

# Sublime Cascades: Water and Power in Coalbrookdale

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*The Coalbrookdale Watercourses Project took place between 2000 and 2006, and comprised the most extensive renovation of the water-power system in over a century. Ironbridge Archaeology undertook historical and archaeological investigation as part of the project. The archaeological work was closely integrated into the engineering programme, and the results of excavation and research were able to inform conservation. This paper outlines the historic origins of the water-power system in Coalbrookdale, and describes the archaeological work undertaken during the project. The results of the work suggest that the basic layout of the original 16th- and 17th-century system is preserved in the present-day arrangement of culverts, sluices and pools. This interdisciplinary project has provoked new ways of looking at this apparently well-known landscape of industry.*

## INTRODUCTION

The importance of water power in the development of the industrial complex at Coalbrookdale (OS NGR SJ 669042; Figure 1) has long been understood. As early as 1754, it was noted that '[t]here is the most work done at these places, with the least water, of any place in England'.<sup>1</sup> By this time the system of six pools was serving five substantial ironworking sites — two blast furnaces and three forges. The watercourses featured strongly in the many descriptions of Coalbrookdale during the late 18th and early 19th centuries, when a variety of tourists came to view the famous ironworks. Many of these visitors were overwhelmed by the 'horribly sublime'<sup>2</sup> scene before them, and resorted to classical imagery to describe the 'heathen hell ... [where] the men and women might easily be mistaken for devils and fairies'.<sup>3</sup> As well as the smoke and flames of the furnaces, the noise of the bellows and the relentless activity, visitors also commented on the picturesque 'fine cascades' of water.<sup>4</sup> However, whilst technological improvements in iron smelting and founding by the Darby family have been extensively studied over many years, relatively little archaeological work had been undertaken on the origins, development and cultural meaning of the water-power system.

This paper describes work undertaken by Ironbridge Archaeology, the archaeology unit of the Ironbridge Gorge Museum Trust, between 2000 and 2006, during which time the watercourses were subject to their first comprehensive renovation programme in over a century. The Coalbrookdale Watercourses Project was a multi-disciplinary project, which resulted from the transfer of ownership of the watercourses, pools and culverts from English Partnerships (the successor body to the Commission for New Towns, itself the

successor to the Telford Development Corporation) to the local authority, the unitary Borough of Telford and Wrekin. The project was funded by English Partnerships and the European Regional Development Fund (ERDF), with additional funding from Advantage West Midlands (AWM), and was managed by the Borough of Telford and Wrekin (BTW). The project had four principal components.

- Ensuring the engineering and hydrological integrity of the system, requiring substantial infrastructure new build and restoration works.
- Developing the improved watercourses as a public amenity for the residents of the Borough and for visitors.
- Securing and enhancing the ecological value of the watercourse system both in its own right and as a resource for locals and educational uses.
- Researching and interpreting the historical and archaeological origins and development of the system.

The project overall had a budget of £2.2 million, most of which was spent on engineering, infrastructure and related works. This took place in five main phases, the location and extent of which are shown in Figure 2. Whilst the main driver of the project remained the need to ensure the stability of the various watercourse structures, there was a great deal of dialogue and discussion between the various partners along the way. Indeed, it would not be an exaggeration to say that this was in many ways a 'model' project of its type. Information flowed freely in both directions — engineering findings informed archaeological research, and the results of archaeological investigation informed engineering and conservation decisions.

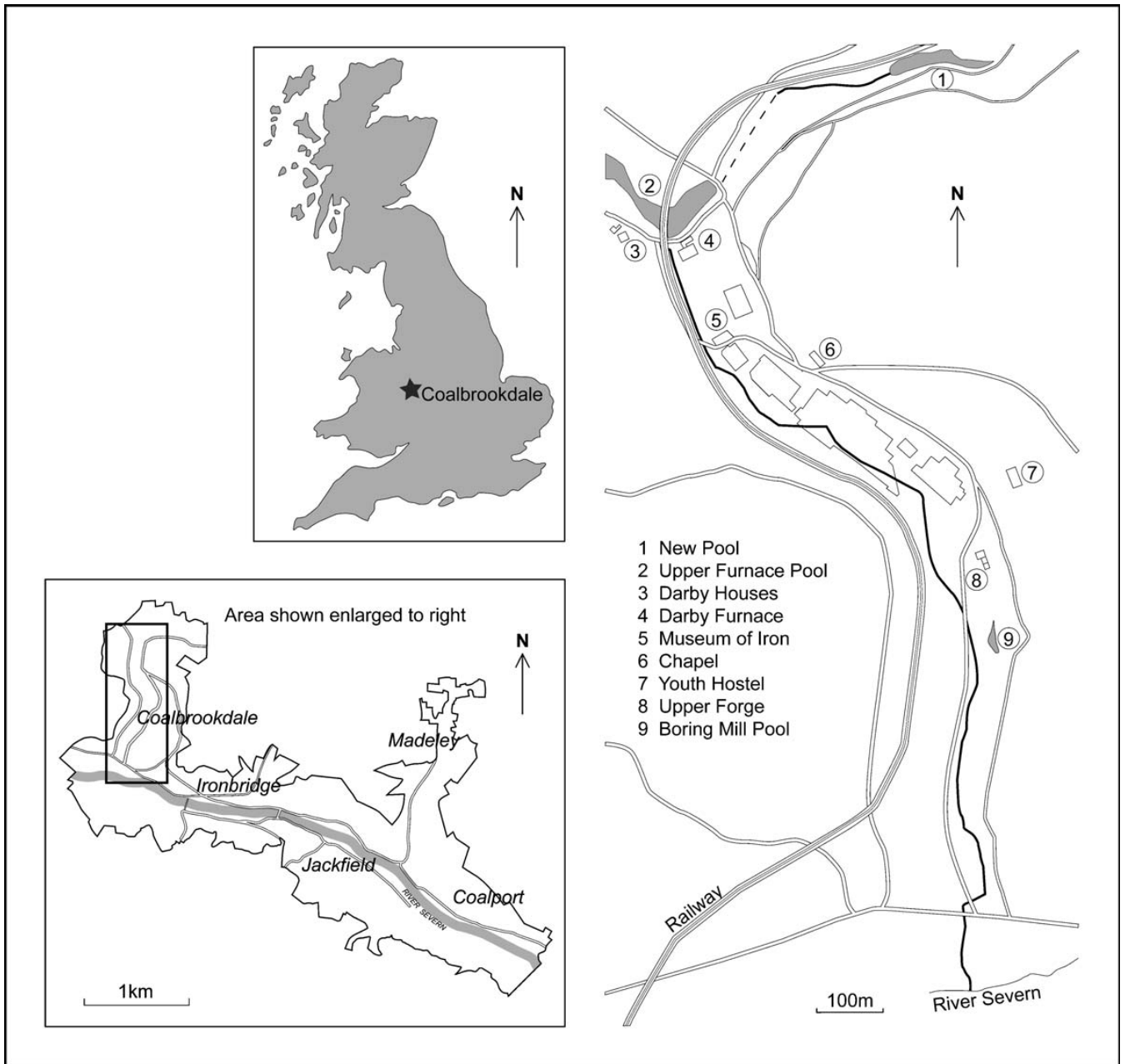


Figure 1. Coalbrookdale Watercourses Project. Site location and key features along the water-power system (Drawing by Paul Belford and Sophie Watson).

