Two Estates Project

The Clackmannanshire Field Studies Society [SCIO]
in partnership with
The Inner Forth Landscape Initiative

The Two Lades Project - The Gartmorn Lades
1690 - 1890

Supported by The National Lottery® through the Heritage Lottery Fund

Project Team

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Published and printed by The Clackmannanshire Field Studies Society [SCIO], 2018.

As most of the historical measurements were imperial, metric equivalents have been given.
Known sites have been given six or ten figure NS grid references.

Version 15-02-2018

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1. Introduction:

The Clackmannanshire Field Studies Society obtained a National Lottery grant through the Heritage Lottery Fund, in partnership with the Inner Forth Landscape Initiative. The Society agreed to undertake a four year research project on aspects of the development of the Two Estates of Alloa and Clackmannan, with particular emphasis on the 18th and 19th centuries. The grant enabled local volunteers to be trained and supported to research a number of topics. The Two Lades Project involved identifying, surveying and recording the remains of the Craigrie and Gartmorn lades systems and adding any new historical evidence which was uncovered.

2. Acknowledgments:

- The volunteers who committed a great deal of time and effort to the project - Robert Dingwall, Fiona Graham, Margaret Schofield, Marilyn Scott, David Seaton, Eddie Stewart, Jenni Stewart, Cameron Tonge and Andrew Wood.
- The Clackmannanshire Field Studies Society Executive and Members for proposing and supporting the project;
- The Clackmannanshire Development Trust who provided encouragement, accommodation and supported research and training;
- The National Lottery, through the Heritage Lottery Fund, for their funding;
- The Inner Forth Landscape Initiative for management and training support;
- Local landowners and residents who have supported our survey work and provided us with local information;
- Ordnance Survey Open Data whose easily accessible maps provided us with a base set of locations;
- The National Library of Scotland whose on-line and library-based Ordnance Survey and geological maps provided the bulk of our locational data; their on-line tools and their staff, who were always knowledgeable and helpful;
- The National Records of Scotland whose amazing collection of family papers, plans and maps, on-line catalogue and supportive staff made our task so much easier and the many families, organisations and individuals who had safeguarded and made this material available;
- The Royal Commission on the Ancient and Historic Monuments of Scotland for their easily accessible and helpful databases;
- The University of St Andrews whose work on the Acts of the Scottish Parliament has made the documents easily accessible;
- The University of Edinburgh who have made the Statistical Accounts of the Parishes of Scotland available online in an easily used format;
- Google and Google Books who have made so much previously hard to access material freely available on the internet;
- Google Earth for their satellite imagery and powerful tools;
- British Newspaper Archive for a source of articles and adverts;
- Microsoft for the satellite imagery;
- Clackmannanshire Council for their support with library work.
- Not least, to my wife, for her patience, support and understanding.

The Gartmorn Lades project involved a considerable amount of volunteer effort from 2016 to 2018. A team of dedicated volunteers spent great amounts of time in all sorts of weather, exploring, measuring, surveying, recording and photographing.

The outcome of all this work has led to the production of two technical reports and a status survey of the remains of the system. This first report covers the first two hundred years of the system's history from the first construction circa 1690 by John, 6th Earl of Mar to its purchase by Alloa Burgh in 1890. Every effort has been made to ensure the accuracy of our reporting and to properly acknowledge the sources we used. The second report covers the period from 1890, when the system was acquired by Alloa Burgh for a public water supply until 2006 when it was finally closed. The third report covers the present status of the current remains of the system, listing their condition and vulnerability.

3. General Background:

The earliest records of systematic coal working in Scotland come from the monastic records of the 12th and 13th Centuries. In 1291 Dunfermline Abbey was given the right to work coal on the lands of Pittencrief. [1] These early workings were located on the coast or on the sides of a valley where seams had been exposed by erosion. Coal was dug out until the workings became flooded or the roof was in danger of collapsing, when new workings were opened further along the surface of the seam. Where seams lay below ground but close to the surface, small shafts were dug and workings belled out at the base. Again, these workings would be abandoned when drainage or roof collapse problems occurred. [2] By the 14th and 15th centuries, more extensive workings became accessible by the use of drainage levels; sloping tunnels driven up from a stream in the base of a valley to intersect with the coal seam. The area of coal above this point could then be drained. Once the initial cost of driving the tunnel, or day-level, had been met, maintenance costs were low and shafts, usually not more than 12 – 13 fathoms (22 - 24 metres) deep, provided a means of getting the coal to the surface. [3]

By 1426, the Scottish Parliament recognised that the volume of coal being traded by sea had a possible value to the crown and passed an act to ensure that goods coming by water, including coal, were recorded and that sellers were obliged not to avoid this process. [4] There is evidence that some coal was used at this time as a domestic fuel. Pope Pius II, on a visit to Scotland in 1435, noted that, *"in the absence of wood, a sulphurous stone, dug out of the earth, was used for fuel"*, and observed *" half-naked beggars at the church doors, receiving this substance by way of alms*". [5] By 1563 the exporting of coal was the subject of punitive legislation as it had resulted in a *"…great multitude of coal continually carried out of this realm, not only by strangers but also by the lieges and inhabitants of the same, which is now becoming the common ballast of empty ships and gives occasion of the most exorbitant dearth and scantness of fuel within the same….*" [6].

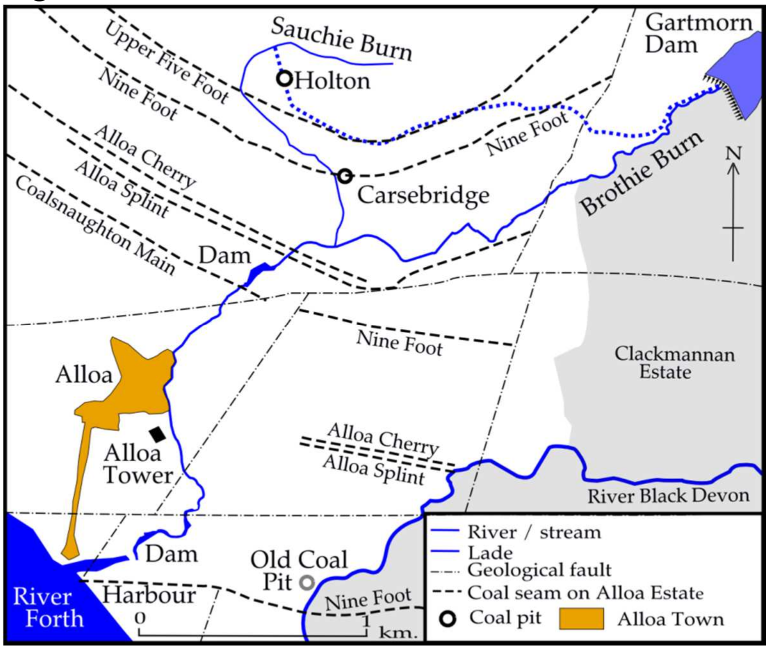
The earliest known record of a coal pit in Clackmannanshire was on the Alloa estate in 1519 [7] and by the end of the 16th century there are records of coal also being worked on the estates of Clackmannan [8] and Sauchie. [9] However, increasing legislation placed heavy burdens on coal owners and in 1609 Sir Alexander Schaw of Sauchie, who was working coal near his home, became the chief spokesman for all Scottish mine owners. He campaigned for the abolition or modification of all restrictive laws, regulations and duties. [10] A custom duty of 48 shillings per ton of coal was rescinded in 1625 in response to answers to the Scottish Parliament who agreed that *"The estaittis haveing at lenth hard the saidis awnaris upoun this poynt and the trewth of thair affirmatioun being knowne to sindrie of thame and the matter being putt to voitting, it was fund that without a seine and evident hurt to the cuntrey this custome could not be impoised upoun the coale*". [11] So successful was Schaw in his demands for a revaluation of the coal-pits in Clackmannanshire that this was ordered in 1649. [12] By the early 17th century much of Scotland's trade was centred round the North Sea [13] and the Alloa and Sauchie estates were transporting coal to Alloa Pow for export. [14]

In 1631 John, 2nd Earl of Mar, wrote a letter of support for Peter Breware, declaring that he "*trades in transporting coal to Flanderis [Vlaanderen, Belgium] and importing other wares to Scotland*" and a request to "*all and sundry to give him aid*". [15] Records show that, by the early 17th century, most of the coal from pits in the Forth estuary was exported by sea and was mined as 'great' or 'sea coal'. These were large pieces of between one and one and a half cwts. (51 to 102 kilogrammes) which were carefully cut by the miners, dragged to the shaft bottom by children, carried by women bearers up stair pits to the surface and packed carefully into ships to prevent breakage. [16] Ships carried only small loads and any Great Coal damaged in transit lost a great deal of value and sometimes was not worth anything. In 1614 an agreement between Sir John Bruce of Airth and a London coal merchant stipulated that "*…all the dust or smaller coal be cast and not accepted..* " and that each ship "*should contain 40 tons of coals and no more*". [17]

Coal pits were small scale and shallow, often being no more than a hole in the ground or in the side of a valley where a coal seam was exposed. Such workings were abandoned when roof stability or drainage became a problem. Close to the shore of the Forth estuary, drainage was usually a problem. The first recorded, large scale use of powered drainage in the area was by Sir George Bruce of Carnock at his Moat Pit near Culross. Among those who visited Culross was John Taylor, "the Water Poet," and his description, which bears the date 1618, states: "*The sea at certain places doth leake or soak into the mine, which by the industry of Sir George Bruce, is all conveyed to one well neere the land, where he hath a device like a horse-mill, that with three horses and a great chaine of iron, going downward many fadomes, with thirty-six buckets" fastened to the chaine, of the which eighteene goe downe still to be rilled, and eighteene ascend up to be emptied, which doe emptie themselves (without any man's labour) into a trough that conveys the water into the sea againe, by which means he saves his mine….*". [18]

4. Early mining developments at Alloa:

Figure 1. Coal seams under the South Alloa Estate.



Based on information from OS OpenData and Geological Survey Maps from the National Library of Scotland.

The Alloa estate was underlain by a significant number of workable coal seams including the Two Foot Coal, Upper Five Foot Coal, Four Foot Coal, Nine Foot Coal, McNeish Coal, Coal Mosie, Lower Five Foot Coal (Alloa Cherry), Alloa Splint Coal and Coalsnaughton Main Coal. Thicknesses ranged from one foot five inches to nine feet. [19] The entire Clackmannan coalfield was greatly influenced by the large Ochil fault lying a few kilometres to the North. The coalfield is in the form of an elliptical basin, lying to the South of the fault. It extends some eleven kilometres from the West of Alva to the East of Dollar and some seven kilometres from the Ochil hills in the North to the river Forth in the South. As a result of the basin shape, most of the coal seams dip to the North or North East at a slope of about 1 in 6. [20] This dip was extremely significant for mine drainage, as any drainage system could only keep that part of the seam to the South drained. The displacement of the Ochil fault also impacted on rocks to the South, creating a number of major West to East faults and a number of lesser North to South faults. [21] This pattern of faulting, particularly in the southern area of the coalfield, created small blocks of workable coal. Once the seam in a block had been worked out, a new pit had to be sunk in the next block. The northern section of the coalfield, being less faulted, was much easier to work.

The Erskine collieries had been active since 1519, [22] possibly starting in the most southern part of the estate where workings were closer to the river Forth, making it easier to export the coal. The rich seams of the Nine Foot Coal and the Alloa Cherry Coal outcropped in this area. However, the rocks were below the level of the river Forth and faulted into small blocks, making coal mining challenging. [23] A Map of the Alloa estate in 1710 shows an "*Old Coal Pit*" on the low lying land beside the river Black Devon in the vicinity of the present Pond Wood (NS896919). [24] The coal seams at this location were below the level of the tidal reaches of the river Forth and would have required some form of powered drainage.

The introduction of horse-powered gins offered the chance to work seams that required powered drainage, but were costly to run. An indication of the cost is found in the granting by King James VI on the 20th of May 1596 of a coal export licence to Sir Alexander Bruce of Airth on payment of £40. The reason given for the request for the licence was the high cost of keeping colliers (both men and women) and the loss of 3 to 4 score (60 – 80) horses "*working continually to keep his coalheuchs dry*". He also stated that he had borne a considerable cost in providing corn and straw for his horses. [25] Windmills were tried as a power source, but not found to be reliable when round-the-clock drainage was required. [26]

In 1625 the Scottish Parliament was considering an act to place a duty of forty eight shillings on a ton of coal which was exported. Following representation from the landowners on both sides of the Forth estuary, Parliament decided not to proceed with the imposition of the tax. One of the major concerns of the landowners was that "*thay wer at suche extraordinar chargis in the intertenying of thair watter workis that the whole cuntrey seale and dispatche of thair coale in a yeir will not interteny thair watter workis ane moneth and that thay ar not able to uphold thair workis without ane aboundant dispatche of thair coale by strangearis;*". [27] They stated that the cost of their colliery '*water works*' was so great that the whole year's sale of coal inland would not pay for one month's drainage and that they were entirely dependent on exports to keep their mines open. In addition to this export trade, there was a local market for "panwood" (i.e. small coals) in the salt pans springing up along the Forth estuary and this growing industrial market became a great encouragement to the development of coal mining. [28] The domestic demand for coal was still very limited and for another century peat remained in use as the main domestic fuel in most country districts. [29]

Figure 2. Horse powered winding gin.

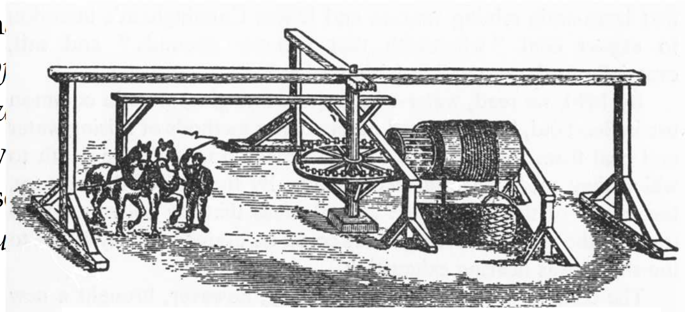
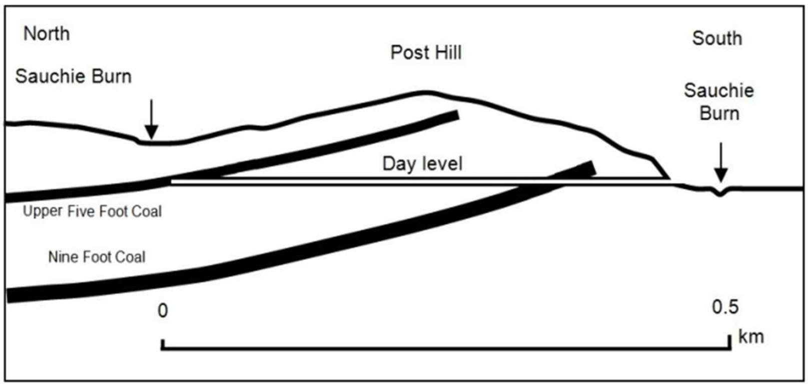


Illustration by Barrowman (1886)

In 1640 a draft royal letter ordained th *Earl of Mar's parks or meadows in the parish o Earl of Mar this will be the undoing of his ov* This gives some indication of the value w mines working. There is a record of a hors in the late 17th Century being *"cog and ru lanthorn pinion, as in the old corn mill"*, with exceeding 15 fathoms (30 metres). (31)

In contrast to the area close to the Forth, the area around Carsebridge and Holton was less affected by faults and had the advantage of being exposed in a valley side. (32) New pits were sunk in Alloa and Sauchie in 1603 (33) and there are accounts of the expense of working the coal mines in 1623 when the price of coal was six shillings and eight pence per chalder (£0.34 per one and a half tons). The Erskine Family papers indicate that *"the coals were wrought there previous to the year 1650 by a day level"*. (34) This involved working coals on a valley side by driving an upwardly inclined tunnel from the bottom of the valley to intersect the seam. The coal in the seam above this point could be kept dry by draining into the day level. Once the initial cost of driving was met, the level cost very little to maintain.

Figure 3. Carsebridge day level.



The day level was noted in 1841 as still being visible (35) and a later map of the Carsebridge area in 1853 shows its position [NS 85968 93705]. (36) This drainage tunnel would have enabled an area of the Upper Five Foot Coal to be worked. (37) Once that part of the seam above the day level had been worked out, some form of powered drainage would be required. This would also have allowed access to the Nine Foot Coal lying below the Upper Five Foot Coal.

By the mid-17th century, the Erskine coal mines were not doing well. A statement of the financial situation of the Mar estates in 1655 with a view to paying debts to the Earl of Callendar [Callander] notes that *"The Alloa coalworks have been unprofitable for 7 years on account of lack of colliers and absence of supervision by the Earl"*. (38) To compound these woes, the support of the 5th Earl of Mar for King Charles I led to considerable losses *"…. amounting to 402,000 merks, including a fine by Parliament, plundering of lands of Alloway [Alloa], his losses at Philliphaugh [Philiphaugh], loss on coal-works on account of tax on coal, damage to his houses at Braemarr [Braemar], Kildrimmie [Kildrummy] and Corgarff by English garrisons, removal of 40 horses from parks of Sterline [Stirling] and Alloway, and removal of 10 brass cannon from his house at Alloway"*. (39) The removal of horses at Alloa, reflects the concerns expressed in 1640 regarding the importance of horses for the coal workings.

