Response by Prof Chris Binnie to Rory Stewart MP's letter to Lord Berkeley 16th June 2015

Attachment to Lord Berkeley's response dated 7 July 2015

Summary

The objective of the UWWTD is "to protect the environment from the adverse effects of the abovementioned waste water discharges. "The Tideway Dissolved Oxygen (DO) standards were set to ensure this.

The Environment Agency (EA) has agreed that none of the Tideway UWWTD DO standards were breached in 2014. The WFD DO standard was met in the upper Tideway in 2014 and, when the Lee tunnel is finished about the end of 2015, about halving the total volume of CSO discharge, it is highly likely that WFD good DO will be met throughout the Tideway thereafter.

One of the standards has a return period of once in 10 years thus the EA state that one has to wait for 10 years to know if the CSO spills resulted in the standards being met. The Mogden STW has a discharge standard which it now meets. However Mogden storm tanks are intermittent discharges similar to the CSOs. These discharges have to meet the Tideway DO standards. After one year of operation the EA and the Minister confirmed that, despite the storm tanks spilling on 54 days in its first year, Mogden intermittent discharges met the relevant Tideway UWWTD DO standards. **Thus there appears no reason why the CSO discharges should not also be judged in the same way as the Mogden intermittent discharges. Thus, CSO discharges would now meet the UWWTD standards.**

The UWWTD includes within a footnote to an annex that CSO spills should only occur during unusual rainfall conditions. The European Commission "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 91/271." This statement is not overruled by the ECJ judgement.

Historically the greatest annual average CSO spill frequency was about 50 spills/year. On completion of the current works costing some £1.2bn, this will reduce to about 40 spills/year.

In about 2003 the TTSSG studied the cost of sewer separation but as a solution for all of the relevant catchment. With some new developments storm runoff which used to go into the combined system can now be diverted, particularly the many developments along the Tideway. The large Kings Cross development will discharge into the Regents Park canal. Sustainable Drainage schemes were studied in outline by TTSS but were considered an insufficiently proven technology then. Since 2003, the technology has developed, including such as green roofs and there is much more experience of implementing SuDS. The study team for the Putney pilot area was instructed to ignore infiltration into the underlying gravels, other restrictions were placed on the study, and the sewer modelling was incorrect. Thus the conclusions of that study are not reliable. About 2/3 of London would be suitable for infiltration, subject to some technical adjustment. Real Time Control has been developed and has been used successfully elsewhere. The conditions in London imply it should be

successful there. In addition detention tanks have been used to reduce spill frequency at Acton. There are restrictions in the sewer system which, if removed, should result in reduced spill frequency.

The optimum solution is likely to be a combination of partial options using each where it is most cost effective. Although this is now a requirement on the EA, no such study of a combination of all partial measures is available. Such a combination of partial measures should be much less expensive than the tunnel, and the benefits would occur sooner than the 8 years to build the tunnel. An opportunity to discuss is welcomed.

Detailed response to Rory Stewart MP's letter dated 16 June 2015

*Note: Minister's statement in red italics. – R*esponse in black.

The Environment Agency does not agree with your and Professor Binnie's assertion that the Thames meets the dissolved oxygen (DO) standards. The overriding point is that a single year's data (2014) cannot be used to assess compliance with standards 2,3, and 4 which require periods at least 3,5, and 10 years respectively to assess for failure.

Standards

The dissolved oxygen standards were set under Professor Binnie's chairmanship. They cover the whole Tideway. They were set to protect ecology and were based on what was taken as the most representative ecological species, fish. Level 1 standard with a return period of one year, was set so as not to limit fish migration. Other standards were set to ensure sustainability of fish populations, i.e. not to kill more than a limited proportion of fish. Level 4 standard, 1.5mg/l for one complete tide, is allowed to occur only once in 10 years.

Tideway improvement programme

There are three parts to the Tideway works, upgrading the sewage treatment works, the Lee tunnel from Abbey mills to beckton STW, and the Tideway tunnel. The west London Mogden sewage works upgrading was completed in March 2013 and upgrading of the east London sewage treatment works at Beckton and Crossness was completed in late 2013. The upgrades, along with the Lee tunnel, have cost about £1.2bn.

Monitoring

There are 9 Automatic Quality Monitoring Stations (AQMS) 6 in the upper Tideway above Westminster, and 3 monitoring the middle lower Tideway. These record a number of factors every 15 minutes including dissolved oxygen.

Results of the monitoring

Since the upgrading of the Mogden STW in March 2013, the upper Tideway has not breached the Tideway DO standards. This is agreed by the Environment Agency.

Since the Beckton and Crossness upgrade was completed about the end of 2013, the middle/lower Tideway has not breached the Tideway standards. This is agreed by the Environment Agency.

Comments on the 2014 results

The lowest single dissolved oxygen reading in the upper Tideway since the Mogden STW upgrade was completed was 3.1mg/l. There would need to be a whole tide below 1.5 mg/l for failure of level 4 to occur. The DO levels achieved were so much higher than the level 4 standard that the likelihood of breaching them in the future seems remote.

Environment Agency records of fish kills

The level 2, 3, and 4 standards are designed to protect against fish kills. The Environment Agency record of fish kills over the ten years 2003 to 2013 shows 3 fish kills due to Mogden STW, 2 due to Abbey Mills overflows and one caused by spills from CSOs to be connected to the Tunnel. It is possible that some other fish kills occurred that were not seen and reported. However fish kills occur in summer when the river temperature is high and the fluvial flow low. Thus the daylight hours are longer. The fluvial excursion is about 15km. Thus the likelihood of fish kills being seen is high. Certainly the Mogden based fish kills in 2004 and 2011 were widely reported. Thus it seems unlikely that there were a significant number of other fish kills.

The Mogden STW has been upgraded and is now satisfactory. Abbey Mills spills will shortly be conveyed by the Lee Tunnel to Beckton STW and treated there, so that will not result in future fish kills. Thus, even before the upgrading of the Beckton and Crossness sewage treatment works , the record over 10 years shows only one fish kill, of only one fish, caused by the CSOs to be connected to the tunnel. This is within the environmental target which allows one major fish kill in 10 years.

In any case the TTSS fishery studies allowed at least 10% of all the species to be killed and still be classified as sustainable.

Thus the EA records show the Tideway already met the fish sustainability criterion over the last 10 years, even before the STW upgrades.

Water Framework Directive standards for dissolved oxygen

The requirement of the Water Framework Directive is to achieve Good ecological standard, as an HMWB “potential”. For dissolved oxygen the standard is that 95% of the time the dissolved oxygen should be above 5mg/l.

In 2014 the upper Tideway achieved about 99% above 5mg/l and thus achieved good dissolved oxygen content by a wide margin.

The middle/lower Tideway achieved about 92% above 5mg/l. The Lee tunnel will collect the over flow from Abbey Mills pumping station and take it to Beckton STW for treatment. Thus when the Lee tunnel is commissioned about the end of 2015 the volume of CSO overflow into the Tideway will reduce to about half what it was. Thus there is every expectation that then the middle/lower Tideway will meet the EU WFD standard for good dissolved oxygen conditions.

The Environment Agency state that they only consider the WFD conditions in 3 year groups and that the last period was 2011-2013 and that over that period the WFD good DO condition was not met.

That may well be true as two of those years were before the Mogden STW was upgraded. However when assessing the water quality of the Tideway now, it does not seem sensible to effectively ignore the substantial benefit already achieved by the STW upgrades. The analogy is taking ones car in for a MoT and then the garage saying the car won't pass until it has completed a further year of operation satisfactorily!

Period of consideration

The Environment Agency state that they cannot say whether the Tideway standards have been met until the longest period, ten years, has passed. The analogy to that is the design and construction of a 1 in 100 year flood defence scheme. Does one have to wait for 100 years before accepting that such a scheme is satisfactory? That delay is not what happens normally.

One way of looking at the Environment Agency approach is that one waits for 10 years to see if there is any breach of the standards. Then it would be highly likely that the conclusion is that no breach occurred and therefore the standards are already met. However by then the £4bn will have been spent on the tunnel. Thus the EA approach is effectively "*spend the money and then find that one did not need to spend it.*" Is that a good approach?

Thus it is concluded that

1. Since the STWs upgrading, the relevant part of the Tideway has not breached any of the Tideway DO standards.
2. Once the Lee tunnel is operational about the end of 2015, the Tideway will almost certainly meet the WFD good dissolved oxygen standards throughout.

Professor Binnie erroneously applies comments by the Environment Agency in relation to the spills from Mogden sewage Treatment Works (STW) to the central London Combined Sewer Overflow (CSO) spills. The discharge permit for Mogden sets out the requirements and defines the minimum flow that must receive full treatment, as well as the quality of the treated effluent that results. It also sets out the minimum standards for the operation of the storm tanks and the secondary treatment that the treatment works provides. To say that the Environment Agency used just one year of DO data to assess Mogden is to misunderstand and oversimplify matters. The Environment Agency explained that there are several requirements in its email of 24th July 2014, which was included in Professor Binnie's original Appendix G to his "Review of Tideway spills" report.

