APPENDIX B

DYE TEST AT PROPOSED OUTFALL SITE IN THE ILEN ESTUARY (FEBRUARY 1993)

IRISH HYDRODATA LTD.

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DYE TEST AT A PROPOSED OUTFALL SITE IN THE ILEN ESTUARY

REPORT

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CONTENTS

1. INTRODUCTION

This report presents the findings of a dye study conducted to assess the affects of a proposed treated effluent discharge to the Ilen estuary (Figure 1.1). The proposed discharge point is approximately 330m downstream from the New Bridge and 2000m from the town of Skibbereen itself (Figure 1.2).

At the present untreated municipal wastes discharge to the estuary at several points within the confines of the town. The new sewerage scheme will incorporate full secondary treatment and phosphate removal to ensure that effluent quality is better than the 20:30 Royal Commission Standard. A holding tank is to be provided to allow the waste water to be discharged during a four hour period on the ebbing tide. The field work and subsequent analysis conducted for this study are based on the following treated effluent design values specified by the consulting engineers:

Flow Into Works= 3 x Dry Weather Flow = $0.032m^3/s$;
Outfall Discharge = 3 x 3DWF = $0.096m^3/s$ (over 4 hours);
Biochemical Oxygen Demand @ 3DWF = 20mg/l;
Mean Faecal Coliform Concentration @ 3DWF = $5x10^4$ per 100ml.

The Ilen forms a long narrow estuary stretching some 25km from the sea to Skibbereen town. At its outer end it is approximately 350m wide and decreases to about 30m at its head. Maximum channel depths range from about -4m below Ordnance Datum Poolbeg at the seaward end to zero at Oldcourt. Further upstream the river bed lies above datum and thus dries fully (except for river flow) during spring tides. At the proposed outfall site the bed level is about +1.5m O.D.P. Tidal influences can be observed for some 4km upstream of the town on spring tides, though a more typical distance would be 3km. Admiralty Tide Tables suggest a mean high water spring level of 3.7m O.D.P. and a mean high water neap level of 3.0m O.D.P. for Baltimore.

2. METHODOLOGY

2.1 DYE RELEASES

The effects of the proposed outfall were simulated by discharging Rhodamine B tracer dye at the site for a five hour period (ebb tide) on both springs and neaps. The dye was pre-mixed with water to provide a plume of large dimension (see photographs) which would mix with the surrounding water in the manner of the effluent.

2.2 SURVEY LAUNCH

A fast, shallow draft survey launch fitted with a Turner Designs Model 10 fluorometer was employed for the survey work. A continuous pumped flow system enabled the Rhodamine concentration to be logged on computer and chart recorder in real time along with the boat's position, determined by G.P.S. navigation instrumentation.

2.3 FIXED INSTRUMENTATION

In order to provide ancillary information over the study period a recording current meter, fitted with salinity and temperature sensors, and a digital recording tide gauge were installed in the estuary. These were positioned about 0.3m above the river bed just upstream of the outfall point and recorded the current speed and direction, temperature and salinity and water level at ten minute intervals for the duration of the survey works.

2.4 MOBILE INSTRUMENTATION

The survey launch also carried a direct reading temperature/salinity meter which was used on a regular basis while dye tracking to determine the extent of the salt wedge excursion into the Ilen river.

3. SURVEY ACTIVITIES

3.1 SURVEY DIARY

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3rd Dye injection equipment set up on site. Survey vessel launched and fitted with tracking equipment. Current meter and tide gauge deployed.

Dye released on ebb tide @ 1420 hrs. continued until 1920 hrs. Plume tracked until 2200 hrs.

4th Continue tracking on high and low waters.

5th Continue tracking on low and high waters.

7th Continue tracking on high water. Concentration levels approaching background values.

8th Commence spring tide dye release at 0630 hrs on the ebbing tide. Continue release until 1115 hrs. Track dye until 2000 hrs.

9th Continue tracking on high and low waters.

11th Complete tracking. Demobilise survey vessel & equipment.

18th Recover tide gauge and current meter.

4 SURVEY RESULTS

4.1 DYE RELEASE NO. 1 - 3/2/93

This dye release took place during average neap tides. Predicted high water on the day was 1358 hrs and the release commenced shortly afterwards at 1420 hrs. The flow was downstream at this time, and had begun to strengthen. The dye release continued until 1920 hours and over the 5 hour period some 6.5 kg (6 litres) of concentrated dye solution was released.

Tracking of the dye plume commenced soon afterwards and continued until 2200 hrs. Weather conditions on the day were exceptionally good with no wind or rain.

Dye concentration presented in the following sections have been normalised to represent a unit source (i.e. 1 unit of effluent per second for the release period) by dividing by the dye flow rate which was $3.3 \times 10^{-7} m^3/s$ (6 litres in 5h). Thus they can be related to an effluent discharge by multiplying by the appropriate flow and concentration values.

In the early stages of the track, while the water level was still high and the flow quiescent, the plume remained relatively compact and did not mix laterally. Observations of the concentration variation showed this limited mixing (see photographs). Later as the tide fell and only river flow remained more energetic mixing occurred. Results from cross-section measurements are shown in figure 4.1. At 1500m downstream the central peak can be clearly seen. By the time the dye has reached Oldcourt it had become reasonably well mixed across the river.

At low water (approx. 2000 hrs) the plume had travelled downstream as far as the west end of Inishbeg Island, a distance of some 9.5km. A salinity profile at this point showed the surface water to have a salinity of 11ppt while at 1 metre it had increased to 23ppt and to 30ppt at 3 metres. The axial concentrations recorded during the track are shown in Figure 4.2a. Schematic plan illustrations of the low water and high water extents are shown in Figures 4.2b. and 4.2c together with the areas of highest concentration. Note that dilutions shown are based on an effluent discharge of 9 times the dry weather flow (3x3 DWF).

