Butterley Spillway

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BUTTERLEY SPILLWAY

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INTRODUCTION

Engineering works at Butterley Spillway in 2017 have focused attention on this historic structure. The spillway, completed in 1906, is a stepped channel that runs down the bank of Butterley Reservoir. As well as acting as a safety feature, the spillway was designed by the renowned engineers T & C Hawksley to be an attractive feature symbolic of the civic ambition of the Huddersfield Corporation.

Following damage in 2002 caused by a minor flood and inspection of the structure under The Reservoirs Act 1975, remodelling of the original structure was necessary to avoid the risk of harm to the public. Yorkshire Water has worked with the local interest groups and Kirklees Council to secure the best possible degree of conservation of the spillway within safety parameters.

This booklet provides an introduction to Butterley Spillway, with information about the spillway and reservoir in the context of the local area. The development of the reservoirs around Marsden and an introduction to the history of spillways is outlined along with the circumstances of the construction of Butterley Reservoir.

Butterley Spillway is a beautiful and much loved structure which should inspire and delight local residents and visitors for years to come.

MARSDEN AND THE WESSENDEN VALLEY

Marsden with Bank Bottom Mill

The village of Marsden in the Kirklees district of West Yorkshire is located at the confluence of the River Colne and Wessenden Brook. Marsden is surrounded on three sides by the high moors of Marsden Moor and Meltham Moor, over 2000 hectares of which are managed by the National Trust. The scenery around Marsden is spectacular and has attracted visitors for generations. The major town of Huddersfield lies 11 km to the east of Marsden.

The British Geological Survey records that the area around Marsden is underlain by bedrock geology consisting of a variety of sedimentary rocks belonging to the Millstone Grit group that characterises much of the Pennines. Specifically, Butterley Spillway is underlain by rocks of Upper Kinderscout Grit, dating from the Carboniferous period.

Butterley Reservoir is the lowest in a series of reservoirs situated in the Wessenden Valley which runs south from Marsden. The reservoirs are fed by rainwater falling on roughly 15 square kilometres of moorland. The catchment area of the reservoirs is bounded by the round hills White Moss and Black Moss in the west, the A635 to the south and by the hill West Nab in the east.

The highest reservoir in Wessenden Valley is Wessenden Head. Wessenden Brook connects Wessenden Head Reservoir to Wessenden Old Reservoir, and then into Blakeley Reservoir and finally Butterley Reservoir. Swellands Reservoir, situated on Black Moss, also feeds into Butterley Reservoir. All of these structures sit within the northern part of the Peak District National Park, with the dam of Butterley Reservoir forming the northern limit of the Park. Butterley Spillway lies to the north of Butterley dam and therefore lies just outside of the National Park.

From the reservoir a 24 inch diameter (over 60 cm) main provides water for domestic and commercial purposes and runs through Marsden, Lingards, Linthwaite and Golcar to the Longwood Reservoirs just outside Huddersfield.

Water from the spillway and scour portal flows through the former Bank Bottom Mill and other mills in Marsden before joining the River Colne, which runs parallel to the Huddersfield Narrow Canal. Both waterways pass through Huddersfield, before the Colne joins the River Calder which flows to the south of Dewsbury and Wakefield. The Calder joins the Aire at Castleford, and the Aire in turn joins the Ouse near Goole. The water ultimately discharges into the Humber Estuary.

Wessenden Head (near) and Wessenden Old (far) Reservoirs

EARLY HISTORY

Pule Hill seen from above Butterley Reservoir

The earliest known archaeological remains in the Marsden area are scatters of flints from the Mesolithic period (8500–4000 BC). Mesolithic flints have been recovered from Pule Hill overlooking Butterley Reservoir. Evidence for Roman activity includes an inscribed Roman stone altar found at nearby Longwood in 1881.

In 1067 as part of a gift of 204 manors, William the Conqueror gave the land of the Colne Valley to Ilbert de Lacy, Lord of Pontefract. De Lacy was a Norman, and as well as holding Pontefract, his principal castle was at Lassi (that is, Lacy) in Normandy. Throughout the medieval period (1066–1500) the Marsden area was a hunting ground known as a 'forest' although the area was probably not heavily wooded.

A chapel was established in the 15th century, at which time Marsden was split between the parishes of Almondbury and Huddersfield and Holmfirth was the principal town in the area. Until the onset of the Industrial Revolution, the area of Marsden retained an agricultural character with scattered farmsteads across the landscape. The population were dependent on two livelihoods: textiles and agriculture.

INDUSTRIAL HISTORY

The area around Marsden was sporadically settled until the development of a central village in the 17th century. Marsden grew throughout the Industrial Revolution, with highly skilled woollen workers drawn from surrounding farms into the new woollen mills.

In 1710 Marsden's first fulling mill was established at Hey Green, built by Robert France. Fulling is also known as tucking or walking, and is a step in woollen cloth making which eliminates oils, dirt, and other impurities, and makes the cloth thicker and encourages felting. The other steps in the woollen making process, including carding, spinning and weaving, were done by families in farmhouses. Only the finishing of the cloth was done in the mill.

By the early 19th century, mills in Marsden included cotton mills, silk mills and woollen mills. All of the processes involved in woollen cloth manufacture had now been taken into the mills, and the workforce had followed. The population expanded to work in the many new textile mills, mainly living in terraced housing in the village.

Bank Bottom Mill and Butterley Reservoir

TRANSPORTATION

Until the mid-18th century, transport was limited to packhorses, as evidenced by two packhorse bridges which survive in Marsden. The growth of industry was encouraged by the installation of turnpike roads (built between 1759 and 1839), the Huddersfield Narrow Canal (1811) and the London and North Western Railway (1849). The Pennine hills split the industrial regions of Yorkshire from those in Lancashire, and each new transport link was drawn to the area by the Standedge crossing, one of the few routes across the uplands. Although the Standedge crossing is suitable for road transport, both the canal and the railway pass through long tunnels. The new lines of communication helped Marsden to grow by reducing costs and increasing the volume of goods that could be transported.