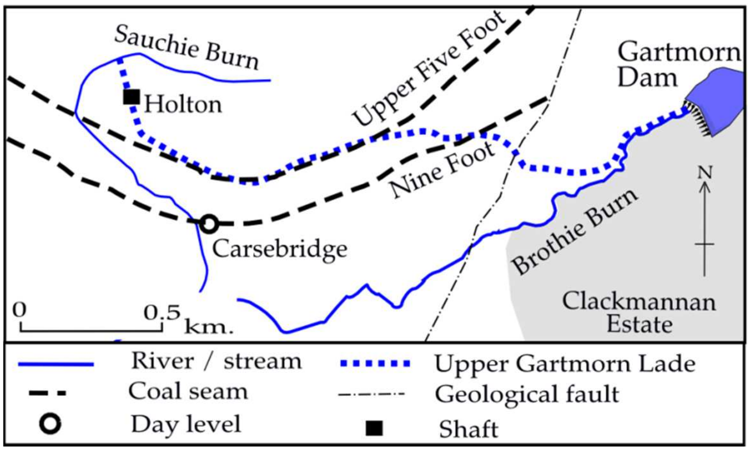
The 5th Earl's estates and titles were returned to him by Charles II upon the restoration of the monarchy in 1660 and there is evidence in the Erskine Family papers of the working of coals at Holton where, in 1661, *Walter Coult [Colt], was the smith at the coalheuch of Holtoun [Holton]*. Working coals from the Holton area would have required some form of powered drainage. (40) Sir Robert Bruce of Clackmannan was granted a 19 year patent for a mine drainage engine in 1646 (41) so mine draining technology was locally available. There is an estimate in the Erskine Family Papers of the cost of operating a horse gin for winding coal in 1735. (42) This put the cost of maintaining a horse for a year at £120 each, a man for a year at £95 with an additional cost of £300 *"To tear and wear of gins, horses, corves, horse shoes, etc."*. A horse gin driving a set of buckets and chains might need 16 or more horses to provide 24 hour drainage all year round with several teams of men to support them. This could come to some £3,000 a year for each gin. Little wonder that water power was considered a better option. Once a reliable supply of water had been obtained and brought to the site of the gin, running costs would be very much lower than using horse power.

The evidence suggests that the Erskine collieries had been working coal seams on the North bank of the river Black Devon, but these had been abandoned before the end of the 17th century. The same coal seams had been worked by David Bruce of Clackmannan at the close of the 17th century. He had used water drawn off from the river Black Devon at Linn Mill to power a water wheel to drain his pits (See the CFSS, Two Estates, Craigrie Lade report). Unfortunately, the Erskine estate had no such availability of water and would have had to rely on horse-powered drainage engines. Certainly, the 5th Earl of Mar was very protective of his horses, which he insisted were essential to the working of his coalmines. By the mid-17th century the Erksine family were working coals in the Carsebridge area and had established a day level to drain their workings, but they were still maintaining that they were dependent on the use of horses. In 1688, the 5th Earl of Mar wrote to the provost and bailies of Perth "*anent their employment of five of his colliers without advising him*". (43) In 1689, the 5th Earl died and John, 6th Earl of Mar, succeeded to the family estates. He found his property heavily encumbered due to the loyalties of his father and grandfather to the Stuarts and set out to retrieve the family fortunes. (44)

5. The introduction of water powered drainage:

In the latter part of the 17th century two lade systems were built to supply water to power mine drainage engines on the Clackmannan and Alloa estates respectively. The Clackmannan (Craigrie) lade was built first, fed directly from the River Black Devon at Linn Mill [NS255092898]. (45) It had an additional supply from the Garrison or Tullygarth Dam [NS9310892576]. The lade initially took water to a drainage engine to the South of Clackmannan Tower [9043591505]. (46) It went on to power another mine drainage engine, (47) a waulk mill (48) and a distillery. (49) The Craigrie lade was abandoned as a source of water power by the mid-19th century and was refurbished in 1865 by the Earl of Zetland, the local landowner, to provide a water supply for the town of Clackmannan. 50) This served the inhabitants until a supply from Gartmorn Dam replaced it in 1893. (51)

Figure 4. Gartmorn Dam and the Upper lade:



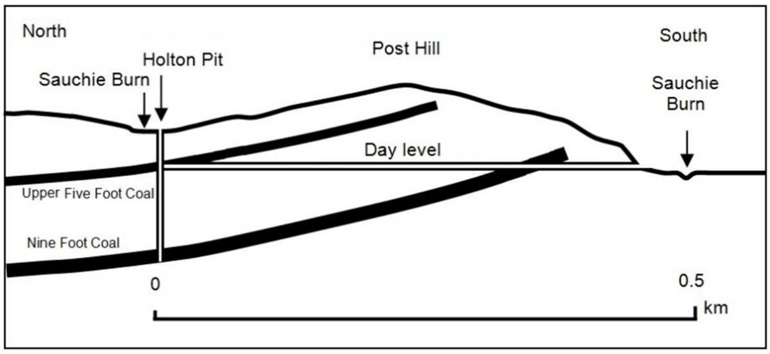
The Gartmorn system was begun at the close of the 17th century and was grander in scale. It started off as a small lade fed from an earthen dam across the Brothie Burn at the western end of Gartmorn Loch taking a supply of water to the Holton pit. (52)

Figure 5. The Brothie Burn above Gartmorn Loch.

A map by John Adair dated 1681 shows a small loch at Gartmorn with the Brothie Burn draining from it towards Alloa. (53) The Brothie Burn had only a small catchment area and, as a result, had only a small volume of water. The small marshy hollow of Gartmorn Loch offered the potential to store water from the upper reaches of the burn and make it available in times of reduced flow.

The earthen dam considerably increased the volume of water which could be stored there. A witness statement given by a local man in 1735 indicated that the dam and the first water powered engine at Holton was built "*45 to 46 years ago*", dating these first constructions to c. 1690, which would have been by John, the 6th Earl of Mar. (54)

Figure 6. Day level and the Holton drainage shaft.



A lade (the Upper Gartmorn Lade) then carried water from the dam to a drainage engine at the Alloa colliery in Holton [NS 894940]. The dam was repaired in 1694 by the 6th Earl (55) and was perhaps extended in height. (56)

Water was carried to the town of Alloa and Alloa Harbour by the Sauchie Burn and then the Brothie Burn. The Brothie Burn carried the water through the town of Alloa to the pleasure gardens of Alloa House and was then collected in a dam at the harbour [NS 885919], where it was released at low tide to clear the harbour of silt. (57)

In 1705 the 6th Earl of Mar wrote to the Duke of Hamilton, explaining that he has been "*too busy at Alloa to wait on his Grace, since his colliers are all idle for want of water to work their mill and he is arranging for them to work a water-lead to his dam instead*". (58) This suggests that the supply of water from Gartmorn Loch was by then not reliable enough to provide for the all-year-round drainage required to keep the coal workings at Holton dry. This was a major problem, as the Holton engine gave access to a large area of the Nine Foot Coal.

In 1705 the Earl of Mar became Secretary of State for Scotland (1705-1709) and later became a member of the British Privy Council (1707-1714) [59]. In 1707 William Hutton was reporting on improvements to Alloa House and was commissioned to act as "*overseer of the coal works of Alloa*". [60] Hutton was to play a key role in the future development of the estate coalmines. In 1707 George (Baillie) Erskine, the Earl of Mar's estate factor, consulted William Robertson of Gladney regarding the drainage of the Alloa Colliery. [61] Gladney had previously advised the Buccleuch estate on the state of the unworked portion of their Sheriffhall coalfield in Midlothian and whether it could be drained and made workable. [62] Unfortunately, we have not been able to find any reference to the advice given, only a reference to the fact that William Hutton, the colliery manager, did not agree with it. [63]

In 1708 the Earl of Mar married the wealthy Lady Frances Pierrepont, daughter of the Duke of Kingston-upon-Hull. [64] At this time the Earl of Mar was considering the problem of drainage at Holton and looking to improve the supply of water to his pits. He had the height of the earthen dam at Gartmorn raised, writing to his brother, Lord Grange, regarding his "n*ew dam dyke*" at Gartmorn. [65] He was concerned that Mr. Inglis (or Inglis), co-owner of the Clackmannan Estate, had questioned the building of part of the new dam on the Clackmannan estate and claimed that the new dam "*drowns eight acres of ground to them more as the old one did*."

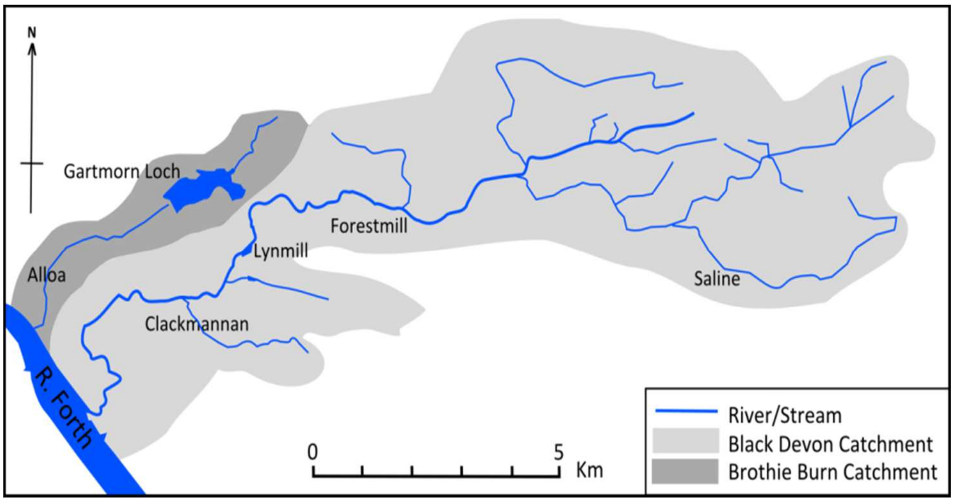
In a letter dated 1708 to Colonel John Erskine, Deputy Governor of Stirling Castle, London, William Hutton, colliery manager at Alloa, wished to know if he can '*enter upon the setting down of the New-miln-sink, and make it of such dimensions (notwithstanding of Gladney's proposals) as may with ease admit of two Chains and a Gin to go in it*', as he has had no directions from the Earl of Mar. [66]

The Earl of Mar, not being able to find sufficient expertise in Scotland to help him solve the problem of draining his colliery, sent his colliery manager to Newcastle in 1709 to examine the methods used there to drain the mines and to return with drawings of the machinery required. His manager reported water wheels and horse gins driving chain pumps, the depths of pits commonly being 20 to 30 fathoms (37 – 55 metres). He reported that horse gins were expensive and only worked in shallow pits. [67] If the colliery was to continue working, a more reliable source of power was needed.

6. The development of the Forestmill lade:

In 1710 the Earl engaged Mr. George Sorocauld, an engineer from Derby. He visited Alloa for several days and, for a fee of £50, advised the construction of a series of pumps driven by a water-wheel. [68] Fortunately, the Mar estate included land at Forestmill where, in 1368, Robert Erskine had been granted the "*mills and multures*" in the lands of Alloa and Forestmill [69] and Sorocauld surveyed a line for a new lade from there to Gartmorn loch. Here the water from the river Black Devon would be fed into the extended loch held back by the existing earthen dam. Levels for the lade were taken using "..*a large wooden quadrant, set upon a tripod with brass lights, along the upper radius, the index being a plummet suspended by a fine thread*." [70] A small boy carried a bucket of water into which the plummet was submerged. This helped to prevent the plummet swaying if there was a wind blowing. Despite the simplicity of the equipment, the line of the lade maintains a slow drop in level all the way to the point where it crosses into the catchment of the Brothie Burn. Beyond this, it drops down more steeply into Gartmorn dam.

Figure 7. Brothie Burn and Black Devon catchment areas.



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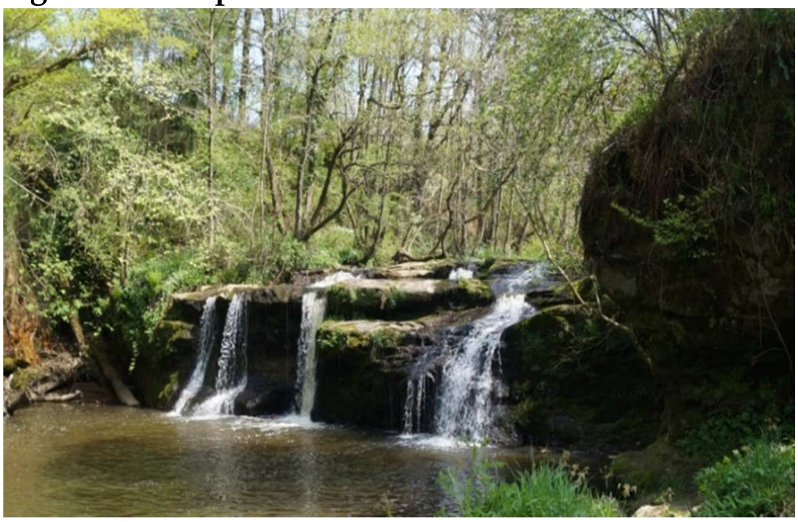
The river Black Devon rises in the western area of the Saline Hills and has a much more extensive catchment area than the Brothie Burn. Although it had a much larger catchment area, it was still prone to running short of water during the summer. (71) In order to ensure there was no interruption to supplies of water, storage dams had to be constructed. The Craigrie lade had the corn mill dam at Lynmill (Linn Mill) [NS9262693006] and a dam at Tulligarth [NS9310892576] to provide storage facilities. (72)

Figure 8. Nick point at Linn Mill.



The river Black Devon cut a gorge section from the Mary Bridge at Clackmannan [NS 90849 92302] to Linn Mill [NS NS255092898]. Here the river crossed beds of resistant sandstone creating a nick point. The course of the river drops some five metres giving the potential for water power. A corn mill was constructed here by the mid-14th century. (73)

The gorge of the river Black Devon continued upstream to Forestmill [NS 95437 93823], where there was a second nick point. The waterfall here is no longer visible as it has been built over by the Forestmill weir, but an outcrop of sandstone is visible underneath the base of the weir.

Figure 9. Traces of the corn mill.

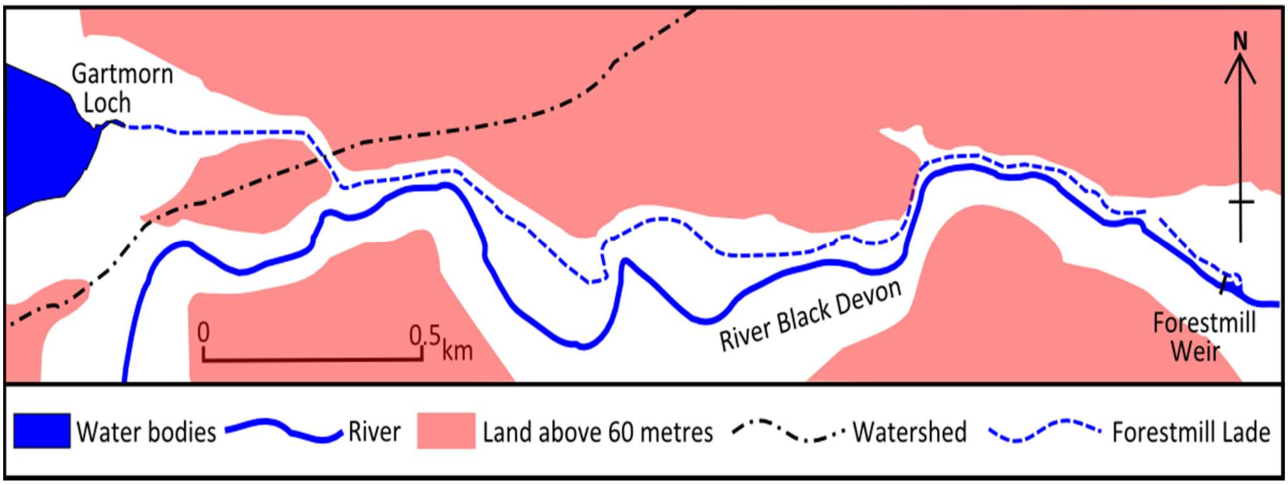
There had been a water powered corn mill at Forestmill since at least the middle of the 14th century. (74) The mill is long gone, but it was shown on the First Edition Ordnance Survey of the area [NS 995297 93947] and there are still traces of the tailrace which returned the water from the mill to the river Black Devon (small ditch on the right.

Sorocauld's planned route for the lade started from the site of the dam for the corn mill at Forestmill. (75) It used the route of the old corn mill lade and then contoured 3.02 kilometres down the northern side of the gorge of the river Black Devon before crossing into the catchment area of the Brothie Burn and flowing into Gartmorn Loch.

Figure 10. Valley across the watershed.

There is a point where the river Black Devon approaches extremely close to the watershed between itself and the Brothie Burn. At this point the watershed is breached by a slight valley, offering an easier route across the ridge. A very short stream flowed out of one end of this valley into Gartmorn Loch. An even shorter stream flowed out of the other end, dropping into the gorge of the river Black Devon. Sorocauld's proposed route utilised this valley, enabling the watershed to be crossed using a shallower cutting.

Figure 11. Sorocauld's route for the Forestmill lade.



Based on information from OS OpenData.

In 1710 the 6th earl entered into discussions with Colonel Dalrymple and Mr Inglis (Ingles), the owners of the Clackmannan estate, to take water from the river Black Devon at Forestmill to Gartmorn Dam (76). Agreement was reached in principle with Dalrymple and Inglis (77), but discussions continued regarding the inclusion of a water gauge into the "*trows*" (trough) at Lynmiln (Linn Mill) on the Clackmannan estate's lade, ensuring the supply of water to their mine drainage engine. (78) A water gauge consisted of a metal plate with a rectangular section cut out of the top. If the flow of water through the trough did not fill the section cut out of the plate, then the sluice on the lade at the weir at Forestmill needed to be lowered to let more water flow over the weir and into the lower reaches of the river Black Devon.

