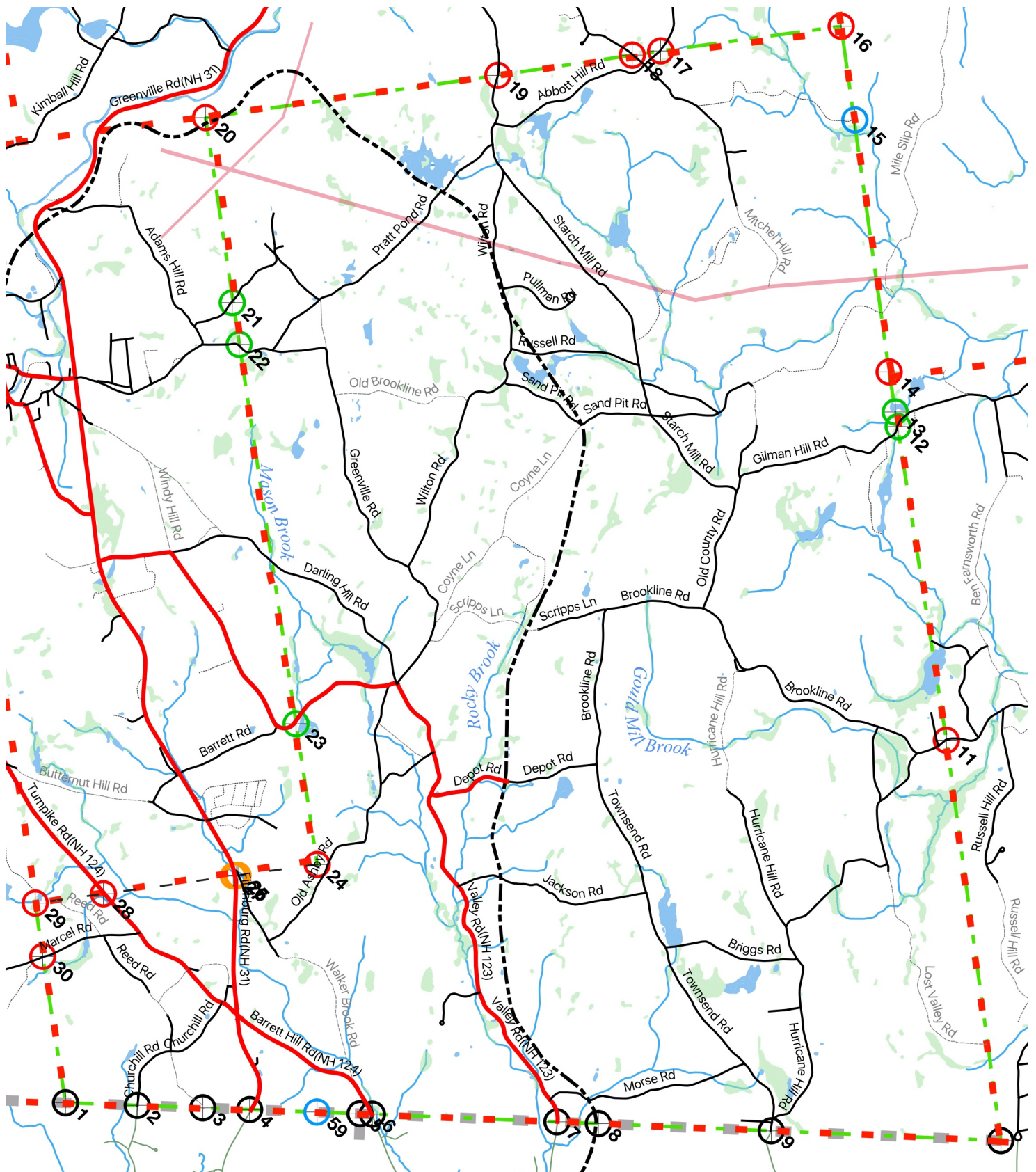


A Study of Mason's Borders



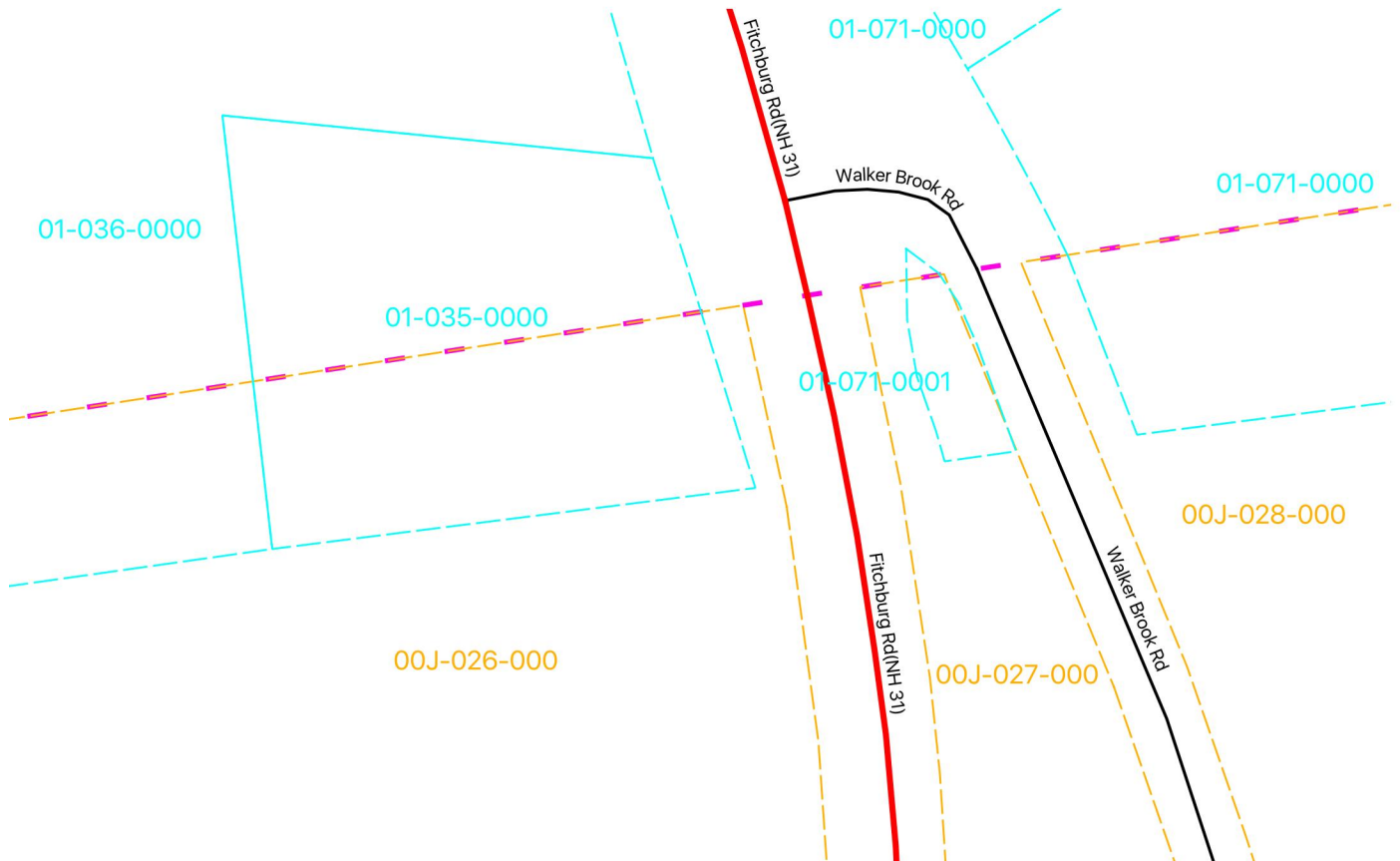
Garth Fletcher
Mason, New Hampshire
May 2020

A Study of Mason's Borders

This is a personal project motivated by curiosity rather than a specific purpose [1]. It was enabled by the availability of powerful open source GIS software (QGIS) plus the extensive public GIS data files from NH GRANIT and MASS-GIS.

My curiosity was aroused by an obvious discordance in GRANIT's 2018 NH DRA parcel mosaic files. These show significant parcel overlap between parcels in Greenville and Mason.

For example, consider these parcel mosaic lines along the Greenville / Mason border area:



The parcel lines and lot numbers for Greenville parcels are shown in cyan, those for Mason lots are shown in orange. The town line, according to USGS topo maps and GRANIT's NH Political Boundaries pba.shp shape file, is shown as a heavy dashed magenta line.

Note that Mason's parcel lines continue up to the USGS town line while Greenville's continue Southward beyond that line.

Mason's J-26 (00J-026-000) parcel appears to include almost half of Greenville's 01-35-0 parcel as well as a significant portion of Greenville's 01-36-0 parcel.

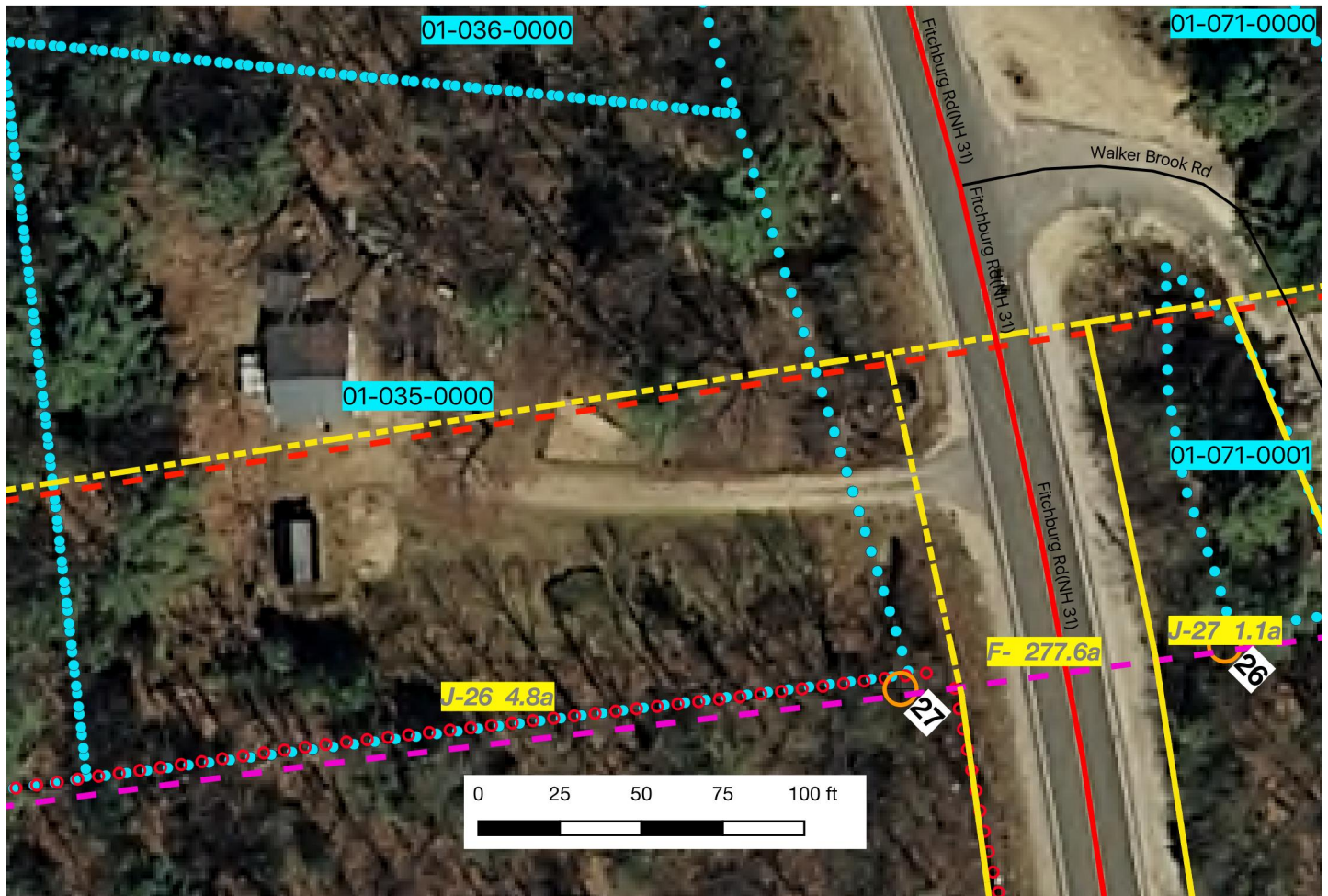
Clearly both town parcel lines cannot be correct; the question is "which is wrong"?

If Mason's parcel lines and the USGS town line, are correct, then Greenville's parcel lines must be wrong.

On the other hand, if Greenville's parcel lines are correct, then both Mason's parcel lines **and** the USGS town line must be in error.

How could one determine which is the case?

Comparison of areal orthophotography with the parcel lines provided an answer.



The dotted cyan outlines are from the NH Mosaic for Greenville while the yellow dashed lines are the parcel lines for Mason. Both buildings and the driveway, are known to be part of Greenville parcel 01-35-000. Parcel J-26 in Mason intrudes over 01-035-000 in Greenville by ~ 95 feet.

Further evidence is provided by the 1976 survey of the Mason/Greenville town line (HCRD Plan #12962) which references a stone wall with a NH Highway marker. The lines of small red circles highlight a stone wall that is visible in the areal photography, and which includes a highway marker indicated above by an orange circle labelled 27; this line aligns to Greenville's parcel map.

The dashed red line (just below the dashed yellow line) is the town boundary as shown in USGS Topo maps and in GRANIT's NH Political Boundaries pba.shp shape file.

The dashed magenta line, which crosses through highway markers 26 and 27, is the town line as surveyed in 1976 (discussed in more detail later in this report).

In summary, the evidence strongly suggests that both the USGS town line and Mason's parcel lines are in error, and that Greenville's parcel lines are correct.

Mason's parcel lines do match the USGS town boundary line, indeed I believe they were fitted to it, but both are clearly offset Northward from the the 1976 survey and from the "ground truth" of buildings, driveways, stone walls and highway markers.

The above errors caused me to question in general the accuracy of the town border lines as shown by the USGS topos and the derived GRANIT NH Political Boundaries pba.shp shape file. This suggested a need to find a way to test the positioning of those lines against "ground truth".

