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SIR JOSEPH BAZALGETTE (1819-1891) AND THE CLEANSING OF THE VICTORIAN METROPOLIS

DR STEPHEN HALLIDAY

Chapter five: Sir Joseph Bazalgette and the Great Stink

"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 in an address to the Institution of Civil Engineers, March 1865, on the debate as to whether cholera was conveyed in polluted air or polluted water)

In 1856 *Joseph Bazalgette* (1819-92) was appointed Chief Engineer to the Metropolitan Board of Works. He was of French descent but Joseph and his father, also Joseph, were born in England, descendants of a grandfather who had arrived in England in the 1770s. He had learned his engineering, as most did at those times, by being an articled pupil, in his case to Sir John MacNeill who gave him his first experience of drainage by employing him on land drainage schemes in Northern Ireland. He also worked on proposals for railways, which gave him experience of dealing with politicians in the negotiation of routes and he became a member of the Institution of Civil Engineers in 1838. When he applied for the post of Chief Engineer to the Metropolitan Board of Works he gave as his referees *Robert Stephenson*, designer of *The Rocket,* and *Isambard Kingdom Brunel.*

Bazalgette's was not the first such appointment. In May, 1847, *James Newlands* (1813-71) had been appointed as the first Borough Engineer in Britain to prepare a comprehensive sewerage plan for the troubled, disease-ridden city of Liverpool whose population had been swelled by impoverished Irish fleeing the potato famine and who were living in conditions of inconceivable squalor, in flooded cellars without sanitation. Liverpool was at that time the most populous city in Britain beyond London, with a population approaching 400,000. The appointment of Newlands had been preceded, in January of the same year, by the appointment of Dr *W.H.Duncan* (1805-63) as Britain's first Medical Officer of Health. Together the two men campaigned, with eventual success, for the construction of sewers and clearance of cellars that meant that when cholera returned to Britain in 1854 its effects were far less virulent than previous epidemics. Newlands has a claim to have been the first engineer to introduce egg-shaped sewers (sometimes referred to as "English sewers"), designed to concentrate the liquid in a narrow channel during times of low flow levels. This speeds the movement of the water and the solids it carried though even the Cloaca Maxima (see chapter one) the ancestor of all large sewers, was higher than it was wide. During the Crimean war James Newlands was sent to the Crimea as Sanitary Commissioner, earning from Florence Nightingale the accolade "Truly I may say that to us sanitary salvation came from Liverpool". Dr Duncan is remembered in Liverpool by *a pub named "Dr Duncan"* in his honour in the city centre and a special brew "*Dr Duncan's I.P.A."*

The Metropolitan Board of Works had a long and troubled birth. For many years London, which in 1801 had a population approaching one million, had struggled with the system of sewage disposal inherited from medieval times. Cesspools were emptied by night soil men who sold the contents to farmers just outside the city. Public

sewers in and beneath the streets were for disposing of rainwater though garbage, including butchers' offal was surreptitiously dumped in them and the kennels, as observed in the reign of Edward III in chapter 2. Nevertheless, the Thames was a reasonably clean river and salmon, the litmus, test of water quality, were being caught in the first decades of the nineteenth century. But three factors now combined to interrupt these arrangements. First, London grew, and the fields moved further away. Moorfields and Spitalfields ceased to be fields by the end of the eighteenth century so the night soil men had to carry their sewage further. Secondly, from 1847, a more effective fertiliser became available in the form of guano, solidified bird droppings, which began to be imported from islands off the coast of Chile. The Gibbs family used the enormous fortune they earned from the trade to build *Tyntesfield,* now a National Trust property in Somerset. The night soil men struggled to compete.