Standedge Tunnels

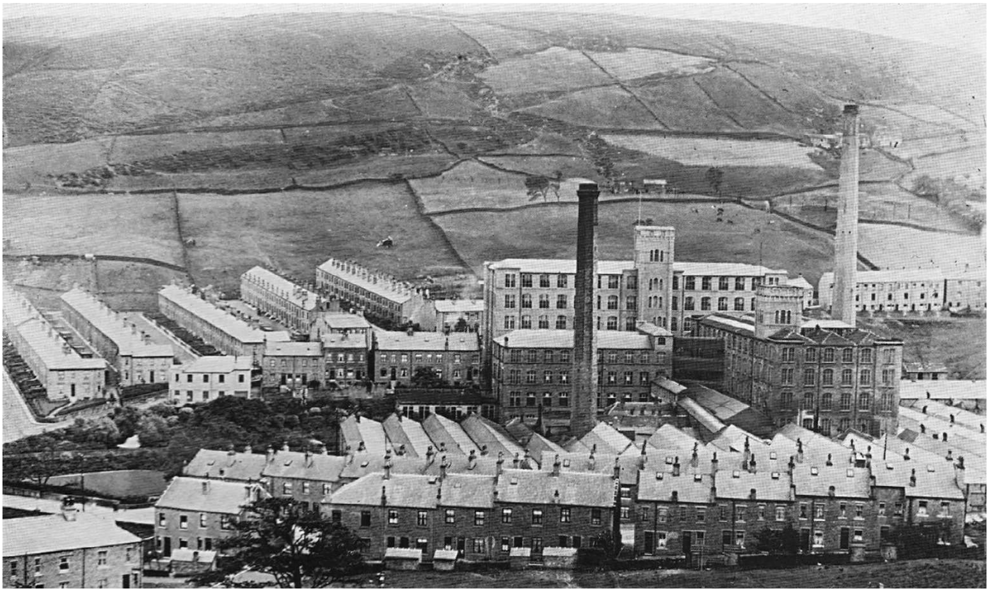
THE MILLS

Water power, a resource in plentiful supply in Marsden, was crucial to the Industrial Revolution. Mills across the country were initially driven by water power, although the development of steam power led many mills to swap to the new technology. The adoption of steam power was slower in Marsden, where mills continued to rely on the plentiful supply of water power. One of the reasons for the success of water power in Marsden was the reliability of the supply, guaranteed by the reservoirs that had been built above the village.

By 1830 there were seven water-powered woollen mills in Marsden. Later, the growth of steam power saw the expansion of the mills at Bank Bottom and Brougham Road which provided much of the employment in the village.

The 19th century was a period of massive change, with new machinery which threatened the livelihoods of workers. Marsden saw Luddite uprisings and machines were vandalised and destroyed. In 1812, William Horsfall, the owner of Ottiwells Mill in Marsden, was shot dead. Three men were hanged for the murder which ended the uprising.

Bank Bottom Mill, Marsden, c. *1923*



Children at work in a cotton mill

Conditions in the mills could be harsh. Throughout the 19th century successive Factory Acts passed in parliament sought to improve the conditions of workers. In the early 1830s there were calls for factory shifts to be limited to 10 hours per day. At this time Bank Bottom Mill belonged to Norris, Sykes and Fisher, who participated in a report into the use of children in factories. Children under the age of 10 were employed at Bank Bottom Mill and were used to piece together broken threads and to feed carding machines. This work was dangerous and took place on moving machinery with little thought given to safety. At Bank Bottom Mill everyone worked 69.5 hours a week, with days off on Sunday, Christmas Day, Good Friday and 'about six other half days during the year' according to the 1834 report.

Norris, Sykes and Fisher was not enthusiastic about the prospect of legislation on the question of child labour, declaring:

> **'We are of the opinion that any legislative interference will prove prejudicial to both masters and workmen, more especially so where only water power is used. There exists no necessity whatever [for legislation] in the mills employed in manufacturing woollen cloths...'**

Child labour at Lancaster Cotton Mills, South Carolina, USA. 1908

The report concluded that the employment of children for long hours led to permanent deterioration of their physical condition, the production of 'irremediable' disease and to the exclusion of adequate education. An Act was passed with measures including banning the use of children under the age of nine and limiting working hours for children under the age of 13 to eight hours per day. It was expected that children would work in two shifts to allow the adults to continue to work shifts of up to 15 hours per day (at Bank Bottom shifts appear to have been about 11 to 12 hours a day). Subsequent Acts demanded further improvements but the situation was clearly problematic.

At the same time that industrial activity was growing in Marsden, nearby Huddersfield was also expanding, and its continued development was dependant on a secure source of fresh water to serve both the industries and a growing population. During the late 19th to early 20th century, Marsden saw an increase in a different type of workforce as men arrived to build the Butterley and Blakeley Reservoirs.


John Edward Crowther

From 1876 Bank Bottom Mill (in this period sometimes known as Marsden Mill) was owned by John Edward Crowther Ltd. In 1914 during the First World War, Bank Bottom Mill was visited by King George V and Queen Mary as a mark of appreciation for the mill's contribution to the production of military uniforms. Conditions in the mill continued to be harsh, with a buzzer sounding across Marsden at 6:30 am. If workers were not at the mill by this time, they were not allowed to work and were not paid. During the great depression, economic realities forced the owners to impose shorter working hours. John Edward Crowther's wife died at about the same time and the mill owner took his own life. Production of woollen cloth at Bank Bottom Mill itself continued and only ceased in 2003.

The population and industry of Marsden continued to grow, with a population peak in 1921 of 5960. In the 1960s, however, the textile industry went into decline, and the mills gradually closed. In recent years, new private housing estates have been constructed in Marsden, predominately serving those commuting to the large cities of Manchester and Leeds.

Marsden was described by John Marius Wilson in 1870–1872 as:

> **'...a village and a township-chapelry in Almondbury and Huddersfield parishes, W. R. Yorkshire. The village stands on the river Colne, adjacent to the Manchester and Huddersfield canal and to the Manchester and Leeds railway, under the backbone of England, 4.75 miles E of the boundary with Lancashire, and 7.25 SW by S of Huddersfield; is a large place; and has a station on the railway, a post office under Huddersfield, and fairs on 25 April, 10 July, and 25 Sept. The chapelry comprises 5,016 acres in A. parish, and 2,050 in H. parish. Real property, £6,226; of which £319 are in quarries, and £150 in gas-works. Pop. of the A. portion in 1851, 2,153; in 1861, 2,027. Houses, 428. Pop. of the H. portion in 1851, 512; in 1861, 662. Houses, 138. The increase of pop. in this portion arose from the enlargement of a cotton mill, and from employment on the railway and in the woollen mills. The property is much subdivided. The manor belongs to Sir Joseph Radcliffe, Bart. Great part of the land is uncultivated moor and mountain. A tunnel of the railway, no less than 3 miles 61 yards long, begins a little W of the village; and a tunnel of the canal adjoins the railway one. A cotton factory, a silk factory, several woollen mills, an extensive iron foundry, and a large corn mill are in operation. The township adopted the local government act in 1860, and is now governed by a local board. A mechanics' hall, connected with a mechanics' institution dating from 1841, was erected in 1861, at a cost of £2,500; is in the Italian style; and has an apartment with capacity for 1,000 persons. Mr. W. Horsfall of Marsden, in consequence of having introduced improved machinery, was shot in 1812 by the Luddites. The living is a vicarage in the diocese of Ripon. Value, £174.* Patron, the Vicar of Almondbury. The old church is a plain, ancient, stone building; comprises aisles and chancel, with a belfry; and was reported in 1859 as bad. The new church was built in 1867, at a cost of £7,235; and is in the geometric middle pointed style. There are chapels for Independents and Wesleyans, a national school, and a town school. The Independent chapel was rebuilt about 1860, and is in the pointed style. The national school was built in 1856, at a cost of £2,000.'**

HISTORIC FLOODS

Historically, Marsden has suffered flooding events caused by dam failures. One of these events was linked to the construction of the Huddersfield Narrow Canal. The Tunnelend Reservoir had been constructed to provide water for the canal. In 1799 when the works were still under construction, heavy rain led to severe damage. The Tunnelend Reservoir was overtopped, devastating Marsden, and several stone canal aqueducts proved to be unable to cope with the unprecedented overflow and had to be replaced with cast iron aqueducts of a new design.

