Review of Tideway spills and environmental impact. by Prof Chris Binnie FREng

Executive summary

1. The European Court of Justice considered the European Commission could adopt guidelines for UWWTD spill frequency. The EC indicated that exceeding a limit of 20 overflows a year would be cause for concern of breaching the UWWTD.
2. Spills alone is not regarded by the Environment Agency as an indicator of failure to comply with the UUWWTR.
3. Thames Water's stated that the model of the uprated Mogden STW showed it would spill about once every two and a half years. In reality Mogden spilled 54 times during the year April 2013 to March 2014.
4. Despite being the regulator, the Environment Agency were not able to provide me with the spill model output for Mogden.
5. For 10 months there were 20 spills when the rainfall was below average. For January/February when there were 34 spills, the annual average spill frequency is likely to be between 5 and 10, making an indicative spill frequency of about 25 to 30 spills a year.
6. The Environment Agency state that the uprated Mogden STW has not caused significant adverse impact on the quality of the river and thus is regarded as satisfactory under the UWWTD.
7. The Tideway dissolved oxygen model level 3 fish kills shows 99 fish kills in the 41 years of modelling. In contrast the Environment Agency record of fish kills is 3 in 10 years, equivalent to 12 fish kills in the 41 years. Clearly the standards and the model do not reflect the actual situation and need revising.
8. The Environment Agency record shows 1 fish kill from the CSOs to be connected to the Thames tunnel. Since the standard is 1 fish kill in 5 years, clearly the current actual Tideway condition meets the required standard.
9. The water quality of the Tideway will be much improved once the STWs effluent quality is much improved, and the annual spill volume is reduced from 39 Mm3/year to about 18Mm3/year, expected shortly. This will improve fish conditions greatly.
10. In view of the wide discrepancy between the modelled dissolved oxygen conditions and the actual failures/fish kills recorded, I recommend that, on completion of the Lee tunnel and the STW upgrades, monitoring of the dissolved oxygen conditions at selected points in the Tideway be undertaken before the government commits the public to paying for additional costly capital expenditure.
11. Data collection and analysis shows that it is not worth spending much more than £1 1/2m on improving the health of river users.
12. The government guidance on unsatisfactory CSOs is that they should have a history of justified public complaint but there are relatively few. Since then there are two litter collector boats who are a real success story. If thought necessary floating booms could be constructed around most of the CSOs to retain litter for collection.
13. Post the Lee tunnel etc, it would appear that, similarly to Mogden, storm water discharges would not cause significant adverse impact on the quality of the river, and, in line with the Environment Agency statement about Mogden, the Tideway spills should be regarded as satisfactory under the terms of the UWWTD.
14. The TTSSG only studied complete solutions and did not study a combination of measures.
15. Defra guidance is that the most cost effective combination of measures should be studied. This has not been done and the Minister has said he will not request it.
16. This review demonstrates that, post the Lee tunnel and STWs upgrades, the CSO spills will not appear to have a significant adverse impact on the quality of the river, and thus the EC is likely to accept at least 20 spills a year. The study of a combination of measures, as required by DEFRA, is likely to show this can be achieved in a much more cost effective way than by the tunnel.
17. The Tideway appears to meet the E A UWWTD criterion of no significant impact.

1. Introduction

Central London has sewer system that combines both foul drainage and storm drainage in one sewer. When a storm occurs the flow is greater than the carrying capacity of the sewers and the storm water, mixed with limited foul water, spills into the Tideway through combined sewer overflows. The spill frequency, at up to 50/year, breaches the Urban Waste Water Treatment Directive (UWWTD) which requires that spills only occur during unusual rainfall conditions. I chaired the Thames Tideway Strategy Steering Group (TTSSG) which studied several single solutions, and, in 2005, recommended the Thames tunnel at £1.7bn as the optimum solution. Since then over £1bn has been spent in improving the Tideway water quality. The Secretaries of State are currently considering granting permission for the £4.2bn at 2011 prices Thames Tideway tunnel to be constructed to collect and convey storm overflows for treatment at Beckton STW and reduce the spill frequency to 4 spills a year. This note considers the response of the Environment Agency to me, whether further remedial work is needed at all, and whether a combination of other options might be more cost effective and ought to be studied.

2. Spill frequency from Infraction Proceedings

The objective of the UWWTD is "*to protect the environment from the adverse effects of... water discharges.*" The Directive says that that spills should only be allowed under certain conditions such as "*unusually heavy rainfall*".