But the most decisive factor was the introduction of the water closet whose invention, by Sir John Harington, is described in chapter two. In 1775, a patent was registered by a Bond Street watchmaker called *Alexander Cumings* for an improved version of Harington's device. In 1778 a Yorkshire-born carpenter and inventor called *Joseph Bramah* (1740-1814) was asked to install one of the closets in a private home and realised that he could improve the design further and simplify the process by which its components were manufactured. He patented his version of the WC and started to make them in large quantities. By 1797 he had made and sold over 6,000 closets and his company continued to flourish until 1890. In 1861 a Victorian businessman called *Thomas Crapper* started a competitive business in Chelsea and in 1870 opened a showroom to display his wares which were advertised under the slogan "A certain flush with every pull". The business continued to operate from 120, King's Road, Chelsea until 1966 and still trades, dealing in sanitary fittings online. Crapper installed thirty of his WCs at *Sandringham House*, equipped with cedarwood seats. The products were of high quality with many still in use – for example at a public house called "The Parcel Yard" adjacent to the Harry Potter Platform 9 3/4 at London's King's Cross station. In 1849 Thomas Twyford opened a factory for the production of sanitary ware in Stoke-on-Trent and in 1883 began to manufacture the "Unitas" ceramic closet for export to the world. To this day the word "Unitas" in Russian means 'Toilet'. The WC was one of Britain's great gifts to civilisation.

But the greatest ingenuity of all was shown by *George Jennings* (1810-82) who was born in Eling, Hampshire, on the fringe of the New Forest and joined the plumbing business of his uncle in Southampton. He is remembered for his enterprise in installing WCs in the *Crystal Palace* which housed the Great Exhibition of 1851. 827,000 people used these conveniences, many experiencing them for the first time, and each paying one penny for the privilege. This gave us the expression "spend a penny" and was a very effective means of drawing attention to the advantages of the devices. But water closets have one major disadvantage when used in conjunction with cesspools. When flushed, they discharge a small amount of faeces and urine, potential fertiliser, and two gallons or more of water, rapidly filling the cesspools with liquid that farmers did not wish to buy, and which leaked. In 1866 *William Farr* the Registrar-General of births, marriages and deaths, drew attention in a report to the fact that "the water-closet system had the advantage of carrying night soil out of the house but the incidental and not necessary disadvantage of discharging it into the rivers from which the water supply was drawn". The subject of Farr's report was a fatal disease which had emerged in the delta of the Ganges river in India. As it made its way westwards, via polluted water towards Europe, it would do more than anything else to galvanise European governments into investing in better sanitation. It was endemic in parts of India and was possibly spread by British troops when they were re-deployed from duties in India. It was called Cholera and remains a familiar scourge in poor communities and refugee camps in the twentieth century. Cholera threatened rich and poor alike when it entered the water supply and prompted the authorities to take steps to improve sanitation in urban communities using the skills of civil engineers which, in the nineteenth century, marked the end of sanitation's Dark Age.

As the cesspools leaked into the surrounding soil some of the content would find its way into underground springs and wells from which drinking water was drawn and this carried waterborne diseases like typhoid and cholera into homes. In London alone in the nineteenth century almost 40,000 people died in four cholera epidemics. At the time, most orthodox opinion held that the epidemics were carried by foul-smelling air rather than by water (the "miasmatic" theory"), a view later revealed as mistaken, but all were agreed that the leakage of cesspools into the soil was a threat to health. So, in 1815 the authorities, for the first time, allowed cesspools and house drains to be connected to public sewers. And in 1847 their connection to the public sewers was required by law. The public

sewers, in turn, carried their contents into underground rivers and thence into the Thames so in the space of thirty-two years (1815-47) the Thames was transformed from a relatively clean river to an open sewer.

In 1855 *Michael Faraday*, then probably the most famous scientist in the world, travelled by steamboat from London Bridge to Hungerford Bridge and on 7th July, he wrote to "The Times" which published his letter. Here are a few extracts:

> "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. ..The condition of the Thames may, perhaps, be perhaps considered as exceptional but it ought to be an impossible state instead of which, 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".

A *Punch Cartoon* followed the letter, depicting "Faraday giving his card to Father Thames and we hope the dirty fellow will consult the learned professor". And later the same year Charles Dickens wrote the first instalments of the novel which became "Little Dorrit" in which he lamented the fact that the Thames, the great artery of Britain's commerce and prosperity, had become a "deadly sewer".

