## SECTION 5: WATER QUALITY

***"Our Vision is a river full of water that is plentiful and clean, and varied in its flow speeds, widths and depths"***

*Wandle Catchment Plan Objective 2: The quality of water flowing in the River Wandle meets the standards required for Good Ecological Potential and is stable with no risk of deterioration*

### 5.1: Overview and historic water quality records

Despite extensive exploitation for public and industrial supply and waste disposal, the River Wandle enjoyed a long historic reputation for the unusual clarity and quality of its chalkstream water. Although not scientifically detailed, water quality can be inferred from multiple descriptions of the river's natural purity, clarity and suitability for pollution-sensitive organisms like trout – and conversely from accounts of the catastrophic levels of pollution to which the river was later subjected.

Numerous early writers eulogised the river as "the best and clearest stream near London" (Davy, 1828) and "one of the most celebrated trout streams in England… the chalkiest of chalk streams (Dewar, 1899). Around 1870, Halford recollected, the upper Wandle in Carshalton "was a beautifully clear stream in which every stone could be seen in four or five feet of water" (Halford, 1903).

Even in 1881, more than a generation after Braithwaite had recorded astonishing levels of aquatic pollution further down the river in the 1850s, general water quality still seems to have been good enough to persuade William Morris to move his printing works to Merton Abbey. His printing processes required a particularly pure quality of water for madder dyeing, and Morris's decision to relocate to the Merton Abbey area of Wandle, over several other contenders including the Colne and Cray (Parry, 1983), almost certainly indicates the dilutive effect of strong baseflows which had not yet been damagingly reduced by abstraction.

This hypothesis is supported by simultaneous developments on the Croydon branch of the river. As industrialisation intensified, and the population of Croydon increased from 5,7423 in 1801 to 134,037 in 1901, these pressures so far exceeded the local councils' ability to provide adequate waste disposal that this stretch devolved progressively into an open sewer and probably contributed to epidemics of cholera and typhoid in the late 1840s and 1875 (Shew, 2012).

The Wallington-based horticulturalist Alfred Smee noted how "the Board of Health of Croydon carried all the sewage of the town into the river which passed through Beddington Park to my garden. The effluvium was noxious; the fish died; and foul mud was deposited on the bottom of the river. It became a question whether I should abandon my garden; but I determined otherwise, and commenced an agitation to stop the pollution of rivers" (Smee, 1872). His landmark court case (Smee v Croydon Board of Health) eventually forced the creation of a purpose-built sewage irrigation farm on the former Carew Manor deer park in Beddington, though not before "a committal (had to be) signed to commit the members of the Board to prison" (Smee, 1872).

But the river's downward spiral now has the all the appearance of inevitability. "By 1905 a newspaper reported that 'Wandsworth knows the Wandle as a sickly stream, sage green and sluggish, soiled by a dozen factories, often smelling vilely'" (Courtney Williams, 1945). In 1899, Dewar had already written, "As for the poor Wandle in Merton, it is a shocking sight and colour: you might as well indeed fly-fish at Wandsworth as at Merton to-day."

New sewage treatment works were eventually built in the 1930s, and the current works were commissioned in December 1960, leading to slow improvement in water quality. Continued investment in sewage treatment technology has now resulted in a river which can sustain healthy populations of stocked fish, including trout which are only able to survive in clean, well-oxygenated water.

However, Beddington STW remains a continuous source of nutrients and chemicals not removed by sewage treatment processes, and an occasionally catastrophic threat to water quality. Abstraction and general urbanisation of the catchment also continue to place considerable pressure on the Wandle's water quality.

<u>Further reading</u>

Braithwaite (1861) *On the Rise and Fall of the River Wandle: Its springs, tributaries and pollution*

Courtney Williams (1945) *Angling Diversions*

Halford (1903) *An Angler's Autobiography*

Smee (1872) *My Garden: Its plan and culture*

### 5.2: Modern water quality assessment

Under the supporting elements categories for WFD assessment, surface water quality is reported and managed by the Environment Agency under two schemes: General Quality Assessment (GQA) and River Quality Objectives (RQO).

GQA makes regular assessments to monitor trends over time and compare rivers in different areas, with 3 classification components:

- General chemistry: 6 grades A (highest) – F (lowest) for dissolved oxygen, biochemical oxygen demand (BOD) and Total Ammonia. (NB chemical content of water samples can be influenced by the time of day at which they were taken: eg the relationship between dissolved oxygen levels and the rate of the photosynthesis-respiration cycle and by the nature of discharges into the watercourse)

- Biology: a proxy measurement based on benthic macroinvertebrate monitoring. Aquatic invertebrates are continuously exposed to changes in water quality, and respond to intermittent and low level pollutants that may not be detected by standard chemical monitoring methods.

- Aesthetics: very labour-intensive, therefore only used in reaches where information is required for a particular reason (eg to monitor storm outfall improvements).

RQO establishes surface water quality targets based on the uses of the watercourse, in order to provide a commonly agreed planning framework for the regulatory bodies and dischargers, with one main component based on the river's ability to support various fish populations:

- River ecosystem (RE): 5 classes RE1 (best - very good water quality suitable for all fish species) - RE5 (worst - water of poor quality likely to limit coarse fish populations)

Under these water quality assessment schemes, the Wandle's Carshalton water body is designated as Good (ie in line to achieve GEP for water quality) while the Croydon-Wandsworth waterbody is failing on phosphate only.

This assessment implies that the Croydon-Wandsworth water body is eutrophic and requires immediate protection and improvement measures to prevent deterioration. As a result, the Wandle has been designated a Phosphate Sensitive Area under the Urban Waste Water Treatment Directive, and Thames Water will be required to install phosphate stripping equipment at Beddington STW during AMP6, with completion due by November 2018 (pers comm. Angela Gorman, EA, 2014).

Statutory water quality monitoring on the Wandle is also supported by two voluntary schemes:

- **Riverfly monitoring**: monthly invertebrate monitoring has been carried out by the Wandle Piscators' fishing club at 11 key sites on the river since 2008. Diversity and abundance of key aquatic invertebrates are noted by trained volunteers as proxy measurements for water quality: if scores fall below pre-defined trigger levels (typically 50% of the running average over six months of the riverfly monitoring score for the site) an EA investigation is launched.

- **Pollution Assessment Volunteers**: a network of volunteers works with the EA and the Wandle Trust to assess Category 3 (minor) pollution incidents, and identify misconnections and other point source pollutions.

In 2013 the EA and Thames Water undertook a very successful pollution prevention project in Croydon town centre, identifying and resolving a large number of regular point sources of pollution. The EA continues to raise awareness of pollution issues and is involved with assessing certain crucial pollution sources, including the Deer Park Road Industrial Area (Merton) and Willow Lane Industrial Estate (Mitcham).

Additionally, through the Surface Water Outfall Programme, pollution hotspots are identified and listed by the EA, and project managed by Thames Water. In February 2014, work started on the Morden Hall Road outfall: cleaning sewer lines, unblocking manholes, identifying misconnections and persistent polluters, and dealing with these through negotiation or legal notices.

Further pollution pathways into the Wandle are discussed in Section 5.8.

### 5.3: Temperature

The Wandle's chalk stream sources emerge from a spring line on the dip slope of the North Downs at a constant temperature of c11°C: a typical temperature for chalk springs. This water becomes progressively warmer as it flows north to the Thames at Wandsworth, with thermal loading occurring at several points, particularly as a result of the inflow of treated sewage effluent from Beddington STW (see Section 5.8.8) which adds an average c2.6°C to water temperatures.

Between January 1998 and April 2009, the EA took regular water samples at six monitoring points on the river for water quality testing. Water temperatures were recorded, and a summary is presented below:

| **Beddington Park Lake** | **Average recorded temp °C** | **11.7** |
|---|---|---|
| **(gauging station)** | Max record | 18.3 |
| | Min record | 0.4 |
| | | |

| | | |
|---|---|---|
| **Butter Hill** | **Average recorded temp °C** | **11.2** |
| | Max record | 18.3 |
| | Min record | 3.7 |
| | | |
| **Goat Bridge** | **Average recorded temp °C** | **11.4** |
| | Max record | 17.4 |
| | Min record | 5 |
| | | |
| **Watermeads** | **Average recorded temp °C** | **14** |
| **(Mitcham)** | Max record | 20.7 |
| | Min record | 8.6 |
| | **Average °C added by STW** | **2.6** |
| | Av max variation | 2.8 |
| | | |
| **Plough Lane** | **Average recorded temp °C** | 13.7 |
| | Max record | 21.5 |
| | Min record | 7.2 |
| | | |
| **Wandsworth** | **Average recorded temp °C** | 13.4 |
| **(Causeway)** | Max record | 20.3 |
| | Min record | 6.3 |

*Fig 5a: Comparative water temperatures at six sites on the Wandle between January 1998 and April 2009: this data illustrates the year-round thermal impact of Beddington STW on the river's temperature regime (data source: EA / Wandle Trust)*

All temperatures were recorded between 8.30am and 1pm. Because these records were generated as part of a general methodology for collecting water samples for chemical analysis, it should be noted that the sampling points and timings were not targeted for maximum information on the thermal range which the Wandle may experience. As a result they may not reflect maximum solar-thermal loading when water has been resident in online impoundments for several hours on a sunny summer afternoon, with associated implications for dissolved oxygen levels (fully saturated water contains 14ppm of oxygen at 1°C, 11ppm at 11°C, and 9ppm at 20°C) (Watson, 1993).

On the other hand, these records provide a long-term data set which allows tentative conclusions to be reached. For example, despite impacts of impoundments, most of the river appears to be well within the comfortable optimum temperature ranges for trout growth (7- 9°C and 16-19°C) (Solbé, 1997), a hypothesis which is confirmed by the observed ability of trout to survive and grow to large sizes in the Carshalton water body, as well as the Croydon-Wandsworth water body above Goat Bridge.

Further downstream, below the influence of Beddington STW, temperatures are also tolerable for salmonids, but become better suited to a wide range of cyprinids. (However, dace and perch are also able to spawn in colder water, at or below 12°C: see Section 7.2.2).

### 5.4: General water chemistry

The effluent carrier channel from Beddington STW significantly increases the flow of the main River Wandle below Goat Bridge by c234,000 m3 (2.708 cumecs) of treated sewage effluent per day.

On 9 July 2009 an investigation into general water chemistry was carried out by representatives from the EA, Wandle Trust and Thames Water, with the objective of providing an understanding of "normal" conditions for the river.

