Peter I have only had limited time to look thro' this & will discuss points with you further

David
26/5/88.

THE TIDEWAY STORM PROBLEM

MAY 1988

P.J.LLOYD

CONTENTS

I SUMMARY

The report summarises the present position with regard to the Tideway storm problem and re-evaluates some of the potential solutions. The scale of the problem is defined and, overall, the conclusions are that it is difficult to perceive of a more effective solution than the Thames Bubbler option. It is unlikely that further research into the problem could change this conclusion.

It is also suggested that there is a need for greater clarity of, and commitment to, a future strategy for pollution control management of the Tideway.

NRA
WSPLC

II INTRODUCTION

This report has been prepared to provide some basic information concerning the Tideway, Thames Bubbler and storm sewage discharges in response to, what appears to be, an increasing lack of clarity and degree of uncertainty regarding the present position and future strategy

Set out facts

As a general theme throughout the report it is hoped to demonstrate and expand on the following points:

(a) There are fewer gaps in our understanding of the problems and more information available than is generally appreciated.

(b) To fill those remaining gaps in our knowledge would be a task of the utmost complexity, requiring extreme resource inputs.

(c) The acquisition of additional information is unlikely, at the end of the day, to prove to be of particular benefit. It is a fairly simple task to make a number of assumptions as to the possible outcome of such data acquisition and to demonstrate that any consequential decisions would lead us along a similar path to the existing.

III THE PROBLEM

At times of prolonged and/or intense rainfall the Tideway receives greatly increased Effective Oxygen Loads (EOL) which cause rapid depletion of dissolved oxygen (DO) to such an extent that fish mortality may result.

These EOL loads arise from three main sources:

(a) Freshwater tributaries
(b) Sewage Treatment Works (STW)
(c) Storm sewage discharges

All parts of the Tideway between Teddington and Gravesend can be affected to different degrees but generally there are two main areas of vulnerability:

(a) Upper Reaches, Hammersmith to Westminster
(b) Middle Reaches, Woolwich to Purfleet

The existence of these vulnerable areas is partly due to the location of the polluting discharges and partly due to the general physical and topographical characteristics of the estuary.

year are measurable demonstrable

For much of the time additional storm loadings to the Tideway can be accommodated without serious effect. The Upper Reaches are particularly sensitive at times of low upland flow, this is due to the relatively small volumes of water present and the extremely slow net seaward movement. In this respect these areas of the Tideway react in a manner not dissimilar to a static lake or canal. Tidal movement merely serves to cause oscillation of segments of water without providing mixing or dilution.

It is interesting to reflect on the likely effects of a totally separate sewerage system on the Tideway. Information on the quality of run-off from other highly urbanised areas suggests that problems would result even without the presence of sewage in the discharge.

<u>Freshwater Tributaries</u>

rapidly

At times of heavy rainfall most of the freshwater tributaries of the Tideway respond fairly quickly and discharge greatly increased polluting loads. Much of this extra load is simply due to urban run-off, but some rivers receive direct discharges of storm sewage and those to which STW's discharge are affected by storm tank discharges and often inferior effluent due to storm conditions.

The extra flow produced by these rivers is not normally of sufficient magnitude to significantly affect retention times in the Tideway. The overall effect caused by the rivers is therefore detrimental.

Various attempts have been made to assess the changes in quality of these rivers during times of storm and to quantify the effect on the Tideway. Automatic samplers have been installed on the Rivers Brent and Wandle and estimates obtained of EOL loadings for different storms. The high level of variability of the results obtained, differences between individual storms and potential sampling error cause doubts as to the worth of such an exercise.

In general however some assumptions and approximations can be made concerning the significance of these rivers during times of storms. For example, one particular storm in 1979 resulted in an estimated load of 50 tonnes of EOL being discharged from the River Brent. This compares with 32 tonnes of EOL from Western Pumping Station for the same storm.

Sewage Treatment Works

All of the larger Tideway STW's experience difficulties, to varying degrees, during times of storm. All discharge greatly increased loads to the river (even if concentrations of pollutants remain similar). ? St. tanks [illegible]

Mogden cannot cope hydraulically with dry weather flow. Storm flows are given tank treatment but the final effluent is, as would be expected, vastly inferior to normal performance with BOD concentrations rising to 30 (compared to normal DWF values of less than 10).

