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REPORT FOR ANGLIAN WATER, NRA
UNIT ON THE USES OF THE ORWELL AND
THE STOUR ESTUARIES AND THE USE
OF THE MATHEMATICAL MODEL TO
DERIVE LONG TERM CONSENT LIMITS
FOR ALL INPUTS TO THE ORWELL
ESTUARY

C.J. PENNEY

APRIL 1989

*National Rivers Authority
Anglian Region*

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ENVIRONMENT AGENCY



102605

MEMORANDUM

FROM: Environmental Manager (East)

TO: Asst. Chief Scientist (Planning)

April 20, 1990

LETTER FROM AWS ON MONITORING OF LONG SEA OUTFALLS

Referring to your memo. dated 11th. January 1990, I attach a further five documents. These are spare copies and do not require copying.

BV Good.

SUMMARY

A survey of the Orwell and Stour Estuaries was undertaken to assess the major uses of the estuaries.

This showed that they are both used extensively for commercial fishing including a number of small scale Shell fisheries with potential stocks for a developing industry.

Watersports, mainly sailing occur in both estuaries with an increasing interest in sailboarding in the Orwell Estuary, which also contains the majority of dinghy sailing.

Both estuaries are especially important for wintering waders and wildfowl with several species of National and International importance recorded. The Orwell and Stour Estuaries are both sites of Special Scientific Interest, and the Stour contains a large RSPB nature reserve.

Taking into consideration its uses and present quality it was agreed to set the long term Environmental Quality Specification to achieve Class B from the freshwater limit (Horseshoe Weir) to Pin Mill and Class A from Pin Mill to the Estuary Mouth.

To achieve this the following EQS limits are proposed:-

| | | | | |
|-------|----------|----------|---|----------------------------|
| B.O.D | 6 mg/l | 95 %tile | - | entire length |
| NH3 | 1.5 mg/l | " | - | entire length |
| D.O | 40% sat. | 5 %tile | - | Horseshoe Weir to Pin Mill |
| D.O | 60% sat. | " | - | Pin Mill to Estuary Mouth |

The Orwell estuary model was used to assess the resulting estuary water quality with different effluent flows and qualities and so used to propose Long Term Consent limits for the major discharges.

Proposed consents:-

| DISCHARGE | FLOW | | B.O.D | NH3 |
|------------|------|------|-------|-----|
| | tcmd | | mg/l | |
| Cliff Quay | 30 | DWF | 200 | 45 |
| Burtens | 0.06 | Mean | 250 | 12 |
| Pauls | 0.47 | " | 250 | 7 |
| B.S.C | 1.49 | " | 250 | 40 |

It is proposed that should the volumes discharged alter then the consent is recalculated to maintain the same load. A matrix of consents for Cliff Quay STW for different flows has been calculated.

The Ipswich B.C. sewage model was assessed and the relevant data extracted to enable the Storm Water Overflows to be added to the Orwell model. The alterations to the computer programme were undertaken by the staff at Anglian Water NRA unit Headquarters at Peterborough.

Due to the complexity of this task and the need of more detailed information on the SWO discharges, currently being produced by WRc, further work is needed to completely assess the impact of the SWO and set consent limits for them.

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1. INTRODUCTION

- 1.1. The Water Research Centre (WRc) were contacted by Anglian Water and asked to provide mathematical models to assist them in determining consent conditions for discharges to the Orwell Estuary relevant to the appropriate quality objectives.

WRc produced a one-dimensional model as data indicated that most of the estuary was not appreciably stratified under normal low freshwater flow conditions. Water quality determinants are predicted as averages over the cross section of the estuary. Intensive fixed - point surveys were carried out by Anglian Water in June and December 1986 to provide data to calibrate and validate the model.

Three types of model were produced - a hydrodynamic model to calculate water levels and water movements, a water quality model to predict the distributions of Dissolved Oxygen and associated substances and a model to predict the distribution of faecal coliforms.

After initial calibration and validation by WRc the Mathematical Model of the Orwell Estuary was transferred to Anglian Water in 1987.

- 1.2. In order for the model to be used to determine consent conditions for discharges Anglian Water adapted the model to include a "Monte Carlo" type procedure to estimate consent conditions in statistical terms.

- 1.3. To enable the model to be used for its design purpose it was felt that further evaluation of the model would be needed and a report on the appraisal and evaluation of the model was produced in 1988. This report went some way in establishing Environmental Quality Standards and levels of discharge qualities needed to achieve them and started to look at the possibility of including Storm Water Overflows in the model, But it was evident that further work was still needed.
- 1.4. This report includes the assessment of the location and extent of the uses of the Orwell and Stour Estuaries, with reference to commercial fisheries and shell fisheries, to enable Environmental Quality Objectives to be agreed. To use the mathematical model to derive long term consent limits, for all the inputs to the Orwell estuary, to ensure compliance with EQO's set to protect the estuary uses. The inclusion of the storm sewage discharges (SWO) into the estuary model using data from the WASSP model of Ipswich sewerage system so that the model can be used to derive the consent limits to be applied to the SWO's.

2. ESTUARY USES

2.1. The Orwell and Stour estuaries are used extensively both commercially and for pleasure. To gain a clearer picture of the extent of these uses various people and organisations were contacted.

The major uses were divided into three groups:-

- (1) Fisheries
- (2) Water Sports and Recreation
- (3) Wildlife

2.2. FISHERIES

Information was obtained from local fishermen and the Eastern Sea Fisheries Committee on the extent of commercial fisheries and location of viable stocks of shellfish.

There are a number of small scale fisheries in the Orwell and Stour. The main species caught are Mullet, Sole and Eels. The shellfish are harvested on an informal basis with a few fishermen making a part time living by hand raking. There are sufficient stocks in some areas to make suction dredging viable but this has not been allowed due to the environmental damage caused.

TABLE 1 - Lists the species caught in the Orwell and Stour Estuaries.

TABLE 2 - Lists the Shellfish harvested in the Orwell and Stour Estuaries.

2.2. FISHERIES

TABLE 3 - Estimated stocks of shellfish in the Orwell Estuary.

All the information obtained on the fisheries is summarised in MAP 1.

2.3. WATERSPORTS AND RECREATION

The main recreational use of the Orwell and Stour Estuaries is sailing, both cruising and dinghy racing. There are water-ski areas in both estuaries but their use is restricted to high tides. Sailboards are becoming increasingly popular and Oysterworld Watersports centre run residential sailboard courses on the Orwell and sail from Ipswich wet dock to Levington Marina.

TABLE 4 - Summary of Yacht Club activities.

There is pedestrian access to the waterside at various points along both banks of the estuary, particularly at Nacton where Suffolk C.C. have purchased a length of river frontage which they are promoting as an amenity area. Mainly for walking and picnics but at high tide swimming and sailboarding are possible.

The information obtained on watersports and recreation is summarised in MAP 2.

2.4. WILDLIFE

The Orwell and the Stour Estuaries are sites of special scientific interest (SSSI). This is because of the large populations of overwintering waders and wildfowl in both estuaries, several of which are of National or International importance.

2.4. WILDLIFE

A site is considered to be of International importance if it regularly holds 1% of the total population of a particular species found in a discrete geographical population. The waders and wildfowl in Britain belong to the overwintering Western European populations. Similarly a site that regularly holds 1% of the total National population is considered to be Nationally important. (Ref: Report by Suffolk Wildlife Trust 1988.)

The Suffolk Wildlife Trust record numbers of waders and wildfowl feeding at low water and their records were used to compile tables 5, 6 & 7. (Pers comm.)

TABLE 5 - Numbers of Internationally and Nationally significant species recorded feeding in the Orwell Estuary, 19th Dec 1988.

TABLE 6 - Numbers of Internationally and Nationally significant species recorded feeding in the Stour Estuary, 18th Dec 1988.

TABLE 7 - Total number of all waders and wildfowl recorded feeding during one complete survey of the Orwell and Stour Estuaries in December 1988.

These counts show that both the Orwell and the Stour are important for wildlife, particularly the North bank of the Orwell and Copperas Bay in the Stour which is an R.S.P.B. Reserve area and Bird Sanctuary.

MAP 3 - Shows the distribution of wintering waders and wildfowl of International and National importance.

3. ENVIRONMENTAL QUALITY STANDARDS - ORWELL ESTUARY

3.1. The Orwell estuary is currently classed from D to A in the CEWP classification as follows:-

- D - Horseshoe Weir to Cliff Quay
- C - Cliff Quay to Orwell Bridge
- B - Orwell Bridge to Pin Mill
- A - Pin Mill to Estuary Mouth

This must be improved and it is proposed that the long long term quality objective should be divided into two stretches:-

- 1: Horseshoe Weir to Pin Mill - Class B
- 2: Pin Mill to Estuary Mouth - Class A

To achieve this it is proposed that the following E.Q.S 's are applied :-

| | |
|------------------|----------------------------------|
| AMMONIA | - 1.5 mg/l 95 percentile |
| B.O.D. | - 6.0 mg/l 95 percentile |
| DISSOLVED OXYGEN | - 40% 5 percentile for stretch 1 |
| DISSOLVED OXYGEN | - 60% 5 percentile for stretch 2 |

3.2. The ammonia limit was derived from consultation with Water Quality staff of Anglian Water who have experience of other estuaries which support good fisheries and taking into account the fresh water EQS for a coarse fishery.

A minimum of 40% dissolved oxygen will also allow the maintenance of a fishery and will prevent objectionable conditions occurring in the upper stretches. It is also sufficient to enable the top section of the estuary to achieve a class B.

The B.O.D. standard has been included for the following reasons:-

- (i) Easier auditing of water quality.
- (ii) Analogy with fresh water rivers.
- (iii) To use with the Estuary model to give confidence to the dissolved oxygen results.

3.3. BACTERIOLOGICAL QUALITY

At present there is no agreed bacteriological standard for the Orwell estuary.

The identification of uses of the estuary showed that Water contact sports occur from the Lock Gates at Ipswich to Shotley Point, including some swimming at Nacton Amenity Beach.

Also viable stocks of shellfish occur from the Orwell Bridge to Shotley Point. These are currently harvested on a small scale by hand raking.

If a coliform standard is applied these uses should be considered.

4. DATA TO BE USED TO DERIVE LONG TERM CONSENT LIMITS FOR ALL INPUTS TO THE ORWELL ESTUARY

To use the model to determine consent limits certain parameters in the model must remain unchanged. The appraisal report (March 1988) validated some of the parameters but additional refinement was needed. The following sections explain the values used.