A second flood occurred when on 29 November 1810 at 1 am, Swellands Dam gave way. People were sleeping in their beds when houses and factories were wrecked. Five or six people lost their lives. The force of the water was such that a 15 ton rock was moved over 3 km down the valley.

Today, the memory of these catastrophic events and others from across the world (the failure of the Oroville spillway in California was international news in 2017) has led to increasingly tighter legislation and guidelines. Spillways and other reservoir infrastructure are regularly checked and tested to ensure that they are safe. Safety must always be the top priority in all aspects of civil engineering.

Dam of Tunnelend Reservoir, which failed in 1799

OTHER RESERVOIRS

Several small early reservoirs in the area (such as Tunnelend Reservoir) are associated with the Huddersfield Narrow Canal, which was built between 1794 and 1810. However, these early canal reservoirs are not related to those in the Wessenden Valley such as Butterley Reservoir.

The earliest reservoir in the Wessenden Valley was Wessenden Reservoir, also known as Wessenden Old Reservoir. Wessenden Reservoir was developed by the Wessenden Commissioners who were empowered to construct and maintain a reservoir under an Act of Parliament, the Wessenden Act of 1836. This reservoir was constructed to supply water to mills located lower down the valley.

By the mid- to late 19th century, Huddersfield had grown substantially and with this growth the demand for a stable water supply had increased. The Huddersfield Waterworks Act of 1871 authorised the Huddersfield Corporation to pay off the mortgage debt of the Wessenden Commissioners, amounting to £10,000, and to take control of the Wessenden Springs and enlarge the reservoir. This plan was abandoned, however, in favour of an additional reservoir at Wessenden Head. The powers for construction were gained in the subsequent Huddersfield Waterworks and Improvement Act of 1876, with Wessenden Head completed in 1881.

Blakeley Reservoir was authorised by the Waterworks Act of 1871, but work was delayed several times. Construction finally commenced in 1896, but was not completed until 1903, when works at Butterley Reservoir were finalised. The Huddersfield Waterworks Act of 1890 empowered the Corporation to purchase Wessenden Reservoir from the Wessenden Commissioners for the sum of £50,000 (equivalent to about £6,000,000 in 2017), which was paid in 1891.

THE ARCHITECT

Thomas Hawksley

T & C Hawksley of Westminster were appointed by the Huddersfield Corporation to design new reservoirs for the area. The sites of both Blakeley and Butterley Reservoirs were selected and the designs prepared by the firm.

Thomas Hawksley was a self-taught engineer and oversaw upwards of 150 water-supply schemes, becoming one of the leading water engineers of the 19th century. He was an advocate of high pressure 'constant supply' which prevented contamination of drinking water and brought him acclaim from the general public.

After receiving a basic education at the Nottingham Grammar School, Thomas began his professional career as an architect with Edward Staveley, architect and surveyor, who combined a role as the Borough Surveyor of Nottingham with his private practice, and introduced Hawksley to municipal engineering. Subsequently the practice became 'Staveley, Hawksley and Jalland', and after Staveley's death in 1837, the remaining two partners continued the business under the name 'Hawksley and Jalland, Engineers, Nottingham' until 1850 after which the business was carried on by Hawksley alone.

In 1830 at the age of 23, while still with Staveley, Hawksley designed and oversaw the construction of the Trent Waterworks near Trent Bridge, Nottingham. This scheme delivered Britain's first high pressure 'constant supply'. This achievement led him to be appointed to many major water supply projects across the country, including large schemes in Liverpool, Sheffield, Leicester, Leeds, Derby, Darlington, Oxford, Cambridge, Sunderland,Wakefield and Northampton.

Blakeley Reservoir

The puddle trench at Butterley Dam under construction

Thomas Hawksley also undertook large drainage schemes in Birmingham, Worcester and Windsor, as well as gas works for a large number of towns. In 1852 Thomas Hawksley moved to London and initially began a partnership with Charles May before establishing his own business at 30 Great George Street, Westminster in 1853, where he continued his profession until his death. The practice became very large and by the late 1850s he had gained such a reputation that he was appointed by the Metropolitan Board of Works to comment on the 'Main Drainage of the Metropolis', that is, London's sewerage system. He gave evidence to Royal Commissions, and his opinion was sought in relation to many inquiries, arbitrations and valuations. He was one of the experts called upon in 1864 to report on the collapse of the Dale Dyke Dam in Sheffield, which had killed 240 people. He remained an engineer to the Sheffield Water Company, later the Corporation of Sheffield, for the rest of his life.

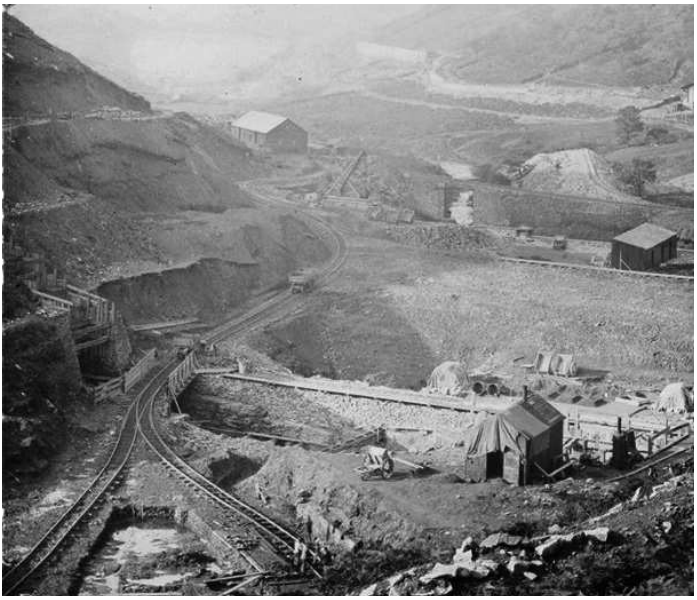
In 1866, Thomas took into partnership his son Charles, although Thomas continued to undertake a huge amount of work himself.

Thomas Hawksley received many professional honours. He joined the Institution of Civil Engineers in 1840; was elected their President in 1872; became President of the British Association of Gas Managers in 1864–7; President of the Institution of Civil Engineers in 1872–3; and in 1876 he became President of the Institution of Mechanical Engineers. In 1878 he was elected a Fellow of the Royal Society. Outside of Britain he was a Commander of the Order of Francis Joseph of Austria, Commander of the Rose of Brazil, a Knight of the Danebrog, and of the Swedish Order of the Polar Star.