Although much of Beckton's sewage flow never arrives at the works - being discharged at various upstream pumping stations and storm reliefs - the hydraulic effects at Beckton can be very severe. As a result activated sludge is often lost to the river and the additional polluting load discharged is extremely high. BOD concentrations can be greater than 50 compared to dry weather values of less than 10.

The performance of Crossness is also extremely variable at times of storm. The existing storm tanks probably serve no useful purpose due to lack of de-sludging and occasionally high levels of solids are discharged with the treated effluent.

The performance of the STW's at times of storm is of great significance to the overall problem.

Storm Sewage Discharges

A reasonable estimate of the quantity of storm sewage discharged from all of the pumping stations is available from pump ratings and duration times. Automatic samplers were also utilised at these stations for a period of many years and much information is available regarding strength of storm sewage from individual stations. Generally BOD values range from 30 to 130 and ammonia from 2 to 10.

The quantity and quality of the discharges from the gravity outfalls has been estimated by visual flow assessment and the taking of spot samples. This information is obviously less reliable than that for the pumped discharges but does, nevertheless, provide an approximate indication of the scale of the problem. The quality of the discharges is similar to that from the pumping stations but flows are much less.

There are enormous problems in obtaining precise information on the loads of storm sewage discharged to the river. The quality of each discharge changes rapidly throughout the storm and spot samples can give quite misleading results even if large numbers of samples are obtained. Sampling errors are of an extremely high magnitude and automatic samplers, due to the presence of solid material, cannot be expected to give accurate results. Each individual storm will give a different pattern of flow and different sewer velocities will be created resulting in different scouring effects.

The large area involved and the complexity of the sewerage system make it impossible to slot rainfall events into precise categories. It is to be expected that apparently similar total rainfall quantities will create completely different patterns of discharge from the outfalls.

The overall result of these complexities is that complete knowledge of the loads discharged can only be obtained by the most detailed and intense study of all the discharges and information gained for one particular event will be of little use for predicting the likely course of a different event.

Tables 1-3 show the 'normal' and storm flows discharging to the Tideway from all sources.

Tables 1-3 STORM FLOWS DISCHARGED TO TIDEWAY

Table 1 SEWAGE TREATMENT WORKS

S.T.W.	Normal Flow Total Daily Discharge (m^3)	Storm Flow Total Daily Discharge (m^3)
Hogsmill	40,000	80,000
Mogden	500,000	1,800,000
Kew	40,000	50,000
Beckton	1,000,000	1,600,000
Crossness	590,000	1,300,000
Riverside	115,000	200,000
Long Reach	190,000	260,000
TOTALS	2,475,000	5,290,000

Table 1 TRIBUTARIES

RIVER	Normal Flow Total Daily Discharge (m^3)	Storm Flow Total Daily Discharge (m^3)
Crane	26,000	432,000
Dukes	17,000	86,000
Brent	17,000	605,000
Beverley	26,000	346,000
Wandle	173,000	432,000
Lea	432,000	3,110,000
Roding	26,000	864,000
Ravensbourne	26,000	173,000
TOTALS	743,000	6,048,000

Table 3 STORM SEWAGE DISCHARGES

LOCATION	Normal Flow Total Daily Discharge (m^3)	Storm Flow Total Daily Discharge (m^3)
Hammersmith	Nil	498,000
Lots Road	Nil	302,000
Western	Nil	384,000
Falcon Brook	Nil	85,000
Heathwall	Nil	140,000
Earl	Nil	61,000
Shad Thames	Nil	186,000
Isle of Dogs	Nil	113,000
Greenwich	Nil	586,000
Abbey Mills	Nil	803,000
N.Woolwich	Nil	92,000
Gascoigne Road	Nil	38,000
Folkestone Road	Nil	125,000
Canning Town	Nil	49,000
N.Western	Nil	60,000
Fleet	Nil	50,000
Brixton	Nil	43,000
Clapham	Nil	45,000
South Western	Nil	30,000
Ranelagh	Nil	35,000
Wandle Valley	Nil	22,000
Acton	Nil	86,000
Charlton	Nil	83,000
Deptford	Nil	90,000
Holloway	Nil	21,000
N.Eastern	Nil	43,000
TOTALS	Nil	4,070,000

Totals from all sources: Normal Flow - 3,218,000 m^3
Storm Flow - 15,348,000 m^3

Summary:-	Normal Flow	Storm Flow
Stw		
Rivers		
Storm Sewage		
Total.		

