“OS mapping of water mills”
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**OS mapping of water mills**

**Paul Bishop**

Richard Oliver’s enduringly popular CCS publication *Ordnance Survey Maps: a concise guide for historians* went into its third edition in 2013, thereby highlighting the interest in using early OS mapping for historical research. Richard notes that such mapping does indeed offer many opportunities for the historian but he is also keen that users of OS mapping are aware of the limitations of the mapping in this regard. He has thus emphasised that much remains to be done to clarify what the mapped symbols actually ‘mean’ and how reliable they are.

Several of us have explored this matter in relation to, for example, the mapping of limekilns, the mapping of horse gins (engines) in understanding the balance between pastoral and arable land-uses in the mid-nineteenth century west Central Belt of Scotland, and in relation to the mapping of ha-has in designed landscapes. With respect to limekilns, we found that OS did not necessarily map all the limekilns in a locality and the reasons for this ‘under-mapping’ remain unclear.

Bill Bignell’s excellent work on OS mapping of windmills provides the benchmark in understanding OS philosophy and practice in such work. Bignell focused on “quite simply … [trying] to gauge how effective the Survey has been, over the long course of its existence, in the mapping of windmills at each of the different scales.” Richard Oliver has highlighted the quality of Bignell’s work, also noting that the exhaustiveness of that work on windmills has yet to be matched for watermills. This note explores OS symbology of watermill mapping in Scotland and what can be discerned about mill operation from the OS representation of watermills. These issues are explored in relation mostly to the First edition 25-inch mapping but there is also some recourse to Second edition 25-inch mapping. The focus is on the 25-inch mapping because, fairly obviously, this of all the scales of OS mapping shows the earliest, and probably the best, detail for the historian.

**GB1900 data set – ‘Away from the Water’**

A PhD project entitled ‘Away from the Water’ is being undertaken by Ms Iara Calton at the University of Glasgow, funded by the Arts and Humanities Research Council via Historic Environment Scotland. The project focuses on when and why factories in Scotland converted from water-power to steam. As part of the project, we are collaborating with

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3 Bishop & Oliver, *Sheetlines* 95 and 96.
4 See also Bishop and others, ‘Lime burning in clamp kilns in Scotland’s western Central Belt: Primitive industry or simple but perfectly adequate technology?’, *Industrial Archaeology Review* 39 (2017), 38-58.
7 As well, Chris Fleet points out that the 25-inch is the most detailed scale for rural areas (and therefore, for the vast majority of mills in Scotland), even though the OS Large-Scale Town Plans at 1:1056 and 1:500 give more detail for some urban mills.
the National Library of Scotland to use the GB1900 data set\(^8\) to build an interactive web portal for watermills in Scotland. This GB1900 Second edition 6-inch data set has been extensively cleaned and tidied by Joe Rose, a retired Canadian engineer, so that the point locators for mills in Scotland along with their various associated infrastructure (dams, lades, sluices etc – see below) all actually sit on the relevant feature. This data set is the “From Water to Steam project – Mills in Scotland”.\(^9\) The relevant 25-inch and 6-inch sheets can be easily located for a particular mill or associated feature, including on the First edition, even though the starting data are the Second edition 6-inch data. First edition sheets can be viewed individually and mapped data can be viewed ‘side-by-side’ from the Second edition mapping onwards. The cleaned data set of the “From Water to Steam project – Mills in Scotland” consists of more than 14,500 mills and mill-related infrastructure (figure 1). This number is clearly a major advance on the data used in an earlier study comparing the landscape settings of water mills in Scotland and England.\(^10\)

In that study, we found that the Ordnance Survey Gazetteer contains a total of 1050 locations in Scotland containing the words “mill”, “milton” and “mln” and 662 locations in England. Before turning to OS 25-inch mapping of water mills, I provide a little background on water wheels that is important to the discussion that follows.