This investigation has also provided an assessment of the direct impact of Beddington STW on the Wandle's water chemistry. The comparative data resulting from this investigation is tabulated below (Fig 5b):

| **Component Name** | **Units** | **U/strm of BSTW** | **D/strm of BSTW** |
|---|---|---|---|
| DO | % | 95.6 | 86.1 |
| DO | mgl | 9.84 | 8.85 |
| Cond | µS | 625.9 | 747.8 |
| TDS | ppm | 338.6 | 487.5 |
| NaCl | ppm | 555.4 | 684.3 |
| Water Temp | °C | 14.4 | 14.9 |
| pH | | 7.06 | 7.43 |
| $P0_4$ | ppm | 0.25 | >4 |
| $N0_3$ | ppm | 7 | 11 |
| BOD (5 Day using ATU) | mg/l | <1.0 | 1.1 |
| COD | mg/l | <10.0 | 19.5 |
| Solids Suspended 105C | mg/l | <2.00 | 5.50 |
| Ammoniacal Nitrogen | mg/l | <0.04 | <0.04 |
| Sulphate as $SO_4$ | mg/l | 24.3 | 41.5 |
| P SOL Reactive | mg/l | <0.03 | 2.67 |
| Neat E. coli 2000 | MPN/100ml | 1203 | >2420 |
| Neat coliform 2000 | MPN/100ml | >2420 | >2420 |
| 1/1000 E. coli 2000 | MPN/100ml | 1 | 1 |
| 1/1000 Coliform 2000 | N | 20 | 26 |

*Fig 5b: Results of an investigation into the Wandle's water chemistry in 2009*

This investigation concluded that the STW's impact on the general water chemistry of the river was moderate. However, the following direct impacts have been noted:

- Phosphate and sulphate levels increase dramatically below Beddington STW: there are currently no limits on the discharge of phosphate and sulphate from the STW (but see below). At the time of this study, the increases were deemed acceptable at a proportional level
- COD and turbidity levels also increase below the STW, although these increases are within the current discharge limits set by the EA (see Section 5.7)
- *E.coli* levels in the river double below the STW
- No increase in ammonia was detected

In 2013 the Wandle was designated as a Phosphate Sensitive Area. Under the Urban Waste Water Treatment Directive, Beddington STW is now on the EA's National Environment Programme (NEP) in AMP6, to have phosphate stripping installed to remove phosphate to a permit of 1mg/l. This scheme is due to be completed by 14 November 2018 (pers comm. Angela Gorman, EA, 2014).

<u>Further information required:</u>

Further detailed interpretation of general water chemistry data

## 5.5: Ecotoxicology

Ecotoxicology is defined as the study of the effects of toxic chemicals on biological organisms, especially at the population, community, and ecosystem level.

Ecotoxicology is a multidisciplinary field, which integrates toxicology and ecology. It differs from environmental toxicology in that it integrates the effects of stressors across all levels of biological organisation from the molecular to whole communities and ecosystems, whereas environmental toxicology focuses upon effects at the level of the individual and below.

The end objective of ecotoxicology is to be able to predict the effects of pollution, including interactions between pollutants, so that the most efficient and effective action to prevent or mitigate any detrimental effects can be identified. In ecosystems which have already impacted by pollution, ecotox studies can suggest the best courses of action to restore ecosystem services and functions efficiently and effectively (Wikipedia, accessed Jan 2014). This approach can be seen in the recommendations relating to sediments, heavy metals and PAHs (see Section 5.8.6 above).

Fish and invertebrates can be affected by pollution in a variety of ways:

- Acute pollution: the effects of short “spikes” of pollution passing down a river can vary widely, depending on factors including concentration, how long the spike persists, and its distribution through water column (sometimes influenced by the mixing effect of weirs etc). Larger fish are more likely to survive pollution incidents, especially if they can find refuge from a short spike, but their food sources may be seriously depleted if the pollution has damaged invertebrate communities as well as small fish

- Chronic pollution: generally related to existing pollutants (often deposited by historic former industries and bound up in sediment deposits) which become remobilised into the water column by high flows, foraging or spawning fish, or other disturbance.

Further information required

Further investigation into pollutants, their interactions and their effects on the Wandle

Further reading:

Brierley (2013) *The characterisation and quality appraisal of riverbed and road runoff sediments within the Carshalton arm of the River Wandle, London, UK*

## 5.6: Historic pollution records

As London’s industrial revolution gathered momentum through the 18$^{th}$ century, much of the energy for this revolution was provided by the Wandle, leading to the frequently-quoted assertion that it was “one of the hardest-worked rivers for its size in the world”.

In addition to sewage pollution from Croydon’s booming population on the headwaters, many industries used river water for their manufacturing processes before discharging it again, or simply exploited the Wandle as a conduit for flushing away waste. From early use as corn mills, most milling sites changed their industrial focus several times according to market forces and other economic pressures.

The textile trade evolved from relatively low-impact sun-bleaching, felting and organic dyeing to widespread use of chemicals, while heavier and more seriously polluting industries included copper, iron (including cannon boring and machine tooling), oil, leather, paper, snuff and gunpowder works, as well as brewing and medical distillation (Shew, 2012; Steel and Coleman, 2012). In the late 18th century, Carshalton became a centre of national importance for paper making, largely due to the expertise of the industrialist Christopher Patch, who from 1789 was one of the first paper makers to use chlorine to bleach the rags for his paper (Steel and Coleman, 2012).

Braithwaite's survey of 1861 provides a vivid picture of the variety of pollutants entering the Wandle, ranging from "pieces of skin" and "flocculent matters" from the tanyards at Goat Bridge, to "sulphuric acid, alum, muriate of tin, chloride of lime, prussiate of potash, nitrate of iron, sulphate of copper and oxallic acid" discharged by silk works at several points along the river. From 1881 onwards, at Merton Abbey Mills, Arthur Lazenby Liberty reportedly gloated that "we send all our dirty water down to Morris".

Heat pollution from quenching processes in forges and foundries would have compounded the effects of these pollutants, and it is still possible to find fig trees growing in the margins of the river: mill workers ate the figs, whose seeds passed out into the river in sewage, and successfully germinated and grew in the heated conditions (a phenomenon also observed on many post-industrial northern mill streams).

In time, as steam power outcompeted water, the industrial focus moved towards light industry and chemical works, many of which would also have polluted the river. Then as now, casual fly-tipping and disposal of household waste were recorded in Ruskin's eulogy for the Wandle in 1870: "Just where the welling of stainless water, trembling and pure like a body of light, enters the pool of Carshalton … the human wretches of the place cast their street and house foulness: heaps of dust and slime, and broken shreds of old metal, and rags of putrid clothes, which having neither energy to cart away, nor decency enough to dig into the ground, they thus shed into the stream to diffuse what venom of it will float and melt far away in all places where God meant those waters to bring joy and health…" (Ruskin, 1870).

Local landowner Charles Dingwall attributed the final decline of the upper Wandle's trout fishery to tar laid on local roads in 1914 (Wilks and Rookledge, 2002): a problem separately identified by Arthur Ransome in the Lake District.

By 1929 the ecological situation was severe enough for a committee of local anglers to draw up a report describing the state of the river: "No fish could survive in the Wandle nowadays; they would immediately die from the poisoning. The once clean, swiftly-moving waters are now black and muddy, cluttered with evil-smelling, putrescent flotsam, and rendered foul and malignant by the outpourings of industrialism. The river has not merely been neglected; it has been deliberately, wantonly, turned into a kind of open sewer. The bottom is littered with old tin cans, scraps of iron, broken bottles, and miscellaneous rubbish of all kinds." (Courtney Williams, 1945).

Even during the modern era of improving sewage treatment, non-biodegradable foaming agents in synthetic detergents were able to pass through Beddington STW, resulting in "masses of floating foam" (Montague, 2005) covering the river from Poulters Park downstream and sometimes blowing across Merton High Street in the late 1960s.

Heat pollution also continued into the 1970s, when cooling water entering the river from Croydon's power stations was measured at 75°C, while damaging discharges of cyanide were recorded from Beddington in 1973 and diesel from Croydon in 1974 (Montague, 2005). Cyanide entering the drainage system was responsible for the failure of Beddington STW in 1995, causing a week-long discharge of untreated sewage, and an accidental spillage of sodium hypochlorite from the STW in 2007 bleached up to 5km of river channel and killed at least c7,000 fish of all species. A month earlier, an untraced pollution episode, possibly containing oil and heavy metals, also killed large numbers of fish in the Mill Green area.

Further reading

Braithwaite (1861) *On the Rise and Fall of the River Wandle: Its springs, tributaries and pollution*

Montague (Merton Historical Society) (2005) *Mitcham Histories 6: Mitcham Bridge, the Watermeads and the Wandle mills*

Steel and Coleman (2012) *River Wandle Companion and Wandle Trail Guide*

## 5.7: Beddington Sewage Treatment Works

As discussed in Section 4.5, Beddington sewage treatment works (STW) provides a significant proportion of flow in the Wandle below Goat Bridge. Since the 1960s, when several other STWs were also operating on the lower Wandle, and the river was officially classified as a public open sewer, centralisation of the STW function at Beddington, and investment in treatment processes, have resulted in great improvements to general water quality.

Today, Beddington STW is operated by Thames Water, and probably still represents the single greatest point source influence on the Wandle's water quality, both generally and in relation to major pollution incidents.

### Influent monitoring

According to Thames Water, the major threat to the proper functioning of Beddington STW is a soluble chemical entering the STW and impairing the biological processes. This is what happened when cyanide entered the STW via the drainage network in October 1995.

Inflowing sewage is monitored for BOD, COD, SS and $NH_4$, so many chemicals are still undetectable at this point, unless they affect these parameters. However, once a damaging chemical has entered the STW system, the microbes on which the STW relies to work will be killed, and continuously monitored dissolved oxygen (DO) levels will start to rise, since the microbes are no longer using this oxygen for respiration. The chemical in question can then be detected, and Thames Water's Trade Effluent Team may be able to work out its source by a process of elimination against consents for discharging this chemical.

Alert levels are assigned percentages depending on severity (since the system also flags up DO levels etc which form part of the STW's regular processes), with levels over c80% flagged as red, and alarms sounded. If the controller has not responded on the computer system within 30 minutes, for instance due to being occupied with another alert, the control centre in Reading is automatically alerted.

### Effluent monitoring and discharge consents

Effluent leaving Beddington STW is constantly analysed by two on-site monitors: one measuring turbidity and $NH_3$, the other measuring $NH_3$, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and suspended solids (SS) in real time via probes installed c2008 in all Thames Water's larger STWs. Turbidity and $NH_4$ are tested daily on site to check the monitoring equipment, and additional samples are taken each week for lab testing

Discharge consent limits for BOD, $NH_3$ as N and SS are tight, and are set as follows by the EA in line with the Urban Waste Water Treatment Directive, with a 95% compliance limit:

| | | | |
|---|---|---|---|
| SS-95%ile (mg/l): | 15 | SS-Upper Tier (mg/l): | none |
| BOD-95%ile (mg/l): | 10 | BOD-Upper Tier (mg/l): | 50 |
| AmmN-95%ile ($NH_3$ as N): (mg/l) | 2.5 | AmmN-Upper Tier (mg/l): | 20 |
| Cadmium (ug/l): | | P (UWWTD) (mg/l): | |
| Copper (ug/l): | | Beryllium (ug/l): | |
| Zinc (ug/l): | | Iron (ug/l): | |
| Chromium (ug/l): | | HCH (ug/l): | |
| Nickel (ug/l): | | Chloroform (ug/l): | |
| Lead (mg/l): | | Boron (ug/l): | |
| Mercury (ug/l): | | Cyanide (mg/l): | |
| Metal/Other Indicator: | Y | Oil & grease (mg/l): | |

*Fig 5c: Discharge consent limits for Beddington STW*

If the upper tier limits are exceeded, the STW fails its consent. Since the introduction of self-regulation, Thames Water are required to take 12 samples per year: if more than one sample fails, the STW will lose its Overall Performance Assessment (OPA) points and Thames Water may have its funding from OFWAT cut by £10 million (a circular problem, since this funding may be needed to stop failures).