Observed and Predicted Effects

In order to test the accuracy of our limited knowledge a detailed study has been made of some storm events in 1987. A simple computer model was used to calculate the amount of oxygen lost from the Upper Reaches after the storm event using sag curves derived from monitoring station data.

Best available data for the loads discharged to the river was also input and the oxygen uptake calculated. Table 4 shows the results obtained. The complex nature of this type of exercise and the potential errors at each one of a large number of stages make it impossible to regard the final result with either satisfaction or despondency. All that can be concluded is that we are probably broadly on the right lines and that the best available data which was used may not be too wayward.

Table 4 COMPARISON OF OBSERVED AND PREDICTED OXYGEN LOSSES

DATE: 29.7.87

	HOURS AFTER STORM EVENT				
	12	18	24	30	36
Oxygen Lost (Observed) (tonnes)	12	26	32	37	44
Oxygen Lost (Predicted) (tonnes)	22	32	43	49	56

DATE: 25.8.87

	HOURS AFTER STORM EVENT				
	12	18	24	30	36
Oxygen Lost (Observed) (tonnes)	21	32	37	39	47
Oxygen Lost (Predicted) (tonnes)	30	43	58	66	76
Oxygen Lost (predicted) including allowance for Thames Bubbler input	26	37	59	56	64

Thames Bubbler was in operation for the second storm (25.8.87) and the last line of predicted values includes an allowance for the input of oxygen from this source.

IV THE SOLUTION

The first major storm sewage fish kill occurred in 1973 and was followed by another mortality in 1977. After much deliberation it was concluded that the mobile oxygenation solution, being the most cost effective, should be pursued. The first experimental 10 tonne unit was commissioned in 1980 and became the "Thames Bubbler". The detailed performance of the unit need not be considered in detail as part of this report but it is generally recognised that fish mortalities would have occurred in 1981, 1984 and 1987 but for the use of the "Bubbler".

It is, however, relevant to consider again the range of possible solutions that could be applied to the Tideway storm problem.

Basically solutions fit into three main categories:

1 Reducing the overall loads discharged.
2. Maintaining greater quantities of DO reserves.
3. Oxygenating the river.

1. Reductions in load discharged

One of the problems attached to solutions involving the reduction in loads discharged to the river is the variability of quantities discharged from individual locations because of the different rainfall patterns. Therefore, the facility to store, for example, 50,000 m^3 at Western need not prove beneficial for an extreme West London storm when there may be a need to store at Mogden, and no discharge is made from Western.

Reductions in load could be achieved by reducing either volume or strength of discharges from rivers, STW's or storm sewage discharges.

There are obvious fundamental problems in reducing loads discharged from rivers and it is difficult to envisage a scheme that could have any significant impact on a river like the Brent where most of the pollution load arises simply from urban run-off. Flows in the River Brent may rise from 0.2 to 5 cumecs during times of storm.

It is always possible to suggest improvements at sewage treatment works. Additional capacity, storm tanks, and hydraulic modifications could all result in reduced loads being discharged to the river. The scale of the problem does, however, need to be appreciated. For example, Mogden STW may discharge an extra 1,000,000 m^3 during times of storm. Existing tank capacity at the works is 90,000 m^3. To significantly reduce the quantity discharged to the river or to supply additional treatment to the storm flows would be an enormously expensive undertaking, notwithstanding practical implications of space.

Various methods for reducing storm sewage loads have been considered previously and are briefly discussed below.