Basic requirement

It is not challenged that the upgraded Mogden sewage treatment works meets its STW discharge consent standards or that the assessment of that is done on an annual basis.

However Mogden discharges into the upper Tideway and the impact of the Mogden intermittent storm discharges must also ensure that the relevant part of the upper Tideway meets the dissolved oxygen standards set for the Tideway.

Intermittent storm tank discharges at Mogden

Mogden STW also has a storm component. Storm flows are retained in the storm tanks and, when these are full, further runoff is discharged from them into the Tideway. Whilst this discharge quality is better than normal CSO discharge, it does not receive secondary treatment as required by the Urban Waste Water Treatment Directive (UWWTD). Thus Mogden storm discharges into the Tideway must meet the same dissolved oxygen standards as the other discharges, such as the CSOs. That is the TTSS derived standards, including level 4 which has a return period of 10 years.

June 2011 fish kill

So has the upper Tideway met the TTSS DO standards as a result of intermittent storm discharges from Mogden for the last 10 years? In June 2011 there was a major fish kill. The EA Press release states "*Heavy rain over the weekend caused the release of ...at least 200,000 tons of storm sewage from the Mogden sewage treatment Works in Isleworth" "More than 26,000 fish were killed along a 2 kilometre stretch of the river between Barnes and Chiswick."* This stretch is downstream of Mogden but well upstream of the most upstream CSO at Hammersmith. Thus clearly, as a result of Mogden storm spills, this part of the upper Tideway did not meet its fish kill standards in 2011.

Condition in 2013/4

It is reported that Mogden storm tanks spilled on 54 days during the first year of operation, 2013/4.

However the EA email to me of 24th July 2014, states "*The Environment Agency is not aware of any instances when storm discharges from Mogden STW have caused a significant adverse impact on the quality of the river since the upgrades to 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....The works only came into effect on the 31st March 2013."*

This was confirmed by the then Minister in PQ0401 14/15 on 30th July 2014 "*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 treatment directive."*

Period of judgment to meet the intermittent dissolved oxygen standards

Clearly the overflow can only be satisfactory if it meets the TTSS derived standards, level 4 of which is 1.5mg/l, for one complete tide once in 10 years. At the most when the email was sent in July 2014, the period of compliance that there could have been would have been 2012 and 2013, two years. Thus the Environment Agency could only have used a maximum of two years data to assess compliance of Tideway to the Mogden storm spills, not the 10 years of data subsequently alleged as necessary.

Thus, if one or two years is suitable to assess the impact of Morgen storm tank spills on the upper Tideway, then surely a similar period would be suitable for the main Tideway CSOs.

Thus it is concluded that

1. It should not be necessary to wait 10 years before deciding whether the Tideway dissolved oxygen is satisfactory and
2. The EA said the upper Tideway met the Tideway DO standards as a result of Mogden intermittent storm tank spills after only about one year

3. Is waiting for 10 years, and spending £4bn on the tunnel, and only then finding that the tunnel was not needed to meet the Tideway DO standards, a sensible approach?

As far as the number of CSO spills is concerned, it is the Court of Justice of the European Union's infraction judgment of October 2012 that provides the position under EU law, rather than the views stated in the Advocate General's Opinion of January 2012 and the European Commission's reasoned opinion of November 2008.

That is true to the extent that the ECoJ statements/judgment overrules the other documents. Where the ECoJ does not consider particular points in the other documents, then they still stand.

Paragraph 93 of the Court's judgement is unequivocal that the collecting system for London (Beckton and Crossness) does not fulfil the obligations under the Urban Waste Water Treatment Directive.
Reading the various documents from the ECJ preliminary and actual hearings, it would appear that the evidence available to the EC was the TTSSG reports dated 2005. These say that the Tideway had on average 4 fish kills a year ie 40 fish kills in 10 years. The EnvironmentAgency fish kill record for the CSOs and Beckton and Crossness STW for the 10 years 2003 to 2013 shows only 3 fish kills. Thus the EC and the ECJ were misled by the information presented to it into thinking the Tideway dissoved oxygen/fish conditions was much worse than it actually was. Further the water quality conditions have improved much since the STW upgrades.

Para 28 ("... (the Commission) 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.") and paragraph 61 ("...the Court does not have jurisdiction to define numerical obligations laid down by that Directive") are particularly relevant to the issue of spill numbers. The European Commission has not subsequently proposed or adopted any guidelines on spill limits. It is clear, therefore, that although the number of spills may provide an indication of compliance or otherwise with the Directive, settling on a particular figure for spills would not necessarily entail compliance or non-compliance with the judgment. In which case what is the criterion for judging compliance? Is it the environment, i.e. dissolved oxygen, of the Tideway?
The key obligation of the Directive remains that there must be a collection and treatment system in place that only spills in exceptional circumstances.

First, the words in the directive are not "*exceptional"* but "*situations such as unusually heavy rainfall."* It seems surprising that Directive is misquoted.

Secondly the quote "*unusually heavy rainfall* "is actually in a sub note to Annex 1 section A. It does not appear in the actual articles of the Directive. Thus how can it be taken to be "*the key obligation of the Directive*"?

Thirdly there is no "*key obligation*" set out in the Directive. The objective of the directive is set out in Article 1 "*to protect the environment from the adverse effects of the abovementioned waste water discharges."* It is that objective that the dissolved oxygen standards were set to ensure compliance of the Tideway.

Those obligations also relate to a collecting system for the remaining central London CSOs, even after the spills from Abbey Mills pumping station are captured by the Lee tunnel. Agreed.

As an example, these CSOs spilled 16 million tonnes into the in 2014, with just three of them (Hammersmith, Lots Road, and Western) contributing 11 million tonnes to that.

The spilled water would be mostly storm water with a foul component. Volume of spill is not mentioned in the Directive. Its relevance would be its effect on the environment and that depends on the volume and water quality of the water body into which it discharges. Thus a volume of discharge that would be lethal for a small stream might not, due to dilution, be noticeable if discharged into an ocean. What is relevant is meeting the objective of the UWWTD to protect the environment of the Tideway. In 2015 the Environment Agency has confirmed that in the Tideway the dissolved oxygen standards were not breached in 2014.

Regarding Professor Binnie's assertion that Thames Water's water quality model should be re-calibrated, using current data and radar methods for assessing rainfall rather than current rainfall data, the Environment Agency has previously advised him that the model was developed to compare proposed solutions, and is fit for purpose in terms of what it is designed to do. It is not intended to give absolute values on a year-by-year basis. Professor Binnie states in his comments on the Annex that the Automatic Quality monitoring Station (AQMS) data gives a better indication of performance of the Tideway than the model. The AQMS data show that the Tideway is currently failing three of the four DO standards that comprise the design objective relating to the ecological impact.

Since the completion of the Mogden STW upgrade in 2013 there has been no breach of any of the DO standards in the upper Tideway.

Since the completion of the Beckton and Crossness STW upgrades at the end of 2013 there has been no breach of any of the DO standards in the middle/lower Tideway. Once the Lee tunnel is operational about the end of 2015, about halving the annual average storm spill, water quality should improve even further.

The Environment Agency consider that 10 years is required to assess compliance of the Tideway resulting from the CSO spills. However they assessed the impact of the Mogden storm water spills on the Tideway after only one to two years. Applying a similar approach would show the Tideway as compliant.

Regarding the WFD dissolved oxygen standards, only by including data from before the upgrades were completed, when water quality conditions were worse, has it been possible for the Environment Agency to claim that the Tideway is currently failing the WFD standards.

Surely, having spent some £1.2bn on the upgrades and the Lee Tunnel, one should use the improved dissolved oxygen conditions when considering the water quality conditions.

Irrespective of arguments about model accuracy, high levels and volumes of CSO spills in London continue, which present a risk to the environment and are in breach of the Urban Waste Water Treatment Directive.

Risk to the environment

The objective of the UWWTD is to protect the environment. Considering the risk to the environment, this appears low when, post the STW upgrades, and there have been no breaches of the dissolved oxygen standards in the relevant reaches of the river.

Modelled spill frequency

Very few of the CSOs have records of their spill frequency, thus spill frequency is largely assessed by modelling. Defra state that the average annual 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. Under these conditions 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 Pumping Station 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. (Note that Mogden storm tanks spilled on 54 days in their first year. Applying the same methodology, then the spill frequency at Mogden would have been 17 spills/year, near the upper end of the EC number.)Thus the 2013 DCO modelling shows the highest annual average spill is about 40 spills/year.

