

## **Summary**

1 The sewerage system of central London combines foul and storm water into a single system of pipes resulting in combined sewer overflows into the Tideway during storms. This has resulted historically in polluted storm discharge and adverse environmental conditions. In 2000 the Environment Agency reported a total of 8 fish kills/year for the Tideway.

2 The European Urban Waste Water Treatment Directive (UWWTD) has the objective “*to protect the environment from the adverse effects of water discharges.*” and requires that spills only occur during unusual rainfall conditions.

3 A programme of work including upgrading of the sewage treatment works (STW) and the construction of the Lee tunnel is nearing completion at a cost of about £1.2bn. The construction of the Thames tunnel at a cost of £4.2bn is due to start soon. However the latest information is that, as a result of the upgrade of the sewage treatment works (STW), the dissolved oxygen in the Tideway now meets the standards set, thus meeting the objective of the UWWTD in protecting the environment. With the completion of the Lee tunnel in late 2015 the modelled spill volume will be halved and the modelled spill frequency reduced to about 40 spills/year. However the model appreciably over estimates the environmental impact and almost certainly significantly overestimates spill frequency.

4 With the completion of the Lee tunnel later in 2015 it is almost certain the Water Framework Directive (WFD) dissolved oxygen (DO) status of good will be reached. Thus expending £4.2bn on the tunnel will still only achieve good DO condition. However even after the £4.2bn tunnel, for other reasons, the Tideway status will still only be moderate. Is this a good use of scarce financial resources?

5 The UWWTD allows spills in unusual rainfall. If it is required to reduce spill frequency further a combination of measures could do this much more cost effectively than the £4.2billion of the tunnel. This should be reviewed prior to construction starting on the £4.2billion tunnel.

## **Thames Tideway Strategy Steering Group Study**

6 From 2000 to 2005 the Thames Tideway Strategy Steering Group (TTSSG), under my independent chairmanship, studied how the Tideway could meet the UWWTD. Its reports were the basis of the European Commission (EC) action in the European Court of Justice (ECJ). The TTSSG was told by the Environment Agency that CSO spills led to, on average, a total of 8 fish kills a year, and 120 days of elevated health risk. Based on then available technology the TTSSG considered several alternatives including Sustainable Drainage Systems (SuDs) and sewer separation as stand alone solutions and found that, as standalone complete solutions, they were too expensive. Thus it recommended the STW upgrading and, at a cost of £1.7 bn, the Tideway Tunnel as the most appropriate solution which would ensure the UWWTD would be met.

## **Needs Report 2010**

7 In 2010 Thames Water (TW) issued a Needs report. As alternatives to the tunnel this only considered standalone solutions and did not consider a combination of measures.

8 TW instructed the SuDs team under Prof Richard Ashley not to include infiltration into the underlying terrace gravels. The sewer modelling, done by others, was later found to be inaccurate. Prof Ashley has disputed the conclusions and that SuDs should be rejected.

9 The London combined sewers, storm relief sewers, and interceptor system has many fixed interconnections, most constructed as much as a century ago when the developed area, sewer flows and storm flows were considerably different. Further, many storms are relatively local so that the sewer system can be overloaded in some places whilst under-loaded elsewhere. Real time control (RTC)/Active system control in the combined sewer network is about diverting storm flows to those sewers with spare capacity and that are best able to handle them. However RTC was rejected for "*insufficient storage capacity*". Storage, whilst helpful, is not a necessity for RTC so that was not a valid reason for rejecting RTC.

10 The Needs report also failed to include the 2006 NERA calculation showing only £1.5m of health benefits.

11 Thus the Needs report was not a reliable report. Technology and environmental information has advanced significantly since 2010 so the Needs report is now even more out of date now and cannot be relied upon as supporting evidence for the tunnel.

### **Dissolved oxygen/ ecology**

12 Compared with the EA statement of an average of 8 fish kills a year, the EA record of fish kills in the Tideway over the last 10 years shows a total of only 3 fish kills, with only one, of one fish, caused by overflow from the CSOs to be connected to the Tideway tunnel. Whilst some more fish kills could have happened, these would occur during the summer months when the temperature of the river is higher. In summer the daylight hours are longer meaning the chances of any fish kill being seen would also be higher. Thus the assessment of the condition of the Tideway on which the tunnel decision was based, and that reported to the EC, was much worse than the actual situation.