A committee was formed in 1887 to raise a subscription in order to commission Thomas Hawksley's portrait from Sir Hubert Herkomer, to mark his 80th birthday. The committee's spokesperson was the Attorney General, Sir Richard Webster, 1st Viscount Alverstone, and the fund was so heavily oversubscribed that a second, duplicate, portrait was painted by Herkomer.

Thomas continued to work until just a week before his death. Thomas Hawksley died on the 23 September 1893, at the age of 86. His great achievements had been the first pressurised clean water supply system which had saved countless lives during the cholera epidemic of 1848–9, and the pioneering of the high-pressure cement grouting process to eliminate leaks from earth embankments, a process used at Butterley.

View of the former Upper Bank Bottom Mill during construction



Blakeley and Butterley Reservoirs under construction

The first-hand involvement of Thomas Hawksley in the design and construction of the spillway is debatable. He was extremely active, even in old age, and it is possible that he directly oversaw the project. However, he was already 84 years of age when the Huddersfield Waterworks Act was passed in 1890.

Considering the volume of work undertaken by the firm, they must have had an extensive team of draftsmen and engineers.Having been at the forefront of the design and construction of reservoir schemes for over 50 years, the firm must have had an extensive 'back catalogue' of similar outflow channels, and the design of the Butterley example is likely to have been a 'reworking' of previously tried and tested design elements adapted to the particular site conditions.

Charles Hawksley was born in 1839 and studied at University College London. On graduating in 1854 he became an apprentice in his father's firm. Following Thomas' death, Charles took his own son Kenneth Phipson Hawksley into partnership in 1900. Charles was elected a Member of the Institution of Civil Engineers on 21 May 1867, and became President in 1901. He was also a Manager of the Royal Institution of Great Britain; President of the Polytechnic School of Engineering from 1900; Member of the Institution of Gas Engineers, and other societies. For at least 50 years he was a prominent figure in the Committee Rooms of Parliament, where he frequently gave evidence as a technical expert, and his services were often sought as arbitrator in civil engineering matters. Charles died suddenly at his home in Bayswater on 27 November 1917, at the age of 78.

Charles Hawksley

CONSTRUCTION OF BUTTERLEY RESERVOIR

Construction of Butterley Reservoir was authorised by the same Act of Parliament which allowed for the purchase of Wessenden Reservoir: the Huddersfield Waterworks Act of 1890.

The first sod at Butterley was cut on 27 August 1892 by Alderman James Crosland, Deputy Chairman of the Waterworks Committee. An elaborately engraved silver spade was used for the ceremony, after which the dignitaries had a celebratory dinner at Huddersfield Town Hall.

Blasting of stone, excavation and construction of the reservoir dam and associated structures would have been a noisy and dirty undertaking, employing large numbers of men. The formerly peaceful valley was disturbed by the cutting back of the bedrock of the hillside, the movement of large volumes of rock and earth the use of noisy steam shovels, and the shaping of stone using steam driven cutting equipment.

The reservoir was constructed by forming an embankment across the Wessenden Brook, approximately 34 m high and 229 m in length. The embankment is one of the tallest Victorian embankments in the country and holds up to 1,773,000 cubic metres of water. It was built to a classic Pennine design with a puddle clay core connecting to a concrete cut off with earth fill shoulders.

For the construction of the embankment, boulder clay was brought about 8 km from Micklehurst. Following the reservoir's completion, much clay was left unused and still remains piled up in the area.

Butterley Reservoir with low water in 2017

THE WORKFORCE

Reservoir construction workers at Puleside Working Men's Club

A workforce of itinerant navvies was employed directly by the Corporation and formed a temporary community. Upper Bank Bottom Mill and Lower Bank Bottom Mill (but not Bank Bottom Mill itself) were converted into dwellings to house the workers. Upper Bank Bottom Mill was positioned where the reservoir embankment now stands and both mills were demolished during the works.

As was common at the time, the navvies were treated with suspicion by locals who increased the price of provisions and alcohol for them. The reservoir navvies used an old 'dove cot' for socialising. Later, a permanent building was constructed: the Puleside Working Men's Club on Mount Road, which is still open and forms a lasting legacy to the navvies. Locals still refer to the club as the 'cot' after the original location.

Construction was delayed by a several factors including a mason's strike in 1901. In 1893 a smallpox outbreak required the isolation of seven workers at the now-submerged Hole Top Cottage.

During the construction works there were two deaths from accidents. On 12 January 1894 a gelignite explosion in the puddle trench killed Robert Baker. John Dyson, a stone mason, was injured by a moving steam crane on 27 January 1899, and died two weeks later.

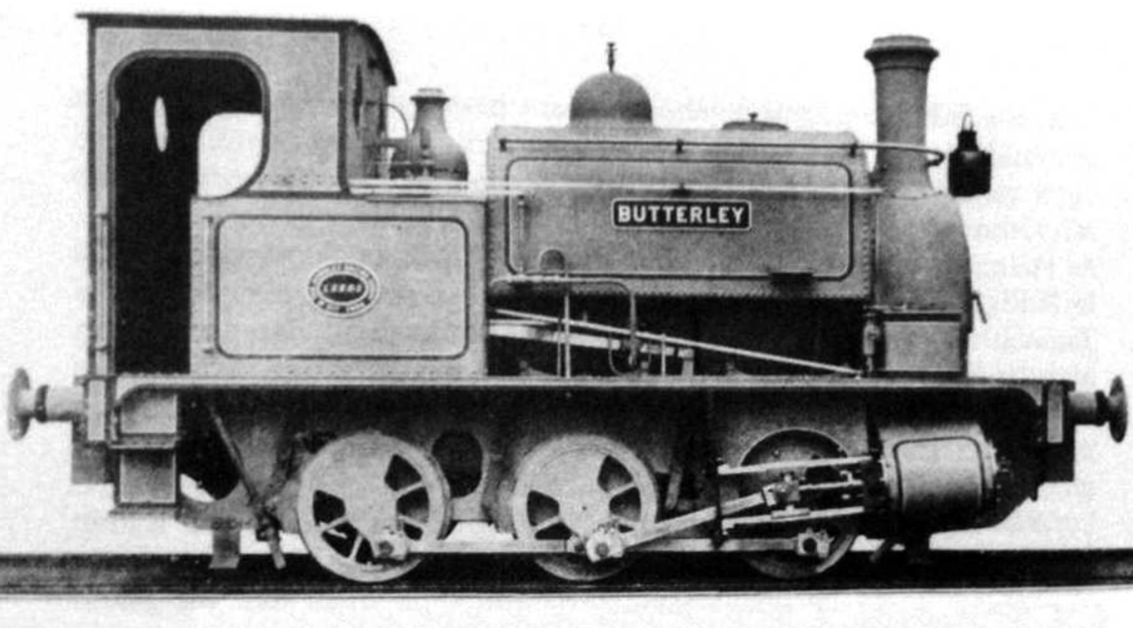
TRAMWAYS

In 1894, the Waterworks Tramroad at Marsden Act enabled a tramway to be constructed which connected the reservoir site with the main rail line near Tunnel End to aid in the delivery of materials. The locomotive on the line, an olive-green six wheeled coupled saddle tank, was called Butterley.