However the data input to the models is described by Thames Water in the TTTT 2006 Vol 2 Modelling and Compliance page 10 which states " *Of the 57 CSO which discharge to the Tideway, indicative flow data only exists for around 9 of the pumped discharges and there is some historical data. There is no flow data and virtually no quality data for the remainder. Obviously, comprehensive flow and quality data is essential for all these discharges if individual rainfall events are to be modelled precisely.* "Which they were. "*Under these conditions it is unlikely that it will ever be possible to acquire sufficiently comprehensive data.*" to model spill frequency sufficiently accurately.

One reason is that the rainfall radar plots show substantial local rainfall variation across London but these were not used as they were unreliable. Instead rainfall on about 80% of the combined sewer area is based on just 4 single point rain gauges. These cannot provide an accurate basis for modelling storms over a large urban area. Further there is no record shown, or mention in the report, of runoff variation between virtually impermeable paved areas and parkland areas with terrace gravel subsoil, such as Hyde Park, where storm runoff would have been much lower. Thus the modelled rainfall and runoff could be substantially at variance from reality.

The models showed that, even with the Lee tunnel operational and halving the annual 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. Whilst the number of breaches of level 1 does vary from year to year, 2014 does appear to be reasonably representative. With the Lee tunnel operational from the end of 2015, it would appear probable that the Tideway is never likely to breach the DO standards. Thus the models appear unreliable and significantly overestimate the impact of spills.

Considering that the gap between the post Lee spill frequency and that required to meet the UWWTD is now much reduced, there are almost certainly other measures which, when used in combination, could reduce this more quickly, and at substantially less cost, than the tunnel. Consideration of these are in the Appendix.

You mention that a programme of combined measures such as sewer separation, real-time sewer controls, plus various so-called blue-green technologies, including sustainable drainage systems, should be able to achieve a reduction in CSO spills to a satisfactory level in a short space of time and at less cost than the Tunnel. As you know, a range of alternative solutions was considered in some detail by the Thames Tideway Strategic study, including some combinations, with a conclusion that a tunnel offered the most timely and cost effective solution.

Professor Binnie chaired the Thames Tideway Strategic Study Group (TTSSG) throughout its time, 2000 to 2005 and he has confirmed the following.
First the alternatives to the tunnel were considered up to 2003, thereafter the work focussing on the evidence to support the tunnel.

Real time control was not considered at all as the technique was not sufficiently proven at that time.

Sewer separation was considered but as a cost to provide a total new sewer system, but not as a partial system where it would be economic.

SuDs was considered but again only as a complete solution. At that time SuDs was not sufficiently developed as a technology for the TTSSG to have sufficient faith in recommending adopting it.

None of these solutions were considered as a combination of partial measures to achieve sufficient spill reduction.

Further, at the time TTSSG was advised that spill frequency would have to be reduced to 8 spills a year or less. In the event the tunnel was selected to achieve 4 spills a year. No other then proven technology could achieve these standards.

This now compares with the 20 spills a year mentioned by the European Commission in the Infraction Proceedings. The higher spill frequency means that alternative measures, when used as partial measures in combination, would almost certainly meet the requirements at substantially less cost and with earlier benefits. No report has been found on such a scheme.

It seems surprising that, over a decade after the original tunnel was selected and after a decade of technological and policy development, that no report on the best combination of partial measures has been issued.

As has been pointed out in earlier correspondence between you and Lord de Mauley, and in discussion between the Environment Agency and Professor Binnie, there have been a number of subsequent studies which have demonstrated that the evidence has not substantially changed since then and the conclusion is still valid.

Appendix A to this response sets out some of the further studies and new techologies. Theses are discussed in outline below.

The TW sewer model, about 2011 and thus significantly later than the TTSS study published in 2005,, 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 2009 and 2014 WRMPs, due to increased metering and demand management measures, would significantly reduce projected sewer dry weather flow, and hence reduce modelled spill frequency even further, particularly from the small events. Thus the later study has used dry weather flow data that does not match with TWs own water supply data.

The EC policy has changed. The European Commission has promulgated in May 2013 its Communication on Green Infrastruture – Enhancing Europe's Natural Capital. COM(2013)249 final. "*Green infrastruture can contribute significantly to achieving many of the EU's key policy objectives...The European Commission adopted today a new strategy for encouraging the use of green infrastructure , and for ensuring that the enhancement of natural processes become a systematic part of spatial planning*."

Appendix E to the Needs report 2010 reviewed SuDs in the Putney trial area. However the modelled discharge for 2 of the 3 areas was subsequently shown to be wrong. The study team were instructed to ignore infiltration although there were significant areas suitable. Professor Ashley who led the study has said the terms of reference were too narrow. Thus the results of the study were not reliable.

BGS has identified areas that would be suitable for infiltration. Bloomberg report Tunnel Vision analysed these and found that " *infiltration SuDS could be developed , subject to some technical adjustments, across 67% of London's surface area. The conclusion is in contradiction with Thames Water's argument that SuDS cannot be implemented in London because it was built on clay*."

Professor Binnie's report Measures to protect the river environment from the adverse effects of waste water discharges found that an area in Fulham which was reported to have "*very significant constraints*" in actual fact did not have any. Whilst this is only one site, it is in a wide area with similar conditions and in a key area for flows in the combined sewer system..

Real Time Control/Active System Control (ASC) of sewer flows is a tecnique used elsewhere but it was not studied by TTSSG. It has since been studied by UKWIR (UK Water Industry Research) in 2013. UKWIR reports 13/SW/01/4 and 13/SW/01/5 state *"it was felt that insufficient consideration of the use of ASC was being made (in UK)." " ASC should be an automatic consideration when considering measures for addressing a problem*."No report on RTC in london has been found.

Sewer separation was studied by TTSSG but only as a catchmentwide construction of a totally new sewer system. There are many areas of london where storm water could be collected separatly at relatively low cost. For instance there is much redevolpment along the banks of the Tideway where the current system is combined. The storm water from these areas could be collected and discharged direct to the Tideway,thus reducing the storm load on the combined sewer system. A similar system is being implement for the King's Cross redevelopment using the Regents Park Canal. Such an approach was not considered by TTSSG.

The TTSSG only sutudied a limited number of total solutions. It should have studied how a combination of partial soutions might work, but it did not. Although in Professor Binnie's Measures report he did indicate what partial measures should be considered, no such report has been identified.

Thus one can only conclude that technology has developed appreciably since the original TTSSG studies , that the evidence has changed, and that it has not been possible to identify any study of the use of partial measures in combination. More detail is set out in Appendix A.

While alternatives may have proved workable and effective in the scenarios where they have been used elsewhere in the world, where the circumstances and conditions are suitable, the evidence remains that they would be very unlikely to deliver the reductions necessary in London to ensure compliance with the directive and avoid the UK being referred to the court for infraction fines. So the conclusions of the Thames Tideway Strategic Study remain valid.

From the text above, it would appear that, once the Lee tunnel is operational about the end of 2015, the Tideway will no longer breach either the specific dissolved oxygen standards or the WFD good dissolved oxygen requirments.

That leaves spill frequency. As set out above, post the Lee tunnel, the spill frequency will reduce to about 40 spills a year. The EC has mentioned a spill frequency of up to 20 spills a year. Ways of reducing spill frequency are outlined below and set out in more detail in the Appendix.

Reducing dry weather flow

TW in its sewer studies assumed that dry weather flow would increase post 2006 mostly in line with population growth, thus increasing spill frequency. Reducing water use would also reduce dry weathe flow in the sewers, thus reducing spill frequency. This can be done by metering (noting that Southern Water have reduced household demand by some 16% compared to the generally used 10%) and further water demand management measures. Reducng mains leakage, as intended by Thames Water, is likely to reduce sewer infiltration. The TW Water Resources Management Plan projections show water into supply being lower that in 2006 at least to 2040. Thus correcting for this error would reduce modelled spill frequency.

Sustainable Drainage Systems

In the Tideway Tunnel Application for Development Consent Planning Statement doc 7.01 Managing effects TW states "*7.4.23 One of the Government's 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 NPS recommends that "opportunities should be taken to lower flood risk by reducing the footprint of previousl-developed sites and using SuDS." (NPS para 4.4.22).*

Sustainable drainage systems (SuDS) methods of reducing the storm runoff include green roofs, green infrastruture, watr butts, swales, pervious pavements and infiltration storage.

As an illustration, the recent SuDS scheme in Llanelli used a mixture of landscaped swales, bio-retention planters, and urban trees but no infiltration. This resulted in an observed 70% peak flow reduction and 60% volume reduction at a cost less than half that of conventional hard engineering.

The GLA Living roofs and walls 2008 report recognises the potential of green roofs to absorb the first 25mm of rainfall while providing CO2 emission savings of 17 tonne/hectare annually. The report also notes that 30% to 40% of rainfall events result in no run-off at all from green roofs and in summer, 70-80% of run-off is retained or evaporated/transpired.