On the flood tide the dye was tracked from Inishbeg Island up to Oldcourt. Tracking ceased at 2200 hours due to poor visibility. The axial concentration distribution at this time is also shown in Figure 4.2a. Salinity measurements at Oldcourt at 2200 hrs (HW-4h) indicated a surface value of 4 ppt, 18.5 ppt at 1 metre and 25 ppt at 3 metres.

Tracking continued on the following day (4th) during both low and high waters. At low water (Release+18h) the dye extended all the way down stream from the Rowing Club to Turk Head and Sherkin Island (Figure 4.2b). Some dye traces were also recorded in Baltimore Harbour. At the outer end however dye concentrations were very low about 0.0015. The region of highest concentration, about 0.02, extended for some 1.5 km along the channel to the north of Inishbeg Island.(Figure 4.2b). The dye was still patchy at this stage and alternate areas of high and low concentration were encountered frequently.

A track through the plume at the following high water (R+24h) recorded trace concentrations from Turk Head right up to the discharge point. The region of highest concentration, about 0.012, lay upstream of Oldcourt and covered some 1.5km of the channel. Concentrations were however reduced considerably from the previous day. Dye was observed up as far as the discharge point.

A low water track on the 5th (R+42h) showed the dye concentrations had fallen further and become more evenly distributed along the estuary axis. A localised peak level of 0.012 was recorded off Inishbeg Island though a more representative peak level was about 0.009. On the following high water (R+48h) trace dye concentrations were observed throughout the estuary from Turk Head to the New Bridge. (The dye had travelled further upstream on this date due to the increasing tidal range). The peak levels were of the order of 0.005 and were recorded between the Rowing Club and Inishbeg Island.

A final track of this release was made at high water on the 7th. (R+96h). Trace concentrations of dye (<0.003) were observed from the release point to Turk Head. Levels were considered too close to background values to permit further worthwhile tracking.

4.2 DYE RELEASE NO. 2 - 8/2/93

This release took place during high spring tides. Predicted high water on the day was 0555 hrs and the release commenced shortly afterwards at 0630 hrs. The dye release continued until 1115 hrs and a total of 15.3 kg (14 litres) of concentrated dye solution were released.

Tracking of the dye commenced soon after release and continued until high water. Weather conditions were good with slack winds and occasional light showers.

Early in the track mixing patterns were very similar to those observed during the neap tide release. The plume remained compact in the slow moving waters and only began to mix laterally past Deelish Pier. As the tide fell and current speeds increased, giving rise to more turbulent conditions, greater mixing was achieved (see photographs).

Cross-sectional measurements of dye concentrations showed typical peaky profiles (Figure 4.3) in the upper reaches. However by Oldcourt the dye had become well mixed across the full cross-section.

At low water (approx. 1230 hrs) the leading edge of the dye plume had travelled some 15 km downstream. Concentrations recorded during the track are shown in Figure 4.4a and schematic plan extents in Figure 4.4b and 4.4c.

On the flood tide the dye was tracked from Ringarogy Island up to Skibbereen. At the seaward end only trace concentrations were observed while appreciable levels were detected from the western end of Inishbeg Island upstream. The area of highest concentration was found to be between the New Bridge and Skibbereen where a peak concentration of 0.04 was recorded. Note again that concentrations represent the dilution of a unit source as indicated in Section 4.1 and therefore this represents an effective 250 fold dilution of effluent (3x3DWF =96 l/s).

Tracking at high water on the following day 9th (R+24h) showed the peak to have decreased substantially to 0.007 . The region of highest concentration now lay between Deelish Pier and the Rowing Club and gradually decreased to background levels past Turk Head. Trace concentrations 0.0004 were recorded in Baltimore Harbour. Continuation of the track at low water showed dye had travelled seaward on both sides of Hare Island. Highest concentrations (<0.002) were observed to the south of Hare Island.

A further high water track on 11th showed residual dye in the estuary from Turk Head to Deelish Pier. Highest concentrations, of the order of 0.0004, were recorded between Oldcourt and the Rowing Club.

4.3 RIVER FLOW

River levels were recorded during the survey period by observing the staff gauge at Ballyhilty Bridge. Rating curves for the Ilen (based on 1977 - 1989 data) allowed the readings to be converted directly to flow (Table 1). Flow exceedances for this gauge computed by the E.R.U. are given in Table 2. On the basis of this data the 3 day sustained low flow is estimated to be 0.25m^3/s (approx. 5 mgd).

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Date	Staff Gauge (m)	Flow m^3/s
3rd	.68	6.7
4th	.66	6.3
5th	.64	6.0
6th	.62	5.5
7th	.61	5.2
8th	.61	5.2
9th	.61	5.2
10th	.61	5.2
11th	.61	5.2
18th	.63	5.8

Table 1 - River flow data for survey period.

Exceedance	Flow m^3/s
5%	41.9
10%	28.5
20%	17.1
30%	11.9
40%	8.2
50%	5.7
60%	3.7
70%	2.5
80%	1.7
90%	0.9

Table 2 - River Flow Statistics. Based on continuous water level records for the period Jan '83 to Dec '85.

4.4 RECORDING INSTRUMENT DATA

Tidal Information

A recording tide gauge was deployed near the proposed outfall discharge point at the start of the field work and left in position for 16 days. A plot of the tidal curve relative to Poolbeg Datum is presented in Figure 4.5.