In addition to the standard gauge tramway, 3 ft (approximately 1 m) gauge tracks were laid around both sides of the reservoir to the quarries and to Blakeley Reservoir, which was also under construction at the time. Two locomotives ran on the narrow gauge line, Blakeley and Brooke. Blakeley had an unusual external frame. Initial work at Butterley used a team of 16 horses to draw wagons along rails. The horses were given names, including Hesketh, Dyson, Rodger, Colonel, Fligg and Denham.

After the construction of Butterley Reservoir, the tramway was removed. It is possible to see the line of the tramway in some places from satellite images, and stone abutments for the viaduct over the River Colne are still present.

Locomotive used at Butterley
Reproduced from Reservoir Railways of the Yorkshire Pennines*, Oakwood Press.*



EARLY REMEDIATION WORKS

The reservoir was completed in July 1901 and filling commenced, although a drought during August caused a delay.
During the filing it became apparent that at about half full, the reservoir was leaking due to the local geology. The Huddersfield Corporation Act of July 1902 allowed for the necessary remediation works. In October 1902, independent opinions were sought from G H Hill and noted geologist and archaeologist Professor William Boyd Dawkins. The reports were highly critical of the original design of the embankments, and as a result T & C Hawksley and George Crowther (the engineering superintendent) were dismissed by the Corporation.

In October 1903, G H Hill and Sons were commissioned to design remedial works which were undertaken by Mr John Scott of Bank Top Chambers, Darlington. The remedial works included the construction of wing trenches and cement grouting. The works were finally completed in June 1906 and the reservoir filled to overflowing in December 1906.

A settling tank was built above Butterley, completed in 1904, to remove silt, sand and peat from the inflowing water.

A curved cast iron framed bridge with oak planking was installed across the weir in 1907. This bridge was replaced in the 1980s but used the same castings as the original access platform at the scour portal, which largely survives *in situ* although with a modern walkway grid.

Detail of Butterley Scour Portal access platform

SPILLWAYS

A spillway or overflow channel is a structure used to provide controlled release of excess water from a dam. Water normally flows over a spillway only during flood periods when there is excess water. This overflow stream is sometimes known as a 'byewash', a word which is in use in the Marsden area. In contrast, an intake is a structure used to release water for a purpose, such as for drinking water or power.

One of the main functions of a spillway is to dissipate the energy within the discharged water. There is often quite some vertical distance from the top of the dam to the base of the valley below, and water dropping this distance gains kinetic energy which can make it potentially dangerous. Spillways are designed to control the behaviour of the excess water and to mitigate this risk.

A number of different designs of spillway are commonly used, but the Butterley Spillway is of the stepped type. Stepped spillways have been in use for around 3500 years, with the oldest known surviving example the stepped weir at Akarnania, Greece, which is still functioning. Roman examples survive in North Africa.

Butterley Spillway in full flow

Stepped spillway design spread around the Mediterranean and was independently discovered in other locations such as South America. By the end of the 18th century, stepped spillways were being built across Europe and the Americas, including in England.

The development of stepped spillways went hand-in-hand with the development of other stepped waterways such as drinking water aqueducts, irrigation channels and waste water channels such as storm drains. Ornamental grand cascades built from the 16th century onwards are also related to this tradition.

Although early stepped cascades were built in cut-stone masonry or timber, a wider range of materials were introduced during the 19th century. The 1890 Gold Creek Dam cascade in Australia was the first concrete stepped cascade. An 1885 unlined cascade at Gold Creek had been destroyed by a heavy scour, but the stepped version is still in use today.

Stepped spillways require frequent maintenance, which can be costly. This was a major cause of their decline in popularity in the early 20th century. In the late 20th century, stepped cascades were 'rediscovered' and reports were written describing stepped spillways as a new technique. The introduction of new materials such as roller compacted concrete has led to the increased popularity of this design.

Gold Creek Dam in Australia

BUTTERLEY SPILLWAY

Butterley Spillway is the only spillway listed in its own right in the country. The spillway, the adjacent scour portal and Bank Bottom Bridge (which pre-dates the reservoir) are all separately Grade II listed. Butterley Spillway forms one of a group of similar structures built by T & C Hawksley and others throughout the North of England and in Wales.

The spillway is approximately 290 m in length from the weir to Bank Bottom Bridge. The stone overflow weir at the top of the dam leads into a tumble bay which leads into the top of the spillway. Adjacent to this, to the west, is the valve house, accessed via the crest bridge which spans the top of the spillway.

The position of the spillway at the north-east corner of the reservoir, hard up against the newly created eastern scarp of the valley, was probably chosen because the geology was favourable: the ground in this area had been less disturbed by the action of the former natural stream. Access for machinery and materials would also have been easier at this location.

The original masonry of the spillway

The original spillway was constructed of local sandstone with a stepped base. The majority of the structure was constructed from ashlar blocks, and the side walls largely rusticated stone. Two curved stepped cascades were located where the gradient was steepest and were lined with ashlar walls. The walls were topped with interlocking coping stones. Five stone piers on either side of the spillway marked the major changes in gradient of the slope and match the terracing of the dam embankment. Each pier was set on a small plinth and was finished with pyramid-shaped coping stones.

Ashlar stone is finely dressed and cut with flat faces. In contrast, a rusticated finish is one that is left rough on the visible face to mimic a natural, unworked appearance.

Water supply systems are sometimes viewed as an opportunity to demonstrate the civic pride and ambition of the commissioning authority, and this was especially true in the 19th century. Sometimes this was done through the construction of elaborate pumping stations. No pumping station was necessary at Butterley, which is gravity fed. Elsewhere, T & C Hawksley built elaborate pumping stations in a variety of styles as appropriate to the setting.

