From *London Soup* and “chimera dire” to clear, bright, agreeable and palatable

By Simon Tyrrell

- **Slow sand filtration – a quest for cleaner water**
- **How two enterprising water companies extended and improved the public supply of clean water**
- **Why they chose to move to Seething Wells to do it**
- **What’s known about what happened, and when**
- **What everything did, and why …**
- **… and the physical legacy it all left behind**

Slow sand filtration

1804: First known instance of water filtration

- John Gibbs’ bleachery in Paisley, Scotland
- experimental slow sand filter
- surplus treated water sold to the public at halfpenny a gallon
- Greenock 1827

(*Quest for pure water, Baker, 1949*)

Existence of pathogenic bacteria was unknown. Slow sand filtration considered a mechanical means of removing suspended solids.

James Simpson also tramped 2000 miles in 1827 to inspect existing filters (in Scotland and North and East England) and experimented with a small scale plant in 1828.

1829: slow sand filtration first adopted for public water supply by James Simpson at the Chelsea Water Company in Pimlico and subsequently used by both Lambeth and Chelsea at Seething Wells.

The *materies morbi* that Snow suggested transmitted infection from previous cholera cases through water could be

- removed, with other solids, through filtration
- avoided by drawing supply upstream of sewer discharge

1858: Regular examination of water supplies started in London and included chemical analysis.

- 1885 (post Pasteur, Koch and Escherich) was extended to include bacteriological examination.

Widespread use followed:

- 1885: first mechanical filters installed in USA
- 1899: automatic pressure filters patented in England
- subsequent improvements largely in construction rather than principles and quality of water delivered
- performance largely unsurpassed until late 20th Century – in use in Netherlands, France, USA, Sweden, Japan, India
- still in use in 21st Century

1892: Convincing proof of effectiveness of filtration

- drinking water drawn from Elbe by neighbouring cities, became infected
  - Hamburg’s was untreated – cholera epidemic infected 1/30 and killed 7,500
  - Altona’s was filtered – escaped unscathed
- Subsequent epidemics across the world – infection almost entirely confined to people drinking unfiltered water.

(*Slow sand filtration, Huisman and Wood, WHO, 1974*)

How it works, in principle …

Slow sand filtration uniquely improves the physical, chemical and bacteriological qualities of the water. As water percolates:

- it is strained, filtered, chemically changed and stored
- organisms are removed or made inactive
- Tests on working filters show bacteria can be reduced by up to factor of 10,000

1. raw water enters reservoir above filter bed
2. heavier particles settle, some lighter particles combine – easier to remove
3. time and sunlight encourage algae, which absorb nutrients from the water, multiply and produce oxygen, which is dissolved
4. chemical reactions with impurities make them more easily absorbed by algae
5. water passes through a highly active slimy organic layer on surface - the *schmutzdecke* or filter skin – containing microorganisms and bacteria that break down and digest organic matter in the water and consume dead algae and living bacteria
6. water takes a few hours to pass through the miniscule gaps between sand grains below
7. Simpson considered his sand beds' distinctive quality to be its 'straining', retaining particles larger than the gaps between grains
    - This view prevailed until bacteria and viruses became better understood
    - The mechanical effect is only a small part of the purification process, with the biological 'screening' by the filter skin and the absorption qualities of the sand particles contributing the majority
8. A mass of microorganisms and bacteria coat the sand grains and feed on the impurities and each other.
9. As the water descends, the amount of 'food' stuck to the grains reduces and organisms feed off each other.
10. When it emerges, the water is free from harmful organisms and has dissolved nutrients that might encourage bacteria

… and in practice

At Pimlico:

- water pumped from Thames into subsiding reservoirs – remained for 6 hours
- then allowed to run onto filter beds
- c1700 gallons per hour
- filters comprised of undulating layers of
  1. fine sand
  2. coarse sand
  3. shells (from Harwich)
  4. fine gravel
  5. coarse gravel

The shells overlap and prevent sand sinking into the porous earthenware pipes below each undulation. These pipes conduct the water to the mains for distribution. Upper sand layer is renewed every 6 months.

