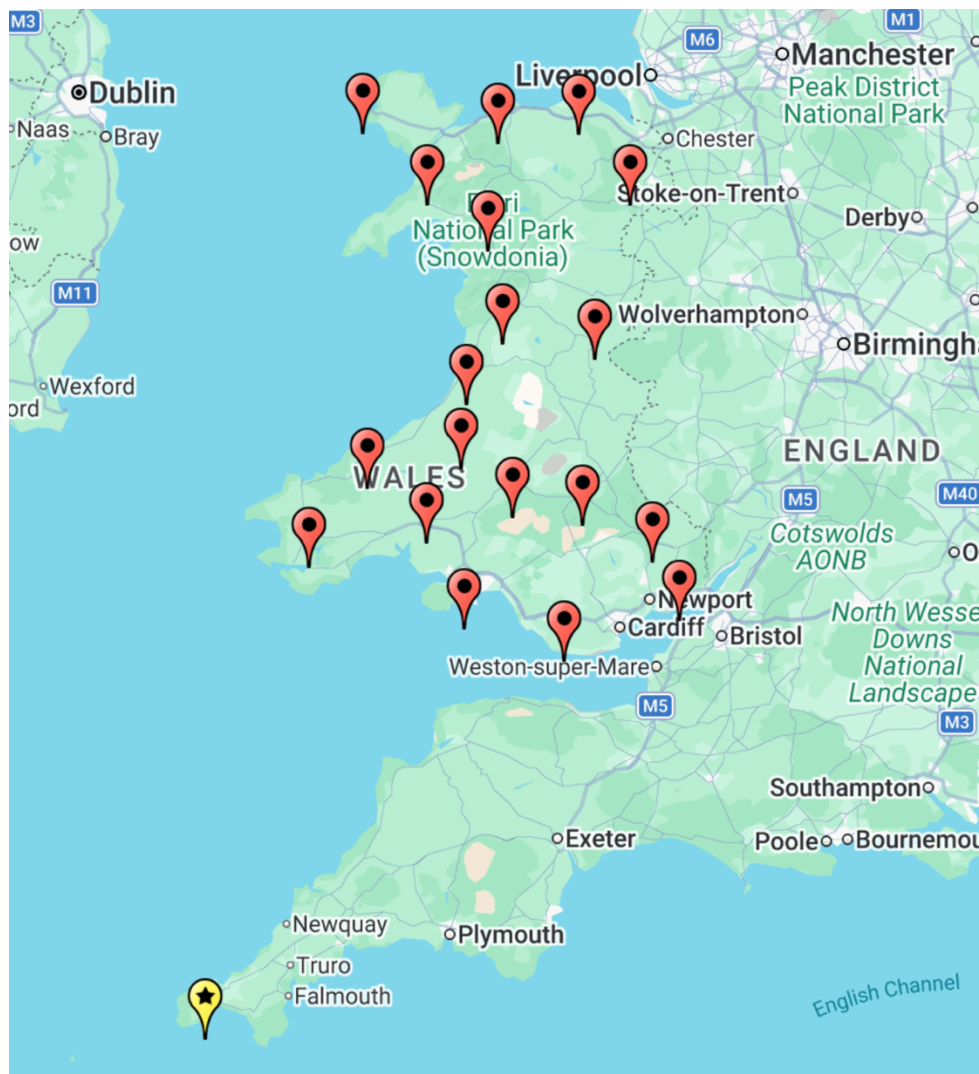


HOW WALES WAS MEASURED

The Ordnance Survey Height Network of Wales



Interactive Map:- <https://tinyurl.com/How-Wales-Was-Measured>



Introduction

Ask what the height of a place is and the answer seems simple, until the second question is asked: height above what? The sea is the only zero the whole country shares, and the sea will not stand still. It rises and falls twice a day, changes with the wind and the seasons, and differs from one coast to another. Before anything in Britain could be given a height, somebody had to decide, once and for all, where zero was. This document, and the interactive map it accompanies, tell the story of how that decision was made and how it was carried, brass plate by brass plate and chisel cut by chisel cut, into every community in Wales.

How the System Came into Being

The Ordnance Survey began levelling Britain in the 1840s, referring its first heights to a tidal datum at Liverpool taken from a mere fortnight of observations. It served for half a century, but a fortnight of tide is a thin foundation for a nation's heights, and by the early twentieth century the Survey resolved to do the thing properly. A purpose-built tidal observatory was raised at the end of the South Pier at Newlyn in Cornwall, chosen for its open Atlantic water and stable granite, and from May 1915 to April 1921 its gauge measured the sea continuously for six years. The mean of those measurements became Ordnance Datum Newlyn, the zero of the national height system, preserved to this day as a brass bolt inside the observatory.

Carrying that zero across the country was the work of the geodetic levelling. The Second Geodetic Levelling of 1912 to 1921 rebuilt the network from Newlyn outward; the Third, from 1951 to 1968, measured it again. The method was spirit levelling of the most exacting kind: a telescope made perfectly level, a graduated staff held on a fixed point, a reading taken, the staff leapfrogged forward, mile after mile, with the lines run twice in opposite directions and rejected if they disagreed by more than a few millimetres. The heights were fixed into a hierarchy of physical marks. At the top stood the Fundamental Benchmarks, granite pillars anchored to bedrock with buried reference chambers, roughly one every forty kilometres. Between them ran the flush brackets, numbered plates set into walls and pillars along the levelling lines. And from those lines the surveyors cut the ordinary marks, the familiar crow's foot arrows found on churches, chapels, bridges, milestones and walls, until around three quarters of a million points in Britain had a published height above the bolt at Newlyn.

