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ENVIRONMENT  
AGENCY

**SOUTH WEST  
REGION**

**ASSESSMENT OF THE  
WATER QUALITY  
BEFORE, DURING AND POST  
COMMISSIONING OF THE  
INTERIM FALMOUTH  
SEWAGE TREATMENT SCHEME**

**Report No. TWQ/98/02**

**September 1998**



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## APPENDIX 1

## 1 EXECUTIVE SUMMARY

The Environment Agency has monitored the environmental performance of the Falmouth Interim (Phase 1) Scheme. Specifically, an extensive assessment of the water quality in the Carrick Roads, Penryn River, Percuil River, and Falmouth Bay, including the EC Designated Bathing Waters, has been made (reference Figure 1a Location Map). The objectives of the monitoring programme are threefold:

- Assessment of water quality before, during, and after commissioning of the scheme.
- Assessment of the dispersion of the effluent plume from the Black Rock outfall using dye and tracer spores.
- Assessment of the impact of the effluent plume on marine macro benthos in the vicinity of the outfall.

The Agency has previously published the results of survey work carried out between 12 March 1998 and 23 April 1998, before and during the commissioning of the Interim Scheme<sup>1</sup>.

This report, however, provides details of and derives conclusions from all the monitoring undertaken in relation to this phase of the scheme. All water quality data from the surveys have been collated in a separate data annex to this report and are available from the Agency on request.

The main conclusion from the programme of surveys is that the primary objectives of the interim scheme have been achieved, namely:

- Water quality at the EC Designated Bathing Waters has significantly improved and compliance with the EC Bathing Waters Directive mandatory and guideline standards is expected at Gyllyngvase and Swanpool. At Maenporth, there has been a marked improvement in water quality and compliance with mandatory standards is expected.
- Protection of the high water quality level within the Classified Bivalve Mollusc Production Area designated by MAFF.
- Removal of the unsatisfactory aesthetic impacts around Swanpool Beach, Gyllyngvase Beach, the old Middle Point outfall and the Quay area of Falmouth, which were associated with previously crude, unscreened sewage discharges.

<sup>1</sup> A report entitled "Preliminary Assessment of the Water Quality before and during commissioning of the Interim Falmouth Sewage Treatment Scheme" was published in May 1998.

## 2 TIDAL PHASING STRATEGY

The release of the screened effluent on the ebb tide is an extremely important element of the Interim Scheme. The main objective of the tidal phasing is to ensure that there is no deterioration in water quality in the Carrick Roads to the north of the Classified Bivalve Mollusc Production Area limit. This has been achieved by detailed measurement and assessment of the current regime and selection of the most appropriate tidal release window. A four hour period is required to completely discharge sewage held within the sewerage system under normal operating conditions. A five hour tidal release window was originally consented to enable the fine tuning of the optimum four hour discharge period.

The tidal release windows were originally determined from historic survey data as follows:

Neap Tides:	15 minutes before HW to 4 hours 45 minutes after HW
Intermediate Tides:	30 minutes before HW to 4 hours 30 minutes after HW
Spring Tides:	45 minutes before HW to 4 hours 15 minutes after HW

During the survey undertaken on 21 April 1998, under worst case conditions of a neap tide and fresh southerly winds, the dye released at the very end of the tidal release window (ie. nearly 4 hours 45 minutes after HW) travelled approximately 1km to the south before turning and moving north to a position off Trefusis Point before dispersing at around the time of High Water. It should be noted that despite the tracer dye re-entering the estuarine waters the results of the sampling confirmed there was no deterioration in the water quality in the shellfish harvesting areas. Nevertheless, as intended within the consenting arrangement, the discharge release period was reduced by one hour in order to optimise the dispersal of the effluent and thereby the protection of the shellfish waters. From 27 April 1998 the consented tidal release windows have been:

Neap Tides:	15 minutes before HW to 3 hours 45 minutes after HW
Intermediate Tides:	30 minutes before HW to 3 hours 30 minutes after HW
Spring Tides:	45 minutes before HW to 3 hours 15 minutes after HW

### 3 MONITORING PROGRAMME

The monitoring programme comprised several components. Detailed descriptions of the surveys can be found in Appendix 1 of this report. Below is a brief description of each survey:

#### 3.1 EC BATHING WATER ROUTINE MONITORING

The Agency routinely monitors water quality at the three EC Designated Bathing Waters at Gyllyngvase, Swanpool and Maenporth. The bathing waters are sampled weekly during the bathing season (May to September) and the results are used by the Department for the Environment, Transport and Regions (DETR) for assessing compliance with the requirements of the EC Bathing Waters Directive.

#### 3.2 BASELINE SURVEYS

The objectives of the baseline surveys were to monitor the general water quality of the Carrick Roads, Penryn River, Percuil River, and Falmouth Bay in order to detect any change which might be attributable to the scheme. Samples were taken from sites throughout the area. Prior to commissioning of the scheme four baseline surveys were undertaken. These were repeated following scheme commissioning.

#### 3.3 PRE-COMMISSIONING SURVEY

An opportunity to measure, directly, the dispersion characteristics of the estuarine waters was available before commissioning of the scheme. Groundwater, which had accumulated in the storage tunnel, was labelled with *B. globigii*<sup>2</sup> and released through the new outfall. Measurements of reductions in concentration in the receiving waters were undertaken.

The objectives of this survey were:

- To measure the dilutions in the plume in the Carrick Roads and Falmouth Bay at the surface and depth.
- To monitor the plume trajectories at different release times within the consented tidal release window.

#### 3.4 COMMISSIONING SURVEYS

These surveys were undertaken during the commissioning of the scheme, when only part of the sewage flow (the Falmouth catchment) had been transferred to the new outfall. However, during these commissioning surveys the discharge was operated in such a way that sewage effluent was discharged at the same rate as that which is being used following scheme commissioning. Therefore, concentrations measured in the discharge plume in these surveys are representative of those during full operating conditions.

<sup>2</sup> *B. globigii*, used in a number of these surveys, is a bacterial spore commonly used to trace the movement and dispersion of water. *B. globigii* is more persistent in sea water than dye and does not suffer significant mortality in seawater over a number of days. Concentrations of spores in samples collected from seawater can be used to obtain the dilution of effluent rather than simply indicating its presence by the use of dye alone.