The sticking point in their agreement appeared to be that Dalrymple and Inglis wanted sufficient water to power their existing mine drainage wheel and more water for a future wheel. In addition, they were looking for the Earl's permission to establish a new harbour and town at Clackmannan Pow and straighten out the river Black Devon where it enters the river Forth. (79)

In 1711 the 6th Earl concluded an agreement with Sir John Schaw of Sauchie for a wayleave across his land and correspondence between William Hutton, the Alloa Colliery mine manager, and the Earl of Mar indicates that the Forestmill lade was started sometime in 1711 and was dug from Forestmill, westwards towards Gartmorn dam. (80) A later piece of work was undertaken at Aitkenhead [NS 94713 94056] where a stream was conducted beneath the lade. (81

Figure 12. Lade at Forestmill Farm.

A partial cutting was made, with the material excavated from the cutting being used to form an upcast bank on the downslope side. In terms of the amount of excavation required, this method of construction was efficient, but it led to the river side of the lade being weaker.

The first section of the lade was cut into glacial clay covering the sandstone bedrock in this area. The clay made the basis for a watertight base and sides to the lade. These would have been "puddled" by walking or stamping down on the clay to consolidate it, by removing all the air.

Figure 13. Section through the lade.

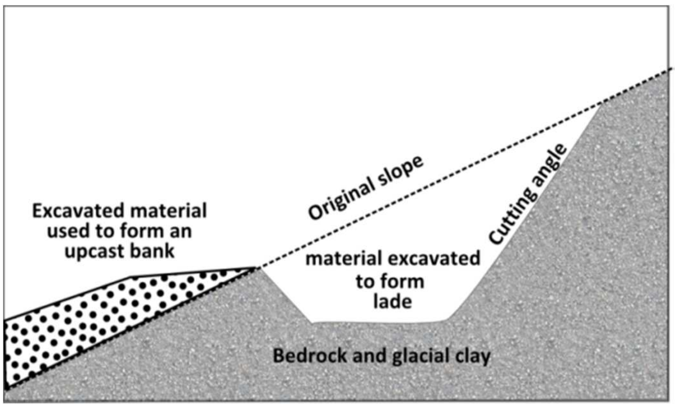


Figure 14. Contouring along the gorge.

The lade contoured round the northern edge of the gorge of the river Black Devon. As the lade maintained its level, the height difference between the lade and the river gradually increased.

Figure 15. Section cut into sandstone.

In a number of places sections had to be cut into the sandstone bedrock. A similar construction technique was used, forming an embankment on the downslope edge of the lade. The use of the local glacial clay provided a means of ensuring that floor and sides of the lade were watertight.

A disagreement arose in late 1711 between the Earl of Mar and Colonel Dalrymple and Mr. Inglis, the owners of the Clackmannan estate, regarding the ownership of the piece of land where the small valley enabled the lade to be carried over the watershed. This started when the tenants of Gartenkeir farm complained that the tenants of Birkhillend farm had removed oak timbers cleared in the construction of the lade. (82)

The matter was referred to Mr Andrew Dickie, Baron Baillif of Clackmannan, who communicated to William Patton, the Grieve of the Clackmannan estate and the tenants of Birkhillend farm, forbidding them remove timber. (83) A counter claim was then made that the lade was, at this point, being built on land owned by the Clackmannan estate. By early January 1712, work in this area had ground to a halt. (84)

The claim related to the location of the marches between the two estates. Difficulty was experienced in finding individuals who knew the exact line of the marches and who lived in the parish of Clackmannan, as the Baron Baillif did not have the power to cite people living outwith the parish. (85) Tensions mounted as the Earl of Mar, Colonel Dalrymple and Mr. Inglis were regularly away on business. On top of this, relations worsened between William Patton, grieve of the Clackmannan estate, and William Hutton, manager of the Alloa Colliery. (86) Matters became even more critical when, in early March 1712, work began on the sinking of the new shaft at Holton. (87) William Hutton informed the Earl of Mar that "*The dam water being all spent both the milns came to be set on Sabath last which is a great loss considering the length we were come to in drawing the five foot coal*." (88) It would appear that the lade from Gartmorn was being used to power two mine drainage engines, the most recent one installed to work a new area of the Upper Five Foot Coal. Even in the Spring there was not enough water in the dam to provide a supply for the two mine drainage engines.

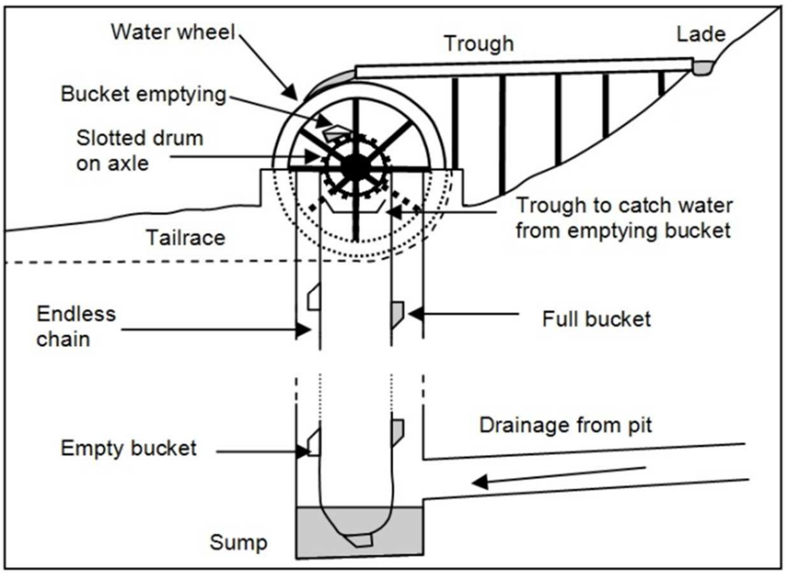
Although desiring a fair bargain, the Earl of Mar was reluctant to upset Colonel Dalrymple and Mr Inglis. The Brothie Burn is the boundary between the Alloa and Clackmannan estates, so at least half of the dam at Gartmorn was built on the Clackmannan estate. In 1712 the 6th Earl of Mar expressed concern about this in a letter to his brother, Lord Grange. (89) This suggests that the dam had been built without a formal agreement from the former Clackmannan estate owner, David Bruce. The Earl was worried in case Mr Inglis insisted the dam be pulled down. In addition, the Earl was in discussion with Colonel Dalrymple regarding the possibility of purchasing the Clackmannan estate, using funds released by cashing in his life pension granted by Queen Anne. It appears that Colonel Dalrymple was sympathetic to the proposal but the Earl doubted that Mr Inglis would agree to it. (90)

By September, 1712 the Earl of Mar had agreed to more water being supplied to the Clackmannan estate from the river Black Devon but the argument over the ownership of land at the critical point on the watershed continued. In a letter to Sir John Schaw, the owner of the Sauchie estate, the Earl's brother, Lord Grange, informed Sir John that *"I had hoped that after this my brother would not have been any more troubled with Mr Inglis's pretences, as if that water was to be carried through any part of Clackmannan ground, the Clackmannan people are to protest against my brother's servants, alleging that the piece of land belongs to them & not to you*." He also indicated that William Patton, the grieve of the Clackmannan estate, was also the tenant of Gartenkier farm on the Sauchie estate (91)

Although there is no evidence as to how the dispute was settled, by the end of the year a formal agreement was made between the Earl of Mar and Colonel Dalrymple that a flow of water was to be maintained in the river Black Devon downstream of the new weir at Forestmill to enable "*Cleansing the Pow at Clackmannan, the Coalworks at Clackmannan, the cornmills of Clackmannan and Lynmiln and the cornmills of Forrest and Parkmiln.*" The volume of water was to be checked by a cast iron gauge "*inserted in the spouts of the trows immediately below the cornmiln dam at Lynmiln*." (92) The desk-based research and fieldwork on the Craigrie Lade project confirmed the location of this section of "trows" on the Craigrie lade [NS 925928].

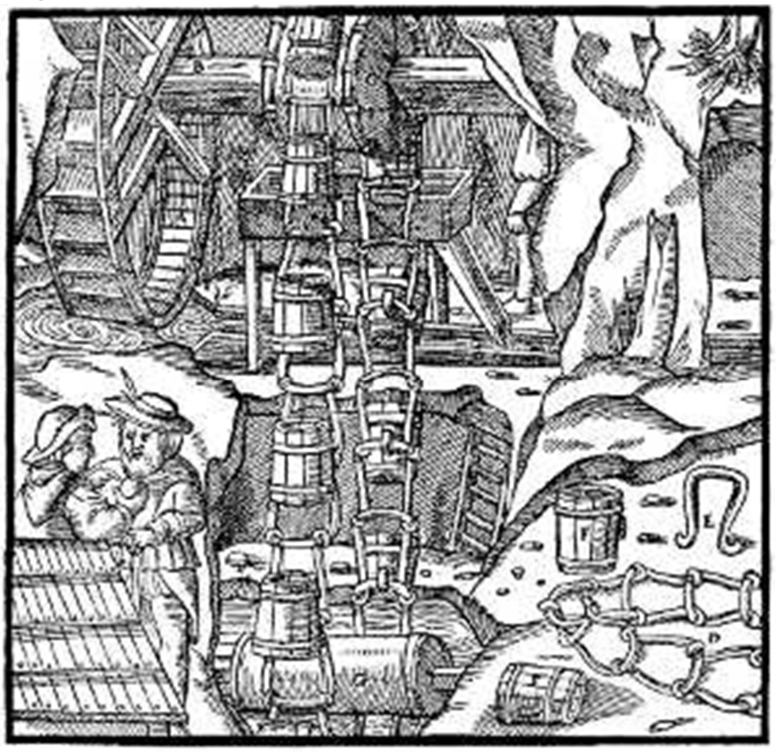
Despite all these difficulties, between 1710 and 1713 a new 16 foot weir was constructed at Forestmill (93) and a lade was constructed from Forestmill to Gartmorn Loch, crossing through the catchment between the Brothie Burn and the river Black Devon. The flow of water from the River Black Devon, together with the extended storage capacity of the Gartmorn Dam, provided the Alloa estate with a substantial and reliable source of water for their colliery drainage engines. In 1713 a new earthen dam was built at Gartmorn, making Gartmorn Loch the largest artificial body of water in Scotland at this time. (94) and (95) The Upper Gartmorn lade, from the dam to Holton, was enlarged. (96)

Figure 16. Water powered bucket and chain gin:



Sorocauld had advised the installation of pumps in the new drainage shaft, but the Earl could not find anyone skilled enough to build them. Instead, he had a new bucket and chain gin installed. (97) A description of a gin and wheel at Holton is given in the New Statistical Account of Alloa " *… a water wheel, with its axle cross the pit mouth; over this* (axle*) were several tiers of endless pudding link chains of iron, and when the water was scarce* (in the lade) *then comparatively few buckets were attached to the chains*". The shaft at "*Hultone*" went down forty fathoms (73 metres) to intersect and drain the seam known as the Nine Foot Coal which underlies Keilarsbrae, Post Hill and Holton. (98)

Figure 17. De Re Metallica:



The description of the water-powered gin bears a striking similarity to the illustration in the 16th century De Re Metallica – a mining guide written by Georgius Agricola and published in German in 1548 in Saxony and later, in 1556, a Latin version was published. (99) This illustration shows a waterwheel with an endless chain over the axle. The chain supports wooden buckets going down a shaft into a sump at the base of the mine. Filled buckets travel up and are emptied into a trough running into the tailrace of the water wheel.

Chain pumps, however, were expensive to install and maintain. Robert Bald, mining engineer, wrote in 1815 that "*The chains for a pit of 80 yards deep cost £160 and, if a bolt gave way, the whole set fell to the bottom and broke every wooden bucket. They were also inefficient as, although each bucket was full of water as it was lifted from the pit bottom, none of them were more than half full at the discharging point near the axle tree, owing to the leakage of the joints and the vibration of the chains.*" (100)

Unfortunately, the 6th Earl of Mar supported the Jacobite cause and, following the failure of the 1715 rebellion, went into exile on the Continent with his wife and children and spent his remaining years abroad (101). Although the estate was forfeited to the Crown, the 6th Earl kept in touch with his family, making numerous suggestions as to its improvement. The Alloa estate was forfeited by the Crown and managed by the Commissioners for Forfeited Estates from 1716-1724. During this time there were no substantial improvements to the colliery, in fact, the output of coal fell dramatically (102) although William Hutton continued to manage the Alloa colliery. (103) and (104)

7. The estate is purchased back by the Erskine Family:

In 1724 Lord Grange (James Erskine, the 6th Earl of Mar's brother) and David Erskine of Dun bought back the estate for the family from the Forfeited Estates Commission (105) and managed it. (106) In 1728 Thomas Erskine, son of the 6th Earl of Mar, was brought home to Scotland from France by his uncle Lord Grange. (107) Lord Grange, David Erskine and Lord Thomas Erskine then managed the estate jointly. In 1735 the estate was still being managed by Thomas, Lord Erskine; James Erskine of Grange and David Erskine of Dun; who were listed as the joint proprietors of the barony of Alloa. (108)

A memorandum was submitted in that year to "*Lord Erskine*" regarding the refurbishment of an old shaft called "*Dickie's Sink*" (109) [See Appendix 1]. The memorandum gives a great deal of detail about the possible refurbishment of the pit, the lade and tailrace, the dimensions of a waterwheel, pumps, water pipes and the partition of the shaft into a pumping shaft and a "*Day stair*" for bringing the coal to the surface. From the specification and comments it is clear that this was proposed to be a shallow pit with a shaft providing both drainage and access. A wooden partition would separate the space occupied by the pump rods and pipes from a "*Day stair*". This stair would allow the coal to be brought up to the surface by bearers, which the memorandum suggests would easier and much more profitable than the use of a horse gin - "*when the coalyers are freed from the circumstances of a gin and brought to ane easier working coall, and easier bearing of it by the farr ebber sinks*." The shaft would access an area of coal which would be easier to work and had much shallower access. Lord Erskine would be spared the expense of operating a horse gin "*because there would be no need of a gin for drawing up the coall of this drift*" and the colliers (and their families) would be able to extract more coal.

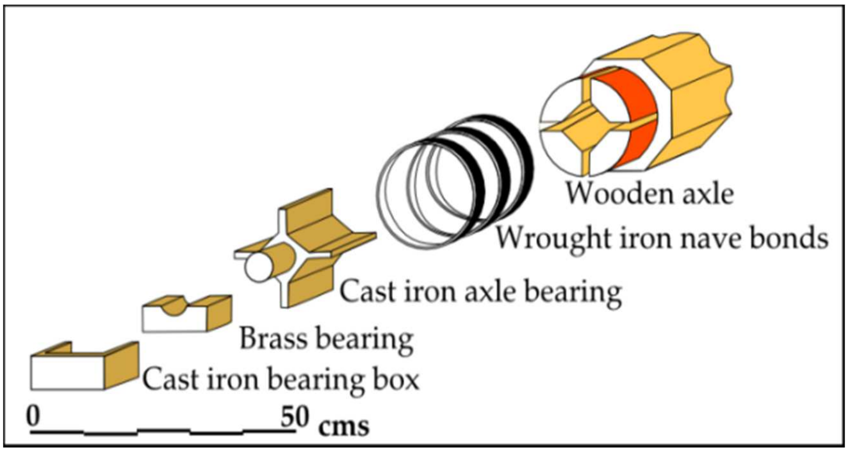
The author goes on to detail the savings of not having a horse gin as:

To 8 horses maintenance at £120 each	*£960.-.-*	
To 10 men at 52 weeks at £18.08.00 weekly is	*£956.16.-*	
To a rope for each of the two gins in a year	*£200.-.-*	
To tear and wear of gins, horses, corves, horse shoes, etc.	*£300.-.-*	*£2416.16.-*

It is also suggested the colliers would be able to bring more coal out of the pit each year: "*It is reasonably to be supposed that each coalyer would be able to work out 29 chalders more of great coals in the year at Dickies' sink than by the gins. Indeed for 36 coalyers 720 chas: at 54 pence free upon the cha: is £1,944.-.-*". These combined savings and extra income would, it is suggested, add up to more than £3,500 extra income for the estate each year. This would have been an extremely attractive proposition for the proprietors of the estate.

The shaft would also provide drainage adjacent to an area of old workings which was a concern to the author of the memorandum. This related to the possibility of a volume of water from the old workings reaching the current workings and overpowering the present drainage gin. "*But there is a current report, and next to a certainty, that there is either hand of us, a good dale of open coall, which when come at, would in all humane probability let through such a quantity of water from the old weast as to drown the machine for all intents and purposes, if the heal quantity of water is not taken out of the old weast as is proposed by the new machine at Dickies' sink.*" The costed list of components for the refurbishment of the shaft and the construction of the waterwheel, pumps and pipes, etc. is extremely detailed. The old "*Dickie's Sink*" would be cleared out to a depth of 10 fathoms (18.3 metres) and a frame built at the base. Some 34 square yards (28 square metres) of sandstone would be quarried, shaped and carted to the shaft top to make a surround. The Waterwheel would have a wooden frame, would be 18 feet (5.49 metres) in diameter, 32 inches (81.3 cms) wide and supported by an axle five feet long (152 cms) and 14 or 15 inches (35.6 to 38.1 cms) square. The wheel would be composed of a substantial axle, with arms connecting to a supporting ring. A shroud (vertical walls) and sole (floor) would form the buckets of the waterwheel. All of these components would be made of wood. There is a reference to "*covering ye wheel from ye weather*".