(a) New trunk sewers and associated pumping stations could be built to transport the storm flows to Beckton and Crossness. Apart from the expense and disturbance factors, consideration must be given to the ultimate fate of the storm sewage. No part of the river above Gravesend has spare capacity during times of storm. The removal of discharges from the Upper Reaches, whilst giving great benefit to this area could therefore simply transfer the problem down river. The storm sewage would either have to be conveyed beyond Gravesend or treated before discharge. Treatment would have to be supplied by new works since there is no available capacity at Beckton and Crossness during times of storm.

(b) The use of storage tanks and tank sewers to (temporarily) store storm flows would again be an extremely costly option, having regard to the quantities of storage required. It would also be necessary to incorporate storage at many sites to ensure that cover was available where needed according to the pattern and path of the storm. To be sure of significantly reducing the impact of storm discharges, it may be necessary to store 1,000,000 m^3.

(c) Reduction in strength of storm sewage could theoretically be achieved by more regular desilting of sewers. It may be the case that high polluting loads arise due to scouring of sewers. It is a fact, however, that when a major rainfall event occurs shortly after a previous event there is no evidence of reduced loads being discharged to the river.

(d) It has been suggested that greater control and understanding of the sewerage system could lead to increased optimisation by utilising spare sewer capacity, where available, and that this would lead to fewer discharges to the river. [It is true that] for many of the minor rainfall events some sewers have spare capacity. For the really big events, however, the whole of the sewerage system is totally overloaded and no amount of added sophistication would make any significant difference to the quantities discharged to the river. An additional 9,000,000 m^3 of storm run-off enters the sewerage system at times of severe storm.

(e) Consideration has also been given to small scale local works to improve weir settings, retain more solids within the system and prevent premature discharge. Similar reservations apply as to the previous case, i.e. the effect of any such improvement would be totally insignificant for major events.

2. Increasing DO reserves

The fundamental problem attached to this solution is that it is impossible to predict the onset of a major event until it has actually happened. This means that DO reserves must be maintained at a high level throughout the entire period when the river is considered to be vulnerable. DO reserves in the Upper Reaches could be significantly improved by maintaining a flow of 40-50 cumecs over Teddington Weir and by providing complete nitrification at Mogden.

rate of oxygen depletion - hours

Increasing Teddington flow after the storm should only be regarded as a partial solution. The small beneficial effect that results from reducing retention times in the Upper Reaches is not sufficient to prevent serious oxygen depletion from occurring. In the middle reaches additional freshwater flow has much less impact and DO reserves could only be significantly enhanced by better effluent quality being provided from Beckton, Crossness or Long Reach. Severe storms in the upper reaches can reduce D.O. levels by 60-70% saturation.

3. Oxygenation of River

Oxygenation can be considered as a natural progression from the above option and could be used to maintain higher levels of DO prior to the storm. Provided that sufficient injection capacity is available and that a speedy response is possible it is, however, obviously more efficient to delay oxygenation until it is necessary after the occurrence of the storm. The provision of a mobile oxygenation source also provides the flexibility to overcome the uncertainties created by the variable nature of individual storms. The river can be treated precisely where and when required.

The oxygenation of polluted water bodies is generally considered, worldwide, to be a scientifically sound and acceptable process. Experience gained with the "Thames Bubbler" has shown that this option provides a satisfactory solution to the problems of storm discharges to the Tideway.

If it is assumed that the new Bubbler will dissolve 20 tonnes of oxygen per day this is equivalent to the oxygen demand exerted by 439,000 m^3 of storm sewage (this is equal to two thirds of the total amount of storm sewage discharged on the 5th July 1986).

The most commonly used arguments against the oxygenation option are that it treats the symptoms of the disease rather than the disease itself and that it is wrong, in principle, to allow storm sewage to be discharged to the river. It is difficult to enter into the realms of philosophical discussion that such arguments entail but a detailed knowledge and understanding of the storm problem tends to make it difficult to view the case in black and white and as a deep matter of principle. The effect on the Tideway is a cumulative problem created by run-off, storm sewage and treated sewage effluent. These three components do not differ markedly from each other. Strong run-off can be more polluting than weak storm sewage. It is difficult to argue that storm sewage is unacceptable in principle when such discharges occur in many other rivers in the Authority's area. No solution to the Tideway problem could realistically remove all storm sewage discharges. It could also be argued that the "disease" is really the depression of DO levels caused at times of storm and that provided this is treated then the symptoms (dead fish) would not occur.

