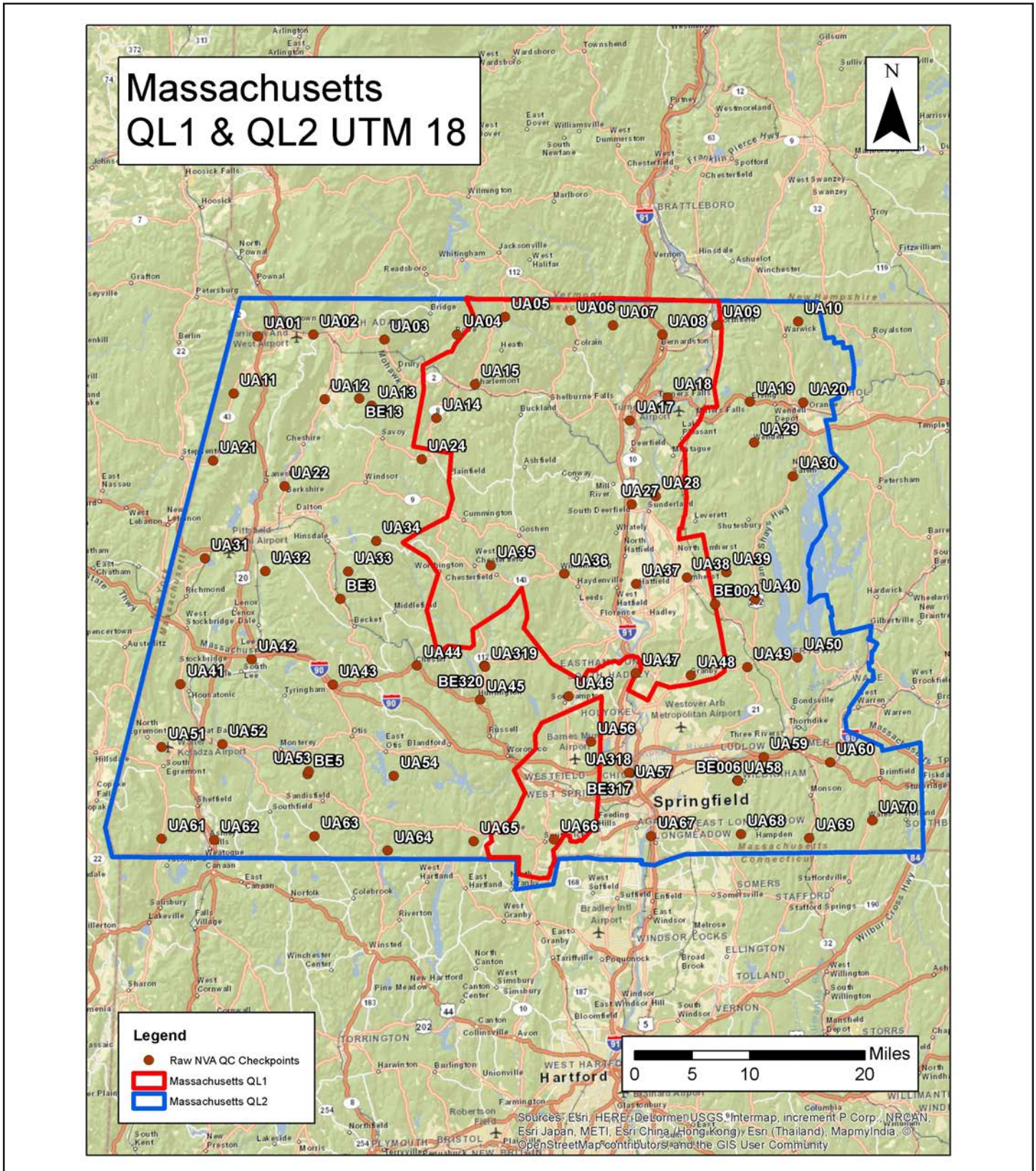
Number	Easting	Northing	Known Z	Laser Z	Dz
UA29	713742.68	4713965.44	354.98	354.98	0
UA30	719147.4	4709253.99	312.66	312.67	0.01
UA31	637010.06	4697784.39	347.11	347.11	0.01
UA318	696249.4	4667861.51	18.8	18.85	0.06
UA319	676168.176	4682701	139.59	139.55	-0.03
UA32	645455.413	4695966.3	300.05	300.2	0.16
UA33	657025.593	4695956.6	487.7	487.71	0.01
UA34	660929.653	4700202	612.87	612.86	-0.01
UA35	676938.156	4696770.2	425.68	425.7	0.02
UA36	687196.206	4695624.6	156.41	156.45	0.04
UA37	697239.159	4694192.4	42.78	42.74	-0.04
UA38	704328.394	4695097.7	86.92	86.97	0.06
UA39	709873.362	4695816.5	172.68	172.62	-0.06
UA40	713884.412	4692081.8	288.31	288.31	0
UA41	633608.579	4680242.2	231.48	231.54	0.07
UA42	643540.603	4683714.3	276.55	276.62	0.07
UA43	654870.782	4680214.4	448.92	449.01	0.1
UA44	666617.263	4682868.2	182.34	182.36	0.02
UA45	675461.873	4678089.1	114.92	114.9	-0.01
UA46	687830.804	4678559.4	86.01	85.98	-0.03
UA47	697179.939	4681796.7	40.82	40.78	-0.04
UA48	704905.513	4681496	102.26	102.33	0.07
UA49	712775.729	4682648.3	148.5	148.56	0.06
UA50	719799.509	4683956.7	120.93	120.97	0.04
UA51	630979.582	4671469.5	227.85	227.95	0.1
UA52	639454.734	4671865.1	298.47	298.55	0.07
UA53	651504.003	4668064.5	515.21	515.37	0.15
UA54	663388.698	4667445.9	444.6	444.64	0.04
UA56	690950.627	4672198.2	81.93	81.92	0
UA57	696179.45	4666156.5	22.59	22.6	0.02
UA58	711434.563	4666757.1	78.98	79	0.01
UA59	715049.537	4670063.7	107.65	107.7	0.05
UA60	724353.259	4669339.4	120.07	120.12	0.05
UA61	630973.453	4658649.1	230.07	230.15	0.09
UA62	638306.262	4658482.6	206.27	206.38	0.11