What the System Was For

The network was never an academic exercise. Every railway gradient, every road, every bridge, every drainage and flood defence scheme, every reservoir, every housing estate and every Ordnance Survey contour line was built or drawn from these marks. A builder anywhere in Wales could walk to the nearest cut mark, read its height from the published lists, and transfer a level to a foundation trench with confidence that it agreed with every other height in Britain. For more than a century the marks were the quiet public infrastructure of altitude, used daily and noticed rarely, free to anyone with a level and a staff.

Why Record It Now

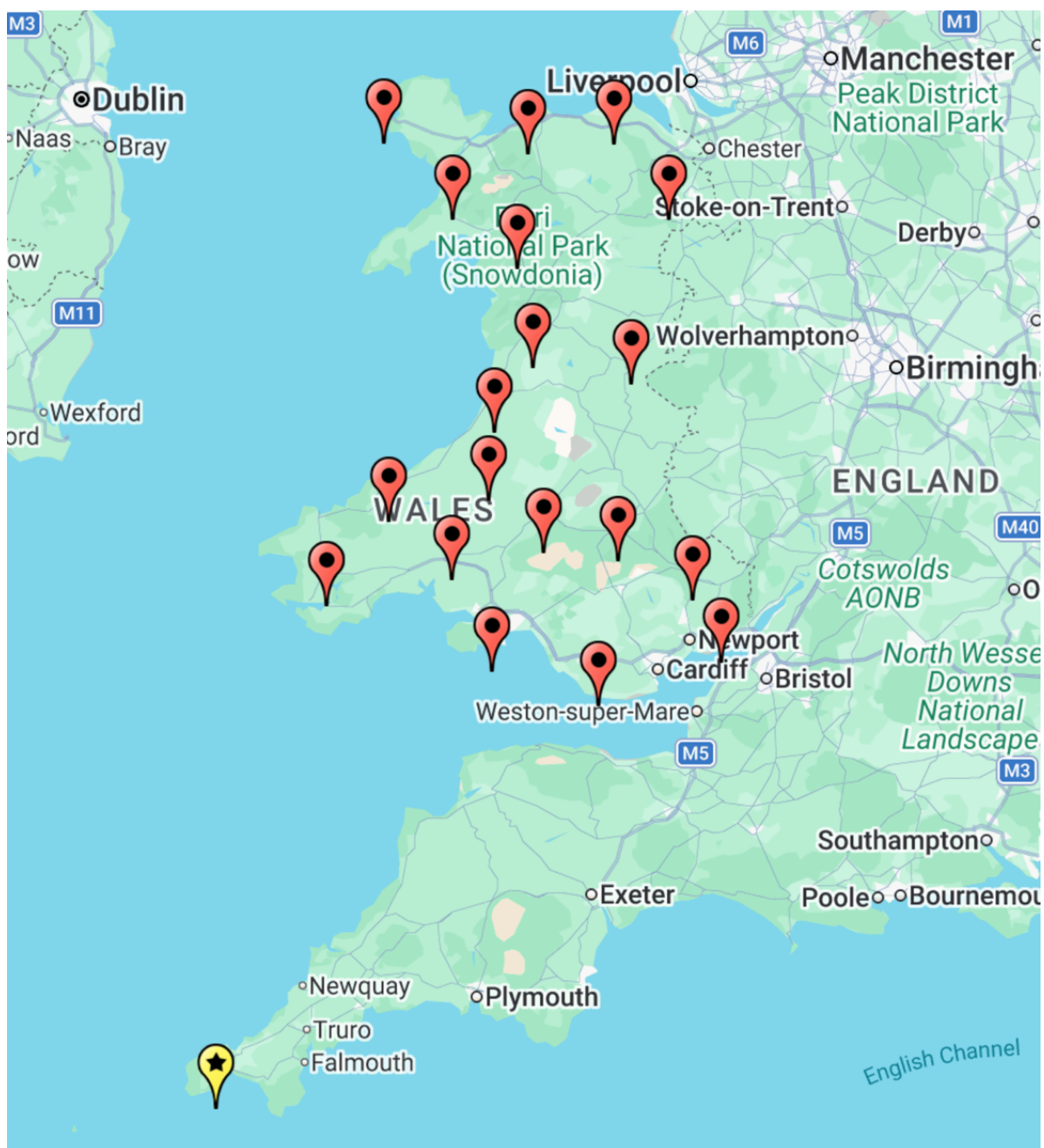
Satellite positioning ended the marks' working life. Ordnance Survey ceased maintaining the ordinary network in the 1980s, and heights are now realised through a geoid model that converts satellite measurements to Ordnance Datum Newlyn, anchored by the Fundamental Benchmarks and a modern network of GPS stations. The pillars endure, still used, still guarded. But the half million ordinary marks were left where they stood, and they are quietly vanishing with the buildings and walls that carry them. The original Fundamental Benchmark at Haverfordwest has already been destroyed and replaced; most Welsh marks have not been seen by an official surveyor for half a century. The Ordnance Survey archive records where every mark stood at its last verification, and this project places that record, for the whole of Wales, onto an interactive map for the first time: forty-six and a half thousand marks, from the granite pillars to the humblest rivet, each with its position, its height to the millimetre and the surveyor's own description of where to find it.

