water
A TURBULENT HISTORY

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WATER AS DEADLY DANGER

Sir Joseph Bazalgette and the Great Stink

By the mere action of the lungs of the inhabitants of Liverpool, a stratum of air sufficient to cover the entire surface of the town, to a depth of three feet, is daily rendered unfit for the purposes of respiration.

Dr W.H. Duncan, Liverpool’s Medical Officer, explaining the causes of cholera to a Royal Commission in 1844

Although great differences of opinion existed, and continue to exist, as to the causes of the disease, yet an inspection of the houses in which deaths occurred was sufficient to show that, however occult might be the connection between death and defective drainage, the places formerly most favourable to the spread of disease became quite free from it, when afterwards properly drained.

Sir Joseph Bazalgette, builder of London’s sewers, explaining how he was banishing cholera from London, 1864

CHARLES DICKENS – AN ALARMING VISIT

In April 1850, Charles Dickens visited the works of the Grand Junction Water Company at Kew. The company had been set up as an offshoot of the Grand Junction Canal Company earlier in the century but had since become independent of its parent. Dickens gave an account of his visit in Household Words of which he was then the editor. He had asked the company engineer ‘How many companies take their supplies from the Thames, near to, and after it has
received the contents of the common sewers? The engineer assured him that only one water company, the Lambeth, took water from the Thames below Chelsea which at that time was on the western extremity of the built-up area. Dickens observed that, since the Thames was a tidal river as far upstream as the weir at Teddington (Tide-end-town), any sewage entering the river in the metropolis would be borne by the incoming tide to the water intakes of all the water companies which took supplies from the river. The engineer assured Dickens that problems of water pollution were more likely to be caused by dirt entering cisterns in houses than by pollution in the river. His complacency echoed that of a spokesman for the company twenty-two years earlier who had informed

A DROP OF LONDON WATER.

"A Drop of London Water"; at this time much of London's drinking water was drawn from the polluted river. (Punch, 1850)
the Royal Commission on Water Supply of the Metropolis that: ‘The impregnating ingredients of the Thames are as perfectly harmless as any spring water of the purest kind in common life; indeed there is probably not a spring, with the exception of Malvern, and one or two more, which are so pure as Thames water.’

There were those who had their doubts, besides Charles Dickens. In the same month that Dickens published his alarming account, an engineer called William O’Brien published an article in the Edinburgh Review entitled ‘The Supply of Water to the Metropolis’ in which he wrote: ‘There are 141 public sewers between London and Battersea Bridges; Richmond, Isleworth, Brentford, Mortlake, Chiswick and Hammersmith furnish 68 more – and the whole of their contents are received into the Thames, and returned by the reflux of the tide – we perceive a state of things which renders exaggeration truly superfluous.’

He was right. Londoners were drinking one another’s sewage and, as a result, by the time the articles appeared, over 20,000 Londoners had perished in the cholera epidemics of 1832 and 1849. Almost 11,000 more were to die in another epidemic in 1854 and over 5,000 in cholera’s final attack, on a small area of Whitechapel, in 1866. To these figures must be added deaths from the other great water-borne scourge, typhoid. Since typhoid deaths came in a steadier stream rather than sudden epidemics, and since it was often confused with typhus, deaths from typhoid are more difficult to identify with certainty but they may well have exceeded deaths from cholera. In the years that followed, controversy raged over the causes of cholera and the remedies to be applied. The most alarming feature of cholera and typhoid, as far as the authorities were concerned, was that they affected all classes equally. Premature deaths from disease and malnutrition were associated with poverty, filth and, occasionally, with degenerate behaviour such as drunkenness. Cholera and typhoid did not defer to rank or class. The most eminent victim of typhoid was probably Albert, the Prince Consort, who died in 1861. Polluted water, the real cause of these diseases, killed indiscriminately. Paradoxically the contemporary belief that they were transmitted through the air (the ‘miasmatic’ theory) made the atmosphere itself the principal suspect and when the crisis arrived, in the form of ‘The Great Stink’ of 1858, fear finally prompted frightened Parliamentarians to take the necessary action they had long delayed.

THE ‘NECESSARY CHAMBER’

The cause of London’s cholera epidemics could be traced to the very first Mayor of London, Henry Fitzalwyn. In 1189, in an early attempt at building
regulations, Fitzalwyn had decreed that the 'necessary chamber' (the cesspool) should be at least 2ft 6in from the neighbouring building if it was made of stone and at least 3ft 6in if it was made of other materials. The centuries that followed provided abundant evidence of the need for this and similar measures. In 1290 some Carmelite Friars petitioned Parliament 'to abate a nuisance, viz. a great stench, which they cannot endure and which prevents them from performing their religious duties'. By 1300 the disposal of sewage in the Sweetwater Bourne in Sweetwater Lane had earned the latter thoroughfare the unofficial name 'Shiteburne Lane'.

This was not supposed to happen. The preferred method of sewage disposal was to store it in Fitzalwyn’s 'necessary chambers' from which it was removed, usually at night, by men known as 'rakers', 'gong-fermers' or 'nightsoilmens'. The work was well paid. In 1281 thirteen men took five nights to clear the cesspools of Newgate jail, each man being paid sixpence a night, three times the normal wage. The sewage was taken on carts to farmers who were happy to buy it as manure for their fields. It did not have to be taken far. 'Moor Fields', just beyond Moorgate, were just that: fields rather subject to flooding in wet weather whose cultivators were glad to purchase the smelly cargo of entrepreneurs like Joseph Waller of Islington, whose business card in the Museum of London advertises his services as 'chimney sweeper and nightman', and who kept 'carts and horses for emptying bog houses, drains and cesspools'. From time to time lord mayors and, occasionally, kings complained about the pollution of streets and streams by refuse. In 1357 King Edward III addressed the mayor and sheriffs of the City in stern terms about the 'fumes and other abominable stenches' arising from 'filth accumulated upon the bank of the river'. He decreed that 'no man shall take any manner of rubbish, earth, gravel or dung out of his stables or elsewhere to throw and put the same into Rivers of Thames or Fleet'.

The aim of such decrees was to ensure that London’s network of rivers, flowing down into the Thames, was used for the purpose nature intended: to convey rainwater into the Thames and thence to the sea. Moreover, until the early nineteenth century it appears that both the Thames and its tributaries were kept reasonably free of pollution. In 1756 an Irish doctor called Charles Lucas had written that London’s water is 'undoubtedly one of the principal causes why our capital is the most healthful city in the world' and in 1818 a publisher called Samuel Leigh had claimed that London’s 'healthfulness is equal to that of any other metropolis in existence' and suggested that its 'plentiful supply of water which is furnished by different water companies,
must also have an effect on the cleanliness, and consequently on the health, of the inhabitants of London.9 As late as 1844 a professor of chemistry called Booth wrote to the magazine The Builder reassuring readers that 'the free currents of air which are necessarily in constant circulation from its [sic] proximity to the majestic Thames have been considered (and not improperly) as a great cause of the salubrity of the metropolis'.10 This was the expression of a theory which was made more explicit by Professor Booth in a following sentence: 'From inhaling the odour of the butcher's wife obtains her obesity.' This theory, known as the 'miasmatic' explanation of disease causation, held that epidemics were caused by foul air, not by polluted water. It was to confuse the deliberations of sanitary reformers for the next fifty years.