\(9\) https://geo.nls.uk/maps/mills/index.html#zoom=7&lat=56.6522&lon=-4.5247

\(10\) Paul Bishop and Esperanza Muñoz-Salinas. ‘Tectonics, geomorphology and water mill location in Scotland, and the potential impacts of mill dam failure’, *Applied Geography* 42 (2013), 195-205. The comparison between Scotland and England reported in that publication will now be expanded in a new 42-month project with funding awarded to Bishop and Dr Adam Lucas (University of Wollongong) by the Leverhulme Trust.
Figure 2 (left). Types of vertical water wheel, modified by the author from Figure 5 in John Shaw’s Water Power in Scotland, John Donald, Edinburgh (1984). The undershot wheel has open-sided radial blades or vanes (also called floats, floatboards or paddles) against which the water flow turns the wheel. The others – breastshot, overshot and pitchback (also called backshot) – have sides to the vanes to form buckets and it is largely the weight of the water in those buckets that turns the wheel. The overshot wheel has a slight inefficiency in that the water leaving the buckets at the bottom of the wheel drains away (to the right here) against the direction of the wheel’s turn (clockwise here).

Figure 3 (below). Generalised and diagrammatic representation of geomorphological differences for watermills between southern Britain (upper) and northern Britain (lower) and the relationship between the stream, lade and water wheel. Note that in southern Britain, the height needed to elevate water for breastshot, backshot or overshot wheels is often obtained by building a high mill dam wall to lift the water. In northern Britain this elevation is often provided by naturally steeper streams, some steeper streams having a knickpoint (step) in the stream’s profile (as shown). In that case, a weir in the stream then directs water into the lade.
**Water wheels**

The vertical water wheels that drive water mills can have several configurations (figure 2). John Smeaton, the famous eighteenth-century civil engineer, published a series of experiments in 1759 that showed that delivering water part-way up the wheel (breastshot) or to the top of the wheel (overshot and pitchback [backshot]) provides at least double the power of the undershot wheel, where the water rushes by the bottom of the wheel, striking the blades or vanes. Thus the optimal site for a mill is one where water can be delivered some way up the wheel, and, for economy, via a channel – lade, lead, leat or race – that is as short a distance as possible to the mill from the water source. The glaciation of northern Britain with the attendant sub-glacial erosion and post-glacial isostatic rebound (uplift) mean that streams tend to be steeper in northern Britain and lades therefore generally shorter (figure 3).

One of the aims of this exploration of watermill symbology is to assess whether water wheels have been represented in OS First edition 25-inch mapping and whether that representation contains information about the type of wheel. The siting of the mill in relation to its water source, and, as far as can be determined from OS mapping, the geomorphology of that water source if it is a river, are also relevant to a mill’s particular technology.

**The full mill system**

*Figure 4* shows the various elements of a watermill system. For some parts of the mill system there are terminological differences across the UK. For example, *Ordnance Survey Maps: a concise guide for historians* notes under “Mill race and mill stream” that ‘It is OS custom to write “mill race” to all water leading to a water mill and “mill stream” to the water leaving it. This custom will be followed unless it disagrees with local practice.’

This instruction is from 1963 and a 10 December 2020 email from Richard Oliver has noted that he does not know of any instructions in this regard earlier than 1963. The local practice in Scotland for the channel that brings water to the mill is generally ‘lade’ or ‘lead’ (though with some variations – see below).

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11 Geomorphologists call a steep drop in the river bed elevation a knickpoint (like a cascade), which can be exploited in setting up a mill.

Figure 4a. First edition 25-inch map of Baldernock Mill and its associated features – mill dam, sluices, lade and the corn and saw mill buildings. (Stirlingshire sheet 32.2 (Baldernock) Surveyed 1860; Published 1863)

Figure 4b. Second edition 25-inch map of the Baldernock Mill set-up. The jetty projecting out from the dam wall is also shown on the First edition 6-inch mapping. This jetty presumably gave access to a shaft that controlled a screw valve (sluice – ‘Sl’) in the bed of the reservoir either for releasing water downstream and hence to the lade and/or for flushing sediment from the reservoir. (Stirlingshire sheet 32.2 (Baldernock; New Kilpatrick) Revised 1896; Published 1897)

Figure 4c. Modern view downstream through the breach in the Baldernock Mill dam wall, showing two cast-iron pillars (centre right) that presumably supported the jetty from the dam wall
The dam
I take ‘dam’ to indicate a structure that holds back and stores water. It seems that mill dams in Scotland often filled overnight and water was then released throughout the day for the mill if there was insufficient flow from the river (particularly, say, in dry periods). For this reason, mill dams in Scotland, especially in the west, are generally small because rainfall and stream flow are reliable. The dam in the example in figure 4 sits atop a knickpoint in the bed of the river and water is taken off the stream a little way down the face of the knickpoint (as in figure 3 lower).