How to Read This Record

The map and this document are arranged in the order of the system's own hierarchy. Part One presents the zero point at Newlyn and the nineteen Fundamental Benchmarks of Wales. Part Two presents the one thousand four hundred and seventy-two flush brackets. Part Three presents the bolts, pivots and brass rods that complete the special marks. The ordinary cut marks and rivets, too numerous for a single national map, follow as a companion series of county maps and county records, published separately, beginning with Carmarthenshire. Throughout, positions are given as the archive records them, to ten metres, with heights above Ordnance Datum Newlyn; every mark is flagged as unvisited until fieldwork confirms whether it survives. The archive tells us where the marks were. Only feet on the ground can tell us what remains, and this record is built to make that walking possible.

HOW WALES WAS MEASURED

Part One: The Fundamental Benchmarks of Wales



Part One: The Fundamental Benchmarks

Every height printed on every Ordnance Survey map of Wales rests, in the end, on a brass bolt at Newlyn in Cornwall. There, between May 1915 and April 1921, the tide gauge of the Newlyn Observatory measured the sea for six unbroken years, and the mean of all those measurements became Ordnance Datum Newlyn, the zero point of the national height system of Great Britain. That datum had then to be carried across the country, and the instruments of that carrying were the Fundamental Benchmarks.

A Fundamental Benchmark is a small granite pillar, about thirty centimetres tall above ground, with a gunmetal bolt set into its top and a plate declaring it an Ordnance Survey Bench Mark. What the passer-by cannot see is what lies beneath: a buried chamber containing the master reference marks, set on stable rock chosen so that the mark can never move. Nearly two hundred were built across Great Britain, most in the first half of the twentieth century, roughly one every forty kilometres. Between them the surveyors ran lines of precise spirit levelling, and from those lines around three quarters of a million ordinary bench marks were cut into churches, chapels, bridges, milestones and walls, so that a builder or engineer anywhere in the land could find a point of known height within a short walk.

Unlike the ordinary marks, which have not been maintained for some forty years and are quietly vanishing as buildings are demolished and walls rendered over, the Fundamental Benchmarks are still used by Ordnance Survey today. They remain the physical realisation of Ordnance Datum Newlyn and the anchors of the model that converts satellite positioning into heights above sea level. Nineteen Fundamental Benchmark sites are recorded in Wales, and every one of them is set out below at its verified position from the Ordnance Survey benchmark archive, with its height above the datum recorded to the millimetre. They range from the Haverfordwest pillar, barely 24 metres above the sea, to the Wrexham pillar on its moorland at over 356 metres. They are presented from north to south, each one a quiet monument to the most patient measuring campaign ever undertaken in these islands. But the sequence begins where the system itself begins, at the point from which all of them were measured.

Ordnance Datum Newlyn, the Zero Point

Newlyn Tidal Observatory, South Pier, Newlyn Harbour, Cornwall

The origin of the national height system. Datum bolt 4.751m above Ordnance Datum.

The first point on the map is not in Wales at all, and that is precisely its significance. At the seaward end of the South Pier at Newlyn in Cornwall stands a small stone tidal observatory, and inside it a brass bolt. For six unbroken years, from May 1915 to April 1921, through the last years of one war and the first years of the peace, the tide gauge here measured the height of the sea, hour after hour, and the mean of all those measurements was declared the zero of the national height system. The bolt preserves it: Ordnance Datum Newlyn lies exactly 4.751 metres below its domed head. Every figure in this record is an answer to the same question, how far above that bolt, and every mark that follows, the nineteen pillars of this part, the one

thousand four hundred and seventy-two brackets of the next, and every bolt, pivot, rod and cut mark in Wales, was levelled from it, staff length by staff length, across the breadth of two nations. It is shown on the map as the point of origin to which everything else aligns: the place where the height of Wales begins.

Holyhead FBM

SH 2411 8282 · Isle of Anglesey · 36.200m above Ordnance Datum Newlyn

Third Geodetic Levelling station. Last verified 1978.

The most north-westerly of the Welsh pillars stands on Holy Island, close to the port and to the tide gauge that made Holyhead one of the observation points of the national levelling. Before the datum moved to Newlyn, mean sea level for the first great levelling of Britain had been taken at Liverpool, and the harbours of the Irish Sea coast remained important checking points as the network was rebuilt. The Holyhead pillar carried the height system to the far corner of Anglesey and anchored the lines that served the island.

Caernarfon FBM

SH 4800 5457 · Gwynedd · 149.400m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1953.

The Caernarfon pillar stands in the landscape of the Castles and Town Walls of King Edward in Gwynedd, a World Heritage Site. It joined the levelling network in the Second Geodetic Levelling of 1912 to 1921 and was promoted to a primary station when the network was remeasured between 1951 and 1968. Through this pillar the heights of the Menai shore and the mountains behind it were tied to mean sea level at Newlyn, four hundred kilometres away in Cornwall.

Conwy FBM

SH 7552 7747 · Conwy · 188.496m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1991.

The Conwy pillar sits high on the slopes of Conwy Mountain above the walled town and castle, another of the Edwardian World Heritage Sites. It served the Caernarvon to Conwy, Conwy to Dyserth and Holyhead to Conwy levelling lines, making it a junction of the North Wales network. Visitors have recorded the pillar in good condition as recently as 2023, a granite block with its gunmetal bolt still crowning the mountain path, unnoticed by most who walk past it.

Trawsfynydd FBM

SH 7066 3642 · Gwynedd · 225.521m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1953.

The Trawsfynydd pillar stands within Eryri, the Snowdonia National Park, in the high country of old Meirionnydd. Fundamental Benchmarks were deliberately sited on stable strata, anchored to bedrock so that the mark could not move, and the mountain geology of

Meirionnydd offered exactly that permanence. From here the levelling lines threaded through the passes to connect the coastal towns with the interior.

Dyserth FBM

SJ 0647 8024 · Denbighshire · 128.902m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1991.