Attracted attention and study (*Filtration of Thames Water at the Chelsea Waterworks*, Communicated by Mr James Simpson, from the Life of Thomas Telford, Civil Engineer and Architects Journal Vol 11, 1837-8) and not only from engineers:
On a peculiar power possesses by porous media of removing matter from solution in water, Henry H Witt, Asst Chemist to Government School of Applied Science (Philosophical Magazine, Issue 76)

"Maturing a noble plan" – extending works, improving supply

Why move?

The "purity" of the Lea and Thames waters, even at their original sources, is only relative, inasmuch as they contain more than ten times the solid matter per gallon to be found in the waters of the mountain lakes … they necessarily become contaminated … with sewage and the earthy and organic matters of surface drainage. The grosser particles may be, and are, separated by subsidence and filtration; but, after all, really pure water, unless it be aqua pura, as distilled by the chemists, is unknown in London.

(Waterworks of London, Colburn and Maw, 1868)

It is become little short of compulsory upon all classes to provide themselves with abundant supplies of pure wholesome water, as one of the most essential elements, not only of private comfort but of public health.

(James Simpson to Lambeth Board of Directors, 1848)

Surbiton water treatment at Seething Wells came about when it had become clear that the tidal Thames was so polluted that it could not provide suitable drinking water for London and its suburbs. Two major London water supply companies moved their intake of water and distribution pumping stations to Thames Ditton / Surbiton, up-river from the Teddington weir, where cleaner water was available.

These moves were driven by significant public opinion, commentator pressure and commercial demand and were enabled by political will, technology developments and the entrepreneurial imagination and courage to deliver significant long-term investment in facilities, engineering and processes.

Why Seething Wells?

"In compliance with their desire" James Simpson presented his recommendations on the extending and improving of water supply to the Directors of Lambeth Waterworks in November 1848.

In searching for a site he wanted to ensure:

- abundant and pure current and future supplies of clean water
- that existing head reservoirs and distribution mains and pipes remained in tact
- any new works would be restricted to improved supplies to existing reservoirs and extension of mains
- a favourable direct route for the clean water from source to reservoirs at Brixton, avoiding hilly land
- a source above highest range of tide at Teddington Lock, sufficiently remote from influence of disturbance

For Simpson, Seething Wells, at Ditton, uniquely met these requirements.

I feel confident that no other site or source can be found, which combines so many advantages, and from which so pure, constant, and abundant a supply can be obtained with so small an expenditure
(Simpson, Report to Lambeth Board 1848)

Simpson's understanding and intention were clear and unequivocal and his report explicit. He proposed abandoning present sources altogether, erecting steam engines at Ditton to propel the water along a cast-iron aqueduct or main pipe of ten miles to reservoirs at Brixton and Streatham, from where it would be distributed through existing works and pipes.

The water at Ditton being "usually very clear", would be passed at once from the river by conduit pipes to filters, from them to the wells of the pumping engines, and then through aqueduct or main pipe to reservoirs.

The filtering apparatus will be erected on such a principle, that the water must of necessity pass at all times through the filtering medium before it can reach the pump-well of the steam-engines.

The new districts to be supplied would include Thames Ditton, Esher, Long Ditton, Surbiton or New Kingston, Kingston-upon-Thames, Putney, Malden, Mordon, Wimbledon, Merton, Mitcham, Tooting, Clapham, Wandsworth, Battersea, Streatham, Croydon, Camberwell, Dulwich, Norwood, Westow Hill, Sydenham, Beckenham Lewisham. Simpson reserved some particular comment for local needs: "*At Kingston on Thames and Surbiton 'New Kingston' (a populous and increasing place) the want of water is much felt*".

And supply would be 'abundant" at 7,500,000 gallons a day - 30 gallons for each individual.