As set out above, the evidence is that, contrary to the Thames Water assertion that SuDS infiltration in London is very limited because it is founded on London clay, Bloomberg report Tunnel Vision found that "*infiltration SuDS could be developed , subject to some techincal adjustments, across 67% of L ondon 's surface area."*

Thames Water in its Strategy Discussion Document page 17 states "*We will take steps to reduce the amount of rainwater that enters our sewers."* As a strategy in the short term (2015-2020) page 19 "*A major part of this long-term goal will involve working with the Environment Agency and local authorities to promote and install sustainable drainage systems.*" However the modelling associated with the DCO Application specifically ignores this benefit.

Regarding timescale and effect of SuDS implementation in London, the Environment Agency in its report An assessment of evidence on sustainable drainage Systems and the Thames Tideway Standards, October 2013 states on page 14 " *Evidence is limited for understanding the timescale for extensive implementation of SuDS inLondon. Estimates vary for different scenarios proposed. Timescales include 10% of core urban areas in ten years through redevelopment only and 20-30 years to provide a reductin of 90% in the number of discharge events.*" Thus after about 20 years the tunnel might no longer be needed at all. But it is likely to take 8 years or so to construct the tunnel. Thus, by the assessment quoted by the EA, the tunnel at a cost of £4bn, would have a needed life of only about 12 years. Whilst this is probably over-optimisitic, it does illustrate the potential.

Separation of foul and storm systems

TW leaflet Why does London need the Thames tideway Tunnel? 2012 on page 18 states "*Separate systems for rainwater and foul sewage are now required for all new development"*. Sewer separation could be implemented where the area is close to a water course which could take the storm water. Thus for the major housing and office re-developments along the Tideway, the storm water could be diverted from the combined sewers into the Tideway, thus significantly reducing the storm flow into the combined sewers. There are other similar areas.

Detention tanks.

The scope for large detention tanks in London is limited. However ss an illustration adding detention tanks at Acton has reduced spill frequency from 29/year to 17/year. There are a number of other CSOs where, although spill frequency is high, average spill voulmes are low. For instance West Putney CSO spills 28/year but the average spill volume is 1,300m3. Thus a detention tank of this size might well reduce the spill frequency appreciably. There does appear space for this. There are almost certainly some other suitable locations uch as under London parks.

Removal of restrictions in the system.

80 flow restrictions were eliminated in Hamburg. It is known that there are some in the London. Removing these could increase the capacity of the system.

Real time control

The UKWIR reports on real time control/active system control state "*Catchments larger than 350 ha*" as in London "*have been shown to have a flood response from spatial rainfall which is different to uniform rainfall. Research (HR Wallingford 2009) in this area is very limited, but analysis of radar rainfall over London carried out by Thames Water (unpublished) indicated that extremely high intensity ranfall"* as in a summer thunderstorm which might affect river water quality " *is constrained to a very small area with storm depths being reduced by half over distances of one to two kilometers. This indicates that there is potential for managing the floodiing by diffusion through a highly inter-connected system, especially in relatively flat areas with inter-connected sewers.*" as occurs in much of London. In london there are also many sewer/storm relief sewer/interceptor junctions. These are controlled by fixed concrete weirs which wer constructed many years ago when development, and hence flow conditions, were different.Thus RTC could maximise use of the availaable sewer capacity reducing spill frequency. Also RTC /ASC would be particularly good at reducing the critical summer thunderstorm spills which are the prime cause that affects water quality in the Tideway.

Combination of measures

The River Basin Planning Guidance 2008 9.5 states " *The WFD requirement is to make judgements about the most cost effective combination of measures, so it is important that the Enviironment Agency considers the inter-relationship between measures."* Thus there is a formal requirement on the Environment Agency to consider a combination of measures. It has not been possible to find any evidence that a study of a full combination of partial measures has ever been done. Also it would appear that the requirment may well extend to others involved such as Thames Water.

The most apprpriate approach would be to use a combination of partial solutions, using each where it would be most cost effective in reducing spill frequency. Thus, there would appear to be every liklihood that a combination of partial methods would be able to acheive a satisfactory situation at less cost than the tunnel and with benfits accruing earlier. No report has yet been found of this.

I am of the view that the case for the continuing with the Tunnel project is justified as the most timely, comprehensive and cost-effective means of addressing the problem of increasing the sewage pollution in the River Thames in london and meeting the requrments of the Urban Waste Water Treatment Directive.

Whilst the tunnel is indeed the most comprehensive means of reducing spill frequency, the evidence presented above and in the Appendix indicates that the Tideway is highly likely to meet the relevant environmental standards shortly and that technology and policy have moved on such that a combination of partial measures is highly likely to provide earlier benefits, and be able to meet the requirements at a much lower cost. Such a combination of measures has never been reported on but should be before placing contracts for a £4bn scheme.

I recognise that you do not agree with the government's position, so rather than further exchange of letters it might be more beneficial if we met. If yu would like totake this up please contact my office.

This response is intended to form a basis for these discussions.

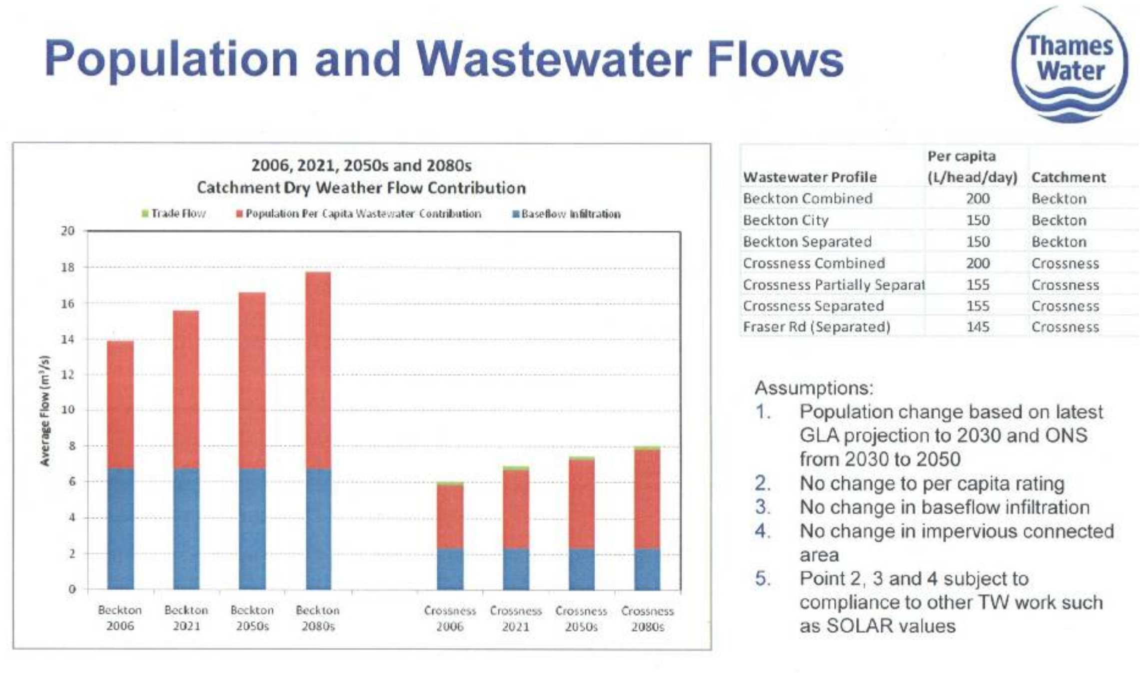
Appendix Other measures to reduce CSO spill frequency

Introduction

Measures to reduce storm runoff include reducing dry weather flow in the sewers, SuDS, detention tanks, separation of foul and storm sewers, removal of restrictions in the system, Real Time Control.

Reducing dry weather flow into the sewers

Thames Water used 2006 as the base year for calculating sewer dry weather flow. They assumed part of dry weather flow was constant, base infiltration, and part varied with population growth, assuming that there would be constant per capita use of water. Thus assuming all other aspects were constant then the sewer dry weather flow would increase and hence spill frequency would increase. This is shown in the histogram below.



Wastewater Profile	Per capita (L/head/day)	Catchment
Beckton Combined	200	Beckton
Beckton City	150	Beckton
Beckton Separated	150	Beckton
Crossness Combined	200	Crossness
Crossness Partially Separat	155	Crossness
Crossness Separated	155	Crossness
Fraser Rd (Separated)	145	Crossness

So what are the actual projections of water supplied.The area sewered to the Tideway interceptors is similar to, but somewhat smaller than, that supplied by Thames Water with water. However the contributions are likely to have similar proportions.