HISTORICAL BACKGROUND

At its height, the water-power system at Coalbrookdale comprised six pools and a network of sluices, channels, tunnels and engines to power the various enterprises of the Coalbrookdale Company (Figure 3). This system modified three streams. The Lydebrook and the Lightmoor Brook flowed into the upper part of Coalbrookdale from the north-west and north-east respectively. They merged into what became the Upper Furnace Pool. From here the Caldebrook (alternatively Coal Brook, Cold Brook or Cawbrook, from which the Dale gets its name) flowed in a southerly direction to its confluence with the River Severn. The total working length of this system, from the uppermost pool to the river, was just over a kilometre,

over which length there was a fall of approximately 100m (Figure 4). Historically and topographically the Dale can be divided into 'Lower' and 'Upper' sections; both here and in the following section on fieldwork and results, the sites are described in order going upstream from the River Severn.

The Lower Dale

The earliest feature on the watercourse system was probably the Lower Forge Pool (Figure 5). The forge was certainly in existence in the 1530s, and was mentioned again in 1544 when it was leased to Hugh Morrall.<sup>5</sup> Hearth plates dated 1602 were recorded at the site, and by the end of the 17th century it was in use as a 'plating forge' for the manufacture of frying pans.<sup>6</sup> The tenant at this time was

Cornelius Hallen, who continued to occupy the site well into the 18th century.<sup>7</sup> His lease on the 'Plate Forge' was renewed in 1708, and part of the site was still referred to in 1827 as the 'Frying Pan Shop'. From the late 1730s the Lower Forge was also (and perhaps mainly) engaged in producing tools, fixtures and fittings for the other sites in the Coalbrookdale complex.<sup>8</sup> In 1753 the site was known as Hallen's Forge, and in the following year a visitor to Coalbrookdale noted that the forge 'belongs to Mr. Thomas Allen', who made 'Frying pans, fire shovels etc.'<sup>9</sup> The site continued in use until the mid-19th century, and was latterly in use for nailmaking, but the pond was being filled in by 1883 and had disappeared entirely by 1901.<sup>10</sup> The significance of this site, the scene of the earliest ironworking in the Ironbridge Gorge, cannot be overstated, and it is clear that substantial remains of the water-power system survive both above and below ground. These include the remains of at least one water wheel, exposed during developments in the 1880s and again in the 1960s.<sup>11</sup> Bearings for another water wheel, installed by the proprietor of the Dale End Garage in the early 20th century to provide electricity, are still extant in the tailrace outflow from the site of the Lower Forge Pool.

Upstream was the Middle Forge Pool (Figure 5), another early site and possibly contemporary with the Lower Forge; it also appears to have been in operation by the 1540s.<sup>12</sup> Both the Middle and Lower Forge Pools are 'side-valley' type ponds, offline from the main watercourse but connected to one another.<sup>13</sup> The tailrace of the Middle Forge Pool formed the headrace of the Lower Forge Pool. Excavations (see below) have recovered 16th-century pottery from the area of the pool. Rose Cottage, which stands within the original forge complex, dates to at least 1642 with enlargements in 1676.<sup>14</sup> The change of emphasis brought by the Darbys from forge work to the foundry trades may have rendered the Middle Forge under-employed in the first few decades of the 1700s, and it was sublet to a variety of tenants. By 1740 it was in the hands of Cornelius Hallen, and had been refitted six years earlier as a boring mill. At first this was used for 'dressing' (ie. boring) cast iron guns, and over 2,000 cannon of various sizes were finished here by the Coalbrookdale Company between 1740 and 1748.<sup>15</sup> From the 1750s it was used directly by the Company for 'boring their large fire Engine Cylinders',<sup>16</sup> and it appears to have continued in this function well into the 19th century, probably ceasing production in the 1840s.<sup>17</sup> The boring machinery was upgraded in 1780 'to bore cylinders in the manner J[ohn] Wilkinson bores his'; the engine was designed by James Watt and made in the

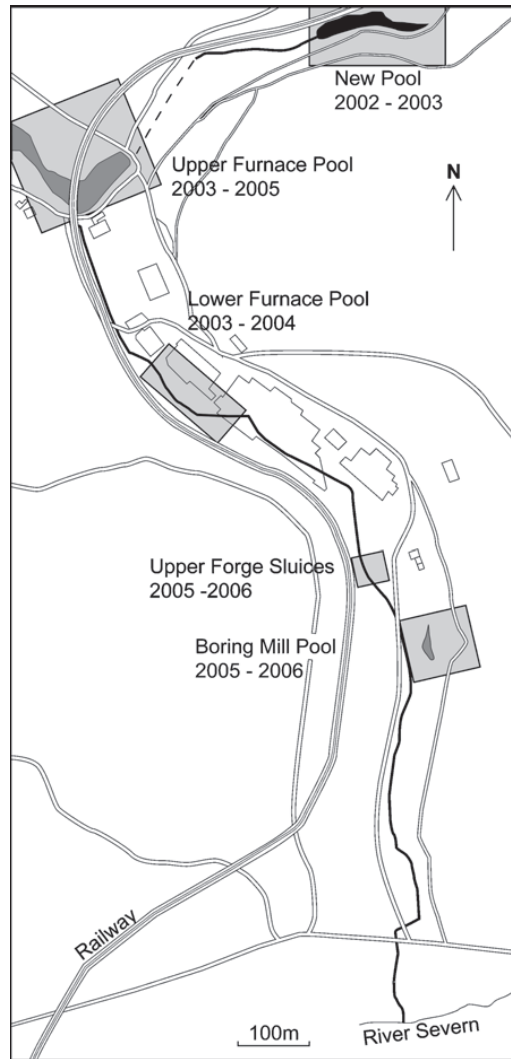


Figure 2. The Coalbrookdale Watercourses showing the principal phases of engineering works undertaken between 2001 and 2007 (Drawing by Paul Belford and Sophie Watson with information from Chris Butler).

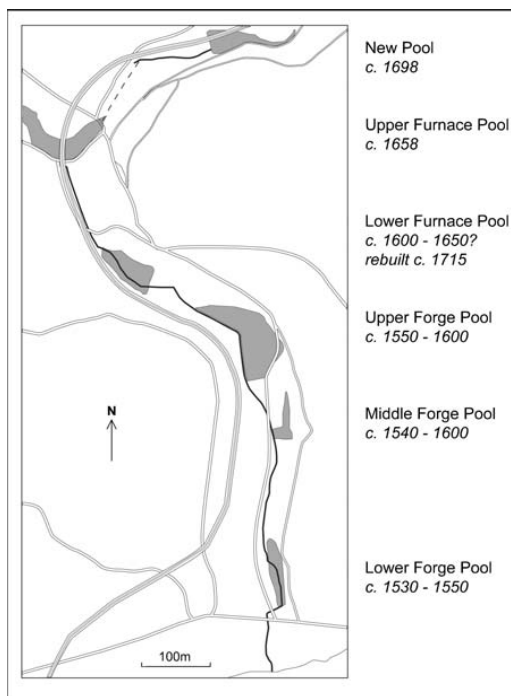


Figure 3. The Coalbrookdale Watercourses. Map showing the extent of the historic water-power system c.1800 (Drawing by Paul Belford and Sophie Watson).

Figure 4.  
The Coalbrookdale  
Watercourses. Profile  
showing the fall of the  
system in c. 1800  
(Drawing by Sophie  
Watson after Clark  
and Alfrey).