Figure 18. Axle and bearing from Linn Mill:

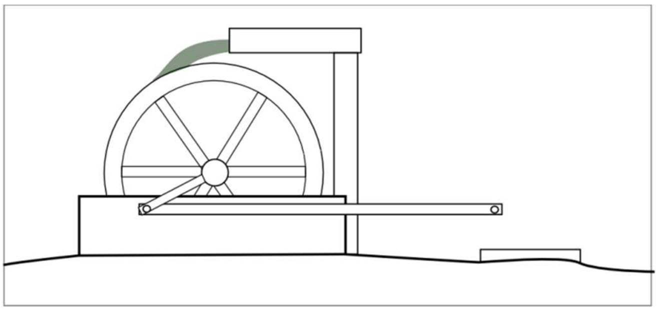


The Clackmannanshire Field Studies Society undertook a survey of the ruined waterwheel pit of the old corn mill at Linn Mill in 1974 [NS 92581 92995]. (110) A similar wooden axle was found there, with a cast iron axle bearing set into the end of the wooden axle.

It is likely that small wooden wedges were inserted between the slots in the wooden axle and the arms of the axle bearing to secure it in place. There were three wrought iron nave bonds which had been used to secure the end of the wooden axle. This axle design was common at the time.

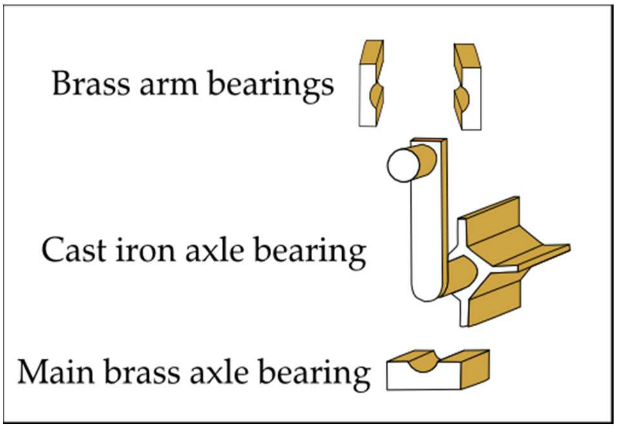
The wheel proposed at "Dickie's Sink" might well have had this type of arrangement, with the simple cylindrical end bearing being replaced by one with a two foot long arm with a smaller circular bearing on the end. There are two separate references to "*arms* "in the memorandum. The first refers to "*20 double trees for arms*" and the second "*30 ten foot deals for arms*". It is possible that one of these references relates to the actual arms of the water wheel, while the other relates to the beams which would be needed to connect the cranks to the top of the pump rods.

Figure 19. Clackmannan drainage engine:



There is an illustration of a similar engine with cranks driving beams on either side of a water wheel at the Clackmannan Craigrie pit in 1775. (111) The waterwheel is fed from a trough connected to a siphon. Here, the wooden beam is lying close to the ground. The two, heavy wooden beams would provide a degree of equilibrium to the system, balancing the weight of the pump rods and giving an on-going degree of momentum when combined with the mass of the rotating waterwheel.

Figure 20. Dickie's Sink bearing:



From the description in the memorandum, two iron cranks with two feet long arms would be connected to the axle, their journals sitting in large brass bearings. Smaller bearings would connect the arms of the cranks to the drive beams. Each rotation of the wheel would move the crank through a circle two feet (61 cms) in diameter, moving the end of the driving beam up and down some four feet (1.22 metres).

The pump rods were made from "Double Trees". As 12 of them were required for two sets in a 10 fathom (18.29 metres) deep shaft, it is estimated that a double tree would be roughly 10 feet (3.0 metres) long. The rods would be held together by iron plates and screw nails and plates (washers?) and connected to the pumps and cranks by iron joints. As the cranks were two feet (61 cms) long, they would describe a circle roughly four feet (1.22 metres) in diameter giving a four foot (1.22 metre) stroke at the pump.

The pumps were formed from two iron barrels six feet (1.83 metres) in length and with an eight inch (20.3 cms) diameter bore. The barrels would be fitted with iron "*buckets and clacks*" (valves) to prevent the pumped water from coming back down the column of pipes. Each revolution of the wheel would move approximately one and a half cubic feet (0.04 cubic metres) of water, some six gallons (27.28 litres), into the pipes. If running at a speed of 2 rpm (revolutions per minute), this could lift some 12 gallons (54.56 litres) a minute or over 17,000 gallons (77,524 litres or 77.52 cubic metres a day).

The wooden pipes were of eight and a quarter inch (21 cms) bore, hooped, bored and jointed. The joints would be of a spigot and faucet design, still a common way of joining pipes today. This description is given of similar pipes installed in the Erskine's Collyland colliery in 1764: "*...made from plane trees, having a hole bored up their centres, fitted with iron hoops and having spigot and faucet joints*". (112) The spigot (male) end was slightly narrowed to fit into the faucet (female) end which was slightly enlarged. The ends would be encircled with an iron hoop to strengthen them.

There was a description of installing the pipes. Firstly, substantial wooden beams (*needles*) would be installed at intervals in the shaft. The pipes would be lowered using capstans and a windlass. The first pipe would be set on a substantial scaffold across the shaft. The remaining pipes would be lowered, fitted together with "*chalk and cloath*" and supported by iron fittings (*dogs)* to the beams. All the pipes would be lowered "*till they are sett upon the bottom of the sink where the dogs are to be relieved"* and the weight of the pipes pressing down on each other and the cloth and chalk seal would act to seal them together. The ends of the pipes would need to be hooped to prevent splitting. Interestingly, the pumps in the shaft were force pumps, which was quite uncommon due to the pressure of water which built up in the wooden pipe. The shallow depth of the shaft, together with the method of using the weight of the whole column of pipes to create a tight joint, allowed this system to work. In all, it was calculated that there would be needed: "*4 st: Garron nails at 4 merks per st: and 10,000 double and 10,000 single nails for doing the hale work*".

It was indicated in the memorandum that the shaft would be 10 fathoms (18.29 metres) deep and require 90 feet (27.43 metres) of "*trows*" (a trough to carry water from the lade to the wheel). This meant that the pit shaft was shallow and not far from the contour line of the lade. There is no contemporary evidence that this shaft was improved and these pumps were installed at this time. However, a map of '*Carsebridge and Adjoining Area*' in 1853 [(113)] shows a pit marked "*Old Pumpmill Pit*" [NS 89456 93919) which the Geological Survey map [(114)] shows lies 10 fathoms (18.28 metres) above the Nine Foot Coal and is located approximately 28 metres away from the contour line of the Upper Gartmorn lade. This pit is a good candidate for the site of "*Dickies' Sink*". In the same year (1735) Lord Thomas Erskine extended and raised the height of the dam head at Gartmorn by two to three feet (0.6 to 0.9 metres). This flooded the margins of the previous Gartmorn Loch and made a road along the northern edge of the dam impassable. [(115)] A legal complaint was issued by the Schaw family, owners of the Sauchie estate, seeking compensation for the land lost. [(116)] The dispute was settled when Lord Thomas Erskine exchanged the farm of Gartmorn, except the island in Gartmorn Loch, in compensation for the land lost. [(117) and (118)]

8. The Alloa estate is managed by Thomas Erskine:

The estate was finally handed over to Lord Thomas Erskine in 1739. [(119)] He immediately continued with improvements, constructing a water-powered winding engine to hoist coal. [(120)] We have no contemporary description, but Robert Bald refers to it in his publication "*A General View of the Coal Trade of Scotland*," and records the description of a later version, commenting that the design had remained unchanged. [(121)] A detailed description of this machine is given on page 21. Unfortunately, we have not been able to identify the location of this engine.

The next development was construction of the Watermill pit circa 1760. [(122)] Water came from the Upper Gartmorn Lade just before it entered into the Keilarsbrae mill [NS 89602 93849]. It ran into a vertical cast iron pipe [NS 89588 93819]. This acted as a siphon, carrying the water down under the Sauchie Burn and up to a trough which fed the water to a 30 foot (9.14 metres) overshot water wheel with three feet (91.4 cms) wide buckets and three foot (91.4 cms) cranks. These cranks connected to two wooden beams on a stone pillar which were linked to pump rods in the pit shaft. As each beam lowered the pump rod in the shaft, a series of 10 inch (25.4 cm) diameter cast iron lift pumps, at about 30 foot (9.14 metres) intervals, lifted the water from the colliery sump and added it to the lade. A similar system was in operation at the Collyland colliery where a steam engine supplied the power and the pipes were "*...made from plane trees, having a hole bored up their centres, fitted with iron hoops and having spigot and faucet joints*". It is interesting that the pumps proposed at Dickie's pit in 1735 were force pumps with wooden pipes.

The change to lift pumps for this deeper shaft at the Watermill pit in 1760 is indicative of the lack of pipes at this time capable of coping with the pressure of this extra height of water. The Second Statistical Account refers to the Carsebridge Colliery being started at this time and indicates that this shaft drained the Upper Five Foot Coal at a depth of 50 fathoms (91 metres). However, a check with the Geological Survey map of the area shows that it must have been the Lower Five Foot Coal (also known as the Alloa Cherry Coal). The First Statistical Account notes that the Alloa Cherry coal and the Alloa Splint coal were begun working about 1760 (123) when the Nine Foot Coal was worked out. (124)

Each column was worked by one of the pump rods, the "pump stroke" being the down stroke of the pump rod so that the weight of the rod was used to lift the water out of the workings. Although each pump rod weighed several tons, the beams were arranged so that the two pump rods were counterbalanced. With three foot (91.4 cms) cranks giving a six foot (182.8 cms) stroke on the pumps, at a speed of 2 rpm this would raise some 45 gallons (204,57 litres) a minute. During the course of a day this would pump some 64,000 gallons (290,949.76 litres or 291 cubic metres) of water out of the pit. This is more than three times the amount of water lifted by the first pump proposed in 1735.

This waterwheel, with cranks and beams working pumps was very efficient and cost effective. Robert Bald noted in 1814 that *"….This machine is the most simple of all the hydraulic engines, it remains in common use to the present day. It is so easily kept in repair, that any colliery which is drained by it, is nearly on a footing with a level free colliery,"*. (125) The top of the Watermill pit siphon is shown on the First Edition of the 25 inch Ordnance Survey map (126) at the end of a short extension of the Upper Gartmorn lade just before it enters the Keilarsbrae mill [NS 89588 93818]. The Watermill Pit is shown on the same map [NS 89473 9370].

9. The Alloa estate is managed by John Francis Erskine:

Thomas, Lord Erskine, died without heirs in 1766 and the estate passed to John Francis Erskine, son of Thomas's half-sister Lady Frances Erskine (1716 -1776) who had married her cousin James Erskine, son of Lord Grange, in 1740. (127) In November 1770, Alexander Thomson, Overseer of the Alloa Coal Works at Alloa and Coallyland (Collyland) wrote a memorandum which indicated that "*Agreeable to instructions I have begun to sett down a new pitt for the water gin for drawing coals with the addition of 90 fathoms* (164 metres) *of new water pipes for the said engine. It will be necessary to come forward the waggon road to the new pitt and to put on a new bridge to the Glasshouse pitt for a waggon road to that pitt. The engine at Alloa colliery will soon need a new wheel notwithstanding all the repairs that were gote lately. It will also be needful to make some repairs soon on the Gartmorn Dam."* (128) By 1770 it would appear that many, if not all of the engines and the Gartmorn dam were in need of repair or replacement. This memorandum referring to a new winding engine confirms that there were two separate pits served by water-powered winding engines. The first was constructed in 1739 under Thomas, Lord Erskine's management and the second in 1770 under the management of John Francis Erskine. We have not been able to identify the site of the first winding engine pit. However, the First Statistical Account of Alloa notes in 1796 that "*A lint mill has, within these few years, been built, just before the water is conveyed into pipes for forcing it up, to the engine for raising the water out of the coal pits, and to another for drawing up the coals*." [129] This description of the location of the water supply for these two engines places the winding engine at or close to the Watermill Pit site.

A description of the second winding engine is given by the author of the Second Statistical Account [130] and by Robert Bald in his publication "A General View of the Coal Trade of Scotland". [131] So that the drum could be worked in both directions the 18 foot diameter water wheel was divided into two sets of buckets facing in opposite directions. Valves in a trough above the wheel directed the flow of water into either set of buckets or closed off altogether. A length of rope was wound several times round the axle and the ends adjusted so that when one end was at the base of the shaft the other was at the surface. A wooden bucket was then attached to each end of the rope. When the bucket at the bottom of the shaft was filled with some 6 cwt of coal, the appropriate valve was opened and the wheel turned to wind up the full bucket while the empty bucket, acting as a counter balance, travelled down. This winding engine was so efficient and so cheap to run that the managers of several English collieries paid visits to the Alloa colliery to study its construction and mode of operation with a view to introducing it into their own workings. Mr Brown, engineer and coalmaster from Newcastle was so impressed when he visited in 1774 that he took a drawing of it to construct one to drain deep pits in Newcastle. [132] There is an illustration of a winding engine matching this description in 'A Glossary of Scotch Mining Terms' by J Barrowman in 1886. [133]

The similarity between the description of the Alloa machine and the illustration by Barrowman is even more striking when both are compared to the illustration of a water-powered winding engine by Georgius Agricola in De Re Metallica in 1556. [134]

Figure 21. Water-powered winding gins:

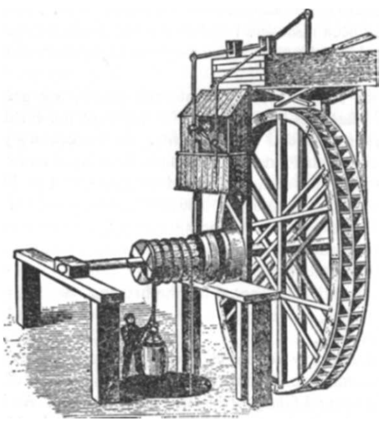


Illustration by Barrowman (1886)

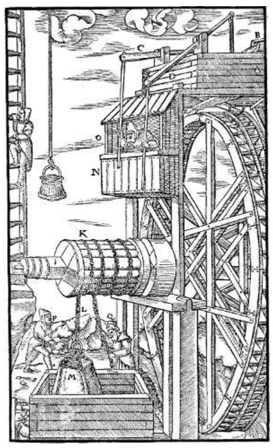


Illustration by Agricola (1556)

The similarity between the descriptions of the bucket and chain gin and the winding engine at Alloa with those in De Re Metallica suggests that the Erskine family might have had access to De Re Metallica.

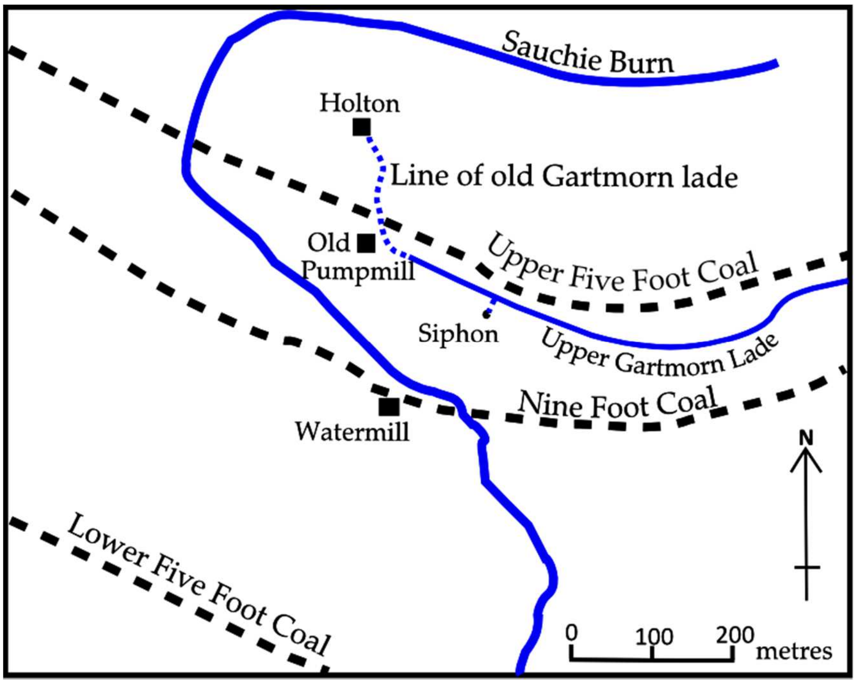
A map of Carsebridge and adjoining lands drawn in 1853 shows the site of "*The Old Pumpmill Pit*" next to a small row of cottages called "*Pumpmill Row*". (135) The pit is shown just to the South of the line of the Upper Gartmorn lade where it leaves Keilarsbrae mill. The sites of the "Holton No. 1 Pit" [NS 89416 94136] and the "Watermill Pit" [NS 89472 93709] are also shown. The Geological Survey map (136) shows these pits lie above the following coal seams:

Holton No. 1 Pit: Upper Five Foot Coal at 23 fathoms (42.06 metres) and Nine Foot Coal at 40 fathoms (73.15 metres);

Old Pumpmill Pit: Nine Foot Coal at 10 fathoms ((18.3 metres) and Lower Five Foot Coal at 60 fathom (109.73 metres): and

Watermill Pit: Lower Five Foot Coal at 50 fathoms (91.44 metres) (Also known as the Alloa Cherry coal).

Figure 22. Location of water engines:



Using this information, it is likely the first bucket and chain gin was sited at, or very close to, the site of the Holton Number 1 Pit in 1713, working the Nine Foot Coal. The information given from the '*Dickie's Sink*' memorandum indicates that the pit was 10 fathoms (18 metres) deep and was fed by a trough 90 feet (27 metres) long.

Putting this information together with the location and geological information from the site of the Old Pumpmill pit, we conclude that the first pump drainage engine was most probably located at this site circa 1735. The description given for the second pump drainage engine places it at the Watermill Pit site. It was constructed circa 1760 and was draining the Alloa Cherry Coal (also known as the Lower Five Foot Coal). Soon after this pumping engine was constructed a second winding engine was located at or close to this pumping engine.