The gauge data compares favourably with the Admiralty Tide Table predictions for Baltimore when allowances are made for distance (20km) and river flow. Mean high water spring is approximately 3.8m and mean neap high water approximately 3.1m. Measured times of high water are within about 10 minutes of those computed for Baltimore from the tide tables.

The data plot (Figure 4.5) shows that at about HW+4h the tide had fallen to the level of the river flow in the channel. This was about 0.5m for the $6m^3/s$ which prevailed during the survey. Under the very low river flow conditions the channel will almost dry out at low tide. Extrapolation of the measured data shows that this would occur between HW+4.5h and HW+5h.

Recording Current Meter

The recording current meter was located at about 0.3m above the bed in mid-channel just upstream and provided over two weeks of data on current speed and temperature/salinity variations.

At the outfall site peak speeds were about 0.5m/s. These occurred on the ebbing tide about 1.5 hours after high water. For the remainder of the tide a constant speed of 0.4m/s prevailed due to the river flow. The data plot is shown in Figure 4.4. Temperature and salinity data from the same site is shown in Figure 4.6. Peak salinities reached 12ppt and temperatures 9.2°C.

4.5 INTERPRETATION OF RESULTS

Data from the ebb tide dye release on 3/2/93, Figures 4.1 &4.2, shows how the dye concentration changes with distance from the source for a given river flow rate and neap tides. Similar plots, Figures 4.3 & 4.4 from the release on 8/2/93 show the effect of the spring tide. The position of the mixing zone is not fixed but depends on the tidal level and the river flow. The dye data suggests that the limit of the mixing zone, the point at which full cross-sectional mixing has occurred, will lie somewhere between Deelish Pier and the Rowing Club bend.

As the dye acts like a conservative contaminant the results can be used to estimate the concentrations arising from effluent discharging from the outfall. At any given time the total concentration will be a summation of all contributions from previous releases. The peak concentration in the estuary during neap tides can thus be expressed as:

$$C = [\text{Plume Concentration} + \text{Peak Background Concentration}]\ \text{units/m}^3$$

or

$$C = [\text{Plume Concentration} + 0.34]\ \text{units / m}^3.$$

The plume concentration represents the levels in the area affected by a discharging outfall. Outside the immediate plume the peak background concentration will be about 0.34 units/m^3. This is based on a source of 1 unit per second and so for a typical effluent discharge of 3x3DWF releasing, for example, 55kg of BOD over 24 hours the peak concentration (excluding the plume) will be:

$$Cp = 0.34 \times 55 / (24 \times 3600)\ \text{kg/m}^3$$

$$Cp = 0.21\ \text{mg/l}$$

A similar calculation based on the spring tide release of 8/2/93, gives a peak value Cp = 0.09mg/l (0.13 units/m^3 for unit source). Thus the average increase in peak background BOD concentration will be approx. 0.15mg/l.

The position of the peak background concentration will be influenced primarily by the previous ebb tide release and therefore occur in the vicinity of the outfall as shown by the axial concentration profiles in Figures 4.2 & 4.4.

On the flooding tide waters mixed with recently discharged effluent will be pushed upriver towards the town. Contaminant concentrations in these waters can be estimated from the dye test results. The profile at *Release + 12 h* in Figure 4.4a (spring tide) shows a peak of 0.041 for a unit discharge. Therefore for 3x3DWF (96 l/s) the dilution is approximately 250 and thus the BOD concentration will be 20/250 = 0.08mg/l. No profile was recorded at *Release +12 h* during the neap tide. However by scaling the concentration peaks at later times with the corresponding spring tide values the dilution is found to be of the order of 85. Thus the BOD concentration will be 20/85 = 0.24mg/l.

Bacterial concentrations can also be obtained from the dye results though as the dye is conservative decay is not readily accounted for. Realistic estimates of the background levels are therefore not possible though good indications of the short term concentrations, such as those that occur at high water on the flooding tide, can be made. From the dilutions outlined in the previous paragraph upstream levels at high water will range from 200 to 580 per 100ml. Allowing for a 70% die off over the time from discharge to high water reduces the range to 60 to175 per 100ml.

The concentration in the plume itself will vary depending on the state of the tide and the river flow. The likely dilutions, based on the recorded current speeds and model simulations are presented in Section 5.

5. MODEL SIMULATIONS OF DISCHARGES TO THE ESTUARY

To assist with the evaluation of the proposed effluent discharges and provide further indications of how the dilutions/concentrations will vary with distance from the source various numerical models were employed. These were principally a mid-field dispersion model and a tidally averaged model. The near-field effects were examined in a more qualitative way. The results, together with details of the models, are outlined in the following paragraphs.

5.1 NEAR FIELD MIXING

An indication of the probable concentration ranges of effluent, for example BOD, in the immediate area of the outfall can be derived from straightforward physical arguments.

During periods of low river flow (i.e. 5 mgd or 0.25m^3/s) the effluent concentrations in the near field will be increased particularly in the later stages of the discharge period as the volume of tidal waters upstream of the site reduce to zero. The worst case will occur when the tide level has fallen below the bed level leaving only river water available for mixing.. The maximum dilution achieved when the effluent (3x3DWF) mixes with the river flow is 0.25/0.096 = 2.6. Thus if the effluent BOD concentration is 20mg/l then at maximum dilution the river BOD will be 7.7mg/l above any existing background level. This level will be reached when full cross-sectional mixing is achieved, probably just downstream of Deelish Pier.

High tides combined with low river flows will produce more immediate dilutions due to the mixing of the effluent jet with ambient water. The initial dilution of 3x3DWF at high water neap is estimated to be 6 (see Section 5.4) and therefore the peak BOD concentration will be 20/6 = 3.3mg/l in the mixing zone.