Number	Easting	Northing	Known Z	Laser Z	Dz
UA63	652321.113	4658969.7	429.52	429.55	0.03
UA64	662555.03	4656999.1	278.79	278.7	-0.09
UA65	674579.181	4658277.4	345.86	345.89	0.03
UA66	685786.385	4658529.7	72.11	72.15	0.04
UA67	699343.241	4659004.5	17.15	17.17	0.02
UA68	711869.632	4659303.9	76.14	76.18	0.05
UA69	721450.372	4658735.8	198.38	198.35	-0.04
UA70	730288.864	4661235.4	282.84	282.87	0.03
Average Dz		0.03 m			
Minimum Dz		-0.100 m			
Maximum Dz		0.225 m			
Root Mean Square		0.070 m			
95% Confidence Level		0.138 m			

Point UA02 was removed due to a man-made obstruction at the point location.



Figure 24. QA Checkpoints: NVA - MA UTM 18

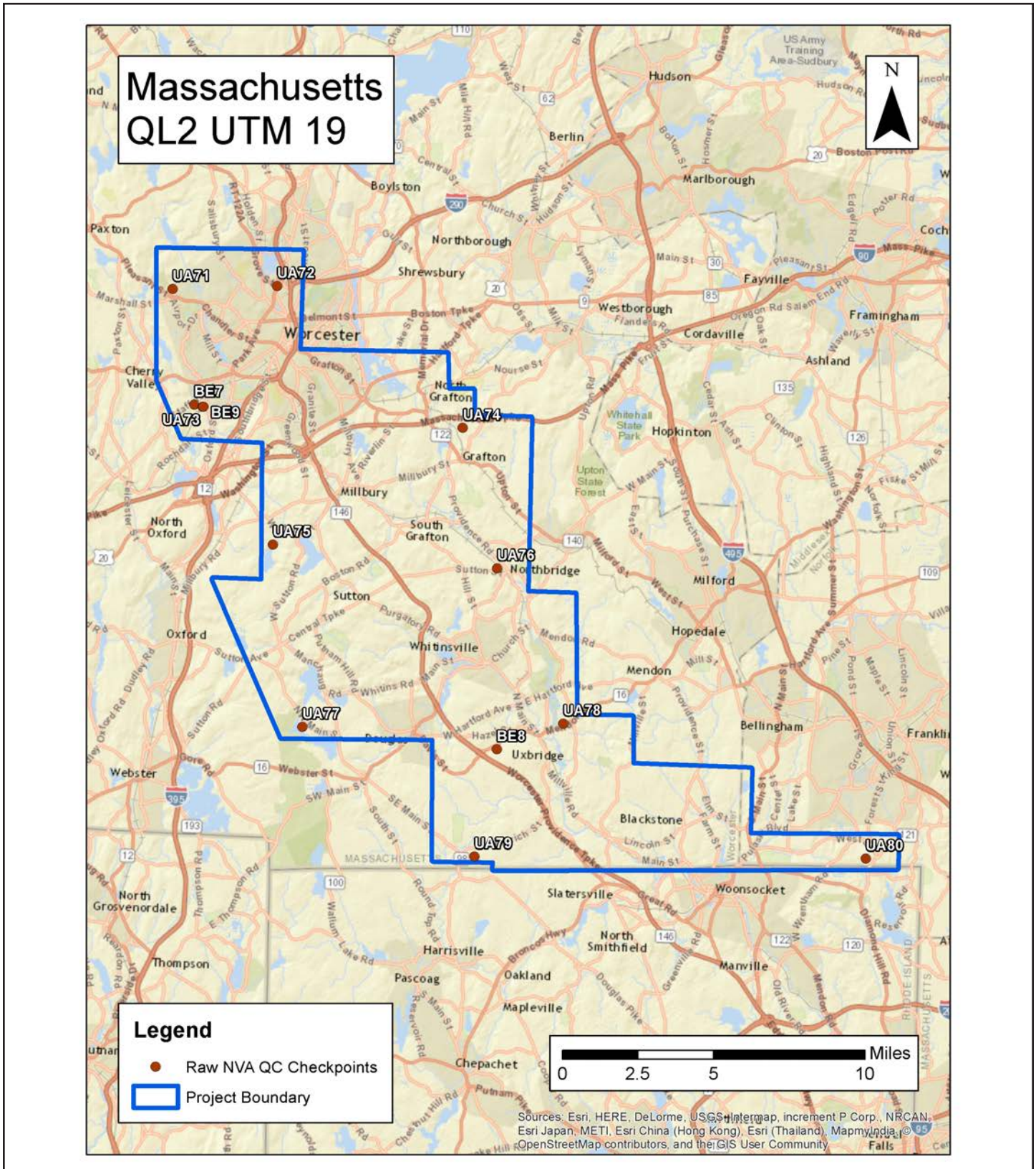


**Table 17. QA Checkpoint Report: NVA - MA UTM 19**
**Units = Meters**

Number	Easting	Northing	Known Z	Laser Z	Dz
BE7	264202.07	4679218.21	208.16	208.23	0.07
BE8	280280.98	4660899.97	116.73	116.75	0.02
BE9	264656.33	4679110.42	163.17	163.18	0.01
UA71	263039.21	4685378.15	291.61	291.63	0.02
UA72	268593.24	4685542.31	155.35	155.36	0.01
UA73	264671.92	4679117.09	163.55	163.58	0.03
UA74	278475.94	4677985	134.79	134.81	0.02
UA75	268364.85	4671782.34	194.12	194.11	-0.01
UA76	280301.41	4670508.69	95.98	95.99	0.01
UA77	269936.05	4662093.63	202.19	202.16	-0.03
UA78	283823.85	4662273.98	73.79	73.79	-0.01
UA79	279094.11	4655199.97	170.47	170.47	0.01
UA80	299897.1	4655089.21	120.65	120.65	0
Average Dz		0.01 m			
Minimum Dz		-0.028 m			
Maximum Dz		0.069 m			
Root Mean Square		0.026 m			
95% Confidence Level		0.050 m			