Following Board and Parliamentary approvals, Lambeth were the first to "mature a noble plan" (Lancet Editorial January 1848) , and work commenced on their £123,000 move to Seething Wells in 1850. Although pioneering slow sand filtration, and sharing the same chief engineer in James Simpson, Chelsea trailed Lambeth and only moved their intake and treatment works to a site adjacent to Lambeth's, in 1856.

From Chelsea to Cairo, Roberts, 2006
Chelsea Waterworks archive material, London Metropolitan Archive

What happened, and when …

	Lambeth Waterworks	Chelsea Waterworks
1829		Slow sand filtration introduced at Pimlico
1847	Decision to move intake and extend supply • Simpson recommends Seething Wells	
1848	Parliamentary approval secured through Extension of Works and Improvement of Waterworks Act, Lambeth WWC • Authorized intake and construction at SW	

1850	First contracts • "to construct erect and execute the Engine and Boiler House Workshops Filters Drains Timber Pile Wharf and other works" • £29,439 • work proceeds too slowly –pressure applied	
1851	Engineers report on progress (14 October) • Engine House, Boiler House, 105ft Chimney Tower, laying of mains nearly complete • Fixing of engines to commence (after slates for roof delivered) • One double filter bed completed • Pump wells, river works and piling for wharf well advanced • A steam engine to be working by December Further contracts and construction • Workshops • Offices • Toilets • Boundary railings	
1852	Site opens After sand filtration, water pumped to Brixton service reservoirs • Re-pumped to six service reservoirs ○ Norwood ○ Selhurst ○ Streatham Hill ○ Forest Hill	Parliamentary approval to take water from Thames and construct site in parish of Kingston secured through Chelsea Waterworks Act 1852

	○ Rook Hill ○ Crystal Palace	
1854		Engineer reports "that the most important parts of the New Works are about to be commenced" June: work commenced on River Wall, Reservoirs and Filters etc. Bricks arriving and being unloaded daily. August: Committee inspected works, viewing Drainage Engines in operation, River wall, Engine House
1854-6		Steady construction – regular orders and deliveries of materials Engine and Boiler House under construction 1855
1856		Site opens April: old brown horse gone lame. Sold for £10, new one bought for £45 August: locks, hinges, ironmongery ordered for First Engine and Boiler House
1857		Work underway in Boiler and Engine House, Wells and Pipe tunnels
1858		Coal Stores constructed
1859	Contracts for machines, buildings and maintenance • "Steam Engine, Pumps etc for supplying the Surbiton District and draining the Filters"	Auction of old machinery used in construction
1859-60		Ground levelled in Engine Yard - roads, paths and drains constructed Offices, Workshops, Wall and Railings, and Fencing between Chelsea and Lambeth Waterworks constructed
1862		Engine and Boiler House for street watering built Removal and installation of Stone Fountain in Engine Yard Turret Clock for Lodge
1864		New Engine and Boiler House built, with campanile-like

		chimneys
1863/4	Additional Boiler House constructed	Ongoing minor works
1865	Additional Engine House, Boiler House and Chimney constructed	Ongoing minor works
1866	Major extension to site • New Filters, Reservoirs, (Dock and Boathouse?) • Required demolition of Crown and Anchor and Old Three Pigeons pubs	Reservoir and River Wall construction
1869	Small cart shed built on South of site	
1871	Moved intake to Molesey	
1875		Act enabling transfer of intake to Molesey
1878/9	Alterations to original Filters, realignment of road New Boundary Walls and Railings (£40,470), and new Boiler and Engine Houses	Pumping Engine and Boiler repairs (£1,015) Pair of Woolf Engines constructed (£13,531)
1882	Further Engine and Boiler Houses built between existing Boiler and Engine complex and cart shed	
1885		Additional pair of Steam Engines and six Boilers
1886	Engineer's report on Ditton: • 4 Filter beds, 3.5 hectares, lower level by River • 1 Service Reservoir • 4 Filter Beds, 4 acres, upper level of Engine Yard • 1 Service Reservoir for upper Filters • 8 Engines, Pumps etc for Kingston to District • 2 Engines, Pumps etc for pumping to upper Filters • 1 Engine for Drainage Engine ○ Total Power at Ditton: 1740 HP • 5 Engine and Boiler Houses – with 33 Boilers • 3 Chimney Towers	