DISASTER: THE WATER-CLOSET

By the time that Professor Booth was writing his pompous letter to The Builder, the capital's sewage disposal system was in crisis and the water supply increasingly polluted. In 1816 fourteen salmon weighing 179 pounds were caught in the river. Four years later no catches were recorded and this remained the pattern for the next half-century. Three reasons account for the fact that, in the space of a few years, a clean river had become an open sewer.

The first concerned the growth of London. In 1801, at the time of the first census, London's population was recorded as 959,000. By 1821 it had increased by more than 40 per cent to 1,378,000 and by 1861 it had more than doubled again to 2,807,000 – by far the largest city in the world. As the population expanded so did the built-up area, so that the fields which previously lay just beyond Moorgate were now beyond Highbury. As the fields retreated, the nightsoil carts faced longer journeys with their rank contents, making the business less economical. The construction of the canals brought some relief. As late as 1904 the records of the Grand Junction Canal Company show that 45,669 tons of manure were being conveyed by barges from Paddington basin to the fields of Hertfordshire, though by that date most of the cargo would have been horse manure gathered from London's streets. The second blow to the recycling businesses of the nightsoilmen came in the form of guano: solidified bird droppings excavated from guano mountains in South America and imported from the late 1840s onwards. This was more easily handled and less malodorous.

However, the real culprit was the water-closet. This had been invented in the sixteenth century by a courtier called Sir John Harington but he only made two
**Thomas Cubitt (1788–1855)** Thomas Cubitt’s contribution to the building of London compares with that of Sir Christopher Wren. He was trained as a ship’s carpenter and saved enough money during a voyage to India to set up as a builder upon his return. He was the first major builder to employ a permanent (as distinct from jobbing) workforce on large contracts and he became involved in speculative building as a means of providing them with regular employment. In this way he built much of Bloomsbury, Highbury, Belgravia, Pimlico and Clapham, providing dwellings for the aristocracy as well as the middle classes. At the request of Queen Victoria he reconstructed Osborne House on the Isle of Wight as a home for the royal family and built the east front of Buckingham Palace (facing the Mall). He also removed the Marble Arch from its incongruous position in front of Buckingham Palace to its present site. At Prince Albert’s request he negotiated the purchase of the land on which the South Kensington Museums were built with the profits of the Great Exhibition of 1851. He left over £1 million pounds in his will which, at 386 pages, was the longest on record.

of the devices: one for himself and one for his godmother, Queen Elizabeth I. The idea was neglected until the late eighteenth century when a number of improvements were made to Harington’s design, the most notable by a Yorkshire carpenter called Joseph Bramah. Bramah was a serial inventor who in his lifetime registered eighteen patents. In 1778 he was installing a WC in a private house when he realised that he could improve the mechanism to make it both more efficient and easier to produce in large numbers. By 1797 he had made over 6,000 closets and the company he founded continued to produce them until 1890. In 1861 Thomas Crapper, a businessman, founded a competitive business in Chelsea which marketed its wares under the memorable slogan ‘a certain flush with every pull’. Crapper’s business continued to trade from 120 King’s Road until 1966.

By the early nineteenth century a water-closet was a desirable status symbol for householders with social ambitions. They were installed in the new dwellings that were being built in places like Bloomsbury, Belgravia, Highbury and Clapham by builders like Thomas Cubitt (1788–1855) from the 1820s onwards.

In 1844 Cubitt told the Royal Commission on the State of Large Towns and Populous Districts that in the previous twenty years the number of closets
installed in London had increased tenfold. A further stimulus to the popularity of the increasingly fashionable device arose from the Great Exhibition of 1851. An enterprising manufacturer called George Jennings installed his WCs in the Crystal Palace where he charged visitors a penny a time for using them. Some 827,000 took advantage of the novel facility and, in the process, ushered a new phrase into the language: ‘spending a penny’. Jennings and his fellow entrepreneurs also placed unbearable strains on the system of sewage disposal inherited from Henry Fitzalwyn. Every time a WC was flushed, the mechanism despatched to the cesspool a very small quantity of potential manure accompanied by a much larger volume of water – ten or twenty times as much water as manure. The cesspools filled ten times as quickly with liquid which was difficult for nightsoilmen to extract and transport and which farmers did not want to buy. The liquid content of the cesspools overflowed or leaked into surrounding watercourses and thence to the Thames, carrying with it a multitude of germs into the city’s water supply.

By this time the authorities had come to appreciate that the attachment of a modern invention, the WC, to what was still fundamentally a medieval system of waste disposal, the cesspool, had its disadvantages so in 1844 the Metropolitan Buildings Act required new buildings in London to be connected to the street sewers – a practice which had been forbidden in earlier centuries. Thomas Cubitt described the consequences which followed: ‘Fifty years ago nearly all London had every house cleansed into a large cesspool. Now scarcely any person thinks of making a cesspool, but it is carried off at once into the river... the Thames is now made a great cesspool instead of each person having one of his own.’

THE EMPIRE’S SECOND CITY

By the time that Thomas Cubitt gave this evidence London had already suffered the first of its four great cholera epidemics. The water-borne cholera bacillus, carried from victims via the sewers into the Thames and hence the capital’s drinking water, claimed 6,536 victims in 1831–2. However, it was the second city of the empire, Liverpool, which was the first to take active measures to protect its population from sewage and to take in hand the supply of clean drinking water through a publicly managed body. By 1811 Liverpool was second only to London among British cities in the number of its inhabitants, a position which it held until it was overtaken by Glasgow in the 1860s. This human tide was not accompanied by any corresponding
investment in public hygiene. Liverpool's proximity to the sea should have made it fairly easy to dispose of its waste, as observed by the distinguished engineer John Rennie in 1816. His report 'The Sewers and Soughs of Liverpool' recorded that 'no town in the British dominions is better situated than the town of Liverpool for a complete system of sewers but there are few sewers in the town, and these not only deficient in capacity, but ill-calculated to perform the purposes for which they are designed'. For many years the population had been swollen by the arrival of impoverished Irish families, a situation exacerbated after 1845 by the Irish famine. This prompted the Liverpool Town Council to promote its own Sanitary Act which laid down some minimum standards for the construction of dwellings, prohibited the building of houses without drains and, thirty years after London, allowed house drains to be connected to the street sewers. The act also created, for the first time in a British city, the post of Medical Officer of Health.

That first Medical Officer was Dr William Henry Duncan (1805–63). Scottish by parentage, Duncan had qualified in Edinburgh and worked at the
Liverpool Infirmary where he campaigned relentlessly for better dwellings for the poor. Diseases like cholera, typhoid and dysentery were rife in Liverpool but many years were to pass before there was a clear understanding that they were carried in polluted water. The orthodox explanation for epidemics was accepted: that they were caused by a 'miasm' of foul air which carried the diseases into the body via the nose and lungs. At a time when the atmosphere of cities like London and Liverpool was heavy with the smell of human sewage this was a reasonable view to take. A Liverpool builder called Samuel Holme, a fellow campaigner of Duncan's, told a Royal Commission in 1844 that there were dwelling-places that he could not bear to enter because of the foul smells. Duncan was more emphatic, telling the same body that 'By the mere action of the lungs of the inhabitants of Liverpool, a stratum of air sufficient to cover the entire surface of the town, to a depth of three feet, is daily rendered unfit for the purposes of respiration,' a radical expression of the miasmic theory.