Figure 25. QA Checkpoints: NVA - MA UTM 19





**Table 18. QA Checkpoint Report: NVA - ME UTM 19**

Units = Meters

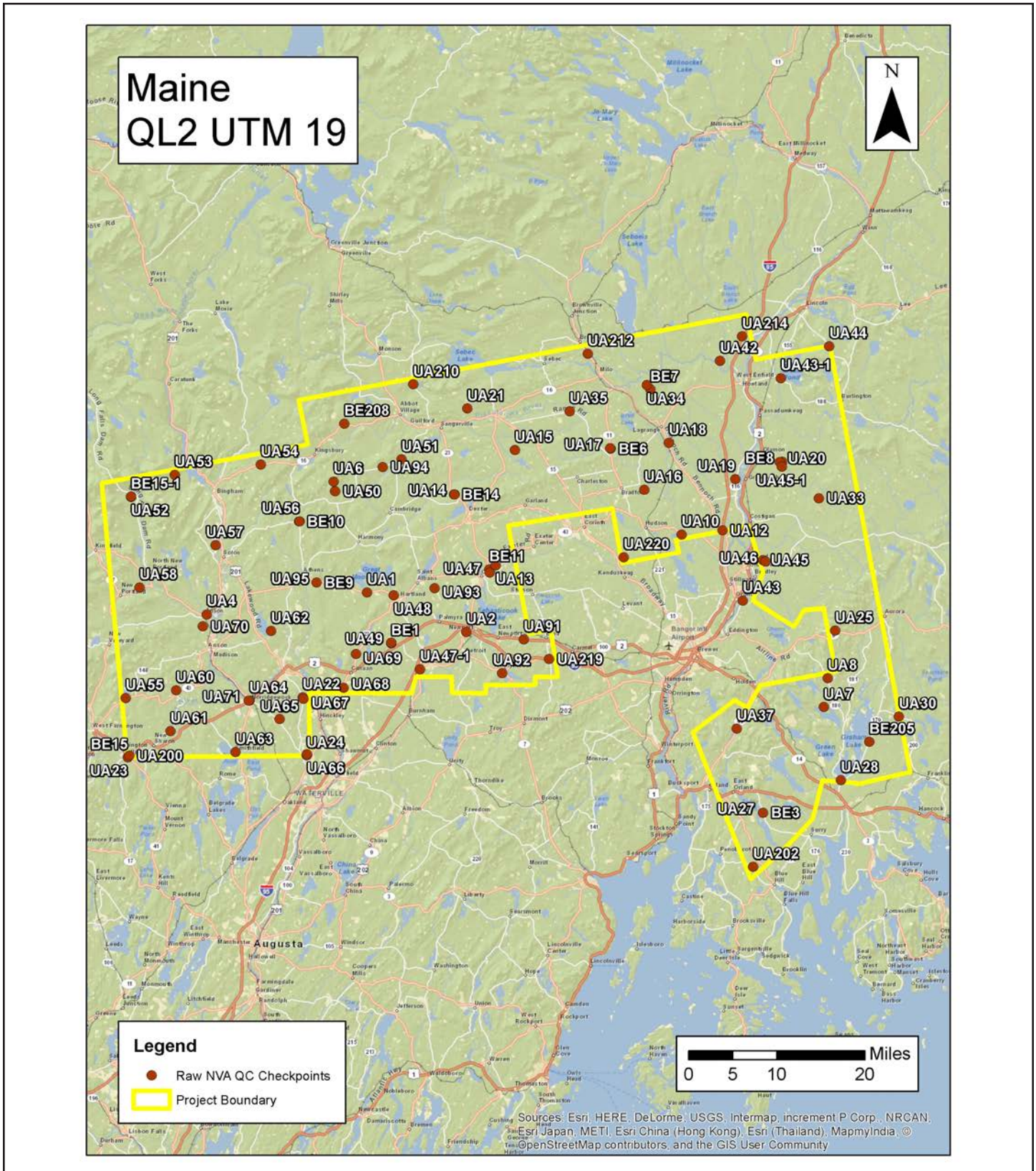
Number	Easting	Northing	Known Z	Laser Z	Dz
BE1	462846.94	4962014.01	123.25	123.3	0.05
BE3	530758.01	4931040.76	86.24	86.3	0.06
BE6	502902.23	4997482.44	102.08	102.13	0.05
BE7	510154.45	5008332.25	143.27	143.25	-0.02
BE8	534284.29	4995078.48	46.25	46.22	-0.03
BE9	449219.69	4973009.53	123.71	123.68	-0.03
BE10	446032.52	4984217.74	251.56	251.58	0.02
BE11	480768.42	4975451.36	80.65	80.65	0
BE14	474344.78	4989145.29	195.97	195.95	-0.02
BE15	414702.35	4941153.23	105.66	105.64	-0.02
BE15-1	415270.94	4988683.49	202.04	202.03	-0.01
BE205	550164.04	4944008.13	41.67	41.74	0.07
BE208	454257.99	5002084.9	290.04	290.03	-0.01
UA1	458396.02	4971209.74	85.33	85.34	0.01
UA2	476544.12	4964054.71	75.45	75.47	0.02
UA4	429111.54	4967252.51	91.43	91.41	-0.02
UA6	452285.67	4991452.37	338.53	338.5	-0.03
UA7	541856.08	4950337.5	102.22	102.19	-0.03
UA8	542566.37	4955617.3	130.99	130.98	-0.01
UA10	515911.99	4981779.02	41.09	41.04	-0.05
UA12	523329.39	4982574.47	43.14	43.09	-0.05
UA13	481895.77	4976157.5	114.56	114.52	-0.04
UA14	474370.7	4989163.74	196.69	196.68	-0.01
UA15	485443.81	4997272.88	148.05	147.98	-0.07
UA16	509049.15	4989959.15	74.51	74.53	0.02
UA17	502863.55	4997548.2	102.16	102.16	0
UA18	513533.47	4998530.72	80.32	80.33	0.01
UA19	525677.88	4991925.74	38.8	38.75	-0.05
UA20	533822.15	4995033.29	56.67	56.7	0.03
UA21	476740.9	5004824.99	175.99	176	0.01
UA22	446672.45	4952142.99	103.13	103.14	0.01
UA23	414692.53	4941159.37	105.35	105.34	-0.01