	• 1 Coal Store for 750 tons of coal • Workshops, Offices etc. • Additional Filters recommended (4 acres, est. £31,000), land available • 2 oldest engines needed renovating and power increasing, as had already been done with 4 others, rebuilt in 1885	
1887	Work completed at Ditton to connect Upper Filters with Molesey conduit	
1889	Major works: • Engineers recommend 2 new Filters, an acre each. ○ Constructed between South end of Prospect Place and Balaclava Road • Workshops extended to South - additional space for Workshops, machinery Engine House, Painters shop, Pattern Shop, Carpenters Shop • Additional Cart Shed • Original Coal Store extended and new Coal Store built	
1890	Engineer's report (March) • Recommends replacing oldest 9 boilers over 3 years (boilers have recommended 'life' of 30 years) New Worthington Engine House constructed between South West of Engine and Boiler House complex and Filter	Coal Shed roof altered to allow trucks to run on extended tramway Iron roof erected on columns
1893	Two further Filter Beds constructed (tbc)	
1894	Engine House built for new Horizontal Low Lift Engine	
1896-7		New Filter Beds (£13,705)

c. 1900	Additional Boiler House, two new Filter Beds, new Boundary Walls and Railings	
?	Six new Filter Beds, additional Service Reservoir constructed Filters and Reservoirs occupy ten times space of buildings	
1900s	Amalgamation of companies under Metropolitan Water Board (date?)	
1924	Major new plant	
1930s	Major alterations	
1950s	Major alterations	

What was it all for, and how did it do it?

While both companies were guided by the same engineering hands, operated in broadly similar ways, and applied similar technology and processes, there were some differences in how they met their otherwise similar goals.

From the outset, Chelsea used subsiding reservoirs and filter beds. Lambeth initially took water straight into its filter beds, but constructed reservoirs for settling in the late 1860s.

The river walls were concrete, with openings taking in river water, guarded by gratings and screens to prevent debris flowing in. Sluices controlled the flow into the subsiding reservoirs. In principle, if not always in practice, the use of reservoirs would be alternated – one would have water that was settling, while another would be taking in water from the river.

Water leaving the reservoirs had a preliminary filtering as it passed through shingle in brick tunnel structures that fed into the adjacent filter beds. It was taken from a little above the bottom of the reservoir, to avoid pollution from any settlement in the reservoir.

In Chelsea's works, water drained from the filter beds through a central inclined channel, connected to drain pipes of a diameter varying from 6"-12", perforated with ¾" holes and with slightly open joints at their ends. Lambeth initially used slate slabs with open joints, on top of small brick walls, as a chamber to collect the filtered water.

These slabs and pipes were covered with filtering material – firstly a c.6" layer of coarse gravel, overlaid with 4" of fine gravel, 6" of shells, 6" of coarse sand, then up to 2'6" of fine sand. The total depth could be nearly 6 feet.

On average weekly, about half an inch of the top layer of sand was scraped to remove impurities, washed and retained for future use. Each filter bed was 'made up' annually. The sand remaining was taken up and put down again as the top layer on top of the fresh sand making up the bed. This meant the longest serving sand would be the next to be scraped.

Water passed into the filters through inlet pipes just below the surface of the sand. A wooden trough with a closed end, but open on top, was attached to the end of the inlet pipes and deflected the water upwards to make sure it wouldn't wash away the filter sand.

Overflow sluices prevented flooding, and draining pipes could be called into use if the filters became clogged.

Hoists were used to raise the sand for cleaning, driven by the same nearby beam engines used by the drainage pumps and for Chelsea, their sand washing machine. The washing machine had two revolving, sloping cylinders made of coarse gauze, into which pressurized water is forced, washing over the sand and rinsing out grit and dirt. Lambeth didn't use a washing machine, instead relying on hosing down the sand until clean in special chambers adjacent to their filter beds.

