

# Survey of Diffwys

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## **1) Introduction**

Diffwys (Hill Number 2058, Section 30D, OS 1:50000 Map 124, OS 1:25000 Map 18W, Grid Ref. SH661234) is listed as a subMarilyn in the Database of British and Irish Hills (DoBIH) with 148m of drop. On the map the bwlch appears to be very narrow on the valley to valley direction with two nearly touching 600m contours, while there are reports of higher ground than the trig point on the summit. Thus the drop could well be 150m or greater, which would reclassify Diffwys as a Marilyn.

The purpose of this survey was to measure accurately the drop for Diffwys to determine if it attains 150m or not and thereby resolve its classification.

Access to the hill was via its West top (Hill Number 2072) which is a Nuttall and subHewitt. While there, we took the opportunity to locate the summit position and use the Trimble GeoXH 6000 to measure the drop.

## **2) Equipment used and Conditions for Survey**

A Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a “1m” E-staff extendable to 5m were used to determine the positions of the bwlch and summit, and also to line survey between these two points.

Absolute heights were measured using Leica Viva GS15 and Trimble GeoXH 6000 GNSS receivers. These receivers are dual-frequency, multi-channel instruments, which means they are capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites as availability dictates, 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 signals. As stand-alone instruments they are capable of giving position and height to an accuracy of about two metres and five metres respectively. Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5metres and a height accuracy of no better than +/-10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these units can achieve a satellite “fix”. Despite the on-board features of the GS15 and GeoXH 6000 receivers, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from Ordnance Survey which were post-processed using Leica GeoOffice 8.3 and Trimble GPS Pathfinder Office respectively. Repeated measurements with the GeoXH 6000 instrument made on the same point give a height precision of +/-0.20m; height precision for the GS15 using the same method is +/-0.05m.

Conditions for the survey, which took place between 13.00hr and 17.00hr BST, were good. The weather was warm and sunny, 18 degrees Celsius with a light wind in exposed areas and visibility was excellent.

### **3) The Survey**

#### **3.1) Character of Hill**

Diffwys lies near the southern end of the Rhinog range of hills, which stretches from Trawsfynydd in the North to Dolgellau in the South, a distance of approximately 18km. The hills have a reputation for being rough and heathery, and the ridge can be difficult to follow in mist. Despite the highest point being only 756m this is a mountain environment. Access to Diffwys may be achieved from the SE, the South or from the West. This last approach is good, but to get to the starting point at Dyffryn Ardudwy requires a longer drive if approaching on roads from the East. The SE approach is short, but requires a steep climb up the East face of Diffwys. Consequently, we chose the South approach starting from the end of the minor road just North of Llechfraith. The ascent is on good paths all the way and arguably the least steep. Once past the West Top it was decided to contour beneath the summit of Diffwys to gain access to the bwlch between it and Y Llethr, where the survey would start. There was no path on this section, but the route was on short grass and progress was easily made. A 2m high wall runs through the bwlch on the hill to hill direction and up to and across the summit. Three stiles provide crossing points, but these are all high up with the last being near the trig point. There is no stile near the bwlch, although the wall may be crossed with care, making access either side possible. Some walkers have reported that on the summit higher ground may exist on the side of the wall away from the trig point and we therefore required a strategy to investigate this.

#### **3.2) Summary of Survey Method**

The survey commenced at the bwlch whose position was identified with the Leica NA730 level and staff. Having collected data at that point with the GS15 and the GeoXH 6000, we then followed the route to the summit. Again using level and staff, the ground either side of the wall was investigated and the true summit position was located. Finally, data were collected with the GS15 and GeoXH 6000.

For the West Top a grid of flags was used to locate the summit position and summit height was measured with the GeoXH 6000. The bwlch position was estimated by eye, since confirmation that the drop was greater than 15m was the only purpose of this measurement.

#### **3.3) The Bwlch**

The first task was to carry out a visual assessment of the bwlch. As indicated on the map this was very narrow and comprised a series of rocky outcrops. The wall which was only a few metres distant was sited at least two metres below the hill to hill line of the bwlch and consequently ground on its West side could be discounted. Two candidate positions were identified about 10m apart on either side of one of the outcrops. With the level set up a few metres away and higher than these candidate positions, each was investigated by taking several staff readings. It was quickly established that the more southerly was the lower by 0.15m.