The Environment Agency have used the water into supply for the analysis so I will do the same. The projection of water to be supplied by Thames Water is given in the Thames Water Water Resources Management Plans (WRMP) 09 and dfWRMP14, table WRP5-FP. This shows water into supply

2006/7	2180 Ml/d
2012/13	2028 Ml/d
2020/21	1948 Ml/d
2030/31	1923 Ml/d
2040	1993 Ml/d

Thus instead of the dry weather flow increasing appreciably compared to the TW base year of 2006, (14% by 2020 and 30% by 2080) it would reduce significantly. This is due to the TW metering programme and some demand managment measures. Thus the spill frequency assessed by the TW model in future years would have over estimated spill frequency.

Although London's population is likely to continue to increase thereafter, the technologies of demand management, and leakage reduction are also developing as will meter penetration and it would be reasonable to assume that, in the longer term, these would about balance leading to only small changes in long term dry weather flow .

Whatever it is clear that spillfrequency in the future will be lower than that found in the TW modelling.

Sustainable Drainage Systems (SuDS)

Definition

SuDS methods of reducing the storm runoff include green roofs, green infrastructure, garden water buttts, swales, pervious pavements infiltration storage and other techniques for reducing storm runoff.

Policy

The European Commission has promulgated in May 2013 its Communication on Green Infrastruture – Enhancing Europe's Natural Capital. COM(2013)249 final. "*Green infrastruture can contribute significantly to achieving many of the EU's key policy objectives...The European Commission adopted today a new strategy for encouraging the use of green infrastructure , and for ensuring that the enhancement of natural processes become a systematic part of spatial planning*."

Drainage Strategy Framework. Good pratice guidance commissioned by the Environment Agency and Ofwat, May 2013 "*Water and sewerage companies are encouraged to invest in natural as well as built infrastruture to deliver their desired outcomes...Water and sewerage companies are encouraged to consdier these approaches where they can deliver cost beneficial outcomes for their customers. This is relevant to drainage planning because it encourages the use of retrofit sustainable drainage system in place of more traditional sewer upsizing and storage*." Page 8. Whereas SuDS was considered by TTSSG, that was only as a total solution and technology and experience has improved hugely since 2003.

"Where a company may historically have preferred to tackle sewer flooding or combined sewer overflow pollution by increasing its undergroundequipment to store more rainfall during storms, it might consider other options in future; such as working with customers to manage rainfall close to source, or preventing it from entering the sewer system...storm water retrofit techniques...enhancing incentives for customers to reduce surface water flowing to sewers...water and sewerage copanies would continue to review and develop other innovative soutions." page 12.

Technology development

The SuDS technology and its application have progressed considerable since the TTSSG report of 2005. In 2007 CIRIA published its SUDS Manual setting out how to implement SuDs. Since then CIRIA has provided its BeST tool and guidance to make assessing the benefits of SuDS easier. "*the tool provides a series of graphs and charts to present the benefits based on Ecosystem Services and Triple Bottom Line*", www.susdrain.org web site.

Experience elsewhere

As an illustration, the recent SuDS scheme in Llanelli used a mixture of landscaped swales, bio-retention planters, and urban trees but no infiltration. This resulted in an observed 70% peak flow reduction and 60% volume reduction at a cost less than half that of conventional hard engineering, Llanelli Green Infrastructure Project Arup May 2015

Consideration in London

In the Tideway Tunnel Application for Development Consent Planning Statement doc 7.01 Managing effects TW states "*7.4.23 One of the Government's 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 NPS recommends that "opportunities should be taken to lower flood risk by reducing the footprint of previousl-developed sites and using SuDS." (NPS para 4.4.22).*

The GLA Living roofs and walls report 2008 recognises the potential of green roofs to absorb the first 25mm of rainfall while providing CO_2 emission savings of 17 tonne/hectare annually. The report also notes that 30% to 40% of rainfall events result in no run-off at all from green roofs and in summer, 70-80% of run-off is retained or evaporated/transpired.

One of the studies referred to is the Appendix E to the Needs Case Thames Water 2010 which investigated SuDS in the Putney area. This was carried out largely by the Pennine Water Group under Professor Ashley with modelling by CH2M Hill. Although there is a significant area of Kempton Park gravel underlying the area, the team were instructed to ignore infiltration, thus significantly reducing SuDS apparent effectiveness.

The Appendix to Lord Berkeley's letter to Lord de Mauley of 9th December 2013 states "*Professor Richard Ashley who was responsible for carrying out the Putney SUDS Study discredits the Study because the underpinning modelling data for the study supplied by the Environment Agency and Thames Water incorrectly presumes that all the impermeable area drains to the West Putney Combined Sewage Overflow (CSO) whereas a very significant proportion discharges not to the CSO but directly to Beverly Brook. In view of the difference between modelled discharges (34,800m3) and empirical (20,100m3) the inferred error is in the region of 40%. This is also confirmed by a cursory view of the drainage plans for West Putney and by inspection of the discharge outfalls licensed by the Environment Agency to Thames Water that exclude a large outfall in Richmond Park.*" Thames Water corrected the modelling for this and other errors and issued a revised model output in June 2011. This also lowers the Frogmore Buckhold Rd existing spill frequency from 29 to 19 spills a year. This is shown in the table below.

catchment	Existing system spill number Appendix E	Existing system spill number TW Model 2011	Appendix E 50% impermeable removed	Likely revision 50% impermeable removed
West Putney	59	26	52	About 20
Putney Bridge	33	33	16	stays at 16
Frogmore Buck Rd	29	19	10	less than 10

Thus in two of the three zones the spill frequency in Appendix E was substantially in error.
Lord Berkeley continued *"The software used by Professor Ashley's team was modelled to calculate the effects of disconnections and as a result it missed obvious, low cost, rerouting of surface water to discharges to Beverley brook such as the Roehampton Gate/Clarence Lane surface water drainage that is already separated but mixed with foul water at the Thames Water pumping station before pumping to West Putney CSO."* Thus rerouting this storm water along, if necessary, with limited SuDs or a detention tank, would reduce the West Putney spill frequency below the 20 spills a year criterion.

This Appendix E study was done under the direction of Prof Richard Ashley head of the Pennine Water group. However he has said in his email to Professor Binnie of 9th October 2013 about the Appendix E study;

"1. TOR too narrow - only to reduce spill volumes and frequencies - no other benefits e.g. flooding, aesthetics and only RWH using barrels
2. study too high level - we could not investigate e.g. local infiltration measures - we were told these would not be viable - for the areas we were given to look at as supposedly being the most 'ideal' for SuDS". Note a significant area is shown in the BGS map and memoire as underlain by several metres of Kempton Park gravel
"3. Time and resources did not allow individual SuDS to be defined and gross assumptions for 'blanket' applications had to be made and scaled up
4. No contact with councils, public or others allowed to test viability or look for synergies and mainstreaming (linking SuDS to other developments)
5. CH2M Hill did all the modelling so we had to presume they did it right
6. SuDS had to be considered as an 'all-or-nothing' option not a partial option as everyone else has done. Even then, significant partial benefits were shown in the modelling, with some overflows eliminated completely."

Geological suitability for infiltration

Parts of London are founded on impermeable London clay and associated head deposits. However the BGS geological maps 270 and 256 show much of the area between a line running approximately east west through Hyde Park and the river is Kempton Park gravel, with a similar situation on the south bank. Table 15 of the BGS memoire shows this as having a general thickness of 10-15m. There are also many other deposits of terrace gravel. Thus there should be scope for infiltration over about half the sewer catchment.

BGS geological map 270 shows Kempton Park gravel covers much, may be about 80%, of the rest of the borough, the rest being Langley silt. The cross section on page 75 of the BGS publication Geology of London shows that generally the thickness of the terrace gravel is about 6m, occasionally overlain by less than 1m of Langley silt. Thus even the areas shown on the BGS map as Langley Silt are likely to be underlain at shallow depth by several metres of terrace gravel. This area is remarkably flat. Whilst alluvial deposits do vary, much of the area marked as Kempton Park gravel and Langley silt should be suitable for infiltration.