Duncan devoted the next sixteen years to campaigning tirelessly for the inspection, cleansing and whitewashing of insanitary dwellings and for the construction of an effective system of sewers and water supply. In the ten years after Duncan's appointment, Liverpool built 146 miles of sewers, compared with 30 miles built in the previous twenty years. The sewage was carried to the River Mersey which was not the source of Liverpool's drinking water. The town council bought out two private companies which had been delivering an inadequate supply of fresh water to the town and augmented them with additional supplies from Rivington, north of Wigan. For the first time the growing community had a reliable supply for drinking, cooking and washing. Thomas Hawsley being the engineer who managed the project.

Duncan died in 1863 'worn down by the uneven contest' of struggling with Liverpool’s health problems. He was 57 years old. His obituary in the Liverpool Daily Post concluded that the health of Liverpool had so improved as a result of his exertions that ‘there is therefore no longer any occasion for a medical officer at a salary of £700 a year’. Wiser counsels prevailed. The year after Liverpool appointed Dr Duncan, London appointed its own medical officer, (later Sir) John Simon. London's problems with contaminated water had become much worse than Liverpool's and would demand a more radical solution.

MICHAEL FARADAY

As observed above, the condition of the Thames was the subject of smug self-satisfaction into the 1840s, by which time the capital's sewage had been
pouring into the river for thirty years. The problem reached one of its many
climaxes in July 1855, when The Times published a letter which gave the
following account of a journey along the Thames:

Sir,

I traversed this day, by steam boat, the space between London and
Hungerford Bridges, between half past one and two o’clock . . . the
appearance and smell of the water forced themselves at once upon my
attention. The whole of the river was an opaque, pale brown fluid . . . . I
tore up some white card into pieces and then dropped some of these pieces
into the water at every pier the boat came to; before they had sunk an inch
below the surface they were indistinguishable. . . . Near the bridges the
scouring rolled up in clouds so dense that they were visible at the surface.
The smell was very bad, and common to the whole of the water . . . the
whole river was for the time a real sewer . . . . The condition in which I saw
the Thames may, perhaps, be considered as exceptional. . . . I fear it is rapidly
becoming the general condition. If we neglect this subject, we cannot expect
to do so with impunity, nor ought we to be surprised if, ere many years are
over, a hot season gives us sad proof of the folly of our carelessness.

I am, sir, your obedient servant

M. Faraday, Royal Institution, July 7th 1855

Michael Faraday was at that time the most famous scientist in Britain and
probably in the world, so his views commanded more attention than do most
letters to The Times. He was also correct in his warning about ‘a hot season’.
Three years later, in the hot, dry summer of 1858, the condition of the Thames
causé ‘The Great Stink’ which finally persuaded a wavering government to
take action.

‘VAGUE, SPECULATIVE, DISQUITIOUS, UNINTELLIGIBLE SCHEMES’

The problem had not been altogether ignored before 1858. Between 1848 and
1855 six sewers commissions had struggled with the problem of creating a
unified system of sewerage for London. Much of their time was spent
quarrelling. Personal animosities were so fierce that one commission was
disbanded and a new one constituted with the government’s representative,
Lord Morpeth, stipulating that ‘neither of the prominent parties in the late disputes and differences should reappear in the latest Commission’. To such animosities were added disputes between local authorities about how much each should contribute to the costs of any scheme. Finally, the commissions’ unfortunate engineer, Frank Forster, was besieged by advocates of different theories concerning the solution to the capital’s problems, many of which were clearly the work of crackpots. He gave the task of evaluating 137 schemes to two of his assistant engineers, Edward Cresy and Joseph Bazalgette. Of these, 116 were given serious consideration while the remaining 21 were described as ‘vague, speculative, disquisitive or collateral... few of which can be said to possess any practical value’. One of these, submitted under the pseudonym ‘Onalar’ was described as ‘long, unconnected and unintelligible’. Several of the plans, including one from the newsagent W.H. Smith (later to be a Member of Parliament and First Lord of the Admiralty) involved conveying sewage by rail. A later proposal recommended that London’s sewage be pumped to Hampstead Heath to the north and Shooters Hill to the south, and allowed to flow away in all directions in order to improve the fertility of the soil. One cannot help reflecting that, had this scheme been accepted, Hampstead would not have become one of London’s most fashionable residential districts.

In 1852 the engineer to the commissions, Frank Forster, died, the victim of ‘harassing fatigues and anxieties of official duties’, according to his obituary. His replacement was one of his assistants, Joseph Bazalgette, who now set about the task of devising a viable plan from the good and bad ideas that he had inherited. Bazalgette, like many other great Victorians, was of French descent. His grandfather, Jean Louis Bazalgette, had arrived in England in the 1770s, having made a considerable fortune in Jamaica. In London he set up in business as a tailor, demonstrating both a considerable ability to make money
and an equal capacity for making imprudent loans. He loaned over £20,000 to
the Prince of Wales and the Prince’s equally improvident brothers, one of
whom, the Duke of Kent, was to be the father of the future Queen Victoria. He
also loaned money to the Prince’s close friend, the playwright, Sheridan, whose
capacity for spending other people’s money rivalled that of his master. It took
an Act of Parliament for Jean Louis to recover most, though not all, of his
money.24 By his first marriage, Jean Louis had three children. One of them was
a son, Joseph William, born in 1783. He entered the Royal Navy and was
promoted to sub-lieutenant on 15 October 1805, six days before the battle of
Trafalgar. He had one son, also Joseph William, the engineer, who was born in
Enfield in 1819 and became an articled pupil of the eminent engineer Sir John
MacNeill who had himself been an assistant to the great Thomas Telford.25

In 1842, aged 23, Joseph set up his own civil engineering practice,
specialising in railway work at the height of the railway boom. He was based in
Great George Street, off Parliament Square, the ‘Harley Street’ of the
engineering profession where the Institution of Civil Engineers still has its
headquarters. As a result of overwork, Joseph became ill but quickly recovered
to gain the post first of assistant engineer and then engineer to the sewers
commission. He also gained a considerable reputation for competence. When
the sewers commission was replaced by a more powerful body, the Metropolitan
Board of Works, in 1855, Bazalgette applied to the new body for the post of
chief engineer and gave as his referees the great railway engineer Robert
Stephenson and the even more celebrated Isambard Kingdom Brunel. Such a
combination was hard to beat. He was given the job.

A GOVERNMENT FOR LONDON

The Metropolitan Board of Works was London’s first metropolitan
government. Prior to that date most of London’s local government outside the
Square Mile of the City of London itself lay in the hands of vestries, loosely
based on parishes, each jealously guarding its own interests regardless of the
effects on its neighbours and anxious, above all, to keep down the rates.
Overlaid on these was a confusing variety of paving and lighting boards and
local sewers commissions. The City, of course, under its Lord Mayor, had since
medieval times operated quite independently of the rest of the Metropolis. An
idea of the confusion which resulted may be gained by examining the
experience of the rector of Christchurch, Regent’s Park, who had enquired of
the government what could be done to improve sanitation in his parish. He
was told: 'In the parish of St Pancras, where you reside, there are no fewer than sixteen separate paving boards, acting under twenty-nine Acts of Parliament, all of which would require to be consulted before an opinion could be pronounced as to what might be practicable to do for the effectual cleansing of your parish as a whole.'