The "hot season" of which Faraday warned followed three years later in the "Great Stink" of 1858 but it was the conditions to which Faraday had drawn attention that led to the creation of the Metropolitan Board of Works in 1856.The board replaced a multitude of parish vestries, liberties, commissions and similar bodies which had come into existence over centuries. Their aims were twofold: to spend as little ratepayers' money as they could; and to despatch their sewage to the adjacent parish as quickly as possible. Sizes and shapes of sewers were not co-ordinated, and the arrangement was particularly unfortunate for those parishes which were situated in the low-lying parts of London, close to the Thames, where everyone's waste accumulated before entering the river. The Metropolitan Board of Works was the first body established for London as a whole, with authority to construct roads, bridges, parks but above all street drains and intercepting sewers or "collectors".

Bazalgette set to work without delay. He knew the task ahead of him as he had previously been employed by one of the sewers commissions which had done some preparatory work and built some new street sewers. By June 1856 he was able to submit his plans, a system of intercepting sewers running parallel to the river. On the north side of the river, the sewage was taken mostly by gravity to Abbey Mills, near West Ham, before being lifted by huge pumping engines into outfall sewers which took it on to Beckton in Essex for discharge at high tide. On the south side it was taken to Crossness, in Kent, where the largest beam engines ever built lifted it into reservoirs where it was discharged into the river at high tide before beginning its voyage to the North Sea. The pumping stations, which have been restored after being replaced by modern equipment, are *magnificent examples of Victorian engineering* with lavish use of highly coloured wrought iron. Both the pumping stations are still in relatively isolated places, their magnificent designs being seen only by sewage workers and a testimony to the importance the Victorians attached to the design of public works.

The legislation setting up the Metropolitan Board of Works required that Bazalgette submit his designs to the Chief Commissioner of Works, a government minister who had to approve the plans before work could start. This was Sir Benjamin Hall (1802-67). Hall was himself a civil engineer who was preoccupied with the rebuilding of the Houses of Parliament on the banks of the Thames following the disastrous fire of 1834 which had destroyed most of the buildings while preserving Westminster Hall itself. Hall was a tall man who is believed to have given his name to the bell that sounds the hours in the Parliamentary clock, "Big Ben". Understandably, Hall needed to be reassured that Bazalgette's system offered enough capacity to deal with the waste of London in the future; and most importantly he needed to be persuaded that it would be discharged into the river so far downstream that it would not return to the city on a very high tide. To that end he engaged the services of two eminent water engineers called James Simpson (1799-1869) and Douglas Galton (1822-99) to examine Bazalgette's calculations. Their opinion was equivocal. Experiments that they undertook with floats suggested that in certain exceptional conditions the sewage could make its way back to Westminster. Hall did not wish to go down in history as the man who, having supervised the reconstruction of the Palace of Westminster, had also authorised sewage works

which would poison its atmosphere. Select Committees deliberated, engineers pondered and cesspools continued to leak into the soil and river. Bazalgette estimated the additional cost of moving the outfalls beyond his proposed sites at Beckton in Essex on the north bank and Crossness in Kent on the south bank. There followed a suggestion that since the capital's sewage was "An Imperial matter" the cost should be paid by the Empire, not just by the citizens of the Metropolis. This did not long survive the objections of communities beyond London and was unceremoniously abandoned.

