FINANCING THE EVOLUTION OF LONDON’S WATER SERVICES: 1582 TO 1904

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Abstract
This paper examines the evolution of water supply as a private, for-profit business from its origins in sixteenth century London until its transfer to a public monopoly at the start of the twentieth century. From 1582 onwards, 29 private water companies operated at different times in the area which became Greater London. By 1850, these had consolidated into eight local monopolies operating within mutually-agreed boundaries. The survival of private services depended on a mix of economic, institutional and political factors. Financial sustainability was achieved through early start-up investment subsidies and a pricing policy that kept the basic charge for a household connection constant in nominal terms for two and a half centuries. As quality regulation was introduced after 1852, services were transformed from low-pressure, intermittent and untreated supply, to a treated, continuous, high-pressure service universally available and affordable to all. Over the long run, users paid for services, with wealthier households providing a cross-subsidy to poorer ones through time. The policy implication is that early public sector financial support in the form of grants, soft loans or patient equity may be necessary to launch private sector solutions for water services, and that quality and price regulation is needed to drive quality improvements, achieve universal coverage and cap excess profits.

JEL Classifications: \(L95, B52, N83, G32, L50\)

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1. Introduction

This paper is concerned with the financing of water supply services and their long-run sustainability. We adopt an evolutionary economics approach, which Nelson (1982, 1994) describes as the co-evolution of technology, industrial structures, and their supporting institutions. OECD (2006) found a dramatic underfunding in the water sector, notably in the developing world, even though this represents almost half of global infrastructure investment needs to 2030. OECD (2009) introduced the idea that financial sustainability needs to be planned for through an appropriate balance of tariffs, taxes and transfers, the so-called 3Ts model. Closing the financing gap requires countries to improve efficiency and mobilise funds from a mix of sources, including more funding from the 3Ts, grants and repayable public or private finance.

The fundamental role that institutions and finance play in the transformation of infrastructure services generally, and water in particular, is widely recognised in the literature (Saleth and Dinar 2004; Estache 2007). Private finance is increasingly seen as an important policy option for relieving stressed public sector finances in both the developed and developing economies; but in practice this has not proven easy. Gomez-Ibanez (2007) gives a litany of failed private infrastructure projects illustrating the many problems faced and multiple causes of failure. Water services have proven to be one of the most difficult areas for private finance (Marin 2009; Bakker 2010). On the one hand, high risks imply the need for high financial returns, but on the other hand, high profitability represents a political risk in itself when private investors are seen to profit excessively from such an essential public services.

Clearly, the context and political meanings of the terms “public” and “private” changed significantly over the three centuries examined here, which witnessed the decline of monarchical power together with the rise of capitalism and democracy. Such changes to both context and meaning were particularly evident in the nineteenth century, characterised by rapid population growth, the extension of enfranchisement and the beginnings of mass politics. For example, these processes arguably led to a very different kind of State – more accountable and responsive to public demands – than the one that had existed when the London water companies began. However, we give primacy to continuities rather than changes in order to maintain focus on the problem of raising and deploying finance for utility infrastructure over time.

The challenge of funding the development of water services is not new. Water supply launched Britain’s infrastructure private finance revolution in the sixteenth century (Goldsmith 2014). Large amounts of private funding were required to take on huge engineering challenges to develop services for which demand was unknown. What were the factors that enabled private services to be successfully financed then and yet are so problematic now?

Analysing the history of water services and other network industries across Europe, Millward suggests that water supply was viewed differently from other local infrastructure service industries. Water supply was seen as a halfway house between social programmes, such as public health and education, and commercial services, such as electricity, gas or tramways. As a result, he argues that “water undertakings generally made a financial loss” (Millward 2005, 50). In contrast, we find that water supply was highly profitable over the long run, but establishing financial viability always took time.

The argument is developed through four research questions. Why did private water supply companies emerge and survive in London some 250 years before the rest of the world? In what way did the raising of funds for investment change over time? How profitable was private investment in water supply over the long run? How was financial sustainability achieved?

Our approach follows that of Geels (2005), who studied the transformation of the Dutch water supply sector from 1850 to 1930 to show how a multi-level perspective can illustrate the complex linkages in the co-evolution of technology and society. On the one hand, this involves technological innovations
on both the supply and demand side, such as improvements to the infrastructure delivering piped water and households adopting new sanitary technologies like flush toilets and baths. On the other, there are the cultural, political, economic and behavioural changes that support or block the transition to a new equilibrium. Geels acknowledges that finance was a key uncertainty delaying the development of water supply systems in the Netherlands, but sees this as just one blocking factor alongside others, such as demand uncertainty.

This paper uses information from a variety of sources to estimate the long-run profitability of some of the early private water companies from their foundation through to purchase by the publicly owned Metropolitan Water Board (MWB) in 1904. Such a very long-term record of the profitability of an infrastructure service industry is unique. Data comes from a mixture of primary and secondary sources, notably the historical and financial review of private companies before 1720 by Scott (1911), different editions of the London Stock Exchange Year Book, the financial returns to Parliament by the water companies, and the reports of various Royal Commissions and Parliamentary Committees enquiring into the state of water supply to the metropolis, held in the London Metropolitan Archives.

The rest of this paper is organised as follows. Section 2 motivates the problem of financing in relation to water services by distinguishing between initial investment, on-going financing needs, sources of revenue and the level and distribution of profits. Section 3 develops a micro-economic historical narrative of the development of water supplies to London by focusing on critical periods in the transformation of services and the key actors involved. After a quantitative and qualitative analysis to answer the research questions posed, some policy implications for today’s policy debates are explored and conclusions drawn.

2. The infrastructure finance problem

The infrastructure finance problem can be simply stated: where to obtain funds for initial capital investments; and how to generate sufficient cash to adequately operate, maintain and upgrade assets, whilst being able to repay debt and reward equity investors? In the short term, funds for investment have to come from either non-repayable finance, which can be private donations or public grant schemes, or from repayable finance, such as debt or equity. In the long run, the cash flow to sustain the service has to come from user tariffs, taxation or transfers. This is a practical problem of insufficient cash flow producing a vicious circle of low expenditure on maintenance and deteriorating services or even an inability to repay outstanding debts. Private water companies can go bust.

From a modern understanding of private finance, we assume that the ability to raise debt or equity depends on the balance between risk and reward as assessed by the market. But at the origins of private infrastructure finance, there were no functioning capital markets, so the process of raising funds was essentially ad hoc. No one knew how risky investments might prove or what the rewards could possibly be. There were those who doubted that the sale of a basic commodity like water could ever be a commercial success.

There is a fundamental difference between raising capital for a “greenfield” project and raising it for a functioning utility with existing revenues and expenses (Tan 2007). Investments to build a new water network for a growing city can be structured as project finance, whereas later financing of further expansion and upgrading become corporate finance with a higher proportion of debt. In this context, it is important to distinguish between speculative finance and long term investors who commit new resources to the success of an enterprise. Someone who trades in existing shares or bonds of a going concern is speculating on future dividends and the share price relative to a near-risk-free alternative such as Government bonds. But they add no new resources to the venture. In contrast, an investor who puts up capital at the start is taking a real risk on the delivery and success of the project.
3. Drivers and change in London’s water supply services

Figure 1 illustrates how the City of London grew from a population of fewer than 50,000 in 1500, largely living within the old Roman walls, to pass one million by 1800 and become the largest city in the world by 1825. It was this spatial expansion and population growth that continuously created new markets for existing and new private waterworks companies.

The story of how London’s water supplies developed from ancient times through to the (then) present day has been told from a variety of perspectives. Starting with John Stow’s description in 1598, there are accounts by engineers that stress technological progress (Matthews 1835; Dickinson 1954; Roberts 2006); the social science perspective looks at changing social relationships around water (Jenner 2000; Trentmann and Taylor 2005); and then there is the medical narrative which identifies London’s pioneering role in public health regulations (Stern 1954; Hardy 1991; Rosen 1993). Legal studies in the late nineteenth century focused on the origins and powers of the different companies (Clifford 1887; Richards et al 1899). Others focus on a particular period of history, theme or actor. Graham-Leigh (2000) describes the origins, battles and aftermath of “London’s Water Wars” between 1805 and 1825, as old and new companies fought for customers and profits. Ward (2003) recounts the 300-year history of the New River Company (NRC) from its origins under Elizabeth I through to its demise as a water company in 1904. Hassan (2001) focuses more on the 20th century and the shift from local to regional to river basin as the organisational unit for water services.

![Growth of London's Population](Figure 1. The demographic and spatial growth of London 1500 - 2000)

Source: Data from [http://www.demographia.com](http://www.demographia.com) and London data store, historic census population at URL: [http://data.london.gov.uk/datafiles/demographics/census-historic-population-borough.csv](http://data.london.gov.uk/datafiles/demographics/census-historic-population-borough.csv) and Robson (1948)

With such varying perspectives, information can seem fragmented or selected to fit a particular narrative. We have an incomplete picture of the nature of services to different categories of consumers, the underlying economic issues of supply and demand, how investment funds were raised, and how long-term financial sustainability was achieved. Finance offers both an alternative narrative and an explanation of the forces driving profitability and long-term survival of the companies. What follows is a highly-condensed version of key events, focusing on how services changed, the main actors, drivers of change, and the balancing of financial flows over time. The account draws heavily
on secondary sources, particularly Scott (1911) for the financial history of the early water companies, enriched by some primary source material held in the London Metropolitan Archives.

3.1 From Roman to medieval times

By the end of the first century CE, Londinium (London) had replaced Colchester as the administrative capital of Roman Britain. Around 200CE, Londonium’s city walls were built. They lasted more-or-less intact well into the late Middle Ages and are still visible in sections today. Their perimeter largely defines “The City” of London district, see Figure 1. At its height, Londinium had a population of between 40,000 to 50,000. Archaeological finds suggest most water supplies came from wells, springs or abundant good-quality water in the Thames and its tributaries, several of which flowed through the city. There are also remains of Roman bucket-and-chain water lifting devices supplying public baths, which were powered by slaves or animals on a treadmill (Blair et al 2006).

The ancient texts of Frontinus and Vitruvius describe methods of construction and operation of water supply systems deployed across the Roman Empire (Hodge 1992). Networks were built and maintained by the state, funded predominantly from taxation plus a minor contribution from user charges by those wealthy or powerful enough to be granted a personal supply to their private villas. Public buildings and baths usually had a continuous supply from springs or powered lifting devices. Most households, however, collected or purchased water daily either from public fountains spread evenly around the city or from a nearby river or stream.

There are scant records of the Dark Ages, but by medieval times Jenner (2000) describes how the City’s medieval mayors and councillors, called Aldermen, sought to construct a civic community by ensuring free, communal sources of water from public conduits, based on traditions dating back to Roman times. The conduits captured remote springs in lead pipes that flowed to a “conduit head”, an ornamental civic buildings holding a large stone and lead tank with taps from which citizens could draw off water freely. Collection by individuals for their own use was free, but trades such as brewers had to pay, which helped fund maintenance. In periods of excess demand, brewers and other commercial users were sometimes banned from using the public supply. As early as 1368, the common conduit was leased to a pair of knights “for the custody of the Common Conduit with its fountains and all its profits and advantages … for a term of ten years …at an annual rent of 20 marks” (Dickinson 1954, 10). The lease was not renewed, but it illustrates that, from earliest times, London’s Aldermen were not averse to private sector solutions.