The Dyserth pillar, in the limestone country behind the North Wales coast, was the terminus of the Conwy to Dyserth line of the Third Geodetic Levelling. From it the network continued eastward toward the Dee and the English border, closing the circuit that carried Ordnance Datum Newlyn along the whole northern coast of Wales. With Conwy, it was among the last Welsh pillars verified by Ordnance Survey, both checked in 1991.

Wrexham FBM

SJ 2564 5285 · Wrexham · 356.593m above Ordnance Datum Newlyn

Primary station of both the Second and Third Geodetic Levellings. Last verified 1959.

The Wrexham pillar is the highest Fundamental Benchmark in Wales, standing at over 356 metres above the sea on the moorland west of the town rather than in the town itself, for the surveyors chose their ground for its geology, not its convenience. It held primary status in both national levellings, a reflection of the position of Wrexham where the routes of north-east Wales converge. Primary stations formed the backbone of the network; between them ran the most precisely measured lines in the country, checked and rechecked until the closing error across hundreds of kilometres amounted to a few millimetres.

Machynlleth FBM

SH 7553 0052 · Powys · 34.396m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1979.

The Machynlleth pillar stands near the Dyfi valley at the traditional meeting point of north and mid Wales, and at barely 34 metres above the datum it is one of the lowest-lying of the Welsh pillars, holding the valley floor while the mountains rise around it. Through it the levelling lines of Gwynedd were joined to those of Montgomeryshire and Ceredigion, carrying the datum across the watershed country where the roads and railways narrow to single routes.

Aberystwyth FBM

SN 6064 7735 · Ceredigion · 168.554m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1977.

The Aberystwyth pillar anchored the levelling lines of the Cardigan Bay coast. Coastal stations mattered doubly to the height network, for the sea itself was the reference: tide gauges at the harbours allowed the surveyors to test whether mean sea level around the coast of Wales truly agreed with the datum fixed at Newlyn, and the differences they found are still studied today.

Newtown FBM

SO 1088 9367 · Powys · 233.092m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1990.

The Newtown pillar stands in the Severn valley in old Montgomeryshire, on the great eastern route into mid Wales. Its buried reference marks now lie beneath a concrete cover plate on a roadside verge, recorded in the archive with the surveyor's usual dry precision. It carried the datum up the Severn corridor and linked the Welsh network to the English lines beyond Shrewsbury.

Lampeter FBM

SN 5798 5263 · Ceredigion · 223.239m above Ordnance Datum Newlyn

Secondary station of the Second Geodetic Levelling; primary station of the Third. Last verified 1974.

The Lampeter pillar has the most eventful modern history of any Welsh FBM. It was found broken in two, the visible granite section lying on the ground, and in 2012 Ordnance Survey surveyors returned to rescue and repair it, bonding the pillar with resin and then re-heighting the top bolt with a digital level capable of measuring to a hundredth of a millimetre. It was the first FBM to be re-heighted in more than twenty years. While the surveyors worked, local residents told them that a Spitfire had crashed at the site during the Second World War, though no trace of it was found. The pillar thus connects the story of Welsh measurement to the story of Welsh wartime skies.

Cardigan FBM

SN 2089 4602 · Ceredigion · 89.472m above Ordnance Datum Newlyn

Primary station of the Third Geodetic Levelling. Last verified 1972.

The Cardigan pillar stands near the Teifi estuary at the southern edge of Ceredigion, close against the Pembrokeshire boundary. It joined the network in the Third Geodetic Levelling, when the system was extended and densified after the Second World War, and it anchored the lines serving the far south-west coast.

Haverfordwest FBM

SM 9673 1574 · Pembrokeshire · 24.392m above Ordnance Datum Newlyn

Replacement pillar; the original FBM was destroyed. Last verified 1971.

The Haverfordwest pillar carries a warning within its own record. The Ordnance Survey archive describes it plainly as a new Fundamental Benchmark, the original having been destroyed, and the replacement was levelled into the network in 1970. If even a Fundamental Benchmark, built of granite on chosen ground with its reference marks buried beneath it, can be lost, the fate of the half million ordinary marks cut into walls and buildings needs no further explanation. At barely 24 metres above the datum it is the lowest-lying FBM in Wales, holding the height system for the Cleddau country and the Pembrokeshire coast.

Llandovery FBM

SN 7751 3270 · Carmarthenshire · 185.901m above Ordnance Datum Newlyn

Primary station of both the Second and Third Geodetic Levellings. Top bolt damaged 1986, re-levelled 1987.

The Llandovery pillar held primary status in both national levellings, anchoring the lines of the upper Tywi valley where the drove roads and the railway squeeze between the hills. Its record carries its own small drama: the top bolt was damaged in 1986 and the pillar was re-levelled the following year, a reminder that even the anchors of the system have needed rescue. From Llandovery the levelling ran down the Tywi toward Carmarthen and eastward over the mountain road toward Brecon, stitching together the heights of three counties.

Carmarthen FBM

SN 4340 2377 · Carmarthenshire · 101.860m above Ordnance Datum Newlyn

Primary station of both the Second and Third Geodetic Levellings. Pillar rebuilt 1964. Last verified 1971.

The Carmarthen pillar is the county town's anchor to Ordnance Datum Newlyn and, with Llandovery, one of two Fundamental Benchmarks on Carmarthenshire ground. The pillar standing today is itself a survivor's replacement, rebuilt in 1964 and re-levelled into the network in the same year. Every bench mark cut into the churches, bridges and walls of the county, including those of Kidwelly, Trimsaran and the Gwendraeth Valley, was ultimately levelled from pillars such as this one. It held primary status in both the Second and Third Geodetic Levellings.