The Metropolitan Board of Works had been set up by an Act of Parliament of 1855 to bring some order to this chaotic situation. The board had more authority than the sewers commissions which preceded it but to allay the fears of local vestries that they were being displaced, the board’s forty-six members were elected by those vestries rather than directly by the ratepayers. The board remained in office until 1889 when it was replaced by the directly elected London County Council. It was enjoined by the Act to ‘make such sewers and works as they may think necessary for preventing all and any part of the sewage of the Metropolis from flowing into the River Thames in or near the Metropolis’. It also had the responsibility for creating new streets, parks and other public spaces. Its powers exceeded anything previously seen in London. It had the right to inspect the construction projects of vestries and to require alterations to them to conform to the board’s own plans. It also had the right to levy rates in each vestry area. These powers even extended to the Square Mile itself despite the protests of the city fathers.

**BAZALGETTE’S PLAN**

Bazalgette was appointed as Chief Engineer to the board on 25 January 1856, within four weeks of its taking office. He had the advantage of familiarity with the schemes which had been considered by the ill-fated commissions and by May he was able to present a comprehensive plan. He did so with a self-effacing modesty that was to become a hallmark: ‘Almost every suggestion which can be made upon the subject has been so often repeated in some shape or other that it would be difficult to detect which were the first authors of the various schemes propounded. Having had the advantage of access to all, I cannot pretend to much originality; my endeavour has been practically to apply suggestions, originating in a large measure with others, to the peculiar wants and features of different districts, with which my position has made me familiar.’

A much more flattering verdict was delivered by Sir George Humphreys who, as Chief Engineer to the London County Council, was responsible for maintaining and extending Bazalgette’s system seventy years after it was built. Men in such a position do not always offer compliments to their predecessors.
preferring sometimes to complain about a lack of foresight which has made the present incumbent's work so much harder! Commenting on Bazalgette's self-deprecatory statement, Humphreys wrote in 1930: 'This fair and frank statement, disclaiming credit which he considered was not due to him, must not be allowed to deprive Sir Joseph Bazalgette of the great credit to which he is entitled as the engineer who not only evolved a practical scheme out of these various proposals but also carried it out in so efficient a manner that to-day, with trifling exceptions, the whole work is still carrying out the function for which it was created.' 28 It should be added that Sir George's view is still shared by the engineers of Thames Water who operate Bazalgette's system in the twenty-first century. 29

Bazalgette himself described the arduous and frustrating nature of the task in an interview with Cassell's Saturday Journal in 1890, less than a year before his death. He described the problems of routeing a sewer, which must have a gradual and continuous fall, across a network of railways, roads and canals: 'It was certainly a very troublesome job. We would sometimes spend weeks in drawing out plans and then suddenly come across some railway or canal that upset everything, and so we had to begin all over again. It was tremendously hard work. I was living over at Morden then and often used to drive down there from my office at twelve or one o'clock in the morning.' 30

Bazalgette's plan called for the construction of huge intercepting sewers which would run parallel to the Thames on each side of the river. They may be seen in the diagram on page 140-1. They would intercept sewage and much of the capital's rainwater and conduct both to sewage works at Barking on the north side and Crossness, near Abbey Wood, on the south side. There the sewage would be released into the river at high tide so that the first movement of the sewage would be out to sea. The combined length of the intercepting sewers would be 82 miles. At their western end, where the sewers began, they would be about 4ft in diameter but as they made their way through the capital they would grow in size as they collected more and more waste. In the east end of London their diameter would reach 12ft - larger than the tunnels that would later be built for London's underground railway. In addition, Bazalgette's plan called for the construction of an additional 1,100 miles of street sewers so that all buildings and streets could be connected to his system, thereby preventing any waste from finding its way into London's underground rivers and wells.

As it passes through London, the Thames falls at a rate of 3in per mile whereas Bazalgette estimated that sewage needed a fall of at least 2ft per mile to ensure that it flowed steadily towards the sewage works without causing
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troublesome blockages. The topography of London meant that this discrepancy between the fall in the river and the fall of the sewers would mean that, as it neared its destination in the east, the sewage would be beneath the level of the river. His solution to this problem was to build huge pumping stations which would lift the sewage into outfall sewers which would take their murky contents on the final stage of their journey. The largest of these would be at Abbey Mills, near West Ham, on the north side and Crossness, near Abbey Wood, to the south. Bazalgette was confident that his proposal would solve once and for all the problem of pollution in the Thames.

**Big Ben intervenes**

Not everyone shared his confidence. The Act of Parliament which had set up Bazalgette's employers, the Metropolitan Board of Works, required that his plan be approved by a government minister, the First Commissioner of Works. This
office was held in Palmerston’s government by Sir Benjamin Hall who had recently presided over the final stages of the reconstruction of the Houses of Parliament after the destructive fire of 1834. He may have been celebrating the fact that the great bell in Parliament’s fine new clock, ‘Big Ben’, had been named after him though an alternative explanation for this name suggests that it was derived from that of Ben Caunt, an 18-stone boxer of formidable reputation whose retirement from the ring coincided with the installation of the bell. Either way, Sir Benjamin Hall took his responsibilities very seriously when he received Bazalgette’s proposals in June 1856. A delay of over two years now ensued while Hall dithered.

Since Sir Benjamin Hall has subsequently been much criticised for the delay, a few words should be offered in his defence. Bazalgette was proposing to construct a system which was unprecedented in its size and scope. He would be using untested techniques and materials. He would need to dig up or tunnel beneath the streets of the world’s largest city, thereby causing immense
problems for London’s traffic. Indeed the expression ‘traffic jam’ possibly originates with him. Moreover, if the system did not work as Bazalgette insisted it would, then sewage would continue to pollute the river and Hall would be remembered as the man who approved a flawed system. He therefore appointed two independent referees to evaluate Bazalgette’s plans. One of the referees was James Simpson, engineer to the Chelsea and Lambeth water companies whose work has been already described.\textsuperscript{31} In particular, Sir Benjamin Hall wanted to be reassured that Bazalgette’s sewage works were sufficiently far downstream. He was worried lest a really high tide should bring the sewage back into the centre of London.

There now followed a debate between Bazalgette, the referees and Hall which, in the words of a later account took ‘a somewhat acrimonious and personal tone’.\textsuperscript{32} The referees calculated that Bazalgette needed to extend his system for another 15 miles downstream in order to ensure that no incoming tide ever bore sewage into the centre of the capital. This, they estimated, would cost £5,437,265 compared with Bazalgette’s estimate of £2,413,376 for his plan.\textsuperscript{33} Bazalgette considered the referees’ plan to be an unnecessary extravagance and asked whether the extra cost would be borne by the capital’s ratepayers or whether the government would make a contribution. The government demurred. Parliament debated.

\textbf{The Great Stink}

In February 1858 Palmerston’s government fell and Sir Benjamin Hall was succeeded by Lord John Manners in the Conservative administration led by the Earl of Derby in the Lords and by Benjamin Disraeli in the Commons. A more significant event, however, was the hot, dry summer which followed and which had been fearfully foreseen by Michael Faraday three years earlier. \textit{The Times} described the consequences in a leading article on 18 June: ‘What a pity that the thermometer fell ten degrees yesterday. Parliament was all but compelled to legislate upon the great London nuisance by the force of sheer stench. The intense heat had driven our legislators from those portions of their buildings which overlook the river. A few men, bent upon investigating the matter to its very depth, ventured into the library, but were instantaneously driven to retreat, each man with a handkerchief to his nose. We are heartily glad of it.’