The most important medieval conduit, known as the Great Conduit, was a 4km long, 15cm diameter lead pipeline which brought a good supply into the heart of the city from the Tyburn Spring. The spring had been given to the city as a gift in perpetuity from the landowner in 1237. Funds for construction came piecemeal from the City Council, mayors and bequests from citizens. Merchants in foreign cities, including Amiens, donated £100 towards the construction of the Great Conduit in return for trading privileges (Matthews 1835). However, the city was growing so fast that, as soon as the Great Conduit was completed, there were plans to double the capacity.

Even before the coming of private household supplies, wealthy and well-connected individuals could petition the City Corporation for a private connection taken direct from the public conduit. Known as a “quill”, this was a lead pipe, typically half an inch in diameter, to divert some flow from the main conduit into a private water cistern in the basement or ground floor of a private house.

The “Cobs” were London’s water carriers paid to bring water from the conduit heads to individual households willing to pay for their services. A day’s supply of water bought from a Cob typically cost a penny. In 1496 the London water-bearers formed a Fraternity in the Augustine Friars, the Fellowship of the Brotherhood of St Christopher of the Water-Bearers of the City of London. They represented and regulated the water-bearers in the City for well over 200 years until the private water companies
led to their demise. Manual distribution of water was common across most large European cities well into the 19th century.

By 1630, the City was still maintaining 12 conduits with paid keepers. But over the following centuries, the conduit heads fell into disrepair and were regularly pulled down to make way for new development. Jenner reports that they had effectively disappeared by 1780, although the City maintained one or two public pumps and wells until the 1860s.

3.2 Shakespeare’s London and the birth of private water supplies

In the three centuries staring from the reign of Elizabeth I, a total of 29 private water companies were established either as independent undertakings or later through mergers to supply different areas of the growing city. A complete list is provided in Annex 1. Many were relatively modest affairs that were sooner or later swallowed up by the eight large companies that ended-up carving up London’s water services between them. The most important companies are discussed below.

3.2.1 London Bridge Waterworks

The pioneer of private water supplies to London, Peter Morris, was a free denizen and servant of Sir Christopher Hamilton MP, Knight of the Garter, lawyer, later Lord Chancellor, and favourite of Elizabeth I. Hamilton petitioned the City of London on Morris’ behalf during negotiations to establish his water-wheel device in the north arch of old London Bridge.

Morris applied for and was granted Letters Patent from the Queen for a “forcier” water-lifting device in 1578, which effectively granted him a monopoly for 21 years, see Annex 3. Once such a pump was in operation, the patent conferred on Morris a monthly payment of £100. Morris then entered into negotiations with the City, culminating in a demonstration of the power of his device by shooting a jet of water 40m over the spire of a nearby Church. This so impressed the Lord Mayor and Aldermen that the City granted him a 500-year lease on the bridge arch at annual rent of 10 shillings (£0.5). The works consisted of a tidal water-wheel that exploited the hydraulics of the narrow bridge arches to drive forcing pumps, which raised river water a nearby storage tower, whence it flowed through timber mains and lead connection pipes to supply properties in the vicinity. The lease was signed in May 1581 and services began in early 1582.

The investment cost of the waterworks is not recorded. However, letters in the archives state that by 1580 Morris had spent £200 of his own funds on “preparing piles and stones for the foundation” and that the City promised £100 in grants and grounds for construction of the water tower. Morris then “proceeded with the work, and entangled himself in bonds and bargains upon the faith of receiving the money of Mr. Randolph” (Overall et al., 1878, Remembrancia, I. 449). This refers to Mr Randolph, the Common Sergeant to the City, who bequeathed £900 for Morris’ device on the condition that a free water supply be provided for the fishmongers. Jenner (2000) reports that Morris borrowed a further £1,000 from the City in 1586, either to pay off other short-term debts or to build another wheel in the second arch leased by the City in 1584. From this evidence, we can deduce that the total cost of the works for the two wheels plus supply system was around £2,500. Some 20 per cent was equity from Morris, 40 per cent grants, and 40 per cent was short-term debt. However, the enterprise remained a private undertaking of an individual, not a company with shareholders.

The London Bridge Waterworks business started to make profits sometime after 1590. The minimum annual charge for a small house connection was £1. Larger houses and businesses paid more. The area of supply was limited by the height of the water tower and the hydraulics of the distribution network. Although technically it would have been possible to provide a continuous supply to a small number of houses, supply was rotated to spread the service more widely and hence maximize revenues.

By the time of the Great Fire of London in 1666, Morris’ heirs were sharing annual profits of around £1,000 through a trusteeship scheme. They were able to borrow £2,000 to rebuild after the works
burnt down in the fire (Dickinson 1954, 24). In 1701, the Morris’ family interest was bought out by a speculator named Soame for £38,000 in a shady deal that eventually bankrupted him (Ward 2003, Chapter 10). The London Bridge Waterworks was amalgamated with other small systems, including Broken Wharf and other public conduits leased from the Corporation, to form the London Bridge Waterworks Company (LBWC). This was formerly incorporated in 1703 with a share capital of £150,000. LBWC leased further bridge arches, rebuilt the pumps and expanded services south of the river. By the time it closed and its service mains sold to the New River Company in 1822, LBWC had just over 10,000 customers and an income of £12,323.

In the years after Morris’ venture started to be seen as a success, at least two other small private ventures started-up. The first was the Broken Wharf Waterworks established by mining engineer Bevis Bulmer in 1593 using a horse-powered water lifting device. The second was a small operation by Henry Shaw to supply houses in Smithfield from a spring and pond at Fogwell. Both were granted 500-year leases by the Corporation of the City of London (Sharpe 1894, 20).

3.2.2 New River Company

By far the most important of the early water companies was the New River Company (NRC). NRC was formally incorporated by Royal Charter of 1619, with King James I as the largest shareholder. The NRC became one of the most enduring, elitist and financially successful firms in history. Only 72 shares were issued until 1866, although these could be sub-divided into part shares. Shareholders could sit on the Board and were eligible to stand as MPs, because share ownership was treated as owning freehold property in two counties. NRC survived right through to 1904 when it was taken into public ownership as part of MWB.

The New River opened with a theatrical ceremony on 29 September 1613. Festivities were overseen by the newly-appointed Lord Major of London, Sir Thomas Myddelton, and his brother Hugh Myddelton, the main financier and promoter of the project. The New River was a 65 kilometre-long, three metre-wide artificial canal running from the Chadwell and Amwell springs in Hertfordshire to the New River Head storage reservoir at Clerkenwell on Islington heights. The scale of the project to bring a new supply to the City can be seen in Figure 1. Bringing fresh spring water to a high point above the City gave NRC a commanding advantage over all future rivals, as it could supply by gravity a huge area north of the city where the population was growing. NRC would dominate the supply of water to London for nearly 300 years. But this didn’t stop the formation of other companies trying to enter this perceived profitable business.

Ward (2003) describes the origins, engineering feats, personalities and shifting fortunes of NRC over its 300-year history. Captain Edmund Colthurst proposed what would become the new river project to Elizabeth I in 1602. When she died, he was granted a Letters Patent on 18 April 1604 to start the project by her successor James I. By 1605, the City Aldermen started taking a renewed interest in the project and made their own application to Parliament to bring water to London from Uxbridge or the River Lea in the north. But in a committee, chaired by Hugh Myddelton MP, the Bill was radically altered to give statutory authority to Colthurst’s patent. Colthurst had bought land and started digging as soon as he was granted the Letters Patent in 1604, but completed only four kilometres before running out of money, having spent around £700.

The project restarted in 1609, with Hugh Myddelton now in charge as both engineer and main funder. Colthurst was given four free shares in the new enterprise and a wage as technical advisor. Myddelton committed to complete the project within four years at his own expense. The project was on a scale unseen since Roman times and Myddelton is considered one of the fathers of British civil engineering.

In 1610 the project ground to a halt again due to opposition from local landowners challenging rights of way and others concerned about its impact on the River Lea navigation. Since Myddelton was also running out of money, he persuaded the King to contribute half the construction costs in return for half
the profits. King James was always eager to find any new source of income that was independent from Parliament. Myddelton also started to raise additional funds and spread the risk of the project by dividing the other half of the equity into 36 “Adventurer” shares to attract other investors. With additional funds and the King as a major stakeholder in the project, all opposition was overcome and construction was completed in 1613. One extra component of the New River project added sometime between 1614 and 1619 was a connection to the River Lea. This was vital to the future of NRC, as it provided an additional source of supply to the less reliable springs.

By 1619, the enterprise was a going concern with just over 1000 tenants connected, both private houses and businesses. All profits were ploughed back into laying new pipes and maintaining the channel. At this point, everything was entirely owned by Myddelton. All other agreements were private contracts, not shares in a company. Myddelton now convinced the King to formally grant a charter by Letters Patent, which established Myddelton, the Adventurers and their successors as a permanent corporate body. The King was not a member of the company and had no power to intervene in corporate affairs, but could claim half of all profits.

The charter granted an effective monopoly, stating that no-one must attempt to convey water to London without the permission of the NRC on pain of incurring the King’s displeasure. Ward argues that Parliament did not confirm the Royal Charter because of this monopoly clause, despite three separate legal attempts to do so in 1621, 1624 and 1642. The charter also granted a strange legal status to the company. Shareholders were considered as owning freehold property in land, so that trading in shares was possible only through legal conveyancing. NRC retained important property interests, which increased in significance when it was able to develop the land it had originally owned in north London around Clerkenwell in the early nineteenth century. Property income represented around 10 per cent of all NRC’s revenues throughout the 1800s.

By 1631, the new King, Charles I, was not happy with the performance of his father’s investment in NRC. Despite efforts to force households to take the company’s supplies, the uptake was slow. The first year in which any profits were paid was 1622 and by 1630 the King had received cumulative dividends of only £4,470, less than half his original investment. The net return was less than 4 per cent. In 1625, the bubonic plague led to a drop in the number of properties connected. Added to this, there was a threat of competition from a rival scheme to build a new closed conduit to supply the north of London. After various negotiations, including a proposal that the King buy out the Adventurers, the Crown agreed to give up all rights to share in profits, in return for an annual payment in perpetuity of £500. Myddelton converted this obligation into 36 additional “King’s” shares that would each be responsible for a proportion of this payment before any dividends were paid. Thus, of the 72 shares, there were now two classes in terms of voting rights and returns. The King’s shares always traded at a slight discount to the Adventurer shares.

Sir Hugh Myddelton died on 7 December, 1631, only three weeks after buying out the King’s share of the company. Some sources suggest that Myddelton did badly out of the New River as it never paid a dividend in his lifetime. On the contrary, Healy (2010) argues that although the project was clearly a financial drain during the construction and early phase of operations, by 1617 Myddelton was already back in sound financial health and able to embark on new ventures in mining and land reclamation. As part of the final funding efforts to complete the project, he had been able to secure a personal loan of £3,000 from the City at 6 per cent interest. He also charged the company an annual fee for maintaining the river. In total by 1630 he had received fees as Governor of almost £13,500. In Myddelton’s will, it was revealed that he owned 13 of the founder Adventurer shares either in person or by proxy.

Including the original works completed by Colthurst, the New River project cost approximately £19,200 to build the canal, storage and a network before it started to generate revenues. This was financed 50 per cent by private equity and 50 per cent by the equity from the King. Myddelton became NRC’s first Governor. Myddelton’s son succeeded, but later other Adventurers took charge.
The Board of Directors were always the main shareholders, so there was never an agency problem. MPs and Lords were also well represented amongst the shareholders, so political influence and conflicts of interest were a matter of course.