#### **3.4.1 Commissioning Survey (Spring Tide): 15 April 1998**

The objectives of this survey were as follows:

- To monitor the bacterial concentrations in the receiving water to the south of Black Rock on the ebb tide for that part of the effluent plume released towards the end of the tidal release window (HW +4:15).
- To monitor the water quality to the north of the boundary of the Classified Bivalve Mollusc Production Area on the following flood tide.

Samples were collected from the plume which was marked with dye and from the southern part of the Carrick Roads over the following HW.

#### **3.4.2 Commissioning Survey (Neap Tide): 21 April 1998**

The objectives of this survey were as follows:

- To monitor the bacterial concentrations in the receiving water to the south of Black Rock on the ebb tide for that part of the effluent plume released towards the end of the tidal release window (HW +4:45).
- To monitor the water quality to the north of the boundary of the Classified Bivalve Mollusc Production Area on the following flood tide.

Samples were collected from the plume which was marked with dye and from the southern part of the Carrick Roads over the following HW.

The conditions encountered during this particular survey represented the predicted worst case conditions, with regard to the behaviour of the plume towards the end of the tidal release window, of southerly wind and Neap tide.

#### **3.4.3 Commissioning Survey (Intermediate Tide): 23 April 1998**

As a further test of the scheme, it was decided to carry out a survey under an intermediate tidal state. Based on the results from the Neap tide survey conducted on 21 April, this intermediate tide survey was designed to monitor that part of the effluent plume released one hour before the end of the then consented tidal release window (ending at HW+3:30).

Samples were collected from the plume which was marked with dye and from the southern part of the Carrick Roads over the following HW.

### **3.5 POST COMMISSIONING SURVEYS**

Since the scheme was commissioned at the beginning of May, two large scale tracer and water quality surveys have been carried out over the periods 2 to 5 June (Neap tides) and 23 to 26 June (Spring tides). The main objective of these surveys was to assess the dispersion of the effluent plume from the Black Rock outfall:

- In the area to the south of the Black Rock discharge;
- At the EC Bathing Waters, Swanpool, Gyllyngvase, and Maenporth, and the non-designated bathing waters in the Carrick Roads;
- Within the Classified Bivalve Mollusc Production Area.

During each of these surveys *B. globigii* was introduced into the effluent throughout the discharge period over four consecutive tidal release windows. A marker dye was also introduced during two of the tidal release windows to assist tracking of the effluent plume in Falmouth Bay during daylight hours. Samples were taken from the discharge plume as it dispersed in Falmouth Bay on the ebb tide and samples were collected at High Water from a grid of sites extending from Flushing to Pendennis Point to determine whether effluent was re-entrained in the estuary on subsequent tides. During the neap survey, for unknown reasons, there was a high variability in the concentration of *B. globigii* measured in the injected tracer stream. There is therefore a considerable degree of uncertainty in the dilutions calculated from the *B. globigii*. Consequently, in relation to the results for this particular survey, the *B. globigii* data are considered to be suitable for use in a semi-quantitative role only.

Samples were also collected from a number of shoreline and offshore sites, at three hourly intervals. These were to cover Low Water as well as High Water, during daylight hours for the three days of each of the Neap and Spring surveys. The sites, shown in Figure 1b, were:

- EC Bathing Waters at Gyllyngvase, Swanpool, and Maenporth;
- Freshwater inputs at Swanpool and Maenporth;
- Non-designated bathing waters at Great Molunan, St Mawes, Castle Cove, Trefusis, Loe Beach, and East Gyllyngvase;
- Sites offshore of the EC Bathing Waters and non-designated bathing waters;
- One site on the southern limit of the Classified Bivalve Mollusc Production Area (Site 13).

## 4 RESULTS

(Note: All times GMT)

### 4.1 EC BATHING WATER QUALITY

The EC Bathing Waters at Gyllyngvase, Swanpool, and Maenporth are shown on Figure 1a.

Concentrations of *B. globigii* measured at the EC Bathing Waters during the Spring and Neap post-commissioning surveys were generally very low. The geometric mean<sup>3</sup> of faecal coliforms found in samples collected during the neap and spring post-commissioning surveys was 39 per 100ml.

It is in the nature of bacteriological sampling and analysis that anomalous results will occur from time to time. However, complementary measurements of *B. globigii* and faecal coliform concentrations have allowed us to 'qualify' some data results in our final assessment. For example, a sample collected at 16:55 on 25 June at Swanpool contained a *B. globigii* concentration of 188 per 100ml, indicating a dilution of 3,830. However, concentrations of faecal coliforms and faecal streptococci were both below the limit of detection (<10 per 100ml). Concurrent with this result, samples collected at distances of 200, 500, and 1000m offshore of

<sup>3</sup> The geometric mean is a statistical measure which is most appropriately used when a data set is log normally distributed.



Swanpool all contained <10 *B. globigii* per 100ml, and no other samples collected at Swanpool or offshore of Swanpool during the whole of that day contained *B. globigii* concentrations greater than 27 per 100ml. As another example, *B. globigii* results have confirmed the elevated bacterial concentrations measured at Maenporth and Swanpool on 26 June did not originate from the Black Rock discharge.

Figure 2 shows the geometric mean concentrations for each bathing season of faecal coliform and faecal streptococci recorded at the three EC Bathing Waters during routine monitoring of EC Bathing Water quality from 1990 until 8 September 1998. The figure shows that there has been a significant decrease in the geometric mean concentrations of faecal coliforms and faecal streptococci since the start of the 1990 bathing season. This improvement in water quality is very encouraging, given that there are freshwater inputs to the Bathing Waters at Swanpool and Maenporth, which, as elsewhere, are sources of bacteriological contamination, and that June and July 1998 were very wet months.

## **4.2 BASELINE WATER QUALITY**

A comprehensive programme of eight baseline water quality surveys has been completed. Four baseline surveys were carried out before the commissioning of the scheme (12 March - 7 April 1998) and a further four baseline surveys were carried out post scheme commissioning (21 May - 23 July 1998). Samples were collected from the sites shown in Figure 3, at each of four states of the tide (HW, HW+3, LW, HW-3).

Figure 4 shows geometric mean concentrations of faecal coliforms at each site for all samples collected before and after scheme completion. These results show that whilst there has been an increase in concentrations immediately over the new Black Rock outfall (site 17) elsewhere little detectable change has been measured, other than as expected, a significant reduction over the old Middle Point outfall (site 9).