There the matter stood until the logjam was broken by a force of nature. The summer of 1858, three years after Faraday's letter warning of a "hot season" to give "sad proof of the folly of our carelessness" delivered the hot, dry summer which Faraday had foreseen. Debates in Parliament now took over and on 7th June 1858 "Hansard" reported that "It was a notorious fact that Hon. Gentlemen sitting in the Committee Rooms and the Library were utterly unable to remain there in consequence of the stench which arose from the river". Even soaking the curtains of the Palace of Westminster in chloride of lime did little to mask the smell. It is essential to remember that most well-informed people, including MPs, were adherents of the "miasmatic" theory of disease propagation which held that germs were spread by foul air, not polluted water. Edwin Chadwick and Florence Nightingale were particularly strong adherents of this theory. Chadwick in particular, towards the end of his life, advocated the construction of an object like the Eiffel Tower from which fresh air would be drawn to street level and circulate health-giving breezes amongst the streets. We now know this to be a mistaken view, but it worked for Bazalgette. Fearful that they would be poisoned by the foul stench a Bill was introduced by Disraeli, (who referred to the river as "That Stygian pool") which removed Hall's veto, authorised Bazalgette to start work immediately and enabled HM Treasury to underwrite any sums raised by the Metropolitan Board to build the sewers. This enabled money to be borrowed at low interest rates.

Work began in January 1859 and by 1865 the sewers serving the less populous South Bank were completed as was the treatment works at Crossness near Abbey Wood in Kent. The official opening of Crossness took place on the 4th April 1865 and was *performed by the Prince of Wales* in the presence of two Archbishops, other members of the royal family, MPs and numerous other dignitaries. One of the four great beam engines which lifted the sewage was named after the Prince and switched on by him, the others bearing the names of other members of the royal family: Victoria, Prince Consort and (future Queen) Alexandra. From that time there were no further cholera epidemics south of the river. The *pumping station at Crossness* has been carefully restored by teams of volunteers working over the past thirty years and one of the great beam engines "Prince Consort" is has been returned to working order and is opened to the public on "steaming days" which are advertised on its website. The pumping station, and beam engine are unsurpassed examples of Victorian engineering in its prime. And they are not unique. A similar example is to be found at *Leicester City's Museum of Science and Technology* and the *Cambridge Museum of Technology*, both of them based like Crossness in former sewage pumping stations, the latter system also designed by Sir Joseph Bazalgette.

The task north of the river was more complex since the area was particularly densely populated and digging up busy streets to build huge sewers was unlikely to be acceptable. Bazalgette solved the greatest problem of all, the route for the low level sewer on the north bank of the Thames, by reclaiming almost 40 acres of land from the Thames to build the *Victoria Embankment*, running from Westminster Bridge to Blackfriars, with *Queen Victoria Street* built to complete the link from Westminster to the Bank of England in the heart of the city. The Embankment thus had the further benefits of providing an additional road link between Westminster and the city to supplement the notoriously congested Strand-Fleet Street- Ludgate Hill route; and a means by which the District Underground Railway (now the District Line) could pass from Blackfriars to Westminster. Finally, he thereby created *Victoria Embankment Gardens,* a much-needed green space in the heart of Westminster. An impression of the scale of the works can even now be gained by standing in these gardens at York Watergate, at the bottom of Buckingham Street, and reflecting that until the 1860s, before the Victoria Embankment was completed, the Dukes of York and Buckingham would step from the Watergate on to their barges. The Watergate is now about 100 metres from the river which is thus much narrower and faster flowing. The *opening of the Embankment* was itself a great event, carried out by the Prince of Wales (Queen Victoria had a headache) and attended by royalty, twenty-four ambassadors, virtually all Members of both Houses of Parliament and ten

thousand ticket holders who were entertained by the bands of the Grenadier and Coldstream Guards. (*Numerous pictures of this event available)*

Another great challenge was the completion of the northern sewers between Abbey Mills, in West Ham and Beckton. Having been conveyed, mostly by gravity, to Abbey Mills, the sewage was lifted thirty-six feet there by *huge pumps* (exceeded in size only by *those across the Thames at Crossness*) into the outfall sewers which took it across five miles of marshy ground, intersected by roads and railways, to the treatment works at Beckton. Massive embankments were built to traverse the unstable terrain, two railway lines had to be lowered and five roads had to be raised by between six and sixteen feet to enable the outfall sewers to pass over the railways and beneath the roads while maintaining a steady downward gradient. A temporary concrete works was built at Beckton and a temporary railway conveyed the material to Abbey Mills as the construction began. As the sewers advanced the railway receded until the sewers reached Beckton, the temporary structures were dismantled and taken for use elsewhere. *(See illustrations on page 85 of Great Stink).*