Near-field coliform concentrations can be estimated by a similar procedure. They will be of the order of $2x10^4$ per 100ml under similar conditions to those described above.

5.2 MID FIELD DISPERSION

Effluent concentrations downstream of the source were estimated using an analytical model. This particular model is based on the differential equations which define the processes of diffusion of a contaminant in flowing waters. The model assumes that the effluent is well-mixed over the water depth. Representative information recorded at the site on depths and current speeds were used to set up the model. Diffusion coefficients were calculated from the empirical approximation $K = 0.5uh$ where u,h are local speed and depth respectively. The model was used to predict typical BOD and bacterial concentrations for times between HW+1h and HW+5h using a flow rate of 3x3DWF @ 20mg/l and a faecal coliform concentration of $5x10^4$ per 100ml. The results are presented in Table 3 and strictly are representative of the mean river flow and neap tide conditions which prevailed during the survey. The restriction of mean river flow is only significant for predictions near the source (i.e. <3000m). Further downstream where the river flow comprises only a small fraction of the tidal flow the differences would be small and thus the results can be taken as indicative of the probable concentrations.

Distance Downstream(m)	B.O.D.mg/l	Coliform Concentration /100ml T90=6h	T90=12h
1000m	0.15-0.30	480	540
3000m	0.025-0.065	225	300
5000m	0.015	15	25
10000m	0.009	<10	<10

Table 3 - Mid-field model simulation of effluent mixing on the ebb tide. (River Flow = $6m^3/s$).

Estimates of the contaminant concentrations upstream of the outfall site were made with a box model. With this method the effluent is assumed to discharge into a box whose volume is defined by the tidal prism upstream of the outfall. The 'steady state' concentrations can then be estimated using the equation: $C_b = Q * E_c/(V * k)$, where Q, E_c are the outfall flow and concentration, V is the box volume ($100000m^3$ for mean neaps) and k a decay rate. The method is conservative as it takes no account of the downstream mixing. The only manner by which effluent can leave the box is through decay. Therefore BOD with a decay (T_{90}) of about 5 days cannot realistically be estimated by this method. Results are presented in Table 4 and are consistent with values estimated from the dye tests (Section 4.5).

B.O.D. mg/l	Coliform Concentration /100ml	
	T90 = 6 hours	T90= 12 hours
Not Applicable.	165	330

Table 4 - Box Model simulation of effluent mixing on the flood tide.(Neap)

5.3 TIDALLY AVERAGED MODEL

Simulations of the longer term fate of contaminants discharged to the estuary and the effects of river flow were made within an estuarine contaminant model, ECOS.

In this model the estuary is divided into equal-length segments, within which the water-column is assumed to be perfectly mixed. ECOS determines tidally-averaged movements of material between these segments. The movements are represented as two separate components - advection (flow), and dispersion (mixing). The advective component represents the average transport of material and round this average flow, the dispersive component embodies the stirring and mixing processes of the estuary. The concentrations which the model calculates are thus tidal averages.

The model allows inputs of fresh water and contaminants into any one of the estuary segments. The various physical processes to which contaminants are subjected can be simulated.

Model Setup For The Ilen

A simplified estuary shape was employed based on a function fitted to the known estuary cross-sectional area at several points. The model assumes a mid-tide level and that water is present upstream of the discharge point at all times. Salinity at the seaward end was taken to be 33ppt and zero at the river end. Dispersion was assumed to be related to the steady state salinity gradient and described by an empirical function.

Simple contaminant descriptions were employed; either decaying at a rate similar to BOD or the more rapid bacterial decay of 12 and 6 hours. Several runs of the model were then made, varying parameters such as river flow, tidal amplitude and contaminant type.

Model Predictions

Simulations of the dispersion of effluent were made for three river flows 0.25, 3 & 6 m^3/s. The predicted concentration profiles along the estuary for neap tides are shown in Figures 5.1 to 5.3 for BOD and bacterial contaminants. Results are also presented in Table 5.

For a $6m^3/s$ river flow, similar to that which prevailed during the dye test, the model predicts peak concentrations of 0.09mg/l at the outfall site from 3x3DWF with a loading of 55kg BOD per day.

A more realistic long term discharge is 1DWF (over 24hrs) and the corresponding BOD loading on the estuary is 18kg/day. Applying the model to this discharge as described above gives a peak of approx. 0.03mg/l.

These results are tidally averaged and so high peaks associated with plumes are smoothed out. Therefore the prediction compares favourably with the neap tide estimate of 0.21mg/l provided directly from the dye experiment (Section 4.5). Thus the model can be used to estimate the effects of river flow with reasonable confidence that the results are accurate to within a factor of about 2-3.

For the lower river flow of $3m^3/s$ the model predictions indicate peak concentrations increasing by a factor of about 1.3 over those arising during a flow of $6m^3/s$. Under very low flow conditions, $0.25m^3/s$, predicted concentrations are 0.15mg/l, a factor of 1.7 above these arising during a flow of $6m^3/s$.

Model predictions of faecal coliform concentrations are illustrated in Figures 5.2 & 5.3 and also in Table 5. These suggest peak values of about 135 and 90 per 100ml for decay times of 12 hours and 6 hours respectively. As expected the values are lower than those indicated by the mid-field model due to the tidal averaging and rapid decay times.

Distance Downstream(m)	B.O.D.mg/l	Coliform Concentration /100ml T90=6h	T90=12h
1000m	0.09-0.12	60	105
3000m	0.060-0.075	15	30
5000m	0.027-0.036	<10	<10
10000m	0.003	<10	<10

Table 5 - Tidally averaged model simulation of effluent mixing on the ebb tide. (River flow = $6m^3/s$).