The temperature may have fallen but the point had been made. One of those seen fleeing from the library, handkerchief to nose, was Benjamin Disraeli, Leader of the House of Commons and Chancellor of the Exchequer. The Great
Sewer interior. (Thames Water)

Stink', as the press dubbed it, concentrated the minds of the government in a way that the disputes of engineers had failed signally to do. On 15 July, Disraeli introduced a bill to the House of Commons which removed the government's veto and gave Bazalgette and the Board of Works all the authority they needed to proceed with the work of constructing the main drainage system. The bill became an act in just eighteen days. The speed with which the bill was passed owed much to fear. At that time the court of Queen's Bench was situated within Westminster Hall, a few yards from the Commons chamber. The business of the court had been interrupted when the foul odours from the Thames which entered the court were described by a surgeon as 'dangerous to the lives of the jurymen, counsel and witnesses. It would produce malaria and perhaps typhus fever.' Later knowledge showed that the surgeon was wrong in his diagnosis but Bazalgette was not complaining.

'The most extensive and wonderful work of modern times'

In the time they could spare from quarrelling with Sir Benjamin Hall and his allies, Bazalgette and his staff had not been idle. He had continued to work on detailed engineering drawings and contract specifications so that, within a few
Building the sewer outfall at Barking: this page from the *Illustrated London News*, November 1861, conveys the scale of the operation with a temporary concrete mill and railway to make and convey the materials.
weeks of Disraeli’s act reaching the statute book, work had begun. It would take sixteen years to complete and would be the largest civil engineering project of the age, perhaps of any age, carried out under the direction of one engineer. Bazalgette’s huge intercepting sewers had to traverse the existing dense network of roads, railways and canals. Usually this was done by tunnelling beneath them as in the case of the New River and the Grand Junction canal but there were occasions when tunnelling would have taken a sewer too low to maintain a steady fall. In such cases roads or railways had to be raised or lowered to enable the sewers to pass. When the northern high-level sewer, beginning in Hampstead, had to cross the Metropolitan Railway without stopping the traffic, Bazalgette designed an aqueduct to be built 5ft above the intended level. It was then lowered into position a few inches above the engine chimneys.

Two problems are worth examining in more detail. All the northern sewers came together in a junction at Abbey Mills pumping station, near West Ham, where the sewage is lifted into ‘outfall’ sewers for the last few miles of its journey to the sewage treatment works at Barking. This outfall sewer, the largest of them all, had to cross low, marshy ground which was already intersected by roads and railways. A temporary cement works was built at Barking to produce the huge quantities of this material that was required to complete the works. A temporary railway also was built to convey the cement and other materials to Abbey Mills. The Barking and North Woolwich railway lines were lowered to enable the sewer to pass over it and five roads were raised by between 6 and 11ft so that the sewer could pass beneath them. As work on the sewer proceeded, the marshy ground was stabilised and the temporary railway retreated towards Barking. When the sewer was completed, the railway and cement works were dismantled and removed. The top of the outfall sewer is now a pleasant path, cycle track and nature trail through this otherwise rather unattractive part of east London. Very few walkers and cyclists know what is flowing beneath them.

The Victoria Embankment

Bazalgette’s second major problem lay in finding a route for the northern low-level sewer which served the most densely populated area. The simplest solution would have been to lay the sewer beneath the Strand and Fleet Street. At the time those streets provided the only direct route from Westminster to the City and were probably the most congested streets in the world. The effect upon
London's traffic of digging them up can scarcely be imagined. Bazalgette therefore decided to create his own land. At that time 'The Strand' was just that — the strand of the river: hence the name. The houses on the south side of the Strand backed directly on to the Thames and owners of such properties could step straight from their gardens into their boats via such steps as those of York Gate, now situated in Victoria Embankment Gardens, a considerable distance from the river. The Thames was thus much wider at that point than it is now.

Bazalgette therefore decided to reclaim thirty-five acres of land to build the Victoria Embankment. This huge structure, stretching for over a mile from Westminster Bridge to Blackfriars Bridge, was designed to meet six pressing needs. First, it was to provide a route for the low-level sewer, the last line of defence against the pollution of the Thames. Second, it provided a service tunnel through which were channelled gas, water and later electricity services. Third, it provided a much-needed road from Westminster to Blackfriars as an alternative to the congested Strand. To round off this part of his work Bazalgette built Queen Victoria Street from Blackfriars to the Bank of England so that travellers could travel from Westminster to the heart of the City on roads entirely built by Bazalgette. The fourth benefit of the Embankment was a
route for the District Underground Railway, now part of the District and Circle Line, which was itself seeking a means of connecting Westminster and the City.

The fifth amenity was Victoria Embankment Gardens, a much-needed green space in this part of London. Finally, by narrowing the river at this point Bazalgette made it run deeper and faster, helping to keep it clean. Never, perhaps, has one engineering project conferred so many benefits upon a great city. Bazalgette later repeated the exercise with the Chelsea Embankment from Battersea Bridge to Chelsea Bridge.

Planning the Victoria Embankment was difficult enough but building it created unprecedented challenges. For most of its length it was built within coffer dams. Piles were sunk in the riverbed and the gaps between them were filled in with clay and spoil. The water was then pumped out leaving a dry area within which the embankment, and its tunnels, could be built by thousands of labourers armed with picks and shovels. For the stretch between Westminster and Waterloo Bridges the riverbed was too unstable to permit piling so Bazalgette specified the use of caissons. These metal chambers, like boilers without bottoms, were lowered into the riverbed at low tide. Gaps between the caissons were plugged with wooden pegs to make a watertight barrier behind which work could proceed.

Victoria Embankment under construction. (Illustrated London News)
One of the consequences of the vast scale of Bazalgette's projects was a shortage of bricks. He used 318 million bricks in the intercepting sewers alone. In his own words to the Metropolitan Board ‘the supply became quite unequal to the demand created by the extensive character of your works, and thus the price of bricks was enhanced from forty to fifty per cent.’ Faced with this problem, Bazalgette therefore decided to use a material which was distrusted by his fellow engineers: Portland cement. This combination of lime and clay had been invented in 1824 by a Yorkshire bricklayer called Joseph Aspdin. When properly made, with materials of the right quality processed in the correct way, it was known to be exceptionally strong when immersed in water. However, it had acquired such a reputation for poor quality that engineers like Brunel would not use it. Bazalgette took the bold decision to use the new material but to install his own quality control inspectors to test to destruction every batch. In the words of one of his contract documents: All cement that shall not bear, without breaking, a weight of five hundred pounds, at the least, when subjected to this test, shall be peremptorily rejected and forthwith removed from the works. Bazalgette used almost a million cubic yards of Portland cement in his works. In the process the manufacturers created their own quality control procedures within their own works on the Medway, in Kent, to avoid the embarrassment and cost of having their materials rejected by Bazalgette. Long immersion in water (or sewage) was shown to strengthen the cement, which soon became the industry’s standard material.