Brecon FBM

SO 0513 2905 · Powys · 184.143m above Ordnance Datum Newlyn

Primary station of both the Second and Third Geodetic Levellings. Last verified 1990.

The Brecon pillar stands within Bannau Brycheiniog, the Brecon Beacons National Park, and held primary status in both national levellings. The Usk valley at Brecon was a natural corridor for the levelling lines linking south-east and south-west Wales, and the pillar sat at the hinge of that route. Its archive record, locating the buried pillar on a farm entrance verge to the nearest five centimetres, shows the exactness with which these monuments were documented.

Abergavenny FBM

SO 3223 1414 · Monmouthshire · 193.222m above Ordnance Datum Newlyn

Primary station of both the Second and Third Geodetic Levellings. Last verified 1969.

The Abergavenny pillar, at the gateway to the Black Mountains, was a primary station in both national levellings. Through it the Welsh network connected to the lines of the English border country and the Severn shore, completing the eastern edge of the circuit.

Bishopston FBM

SS 5743 8932 · Swansea · 70.709m above Ordnance Datum Newlyn

Primary station of the Third Geodetic Levelling. Last verified 1966.

The Bishopston pillar stands on the Gower Peninsula, which in 1956 became the first place in Britain designated an Area of Outstanding Natural Beauty. It joined the network in the Third Geodetic Levelling and anchored the lines serving Swansea Bay and the peninsula, its position recorded beside the Pennard road within sight of the village it serves.

Cowbridge FBM

SS 9668 7567 · Vale of Glamorgan · 91.175m above Ordnance Datum Newlyn

Primary station of the Third Geodetic Levelling. Last verified 1961.

The Cowbridge pillar carried the datum through the Vale of Glamorgan, the agricultural lowland between the coalfield and the sea. It joined the network in the Third Geodetic Levelling and served the lines linking Cardiff, Bridgend and the coast.

Penhow FBM

ST 4261 9109 · Newport · 43.467m above Ordnance Datum Newlyn

Primary station of the Third Geodetic Levelling. Last verified 1961.

The Penhow pillar stands on a verge between Newport and Chepstow, the most south-easterly of the Welsh Fundamental Benchmarks, guarding the corner of Wales where the levelling lines crossed the Severn lowlands toward the English network. It joined the system in the Third Geodetic Levelling and completes the circuit of nineteen pillars through which the heights of Wales were fixed.

Sources

Ordnance Survey Complete Benchmark Archive, published under the Open Government Licence, which records the position of each mark to ten metres, its height above Ordnance Datum Newlyn, its levelling and verification dates and the surveyor's location description. Fundamental Benchmarks List, version six, compiled by Ian Richardson and published at deformedweb.co.uk, drawing on the diagrams of the Geodetic Levellings of England and Wales. Ordnance Survey accounts of the repair and re-heighting of the Lampeter Fundamental Benchmark, 2012. Bench Mark Database, bench-marks.org.uk, for condition reports from field visits. Grid references are given in the Ordnance Survey National Grid; map coordinates were converted from OSGB36 to WGS84 for display.

HOW WALES WAS MEASURED

Part Two: The Flush Brackets of Wales



Part Two: The Flush Brackets

If the Fundamental Benchmarks of Part One were the anchors of the height system of Wales, the flush brackets were its couriers. A flush bracket is a rectangular plate of cast metal, a little over twenty centimetres tall, set flush into the face of a wall or pillar. Its face carries the letters OSBM beneath the Ordnance Survey broad arrow, and above them a serial number, cast into the metal, unique to that bracket across the whole of Great Britain. A fitting slotted into the plate provided a small platform on which the levelling staff could rest, so that a surveyor returning years or decades later could set an instrument on precisely the point measured before.

The brackets were placed along the lines of precise levelling that ran between the Fundamental Benchmarks, fixed to buildings, bridge abutments and purpose-built pillars at intervals of a mile or so. They were the intermediate rungs of the ladder by which Ordnance Datum Newlyn climbed from the Cornish tide gauge into every valley in Wales. Below them in rank came the ordinary cut marks, chiselled by the tens of thousands into whatever solid masonry stood beside the road; but the flush bracket, numbered and registered, was a different order of object, closer to an instrument than a mark. The earliest carry plain serial numbers from the Second Geodetic Levelling, begun in 1912; later campaigns added lettered series, and the numbers on the walls of Wales run from three digits to five.

The Ordnance Survey benchmark archive records one thousand four hundred and seventy-two flush brackets in Wales. Every one of them appears on the accompanying map layer with its serial number, its position to ten metres, its height above Ordnance Datum Newlyn to the millimetre, and the surveyor's own description of where it stands. This part of the record does not attempt to describe them individually. Instead, it describes the system they formed, and then pauses at the places where the record holds something remarkable.

The Shape of the Network

The brackets were not scattered evenly but strung along the levelling lines, and the lines followed the roads, the railways, and the coast. Of the Welsh brackets, five hundred and eighty-six belonged to first-order lines, the most precisely measured routes in the network, with four hundred and six on second order and four hundred and eighty on third-order lines. The first-order lines were the backbone: along them the surveyors worked in matched pairs of observations, forward and back, accepting errors of no more than a couple of millimetres multiplied by the square root of the distance in kilometres. It remains one of the most exacting pieces of manual measurement ever carried out in Britain, done with telescope, bubble and graduated staff, in all weathers, mile after mile.

The county register below shows how the brackets fall across the modern authorities of Wales. The pattern follows the geography of the lines: the large rural counties crossed by many routes hold the most, and Carmarthenshire holds more than any other.