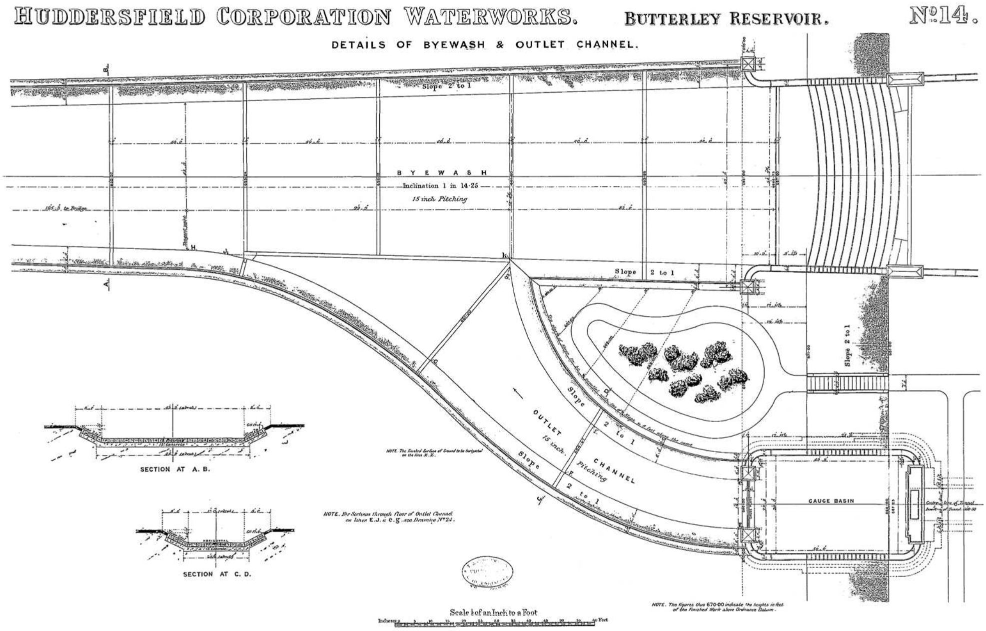
The ornamental cascade at Chatsworth House

At Butterley, there were few structures which could demonstrate architectural 'corporate promotion'. The proximity of the spillway to the settlement of Marsden, set in an area popular for recreation, presented the Huddersfield Corporation with an opportunity to express their ambition and to engage in a sort of public outreach by placing an emphasis on the aesthetic appeal of the spillway and the design and layout of the reservoir structures.

Water cascades had been a feature of designed landscapes and gardens since classical times, and came to the fore again in the classical gardens of Italy and France; reaching their zenith in the French gardens of the 17th century, such as Vaux le Vicomte and Versailles. Cascades were used to carry water between garden terraces, and introduce visual and acoustic interest to transitional areas. It was not long before travellers on the Grand Tour of Europe brought these design ideas to Britain, and a fine early example is the Cascade constructed at nearby Chatsworth in 1696.

The importance of aesthetics to both Thomas and Charles Hawksley is reflected in perpetuity in the form of a scholarship prize in their name, awarded on the joint recommendation of the Institution of Civil Engineers and the Royal Institute of British Architects 'for proficiency in the design of engineering structures combining artistic merit with excellence of constructional design'.

Record shot of original stone pier showing wall with ashlar finish to right of the pier and rusticated finish to the left



Original design plan of Butterley Spillway showing perambulatory walk

Stepped cascades are a feature of a great number of T & C Hawksley's reservoir overflow channels and are a feature of the work of many other water engineers. Essentially, they are a means to incorporate an appropriate fall in the constructed channel, to match the topography on either side. Where the channels traverse a terraced, man-made embankment, the most elegant solution is for the channel to mimic the contours of the adjacent ground. Such was the case at Butterley, where the two flights of stepped cascades could be seen to exactly echo the two lower terraces of the embankment which, interestingly, are the only steep terrace slopes which extend eastwards as far as the spillway. This design can also be seen in the 1885–92 spillway at Cant Clough near Burnley.

Drawings of the scheme from 1892 strongly suggest that the public were encouraged to use the site for recreation, and to enjoy the sights and sounds generated by the water cascades. Plans show a perambulatory route culminating in a small loop around a shrubbery between the spillway and scour portal. This would have provided a welcome respite from the noise and dirt of the nearby mills, however it was probably never built.

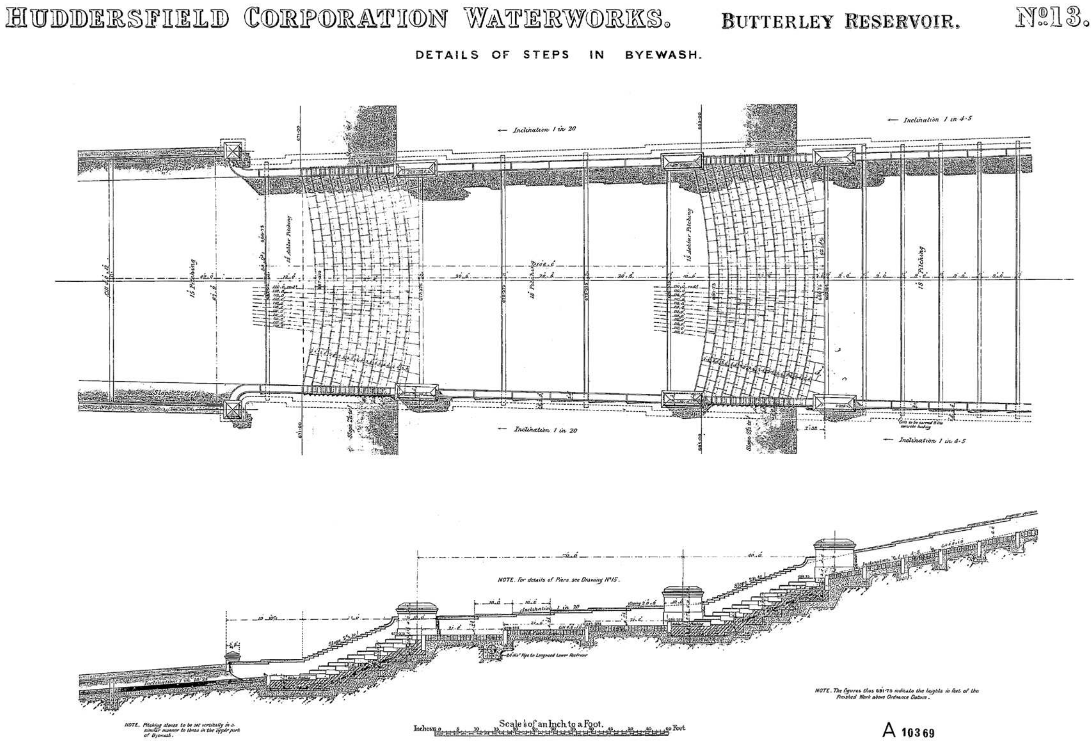
Comparable spillway at Cowm Reservoir, Rochdale, built by Thomas Hawksley

Butterley has design elements in common with numerous examples elsewhere. The upper section of the 1846 Naden Higher Reservoir near Rochdale bears marked similarities to the head of the Butterley Spillway, while the 1868–71 spillway at Cowm Reservoir, also near Rochdale, has two sets of stepped cascades with capped piers in the channel walls.

It is not, however, a design unique to the Hawksley firm. The 1892 spillway at Cantref in the Brecon Beacons, by the Cardiff Corporation Engineer J A B Williams, has at least four sets of cascade steps, of different lengths, and was positioned at the front right-hand corner of the reservoir, as at Butterley.