13 Since fish are the most sensitive ecological indicator, trials were carried out to determine the dissolved oxygen (DO) standards required in the Tideway so fish could be sustainable and the ecology satisfactory. The representative fish species included salmon, the most sensitive of the species, although very few, if any, salmon are now present and the EA has even removed the counter that used to count them. The standards apply to the full Tideway, including the section impacted by Mogden STW and its storm spill. The DO standards do not specify the source, merely the DO quality of the Tideway. Thus, to meet the UWWTD, the Tideway in all the reaches must achieve the set dissolved oxygen standards.

14 In the notes of the meeting on 25 September 2014 the EA state "*The Environment Agency is not aware of any instances when storm water discharges from Mogden STW have caused a significant adverse impact on the quality of the river since the upgrade of the works. On this basis, the overflow from Mogden STW storm tanks is regarded as satisfactory under the terms of the Urban Waste Water Treatment Directive.*"

15 The Minister, in PQ0401 14/15 on 30th July 2014, stated "*the storm discharges from Mogden STW have not led to a significant adverse impact on the quality of the river since the upgrades. The Environment Agency will continue to assess the performance of the upgrade to ensure it continues to comply with the Urban Waste Water Directive.*"

16 Thus the EA has concluded that, provided there is no significant adverse environmental impact from storm water spills, then such storm overflows are satisfactory and the UWWTD is met. "*The EA will consider the effect of discharges, rather than frequency.*" or source. Such a consideration must include the dissolved oxygen conditions.

17 The EA now allege that "we cannot state that the Tideway meets the standards without assessing a longer period than one year." But they already have in the statements above. They refer to the STW consent but that is not relevant when considering the effect of the intermittent discharges on the dissolved oxygen content of the river.

18 To meet its statutory requirement to monitor dissolved oxygen content in the Tideway, the EA has established 9 Automatic Quality Monitoring Stations (AQMS). They have provided 7 years of records and some half tide plots. These show that, since the Beckton and Crossness STW upgrades were completed in early 2014, the Tideway has met all the dissolved oxygen standards. That no breach of the standards occurred during the 2014 critical summer period is confirmed by the Environment Agency.

19 The TW model demonstrated that, on average, with the Lee tunnel operational, there would be about two failures of the dissolved oxygen standards each year. Thus the AQMS data shows the outputs of the TW model to substantially overestimate dissolved oxygen failure. Thus, almost certainly, it also significantly overestimates spill frequency.

20 Once the Lee tunnel is operational in late 2015, about halving the spill volume, then the water quality in the lower Tideway should improve significantly more.

21 The Water Framework Directive requirement for dissolved oxygen to reach good ecological status is for 95% of readings to be above 5mg/l. The AQMS readings show that the upper Tideway now meets this. The worst AQMS downstream for DO, Barrier Gardens, is above 92%. It is probable that, once the Lee tunnel is operational in late 2015 about halving the spill volume, the full Tideway will then meet good ecological status for dissolved oxygen.

22 Thus, post the Lee tunnel and the STW upgrades, it would appear that, similarly to the current Mogden STW storm tank discharges, spills from the Tideway CSOs would not cause significant adverse impact on the ecological quality of the river, and, in line with the Environment Agency statement about Mogden intermittent storm water spills, and subject to continuing monitoring which the EA is doing, the Tideway dissolved oxygen should be regarded as satisfactory under the terms of the UWWTD,

### **Health of recreationists**

23. Because of the muddiness of the foreshore it is not attractive, there is limited access to it, and because of the tidal range it is covered with water much of the time. Thus use of the Tideway foreshore appears limited. The Tideway is not a designated bathing water under the Bathing Water Directive. For navigational reasons the PLA have banned bathing downstream of Putney except with a special licence and guard boats. When contacted last they had only issued one license for one swim.