Authority	Brackets	Authority	Brackets
Carmarthenshire	224	Wrexham	39
Powys	191	Rhondda Cynon Taf	36
Pembrokeshire	158	Flintshire	34
Gwynedd	139	Bridgend	27
Ceredigion	127	Vale of Glamorgan	26
Monmouthshire	90	Cardiff	24
Isle of Anglesey	78	Caerphilly	17
Denbighshire	64	Merthyr Tydfil	14
Conwy	61	Torfaen	11
Neath Port Talbot	49	Newport	10
Swansea	46	Blaenau Gwent	7

The Mountain Brackets

Three hundred and forty-four of the Welsh flush brackets, nearly a quarter of the whole, are not on buildings at all but on trig pillars, the concrete triangulation pillars raised on the summits of Wales between 1936 and the 1950s. The pairing is no accident, and it is one of the quiet elegances of the system. The trig pillar carried the horizontal network, the triangulation by which position on the map was fixed; the flush bracket set into its side carried the vertical network, the height above the sea. Every mountain pillar bearing a bracket is therefore a point where the two great measuring systems of Britain physically meet in a single object, the whole of the national map anchored in one block of concrete on a windy summit.

The five highest flush brackets in Wales are all of this kind. Bracket S2197 stands on the Pant y Creigiau pillar in Powys at 565 metres; S1542 on Llangeinor above the Garw valley at 568 metres; S2117 on the Sugar Loaf above Abergavenny at 596 metres; S2045 on Craig y Llyn, the roof of the old Glamorgan coalfield, at 600 metres; and highest of all, bracket S2166 on Twyn Mhyalehod in Powys, 642 metres above the brass bolt at Newlyn from which its height was carried, staff length by staff length, up from the sea.

From the Mountain to the Tide

At the other end of the scale stands Flush Bracket G2619, set into a tollgate cottage in Gwynedd at just 1.99 metres above Ordnance Datum, the lowest-lying flush bracket in Wales. Between the tollgate cottage and Twyn Mhyalehod lies the entire vertical span of the country, six hundred and forty metres of Wales held between two brass plates. It is worth pausing on what that means: a builder at the cottage door and a walker at the mountain cairn could each, in principle, level from their nearest bracket and their two heights would agree with one another to within a few centimetres, because both were carried from the same six years of tide at Newlyn.

The Oldest Bracket

The earliest verification date in the whole Welsh flush bracket record belongs to Bracket 928, on the south-west angle of Mynydd Bychan Cottage in Powys, checked in 1914. Its plain three-digit serial places it among the very first brackets cast for the Second Geodetic Levelling, begun only two years earlier, and it was fixed to that cottage wall while the datum itself was still being measured at Newlyn, before the First World War had run a single year. A piece of brass on a Powys cottage has now kept its station for more than a century, older than the datum it serves.

The Chapels and the Churches

Around fifty of the Welsh brackets are recorded on chapels and more than a hundred and twenty on churches: Capel Carmel and Capel Seilo, Capel Hermon and Capel Noddfa, and parish churches the length of the country. The reason is practical. The levelling lines followed the roads, and the surveyor needed walls that would not move: solid masonry, well founded, likely to stand for generations. In every Welsh village the building that best answered that description was the chapel or the church. So the religious buildings of Wales became, incidentally, instruments of its measurement, their walls trusted to hold a height as faithfully as they held a congregation. Anyone who has studied the chapels of Wales photograph by photograph will recognise the same intuition at work: that these were the buildings a community built to last, and the surveyors simply agreed.

Carmarthenshire, the County of Brackets

No Welsh county holds more flush brackets than Carmarthenshire, with two hundred and twenty-four. The county's size and its position explain it: the first-order lines from Carmarthen fanned east up the Tywi to Llandovery and Brecon, west into Pembrokeshire, north into Ceredigion and south-east along the coast toward Swansea, and the county's two Fundamental Benchmarks at Carmarthen and Llandovery pinned the whole south-western network. The brackets stand on farm buildings and trig pillars from Carn Wen to Crosshands, on the walls of the Gwendraeth and Tywi valleys, and they will form the spine of the Carmarthenshire county map that follows in a later part of this record.