4.1. WATER QUALITY

4.1.1. BOUNDARY VALUES FOR EACH END OF THE ESTUARY

Incoming water from the river Gipping is assumed to achieve the long term objective as class 1B, with values calculated to put it in the middle of the NWC class. B.O.D. and Ammonia were calculated from the mid point of the 95 - percentile values.

For Dissolved Oxygen a 5 - percentile of 70% saturation was required, a review of 1988 annual statistics for rivers in the area was used to obtain suitable figures.

Seaward boundary quality was estimated from past annual statistics of routine sampling by Anglian Water at Felixstowe.

TABLE 8 - Lists the boundary values for each end of the estuary.

These values result in the quality of incoming water being 0.48 mg/l for NH₃ and 3.8 mg/l for B.O.D. as 95-percentiles and Dissolved Oxygen of 69.5% saturation as a 5-percentile.

4.1.2. BELSTEAD BROOK

As for the river Gipping it is assumed to achieve its RQO as a class 1B river, with values calculated to put it in the middle of the NWC class.

For the Belstead Brook the model requires the Dissolved Oxygen value in mg/l. At temperatures of 16-17 °C they are equivalent, as temperatures recorded occur in this range it was assumed that a D.O of 85% = 8.5 mg/l.

TABLE 9 - Lists the water quality concentrations for the Belstead Brook.

4.2. EFFLUENT QUALITIES

4.2.1. STORM WATER OVERFLOWS

Due to the nature of storm water overflows (SWO) there can be little control over the quality of these effluents.

In the absence of specific monitored data from SWO 's it has been necessary to estimate polluting load. Cliff Quay Sewage works data for 1986/87 has been utilised as to the strength of sewage and a correcting factor applied to take account of the differing quality of storm sewage. (From WRC report SRM-II)

TABLE 10 - Calculation of the Mean Storm Sewage Concentration.

The Mean and S.D of the SWO 's can be estimated from table 10 as :-

| | X | S.D |
|-------|-----|-------|
| B.O.D | 163 | 54.30 |
| NH3 | 11 | 3.70 |

4.2.2. FELIXSTOWE STW.

Those used in the appraisal report, taken from the model as handed over by WRc do not bear any resemblance to the effluent quality from Felixstowe. Updated values for BOD and Ammonia are required. The statistical summary of samples taken in 1987 have been used.

TABLE 11 - Lists the Effluent quality from Felixstowe STW

4.3. RIVER FLOWS

4.3.1. TIDAL LIMIT

The flow of the river Gipping is gauged at Constantine weir. From the flow duration curve for Jan 84 - Dec 84 :-

| | |
|---------------|------------|
| MEAN FLOW | 1.3 CUMECS |
| 95 % LOW FLOW | 0.2 CUMECS |

4.3.2. BELSTEAD BROOK

The Belstead Brook is gauged near Belstead Bridge which is upstream of Chantry STW so some additional flow must be added to allow for this.

River flows were obtained from the flow duration curve for Jan 84 - Dec 84.

Chantry STW flow from 1988 monthly mean daily flows.

4.3.2. Calculation of the flow from the Belstead Brook into the Orwell Estuary :-

| | BELSTEAD BROOK | CHANTRY STW | ESTIMATED FLOW INTO ORWELL ESTUARY |
|---------------------|-------------------|----------------|--|
| MEAN | 0.16 | 0.05 | 0.21 |
| 95 % LOW FLOW | 0.056 | | |
| SD | 0.082 | 0.02 | 0.07 |
| ALL FLOWS IN CUMECS | | | |

The Flows from all the discharges are summarised in TABLE 12.

4.4. INDUSTRIAL DISCHARGES

4.4.1. BURTONS

This discharge is not gauged, it discharges at all stages of the tidal cycle. The effluent is a combination of uncontaminated cooling water (intermittent) and jam condenser water plus floor washings and some roof drainage. A submersible pump cuts in when the collecting sump is full.

An informed guess of the volume discharged is 55 m³/day per day.

The values suggested for use in the model are :-

MEAN = 0.06 TCMD S.D = 0.02

4.4.2. PAULS

The actual discharge is not metered but the water used for production is. By back calculating from the 1988 monthly water usage figures the flows are :-

$$\text{MEAN} = 0.47 \text{ TCMD} \quad \text{S.D} = 0.04$$

4.2.2.

The discharge volume from Pauls is unlikely to increase in the near future as the plant is used at maximum capacity.

This discharge is mainly steeping water from barley, released in batches. A total of 9 batches in 24 hours but from two different production lines so batches could coincide.

Intermittent discharges of this nature cannot easily be incorporated into the model so the total volume discharged in 24 hours is used and the discharge assumed to be continuous.

4.4.3. B.S.C.

Using the gauged discharge for the 1988/89 campaign the flow was :-

$$\text{MEAN} = 1.49 \text{ TCMD} \quad \text{S.D} = 0.58$$

Their current policy is to keep water usage to a minimum but the effluent plant receives a lot of surface run-off in bad weather which would affect the discharge volume. A new beet reception area is also currently under construction which may have an effect.

4.5. STORM WATER OVERFLOWS

The mean and standard deviation of the SWO 's can be calculated from the results of the WASSP model (Ipswich B.C) using the time series rainfall.

For this information WRC have been asked to run the model for the first 26 storms in the series, with the sewage system at the initial development stage.

4.6. SEWAGE TREATMENT WORKS

4.6.1. CLIFF QUAY STW

The validation and appraisal report used flows to Cliff Quay based on a DWF of 25 tcmd, informal discussions with the PLC have suggested a 1992 DWF of 30 tcmd. Assuming the MEAN FLOW = 1.25 X DWF the consent for Cliff Quay has been calculated with the following values:-

MEAN = 37.5 tcmd S.D = 12.5

4.6.2. FELIXSTOWE STW

The flow from Felixstowe is not metered but an informed guess is :-

MEAN = 10 TCMD S.D = 3.3

5. CONSENT CALCULATIONS

5.1. CLIFF QUAY STW LONG TERM CONSENT

5.1.1.

The estuary model was run using the data in section 4 and various effluent qualities for Cliff Quay STW. This resulted in the proposed effluent qualities from Cliff Quay as 95-percentiles of:-

B.O.D. 200

AMMONIA 45

DWF 30 tcmd

5.1.2.

With this quality effluent from Cliff Quay the model predicts a maximum ammonia of 1.39 mg/l and maximum B.O.D of 6.3 mg/l as 95-percentiles. The minimum 5-percentile D.O calculated is 41.4% saturation.

The B.O.D marginally exceeds the recommended E.Q.S. in one segment which is considered acceptable.

FIGURE 1 is a map of the Orwell Estuary showing the position of the segments used by the model to predict water quality.

TABLE 13 - Lists the results for each segment of the estuary for Ammonia and B.O.D, Mean and 95-percentile results and Dissolved Oxygen, Mean and 5-percentile.

These results are displayed as graphs in FIGURE 2.

5.2. LONG TERM CONSENTS FOR INDUSTRIAL DISCHARGES

5.2.1.

The Appraisal Report went some way to producing final consent limits for the industrial discharges into the Orwell Estuary. Using the revised flows and updated water quality the consents were calculated using the following discharge qualities for the industrial effluents:-

| DISCHARGE | B.O.D | | AMMONIA | |
|-----------|-------|-----|---------|-----|
| | Mean | S.D | Mean | S.D |
| Burtons | 150 | 50 | 7.2 | 2.4 |
| Pauls | 150 | 50 | 3.0 | 2.0 |
| B.S.C | 150 | 50 | 24.0 | 8.0 |

5.2.2.

These values have been considered in conjunction with the discharge from Cliff Quay STW in keeping with current H.M.I.P thinking that all discharges should be treated as part of one system with inter-related effects.

5.3. TABLE 14 Summarises the proposed Long Term Consent limits for the major discharges into the Orwell Estuary, expressed as 95-percentiles.

6. CLIFF QUAY STW. CONSENT WITH VARIOUS FLOWS

- 6.1. The consent for Cliff Quay has been calculated, with the aid of the Orwell Estuary model, using a DWF of 30 tcmd and assuming the mean = DWF X 1.25.

It is proposed that the loading of pollutants from the Cliff Quay discharge should remain constant regardless of flow. Thus if the 1992 DWF should exceed 30 tcmd then the consent must be recalculated.

6.2. MATRIX OF CONSENTS WITH DIFFERENT FLOWS

The Orwell Estuary model has been used to recalculate the consent for Cliff Quay at DWF of 32, 36 & 40 tcmd so as to maintain the similar loadings.

The values for B.O.D and Ammonia needed to achieve this are summarised in TABLE 15 - Consent Matrix for Cliff Quay Sewage Treatment Works.

The calculated water quality in the first 12 segments is shown as bar charts for the different consents required at the increasing flows, in FIGURE 3. This demonstrates that the values in the matrix maintain very similar calculated water quality in the estuary at the different flows.

- 6.3. If the relationship between mean flow and DWF for Cliff Quay STW is found to be significantly different to that used then the consent must be recalculated using new mean flow.

7. IPSWICH B.C HIGH AND LOW LEVEL SEWER CATCHMENT DRAINAGE AREA PLAN - RELEVANCE TO ORWELL ESTUARY MODEL

- 7.1. A computer model of the Ipswich high and low level sewer catchment has been produced. In January 1985 Anglian Water initiated a hydraulic Analysis of the Ipswich catchment using WASSP. (Wallingford Storm Sewage Package)

This used the Time Series Rainfall - the 99 most significant observed rainfall events which occur in a typical year, to study pollution effects. For cost effective reasons a selective "run" was done using the 5 highest ranked storms and every fifth storm thereafter.

Ipswich B.C produced a report in March 1988 with the results of this analysis.

- 7.2 A total of 20 storm water overflows have been built into the sewage system discharging into the the River Gipping and Orwell Estuary.

The results from the time series rainfall gives values of the frequency and quantity that each SWO discharges in a "typical" year.

This hydraulic analysis was done at four levels :-

- 1) The existing system.
- 2) A rehabilitated system - the existing system is improved to remove all flooding.
- 3) Initial development - includes discharges from land already set aside for housing or industrial development.
- 4) Final development - utilising all other areas of land where development is possible.

For options 2,3 and 4 it was agreed with A.W that the system should not worsen the situation and ideally some improvement should be achieved, regarding SWO's.

7.3. To use the results of this study in the Orwell Estuary model it was decided that the Initial Development stage should be used. As looking to the future there will be further development in the area, but it is not as speculative as the Final Development.

7.4. POLLUTION ASSESSMENT USING WASSP AT THE INITIAL DEVELOPMENT STAGE

A total of 12 SWO 's discharge into the Orwell Estuary in this scheme, some combine before discharging giving 7 outfalls. Of these number 215 at Cliff Quay is insignificant and will be ignored . FIGURE 4 is a map of the part of the sewer system which discharges to the estuary showing the outfall locations.