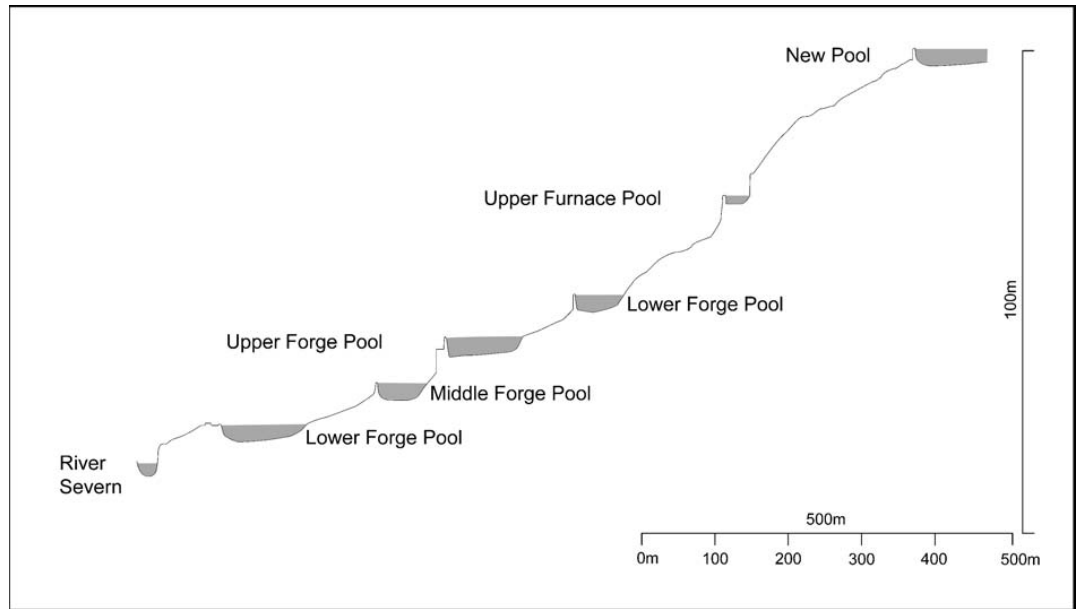
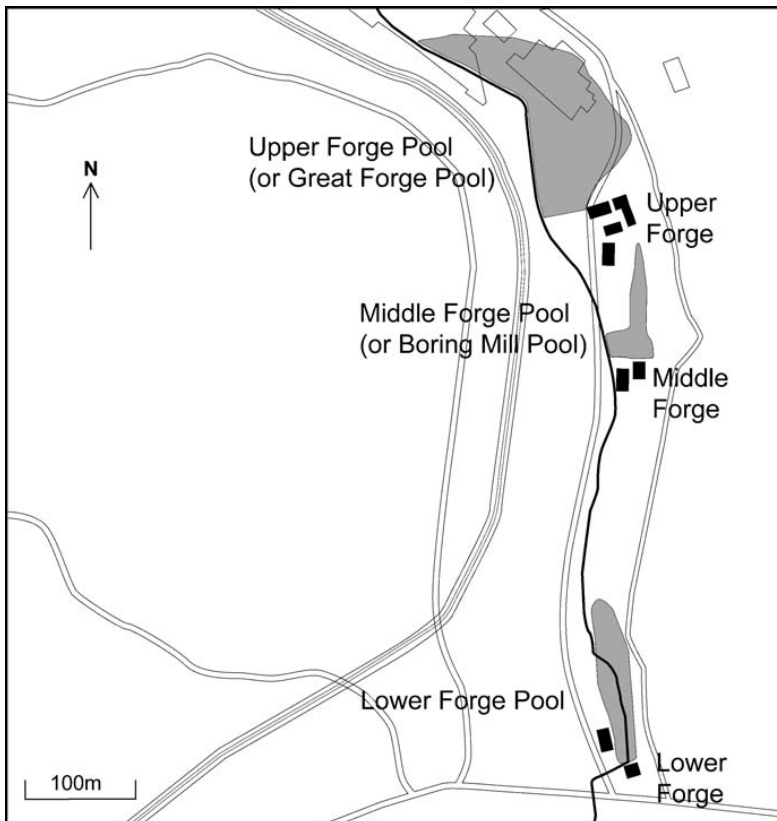


Figure 5.  
Map showing  
the lower part of  
Coalbrookdale and  
water-power features  
associated with the  
Lower Forge (also  
known as the Plate  
Forge or Hallen's  
Forge), Middle Forge  
(after 1734 the Boring  
Mill) and Upper  
Forge (also known as  
Great Forge, and  
before 1718 the  
Middle Forge)  
(Drawing by Sophie  
Watson and Paul  
Belford).



Coalbrookdale works.<sup>18</sup> The Boring Mill Pool was enlarged considerably at around this time by the addition of a large reservoir to its western side which not only helped supply the Boring Mill but also acted as a sump for water to be pumped back up the Dale to the Upper Furnace Pool.

The story of water recycling in Coalbrookdale goes back to the early 18th century, and was a means of overcoming the seasonal variation in water supply which made the summer months unproductive for both forges

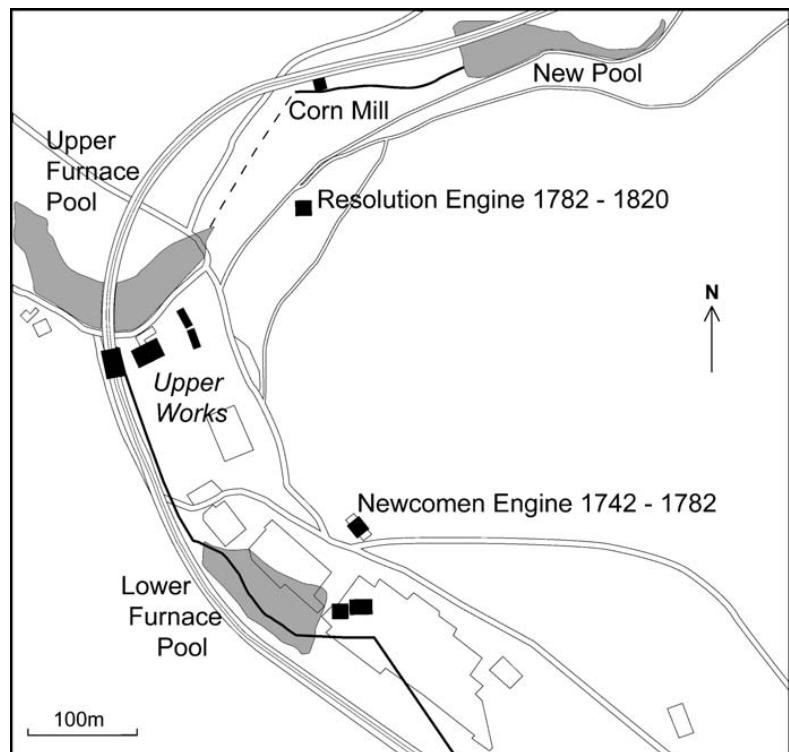
and furnaces. In the drought year of 1735 the Company installed horse-powered pumps to recycle water for the blast furnaces.<sup>19</sup> The horses were replaced in 1742–1743 with a Newcomen engine, built at Coalbrookdale and installed on a site overlooking the Lower Furnace (Figure 6).<sup>20</sup> It continued to work until its replacement, a Boulton and Watt steam engine named 'Resolution', was installed slightly further up the Dale in 1781–1782.<sup>21</sup> It was probably the installation of this more powerful engine that provoked the enlargement of the Boring Mill Pool, from where the water was pumped 'through a subterranean passage about half a mile [0.8km] in length to a pit at the top of the works 120ft [37m] deep'.<sup>22</sup> Even as it was being constructed, 'Resolution' was rendered obsolete by Watt's development of the first rotative engine (supplied to John Wilkinson in 1782), power from which could be applied directly without the need for water wheels. Nevertheless 'Resolution' remained in use until the 1820s, when it was observed that 'the great engine which supplied the deficiency of this stream is now taken partly down'.<sup>23</sup> Unfortunately no archaeological evidence for the necessary culverts and shafts for either engine has been revealed during this project.