The City and the Crown pursued a policy of pressurizing all households able to pay to sign up for the new private supply (Jenner, 2000). By 1638, Jenner estimates that about 10 per cent of houses in the city were supplied, but, by 1677, this had risen to 60 per cent. NRC went from strength to strength and increased its profits as the city and the number of connections grew steadily. The company actually benefited from the Great Fire of London, as its works were not affected, unlike its main competitor Morris’ London Bridge Waterworks, which burned down. In the immediate reconstruction phase, it poached some of its main rival’s customers. Many of the newly-built houses wanted to connect to NRC services. Profits dipped again around 1700, partly due to price competition from LBWC and York Buildings Waterworks Company (YBWC). In response, NRC built a new higher-level reservoir known as Upper Pond and pumped water to it, at first with a combination of windmill and horses, and later using steam engines. The last and most serious dip in profits occurred between 1810 and 1820 because of competition from new companies during London’s Water Wars, as discussed below. Profits quickly recovered thereafter.

In the long run, NRC swallowed all competitors within its service area (Ward 2003, Annex 2). The pattern was always the same: NRC would try to put the rival out of business, but if that failed, it would buy the customers and assets, often at a knock-down price. LBWC successfully expanded its production and supply area south of the river after 1700, but was constrained by the area it could reach and the deteriorating quality of the River Thames, its only water source. The Water Wars hit its profits badly and profitability declined to below 3 per cent by 1800. The news that old London Bridge was to be demolished sounded the company’s death knell. LBWC was purchased by NRC in 1822 for an annuity of £3,750, representing 2.5 per cent return on its shares, payable until the expiry of the original lease in 2082. The City Corporation also paid £10,000 in compensation.

3.2.3 City scandal and financial speculation

A flurry of new company formation and competition occurred in the decades either side of 1700. The original impetus was a scandal involving the City’s mismanagement of the Fund for the Orphans of Freemen, which was found to be in deficit by more than £700,000. In a desperate search for extra cash, the City encouraged new water companies and was forced to lease out any existing conduits that could earn revenue (Scott 1911).

Some companies became embroiled in the financial speculations of the South Sea Bubble era, notably YBWC, which started out in water supply, but rapidly diversified into land development in Scotland. YBWC’s share price soared during the financial bubble of 1720 and then crashed. A Parliamentary inquiry found it to be effectively bankrupt. All its assets other than the waterworks were sold to pay creditors. Declining dividends towards the end of the 18th century led to an attempt at recapitalisation and competition, but YBWC finally sold out to NRC in 1816 after over-extending itself.

3.2.4 Chelsea Waterworks Company

The Chelsea Waterworks Company (CWC) was established by Act of Parliament in 1723 "for the better supplying the City and Liberties of Westminster and parts adjacent", with initial share capital of £40,000 in 2,000 shares worth £20. This sum was rapidly consumed and it had to raise additional capital in 1733 through a further 2,000 shares of £10. High initial capital expenses for new reservoirs, pumps and network expansion meant it only started paying a regular small dividend after 1753.

CWC obtained the contract to supply royal palaces in Kensington, securing a rental income of £150. Under Royal Warrants of 1725, two ponds in Green Park were converted into reservoirs and a third reservoir was constructed in Hyde Park. The supply to these reservoirs was obtained from a system of
small canals extending from north of Victoria Station to the Thames at Chelsea. Its expansion was limited by geography and other company districts surrounding it. CWC managed to survive through continuous innovation. In 1741, it employed an economically successful “Newcomen” steam engine for lifting water; it was the first water company in Britain to trial the use of cast-iron water pipes in 1746; and it built the first slow sand filter in 1829, in response to criticisms of the quality of its supply.

3.3 Water Wars

3.3.1 Prelude

In many ways, the service provided by LBWC, NRC, YBWC and CWC in 1800 was no better than that available 200 years previously to those who had the privilege of a quill. With increasingly contaminated river water and intermittent supply, in many ways it was worse. All companies offered a basic, low-pressure pipe connection, with water available on agreed days and times, usually three or four times a week and never on a Sunday. The quality of supplies deteriorated as the city grew and the pollution of its water courses from both industry and sewage increased. It would take almost another half century before knowledge about the mechanisms of disease transmission and prevention would stimulate radical improvements to the quality of water provided.

Of the four main companies supplying London in 1800, only NRC and CWC would survive the century. NRC was already larger in terms of revenues and customers than the other three companies combined. It was also making huge profits, which attracted a rash of new entrants wanting to share some of the bounty. After a new phase of competition and consolidation, eight companies carved up the territory of London between them. Figure 2 shows the supply districts of the eight companies around 1850. NRC remained the largest company in terms of revenues right through to 1904.

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<tr>
<td>Southwark &amp; Vauxhall</td>
<td>46500</td>
<td>79435</td>
<td>115867</td>
</tr>
<tr>
<td>Kent</td>
<td>16077</td>
<td>42849</td>
<td>80758</td>
</tr>
</tbody>
</table>

Figure 2. London Water Companies: service areas and customers

Source: Connection data from London County Council Water Statistics, London Metropolitan Archives, LCC/CL/WAT/1/15; company service areas derived from Mylne's map of 1856

3.3.2 Competition

The final phase of genuine competition in London’s water supplies occurred in the second decade of the nineteenth century, described as the “Water Wars” by Graham-Leigh (2000). The instigator was a maverick civil engineer named Ralph Dodd who promoted new water companies for south, west and east London. Although each company initially presented itself as seeking to supply only unserved areas, each got into financial difficulties and switched tactics towards aggressive competition in areas of the neighbouring incumbent companies. In each case, Dodd departed in mysterious circumstances very soon after the companies were established. All three raised large amounts of new capital through
a sequence of public subscriptions and share offerings. None of the new companies paid any dividends in early years, because all profits had to be ploughed back into network expansion.

The first to be incorporated was the South London Waterworks in 1805. Through a series of mergers, the company became part of Southwark & Vauxhall Waterworks Company (SVWC), one of the three private companies supplying south London until taken over by MWB in 1904.

The next to be formed was West Middlesex Waterworks Company (WMWC), incorporated in 1806 to supply London’s rapidly-expanding western suburbs. It adopted an aggressive pricing policy, undercutting its rivals, and canvassed the Fire Offices by stating that they would keep their cast-iron pipes permanently full of water. The last of Dodd’s new companies was the East London Waterworks Company (ELWC) incorporated in 1807. ELWC would bring new competition to the eastern boundaries of NRC’s territory.

Kent Waterworks Company (KWC) was incorporated in 1809. It bought the assets of the old Ravensbourne Waterworks, formed in 1701 to supply the royal manor near Greenwich. An Act of 1811 expanded the area of service and authorised additional capital up to a total of £250,000. Through subsequent expansion and acquisition of another bankrupt water company, KWC became the dominant supplier to southeast London.

The Grand Junction Waterworks Company (GJWC) was incorporated in 1811 as an offshoot of the Grand Canal Company, which realised it had a potential business opportunity to sell its canal water as an alternative to supplies from an increasingly-polluted River Thames. Competing directly with WMWC, NRC and CRC, especially in the rich new Marylebone district, it used advertising to promote its superior technology and ability to supply the upper storeys of buildings with a “high service”.

Competition peaked between 1810 and 1815, with aggressive advertising, door-to-door canvassing and even fights between the different companies’ workers as they laid mains down the same streets and disconnected each other’s customers. The new companies were not averse to publicly condemning the poor service and monopolistic tendencies of the old companies. Each company adapted its pricing in response to the behaviour of its competitors. All the new companies laid cast-iron pipes and several advertised “high service” as an option. In response, NRC began dealing with landlords as a single package rather than individual properties. A chaotic situation ensued, with landlords being cut off in one district for having switched supply to a competitor in another.

In the short term, the biggest loser was NRC, which lost customers to all the new companies and faced renewed competition from YBWC, which raised new capital to replace its old wooden pipe network with cast iron. NRC was forced to lower its prices to established customers in order to match the offer of the new rivals. Typically, charges were reduced by 20 per cent. From 1809 to 1814, NRC lost 8.5 per cent of its customers and its revenue fell by 21 per cent. Competition hurt all the companies. WMWC’s financial distress was such that when it tried to raise additional capital with a new share issue in 1813, bidders offered only £30 for shares with a face value of £100. As a result, WMWC and NRC presented a private bill proposing a merger, but Parliament would not sanction such a large monopoly.

Graham-Leigh (2000) notes that the men behind the new companies were a new kind of investor, mainly well-to-do merchants and tradesmen with a few hundred pounds to invest, looking for a long-term investment which would show a steady dividend. Investing was no longer the preserve of Lords, Ladies and Gentlemen. But there were also incidents of suspect share dealings and insider trading in the setting up and capital increases of the new companies, notably by WMWC and ELWC.

Through a series of backroom negotiations, all the companies came to a private agreement in 1817, referred to as the General Arrangement, by which each was ensured a local monopoly. Once their monopolies were established they raised charges by 25 per cent above the 1810 levels and quickly returned to profitability.

In terms of service levels, the main outcome of the Water Wars was that all companies adopted cast-iron mains, both for cost-efficiency reasons and to claim to be able to offer a service to upper floors of buildings. The old companies rapidly followed the lead of the new entrants in replacing their old
wooden pipes. This was most challenging for NRC as they had by far the longest network of pipes. But within 10 years, from 1812 to 1822, they replaced their entire network.

3.4 The start of regulation

The general quality of London water supplies improved steadily throughout the nineteenth century. From distributing untreated river water in the 1820s, by the 1850s most companies were settling and filtering water before distribution. After 1852, all sources of raw water abstraction were gradually removed from the heavily-polluted tidal river. By the 1870s, the quality of all the companies’ water had greatly improved, and progress continued to be made in treatment techniques, until chlorination finally resolved any residual problems in the early 20th century.

A full understanding of the mechanisms of water-borne diseases lagged behind the accepted need to improve the general sanitary conditions of poor urban areas. The role of water in the transmission of infection emerged after 1848, when John Snow observed a connection between polluted water supplies and the spread of cholera during an outbreak around the Broad Street pump in 1854. Although the medical profession was not fully convinced for some years, its implications were taken into account in practical measures whenever cholera threatened thereafter.

One result of the Water Wars and their resolution through the Grand Agreement was to bring the private water companies firmly to the public’s attention. Concerns about monopoly, price and quality were given voice by the Anti-Water Monopoly Association formed in 1819. In 1821, a Parliamentary Select Committee was appointed to ‘inquire into the past and present state of the supply of water to the Metropolis, and the Laws relating thereto’. For the first time, evidence was gathered and made public about the origins, accounts and legal basis of each company. However, the Committee was generally favourable to the companies and proposed an Act that would simply put a cap on the price increases at 25 per cent above 1810 charges for “ordinary service”, which was what the intermittent, low-pressure supply was now called. The Act was never passed.

It took a further eight Select Committee Inquiries, Royal Commissions and 30 years before the first piece of legislation specifically designed to regulate all the London water companies was passed, the Metropolis Water Act of 1852. After this, not only were the companies abstracting from the Thames obliged to seek new, better-quality sources of water further upstream, but they were also obliged to check the quality of the water supplied. This Act was the first general Water Act applying to London. It confirmed the role of the water companies, but introduced a number of important regulations, such as the efficient filtering of water, and the obligation to investigate formal complaints about quality or quantity. The Act placed huge investment obligations on the water companies, which responded by raising new capital and launching major investment programmes.

Throughout this period, there were regular private Acts brought by individual water companies to adjust their powers, primarily to increase the amount of capital they could raise. During the negotiations of these bills, several of the companies had clauses inserted that capped their dividends at 10 per cent on paid-up capital. Any excess profits were to be invested in Government securities and placed in a sinking fund to cover debt repayment and extraordinary expenses.