Number	Easting	Northing	Known Z	Laser Z	Dz
UA24	447350.01	4941502.04	105.58	105.55	-0.03
UA25	543944.52	4964348.44	173.79	173.81	0.02
UA27	530732.9	4931031.56	86.21	86.21	0
UA28	544980.28	4936994.61	31.3	31.35	0.05
UA30	555556.36	4948638.62	87.54	87.58	0.04
UA33	540982.17	4988447.7	124.92	124.96	0.04
UA34	509498.64	5009130.01	166.56	166.55	-0.01
UA35	495419.48	5004309.37	108.52	108.49	-0.03
UA37	525950.5	4946411.77	47.21	47.18	-0.03
UA42	522899.54	5013576.6	56.24	56.24	0
UA43	527026.65	4969745.93	22.47	outside	outside
UA43-1	534022.45	5010394.92	59.24	59.22	-0.02
UA44	542867.24	5016241.16	108.51	108.5	-0.01
UA45	530727.34	4977148.56	34.61	34.6	-0.01
UA45-1	534182.91	4994186.86	41.7	41.7	0
UA46	531236.26	4976834.07	34.04	33.98	-0.06
UA47	480792.72	4974871.33	84.27	84.26	-0.01
UA47-1	468114.53	4957242.21	60.38	60.38	0
UA48	463287.65	4970714.05	99.55	99.51	-0.04
UA49	462838.28	4962135.81	123.32	123.33	0.01
UA50	452588.01	4989721.7	274.99	274.93	-0.06
UA51	464709.43	4995531.12	164.34	164.3	-0.04
UA52	415280.75	4988721.84	204.09	204.07	-0.02
UA53	423302.66	4992724.74	339.01	339.13	0.12
UA54	439015.1	4994582.62	415.94	415.96	0.02
UA55	414329.81	4951976.6	171.75	171.73	-0.02
UA56	446061.6	4984219.3	252.41	252.43	0.02
UA57	430720.5	4979841.39	122.77	122.73	-0.04
UA58	416827.75	4972145.29	131.18	131.14	-0.04
UA60	423571.68	4953423.05	85.14	85.15	0.01
UA61	422513.19	4945936.12	95.42	95.34	-0.08
UA62	440872.22	4964283.09	122.21	122.2	-0.01
UA63	434415.67	4942112.89	83.19	83.21	0.02
UA64	436918.46	4951531.16	69.05	69.03	-0.02
UA65	442456.16	4948131.31	69.84	69.76	-0.08