The headrace of the Middle Forge or Boring Mill Pool was formed by the tailrace from the Upper Forge, also known as the Great Forge and occasionally — just to add to the confusion — the Middle Forge (Figure 5). The name 'Great Forge' reflected its importance under the post-dissolution ownership of the dynamic Brooke dynasty, during which Coalbrookdale had been transformed from a sleepy tributary into a substantial enterprise. The Upper Forge again had its origins in the 16th century, but by the

mid-1600s the site had been expanded by Sir Basil Brooke to include finery and chafery forges, a stamper mill, another forge, two furnaces, two steel furnaces, charcoal stores, house and stables.<sup>24</sup> Steel was being made here from 1619 until the 1680s.<sup>25</sup> The forge itself was extensively refitted in the early 18th century, with a new hammer in the 1720s and the conversion of the steel furnaces to a malthouse by the 1730s.<sup>26</sup> Unlike the pools further downstream, the Upper Forge pool was a 'cross-valley' pond; consequently there were two sets of sluices on the dam itself, the water supply to the forge on the eastern end and the overflow sluices on the western end. The Upper Forge continued to be at the forefront of technological innovation in the 18th century, as the site of the Cranage brothers' experiments in 'Potting and Stamping' as a means of refining iron using mineral fuel.<sup>27</sup> By the mid-19th century ironworking and other industries at the forge had declined, although water power was still employed into the early 20th century to power a grist mill.<sup>28</sup>

#### *The Upper Dale*

The Upper Forge Pool was fed directly by the tailrace from the Lower Furnace complex (Figure 6). The Lower Furnace pool almost certainly predated the construction of the Lower Furnace itself *c.* 1715, and may have originally been referred to as the Upper Forge pool.<sup>29</sup> Inventory evidence suggests that the forge was out of use by 1718, when the complex contained the blast furnace, bellows house, mould room, 'pigg yard', a 'new warehouse' and the 'old forge', as well as the 'Copper Ware House' and 'Copper House'.<sup>30</sup> The references to copper are intriguing, and it has been suggested that copper smelting and brass manufacture took place here from 1703 to 1714;<sup>31</sup> moreover a large quantity of copper ore was discovered during archaeological excavations in 2005 at the Upper Forge site to the south.<sup>32</sup> Traces of the forge, together with associations with non-ferrous metalworking, were swept away by the creation of the 'New Furnace' complex, later known as the Lower Works. In the mid-18th century the complex was mainly geared to the production of castings, with several moulding houses surrounding the Lower Furnace itself.<sup>33</sup> By the 1780s, however, the Lower Furnace site also incorporated a water-powered grinding mill which appears to have remained in use well into the 19th century.<sup>34</sup> Indeed grinding operations on site continued well after the abandonment of the furnace *c.* 1818–1820.<sup>35</sup> From the 1850s the expansion of the Upper Works site to the south, including the construction of the Erecting Shop, began to encroach on the pool, which was completely filled in by 1902.



The Upper Furnace Pool (Figure 6) certainly dates from the construction of the Upper Furnace in 1658, but may well have earlier origins. However the earliest documentary reference is its appearance on the 1753 map.<sup>36</sup> This shows the pool being fed by two converging streams, the Lightmoor Brook to the east and Loamhole or Lydebrook to the west, and the tailrace from this pool culverted beneath the works to supply the Lower Furnace pool downstream. Subsequent mapping shows the enlargement of the pool to the north and west, until reaching more or less its current form by the later 18th century.<sup>37</sup> As with the other sites on the system, the pool seems to have originally powered a forge, and this structure is shown as 'Old Forge' in 1753, located at the south-western corner of the pool.<sup>38</sup> The forge had disappeared by 1805.<sup>39</sup> Throughout its chronicled existence the pool supplied water to at least two elements of the complex — the furnace and forge during the late 17th and early 18th centuries, and the furnace and workshops until the early 19th century. The furnace itself was probably out of use in 1818, and was 'not worked' in 1821.<sup>40</sup> After renewal of the lease in 1827, the Coalbrookdale Company relocated smelting operations to its other sites and Coalbrookdale began the final stages of its decline, becoming a centre for the manufacture of small castings. In 1815 it was noted that 'all the machinery [was] old and clumsy and all the works seem to be conducted upon the old plans of forty years ago'.<sup>41</sup> Water power continued to be used at the upper works complex throughout the

*Figure 6. Map showing the upper part of Coalbrookdale and water-power features associated with the Lower Furnace (before 1718 the Upper Forge), Upper Furnace (also known as the Old Furnace or Darby Furnace) and New Pool (Drawing by Sophie Watson and Paul Belford).*

19th and into the 20th century. The most significant intervention during this period was the construction of the Great Western Railway in the 1860s, the curve down into the Coalbrookdale valley being nicknamed the 'Golden Mile' due to the expense of constructing an elevated railway on a sloping curve whilst avoiding disruption to the works and pool underneath.<sup>42</sup>

Difficulties with water supply during the 1730s have been mentioned above. This problem was caused by the ongoing and ultimately unsustainable development of the ironworks, with an increasing number of features being powered from the same source. This was evidently a problem for the Upper Furnace site in the late 17th century. From 1696 the Upper Works was let to Shadrach Fox, who may have begun experiments there in smelting iron with coke.<sup>43</sup> c. 1698 he dammed the Lightmoor brook upstream of the Upper Furnace Pool to create the New Pool (Figure 6) to act as a reservoir for the furnace complex.<sup>44</sup> This was the scene of a tragic accident in 1756, when Darby Ford, the grandson of Abraham Darby I, 'fell into the New Pool and was drown'd, poor young man about 22 years of age'.<sup>45</sup> For most of the 18th century it remained in use as a supplementary reservoir, but by 1805 a corn mill had been installed between the New Pool and Upper Furnace Pool (Figure 6).<sup>46</sup> This corn mill was located to take advantage of the water pumped up the dale by the 'Resolution' engine, which was returned to the system just upstream. The mill, which was apparently installed by 'Abraham Darby . . . for his workers', was rebuilt c. 1821 and remained in use until the 1870s.<sup>47</sup> Its demise may have been precipitated by the construction of the railway in 1864, which severely truncated the New Pool, effectively halving its capacity.

#### ARCHAEOLOGICAL FIELDWORK

Archaeological investigation and recording was incorporated into the survey and inspection of the culverts, and the restoration of the extant pools and their associated sluices and water management features. Work at Loamhole Dingle, the New Pool and the Lower Furnace Pool did not entail any archaeological involvement and are not described here.

#### *Culvert Survey*

The culverting of the Coalbrookdale watercourse system had begun in the first part of the 18th century, and was already well advanced by the beginning of the 19th. In 1776 a visitor described the Coalbrookdale Company's system of ' . . . Conduits for water to turn the Mills, which . . . serve instead of

Races, and answer much better, as less Water is wasted both by the exhalations of the Sun, and what the Ground would Absorb'.<sup>48</sup> The culverted tailrace beneath the Upper Works is evident on the 1753 map.<sup>49</sup> The complexity and extent of the culvert system was however only fully revealed during the culvert survey undertaken in 2000 and 2001. This work was undertaken by OnSite Surveys of Worcester, who were commissioned by BTW to investigate the structural integrity of the network of culverts. This internal inspection was intended to provide baseline engineering and hydrological data about the nature and condition of the culvert system. However, this work was guided from the outset by archaeological considerations, and the survey methodology was modified to take account of archaeological requirements.