In 2013 the Wandle was designated as a Phosphate Sensitive Area. Under the Urban Waste Water Treatment Directive, Beddington STW is now on the EA's National Environment Programme (NEP) in AMP6, to have phosphate stripping installed with the objective of removing phospate to a permitted limit of 1mg/l. This scheme is due to be completed by 14 November 2018 (pers comm. Angela Gorman, EA, 2014).

**Sewage treatment process**

Raw sewage reaches Beddington STW via pipes, draining under gravity from the Croydon area, and being pumped from the Carshalton side of the STW catchment using a rising main and pumping station at Buckhurst Avenue.

Influent sewage is monitored for BOD, COD, SS and $NH_3$. The sewage flows into uncovered outdoor tanks at the start of the process before entering the treatment process.

- **Preliminary treatment** removes 70 – 75% of coarse solids and other large materials found in waste water. The sewage passes through 6mm band screens to strain off solids: these are transferred to a separate area for compaction and storage as rags, before being transferred to landfill. Grit also drops out of the flowing sewage at a velocity of <0.3 m/s: this is captured and could be reused on road surfaces (where it usually originates as road runoff in any case)

  Before the band screens were installed c1999, much coarser bar screens were used, which enabled much coarser waste to pass through. The band screens have "made a big difference to the river" (pers comm. Thames Water, 2012).

- **Primary treatment** removes settleable solids by sedimentation and skimming off scum. Beddington STW has eight circular primary sedimentation tanks: sewage is piped into the middle of these tanks from underneath, entering the tank through the centre and moving towards the edge. Residence time is around two hours, enabling finer solids to settle out. A bridge slowly rotates, scrapers scrape solids off the walls and bottom, and the conical base of the tank funnels solids down to a hopper in the middle.

  Raw sludge then goes to the sludge digestion process (an anaerobic process taking 15 to 20 days at 35 - 40ºC. The majority of organic material is broken down into biogas and the black secondary sludge is sent to the lagoons for dewatering after which it is spread on to land). At this point, with sludge removed, the effluent's BOD has been lowered by 40 – 50%.

- **Secondary treatment** deals with primary treated effluent, removing residual organics and sewage sludge. This part of the process decreases BOD and nitrate content in line with requirements to reduce BOD from 100 to 10 mg/l and ammonia from 30 to 2.5 mg/l.) At this stage 98% of the BOD requirement and ammonia are removed.

  Mixed with bacterially activated sludge, sewage enters 16 activated sludge settlement tanks (arrayed in four groups of four). Air is blown in through aeration blowers (installed c2007 to improve surface aeration) consisting of 52,000 bubble domes which last 8-10 years. This is the most expensive part of the treatment process, using around 60% of the STW's total energy requirement.

  For maximum microbial activity, solids levels are measured each day and kept constant. Approximately 5% of the solids are removed and pumped back to the beginning of the process, to be mixed with the incoming sewage. The activated sludge is settled out and pumped back in at the start of the secondary process to reseed sewage with bacteria. Denitrification takes place during the anoxic stage of this process: sewage enters at c30 mg/l ammonia as N, and N is reduced to c10-12mg/l.

  The final stage of secondary treatment is secondary settlement in circular tanks, similar to primary settlement but with a more conical shape optimised for settling sludge. The resulting effluent can be discharged without tertiary treatment as it meets all necessary standards and in the past was discharged at this stage. Currently, however, 50% goes on to tertiary treatment.

- **Tertiary treatment** is designed as a final screening process for 50% of the flow from the STW. The remaining 50% (or less if flow is reduced) goes straight out to the Wandle. Effluent is piped into the middle of a drum containing fine disc filters, which remove particles down to a few microns in size. Any solids are washed off the filters and returned to the primary settlement tanks, while the filtered effluent is piped out into the river.

- **Digested sludge** from secondary treatment is transferred to lagoons (3 at present) where the solids settle out leaving supernatant liquor on top. This liquor contains high levels of ammonia, and is returned to the front of the works for treatment. A sludge thickener was installed c2009 to reduce volumes of sludge by up to 50%. The sludge is pumped out of the lagoons and applied to the land in a leased area, or made into sludge cake in a clam press and dried on land.

  The lagoons are scheduled for decommissioning and replacement by a dewatering plant: the resulting sludge cakes will be used as farming fertiliser, with additional treatment to reduce pathogens to regulation levels.

- **Biogas** produced by the sludge digestion process (c65% methane) is used to fuel the plant. The digestion process can produce 10-12,000 m3 of gas per day for this purpose, which was historically converted to electricity via turbines in the control centre building

**Control and monitoring**

Until 21 August 2012, Beddington STW was run from the original 1960s control centre, which had been updated as necessary with equipment including a Scada control system. In 2012, the control centre was burned to the ground by a fire, resulting in the release of a large volume of partly treated sewage including the sludge caps from the secondary treatment tanks.

During construction of a new control centre, Beddington STW has been remotely controlled and monitored from Thames Water's Hogsmill STW.

**Major pollution incidents**

Despite improvements in general sewage treatment, Beddington STW has been the source of several very serious pollution incidents during the last four decades:

- **Summer 1969**: a discharge of partially digested sludge, which led to children's boating being banned in Ravensbury Park (Montague, 2005)

- **October 1995**: an extended discharge of untreated sewage, caused by cyanide illegally dumped into a factory drain, which entered the STW and disabled its biological processes for up to a week. As a result, the Wandle suffered a major fish kill.

- **September 2007**: a discharge of 1,600 litres of sodium hypochlorite bleach into the Wandle as a result of contractor's error at the end of a cleaning process on the STW's tertiary treatment disc filters. Up to 5km of the river were heavily affected, and at least c7,000 fish of all species were killed. (NB during the previous month, a still-untraced pollution incident had already killed large numbers of fish in the Mill Green area). An alternative cleaning procedure has been developed to prevent any such incident from recurring.

- **August 2012**: a discharge of partly treated sewage sludge resulting from a catastrophic fire in the STW's control centre. Despite emergency deployment of aeration equipment, several thousand fish of 11 species were killed.

- **January 2014 onwards**: as a result of high ground water entering the combined sewage system, the STW ran at storm capacity for several weeks, with all inflowing effluent being discharged untreated into the river. Due to high dilution and low temperatures, no fish kills were reported, but sewage fungus was noted in several areas, and invertebrates may have been adversely affected.

At least one additional pollution incident has also been narrowly averted:

- **February 2009**: during cold winter weather, the screw mechanism on the inlet penstock jammed it shut so that raw sewage was diverted into the storm tanks. Without the use of heavy machinery to lift the penstock by force, sewage would have started overflowing into the Wandle within hours. The penstock has now been refurbished with a constraints system and different materials, with frequent inspections to check proper functioning.

**Mitigation measures**

Given the domination of treated effluent below Beddington STW and the history of pollution incidents arising from the STW, total elimination of accidental pollution from this site is probably unrealistic.

However, in light of the damage which such incidents can inflict on this recovering river (including failure of WFD metrics), it would seem prudent to implement mitigation measures for the river. These could include:

- Installing an interceptor pipe linking Beddington STW to an existing main sewer to Crossness STW
- Investigating the feasibility of introducing large lagoons or wetland areas for effluent to traverse before entering the main channel of the Wandle
- Increasing the Wandle's resilience to catastrophic pollution incidents by means of river restoration, including creation of refugia for fish.

  In particular, it has been noted that basic river renaturalisation along the effluent channel at Mill Green would probably not slow down pollution appreciably, due to the velocity of treated effluent in this area. However, large online and back channel fish refugia may be beneficial where possible.
- Ensuring that the STW has a backup power supply controlled from a remote location.

## 5.8: Pollution sources and pathways

The urban nature of the Wandle's surrounding landscapes means that the river is at risk of pollution from a wide variety of sources.

Diffuse urban pollution has sometimes been described as "lots of point source pollutions", and it will eventually be necessary to identify, prioritise and tackle each of these individually. On the other hand, it is recognised that the Wandle's urban environment means that the river may always be subject to such pressures. It is therefore the Wandle Catchment Plan's overarching objective to make the river as resilient as possible when inevitable pollution incidents do occur, as well as identifying particular threats and working with all appropriate partners to mitigate them.

The following broad pollution types and pathways have been identified:

| Type of pollution | Specific pollutant | Vector of transmission into the river | Sources & pathways |
|---|---|---|---|
| | | | |
| **Nutrients** | P | Treated sewage effluent | Beddington STW |
| | | Untreated sewage, detergent, oil, fat etc | Misconnections into surface water drainage |
| | | Animal waste | Ducks, geese, dumped dog waste |
| | | | |
| | N | Garden and park fertiliser | Runoff into surface water drainage |

| | | | |
|---|---|---|---|
| | | Grass clippings / garden waste | Dumped into river or onto banks |
| | | Bread | Duck feeding |
| | | Animal waste | Ducks, geese, dumped dog waste |
| | | | |
| **Urban runoff** | Heavy metals | | Road runoff into surface water drainage |
| | PAHs | Oil | Road runoff into surface water drainage |
| | | Petrol / diesel | Road runoff into surface water drainage |
| | | Tyre fragments | Road runoff into surface water drainage |
| | Winter road treatments | Sand | Road runoff into surface water drainage |
| | | Salt | Road runoff into surface water drainage |
| | | Sugar | Road runoff into surface water drainage |
| | | | |
| **Point source specific** | Untreated / semi-treated / raw sewage | | Beddington STW |
| | | | Misconnections into surface water drainage |
| | | | Overflow from blocked sewer pipes |
| | | | Cracked sewer pipes near river |
| | | | CSOs |
| | Endocrine disrupters | | Beddington STW |
| | | | Misconnections, sewage overflows, cracked pipes and CSOs |
| | Chemicals (incl industrial waste) | Various | Beddington STW |
| | | Various | Factory spillages |

| | | | |
|---|---|---|---|
| | | Various | Road accident spillages |
| | | Various | Illegal dumping (gully pots or direct into river) |
| | | Various | Leachate from contaminated land or landfill |
| | | Various | Domestic disposal via misconnections |
| | | Pesticides / herbicides | Used on riverside land |
| | | Permethrin | Pet flea treatments (dogs in river) |
| | Petrol / diesel | | Breached pipes or storage into surface water drainage |
| | | | Road accident spillages |
| | | | Vehicles illegally dumped into river |
| | Fire fighting water and foam | | Runoff into urface water drainage |
| | Silt and sediments | | Eroded from banks or mobilised within water column |
| | | | Building site washoff (surface water drainage or direct into river) |
| | Plastic microbeads (from eg exfoliating face and body washes) | | Beddington STW |
| | | | Misconnections into surface water drainage |
| | | | |
| **Fly tipped rubbish** | | | Illegal dumping direct into river or onto banks |
| | | | Light litter (esp plastic bags) blown into river |
| | | | |
| **Sediments** | Heavy metals | | Already in river |
| | PAHs | | Already in river |
| | P | | Already in river |

| | | | |
|---|---|---|---|
| | N | | Already in river |
| | | | |
| **Heat** | | | Beddington STW |
| | | | Urban runoff |
| | | | Solar heat taken up during water residency in impoundments |

*Fig 5d: Pollution types and pathways impacting the River Wandle*

Further information required

Full investigation into receptors and impacts of all types of pollution entering the River Wandle

### 5.8.1: Phosphorus

***"We don't like the way the river sometimes smells of detergent, especially below the sewage works."***

***- from Ketso community and stakeholder workshops***

Elemental phosphorus is extremely toxic to aquatic life, but phosphate (the most commonly appearing form) is generally damaging only at concentrations of parts per million or higher, for instance as a result of STW discharges. As such they exert a primarily indirect effect, for example by causing eutrophication with features including algal blooms.