Number	Easting	Northing	Known Z	Laser Z	Dz
UA66	447470.77	4941726.39	106.86	106.79	-0.07
UA67	446811.81	4951867.59	98.4	98.42	0.02
UA68	454124.21	4953863.93	56.08	56.12	0.04
UA69	456376.28	4960049	96.42	96.45	0.03
UA70	428391.35	4965113.31	127.1	127.09	-0.01
UA71	436806.48	4951559.35	69.03	68.98	-0.05
UA91	487025.36	4962710.21	78.41	78.46	0.05
UA92	483113.13	4956549.83	104.82	104.72	-0.1
UA93	470734.74	4972004.28	147.88	147.86	-0.02
UA94	461302.01	4994134.33	265.75	265.76	0.01
UA95	449220.83	4973001.88	123.62	123.62	0
UA200	414940.01	4941485.06	105.81	105.74	-0.06
UA202	528924.95	4921140.89	109.04	109.09	0.06
UA210	466836.38	5009236.63	151.86	151.91	0.04
UA212	498750.8	5014859.19	139.43	139.46	0.04
UA214	526945.52	5017999.74	71.31	71.28	-0.03
UA219	491668.77	4959153.12	91.96	91.95	0
UA220	505272	4977652	55.09	55.13	0.03
Average Dz		-0.01 m			
Minimum Dz		-0.101 m			
Maximum Dz		0.117 m			
Root Mean Square		0.038 m			
95% Confidence Level		0.075 m			