24 The 2004 E A assessment used a theoretical matrix of location and volume of discharge to assess the impact of CSOs on health but provided no data on health impact to support its assumptions. It concluded that 19 CSOs were unsatisfactory for health reasons

25 The EA 2006 recreational users study found that most recreationalists were some 5,000 rowers, largely in the Chiswick-Putney area. The Health Protection Agency (HPA) found that their gastric illness was less than one tenth that of the general population. Using the Quality Adjusted Life Year analysis, as used by NICE, the respected economic consultants NERA found that the benefit of curing all their gastric events would be £1 1/2m. Defra suggest that it would be "somewhat in excess", maybe £2m? Thus it would not be worthwhile spending more than this amount to deal with health aspects. Thus the health aspect of the CSO spills

is not significant. Thus the EA classification of 19 overflows unsatisfactory for health reasons appears invalid.

## **Aesthetics**

26 The TTSS aesthetic objective is to limit pollution so it ceases to have a significant adverse effect. The HPA state the *“floating matter disseminates relatively quickly”* and Jacob Babties expect *“little aesthetic change due to the Tideway Strategy Options”* which includes the tunnel.

27 The 1997 “Defra” guidance criterion for unsatisfactory overflows is that they should have *“a history of justified public complaints”*. For the 2004 assessment the EA identified only 3 CSOs as meeting this criterion. Instead the EA assessed CSOs on a largely theoretical and unsubstantiated basis, with no field data provided to support the assumptions. They then classified 33 CSOs as unsatisfactory for aesthetics reasons.

28 Since 2007 Thames Water has operated two litter collector boats which they say *“are a real success story enabling them to collect quantities of sewage litter”*.

29 The EA carried out a similar assessment in 2011, but with no consideration of the benefit of the floating litter collectors, and this found the same 33 CSOs as unsatisfactory. However, in 2012 the EA confirmed there were *“relatively few CSOs that have a history of justified public complaints”*.

30 Foreshore surveys by Thames 21 in early 2015 showed that there was no increase in the number of sanitary products found downstream of Hammersmith, the most upstream CSO. This would indicate that the CSOs are unlikely to be a major source of sanitary products on the foreshore. Further, sanitary products made up only 2% of all litter.

31 Many developers are now developing expensive apartments overlooking the Tideway so they must consider that a view of the Tideway is a significant selling point.

32 Thus there appear to be few, if any, CSOs that should be classified as unsatisfactory for aesthetics reasons.

33 Should further measures be required to achieve no significant adverse aesthetics effect, then floating booms could be placed around most of the CSOs and the retained debris collected for treatment and disposal at a capital cost estimate of about £2m and achieved within about 1-2 years. Such a system is an *“end of pipe measure”* and appears to conform with the UWWTD to collect and treat. Such a boom litter collection system is already in operation elsewhere in London. Floating booms were proposed by me some two years ago. Despite its low cost, the authorities have not carried forward the idea of floating booms. Thus one could conclude that, since the cost is not significant in comparison to the tunnel and could provide about 8 years control of most of the sewer debris prior to tunnel commissioning, the authorities have concluded that their benefit is less than their cost of about £2m. Therefore there is not a significant adverse aesthetics impact.

## **Overall impact**

34 Thus, now the STW upgrades are operational, the conclusion is that the Tideway now meets the requirement for *“no significant adverse environmental impact”* from the CSOs and thus the objective of the UWWTD. The completion of the Lee tunnel in late 2015 and, if thought appropriate, floating booms, will improve conditions further. The STW upgrades and the Lee tunnel have already cost about £1.2bn. Thus the conditions understood by the EC at

the time of the ECJ hearings, such as 8 fish kills a year, are no longer relevant and the EC should be informed of the current much improved environmental situation.

### **Cost Benefit analysis**

35 In 2003 the TTSS carried out a willingness to pay (wtp) study based on a show card that stated there were 4 to 8 fish kills and 120 elevated health risk days per year, and assessed the benefits Thames Water customers would pay for the tunnel as some £5bn, substantially in excess of the then £1.7bn estimated cost of the tunnel. In 2006 a similar study used a show card with 1 or 2 fish kills per year and found the benefits varied from £1.5bn for Thames Water customers and about £4bn for all householders in England.