In the summer of 1866 London suffered its last cholera epidemic in about one square mile of Whitechapel, costing 5,596 lives. This was the only part of Bazalgette's system that was not complete, and it is hard to imagine how great would have been the death toll if the rest of the city had been lacking sewers. The Whitechapel epidemic was caused when the water closet of a man called Hedges who, with his wife, had died of cholera, discharged into the river Lea half a mile below the East London Water Company's reservoir, but their discharges were, after a careful inquiry, found to penetrate the East Company's reservoirs. Indeed, as In Hamburg, eels were found to have entered the reservoirs via the company's pipes.
Bazalgette wrote that:

> "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 Milla 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".

The temporary pumping station was erected, the sewage removed from the water supply and conveyed to Beckton, near Barking, for discharge to the river and the cholera outbreak subsided. In 1868 the new, permanent pumping station was opened at Abbey Mills, near West Ham. It still serves the capital. In 1892 there was a severe outbreak of cholera in Hamburg, one of London's principal trading partners. London braced itself for an epidemic but none occurred. In England 132 deaths were reported in 64 towns, 17 of the deaths in London, probably amongst people who had contracted the disease abroad. Bazalgette had died the previous year, his legacy being a system of sewers that protected London's water supply. The cost of the whole enterprise was £ 4.2 million for the sewers and £2.4 million for the Embankments. Haussmann's less comprehensive system for Paris, a much smaller city, cost almost five times as much.

Bazalgette's sewers are a "Combined System" which collects both wastewater from premises and rainwater that falls on the streets. The flow of wastewater can be forecast with some accuracy, almost by the hour, as the engineers know when people will be awake and active and when commercial premises are at work. Rainfall is impossible to forecast in this way and is notoriously subject to peaks and troughs, when a sudden summer storm can deposit a month's normal flow in a matter of hours. To accommodate every eventuality would require sewers of unrealistic size so it was agreed that, on the rare occasions this happened, the sewers could deposit their surplus rain directly into the Thames. The first test of the system fell on 26th July 1867 when one eighth of the average annual rainfall fell in nine hours. The system coped. Modern sewerage systems, built in new towns and estates, are usually "Separate Systems" in which wastewater and rainwater are collected in separate pipes. This reduces the volume of water going to the treatment works, which makes their job easier, and permits the relatively clean storm water to pass harmlessly into rivers and lakes.

In 1878 a pleasure steamer, the *Princess Alice,* collided with the freighter *Bywell Castle*, causing the Princess Alice to sink at the cost of many lives. The accident occurred close to Crossness at the time of discharge and it was suggested in some quarters that some fatalities had resulted from poisoning rather than drowning. By this date the

areas around Crossness and Beckton had become homes rather than sites of heavy, often polluting, industries as in the past. After much procrastination it was decided that in future the sewage from Beckton and Crossness, instead of being discharged direct to the river, would be pumped into settlement tanks to which lime was added to aid the process of settlement and to de-odorise the liquid, which would then be released to the river. The settled sludge would then be pumped on to boats (one of them called *Sir Joseph Bazalgette*) and dumped beyond the estuary in the North Sea. This was the system bequeathed by Bazalgette when he retired as Chief Engineer in 1889, dying two years later. And the system survived, virtually unchanged, until 1998 when it was replaced by a modern system described in chapter nine.