The town boundaries were established over centuries through grants, deeds, or legislation - most recently by the June 28, 1872, legislative act partitioning Greenville from Mason.

At various times *monuments* have been placed along the boundaries. These include granite posts marking State or Town lines along with secondary monuments (granite, cement or iron pipes) placed during subdivisions or road constructions. Of course the accuracy of any such monument depends on the surveyor's success in tracing the history of the boundary, deducing its physical location and setting the monument accurately at that location. Generally speaking, monuments *witness* the deduced location rather than defining it.

Nevertheless, these monuments provide the only practical means I had for checking the USGS maps and derived shape files. Of course, at best, these monuments mark a point along a boundary which itself may not follow a straight line to the next monument.

The monuments along Mason's Southern border are state line monuments, all dated 1894 (#1-10). These are carefully finished 14" x 14" granite posts, deeply inscribed with dates and labels, generally standing about 4 feet tall on solid foundations. I rate these as having the highest credibility.

There are a number of granite "town line monuments", generally smaller than the state line monuments, some square and others irregular. Some are inscribed with dates and town abbreviations, often hard to read due to weathering. Some of these are marked on USGS topo maps as small squares while others are not. I am assuming that these monuments are accurate witnesses.

Greenville was separated from Mason by an act of the Legislature on June 28, 1872. That Act describes the changes as follows:

*"That all that part of the town of Mason lying within the following lines and boundaries, to wit: Beginning at the Northwest corner of said Mason on the line between Mason and Temple, thence running on the town line between New Ipswich and Mason to the Southwest corner of lot number ten in the sixth range of lots in said Mason, thence Easterly on the South lines of lots numbered ten, nine and eight in the aforesaid sixth range, to the South East corner of said lot numbered eight; **thence Northerly on the East line of lot numbered eight in a straight line to the town line between Mason and Wilton;** thence Westerly on the town lines between Mason, Wilton and Temple to the point of beginning, be and the same hereby is severed from the said town of Mason, and made a body politic and Corporate by the name of Greenville." (emphasis mine)*

The Southern portion of that border was surveyed for the towns in 1976 by TF Moran (HCRD Plan #12962) and granite monuments (24,28,29) were set in 1979 at each end and next to its crossing with Rte 124 to mark the border. Three existing NH Highway markers (25-27) were also noted as already existing on the border line near where it crosses Rte 31 and Walker Brook Road.

I was also able to find a number of "survey monuments" set by surveyors during property surveys and noted on plans filed at the Hillsborough County Registry of Deeds (HCRD). Those of interest were noted on the plans as being on the town line, though in many cases this was qualified as being the "assumed town line". Some are low granite posts, others capped iron rods (IP), and one a drill-hole in a stone wall. Because of the disclaimers I rate these as the lowest credibility.

In all, 30 monuments along Mason's border were identified. The 30 monuments were labelled 1..30 in counter-clockwise direction starting at Mason's SW corner where Mason and New Ipswich meet the Massachussets border.

A preliminary exploration using a Garmin hand-held GPS instrument (Garmin *etrex* 20) confirmed significant differences between USGS lines and some monuments. However, the accuracy of such hand-held instruments, optimistically +/- 20' RMS, was too low for an accurate report.

The monuments were then re-visited using a modern multi-frequency (L1 + L5) multi-constellation (US GPS + Russian GLONASS) iGage iG3s Geodetic GNSS Receiver (S/N 973174). Satellite data was recorded at each monument for at least 30 minutes (longer for locations under heavy foliage).

The recorded data were then post-processed by Canadian Natural Resources's Geodetic Survey's CSRS-PPP service (<https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php?locale=en>) to provide corrected locations with error estimates. The CSRS-PPP calculated error ellipses (95% probability) were all less than +/- 3 feet. [2]

CSRS-PPP was used instead of the US Geodetic Survey's OPUS post-processing service because while OPUS only handles data from US GPS satellites, CSRS-PPP will also make use of GLONASS data. Mason's heavy forest cover reduces GPS satellite reception, so inclusion of Russian GLONASS satellites could double the number of visible satellites and thereby significantly reduce the observation times needed to attain the desired accuracy.

Measured coordinates and other data for each monument is listed in Appendix A.

Map 1: Monument locations versus lines on maps

shows the locations of the monuments on a map of Mason (~ 1:40,000 scale) along with enlarged details (~ 1:2,400 scale) of each monument on a 100' grid.

The monuments are marked by circled cross-hairs, color coded to indicate the type of monument:

black: 1894 State Line monuments,

red: Town Line monuments, **orange** for NH Highway markers,

green: miscellaneous survey monuments and

blue: #15 which is the S post of a gate on the "Mason Conservation Commission Trail" where it crosses a stone wall which is likely part of the boundary with Milford
#59 an IP at a missing State Line monument location, see page 15 for discussion

The town line, per USGS, is shown as a heavy red dashed line. The 1976 town line survey by Moran is shown as a heavy magenta dashed line. Thin green dashed straight lines join the State Line and Town Line monuments (but not lesser survey markers) to suggest the approximate location of the border.

The Town lines from Mass GIS's town line files were drawn with a thick grey dashed line.

Some observations from Map 1:

Along Mason's Southern town line (1...10), the state line monument locations conform very well with Mass GIS's version of the town line (grey) while the USGS version (red) is slightly offset.

Mason's Western border (29,30,1) with New Ipswich (per USGS) also conforms fairly well.

Greenville's Southern town line (#24-29), per USGS, aligns at its Western end (29) with Moran's survey, but is rotated approximately 0°55' counter-clock-wise, resulting in a ~ 160' offset NNW at its Eastern end (#24). This rotation is the source of most of the overlap between Greenville and Mason parcels discussed above along this border.

Along Greenville's Eastern border (20-24) there are similar discrepancies between the USGS town line and the monuments. The parcel lines show overlapping parcels along this boundary as well; however these do not so simply align with monument locations.

Mason's NW corner, per USGS, is offset by ~ 210 feet Eastward.

Mason's NE corner, per USGS, is offset by ~ 160 feet Southward.

Mason's corner with Brookline & Milford, per USGS, is offset ~ 170 feet SSE.

Stone walls

While the monuments provide credible evidence of locations along the boundary, they are widely spaced - especially along Greenville's Eastern boundary which is marked only at its ends by monuments 20 and 24, over 4.25 miles apart.

Stone walls, mostly built in the 18th and 19th centuries, may provide some evidence of where the boundaries were thought to be at the time of their building.

The advent of high resolution (1 foot) orthophotographs and high resolution LIDAR elevation data made it possible to detect some walls.

In the case of orthophotographs the walls can be seen as shadows when, and only when, the conditions are suitable. Such conditions include that the ground not be obscured by forest canopy, that when the photographs were taken the sun was low enough for walls to cast shadows (i.e., not high noon), and that the sun be at enough of an angle to the wall to cast visible shadows. The Fall 2010 photography, taken after the leaves have fallen, was used here.

LIDAR can, to some extent, penetrate through light forest canopy to bounce off the ground. The data is converted into quite precise elevations on a grid. LIDAR data for Mason was collected in 2011 as part of a study of the Nashua River Watershed. Unfortunately this data was collected for flood control purposes and does not meet the highest standards; new data is being collected this year to higher standards and should be released in 2021. The 2011 LIDAR data was used here.

By using the LIDAR based elevations grids one can compute a "hillshade" presentation. Because this is done in computer, the location of the "sun" can be adjusted to any desired angle and azimuth, thus allowing detection of walls at any angle. On the other hand, the LIDAR data has substantial gaps ("no-data") in areas where the forest canopy was too thick to penetrate down to ground and back. Also, the sub-standard 2011 LIDAR data only allows the detection of quite substantial walls. The newer LIDAR data, when available in 2021, will make many more walls detectable. Either approach shows walls as shadows offset to the side away from the "Sun".

Maps 2 and 3: Walls (ortho & Lidar)

show the locations of walls which could be detected - red circles for shadows seen in orthophotographs and red stars for walls detected in LIDAR data.

Where these walls align to the monument-to-monument straight lines (green) rather than to the USGS town lines it lends some credibility to the former. The walls are indirect evidence of where the boundary was believed to be at the time, indeed they may have guided the perambulation of those boundaries.

Map 4: Parcels & Overlap: Greenville Borders

The overlap of parcel lines between Mason and Greenville was the initial trigger for this study.

Parcel lines do not overlap along Mason's borders with Wilton, Milford and Brookline. The lines often are somewhat offset from my lines aligned to boundary monuments, but they are congruent.

It is only along the Mason/Greenville boundaries that parcels overlap.

Map 4 shows these overlapping parcel lines with the areas of parcel overlap and highlights the areas of intrusion into the wrong town.

The Greenville parcel outlines are drawn in blue, the Mason parcel lines in magenta.

When the Legislature defined Greenville's borders in 1872, it specified its Eastern border as a straight line drawn from Greenville's new SE corner Northward to the Mason/Wilton line. I have drawn this as a straight line between monument 24 and 20.

The Legislature was less geometrically specific about Greenville's Southern border, instead referencing Mason's original range and lot lines. However, this boundary was surveyed in 1976 so is now well defined; it runs from monument 29 to monument 24 (both set as a result of the survey). In the following discussion I use those lines - the survey from monuments 29 to 24 and a straight line from 24 to 20 - as Mason's assumed boundary.

Where Greenville parcels extend into Mason (as defined above) the overlap is highlighted in blue. Where Mason parcels extend into Greenville the overlap is highlighted in yellow.

The situation is fairly simple along Greenville's Southern border - primarily caused by a $\sim 0^\circ 55'$ counter-clockwise rotation of the USGS line. Mason's parcels are everywhere drawn to meet the (incorrect) USGS line.

From about half-way between Rte 124 and Rte 31, going Eastward Greenville's parcel lines are (correctly) drawn to meet the actual boundary as determined by the 1976 survey, so in this area Mason's parcels are intruding into Greenville.

This Southern "wedge" infringes on about 13 acres of Greenville's land - not a huge intrusion but the owner of Greenville parcel 01-035-000 might reasonably take umbrage at Mason's parcel J-26 claiming half his lot and one of his buildings...

Westward of that point midway between Rtes 124 and 31, Greenville's lines meander, and beginning near Rte 124 diverge Southward eventually ending up $\sim 80'$ South of the survey line, thus intruding into Mason.

The situation along Greenville's Eastern border is much more confused. Mason's parcel lines always conform to the (incorrect) USGS town line while Greenville's parcels take a varied path.

From the North corner down to near Nutting Hill Rd Greenville's parcel lines do not overlap but also follow the (incorrect) USGS border. Since this is East of the monument to monument line the parcels do intrude into Mason.

South of Nutting Hill Rd the Mason parcel lines continue to follow the (incorrect) USGS line while the Greenville parcel lines follow a different course, neither following USGS line nor the monument to monument line while crossing the latter a couple of times and finally rejoining the USGS line at the Southern end.

Over all, Mason's parcels intrude into Greenville by as much as 120' while Greenville's parcel lines intrude as much as 200' into Mason. The maximum parcel to parcel overlap is $\sim 160'$.

Summary:

Town lines as shown on USGS topo maps, and in the derived shape files, are significantly in error. Mason parcel lines have been adjusted to match the (incorrect) town lines and need corrections. Greenville parcel lines along the Mason border also need corrections.

The monument location data included in this report provide a good starting point for such corrections.

Footnotes:

[1]: Disclaimer: This was an "amateur" effort in the best sense of the word - for the love of the work. I have no relevant credentials, qualifications or certifications. All I offer is a study done with modern equipment (see below), considerable care and well documented. My hope is to encourage those more qualified to be stimulated to explore the inconsistencies I have found and to correct them.

[2]: Those not familiar with GNSS post-processing technology may find the following explanation helpful. GPS works by measuring the distances to visible satellites and using the known position of the satellites to calculate the location of the GPS instrument. This assumes that all the satellites are sending their signal at the same instant, so the differences in arrival times at the GPS instrument indicate the differences in distances.

The signals from the GPS satellites are subject to several sources of error including variable propagation delays in the ionosphere and errors in the satellite clocks or actual positions. Post processing, such as that provided by CSRS-PPP or OPUS, continuously record the satellite signals at a large number of fixed positions. Since those positions are fixed, changes in their apparent positions as derived from the satellite signals must be due to the aforementioned errors, which makes it possible to measure the errors themselves. Measuring the errors from a large number of distributed fixed locations makes it possible to "model" the disturbances over time and space and to estimate, and thereby correct, the errors at any GNSS instrument location within the covered area.

The accuracy of the corrections depends on the accuracy of the model which in turn depends on the amount of error data collected. CSRS-PPP provides 3 levels - an "ultra-rapid" version which uses 90 minutes of error data and is available within 90 minutes of the recording session; a "rapid" version using 24 hours of data but which is not available until 24 hours after the recording session; and a "final" version using a full week of data which is available 2 weeks after the recording session.

Each recording is uploaded to CSRS-PPP which processes the data and emails back a lengthy PDF report. Each report provides a corrected instrument position along with an estimate of the accuracy in the form of an "error ellipse" which has a 95% probability of containing the true position.

Long recordings, say 8 hours, processed using a week of error data ("final" post-processing) can result in very small error ellipses - a matter of a few inches. Short recordings using "ultra-rapid" post-processing result in larger error ellipses, possibly tens of feet.

For this study, recordings lasting 30 to 60 minutes were made at each monument which, with "final" CSRS-PPP post-processing, resulted in error ellipses of less than 1 meter (3 feet) major semi-diameter. In other words, according to CSRS-PPP the corrected locations reported here had a 95% probability of being within less than +/- 3 feet of the true location.

The error ellipses for the 30 monuments are shown in the upper left of Map A on a 1 foot grid.

Appendix A : Monument details

LEGEND:

SLM = State Line Monument, These are shown on USGS Topo maps and those along Mason's border are numbered 55..65 on the topo maps. All 14" x 14" carefully finished and incised, standing ~ 4' tall, placed in 1984.