## **4.3 DISPERSION OF THE PLUME IN FALMOUTH BAY**

### **4.3.1 Neap Tides**

The first survey under Neap tidal conditions took place during commissioning on 21 April. Figure 5 shows the faecal coliform concentrations in the dye, released at HW+4:45 (the end of the consented discharge period), as it was tracked to the south of the outfall.

As discussed in Section 3.4.2, the dye released in this survey travelled as far north as Trefusis Point on the flood tide, owing to the combination of late release time (HW+4hrs:45mins), neap tides, and fresh southerly winds. However, concentrations of faecal coliforms and faecal streptococci within the dye patch were low, with maxima of 40 per 100ml and 70 per 100ml respectively. Nevertheless, the survey observations were used to optimise the system and the consented discharge period now finishes one hour earlier.

Faecal coliform concentrations in Falmouth Bay under Neap Tide conditions during the major post-commissioning survey (3 and 4 June 1998) are shown in Figures 6 and 7 respectively. The figures show concentrations of bacteria as the plume was tracked out into Falmouth Bay and

concentrations north of Pendennis Point around the subsequent High Water. Any elevated concentrations measured were at locations well removed from the EC Bathing Waters.

In addition to the samples collected within the plume, samples were also collected over three days from sites along transects off each of the bathing waters in Falmouth Bay and off the beach at the east end of Gyllyngvase. Over the three day period, a significant majority of these samples had faecal coliform concentrations below the detection limit of 10 per 100ml. The highest *B. globigii* concentration in the 148 samples collected was 63 per 100ml, found in two samples. The first sample, collected 200m off Maenporth, contained faecal coliforms at a concentration of 30 per 100ml and faecal streptococci at a concentration below the limit of detection of 10 per 100ml. The second sample, taken 200m off Gyllyngvase, contained faecal coliforms and faecal streptococci at concentrations below the detection limit of 10 per 100ml.

#### 4.3.2 Intermediate Tides

The survey undertaken on 23 April 1998 was during a period of intermediate tides. Dye was released at HW+3:28 (i.e the end of the revised tidal release window). Figure 8 shows concentrations of faecal coliforms in the plume to the south of the outfall. Only two samples had concentration in excess of 2000 per 100ml (depicted by red dots); the values were 7200 and 5800 per 100ml.

#### 4.3.3 Spring Tides

For the first spring tide survey on 17 March, groundwater marked with *B. globigii* was released from the outfall. Dilutions were calculated from the concentrations of *B. globigii* in the samples collected in the effluent plume. Figure 9 shows these dilutions as a composite plot of measurements taken over four separate survey periods over the complete tidal release window and for 3.5 hours beyond the end of the window.

The second survey took place during commissioning on 15th April. Figure 10 shows the faecal coliform concentrations in the dye patch which was released at HW+4:15, the very end of the original tidal release window.

The plume behaviour results of the third and final spring-tide survey, on 24 and 25 June 1998, are shown in Figures 11 and 12 respectively. Any elevated concentrations measured were at locations well removed from the EC Bathing Waters.

In addition to the samples collected within the plume, samples were also collected over three days from sites along transects off each of the designated bathing waters in Falmouth Bay and off the non-designated bathing water at the east end of Gyllyngvase. Over the three day period, the results demonstrated high levels of dilution of the plume within Falmouth Bay. With the exception of one sample (15:18 on 26 June), which has been disregarded because of assumed cross-contamination, the highest *B. globigii* concentration found in any of the 192 samples collected was 310 per 100ml, 1000m off Maenporth, representing a dilution of 2,300. Faecal coliform and faecal streptococci concentrations in this sample were below the limits of detection of 10 per 100ml.

## 4.4 WATER QUALITY IN THE FAL ESTUARY

### 4.4.1 Neap Tides

Figures 13 to 15 show the faecal coliform concentrations recorded in the area north of Pendennis Point approaching High Water during neap tides. Generally the concentrations of faecal coliforms were very low. Two samples collected on 4 June north of the Classified Bivalve Mollusc Production Area southern limit were found to have concentrations of faecal coliforms of 170 per 100ml and 440 per 100ml. All sewage discharges from the Black Rock outfall during the preceding three tidal release windows were labelled with *B. globigii*. However, *B. globigii* concentrations in samples with these elevated faecal coliform concentrations were below the limit of detection of 9 per 100ml. We have concluded that the source of the faecal coliforms in these two samples was therefore not the discharge from Black Rock but from source(s) elsewhere within the estuary.

Samples collected from the offshore sites within the estuary (shown in green in Figure 1b) over the three day period 3 to 5 June showed very low concentrations of *B. globigii*. The great majority of samples contained concentrations below the limit of detection of 9 per 100ml and the highest concentrations found were 27 per 100ml found in just two samples. Faecal coliform and faecal streptococci concentrations in these two samples were all at or below the limit of detection of 10 per 100ml.

### 4.4.2 Intermediate Tides

The faecal coliform concentrations measured at the estuary sites during the intermediate tidal survey undertaken on 23 April 1998 are presented in Figures 16 and 17. The survey was undertaken during a period of persistent, heavy rain and, as expected, the storm discharge was operating during the survey period, including outside of the tidal release window. However, even with these storm discharges, the geometric mean of the measured faecal coliform concentrations was 38 per 100ml, with a maximum of 400 faecal coliform per 100ml.

### 4.4.3 Spring Tides

Figures 18 to 20 show the faecal coliform concentrations recorded in the area north of Pendennis Point approaching High Water on 24 and 25 June. Generally, concentrations of faecal coliforms were very low. However, on 24 June 1998, one sample to the south of the Classified Bivalve Mollusc Production Area limit and one sample on the line of the area limit were found to contain faecal coliform concentrations of 250 per 100ml and 180 per 100ml respectively. Although these levels are better than the recommended water quality standard for shellfish classification 'B' we need to understand their origin. Sewage discharged from the Black Rock outfall during the preceding tidal release window was marked with *B. globigii*. However, *B. globigii* concentrations in the two samples were below the limit of detection of 9 per 100ml indicating that the source of the faecal coliforms was not the discharge from the Black Rock outfall made during the previous tidal release window. During the preceding 24 hours the rainfall gauge at the Screening Plant measured 8.2mm of rainfall. The source of contamination may therefore have been storm discharges which occurred within the tidal release window.