3.5 Quality regulation, constant supply and the slow move towards public ownership

The second half of the nineteenth century was characterised by ever-tightening regulation and greater scrutiny, with increasing scientific knowledge and public awareness of the links between water supply, sanitation and public health. After 1871, the London water companies were obliged to submit audited accounts and the quality of services were independently regulated. In 1891, the Public Health (London) Act, in declaring that an occupied house without a proper and sufficient supply of water was unfit for human habitation, gave the newly-created London County Council (LCC) powers to ensure that the water companies provided a constant supply to all dwellings.
After 1852, the requirement for improved water supply and sanitation was supported both by law and increasing evidence of direct public health benefits. Following the 1842 Poor Law Commissioners report, an 1843 Royal Commission on the Health of Towns investigated the sanitary arrangements of 50 English towns. Its findings gave rise to the 1848 Public Health Act. Edwin Chadwick, a public health campaigner who had authored several of the Royal Commission reports, advocated the creation of a unitary public body responsible for both water supply and sewerage. But this vision would take many decades to become a reality.

After 1847, the general Waterworks Clauses Act required that a constant supply be provided to the top floor of every house, but exempted all the Metropolitan water companies from this provision. However, in the 1852 Metropolis Water Act this exemption was lifted, if requested by four-fifths of the owners or occupiers of houses on a district mains pipe. The companies were able to avoid this obligation if they could show that 20 per cent of the properties were not fitted with appropriate plumbing. Most of the companies delayed investment, since their priority was to identify and develop new raw water sources to improve quality. The 1869 Royal Commission found that progress was extremely slow in delivering a constant supply. The 1871 Amendment Act forced the companies to go faster and appointed an independent regulator, the Water Examiner, to report annually to Parliament on progress.

Figure 3. Growth in coverage of continuous service
Source: Hardy (1991) and LCC/CL/WAT/1/15

From 1871, the companies took the issue of continuous supply seriously and raised funds for much-needed investment, largely by issuing debenture stock paying a fixed interest rate. Progress of selected companies and for London overall in achieving 100 per cent constant high-pressure service is shown in Figure 3. Hardy (1991) discusses the relative progress and performance of individual companies, showing that there was a difference of around 20 years between the leader and laggard. NRC, CRC and WMWC were the slowest to start the necessary investments and each had less than 50 per cent coverage as late as 1891. However, the companies accelerated their investments so that all except Lambeth had achieved a 100 per cent continuous supply by 1904. It should be noted that there was considerable resistance to the policy of constant supply from landlords and others, who objected to having to pay for new water fittings in their houses. Regulation - rather than consumer demand - pushed for universal continuous service.

From 1852 onwards, whenever a company petitioned Parliament for a new Act to amend its powers, new articles were included on setting rates. Before this, companies were effectively free to charge what they liked. In accordance with the 1847 Waterworks Clauses Act, water charges were to be based
on the rateable value of the property supplied. The “rates” were an assessment of property value used as a basis for local taxation. Typically, the Acts set the water rates at between 3 to 4 per cent of the rateable value. This presented the companies with an unexpected windfall benefit. Whenever rates were revalued for local taxation purposes, the water company charges would increase accordingly, giving rise to large increases in their income which were completely decoupled from any increases in their costs or their performance. This translated straight into increased profits, limited only by the 10 per cent ceiling.

By 1895, quality and continuity of supply were increasingly converging across London's different companies, but there remained large differences in the price of services between different categories of property and between different companies, see Table 1. Thus, a house on one side of a boundary could be charged twice as much as an identical house on the next street served by another company. The poorest districts, notably those in the East End served by ELWC, paid some of the highest prices for a relatively poor service. Pressure to harmonise rates and allow more flexible resource management across company boundaries added to the pressure to find an "all London" solution.

### Table 1. Annual water rates in 1895

<table>
<thead>
<tr>
<th>Company</th>
<th>Rateable value of property:</th>
<th>max/min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>£10</td>
<td>£20</td>
</tr>
<tr>
<td>New River</td>
<td>£0.40</td>
<td>£0.80</td>
</tr>
<tr>
<td>Grand Junction</td>
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<td>£0.80</td>
</tr>
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<td>Chelsea</td>
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<td>£0.80</td>
</tr>
<tr>
<td>West Middlesex</td>
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<td>£0.74</td>
</tr>
<tr>
<td>Kent</td>
<td>£0.60</td>
<td>£1.20</td>
</tr>
<tr>
<td>Lambeth</td>
<td>£0.75</td>
<td>£1.50</td>
</tr>
<tr>
<td>East London</td>
<td>£0.50</td>
<td>£1.00</td>
</tr>
<tr>
<td>Southwark &amp; Vauxhall</td>
<td>£0.50</td>
<td>£1.00</td>
</tr>
<tr>
<td><strong>max/min</strong></td>
<td>2.02</td>
<td>2.02</td>
</tr>
</tbody>
</table>

Source: Adapted from Hardy (1991)

The final act in the drama of London’s private water companies was the protracted series of public debates and private lobbying about how to create a single, publicly-owned body and what the compulsory purchase price should be for each company’s business. The first clear proposal to create a single public water services company had been made in the first draft of the 1852 Act, but that provision was removed in Committee. The 1869 Duke of Richmond Commission recommended that the service should be put under the control of a single public body. In 1880, the companies cooperated with a proposal to create a “Water Trust” to which all their assets would be transferred for a total compensation of £33 million. A fully worked-out Bill was presented to Parliament on that basis, but was defeated as it was perceived as being too generous to the water companies.

More Committees and Commissions followed. The creation of the London County Council (LCC) in 1889 introduced a new strong advocate for a London-wide public body responsible for water supply, but all proposals were defeated in Parliament. Finally, in 1902 the Government passed a law to create a Metropolitan Water Board for London and to compulsorily purchase the assets of the eight private water companies.
The contentious question of compensation to the owners of the companies was referred to a court of arbitration consisting of a distinguished ex-Lord of the Appeal Court, an eminent engineer, and a former Permanent Secretary of the Local Government Board. The Act directed them to ignore share price appreciation or depreciation arising from the prospect of compulsory purchase, and instead to base their decision on the cost of reinvestment to achieve a similar return.

The final arbitration decision was extremely favourable to water company shareholders, although compensation was paid only to the holders of ordinary shares. Debenture stock paying fixed interest was taken over by the MWB, and later replaced by new "water stock", producing an equivalent amount. The MWB financed the purchase by issuing "water stock" bearing 3 per cent interest with a tenure of 100 years. Ordinary shareholders were paid a total of 2 million above the average Stock Exchange valuation of the companies’ undertakings prevailing between 1900 and 1902. The compensation was almost double the total capital expenditure on the company books. Adding in the costs of arbitration, directors’ compensation and debentures taken over, the total debt of the MWB at start-up was £43 million. The MWB had used its borrowing powers as a public-sector entity to replace equity paying 10 per cent with long-term debt paying 3 per cent, but the amount of compensation was so huge that the Board started its life with a “millstone around its neck” according to MWB’s parliamentary officer (Robson 1948, 119). For the following 85 years, water infrastructure investments in London were funded entirely by long-term debt.

After 1904, MWB faced two challenges: network integration and pricing. First, it needed to integrate the network so as to manage resources more efficiently and ensure adequate supply during droughts. Second, it needed to establish a uniform scale of charges across London. In 1907, the Metropolitan Water Board ( Charges ) Act set domestic water rates at 5 per cent of the rateable value of the property supplied. Unfortunately, with the high level of inherited debt to pay for the compensation costs, this proved to be too low, leading to an annual shortfall of £25,000 to £74,000. This had to be recouped from the general rates. Water pricing had become a political rather than a purely commercial consideration.

4. Analysis and discussion

4.1 Emergence, competition and survival

Why did private, piped-water supply services emerge and survive in Elizabethan London some 250 years ahead of the rest of the world? The establishment of household water supply as a private economic activity in the London of Shakespeare set a precedent that resonates down to the present day. During the reign of Elizabeth I (1558-1603) London’s population more than doubled to above 200,000, making it one of the largest cities in Europe. The ancestors of private finance and the joint stock company were partnerships and trading ventures, such as the Merchant Adventurers established in the Elizabethan period (Kindleberger 1984, 196). Speculative finance entered the picture very early on through partial payment for shares. NRC’s first shareholders were called Adventurers, just like the Merchant Adventurers and Guinea Adventurers making speculative voyages to unknown lands.

For the upper echelons of society, there was an enormous influx of new wealth derived from the activity of legalised piracy. This was the age of privateering, organised as secretive joint-stock companies to expropriate Spanish gold on the high seas. As a result, there was a surplus of capital looking for productive uses.

At the other end of the social scale, the population was swelling from the influx of poor peasants, some attracted to London’s opportunities, others forced off their land by the enclosure movement. Unskilled wages fell and prices started to rise. These economic forces and evident social disparities led to a succession of laws for relief of the poor, culminating in the 1601 Poor Law that made each parish...
responsible for supporting the “legitimately needy” in their community. Money was raised from local taxation.

Against this backdrop, there was huge pressure on the public water supply system from rich and poor alike, with reports of conflicts, near riots and Lords highly disgruntled about having their quills cut-off (Jenner, 2000, 252-255). So the City Aldermen were always alive to new possibilities for developing additional supplies. As well as the projects at London Bridge, Broken Wharf and New River, they actively considered other schemes such as bringing water from Hampstead, Hackney, Watford or Uxbridge.

An important driver of change was unmet demand, but other enabling factors were at work, notably the security for investment provided by Letters Patent and long-term contracts, high-level political support to overcome difficulties during construction, and different forms of investment subsidy.

Under Elizabeth I, the use of Letters Patent increased dramatically. Letters patent are a form of legislation that does not need the consent of Parliament as they are issued under royal prerogative powers. They can be used to grant a title, an office, or a monopoly to an individual or corporation. The earliest date from 1201. From 1561 to 1590, Elizabeth granted some 50 patents entitling recipients exclusive rights for activities ranging from the manufacture of white soap to mining. Water lifting devices were the most common category of mechanical invention. Hulme (1909) found that many such patents were granted to immigrants, notably Protestants from Holland and Germany, such as Morris. However, Elizabeth and later James I were accused of abusing this privilege, which eventually led Parliament to establish the first modern patent law. The 1624 Statute of Monopolies, introduced the doctrine of public interest and the protection of inventors rights for a limited term (Price 1906).

Whilst Letters Patent were important for establishing the early water companies, another factor was the ability to enter into binding long-term contracts. The original lease of London Bridge arch was for 500 years at an annual rent of 10 shillings. The contract was honoured for 240 years until the bridge was pulled down, and even then compensation annuity payments were made to cover the remaining term of the lease. From a modern perspective, this seems extraordinarily long, but it certainly gave confidence and security to the venture. Later leases linked to water supply were not so generous. In 1692, the Hampstead Waterworks was granted an initial lease of only 31 years for the springs, although this was routinely renewed thereafter. In 1694, the Marchmont Company was granted a 99-year lease to exploit the power of flows in the common sewers to pump water from the Thames. In short, long-term contracts were entered into and private property rights were strongly protected.

Another vital ingredient was strong political support for all early project promoters. Sir Christopher Hatton intervened in writing to both the Mayor and then to the Privy Council to make sure Morris’ agreement with the City was upheld. Sir Bevis Bulmer who founded Broken Wharf Waterworks was one of the “sworn servants” of the Queen, who invested in several of his ventures. Hugh Myddelton’s relationships with his brother, the Mayor, and with other MPs was important in re-launching the stalled New River project, as was the later involvement of the King to complete it.