When nutrients reach eutrophic levels in rivers, filamentous algae proliferates, blocking essential light from macrophytes like *Ranunculus*, which may also be outcompeted by *Potamogeton* (Spink, below).

Algae also increase dissolved oxygen (DO) levels by photosynthesising during daylight, while reversing this process at night, potentially reducing DO below fatal levels for fish. Toxins produced by specific algae are some of the most toxic known (Solbé, 1997).

For many years the EA has routinely taken monthly water samples on the Wandle at Beddington Park (Beddington branch) and Butter Hill (Carshalton branch) for nutrient analysis. Results of these samples are shown below (graphs supplied by the EA):

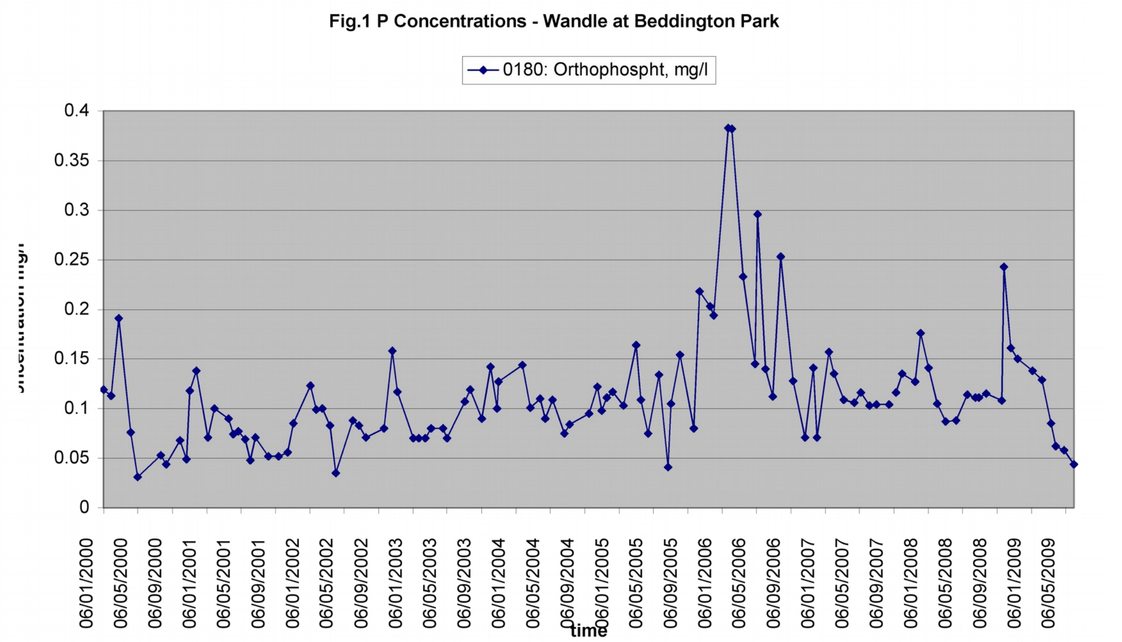


*Fig 5f: Long-term results of P sampling on the Wandle at Beddington Park (Croydon arm) (source: EA)*

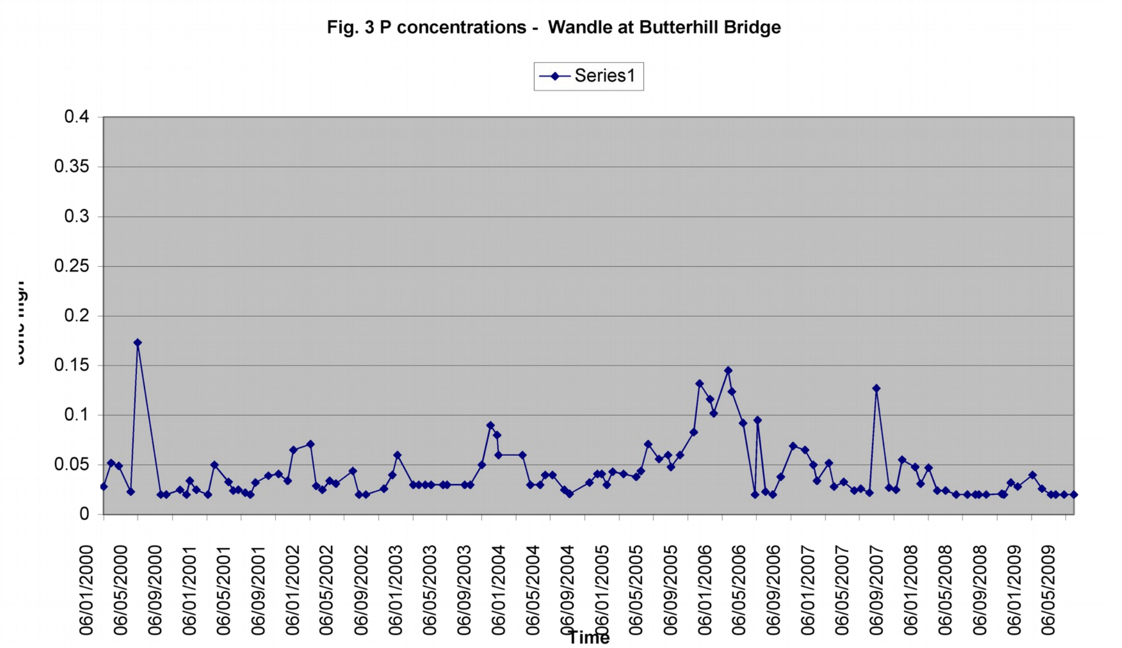


*Fig 5g: Long-term results of P sampling on the Wandle at Butter Hill (Carshalton arm) (source: EA)*

These graphs show a close correlation between the results from each of the Wandle's upper branches. This suggests either the same source of P over a wide area (eg shown in patterns of runoff) or higher concentrations of P in the Croydon arm which are mirrored but muted on the Carshalton arm, possibly as a result of recirculation through the low flow augmentation system.

P levels in the Wandle increase dramatically below Goat Bridge as a result of the input of treated effluent from Beddington STW. The Wandle is now included in the EA's calibrated SAGIS model, which confirms that approximately 91% of the P load at the bottom of the Wandle derives from Beddington STW (pers comm. Robert Kenway, EA, 2014). The Wandle has been designated a Phosphate Sensitive Area under the Urban Waste Water Treatment Directive, and Thames Water will be required to install phosphate stripping equipment at Beddington STW during AMP6, with completion due by November 2018 (pers comm. Angela Gorman, EA, 2014).

Expert observational experience has found that c1mg/l is often a tipping point between systems supporting *Ranunculus* and *Cladophora* filamentous algae, with algae preferring the higher concentration, leading to *Ranunculus* being replaced. The presence of *Cladophora* is indicative of elevated nutrient concentrations, and CB communities can be compromised by poor water quality, depleted flows and other effects of urbanisation.

P stripping at Beddington STW may not be the only solution to reducing P levels in the Wandle. To enable P stripping benefits to be realised, naturalisation of the river and its hydromorphology will help to restore natural processes, moving P-laden silt out of the system.

In order to achieve Good status for WFD purposes, P is required to be <0.1mg/l (equivalent to chalkstream reference conditions). P levels have not been defined for GEP on HMWBs like the Wandle: however in expert discussion with the EA, it has been suggested that if P levels can be reduced to 1mg/l, and the river's hydromorphology is improved to help CB communities and flush sediment-bound P out of the system, this could represent a definition of GEP for an urban chalkstream.

<u>Further information required</u>

Further investigation to establish sources of P in the upper Wandle

<u>Further reading:</u>

Spink, *Effects of Eutrophication on Ranunculus and Potamogeton*:
**http://www.andrewspink.nl/ranunculus/wrec.htm**

### 5.8.2: Nitrogen

***"Too many people feed whole loaves of bread to the ducks, which just sinks to the bottom and rots. Others let their dogs mess on the banks and don't clear it up. These things aren't good for the river."***

***- from Ketso community and stakeholder workshops***

Like phosphorus, nitrogen in nitrate form can contribute to eutrophication, but has no measurable toxicity per se at any realistic concentrations that are likely on the Wandle. In alkaline chalk stream waters, however, nitrate ($NO_3$) can reduce to nitrite ($NO_4$): this induces anaemia in fish, and is therefore highly toxic to all fish species. Sources of nitrite can also include ammonia ($NH_3$) from STWs, which is oxidised first to $NO_2$ by the bacterium *Nitrosomonas* and finally to $NO_3$ by *Nitrobacter* (Solbé, 1997).