**Public interest**

Bazalgette and the Board of Works showed considerable skill in managing their relations with politicians, the public and the press during the sixteen years that the main drainage took to complete. The interest shown by all in Bazalgette's work as it progressed reflects the importance attached to the task of ridding the Thames of sewage. One Sunday newspaper, the Observer, had been critical of Bazalgette's plans but in April 1861 it was writing 'It is two years since the most extensive and wonderful work of modern times was commenced.' The City Press which had long reflected the resentment of the City of London that the Metropolitan Board exercised authority within its sacred walls, was also won over, writing later the same year: 'Looking at the results attained so far, we must do the Board the justice of uttering our opinion that it has accomplished wonders and if we were to contemplate the transference of its powers to the hands of government we should at the same time entertain grave
doubts if the future progress of these immense undertakings would be prosecuted with one-tenth the speed or with anything like the same efficiency.\textsuperscript{39} Even the \textit{Marylebone Mercury}, which had been a long-standing critic of the Board and all its activities and had penned an article in March 1861 headed 'The Uselessness of the Board of Works' was won round. In October of the same year, after a tour of the works by the paper's editor, the paper declared that 'To Mr Bazalgette no tribute of praise can be undeserved.'\textsuperscript{40}

Further heights of acclaim were scaled when the Victoria Embankment, containing the great low-level sewer, was opened in July 1870. The importance of the occasion was reflected in the guest list. The opening ceremony was performed by the Prince of Wales who was accompanied by five other members of the royal family, twenty-four ambassadors, virtually every member of both Houses of Parliament and ten thousand ticket holders who watched the event from specially erected stands. The bands of the Grenadier and Coldstream Guards provided a musical accompaniment to the cheering of the excited
crowds and *The Times* devoted its main news story to the event, commenting that it 'marked the completion of a work of which it would be difficult to speak in terms of too much praise and admiration. ... For the principal engineer, of course, it will be a monument of enduring fame, second to none of the great achievements that have marked the Victorian age.' Four years later, following the opening of the Chelsea Embankment, Bazalgette was knighted.

The Victoria Embankment was an impressive structure but it was the invisible and forgotten sewer which really mattered. Four great cholera epidemics had carried off 40,000 Londoners between 1832 and 1866. To these must be added the steady flow of unnumbered victims of typhoid, dysentery and other diseases spread by polluted water. Bazalgette's greatest achievement was to banish these water-borne epidemics from London and elsewhere.

**CHOLERA**

From the late 1820s the spread of cholera from India across Asia and continental Europe had been the cause of much anxious speculation and comment. It is a particularly unpleasant disease, being characterised by acute diarrhoea and dehydration, usually followed by death within a few hours. The anxiety which followed its arrival in Britain in 1831 (where it first came ashore at Sunderland) was unprecedented since the plagues of the seventeenth century. In 1832 alone, thirty riots were caused by fear of this scourge. In November 1831, early in the first of four epidemics which hit Great Britain, the respected medical journal *The Lancet* reported that a community of Jews in Wiesnitz, Austria, had escaped its effects by rubbing their bodies with a mixture of camphor powder, wine, vinegar, garlic and ground beetles. Between 1845 and 1856 over seven hundred works were published in London alone on the subject of cholera. At the height of the second epidemic in September 1849, *The Times* published a series of articles which explored some of the theories that had been advanced to explain the rapid spread of the disease. These included the 'Telluric' theory which 'supposes the poison of cholera to be an emanation from the earth'; the 'Electric' theory which attributed the disease to atmospheric electricity; and the 'Ozonic' theory which laid the blame on a shortage of ozone. More space was devoted to the 'Zymotic' theory advocated by Justus von Liebig, Professor of organic chemistry at the University of Giessen (and inventor of the Oxo cube). Liebig believed that the putrefaction of bodies afflicted with cholera would produce ammonia which could be 'the means through which the
contagious matter received a gaseous form’ thereby creating a ‘miasma’ in the 
atmosphere which would spread the infection. The word ‘miasma’ is derived 
from a Greek word meaning ‘pollution’.

The perils of plums

None of the theories discussed by The Times involved polluted water, the real 
cause of the epidemics. At the time the science of microscopy had not 
advanced to the point where microbes in water could be identified with 
certainty. Cholera bacilli in water were then invisible both to the naked eye and 
to the scientist with his microscope. On the other hand the foul smell of 
London’s air, infected with the odours of its sewage-laden river, was all too 
visible. In these circumstances it was perfectly reasonable to suppose that the 
disease was carried in air rather than water. Indeed, as observed earlier, we 
have the Parliamentarians’ fear of airborne disease during ‘The Great Stink’ to 
thank for the fact that the deadlock over the construction of Bazalgette’s 
system was broken in the summer of 1858. Liverpool’s redoubtable public 
health campaigner, Dr W.H. Duncan, had expressed his firm belief in the 
dangers of an infected atmosphere, or ‘miasma’, in 1844.45 Another doctor 
who practised in Liverpool advanced a stranger theory: plums. Dr John 
Sutherland (1808–91) opened a medical practice in Liverpool in the 1840s. He 
told the Board of Health that the death from cholera of three German seamen 
from the Prussian barque Pallas was due to the fact that they had overindulged 
on the cargo of plums they had been transporting from Hamburg to Hull: 
‘during an epidemic constitution such indulgence is well known to be fraught 
with extreme danger’.46

Duncan and his fellow ‘miasmatisms’ were in respectable company. The great 
public health campaigner Edwin Chadwick (1810–90) informed a Commons 
Committee in 1846 that ‘all smell is, if it be intense, immediate acute 
disease’.47 In 1890, the year of his death, he advocated the construction of an 
edifice like the Eiffel Tower from which, by some unspecified means, air would 
be drawn down from a great height with a view to ‘distributing it, warmed and 
fresh, in our buildings’.48 One of Chadwick’s allies was Florence Nightingale 
(1820–1910) who in her seminal work Notes on Nursing, inveighed against the 
practice of laying drains beneath houses on the grounds that odours would 
escape from them, penetrate the dwellings and cause measles, smallpox and 
scarlet fever.49 That formidable lady went to her grave in 1910 convinced that 
air was the principal culprit in the spread of epidemic disease.
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John Snow and the Broad Street pump

Others were providing a more thoughtful analysis of the causes of cholera. Dr John Snow (1813–58), a pioneer in the use of anaesthetics during surgery and childbirth, began to practise medicine from premises in Soho in 1843. In 1849 he published a paper ‘On the Mode of Communication of Cholera’ in which he argued that water polluted by sewage might be the means by which the disease was transmitted. He further argued that the practice of flushing cesspools and sewers into the river made the epidemic worse and developed his thesis in a series of well-argued articles in the Medical Times and Gazette. He drew particular attention to the fatal effects of the water-closet: ‘If the general use of water-closets is to increase, it will be desirable to have two supplies of water in large towns, one for the water-closets and another, of soft spring or well water from a distance, to be used by meter like the gas.’