Prior to the survey the OnSite team had a day of training with Ironbridge Archaeology staff which included historical background information as well as training on the identification of building materials, bonding patterns, mortar types and so on. The survey itself was divided into a series of sections, defined by access points. The location of the culvert was recorded in plan using a radio transmitter, where signal could be obtained, and the location of features within each section were denoted by their distance from the entry point (chainage). Recording was principally photographic, with supplementary descriptive notes. An archaeologist was present throughout fieldwork.

The results of the culvert survey are shown in Figure 7, which outlines the overall phasing of the system. Perhaps the most striking finding was the relatively late date of the present fabric, most of which dates to the second part of the 19th century. This can be explained in part by the pattern of infilling of the pools, but is also the consequence of the agreement reached in the 1860s to 'replace and reconstruct the . . . culverts' affected by the building of the railway.<sup>50</sup> The earliest extant fabric was found on the section of the system least affected by either the railway or the 19th century expansion of the works, namely on the stretch between the New Pool and the Upper Furnace Pool. This section of culvert was relatively small in section, being 1.24m wide and only 1.37m high. Two phases were identified. The first phase corresponded with the area where there is a 'gap' in the depicted watercourse on the 1805 map, broadly in the middle of this section and upstream of the corn mill. This was built entirely of stone blocks (Figure 8). Culverting to the east and west of this had taken place later, as the tunnel was a brick arch overlying stone blocks (Figure 9). It seems likely that the culverted section was an original part of the design of

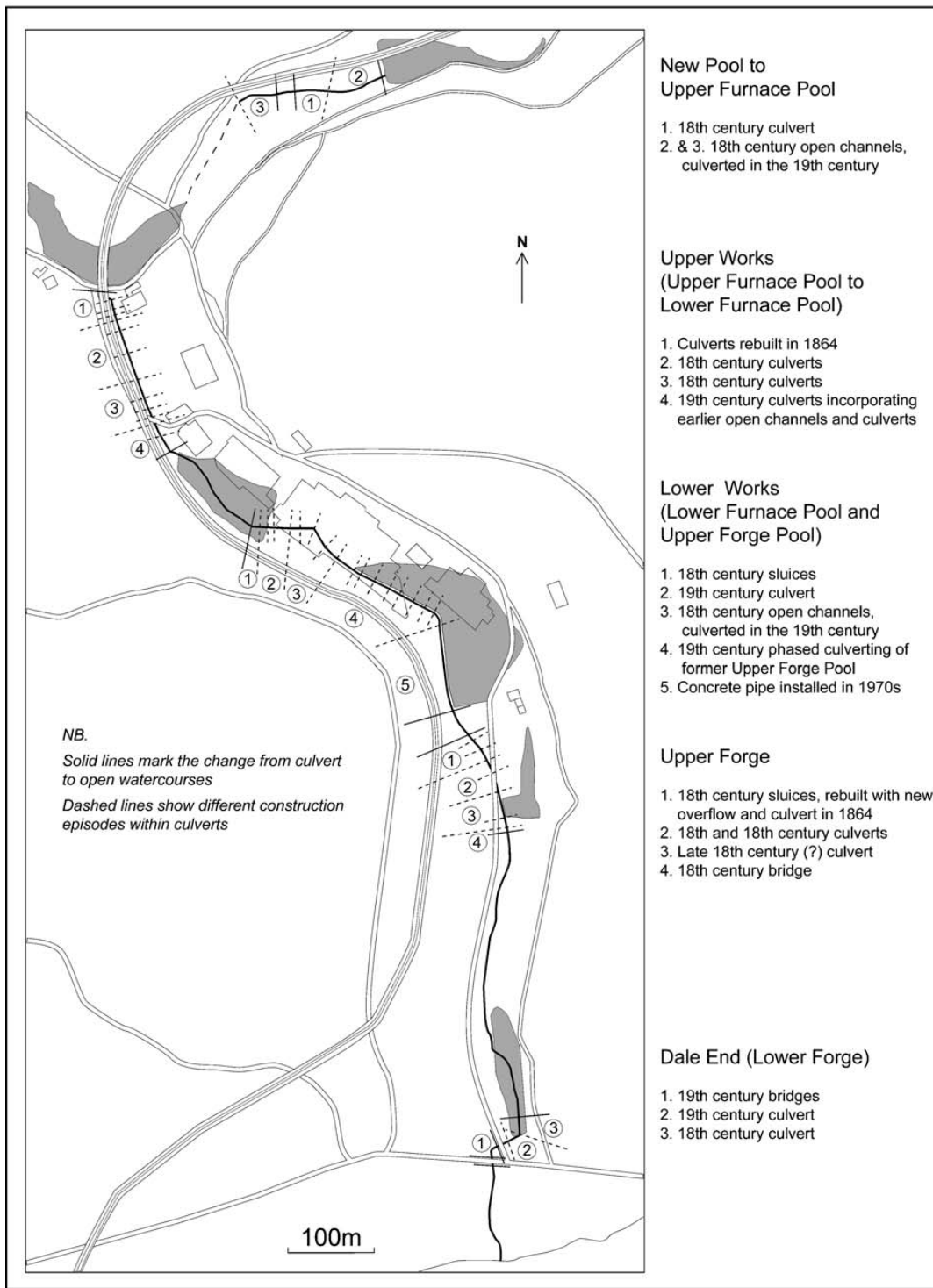


Figure 7.  
Map of the culverted watercourse system as surveyed in 2000, and 20 showing principal construction and development. Historic pools are shown shaded (Drawing by Paul Belford, Sophie Watson and William Mitchell).

this section of watercourse, which probably dated to the 18th century.

There is insufficient space here to detail all of the various phases of the culvert system revealed by the survey.<sup>51</sup> However, there were a number of good examples where surveyed archaeological evidence was supported by the available documentary evidence. Perhaps the most interesting sequence was the infilling of the Upper Forge Pool. A pencil sketch of 1789 shows the pool at least partly filled in,<sup>52</sup> and a series of views during the 19th century,

together with map evidence, confirms gradual infilling (Figure 10). Our survey found that the line of the culvert closely followed the original western edge of the old pool. Three broad culverting episodes were identified. The earliest, immediately downstream of the Lower Furnace site, probably coincided with the abandonment of the furnace *c.* 1815 (see below). The final phase, large-diameter concrete pipe containing the southernmost third of the former extent of the pool, took place during the 1970s. In contrast the 82.5m-long

Figure 8. Stone-built culverted watercourse between the New Pool and the Upper Furnace Pool, one of the earliest elements of the culvert system dating to the 18th century (Photograph by OnSite Surveys, reproduced courtesy of the Borough of Telford and Wrekin).



Figure 9. Stone-built open watercourse later culverted in brick, between the New Pool and the Upper Furnace Pool (Photograph by OnSite Surveys, reproduced courtesy of the Borough of Telford and Wrekin).



central section comprised a brick-built culvert measuring 3.0m wide and 2.0m high. This was constructed in a series of abutting sections each between 9.0 and 18.0m in length. This seems to represent a piecemeal response to the infilling of the pool with spoil, tipping of which evidently took place on the eastern side and gradually encroached to the west. When the encroachment became critical to the water flow then a new section of culvert was installed. Some of this structure was very sophisticated, with cast iron reinforcements (Figure 11). A similar pattern of development, although less extensive, was apparent in

the Lower Furnace Pool to the north, and suggested similarly *ad hoc* landscape alteration.