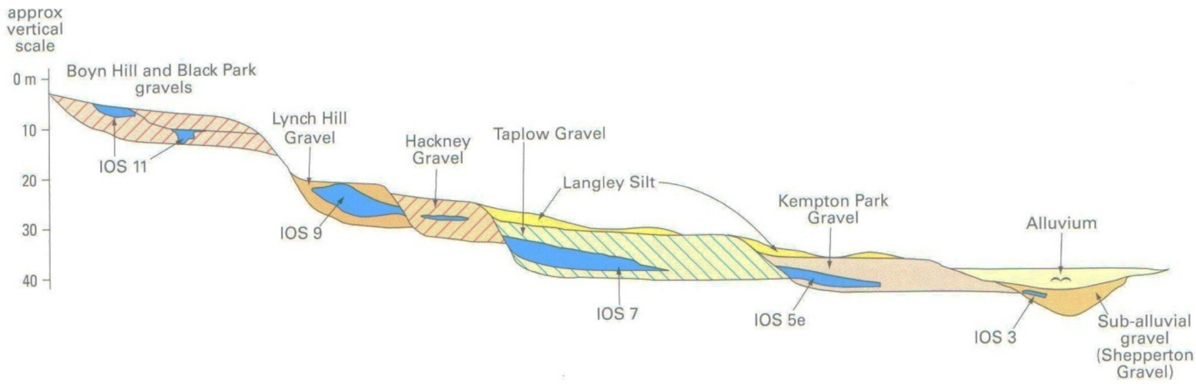


Figure 41 Schematic cross-section through the Thames River Terrace Deposits showing their relationship to interglacial deposits and their oxygen isotope stages (IOS) (after Bridgland, 1994).

The Environment Agency report: An assessment of evidence on Sustainable Drainage Systems and the Thames Tideway Standards October 2013 shows the BGS suitability of the subsurface for infiltration SuDS for each borough. This is split into 4 categories, Compatible for infiltration SuDS, Probably compatible for infiltration SuDS, Opportunities for bespoke infiltration SuDS and Very significant constraints indicated.

The Environment Agency report states in the Executive Summary "*The British Geological Survey (BGS) evidence highlights the limited scope for implementing wide-scale infiltration in the combined sewer network.*" On page 13 this is referred to as "*key evidence*".

Bloomberg 2013 report Tunnel Vision page 19 provides the breakdown of the GLA area as 8%, 20% 39% and 33%. Whilst the sewer catchment area is somewhat smaller than the GLA area, there is no breakdown for the sewer catchment area and without such data one has to assume that, for this assessment, the GLA area represents sufficiently well the breakdown of categories in the sewer catchment area. "*In other words, infiltration SuDS could be developed, subject to some technical adjustments, across 67% of London's surface area. This conclusion is in contradiction with Thames Water's argument that SuDS cannot be implemented in London because it was built on clay.* " Bloomberg 2013.

It would seem appropriate to assume that "*Very significant constraints*" would generally not be suitable. The title "*Opportunities for bespoke infiltration on SuDS*" is defined as "*The subsurface is* *potentially suitable for infiltration SuDS, but the design will be highly influenced by the ground conditions.*"

In Professor Binnie's report Measures to protect the river environment from the adverse effects of waste water discharges 2014 a comparison was made with a site in Fulham which was classified by the BGS as very significant constraints due to groundwater likely to be less than 3m below the surface. Site investigation and then construction confirmed that no such constraint existed. Whilst this is only a single site, it is in an important area and indicates that the use of SuDs in such an area may well be more applicable than shown by BGS. Thus infiltration based SuDs may well be more widespread than the 67% assumed in the Bloomberg Report.

Thus the evidence which has been referred to in Professor Binnie's reports, is that SuDs could have a greater effect than assumed in the Appendix E to the Needs case .

Thames Water in its Strategy Discussion Document page 17 states "*We will take steps to reduce the amount of rainwater that enters our sewers."* As a strategy in the short term (2015-2020) page 19 "*A major part of this long-term goal will involve working with the Environment Agency and local authorities to promote and install sustainable drainage systems.*" However the modelling associated with the DCO Application specifically ignores this benefit.

As an illustration of what can be done NCE online reported on 26th march 2014 " *The £3.7M Dulwich and belair parks sustainable drainage system project was passed by Southwark Council. It included a new wetland are in belair Park and more trees and shrubs in Dulwich Park to soak up rainwater. Underground tanks will also be installed in the parks providing storage for rainwater which will gradually be released into the sewer system"*

Implementation of SuDS

It must be recognised that SuDS and BGI would require to be implemented by a number of different authorities, developers and householders. For instance householders/housebuilders would need to put in green roofs, rainwater butts and soakaways in new or renovated properties. However redevelopment of London is only about 2% of properties a year so after 10 years only about 20% would be expected to be revised. However I am informed by Roland Gimore email 14/2/14 that many of the side roads in London need repair and the provision of permeable surfaces with storage underneath could provide storage relatively cheaply. Disruption would be localised,dispersed, and for fairly short periods of time.

Unlike the tunnel solution, where the benefit would come only once the tunnel is operational in about 10 years time, benefit fromSuDS occurs from the beginning of a SuDs programme. The speed at which the programme is implemented is a matter for others but the most cost effective approach found in Philadelphia, is to develop a 20-25 year programme which integrates these works with others, thus minimising costs. Thus such an approach would make a continuing reduction in storm spills it would also be able to mitigate any increase in storm runoff resulting from climate change.

Regarding timescale and effect of SuDS implementation in London, the Environment Agency in its report An assessment of evidence on sustainable drainage Systems and the Thames Tideway Standards, October 2013 states on page 14 " *Evidence is limited for understanding the timescale for extensive implementation of SuDS inLondon. Estimates vary for different scenarios proposed.*

Timescales include 10% of core urban areas in ten years through redevelopment only and 20-30 years to provide a reduction of 90% in the number of discharge events." Thus, on this scenario, after about 20 years the tunnel might no longer be needed at all. But it is likely to take 8 years or so to construct the tunnel. Thus, by the assessment quoted by the EA, the tunnel at a cost of £4bn, would have a useful life of only about 12 years. whilst this scenario may be over-optimistic, it does demonstrate the potential.

Detention tanks

The scope for large detention tanks in London is limited. However as an illustration adding detention tanks at Acton has reduced its CSO spill frequency from 29/year to 17/year. A potential scheme is West Putney which spills 28/year but the average spill volume is 1,300m3. Thus a detention tank of this size might well reduce the spill frequency appreciably. There does appear to be space for such a storage tank. There are a number of other CSOs where, although spill frequency is high, average spill volmes are low.

There may also be scope for utilising some open spaces to retain storm water. For instance the Serpentine discharges into a combined sewer system. Revising its outflow system could reduce flood spills from it.

Removal of restrictions in the system.

80 flow restrictions were eliminated in Hamburg. It is known that there are some in the London sewer system. One is the connection between the Fleet sewer (spills 20/year) and the Northern Low Level Interceptor where the junction is very small. Removing these could increase the capacity of the system and thereby reduce spill frequency.

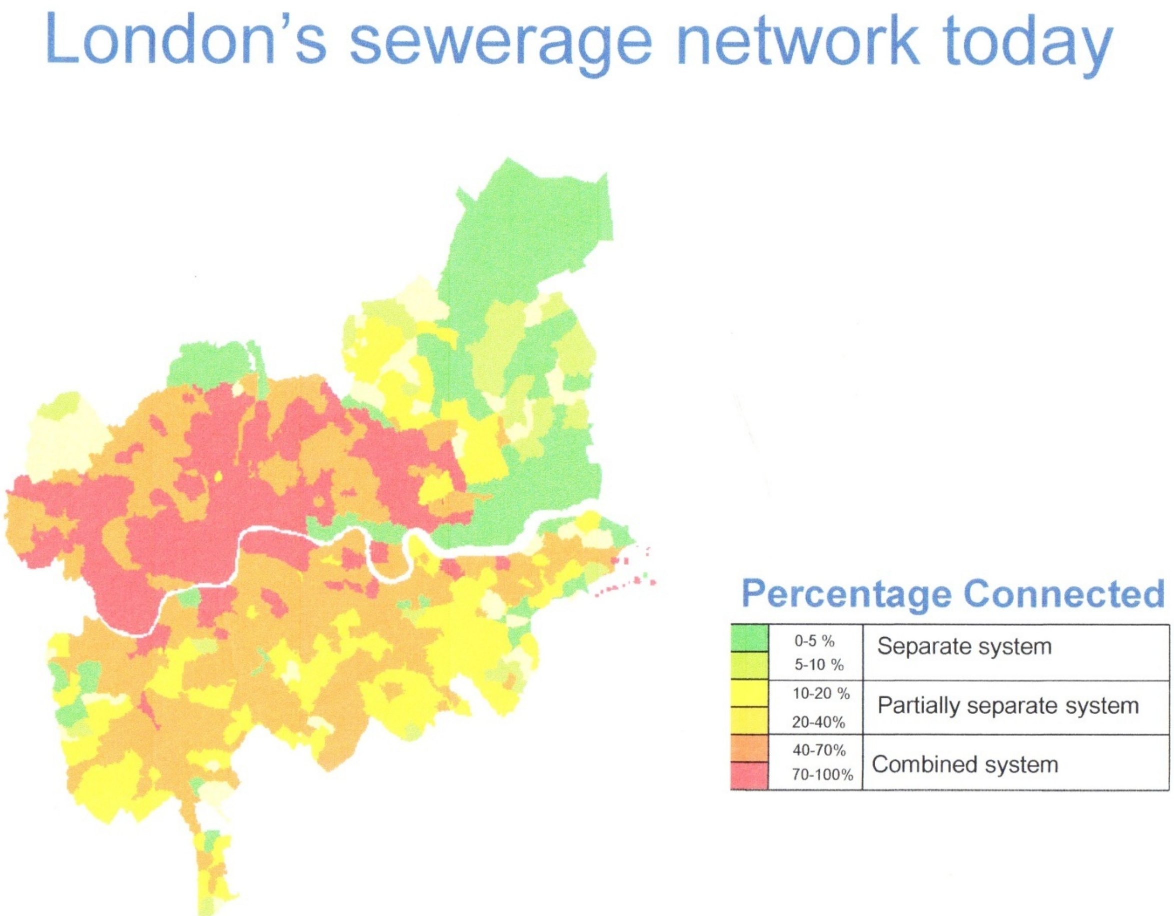
Separation of foul and storm sewers.