Figure 1 illustrates the effect of the storm loads in comparison to the input of oxygen from the Thames Bubbler.

follows p16

OTHER SOLUTIONS

The scale of the Tideway storm problem is immense and the complexities of all the different components enormous. It would be foolish to suggest that no other solution exists but it is equally inconceivable that the problem could be resolved without great practical difficulty and huge financial investment. Quite simply there is nothing that can prevent the formation of large quantities of contaminated water during times of storm. There is very little prospect of preventing the bulk of this water from reaching the Tideway and the nature of the Tideway is such that consequential reductions in dissolved oxygen levels are inevitable.

Perhaps, not unnaturally, there is often a degree of optimism when faced with a problem of this magnitude. The hope is that there may be a solution, as yet unseen and totally unperceived, that will be politically acceptable, scientifically sound and cost very little money. All we have to do is keep looking and collecting data.

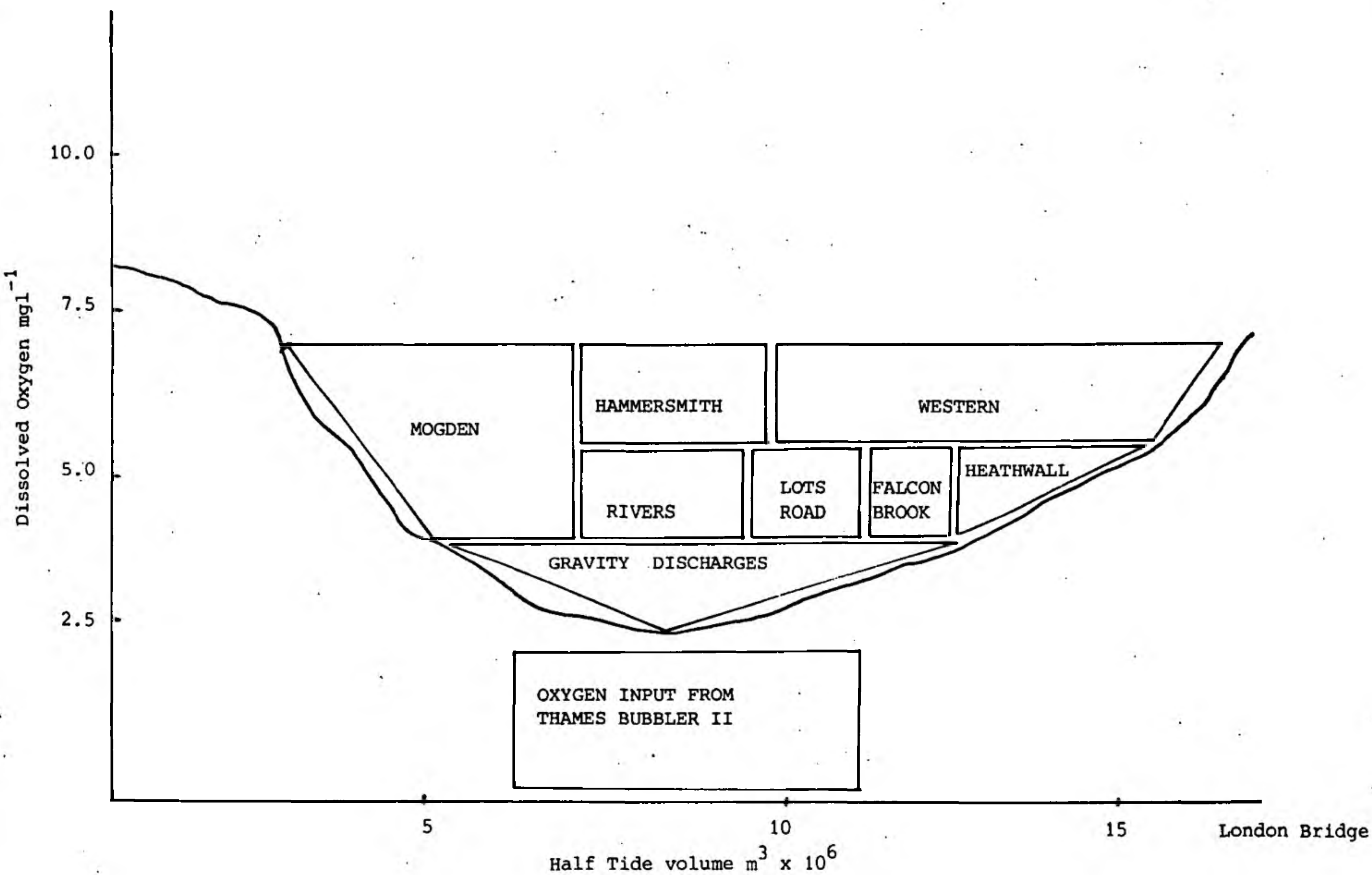
THE THAMES BUBBLER STRATEGY

It is important to be aware of the implications of the adoption of the oxygenation strategy if the advantages that such a solution offers are to be fully exploited. One of the principle attractions that the Bubbler offers is its total flexibility. It can respond to DO problems in any part of the river however they are caused. One of the benefits that this flexibility offers is that it becomes unnecessary to know precise details of volumes, strength and location of the causative polluting discharges. Whatever the variable cumulative effect of the discharges the Bubbler can provide the required degree of response.

An integral part of the Bubbler strategy is a comprehensive and reliable system for detecting problem areas in the river, for initiating the call out of the Bubbler and for ensuring its correct deployment. These systems not only ensure that the Bubbler is used when required but also capitalise on the cost effectiveness of this option by preventing unnecessary operations.

Figure 1 Diagramatic Representation of Storm Effects on Upper Tideway Sag Curve

D.O. is plotted against volume, area of sag is therefore tonnes of oxygen



V TIDEWAY STRATEGY

It is vital to have a clear strategy that is understood and accepted by all. Changes may be necessary as knowledge is extended and further information comes to light. Financial restrictions may at times cause some deviations to occur but unless a general framework and logical approach to the Tideway problem is adopted it will be impossible to make progress.