#### Boring Mill Pool

The Boring Mill (Middle Forge) Pool was not only one of the earliest features of the water-power system, but was also critical to the development of the 18th-century water-recycling system. Some exploratory coring work in the pool was carried out in 2003, but this was not successful due to the presence of slag deposits. Excavation as part of the a separate research project took place in 2004 and 2005, recovering in the process some 16th-century pottery, but it was not until August 2005 that a more robust investigation of pool deposits was achieved. The pool was found to contain at least 2.5m depth of silt. Despite some modification, notably to the headrace, sluice and tailrace features in the 19th century, the overall shape of the original pool had survived intact. The extension of the pool to the west in the 1730s was infilled by the later 19th century. Archaeological excavation in this area recovered a large quantity of domestic ceramics datable to the 1880s and 1890s. Some timbers were recovered from the pool itself, but were not suitable for radiocarbon or dendrochronological dating.<sup>53</sup> Desilting of the pool as part of the Coalbrookdale Watercourses Project removed only the upper 0.5m of silt, so there is still potential for future recovery of environmental and dating evidence from this important site.

#### Upper Forge Pool Sluices

The sluices at the Upper Forge Pool were the final stage of restoration works to be

Figure 10. View of Coalbrookdale by J.C. Bayliss, engraved c. 1845, showing the progressive infilling of the Upper Forge Pool with slag and spoil from the Upper Works. This process continued until the 1960s (Reproduced courtesy of the Ironbridge Gorge Museum Trust (IGMT 1984.6351)).



completed as part of the Coalbrookdale Watercourses Project. Tree clearance and preliminary enabling works took place in 2005, and this also included an archaeological evaluation of the site.<sup>54</sup> This work revealed a great deal of hitherto unknown information about the structure, which was in an extremely poor state of repair (Figure 12). Parts of the extant structure were 18th century in origin, and indeed the main sluice mechanism from this period was still *in situ*. However the upper parts of the watercourse walls, as well as the culvert into which it flowed, were substantially rebuilt as part of the railway-related agreement to ‘reconstruct the flood-gates, sluices and culverts’ in the 1860s.<sup>55</sup> The tunnel downstream of the sluices supported the road up to the former Coalbrookdale railway station. As noted above, infilling of the Upper Forge Pool had been gradually ongoing since the mid-19th century, and the forge itself had abandoned water power in the first half of the 20th century. Road realignment in the 1930s effectively truncated the original dam, cutting off the forge from its water supply forever. The continuing deposition of spoil by the Coalbrookdale Company until the late 1970s buried surviving features.

This component of the watercourses restoration was perhaps the most difficult to resolve. Three main elements were required — the removal of slumped material and overburden, the conservation of the historic fabric and the creation of new water management features. The proximity to the railway entailed protracted conversations about access with Network Rail, and modelling of various solutions to water management required continuous consultation with the Environment Agency (EA). An early proposal agreeable to the EA involved the infilling of the bypass channel and the creation of large concrete ‘steps’ within the main flow channel that would have seriously compromised the historic integrity of the structure. It was to BTW’s credit that they rejected this in favour of a more complex but ultimately more sensitive solution. The process was made more difficult by very restricted access, with heavy plant only able to work on one side of the watercourse, and working around the inconveniently-placed historic brick pillars marking the entrance to the former railway station.

It was during this protracted multi-agency design and consultation process that archaeological investigations took place which ultimately inspired the final solution. Analysis of surviving brickwork in the bypass channel revealed that this channel, thought to have been originally an open watercourse and possibly one created by erosion, was in fact the collapsed remains of a brick arched culvert which had been rebuilt in at least two phases

in the 18th and 19th centuries. At the same time, trial trenching discovered a brick-built overflow channel to the east of the sluice structure. Further exploration found that it had originally ran for at least 15m along the top of the old dam wall, and although the connection between it and the culvert had been destroyed by structural collapse and erosion, the overall layout was evident. BTW engineers used this information to design a solution, reconstructing the overflow channel and creating a new culvert bypassing the main sluices. The restoration and construction work was undertaken in early 2006 (Figure 13). The installation of a weir meant that most of the water flow could be diverted into this new culvert, thus removing the main threat to the upstanding sluice structure and obviating the need for expensive and intrusive remediation works. The proof of this particular pudding came in the exceptional summer flooding in 2007, when the ‘one in one hundred year event’ for which the new structures had been designed actually occurred. Had the restoration work not been undertaken, there is no doubt that the historic sluice structure would have been lost.

#### *Lower Furnace Pool Sluices*

The Lower Furnace Pool sluices, like their counterparts to the south, contained both 18th- and 19th-century fabric. Unlike the sluices for the Upper Forge Pool, however, these originally served both to control water supply to the ironworks and acted as an overflow system. Work on this site, which remains in the ownership of Aga-Rayburn (the successor to the Coalbrookdale Company), was undertaken in winter 2003–2004. This was one of the most dramatic structures on the watercourse system, with a fall of over 6m from the top of the sluices to the base of the culvert arch. In 1801 this was described as a ‘fine cascade, the water falling into the mouth of a large aqueduct’.<sup>56</sup> Since the mid-18th century the pool had been used to power grinding wheels as well as the furnace bellows. Even after the furnace had gone out of use, the split water-power arrangement was evidently retained into the late 19th century, when the pool continued to provide power for ‘two waterwheels’ — one powering charcoal-grinding machinery, ‘lathes and circular saws’; the other driving ‘grindstones and . . . wheels for glazing and polishing’.<sup>57</sup> The divergence of the two headraces in this system was shown quite clearly on the 1786 and 1794 maps, and was also noted during the culvert survey.<sup>58</sup> This found a tributary entering the main culvert to the south of the Lower Furnace site (Figure 14). Map regression analysis revealed this to be the tailrace from the grinding wheels re-entering the main system, and analysis

*Figure 11.*  
Iron-framed brick  
culvert section of the  
former Upper Forge  
Pool, which was  
culverted piecemeal  
during the expansion  
of the works in the  
19th century  
(Photograph by  
OnSite Surveys,  
reproduced courtesy  
of the Borough of  
Telford and Wrekin).



*Figure 12.*  
Upper Forge Sluices  
in 2005, prior to  
restoration. The main  
sluices were blocked  
by landslip and other  
debris, and the water  
had forced its way  
past the structure,  
collapsing an early  
overflow culvert to the  
east (Photograph by  
Paul Belford).



*Figure 13.*  
Upper Forge Sluices  
during restoration  
work in 2006. The  
original overflow  
structure is being  
rebuilt to the original  
design, and the culvert  
into which it originally  
fed, which had  
collapsed after many  
years of neglect, was  
reinstated to modern  
specifications  
(Photograph by Paul  
Belford).



of the fabric suggests that this was probably constructed in the second quarter of the 19th century, following the abandonment of the Lower Furnace by the 1820s.<sup>59</sup>

There was little remedial construction work required on this part of the system, the main work in this area involving the clearance and

restoration of the watercourse to the north (on land owned by the Ironbridge Gorge Museum Trust) and the removal of debris from the sluices themselves. This was a protracted operation which was monitored archaeologically. The cavernous single arched entrance to the culvert below the sluices narrowed down within 6m to two much smaller-diameter culverts. Debris had blocked the eastern one completely, and was also seriously compromising the efficiency of the western tunnel. The fascinating process of clearance resulted in the recovery of a variety of wooden foundry patterns; some substantial structural timbers; a large intact section of line shafting and a series of line shafting fragments (including various wheels and pulleys); several ladles, tongs and other tools; some crucibles and other miscellaneous foundry debris as well as a wide variety of non-industrial debris. Whilst the majority of it was of fairly recent origin, some of this had certainly been discarded in the early 20th century and probably represented structures that were older still. All significant finds were recorded, but none was suitable for dating or further analysis and so none were retained.