In some cases in OS mapping, a structure labelled as a ‘Dam’ would normally be thought of as a weir to direct stream flow into the lade. In the example in figure 5, the ‘Dam’ so labelled in the First edition does not actually store water for mill operation and it has become a ‘Weir’ by the Second edition. Cowden Mill (NS 567 883) near Balfron has a ‘Dam’ labelled on the Endrick Water on the First edition and a ‘Dam’ and a ‘Weir’ both labelled on the Second.13 The ‘Dam’ does not appear to act to store water, rather serving to direct water into a large artificial side channel (like a large lade) and the ‘Weir’ then directs the flow into the lade itself, controlled by a sluice.

Figure 5. Dawsholm paper mill on the River Kelvin in Glasgow
Left: Dumbartonshire sheet 28.4 (Combined) Surveyed 1857 to 1860; Published 1893
Right: Lanarkshire sheet 1.13 (Cadder; Glasgow; New Kilpatrick) Revised 1893; Published 1896

13 See https://maps.nls.uk/view/82905861#zoom=6&lat=9648&lon=8192&layers=BT
**Weir**

Dam or no dam, mills in Scotland powered by water from a stream usually have a weir directing stream flow into the lade, the channel to the mill. In the Baldernock example in *figure 4*, remains of such a weir that directed flow into the lade can be discerned but it was presumably already too ruinous to be mapped when the First edition was surveyed. In that situation, the mill is a run-of-the river mill, reliant on water that flows naturally into the head of the lade.

These weirs in Scotland are generally low structures because, firstly and as noted above, weirs generally did not function for water storage, and, secondly, stream steepness means that only a relatively small elevation of the water surface is necessary to direct flow into the lade. The weir is usually labelled on OS mapping in Scotland (*eg* figure 6). In this not particularly systematic trawl of “From Water to Steam project” data, one example was found of a weir labelled as ‘Caul’, a Scots word for weir.

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**Sluices**

The sluices regulate flow into, along and out of the lade. As far as I have seen, they are indicated only by a label and are not represented by a symbol. One sluice is at the upstream head of the lade, shown in the First edition (*figure 4a*) but not in the Second edition (*figure 4b*). It must have been present at the survey for the Second edition, however, because the short channel that is an integral part of a sluice, returning water to the stream when the sluice was closed, is shown.

A second sluice is found some way along the lade, generally close to the mill, and used temporarily to stop flow to the water wheel but retain water in the lade. This sluice, sometimes called a penstock, is labelled in both First and Second editions in *figure 4* and

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15 https://maps.nls.uk/view/74947387#zoom=8&lat=7713&lon=9276&layers=BT
is also evidenced by a channel to return flow to the stream when the lade has been blocked by that sluice. Somewhere also close to the mill will be a heck (also called a ‘haik’ is Scotland), a screen to stop debris reaching the water wheel. At Baldernock Mill, the heck is immediately ‘down-lade’ of the second sluice.

**Lade**
The OS custom quoted above is to use “mill race” for water leading to a mill and “mill stream” for the water leaving the mill but local practice in Scotland is clearly to use ‘Lade’ or ‘Lead’ for the channel taking water to the mill. There are only ten examples of ‘Race’ in the GB1900 “From Water to Steam project – Mills in Scotland” data set (the mustard-coloured dots that might just be visible in figure 1); eight of these ten are in southern Scotland (in the Borders and Dumfries & Galloway). An interesting example of how local practice varied over short distances is shown in figure 7.

![Figure 7. Evidence of differing local practices in labelling the channels that take water to watermills either side of the border between Scotland (lower part of the figure: ‘Mill Lead’) and England (‘Mill Race’). Yetholm Mains farm is at bottom left. (Northumberland (Old Series) sheet 18.2 (Paston) Revised 1896; Published 1898)](https://maps.nls.uk/view/74478365#zoom=7&lat=10485&lon=11176&layers=BT)

In some examples, which were not mapped at the 25-inch scale for the First edition, a ‘Mill Race’ is labelled on the new series of the 1890s but has become a ‘Mill Lade’ by the edition of 1909 (figure 8). The OS-specified label of “mill stream” for the water leaving a mill has not so far been observed for any mills in Scotland. Indeed, I have seen only such channel actually labelled, as Mill Lade, which seems reasonable given that it should

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16 Garscube Mill on the Second edition Dumbartonshire sheet 28.4 (Combined) https://maps.nls.uk/view/74478365#zoom=7&lat=10485&lon=11176&layers=BT  The mill is
be quite obvious what the channel is. If I have to name such a channel that leaves the mill, I am inclined to call it the ‘tail race’ or ‘outflow lade’. I have no justification for those terms except that ‘tail’ and ‘outflow’ seem to me to convey better than does ‘stream’ the sense of water leaving the mill.