If the "Thames Bubbler II" is to be the final long term solution to the Tideway problem then it becomes unnecessary to pursue investigation into other solutions. If, however, it is intended that the Bubbler solution is only a partial or medium short term measure then it is necessary to know more about the reasons for this approach. If, for example, there is concern over the possible reliability of Bubbler II and a secondary line of defence is required, then a specific series of proposals could be made. // by whom? If there is any question of political unacceptability of the storm outfalls then an entirely different solution may be necessary. Some potential options may require detailed studies and research, others may not. Until all the reasons and requirements are made clear there can be no definitive strategy and there will be confusion, lack of progress and wasted resources.

Sewerage - prevention of flooding
- public health
- "fail-safe" system.
- maintenance & structure.

Biota monitoring
- stress effects
- opportunity to move in case of fish.
- insufficient known about requirements or movements of salmon.

VI CONCLUSIONS

1. The Tideway storm problem involves discharges that are of such a magnitude that there is no simple method of dealing with them. All solutions require massive capital expenditure.

except Bubbler

2. The variability of the problem also creates difficulties in carrying out work at specific locations since, depending upon the type of rainfall event, the effect of an individual discharge could vary from being insignificant to paramount.

3. There are still gaps in our TW's total knowledge of the system but * it is difficult to envisage how the acquisition of further data could be of practical benefit.

4. Although at the time that the Bubbler option originated there was only a very general understanding of the problem, the more knowledge that is acquired the more appropriate would appear to be the choice of this solution. The inherent flexibility of the Bubbler option ensures that the storm problem is tackled when and where required. All effects on the river that occur can be dealt with regardless of our lack of total understanding of the individual components of the effect.

5. There is a high risk in seeking to find new solutions that large amounts of money could be diverted to projects which are only of marginal value and make no real significant contribution at times of really big storm events.

6. There is a need to have a clear understanding of the future Tideway strategy.

* at the expense of collecting info on the river + improving data (operational)
Bubbler has finite chance of failure - so do other systems. What reliability wanted 100% ?!