- 1 - D/S Horseshoe Weir
- 2 - D/S Constantine Weir
- 3 - D/S Constantine Weir
- 4 - U/S Stoke Bridge
- 5 - D/S Lock Gates
- 6 - West Bank Ferry Terminal

7.5. The Ipswich B.C report included the following results relating to SWO's which discharge into the Orwell Estuary.

- 1) The number of times each SWO discharged in a "typical" year.
- 2) The Maximum spill volume.
- 3) The annual spill volume.

This information was collated for the following discharge points 1 to 6 and is summarised in TABLE 16.

Using the estimated strength of the storm water as detailed in section 3 the loadings can be calculated.

7.6. More information is available in the raw data produced by the model including the length of time each SWO discharged for.

8. INCLUSION OF STORM WATER OVERFLOWS INTO THE ORWELL ESTUARY MODEL

8.1. To enable the estuary model to assess all discharges in relation to each other the information available from the Ipswich B.C. report was utilised so that the Storm Water Overflows (SWO) could be included in the Orwell Model.

Information on the SWO 's was supplied to Anglian Water, NRA Regional Headquarters to enable the SWO to be included.

The data required was:-

- 1) Position of the SWO, Km d/s of Horseshoe Weir.
- 2) Maximum Length of operation.
- 3) The Volume discharged.
- 4) The quality of the discharge.

8.2. The positions of the SWO 's was obtained from the Ipswich B.C. report.

Ipswich B.C did not run the full TSR but the first 5 then every Fifth storm. This showed that the SWO 's only discharged during the first 25/26 storms. It was assumed at this stage that the first storm in the TSR would cause the longest discharge from the SWO. So this data was extracted from the print out of the initial development stage (supplied by Ipswich B.C.) A request was also made to at this time to run the first 26 storms of the TSR at the initial development stage.

The volume discharged was initially calculated by taking the maximum volume discharged as a 95-percentile and calculating the mean and standard deviation from this. When the run of the first 26 storms of the TSR is completed more accurate figures can be used.

The quality of the discharge was calculated as described in section 4.

8.3. To make an initial assessment of the impact of the SWO 's on the water quality of the Orwell Estuary the SWO 's were added to the model so that it could be run with them all discharging or for them to be turned off independently of each other. The model was run with the proposed consents from the main discharges and a mean flow from Cliff Quay of 37.5 tcmd.(at this stage of development of the model the quality of incoming river water was at the bottom of NWC class 1B and the ammonia limit for Cliff Quay was 40 mg/l)

The following combination of SWO 's discharging was used:-

- 1) All on.
- 2) 4 Off.
- 3) 4 & 5 Off.
- 4) 4,5 & 6 Off.
- 5) 1,4,5 & 6 Off.
- 6) 1,2,4,5, & 6 Off.

This relates to the frequency with which discharges occur from the different points.

8.4. The resulting water quality in the first 9 segments of the estuary are plotted in FIGURE 5.

This shows an anomaly of worse conditions in the first 2 segments of the estuary when SWO 4 is not discharging! This may be due to the geography of the top segments of the estuary or in the programme. Apart from this as each SWO is turned off there is the expected improvement in quality.

The greatest improvement in quality occurs when SWO 1 is removed - the Ammonia level decreases by 0.81 mg/l, the B.O.D decreases by 11.3 mg/l and Dissolved Oxygen increases by 5.1 % saturation.

Apart from SWO 1 the SWO 's which discharge less frequently but greater volumes are having the greatest effect on water quality.

8.5 In this form the model is assuming the SWO 's are discharging for every shot of the Monte-Carlo calculation and these results cannot be used to show compliance with the EQS.

The model is therefore being refined further by the NRA headquarters so that the SWO 's operate for a proportion of the time according to their frequency of operation. The results tables are also being extended to include 99-percentiles as since they operate less than 5 percent of the time their effect on the estuary water quality will not be apparent in the 95 percentile table.

8.6. Current RQS 's are expressed in terms of standards for continuous pollution control. The NWC classification takes no explicit account of transient pollution caused by intermittent discharges such as SWO 's. For current rehabilitation schemes interim procedures are required. Two such procedures have been produced for river systems which use empirically derived, acceptable, transient river quality conditions based upon the NWC classification system (report ER317E)

A draft report by Welsh Water Authority (pers. comm.) also propose the use of Maximum Acceptable Concentrations (MAC values) of pollutants in the watercourse receiving a SWO discharge. These are derived by using 99 percentile relationships to 95 percentile NWC Standards.

Extending this theory to the Orwell Estuary proposed EQS would result in MAC values of:-

| | |
|---------|----------------------------|
| Ammonia | 3.0 mg/l |
| B.O.D. | 12 mg/l |
| D.O. | 20% sat. (min) - stretch 1 |
| D.O. | 30% sat. (min) - stretch 2 |

- 8.6. This suggests that intermittent discharges such as SWO 's can cause a local deterioration in the receiving water and providing it does not exceed the MAC value then no long term damage will result and it will not negate any improvements in water quality achieved by improving other discharges into the watercourse.
- 8.7. Once the alterations to the estuary model have been completed and the results of the WRc WASSP run have been received the work on setting consent limits for the SWO can proceed.

TABLE 1 - COMMERCIALY FISHED SPECIES CAUGHT IN THE ORWELL AND STOUR ESTUARIES

In alphabetical order

| SPECIES | AREAS FISHED | |
|------------------------|-----------------------------------|---|
| | ORWELL ESTUARY | STOUR ESTUARY |
| Bass | Limited numbers up to Pin Mill | Limited numbers up to Holbrook Bay |
| Cod and some Whiting | | Mainly offshore but in estuary mouth |
| Eels | Prolific up to Fresh Water | |
| Herrings | | Local discrete stock up to Holbrook Bay |
| Grey Mullet | Lock gates to Harwich | Manningtree to Harwich |
| Sole/Place | Felixstowe to Pin Mill | Harwich to Manningtree |
| Flounders, Skate/Dabbs | Caught with Sole in small numbers | |
| Sprats | | Commercial quantities every few years |

TABLE 2 - SHELLFISH HARVESTED IN THE ORWELL AND STOUR ESTUARIES

| SPECIES | AREAS FISHED | |
|---------|---|---|
| | ORWELL ESTUARY | STOUR ESTUARY |
| Cockles | North bank, Orwell Bdg. to Levington - several sites. | Large pop. in Holbrook Bay and Shotley Point. |
| Lobster | | Harwich & Landguard Pt. |
| Mussels | Sites d/s Orwell Bdg, Woolverstone, Fagbury, and Shotley. | Holbrook Bay |
| Shrimps | | small local fishery |
| Whelks | | Wrabness/Holbrook to Harwich |
| Winkles | most banks, main area Shotley to Levington. | Shotley Point to Holbrook Bay |

TABLE 3 - ORWELL ESTUARY SHELLFISH - ESTIMATED STOCKS

| AREA | TYPE OF STOCK | SIZE OF BED (acres) | ESTIMATED TONNAGE |
|-------------------|--------------------|---------------------|-------------------|
| Pond ooze | Cockles Mussels | 173 1 | 750 25 |
| Downham Reach N. | Cockles Mussels | 15 5 | 75 70 |
| Downham Reach S. | Cockles | 50 | 160 |
| Potter Reach N. | Cockles | 7 | 20 |
| Buttermans Bay N. | Cockles | 40 | 216 |
| Long Reach N. | Cockles | 33 | 240 |
| Long Reach S. | Cockles Mussels | 34 1 | 136 15 |
| Lower Reach S. | Mussels | 2 | 20 |

Table compiled from data supplied by the Eastern Sea Fisheries Joint Committee.