Alexander Thomson noted in his 1770 memorandum that "*The engine at Alloa colliery will soon need a new wheel notwithstanding all the repairs that were gote lately. It will also be needful to make some repairs soon on the Gartmorn Dam.*" (137). In 1774 Alexander Bald (father of Robert Bald) was appointed manager of the collieries and managed them until 1813. (138) In 1785 the earthen dam at Gartmorn was replaced by a 320 yards (293 metres) long, rough-hewn, stone-faced dam at a cost of several thousand pounds. (139)

Figure 23. Early spillway ditch for the dam:

A plan of the dam in 1878 shows it very much in its modern location, but with a stone-built spillway close to its southern end. (140)

A ditch is shown carrying the overspill northwards back into the Brothie Burn. The remains of this ditch can still be seen running within a thin section of woodland next to the West of the base of the dam.

10. The Erskine estate releases direct control:

Gradually, the Erskine family relaxed direct control of their colliery workings, firstly leasing them out in 1825 to Robert Bald and Robert Jameson (factor of the Alloa estate). (141)

a. Repairing the Gartmorn Dam.

The Gartmorn Dam was rebuilt in 1827 by John Craich, the Alloa Colliery manager, for £300 when it threatened to give way (142). One of his colleagues later reported that "*In 1827, the damhead of Gartmorn Dam was then in very ruinous state, so much so that an eminent engineer was brought to inspect it, and report the probable expense of putting it in complete repair. The probable sum was about three thousand five hundred pounds sterling. Mr Craich, after carefully inspecting the dam-head, suggested that the repairs might be done for less money by their own workmen, accordingly the repairs were commenced and completed under his management, for a sum not exceeding five hundred pounds sterling, this damhead has since withstood the storms and floods of twenty-three winters, and still as good as ever*". (143)

b. Rebuilding the Forestmill weir.

The Alloa Colliery started work on rebuilding the Forestmill weir in June 1835. (144) On August 10th the Alloa Coal Company was founded as a partnership between William Mitchell, John Moubray, John Craich and David Ramsay. (145) The new Company accepted responsibility for Gartmorn Dam and the Forestmill and Upper Gartmorn lades and completed rebuilding the weir at Forestmill. (146) This was a major undertaking as, during a period of five months, an average number of some 20 men were employed each week, working 1,767 days in total.

£248:12:04	Labour costs
£29:15:01	124 feet (37.79 metres) of stone from the Culross quarry.
£16:11:11	lime for building
£ 1:17:04	16 carts of stones from Alloa
£ 2:13:00	mine dust from the Craigrie Mine and Devon Quarry
£0:05:00	"Roman cement" (providing a seal on the back wall of the weir).

This list records two different types of stone, together with lime and mine dust mortar and a seal of "*Roman Cement*". The Culross stone might well relate to the substantial pavement on the weir surface. This area is just over 17.5 metres wide; just under half the length of stone purchased from Culross. The work undertaken in 1835 seems to have kept the weir in working order, as there are no records of further building works. In 1893 the Alloa Burgh Water Commissioners made an inspection of the "*old damhead and the sluices which regulate the supply to the lower aqueduct*". [147]

The weir is extremely complex in shape. It is constructed of well-cut blocks of sandstone with a separate rear section built of coarser blocks. The structure is still relatively well preserved, but has suffered some damage from tree roots. There is a considerable development of vegetation covering most of the flat areas of the structure and a large quantity of silt deposited in the pond behind.

Figure 24. Panoramic view of Forestmill weir looking upstream.

Figure 25. Reconstructed view of Forestmill weir.

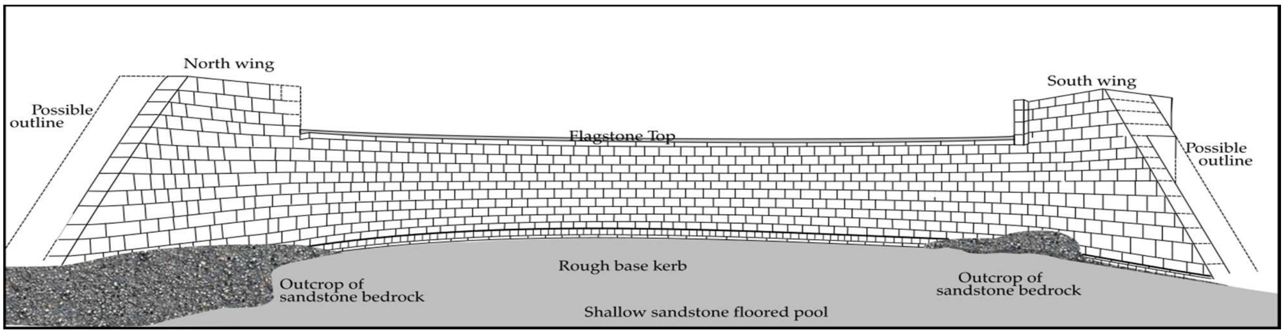
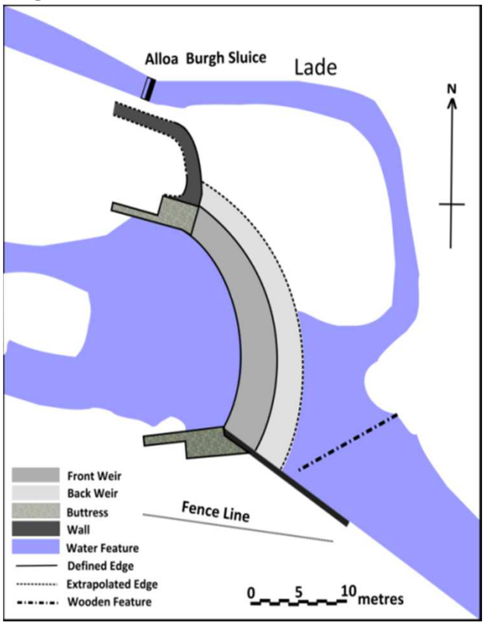


Figure 26. Weir details.



The front weir consists of a curved, ashlar block-built structure of sandstone supported on both banks by buttresses. The weir sits directly on top of the sandstone bedrock. There is a second structure lying behind and in contact with the first. This second structure is constructed of much courser blocks of sandstone and the rear line was difficult to identify due to the silty nature of the water. On the northern side of the main weir the buttress is extended into a supporting wall which curves round to support a section of the lade. The southern buttress is extended with a low sandstone wall along the bank of the river. This wall compensates for a drop in the level of the land on the southern side of the river.

The front weir and the two buttresses are all one construction. The front section of the weir is built on a two-part stone kerb which sits directly on the bedrock. The two buttresses are built directly on top of the bedrock.

Figure 27. Two views of the stone kerb:

The top surface of the front weir is composed of a well fitted pavement of extremely thick and substantial blocks of sandstone overhanging the wall of the weir. The surface slopes downstream at a gradient of about 1:19.

Figure 28. Sandstone pavement, front and surface.

Figure 29. Junction between structures.

An examination of the junction between the front and rear sections of the weir revealed that they are two entirely separate structures, but they are sitting very tightly against each other. It is almost certain that these two structures represent two different periods of building, with the rear structure, having a much rougher construction, being the earlier.

We know that the weir was rebuilt in 1835, started by the Coal Company and finished by the Alloa Coal Company (see page 21). The scheduled works for the improvements to the Gartmorn water supply listed in the Water Act of 1980 makes no mention of any work to be undertaken on the Forestmill weir so it is likely that the front structure is the 1835 rebuilt weir and the rear structure is an earlier weir. The rear structure is composed of roughly shaped, squared off blocks of sandstone and has a surface inclined up stream at gradient of about 1:8.

Figure 30. Rear sandstone structure.

Views of damaged parts of the surface sections of both the front and rear weirs suggest that they both have a rubble core. A number of eroded areas in the rear weir have been damaged by tree roots which are coppicing. These sections are in urgent need of repair and the tree roots require to be treated.

Figure 31. Rear weir blocks.

Due to the muddy nature of the water, it was difficult to identify the upstream edge of this structure, but large pieces of broken sandstone were seen lying on a solid surface close to the water's edge. Some of these stone blocks are lying together, as if in a pattern. This suggests that this feature might be quite extensive.

Figure 32. Section through the East weir.

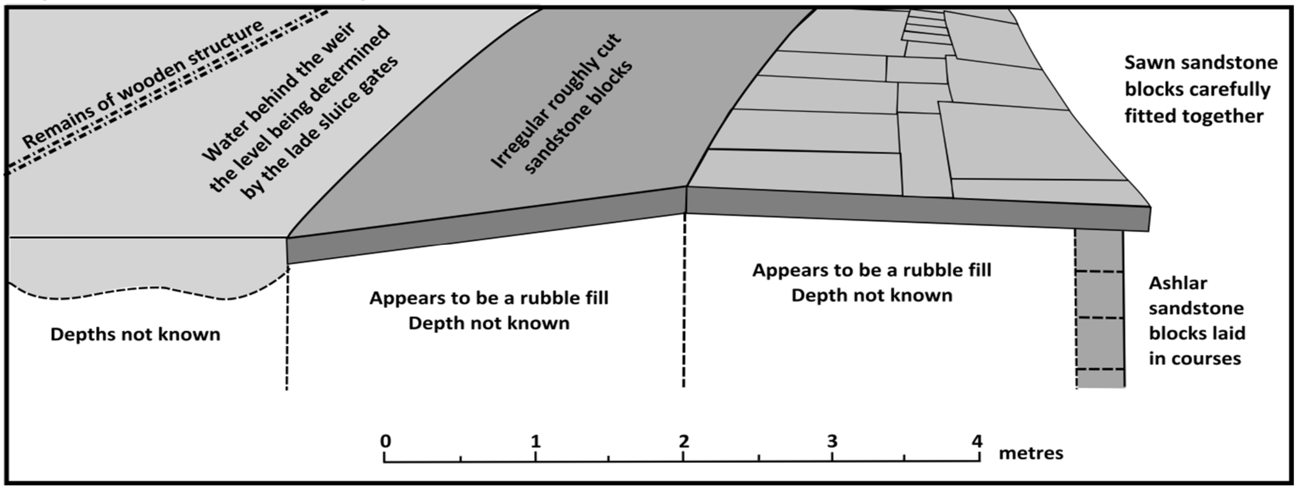


Figure 33. The southern buttress.

The southern buttress is a continuous part of the front weir and built on the bedrock. The front wall is vertical and the downstream end reduces in height. There has been some damage from tree roots, especially at the downstream end. The trees within and around the weir have been felled by the local landowner. This had made the entire structure much safer. The ground falls away quite substantially to the South of the weir at this point so a retaining wall has been built from the upstream edge of the buttress to prevent the water flowing into the adjacent field.

Figure 34. Retaining wall.

Figure 35. Weir edge of wall.

The retaining wall starts from the edge of the buttress built with ashlar blocks and then continues as built rubble.

Figure 36. Rubble built wall.

Figure 37. Wall from above.

Figure 38. Northern buttress.

Figure 39. Inclined wall.

This buttress is more complex, starting as a part of the weir but then inclining at a slight, but definite angle away from the river. The buttress not only provides support for the front weir but also has to support the substantial wall supporting the edge of the main weir and the lade and lade path.

Figure 40. North buttress retaining wall.

There is a substantial wall running towards the lade from the top of the buttress. It starts off as an ashlar construction and, unlike the retaining wall on the southern side of the weir, continues ashlar throughout.

Figure 41. Ashlar corner bocks.

The corner blocks of both the northern and southern retaining walls are different to the rest of the blocks on the weir. This might represent some minor repair work carried out by Alloa Burgh in 1892-93.

Figure 42. Wall damage.

The wall curves round to the East, supporting the lade path and the lade. Due to large amounts of shrubbery, an infill of cut branches and the stump of a large ash tree, we have not been able to photgraph this area successfully. The top corner section of the buttress where it meets the face of the retaining wall has been pushed out by tree roots. A large ash tree growing out of the western face of the retaining wall has been felled, but requires additional treatment. Several ashlar blocks have fallen into the pool below the weir. They are still in good condition and could easily be recovered and replaced on top of the wall.

c. Wooden structure.

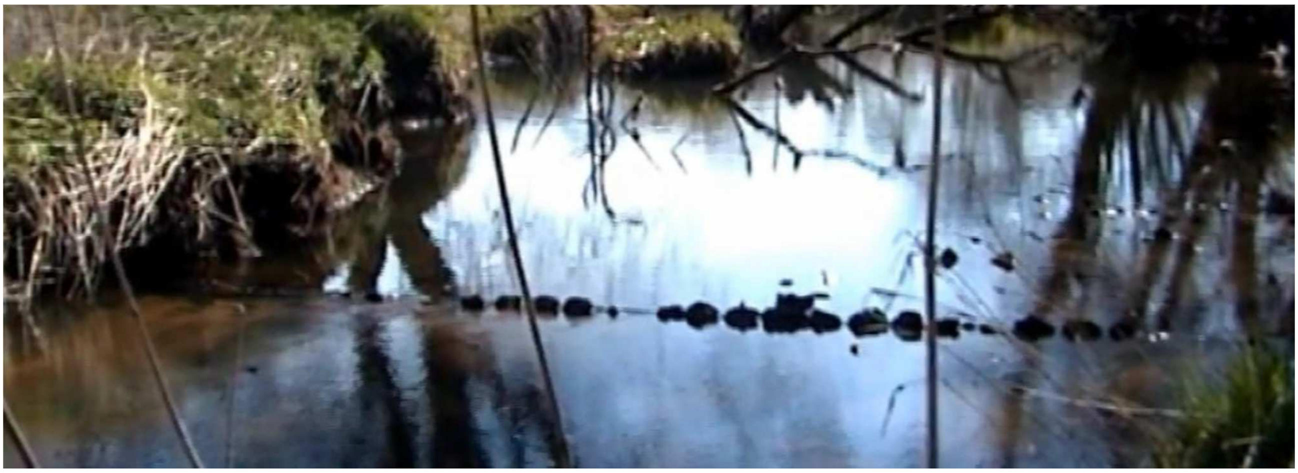
While surveying the weir a line of woodwork was seen in the water of the pool above the weir. The river Black Devon is still receiving quantities of very fine material from the abandoned opencast mine just upstream, so this feature is only seen clearly in times of dry weather when the mine pond is not flowing into the river.

The feature can be seen faintly in the photograph below, which was taken from the South bank of the pool behind the weir. It shows up as a faint line in the water, running across most of the width of the river Black Devon from X to Y.

Figure 43. Wooden feature.

One of the volunteers discovered that the feature had been captured on a video made by David Bytheway. (148) The shot was taken from the centre of the weir looking upstream. A section of a frame from the video is shown below. It shows very clearly that the visible parts of the feature are a closely spaced set of wooden posts crossing the whole width of the river.

Figure 44. Earlier view of the wooden feature.



© David Bytheway, 2018

The views of the feature below shows that a series of close set, square-cut, wooden posts are supporting both sides of a horizontal wooden plank.

Figure 45. Closeup of wooden feature.

The close-up view below shows that the posts are formed from long, square-cut wooden lengths some 10 to 13 cms square, supporting a plank about 3 cms thick.

Figure 46. Small section of feature.

It is possible that these wooden posts are the remains of a temporary weir built to divert the waters of the Black Devon into the Forestmill lade while rebuilding the stone weir in 1835. The rebuilding work was started in June when the water level would be at its lowest.

The lade starts as an open ditch from the northern side of the pool behind the weir. The whole area around the pool has been heavily silted and has developed a thick cover of vegetation. The lade turns westwards, running parallel to the river.

Figure 47. Start of the Forestmill lade from the pool behind the weir.

Figure 48. Location of the structures on the Forestmill weir site.

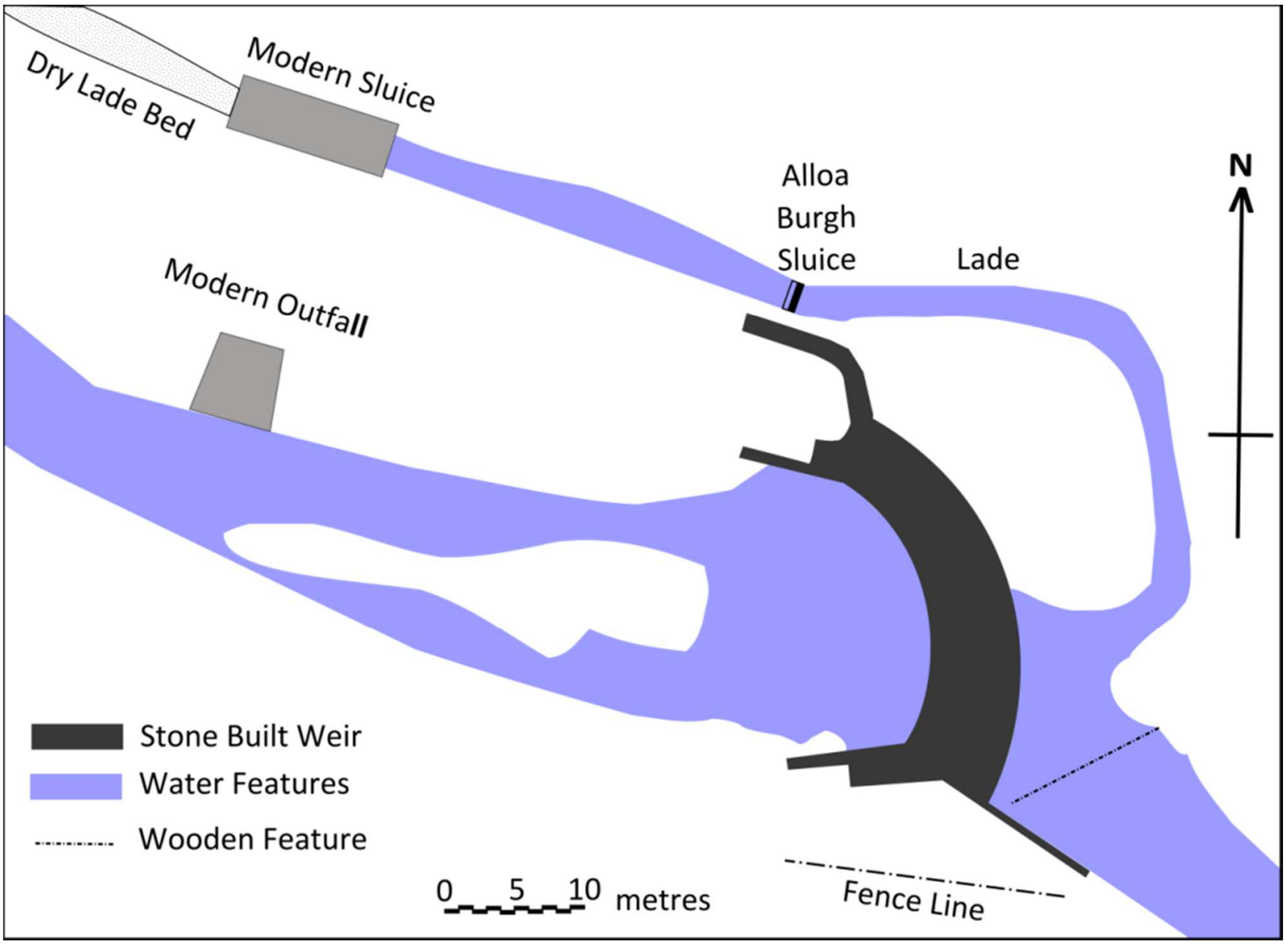


Figure 49. Tree roots coppicing.