During the 1854 epidemic, which killed almost 11,000 citizens, Snow observed a high incidence of cholera among people who drew water from a well in Broad Street (now Broadwick Street, off Carnaby Street), near his Soho surgery. He also noted that workers at the nearby brewery, which had its own water supply, were not affected by the epidemic, despite breathing the same air. Further investigation revealed that a sewer (later found to be leaking) passed close to the well. Snow persuaded the parish authorities to remove the pump handle on the suspect well. This may have made Dr Snow temporarily unpopular but it certainly saved lives. Even so, very few were prepared to believe that the epidemic was caused by infected water despite the evidence of Snow’s observations and the inexorable logic of his arguments: ‘Rivers always

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**Dr John Snow (1813–58)** John Snow was born in York and apprenticed to a surgeon in Newcastle. He became both a vegetarian and a total abstainer from alcohol while a student – an unusual development even in those more abstemious days. He was one of the first to use ether and chloroform as anaesthetics, administering chloroform to Queen Victoria for the birth of Prince Leopold in 1853. He is best remembered for his seminal papers on cholera, though their significance was appreciated by very few during his lifetime. The site of the pump on which he based his observations, now in Broadwick Street, is adjacent to a pub which bears his name. The site of the pump itself is marked by a granite kerbstone and a replica of the pump has been positioned nearby.
receive the refuse of those living on the banks, and they nearly always supply, at the same time, drinking water of the community so situated... the water serves as a medium to propagate the disease among those living at each spot and thus prevents it from dying out through not reaching fresh victims.' 52

Most of his colleagues remained sceptical so in 1857, a year before his early death, John Snow published a comparison of death rates in Lambeth, whose water was supplied by James Simpson's Lambeth Company and the adjacent parish of Southwark, which was supplied by the Southwark and Vauxhall Company. In the 1849 epidemic Lambeth had suffered a slightly higher death rate. In the 1853-4 epidemic Lambeth's mortality rate was one-sixth that of Southwark. In the intervening four years Simpson had moved the Lambeth Company's intake to Seething Wells, above Teddington lock, where it was untainted by metropolitan sewage. 53 Snow offered this as further evidence that cholera was water-borne. The marked difference in the mortality rate of the two parishes, breathing the same air, cast further doubt on the 'miasmatic' explanation. Snow recommended the use of filters by water companies, as Simpson was already doing, and the boiling of drinking water during epidemics. 54

The Whitechapel epidemic

John Snow died in 1858, the year of 'The Great Stink', still surrounded by scepticism. The role of polluted water in causing cholera was at last publicly acknowledged in 1866 when William Farr, statistician to the Registrar General, carried out an investigation into the virulent epidemic which struck Whitechapel in that year. Whitechapel was not yet connected to Bazalgette's system of intercepting sewers. The East London Water Company denied that sewage could enter its reservoirs, yet at the height of the epidemic two customers of the company announced that they had found eels in their water pipes from the River Lea (also spelt Lee). This small tributary of the Thames was still receiving sewage from water-closets, including that of a labourer called Hedges who had died of cholera on 27 June. Farr demonstrated that the epidemic was caused by the company's carelessness in allowing its reservoirs to be polluted by water from the lower reaches of the Lea. Farr wrote to Bazalgette about the pollution of the water supply. Bazalgette responded quickly, telling Farr: 'It is unfortunately just the locality where our main drainage works are not complete. The low level sewer is constructed through the locality, but the pumping station at Abbey
Mills will not be completed until next summer. . . . I shall recommend the Board to erect a temporary pumping station at Abbey Mills to lift the sewage of this district into the Northern outfall sewer. This can be accomplished in about three weeks.\textsuperscript{55} The temporary pumping station was built and the epidemic ended, though not before 5,596 people had died of the disease in this small area of London. Farr’s verdict on the Whitechapel epidemic was damning. In his report he included a reference to the ruthlessness and skill with which the water companies had defended their interests, writing:\textsuperscript{56}

As the air of London is not supplied like water to its inhabitants by companies the air has had the worst of it both before Parliamentary Committees and Royal Commissions. For air no scientific witnesses have been retained, no learned counsel has pleaded; so the atmosphere has been freely charged with the propagation and the illicit diffusion of plagues of all kinds; while Father Thames and the water gods of London, have been loudly proclaimed immaculate and innocent. . . . An indifferent person would have breathed the air without apprehension; but only a very robust scientific witness would have dared to drink a glass of the waters of the Lea at Old Ford after filtration.

John Snow was thus posthumously vindicated, though sceptics like Edwin Chadwick and Florence Nightingale remained unconvinced, even after the German scientist Robert Koch had identified the cholera bacillus in India in 1883 and established that it was carried in infected water.
completed until 1865. I shall not dwell on the importance of dealing with the sewage of the city at the soil level, and the Nor
thern Metropolitan After this, the epidemic had not been registered before 5,596 deaths from the disease in the same area of London. Farr’s paper on the Whitechapel epidemic was of great
importance. Its mention of the connection between the disease and the air, and the skill with which the sanitary authorities had traced the sources of the disease, was in itself a great

Robert Koch (1843–1910) Robert Koch, an early practitioner of the science of bacteriology, identified the organisms that cause anthrax (1876) and tuberculosis (1882). He visited India and Africa to identify the sources of epidemics. In 1883 he identified the cholera bacillus in India and confirmed John Snow’s hypothesis that it was carried in polluted water. Koch’s reputation suffered a setback in 1890 when he announced that he had discovered a cure for the scourge of tuberculosis. One-and-a-half thousand doctors enthusiastically gathered in Berlin only to learn that Koch had been mistaken. Nevertheless his pioneering work in the field of bacteriology was widely applauded in both medical and wider scientific circles and in 1905 he was awarded the Nobel Prize for medicine.

By 1868, two years after the Whitechapel epidemic, Bazalgette had almost completed his system of main drainage. Another seven years would pass before the western extremities of the metropolis, around Fulham, were fully connected to the intercepting sewers, but this was a thinly populated area which was less susceptible to epidemics than densely populated areas like Whitechapel. In 1865 the Crossness pumping station, completing the southern drainage, was opened by the Prince of Wales. The four great pumping engines which lifted the sewage into reservoirs from which it could be released to the river were the largest ever built and were named after members of the royal family: Victoria, Prince Consort, Albert Edward and Alexandra. They were in fact so large that when modern replacements were built in the 1950s no means could be found of removing them so they remained in place and are now being restored. Abbey Mills, serving the northern system, was opened in 1868.

The epidemic that did not happen

In 1892 there was a severe cholera epidemic on the continent, especially in Hamburg which traded extensively with London. This caused the greatest anxiety since epidemics had invariably arrived in Britain from foreign seaports. The government commissioned a report on the subject from a Parliamentary Committee and set up a committee to advise on how to deal with the expected mortality. Kaiser Wilhelm II conferred on Robert Koch such draconian powers to deal with the Hamburg outbreak that the Burgomeister complained. The Illustrated London News devoted three successive issues to the virulent Hamburg epidemic. In the last of these it printed a dramatic picture entitled ‘Death in
the Cup’ based upon an account by its artist, J. Schonberg who had ‘witnessed in a shop where he called to make some purchase, a little girl drinking freely of water, the purity of which may be doubted. A few hours later he was told that this child was dead.’ There was no British epidemic. One hundred and thirty-five people died from ‘a disease reputed to be of the nature of cholera’. They were spread across sixty-four towns. Seventeen people in the capital died, nearly all of whom had contracted the disease abroad and brought it to London. But they did not pass it on to others. Bazalgette had died the previous year but his system of intercepting sewers ensured that London’s drinking water was protected from London’s sewage.