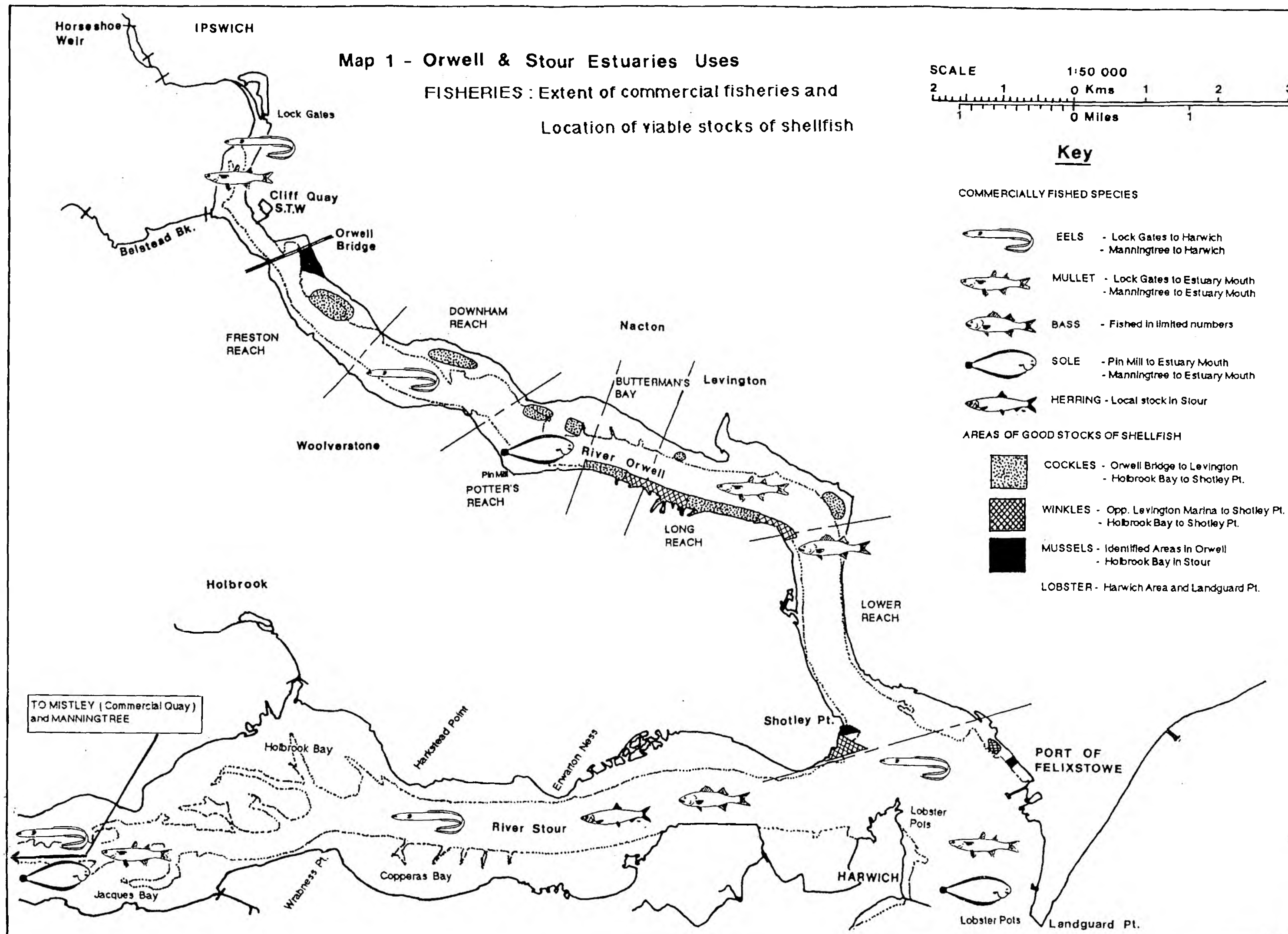


TABLE 4 - WATERSPORTS : SUMMARY OF YACHT CLUB ACTIVITIES

| CLUB NAME | EXTENT OF DINGHY SAILING | OTHER INFORMATION |
|--------------------------|--|--|
| Orwell Yacht Club | Slipway to 1 Km d/s of the Orwell Bridge. | Do not allow Sailboards to launch |
| Royal Harwich Yacht Club | Aprox. 1.5 Km u/s of slipway to Collimer Pt. - most racing only d/s to Pin Mill. | |
| Pin Mill Sailing Club | Limited amount - use area aprox. 1 Km u/s of Pin Mill to 2 Km d/s. | No sailboards - mud flats limit launching. |
| Shotley Sailing Club | Shotley Pt. marina to Erwarton Ness, North of dredged channel | strong tides so no sailboards. |
| Haven Ports Yacht Club | Levington Marina to Trimley Marshes | Also water bikes, water skiing & sailboards. |

CRUISERS sail from all the clubs and marinas from Ipswich and Manningtree out to sea.

Horseshoe Weir
IPSWICH

Oysterworld Watersports Centre

Neptune Marina

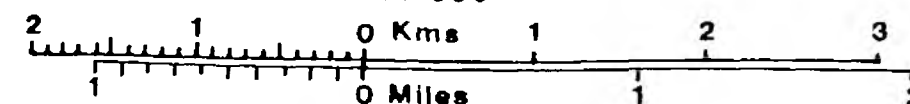
Wet dock

Map 2 - Orwell & Stour Estuaries Uses

Areas used for Watersports

SCALE

1:50 000



Key

POSITION OF MARINAS

WATER-SKI AREA

SAIL BOARDS : Launch sites
sail from Ipswich wet dock to
Levington Marina

DINGHY SAILING
Arrows indicate the extent of
main areas used

CRUISING
From Ipswich and Manningtree
To Estuary Mouth

SWIMMING - High Water only

Orwell Yacht Club

Cliff Quay S.T.W.

Orwell Bridge

Belstead Bk.

Fox's Marina Ipswich

Stoke Sailing Club

Nacton

Amenity Beach

Levington

Levington Marina

Haven Ports Yacht Club

Woolverstone Marina

Woolverstone

Royal Harwich Yacht Club

Pin Mill

River Orwell

Coltmer Point

Holbrook

Fagbury Point

FERRY TERMINALS

PORT OF FELIXSTOWE

TO MISTLEY (Commercial Quay)
and MANNINGTREE

Hartwood Point

River Stour

Parkstone Quay

FERRY TERMINALS

HARWICH

TABLE 5 - NUMBERS OF INTERNATIONALLY & NATIONALLY
SIGNIFICANT SPECIES RECORDED FEEDING IN THE ORWELL
ESTUARY ON 19th DEC 1988

| SECTION | BRENT GOOSE I | DUNLIN N | GREY PLOVER N | RINGED PLOVER I | REDSHANK N | SHELDUCK I |
|---------|---------------------|-------------|---------------------|-----------------------|---------------|---------------|
| A1 | - | - | - | - | - | - |
| A | - | 27 | - | 11 | 23 | - |
| A3 | - | 383 | 3 | 68 | 102 | - |
| B1 | - | - | 4 | 1 | 11 | 1 |
| B2 | - | 150 | - | - | 101 | 188 |
| B3 | - | 30 | 5 | 12 | 76 | 28 |
| C1 | - | 39 | - | - | 29 | - |
| C2 | - | 30 | 6 | 7 | 12 | 50 |
| C3 | 6 | 135 | 18 | 12 | 35 | 6 |
| D1 | 375 | 616 | 53 | 19 | 155 | - |
| D3 | - | 338 | 10 | 27 | 25 | 42 |
| E1 | 1 | 465 | 42 | 28 | 89 | 168 |
| E2 | - | 2167 | 37 | - | 59 | 21 |
| F1 | - | 870 | 19 | - | 67 | 108 |
| F2 | - | 4304 | 53 | 11 | 427 | 72 |
| F3 | - | 283 | 2 | 2 | 174 | - |

TABLE 6 - NUMBERS OF INTERNATIONALLY & NATIONALLY SIGNIFICANT SPECIES RECORDED FEEDING IN THE STOUR ESTUARY ON 18th DEC 1988

| SPECIES | SECTIONS | | | | | | | | | |
|-----------------------------|----------|-----|-----|------|-----|----|------|------|-----|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| DUNLIN N | 679 | 812 | 569 | 4547 | 188 | 57 | 1071 | 2768 | 170 | 1058 |
| BLACK TAILED GODWIT I | 432 | 6 | 1 | 151 | - | - | 15 | 7 | 21 | 242 |
| BRENT GOOSE I | 48 | 3 | 486 | 378 | - | - | - | 26 | 602 | 69 |
| GREY PLOVER I | 10 | 15 | 76 | 162 | - | - | 9 | 67 | 15 | 34 |
| RINGED PLOVER N | 4 | - | 3 | 3 | - | - | 3 | 14 | 42 | 22 |
| REDSHANK I | 33 | 77 | 81 | 202 | 74 | 7 | 160 | 169 | 68 | 76 |
| SHELDUCK I | 150 | 64 | 312 | 482 | 147 | 2 | 137 | 86 | 4 | 36 |
| MUTE SWAN N | - | - | - | 155 | 2 | 5 | 2 | - | - | - |
| TURNSTONE N | 1 | 2 | 37 | 21 | - | - | 5 | 11 | 4 | 45 |
| WIGEON N | - | 46 | 552 | 678 | 117 | - | 413 | 768 | 117 | 207 |

**TABLE 7 - TOTAL NUMBERS OF WADERS & WILDFOWL RECORDED
FEEDING IN THE ORWELL & STOUR ESTUARIES IN DECEMBER
1988**

| SPECIES (alphabetical order) | TOTAL NUMBERS RECORDED | |
|-------------------------------------|------------------------|---------------|
| | ORWELL ESTUARY | STOUR ESTUARY |
| Coot | 78 | - |
| Cormorant | 85 | 83 |
| Curlew | 564 | 588 |
| Tufted Duck | 60 | - |
| Dunlin | 9837 | 11919 |
| Gadall | - | 2 |
| Eider | - | 7 |
| Bar-Tailed Godwit | - | 5 |
| Black-Tailed Godwit | 440 | 875 |
| Goldeneye | 27 | 72 |
| Brent Goose | 382 | 1612 |
| Canada Goose | 70 | 3 |
| Great Crested Grebe | 22 | 101 |
| Little Grebe | 1 | 3 |
| Black-Headed Gull | 3017 | >1543 |
| Common Gull | 39 | >114 |
| Great B-Backed Gull | 33 | 72 |
| Herring Gull | 181 | >30 |
| Lesser B-Backed Gull | 2 | >40 |
| Grey Heron | 1 | 10 |
| Knot | 1384 | 1653 |
| Lapwing | 61 | 722 |
| Mallard | 407 | 1404 |
| Red-Breasted Merganser | - | 18 |
| Moorhen | 3 | - |
| Oystercatcher | 273 | 782 |
| Pintail | 281 | 274 |
| Golden Plover | - | 320 |
| Grey Plover | 252 | 388 |
| Ringed Plover | 198 | 91 |
| Pochard | 4 | 1 |

Table continued on next page

TABLE 7 - CONTINUED

| SPECIES (alphabetical order) | TOTAL NUMBERS RECORDED | |
|---------------------------------|------------------------|---------------|
| | ORWELL ESTUARY | STOUR ESTUARY |
| Redshank | 1385 | 947 |
| Sanderling | 9 | - |
| Shelduck | 611 | 1420 |
| Shoveler | - | 19 |
| Smew | - | 3 |
| Snipe | 36 | 12 |
| Mute Swan | 45 | 164 |
| Whooper Swan | - | 1 |
| Teal | 15 | 609 |
| Turnstone | 128 | 126 |
| Wigeon | 684 | 2898 |