The UK was taken to the European Court of Justice (ECJ) by the European Commission for infraction of the UWWTD in London. Mr Simon Hughes of the Environment Agency, in his email to me of 24th July, states that *"my assertion that the European Commission proposed a 20 spills limit is incorrect"*. Let us examine the references below.

Clause 61 of the Judgement of the European Court of Justice states "*since the concept of "unusually heavy rainfall is not defined by Directive 91/271 it is legitimate for the Commission... to adopt guidelines* ..."

The European Commission Additional Reasoned Opinion dated 27/11/2008 states in clause 21 "*Assessing this information"* about spill frequency in other countries *" also in the light of developments since the Directive has come into force, the Commission would conclude that an acceptable spill frequency taking into account best available knowledge not entailing excessive cost cover a* ***range of up to 20 spills per year*** *taking place at times of heavy rainfall with a varied spill frequency depending on local situations and in particular the status of the receiving waters in each case*." My emboldenment. Thus the Commission "would conclude" that up to 20 spills a year would be acceptable.

Further the Advocate General's Opinion of the infraction proceedings, January 2012, states in para 48 "*On several occasions, however, both in the pre-litigation stage and before the Court*, *the Commission did indicate that, as a rule, exceeding* ***the limit of 20 overflows a year*** *would be a cause for concern, suggesting a* ***possible failure*** *to fulfil obligations. Despite all its limitations and without prejudice to the need for a case-by-case assessment,* ***a numerical criterion of that nature may be reasonable and acceptable as it had been determined by comparing the practices existing in the various Member States****."* Emboldenment added by me. First this is a suggestion by the Commission. This implies that above 20 overflows a year would possibly lead to failure, thus when environmentally appropriate, more than 20 spills a year might be allowable.

The ECJ judgement October 2012, para 28, states that 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."* Thus, where the

environmental impact is satisfactory as required by the Directive, a spill frequency above 20 spills a year could still be acceptable.

Whilst the “up to 20 spills a year” criterion was not formalised by the EC or by the British Government, such a criterion was suggested by the Commission and would appear to be acceptable where environmental conditions would be satisfactory.

3. **Mogden annual average spill frequency**

To assess annual average spill frequency reliably it is necessary to model rainfall and sewer flows over a sufficient period of time. The Mogden STW has recently been much extended and upgraded to improve water quality of the effluent and to reduce spill frequency. This was completed in March 2013. I have requested the output from the uprated Mogden STW model from the Environment Agency.

Mr Simon Hughes of the Environment Agency, in his email to me of 24th July, states that the Environment Agency is not able to provide me with the model output I requested. Surely the spill frequency is something that a Regulator should have for the important discharges it regulates.

He states that "*It is not possible to provide the annual average frequency of discharge of storm sewage from the uprated Mogden sewage treatment works because the upgrades only came into effect on 31st March 2013."* It is not necessary to wait for many years of operation to obtain the annual average spill frequency. What is required is to calibrate the model against the recent events that have taken place and then to run the model with the long term variation of rainfall events to arrive at the average annual spill frequency. This was done previously for Mogden STW by Thames Water who said in an email to Shirley Passmore of 29th March 2011 "*If the current improvements we are making had been in place, and assuming the same weather patterns were experienced, we estimate that Mogden would only have discharged to the river on a total of five occasions during those... 13 years. Following the current works there may be no discharges for many years. But, on average, about once every two and a half years, we would expect flows reaching Mogden STW to exceed the capacity of the extended treatment plant and its storm tanks."*

Whilst this statement clearly shows that the Thames Water model on which the design of the Mogden STW upgrade was based was in error and needs recalibrating, it does show that that modelling is the way to assess annual spill frequency and that the Mogden spill model exists. There is now some fifteen months of post completion operation data which should be quite sufficient to recalibrate the model and provide the revised output.

Despite the UWWTD requirement for spills only to occur during unusual rainfall events, the Environment Agency has not assessed the actual frequency of the Mogden STW spills. Should not the Regulator have required this model to have been updated and rerun already?