The sweeping curve in the course of the spillway seems to have been a particular element of the Hawksley style, as demonstrated at the 1869–76 Lindley Wood, and 1871–78 Swinsty Reservoirs, both for Leeds Waterworks Company, and the elegant shallow curve of the cascade steps is a detail also used by T & C Hawksley at their 1899–1905 spillway at Catcleugh, Northumberland.

However, the channel walls at Butterley displayed the greatest level of architectural treatment, most significantly in the robust, rectangular capped piers and in the curved ashlar walls terminating the channel and enclosing the scour portal.



One of the original design drawings of Butterley Spillway

The original construction used concrete to form the base of the channel, which was overlain with local sandstone of the Millstone Grit formation. Surviving design and construction drawings clearly describe the construction of the walls and channel base, though there is evidence that the original spillway 'as built' did not exactly correlate with the design drawings. The base of the upper channel comprised rectangular masonry blocks of differing sizes, which are shown on the design drawing as being laid on edge to a slightly stepped profile between deeper set kerbs.

However, the damage caused by a flood in 2002 indicates that the blocks were, in fact, laid on bed; a less strong form of construction. Although construction drawings through the channel wall show the masonry of the channel base abutting the wall, site observations indicated that the blocks of the channel base extended under the masonry of the wall.

Butterley Scour Portal

A great deal of care in design was demonstrated by the correlation between the length of the capping stones on the channel walls, and the spacing of the steps in the base of the channel. For the greater length of the channel above the cascades, their dimensions matched, while through the two stepped cascades there are two short capping stones per step, and the three long shallow steps between the cascades had two long capping stones per step.

Similarly, great care was taken with regard to the outward curving terminals of the channel walls, ending with square capped piers. These were identically detailed, and accurately aligned with the inward curving walls leading to the scour portal to the west.

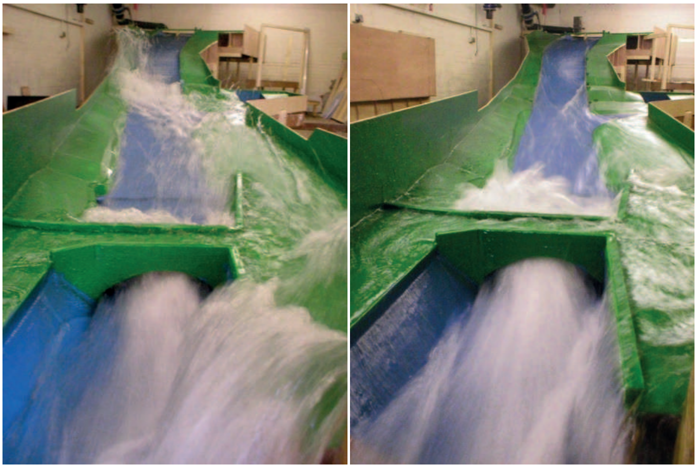
Where the scour outlet channel meets the spillway, the spillway walls curved out and terminated with a pier. The walls varied in height from 3 m at the upper end to 1.2 m at the lower end. The scour portal is contemporary with the original spillway and was constructed in the same architectural style.

Severe damage to spillway caused by minor flood in 2002

In 2008 a statutory inspection by the All Reservoirs Panel found that Butterley Spillway had defects which represented 'a real risk of failure.' It was assessed that flood events likely occurring every 12–100 years would pose a danger if the current structure remained in the state it was in. Yorkshire Water was therefore required, under the Reservoirs Act 1975, to implement remedial works to remove any potential risk to public safety.

The vulnerability of the channel base was demonstrated during a modest flood in 2002, when the impact of water landing at the base of the upper curved cascade dislodged masonry blocks. Water was also known to flow between the concrete base of the spillway and the overlying masonry.

Model tests were run and identified four main defects. The sweeping curve of the channel concentrated flow along the outer wall, leading to overtopping of the wall. The offset piers in the channel wall caused water to plume. The steep cascades of the curved steps caused the flow to leap and impact the channel base beyond the steps. Where the channel straightened, a cross wave was created which caused overtopping. Alterations were proposed to mitigate these defects.



Hydraulic model of Butterley Spillway showing flood flows before and after modification

The necessary works to the channel included removing the curved cascades and some associated piers. Elements of the base of the channel and the walls were rebuilt in concrete. The height of the east wall was raised, re-using the original coping stones. The piers at the top of the former upper cascade were raised using re-used stone. Existing offset piers were cut back to make them flush with the channel walls. New fill material was brought in to raise the level of the embankment to the height of the raised walls.

As a requirement of planning permission, Wessex Archaeology was commissioned by Yorkshire Water to undertake a photographic survey. The survey shows the original spillway in its modern setting, and recorded any details which were lost following the alteration works. The survey was designed by West Yorkshire Archaeological Advisory Service, advisers to the planning department at Kirklees Council. Archival and documentary research has also been undertaken to provide a historical context for the structure. A 3D laser scan of the spillway was undertaken by Mott MacDonald Bentley and this data was used by Wessex Archaeology to illustrate their report. The archive resulting from Wessex Archaeology's work will ultimately be deposited with the Kirklees Office of the West Yorkshire Archives Service.

CONCLUSIONS

Although it is a functional structure, Butterley Spillway is also a monument to the civic ambition of the Huddersfield Corporation, and to the expertise of the men who built it: Thomas and Charles Hawksley, G H Hill, and untold numbers of labourers and draughtsmen. Not least among those workers were the two men who lost their lives during the construction of the dam: Robert Baker and John Dyson. The spillway stands symbolically above Marsden, encapsulating the progress of the Victorian era. Clean reliable drinking water contrasts with the hard life and poor conditions of the mills. Dependable water power reminds us of the driving forces of the Industrial Revolution. The beauty and the architectural style of the structure signpost the tradition of formal garden water features and of the use of the area for recreation.

Following the necessary remedial works the detail of the structure has been altered. Remedial works have always been necessary at Butterley, with alterations and repairs first occurring before the reservoir was even complete. Where possible, existing stonework has been retained or re-used and the new work has tried to remain in keeping with the original intent of the designers.

Butterley Spillway is more than just a functional structure. However, the safe function of the spillway is essential to ensure the safety of the public. It is regrettable that some of the original fabric and detail of the spillway has been lost. However, the exceptional circumstances of the prevention of catastrophic failure in a serious flood clearly constituted a substantial public benefit that outweighed the harm to the listed spillway.

Remediation works at Butterley Spillway

We are left with a structure which retains the curving shape, most of the architectural treatment, and some of the original unaltered form. In times of heavy rain, the spillway is still a beautiful sweeping curve of silver descending the steep terraces of the dam embankment. The intent of both the Hawksleys and of the Huddersfield Corporation can still be read and the techniques and form used in the original construction are preserved, both *in situ* and in the record made by Wessex Archaeology.