5.4 INITIAL DILUTIONS

A near-field model was used to investigate the likely initial dilutions available at the outfall site. The model solves the steady state equations describing various conservation equations which define the trajectory, dimensions and dilution factor of the effluent stream. Current data recorded upstream of the outfall site were used and results for spring and neap tides are presented in Table 6.

Flow	Spring	Neap
32 l/s.	8	6
96 l/s	7	5

Table 6 - Predicted Maximum Initial Dilutions (HW+1h) at the Outfall Site.

5.5 REGULATORY REQUIREMENTS

Various National and European directives regulate the discharge of waste waters to the coastal and estuarine environments. Of these, those that relate to bathing & shellfish waters are probably the most relevant to this location. In particular it is found that the criteria which govern bacterial contamination are the most stringent and once these are met a discharge will normally satisfy all other requirements. The relevant levels are outlined in Table 7 and it can be seen that the proposed discharge to the Ilen will meet the requirements outside the immediate mixing zone.

Bathing Waters	National Limit Value	1000 faecal coliform (F.C.) per 100ml
	EEC 76/160-1975	2000 faecal coliforms per 100ml
Shellfish Waters	EEC 79/923-1978	300 faecal coliforms per 100ml
	Dept of Marine	Approved -mean FC: <14 per 100ml
		Conditional -mean FC : 14-140 per 100ml
		Restricted -mean FC: >140per 100ml

Table 7 - Water Quality Directives on Bacterial Contamination.

6. DISCUSSION

This document presents the results of dye dispersion tests conducted on the Ilen estuary during neap and spring tides and average river flows. Dye released from the proposed outfall site on the ebb tide was found to mix rapidly and peak concentrations to reduce below measurable levels within eight tidal cycles.

Results enabled peak contaminant concentrations to be estimated. These show that a maximum BOD discharge of 55kg/day from the proposed outfall will produce a peak increase in the background level of about 0.21mg/l during neap tides and for river flows of 6m^3/s (50 percentile flow). The corresponding value for spring tides will be 0.09mg/l. The flooding tide will carry effluent contaminated waters upstream towards the town. Estimates of the likely increase in BOD and faecal coliform levels in this region at high water are 0.08-0.24mg/l and 60-175 per 100 ml respectively. These estimates were compared with the predictions of various numerical models and found to be in close agreement thus confirming the reliability of the approach.

A numerical model was also used to examine the estuary for different river flow situations. For neap tides and a 6m^3/s flow, which prevailed during the field study, the model predicts a BOD peak background level of 0.09mg/l. This is lower than that estimated from the dye experiment but considered close given the averaging inherent in the model. The model predicts an increase in these peak values to 0.15mg/l for a river flow of 0.25m^3/s. Thus, allowing for underestimation by the model by a factor of about 2, the true increase in the peak background value is likely to be of the order of 0.3mg/l under low flow conditions..

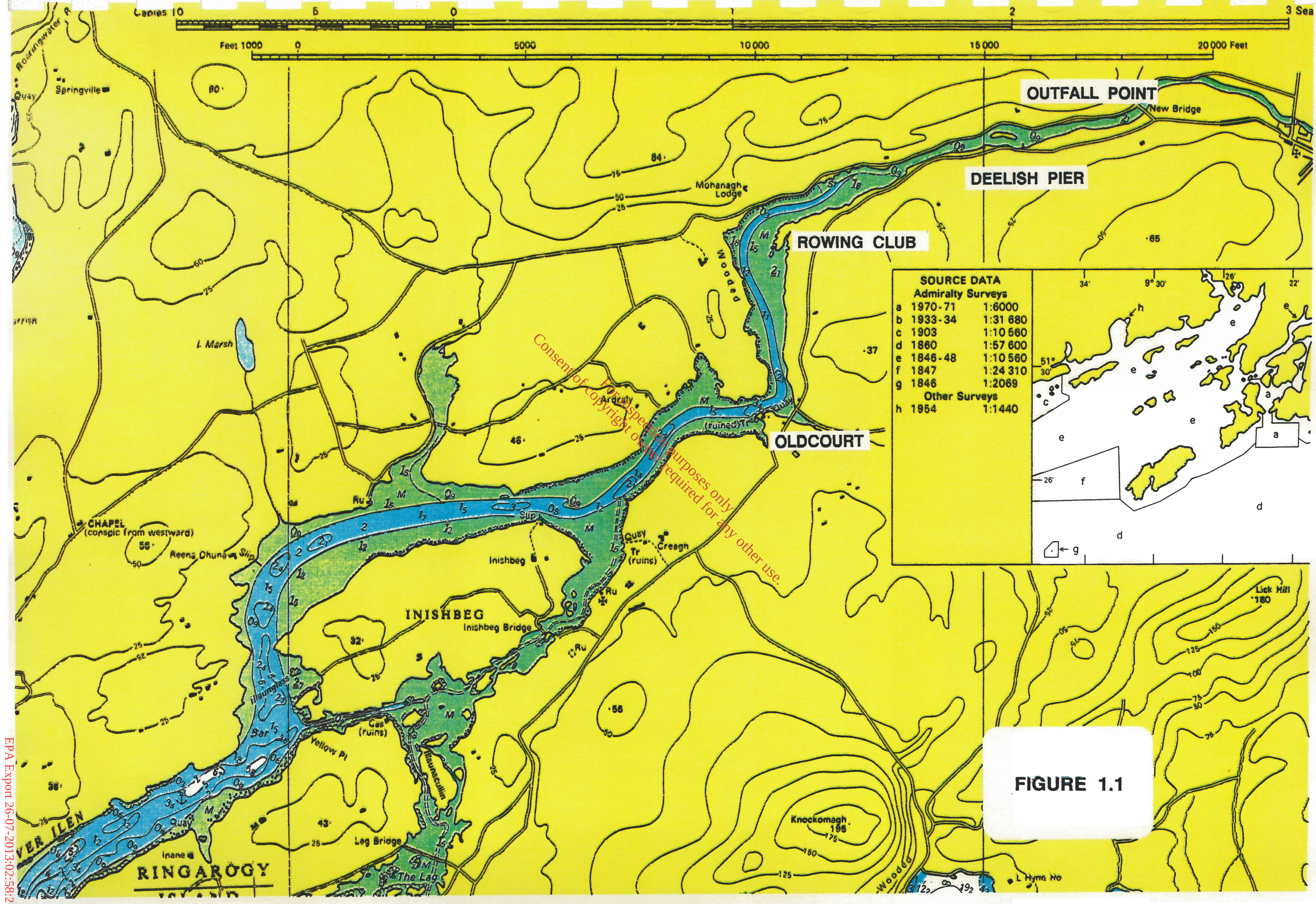
Effluent plume concentrations in the near-field mixing zone were estimated for the various combinations of flow and water level. When some initial mixing occurs the peak value was found to be about 3-4mg/l. This value decreases with distance from the source. The limits of the mixing zone are variable depending on the state of the tide and the river flow. Typically full mixing will occur between Deelish pier and the Rowing Club bend.