Routine monthly water sampling by the EA has provided the following nutrient analysis for nitrates in the Wandle. As for phosphates (above) these graphs have been supplied by the EA:

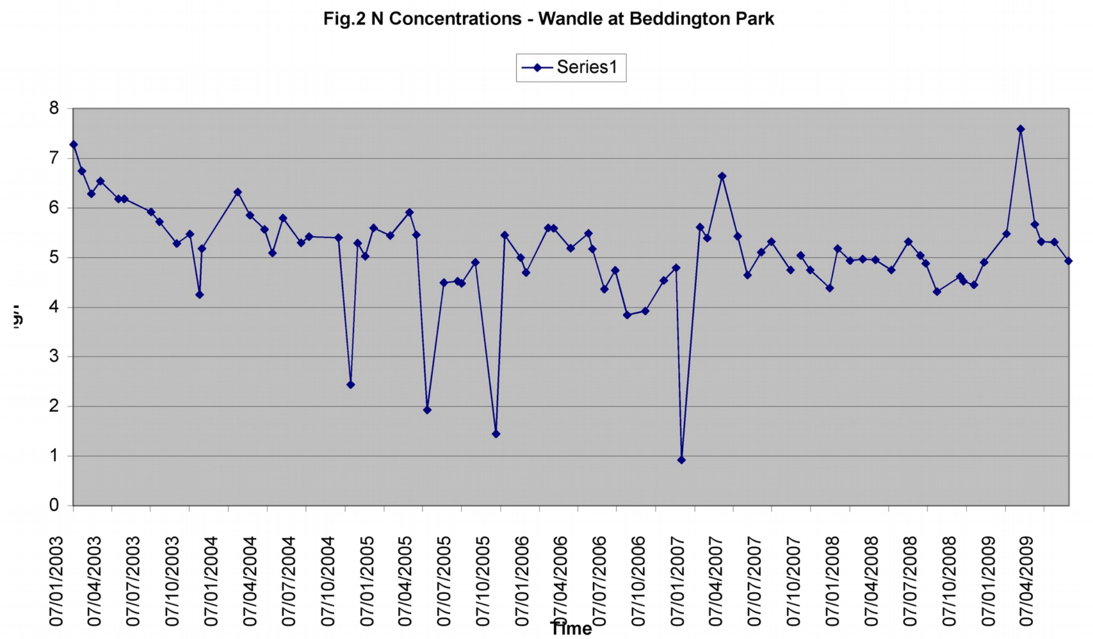


*Fig 5h: Long-term results of N sampling on the Wandle at Beddington Park (Croydon arm) (source: EA)*

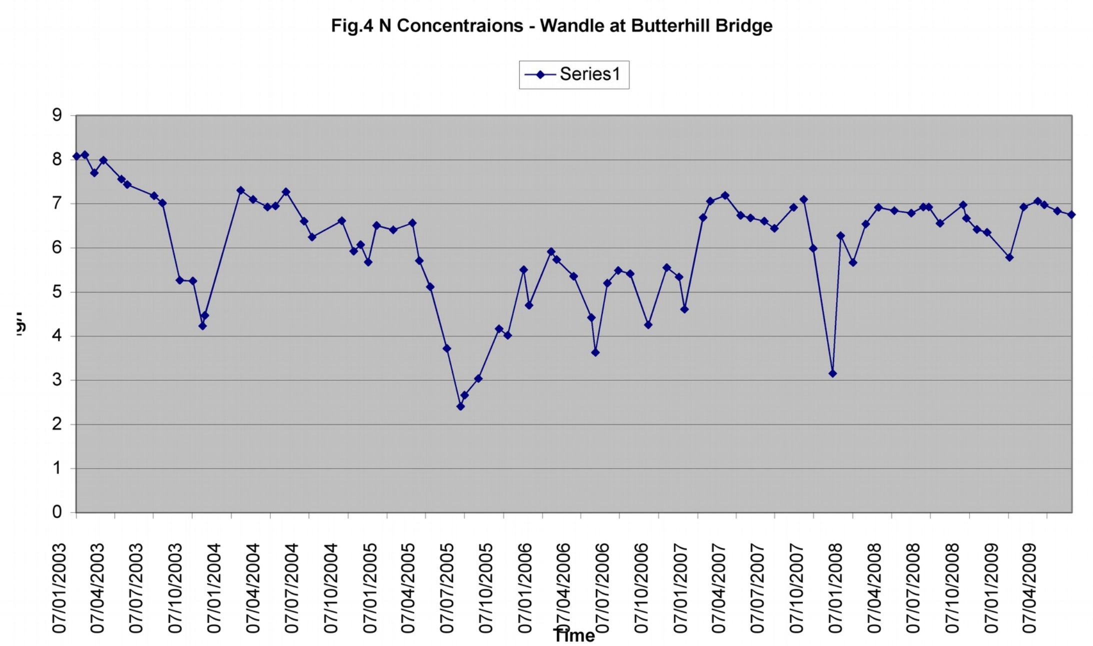


*Fig 5i: Long-term results of N sampling on the Wandle at Butter Hill (Carshalton arm) (source: EA)*

Assessment of these results suggests clear seasonality in terms of N, with particularly dramatic variations on the Croydon arm of the upper river. Lower N in October on the Carshalton arm may suggest the effects of the augmentation system.

<u>Further information required</u>

Further investigation to establish sources of N in the upper Wandle

### 5.8.3: Urban runoff

***"The Wandle shouldn't turn black every time it rains in Croydon. We want to see more measures to stop dirty water getting into the river in the first place."***

***- from Ketso community and stakeholder workshops***

The highly urbanised nature of the Wandle's catchment, especially in the vicinity of its surface waters, means that the river is at permanent risk of pollution by urban runoff: a cocktail of pollutants including heavy metals, polycyclic aromatic hydrocarbons (PAHs: oil, petrol and tyre fragments) and winter road treatments.

Polluted water can also enter the river from the sewer network, either from overflows during periods of high rainfall, or at source, where misconnections occur due to the foul water system being mistakenly connected to surface water drainage.

Modern urban planning now champions source control as the most sustainable route to mitigating urban runoff, ideally by identifying pollution sources and addressing runoff as close as possible to the point of precipitation – for instance, by installing SuDS (see Section 6.2). As such, this is also a means of minimising flood risk, which is often elevated in urban areas.

Depending on rainfall, road runoff into the Wandle during winter months is likely to contain high concentrations of salt, which together with sand makes up the components of de-icing road grit. High levels of chloride discharged into freshwater bodies may be harmful to fish and other aquatic organisms which are not adapted to living in saline environments. Nutrient levels (and hence de-oxygenation due to BOD) may also be increased by novel de-icing techniques such as adding molasses to road grit in order to prolong its adhesion to the road surface.

Further discussion of heavy metals and other contaminants in urban runoff, and thus in sediments, appears below.

### 5.8.4: Point source specific pollution

The almost entirely urbanised nature of the fluvial Wandle's landscape means that most of its course is vulnerable to occasional or one-off point source pollution.

Some point sources of pollution have already been identified as major (if intermittent) risks to the river's health: for instance Beddington STW and unmapped misconnections into the River Graveney, which in turn flows into the Wandle near Plough Lane. Point source pollutions resulting from misconnections are being progressively identified by organisations like the Wandle Trust, and addressed via liaison with Thames Water and the EA.

Since 2013 the Wandle Trust has also been running a Pollution Assessment Volunteers' scheme in partnership with the EA. This scheme enables trained local volunteers to assess Category 3 minor pollution incidents reported to the EA, enabling faster and more efficient response, and potentially more effective follow-up by EA pollution prevention teams. The network of volunteers will also enable efficient monitoring of more serious incidents (Wandle Trust, 2014).

### 5.8.5: Fly tipped rubbish

***"We don't like seeing the river being used as a rubbish dump. We want to see the Wandle Trust's community cleanups continue, with more bins near the river, and campaigns asking people to take their rubbish home with them."***

***- from Ketso community and stakeholder workshops***

Fly-tipping has long been recognised as a blight of urban rivers like the Wandle, and Ruskin specifically recorded domestic fly-tipping on the Carshalton water body in 1870 (see Section 5.6).

Although urban litter is highly unsightly and contributes to general public perception that the river is polluted and even lifeless, an ongoing loophole in the law means that this rubbish is no-one's responsibility to remove unless it threatens to cause a flood risk. In this case, it falls within the responsibility of the EA's FRM teams: in all other cases the usual interpretation of the law is that rubbish removal is left to community groups.

In 1982 the Beddington Society instigated annual Wandle cleanup days, which appear to have lapsed within a few years (Shew, 2012). Since the start of the 21$^{st}$ century, monthly community river cleanups, rotating through the Boroughs of Sutton, Merton and Wandsworth, and supported by each council, have been organised by the Wandle Trust.

These cleanups engage up to c70 local volunteers every month, providing them with the necessary equipment, confidence and health and safety support to increase their engagement with their local environment. Each cleanup removes c5.6m$^3$ of assorted rubbish from the river: notable items include motorbikes (many leaking oil and petrol), shopping trolleys, bicycles, traffic cones, car tyres and other parts including discarded batteries, domestic furniture and appliances, demolition and builders' waste, plastic bags, drinks cans and bottles, and even handguns (pers comm. Wandle Trust, 2014).

Blackspots for rubbish dumping appear to be bridges and other locations where road access to the river is easy but secluded: from these points the rubbish is swept downstream by peak flows, collecting in pools or at pinch points, and accumulating other debris and silt around it. As plastic drinks bottles and other items break down, they release toxins, so removing this litter promotes water and substrate quality for beneficial macrophytes such as *Ranunculus*, which in turn will improve habitat for all species.

Particularly in the highly engineered channels of the middle and lower Wandle, it has been noted that fish use heavy rubbish as shelter and habitat, and there are concerns that removing this rubbish results in loss of habitat in otherwise featureless areas. Current consensus is that removing heavy rubbish and the lighter litter that collects around it should be prioritised in order to improve public perception of the river, thus reducing fly-tipping and pollution in the long term (pers comm. Wandle Trust, 2014: cf Broken Windows Theory). However, the Wandle Trust has noted the urgent need to devise some means of replacing c67m3 per annum of unconsented rubbish with consented, well-designed and properly–secured habitat structures to help fish of all species to survive in highly channelised reaches of the Wandle (pers comm. Wandle Trust, 2014).

<u>Further information required:</u>

Research into habitat structures to provide fish habitat in highly channelised urban river reaches

Further reading:

Gallay (2013) *A Broken Windows Theory for Environmentalism*:
**http://www.huffingtonpost.com/paul-gallay/a-broken-windows-theory-f_b_4497904.html**

Wilson and Kelling, *Broken Windows*: http://www.manhattan-institute.org/pdf/_atlantic_monthly-broken_windows.pdf

Wandle Trust: monthly community river cleanup blog reports at www.wandletrust.org

**5.8.6: Sediments: metals**

***"Twenty years ago you could wade across the river to Wilderness Island on clean gravel. Now you'd be waist deep in silt with a metallic, chemical smell."***

***- from Ketso community and stakeholder workshops***

A notable impact of urbanisation on many rivers is the accumulation of fine-particulate sediment (sometimes termed "road dust") deposited in the river channel by urban runoff. Highly modified urban rivers like the Wandle can act as sediment sinks, collecting contaminated sediment in very large volumes behind impounding structures like weirs where normal sediment transport is inhibited.

Apart from the smothering effect that even clean sediments can have on river gravels (pers comm. Paul Gaskell, 2014) road dust contains elevated concentrations of sediment-bound contaminants including heavy metals and polycyclic aromatic hydrocarbons (PAHs) which may have serious impacts on fish and macroinvertebrates. Stormwater flushes fine grain sizes from road surfaces more efficiently than coarser grain sizes (Droppo et al., 1998 cited by Brierley, 2013) which tend to be left on the road. These easily-transported fine sediments (<63µm) contain higher trace metal and PAH concentrations (Horowitz, 1991 cited by Brierley, 2013), which may then remain in urban rivers for prolonged periods of time, leading to almost indefinite water quality problems.