Water passed from the filter beds through a culvert under the road to the engine pump wells . The inaugural engines and the building housing them were constructed with potential future expansion in mind – designed to be able to connect to new engines, and requiring new boilers all to be comfortably accommodated in buildings with spare capacity.

All engines were at least initially bucket and pump class beam engines, specially designed for the Seething Wells works and able to operate independently or coupled with others. The Chelsea engines also pumped the water through a 30" main for 6 ½ miles to covered reservoirs at Putney Heath, those from Lambeth the 10 ½ miles to Brixton. The main to Putney was initially carried over the Thames by an iron aqueduct. Subsequently, mains piping was integrated under the Thames bridge (?).

Cornish boilers supplied steam for the engines, and were housed below the level of the engine house floor, to allow condensation to drain back into them.

The coal used was largely slack, in some cases mixed with a small proportion of Welsh. Coal was brought to the works by barge, unloaded by hydraulic crane fixed on the river wall, powered by mains water. The coal was raised in iron boxes, which were placed on trucks and run down an inclined railway, passing through a tunnel under the turnpike road to an area beneath the coal stores. The railway had twin tracks – trucks were coupled to wire rope passing over pulleys at the head of the slope so those descending with a load hauled up the empty ones. The boxes of coal were raised by hydraulic hoist to the top of the stores where their contents were emptied onto the heap through a hinged side to the box.

Unfiltered water was also pumped through 15” mains to another, open, reservoir on Putney Heath for use in road watering and to supply the Serpentine. The condensing beam engines used for this were originally used to supply water to the fountains at the Great Exhibition of 1851.

The main to Putney Heath rises and falls according to the gradients of the road alongside which it was laid, and was provided with air-cocks at high points. These were inspected weekly. Putney Heath’s reservoirs were on the highest part of the heath and the filtered water was distributed to the district by gravitation, through two 24” mains. The unfiltered water was carried by a 12” main.

The total length of Chelsea Waterworks’ piping was about 270 miles.

The Brixton reservoirs supplied Lambeth and adjoining parishes through gravitation through two 20” and one 10” main. Three engine houses at Brixton carried engines that pumped water between the 100ft and 250ft contours above the river to supply Brixton, Dulwich, Beckenham, Penge, Balham, Tooting and reservoirs at Streatham and Selhurst. Lambeth also supplied Kingston and its neighbourhood.

The total length of Lambeth Waterworks’ piping was nearly 300 miles.

(*The Waterworks of London, a series of articles,* Colburn and Maw, Reprinted from ‘Engineering’, 1868)
From Chelsea to Cairo

And what were the physical results on site?

Lambeth Waterworks at Seething Wells		
Engine and Boiler Houses (1850)	• First Engine House in buttressed Norman Keep ○ two pairs compound beam engines • First Boiler House adjoining to North • Chimney tower to west of Boiler House	Part of site now Lambeth Houses Considerably altered Chimney gone Boiler House occupies 1st floor present single storey building *Listed*

Workshops (1850)	• An early construction
	• Southeast and in yard of Engine and Boiler Houses
	  ○ Single block
	  ○ Smiths', Engineers' and Carpenters' Shops
	  ○ Small offices
		Survives – flat roof replaces original

Offices (1851/2)
Toilets (1851)
	• Offices at entrance to site
	• Toilets block to west of Engine House
	  ○ Small, single storey, flat roofed
	  ○ In style of Workshop
	  ○ Bathrooms, WCs, wash room
		Office survives, and is little altered
		Toilets demolished when Engine House enlarged

Boundary Railings and Brick Piers (1852)	• Same contract as toilets and offices	Largely survive
Engine and Pump House (1859)	Small buildings on land between river and	Engine and Pump House survives – blind