TLM = Town Line monument

Hwy = NH Highway markers, included in the 1976 survey

SM = other Survey markers, referenced in HCRD Plans

Spc = special, not classified above

1: (SLM) SLM_55_SW_corner

NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'32.37033", -71°48'19.26846"**, 261.03

UTM 19N N,E: 4732316.149, 270256.735

Obs. File, Date, Duration: 01_2019_07_19_SLM_55_SW_corner.obs, 2019-07-19, 1:00:05

SIG-PPP(95%) Lat, Long: 0.13, 0.36 Err Ell (95%) 0.45 x 0.15 meters

Access: beginning at 288 Marcel Rd, walk ~ 1600' S on driveway to sharp turn to residence, then ~ 180' W to stone wall, then ~ 2800' S along stone wall (crossing 2 perpendicular walls) to monument.

2: (SLM) SLM_56_ChurchillRd_2

NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'31.62300", -71°47'50.54387"**, 260.73

UTM 19N N,E: 4732271.406, 270909.454

Obs. File, Date, Duration: 02_2019_08_03_SLM_56_ChurchillRd_2.obs, 2019-08-03, 1:01:15

SIG-PPP(95%) Lat, Long: 0.12, 0.27 Err Ell (95%) 0.33 x 0.15 meters

Access: near road, W side

3: (SLM) SLM_57_ReedRd_2

NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'30.93422", -71°47'24.26510"**, 225.96

UTM 19N N,E: 4732230.370, 271506.595

Obs. File, Date, Duration: 03_2019_08_03_SLM_57_ReedRd_2.obs, 2019-08-03, 1:01:40

SIG-PPP(95%) Lat, Long: 0.25, 0.28 Err Ell (95%) 0.42 x 0.20 meters

Access: at end of Class VI Reed road, ~ 300' past last residence, in back of target backstop

4: (SLM) SLM_58-Rte_31

NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'30.42872", -71°47'5.47988"**, 229.55

UTM 19N N,E: 4732200.663, 271933.446

Obs. File, Date, Duration: 04_2019_07_13_SLM_58_Rte_31.obs, 2019-07-13, 0:32:55

SIG-PPP(95%) Lat, Long: 0.26, 0.35 Err Ell (95%) 0.44 x 0.32 meters

Access: near road, W side

59: (Spc) SLM_59 *Note: a SLM #59 monument is indicated on the USGS topo maps, but no granite monument could be found. An old iron pipe within a semi-circle of stones was found at the indicated area, see page 15, "The Mystery of State Line Monument #59". As this IP location lies on a straight line between SL monuments #58 (#4 on map) and #60 (#5 on map), I assume that it was set during the original 1894 survey and noted on the topographic map, but never replaced by a granite monument since it would not mark any line intersection or transport corridor.*

NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'29.73106", -71°46'38.50935"**, 242.677

UTM 19N N,E: 4732158.925, 272546.322

Obs. File, Date, Duration: 05_59_SLM_2020_04_29.obs, 2020-04-29, 0:31:10

SIG-PPP(95%) Lat, Long: 0.168, 0.443 Err Ell (95%) 0.55 x 0.21 meters

Access: starting at monument 5 described below, walk ~ 1300' W up steep hill.

- 5: (SLM) SLM_60_Ashby-Twnsnd-Mason**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'29.24942", -71°46'21.22057"**, 155.31
 UTM 19N N,E: 4732131.136, 272939.157
 Obs. File, Date, Duration: 05_2019_07_28_SLM_60_Mas_Ashby_Townsend.obs, 2019-07-28, 0:58:45
 SIG-PPP(95%) Lat, Long: 0.32, 0.39 Err Ell (95%) 0.57 x 0.26 meters
 Access: starting at monument 6 described below, walk ~ 360' W up steep hill. Monument is next to stone wall and old cart road.
- 6: (SLM) SLM_61_Rte_124S {aka Barrett Hill Rd}**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'29.12538", -71°46'16.30305"**, 132.38
 UTM 19N N,E: 4732123.636, 273050.906
 Obs. File, Date, Duration: 06_2019_07_13_2_SLM_61_Rte_124S.obs, 2019-07-13, 0:31:55
 SIG-PPP(95%) Lat, Long: 0.15, 0.16 Err Ell (95%) 0.21 x 0.16 meters
 Access: near road, E side
- 7: (SLM) SLM_62_ValleyRd**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'26.91231", -71°45'2.31824"**, 113.14
 UTM 19N N,E: 4732000.312, 274731.854
 Obs. File, Date, Duration: 07_2019_07_13_3_SLM_62_ValleyRd.obs, 2019-07-13, 0:31:20
 SIG-PPP(95%) Lat, Long: 0.17, 0.30 Err Ell (95%) 0.40 x 0.15 meters
 Access: near road, W side
- 8: (SLM) SLM_63_RR**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'26.41673", -71°44'45.71456"**, 130.73
 UTM 19N N,E: 4731972.726, 275109.097
 Obs. File, Date, Duration: 08_2019_07_29_SLM_63_RR.obs, 2019-07-29, 2:11:05
 SIG-PPP(95%) Lat, Long: 0.08, 0.14 Err Ell (95%) 0.17 x 0.09 meters
 Access: from Morse road walk ~ 770' SSE on RR trail; monument is E ~ 30' from RR trail
- 9: (SLM) SLM_64_TownsendRd**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'24.31120", -71°43'36.43321"**, 200.54
 UTM 19N N,E: 4731856.678, 276683.183
 Obs. File, Date, Duration: 09_2019_07_15_SLM_64_TownsendRd.obs, 2019-07-15, 0:32:50
 SIG-PPP(95%) Lat, Long: 0.18, 0.21 Err Ell (95%) 0.30 x 0.17 meters
 Access: near road, E side
- 10: (SLM) SLM_65_SE_corner**
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°42'21.46105", -71°42'4.40362"**, 173.68
 UTM 19N N,E: 4731701.440, 278774.103
 Obs. File, Date, Duration: 10_2019_07_16_SLM_65_Mason_SE_corner.obs, 2019-07-16, 0:47:05
 SIG-PPP(95%) Lat, Long: 0.11, 0.21 Err Ell (95%) 0.29 x 0.09 meters
 Access: from the S end of the West Hill Rd cul-de-sac in Brookline (where there is another SLM monument, #66) walk ~ 500' W following wall. Monument is near edge of cleared field in Mason lot L-22.

11: (TLM) TLM_BrooklineRd_2
NAD83 (2010) Lat, Long, OrthoElev(m): **42°44'19.76503", -71°42'26.30787"**, 125.12
UTM 19N N,E: 4735366.849, 278392.841
Obs. File, Date, Duration: 11_2019_08_02_TLM_BrooklineRd_2.obs, 2019-08-02, 1:03:45
SIG-PPP(95%) Lat, Long: 0.05, 0.23 Err Ell (95%) 0.29 x 0.05 meters
Access: near road, SE side

Note: a Town Line monument is indicated on USGS Topo maps on the N side of Gillman Hill Rd, but could not be found. Long-time town employees report having last seen it many years ago. HCRD Plan #8062 (1974) references it.

12: (SM) SM-GillmanHill_IP#1
NAD83 (2010) Lat, Long, OrthoElev(m): **42°45'52.43601", -71°42'45.71904"**, 135.18
UTM 19N N,E: 4738239.758, 278043.399
Obs. File, Date, Duration: 12_2019_07_30_GillmanHillRd_IP_1.obs, 2019-07-30, 0:36:30
SIG-PPP(95%) Lat, Long: 0.34, 0.34 Err Ell (95%) 0.47 x 0.37 meters
Access: near road, SE side, capped IP, see HCRD Plan #35,186

13: (SM) SM_D-10_beaver_dam
NAD83 (2010) Lat, Long, OrthoElev(m): **42°45'56.75995", -71°42'46.88792"**, 134.90
UTM 19N N,E: 4738373.999, 278021.122
Obs. File, Date, Duration: 13_2019_07_25_SM_D-10_Beaver_dam.obs, 2019-07-25, 0:30:40
SIG-PPP(95%) Lat, Long: 0.18, 0.23 Err Ell (95%) 0.30 x 0.20 meters
Access: starting from a pull-over on Gillman Hill Rd, ~ 350 W of the town line , follow the trail N ~ 700' to the pond, then E ~100' to the stream. IP set in a beaver dam, referenced in HCRD Plan #36,032

14: (TLM) TLM_Mas_BrklN_Milf
NAD83 (2010) Lat, Long, OrthoElev(m): **42°46'8.60272", -71°42'49.35348"**, 147.27
UTM 19N N,E: 4738741.131, 277976.841
Obs. File, Date, Duration: 14_2019_07_25_TLM_Mas_BrklN_Milf.obs, 2019-07-25, 0:35:45
SIG-PPP(95%) Lat, Long: 0.17, 0.20 Err Ell (95%) 0.27 x 0.18 meters
Access: starting from monument 13 described above, go N skirting W shore of pond ~ 1220' as the crow flies (~ 1400' on foot) to the monument

15: (Spc) CC_Gate_Spost_MM {Southern post of Conservation Commission gate}
NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'23.07226", -71°43'3.16012"**, 153.07
UTM 19N N,E: 4741048.496, 277737.104
Obs. File, Date, Duration: 15_2019_07_27_CC_Gate_Spost_MM.obs, 2019-07-27, 0:30:55
SIG-PPP(95%) Lat, Long: 0.17, 0.26 Err Ell (95%) 0.34 x 0.19 meters
Access: from Milford's Mile Slip Town Forest parking area (on the West side across from 395 Mile Slip Rd in Milford), take the trail (a woods road) that exits the parking lot heading N, follow it as it bears ~320' N, 700' NW and 1170' W to gate on the Mason/Milford line.

- 16:** (TLM) TLM_NE_corner_MMW
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'50.73677", -71°43'8.68055"**, 199.55
 UTM 19N N,E: 4741905.946, 277639.214
 Obs. File, Date, Duration: 16_2019_07_27_TLM_NE_MMW.obs, 2019-07-27, 1:29:20
 SIG-PPP(95%) Lat, Long: 0.14, 0.15 Err Ell (95%) 0.21 x 0.15 meters
 Access: from 15 described above, walk ~ 2800' N along trails paralleling stone walls to monument. At some point the North trending Mile Slip Town Forest trail will take a sharp turn E, at that point bushwhack W to cross over the wall and follow it Northward (there are parallel trails / woods roads).
- 17:** (TLM) TLM_AbbottHillRd_2
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'43.40625", -71°44'21.08765"**, 251.97
 UTM 19N N,E: 4741733.084, 275986.957
 Obs. File, Date, Duration: 17_2019_08_01_TLM_AbbottHillRd_2.obs, 2019-08-01, 0:44:50
 SIG-PPP(95%) Lat, Long: 0.20, 0.15 Err Ell (95%) 0.26 x 0.17 meters
 Access: near road, SE side. Caution, there is a 2nd similar monument on NW side near driveway.
- 18:** (TLM) TLM_MitchellHillRd_2
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'42.17480", -71°44'32.49542"**, 254.85
 UTM 19N N,E: 4741703.524, 275726.557
 Obs. File, Date, Duration: 18_2019_08_01_TLM_MitchellHillRd_2.obs, 2019-08-01, 0:45:35
 SIG-PPP(95%) Lat, Long: 0.24, 0.37 Err Ell (95%) 0.48 x 0.27 meters
 Access: near road, W side. Caution, road name changes to Abbott Hill in Wilton
- 19:** (TLM) TLM_StarchMillRd_2
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'36.15008", -71°45'26.46867"**, 205.23
 UTM 19N N,E: 4741557.683, 274494.292
 Obs. File, Date, Duration: 19_2019_08_01_TLM_StarchmillRd_2.obs, 2019-08-01, 0:49:45
 SIG-PPP(95%) Lat, Long: 0.20, 0.35 Err Ell (95%) 0.46 x 0.21 meters
 Access: near road, W side
- 20:** (TLM) TLM_NW_corner_MGW
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°47'23.56109", -71°47'23.73601"**, 211.72
 UTM 19N N,E: 4741257.018, 271817.237
 Obs. File, Date, Duration: 20_2019_07_26_TLM_NW_MGW.obs, 2019-07-26, 1:24:15
 SIG-PPP(95%) Lat, Long: 0.16, 0.15 Err Ell (95%) 0.24 x 0.13 meters
 Access: from Adams Hill Rd in Greenville, follow RR trail NE ~ 6,000', monument is ~ 120' down steep embankment.
- 21:** (SM) SM_NuttingHillRd_S
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°46'28.88846", -71°47'12.91440"**, 321.62
 UTM 19N N,E: 4739562.318, 272007.343
 Obs. File, Date, Duration: 21_2019_07_16_SM_NuttingHillRd_S.obs, 2019-07-16, 0:30:55
 SIG-PPP(95%) Lat, Long: 0.33, 0.27 Err Ell (95%) 0.42 x 0.33 meters
 Access: near road on S side, HCRD Plan #34,785, low square post with medallion

- 22:** (SM) SM_GreenvilleRd_N
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°46'16.55594", -71°47'10.13187"**, 302.25
 UTM 19N N,E: 4739179.789, 272058.005
 Obs. File, Date, Duration: 22_2019_07_16_SM_GreenvilleRd_N.obs, 2019-07-16, 0:30:55
 SIG-PPP(95%) Lat, Long: 0.54, 0.59 Err Ell (95%) 0.78 x 0.62 meters
 Access: near road on N side, HCRD Plan #34,785, low square post with medallion
- 23:** (SM) DH_TLM_MerriamHillRd_2~ 120
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°44'24.43966", -71°46'47.09122"**, 252.15
 UTM 19N N,E: 4735703.905, 272467.651
 Obs. File, Date, Duration: 23_2019_08_03_SM_DH_MerriamHillRd_2.obs, 2019-08-03, 1:01:00
 SIG-PPP(95%) Lat, Long: 0.09, 0.19 Err Ell (95%) 0.24 x 0.11 meters
 Access: near road, ~ 55' SW from C/L. DH in boulder at end of wall. Look for metal plate nailed to tree above. See also HCRD Plan #40,433
- 24:** (TLM) TLM_Gvl_SE_corner
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'42.89225", -71°46'38.52636"**, 242.74
 UTM 19N N,E: 4734415.826, 272620.210
 Obs. File, Date, Duration: 24_2019_07_15_TLM_Grnv_SE_corner.obs, 2019-07-15, 1:12:40
 SIG-PPP(95%) Lat, Long: 0.05, 0.09 Err Ell (95%) 0.11 x 0.06 meters
 Set by 1976 survey (HCRD Plan #12962)
 Access: from residence on lot G-64, ~ 250' SSW through field to stone wall corner.
- 25:** (Hwy) HWY_1_WlkrBrkRd
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'39.65559", -71°47'10.28139"**, 209.41
 UTM 19N N,E: 4734339.791, 271894.716
 Obs. File, Date, Duration: 25_2019_07_29_HWY_1.obs, 2019-07-29, 0:36:20
 SIG-PPP(95%) Lat, Long: 0.08, 0.51 Err Ell (95%) 0.64 x 0.10 meters
 Hwy markers (#25-27) are referenced by 1976 survey (HCRD Plan #12962)
 Access: near road, ~ 20' W of Walker Brook Rd C/L, behind boulder, low cement post
- 26:** (Hwy) HWY_2_Rte31_Eside
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'39.60646", -71°47'10.84115"**, 208.65
 UTM 19N N,E: 4734338.696, 271881.935
 Obs. File, Date, Duration: 26_2019_07_29_HWY_2.obs, 2019-07-29, 0:47:55
 SIG-PPP(95%) Lat, Long: 0.22, 0.55 Err Ell (95%) 0.73 x 0.16 meters
 Access: near road, 50' E' from Rte 31 C/L, low cement post
- 27:** (Hwy) HWY_3_Rte_31_Wside
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'39.46906", -71°47'12.16160"**, 210.86
 UTM 19N N,E: 4734335.449, 271851.764
 Obs. File, Date, Duration: 27_2019_07_14_10_Hwy_Rte_31_Wside.obs, 2019-07-14, 0:32:00
 SIG-PPP(95%) Lat, Long: 0.27, 0.45 Err Ell (95%) 0.58 x 0.31 meters
 Access: near road at stone wall corner, 50' W from Rte 31 C/L, behind boulder, low cement post