In 2013 an MSc study investigated fine grain sediments and contaminant sources on the Carshalton water body, which has provided an excellent baseline analysis for further research (Brierley, Wandle Trust, 2013: *The characterisation and quality appraisal of riverbed and road runoff sediments within the Carshalton arm of the River Wandle, London, UK*). A summary of the paper's findings on heavy metals appears below:

| Metal | Lowest Effect Level (LEL) | Severe Effect Level (SEL) | Butter Hill | Mill Lane | Denmark Road | Upstream |
|---|---|---|---|---|---|---|
| Cd | 0.6 | 10 | 0.94 | 0.76 | 0.46 | 0.89 |
| Cu | 16 | 110 | 126.59 | 84.52 | 76.83 | 73.23 |
| K | N/a | N/a | 2040.14 | 1830.14 | 1803.21 | 1587.77 |
| Mg | N/a | N/a | 3154.39 | 2728.43 | 2194.27 | 1736.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mn | 460 | 1100 | 152.91 | 131.00 | 163.51 | 81.40 |
| Na | N/a | N/a | 804.55 | 646.42 | 742.12 | 706.92 |
| Ni | 16 | 75 | 20.25 | 16.70 | 16.17 | 18.81 |
| Pb | 31 | 250 | 144.32 | 106.47 | 134.39 | 101.57 |
| Sr | N/a | N/a | 96.02 | 78.03 | 134.39 | 78.48 |
| Zn | 120 | 820 | 285.33 | 247.10 | 196.08 | 158.55 |

*Fig 5j: Mean metal concentrations in river sediments (mg/kg) in each sub reach of the Carshalton water body compared to the Canadian Provincial Sediment Quality Guidelines (PSQGs) for Lowest Effect Level and Severe Effect Levels of trace metals on freshwater biota. Metal concentrations exceeding Lowest Effect Level are highlighted in yellow, and those exceeding Severe Effect Levels are highlighted in red (Brierley, 2013)*

| Metal | Min | Max | STD | %CV |
|---|---|---|---|---|
| Cd | 0.12 | 2.15 | 0.41 | 58.02 |
| Cu | 20.5 | 388.68 | 60.51 | 64.52 |
| K | 614.88 | 4879.87 | 739.05 | 39.42 |
| Mg | 771.71 | 9741.46 | 1413.13 | 54.23 |
| Mn | 53.37 | 791.84 | 99.68 | 66.64 |
| Na | 207.93 | 2879.9 | 440.37 | 59.68 |
| Ni | 8.54 | 50.27 | 6.62 | 37.52 |
| Pb | 5.23 | 461.91 | 74.65 | 57.41 |
| Sr | 32.01 | 206.16 | 26.4 | 32.09 |
| Zn | 66.26 | 920.76 | 141.29 | 60.41 |

*Fig 5k: Minimum and maximum mg/kg concentrations within the entire study site on the Carshalton water body as well as standard deviation (SD) and CV (%) values. Metal concentrations exceeding Lowest Effect Level are highlighted in yellow, and those exceeding Severe Effect Levels are highlighted in red (Brierley, 2013)*

Sources and effects of heavy metals include:

- Pb: until the 1970s, petrol was a primary source of lead pollution. Today, petrol rarely contains lead, but it is still commonly found in paper, plastics and ceramics (Callander and Rice, 2000 cited by Brierley 2013). In sediment, Pb and Cd concentrations can be transformed into organo-metallic compounds, which enhances their bioavailability and toxicity even at low levels (Sutherland, 2000; Nicolau et al., 2006; Wong et al., 2006 cited by Brierley, 2013).

- Zn: environmental concentrations of Zn are greater than Pb within urban catchments, because Zn is used in a wide range of metal works, including tyre manufacture and steel galvanization (Callander and Rice, 2000 cited by Brierley, 2013). Although Zn is a biologically essential element, it may cause toxic effects at elevated levels.

- Ni, Sr, Cr and Mn are commonly derived from automobile parts. They often accumulate on roads and car parks, and are flushed into rivers by rainfall.

Because of the impact of heavy metals on water quality and fish, the study also notes a variety of surface water implications for WFD purposes. Al and Fe have been designated as specific pollutants in England and Wales, and Surface water Environmental Quality Standards (EQS) have been set forward for both to meet the requirements of the WFD:

- Fe: in 2007 new EQSs were proposed by the UK Technical Advisory Board (TAB) on the WFD for Fe from the current dissolved Fe EQS from 1 mg/l to 0.016 mg/l (EA, 2007). However, a UK TAG report for further EQS for specific pollutants in April 2012 has yet to accept the proposed Fe EQS from 2007. The EA still refers to the previously existing Fe EQS of 1 mg/l as its current guideline for dissolved Fe (EA, 2012). This may have implications for the Carshalton water body's ability to reach GEP by 2015 or 2027. If the proposed UK TAG EQS is accepted for iron, it will have a significant impact on the Carshalton water body's ability to maintain Fe levels under the new EQS.

- Al: concentrations recorded in sediments in the Carshalton water body are one order of magnitude above the proposed UK TAG EQS of 0.005 mg/l. However, the UK TAG has not accepted any EQS proposals for Al, suggesting that more data is needed (EA, 2012). Currently there is still no surface water environmental quality standard for Al.

The presence of heavy metals may also have implications for the Wandle's WFD status in relation to fish:

- Fe: concentrations of Fe may be the most significant threat to fish in the Carshalton water body, since formations of Fe on biological surfaces can effect survival, reproduction, and behaviour of aquatic animals. At a neutral pH, ferric hydroxide can have toxic effects on fish eggs, as well as gills, where it impedes respiratory and immune functions (Vuori, 1995 cited by Brierley, 2013). Other studies show that even at low concentrations, Fe can have significant effects on hatching, fry and growth. The maximum Fe concentrations collected in surface water samples from the Wandle were taken at relatively high flows, and were still recorded at 0.12 mg/l, a level which has been found to negatively impact brown trout. If surface water samples had been collected during base flow conditions, it is likely that both Fe concentrations would have been higher (Brierley, 2013)

- Al: due to the high pH of the chalk-derived water in the Carshalton branch, which ranges from 7.68 to 7.81, Al toxicity is not thought to pose a significant threat to fish health.

Throughout the study site on the Carshalton water body, mean concentrations of Cd, Cu, Ni, Pb and Zn all exceeded the PSQGs lowest effect level. This means that the actual ecotoxicological effects become present, as the sediment exceeding LEL is considered marginally polluted (OME, 2008):

- Maximum concentrations of Cu, Pb and Zn all exceeded PSQG severe effect levels, indicating heavily contaminated sediments that could potentially eliminate most of the benthic organisms present (OME, 2008 cited by Brierley, 2013). This may limit the ability of the Carshalton water body to meet WFD ecological guidelines.

- Trout interact with riverbed sediment through the construction of redds, removing fine sediments in order to create an area of loose gravels which permits oxygen transfer to eggs. Egg survival within redds can be affected by oxygen-consuming metals like Cd and Pb, which were recorded above LEL in the Carshalton water body, as well as by deposition of fine sediments blocking egg pores.

- Fish of all species also disturb and re-suspend sediments and their contaminants through foraging activity, allowing contaminants to be absorbed and stored in tissue (Gao, 2001 cited by Brierley, 2013). Metal concentrations typically enter the food chain through uptake by invertebrates, which are then consumed by fish (Brierley, 2013). Heavy metal concentrations within sediment are likely to result in high concentrations in fish tissue, with heavy metal concentrations within fish tissue at higher levels than those found in the general water column (Yi et al, 2008 cited by Brierley, 2013).

On the other hand, this study found lower concentrations of dissolved metals, such as Cu, Pb, Cd and Zn, within surface water samples compared to water samples analysed in 1995 when the BP site on Mill Lane was being decommissioned. This may indicate that water quality in the Carshalton branch has improved since 1995: a position also suggested by the EA River Basin Management Plan (2009) in which Cu and Zn received 'High' statuses due to the concentrations measured.

As a result of this study, the following recommendations were made:

- Hydrodynamic vortex silt traps should be installed on 3 key stormwater outflows on the Carshalton arm, and monitored to determine whether contaminants are being successfully intercepted. These silt traps were installed by the Wandle Trust in summer 2013.

- Continued monitoring of the health and abundance of invertebrates will also assist ongoing understanding of the impact of metals on the Carshalton water body

- Continued river restoration including channel narrowing, introduction of new gravels, and planting marginal vegetation, will increase water depth, flow diversity and velocity, promoting scour and removal of fine sediments.

- A programme of street sweeping within the Carshalton water body's surface water catchment would reduce the amount of transportable sediments being flushed into the river. Research has shown that brush street sweepers remove a larger amount of coarser grained sediment, while vacuum street cleaners are most efficient at removing the fine grained fractions which generally have the highest loading of contaminants (Pitt and Clark, 2003; Brinkmann and Tobin, 2003 cited by Brierley, 2013).

It has been noted that large online impoundments like Carshalton Ponds and Beddington Park Lake may act as sediment traps – to the benefit of lower reaches of the river. If such online impoundments are taken offline, consideration should be given to alternative means of trapping contaminated sediments on their downstream journey.

<u>Further information required</u>

Extend investigation into metals from the Carshalton water body to the Croydon-Wandsworth water body

<u>Further reading:</u>

Brierley (2013) *The characterisation and quality appraisal of riverbed and road runoff sediments within the Carshalton arm of the River Wandle, London, UK*

Solbé (1997) *Water Quality for Salmon and Trout*

**5.8.7: Sediments: PAHs**

Polycyclic aromatic hydrocarbons (PAHs) are produced by incomplete combustion of fossil fuels like petrol, diesel and coal.

Due to high concentrations and widespread availability within the environment, as well as their carcinogenic and mutagenic properties, PAHs have become a major concern in the context of restoring urban rivers. In the course of the investigation into heavy metals in the Carshalton water body (Brierley, 2013) described above, PAHs were also studied.

Like metals, PAHs bind easily to fine sediments, and are known to have adverse effects on biological organisms in fresh water. PAHs are non-volatile, hydrophobic and bind easily with bed sediment, thus removing themselves from the water column: as a result, they are readily absorbed by fish and invertebrates as a result of exposure to contaminated food and sediments. They become toxic at high concentrations, and have the potential to impact fish reproduction and egg development (Tuvikene, 1995 cited by Brierley, 2013). By physical interactions with cells, they can also lead to mutations, teratogenesis and cancer. To varying extents, however, fish are able to mitigate dangerous bioaccumulation within tissue by metabolising PAHs.