An instance of where separation of combined sewers proved appropriate is the city of Spokane which spent about $50m to separate the storm and foul systems and eliminated about 85% of the volume of the combined sewer overflows.

The TTSS considered separating out the combined sewer system of all of London into foul water pipes and storm water pipes. This was found to be very expensive, as well as resulting in digging up every street in London with the disruption that that would entail. Thus, as a single solution, it was rejected.

However, there are places where separate storm water pipes exist and there are places where new storm water systems could be installed economically.

The percentage of properties served by combined sewer systems is shown on the plan below.



Thus the plan shows that there are many areas where there are extensive separate sewerage systems. There has been some misunderstanding of the nature of London's sewerage system throughout the history of this scheme, with comments being made at times that there are no surface water sewers in London. This is incorrect and has probably lead to some incorrect assessments being made about the viability and the cost of alternatives.

In 2012 TW issued a leaflet "Why does London need the Thames Tideway Tunnel?" On page 18 this quotes the cost of separating the combined systems in Putney Bridge as £27m. For instance this is a CSO that has a spill frequency of 33/year. Thus sewer separation may be an economic solution to the Putney Bridge CSO spill. Thus it would seem that there may be a number of places where sewer separation may be economic.

It is interesting that much of the length along the banks of the Tideway are over 70% combined sewer system. However here it should be relatively cheap to connect the storm water systems to the Tideway. Such an approach was done by the London Docklands Development Corporation. There are quite a few existing developments that could probably be retrofitted with separate systems such as Chelsea Harbour, and Queens Walk, from Tower Bridge back to Westminster Bridge on the South Bank taking in the Concert halls, the Oxo Tower, and the Mayor's office.

In addition there are many new developments near the Tideway, both for offices and housing. It would be relatively straight forward for the new properties to discharge their storm water, rather than to the combined sewers as at present, direct to the Tideway.

Provision of new drainage

The TW leaflet "Why does London need the Thames Tideway Tunnel?" September 2012 states on page 18 that "*Separate systems for rainwater and foul sewage are now required for all new development.*" The consultation on the Guidance to Schedule 3 of the Flood and Water Management Act 2010 states, page 26 "*to ensure that there is no runoff to the receiving waterbody from small rainfall events, interception mechanisms are required to capture and retain the first 5mm.*"

I understand that the large King's Cross redevelopment is to discharge its storm water to the Regents Park Canal.

Real time control and active system control.

The Bloomberg October white paper Tunnel vision page 20 states *"in the case of sewer overflows, utilities can use control systems to store and move wastewater in real-time during heavy rain events and to adapt to the unique features of each event, therby decreasing the number of overflows.To that effect, dynamic mathematical models and simulators are used to develop a program for a specfic sewer system to guide automatic control systems when a wet weather event is approaching. The most advanced systems use radar-based rainfall measurement* " as is avialable in UK, see the diagram on the next page " *and forecasting tools to anticipate where exactly in the city the sewer system is expected to be under pressure and adjust accordingly.*

In a numaber of projects, utilities have managed to lower their sewer infrastructure investment needs using these technologies. For instance, Paris eliminated the need for $800m in sewer infrasturture investement by adopting smart monitoring and control devices at the beginning of the 2000s. Other cities have achieved savings using these technologies including Louisville, Quebec, Copenhagen, Montreal, Barcelona, Milwaukee and South Bend. "

Experience elsewhere

In Quebec real time control alone reduced spill frequency from 45 spills to 26 spills, a near halving. Bloomberg's Table 7 showed that real time control has reduced CSO project costs by 27% in Paris up to 95% in South Bend.

It is reported in the Needs case Appendix B that in Barcelona storm events are managed using real time control (RTC) and detention tanks. Page 6 also lists RTC as also being implemeted in Lisbon, Marseilles, Vienna. Many cities have also built detention tanks to assist RTC and minimise CSO spill.

I have also been told that, in the town of Boulogne Billancourt, RTC is expected to reduce the CSO discharge volume into the Seine by 80%, and hence spill frequency. The email Gilmore/Binnie 28th October 2013 states "*Confronted with the problem of overflows from its combined sewer system into the River Seine during rainfall, the department of the Hauts de Seine (which covers some thirty urban districts on the west side of Paris) has decided to implement the real time control of its sewer system. The preliminary studies, based on a MOUSE computer model of the sewer system, showed that the real time control of the sewer network under study has a high potential benefit, since it would allow an 80% reduction of the volumes of waste water discharged into the Seine annually in the study zone. Following on from these encouraging results, the installation of a complete real time control system* *was set in hand. The system, at present undergoing testing and evaluation, consists principally of a MOUSE ON LINE real time model and a system for forecasting rainfall by means of radar images."*

Thus real time control, occasionally assisted by detention tanks, has been shown to have major benefits.

Can real time control be of benefit in London? In London there are many interconnections between the sewers, flood relief sewers, and the interceptors.

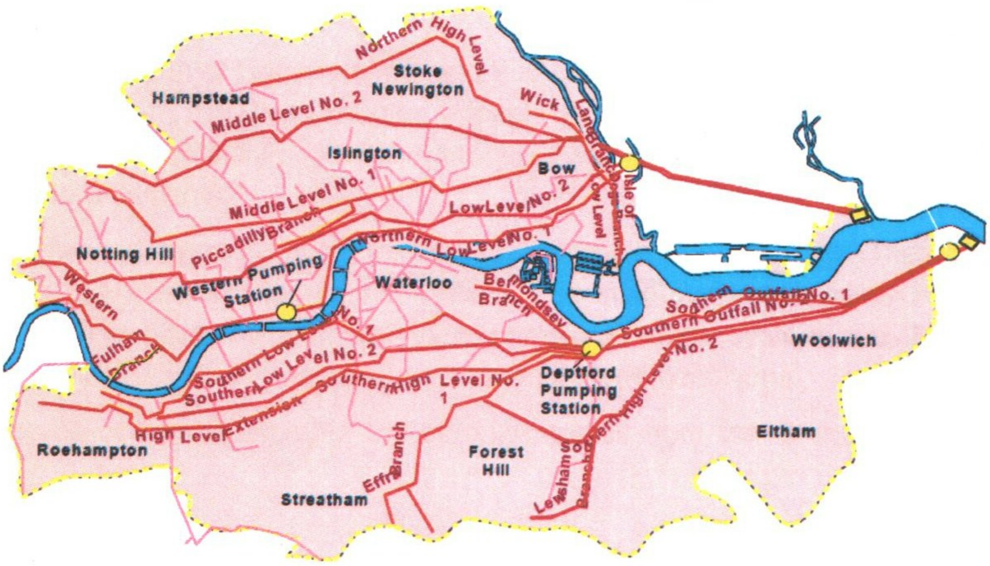
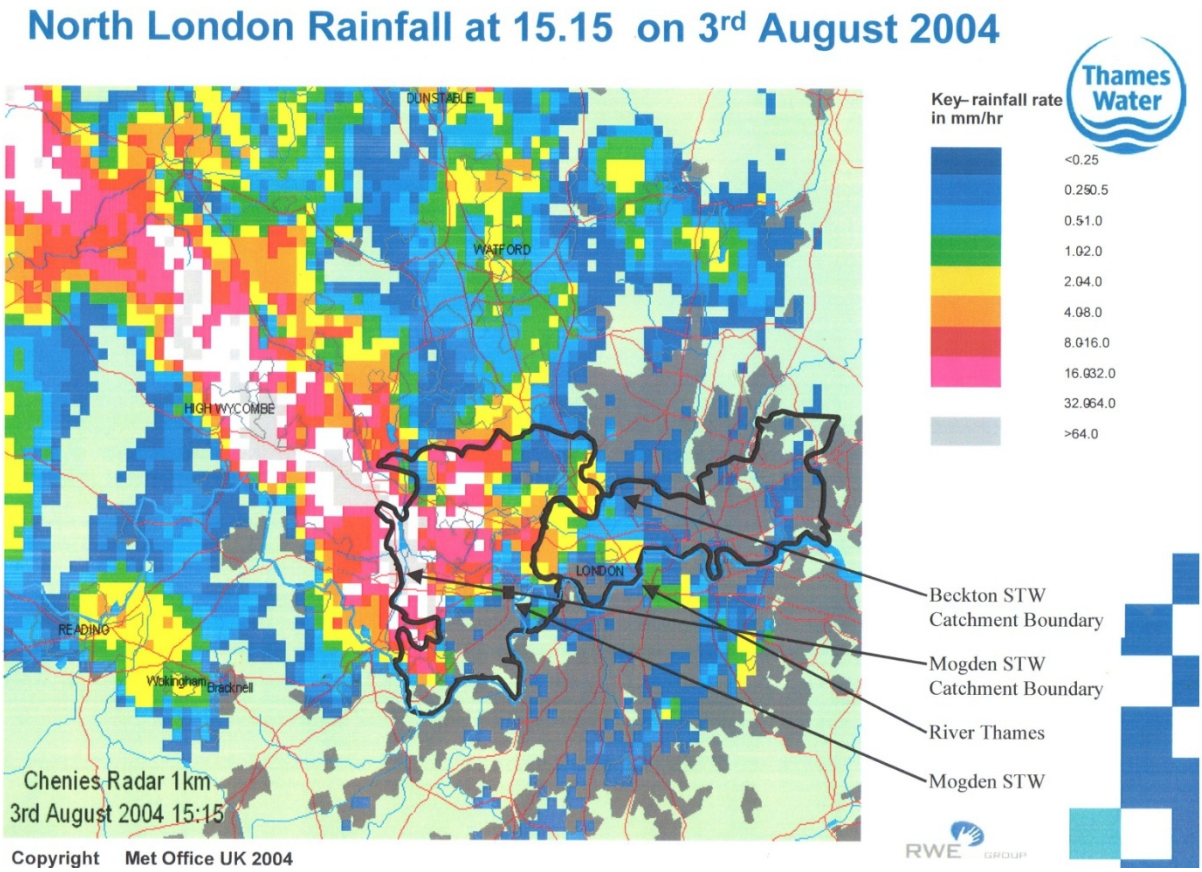