Figure 8. Corra Mill near Kirkgunzeon

Left: Mill Race (Second edition; this area not mapped at the 25-inch scale for the First edition) (Kirkcudbrightshire sheet 37.9 (Kirkgunzeon) Revised 1893; Published 1894)
Right: Mill Lade (edition of 1907) (Kirkcudbrightshire sheet 37.9 (Kirkgunzeon) Revised 1907; Published 1909)

Lades are generally represented by a pair of parallel lines, often with blue shading on First edition 25-inch mapping (and occasionally on Second edition). They may also be indicated by a single line that is identical to a field boundary. I assume that whether a lade is shown as a double- or single-line follows the OS prescription for mapping a channel on National Grid mapping and, Richard Oliver assumes, on County Series mapping. That is, that “watercourses are shown by a single line if less than … 2 metres (1:2500) [in width]; otherwise by double lines.” Figure 4 shows the lade narrowing in this way close to the mill, downstream (south) of the second sluice. Richard Oliver notes in the email quoted above that the specification of 2 metres is from 1963 but the fact that 2 metres is practically the same as 10 links, give or take a few centimetres or inches, does

also mapped on the Second edition Lanarkshire sheet 1.13 but the outflow lade is not labelled on that sheet.

suggest that the specification of 2 metres continues the earlier practice of 10 links being the minimum width for representing a channel by double lines.

A lade might be less than 2 metres wide for its whole length and so will be represented as a single line throughout. This can be confusing – is the single line a field boundary, a lade or both? – but the labelling of sluices and the path(s) of the single line help. Figure 9 shows the two lint mills near Avonbridge with the various lades represented by single lines. That these are not simply field boundaries is confirmed by the ways in which the lines connect the dam to the two buildings labelled as mills and the sluices associated with those line connections. The line connecting the northern mill building back to the stream is also telling, but the lack of an outflow lade from the southern mill building (the larger building to the east of the dam) and the fact that it seems that not all sluices have been labelled could be confusing.

![Figure 9. The two lint mills at Linn near Avonbridge. (Stirlingshire sheet 35.8 (Slamannan) Surveyed 1860; Published 1862)](image)

Not all lades are channels. Some lades are piped (figure 10) and sometimes the lade is underground (figure 11). In the latter case, Canmore, Historic Environment Scotland’s catalogue to online records of archaeological sites, buildings, industry and maritime heritage across Scotland, reports the “later piping of the lade”.19

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19 https://canmore.org.uk/site/128360 (consulted 18 November 2020)
Figure 10. The threshing mill at Chapel farm near Dunscore, Dumfriesshire
Top left: First edition 25-inch showing lade as represented by a single line (narrow channel?) (Dumfriesshire sheet 40.9 (Dunscore) Surveyed 1856; Published 1856)
Top right: Second edition with the same representation of the lade (Dumfriesshire sheet 40.9 (Dunscore; Glencairn) Revised 1899; Published 1899)
Lower left: the threshing barn with overshot water wheel driven by water from the pipe at upper left
Lower right: view along the piped lade towards the water wheel
It is also noteworthy in figure 9 that the northern mill building is adjacent to the drop in the bed of the stream marked by the rock exposed in the stream bed. The siting of the mill is exploiting the drop in water level so that water can be brought by the lade to some way up the water wheel (as in figure 3, bottom). On larger and more perennial streams in Scotland, where there is generally always enough flow and a dam is not needed, a mill can be sited beside the drop in the river bed (ie, beside the knickpoint). The mill exploits the drop in the river bed across the knickpoint by being located on the drop itself, thereby avoiding the costs of one or more of the dam, weir and/or lade (figures 12 and 13).
The role of the water wheel in generating the power needed for a mill’s operation and whether the type of wheel can be discerned, or at least inferred, from OS mapping, make water wheel symbology an important consideration. The water wheel is occasionally labelled by OS (figure 14) but mostly is not. And it was unclear to me at the start of this exercise whether the wheel was ever represented. In fact, I began to look at this issue of water wheel symbology only when I noticed a water wheel apparently represented for the abandoned and unroofed Townhead Paper Mill near Kilsyth (figure 15). That wheel apparently ‘hung down’ into the channel and was therefore presumably undershot.