Figure 26. QA Checkpoints: NVA - ME UTM 19



**Table 19. QA Checkpoint Report: VVA - MA UTM 18**

Units = Meters

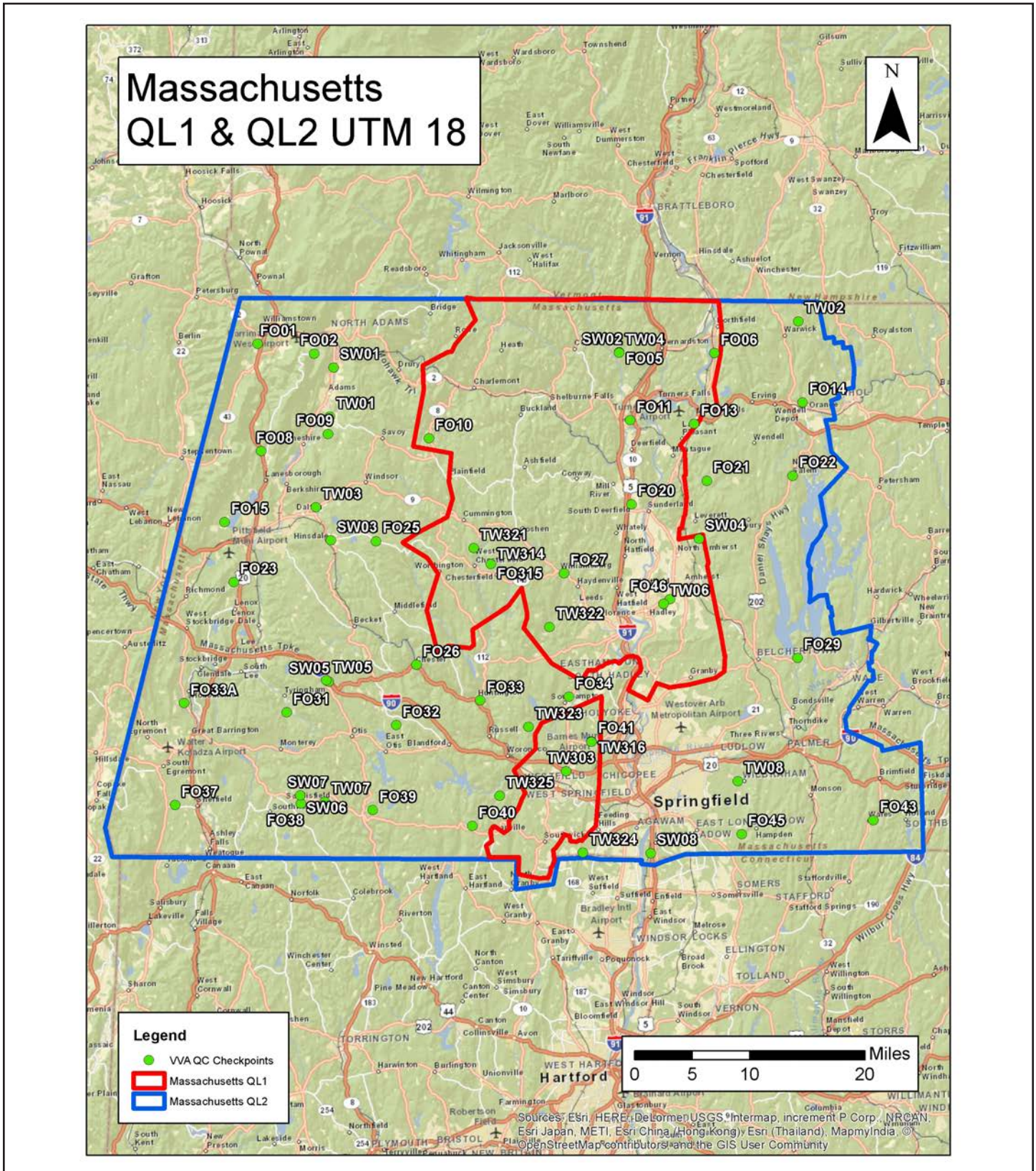
Number	Easting	Northing	Known Z	Laser Z	Dz
FO01	644382.27	4727755.17	292.01	292.09	0.08
FO02	652265.69	4726389.37	424.29	424.62	0.33
FO05	694881.73	4726566.37	216.87	216.95	0.08
FO06	708165.69	4726449.65	83.1	83.19	0.09
FO08	644848.3	4712752.87	372.6	372.59	-0.01
FO09	654201.12	4715167.56	427.74	427.83	0.09
FO10	668309.79	4714547.98	415.97	416.25	0.28
FO11	696382.19	4717061.67	81.21	81.33	0.12
FO13	705352.11	4716584.17	98.29	98.43	0.14
FO14	720505.51	4719590.54	203.07	203.2	0.14
FO15	639775.29	4702859.32	354.14	353.87	-0.27
FO16	655777.97	4706643.45	493.74	493.8	0.06
FO20	696591.4	4705329.2	60.15	60.46	0.31
FO21	707117	4708603.38	166.99	166.97	-0.02
FO22	719113.93	4709313.69	314.28	314.37	0.1
FO23	641038.03	4694458.39	372.45	372.48	0.03
FO25	660922.88	4700177.13	613.02	613.25	0.23
FO26	666562.98	4682956.99	183.81	183.99	0.18
FO27	687145.8	4695666.86	156.24	156.44	0.2
FO29	719765.41	4683931.25	119.82	119.92	0.11
FO31	648450.4	4676302.6	307.01	306.71	-0.3
FO315	676948.4	4696988.48	426.42	426.62	0.2
FO32	663735.82	4674520.5	512.2	512.16	-0.04
FO33A	634093.58	4677606.13	227.71	227.76	0.06
FO33	675469.26	4677984.39	112.45	112.48	0.04
FO34	687858.2	4678499.08	83.19	83.43	0.24
FO37	632853.36	4663349.81	211.91	212	0.08
FO38	650404.83	4663537.89	519.79	520.04	0.25
FO39	660472.37	4662657.16	418.15	418.16	0.01
FO40	674349.7	4660430.66	366.56	366.48	-0.09
FO41	691003.36	4672252.15	82.17	82.39	0.21
FO43	730385.68	4661249.77	282.69	282.77	0.08

Number	Easting	Northing	Known Z	Laser Z	Dz
FO45	711969.21	4659308.25	76.14	76.24	0.1
FO46	701944.01	4692050.7	49.76	49.8	0.04
SW01	655008.28	4724440.78	221.32	221.38	0.06
SW02	694853.66	4726546.55	213.73	213.63	-0.1
SW03	654601.35	4700291.92	438.52	438.65	0.13
SW04	706039.32	4700513.9	99.85	99.98	0.13
SW05	654292.84	4680614.78	411.25	*	*
SW06	650345.53	4664680.34	496.55	496.8	0.25
SW07	650345.54	4664680.34	496.53	496.8	0.27
SW08	699298.16	4656620.09	15.08	*	*
TW01	654456.15	4717563.05	344.7	344.83	0.13
TW02	719910.01	4730903.65	310.78	310.79	0
TW03	652529	4704914.79	353.05	353.14	0.09
TW04	694843.55	4726513.41	215.88	215.76	-0.12
TW05	653938.92	4680772	420.31	420.48	0.17
TW06	701079.69	4691430.4	44.42	44.46	0.04
TW07	653761.12	4663829.25	480.29	480.37	0.07
TW08	711444.58	4666712.29	77.23	77.21	-0.02
TW303	687482.01	4668098.51	69.4	69.43	0.03
TW314	676937.14	4696956.31	427.05	427.28	0.23
TW316	691009.3	4672176.43	82.37	82.48	0.1
TW321	674563.05	4699206.38	415.82	415.99	0.17
TW322	685154.82	4688234.09	163.11	163.21	0.1
TW323	682214.98	4674278.74	242.79	243.02	0.23
TW324	689816.64	4656689.17	64.06	64.16	0.1
TW325	678168.08	4664637.82	199.11	199.15	0.04
Average Dz		0.09 m			
Minimum Dz		-0.303 m			
Maximum Dz		0.328 m			
Root Mean Square		0.155 m			
95th Percentile		0.287 m			

Please note that points SW05 and SW08 were not used in the MA UTM 18 calculations as the ground was not visible and was obscured due to dense vegetation in the bare earth at those locations.



