

# Survey of Thack Moor

**22 August 2012**

The Team: John Barnard, Graham Jackson and Myrddyn Phillips

**03 March 2013**

The Team: John Barnard, Graham Jackson, Myrddyn Phillips and Bob Smith (Grough)

## 1) Introduction

Thack Moor, (Hill 2770, Section 35A, OS 1:50000 Map 86, OS 1:25000 Map 31W, Grid Ref. NY611462), which has also in some sources been referred to as Renwick Fell, is currently listed as a “Dewey” and is situated in the Western Fells of the North Pennines, 11km West of the village of Alston. The latest 1:25000 and 1:50000 OS maps mark the summit with a trig point with a spot height of 609m. The OS database quotes the height of the Flush Bracket on this trig point as 609.60m that is 2000.0feet.

The purpose of these surveys was to measure the height of Thack Moor accurately in order to see if it is above 609.60m which would mean that the status of this hill would change to Nuttall (P15) /Hewitt (P30). In order for this to happen, there needs to be natural ground higher than the Flush Bracket and/or the quoted Flush Bracket height has been underestimated.

## 2) Equipment used and Conditions for Survey

Ground surveys to determine the position of the summit were carried out using a Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a “1m” E-staff extendable to 5m.

Absolute heights were measured using a Leica Geosystems 530 GPS receiver and a Leica Viva GS15 Professional GNSS receiver. They are dual-frequency, 24-channel instruments, which means they can lock on to a maximum of 12 satellites and receive two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signal. As stand-alone instruments, they are capable of giving position and height to an accuracy of about one and five metres respectively. Note that a hand-held GPS receiver can only receive up to 12 satellites and each at a single frequency and therefore it has a poorer positional accuracy of +/-5m and a height accuracy of no better than 10 metres. Despite the on-board features of the receivers, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GPS data via imported RINEX data from the Ordnance Survey which was post-processed using Leica Geo Office Version 7.01 software.

Conditions for the first survey, which took place between 11.30hr and 14.30hr BST on 22 August 2012, were satisfactory. The weather was mild, about 15 degrees Celsius, but with sunshine and an occasional shower. The wind was quite strong at an average speed of 30mph but the shelter from the summit ridge wall was able to provide some protection and so the survey was not affected by it.

Conditions for the second survey which took place between 12.45hr and 16.45hr GMT on 03 March 2013 were also satisfactory. The sky was overcast and visibility, although only needed to about 50m, was good. There was almost no wind and the temperature was about 3 degrees Celsius. Snow

was piled up against the stone wall that crosses the summit area and this would have prevented a full survey with level and staff to identify the summit position. This work had been carried out in the first survey, however, when it was confirmed that ground nearer the wall was lower as described below. Consequently, its presence in the second survey turned out not to be an issue preventing progress.

## **2.1) Character of Hill**

Thack Moor is one of the hills that form the South West rim of the Western hills of the Northern Pennines. Its summit is about 3.5km North East of the hamlet of Renwick from where access can be gained. A track starting at Renwick (limited car parking) and marked on the OS maps can be followed to a fork about 1.5km from the hamlet. The left hand path is taken which peters out from a farm track to a footpath as it makes its way up to the summit ridge of Thack Moor. The hillsides are not steep and are covered with grass which being not too long or tussocky, made going underfoot quite easy once off the path. A high stone wall follows the line of the ridge across the summit and the trig point lies approximately two metres away from the wall on the South Western side of it.

## **2.2) The Summit**

### **2.2.1) Survey 22 August 2012**

Since the summit area is quite flat and split by a high stone wall, an initial visual inspection provided no clear identification of high points and therefore systematic surveying with level and staff was needed either side of the stone wall.

We set up the level at a convenient position on the North Eastern side of the wall and took readings from staff placements. This showed that there was a slight ridge running parallel to the wall and about 7metres away from it. We were able to identify two high points, one on this ridge and another close to the base of the wall. The point on the ridge was measured to be 0.01m higher.

The next task was to try to identify any higher ground on the opposite side of the wall. The level was set up on the ground on that side of the wall and with systematic use of the staff the highest point was found. Having now identified the highest points either side of the wall, we now needed to compare their heights. To do this we had to improvise a tripod arrangement with Quickset tripod and GPS antenna poles in order to be able to mount the level so that it had a field of view over the high summit wall. The relevant staff readings then taken were:-

Highest point on North East side of wall = 1.530m

Highest point on South West side of wall = 1.650m

Flush Bracket = 1.235m

These readings show that the highest point on the hill is on the North East side of the wall on the minor grassy ridge and this is 0.12m higher than the highest point on the opposite side of the wall.

The Flush Bracket is actually 0.295m higher than the highest natural ground.

The Leica 530GPS was set up over the summit position. (See Appendix 1 for photograph). The AT502 antenna was set on a 1.000m pole and data were collected for 2 hours with an epoch time of 30 seconds.