Next the tripod was set-up over this position and the Leica Viva GS15 was then fixed to it with a clamp and tribrach (the "short tripod" configuration). The height of the receiver above the ground was then measured with the integral tape. The vertical offset from measuring point to the ground was 0.695m (see photograph in Appendix) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

The Trimble GeoXH 6000 was placed on the outcrop less than a metre North of the bwlch where its view of the sky was uninterrupted. A staff reading of this position had previously been taken so that the height difference between the set-up position and the bwlch could be determined. GNSS data were collected for 5 minutes once the receiver accuracy measurement had reached 0.1m.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations and the Trimble GeoXH 6000 data were processed in Trimble GPS Pathfinder Office using the five nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	266613.380	0.002	324396.339	0.001	602.746	0.005
Trimble GeoXH 6000	266613		324396		603.880	

Staff reading for bwlch = 1.751m

Staff reading for Trimble GeoXH 6000 set-up position = 0.712m

The Trimble GeoXH 6000 set-up position is  $1.751 - 0.712 = 1.039$ m higher than the bwlch

Bwlch height measured by Trimble GeoXH 6000 =  $603.880 - 1.039 = 602.84$ m

Bwlch height measured by Leica Viva GS15 = 602.75m

The ten-figure grid reference for the bwlch is SH 66613 24396

### 3.4) The Summit

The first task was to determine whether the summit lay on the East side of the wall near the trig point or on its West side. To achieve this, the Leica NA730 was set up on a small tripod on the top of the wall by the stile (see photograph in Appendix). Surprisingly, the wall provided a stable base for the tripod which enabled staff readings to be taken on each side of the wall. It was quickly established that the highest ground on the West side of the wall was nearly 0.5m lower than ground on the East side of the wall just North of the trig point.

The staff readings obtained were:

Highest ground on West side of wall = 1.550m

Highest ground on East side of wall = 1.069m

East side of wall is  $1.550 - 1.069 = 0.481$ m higher than highest ground on West side of wall

Next, the Leica NA730 level was repositioned on the East side of the wall on the larger tripod and a more detailed survey of this area was carried out. The first position identified was indeed the highest point and this is approximately 5m North of the trig point (see photograph in Appendix). A staff reading was also taken on the flush bracket.

Staff reading for summit = 0.743m

Staff reading for flush bracket = 0.439m

Lastly, the height difference between the flush bracket and top of trig point was measured with a tape and found to be 0.875m

Next the Leica Viva GS15 was attached to the tripod over the summit and fixed to it with a clamp and tribrach (the “short tripod” configuration). The height of the receiver above the ground was then measured with the integral tape. The vertical offset from measuring point to the ground was 0.575m (see photograph in Appendix) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

The Trimble GeoXH 6000 was placed on the top of the trig point. GNSS data were then collected for 5 minutes once the receiver accuracy measurement had reached 0.1m.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations and the Trimble GeoXH 6000 data were processed in Trimble GPS Pathfinder Office using the five nearest base stations. The results are given in the table below:-

System	Easting	Northing	Height(m)
GS15	266127.710	323413.408	750.346
Trimble GeoXH 6000	266127	323413	751.540

The height of Diffwys measured by the Trimble GeoXH 6000 is  $751.54 - 0.875 - (0.743 - 0.439) = 750.36\text{m}$

The height of Diffwys measured by the Leica Viva GS15 is 750.35m

The easting and northing positions given for the Trimble GeoXH 6000 in the above table were taken from the summit and not the trig point.

The height of the flush bracket measured by the Leica Viva GS15 is  $750.346 + (0.743 - 0.439) = 750.650\text{m}$

The Ordnance Survey value for the flush bracket height is 750.722m. The difference between the two values is 7cm.