28: (TLM) TLM_Rte_124_N
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'34.13995"**, **-71°48'4.23378"**, 256.97
 UTM 19N N,E: 4734210.271, 270662.021
 Obs. File, Date, Duration: 28_2019_07_14_7_TLM_Rte_124_N.obs, 2019-07-14, 0:31:00
 SIG-PPP(95%) Lat, Long: 0.33, 0.43 Err Ell (95%) 0.57 x 0.36 meters
 Set by 1976 survey (HCRD Plan #12962)
 Access: near road, SW side

29: (TLM) TLM_Grnv_Mas_NI
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'31.36002"**, **-71°48'31.52997"**, 265.83
 UTM 19N N,E: 4734145.153, 270038.350
 Obs. File, Date, Duration: 29_2019_07_24_Grnvl_Mas_NI.obs, 2019-07-24, 1:04:20
 SIG-PPP(95%) Lat, Long: 0.04, 0.08 Err Ell (95%) 0.11 x 0.03 meters
 Set by 1976 survey (HCRD Plan #12962)
 Access: From Marcel Rd follow Reed Rd Northward (Class VI) ~2100' to stream crossing with wetland/pond to W; follow S side of wetland/pond ~350', then wade (tall boots recommended) ~ 100' to monument. Unlikely to be visible from shore in Summer due to vegetation; may be visible in Winter.

30: (TLM) TLM_MarcelRd
 NAD83 (2010) Lat, Long, OrthoElev(m): **42°43'15.60636"**, **-71°48'28.50418"**, 278.74
 UTM 19N N,E: 4733656.889, 270090.998
 Obs. File, Date, Duration: 30_2019_07_17_TLM_MarcelRd.obs, 2019-07-17, 0:32:05
 SIG-PPP(95%) Lat, Long: 0.21, 0.35 Err Ell (95%) 0.43 x 0.27 meter
 Set unknown date subsequent to 1976 survey (HCRD Plan #12962)
 Access: near road, N side

Images of some representative monuments:



1..10 SLM, various



11 TLM Brookline Rd



12 SM IP Gillman Hill Rd



13 SM: IP in beaver dam



16 TLM NE corner



19 TLM Starch Mill Rd



20 TLM NW corner



21 SM Nutting Hill Rd



26 Hwy Rte 31 E



29 TLM in swamp

Summary of monument data in spread-sheet format.

RINEX observation data				Monument				d'm's"				meters				meters				UTM-E			
file	name	st_date	st_time	duration	type	reject	lat	long	elev	Σlat	Σlong	Σelev	er_maj	er_min	er_az	Ortho_H	UTM-N	UTM-E	Kind	Sequ			
01_2019_07_19_SLM_55_SW_corner.obs	SLM_55_SW_corner	2019-07-19	15:05:00.00	1:00:05	Fin		0 42°42'32.37033"	-71°48'19.26846"	233.32	0.13	0.36	0.69	0.45	0.15	-89	261.03	4732316.149	270256.735	1	1			
02_2019_08_03_SLM_56_ChurchHillRd_2.obs	SLM_56_ChurchHillRd_2	2019-08-03	14:08:25.00	1:01:15	Fin	0.27	42°42'31.62300"	-71°47'50.54387"	233.01	0.12	0.27	0.73	0.33	0.15	-89	260.73	4732271.406	270909.454	1	2			
03_2019_08_03_SLM_57_ReedRd_2.obs	SLM_57_ReedRd_2	2019-08-03	15:21:45.00	1:01:40	Fin	0.42	42°30.93422"	-71°47'24.26510"	198.23	0.25	0.28	0.75	0.42	0.20	87	225.96	4732200.370	271506.595	1	3			
04_2019_07_13_SLM_58_Rte_31.obs	SLM_58-Rte_31	2019-07-13	18:18:35.00	0:32:55	Fin	0.42	42°30.93422"	-71°47'54.47988"	201.81	0.26	0.35	0.91	0.44	0.32	89	229.55	4732200.663	271933.446	1	4			
05_2019_07_28_SLM_60_Mas_Ashby-TownsendMason.obs	SLM_60_Ashby-TownsendMason	2019-07-28	15:19:10.00	0:58:45	Fin	0.85	42°42'29.24942"	-71°46'21.22057"	127.56	0.32	0.39	1.17	0.57	0.26	87	155.31	4732131.136	272939.157	1	5			
06_2019_07_13_SLM_61_Rte_1245.obs	SLM_61_Rte_1245	2019-07-13	18:59:25.00	0:31:55	Fin	0.42	42°29.12538"	-71°46'16.30305"	104.63	0.15	0.16	0.55	0.21	0.16	-89	132.38	4732123.636	273050.906	1	6			
07_2019_07_13_SLM_62_ValleyRd.obs	SLM_62_ValleyRd	2019-07-13	19:42:55.00	0:31:20	Fin	0.42	42°26.91231"	-71°44'52.31824"	85.37	0.17	0.30	0.95	0.40	0.15	-89	113.14	4732000.312	274731.854	1	7			
08_2019_07_29_SLM_63_RR.obs	SLM_63_RR	2019-07-29	15:20:00.00	2:11:05	Fin	0.06	42°42'26.41673"	-71°44'45.71456"	102.96	0.08	0.14	0.43	0.17	0.09	89	130.73	4731972.726	275109.097	1	8			
09_2019_07_15_SLM_64_TownsendRd.obs	SLM_64_TownsendRd	2019-07-15	17:23:00.00	0:32:50	Fin	0.42	42°24.31120"	-71°44'36.43321"	172.77	0.18	0.21	0.64	0.30	0.17	88	200.54	4731856.678	276683.183	1	9			
10_2019_07_16_SLM_65_Mason_SE_corner.obs	SLM_65_SE_corner	2019-07-16	19:48:40.00	0:47:05	Fin	0.42	42°21.46105"	-71°44'24.40362"	145.90	0.11	0.21	0.47	0.29	0.09	89	173.68	4731701.440	278774.103	1	10			
11_2019_08_02_TLM_BrooklineRd_2.obs	TLM_BrooklineRd_2	2019-08-02	19:27:25.00	1:03:45	Fin	0.42	42°41.76503"	-71°44'26.30787"	97.39	0.05	0.23	0.23	0.29	0.05	89	125.12	4735366.849	278392.841	2	11			
12_2019_07_30_SLM_D-10_Beaver_dam.obs	SMI-GillmanHill_IP1	2019-07-30	15:12:00.00	0:36:30	Fin	0.42	42°45'52.43601"	-71°44'45.71904"	107.48	0.34	0.34	1.04	0.47	0.37	-7	135.18	4738239.758	278043.399	4	12			
13_2019_07_25_TLM_Mas_Brkin_Milf.obs	SLM_D-10_beaaver_dam	2019-07-25	17:26:00.00	0:30:40	Fin	0.42	42°45'56.75995"	-71°44'42.46879"	107.21	0.18	0.23	0.59	0.30	0.20	-89	134.90	4738373.999	278021.122	4	13			
14_2019_07_25_TLM_Mas_Brkin_Milf.obs	TLM_Mas_Brkin_Milf	2019-07-25	16:34:10.00	0:35:45	Fin	0.42	42°46'8.60272"	-71°44'24.93548"	119.59	0.17	0.20	0.68	0.27	0.18	-89	147.27	4738741.131	277976.841	2	14			
15_2019_07_27_TLM_NE_MMW.obs	CC_Gate_Spot_MM	2019-07-27	17:29:30.00	0:30:55	Fin	0.42	42°47'23.07226"	-71°44'33.16012"	125.41	0.17	0.26	0.80	0.34	0.19	-89	153.07	4741048.496	277737.104	5	15			
16_2019_08_01_TLM_AbbottHillRd_2.obs	TLM_NE_corner_MMW	2019-07-27	15:32:30.00	1:29:20	Fin	0.23	42°47'50.73677"	-71°44'38.68055"	171.90	0.14	0.15	0.50	0.21	0.15	-85	199.55	4741905.946	277639.214	2	16			
17_2019_08_01_TLM_MitchellHillRd_2.obs	TLM_AbbottHillRd_2	2019-08-01	15:30:05.00	0:44:50	Fin	0.93	42°47'43.40625"	-71°44'21.08765"	224.32	0.20	0.15	0.68	0.26	0.17	0	251.97	4741733.084	275986.957	2	17			
18_2019_08_01_TLM_MitchellHillRd_2.obs	TLM_MitchellHillRd_2	2019-08-01	14:34:30.00	0:45:35	Fin	0.42	42°47'42.17480"	-71°44'32.49542"	227.21	0.24	0.37	0.77	0.48	0.27	-89	254.85	4741703.524	275726.557	2	18			
19_2019_08_01_TLM_StarchmillRd_2.obs	TLM_StarchmillRd_2	2019-08-01	16:25:10.00	0:49:45	Fin	0.42	42°47'36.15008"	-71°44'56.2646867"	177.60	0.20	0.35	0.62	0.46	0.21	89	205.23	4741557.683	274494.292	2	19			
20_2019_07_26_TLM_NW_MGW.obs	TLM_NW_corner_MGW	2019-07-26	15:39:10.00	1:24:15	Fin	0.42	42°47'23.56109"	-71°44'23.73601"	184.11	0.16	0.15	0.45	0.24	0.13	1	211.72	4741257.018	271817.237	2	20			
21_2019_07_16_SLM_NuttingHillRd_5.obs	SM_NuttingHillRd_5	2019-07-16	16:42:15.00	0:30:55	Fin	0.42	42°46'28.88846"	-71°44'12.91440"	293.99	0.33	0.27	1.31	0.42	0.33	0	321.62	4739562.318	272007.343	4	21			
22_2019_07_16_SLM_GreenvilleRd_N.obs	SM_GreenvilleRd_N	2019-07-16	15:57:40.00	0:30:55	Fin	0.42	42°46'16.55594"	-71°44'10.13187"	274.61	0.54	0.59	1.57	0.78	0.62	84	302.25	4739179.789	272058.005	4	22			
23_2019_08_03_SLM_DH_MerriamHillRd_2.obs	DH_TLM_MerriamHillRd_2	2019-08-03	22:04:40.00	1:01:00	Fin	0.42	42°44'24.43966"	-71°44'47.09122"	224.47	0.09	0.19	0.29	0.24	0.11	-89	252.15	4735703.905	272467.651	4	23			
24_2019_07_15_TLM_Grnv_SE_corner.obs	TLM_Gv_SE_corner	2019-07-15	15:46:40.00	1:12:40	Fin	0.42	42°43'42.89225"	-71°44'38.52636"	215.04	0.05	0.09	0.23	0.11	0.06	89	242.74	4734415.826	272620.210	2	24			
25_2019_07_29_Hwy_1.obs	Hwy_1_WilkrBkrd	2019-07-29	20:19:45.00	0:36:20	Fin	0.52	42°43'39.65559"	-71°44'10.28139"	187.71	0.08	0.51	0.65	0.64	0.10	-89	209.41	4734339.791	271894.716	3	25			
26_2019_07_29_Hwy_2.obs	Hwy_2_Rte31_Eside	2019-07-29	20:59:30.00	0:47:55	Fin	0.52	42°43'39.60646"	-71°44'10.84115"	180.94	0.22	0.55	0.89	0.73	0.16	-89	208.65	4734338.696	271881.935	3	26			
27_2019_07_14_Hwy_Rte_31_Wside.obs	Hwy_3_Rte_31_Wside	2019-07-14	18:43:15.00	0:32:00	Fin	0.42	42°43'39.46906"	-71°44'12.16160"	183.16	0.27	0.45	1.48	0.58	0.31	-89	210.86	4734335.449	271851.764	3	27			
28_2019_07_14_TLM_Rte_124_N.obs	TLM_Rte_124_N	2019-07-14	16:12:05.00	0:31:00	Fin	0.42	42°43'34.13995"	-71°44'4.23378"	229.28	0.33	0.43	0.79	0.57	0.36	-88	256.97	4734210.271	270662.021	2	28			
29_2019_07_24_Grnvl_Mas_NI.obs	TLM_Grnv_Mas_NI	2019-07-24	19:10:30.00	1:04:20	Fin	0.42	42°43'31.36002"	-71°44'8.152997"	238.15	0.04	0.08	0.12	0.11	0.03	89	265.83	4734145.153	270038.350	2	29			
30_2019_07_17_TLM_MarcelRd.obs	TLM_MarcelRd	2019-07-17	15:41:30.00	0:32:05	Fin	0.42	42°43'15.60636"	-71°44'28.50418"	251.05	0.21	0.35	0.78	0.43	0.27	89	278.74	4733656.889	270090.998	2	30			
59_SLM_2020_04_29_obs	SLM_59_IP	2020-04-29	15:02:55.00	0:31:10	24h		0 42°42'29.731106"	-71°46'38.50935"	214.935	0.168	0.443	0.592	0.53	0.209	-89	242.677	4732158.925	272546.322	5	59			