Bazalgette made the connection between cholera and efficient sewers before William Farr. In 1865 he described his system of main drainage to the Institution of Civil Engineers, commenting: ‘although great differences of opinion existed, and continue to exist, as to the causes of the disease [cholera], yet an inspection of the houses in which deaths occurred was sufficient to show that, however occult the connection between death and defective drainage, the places formerly most favourable to the spread of disease became quite free from it when afterwards properly drained’.59 London’s water was safe.

Bazalgette designed sewage systems for many other communities including Cambridge, Norwich and Budapest, which he visited in 1869 in response to a request by the Burgomeister. He submitted a plan for the City and in his covering letter commented ‘No-one can calculate how great the saving of life may be in case the City should be visited by Cholera.’60 He also designed a system for Port Louis, Mauritius, sending his engineer son Edward to survey the town on his behalf before designing a system of pipes to be made in England and shipped out to Port Louis for assembly there.

By 1896 cholera was so rare in Britain that it was classified in official publications as one of a number of ‘exotic diseases’.61 It continued to plague continental cities with inadequate sewerage systems and remains a threat in less developed countries, particularly Asia and Africa. In the 1990s there have been epidemics in South America, India and Bangladesh and over 106,000 cases were reported to the World Health Organisation in the first nine months of 2002, the great majority being in Africa. It remains a familiar horror in refugee camps and similar communities which lack proper sanitation.

Sir Joseph Bazalgette was not the only Victorian engineer who was building sewers in towns and cities but the scale of his great works mark him as the man who set the standards for the others and developed many of the materials
and techniques that they used. The significance of his achievements was well summarised in the closing paragraph of his obituary in The Times which appeared on 16 March 1891, the day after his death:

When the New Zealander comes to London, a thousand years hence, to sketch the ruins of St Paul’s, the magnificent solidity and the faultless symmetry of the great granite blocks which form the wall of the Thames Embankment will still remain to testify that, in the reign of Victoria, ‘Jerry-building’ was not quite universal. Of the great sewer that runs beneath Londoners know, as a rule, nothing, though the Registrar-General could tell them that its existence has added some twenty years to their chance of life.62

POSTSCRIPT

Bazalgette retired from his post as Chief Engineer to the Metropolitan Board of Works when the board itself was replaced by the London County Council in

Crossness from the air, still protecting Londoners from diseases. (Thames Water)
1889. In the last three years of his service he modified the system of sewage discharge to reflect the changes which had occurred in the thirty years since he first designed it. The areas around the sewage works at Barking and Abbey Wood were themselves becoming populated and the residents did not appreciate a 'Great Stink' of their own in the adjacent river. Bazalgette therefore constructed settling tanks at Crossness and Barking where lime and sulphate of iron were added to assist the settling process and reduce the smell. The liquid, thus deodorised, was released to the river and the solids were loaded into sludge boats (one of which was named Sir Joseph Bazalgette) which dumped their cargo in the North Sea. This arrangement continued for over a century after Bazalgette's death, until December 1998. Since that date the solids have been incinerated at Crossness and Barking, the energy generated by the process being fed into the national grid as 'green' electricity. The night soilmen would surely approve. They recycled London's waste as manure in an agricultural economy. Their successors recycle it as electricity in a world of high technology.

11. See ch. 6, pp. 181ff. above for an account of the poet's views on this matter.

12. The Lady Isabella Waterwheel of the Great Lexey Mining Company by A. Jespersen, 1970; British Library ref. X.615/612 gives a good account of the origins of the wheel.

13. The Manx Sun, 30 September 1854, described the event.

14. Hero of Alexandria is credited with making a steam-operated device in the first century BC but if it was ever made, it was for entertainment, with no practical application.

15. See p. 205 for an account of Goldsworthy Gurney's career.

16. The world's oldest surviving steam locomotive, now in the Science Museum.

17. Durham County Advertiser, 1 October 1825.


22. Parliamentary Papers, 1898, vol. 45 contain the evidence given to the inquiry.

23. British Road Steam Vehicles by Brown, Riley & Thomas, Bramley Books, 1999, p. 5.


25. A megawatt is 1 million watts; 25 megawatts would provide electricity for the homes of about 170,000 people: roughly the resident population of the city of York.


27. See p. 102 above for this reference.

5. Water as Deadly Danger

1. See ch. 3 for an account of the Grand Junction Canal Company.

2. Household Words, 13 April 1850.


5. The cause of Albert's death is not certain: cancer has also been suggested.


7. Now the more decorously named Sherborne Lane, off King William Street, EC4.


10. The Builder, 18 July 1844, pp. 350–1; the origin of the professor's title is lost to history.


14. See p. 21 for an account of Liverpool's enterprise in this respect.
15. Liverpool City Archives ref. Hq.050 KAL.
17. See p. 20 for an account of the work of Thomas Hawsley.
20. The abolition of Duncan's post was eventually announced on 10 September 2001, as a result of the reorganisation of health care in Merseyside and Cheshire.
21. The Times, 16 March 1850, p. 7 described the schemes.
23. The engineer, Isambard Kingdom Brunel, and London's first medical officer, Sir John Simon, are two other examples.
24. The Royal Archives, which the present author was allowed to consult by gracious permission of Her Majesty the Queen, contains details of Jean-Louis's attempt to recover his money: Royal Archives boxes 7/32 and 7/34.
25. See p. 72 above for an account of the work of Thomas Telford.
27. Metropolitan Board of Works, printed papers, vol. 1, no. 10, Metropolitan Archives.
28. The Main Drainage of London by Sir George Humphreys, ICC, 1930, Metropolitan Archives.
29. A verdict that invariably has been repeated by the many Thames Water employees with whom the author has discussed the matter.
31. See ch. 1 for an account of Simpson's work.
33. Metropolitan Board of Works Annual Report, 1857–8, pp. 5–6 gives the estimates.
35. Enough bricks to build 64,000 modern semis, for which information I am indebted to Mr E. Keane, builder by trade.
37. Metropolitan Board of Works contract document 2431/1, Thames Embankment, 27 October 1863.
38. The Observer, 14 April 1861, p. 5.
40. Marylebone Mercury, 12 October 1861, p. 2.
41. The Times, 14 July 1870, p. 10.
42. A History of Epidemics in Britain by C. Creighton, Cambridge University Press, 1894, p. 858.
44. The Lancet, 12 November 1831, p. 216.
45. See pp. 134–5 above for an account of Dr W.H. Duncan's work in Liverpool.
6. Water, Landscape and Literature

4. Not to be confused with the other Seathwaite further south in the valley of the River Duddon.
5. For example, the picture taken from a satellite which is featured in *Land of the Lakes* by Melvyn Bragg. Hodder & Stoughton, 1990, p. 4.
6. The period of glaciation ended as recently as c. 10,000 years ago.
7. Thirlmere and Haweswater are both reservoirs for Manchester.
9. *The Prelude*, Book 12, lines 102ff., from which the quoted passage is an extract.
11. The *Journal* entry relates to 15 April and David McCracken has identified the site as south of Glencoyne Beck on the western shore of Ullswater; see *Wordsworth and the Lake District* by David McCracken. Oxford University Press, 1984, p. 143.

53. See pp. 19–20 for the events surrounding these changes.
57. The restoration is being carried out by the Crossness Engines Trust; see their website www.crossness.org.uk for details of opportunities to visit the site.
58. 10, 17 and 14 September 1892.
60. Institution of Civil Engineers Archives B867 BAZ RDT. pp. 454–9.

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