This beautiful structure can now be expected to serve both the practical and the aesthetic needs of residents and visitors for years to come.

Computer generated image showing an artist's impression of Butterley Spillway following remediation works

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GLOSSARY

Act of Parliament: creates new legislation or amends existing ones. During the Industrial Revolution, Acts of Parliament were commonly used to enable large-scale engineering projects

ashlar: masonry made of large square-cut stones, often used as a facing material

cascade: a fall or sequence of falls of water. Cascades have been used for aesthetic value to add ornament and enjoyment to a garden or water course

compensation flow: a constant flow of water allowed to escape from a reservoir in order to preserve the natural characteristics of a river interrupted by the dam of the reservoir

coping stones: the stones that form the top of a wall or building; an architectural finishing touch

fulling: a step in woollen clothmaking to clean cloth by removing oils, dirt and other impurities

gelignite: a high explosive made from a gel of nirtoglycerine and nitrocellulose in a base of wood pulp and sodium or potassium nitrate used for rock-blasting

Industrial Revolution: a period of major industrialisation in the late 18th and 19th centuries

intake: a structure used to release water for a purpose, such as for drinking water supply or power

kerb: blocks of masonry used as edging

Listed: a building or structure that had been placed on the Statutory List of Buildings of Special Architectural or Historic Interest

Luddite: a member of a group of textile workers who in the 19th century destroyed machinery as a protest, believing their jobs were threatened by increased mechanisation

medieval: the period between approximately 1066 AD and 1500 AD, or, in some contexts, between approximately 410 AD and 1500 AD

Mesolithic: the period between approximatel 8500 BC and 4000 BC

navvies: manual labourers working on major civil engineering projects. Short for ‘navigator’ or ‘navigational engineer’

on bed: stones or bricks aligned with the largest face down

on edge: stones or bricks aligned with the second largest face down (‘on end’ denotes smallest face down)

packhorse: a horse or similar animal used to carry goods

piers: vertical architectural elements

reservoir: an artificial lake created to stockpile water

Roman: pertaining to the Roman empire. In Britain, the period from approximately 43 AD to 410 AD

rusticated: a finish applied to visible surfaces of masonry creating a rough unfinished appearance

scarp: a very steep bank or slope

scour: a flow of swiftly moving water

scour portal: at Butterley, the end of a tunnel through which a compensation flow is released from the reservoir into the Wessenden Brook

smallpox: an infectious disease causing a variety of symptoms, frequently leading to blindness, or even death. Eradicated by vaccination

spillway: an overflow channel designed to carry flood waters away from a dam

terrace: a flat area cut into a slope

tramway: a minor railway used for local transport

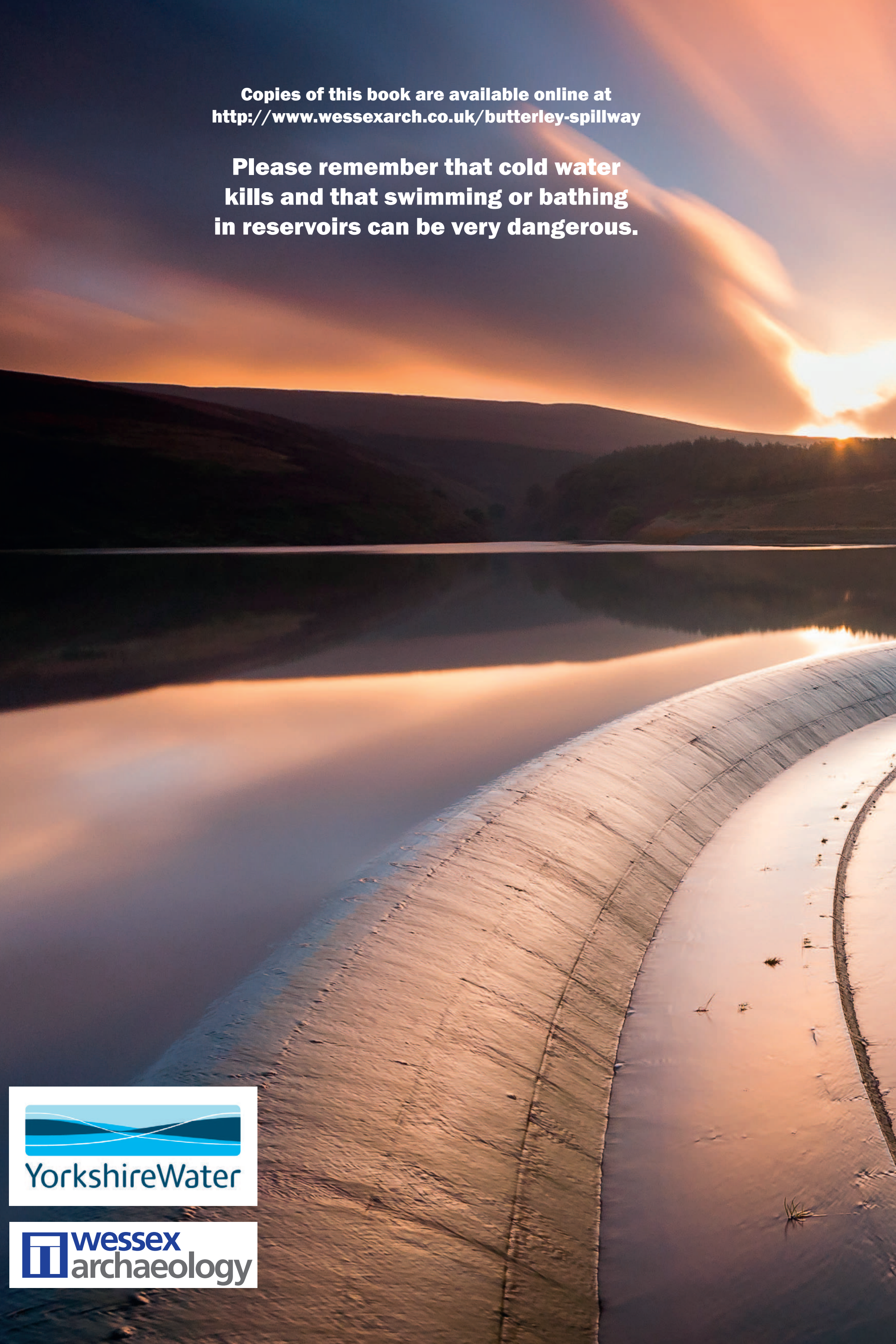
tumble bay: the outfall from a reservoir or other body into a pool designed to dissipate energy

turnpike: a road or highway usually maintained by tolls

Victorian: the period when Victoria was Queen of the United Kingdom of Great Britain and Ireland; 1837–1901

Copies of this book are available online at
http://www.wessexarch.co.uk/butterley-spillway

Please remember that cold water kills and that swimming or bathing in reservoirs can be very dangerous.



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