All of these were necessary, but not sufficient, conditions for establishing financially sustainable, private, water supply companies. The other vital ingredient was financial – would households purchase the service at the price proposed and would it make money? Here we have a survivor problem, in that, by definition, those that survived did so because they were profitable. Most early companies required public subsidies in the form of grants, soft loans or investment by the King. Without these, it is unclear if any would have been built, let alone been financially successful. Both the initial finance to complete the projects and long-term financial viability were needed.

Once the projects were built, the critical issues became costs and pricing. The capital costs were sunk and operating costs were more-or-less fixed, so the priority was to sign up more and more household
connections over which to spread these costs. As a minimum, that needed to be enough to cover the short-run marginal costs. That brings us to price, which in many ways is the key to the whole story.

4.2 Pricing and competition

Pricing decisions are the market-clearing mechanism of neoclassical micro-economic theory. A rational business should set a price to maximise profits, subject to constraints from competition and what users can afford. However, we are dealing here with an infrastructure service, not a new product. Infrastructure services are never really new, since new ways of delivering those services are simply substitutes for an existing alternative. Thus, what Morris was offering in 1582 was a substitute for the Cob or a quill.

So how did Morris set his price? We know that he charged 20 shillings (£1) a year for a basic household connection, with higher charges for larger properties and businesses. The Morris family waterworks maintained this price until they sold out in 1701 (Graham-Leigh 2000). LBWC kept that pricing for the rest of its existence, so we can assume that it “worked” financially.

What were people paying already? Those without the influence to obtain a quill, but who could afford it, paid the Cobs to bring water from the nearest conduit to their homes. At a price of “a penny for four tankers-a-day”, an annual supply would cost some 30 shillings. If this was unaffordable, people could always fetch water themselves, paying through the opportunity cost of their own time and efforts.

What about the quills?

A letter to the Lord Mayor and Aldermen from the Marquis of Winchester in the Remembrancia records (Overall et al 1878) throws some light on this question. Dated May 1582, a few months before Morris’ waterworks at London Bridge opened, the letter claims that the Marquis’ grandfather had obtained licence to lay certain conduit pipes for the use of his house in Broad Street, near Bishopsgate. The pipes ran through different properties and had become decayed. In order to repair them, the tenant of the house proposed building a new brick vault at his own expense and to pay an annual rent of 20 shillings to the City for the ground. Here is a contemporary precedent for a tenant to lease a direct connection to the City’s own conduit at 20 shillings. This is the sum that Morris charged for a normal household connection later that same year.

Sir Hugh Myddelton also charged £1 for a “typical” water rent 30 years later, when NRC started its service. This price was almost certainly set in order to compete with London Bridge Waterworks. Larger users, private houses or commercial premises, might pay anything up to £40. Hugh Myddelton paid £2 for his own large house, whilst his clerk paid the usual £1. NRC also charged a one-off fee for new connections, typically one year’s rent. This upfront payment for a new connection, followed by quarterly rental payments, would have been a barrier for poorer households. It made the service unaffordable for those without large amounts of ready cash or credit. However, NRC dropped this practice by 1700 in the face of competition from LBWC. By the early 1800s, the water rents were more differentiated, but the rate charged by the NRC in 1852 for a four-room house was still £1.

How affordable were these charges? Figure 4 shows the affordability of a typical annual household connection charge of £1 by expressing this as a percentage of the average annual wage over time. In fact, wages in London were consistently above the national average, so this ratio tends to understate affordability. A frequently-used modern benchmark for affordability of water charges is that they should not exceed 2 per cent of household income for water supply (Hutton 2012). By this measure, London’s water service became affordable to all around 1870. However, the point is that, by holding water charges constant in nominal terms, the service of a household connection became ever cheaper in real terms. After 1850, all companies reduced the basic charge for very low-value properties below £1, so the service became even cheaper for poorer households.
A critical feature of London’s private water supply was that it was charged on the basis of a rental contract and not by the quantity consumed. Technically, there was no alternative as water meter technology did not exist before the 1800s. Once metering became widely available in the mid-1800s, trade customers were switched to a metered supply and paid according to volume. But unmetered service continued for households and persists in Britain through to modern times.

Lawyers did not consider water services to be like the sale and purchase of a quantity of goods (Ward, 2003). The nature of the transaction was one that continued over many years. Households needed to be prevented from extending the connection to another property or on-selling water. The solution proposed by Myddelton’s lawyers was a standardised lease in which the household was considered a tenant of NRC water supply. The lease specified that tenants received water at least three days a week. If there was a fault, the householder could withhold payment until it was rectified, but continued refusal to pay for a functioning service would lead to disconnection. All subsequent companies followed NRC’s pricing model. This meant that companies had a very stable income, independent of water consumption.

Over the three centuries starting in the reign of Elizabeth I, a total of 29 private water companies were established either as independent undertakings or later through mergers to supply different areas of the growing city. See Annex 1 for a complete list. Many were relatively modest affairs that were sooner or later swallowed up by the 8 large companies that ended-up carving up London’s water services between them. There were 3 periods of intense competition, both on price and quality. Immediately after the Great Fire of London in 1666 between NRC and London Bridge Waterworks; in the decade either side of 1700, and during the Water Wars at the start of the nineteenth century. But the system quickly settled down to monopoly services within uncontested boundaries.

4.3 Funding and profitability

The ways in which capital was raised and the organisation of the succession of companies formed to supply water to London reads like a history of the development of the joint-stock company. Morris’ London Bridge Waterworks was an individual initiative and remained a family business for 120 years, until it was converted to a joint-stock company in 1703. During the start-up construction phase, NRC was a project financed by private individuals: first Colthurst then Myddelton. But when Myddelton got
into financial difficulties, other shareholders were brought in to spread the risk and raise more capital to complete the project. Getting the King to invest as the largest shareholder was critical to success.

All early companies were first incorporated by Letters Patent and only later obtained Parliamentary Acts of incorporation confirming their powers. After the financial speculative excess resulting in the 1720 Bubble Act, all private companies had to be formed through the scrutiny of an Act of Parliament. Over time, capital raising shifted from relying on individual wealth and personal relationships to equity subscription from a broad base of investors. As the nominal amounts needed for start-up increased, so did the number of investors, moving up from tens into thousands of shares.

Each of the new companies formed in the “Water Mania” of 1805 to 1811 relied entirely on private equity for their initial funding. However, as with earlier projects, each company rapidly ran out of funds and had to go back to investors to roughly double their capital. A 50 per cent underestimate of capital requirements seems to be a perennial characteristic of over-enthusiastic project promoters.

Public-sector support was vital to the successful establishment of both LBWC and NRC. Without the grant support from Mr Randolph or the injection of the King’s equity it is unlikely that either project would have been completed. The 100 per cent equity funding model worked because there was a supply of smaller investors looking for opportunities. Once investors had committed funds, they risked losing everything already staked if they did not contribute to later stages of capital raising.

Figure 5 shows the growth of dividends for NRC, CWC and WMWC over the course of the 18th and nineteenth centuries. A common feature of all new companies is that it took a long time for regular profits to be paid, as all early surpluses had to be ploughed back into network expansion. However, once profitability was established, returns grew steadily.

By 1890, all water companies were paying 10 per cent dividends. Once the cap was reached, the companies could compensate for previous dividend shortfalls by up to 10 per cent according to Clause 75 of the 1847 Waterworks Clauses Act. On this basis, WMWC was able to pay past dividends right back to 1852. NRC paid a maximum of dividend of 14% just prior to purchase by MWB. However, all statements about the profitability of NRC must be treated with extreme caution for reasons discussed below.

![Dividends paid as % nominal ordinary share value](image)

**Figure 5. Dividends to shareholders**

*Source: Early dividends for CWC from Scott (1911); all other data from analysis of company accounts LCC/CL/WAT/1/15*
Once dividends reached the cap and backdated dividends paid, the companies found new ways to benefit shareholders by adjusting their capital structure. For example, new equity and debt (debenture stock paying a fixed interest) was usually offered preferentially to existing shareholders at par value rather than on the open market. Clifford estimates that the gains of water shareholders during 1872-83, in addition to their dividends and the increase in value of equity capital already issued, amounted to over 100%, and the increase in value of loan stock to 42% (Clifford 1885, 196-197).

The impact of the 1852 Metropolis Water Act was different for each company, depending on subsequent changes to capital structure to raise new funds for investment. CRC raised new capital by issuing new shares that more than doubled the capital base. This meant that dividends per share fell even though profits remained steady. For WMWC, the 1852 Act revalued the nominal value of shares from £100 down to £61 to reflect the true amount of capital raised during start-up (Bolton 1884). This meant dividends appeared to go up as profits were spread over a smaller nominal share capital.

What about profitability over the very long term? Figure 6 shows the long-run growth in NRC dividends and share value over the full 290-year existence of the company. Although the data is patchy, the trend is clear. Profits grew at a constant rate and the share price was a more-or-less fixed multiple of dividends. Profits started to be paid in 1622. They dipped around the sale of the King’s share in 1632 and were lowest just after Myddelton’s death in 1633. Although no data for the period is shown on the graph, Ward states that dividends fell immediately after the Great Fire. After that, dividends only fell twice – once around 1703 during the renewed competition with LBWC and YBWC and then most dramatically, starting in 1810, during the Water Wars. In each case, profits recovered within a few years and dividend growth returned to trend once the monopoly over the supply area was re-established. This demonstrates that in the absence of competition, NRC was capable of generating year-on-year profit growth by expanding services.

**Figure 6. New River Company Adventurer share price and dividends**

Source: Data from Scott (1911); Ward (2003); Gentleman's Magazine Sept 1811 p253; LCC/CL/WAT/1/15

Shares in NRC traded very rarely and were usually sold at auction. The share value remained a more-or-less constant proportion of the dividends, ranging from 25 to 35 times, equivalent to pricing the shares at a return of 3 to 4 per cent. The jump in dividends and share price after 1870 was due to a combination of rises in the average revenue per connection following revaluation of general rates, and increased leverage from issues of debenture stock paying fixed interest. An added factor after 1880
was speculation in the share price about the level of compensation expected to be paid out when the company was purchased by the public sector.

When Parliament started investigating the water companies in the run-up to the 1852 Act, NRC was something of an enigma. It was still incorporated by Letters Patent dating back to 1619 and there was no mention of any paid-in-share capital in any Act. Various historic legal judgements had established that its shares were actually title to real estate and that the incorporated company was just a manager of a water supply business (Cooke 1951, 71). Ward (2003) recounts how the company suffered from corporate amnesia and claimed all records had been lost in a fire in 1769, despite a well-researched internal monograph on the subject and Hugh Myddelton’s original accounts still held in the Royal Archives. NRC declared its capital for the purposes of the 1852 Act as £1,519,958 - the estimated total amount invested before that date. The actual nominal capital originally contributed by the Adventurers and the King was £19,200 and there is no evidence of any further equity subscriptions until 1866.

All subsequent NRC dividend information published uses the capital assessed in 1852 as its basis. So the dividends shown in Figure 5 understate the return on the original nominal shares by a factor of 80. From the perspective of an owner of an original Adventurer share, the returns were comparable with anything returned by the Elizabethan privateers. Not only did annual dividends grow year-on-year well above inflation, but also after 290 years a share that had originally required a paid in capital of £267 was purchased by the MWB for £67,800. Short-term speculators did not always do well, however, as the highest price paid for an Adventurer share was £125,500 in 1897. Nonetheless, it seems that when in 1888 an auction house selling a share in NRC claimed it to be "the most remunerative and successful of all the trading companies in the world" (Ward 2003, 228), they were not using hyperbole.