The recorded tidal data confirmed the general patterns given in the Admiralty Tide Tables for Baltimore Harbour. However analysis of the results showed that the tide level will fall below the bed level at the proposed discharge site sometime between HW+4.5h and HW+5h. Therefore it is recommended that the discharge period extend from HW+0.5h to HW+4.5h.

The findings of this study are in good agreement with earlier studies carried out by the Consulting Engineer which indicated probable maximum BOD increases, outside the mixing zone, of 0.2 to 0.5mg/l for the design conditions. Both dye measurements and model predictions have shown that the BOD and coliform concentrations arising from the proposed discharge will be well within the mandatory levels set by the various National and European directives which regulate waste water discharges to estuarine and coastal waters. Therefore this site is considered suitable for the proposed outfall.

PHOTOGRAPHS

No.	Content
1	View of dosing equipment and dye plume with premixing via submerged water pump (6l/s).
2	Dye plume at approx. HW+1.5h on 3/2/93 (Neap Tide).
3	Survey launch with dye plume in the background. Approx. 150m downstream from the outfall point.
4.	View of dye plume at approx. HW + 1.5h on 3/2/93 at 400m downstream from the discharge point.
5.	View of dye plume on 8/2/93 at approx. HW+3.5h looking down river.
6.	View of dye plume from bank as per photograph 5.
7.	View of dye plume on 8/2/93 at HW+3.5h approx. 250m downstream from the discharge point.
8.	As for photograph 7.
9 & 10	View of dye plume 8/2/93 at HW+3h approx. 450m downstream from discharge point.
11 & 12	View of dye plume from southern side of channel approx. 550m downstream from the source at approx. HW+3.5h. Dye is well mixed and extends across three quarters of the full channel width. Clear water running down the opposite shoreline, travels on the northern side of the Island.



OUTFALL POINT
DEELISH PIER
ROWING CLUB
OLDCOURT
New Bridge
Mohanagh Lodge
Wooded
INISHBEG
Inishbeg Bridge
Inishbeg
Quay
Creagh
Tr (ruins)
Ardralty
L Marsh
Springville
CHAPEL (conspic from westward)
Reens Dhuna
Yellow Pt
Cas (ruins)
Lag Bridge
The Lag
Inane
RINGAROGY
Knockomagh
Lick Hill
L Hyne Ho
Feet 1000
0
5000
10 000
15 000
20 000 Feet
Cables 10
SOURCE DATA
Admiralty Surveys
a 1970-71 1:6000
b 1933-34 1:31 680
c 1903 1:10 560
d 1860 1:57 600
e 1846-48 1:10 560
f 1847 1:24 310
g 1846 1:2069
Other Surveys
h 1954 1:1440