Figure 1.4: The Beckton Sewer Catchment

At present these interconnections operate with a fixed weir. However the levels of the weirs were constructed many years ago, some may be 150 years ago. London, and hence its sewer flows, has changed considerably since then and the fixed weir settings may no longer be optimum.

Of importance, many of the most polluting storms are localised summer thunderstorms when the river flows are lowest. Thus conditions will vary appreciably from one storm to another. Thus there may be spare capacity in an interceptor because the rain has not fallen in the part of the catchment draining to it. Thus, in the illustration below, some rain fell in the west of the Beckton catchment but none in the eastern part, thus there would have been spare capacity in the eastern parts of the interceptors.



These measures would require moveable weirs with actuating motors.

The Thames Water Strategy discussion document of about 2012 states on page 19 "*Our strategy also includes the increased use of innovative, real-time control and monitoring systems. We have already begun installing this technology, which will help us to manage our network more actively and take swifter action to avoid operational problems.*"

However my understanding is that the action focuses on water supply pipes and the model does not include real time control througout the sewer interceptor system. Further,the model results which the Environment Agency uses to reject SuDS as not giving sufficient benefit, was run before this strategy and the EA makes no mention of RTC or associated detention tanks.

UKWIR reports on Active System Control

UKWIR, of which Thames Water is a member, has produced two research reports 13/SW/01/4 and 13/SW/01/5. Whilst these include real time control, UKWIR has broadend the scope to active system control of sewerage systems. Thus the latter is entitled "The use of Active System Control When Designing Sewerage Schemes-A Guide." The writeup states "*The project considered the current usage of ASC in the UK where it was felt that insufficient consideration of the use of ASC was being made , and also investigated its application elsewhere in the world.*"

The Guide states "*Measurement of the hydraulic state of a sewer and the tools necessary to take action to activate equipment in the sewer already exist and are widely used. ASC should be an* *automatic consideration when considering measures for addressing a problem*." Such as consideration of high CSO spill frequency.

"*Catchments larger than 350 ha*" as in London "*have been shown to have a flood response from spatial rainfall which is different to uniform rainfall. Research (HR Wallingford 2009) in this area is very limited, but analysis of radar rainfall over London carried out by Thames Water (unpublished) indicated that extremely high intensity ranfall"* as in a summer thunderstorm which might affect river water quality " *is constrained to a very small area with storm depths being reduced by half over distances of one to two kilometers. This indicates that there is potential for managing the floodiing by diffusion through a highly inter-connected system, especially in relatively flat areas with inter-connected sewers.*" as occurs in much of London. Thus RTC/ASC would be particularly good at reducing the critical summer thunderstorm spills which can affect water quality in the Tideway.

"*The conclusions of the project confirmed the limited awareness and use of ASC for sewerage scheme and a risk-averse attitude to considering its use. However it was understood that there were many potential benefits to using ASC more widely The research hs resulted in a Guide to assist the water industry in considering the use of ASC systems where a number of operational and performance benefits can be gained by using active system control* ."

Supporting statements by the Envionment Agency and ofwat.

In UKWIR 13/SW/01/5 there are supporting statements by the Environment Agency and Ofwat.

"*The Environment Agency supports the use of Active Control Systems and requires it to be considered as part of the options appraisal stage of all schemes....**The Environment Agency wants to work closely with industry on the use of ASC for sewerage systems to avoid regulatory barriers, maximise cost effective investment and promote innovation."***

"Ofwat has the view that it is important to look at different ways of enhancing the service companies provide to customers.This Guide, along with the drainage Strategy Framework, will enable companies to maximise the operation of their drainage networks....It is hoped that this Guide will encourage companies to look at alternative ways of optimising their neworks and reducing sewer flooding."

Thus both the Environment Agency and ofwat support real time control/Active system control and the EA requires it to be considered. But it has not been considered as an alternative to the tunnel.

Conclusions for real time control

Technology now includes rainfall radar, water level sensors, sewer models and control systems such as moveable gats and moveable weirs to provide active real time control. The rainfall over the London catchments is seldom uniform, thus, during storm events, some storm sewers will be loaded more than others.

The London sewer and interceptor network has many interconnections. Thus there would seem to be scope for ASC/RTC to actively manage sewer flows, and reduce spills to the Tideway. Such active control systems have been used with success in other countries including Quebec where spills of 45/year were reduced to 26/year.

The rainfall and sewer model should be run to see what benefit could be obtained from RTC/ASC, with detention tanks where appropriate. Were such measures found to be sufficiently beneficial in reducing CSO spill they should be implementeable within a relatively short time scale.

Combination of measures

Previously methods were studied as standalone, such as total separation which would acheive zero spills, but were found to be too expensive.

The River Basin Planning Guidance 2008 9.5 states " *The WFD requirement is to make judgements about the most cost effective combination of measures, so it is important that the Enviironment Agency considers the inter-relationship between measures."* Thus there is a formal requirment on the Environment Agency to consider a combination of measures. It has not been possible to find any evidence that a study of a full combination of partial measures has ever been done. Also it would appear that the requirment should extend to others involved such as Thames Water.

Drainage Strategy Framework 2013 page 30 *"It is becoming common place for North American cities to address the issue of frequent combined sewer ovrflow (CSO) operation by using a combination of grey infrastructure (sewers) and green infrastructure. The wider health and ecological benefits of green infrastructure approaches and the reduced reliance on materials and energy are attractive to utility planners and cities alike...Based on this new York has committed itself to an aggresive green infrastructure based runoff control strategy to provide long term reductions in CSO spills."* Thus, with the general committment elesewhere to a combination of such measures, the tunnelsolution may well be outdated and it should be for the tunnel proponents to show otherwise by a consideration of a combination of measures including SuDS/BGI.

Conclusion

It would appear that spill frequency would need to be reduced from about 40 spills a year on average to up to 20 spills/year.

The measures available to reduce spill frequecy include reducing dry weather flow, detention tanks, sustainable drainage systems, sewer separation, removal of restrictions and real time control/active system control.

All of these have been used successfully in other countries.

SuDS and sewer separation were studied by TTSSG, but only as complete individual systems for the whole of the catchment.

The technology of SuDs and real time control have developed appreciably in the 10 years since TTSS.

A combination of partial measures should have been studied where each measure is most cost effective but there is no report on any such study.

Considering the various measures available the it would appear likely that a combination of partial measures would be likely to provide the benefit needed, both sooner, at appreciably less cost, and providing greater collateral benefit.