Boiler House (1859)	Portsmouth Road, North East end of filter beds • Boiler House – two boilers • Engine and Pump House – steam engine and pumps • Continued architectural theme	rounded arched opening to road, Romanesque archway to River
Additional Boiler House (1863/4)	At Southern end of Engine House	Survives – has lost roof-light and two blind arches in South elevation
Additional Engine House, Boiler House and Chimney (1865)	At Northern end of original main Engine and Boiler Houses • Extended the Boiler House with a fourth matching bay • Two storeys, four buttresses, four Romanesque windows • Front entrance raised above deep basement, approached by steps • Ends ornamented with tall blind arches Additional Boiler House to North of new Engine House indicated on plans • Similar to that at South end	Additional Engine House survives in (externally) unaltered state
New Filters and Reservoirs (1866) (Dock and Boathouse tbc)	New Filters between existing Filters and Road New Reservoirs to West of Filters, between River and Road • Separated from Filters by small dock and boathouse (new?) • Required demolition of two public houses and outbuildings	

Cart Shed (1869)	Small Cart Shed built to South of 1863/4 Additional Boiler House	Demolished 1889, when new Cart Shed built
Filter Bed alterations (1878/9) Boundary Walls and Railings (1878/9) New Engine and Boiler Houses (1878/9)	Original Filters altered • Slight realignment of road – moved towards river by softening of curve New Boundary Walls and Railings erected, matching original New Engine and Boiler Houses at North end of those built in 1865	New Engine and Boiler Houses survive
Further Engine and Boiler Houses (1882)	Freestanding building between 1869 Cart shed and to South of Engine and Boiler complex	No longer exist
Workshop extensions (1889) New Filters (1889) Additional Cart Shed (1889) Coal Storage enlargement (1889)	Workshops extended to South - additional space for Workshops, machinery Engine House, Painters shop, Pattern Shop, Carpenters Shop - subsequently became second Muniments House (1912) New Filters, between South end of Prospect Place and Balaclava Road New Cart Shed built behind North end extended Workshops. Earlier Cart Shed demolished. Original Coal Store extended, additional Coal Store constructed to its North East (became 1st Muniment House in 1909).	Second Muniments House (1912) survives Original Coal Store heavily altered Additional Coal Store survives in recognizable form (1st Muniment House)
	New Engine House for Worthington Engine constructed between South West of Engine and Boiler House complex and Filter	Worthington Engine House no longer survives

Horizontal Low Lift Engine House (1894)	Engine House built for new Horizontal Low Lift Engine – South East flank of 1878 Engine House	Survives
Additional Boiler House (1900) New Filter Beds (1900) New Boundary Walls and Railings (1900)	Boiler House - South West of Engine House complex, adjacent to Worthington Engine House Two new Filter Beds – constructed in angle of Portsmouth and Windmill Lane New Boundary Walls and Railings erected	
? (contract 154)	Six new Filter Beds, additional Service Reservoir fronting Windmill Lane to South East of Filter Bed	

Chelsea Waterworks at Seething Wells		
Drainage Engine House (1854)	Located by Filter Beds between Road and River One building housed Boilers and Engine, with Chimney to one side	Somewhat altered building survives, without chimney
First Engine and Boiler House (1855)		
Coal Store (1858) Fountain (1858)	Italianate, with tower to North West Tunnel runs from tower to coal wharf by river Simpson-designed fountain possibly moved from original reservoir site	Coal Store and Fountain *Listed*
Offices (1860) Workshops (1860)	Offices at entrance to Chelsea Works Tall narrow campanile tower - ventilation	Offices/lodge *Listed*

Wall and Railings (1860)	shaft for steam railway tunnel serving coal store? Workshops at far end of yard Wall and Railings along Portsmouth Road	
Engine and Boiler House (for street watering) (1862)	May have been located close to River Bank	No longer survives
New Engine and Boiler House (1864)	Formed pair with first Engine and Boiler House On East of roadway into Works – earlier one further from Portsmouth Road Both had campanile-like chimney	Remains of building survive, with only lower storey and greatly altered Chimneys no longer survive

Surbiton Water Treatment Works, Gilman
English Heritage List Entries
Kingston University