36 The project was then split with some benefit applied to the improvement of the STWs and some for the Lee tunnel which, between them, would about halve the volume of spill into the Tideway. The cost of the Tunnel was then re-estimated at some £4.1bn at 2011 costs base. In 2011 Defra then issued a Cost benefit report, revising a number of key assumptions and estimating the benefit as between £3bn and £5bn. I have reviewed the Defra report. Putting in the NERA health benefit of £1.5m, assuming the DO and thus fish benefit as sustainable, keeping the benefit area as the TW area of those that would actually pay, correcting the economic growth since 2006 to what has actually happened, correcting the benefit split between the Thames tunnel and the other works, and including the construction and operation dis-benefits, resulted in a benefit of about £500m. This is a small proportion of the current cost estimate of £4.2bn and would not normally receive funding. Indeed it would be considered as disproportionate under the Water Framework Directive, especially when more cost effective solutions are possible.

### **Spill frequency**

37 Very few of the CSOs have records of their spill frequency, thus spill frequency is largely assessed by modelling. Defra state that the CSO spill frequency is up to 50 to 60 spills/year but this is largely based on the TW sewer model. The base case is with the completion of STWs upgrade, now done, and the Lee tunnel connecting Abbey Mills to Beckton STW, due later in 2015. Abbey Mills spill of about 50/year drops to zero and Greenwich CSO drops from 51 to 28 spills/year. Thames Water issue notifications of discharge of Hammersmith PS spills. On the assumption that spill notifications on successive days are the same spill event, very likely, then its spill frequency over the last 2 ½ years is not about 50 spills a year but about 24 spills/year. Thus the 2013 DCO modelling shows the highest annual average spill is about 40 spills/year.

38 However the data input to the models is described by Thames Water as “ *it is unlikely it will ever be possible to acquire sufficiently comprehensive data.*” One reason is that there are no reported records of discharge from the gravity CSOs and only pumped hours for the pumping stations. The rainfall radar plots show substantial local rainfall variation across London but these were not used. Instead rainfall on about 80% of the combined sewer area is based on just 4 raingauges. These cannot provide an accurate basis for modelling storms over a large urban area. Further there is no record shown of runoff variation between virtually impermeable paved areas and parkland areas with terrace gravel subsoil, such as Hyde Park. Thus the modelled rainfall and runoff could be substantially at variance from reality.

39 The models show that, even with the Lee tunnel operational and halving the volume of CSO discharge, the dissolved oxygen standard 1 would be breached about twice a year. The reality is that, even without the Lee tunnel, the Tideway has not breached that standard

in 2014. Thus clearly the models are not reliable and overestimate the impact of spills. Thus recalibrating the sewer model against current Tideway conditions would almost certainly reduce modelled spill frequency further, maybe to in the 30s/year.

40 The sewer model has assumed constant per capita water use in the future. However correcting the water use for the per capita reductions agreed with Defra in the WRMPs due to increased metering and demand management measures, would significantly reduce projected sewer dry weather flow, and hence spill frequency.

41 In the UWWTD, spills are allowed during unusually heavy rainfall. There is no definition of this but the European Commission (EC) is reported by the Advocate General as stating that it *“does not propose a strict 20 spill rule but points out that the more an overflow spills...the more likely it is that the overflow’s operation is not in compliance with Directive 91/271.”* Thus the EC appears prepared to consider more than 20 spills/year as acceptable, provided there is no significant environmental impact on the receiving water.

42 Thus the gap between the current spill frequency and that acceptable to the EC may not be that large. It is up to the British government to arrange for the modelled spill frequency to be reassessed and then demonstrate to the EC the no significant environmental impact and agree appropriate spill frequency.