Figure 27. QA Checkpoints: VVA - MA UTM 18

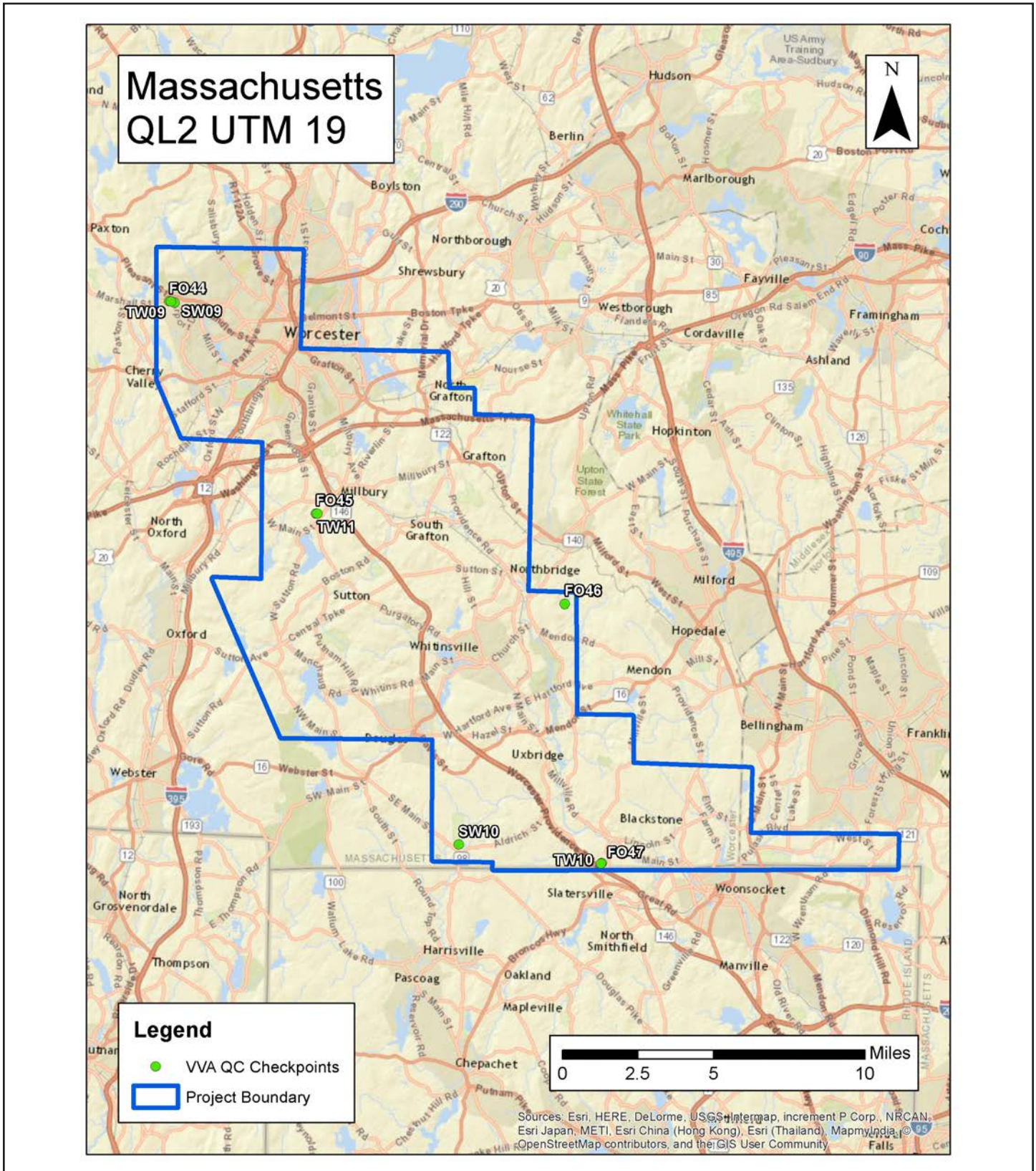


**Table 20. QA Checkpoint Report: VVA - MA UTM 19**
**Units = Meters**

Number	Easting	Northing	Known Z	Laser Z	Dz
FO44	262861.56	4684699.36	265.85	265.89	0.04
FO45	270657.36	4673403.81	163.08	163.13	0.05
FO46	283887.63	4668603.59	78.02	78.14	0.12
FO47	285861.99	4654842.12	88.73	88.79	0.06
SW09	263131.25	4684620.97	261.25	261.34	0.09
SW10	278265.1	4655817.78	148.5	148.48	-0.02
TW09	262946.91	4684693.89	263.56	263.6	0.04
TW10	285818.42	4654793.67	92.21	92.27	0.06
TW11	270727.36	4673405.85	161.19	161.22	0.03
Average Dz		0.05 m			
Minimum Dz		-0.017 m			
Maximum Dz		0.374 m			
Root Mean Square		0.064 m			
95th Percentile		0.107 m			