So why does Millward claim that water services in Britain were not profitable? The data he presents (Millward 2005, 51 Table 3.3) derive from Mitchell (1988) and show that the net profits of water services run by local authorities were negative after 1903. Before that date gross profits are shown as positive, but loan charges are not included. After 1905, the values for revenues and costs jump by around 60% due to the inclusion of data for MWB, which includes the debt burden to pay the high compensation to London’s private water companies. Earlier data from the Municipal Corporation (Reproductive Undertakings) Return of 1899 for 173 municipal boroughs across England and Wales which owned waterworks undertakings, and therefore excludes London, shows that of the £48 million declared cumulative capital expenditure, all but £2 million was borrowed. The average annual income of the undertakings is given as £2.64 million, operating expenditure was £0.90 million and capital charges (principal and interest) amounted to £1.70 million. At this time, smaller local authority schemes were in a phase of high capital expenditure to expand networks and deliver continuous service. Many had already purchased a previous private waterworks company and were still paying off the debt used to fund the purchase. These public undertakings were almost entirely debt funded and set water charges to balance the books rather than to maximize profits.

In contrast, the Stock Exchange Yearbooks show that even after 1905 the remaining private water companies outside London were all able to make healthy profits. For example, in 1920 the entry for York Waterworks Company (established 1846) states “For the fifty-one half-years to December 1919, the maximum dividends were paid”, in that case 10% on ordinary shares (Skinner 1920, 759). The analysis of Bristol Water Works Company (established 1846) by Thornton and Pearson (2013) shows a pattern similar to that of the London companies, with no dividends paid for the first 9 years, followed by a steadily rising return up to 10% (the maximum payable) by 1872 and constant thereafter. We can conclude that the private water supply business was inherently profitable, but that profitability took time to establish.
4.4 The ingredients of sustainability

What were the factors that sustained the model of private enterprise delivery of water services for more than three centuries? As already discussed, the drivers of changes were demand and supply, technological progress and the evolution of institutions. Getting the price right and then keeping this fixed in nominal terms was a critical factor in the overall financial sustainability of the system.

On the demand side, once the basic price of a household connection was set at £1, the pace of new connections determined revenues. Over time, as households became wealthier and the price of services fell in real terms, more and more households chose to connect. The disappearance of alternatives in the form of conduits, clean river water and public wells as alternatives was a further driving factor. Whereas originally supply was effectively rationed by the days it was available and low pressure, the introduction of high-pressure continuous supply opened up a demand-side revolution in markets for new products: baths, flush toilets and other household plumbing equipment. It also meant people lived healthier, longer, more productive lives. No-one had to waste time carrying water. Positive feedback between improved infrastructure services, product markets and welfare meant that infrastructure investments induced real economic growth.

On the supply side, companies had an incentive to extend networks to reach new customers. They also looked to adopt any new technology that would save costs and hence boost profits. The water companies were early and heavy investors in new technology such as steam engines for pumping. But only in 1805 after the new-entrant companies adopted cast-iron pipes did NRC and other old companies make the switch from timber pipes, which disappeared entirely from the network by 1825.

There was no perceptible service improvement to customers, although there were benefits to London streets with less waterlogging from leaking pipes and fewer repairs. But the combination of pumping and cast-iron pipes created the potential for a continuous, high pressure service. It was, however, more expensive to operate, so the companies delayed its introduction until forced by regulation after 1852; even then, it took another 50 years to complete the switchover.

Quality improvements were almost entirely driven by regulation. Shifting sources away from the tidal Thames and filtering river water required huge investments, which the companies undertook reluctantly, after mounting scientific evidence showed the link between water quality and public health. The 1852 Act marked the start of tighter regulation and enforcement.

### Table 2. Changing capital structure of the New River Company

<table>
<thead>
<tr>
<th>Year</th>
<th>Issue</th>
<th>New equity £</th>
<th>New debt £</th>
<th>Total equity £ (a)</th>
<th>Total debt £ (b)</th>
<th>Gearing ratio: (b/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1852</td>
<td>Capital declared &quot;by existence&quot;</td>
<td></td>
<td>1519958</td>
<td>0</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>1861</td>
<td>Debenture stock 4%</td>
<td>1000000</td>
<td>1519958</td>
<td>1000000</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>1866</td>
<td>5000 New shares</td>
<td>500000</td>
<td>2019958</td>
<td>1500000</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>1880</td>
<td>Debenture stock B 4%</td>
<td>500000</td>
<td>2019958</td>
<td>1500000</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>1897</td>
<td>Debenture stock C 3%</td>
<td>240000</td>
<td>2019958</td>
<td>1740000</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>1900</td>
<td>Debenture stock D 3%</td>
<td>400000</td>
<td>2019958</td>
<td>2140000</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>1902</td>
<td>Intercommunication Debenture stock 3%</td>
<td>680000</td>
<td>2019958</td>
<td>2208000</td>
<td>1.09</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** The Stock Exchange Yearbook 1903; and LCC/CL/WAT/1/15

Before 1850, water companies funded themselves predominately by equity and retained earnings. Over the following half century, they all issued increasing volumes of debenture stock paying fixed interest and modified their financial structure towards that of a modern utility, with NRC reaching a
gearing ratio above 1, see Table 2. This leverage allowed the companies to continue paying high levels of dividends to ordinary shareholders. New debt instruments were in high demand, with the tender for New River Company's 3% Debenture stock "D" more than three times over-subscribed. This shift from equity to debt funding allowed the companies to finance the huge additional capital programmes required to meet higher standards, whilst continuing to meet the expectations of shareholders.

However, another critical development after the 1852 Act was increased transparency about finances. The 1871 Act required water companies to submit audited accounts to Parliament, so that legislators and customers all had access to the same information. Just how profitable water services were became increasingly visible and a matter of public concern. One of the reports in the archives prepared for LCC illustrates this vividly. It shows a large-format coloured graph of how revenue was divided up each year between expenditure on operating costs, maintenance, works and capital costs for each water company. The amount that would be paid if capital were remunerated at 4 per cent is coloured light pink. Dividends paid over and above 4 per cent are shown in dark pink. The dark pink wedge grows steadily over time and makes up about 30 per cent of revenues for a company such as WMWC, see Figure 7. This was money that a publicly-owned water company funded by debt would not have to pay out. Hassan (1985) concludes that one of the main forces driving the push towards municipal ownership of water services across the country was the desire to eliminate the “avoidable costs” of private ownership.

Figure 7. The pink wedge of avoidable costs: WMWC accounts analysis 1853 to 1894
Source: LCC/CL/WAT/1/15

Throughout the centuries, what made the whole financial machinery tick was the pricing of services. The £1 basic annual service charge fixed in nominal terms in tandem with rising real wages, was enough to keep a constant flow of customers signing up as the city grew. New property developers started to put in a household water connection as standard to increase property values. For multi-tenement dwellings, especially in the courts and alleys of the poorer East End, a yard tap service was usually provided by the landlord. But the water companies themselves disliked this form of supply, as the shared tap was no-one’s responsibility and could be left running wastefully. Eventually, all such
connections were eliminated and replaced by constant supply. By 1895, the annual connection charge for the lowest category of property for treated, continuous supply was half what it had been 300 years earlier in nominal terms for a discontinuous, untreated supply (see Table 1). What had started as a luxury for the few had become an affordable necessity for all.

A less obvious feature of the way the system evolved was that it provided cross-subsidy mechanisms from wealthier to poorer households, particularly over time. NRC would lay a new water main to any new area of housing, provided that a minimum number of well-to-do residents requested the service. So the cost of new service to an area was paid for by its wealthiest residents. Once the mains pipe was laid, the marginal cost of new connections was limited to installing an additional service pipe. So it became cheaper and cheaper to connect new customers. With the capital costs of the original project and maintenance of the ever-expanding network spreading across a growing customer base, the marginal cost of a connection continued to fall. Higher-value houses also paid more for a connection and were billed additional charges if they had a bathroom or flush toilet. As payment was for access to water supply, not for the quantity of water consumed, the wealthier households effectively subsidised the connection of poorer households.

The price was right, but not in the sense of instantaneous market clearing. Rather, with the help of initial investment subsidies, it worked for the two key actors in this drama: wealthier households and investors. Fixing that price in nominal terms allowed the slow evolution of more efficient, higher-quality services that became ever more affordable in real terms, eventually leading to universal service coverage. The market cleared, but it took 320 years and a strong regulatory push to finally meet the needs of all the poor.

4.5 The politics of change

The final factor which was both enabling and blocking at different times was the political influence of the water companies. From Morris and Myddleton onwards, having the right connections with the City of London Corporation, the Monarch, or Parliament could make funding available, get projects approved, grant Letters Patent or Acts of Incorporation, promote special Acts or amend legislation unhelpful to profits. The importance of powerful backers at critical moments for the launch and survival of companies has already been noted above. In this respect, NRC had by far the most powerful and long lasting political influence, as its shareholders and directors represented some of the most wealthy and powerful men in the country. Myddleton’s brother was the Mayor of London. Eight of the 29 original Adventurer shareholders were Knights, including the Lord Chief Justice. By 1699, NRC’s largest shareholder with 14 shares was Edward Hyde, 1st Earl of Clarendon, who had been both Chancellor of the Exchequer and Lord Chancellor and was a close adviser of Charles II. Another shareholder at the time was Robert Harley, Speaker of the House of Commons.

The century leading up to the creation of MWB in 1903 witnessed long delays, often measured in decades, between evidence and action (see Annex 2). Neither Parliament nor the City of London Corporation and other Boroughs showed any sense of urgency to resolve the problem of water supply to the capital even when this was demonstrably in the public interest. During regular debates in Parliament from 1821 to 1902, there are frequent references to lobbying by the different companies, all of which had one or more MPs or Lords on their Board. It was not until 1880 that the principle was agreed that no MP with any interest in a water company should be eligible to sit on the new Parliamentary Committee to inquire and report as to the expediency of acquiring on behalf of the Inhabitants of London the undertakings of the existing Metropolitan Water Companies.

Robson argues that London was governed not as a local authority concerned with public welfare, but as a private club of vested interests: “The apathy towards the considered advice of a multitude of Royal Commissions and official committees, the refusal to apply proved remedies to known evils, the indifference to the discomforts of the poor no less than to the dangers of the rich, the utter disregard
for economy or efficiency in administration, the feeble compromise at the last moment, the frittering away of golden opportunities for reform, the readiness to give way to vested financial interests, the absence of any enthusiasm for the public welfare, above all the incapacity to conceive the problem of London government as a whole: all these tendencies are perfectly displayed by the discreditable history of London’s water supply in the 19th century” (Robson 1948, 120). This is an extreme position, but the contrast is striking between London and Birmingham, where a city with strong political leadership pushed the private water company to achieve continuous, universal supply by 1853 and then municipalized the waterworks in 1875.

5. Conclusions and policy implications

The way in which private water supply services evolved in London over more than three centuries illustrates how the dynamic forces of demand, supply, pricing, technological progress and institutions, including powerful vested interests, can interact to speed-up or delay improvements in basic infrastructure services to consumers over the long run.

The success of the early private companies was due to a combination of factors: rapid population growth in the Elizabethan city creating excess demand; innovative technology; the willingness of public authorities to embrace private sector solutions; a robust institutional environment in the form of intellectual property rights and long-term contracts; and a start-up funding mix of equity, loans and grants combined with a pricing policy that made the projects financially viable. The later transition from a low-pressure, intermittent and untreated supply to a treated, continuous, high-pressure service universally available and affordable to all was made possible through technological progress, bouts of competition, new knowledge about public health, and the pressure of regulation.