### 3.5) Diffwys West Top

There are two areas that, to the unaided eye, vie for summit position. One is a small mound on the South side of the fence and immediately adjacent to it. The mound is adorned with a few stones. The second position is ground on the North side of the fence and to the NE of the mound by about 100m. The Leica NA730 level was set up near the latter position and it was immediately established by sighting through the level that the mound was approximately 1m lower. Effort was now concentrated on ground on the North side of the fence. A grid of three rows of flags was laid, each row being about 10m apart and containing about six flags. By systematically taking staff readings for each flag, the summit area was relatively quickly established to be near a small pile of stones. More readings of interpolated positions in this area finally showed the summit to be just 4m from this feature. Congratulations to Simon Edwardes who had surveyed the summit previously with an Abney level, because the whole area is very flat and there are just a few centimetres of height change in the immediate vicinity of the summit. The stones were subsequently moved to the new position. The Trimble GeoXH 6000 was placed on one of the stones and measured to be 0.2m above the ground. GNSS data were then collected for 5 minutes once the receiver accuracy measurement had reached 0.1m. Data were also collected from the area of the bwlch for confirmation that the drop was over 15m. For this purpose the bwlch position was estimated and no attempt was made to find it in a systematic way as we did for the summit.

The data for the Trimble GeoXH 6000 data were processed in Trimble GPS Pathfinder Office using the five nearest base stations. The results are given in the table below:-

System	Easting	Northing	Height(m)
Trimble GeoXH 6000 (summit)	264821	322928	643.319

Trimble GeoXH 6000 (bwlch)	265200	322995	621.371
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The drop is calculated to be  $643.319\text{m} - 0.2\text{m} - 621.371 = 21.7\text{m}$

#### 4) Discussion of Results

The summit position of Diffwys was well defined and the height error in its location is estimated to be  $<0.01\text{m}$ . The measurement uncertainty associated with the GNSS measurement for the Leica Viva GS15 is  $\pm 0.06\text{m}$  while that for the Trimble GeoXH 6000 is  $\pm 0.2\text{m}$ . The two height measurements agree to within  $0.01\text{m}$ . The summit height of Diffwys is  $750.35\pm 0.06\text{m}$ . Similarly the estimated height error associated with locating the position of the bwlch is  $0.01\text{m}$  and once again the measurement uncertainty for the Leica Viva GS15 is  $\pm 0.06\text{m}$  and for the Trimble GeoXH 6000  $\pm 0.2\text{m}$ . The height of the bwlch is  $602.75\pm 0.06\text{m}$ .

Therefore the drop for Diffwys is  $147.6\text{m}$

It was estimated that the summit of the West Top was located to within a height uncertainty of  $0.1\text{m}$  and the measurement uncertainty of the Trimble GeoXH 6000 is  $\pm 0.2\text{m}$ . Therefore the summit of the West Top is  $643.1\pm 0.2\text{m}$ .

The bwlch position was estimated by eye and there may be  $0.5\text{m}$  in height error associated with its location. The bwlch of the west Top is  $621.4\pm 0.5\text{m}$

The drop for the West Top is  $21.7\pm 0.5\text{m}$

#### 5) Summary and Conclusions

The **summit of Diffwys** is at grid reference \* SH 66131 23417 and is the top of a rounded rock. Its height is  **$750.35\pm 0.06\text{m}$** .

The **bwlch of Diffwys** is at \* SH 66616 24400 and is unfeatured ground lying between two outcrops of rock. Its height is  **$602.75\pm 0.06\text{m}$** .

The **drop for Diffwys** is  **$147.6\pm 0.08\text{m}$**  and therefore this hill **remains a subMarilyn**.

The summit of **Diffwys West Top** is at \* SH 64824 22932 and is  **$643.1\pm 0.2\text{m}$**

The bwlch of **Diffwys West Top** is at \* SH 65203 22999 and is  **$621.4\pm 0.5\text{m}$**

The drop for **Diffwys West Top** is  **$21.7\text{m}\pm 0.5\text{m}$**

- NB: Grid references “corrected” to Garmin are quoted in the summary.

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## Appendix



**Surveying the bwlch of Diffwys**



**Offset for Leica Viva GS15 set-up at bwlch**



**Surveying either side of the wall on the summit of Diffwys**



**Surveying on East side of wall with staff on summit**



**Leica Viva GS15 collecting data on the summit of Diffwys**



**Offset for Leica Viva GS15 set-up at summit**



**Surveying the summit position of Diffwys West Top**