What Remains

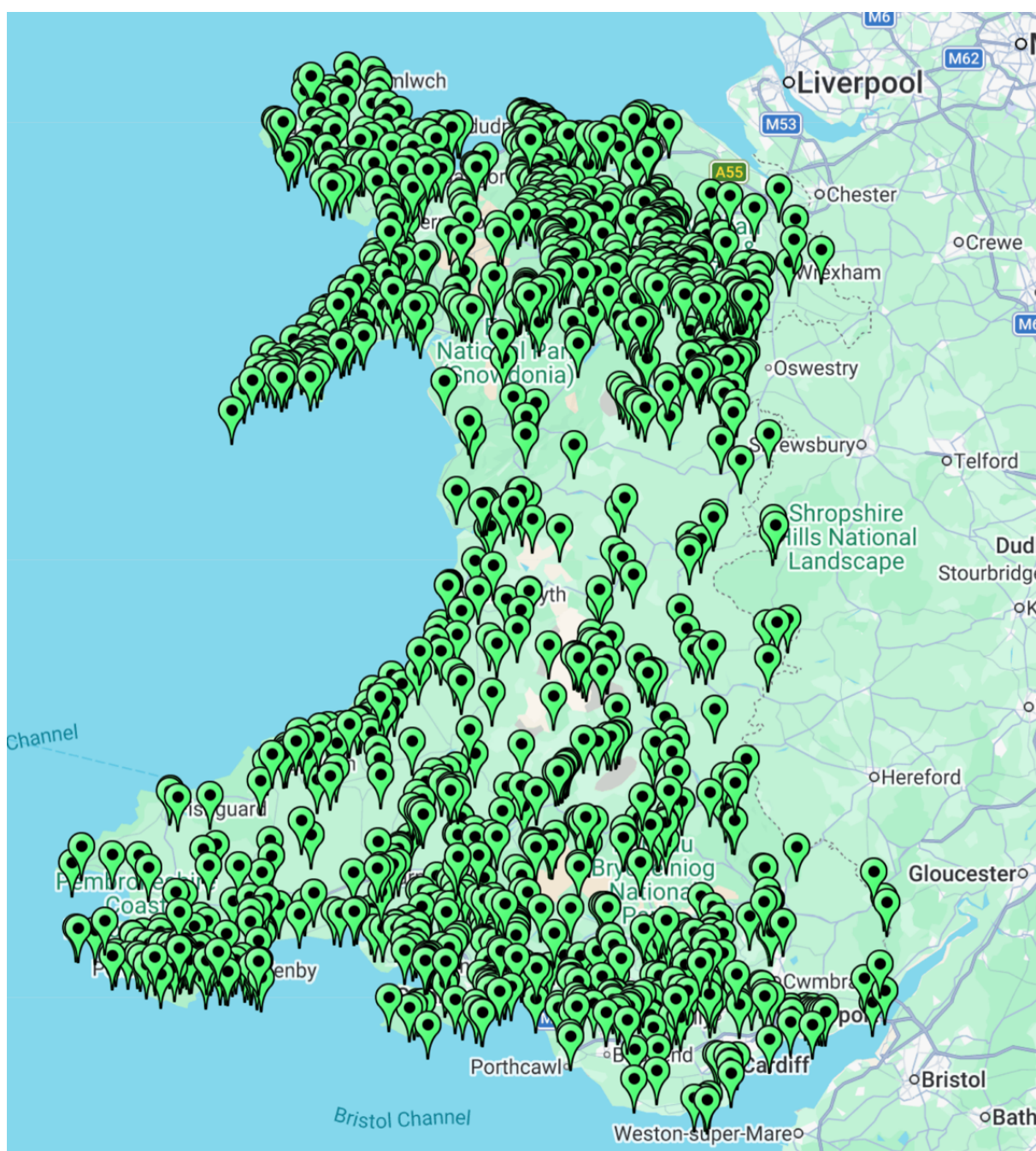
The verification dates in the archive tell the end of the story. A third of a thousand Welsh brackets were last checked in the 1950s, four hundred and twenty-two in the 1960s, and six hundred and seventy-three in the 1970s, the busiest decade of maintenance. Then the programme stopped. Only some thirty brackets in all of Wales have been verified since 1980, and the ordinary maintenance of the network ceased entirely as satellite positioning took over. Most of the brackets on this map have therefore not been seen by an official surveyor for half a century. Some have certainly gone, lost with the buildings that carried them, as the original Haverfordwest Fundamental Benchmark was lost. How many survive is a question the archive cannot answer. It is a question that can only be answered on foot, bracket by bracket, and that is the purpose of recording them now, while the answer can still be found.

Sources

Ordnance Survey Complete Benchmark Archive, published under the Open Government Licence, from which every flush bracket position, serial number, height, levelling order, verification date and location description in this part is drawn. Ordnance Survey list of benchmark abbreviations, used to read the location descriptions. Counts and analysis prepared from the archive for the whole of Wales, with each mark assigned to its modern local authority by boundary. Grid references are given in the Ordnance Survey National Grid; map coordinates were converted from OSGB36 to WGS84 for display. Positions record where each mark stood at its last verification; survival on the ground is unconfirmed until verified in the field.

HOW WALES WAS MEASURED

Part Three: Bolts, Pivots and Brass Rods



Part Three: Bolts, Pivots and Brass Rods

After the granite pillars of Part One and the numbered brackets of Part Two come the humbler instruments of the system: the bolts, the pivots and the brass rods. These were the marks the surveyors used where the grander furniture of the network was not needed or could not be placed, and the archive records one thousand four hundred and twenty-five of them in Wales: one thousand and eighty-eight pivots, two hundred and seventy-seven bolts, fifty-seven projecting bolts, and just three brass rods. Together with the pillars and brackets already described, they complete the register of every special mark in the Welsh height network. All of them appear on the third layer of the accompanying map.

The Pivots of the Mountains

The pivot is the simplest mark in the whole system: a small polished depression worked into a horizontal surface, in which the rounded foot of a levelling staff could be seated and turned. Its simplicity was its purpose. Where the levelling lines climbed beyond the last farm and the last field wall, there was nothing left to cut a mark into except the mountain itself, and so the pivot went onto bare rock. More than half of the Welsh pivots, over five hundred and fifty of them, are recorded on rock outcrops, boulders and stones. The county tallies tell the same story: Conwy leads Wales with one hundred and eighty-one pivots and Gwynedd follows with one hundred and seventy-two, for these are the counties of Eryri, where the network had to cross the highest ground in the country. The highest pivot in Wales sits on rock beside a mountain track in Powys at five hundred and ten metres above the datum.