Fixing the price for an annual connection at £1 and not changing it for three centuries was critical to financial sustainability from both a household and investor perspective. Whilst all the private companies struggled financially during early years, in the long run they became highly profitable. For the first companies, financial viability depended on significant public sector support, of the order of 50 per cent, from grants or investment by the King. Later entrants all had to raise extra capital from shareholders before financial sustainability could be achieved. Eventually, profits grew so large that they had to be capped at 10 per cent by legislation. In contrast to Millward, we find that water services in London were highly profitable. In terms of the 3Ts, the users paid for services through fixed tariffs based on property value. Wealthier households provided a cross-subsidy to poorer ones over time.

Does the history of how London’s private water services evolved hold any lessons for contemporary policy debates? History does not necessarily repeat itself, but decision-makers can still look for the rhymes. The challenge of first-time connection for the poor in rapidly-growing cities and how to regulate private utilities in the developed world is as relevant today as it was then.

A first point to make is that bringing private entrepreneurship into water services should not be taboo. With hindsight, Morris, Myddelton and Dodd were more heroes than villains, managing to get new infrastructure built and changing the status quo. How to align the profit motive with the public good, get the prices right for financial sustainability, and how to build a robust, regulatory framework to balance the interests of consumers with that of investors, remains as much a challenge today as then.

There are many interesting ideas from the past that are worthy of re-assessment. The modern equivalent of the King’s share could be "patient" equity rather than grants, with a willingness to wait decades before services become profitable. Like the first Governor of NRC, private water companies could be rewarded through an operations fee rather than short-run profits. Other ideas, such as granting property rights together with water resource development to allow land value capture, are also worth revisiting. A key policy implication is that early public-sector financial support, in the form of grants, soft loans or patient equity, may be essential for developing private-sector solutions to
water services. Quality and price regulation is needed to cap excessive profits from a naturally monopolistic, essential, public service.

The evolution of London’s water supply is neither a melodrama nor a morality play. It is another opportunity to learn how actors, innovation and economic forces play out in the real world. Perhaps the greatest irony in this whole story is that whereas the first private companies received large start-up subsidies from the public sector, the newly-formed public Metropolitan Water Board that replaced them found itself burdened with huge debts from buying out the previous private owners. That is a plot twist worthy of Shakespeare: the new public-sector baby starting life with crippling debts to pay for the inheritance of her older, shrewder, private-sector sibling.
References


LCC/CL/WAT/1/15. Analysis of accounts of metropolitan water companies 1721 - 1895/6. Water statistics relating to the London water companies from the earliest date of the companies’ published accounts. Ordered by the Parliamentary Committee to be published 16th May 1895.


Annex 1. Private water companies that supplied London until 1904

<table>
<thead>
<tr>
<th>Private Company</th>
<th>Earliest date of supply*</th>
<th>Incor-</th>
<th>Ceased trading</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>New River Company (NRC)</td>
<td>1582</td>
<td>1619</td>
<td>1904</td>
<td>River completed and first households supplied in 1613. Sold to MWB in 1904</td>
</tr>
<tr>
<td>London Bridge Waterworks Company (LBWC)</td>
<td>1582</td>
<td>1703</td>
<td>1822</td>
<td>Morris' original waterworks sold to private investors in 1701 to form LBWC.</td>
</tr>
<tr>
<td>Broken Wharf Waterworks</td>
<td>1593</td>
<td>1594</td>
<td>1703</td>
<td>Water lifting device built by mining engineer Bevis Bulmer. Sold to LBWC in 1703.</td>
</tr>
<tr>
<td>Fogwell Pond</td>
<td>1595?</td>
<td>-</td>
<td>1614</td>
<td>500-year lease granted to Henry Shaw to supply houses in Smithfield. Purchased by NRC.</td>
</tr>
<tr>
<td>Sir Edward Ford's Waterworks</td>
<td>1660</td>
<td>1655</td>
<td>1667</td>
<td>Originally in grounds of Somerset House. Sold to NRC for £6,100 in 1667.</td>
</tr>
<tr>
<td>Hampstead Waterworks Company (HWC)</td>
<td>1590</td>
<td>1692</td>
<td>1856</td>
<td>Formed in 1692 as private company with lease on ancient springs.</td>
</tr>
<tr>
<td>York Buildings Waterworks Company (YBWC)</td>
<td>1676</td>
<td>1691</td>
<td>1816</td>
<td>Taken over by New River Company in 1816 after competition and declining profits.</td>
</tr>
<tr>
<td>City Conduits Company</td>
<td>1694</td>
<td>1694</td>
<td>1703</td>
<td>Old conduit supply leased by City to LBWC in 1703.</td>
</tr>
<tr>
<td>Marylebone Conduits</td>
<td>early</td>
<td>1691</td>
<td>1703</td>
<td>Ancient conduit supply leased by City after Orphan’s Fund scandal then sold to LBWC.</td>
</tr>
<tr>
<td>Marchmont’s Waterworks</td>
<td>1695</td>
<td>1694</td>
<td>1754</td>
<td>Used sewer flows to power water lifting devices. Not mentioned after 1754.</td>
</tr>
<tr>
<td>North Middlesex Waterworks</td>
<td>1867</td>
<td>1867</td>
<td>1871</td>
<td>Only had 250 customers when sold to NRC for £4,500 in 1871.</td>
</tr>
<tr>
<td>Pocock's Holloway Waterworks</td>
<td>1810</td>
<td>1810</td>
<td>1815</td>
<td>NRC laid pipes to take its customers forcing bankruptcy.</td>
</tr>
<tr>
<td>East London Waterworks Company (ELWC)</td>
<td>1669</td>
<td>1807</td>
<td>1904</td>
<td>Bought Shadwell and West Ham from London Dock Co. in 1808. Sold to MWB in 1904.</td>
</tr>
<tr>
<td>Shadwell Waterworks</td>
<td>1669</td>
<td>1680</td>
<td>1801</td>
<td>Purchased by the London Dock Company in 1801.</td>
</tr>
<tr>
<td>West Ham Waterworks</td>
<td>1745</td>
<td>1747</td>
<td>1807</td>
<td>Purchased by the London Dock Company in 1801.</td>
</tr>
<tr>
<td>Hackney waterworks</td>
<td>1707</td>
<td>1760</td>
<td>1830</td>
<td>Also referred to as Lea Bridge Old Ford waterwheel. Taken over by ELWC in 1830.</td>
</tr>
<tr>
<td>Southwark &amp; Vauxhall Waterworks Company (SVWC)</td>
<td>1690</td>
<td>1845</td>
<td>1903</td>
<td>Southwark and Vauxhall companies merged to avoid competition. Sold to MWB in 1904.</td>
</tr>
<tr>
<td>South London Waterworks Company</td>
<td>1806</td>
<td>1805</td>
<td>1845</td>
<td>Renamed Vauxhall Waterworks in 1834. Merged with Southwark Water Co. in 1845.</td>
</tr>
<tr>
<td>Borough Waterworks Co.</td>
<td>1900</td>
<td>1771</td>
<td>1845</td>
<td>Bought LBWC supply areas south of river in 1822. Renamed Southwark Water Co.</td>
</tr>
<tr>
<td>Chelsea Waterworks Company (CWC)</td>
<td>1675</td>
<td>1723</td>
<td>1903</td>
<td>Sold to MWB in 1904.</td>
</tr>
<tr>
<td>Millbank (Horse Ferry) Waterworks</td>
<td>1675?</td>
<td>1675</td>
<td>1727</td>
<td>Sold to Chelsea Waterworks in 1727 – very little information available.</td>
</tr>
<tr>
<td>Kent Waterworks Company (KWC)</td>
<td>1699</td>
<td>1809</td>
<td>1903</td>
<td>Sold to MWB in 1904.</td>
</tr>
<tr>
<td>Ravensbourne Waterworks</td>
<td>1699</td>
<td>1701</td>
<td>1809</td>
<td>Bought by KWC in 1809.</td>
</tr>
<tr>
<td>North Kent Waterworks Company</td>
<td>1860</td>
<td>1860</td>
<td>1864</td>
<td>Amalgamated with KWC in 1864.</td>
</tr>
<tr>
<td>Plumstead, Woolwich &amp; Charlton Co.</td>
<td>1854</td>
<td>1854</td>
<td>1858</td>
<td>Bought by KWC in 1861 following bankruptcy.</td>
</tr>
<tr>
<td>Lambeth Waterworks Company (LWC)</td>
<td>1785</td>
<td>1785</td>
<td>1904</td>
<td>Sold to MWB in 1904.</td>
</tr>
<tr>
<td>Grand Junction Waterworks Company (GJWC)</td>
<td>1798</td>
<td>1811</td>
<td>1904</td>
<td>Offshoot from Grand Junction Canal Company (founded 1793). Sold to MWB in 1904.</td>
</tr>
<tr>
<td>West Middlesex Waterworks Company (WMWC)</td>
<td>1806</td>
<td>1806</td>
<td>1903</td>
<td>Derived most of its income from Marylebone district. Sold to MWB in 1904.</td>
</tr>
</tbody>
</table>

* Earliest date of private household supply within the company’s service area.