The 2013 study showed that the Carshalton water body's substrate is severely contaminated by PAHs:

| | **Lowest Effect Level** | **Severe Effect Level** | **Butter Hill** | **Mill Lane** | **Denmark Road** | **Upstream** |
|---|---|---|---|---|---|---|
| Acenaphthene | 6.71 | 88.9 | 227.81 | 446.35 | 211.12 | 138.07 |
| Acenaphthylene | 5.87 | 128.2 | 140.76 | 272.45 | 127.7 | 114.03 |
| Anthracene | 46.9 | 245 | 681.4 | 1368 | 720.82 | 518.67 |
| Benzo(a)anthracene | 31.7 | 385 | 3310.9 | 6852.5 | 3480 | 2910 |
| Benzo(a)pyrene | 31.9 | 782 | 3793.4 | 6852.5 | 4064 | 3360 |
| Benzo(b)fluoranthene | | N/A | 5688 | 9382.5 | 5005 | 4586.67 |
| Benzo(ghi)perylene | 240^ | 13400^ | 2891 | 4907.5 | 2757.1 | 2260 |
| Benzo(k)fluoranthene | 170^ | 3200^ | 2008.9 | 3601.88 | 2208.5 | 1568.33 |
| Chrysene | 57.1 | 862 | 3542.2 | 6763.75 | 4115 | 2950 |
| Coronene | | N/A | 717.5 | 1013.38 | 476.74 | 579 |
| Dibenzo(ah)anthracene | 6.22 | 135 | 773.8 | 1310.13 | 626.7 | 662 |
| Fluoranthene | 111 | 2355 | 7498 | 14832.5 | 8006 | 6500 |
| Fluorene | 21.2 | 144 | 257 | 595.13 | 270.3 | 189.33 |
| Indeno(1,2, 3-cd)pyrene | N/A | 3669 | 6750 | 3547.4 | 3330 | |
| Naphthalene | 34.6 | 391 | 208.17 | 405.25 | 334.7 | 268.33 |
| Phenanthrene | 41.9 | 515 | 3014.2 | 6370 | 3182 | 2405.33 |
| Pyrene | 53 | 875 | 6109.45 | 12416.25 | 6659 | 5333.33 |

*Fig 5l: Mean PAH concentrations in river sediments (µg/kg) in each zone WRS compared to the Canadian Sediment Quality Guidelines (CSQGs) and Ontario Sediment Guidelines (^) for Lowest Effect Levels and Severe Effect Levels of PAHs on freshwater biota. PAH concentrations exceeding Lowest Effect Level are highlighted in yellow, and those exceeding Severe Effect Levels are highlighted in red.*

| PAH | Mean | Min | Max | STD | %CV |
|---|---|---|---|---|---|
| Acenaphthene | 275.73 | 61.2 | 1220* | 218.7 | 79.32 |
| Acenaphthylene | 169.35 | 35.3 | 541 | 111.23 | 65.68 |
| Anthracene | 851.34 | 144 | 3450* | 625.36 | 73.46 |
| Benzo(a)anthracene | 4122.78 | 609 | 9910* | 2344.51 | 56.87 |
| Benzo(a)pyrene | 4662.31 | 724 | 11600* | 2589.53 | 55.54 |
| Benzo(b)fluoranthene | 6335 | 1050 | 17700 | 3735.58 | 58.97 |
| Benzo(ghi)perylene | 3337.53 | 610 | 8910 | 1935.61 | 58 |
| Benzo(k)fluoranthene | 2479.19 | 419 | 6790 | 1454.16 | 58.65 |
| Chrysene | 4516.63 | 672 | 11100** | 2547.98 | 56.41 |
| Coronene | 693.01 | 90.4 | 2170 | 497.74 | 71.82 |
| Dibenzo(ah)anthracene | 853.13 | 168 | 2300* | 545.12 | 63.9 |
| Fluoranthene | 9487.5 | 1450 | 24000* | 5456.51 | 57.51 |
| Fluorene | 345.34 | 88 | 1850* | 311.51 | 90.2 |
| Indeno(1,2,3-cd)pyrene | 4402.63 | 690 | 10900 | 2758.51 | 62.66 |
| Naphthalene | 307.37 | 45.6 | 718 | 175.96 | 57.25 |
| Phenanthrene | 3892.75 | 562 | 14400** | 2790.23 | 71.68 |
| Pyrene | 7871.08 | 74.5 | 20500** | 4682.09 | 59.48 |

*Fig 5m: Table showing minimum and maximum ug/kg concentrations within the entire study site, as well as standard deviation (SD) and CV (%) values. PAH concentrations exceeding Lowest Effect Level are highlighted in yellow, and those exceeding Severe Effect Levels are highlighted in red.*

**Indicates the order of magnitude above Severe Effect Level*

These results confirm that the Carshalton water body is heavily contaminated with PAHs, probably largely derived from combustion, and deposited through road runoff. The study's recommendations for mitigating PAHs are the same as for silt: hydrodynamic vortex silt traps, continued invertebrate monitoring and river restoration, and street sweeping across the Carshalton water body's surface water catchment.

<u>Further information required</u>

Investigation into PAHs on the Croydon-Wandsworth water body

<u>Further reading:</u>

Brierley (2013) *The characterisation and quality appraisal of riverbed and road runoff sediments within the Carshalton arm of the River Wandle, London, UK*

Solbé (1997) *Water Quality for Salmon and Trout*

### 5.8.8: Thermal impacts

As discussed in Section 5.3, the Wandle's naturally constant (and relatively low) spring-fed water temperature is subject to thermal loading from several sources.

Now that Croydon's power stations are no longer discharging heated cooling water into the Wandle via channels across Beddington farmlands, the most significant thermal input is probably Beddington STW, which adds an average 2.6°C to the temperature of the river between Goat Bridge and Watermeads. Thermal loading is also likely to take place in slow-flowing water which is exposed to the sun for long periods, for instance when ponded behind weirs and other obstructions in summer low flow conditions. On the Wandle, several impoundments retain large volumes of water over substrates dominated by silt and road dust particulates (which are dark and therefore likely to absorb solar heat more readily) at Carshalton Ponds, Beddington Park Lake, Goat Bridge, Watermeads, Ravensbury Park and Morden Hall Park.

Intermittent flushes of thermally-loaded water may also be caused by summer storms, when high volumes of precipitation fall on sun-heated surfaces and flash off into the river. Such runoff typically has very low dissolved oxygen content and may result in fish kills.

In urban conurbations, the urban heat island effect often results in air temperatures several degrees warmer than surrounding rural areas. Although the Wandle is likely to provide local mitigation of London’s heat island local people, the river will also be subject to its influence, since surface water temperatures reflect air temperatures.

With regard to the biotic impact of heat loading, different organisms have different thermal preferences and optimal ranges, and the Wandle may experience subtle ecological shifts due to these preferences. Higher temperatures can cause pollutants to have greater effects, in particular increasing the toxicity of metals and ammonia.

Although some experts recommend reducing shading on many reaches of the Wandle in order to promote growth of valuable aquatic macrophytes like *Ranunculus*, this recommendation probably needs to be balanced against the shading benefits offered by riparian trees, which is likely to help mitigate solar heating in summer months. Considerable investigation by the river restoration community is still required to define the effects of shading on small river channels – and particularly with regard to chalk streams where aquatic plants form an important component of the total ecosystem. However at this stage it is thought likely that the generally-accepted optimum 60:40% light:shade ratio will offer the widest range of benefits.

<u>Further information required:</u>

Research to confirm water temperatures and impacts of impoundments etc year round on the full length of the river

<u>Further reading:</u>

Solbé (1997) *Water Quality for Salmon and Trout*

**5.8.9: Light**

***“We’d like to see better lighting to make some parts of the Wandle Trail feel safer at night, but it shouldn’t disturb the bats and other wildlife.”***

***- from Ketso community and stakeholder workshops***

Light pollution, which is defined as brightening of the night sky caused by anthropogenic artificial light, has increased dramatically over the last century. This artificial light derives from floodlights and building illumination, security lamps, advertising and display lighting, car headlamps, and reflection from roads, pavements and buildings. However, the single largest source of light pollution is street lighting (Royal Commission on Environmental Pollution, 2009).

Light pollution has been noted to cause ecological disruption: bird migrations can be affected, and insects are attracted to light. Changes to plant life history, including flowering and leaf fall, have also been observed. These effects are most noticeable in urban environments, where artificial light sources are concentrated, and it is thought that they may be particularly pronounced in London.

Different street lights have different spectral compositions. The most numerous low-pressure sodium lamps emit light that is concentrated in the longer wavelengths of the visible spectrum, appearing yellow or orange to the eye. Millions of these are now scheduled for replacement with a new generation of shorter wavelength lamps, which shed a brighter, whiter light across a fuller spectrum, and could precipitate significant changes in impact on natural systems (Rich and Longcore, 2006).

Recent research shows that white light pollution can severely affect fish behaviour. Synchronous emergence and dispersal of swim-up salmonid fry from gravel, and downstream migrations of smolts, occur at night. These timings are generally accepted to be predator avoidance strategies, so any alteration or disruption to these processes may increase rates of predation and affect recruitment (pers comm. CEFAS, 2012).

Preliminary results from a CEFAS study based on the River Itchen in 2012 showed that:

- Without light pollution from street lighting, mean fry dispersal took place around 4.17 hours after dusk, with less than 2% dispersing in hours of daylight

- When street lighting was present, mean fry dispersal was delayed by at least 2 hours, to 6.38 hours after dusk, with 32% of fry now dispersing in daylight hours

- In incubators exposed to street lighting, fry emergence was delayed until 2.8 days later, while these fry were smaller than those in control conditions without light pollution

These results suggest that salmonids can be severely affected by the presence of white light pollution at a critical stage of population recruitment. It has also been noted that although modern street lamp designs are often deliberately angled to limit the levels of light cast upwards into the night sky, and are instead angled downwards to illuminate footpaths, car parks and other areas, this may often result in brighter light pollution sources shining directly into adjacent urban rivers Artificially enhanced light levels are also likely to facilitate heavier predation on fish of all species at other life stages (pers comm. Wandle Trust, 2014).

<u>Further information required</u>

Research to determine the effect of different wavelengths of artificial light on all life stages of all fish species

### 5.8.10: Water quality action tables

The information in these tables has been assembled from suggestions made in community consultations, TAG meetings and specific stakeholder input to develop a series of Objectives, Targets and Actions. Information on existing projects has been collated and used to identify gaps, and where additional projects may need to be developed to fulfil Actions, Targets and Objectives.