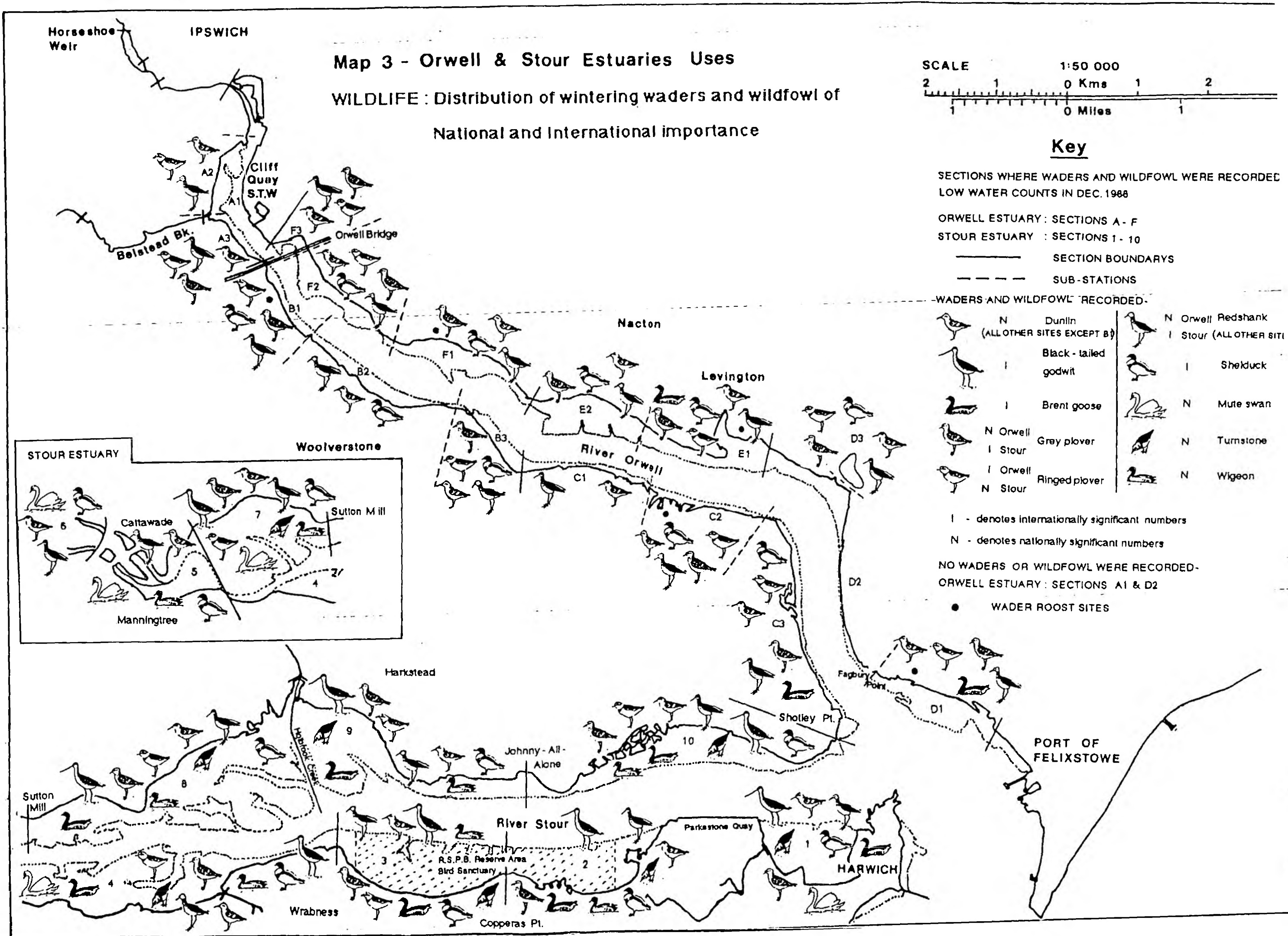


TABLE 8 - BOUNDARY VALUES FOR EACH END OF THE ESTUARY

Mean (X) and Standard Deviation (SD) values in mg/l

| LANDWARD | | SEAWARD | | VARIABLE |
|----------|-------|---------|---------|-------------------|
| X | SD | X | SD | |
| 2.4 | 0.80 | 2.5 | 0.83 | BOD |
| 0.2 | 0.07 | 0.1E-10 | 0.1E-10 | TOTAL ORGANIC N. |
| 0.3 | 0.10 | 0.1 | 0.1 | AMMONIA |
| 7.9 | 2.37 | 0.2 | 0.07 | OXIDISED NITROGEN |
| 85.0 | 10.00 | 100.0 | 15.0 | DISSOLVED OXYGEN |
| 10.8 | 5.92 | 13.0 | 5.0 | TEMPERATURE |

TABLE 9 - WATER QUALITY CONCENTRATIONS FOR THE BELSTEAD BROOK

Mean (X) and Standard Deviation (SD) values in mg/l

| X | SD | VARIABLE |
|-----|-----|------------------------|
| 2.4 | 0.8 | BOD |
| 0.3 | 0.1 | AMMONIA |
| 7.9 | 2.6 | OXIDISED NITROGEN |
| 0.5 | 0.2 | TOTAL ORGANIC NITROGEN |
| 8.5 | 1.0 | DISSOLVED OXYGEN |

TABLE 10 - CALCULATION OF MEAN STORM SEWAGE CONCENTRATION

| DETERMINAND | STRENGTH mg/l | FACTOR SRM TABLE F1 | STORM FLOW CONC. mg/l |
|-------------|------------------|------------------------|--------------------------|
| BOD | 327 | 0.5 | 163.5 |
| AMMONIA | 38.8 | 0.3 | 11.64 |

TABLE 11 - EFFLUENT QUALITY FROM FELIXSTOWE STW

Mean (X) and Standard Deviation (SD) values in mg/l

| X | SD | VARIABLE |
|---------|---------|------------------------|
| 200 | 60 | BOD |
| 50 | 11 | AMMONIA |
| 0.1E-10 | 0.1E-10 | OXIDISED NITROGEN |
| 0.5 | 0.2 | TOTAL ORGANIC NITROGEN |
| 0.1E-10 | 0.1E-10 | DISSOLVED OXYGEN |

TABLE 12 - SUMMARY OF FLOWS OF INPUTS INTO THE ESTUARY

All flows in tcmd unless otherwise stated

| INPUT | MEAN FLOW | STANDARD DEVIATION | LOW FLOW |
|----------------|-------------|--------------------|------------|
| Tidal Limit | 1.3 CUMECS | | 0.2 CUMECS |
| Belstead Brook | 0.21 CUMECS | 0.07 CUMECS | |
| Burtens | 0.06 | 0.02 | |
| Pauls | 0.47 | 0.04 | |
| B.S.C | 1.49 | 0.58 | |
| Cliff Quay | 37.5 | 12.5 | |
| Felixstowe | 10.0 | 3.3 | |

FIGURE 1 - MAP OF THE ORWELL ESTUARY SHOWING THE SEGMENTS

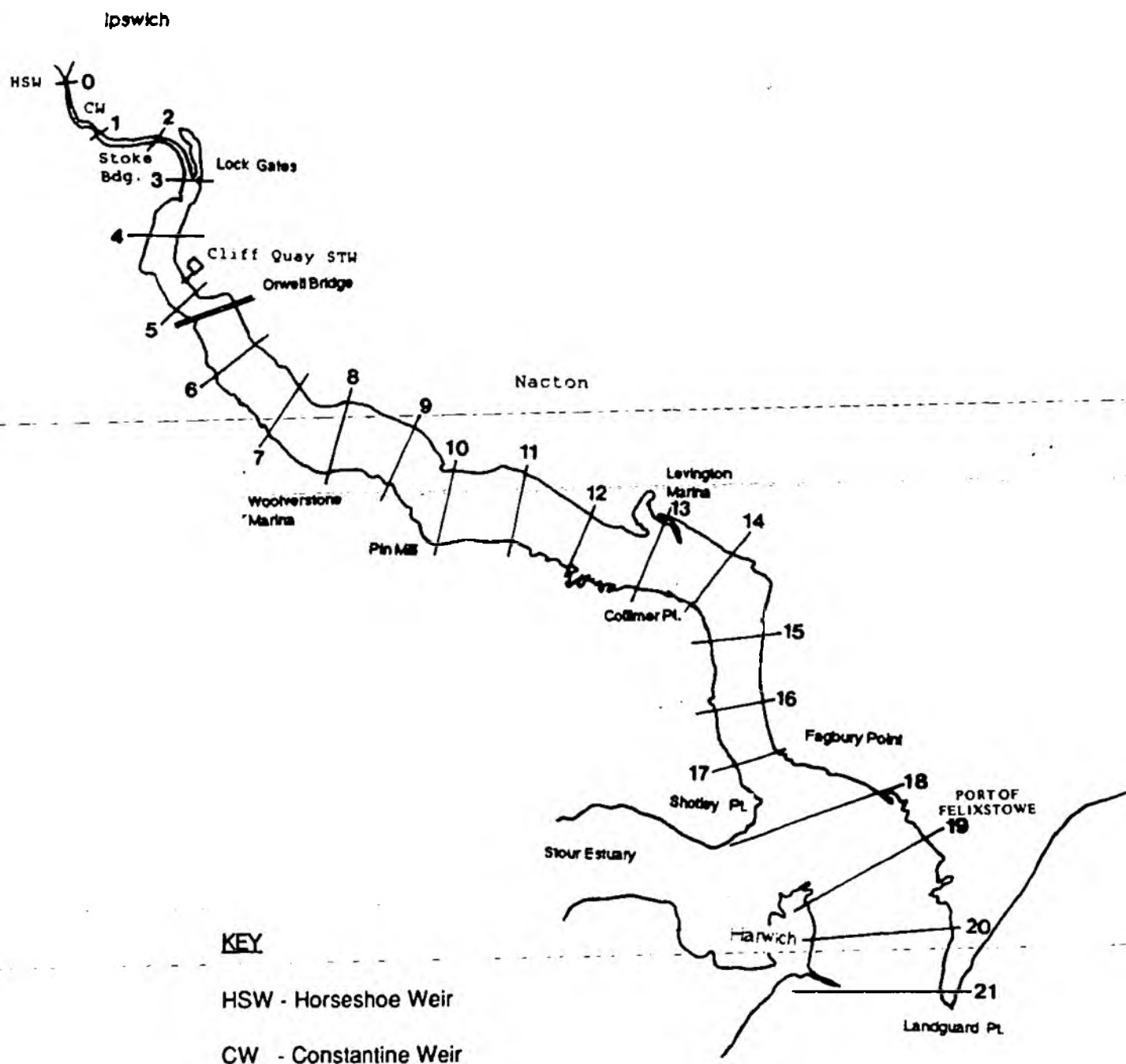


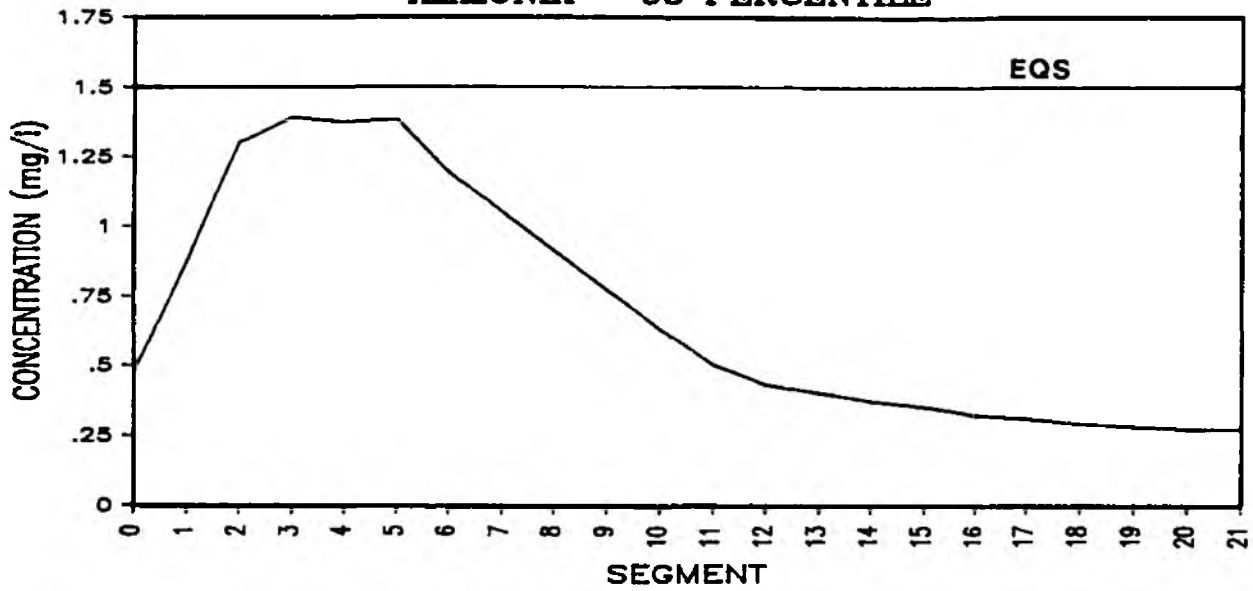
TABLE 13 - CALCULATED WATER QUALITY FOR EACH SEGMENT OF THE ESTUARY WITH THE PROPOSED CONSENT FROM CLIFF QUAY STW.