Figure 14. Three examples of labelling of the water wheel on First edition 25-inch maps
Left: near Loch Winnoch (Renfrewshire sheet 15.1 (Lochwinnoch) Surveyed 1856; Published 1858)
Middle: Plean (Stirlingshire sheet 24.2 (St Ninians) Surveyed 1859; Published 1862)
Right: Larbert (Stirlingshire sheet 24.14 (Combined) Surveyed 1859 to 1860; Published 1891)

Figure 15. Townhead paper Mill in First edition 25-inch mapping. It is assumed that the ladder-like symbol on the eastern edge of the channel represents the water wheel. (Stirlingshire sheet 29.9 (Kilsyth) Surveyed 1859; Published 1862)

Before I explore water wheel symbology further, I note that it is reasonable in some situations to infer what type of wheel was installed. For the mill in figure 16, for example, the wheel was almost certainly undershot. Flow in the adjacent Luggie Water is from right to left, and the outflow lade is still present. The inflow lade has been infilled by sediment from floodwaters flowing into that lade, in the same way that the upstream end of a meander cutoff (oxbow) is more quickly filled with sediment than the downstream part of the cutoff.20 Figure 17 shows that there is no knickpoint in the stream, which meanders within its floodplain (a setting that can be inferred from the OS mapping). The stream does not have a steep reach and so the water must have come to the water wheel at a relatively low elevation, presumably having been ‘lifted’ to the inflow lade by a weir, now long gone. The water could not have been brought to any appreciable height on the

wheel which therefore was almost certainly undershot. Basic geomorphology and OS First edition mapping enable these conclusions.

In a similar vein: for the mills in *figure 9*, it was noted that the northern mill sits beside the rocky drop in the river bed (a knickpoint) and given this fall in elevation through the mill building it is likely that its water wheel would have been at least breastshot and perhaps overshot or backshot. On the other hand, the southern mill in *figure 9* does not seem to be associated with any drop in the river bed, being beside the flatter reach upstream of the knickpoint. Thus, a first ‘guess’ would be that that mill is powered by an undershot wheel.

Should we expect the water wheel to be indicated on OS maps? In some mills, the wheel was often completely internal and so there can be no indication as to the wheel (*figure 18*). Where the wheel is hidden beneath a launder, it might also be expected that the wheel will not be indicated. *Figure 19* shows the situation at Baldernock Mill (see also *figure 4*). This is a backshot (pitchback) wheel with the water coming to the wheel via the launder, the black timber trough which is the same width as the wheel. A sloping trapdoor in the floor of the launder turns the water back as it falls from launder to wheel, driving the wheel clockwise in this view. The water wheel is hidden by the launder. Moreover, the wheel was historically enclosed by timber cladding.\(^\text{21}\) In some situations, but not in this Baldernock example, OS does indeed indicate by the colour of shading that a timber building is attached to the end of a mill building, possibly enclosing the wheel.

\(^\text{21}\) See [https://canmore.org.uk/collection/643567](https://canmore.org.uk/collection/643567) and [https://canmore.org.uk/collection/643568](https://canmore.org.uk/collection/643568) (consulted 22 November 2020)
For an overshot wheel, the visibility of the wheel depends on the arrangement with the lade. For the overshot wheel at Chapel (figure 10), where a pipe delivered water to the wheel, the wheel should be mappable. The Second edition map in figure 10 shows a small rectangle where the wheel is, suggesting some attempt to indicate a structure. On the other hand, it would be difficult for the OS to represent the wheel in the more usual overshot situation of a launder projecting out to beyond half-way across the wheel. This set-up leaves only a part of the outer ‘half’ of the wheel visible, as in figure 20, for which the OS does not attempt to represent the wheel. One wonders if the representation in figure 21 is the OS’s attempt to represent the situation of a backshot wheel of the type shown in figure 19, with a launder hiding the wheel, or perhaps the situation of an overshot wheel.
Figure 20. Overshot wheel at Gavin’s Mill, Milngavie Dunbartonshire

Figure 21. Gardrum Mill, near Fenwick Ayrshire. (Ayrshire sheet 13.15 (Fenwick) Surveyed 1856; Published 1857)
The most common symbol used by the OS when it does represent the wheel is a ladder-like symbol that is very similar to the symbol for outside stairs on a building (figure 22). That this ladder-like symbol does indeed represent the water-wheel is confirmed by the examples in figure 23.