FIGURE 1.1

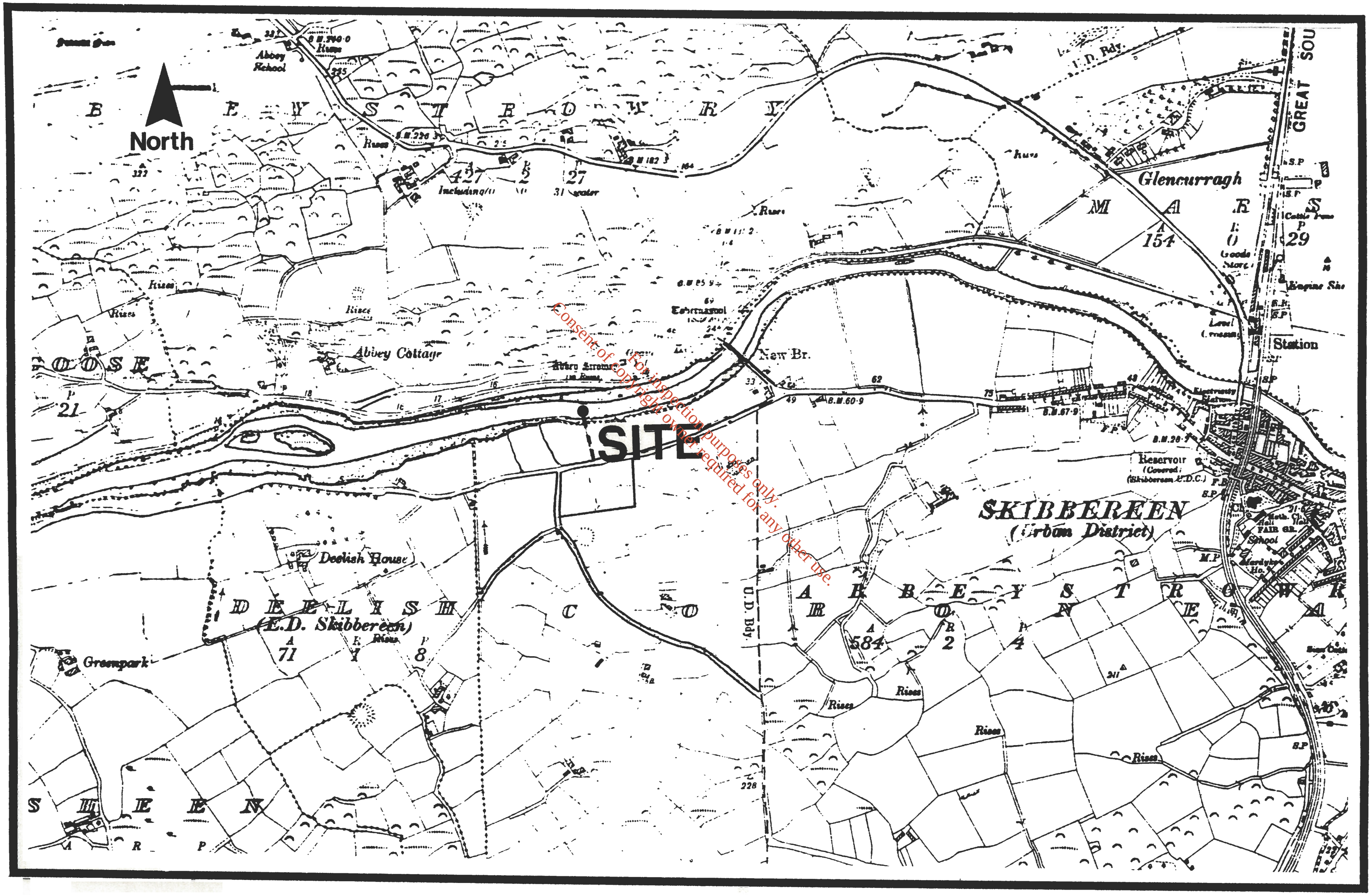
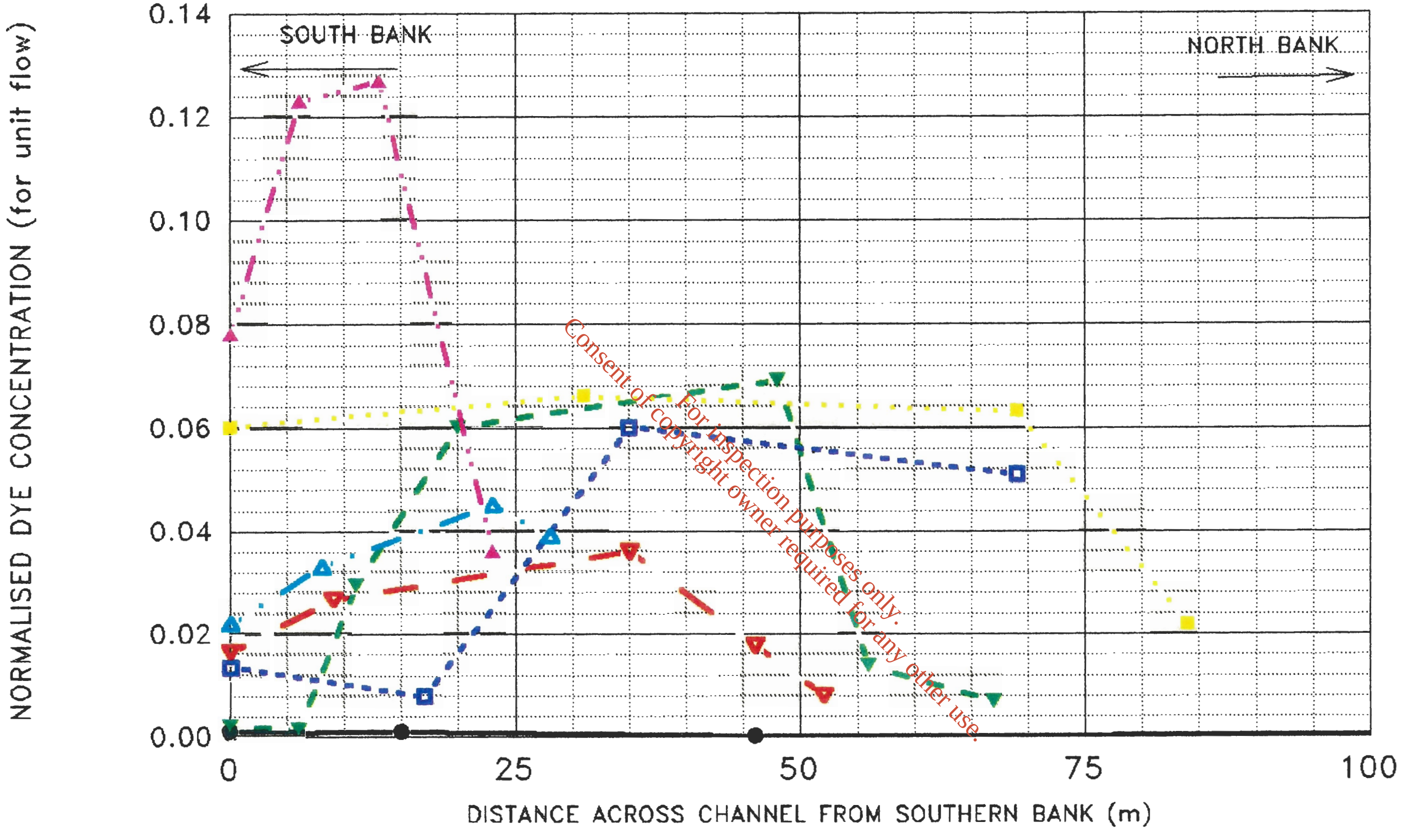