The weir is at present still in moderately good condition. It is threatened by a large number of trees which have found a foothold in the stone work. The present landowner has had these all felled, which has been of immense value as, if they had been blown over, they would have caused considerable damage. The tree roots are have lifted several courses on the front weir and the buttresses and are actively coppicing. They require to be trimmed back and treated, offering a longer term solution to the problem. The removal of all the wooden batons from a modern sluice has reduced the level of water in the pond behind the weir to a point where it seldom flows over the weir. As a result, there is a very heavy growth of vegetation on the weir surface and the pond is silting up.

11. Industrial water supplies to Alloa:

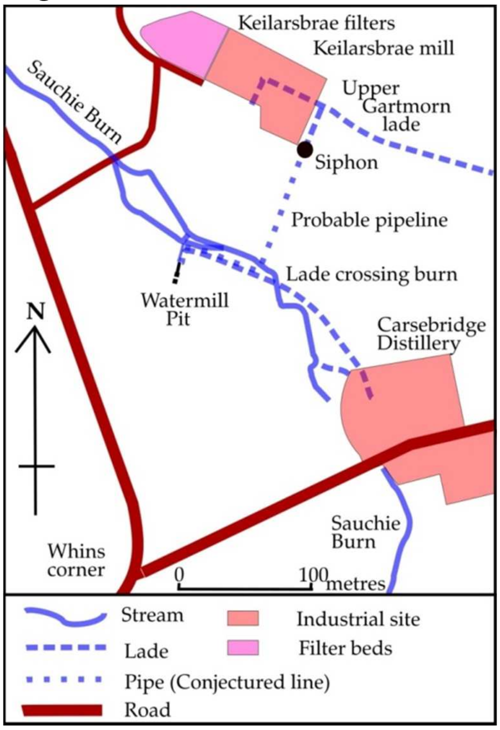
The addition of water from the river Black Devon together with the volume pumped out of the pits greatly increased the amount of water flowing down the lade and into the Brothie Burn. A map of 1681 shows a small dam had been built on the Brothie Burn, just to the North of the town of Alloa (149) suggesting that the water was already being stored there. It is not clear whether this was for domestic or industrial purposes. This might well be the site of the Gaberston Dam – the name Gaberston was first referred to in Roy's map of 1747. (150) The original lade powered a corn mill at Forestmill. In 1861 this was shown with a saw mill on the eastern side. (151) By 1898 the site was shown as a stand-alone saw mill no longer connected to the lade (152) but the farmer at Forestmill Farm was still using the water to power a threshing mill. (153)

Figure 50. Ruins of Jellyholm Mill, 1976.

Soon after the Forestmill lade was completed in 1713 a mill was built on the Upper Gartmorn lade next to Jellyholm Farm for grinding snuff and shredding tobacco [NS 90630 93921]. (154)

In 1731 a corn mill was built on the Brothie Burn opposite the town of Alloa. (155) The first historical reference to a dye house on the line of the lade was in 1758, when a complaint was made to John Francis Erskine that a dam supplying the dye house below the town mill was flooding adjacent properties. (156)

Figure 51. Watermill Pit lades.



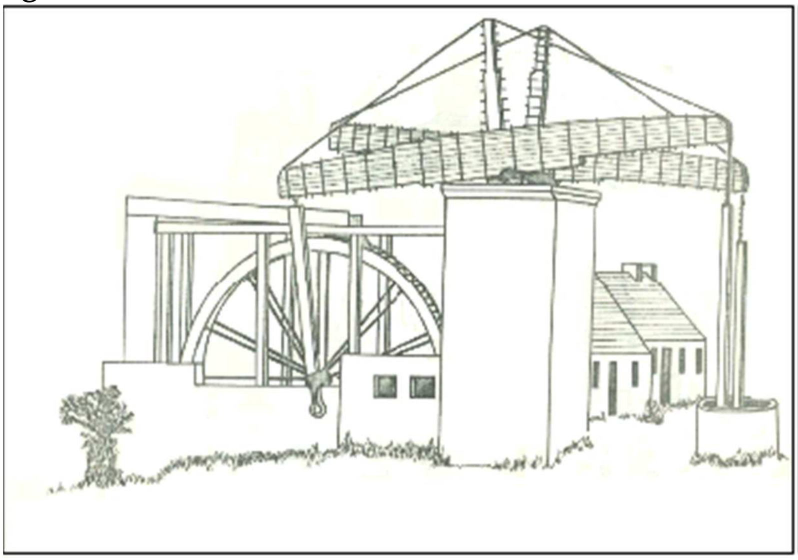
Based upon information from OS OpenData and the National Library of Scotland.

A lint mill was built at Keilarsbrae in 1770 on the line of the Upper Gartmorn lade (157) and by 1791 it was recorded as being a "*carding and lint mill*". (158) In 1794 the mill at Jellyholm was converted to chipping and grinding wood for dyestuffs. (159) By this time the courses of the Sauchie Burn and the Brothie Burn had become part of the complex Lower Gartmorn lade. It was reported in that year that the town mill now had two waterwheels of 19 feet (5.8 metres) in diameter and that seven mills were powered by the waters from Gartmorn Dam. (160)

The Carsebridge distillery site was feud by John Francis Erskine to Alexander Bald in 1798 (161) and supplied with water from the Upper Gartmorn Lade and power from the Lower Gartmorn lade. (162) The association of the Carsebridge supply to two kinds of water led to a complex arrangement of water courses adjacent to the Watermill Pit.

The Sauchie Burn ran in the middle of the valley. It was banked in stone walls and ran to the edge of the Carsebridge distillery, where it split in two. The eastern branch entered into the centre of the distillery, while the western branch continued southwards, finally exiting the distillery and continuing southwards to join the Brothie Burn.

Figure 52. Watermill Pit.



The Watermill Pit was supplied with water from the Upper Gartmorn lade, just before it entered the Keilarsbrae mill. A short branch from the lade took water into a vertical cast iron pipe which was the top of a siphon. Cast iron pipes conveyed the water down the slope, under the Sauchie Burn and up into a vertical pipe which fed a trough on top of the waterwheel.

The pit had two separate outputs of water, one from the water wheel and one from the drainage shaft pumps. We think that the outlet from the water wheel ran into a lade which crossed the Sauchie Burn in a trough and entered the distillery to the East of the two branches from the burn. As the waterwheel was supplied directly with water from the Upper Gartmorn lade by means of a cast iron siphon and pipes, this water was much less polluted than water from the Sauchie Burn or the drainage pumps. The output from the pit shaft drainage pumps was fed directly into the Sauchie Burn. We surmise that the supply of water in the lade was used in the manufacturing processes in the distillery while the burn supply was used to drive one or more waterwheels to provide power.

Figure 53. Stone culvert of Sauchie Burn.

Figure 54. Remains of lade crossing.

The Kilncraigs woollen mill was in operation in 1813, (163) a plan of the Alloa Estate in 1814 indicates that the dam immediately adjacent to the harbour was called the "*Saw Mill Dam*" (164) and in 1827 the Jellyholm mill on the Upper Gartmorn lade was converted to paper making by John and Andrew Young, paper makers, of Alloa. (165) Gaberston mill was built on the Lower Gartmorn lade in 1837. (166) In 1852 the Jellyholme mill became an adjunct to the Keilarsbrae mill. (167)

The growth of industry in Alloa was helped greatly by the water supply available from Gartmorn dam. Unfortunately, there was a price to pay for this, as they used the lade and the Brothie Burn to dispose of their wastes. This was a particular problem in terms of the distillery as the dregs were rich in organic material. By 1854 there were regular complaints about the quality of water in the Brothie Burn and, in particular, the stench coming from the Gaberston dam. The complaints were directed at the manufacturers sited along the Upper and Lower Gartmorn lades, especially at the Carsebridge distillery.

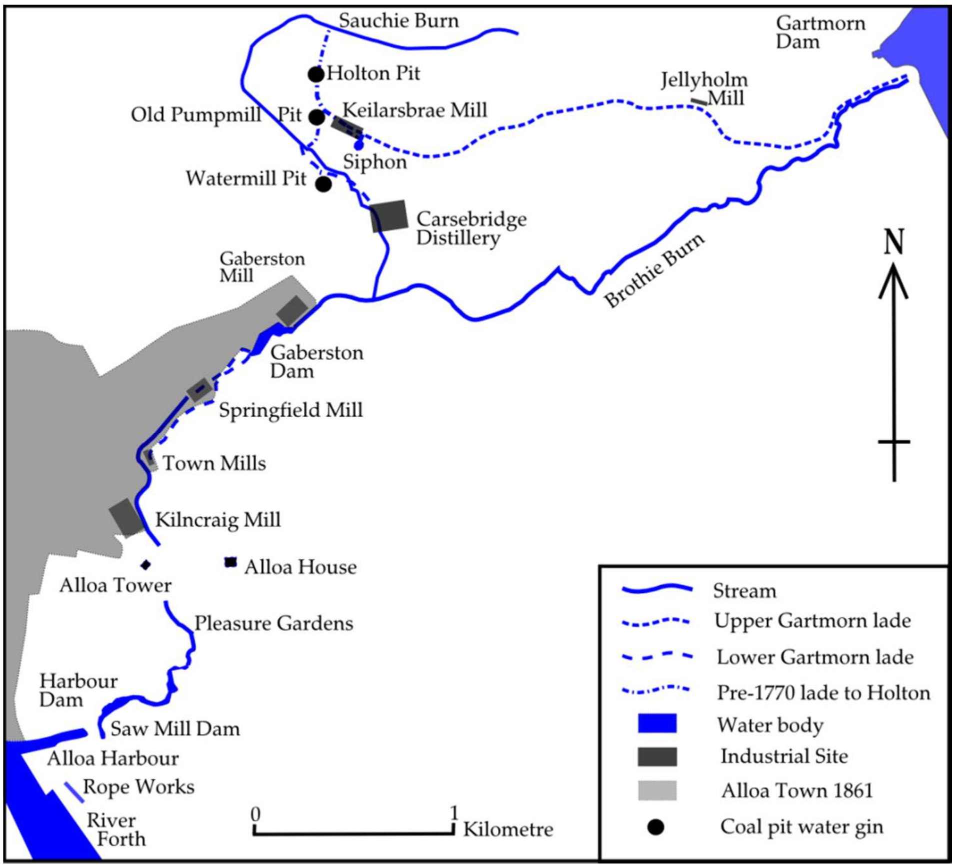
As the population of the town of Alloa increased, there was growing concern regarding the town's sewers, with many being blocked and overflowing. (168) The Police and Improvement Act of 1850 enabled the Burgh to elect Commissioners responsible for drainage and able to raise monies through local rates or borrowing. (169) The adoption of the Act led to improvements to the town's water and drainage systems. It was reported to the Commissioners in 1854 that ".. *in June last, the town, wherever was required, was thoroughly limewashed. At that time there were 103 pig-stys, and its number now reduced below 100. A number of dung stances had been removed. Fifteen parties had been prosecuted for keeping filthy pig-stys. A number of offensive privies had been condemned, and eight large public conveniences erected. There had been 32 house-drains made, and present there were five in progress. He had written to sixty-two parties to have drains formed. The common sewers are flushed every morning, and about half a of chloride of lime pot into each. The public wells are kept running about an hour every morning*". (170) The main town sewer was mentioned in 1871 where it was noted that it discharged into the Brothie Burn just to the South of Kilncraigs mill within the Alloa Policies of Lord Mar. (171)

In 1858 the Springfield mill was built (172) and the Town Commissioners had the Gaberston dam cleaned out (173) but this did little to help. A pipeline was laid that year from the dregs cistern at the Carsebridge distillery down the length of the Brothie Burn to Kilncraigs mill and into the Alloa Park policies of the Earl of Mar. It passed some 60 yards (55 metres) to the East of Alloa Tower and headed to the river Forth, reaching the embankment of the river between the garden of Forthbank House and the eastern end of the Alloa rope walk, where it ended in a tidal sluice. The pipeline collected liquid waste from the distillery, together with the wastes from the all the mills along its length. The main pipeline was of spigot and faucet fireclay pipes, jointed with cement. The exposed parts and the outlet were made of cast metal (174) and there were regular "*joints*", allowing the pipeline to be examined and cleaned. (175)

After the pipe was laid part of the Gaberston dam was filled in but, unfortunately, the pipe was only four inches (5 cm) in diameter at the distillery and subsequently suffered many breaks and leaks. (176) Gaberston dam was still being used by the town corn mills in 1862 to store water overnight and at weekends. (177) As the pipes draining the dregs for the distillery did not take all the liquid and some leaked into the Brothie Burn, the dregs were collecting in the Gaberston dam. There were numerous complaints from local residents about the smell coming from the dam and the Brothie Burn and worries were expressed about disease, particularly cholera. (178) In 1874 Carsebridge distillery increased the size of the upper pipe from the distillery and introduced a tank to trap sediment. Despite this, there were moves to take legal action to remove the Gaberston dam. (179)

The quality of water in the Brothie Burn was further lowered by all the sewage from Newton Schaw (Sauchie) and Holetown (Holton) and the waste from the Keilarsbrae mill entering the Sauchie Burn and flowing into the Brothie Burn. This was added to by the waste from the Carsebridge distillery and Gaberston mill. (180) Concern with the water quality at the Gaberston dam was being linked with cholera (181) and in 1866 the Earl of Mar and Kellie had the Gaberston dam filled up at his own expense and the Brothie Burn was reduced to a narrow stream. (182) In 1867 , the Earl covered over a large section of the Brothie Burn southwards from his boundary wall, but was still concerned about the smell from the burn and contamination with grain and wool. (183) There were concerns about the Alloa mills taking the flow of water from the burn and a petition of residents in 1867, sought to ensure that water was allowed to flow into the course of the burn when the corn mills were not working. (184) The Earl of Mar started drainage works at Gaberston in 1874 (185) and in 1875 Carsebridge distillery was connected to the main town sewer. (186) There were still problems in 1879 with houses at Gaberston discharging sewage into the burn and the owners were obliged to connect to the town sewer. (187)

Figure 55. Industrial activity on the lades



Based on information from OS OpenData the National Library of Scotland.

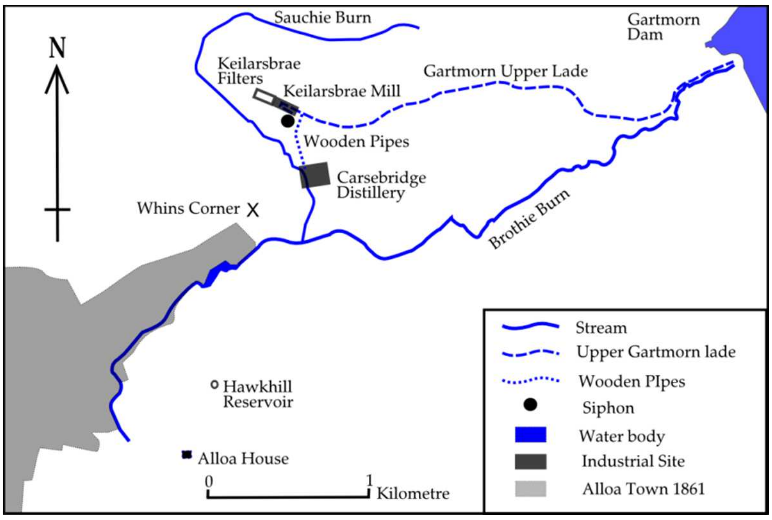
A survey of the town sewer in the valley of the Brothie Burn at Gaberston that year found it was 24 inches (61 cms) in diameter and working well, but the old Carsebridge pipeline was still in operation and leaking. (188) As a result of industrial and domestic pollution, the Brothie Burn became an open sewer and, despite continuous complaints and considerable effort, remained so for over a century.

By 1891, the Gartmorn Dam was still supplying the pumping engine at Watermill Pit as well as a large number of water powered and water using industries, including Carsebridge distillery, Keilarsbrae spinning mills, Gaberston woollen mills, and Springfield woollen mills and to the woollen mill at Kilncraigs as well as a domestic supply in Alloa and Sauchie.