| SEGMENT | AMMONIA | | B.O.D | | D.O | |
|---------|---------|---------|-------|---------|-------|--------|
| | MEAN | 95%tile | MEAN | 95%tile | MEAN | 5%tile |
| 0 | 0.29 | 0.48 | 2.35 | 3.8 | 84.95 | 69.5 |
| 1 | 0.46 | 0.87 | 3.29 | 5.3 | 82.22 | 67.2 |
| 2 | 0.67 | 1.30 | 3.95 | 6.3 | 74.88 | 55.3 |
| 3 | 0.74 | 1.39 | 3.84 | 6.0 | 69.06 | 44.5 |
| 4 | 0.75 | 1.37 | 3.63 | 5.6 | 66.46 | 41.4 |
| 5 | 0.75 | 1.38 | 3.67 | 5.6 | 67.65 | 44.6 |
| 6 | 0.65 | 1.19 | 3.31 | 4.9 | 70.19 | 48.8 |
| 7 | 0.56 | 1.05 | 3.04 | 4.5 | 71.88 | 51.4 |
| 8 | 0.48 | 0.91 | 2.81 | 4.2 | 73.81 | 54.5 |
| 9 | 0.41 | 0.77 | 2.61 | 3.9 | 76.05 | 58.2 |
| 10 | 0.33 | 0.63 | 2.45 | 3.7 | 78.48 | 62.3 |
| 11 | 0.26 | 0.50 | 2.33 | 3.5 | 81.13 | 66.6 |
| 12 | 0.21 | 0.43 | 2.28 | 3.5 | 82.84 | 69.3 |
| 13 | 0.20 | 0.40 | 2.27 | 3.5 | 83.55 | 70.3 |
| 14 | 0.18 | 0.37 | 2.26 | 3.5 | 84.30 | 71.8 |
| 15 | 0.17 | 0.35 | 2.26 | 3.5 | 85.14 | 73.2 |
| 16 | 0.15 | 0.32 | 2.27 | 3.5 | 86.13 | 75.0 |
| 17 | 0.14 | 0.31 | 2.29 | 3.6 | 87.28 | 77.4 |
| 18 | 0.13 | 0.29 | 2.31 | 3.7 | 88.63 | 79.6 |
| 19 | 0.12 | 0.28 | 2.33 | 3.7 | 90.37 | 82.6 |
| 20 | 0.11 | 0.27 | 2.36 | 3.7 | 92.72 | 86.7 |
| 21 | 0.10 | 0.27 | 2.40 | 3.8 | 95.83 | 92.4 |

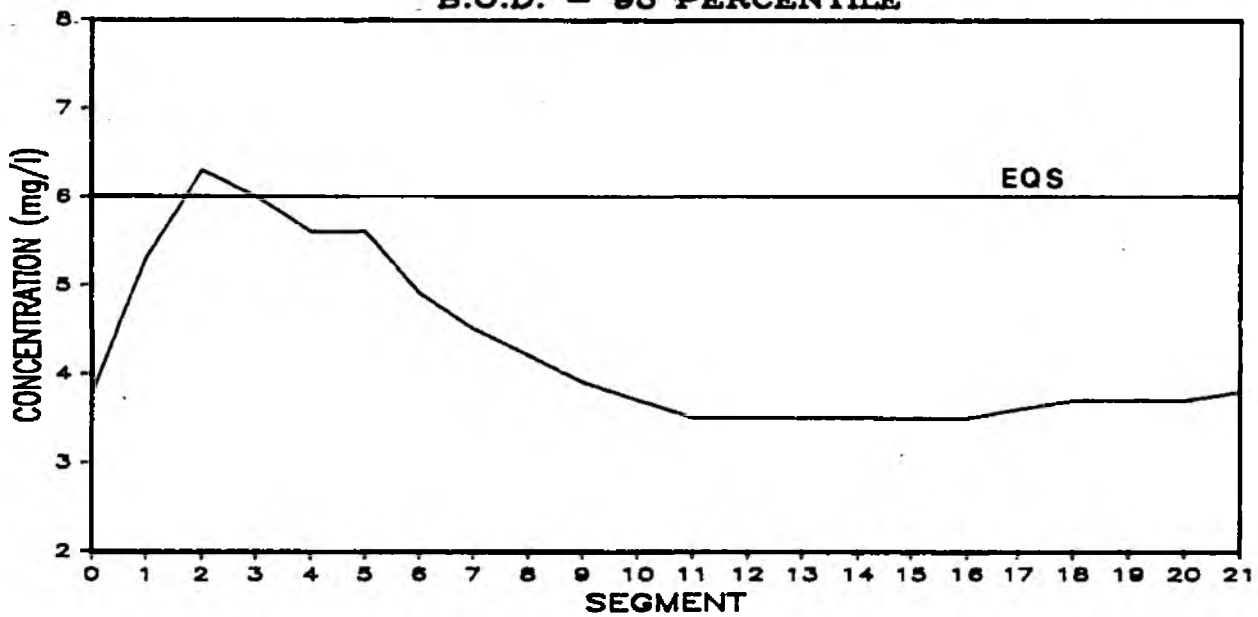
FIGURE 2

ORWELL ESTUARY — CALC. WATER QUALITY

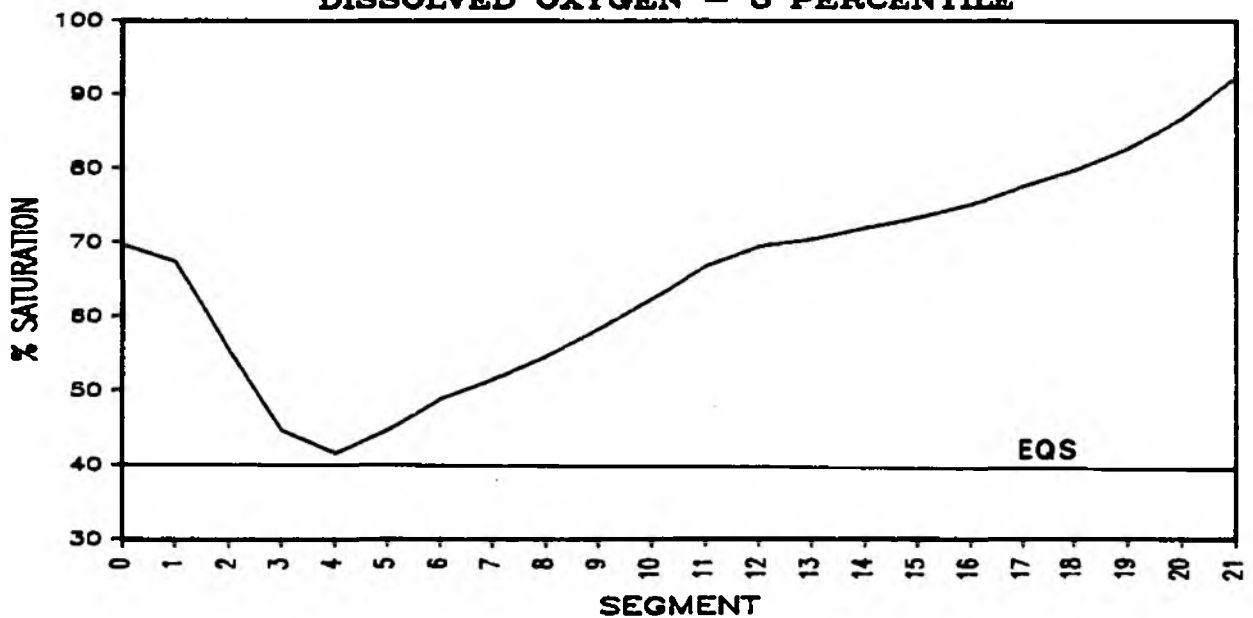
AMMONIA — 95 PERCENTILE



B.O.D. — 95 PERCENTILE



DISSOLVED OXYGEN — 5 PERCENTILE



**TABLE 14 - PROPOSED LONG TERM CONSENT LIMITS FOR
MAJOR DISCHARGES INTO THE ORWELL ESTUARY**

| DISCHARGE tcmd | FLOW mg/l | B.O.D | NH3 |
|-------------------|--------------|-------|-----|
| Cliff Quay | 30 DWF | 200 | 45 |
| Burtons | 0.06 Mean | 250 | 12 |
| Pauls | 0.47 " | 250 | 7 |
| B.S.C | 1.49 " | 250 | 40 |