#### *Upper Furnace Pool*

The Upper Furnace Pool was the largest single component of the watercourses project, and absorbed the bulk of funding. The work on this site took place from spring 2004 into autumn 2005, and included work upstream installing silt traps, the refurbishment of the sluices and the construction of new roads, paths and bridges, as well as the main work of desilting the pool itself. Only the upper 2 or 3m of silt was removed. Archaeological investigation, monitoring and recording accompanied all phases of construction works.

The pool itself was the only body of water on the Coalbrookdale system to have survived more or less intact throughout its existence. This was partly due to the continuing partial use of water power into the 20th century, and its subsequent industrial function as a reservoir for the boilers of the Coalbrookdale Company.<sup>60</sup> Its presence as a picturesque landscape feature, noted since the 18th century, may also have contributed to its survival.<sup>61</sup> In the post-war period, however, with the decline of the Upper Works, the pool fell into desuetude and began to silt up. The process of silting was exacerbated by the practice since the 1960s of tipping fly-ash from the Ironbridge Power Station in the upper reaches of Loamhole Dingle.<sup>62</sup> The Upper Furnace Pool was partially cleared in the late 1970s,<sup>63</sup> but resilting rapidly occurred and by the early

21st century the pool was entirely infilled. Due to access and other problems it proved impossible to remove the tipped ash from upstream, and so a series of easily maintained silt traps were constructed in Loamhole Dingle during 2003 in order to prevent future resiltting.

The programme for the 2004–2005 works on the Pool required management of a range of complex issues. A serious concern was the stability of the dam wall itself which was already known to contain a number of voids and areas of differing construction.<sup>64</sup> The logistics of removing the silt was problematic, due to restricted site access and environmental concerns, as well as the ever-present railway. A number of approaches were considered, including the possibility of removing the silt directly onto trains waiting on the viaduct above, but removal by road was eventually decided upon. This entailed the construction of a haul road into the centre of the pool, supporting an excavator which gradually worked back to the edges of the pool (Figure 15). The haul road was largely removed as the project continued, but a section of it was retained around the northern edge of the pool to facilitate future maintenance (Figure 16).

Archaeological work began in 2003 with a series of cores taken in the pool by Dr Tim Mighall, then Senior Lecturer in Physical Geography at the University of Coventry



*Figure 14. Brick culvert sprung from stone walls to the south of the Lower Furnace site. The tunnel visible in the right-hand (eastern) wall, adjacent to the upturned crate, is the tailrace to the grinding wheels returning to the main watercourse, fossilised in the culvert structure (Photograph by OnSite Surveys, reproduced courtesy of the Borough of Telford and Wrekin).*

(Figure 17). The results of these, together with boreholes, showed that the pool itself contained over 17m of silt at its deepest part to the north-west of the Darby furnace.<sup>65</sup> The height of the dam at this point was only 8m above the 17th-century ground level. This suggested that the pool itself pre-dated the construction of the furnace in 1658, and that the history of the site is potentially considerably older even than the 17th century. It seems most likely that a natural pool had formed at the confluence of the two streams, and that this was enhanced during the first phase of the development of the watercourses during the post-dissolution period. Unfortunately samples taken from the cores were not suitable for radiocarbon dating, and environmental evidence was inconclusive.<sup>66</sup> However, these lower levels of silt remain undisturbed and there is considerable potential for further



*Figure 15. Upper Furnace Pool during the first phase of desilting operations in 2004. The haul road has been constructed into the centre of the pool (in front of the viaduct) to enable plant to access the southern part of the pool (Photograph by Paul Belford).*

*Figure 16. Upper Furnace Pool after the second phase of desilting works in 2005. The central haul road has been removed, and operations were undertaken along the road along the northern side of the pool (Photograph by Paul Belford).*



*Figure 17. Coring being undertaken in the Upper Furnace Pool in 2003, prior to restoration of the pond (Photograph by Paul Belford).*



work in this area. One interesting discovery was the nature of the foundations of the pillars of the railway viaduct, the bases of which appear to have been built on piles of stone laid down on the pool bottom. Other archaeological work included monitoring the refurbishment of the sluices. These were overflow sluices which had been built entirely as new in conjunction with the railway viaduct; the original overflow appears to have been slightly to the east and was encroached upon by the line of the viaduct. Part of this original structure survives as a void in the dam wall.

#### *Interpretation*

The final element in the Coalbrookdale Watercourses Project was a scheme of interpretation for the system as a whole. This was designed by consultants engaged by BTW, in close co-operation with the Ironbridge Gorge Museum, Severn Gorge Countryside Trust and other stakeholders. Local community consultation, in particular with local schools, was extremely important and was integral to the development of some features. The interpretation strategy involved a trail with a hierarchy of 'waymarkers' at points of interest, together with supporting literature and interpretation panels. The ultimate scope of the stand-alone interpretation strategy was limited by funding constraints; nevertheless it did incorporate physical interpretation of archaeological features on the ground surface, as well as data recovered from other aspects of the archaeological work. The site

of 17th-century steel furnaces — the earliest of their type in England — excavated in 2004 and 2005 by Paul Belford and Ron Ross as part of a separate but adjacent programme of research excavations, was landscaped to show both the furnaces and associated features (Figure 18).<sup>67</sup> Other landscaping works included the area around the Upper Furnace Pool and a new viewing platform and access at the Upper Forge sluices.