**Figure 22. Bennet’s House, Culross**

OS First edition 25-inch map of Culross with the ladder symbol showing that multiple buildings have outside stairs. Bennet’s House is the long, narrow north-south rectangular building with the stairs at its northern end, to the immediate west of the Town House. (Perth and Clackmannanshire sheet 142.8 (Combined) Surveyed 1859; Published 1893)

**Figure 23a. Postcard postmarked 1906 of the Old Mill at Waterside near Kirkintilloch, Dunbartonshire, showing the main wheel and a subsidiary wheel (author’s collection). The larger wheel would have been breastshot and the smaller most likely undershot, powered by the outflow from the first wheel.**

Inset: Second edition 25-inch mapping of Waterside Old Mill. Note the two ladder-like symbols, one large and in the lade immediately below the weir, and a second, smaller one driven by the outflow from the first. The approximately diagonal line-work beside that smaller wheel is poorly executed shading to indicate the small stone-built lean-to beside the smaller wheel. (Dumbartonshire sheet 33.7 (Kirkintilloch) Revised 1896; Published 1898)
Figure 23b. Photograph dated 1910 of Garshake Mill Dunbartonshire showing a low breastshot wheel (Courtesy of West Dunbartonshire Council)

Inset: Second edition 25-inch mapping of Garshake Mill showing the lade leading to the ladder-type symbol, being the water wheel. (Dumbartonshire sheet 22.2 (Cardross; Dumbarton) Revised 1896 to 1897; Published 1898)

Figure 23c. A low breastshot wheel at Dalgarven Mill Ayrshire

Inset: Second edition 25-inch mapping of Dalgarven Mill showing the lade leading to the ladder-type symbol, being the water wheel. (Ayrshire sheet 11.12 (Dalry; Kilwinning) Revised 1895; Published 1897)
It would be of course possible to confuse the ladder-type symbol for a water wheel with that for outside stairs but the symbol’s meaning should be clear, especially if a channel (lade) is also mapped. Corra Mill (figure 8) shows a ladder-like symbol that is clearly on the end of the building and fed and drained by channels (lades). Moreover, a lade to by-pass the wheel can also be discerned in the highlighted extract of the 1907 map in figure 8, as also in Kilmahew Mill, near Cardross Dunbartonshire, where the water wheel is represented by the ladder symbol (as confirmed by the lade coming in from the north and having a loop for bypassing the wheel) (figure 24). In figure 25 the ladder-like symbol clearly represents stairs on the outside of the building. Further examples of the wheel symbol are given in figure 26.

A single example has been found of a somewhat unusual symbol to represent the water wheel (figure 27). Here the wheel is represented with the ‘vanes’ being shown in a perspective kind of way (getting closer together as you move away from the top of the wheel). In other words, this mapping symbol seems to be more ‘pictographic’, attempting to represent visually a three-dimensional image of the object from an overhead viewpoint (figure 28). The representation of the Malt Land wheel in figure 27 is changed on the Second edition to the much more conventional ladder-type symbol.

A delightful example of the same representation is found in a plan from the papers of Robert Stevenson, the ‘founding father’ of the Stevenson civil engineer dynasty which
is so well known for the construction of lighthouses in Scotland.22 This is on an 1814 plan of the Belton Waulk Mill with the mill and its water wheel depicted as if the roof of the mill was not present (figure 29). The representation of the Belton Waulk Mill wheel has that same sense of the water wheel being depicted not so much as by a symbol as by a representation of it as seen from above.

Figure 26. Examples of OS representations of water wheels

Top L to R: Saw mill in Croftamie Stirlingshire with water wheel apparently ‘hanging down’ into the Catter Burn but actually fed by water brought from a mill dam by a lade (Dumbartonshire sheet 15.9 (with inset 15.5) (Kilmarnock) Surveyed 1859; Published 1862); Saw mill in Croftamie Stirlingshire, a little further downstream, with water wheel fed by a lade from Catter Burn (Dumbartonshire sheet 15.9 (with inset 15.5) (Kilmarnock) Surveyed 1859; Published 1862); Maidenholm Forge near Dalbeattie Kirkcudbrightshire, showing two water wheels fed by short individual lades from the mill dam (Kirkcudbrightshire sheet 43.8 (Kirkgunzeon; Urr) Revised 1893; Published 1894)