There were other consequences of Bazalgette's work. One was the rapid growth of the firm of Doulton and Watt usually associated with fine china. It was founded by John Doulton (1793-1873) in Lambeth where he had the foresight to buy cheaply, in that poor part of London, land which was exceeded in size only by the grounds of the Archbishop of Canterbury's Lambeth Palace. The business flourished as a manufacture of large stone jars until 1845 when the ubiquitous Edwin Chadwick "the Father of sanitary science" (a title that immodest gentleman may well have awarded himself despite his deficient knowledge of the subject) persuaded John Doulton's sons and heirs, Henry and Frederick Doulton, that the future lay in a market for glazed earthenware sewers. Doulton built a *factory on his land in Lambeth* and by 1854, according to the magazine "The Builder" was producing ten miles of pipe sewers per week, a practice which continued until the 1930s, much of the output being exported. It was extensively used in the street sewers which Bazalgette used to feed the great interceptors though the latter, by virtue of their size, ranging from 1.4 metres diameter at the western end to 3.3 metres at Abbey Mills, were built of brick. Many of the bricks installed at the bottom of the sewers were also made by Doulton. These are known as "Staffordshire Blues" and were made from the 1850s using clay from Staffordshire and fired at very high temperatures to give bricks of exceptional strength which absorb very little water. They continue to serve Bazalgette's sewers in the twenty-first century and are also used in the foundations of modern buildings.

A further consequence of Bazalgette's work was the widespread use of Portland cement. Patented by a Yorkshire bricklayer called Joseph Aspdin in 1824 it was superior to the traditional Roman cement, which consisted mostly of lime. Portland cement was a mixture of chalk and clay, ground very fine and heated to a very high temperature. When properly made it was much stronger than Roman cement and actually became harder under water but if the ingredients, grind or heat were wrong it did not come up to expectations. I.K.Brunel and Robert Stephenson did not trust it because they regarded it as unreliable. Bazalgette, worried by the cost and availability of bricks, decided to adopt it and imposed a drastic quality assurance regime which tested every batch to destruction. The suppliers, based in the Medway valley in Kent, installed their own quality assurance procedures on site, raised the quality and reliability of the product and it became an industry standard, which it remains, firmly installed by Bazalgette in the sewers which still serve London.

In 1861, as Bazalgette began his work, the population of London was 2.8 million. By 1901, ten years after his death, it had reached 6.5 million. Fortunately, his designs anticipated a substantial increase in the population of the Metropolis, but he cannot have expected that, by the outbreak of the Second World War in 1939, it would peak at 8.6 million. To accommodate this burgeoning population, huge public housing developments were created. Thus between 1921 and 1935 the world's largest public housing estate was built at Becontree in East London, accommodating 100,000 people in 26,000 homes which necessitated a major extension to Bazalgette's system, notably additions to the outfall sewers from Abbey Mills to Beckton. This vast structure is now topped by a five-mile-long foot and cycle path in Tower Hamlets running from Wick Lane in Bow to Beckton. Formerly bearing the accurate but forbidding name "sewerbank" it was renovated and landscaped in the 1990s to provide a pleasant route called "Greenway" with a vista over the landscape below including a fine view of the Olympic Park. It also gives a good impression of the sheer size of the work of Bazalgette and his successors.

The population growth of the inter-war period was followed by a slow but relentless decline in the years following the war, falling to less than 6.6 million in 1991 as much of the population was relocated from poor housing, much of it damaged by bombing, to communities in new towns like Hemel Hempstead, Stevenage and Crawley. Moreover, although the Metropolitan population was in decline, in the 1950s the replacement of housing of poor quality within London meant that, for the first time, many families had hot and cold running water and water

closets for the first time, putting further strains on the system and necessitating further additions to its capacity. And this process continues. London's docks have been transformed into offices and their warehouses have become luxury flats, lavishly equipped with every water-bearing facility (baths, showers etc.) that money can buy. Moreover, in the last decade of the twentieth century the population began to recover and has now passed its 1939 peak, reaching nine million for the first time in the second decade of the century with consequences which are examined in the final chapter.

Bazalgette was much admired in his time and the importance of his works recognised by his fellow citizens, was reflected in his obituary in "The Times" published on 16th March 1891. Referring to his most visible work, the Victoria Embankment the obituarist wrote:

> "Of the great sewer that runs beneath, Londoners as a rule
> know nothing though the Registrar-General could tell them
> that it has added some twenty years to their chance of life".

Bazalgette's work continues to accommodate the needs of a city larger than he could possibly have imagined.