Figure 28. QA Checkpoints: VVA - MA UTM 19





**Table 21. QA Checkpoint Report: VVA - ME UTM 19**

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
F1	415313.71	4988713.25	209.99	210.1	0.11
F2	446739.72	4952001.58	102.01	102.1	0.09
F4	458395.27	4971229.38	84.11	84.34	0.23
F5	476364.32	4963718.12	76.37	76.48	0.11
F7	452699.77	4991648.02	331.85	332.08	0.23
F8	487254.75	4963867.06	77.63	77.63	0
F9	442498.7	4948144.96	70.26	70.33	0.07
F15	525867.78	4946302.13	43.62	43.58	-0.04
F16	530784.66	4931011.64	86.17	86.24	0.07
F17	545021.88	4936960.4	32.07	32.03	-0.04
F18	542185.98	4949629.3	88.9	88.83	-0.07
F19	542543.75	4955687.1	135.73	135.75	0.02
F22	529564.4	4969691.6	42.19	42.15	-0.04
F23	516276.64	4981390.9	35.51	35.48	-0.03
F25	461397.25	4994150.7	259.51	259.49	-0.02
F26	474378.14	4989391.3	186.31	186.36	0.05
F27	485647.74	4997059.9	150.95	150.95	0
F28	502848.08	4997515.7	105.61	105.75	0.14
F29	525233.51	4991484.6	41.26	41.22	-0.04
F30	534128.14	4994343.1	44.57	44.55	-0.02
F31	476735.7	5004678.3	173.38	173.44	0.06
F39	522929.7	5013522.5	54.8	54.77	-0.03
F40	535724.73	5009343.6	104.11	104.19	0.08
F41	542864.78	5016286.9	108.99	108.89	-0.1
F42	533600.8	4995576.1	60.13	60.18	0.05
F43	531245.39	4976791	34.16	34.17	0.01
F44	468107.64	4957347.7	58.95	59.02	0.07
F45	470841.2	4972552.1	134.99	135	0.01
F46	452599.83	4989759	276.5	276.52	0.02
F47	439031.35	4994598.9	413.28	413.45	0.17
F48	423337.87	4992658.1	333.96	334.15	0.19
F49	446012.27	4984233.6	253.34	253.51	0.17

Number	Easting	Northing	Known Z	Laser Z	Dz
F50	430732.8	4979956.5	118.65	118.68	0.03
F51	416755.09	4972113.3	131.14	131.02	-0.12
F52	440839.32	4964316.3	121.36	121.42	0.06
F53	434566.18	4942014.3	90.81	90.95	0.14
F54	449217.5	4973131.3	128.1	127.98	-0.12
FO203	528912.806	4921158	107.47	107.57	0.1
FO209	454233.733	5002093.1	289.91	289.97	0.07
FO211	466816.1	5009273.3	149.28	149.27	-0.01
FO213	498777.065	5014791.1	143.53	143.54	0.01
FO215	526920.812	5017967.9	72.11	72.02	-0.08
TW1	476498.73	4963973.3	75.8	76.08	0.28
TW2	483089.94	4956548.4	106.03	106.39	0.36
TW3	452734.7	4991616.4	328.67	328.83	0.16
TW7	522888.06	5013545.4	54.77	54.95	0.18
TW9	439067.77	4994561.4	414.23	414.32	0.09
TW10	446016.39	4984210.5	250.69	250.82	0.13
TW11	416783.31	4972140.4	130.66	130.81	0.15
TW12	428402.71	4965088.1	127.5	127.66	0.16
TW13	423518.21	4953406.1	84.44	84.61	0.17
TW201	414949.257	4941468.8	105.18	105.26	0.08
W204	549971.58	4943408.1	36.91	37.19	0.29
W1	458283.32	4971174.7	84.2	84.57	0.37
W2	516129.64	4981420.5	35.8	36.04	0.24
W3	534521.17	4995038.6	40.59	40.77	0.18
W4	414341.56	4951946.4	169.67	169.75	0.08
W5	483918.47	4956482.3	81.67	81.69	0.02
W8	493756.19	5005831.1	85.03	85.29	0.26
W10	466332.59	5009626.1	123.32	123.57	0.25
W12	542848.49	5016247.4	107.47	107.78	0.31
W13	534208.1	4994199.8	37.96	38.09	0.13
W14	531309.33	4976681.2	30.32	30.41	0.09
W15	529705.94	4969707.9	40.6	40.69	0.09
W16	439076.1	4994565.1	413.77	413.93	0.16

Number	Easting	Northing	Known Z	Laser Z	Dz
	Average Dz	0.09 m			
	Minimum Dz	-0.120 m			
	Maximum Dz	0.374 m			
	Root Mean Square	0.145 m			
	95th Percentile	0.286 m			



Figure 29. QA Checkpoints: VVA - ME UTM 19