Notes
 Σlat, Σlong, Σelev are 95% are CSRS-PPP calculated SIG_PPP(95%) errors in Latitude, Longitude and Elevation, respectively, all in meters
 er_maj, er_min are length in meters of semi-major and semi-minor axes of 95% probability error ellipses
 er_az is azimuth to nearest degree of semi-major error ellipse axis
 Ortho-H, UTM-N, UTM-E are Orthometric Height, Northing and Easting in UTM 19N CRS
 Kind is monument code: 1=state line, 2=town line, 3=NH Highway, 4=Survey marker, 5=special

The Mystery of State Line Monument #59

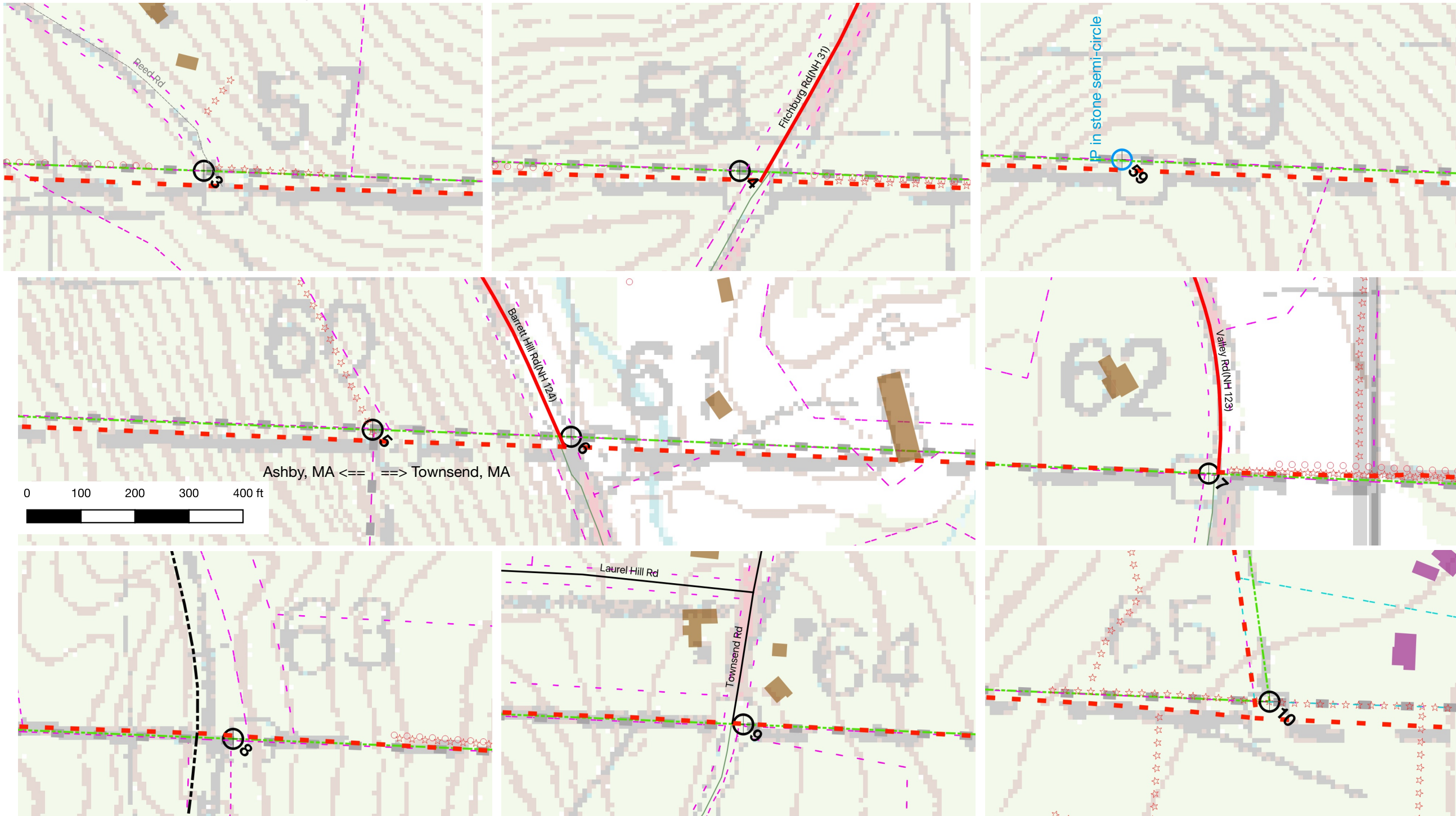
The USGS topographic 1:25,000 quadrangle maps show 11 state line monuments along the Mason / Massachusetts border as square symbols numbered 55...65. Of these, #55 and #65 mark Mason's Southwest and Southeast corners respectively. Seven are set where transport corridors cross the line: #56 at Churchill Rd, #57 at Reed Rd (Class IV), #58 at Fitchburg Rd (Rte 31), #61 at Barrett Hill Rd (Rte 124), #62 at Valley Rd (Rte 123), #63 at the Rail Road and #64 at Townsend Rd, while #60 marks the Ashby - Townsend - Mason town line intersection. All the above are substantial 4' tall 14"x14" granite posts. Monument #59 could not be found, but a low semi-circle of stones around an old 1/2" iron pipe was found near that location - see photograph below. There is no evidence of a granite post ever being set here but the IP does fall on a straight line between #58 and 60. It would have been an unusual monument location as it adjoins neither transportation corridors, intersecting town lines nor parcels or even stone walls. I suspect an original survey marker (the IP) was never replaced with a granite post but the location was shown on maps incorrectly as having a monument.



LEGEND:
 Background: USGS Topographic maps from GRANIT raster files
 Black circles + crosshair, #1..10: monuments, located ±3 feet using GNSS receiver.
 Blue circle + crosshair, #59: IP in stone semi-circle, located ±3 feet using GNSS receiver.
 Thin magenta dashed lines: parcel lines
 Heavy dashed red line: state line per USGS shape file from GRANIT
 Heavy dashed grey line: state line per MASS-GIS shape file
 Thin green dashed line: monument to monument (1..10) straight lines
 Small red circles and stars: stone walls detected in orthophotos (circles) and LIDAR data (stars); suggestive of parcel lines, etc.

Note close correspondence between monuments and MASS-GIS state line shape files.

SCALE: 1:2400 (1"=200'), Proj. EPSG:3614, NAD83(NSRS2007)/NH (ftUS) v2020_04_29



A Comparison of Mason, NH, Border Monuments v Town Lines per USGS

DATA SOURCES:

30 "monuments" were found along the border. These are displayed as numbered color coded circles:
 black: State Line monuments set in 1894, 14"x14" tall granite posts, #1 ... 10
 red: Town Line monuments, various granite posts
 orange: NH Highway markers, low concrete posts (#25 ... 27)
 green: survey markers (low granite posts or iron pipes) shown on HCRD plans
 blue: #15, centerline of Conservation Commission gate in stone wall
 #59, no monument found at location of #59 shown on topos, but IP found in stone semi-circle
 The locations 1...30 are numbered in counter-clockwise order starting at Mason's SW corner.

Current GRANIT GIS files were used for: Town lines (pba.shp, thick red dashed lines); transport (Roads_DOT.shp, rr.shp, pipe.shp) and hydrology (NHDFlowline.shp, NWIplusNH.shp).

The thin green dotted lines are straight lines connecting the measured locations of "border monuments" (only black, red and orange circles), added only to suggest the general path of the boundary. Note that actual boundaries may follow stone walls or other features rather than straight lines.

Greenville's Southern border (#24 ... 29, dashed magenta line) is based on the 1976 survey of the town line by TF Moran (HCRD Plan #12962). Thick gray dashed line: State line per MASS-GIS shape file.

Each measured location is also shown around the edges of the main map in an expanded detail with a 100' grid.

DISCUSSION:

Mason's South town line is offset slightly from the 1894 State Line monuments; MASS_GIS line is right. Mason's border with New Ipswich is slightly offset at its N end. Greenville's Southern town line, per USGS, deviates about 0°55' counter-clock-wise from Moran's 1976 survey, resulting in a ~ 157' offset NNW at its Eastern end at the SE corner of Greenville. Mason's NW corner, per USGS, is offset by ~ 210 feet Eastward. Mason's NE corner, per USGS, is offset by ~ 158 feet Southward. Mason's corner with Brookline & Milford, per USGS, is offset ~ 168 feet SSE.

METHODS:

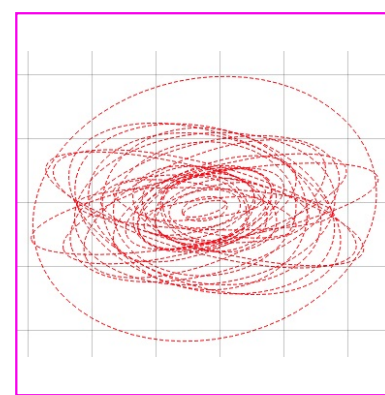
The location of monuments along the town lines were measured using an iGage iG3s dual-frequency (L1+L5) dual constellation (US GPS + Russian GLONAS) Geodetic GNSS Receiver (S/N 973174). At each location satellite data was recorded for at least 30 minutes (up to 1 hour for sites with extra dense foliage cover) to provide 95% probability of less than +/- 3 foot uncertainty in position.

The recorded data were then post-processed by Canadian Geodetic Survey of Natural Resources's CSRS-PPP service (<https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php?locale=en>) to provide corrected locations with error estimates. CSRS-PPP calculated error ellipses (95% probability) for the 30 monuments are displayed on a 1 foot grid in the magenta detail box above.