Samples collected from the offshore sites within the estuary shown in green on Figure 1b over the three day period 24 to 26 June showed very low concentrations of *B. globigii*. The great

majority of samples contained concentrations below the limit of detection of 9 per 100ml and the highest concentration found was 99 per 100ml found in a sample collected 200m off Great Molunan Beach. Faecal coliform and faecal streptococci concentrations for this sample were both below the limit of detection of 10 per 100ml.

#### **4.5 WATER QUALITY AT NON-EC BATHING WATERS**

During the Spring and Neap post-commissioning surveys, the non-identified bathing waters at Great Molunan, Castle Cove, St Mawes, Loe Beach, Trefusis, and East Gyllyngvase were monitored.

During the neap tide survey, the highest concentration of *B. globigii* found in any of the samples collected at the non-EC bathing waters within the estuary at Great Molunan, Castle Cove, St Mawes, Loe Beach, and Trefusis was 27 per 100ml, with the majority having concentrations at or below the limit of detection of 9 per 100ml.

At East Gyllyngvase, a *B. globigii* concentration of 973 per 100ml was recorded for the sample collected at 12:11 on 3 June 1998. The corresponding faecal coliform and faecal streptococci concentrations, 40 and <10 per 100ml, were very low. Other samples collected in the area during the same period had very low concentrations of *B. globigii*, faecal coliforms and faecal streptococci. The geometric mean of all the samples taken at the non-designated bathing waters during the neap tide surveys for faecal coliforms and faecal streptococci were 14 and 11 per 100ml respectively.

During the spring tide survey, the highest concentration of *B. globigii* found in any of the samples collected at the above sites was 27 per 100ml found in at Great Molunan on 26 June, representing a dilution of about 27,000. The majority of other samples were at or below the limit of detection of 9 per 100ml. The geometric mean of all the samples taken at the non-designated bathing waters during the spring tide surveys for faecal coliforms and faecal streptococci were 22 and 15 per 100ml respectively.

#### **5 FUTURE MONITORING**

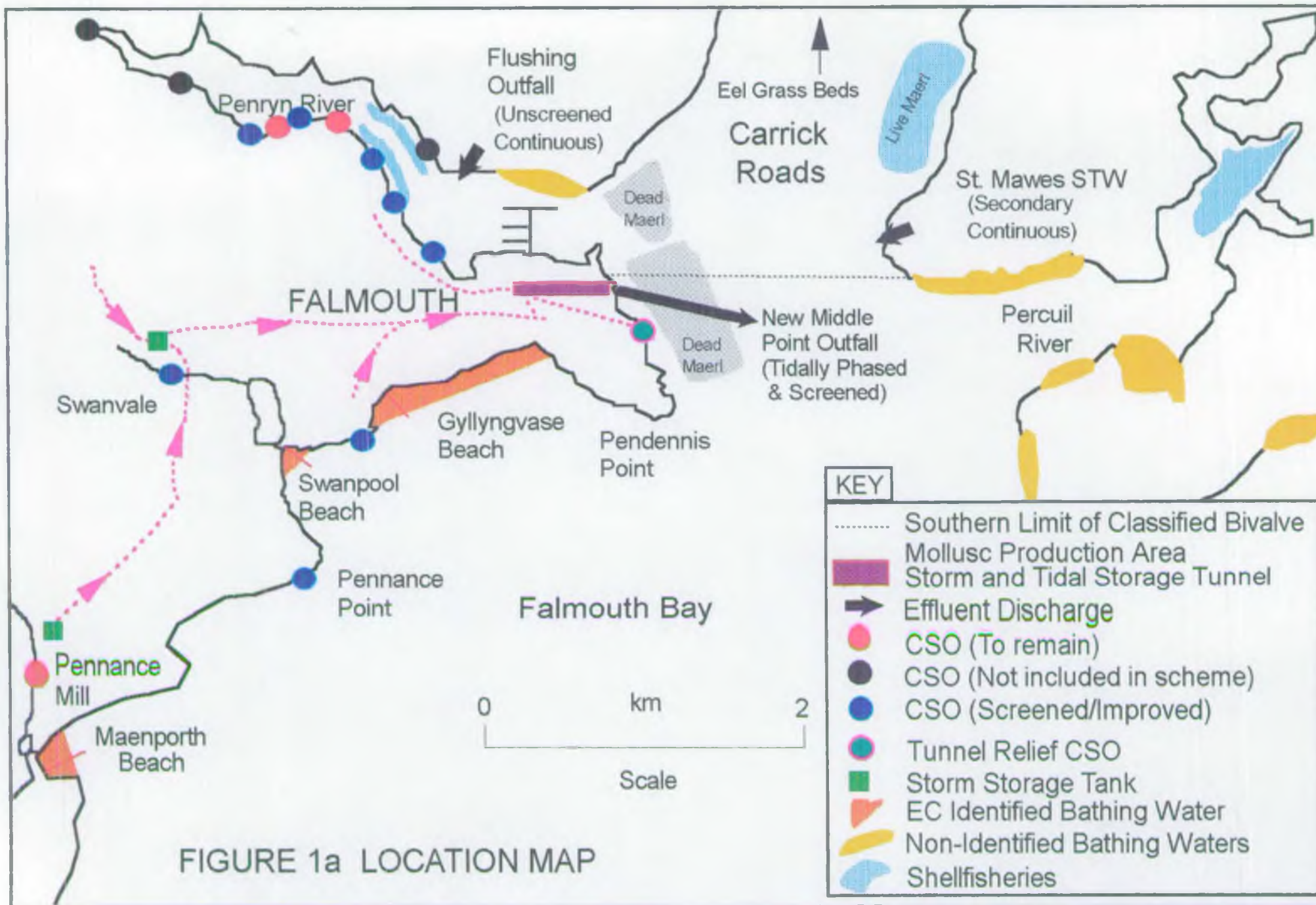
Outstanding programmed survey work is as follows:

- Undertake an assessment of the impact of the effluent plume on marine macro benthos in the vicinity of the outfall. A pre-scheme baseline survey was undertaken in February 1997. This survey will be repeated in February 1999 to assess any changes in the marine macro benthos.
- Routine monitoring of the EC Bathing Waters at Gyllyngvase, Swanpool, and Maenporth will continue as normal.
- Identify sources of bacteriological contamination to the Maenporth Stream.