#### CONCLUSIONS

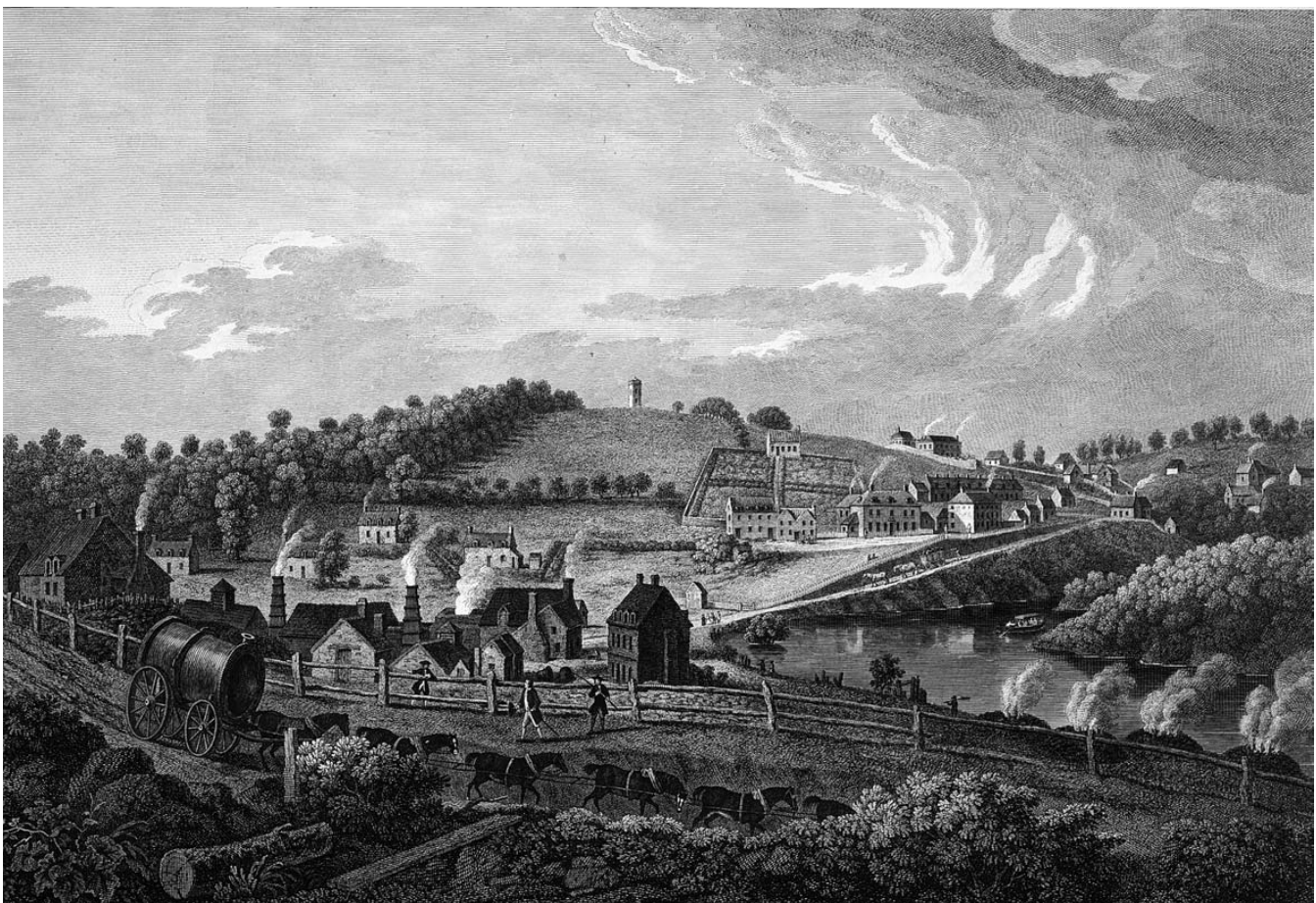
The multi-agency and multi-disciplinary nature of this project has been extremely rewarding for all parties. The long-term nature of this project was an important factor in its success from both engineering and archaeological points of view. Everyone had the rare luxury of time to think through the implications of their work. For the engineers this meant being able to consider several options both for the ultimate design and for working methods and implementation. From an archaeological point of view there was time to consider the watercourses in their historic landscape setting, as well as being able to draw in the results of other studies that were not conceived as part of the project. As with the many other archaeological projects that we have undertaken in the Ironbridge Gorge



Figure 18. Site of 17th-century steel furnaces marked out as part of the watercourses interpretation strategy — tourist's-eye view (Photograph by Paul Belford).

World Heritage Site over the last few years, there is a growing realisation that even after more than 30 years' research, we are still only scratching the surface of understanding. As with other elements of the historic landscape we are indebted to the near-failure of 19th-century industry for the survival of large parts of the watercourse system. When the Coalbrookdale Company reached an agreement with the Great Western Railway in 1864 to 'replace and reconstruct the floodgates, sluices and culverts' affected by the railway construction, the use of water power should have been in its final years.<sup>68</sup> But, as with the failure of the Dale Dyke reservoir in Sheffield in the same year, reconstruction of an outdated technology not only prolonged its

Figure 19. Francois Vivares' engraving of Coalbrookdale, 1758 (Reproduced courtesy of the Ironbridge Gorge Museum Trust (IGMT AE185.769)).



use but also fossilised elements that would otherwise have been lost.<sup>69</sup> Thus the railway enabled the survival of the watercourses, even though the system itself was close to redundancy.

More significantly, it has been possible to re-evaluate the notion of what makes an industrial landscape. The well-known 1758 engraving by Vivares (Figure 19) has often been used to illustrate the industrial activity of 18th century Coalbrookdale.<sup>70</sup> Indeed a detail of it features on the cover of Arthur Raistrick's 1953 book, a book which ultimately precipitated the (re)creation of the Coalbrookdale story as what David Cransstone has called the 'origin myth' of industrial archaeology.<sup>71</sup> However, on the cover of Raistrick's book, and in the minds of everyone who has studied the Coalbrookdale landscape, the engraving has been cropped to show only the bottom left-hand corner. This mass of industrial buildings and chimneys, together with the vast cast-iron cylinder, has been the focus of all interpretations of Coalbrookdale, painstakingly lining up

*Figure 20.*  
*The outflow of the culvert between the New Pool and the Upper Furnace Pool, probably constructed in the late 18th century (Photograph by Paul Belford).*



chimneys and buildings in the engraving with features on 18th-century maps and drawing conclusions about the efficiency of the iron-works and the development of technological processes.

However, when we look at the engraving as a whole a very different picture emerges. At the true centre of the image is a tower on top of a hill — a folly, not a functional building. Leading down from this is an avenue of trees, drawing the eye to a formal walled garden associated with some pleasantly proportioned gentry housing. These houses in turn overlook the Upper Furnace Pool, which is clearly being used for pleasure as much as for industry — indeed the sluice mechanism is not depicted at all, whereas the picturesque view off/from the houses and a refined boating party are emphasised. This view has been lost since the 1860s due to the intervention of the railway, and its significance has hitherto been overlooked. In similar vein was the discovery that the earliest extant section of culvert was between the New Pool and the Upper Furnace Pool. In the late 18th century this was a sparsely inhabited part of the dale, with no ongoing or future expansion of industrial premises. In other words no purely functional argument existed for creating a culvert as opposed to an open watercourse. The architectural treatment of the outflow of this culvert is far from an industrial aesthetic however (Figure 20), being more reminiscent of the contemporary enthusiasm for cascades, grottoes and, as Humphrey Repton described them, other 'wild and romantic situations . . . [with] rocks, and dashing mountain-streams, or deep umbrageous dells'.<sup>72</sup> This deliberate manipulation of an industrial landscape to conform to prevailing notions of landscape is not without precedent. The elaborate network of canals around Boulton and Watt's neo-Palladian Soho Manufactory (1762–1767) were in fact water supply reservoirs, and Coalbrookdale slag was used to create the grotto in the Goldney garden in Bristol (1737–1764) — the Quaker Goldney family being closely associated with the Darby family and the development of the Coalbrookdale complex.<sup>73</sup> Moreover, there was a long-standing Quaker enthusiasm for water features and water gardens which can be traced back to the 17th-century origins of the movement.<sup>74</sup>

An examination of these issues was the central theme of a paper presented by the author in 2003, and subsequent discussion resulted in the development of the Upper Coalbrookdale Landscape Project from 2004 onwards.<sup>75</sup> Further work is ongoing, since it is evident that the role of the Coalbrookdale watercourses as part of a 'designed landscape' was just as significant as any strictly functional role as an industrial feature during the

18th and early 19th centuries. This past perception is perhaps the one which has the most relevance for the future, for now that water power is no longer needed for industry, the environmental component of the watercourse system is valued more highly than its industrial heritage. Legends of the watercourses still live on — according to children of Coalbrookdale School who visited in 2005, a monster waits in the culvert below the Upper Forge Sluices to gobble up naughty children who dare come too close to his lair.

#### ACKNOWLEDGEMENTS

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