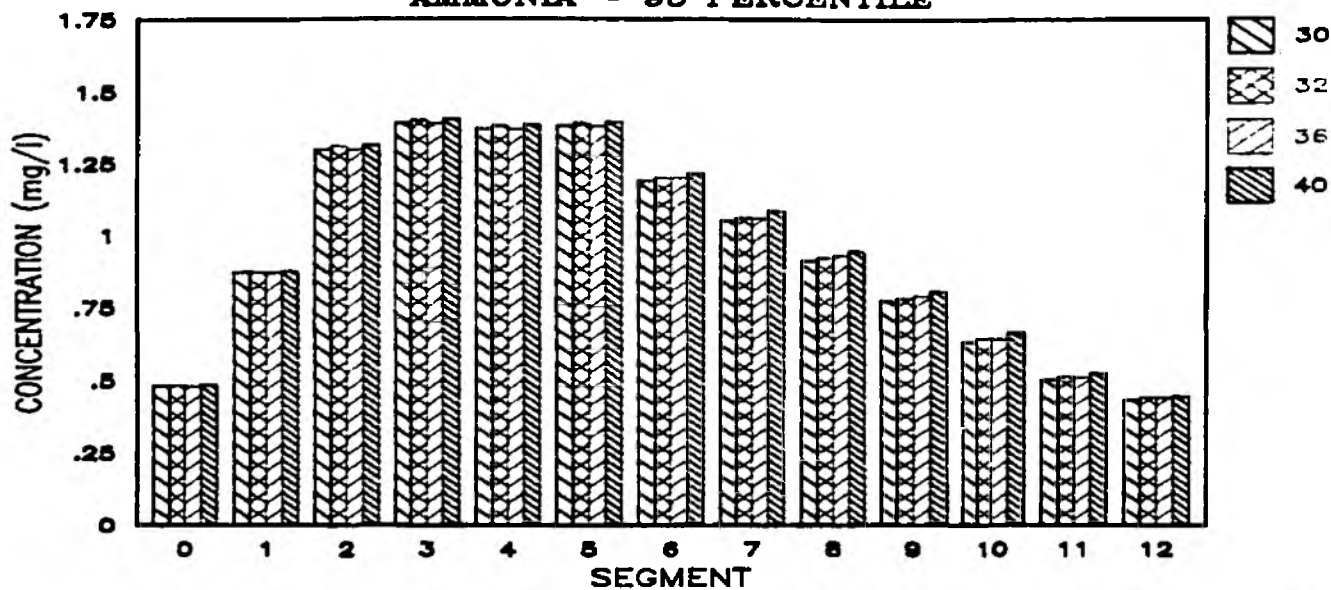
TABLE 15 - CONSENT MATRIX FOR CLIFF QUAY STW.

| DWF tcmd | CONSENT | |
|-------------|---------|---------|
| | B.O.D. | AMMONIA |
| 30 | 200 | 45 |
| 32 | 185 | 42.5 |
| 36 | 170 | 37.5 |
| 40 | 150 | 34 |

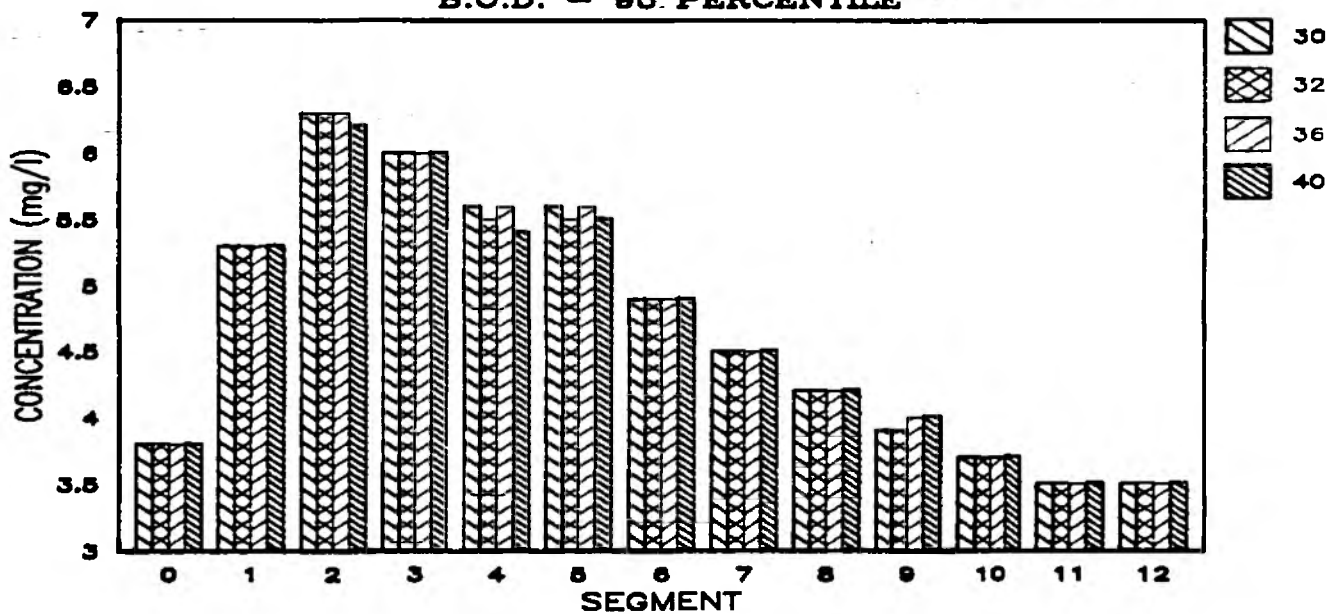
FIGURE 3

WATER QUALITY WITH DIFF. CONSENTS & DWF.

AMMONIA - 95 PERCENTILE



B.O.D. - 95 PERCENTILE



DISSOLVED OXYGEN - 5 PERCENTILE

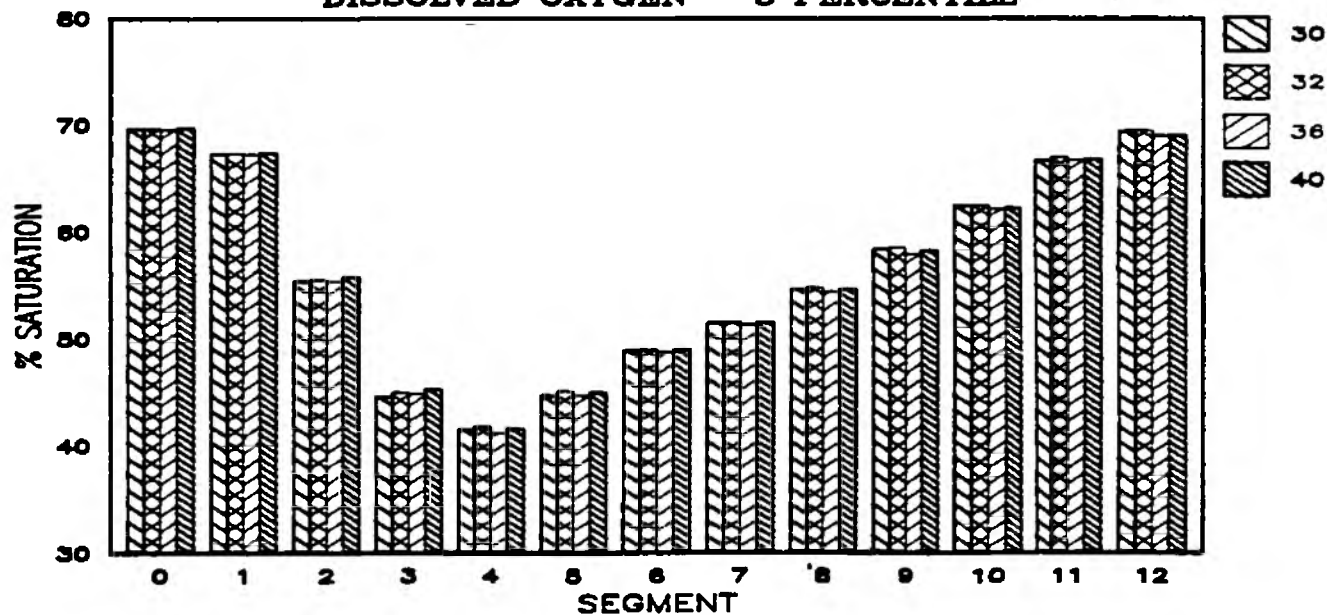
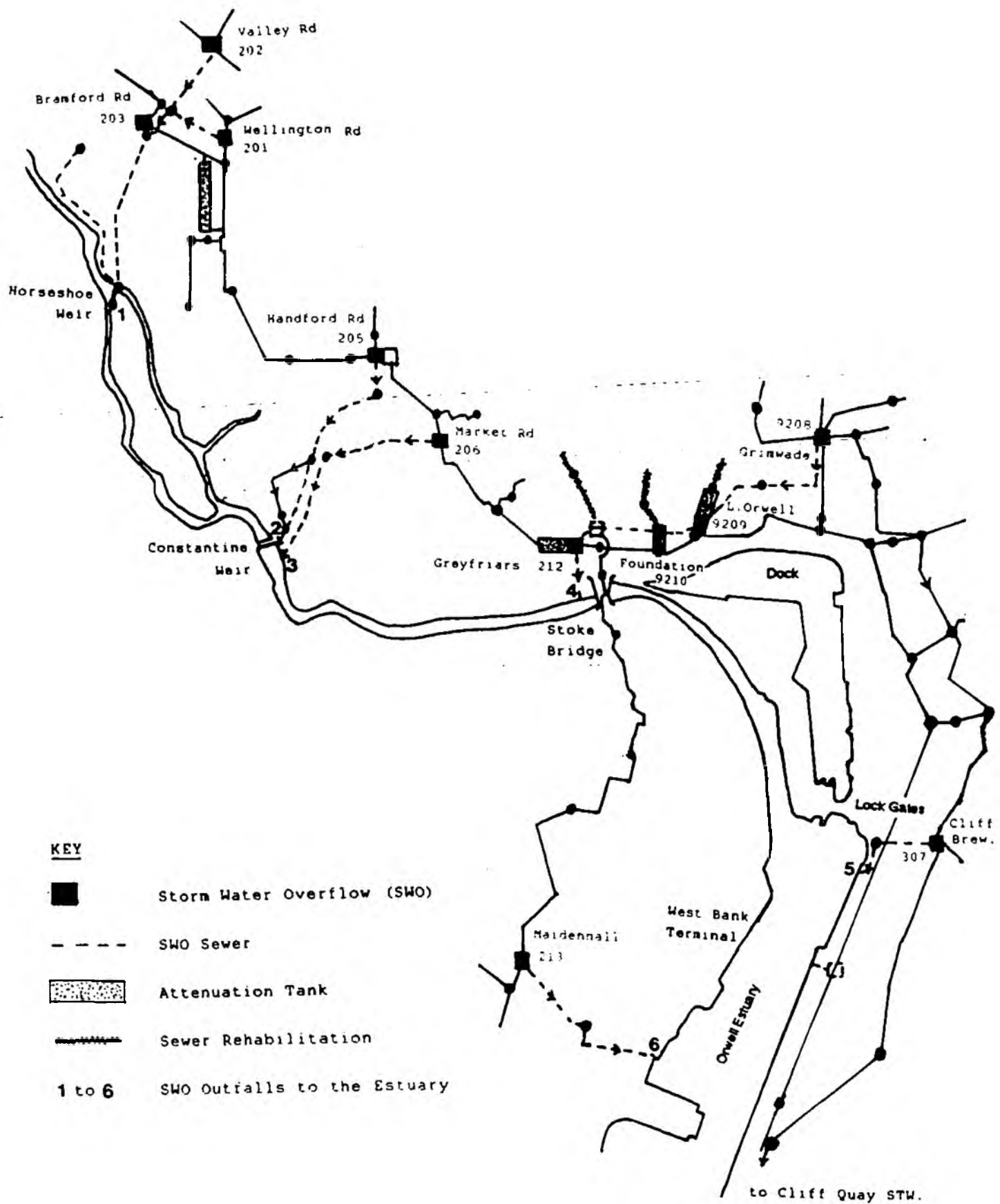