Mr Hughes states that using monthly rainfall figures is not a reliable method of assessment of spill frequency. However, since the Environment Agency has not, yet again, provided me with the modelled output, the only broad appreciation one can do is to use the best that is available, monthly rainfall data. I have also collected records of spills from Mogden. I have a complete set of the Sewage Discharge Notifications issued by Thames Water for the period. I also have a full set of the discharge hydrographs to the end of August 2013. These indicate that for monthly rainfall,

Less than 25mm rain	0 discharges
25mm to 45mm	1 discharge
Greater than 45mm	2 or more discharges

Thus the greater the monthly rainfall, the greater the number of spills. I believe that, in the absence of any modelled output, using the only data there is, monthly rainfall, at least provides an indicative spill frequency.

The recent reply in Hansard (HL6961) states that Mogden spilled 54 times in its first year, 34 times during the wet January and February.

Taking out January and February 2014, the remaining period of 10 months had a rainfall of 518mm which was significantly below the long term average rainfall for these months of 548mm. During this period the number of Mogden spills was 20. The average monthly rainfall during this period only varied from 48mm to 62 mm. Whilst there is always a natural rainfall variability, with such a consistent monthly average amount, natural frequency of rain is unlikely to be that dissimilar. Thus the annual average spill frequency for this period is unlikely to be less than the 20 spills recorded for this period of below average rainfall.

My previous indicative assessment for the annual average for the January/February period was 10. Because of the 34 spills in 2014 the annual average for January/February is unlikely to drop below 5.

Thus the indicative average annual spill frequency of Mogden is likely to be in the range 25 to 30 spills/year.

4. Mogden Sewage Treatment Works spill requirement

Mogden STW does not have a spill frequency in its consent to discharge.

I am grateful to Mr Simon Hughes of the Environment Agency for confirming in his email of 24th July that "*spills...alone is not regarded by the Environment Agency as either an indicator of the failure of the scheme ... or of Mogden STW to comply with the UWWTR*." Since the UWWTR apply to all sewerage systems then I presume that this Environment Agency criterion would apply to all sewerage systems.

This is amplified by his statement that "*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 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."*

Lord de Mauley, in his answer to 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."*

Thus, as I understand the Environment Agency's view, it is that, provided discharges do not cause significant adverse impact on the quality of a river, then spill frequency is not in itself relevant.

It is indeed heartening that the Environment Agency considers that Mogden STW now conforms with the UWWTD and all those involved should be proud. However this has occurred when Mogden STW spilled 54 times during the period April 2013 to March 2014 inclusive, with an indicative average annual spill frequency of 25 to 30 spills a year. Presumably such consideration can also be applied elsewhere.

5. Environment impact of Tideway spills.

The Environment Agency view is that, " *spills alone is not regarded by the Environment Agency as an indicator of failure*" and *provided spills have not caused a significant adverse*

impact on the quality of the river...overflow is regarded as satisfactory." So what are the potential adverse impacts of the Tideway CSO overflows on the Tideway?

The three environmental considerations identified by the TTSS for the Tideway are ecology, for which fish were taken as a surrogate, health of the river users, and aesthetics.

Fish

The Tideway water quality standards were set by the TTSS on the basis of the trials of the reaction to various dissolved oxygen conditions of a suite of fish species taken to represent those fish species present in the Tideway. The standards were set on the basis of the best information available at the time, but were somewhat subjective and arbitrary, there being no definitive number. In any case fish can withstand some mortality, generally thought to be 10% to 30% in the fish trials report, and remain sustainable.

The latest water quality modelling output is that shown by Thames Water in its Application for Development Consent doc 7.23 table 3.1 on page 10, see attachment. The main fish kill criterion is level 3 of 2mg/l for 1 tide. The required standard is once in 5 years, ie 8 events in 41 years of modelling. The model output for the current situation is 99 occasions, clearly nowhere near. The design criterion for the Tideway is not the current situation but the situation once the Lee tunnel and the STW upgrades are operational. My understanding is this will be within about half a year. The modelling shows that, once these improvements are operational, the number of modelled failures drops to 12 in the 41 year period. This is not that far different from the 8 failures in the standard. For instance, were the level 3 standard for fish kill to be changed from 1 in 5 years to 1 in 3 years then the post Lee tunnel situation would meet the required standard.

One would expect each breach of level 3 of dissolved oxygen, 2mg/l for 1 tide, to result in a fish kill in the Tideway. For the current situation the model predicts 99 such breaches in 41 years. The Environment Agency record of fish kills in the Tideway, sent to me on 13th January 2014, shows, for the CSOs and Abbey Mills spills, 3 fish kills in the previous 10 years, ie the equivalent of 12 fish kills over the 41 years of modelling. Whilst there might be a few more fish kills that occurred but were not recorded, fish kill events are more likely to occur in the summer when the river temperature is higher and the natural dissolved oxygen content lower, rather than in the winter. Then daylight hours are longer and thus fish kills are more visible. With the tidal excursion dead fish would move with the tide and be more likely to be seen somewhere.