The ten-figure Grid References measured for the summit were:-

Garmin 60CSx	NY 61169 46277	Accuracy 4m Height = 612m
Garmin Venture	NY 61167 46277	Accuracy 5m Height = 615m
Garmin Etrex	NY 61167 46278	Accuracy 6m Height = 612m
Magellan Explorist100	NY 61167 46277	Accuracy 6m Height = 612m

The ten-figure Grid References measured for the highest point next to the wall and on the same side as the summit were:-

Garmin 60CSx	NY 61180 46266	Accuracy 5m Height = 608m
Garmin Venture	NY 61180 46268	Accuracy 6m Height = 614m
Garmin Etrex	NY 61179 46266	Accuracy 6m Height = 611m
Magellan Explorist100	NY 61181 46265	Accuracy 6m Height = 612m

The ten-figure Grid References measured for the Trig Point were:-

Garmin 60CSx	NY 61153 46278	Accuracy 4m Height = 611m
Garmin Etrex	NY 61153 46278	Accuracy 6m Height = 612m

The position and height data for the summit that were recorded by the Leica 530 and post-processed with Leica GeoOffice 7.01 using the computed Tropospheric Model and imported OS RINEX data from the nearest eight OS Active Base stations were:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
SR 530	361165.981	0.003	546278.970	0.003	609.645	0.005

### **2.2.2) Survey 03 March 2013**

As the summit of the hill had been located on the previous survey on the North Eastern side of the wall, the ground on the opposite side of the wall was not resurveyed. The summit was first located approximately from the hand held GPS measurements taken during the first survey. However this procedure was not adequate to exactly locate the summit position, so systematic staff readings were taken with the Leica NA730 level until the highest point had been relocated. Fortunately the summit position was just on the edge of the snow that was piled up against the wall so the minimum of snow clearing was required.

The Leica GS15 was set up on a 2 metre pole over the summit position and data were collected for 4 hours with an epoch time of 15 seconds (See Appendix 1 for photograph).

The position and height data for the summit that were recorded by the Leica GS15 and post-processed with Leica GeoOffice 7.01 using the computed Tropospheric Model and imported OS RINEX data from the nearest eight OS Active Base stations were:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	361166.165	0.002	546279.080	0.002	609.625	0.004

### **2.2.3) OS Calculations on GPS Data Sets**

As the height of Thack Moor at 609.645m measured on the first survey is so close to 2000.0 feet (609.60m) the Ordnance Survey were consulted for advice. They recommended the second survey where we were advised to collect 4 hours of GPS data. Both of these data sets were sent to Mark Greaves at the OS who evaluated the data sets using Bernese software. The results were computed as accurately as possible and included precise ephemeris and Ocean Tide Loadings.

In order to check the accuracy of the data set, the OS use routinely a system called Coordinate Recovery. The position and height of the survey point is computed relative to the nearest OS Base Station. Then the surveyed point is set as a reference point and the coordinates and heights of the next few, usually 5, nearest OS Base Stations are computed. These results are then compared with the known coordinates and heights of these Base Stations. For the SR530 and GS15 data sets, the heights coordinate recovery were 25mm and 19mm respectively. Thus the GS15 dataset is a slightly more consistent data set and reflects the longer collection time and improved receiver.

The OSGB36 coordinates and ODN heights for Thack Moor for the two data sets were:-

SR530 data set; Easting 361165.977, Northing 546278.972 and Height 609.6196m

GS15 data set; Easting 361166.171, Northing 546279.087 and Height 609.6184m

The mean height from the two data sets is 609.619m and therefore the OS have concluded that Thack Moor exceeds 2000.0 feet by just 0.02m and a new height of 610m will be put onto OS Maps.

### **3) Discussion of Results**

The height of Thack Moor was measured to be 609.62m, exceeding 2000.0 feet by only 0.02m! We measured the Flush Bracket on the Trig Point to be 0.295m higher than the natural summit of the hill and therefore calculate its height to be 609.914m. This compares with a figure of 609.60m taken from the OS database. The difference in the two measurements of 0.31m is very surprising because normally we only measure a difference of a few centimetres. (The greatest difference we have found from previous surveys was with Earl's Hill in Shropshire where the difference was 0.20m.). Ordnance Survey was consulted and it appears that there is no evidence for a levelled height in the OS records; the height was probably derived from vertical angle measurements taken as part of the pillar's initial observation. Consequently we are advised to ignore the quoted height in this instance.

We estimate that we were able to locate the position of the summit to within a height uncertainty of +/-0.01m. Combining this with the uncertainty in the GPS measurement for height as +/-0.05m (three times standard deviation) for a 4 hour dataset, the overall uncertainty in the height measurement is estimated to be +/-0.05m.

Since the over all uncertainty in the height measurement of +/-0.05m is greater than the measured height of 0.02m above 2000 feet, this means that the probability that Thack Moor exceeds 2000.0 feet is about 70%. However, the coordinate recovery heights calculated by the OS and the consistency between the heights of 0.0012m measured for the two totally independent surveys reinforce the conclusion that Thack Moor exceeds 2000 feet and becomes a new English "Mountain".

#### 4) **Summary and Conclusions**

The **summit** of **Thack Moor** is at grid reference \* **NY 61167 46277** and has no feature. Its **height** was measured to be **609.62+/-0.05m, 0.02m higher than 2000 feet.**

**Thack Moor is a new 2000 foot mountain in England.**

**Thack Moor** has been submitted to the **relevant list authors and has been agreed by them for reclassification from the Dewey list to the Nuttall (P15) /Hewitt (P30) lists.**

\* NB average hand-held Garmin/Magellan GPS grids are quoted in the summary.

John Barnard, Graham Jackson and Myrddyn Phillips, 02 April 2013.

## Appendix 1

**Leica SR530 set up on a 1 metre pole over the summit of Thack Moor**



**Leica GS15 set up on a 2metre pole over the summit of Thack Moor**