12. First public water supply to the town of Alloa, 1803 to 1822:

One of the main considerations for any Scottish town at the beginning of the 19th century was the availability of a reliable supply of clean drinking water. Between 1784 and 1841 the population of the town of Alloa grew from 3,482 to 5,443 and was showing sign of increasing. (189) and (190) Like other districts, in early days Alloa was supplied with water from dipping or drawing wells. In 1896 is was noted in a paper to the Alloa Society of Natural Science and Archaeology (191) that an older resident could remember that in *"the High Street there were half a-dozen pump wells, besides the ' Tron" Well, Oul Doo's Well in the West Vennel; the "King's well near Springfield Mill; and others throughout the town."*, As the town gradually increased in size and public works of various kinds sprung into existence, the necessity of securing better supply of water became urgent.

Figure 56. First attempts at a public water supply.



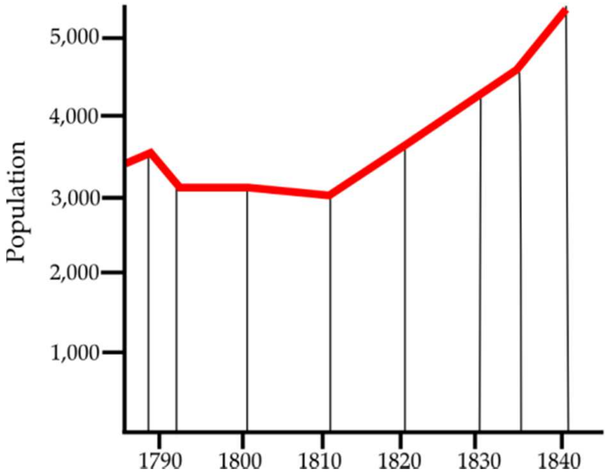
Based on information from OS OpenData and the National Library of Scotland.

It was noted in the 1896 report that *"When Lord Mar gave a grant of water from Gartmorn to Alloa, the water was conveyed to the town in wooden pipes. When the Carsebndge Distillery was feu'd a reservoir was constructed on the top of Hawkhill, but in these days I am afraid precautions were not taken in the matter of construction and the water could not be retained and new filters had to be made at Keilarsbrae."*

In 1798, John Francis Erskine leased Waulkers Park near Carse Bridge to John Bald and Company, distillers. (192) This places the first grant of water and construction of the first town supply to the beginning of the 19th century. It is likely that most of the water was made available through public taps or "wells". It was noted in 1854 that, as a health measure, *"The public wells are kept running about an hour every morning".* (193) This arrangement was adopted in Clackmannan in 1867 when the Earl of Zetland provided a public water supply from the Craigrie lade. The public taps in the streets only flowed when a hand was held on them so that water was not wasted. (194) The Alloa Harbour and Town Improvement Act, 1803 (43 Geo. III, ch.lv) led that year to a body of Town Trustees being nominated by the Earl of Mar, in his capacity as feudal superior, for the supervision and control of the town (195).

In 1840, Robert Jameson, Sheriff Clerk of Clackmannanshire and Trustee appointed for "*Cleaning the Streets of Alloa and of supplying the inhabitants of the said town with water*" signed an affidavit declaring that, in terms of the Act of Parliament, on the 28th July 1806, a contract was agreed between the Trustees and John Frances Erskine for a bond of £1,700. The contract made the Trustees responsible for the debts and interest regarding the costs of bringing water to the town. The contract would run for 21 years and limited the Trustees to a maximum borrowing limit of £1,700. (196) This pins down the date of the first grant of water to the town of Alloa to 1806, with the grant being made by John Francis Erskine, grandson of the John, the 6th Earl of Mar.

Figure 57. Population of the town of Alloa.



Based on information from ScotlandsPeople

Prior to this period, residents of Alloa had to rely on wells for drinking water. They also used water from the Brothie and Sauchie burns. The supply of well water was limited and the burns were unreliable and becoming polluted. A distillery, followed by breweries, woollen mills and domestic sewage from houses close to the burns all contributed to the pollution of the Brothie Burn.

The author of the Second Statistical Account stated in 1845 that "*the town of Alloa is well supplied with excellent water, brought by pipes, at great expense from Gartmorn Dam, about thirty five years ago*". This dates the original supply from Gartmorn at circa 1805-1810. An Alloa estate plan of 1813 shows a circular reservoir on top of the Hawkhill [NS 89316 92765]. (197) A line of "*Wooden Pipes*" is shown on a map of "*Carsebridge and Adjoining Lands*", dated 1853 [NS 89606 93829 to NS 89599 93616]. (198) The pipes started from the Upper Gartmorn lade, just before the trough to the siphon for the Watermill Pit and skirted the western edge of the grounds of Carsebridge House before entering the grounds of Carsebridge distillery. This line might represent the start of the original supply of water to the town. A section of wooden pipes was discovered when undertaking road repairs at the Whins corner, (199) suggesting that the line from Keilarsbrae continued through the Whins corner to Hawkhill. The find of this section of wooden pipe, together with later historical records, (200), (201) and (202) point to the lower section of Carsebridge Road leading to the Whins corner as being the starting point where the various supplies of water supplied from the Gartmorn Dam were distributed to the town of Alloa.

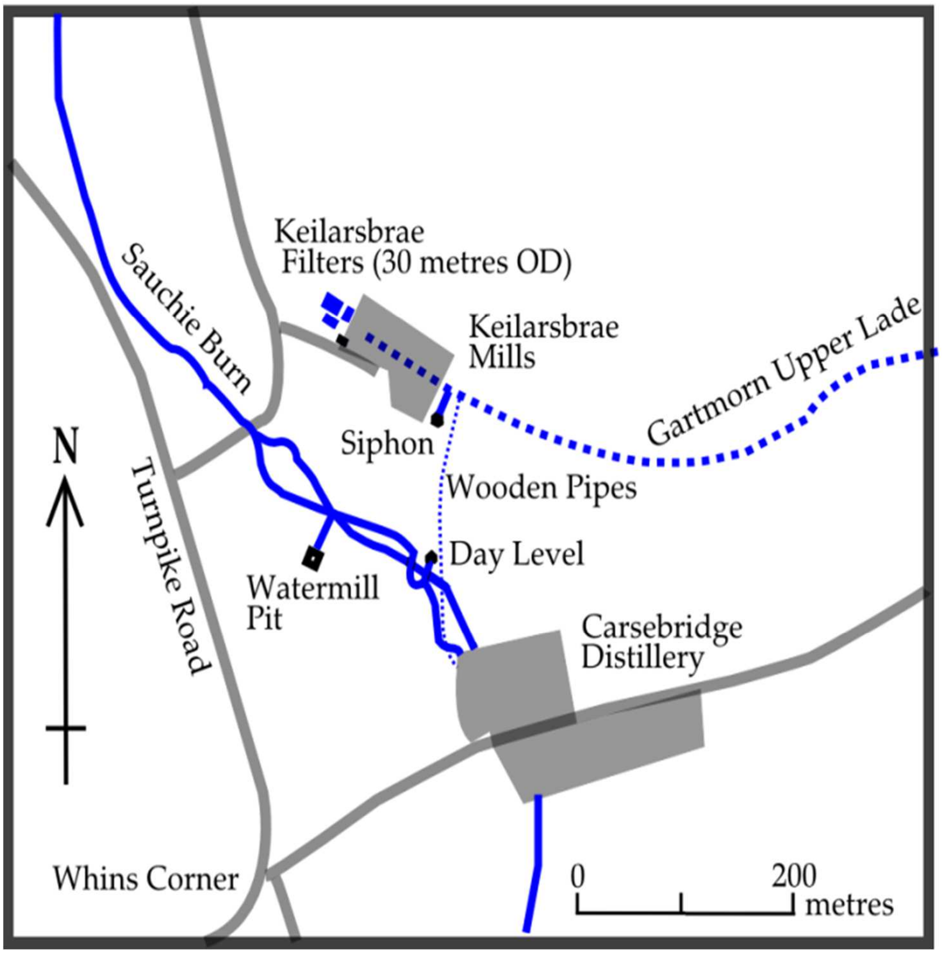
13. Keilarsbrae filters, 1822 -1866:

The report given to the Alloa Society of Natural Science and Archaeology in 1896, noted that the reservoir on top of Hawkhill did not hold water and a set of filter beds was constructed at Keilarsbrae to supply water to the town. (203) We have not been able to identify the date of the construction of these filters. However, the Alloa Improvement Act 1822 (3 Geo. IV, ch.lxxxiii) amended the earlier Act of 1803 and confirmed the administration of the town in the hands of the Trustees whose duties included supplying the residents with water. (204) It is possible that the new Trustees set up after this Act was passed were responsible for the construction filters at of the Keilarsbrae. In 1825 the colliery was leased to Robert Bald and Robert Jameson. (205) In 1835 the Erskine Collieries were leased to the Alloa Coal Company, who accepted responsibility for Gartmorn Dam and the associated lades. Water continued to be supplied to the town and an increasing number of industries. (206)

In 1850, as the result of an application to the Sheriff of Clackmannanshire under the Police of Towns (Scotland) Act 1850 (13 & 14 Vict., c.33) by William McGowan, a local physician, and twenty-seven other local householders, the Earl of Mar agreed "*to grant to the Commissioners full liberty in terms of the said Act to take off from the aqueduct at Carsebridge, as much water would pass through a pipe three inches* (7.62 cm) *in the bore, during the lease of the Alloa Colliery which expires at Whitsunday 1873, and from that term as much as would pass through a pipe four and half inches* (11.43 cms) *in the bore, during the then remaining period of said grant, and to conduct the same in pipes to the present reservoir, erected by the Trustees for the town of Alloa at Keilarsbrae, and from thence to convey the water in pipes to the different streets of the town*." (207).

The modern Burgh of Alloa came into being in 1854 under the Police of Towns (Scotland) Act 1850. The boundaries of the burgh were fixed on 22nd December 1853. Adoption meetings were held on 19th January 1854 and elections on the 16th February 1854 returned William McGowan, the first Senior Magistrate, and eight Commissioners. (208)

Figure 58. Keilarsbrae filters, 1822 -1866:



Based on information from OS OpenData the National Library of Scotland.

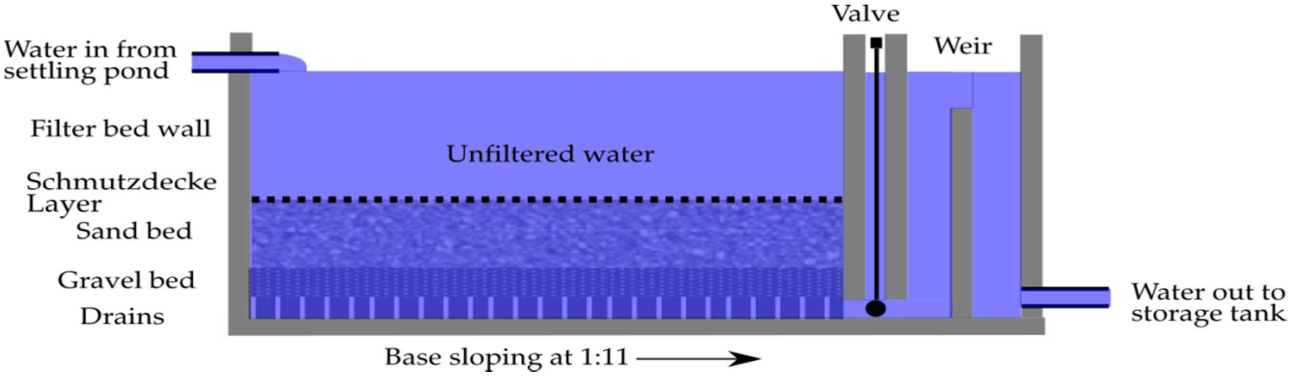
A map of Carsebridge, dated 1853, (209) shows a set of three beds and a water house built on the line of the Upper Gartmorn lade on the western edge of the Keilarsbrae woollen mills [NS894938]. It is likely that the filters at Keilarsbrae were slow sand filters.

The first large scale slow sand filters to be installed were built in Paisley by John Gibb in 1804 to supply his factory, with the surplus being placed in barrels

By 1810 a set of filters were installed in Glasgow by Robert Gillespie to supply water to his print works, again with the surplus being sold to the public. He used a settling basin to remove some of the suspended material in the water before leading it to a filter bed. This bed had several feet of sand and gravel with drains below leading the filtered water to a clean water basin. (210)

Slow sand filters work on the principle of physically filtering out organic matter from the water. The filter bed is a walled structure with a set of drains in the base. Gravel is laid on top of the drains, overlain by a thick layer of sand. Water is fed onto the top of this sand layer and clean, filtered water is collected from the drains. The active filtering is achieved by the development of a thin layer of Schmutzdecke on the surface of the bed of sand.

Figure 59. A slow sand filter bed:

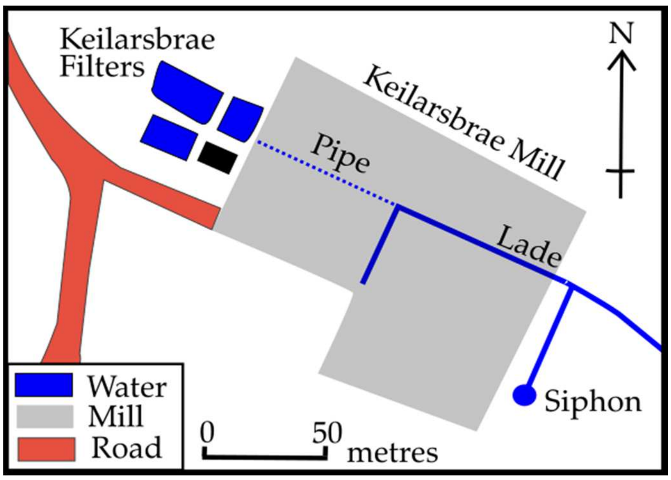


After Huisman and Wood, WHO, 1974.

Schmutzdecke is formed of a layer of trapped matter at the surface of the sand bed in which a dense population of micro-organisms develops. These micro-organisms break down incoming organic material. In doing so, they both remove organic matter and add mass to the layer, further developing the layer and increasing its physical straining action. At infrequent intervals the top layer of sand needs to removed, cleaned and restored. Slow sand filters are extremely effective in removing most of the polluting material from raw water. They do require the water to first go through an effective settling pond to remove larger particles and the top layer of sand needs to be cleaned at regular intervals [(211)]

By 1854 the Keilarsbrae filters had been supplying the town of Alloa with water from the Upper Gartmorn lade through an iron pipe of three inches (7.6 cms) in diameter – "*A conversation took place as to the supply of water to the town, and whether a three inch pipe was sufficient, but the opinion prevailed that the supply was quite adequate to the wants of the Town, and that were the pipes cleared of rust, a great additional supply would be obtained*". [(212)]

Figure 60. Keilarsbrae filters:

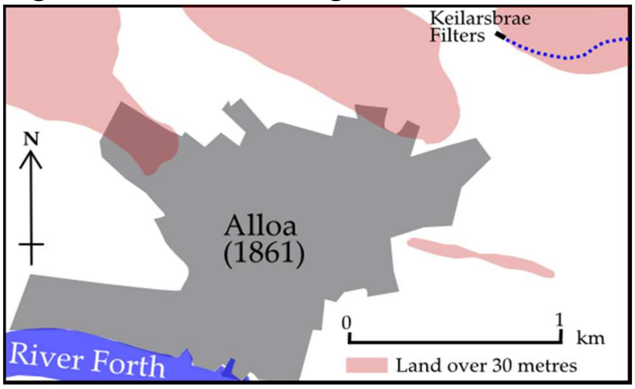


Based on information from OS OpenData and National Library of Scotland.

The location of three beds and a water house at Keilarsbrae is also shown on the First Edition 25 inch Ordnance Survey map of 1863 [NS894938]. [(213)] It is likely that there were one or two settling ponds to remove coarser materials from the lade water, leading to a slow sand filter bed to provide a supply of clean water. The water house is likely to have enclosed a supply tank storing water from the filters.

The level of the Upper Gartmorn lade at Keilarsbrae was at a point lying higher than the majority of the areas occupied by the town of Alloa. While repairs were made to the iron pipes to increase the supply, there was public concern by 1854 regarding the fact that the water for the Keilarsbrae filters was taken from Gartmorn Dam by an open lade and exposed to the possibility of pollution.

Figure 61. Relative heights:



Based on information from OS OpenData and National Library of Scotland.