Thus it would appear that the Tideway dissolved oxygen modelling considerably over estimates the number of fish kills, and hence the breaches of the standard. This could be because the standards or the modelling, or both, need revising. One reason could be that the most sensitive fish species in the representative fish suite was salmon. At the time salmon were stocked in the river and, in previous decades, several hundred had returned each year. Since 1997 the stocking regime changed and now stocking has ceased altogether such that returns are now in single figures, 2013 recording only 3 salmon. There is no record of any salmon spawning in the Thames in the last hundred years.

Thus it is quite likely that, with the revised standards/modelling needed to replicate actual fish kill conditions, that the post Lee tunnel/STW upgrade situation would meet the appropriate environmental criterion.

This is supported by the Environment Agency record for the last 10 years which shows only one fish kill, of only one fish, recorded as having been killed by spills from the Combined Sewer Overflows to be connected to the proposed Thames Tunnel. The current allowable standard level 3 is one breach/fish kill in five years. Thus the one recorded fish kill in 10 years would meet even the current standard for fish kill. Whilst several fish might have been

killed only one fish is recorded killed. Thus the actual Environment Agency record of fish kills shows that the Tideway CSOs already meet the critical level 3 fish kill criterion.

This latter analysis does not take account of the improvements to the upstream Mogden STW where an annual average spill frequency of over 100 spills has been reduced both in volume and to a frequency to about 25 to 30/year and is now classified as acceptable to the EA. Also it does not take account of the improvements in environmental water quality due to the other STW upgrades including Beckton and Crossness STWs, or the halving of the volume of spills into the Tideway from about 39Mm3/year to about 18 Mm3/year.

In view of the wide discrepancy between the modelled dissolved oxygen conditions and the actual failures/fish kills recorded, I recommend that, on completion of the Lee tunnel and the STW upgrades, monitoring of the dissolved oxygen conditions at selected points in the Tideway be undertaken before the government commits the public to paying for additional costly capital expenditure. This would be similar to the Mogden STW situation where the Environment Agency is monitoring the Tideway to confirm no significant environmental impact and hence compliance with the UWWTD. Thus one could demonstrate whether or not the Tideway tunnel would be needed to improve dissolved oxygen conditions and ensure no significant environmental impact.

Human health

The Tideway is not a bathing water and, for navigational reasons, the PLA has banned bathing in it except with a special licence requiring guard boats. Studies by the EA show the predominant use of the river as being rowers in the Chiswick/Putney area. The Health Protection Agency study showed rowers here to be ten times less susceptible to gastric events than the general population. Analysis by NERA using the NICE QALY methodology resulted in them concluding that, at most, it would be worthwhile spending £1.5m to cure all such events in rowers. The Minister stated in his letter of 24th February 2014 to Lord Berkeley that defra *"would expect a true valuation of the health benefit to be somewhat in excess of the QALY value."* Even if that were double, that would still be a very small number compared to the £4bn expenditure proposed.

Aesthetics.

The criterion for a CSO being classified as unsatisfactory for aesthetics, as set out in the DETR 1997 guidance on the UWWTD, is that it should have "*a history of justified public complaint*". The Environment Agency has stated that there were relatively few such complaints and this would have been when the classification was made in 2004 at a time when no remedial work had been proposed. The assessment by the Environment Agency was done on a theoretical basis with no actual field data quoted in the report.

Since then Thames Water have provided, and now operate, two litter collector boats, and say they are "*a real success story*" and "*greatly contributed to improving its environmental and aesthetic quality*".

If thought appropriate, floating booms could be placed around most of the CSOs, thus retaining much of the litter for collection by river craft. This is not a general in river scheme but an end of pipe scheme at the relevant CSO. The quotation for this work is less than £2million.

Conclusion

Thus, post the Lee tunnel and the STW upgrades, it would appear that, similarly to the current Mogden STW, storm discharges would not cause significant adverse impact on the quality of the river, and, in line with the Environment Agency statement about Mogden, the spills should be regarded as satisfactory under the terms of the UWWTD.