The Bolts

The bolt is a rounded head of gunmetal or brass set into a horizontal surface, usually stamped with the broad arrow, and it favoured a particular kind of home: the bridge parapet. Bridges offered what the surveyor always wanted, solid engineered masonry standing directly on the line of the road, and the Welsh bolts run from the parapet of Pont y Garreg-fechan in Gwynedd, barely three metres above the sea, to a concrete block on the high ground of Neath Port Talbot at five hundred and thirty-one metres. Alongside them the archive records fifty-seven projecting bolts, the same instrument turned sideways to stand out from a vertical face where no horizontal surface offered itself, among them the bolt on the parapet of Pont ar Ddyfi near Machynlleth, in place since at least 1942. Pembrokeshire holds more bolts than any other county, with Powys close behind.

The Three Brass Rods

The rarest mark in Wales is the brass rod, a rod set vertically into a purpose-made surface block, and the archive records only three in the entire country. One stands at Caedu in Bridgend, four hundred and eleven metres up. The other two are both in Carmarthenshire: one on a surface block at Bodyst, and one on a concrete block at the Banc Cwmhelen trig station, high on the county's northern uplands. That two thirds of the rarest bench mark type

in Wales should stand on Carmarthenshire ground is a small distinction, but it is one more thread drawing this record home, and both rods will take their place on the county map to follow.

The Oldest Date in the Record

Among the pivots of Gwynedd the archive holds the oldest verification date anywhere in the Welsh record: a pivot on a wall face, recorded as verified in the year 1900. If the date is taken at face value, the mark was checked before Ordnance Datum Newlyn existed, in the era when the heights of Wales were still reckoned from the old datum at Liverpool, and it was carried forward into the new system rather than replaced. A small hollow in a Gwynedd wall may therefore be the longest-serving working point in the height network of Wales, older than the datum that now defines it.

What Remains

The verification pattern repeats the story told in Part Two. Four hundred and fifty-nine of these marks were last checked in the 1950s, two hundred and eighty-one in the 1960s and six hundred and forty-five in the 1970s; since 1980, barely thirty of the one thousand four hundred and twenty-five have been seen by an official surveyor. The pivots on their mountain rocks may prove the great survivors, for no one demolishes a boulder; the bolts on their bridge parapets face every road-widening scheme in Wales. Which of them endure is, once again, a question only fieldwork can answer, and this layer of the map is the register from which that fieldwork can begin.

Sources

Ordnance Survey Complete Benchmark Archive, published under the Open Government Licence, from which every position, height, mark type, levelling order, verification date and location description in this part is drawn. Ordnance Survey list of bench mark abbreviations, used to read the location descriptions. Counts and analysis prepared from the archive for the whole of Wales, with each mark assigned to its modern local authority by boundary. Grid references are given in the Ordnance Survey National Grid; map coordinates were converted from OSGB36 to WGS84 for display. Positions record where each mark stood at its last verification; survival on the ground is unconfirmed until verified in the field.

Summary: The Map in Whole

The map now stands complete in its three layers, and the whole of it can be said in a paragraph. One star at Newlyn marks the zero. Nineteen granite pillars carry that zero into Wales, from Holyhead to Penhow, the lowest at 24 metres above the sea at Haverfordwest and the highest at over 356 metres on the moor above Wrexham. Between the pillars run one thousand four hundred and seventy-two numbered flush brackets, from a tollgate cottage in Gwynedd two metres above the tide to the trig pillar on Twyn Mhyalehod at 642 metres, the oldest of them in place since 1914. And around them stand one thousand four hundred and twenty-five bolts, pivots and brass rods, the pivots polished into the bare rock of Eryri where the walls run out, the bolts on the bridge parapets, and the three brass rods of which two stand on Carmarthenshire ground. Two thousand nine hundred and sixteen special marks in all, every one shown at its recorded position with its height above Ordnance Datum Newlyn to the millimetre.

The Data in Full

The Ordnance Survey benchmark archive records 46,522 marks in Wales, assigned in this project to their modern local authorities by boundary. The special marks shown on this map account for 2,916 of them: 19 Fundamental Benchmarks, 1,472 flush brackets, 1,088 pivots, 277 bolts, 57 projecting bolts and 3 brass rods. The remaining 43,606 are the ordinary marks, 34,516 cut marks and 9,090 rivets, which belong to the county map series that continues this project. Across all types, Powys holds the most marks of any authority with 6,725, followed by Carmarthenshire with 4,972 and Pembrokeshire with 3,822. The levelling orders divide the flush brackets into 586 on first-order lines, 406 on second and 480 on third. The verification dates close the account: the great majority of all Welsh marks were last checked between 1950 and 1979, and only a few dozen have been seen officially since 1980.

What the Map Shows That Lists Cannot

The archive has always existed as a list, and a list of forty-six thousand grid references tells the eye nothing. Placed on the map, the system becomes visible as a system. The lines of the levelling reveal themselves in chains of pins along the roads, the railways and the coast. The pivots cluster where Wales is highest and emptiest, the brackets thicken through the market towns, and the whole network can be seen hanging, as it truly does, from one point of light in Cornwall. It is the difference between an inventory and a portrait, and it is the reason this record was made as a map first and a document second.

The Road On

Two tasks remain, and they are the purpose of everything assembled here. The first is the county series, carrying the 43,606 ordinary marks onto standalone maps county by county, each with its own record in this style, beginning with Carmarthenshire and its 4,608 cut marks and rivets. The second is the fieldwork, for which every pin on every layer carries the same

waiting line: unvisited. Each mark found, photographed, and confirmed turns a line of a fifty-year-old archive back into a living record, and each mark found missing is a loss documented before it could be forgotten entirely. The surveyors who cut these marks worked to millimetres over hundreds of miles and expected their work to outlast them. Recording what remains of it is a way of honouring that expectation, one wall, one bridge and one mountain at a time.

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Master File

<https://tinyurl.com/How-Wales-Was-Measured-Master>



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