**Actions to achieve the Catchment Plan's overall aim for water: Water is plentiful and clean, and varied in its flow speeds, widths and depths**

| **Objective 2: *Water quality:* quality of water flowing in the River Wandle meets the standards required for Good Ecological Potential and is stable with no risk of deterioration** | | | | |
|---|---|---|---|---|
| **Specific Actions to attain GEP** | | | | |
| **Target** | **Actions** | **Project** | **MM** | **Indicative cost to deliver these Actions** |
| 2.1: Identify the current chemistry of the River Wandle and a set of parameters to achieve as an 'ideal' for GEP<br>Carshalton WB by 2015<br>Croydon-Wandsworth WB by 2027 | 2.1.1 – Draw together existing monitoring data to understand the current 'supporting elements' (physico-chemical) classifications more fully. | None | N/A | The TAG is fulfilling this Target, with input from the Steering Group as appropriate. Both the Steering Group and TAG have demonstrated a commitment to remain constituted and complete the implementation of these Actions.<br><br>Costs will be incurred in undertaking this research, even if it largely desk-based. |
| | 2.1.2 – Identify the certainty of each 'supporting element' classification, the methodology used to ascribe each classification and whether this is a robust approach. | None | N/A | |
| | 2.1.3 – Identify suitable response measures for any chemical parameters that may fail WFD in the future and the associated costs of implementing such measures. | None | N/A | |
| | 2.1.4 – Set up a monitoring programme to assess chemical status for GEP and whether measures implemented to improve and maintain good quality are successful. | (A1 – support this Action but does not wholly deliver the Action) | N/A | Time and expertise will be required. Training partners to help with monitoring will also incur an expense. |

| | | | | |
|---|---|---|---|---|
| 2.2: The impact of diffuse pollution entering the river from urban surface runoff is minimised<br>Carshalton WB by 2015<br>Croydon-Wandsworth WB by 2027 | 2.2.1 – Identify existing pollutant pathways and threats to surface water quality. | A2, B3, B12 | N/A | The TAG is fulfilling this Target, with input from the Steering Group as appropriate. Both the Steering Group and TAG have demonstrated a commitment to remain constituted and complete the implementation of these Actions.<br><br>Independent work to undertake walkover surveys and associated investigations, eg dye tracing, mapping and consultations is **estimated to cost £35,000**. |
| | 2.2.2 – Surface water flooding is also associated with diffuse pollution from urban runoff. Therefore, identify the main pollutants involved (such as heavy metals and particulates from vehicle exhausts and tyre wear) and which water sensitive urban designs might best prevent them from being washed into the river in heavy rainfall conditions, including silt traps at surface water outfalls. | B12, C1, C2 | 9 | Independent analysis of Water Sensitive Urban Design techniques for the whole catchment, including the suitability and cost-implications of various SuDS measures to help replicate natural drainage patterns is **estimated to cost £100,000**.<br><br>The cost for installing SuDS and other measures to help replicate natural flow patterns varies considerably, depending on the location, ease of access, flood risk implications, ease of installation and maintenance, and whether such work can be incorporated into new developments or has to be retro-fitted. For example, **porous and permeable paving can cost between £100 per 20m$^2$ driveway** (to purchase and install gravel) and **£2000** to purchase and install Concrete Block Permeable Paving for the same area. |

| | | | | |
|---|---|---|---|---|
| | 2.2.3 – Identify and obtain funding sources for installation of pollutant interception measures | C1 | 9, 10 | The cost of installing micro-wetlands is highly dependent on a number of factors, notably land prices. An **indicative cost, based on a location in Hackbridge, LB Sutton, is estimated at £20,000 per acre to install, plus monthly management costs and health and safety considerations such as fencing** Estimations of cost for the whole river would be dependent on walkover surveys and detailed feasibility studies drawing on the local authorities Surface Water Management Plans.<br><br>Design and installation of silt traps being retrofitted in an urban environment is **estimated to cost £40,000** (small), **£50,000** (medium) and **£60,000** (large). |
| 2.3: Domestic and industrial plumbing do not cause pollution in the river<br>Carshalton WB by 2015 | 2.3.1 – Survey for sewage fungus at outfalls into river (as an indicator of misconnected plumbing) | A2 | 10 | These Actions are likely to be fulfilled by Thames Water, the EA and Wandle Pollution Assessment Volunteers.<br><br>This could be delivered by maintaining and extending the existing Wandle Pollution Assessment Volunteer project. It would need support from landowners and managers (eg for access to land). **Estimated cost to run approx £8,000/pa**. |
| | 2.3.2 – Inform and educate the local community including businesses within the catchment to identify pollution hotspots and behaviour which may lead to pollution. | A2 | 10 | |

| | | | | |
|---|---|---|---|---|
| Croydon-Wandsworth WB by 2027 | 2.3.3 – Using examples from elsewhere in the UK and overseas, undertake a programme of education and awareness-raising to promote correct installation of domestic and industrial plumbing (eg the 'Yellow Fish' campaign initiated in Canada and replicated around the world which raises awareness of drains flowing to rivers and not putting potentially polluting substances down them; engaging local centres that run plumbing courses to show correct installations and retro-fitting, and appropriate disposal of toxic substances). | None | 10 | Thames Water and the EA will fulfil this Action in part at least.<br><br>This Action could be assisted via an MSc student desk-based research project into applying best practice in the Wandle catchment, which would inform a funding bid or an awareness raising campaign. Voluntary co-operation campaigns have been shown to be effective eg in Stockholm with mercury interception from dentists, and cadmium from paint. |
| 2.4: Phosphate stripping is in place at Beddington STW to meet requirements for the Urban Waste Water Treatment Directive<br>Carshalton WB N/A<br>Croydon-Wandsworth WB by 2027 | 2.4.1 – Thames Water to submit plans to Ofwat as part of their AMP6 and business planning procedures in 2014, which would then make implementation likely between years 3 and 5 (2018-2020). | None | N/A | This Target and Action are being fulfilled by Thames Water's ongoing preparation of their AMP6 Business Plan for submission to Ofwat in 2014. Liaison, additional financial outlay for further investigations and future recommendations for good practice working that maintain required treated effluent discharge quality will be led by Thames Water, the EA and Ofwat. |

| Wider Actions to improve the ecological functioning of the river | | | | |
|---|---|---|---|---|
| **Target** | **Actions** | **Project** | **MM** | **Indicative cost to deliver these Actions** |
| 2.5: The Wandle is free from fly-tipping and other rubbish, both in-stream and on the banks<br>Carshalton WB by 2015<br>Croydon-Wandsworth WB by 2027 | 2.5.1 – An awareness-raising campaign is designed and undertaken throughout the catchment to explain the dangers and consequences of rubbish, and to deter this anti-social and ecologically damaging activity. | None | 10 | These Actions are being fulfilled by several organisations within the Wandle catchment, in particular the Wandle Trust in partnership with the local authorities.<br><br>A monthly site-specific cleanup event, involving approximately 45 local volunteers each time, is **estimated to cost £1500 per event**. As well as enhancing water quality, this provides several added benefits of local community engagement, building social capital and sense of community empowerment, educating local stakeholders in key ecological issues, and engendering stewardship of the river. All these added benefits are likely to help prevent anti-social behaviour (such as fly-tipping and damage to natural habitats) in the future. Extended benefits could be generated via the ongoing partnership work already taking place in the catchment, such as the Wandle Forum and Wandle Valley Regional Park Trust. |
| | 2.5.2 – Existing river cleanup volunteer workdays are maintained and expanded through secure funding streams, designated staff support and strengthened relationships with local authorities and community groups. | A4 | 10 | |
| | 2.5.3 – Develop and maintain relationships with a broad range of sectors within the Wandle catchment to identify future opportunities for developing initiatives to discourage fly-tipping and reward responsible waste disposal. | A4 | 10 | |
| 2.6: Groundwater inputs are protected from contamination | 2.6.1 – Understand how groundwater behaves within the catchment and what factors affect its movement, quantity and quality (consider modelling to help). | None | | These Actions are being fulfilled by the EA's ongoing National Environment Programme (NEP) investigations on both sources of the Wandle. Thames Water, which operates the largest and closest groundwater abstraction borehole to the Croydon / Beddington branch, reported early findings in 2013. Sutton & East Surrey Water operates boreholes near the Carshalton branch and is due to report its findings in 2015. Liaison, additional financial outlay for further investigations |

| | | | | |
|---|---|---|---|---|
| | 2.6.2 – Existing pollution pathways and threats to groundwater quality are identified, including the perceived severity of those threats and priorities for action. | None | | and future recommendations for good practice working that maintain required flow and quality will be led by the EA, the water companies and Ofwat.<br><br>The cost of installing micro-wetlands is highly dependent on a number of factors, notably land prices. An **indicative cost, based on a location in Hackbridge, LB Sutton, is estimated at £20,000 per acre to install, plus monthly management costs and health and safety considerations such as fencing.** Estimations of cost for the whole river would be dependent on walkover surveys and detailed feasibility studies drawing on the local authorities' Surface Water Management Plans. |
| | 2.6.3 – Embark on an awareness-raising programme targeted at those groups identified as most likely to be posing a risk to groundwater contamination (probably commercial enterprises), educating them on the pressures and risks to groundwater quality, the impacts these can have on the ecological health of the river, and on ecosystem service benefits for people. | None | | |

| | | | | |
|---|---|---|---|---|
| | 2.6.4 – Identify, and obtain funding for, measures to reduce pollutants entering groundwater systems (eg installing SuDS to help filter out pollution using natural processes). | None | 9, 10 | |
| | 2.6.5 – Implement measures to reduce pollutants entering groundwater systems. | None | 9, 10 | |
| | 2.6.6 – Instigate a monitoring programme to assess groundwater quality and whether measures implemented to improve and maintain good quality are successful. | None | N/A | |
| 2.7: The contamination of surface water runoff is minimised. | 2.7.1 – Embark on an awareness-raising programme regarding the pressures and risks to surface water quality (eg encouraging households not to use artificial fertilisers and pesticides in their gardens), educating them on the impacts these can have for the ecological health of the river and the ecosystem service benefits for people. | None | 9, 10 | These Actions are likely to be fulfilled by Thames Water and the EA in part at least, with support from the TAG and Steering Group as appropriate.<br><br>Independent work to undertake walkover surveys and associated investigations, eg dye tracing, mapping and consultations is **estimated to cost £35,000**.<br><br>Independent analysis of Water Sensitive Urban Design techniques for the whole catchment, including the suitability and cost-implications of various SuDS measures to help replicate natural drainage patterns is **estimated to cost £100,000**.<br><br>The cost for installing SuDS and other measures to help replicate natural flow patterns varies considerably, depending on the location, ease of access, flood risk implications, ease of installation |
| | 2.7.2 – Effective interception of contaminants may require addressing pollutants and their specific pathways into the river on an individual basis. Research measures that have been implemented successfully in other countries, and adopt / adapt these as appropriate. | None | 9, 10 | |
| | 2.7.3 – Identify and obtain funding sources for installation of pollutant interception measures. | None | 9, 10 | |

| | | | | |
|---|---|---|---|---|
| | 2.7.4 – Investigate the impact of salt (for winter road gritting) on the osmoregulation of plants and animals. | None | 9, 10 | and maintenance, and whether such work can be incorporated into new developments or has to be retro-fitted. For example, **porous and permeable paving can cost between £100 per 20m² driveway** (to purchase and install gravel) and **£2000** to purchase and install Concrete Block Permeable Paving for the same area.<br><br>The cost of installing micro-wetlands is highly dependent on a number of factors, notably land prices. An **indicative cost, based on a location in Hackbridge, LB Sutton, is estimated at £20,000 per acre to install, plus monthly management costs and health and safety considerations such as fencing.** Estimations of cost for the whole river would be dependent on walkover surveys and detailed feasibility studies drawing on the local authorities' Surface Water Management Plans.<br><br>Design and installation of silt traps being retrofitted in an urban environment is **estimated to cost £40,000** (small), **£50,000** (medium) and **£60,000** (large). |
| 2.8: Effluent outflow from Beddington STW is effectively managed and regulated to ensure no accidental discharges cause pollution incidents on the river | 2.8.1 – Explore the possibilities of increased storm tank storage. | None | N/A | This Target will need to be led by the water companies and Ofwat working with the EA. |
| | 2.8.2 – Investigate the possibility of diverting effluent to Crossness in times of emergency. | None | N/A | |
| | 2.8.3 – Ensure there is always a backup power supply controlled from a separate location. | None | N/A | |