Thus, considering that it would appear that, post the completion of the Lee tunnel and the STW upgrades, the Tideway with up to about 50 CSO spills a year, not that dissimilar to the Mogden STW with 54 spills in 2013/14, could apparently meet the environmental aims of the Directive,

Lord de Mauley's letter to Lord Berkeley of 24th February states that "*we have no reason to believe that the Commission would view a spill limit of 20 in London as an acceptable way of meeting our obligations."* Considering the large potential future investment of some £4.2 bn (at 2011 prices, £4.5bn at 2014 prices), would it not be appropriate to demonstrate to the Commission the great improvement to be achieved shortly by the Lee tunnel and STW upgrades at a cost of over £1bn, and request that, based on the very limited environmental impact, consideration be given to an appropriate allowable spill frequency?

6. Measures to reduce spill frequency

Design conditions

The Thames Water model of the existing spill frequency shows CSOs spilling on average up to 50 times a year. The tunnel is shown as spilling 4 times a year on average. It would appear from the Review above that, post the completion of the Lee tunnel and the STW upgrades, the Tideway would meet the requirement of no significant environmental impact. Thus, with the Environment Agency's current approach, then the CSOs would meet the UWWTD as at Mogden.

However it is possible that the EC would still require the sewerage system to only spill during unusual rainfall conditions. Thus the limited environmental impact should be confirmed and an appropriate spill frequency discussed, and agreed with, the European Commission.

TTSSG studied stand alone schemes

The TTSSG, which I chaired, studied several alternatives which, by themselves, would be complete solutions. For instance for sewer separation we were provided by Thames Water with the cost of a completely new sewerage system in London which would then act as a separate sewer in parallel with the existing sewers. We did not consider a combination of measures for which I, as chairman, must take part of the blame. All these standalone systems were considerably more expensive than the then cost of the full length tunnel of £1.7bn. Thus at the end of phase 1 in 2003, we recommended the tunnel, and this was amplified in our final report in 2005.

Thames Water 2010 Needs report

In 2010 Thames Water (TW) published its Needs Report. In Appendix E it considered the alternative of Sustainable Urban Drainage Systems (SuDs) in the Putney area and concluded that SuDs would not reduce the spill frequency to below 10 spills a year and SuDs was rejected. Subsequently it was found that some of the sewer modelling output was wrong. Also, despite there being river terrace gravels in the area, the study team was instructed by TW to ignore the benefit of infiltration. There is also an instance where a very short length of new sewer could take storm water from being discharged to a combined sewer to discharging to the Beverly Brook, thus reducing the spill frequency of that CSO. Only the single measure SuDs solution was considered and no combination of measures.

Design flow conditions.

Thames Water, in its presentation to me on 30th September 2011, showed design sewer dry weather flows increasing in line with population increase, thus reducing spare flow capacity in the sewers and increasing spill frequency.

However Thames Water's Water Resources Management Plans show that, with demand management and increased metering, water supplied is reducing and is not expected to return to 2006 levels until the late 2030s, thus providing greater storm water capacity in the sewers than in 2006.

Remove restrictions

It is known that there are some restrictions in the London sewer network, one being the too small connection between the large Fleet sewer and the Northern Low Level Interceptor, resulting in a higher spill frequency for the Fleet CSO. Hamburg removed 80 restrictions to improve flow and reduce spills. London should do so also.

Sewer separation

Separation of the combined sewers into foul and storm sewers could be economical where there is a nearby discharge place. This could be near the banks of the Tideway where there is appreciable development taking place, near the tributaries such as the River Wandle or Lee, near the Regents Park Canal to which the storm water from the Liverpool Street redevelopment is due to be connected, near the existing Thames to Lee water transfer tunnel shafts or near an existing separate sewer system.

Technology development

Since 2003 technology has developed and international practice has switched away from tunnel solutions to sustainable drainage solutions. As an example see the EC Blueprint for Water and examples from the USA such as Philadelphia. In addition it would be sensible to adopt a combination of measures, using each where it was most cost effective.

At the time of the TTSS study there was little emphasis on energy use and greenhouse gas emissions due to its use. This is now required to be considered in new projects. The CSO discharges to the tunnel will require pumping out before the next storm arrives. This will mean pumping the annual average of about 19 Mm3 up an average height of about 60m. I can find nowhere where this appreciable energy use and that in constructing the tunnel has been assessed. In contrast surface measures, such as SuDs, will use minimal amounts of energy.