### **Measures to reduce spill frequency**

43 Ways of reducing modelled spill frequency include;

- removal of restrictions in the sewer system which increase spill frequency. In Hamburg 80 restrictions were removed to reduce spill frequency,
- separation of foul and storm flows into separate pipes in some areas, especially in areas close to the Tideway, Regents Park Canal, River Wandle, River Lee, or other water courses,
- local detention tanks retaining the peak of storm runoff for release later. For instance the provision of more storm tanks at Acton reduced modelled spill frequency from 29 to 17 spills a year.
- real time control/active system control (RTC), The interconnections between the sewers, storm relief and interceptors are fixed weirs and were constructed many years ago, (many about 150 years ago), since when the runoff characteristics of London have changed. As an illustration Bloomberg report RTC reduced spills in Quebec from 45/year to 26/year and is reported as being implemented in Lisbon, Marseilles, Vienna and elsewhere,
- sustainable drainage systems (SuDs) such as green roofs, local storage in swales and pervious pavements and roads utilising the granular sub base for storm water storage. TW have said *“One of the governments key policy objectives (NPS para 2.2.3) is to reduce demand for wastewater infrastructure capacity by diverting surface water drainage away from the sewerage system using SuDs.”* The use of SuDs is the way that many European and American cities are now going to overcome similar problems.
- Blue Green Infrastructure (BGI) including trees which would slow down storm runoff and improve air quality.
- infiltration into the terrace gravels which underlie much of London near the Tideway. In its SuDs review the EA stated *“A more recent key source of evidence is work from the British Geological Survey assessing the potential for the use of infiltration”.*

Bloomberg analysed this and found that, with some technical adjustments, 67% of the area could be developed for infiltration storage in the terrace gravels underlying much of central London. A single example from Fulham indicates this percentage could be even higher,

- Use these measures in combination where each is most economical.

44 When the original selection of the tunnel was made about 10 years ago, several of these technologies had not been developed or knowledge of their implementation was insufficient for them to be recommended as appropriate measures.

45 Most of these measures, to the extent needed for an economical combination, could be implemented within about 3 years, much quicker than the tunnel and much cheaper.

46 Whilst Defra state that "*the WFD requirement is to make judgements about the most cost effective combination of measures*" this has never been done, each being considered previously as standalone solutions. It should be and an updated review carried out using up-to-date technology and data.

47 It is believed that a combination of such measures could reduce the spill frequency from the current about 40 spills/ year to a level acceptable to the EC at a much smaller cost than the tunnel.

48 The tunnel would collect most of the spill volume of 19 Mm<sup>3</sup> and this would need to be pumped out with an average lift of some 60m. This would require significant amounts of energy. Were a combination of other measures be utilised, the energy use would be minimal., thus obviating the emissions related to the pumping energy and the construction of a major scheme.

### **Best Technical Knowledge Not Entailing Excessive Cost**

49 Defra have stated "*If there is more than one solution to the problem, there would be a strong argument that any solution more costly than the least expensive could be viewed as excessive cost, so long as the solution chosen fulfils the objective and requirements of the directive.*" Since the STW upgrades and the Lee tunnel, cost about £1.2bn, appear to fulfil the objective of protecting the environment from the adverse effects of water discharges, it is concluded that no further measures are required until climate change effects become significant in a few decades time. Were it required to reduce the spill frequency then there are a combinations of measures that could do that, almost certainly to whatever spill frequency would be required.

### **Future**

50 Over the next decades, the increasing population and climate change will worsen the situation but this would take place over many decades. Thus more measures, particularly SuDS, could be taken, to ensure that the no significant adverse environmental impact status occurs.

### **Conclusions**

51 It does appear that, once the Lee tunnel is operational later in 2015, the dissolved oxygen conditions in the Tideway will meet the WFD good criterion. Thus the construction of the tunnel at £4bn will not benefit this. However it is reported that the Tideway has overall only moderate status and that, for other reasons, even after the construction of the tunnel it will

still only achieve moderate status. I question the sense of this major expenditure. If it is necessary to achieve good status for the Tideway, would it not be better to do the economical minimum combination of measures to achieve the required spill frequency and to put the remaining funds into overcoming the features that currently restrain the status of the Tideway to moderate under the WFD?

### **Recommendations**

52 It is recommended that, before Thames Water places large and expensive construction contracts about June 2015, the sewer and water quality models should be recalibrated against the records of dissolved oxygen and the spill frequency of the CSOs be reassessed.

53 An independent study of what combination of measures would reduce the spill frequency to an acceptable level at what cost should be commissioned urgently. An informed decision could then be taken as to whether the Thames tunnel is actually needed to achieve no significant adverse environmental impact and meet the requirements of the UWWTD. These actions should also save a substantial proportion of the potential fines for breach of the UWWTD. If other measures were found to be sufficient, this could save the country, and in particular Thames Water customers, a substantial amount of money, may be £3 billion.

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4th May 2015

TTT need summary 14.4.15