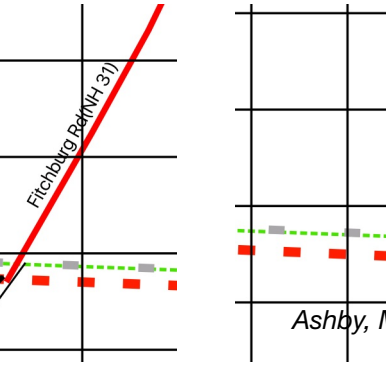
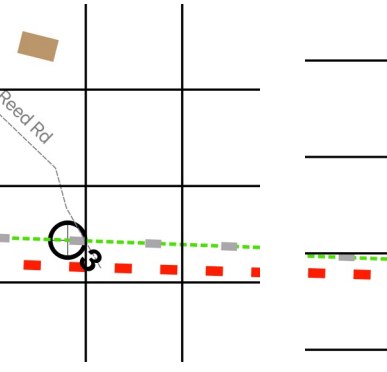
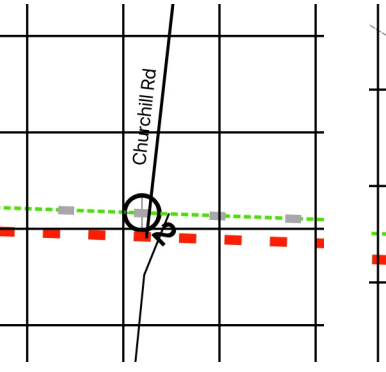
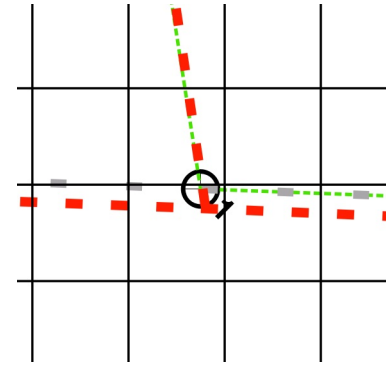
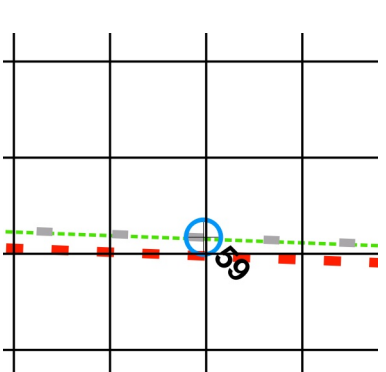
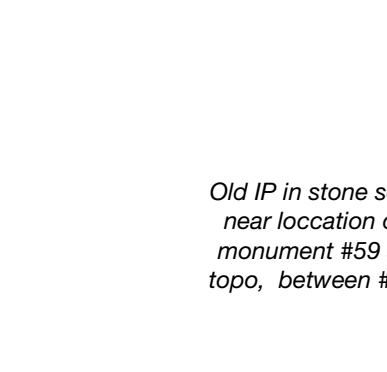
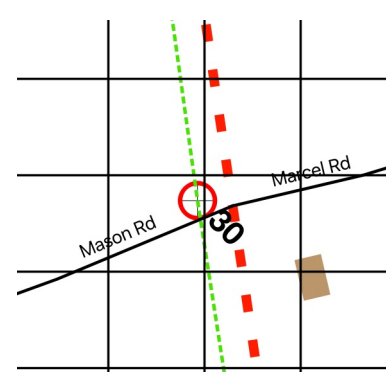
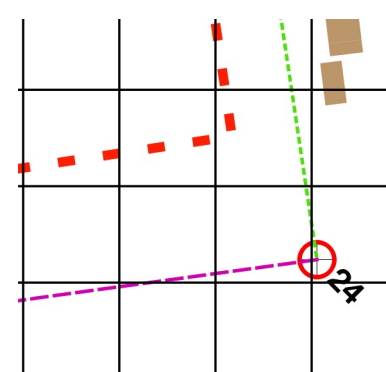
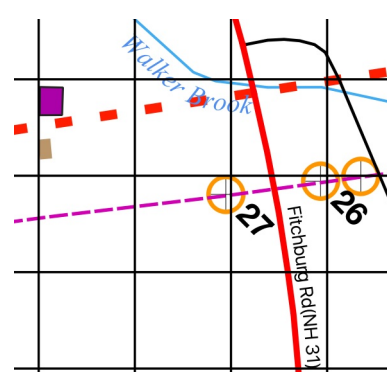
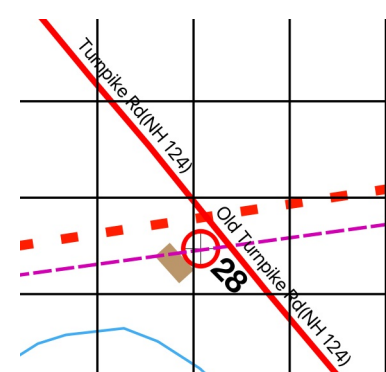
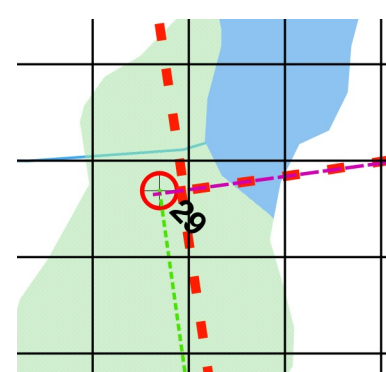
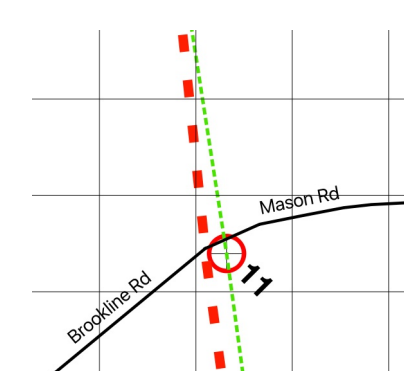
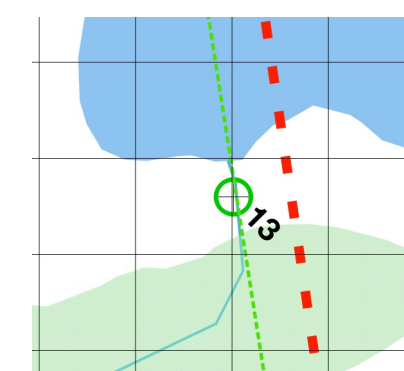
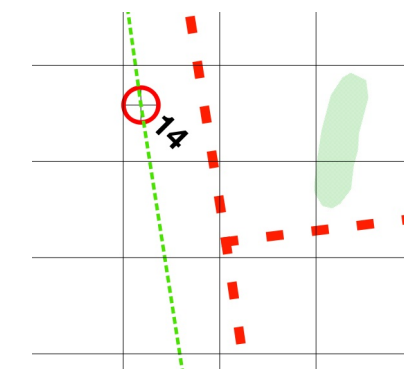
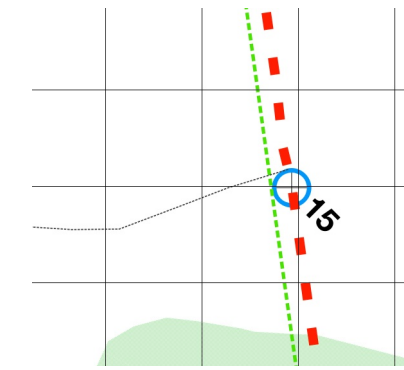
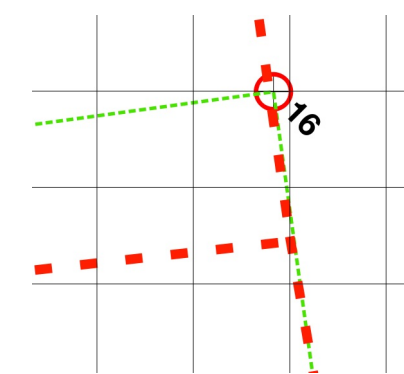
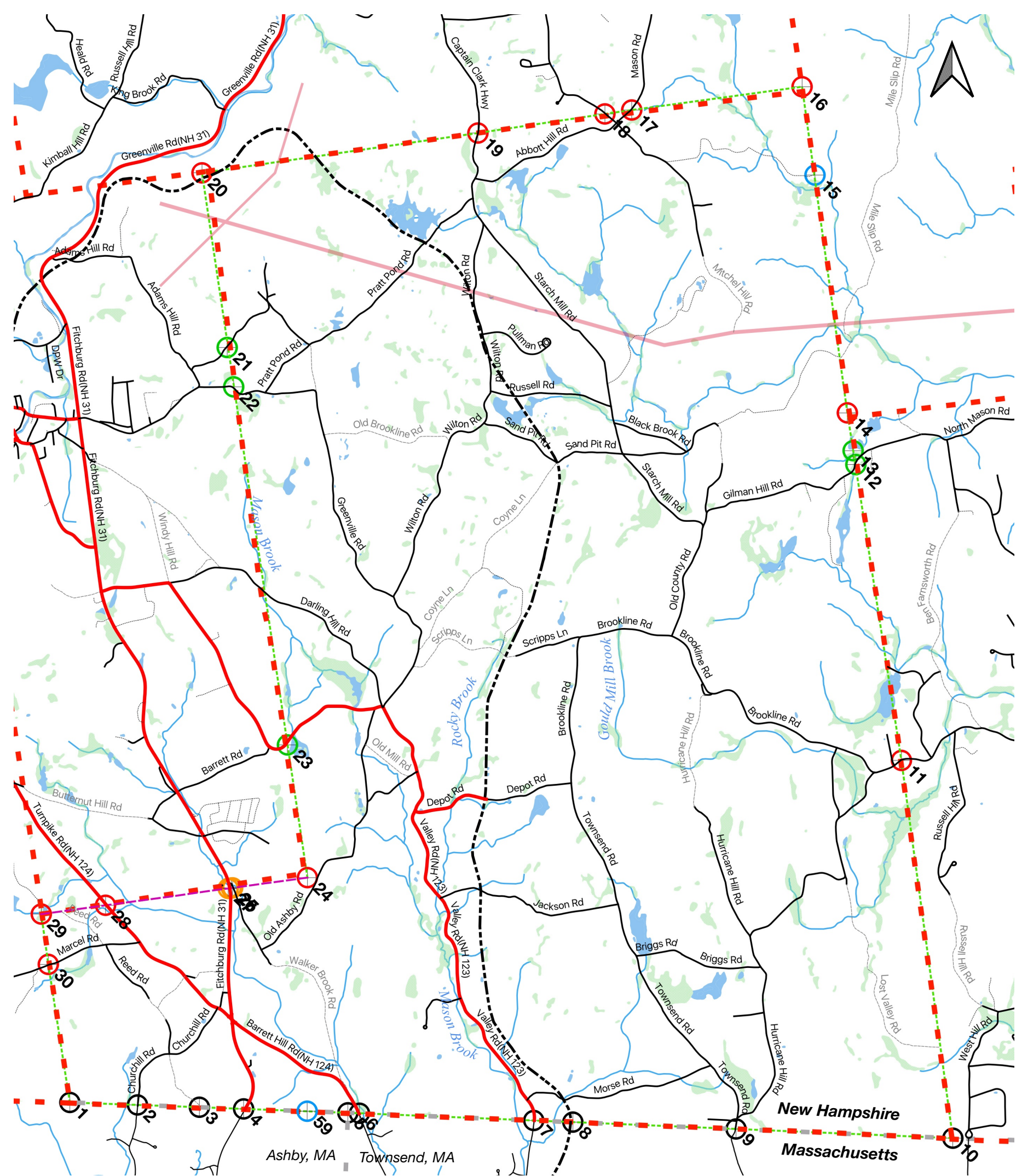
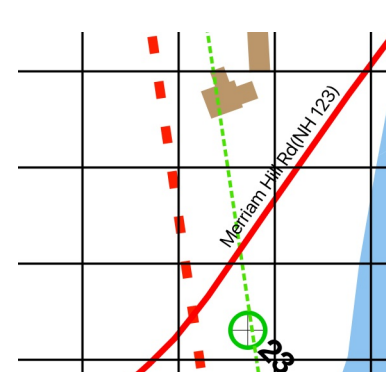
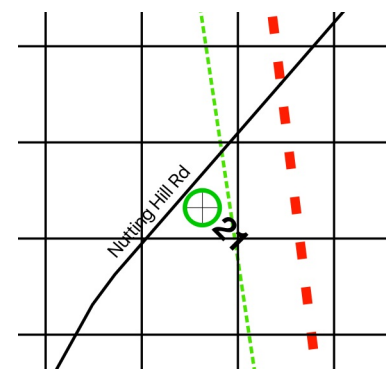
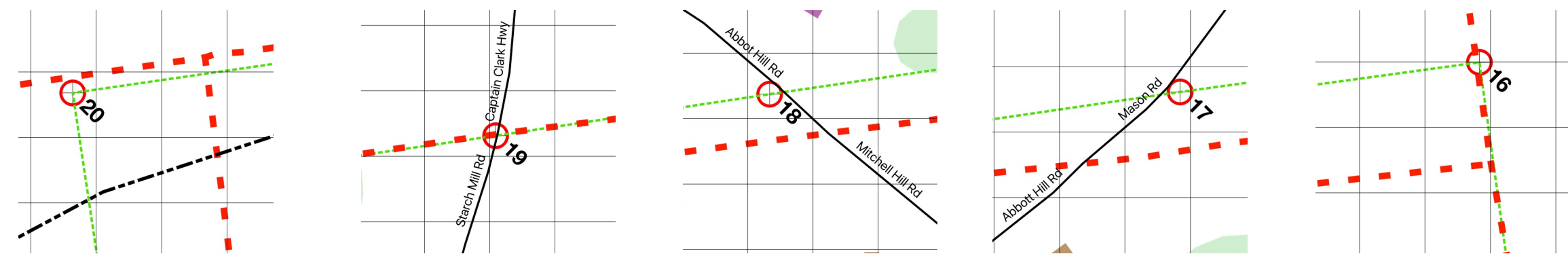
CSRS-PPP was used instead of the US OPUS post-processing which only handles data from US GPS satellites. Mason's heavy forest cover reduces GPS satellite reception, so inclusion of Russian GLONASS satellites can double coverage and significantly reduce the necessary observation times.

Map projection: EPSG:3614, NAD83(NSRS2007) / NH (ftUS);
 scale: main map 1:40,000, details 1:2,400

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CSRS-PPP error ellipses, 1' grid



Old IP in stone semi-circle near location of missing monument #59 shown on topo, between #4 and #5.

Ashby, MA | Townsend, MA

Walls versus Boundaries: Mason's Eastern & Northern Borders

The presence of walls may suggest the path of municipal boundaries, but are by no means a certain indicator. It may be that the wall builders built along what they believed to be a town boundary, but were misled; or that they were building what they thought to be walls well away from the boundaries. Caution is required.

Nonetheless, if two versions of a boundary exist and one version is lined with walls while the other is not, then it may be reasonable to argue that the wall lined version is more likely to be the real one. In such cases the presence of walls may be a witness to what people historically believed to be the boundary. Indeed it may be the path they would have "perambulated" when maintaining town lines.

Walls can be detected in two ways:

- 1) As linear shadows visible in the orthophotos when the illumination from the sun is somewhat low (not high noon) and is at an angle to the wall and the forest canopy is thin enough to see the shadow on the ground.
- 2) As linear shadows visible in "hillshade" renderings of LIDAR elevation data. LIDAR can penetrate forest canopy to some extent - an advantage over orthophotos which cannot.

Some of the orthophotos were taken at suitable times; others with the sun directly overhead when there may be no shadows to see. Also, the sun's angle is determined by the season; walls running West to East along the Sun's path may simply not cast visible shadows.

LIDAR does have the advantage of penetrating, to some extent, forest canopy. Also, in creating "hillshade" renderings one can vary the position of the "sun" so E/W running walls can be detected as easily as N/S ones. However, the LIDAR data for most of Mason (in the Nashua River Watershed) is of inferior quality. Fortunately, new high quality LIDAR data is being collected and should be available by Summer 2022. Note that with either approach the shadow is offset away from the "Sun".

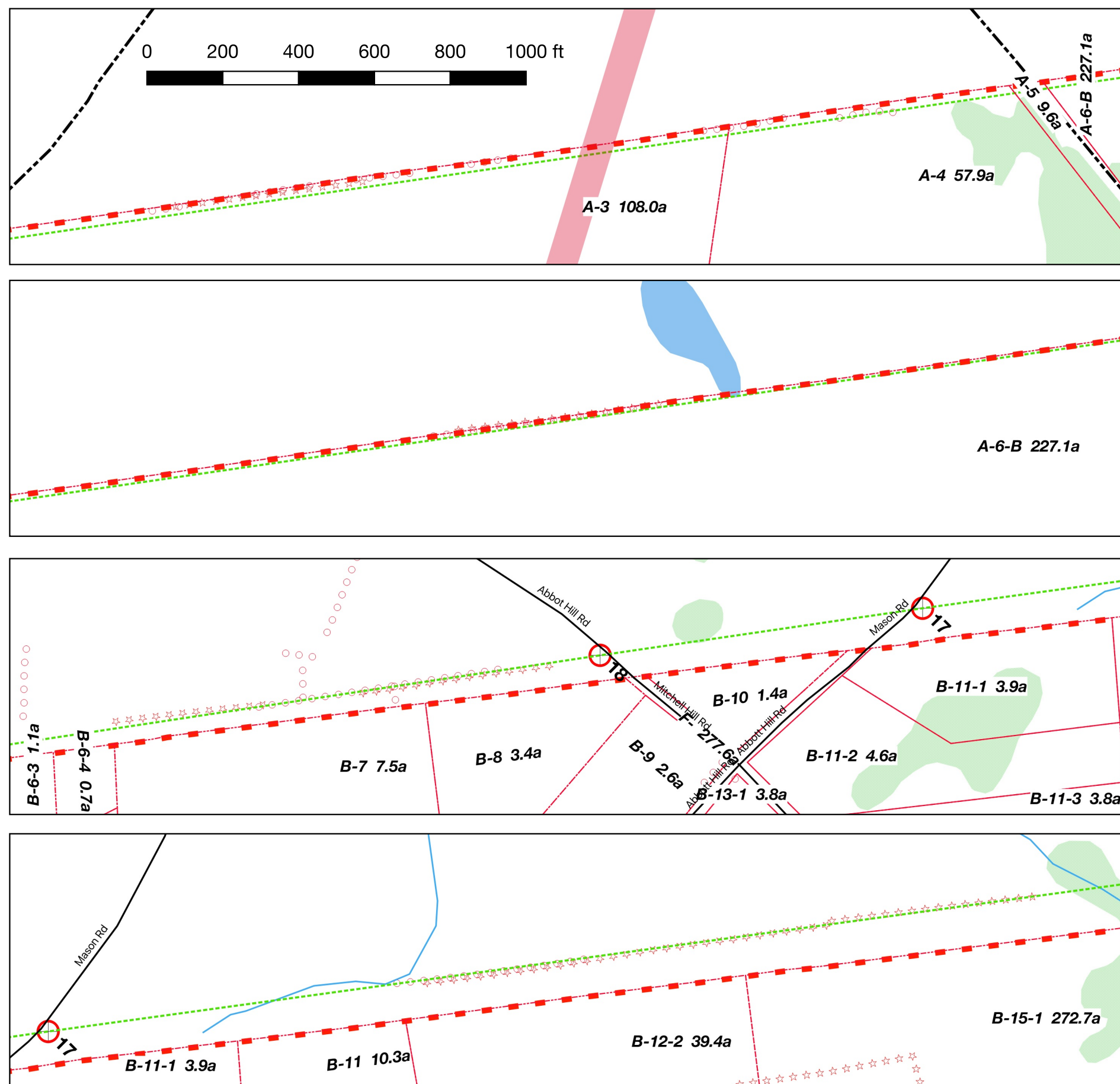
These maps show stone walls which were detected either as shadows in the orthophotos (red circles) or from "hillshade" renderings of the LIDAR elevation data (red stars). Also shown are the USGS town lines (heavy dashed red lines) and my thin dashed green "connect the monuments" lines. Parcel lines and lot numbers are included for orientation.