Real Time Control

The greatest impact on the water environment comes during summer thunderstorms. However these are relatively local with areas away having much less rainfall. The sewer network has many interconnections between the near horizontal west east interceptors and the much steeper storm relief sewers down the historic stream courses. The interconnections are fixed weirs put in as long ago as a century. Thus development, and hence storm runoff, may have changed much since then. The technology of Real Time Control/Active System Control has been developed in the last decade. This utilises rainfall radar to assess likely flows, in sewer censors, and moveable weirs to make maximum use of spare sewer capacity. In Quebec real time control alone reduced spills from 45 to 26 a year. I am told it is being implemented in Lisbon, Marseilles, Vienna and elsewhere. UKWIR report states that the Environment Agency "*requires it to be considered as part of the options appraisal stage of all schemes."* The feasibility, benefit and cost of this should be considered.

Sustainable Urban Drainage systems/Blue Green Infrastructure.

The technology now being used in many major cities elsewhere is Sustainable Urban Drainage Systems (SuDs). This involves systems for storing water locally such as roof gardens, swales, porous pavements, storage tanks under pavements and roads, etc.

There is terrace gravel under much of central London and this can be used for storm water infiltration. Bloomberg reported that, "*subject to some technical adjustments, SuDs infiltration could be developed across 67% of London's surface area.*" Infiltration has been excluded from previous analyses by Thames Water and the Environment Agency.

An extension, Blue Green Infrastructure includes the use of trees and other features to provide other benefits such as reducing temperature and improving health. The Mayor's recent London Infrastructure Plan consultation states on page 5 of the supporting document, *"green infrastructure is still not considered as infrastructure in its own right. A lock of a strategic London wide approach that makes investment decisions considering the whole range of benefits green infrastructure brings (drainage, shade, walk and cycle ways and much more) has resulted in below optimum investment*." As an instance in 2011 the city of Philadelphia created the green City, Clean Waters programme, a 25 year plan of approximately £1.5 bn to protect and enhance the city's water sheds by managing stormwater with innovative green infrastructure. The city estimates that the use of green infrastructure in lieu of traditional approaches will save around £4.7bn over the life of the programme.

Combination of measures

More information about the measures is given in my report Measures to protect the river environment from the adverse effects of waste water discharges, dated 13th April 2014.

Using the measures where they are each most economical should produce the most economical way of meeting the required spill frequency. Whilst the cost would depend on many factors, including the spill frequency to be achieved, it is likely that the cost of a combination of measures could be several £ billions less than the tunnel cost, £4.5bn at 2014 prices.

The DEFRA River Basin Planning Guidance Vol 2 August 2008 states in 9.4 that "*the Environment agency should consider the full range of measures which are available"* and in 9.*5 "The WFD requirement is to make judgements about the most cost-effective combination of measures, so it is important that the Environment Agency considers the interrelationship between measures."* The July 2014 update includes almost identical words but adds "*13.8 The Agencies should, where possible, use cost effectiveness analysis to determine the combination of measures that will achieve WFD objectives at the lowest cost."*

I can find no report where the Environment Agency has considered the full range of measures or a combination of measures or effectiveness analysis.

On requesting the Minister, Lord de Mauley, to have a study done of a combination of measures, he replied to Lord Berkeley on 24th February that he did not propose to ask the Environment Agency to consider an independent study of alternatives, or combinations of alternatives, to the Thames tunnel. This is in contrast to commonsense to ensure that the solution selected some 10 years ago is still the most appropriate and economical, and the DEFRA Guidance to study a combination of cost effective measures.

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Table 3.1 Scenario compliance against dissolved oxygen standards

Dissolved Oxygen Standard	1	2	3	4
Dissolved Oxygen concentration duration threshold	4 mg/l for 29 tides[1]	3 mg/l for 3 tides	2 mg/l for 1 tides	1.5 mg/l for 1 tides
Allowable exceedances in 41 years	41 (1:1 year)	13 (1:3 years)	8 (1:5 years)	4 (1:10 years)
Scenario modelled	**Maximum number of exceedances of thresholds**			
Existing System	**211**[2]	**193**	**99**	**60**
STW improvements and Lee Tunnel (2020)	**75**	**40**	**12**	**7**
STW improvements with Lee and Thames Tideway Tunnels (2020)	21	4	1	1

1. A tide is a single ebb or flood. Failure = predicted exceedances > allowable exceedances