FIGURE 4 - DIAGRAM OF THE IPSWICH SEWER SYSTEM SHOWING THE POSITION OF STORM WATER OVERFLOWS INTO THE ORWELL ESTUARY

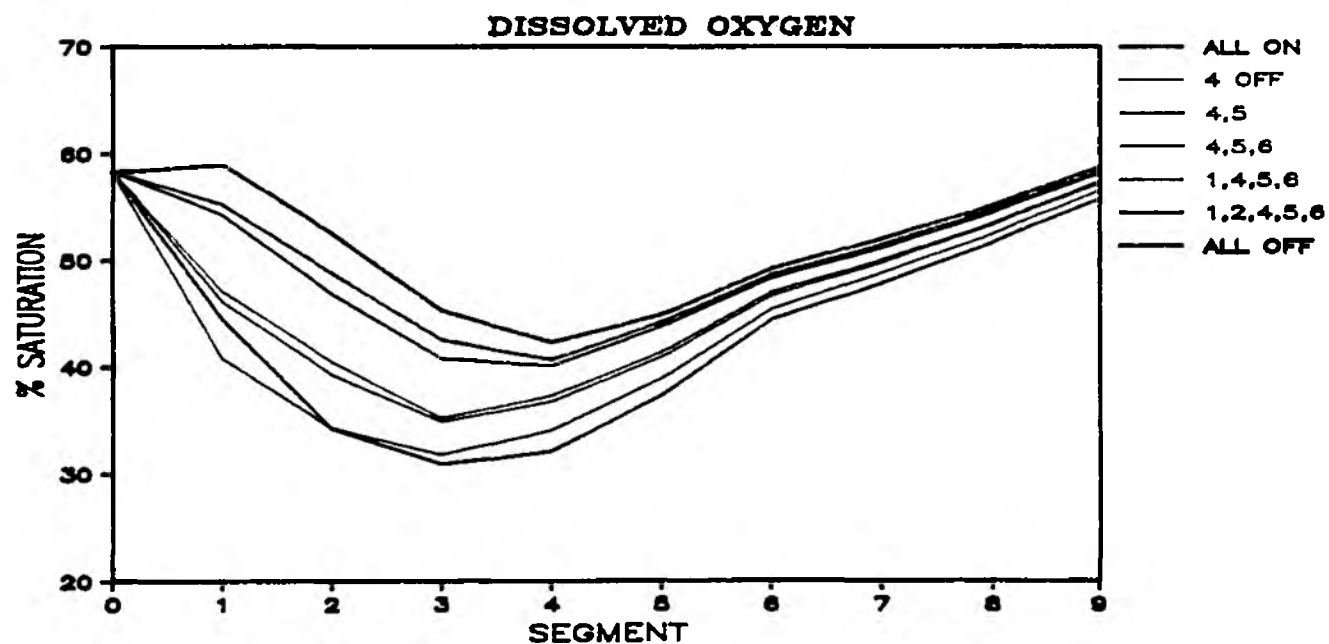
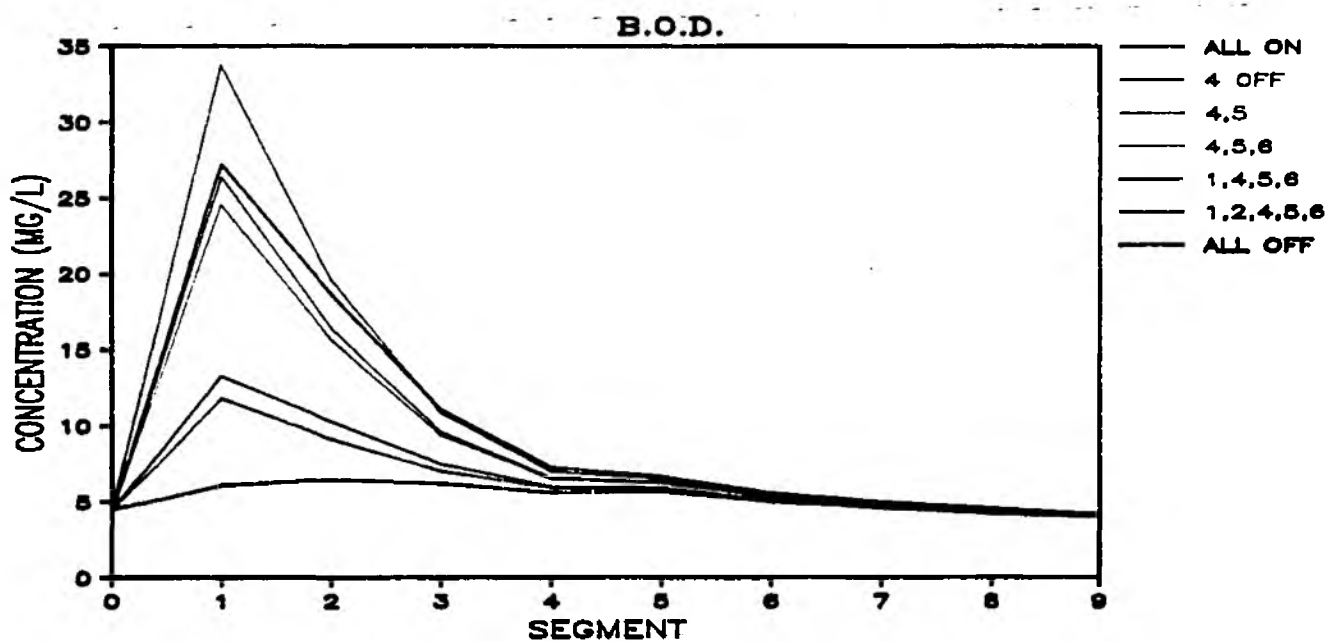
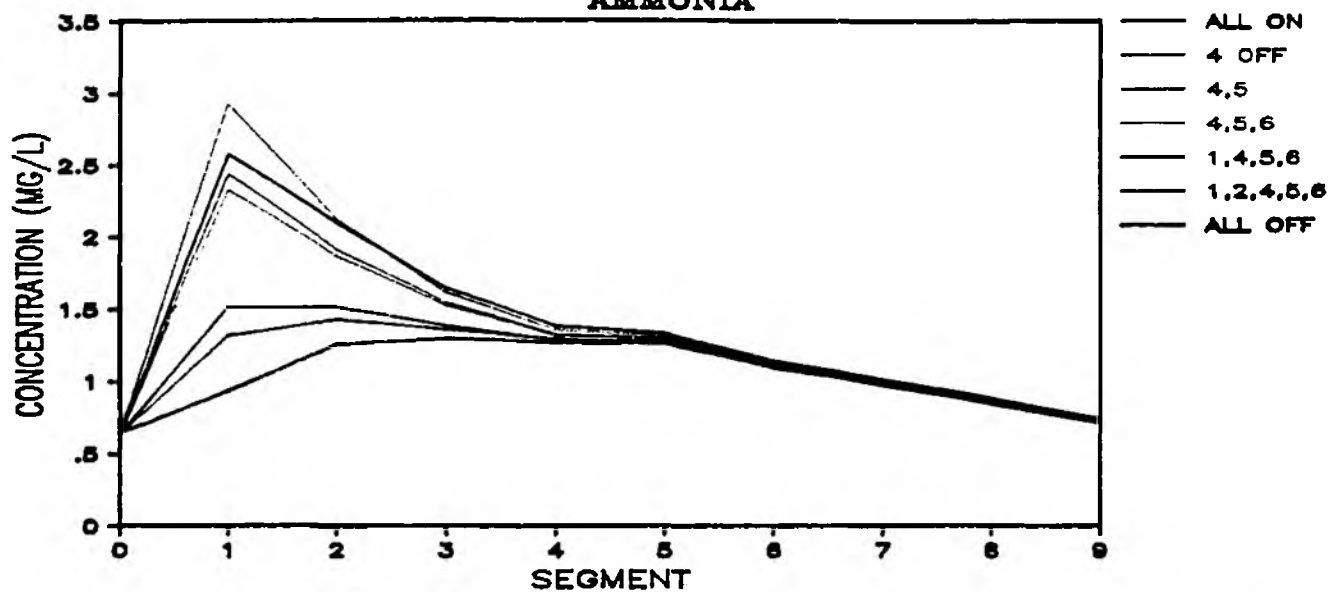


**TABLE 16 - STORMWATER OVERFLOWS - ESTIMATED DISCHARGE
WHEN INITIAL DEVELOPMENT IS COMPLETED**

| Discharge Point (map ref) | LOCATION SWD/TANK | Ref No | Adjust No. of events | MAX SPILL VOL. | MAX VOL. per point | ANN. SPILL VOL. | AVE. VOL. per event | AVE. VOL. per point |
|------------------------------|----------------------|--------|----------------------------|----------------------|-----------------------------|-----------------------|------------------------------|------------------------------|
| 1 | Valley Rd | 202 | 17 | 1291 | | 5212 | 306 | |
| | Bramford Rd | 203 | 17 | 1527 | 4542 | 5618 | 90 | 529 |
| | Wellington | 201 | 13 | 1724 | | 5141 | 133 | |
| 2 | Handford Rd | 205 | 17 | 982 | 982 | 3507 | 206 | 206 |
| 3 | Market Rd | 206 | 22 | 899 | 899 | 4349 | 198 | 198 |
| 4 | Greyfriars | 212 | 2 | 289 | | 290 | 145 | |
| | Foundation | 9210 | 3 | 450 | | 618 | 206 | |
| | L.Orwell | 9209 | 4 | 1422 | 3010 | 3134 | 784 | 1512 |
| | Grimwade | 9208 | 4 | 849 | | 1506 | 377 | |
| 5 | Cliff Brew. | 307 | 8 | 3545 | 3545 | 8734 | 1092 | 1092 |
| 6 | Maidenhall | 213 | 13 | 627 | 627 | 1286 | 99 | 99 |

ALL VOLUMES IN m3

FIGURE 5
ORWELL ESTUARY MODEL — INCLUDING SWO
AMMONIA



9. REFERENCES

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