In some cases, for example along the Northern border below, the lines of walls seem very suggestive of the actual boundary locations...

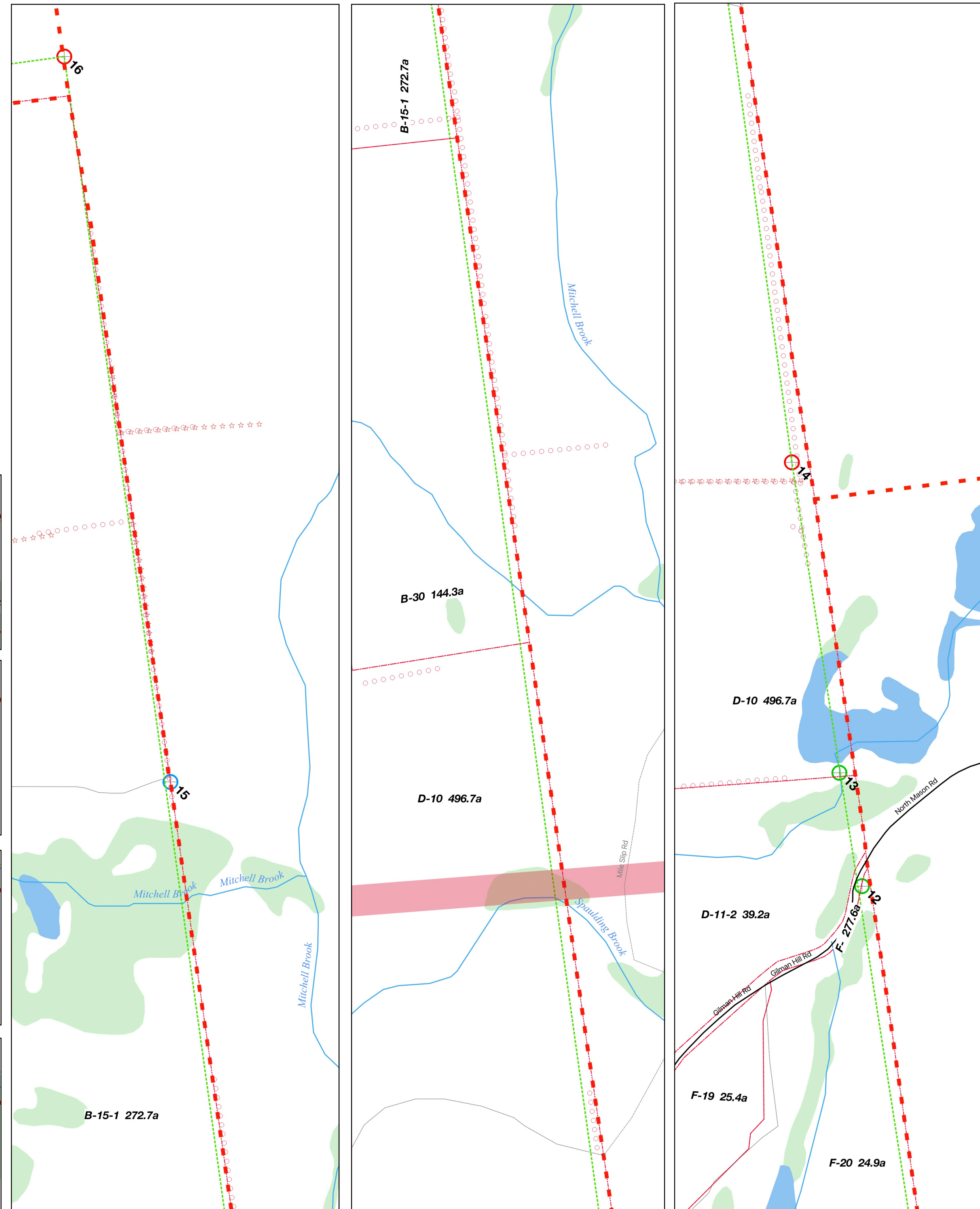
Scale: 1:3,600

v2020_05_02

Mason's Northern Border



Mason's Eastern Border



Map 2: Walls (ortho & Lidar), East & North sides

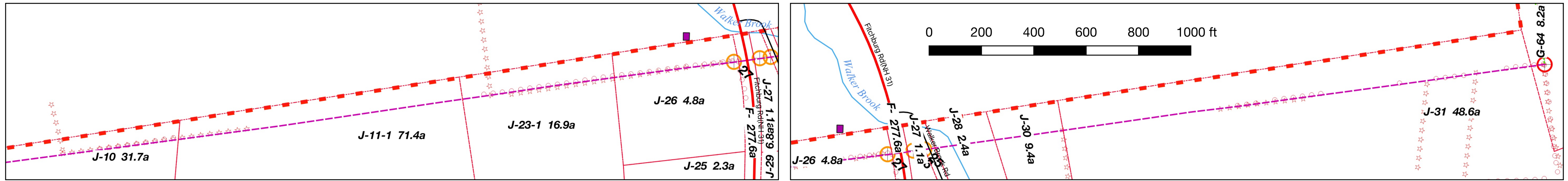
Walls versus Boundaries: Mason's Western & Greenville Borders