### Annex 2a. London Water Supply Key Events 1802 to 1852

<table>
<thead>
<tr>
<th>Year</th>
<th>Event / Legislative Act</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1805-9</td>
<td>&quot;Water mania&quot; investment craze</td>
<td>Several new large joint stock companies created to supply East, West and South London with aggressive pricing policies and using cast iron pipes and pressure pumping to be able to offer &quot;high&quot; service to upper floors</td>
</tr>
<tr>
<td>1810</td>
<td>Start of London's Water Wars</td>
<td>Strong competition (price &amp; quality) for new customers. Older Water Co. profits fall.</td>
</tr>
<tr>
<td>1817</td>
<td>General Agreement to avoid competition</td>
<td>Informal agreement between water companies to avoid competition marks end of war. Each Co. took an agreed supply area with exchange of pipes and customers.</td>
</tr>
<tr>
<td>1817</td>
<td>Metropolis Pavement Act</td>
<td>All new water mains had be cast iron, but old water companies lobbied successfully to ensure existing mains could be repaired with timber.</td>
</tr>
<tr>
<td>1817</td>
<td>First Parliamentary debate</td>
<td>Public complaints at monopoly agreement and 25% price rise above 1809 levels</td>
</tr>
<tr>
<td>1819</td>
<td>Anti-Water Monopoly Association formed</td>
<td>Pamphleteering association founded by James Weale tries to block price increases</td>
</tr>
<tr>
<td>1821</td>
<td>First Select Committee Inquiry into water supply of the Metropolis</td>
<td>Resulted from public complaints following the water wars and private cartel agreement by the water companies in 1817 to define boundaries and then raise prices. First transparency attempt into water company finances, but no concrete action.</td>
</tr>
<tr>
<td>1827</td>
<td>Royal Commission into quality of supply of water in the Metropolis</td>
<td>Water quality problems in tidal section of River Thames identified. Water Co.s start to improve supplies by moving sources, constructing new reservoirs and installing filtration. More detailed information presented on water company finances and profits.</td>
</tr>
<tr>
<td>1828</td>
<td>House of Commons Select Committee</td>
<td>Appointed Engineer Thomas Telford to identify new good quality sources for London</td>
</tr>
<tr>
<td>1831-2</td>
<td>Cholera outbreak in London</td>
<td>The first outbreaks of cholera in London, some 6,500 die</td>
</tr>
<tr>
<td>1834</td>
<td>House of Commons Select Committee</td>
<td>Looked into Telford's recommendations, but took no action</td>
</tr>
<tr>
<td>1840</td>
<td>House of Lords Select Committee</td>
<td>Another Inquiry into the on water supply to the Metropolis. No action</td>
</tr>
<tr>
<td>1845</td>
<td>Royal Commission on Health of Towns</td>
<td>Chadwick's report included a separate chapter on the supply to the Metropolis</td>
</tr>
<tr>
<td>1847</td>
<td>Waterworks Clauses Act, 1847</td>
<td>Established general rules for all public or privately owned water undertakings in terms of service, unless specific clauses were included in Special Acts for each company. Defined basis of charging as the general rateable value of the property supplied and principle that dividends should not exceed 10% of the paid up capital.</td>
</tr>
<tr>
<td>1848</td>
<td>Public Health Act</td>
<td>The Act aimed to improve the sanitary condition of towns and populous places in England and Wales by placing the supply of water, sewerage, drainage, cleansing and paving under a single local body. The Act applied to any place in England and Wales except the City of London and areas in the Metropolis already under the control of the Commissioners for Sewers.</td>
</tr>
<tr>
<td>1848-9</td>
<td>Cholera outbreak in London</td>
<td>Outbreak particularly severe in Lambeth. Some 14,000 die.</td>
</tr>
<tr>
<td>1850</td>
<td>Report of the General Board of Health on water supplies to the Metropolis</td>
<td>Following 1849 Cholera outbreak in London, proposed: (a) Thames should be abandoned as a source; (b) supply should be continuous and unlimited; (c) works for water supply and drainage should be done jointly; (d) the water companies should be replaced by the Consolidated Metropolitan Sewers Commission.</td>
</tr>
<tr>
<td>1851</td>
<td>Royal Chemical Commission</td>
<td>Scientific Commission into the chemical quality of the water concludes that Thames water should only be used if taken upstream above the tidal limit and free from contamination. Government acknowledged that legislation was essential</td>
</tr>
<tr>
<td>1851</td>
<td>Metropolitan Water Bill proposed</td>
<td>Proposed merging all the existing companies into a single public body, the &quot;Metropolitan Water Company&quot;, which would then ensure high quality supplies. The Bill empowered compulsory purchase of the property, works and rights of the private water companies with compensation of £125 for every £100 of capital stock. The Bill was defeated in Committee.</td>
</tr>
<tr>
<td>1852</td>
<td>The Metropolitan Water Act, 1852</td>
<td>First general Water Act applying to London confirmed role of the water companies, but introduced important quality regulations that: (a) no water sources from tidal Thames after 31st August 1856; (b) all reservoirs and aqueducts to be covered; (c) all domestic water supply not pumped direct from wells to be efficiently filtered; (d) formal complaints about quality and quantity to be investigated; and (e) after 5 years from passing of the Act a constant supply at high pressure, was to be provided when requested by 80% customers in a district. The Act placed huge investment obligations on the water companies.</td>
</tr>
</tbody>
</table>

**Note:** Events in **BLACK** had a bearing on development of London’s water services  
Events in **RED** are formal Acts of Parliament  
Events in **BLUE** are formal Inquiries, Parliamentary Committees or Royal Commissions into different aspects of London’s water supply
### Annex 2b. London Water Supply Key Events 1853 to 1904

<table>
<thead>
<tr>
<th>Year</th>
<th>Event / Legislative Act</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1853-4</td>
<td>Cholera outbreak in London</td>
<td>Third major outbreak of cholera in London with over 10,500 deaths</td>
</tr>
<tr>
<td>1854-7</td>
<td>Board of Health Inquiries</td>
<td>Following cholera outbreak in 1854, examined pollution of water sources and effectiveness of water company investments. Recommended constant supply.</td>
</tr>
<tr>
<td>1866</td>
<td>Cholera outbreak in East London</td>
<td>East London Waterworks company switches sources and enlarges treatment works</td>
</tr>
<tr>
<td>1867</td>
<td>Select Committee inquiry into operation and results of 1852 Metropolitan Water Act</td>
<td>Recommended a) constant service should be enforced but with strict provisions to avoid waste; b) the Metropolitan Board of Works should ensure statutory obligations of the water companies were fulfilled; c) new legislation was required to consolidate all the existing laws on water supply for the Metropolis.</td>
</tr>
<tr>
<td>1869</td>
<td>Royal Commission on water quality for London (Duke of Richmond Commission)</td>
<td>Recommended constant service to be introduced as soon as possible. To achieve this, the control of the water supply should be entrusted to a responsible public body, with power to purchase and extend existing works and to levy water rates.</td>
</tr>
<tr>
<td>1871</td>
<td>Metropolitan Water Act, 1871</td>
<td>Required the introduction of continuous supply. Increased regulation of companies, including oversight by a Water Examiner. Original proposals in the draft Bill for compulsory purchase of water companies were removed in Committee.</td>
</tr>
<tr>
<td>1874</td>
<td>Final Report of the Rivers Pollution Commission</td>
<td>Required covered water supplies to London and gave a comprehensive analysis of the financial history of the companies and their statutory powers to levy charges.</td>
</tr>
<tr>
<td>1875</td>
<td>Public Health Act, 1875</td>
<td>Required sanitary authorities to ensure that water supplies were adequate in their areas, if necessary by acquiring private waterworks. The Act encouraged, but did not oblige municipalisation. All new residential construction should include running water and an internal drainage system. The Act also required every public health authority to have a medical officer and a sanitary inspector.</td>
</tr>
<tr>
<td>1880</td>
<td>Metropolitan Waterworks Purchase Bill</td>
<td>Proposal to transfer the assets and operations of all 8 metropolitan water companies to a public &quot;Water Trust&quot;. Blocked - accused of being too favourable to the Water Co.s</td>
</tr>
<tr>
<td>1880</td>
<td>Select Committee</td>
<td>&quot;to inquire and report as to the expediency of acquiring on behalf of the Inhabitants of London the undertakings of the existing Metropolitan Water Companies&quot;. In the debate, the principle was greed that no member with any interest in a water company should be eligible to sit on such a committee.</td>
</tr>
<tr>
<td>1884</td>
<td>Metropolitan Water Bill</td>
<td>This private bill was promoted by the Corporation of London. The bill involved strict regulation of water companies in terms of charges, dividends and issue of new capital. It also required water companies to give customers the option to switch from rateable value of property to metered supply and charging by measured consumption (already the case for commercial customers) if they chose. The bill was defeated.</td>
</tr>
<tr>
<td>1885</td>
<td>Waterworks Clauses Act (1847) Amendment Bill</td>
<td>Attempt to have the basis of charges for water services put on a firm legal basis is opposed by those representing the position of shareholders. It would also have stopped companies being able to increase water charges simply because of a change in the rateable value of properties unrelated to the cost of providing water services. The amendment bill was defeated.</td>
</tr>
<tr>
<td>1887</td>
<td>Water Companies (Regulation of Powers) Bill</td>
<td>Another failed bill to regulate the private Water Co.s</td>
</tr>
<tr>
<td>1891</td>
<td>Metropolitan Water Supply Bill</td>
<td>Bill to transfer private water companies assets and responsibilities to a new public body. The Bill was jointly promoted by the newly created London County Council and various metropolitan boroughs. Failed to reach the statute books.</td>
</tr>
<tr>
<td>1892</td>
<td>Royal Commission (Lord Balfour)</td>
<td>Examined quality and adequacy of Rivers Thames and Lea to supply London</td>
</tr>
<tr>
<td>1894-7</td>
<td>LCC Water Bills to purchase water co.s</td>
<td>Series of failed bills promoted by London County Council to purchase all 8 water companies</td>
</tr>
<tr>
<td>1897</td>
<td>Metropolitan Water Act, 1897</td>
<td>Granted regulatory powers to Railway &amp; Canal Commissioners to determine complaints by consumers and local authorities about water quality and quantity</td>
</tr>
<tr>
<td>1899</td>
<td>Royal Commission (Lord Lllandaff)</td>
<td>Examined desirability of setting up a public authority to acquire and manage the 8 companies, constitution of the authority, and possibility of intercommunication</td>
</tr>
<tr>
<td>1899</td>
<td>Metropolitan Water Act, 1899</td>
<td>Required companies to supply each other in case of emergency.</td>
</tr>
<tr>
<td>1902</td>
<td>Metropolitan Water Act, 1902</td>
<td>After considering the recommendations of the latest Royal Commissions and Select Committee's the Government successfully passed a bill to take over the London water companies and to create a Metropolitan Water Board.</td>
</tr>
<tr>
<td>1903</td>
<td>Creation of the Metropolitan Water Board April 1903.</td>
<td>MWB to take over and organize the water undertakings under a single administration.</td>
</tr>
<tr>
<td>1904</td>
<td>Water Company assets and business formally transferred to MWB</td>
<td>The transfer of existing businessess took place over several months depending upon the resolution of both technical and financial issues and appeals by some of the companies as to the level of compensation. After dealing with the financial and other matters arising from the proceedings of the Court of Arbitration, it was not until July 1905 that the whole of all the private Companies' undertakings were formally vested in MWB</td>
</tr>
</tbody>
</table>
Annex 3. Transcription of Letters Patent granted to Peter Morris in 1578 and earliest known illustration of London Bridge Waterworks

Patent Roll, 20 Eliz., p. 10, m. 34.
De possessione pro Pet' Morris pro xx Auctorum.

Elizabeth by the grace of God etc. To all justices mayors sherifffes bayles cons
stables Heedborough and all other our officers ministers and subjects whome
these presents shall come greeting. Whereas our wellbeloved subjecte Peter Morris hath
by his great labor and charges founde out and learned the skill and cunninge to make
some newe kyndle and manner of engines to drawe and raise vp waters higher then
nature of yt selfe only seveth out of any manner of home grondes or other places
not nowe or heretofore as we are informed made practiced or vsed by any other within
thisour realme of Englande whereby grete benefyte maye come to our subjectes and
whole coloni wealth and to the ende he maye not be destrad of the frute of his labours
herin employed by others that should aitrite the making or practionyng of the same works hath made humble sute mo to that yt myghte please vs to grante
mo hym privilidge and lycence that none
but his executors administrators and assigns or suche as he by lawe shall specially
appoynte or lycence shall inteyprise to make or putt in pratice any suche works within
the space of twentye yeares nowe next ensueng and therefore we will and straith charge and command all and singular our subjectes of what
condyeyon or estate sober they be that
nether they nor any of them do make or cause to be made or vsed any suche engine or
engynes for any suche kyndle of works or works in the space of twentye yeares nowe next ensueng the date hereof with our speciall consenthe lycence or appoyntmente straithly charging all our officers ministers and subjects whome
yt shall apperteyn not only to ayt and assisting in the
said Peter Morris his executors administrators and assigns and his and theire servants
deputies and assigns in the puttting in vs of all the said engynes and works but also
from tymo to tymo to apprehend and commytt to warde all and every suche parson and
parsons as countray to thys our graunte shall after warning given by the said Peter
Morris his executors administrators or assigns or any of them make or cause to be
made or cause to be vsed any suche engine or engrynes for any suche kyndle of
worksduring the space of twentye yeares nowe causing all such offenders to remaine in
warde without byle or manyrise vntill he shall have made fyne vnto vs for such
temptye. And also payd vnto the said Peter

Source: Hulme and Jenkins (1895)