North
SITE
New Br.
SKIBBEREEN
(Urban District)
Glencurragh
Station
Abbey Cottage
Deelish House
DEELISH
(E.D. Skibbereen)
Greenpark
Reservoir
U.D. Bdy.
Abbey School
GREAT SOU

FIGURE 1.2

SKIBBERREEN SEWERAGE SCHEME

NEAP TIDE DYE RELEASE – DYE CONCENTRATIONS AT CROSS SECTIONS



PROFILES	DISTANCE FROM SOURCE	TIME
N7	5100m	R+3.3h
N6	4600m	R+3.4h
N5	4000m	R+3.5h
N4	3400m	R+3.6h
N3	2900m	R+3.7h
N2	2000m	R+3.9h
N1	1500m	R+4h

FIGURE 4.1

SKIBBERREEN SEWERAGE SCHEME

DYE CONCENTRATION VARIATION ALONG ILEN ESTUARY

NEAP TIDE DYE RELEASE – 3/FEB/'93

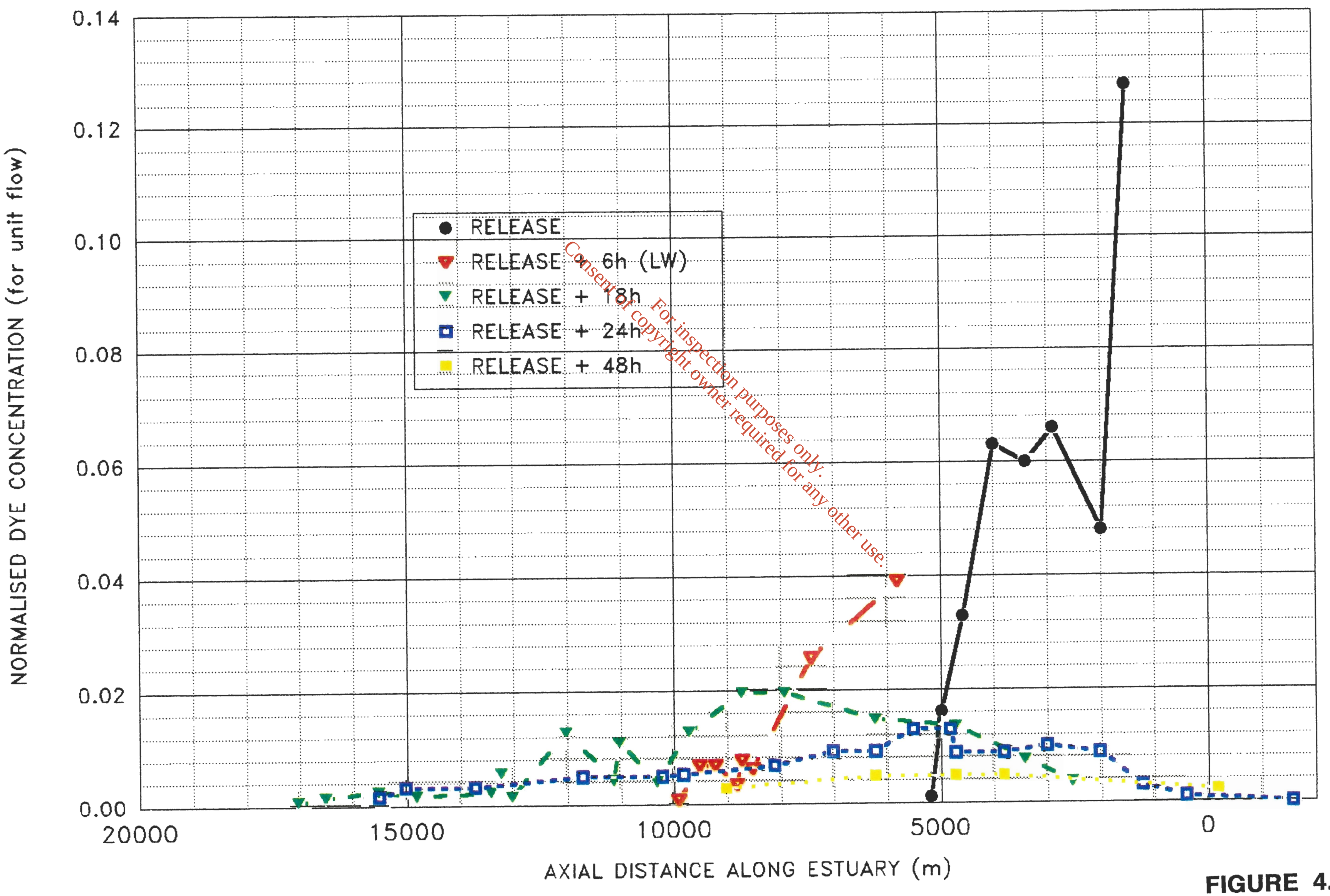


FIGURE 4.2a