Bottom L to R: Midtown of Urr Mill near Hardgate Kirkcudbrightshire (Kirkcudbrightshire sheet 36.10 (Crossmichael; Urr) Revised 1893; Published 1894); Milligs Mill, Helensburgh Dunbartonshire, with an apparently large wheel spanning the whole of the southeast end of the mill building (also shown this size on the Second edition). Note outside stairs on the southwest wall (Dumbartonshire sheet 17.5 (Row) Surveyed 1860; Published 1862); Spottes Saw Mill on Spottes Burn a short distance upstream of its confluence with Urr Water Kirkcudbrightshire (Kirkcudbrightshire sheet 36.10 (Crossmichael; Urr) Revised 1893; Published 1894)

Figure 27. First edition 25-inch labelling and representation of the water wheel at Malt Land on the River Aray a short distance inland of Inveraray (Ayrshire and Buteshire sheet 133.5 (Combined) Surveyed 1868; Published 1892).

22 https://maps.nls.uk/projects/stevenson/about.html The Stevenson papers have been digitised and put online at the National Library of Scotland.
Figure 28. The water wheel at Gavin’s Mill Milngavie illustrating how the vanes ‘facing the camera’ appear more widely spaced than those on the curve away from the camera. This is a side-on view of the wheel but the same effect operates from above.
The section through the mill in figure 29 confirms that the water wheel was a low breastshot wheel. The Belton Waulk Mill was roofed but in the more common external wheel set-up, a breastshot wheel would be visible from above and not covered by a launder of the types shown in figures 19 and 20. A working hypothesis, then, is that where a water wheel is represented by a symbol, the wheel would have been undershot or breastshot. This hypothesis is supported by the examples in figure 23. However, known undershot or breastshot wheels that are not represented by OS by any wheel-type symbol include, for example, those at Preston Mill in Haddingtonshire (modern East Lothian) and Killin Mill in Perth & Clackmannanshire (modern Stirling). The latter sits astride the Falls of Dochart knickpoint.

A further issue in whether the wheel was represented relates to the size of the wheel and has been raised by Richard Oliver in his 10 December 2020 email. Richard wonders
whether the “2 metres/10 links/6.6 feet minimum width … noted for watercourses” might also apply in some way to water wheels. He speculates that water wheels not projecting as far as 10 links might not have been mapped (or supposed to have been mapped). Richard’s use of the word “projecting” implies the width of the wheel, being the horizontal dimension of most relevance to mapping. It is obvious that if a water wheel is mapped and at the same width as the lade, which is represented by a double-line, then the wheel must have been at least 2 metres/10 links/6.6 feet wide (e.g., figures 8, 23, 24, 26). This notion can be tested further by using the distance measuring function on the ‘Explore georeferenced maps’ feature on the NLS Maps website to measure the width (the projection) of a water wheel (albeit that the measurement of such small features, even on the 25-inch maps, must be subject to a fair degree of uncertainty). All water wheels on the Second edition 25-inch maps given above are indeed at least 2 metres wide when measured in this way, except for the smaller of the two wheels at the double-wheeled mill at Waterside, which is just 1 metre wide (figure 23a). Perhaps the novelty of having two wheels, one ‘below’ the other, prompted the representation of both wheels.

Thus, two issues emerge in whether the OS indicated a water wheel by a symbol: (i) whether the wheel was mappable in terms of being visible from above, and (ii) how wide the wheel was. The latter is important in terms of the water wheel’s power, given that it is fundamentally the weight of the water in the buckets of overshot, breastshot and backshot (pitchback) wheels that generates the power. An internal water wheel, generally in the basement of a mill buildings, in a wheel pit so that the water could be brought to some height up the water wheel, was often wide so as to generate the necessary power using a wheel with relatively few buckets (because of its small diameter). For example, images of the 25-feet-diameter breastshot wheel at Aberdeen’s Grandholm(e) Mill, which generated 200 hp, indicate that its width must have been close to its diameter. These particular internal water wheels are not relevant to the issue of symbology and mapping but they demonstrate the importance of the water wheel’s width and hence the potential for OS mapping to elucidate the power generated by mapped external wheels.