circles: shadows in orthophotos
stars: LIDAR edges

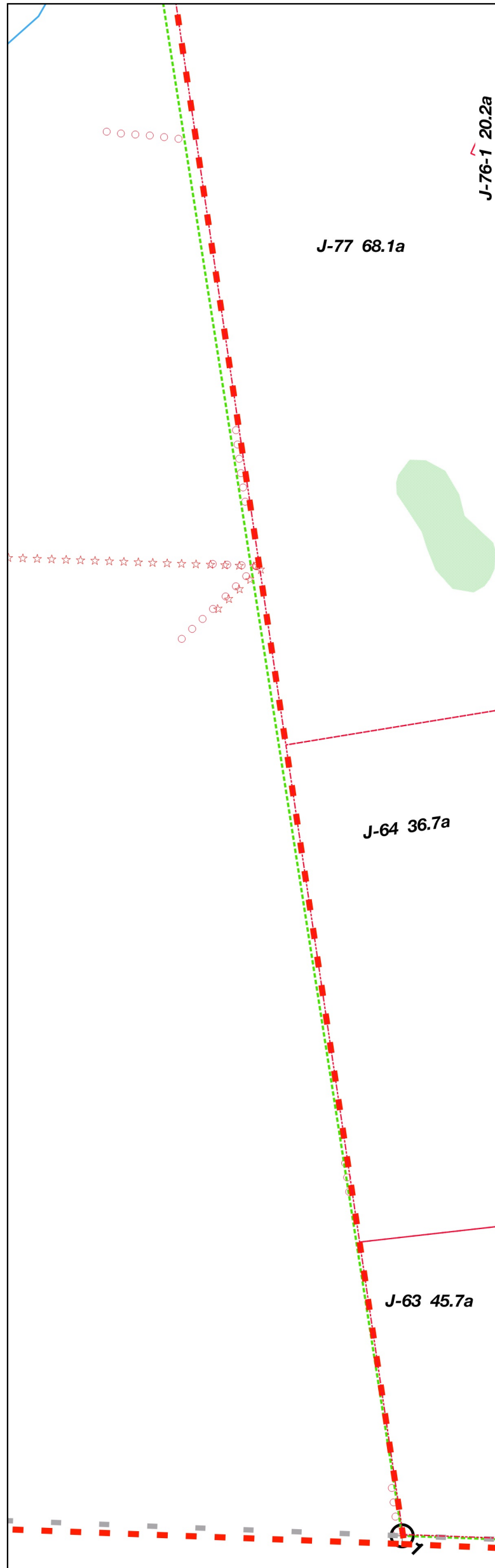
See Map 2 for detailed description

Scale: 1:3,600, 1" = 300'
v2020_05_02

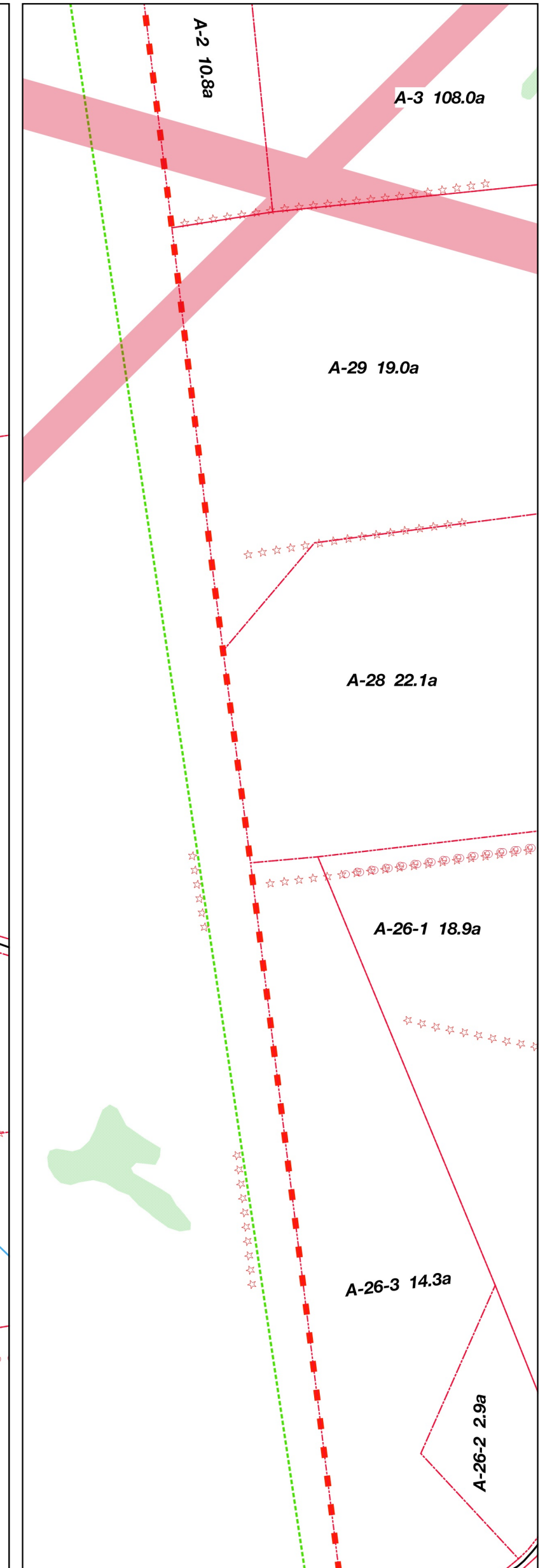
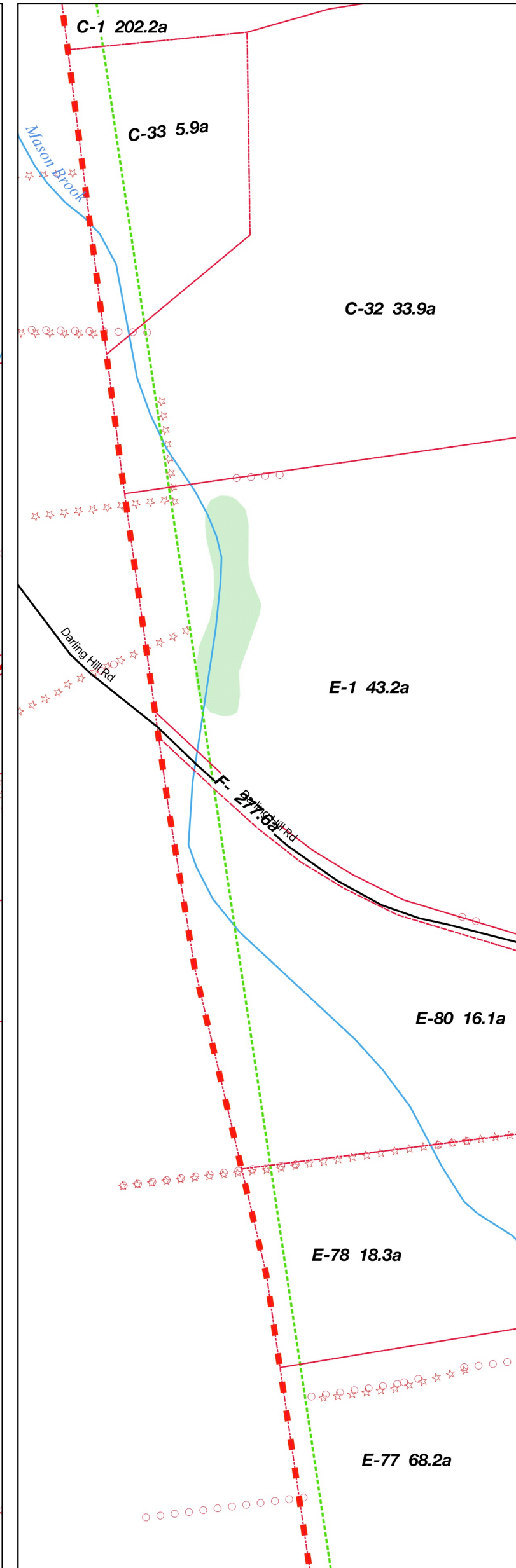
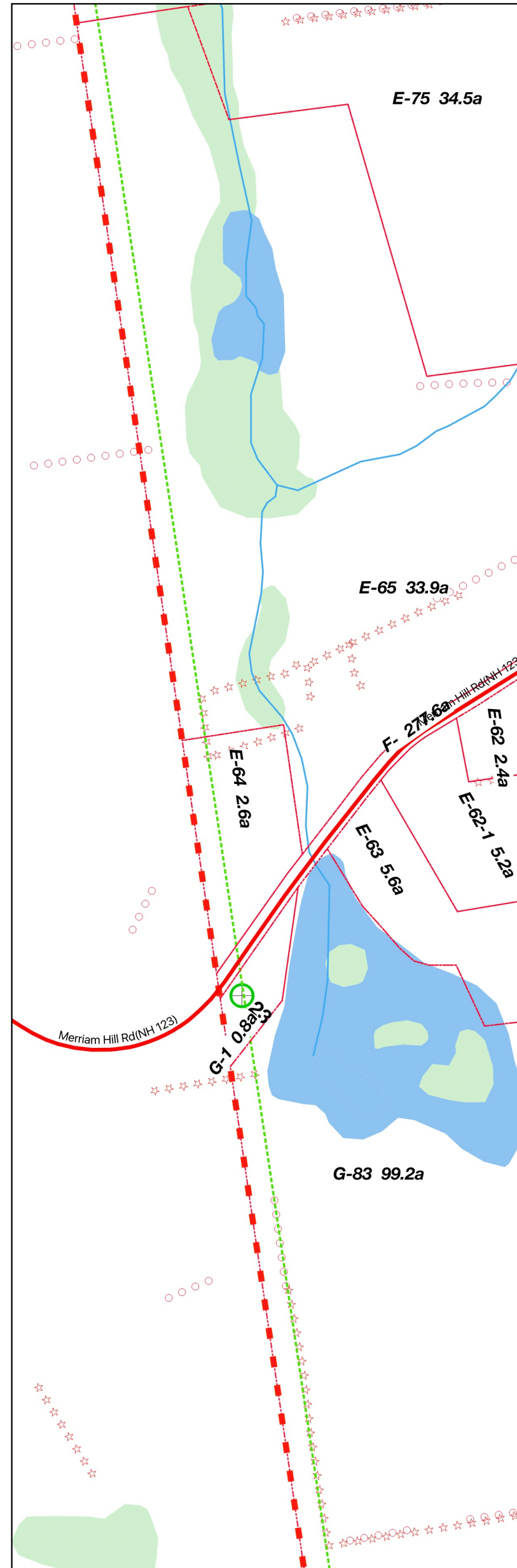
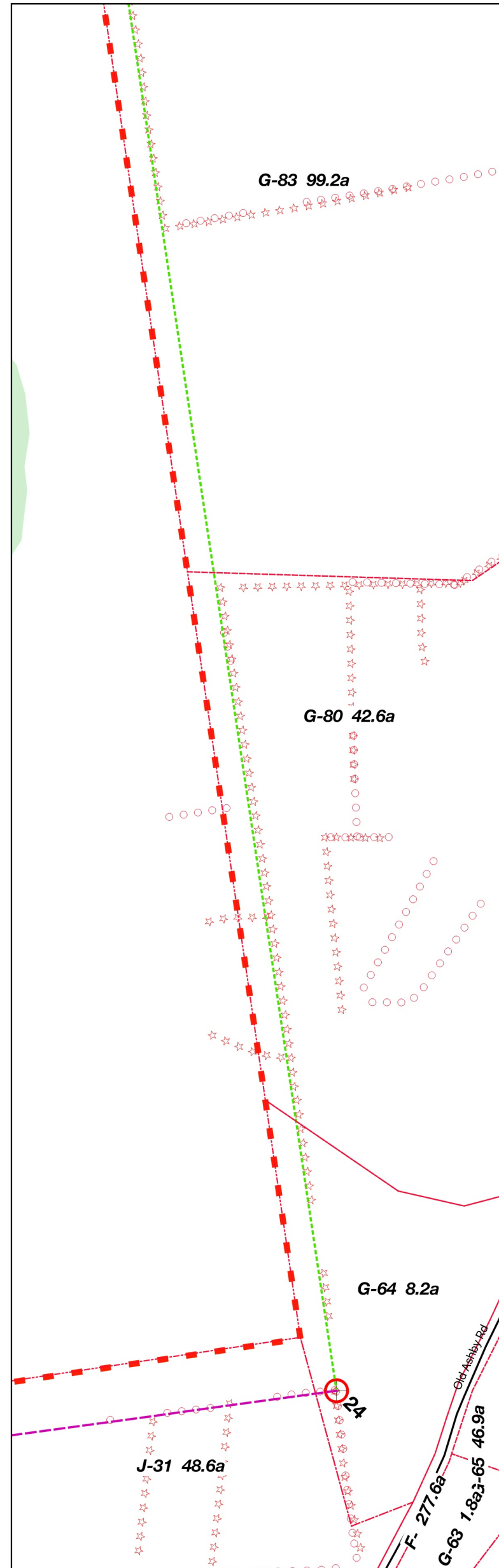
Greenville's Southern Border with Mason



New Ipswich's Eastern Border



Greenville's Eastern Border with Mason:



Map 3: Walls (ortho & Lidar), Western side

Parcel Maps versus Boundaries: Mason / Greenville Borders

This map highlights in yellow the areas of overlap between parcels in Mason and Greenville.

Greenville parcels are outlined with blue dashed line and labelled with blue Parcel #
 Mason parcels are outlined with magenta dashed line and labelled with magenta Parcel #.

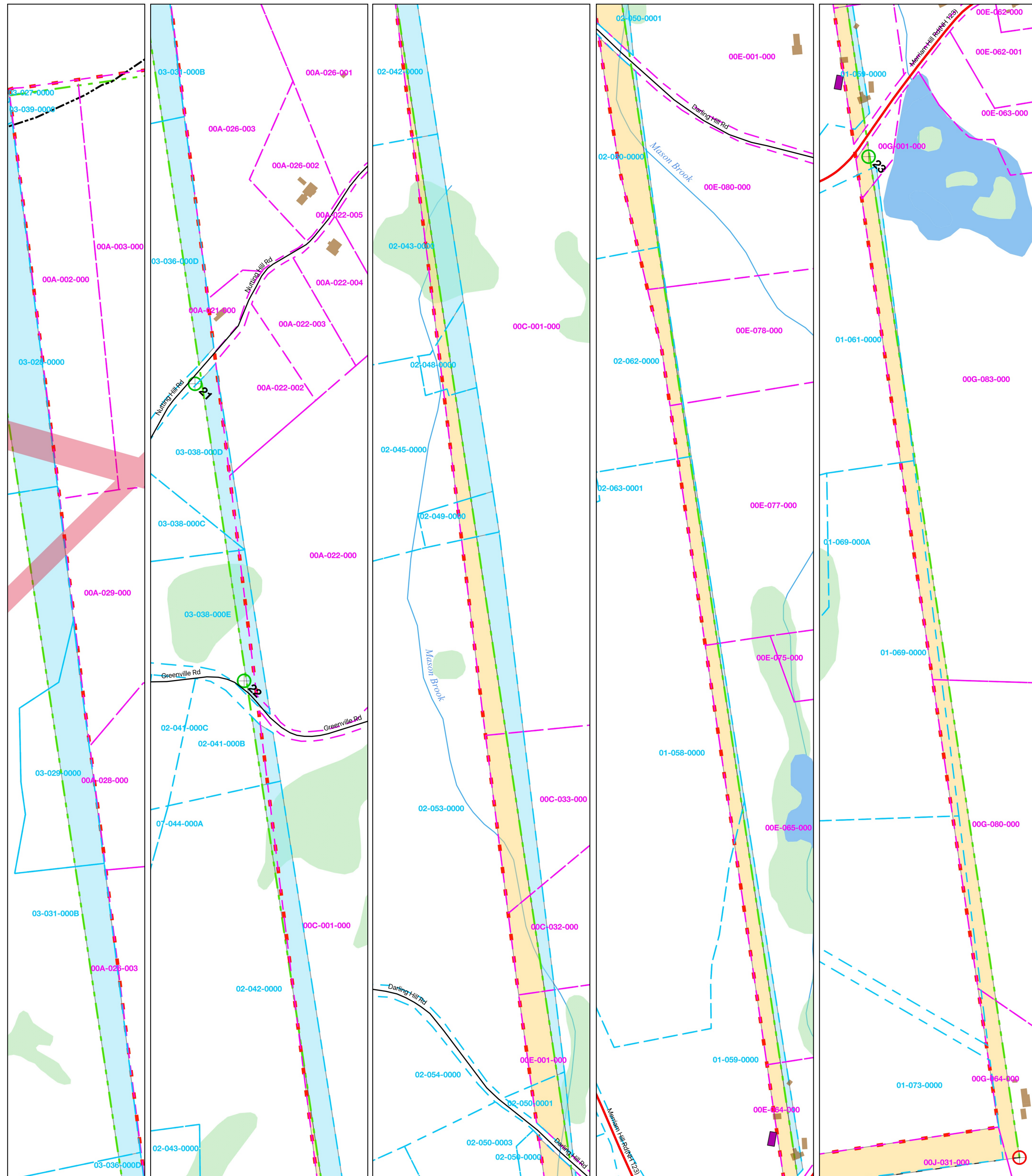
USGS town boundaries: heavy dashed red line
 1976 TF Moran survey of town line: dashed black line
 Straight dashed green line connects the Town Line (red), State Highway (orange) or State Line (black) monuments
 Monument symbols and data sources are as described on Map 1

Parcel overlaps occur along Greenville's Southern border and along the Southern part of its Eastern border.
 From monument 27 (Rt 31) Eastward the Greenville parcel lines follow the Moran survey. However, West of the intersection of Greenville parcels 01-29-3 and 01-31-0 they deviate from both the survey line and the USGS line.
 Along Greenville's Eastern boundary the parcel lines follow a variable path, only occasionally matching either the USGS lines or the monument to monument line.

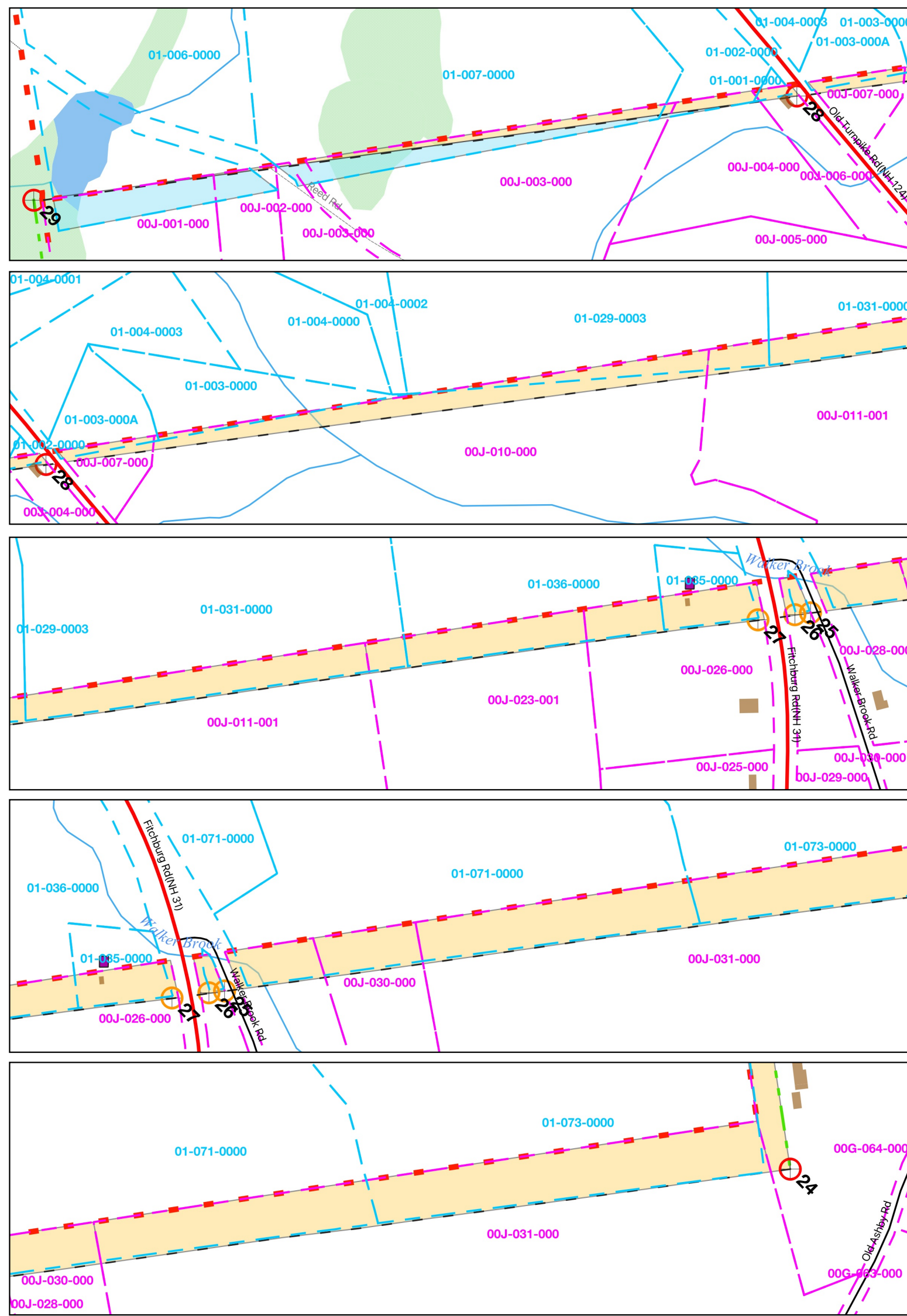
Scale: 1:3600 (1" = 300')

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Greenville's Eastern Border with Mason, N to S



Greenville's Southern Border with Mason, W to E



Map 4: Parcels & Overlap: Greenville Borders