It was reported that – *"It is a fact that numbers of children about Sauchie amuse themselves in the water which comes from Gartmorn, and at a place just before it enters the pipes to be filtered little above Alloa. These children dance, and duck themselves, in the water, and if our town's people were to witness the sights that I have seen, they would not drink a tumbler of water with very much relish. It is painful to think that we must either drink water which passes through the ordeal I have mentioned, or want. In addition to the nuisance of collier children disporting themselves in the water, I might mention the fact of cows and horses occasionally refreshing themselves with what is intended for us. But will not expatiate on this. I trust some check may be given to the evil of which complain. I know that the drum has occasionally been sent through Sauchie, but I think the sticks, wielded by a humane policeman, would be a more effective check. I am, Ac., Water Drinker. Alloa."* **(214)** Polluted drinking water had led to outbreaks of cholera. On April 5th 1832, eight cases were recorded at Alloa, with three of the victims dying. **(215)**

In 1854 discussions were held between the Alloa Town Trustees and Lord Mar regarding the grant of a supply of water to the town and the responsibility for the maintenance of Gartmorn Dam and its associated lades. A new contract of 38 years was being offered to the Alloa Coal Company and there was concern that, if the Company ceased to work the Alloa Collieries, the town might be responsible for Gartmorn Dam *"The Clerk then read the Deed of Grant to the Commissioners on the part of the Earl of Mar, and prolonged discussion ensued as to the probability of a day arriving when the keeping up of the dam of Gartmorn would devolve on the inhabitants, in consequence the Alloa Colliery ceasing to worked, and Lord Mar declining to be held liable for the expense."***(216)**

The grant allowed water to be taken off the Upper Gartmorn Lade at Keilarsbrae through a three inch pipe until the expiry of the Alloa Coal Company lease on Whitsunday 1873, when they would be able to install a four and a half inch pipe. The Commissioners were of the view that *"no obligation to keep up the Dam would be come under, unless a greater supply of water than was afforded by the three-inch pipe was obtained"*. **(217)** Lord Mar was seeking to be freed from the assessment of his house and park in compensation for a new water supply for the town, which was thought to be reasonable. **(218)** Further concern was raised in 1855 regarding the reliability of the supply from Gartmorn Dam when it was reported that *"… there is not water for the wants of the Burgh, and other purposes, adequate for the demand of a single week."* **(219)**

14. Jellyholm filters:

At the same time there was also a concern about the pollution of the lower lade from Carsebridge to the Town mill - "*…in consequence of the length of time the burn has been used as a common sewer*". (220) All of these concerns encouraged the Commissioners to improve the sewer system for the town and seek a better supply of water with more pressure. Fortunately, the Upper Gartmorn lade was slightly higher nearer to Gartmorn dam. This offered the possibility of building a new set of filters to take water directly from the dam by means of a short pipe. In 1866 the Town Commissioners successfully obtained a new grant of water from Lord Mar to replace that supplying Keilarsbrae. They had obtained the consent of the Alloa Colliery lessees and Messrs A. A. Mitchell, merchants in Alloa, lessees of the mills of Alloa, in exchange for an agreed amount of compensation water reflecting their existing grants from Lord Mar. The Commissioners also agreed to renounce the present grant of water from the aqueduct at Keilarsbrae when the new Jellyholm filters were completed and restore and return the land to Lord Mar. (221)

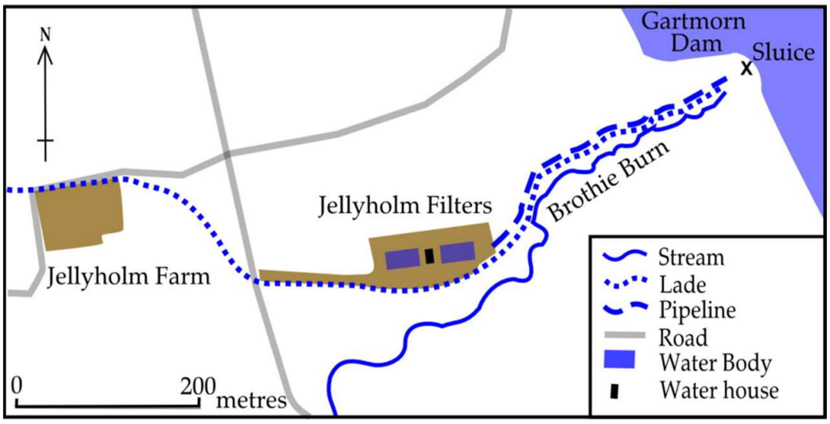
The new grant enabled them to take off from the aqueduct from Gartmorn Dam as much water as would pass through a pipe nine inches in diameter and conduct the same to a settling and filtering pond. The Commissioners agreed to construct a new set of filter beds further up the Upper Gartmorn lade next to Jellyholm farm [NS 909938] with a piped supply to take water directly from Gartmorn Dam. (222) Discussions were held with the Earl of Zetland's Commissioners to acquire a piece of land below Gartmorn dam for a new water-works. (223) Lord Zetland gave his approval, but his legal advisers requested sight of the Earl of Mars titles to Gartmorn Dam, a reminder of the uncertainty which had surfaced in 1712 regarding the legal status of the portion of the dam which lay to the South of the Brothie Burn. (224)

In 1866 the Commissioners advertised for estimates – "*Estimates wanted for the construction of these WORKS, including Settling Pond, Two Filtering Ponds, Water House, Pipe Track, Furnishing and Laying of Pipes, Making a Road, &c. The Works are to be formed near Gartmorn Dam, some distance to the east of Alloa, and the Water thence conducted—above 2,000 yards* (1,455 metres) *of 10 and 18 inch* (25.4 and 45.7 cms) *Cast-iron Pipes."* (225) This length of pipes would be sufficient to take water from the dam at Gartmorn to the new filters at Jellyholm and then on to the Whins corner. The estimate of £2,500 for the construction of these works from Mr William Kerr, Helensburgh, was accepted. (226)

To begin with, the contract was negotiated between the Right Honourable the Earl of Mar and the Commissioners of Police for the Burgh of Alloa. However, following the death of the Earl, his cousin, the Earl of Kellie, agreed the contract. (227) The contract was finally given in February 1867 by the Burgh Commissioners to Messrs Chalmers and Mackenzie, Dunfermline with the details given below. (228) Pipes, ten inches (25.4 cms) in diameter, were to be laid from the Dam along the sloping bank of the wood, for a distance of nearly 600 yards (549 metres), to the filters. There would be two filters; built of hard white freestone, squared and dressed. Each was 100 feet (30.5 metres) long by 40 feet (12.2 metres) wide at the bottom, sloping off 11 horizontal to 1 perpendicular and set on a bed of gravel. They would be filled up to a depth of four feet with sand and gravel, with a filtering surface of nearly 1,300 square yards (1.087 square metres). The filtering material would be supplied by Mr Glendinning, factor to the Earl of Roseberry, who allowed it to be taken from the beach at Dalmeny. The water was then to be collected in a roofed and slated house from which the main pipe, eight inches (20.3 cms) in diameter, would be laid to connect with the distributing pipe at the Whins corner. This new pipe would convey considerably more than double the previous pipe, which was much encrusted.

A branch was placed upon the connecting-pipe at the Whins corner so that, in the future, another distributing pipe could lie placed along side. The pipes were provided by Messrs Robert McLaren and Company's Eglington Foundry in Glasgow and were coated (japanned) inside and outside with a rust preventive known as Adam's patent. The water house contained a storage tank for filtered water.

Figure 62. The Jellyholm filters:



Based on information from OS OpenData the National Library of

By this time the Burgh was meeting half the cost of the Alloa Colliery Company's expense of the maintenance, rents, and officers' salaries for the up-keep of Gartmorn Dam and aqueducts and for the supply of water. For the year to 15th Mar, 1875, this came to £40.0.0d. There were also the cost of the rent of the filter ground at Jelly holm, £4.14.9d; repairing the East filter at Jellyholm (Wages, Repairs, and Sundry Furnishings), £123.9.5; new water pipes for Greenfield, Glebe, Kellie Place, Marshill, and Clackmannan Road and a new sand-washing machine, £800.14.11d. (229)

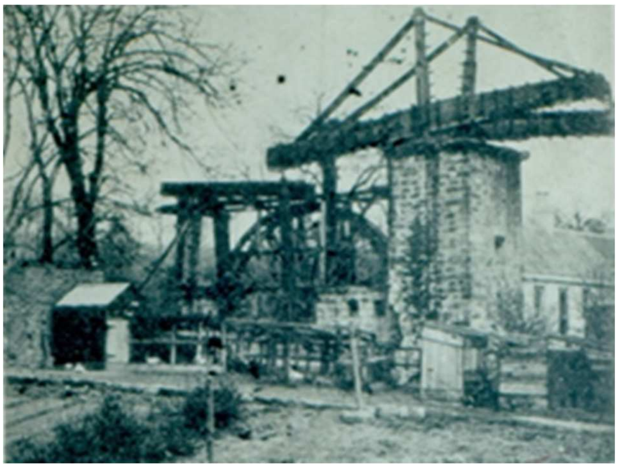
By 1876 the population of New Sauchie were seeking to obtain a supply of water from the Upper Gartmorn lade. It was suggested by the Alloa Water Commissioners that the Sauchie people could negotiate with the Alloa Coal Company for a supply from the Keilarsbrae filters. These filters had been handed back to Lord Mar when the Jellyholm filters had been opened and would require to be repaired. On the 10th July, 1876 Thomas Russell, Inspector for Clackmannan wrote to the Alloa Colliery offering the sum of £10 per annum for the privilege of taking water from the Keilarsbrae filters. (230) Concern was expressed by the Alloa Water Commissioners that if Sauchie obtained a supply from the Alloa Coal Company, who leased the Gartmorn Dam and lades from Lord Mar, they would not be responsible for the maintenance of the dam and would, if Alloa Burgh became responsible for the dam and lades, be entitled to compensation. This was the case when Alloa Burgh eventually took over the Gartmorn Dam in 1891. (231) The Commissioners were also dealing with requests from builders and developers as new properties were built. Applications were received in August 1876 from Mr. Gloag, builder, for an extension water-pipe to his house at the new street (near Park Villas off Clackmannan Road) and Mr. Alexander Ferguson for extension of water-pipe belonging to him in the new street, off Tullibody Road. (232)

Figure 63. 1878 dam spillway ditch:

A plan of the dam at Gartmorn, dated 1878, [233] shows the outline of the dam very much as it is today, but the spillway was located close to the southern end. Water from the spillway was taken by a ditch running along the base of the embankment of the dam. The remains of the ditch can still be seen at the edge of a strip of mixed woodland.

By 1883 the eight inch (20 cms) pipe had been augmented by one of 12 inches (30 cms). Both pipes had developed leaks in fields at Jellyholme farm and Carsebridge distillery and Alloa Burgh had received complaints from the farmer about damage and residents at Claremont who had suffered reduced water pressure. In 1890, 200 years after it was first constructed, the dam at Gartmorn was only supplying water to a single pumping engine in a small colliery which was reaching the end of its working life.

Figure 64. Watermill Pit.



The Alloa Coal Company continued to rely on the Watermill pit engine as it was much cheaper to run than a steam-engine. [234] However, steam engines were installed in other pits for drainage and bringing up the coal. [235] The seams worked from the Carsebridge colliery were abandoned, starting with the Nine Foot Coal in 1882, the Lower Five Foot Coal in 1884, the Coal Mosie in 1887 and, finally, the McNeish coal in 1898. [236]

By 1899, the Watermill Pit was shown as abandoned on the OS map [237] and Gartmorn's long history of supporting mining in Alloa was finally ended. As its importance to mining had declined, its importance as an industrial power source and an industrial and domestic water supply had rapidly expanded. Owned by the Erskine family and leased to the Alloa Coal Company it was already part funded by the Burgh of Alloa. [238] The scene was set for a new chapter in the life of the Gartmorn dam and lades.

15. Appendix 1:

(GD124/17/546) Expense of redding ane old sink commonly called Dickies' sink at Alloa Gin and cradling of it, and erecting a pump work for the draining of the water of it, and a level for carrying off the water from the pumps, etc.

To Redding 10 fths: of the sink down to a scaffold in the middle ye of which supports the rod at £12 per fth:		£120.-.-
To winning out of the quarry six roods of stones for cradling Ds' sink at 10 merks per rood	£40.-.-	
To Bigging ditto stones at 10 merks per rood	£40.-.-	
To leading ditto stones from quarry to the sink at 2 ship loads at £12 per rood	£72.-.-	£152.-.-
To mounting a water wheel of 18 foot diameter, 32 inches over with two cranks as follows		
To ane axle tree of 5 foot length 14 or 15 inches square with its planting	£38.-.-	
To 20 double trees for arms at £1.04.-	£24.-.-	
To sauch timber for ring, sole and streud	£40.-.-	
To 30 ten foot deals for arms at 12sh:	£18.-.-	
To 12 stones of iron made work in nave bonds, etc at £2.5.- per stone	£30.-.-	
To 2 cranks of two ft: in length of the fangs or arms of 20 stone wt: each at £4.-.- per stone	£160.-.-	
To two big brasses for the journals of the cranks at 16 pds wt: each and 4 for the hands of the cranks at 6 pds each is in all 56 lbs at 14 sh: per pd	£39.04.-	
To the workmanship of the wheel	£48.-.-	£388.04.-
To 6 logs for stelling to support the wheel at £6 each	£36.-.-	
To 9 score ten foot deals for the stelling and covering ye wheel from ye weather and making nine deal length of trows at 10 sh: each is	£90.-.-	
To 10 double trees for supporting the trows	£24.-.-	£160.-.-
To 32 fths: of pumps of 8 ¼ inch bore, hooped, bored and jointed at £12 per fth: is		£384.-.-
To two iron barrels six foot in length and 8 in: diameter bore		£200.-.-
To 12 double trees for pump rods at £12.4.- each is	£14.08	
To six buckets and clacks of iron, 7 pds weigth each at 6 sh: per pd is	£12.12.-	
To 20 double trees for needles to support the pumps	£24.08.-	
To 18 stone of iron in joints and plates for the pump rods made work at £2.05.- per stone	£40.10.-	
To 16 stone of iron made in screw nails and plates for the plug holes	£36.-.-	
To the making of 4 st: iron into dogs for fixing the pumps to the needles till they are sett upon the bottom of the sink where the dogs are to be relieved at 13 sh: 04d per st:	£2.13.04	£118.03.04
To two kemstocks timber & workmanship		£48.-.-
To 120 fths: ropes for setting down the pumps from time to time to ye bottom of the sink, commonly called ground ropes		£120.-.-
To a pair of blocks, taikle, fauld, a triangle, windlass yrto, for drawing the pumping rods and assisting the kemstocks at setting the pumps, etc		£2.19.04
To 7 score ten deals for trapping the sink at 10 sh: per deal	£70.-.-	
To 60 single deals for Day stair	£36.-.-	
To 16 double trees for a partition wall betwixt the pumps and stair	£192.04.-	
To six score deals for that partition	£60.-.-	
To 4 men 12 days putting in the stair and partition at 12 sh: per day	£28.16.-	£219.-.-
To 150 days of two men letting down and seeking the pumps when needful, leathering buckets, making scaffolds, putting in needles, etc		£180. - . -
To 4 st: Garron nails at 4 merks per st: and 10000 double and 10000 single nails for doing the hale work at £7 the 1000 double and £3.10.- the 1000 single		£115.13.04
To making and bigging a tail level for carrying off the water from ye pumps at £6 per fth:		£180. - . -
To workloom of all kinds, such as mattocks, picks, shovels, , for battons, chalk and cloath to the joints of the pumps, windlass and pump ropes and for a great dale of incidental charges & unforeseen accidents that cannot now be thought of		£480.- .-
		£2,868.-.-

16. Appendix 2:

Abbreviated Extract from the Erskine Family Papers, GD124/17/594, National Records of Scotland.

Account of Expenses for Wages and Materials for Rebuilding the Damhead at Forest Mill advanced by the Alloa Colliery.

Date	Men	Days	Wages	Notes
June 24	27	131	£10:01:07	
July 7	23	171	£12:17:08	
July 22	24	199	£18:14:02	
Aug 8	28	329	£29:12:03	and mason and quarrying tools sharpened.
Aug 20	27	244	£22:14:08	
Sep 4	25	251	£23:17:09	
Sep 17	23	144	£13:16:05	
Oct 2	19	234	£22:09:08	
			£ 0:08:03	Toll and carriage of stone.
			£ 0:04:00	Roman cement.
Oct 17	6	30	£ 2:04:09	
Nov 13	13	13	£ 1:01:03	
Nov 28	7	21	£ 1:10:01	
			£159.07.06	
Materials			£ 0 :01:00	Roman cement.
			£ 29:15:01	Culross quarry, 124 feet of stone.
			£ 16:11:11	Lime for building of damhead
			£ 1:17:04	16 carts of stones from Alloa
			£ 2:13:00	Mine dust from Craigrie Mine and Devon Quarry
			£ 0:12:00	A Janker frame
			£ 3:04:00	Waste of wheel and hand barrows
			£ 0:14:06	Gabberston toll keeper and carriage
			£ 1:00:00	Pails and scoop
			£ 56:08:10	
		75	£ 18:15:00	Costings to the Old Company up to 10th August
		65	£ 16:05:00	Costing to the New Company from 10th August till the job was finished
			£250:06:04	

17. Terms Used:

Axle Tree:	The wooden axle of a waterwheel.
Bigging:	Building or shaping.
Buckets:	The piston end in the pump barrel, sealed with leather.
Clacks:	The valve closures to prevent water returning after the pump stroke.
Deal:	Sawn timber.
Dogs:	Metal support for logs.
Double Tree:	Length of unshaped timber.
Ebber:	Shallow.
Farr:	More.
Fangs:	Arms (of a crank).
Fauld:	Enclosure.
Gin:	Engine.
Janker:	A long bar on a frame with a pair of wheels at each end for transporting heavy weights.
Journal:	The part of a shaft sitting in the bearing.
Kemstock:	Capstan for winding ropes for lifting.
Nave Bond:	Circular hoop of iron for binding the axle to the crank.
Needle:	Beam of wood set into the walls of the shaft at each end to provide a cross-shaft support.
Pudding link chain:	An iron chain formed by bolting together short pieces of wrought iron.
Pump:	Pipe
Redding:	Clearing out.
Ring:	Circular supporting frame linking to the arms of a waterwheel.
Roman cement:	Burnt nodules containing a mixture of clay and calcium carbonate. When mixed with sand and water, it set in 10 to 15 minutes.
Rood (or Rod):	6.175 yards (5.65 metres)
Sink:	Shaft.
Sole:	Inner lining of a waterwheel forming the base of the buckets.
Stelling:	Sheltering or supporting.
Streud:	Side panel of a waterwheel forming the outside of the buckets.
Taikle:	Tackle (part of block and tackle for lifting/lowering).
Tail level:	Ditch for carrying off water from the waterwheel.
Trapping:	Cladding timber.
Triangle:	Three legged pit head frame for lowering and lifting.
Trow:	Trough.
Windlass:	Winding equipment.
Winning:	Quarrying.
Workloom:	Tools.

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