**Discussion and conclusion**

Historically, the UK had thousands upon thousands of watermills, providing the power for a multitude of different industries, almost too numerous to list. These industries had differing power requirements and these different energy needs were an important determinant of the type of waterwheel and mill setup that was implemented. Or put another way, a particular locality’s geomorphology (river steepness) and hydrology (amount and reliability of river flow) determined what watermill-based industries could be established in that locality. A corn-grinding mill, powered by a waterwheel turning a heavy stone on a stationary nether stone (bed stone), required substantial amounts of power, particularly once all the added machinery of a fully developed 19th century grain mill – multiple pairs of stones, sack lifts, blowers, fans, etc – had been installed. Thus, while it is possible that Baldernock Mill was early powered by an undershot wheel, it had converted to backshot by the time of mid-19th century OS mapping, when a saw mill was also being powered. Mills such as lint (flax) mills and threshing mills had lower energy requirements because of their lighter machinery. Thus, it is reasonable that a flax

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23 http://www.mcjazz.f2s.com/GrandholmMill.htm
mill could be driven by an undershot wheel, as has been argued for the flax mill shown in figures 16 and 17; this mill’s setting on a low gradient, floodplain river is thus understandable. If breastshot or overshot/backshot wheels were necessitated by the power requirements of a mill in an area with streams of only gentle gradients – as such the downstream reaches along floodplains – then the lade was long, having to take the water off the river far enough upstream so as to bring the water to part-way up the wheel. The set-up at Kilmahog textile mill, near Callender on the floodplain of a tributary to the River Teith, is one such example, with a long lade that brings the water to a low breastshot wheel.25

Overall, the OS mapping of watermills generally identifies all of the key features of the whole mill system but not necessarily for every mill. In some instances, it seems that the OS does not label all sluices but it is also noteworthy that the OS records details such as the jetty projecting out into the dam in figure 4b, along with its labelled sluice, thereby informing our understanding of the operation of the whole system. Representing a lade by a single line can be ambiguous but considering such mapping within the context of the mill and its water supply system generally resolves such ambiguities.

The wheel symbology is perhaps the most interesting issue in OS mapping of watermills. The importance of knowing the type of waterwheel is that it informs our understanding of the spatial distribution of water milling technology (ie., whether more powerful wheels were regionally concentrated) as well as the ways in which the Scottish situation exploited Scotland’s particular river geomorphology (generally steeper rivers) and hydrology (generally more reliable stream flow). And whether the representation of a water wheel indicates that the wheel was wider than 2m and therefore potentially more powerful certainly deserves more attention.

It is so far unclear as to whether the appearance of a water wheel symbol on the Second edition, when a water wheel is not indicated on the First, signals a change in the operation of the mill (from, say, an overshot wheel or one that was internal at the time of First edition mapping to an external backshot or breastshot wheel). I think it more likely that the wheel set-up has not changed between the First and Second editions and that a decision was taken to represent the wheel on the Second edition. Garshake Mill (figure 23b) is a case in point. The First edition mapping26 shows, in effect, the same lade as is present in the Second edition mapping (and now) and a rectangular shape coinciding with the wheel pit. I think the wheel was simply not represented on the First edition. Lower precision in mapping, with subsequent improvements, is not restricted to the First edition. The poor representation of the lade by-passing the wheel in the Second edition mapping of Corra Mill (figure 8 left) is corrected in the mapping for the edition of 1907 (figure 8 right).

First edition mapping is evidently more variable in its symbology, which seems to become more standardised by the Second edition, often adding more detail and the ladder-type symbol for the water wheel. It is clear that OS mapping of watermills forms a rich seam that will repay further exploration, in terms of both OS symbology and the details of individual mills and their operation, and also of mills by region.

25 https://maps.nls.uk/view/74956872#zoom=6&lat=3717&lon=13017&layers=BT
26 https://maps.nls.uk/view/74941039#zoom=8&lat=3392&lon=15579&layers=BT
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Unreliable Explorers!

The Blackmore story (Sheetlines 119,43) showed how Explorer and Landranger maps differed in their depiction of that Essex village. The examples on the left, (all taken from current online OS maps) show Explorer mapping that is considerably out-of-date. In both cases, the Landranger shows the true situation on the ground, as it is and has been for many years.

Both examples are in the vicinity of the London / Essex border. Bowland Road, missing from the Explorer, appeared as long ago as the 1986 revision of Landranger 177, whilst Lodge Road was de-surfaced and reverted to a woodland track about twenty years ago.

John Davies