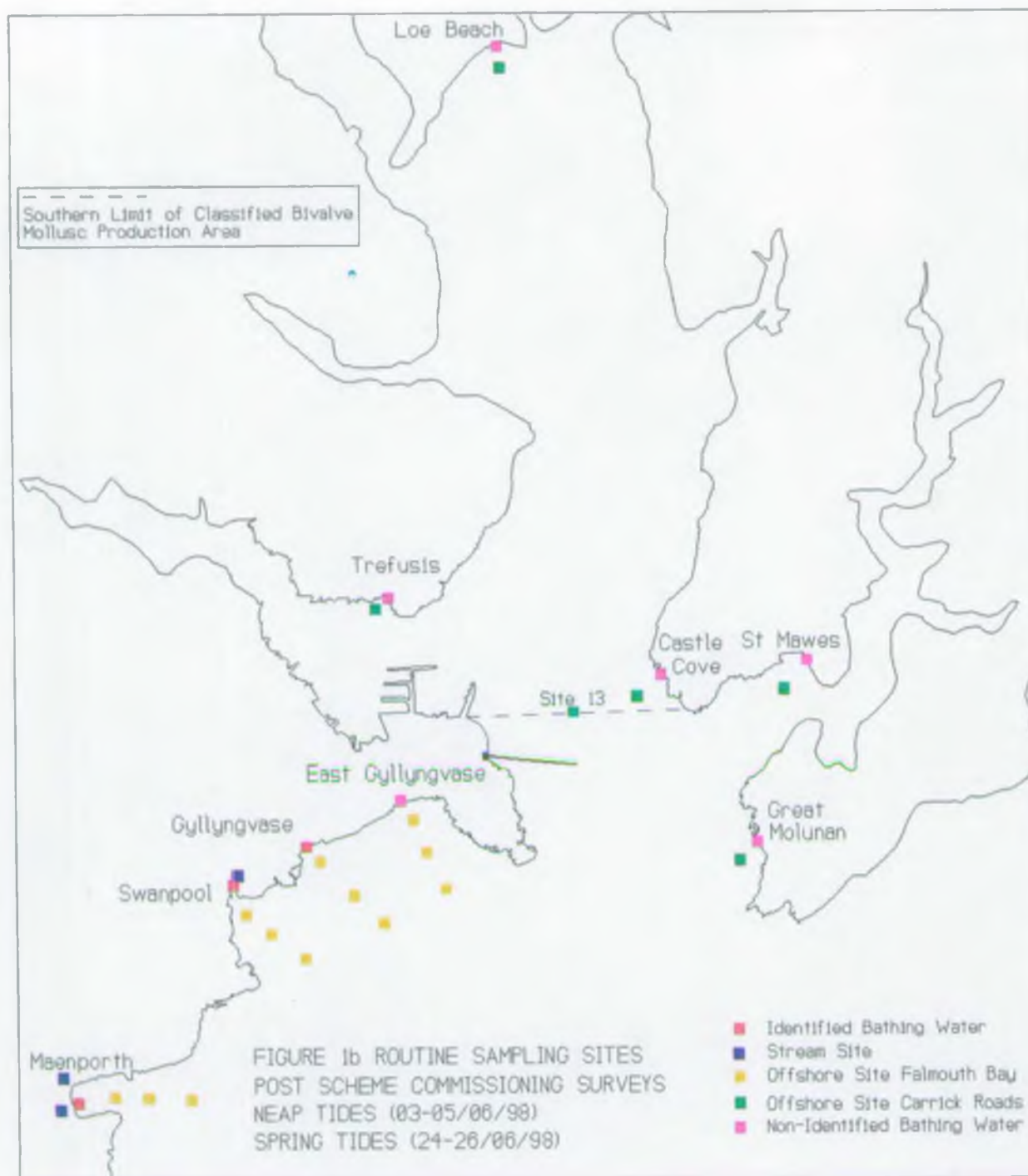
## 6 CONCLUSIONS

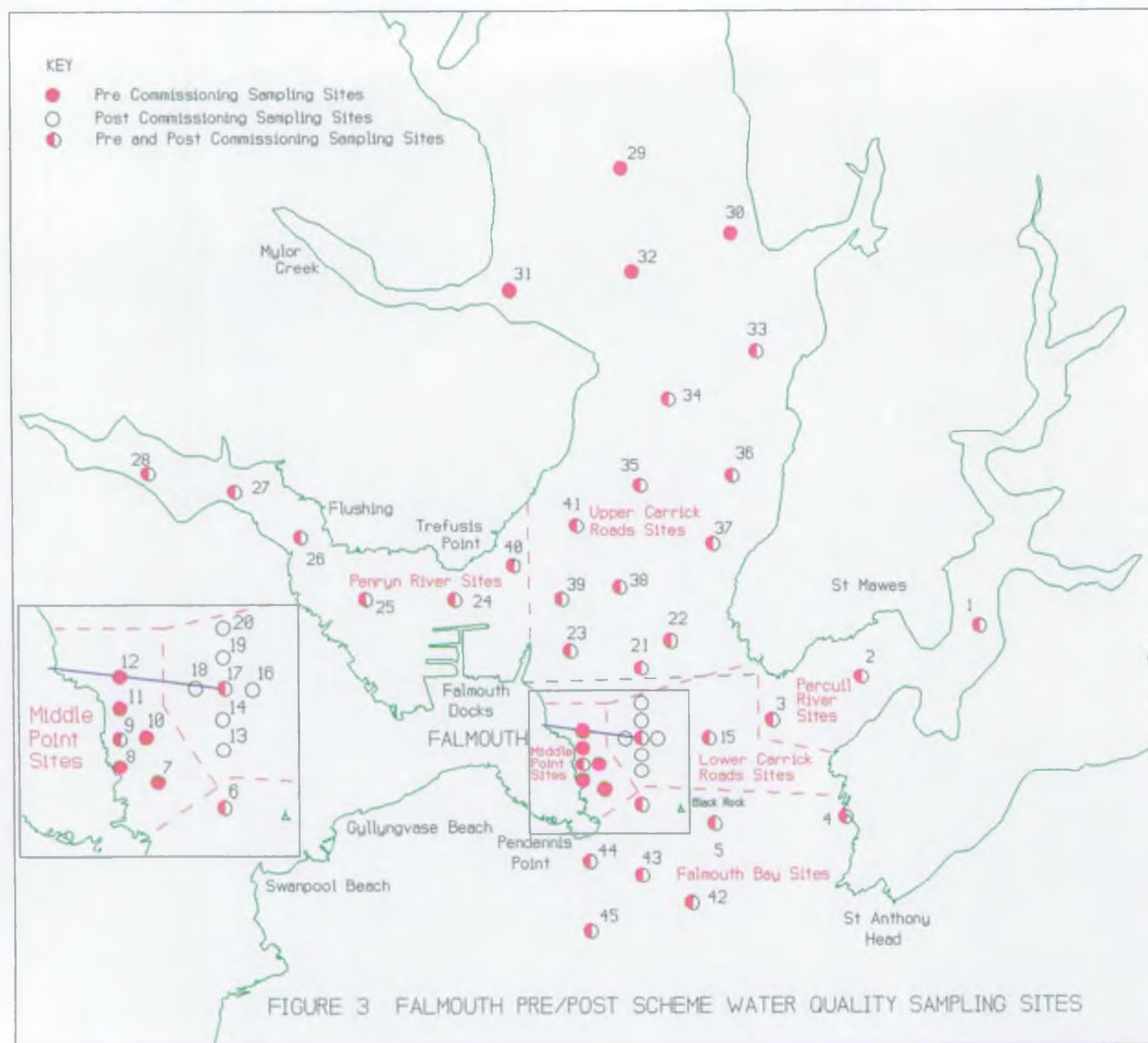
Monitoring of the performance of the Falmouth Interim (Phase 1) Scheme undertaken by the Environment Agency has demonstrated that the objectives of the scheme have been met:

- Routine monitoring and survey data demonstrate a significant improvement in the water quality at the EC Designated Bathing Waters at Gyllyngvase, Swanpool and Maenporth since the commissioning of the Interim Scheme. Compliance with the EC Bathing Waters Directive mandatory and guideline standards is expected at Gyllyngvase and Swanpool. At Maenporth, there has been a marked improvement in water quality and compliance with mandatory standards is expected. However, this beach is affected by freshwater inputs which have impacted on guideline compliance.
- The relocation of the Middle Point outfall to the new location close to Black Rock, in conjunction with the tidal phasing of the discharge, has not resulted in any deterioration in water to the North of the limit of the Classified Bivalve Mollusc Production Area as designated by MAFF.
- Elimination of the water quality problems and unsatisfactory aesthetic impacts around Swanpool Beach, Gyllyngvase Beach, the old Middle Point outfall and the Quay area of Falmouth, which were associated with previously crude, unscreened sewage discharges.

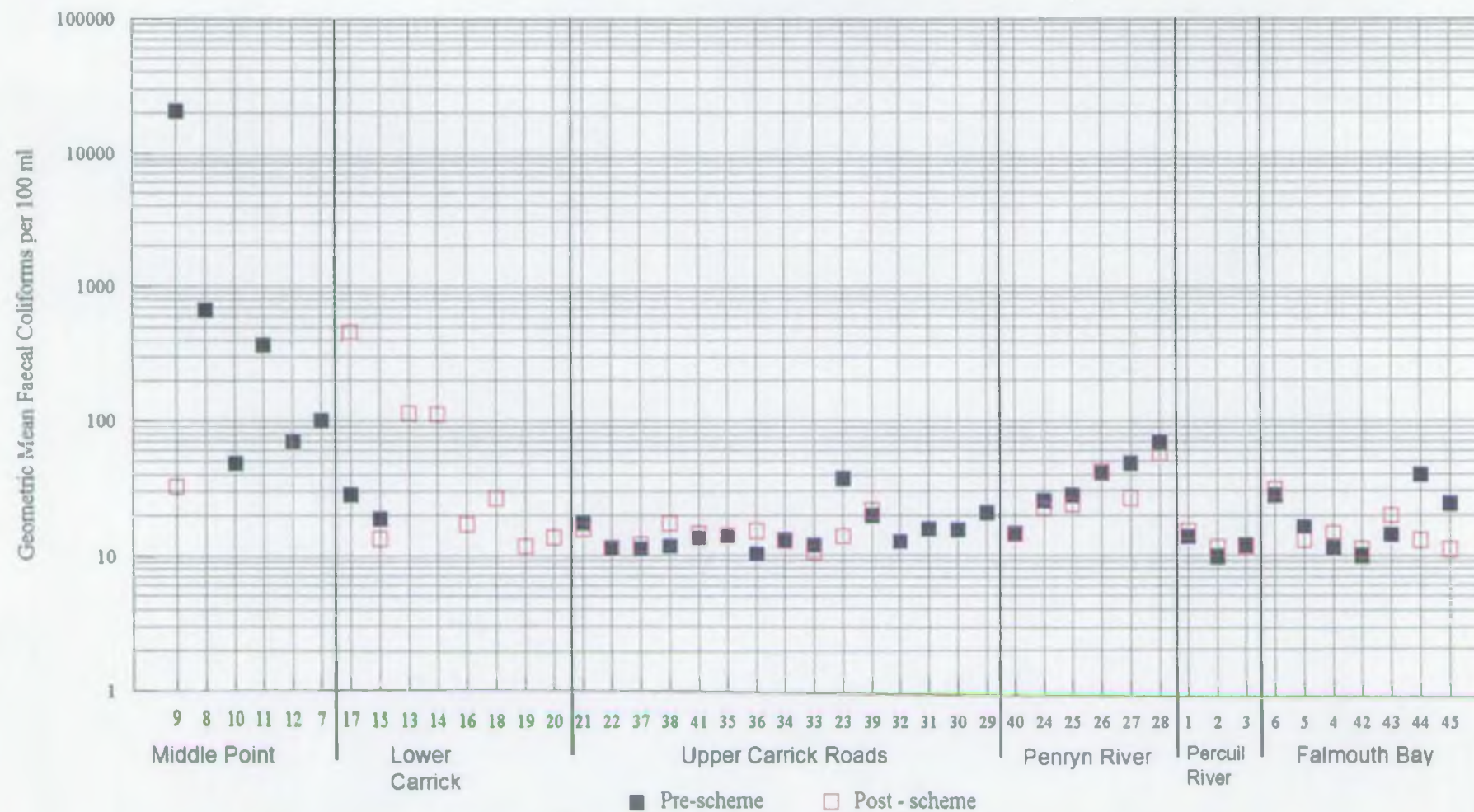












**Figure 4 Falmouth Pre and Post Scheme Baseline Water Quality Surveys  
Faecal Coliform Results (Geometric Mean)**

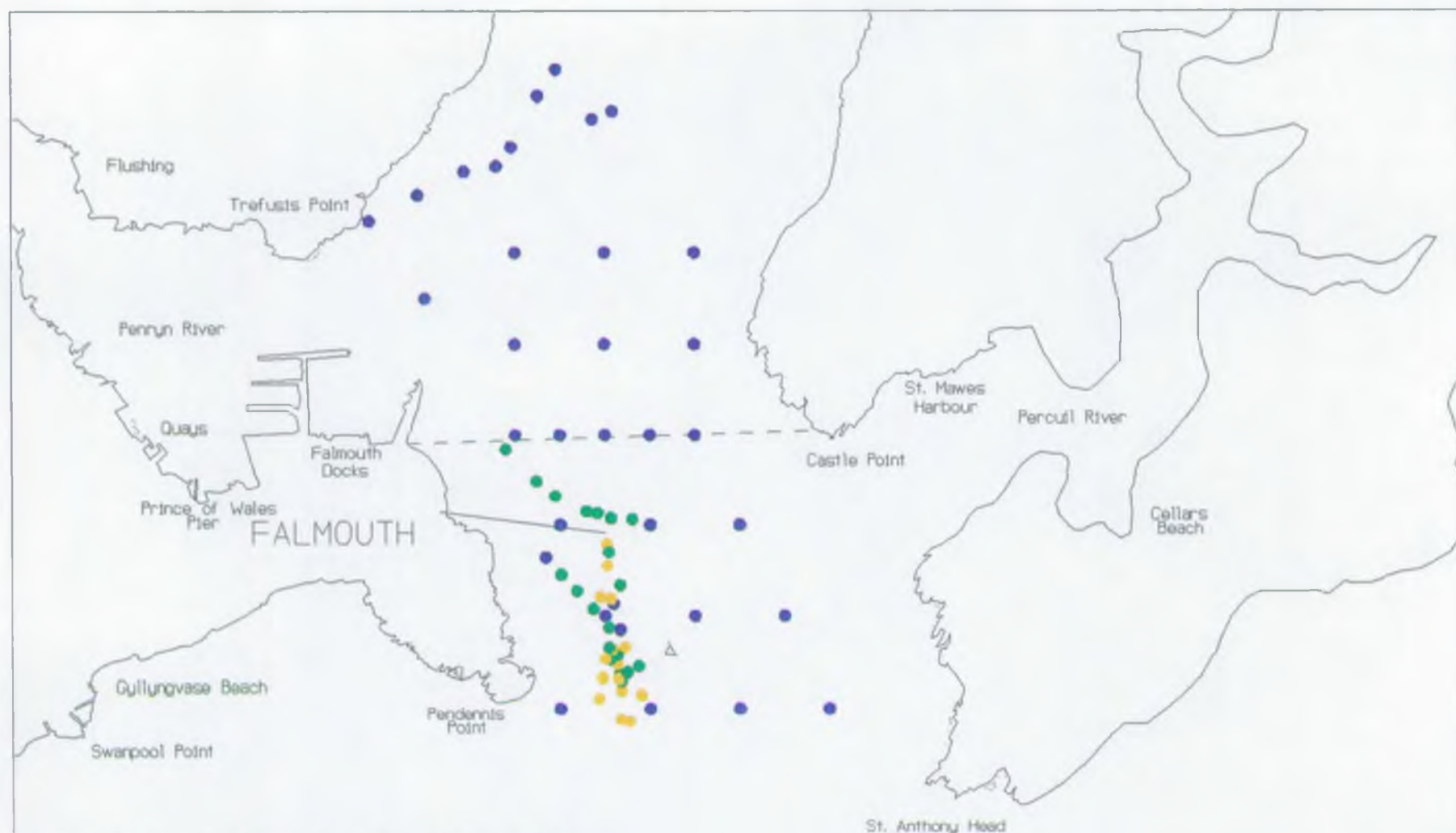
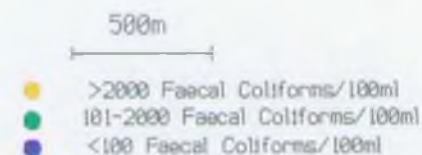
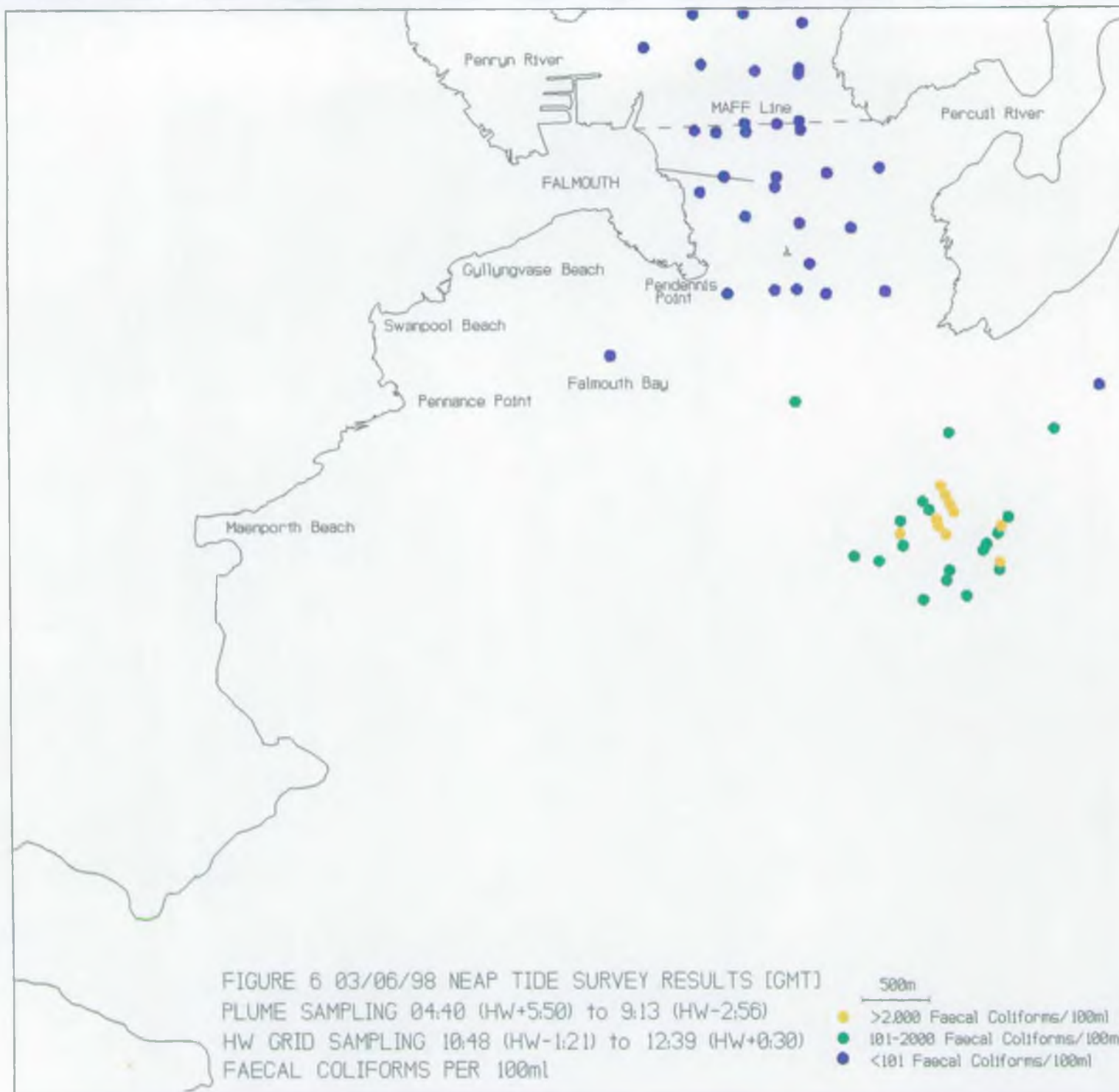
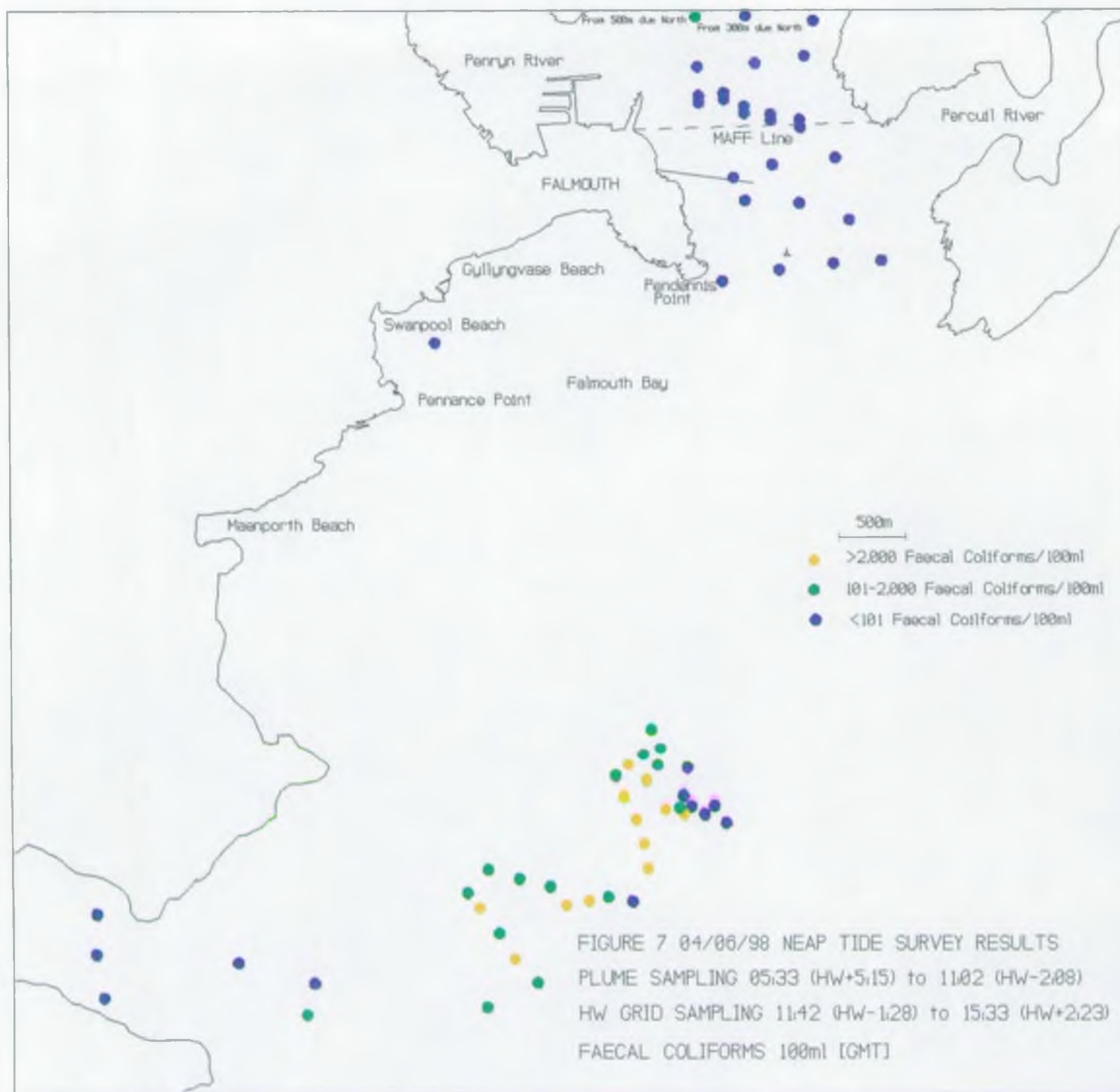


FIGURE 5 21/04/98 NEAP TIDE SURVEY  
 PLUME SAMPLING 04:18 (HW+4:53) to 07:49 (HW-4:26)  
 HW GRID SAMPLING 09:09(HW-3:06) TO 11:07(HW-1:08)  
 SAMPLING NE OF TREFUSIS POINT 11:17(HW-0:58) TO 11:51(HW-0:24)  
 FAECAL COLIFORMS PER 100ml [GMT]









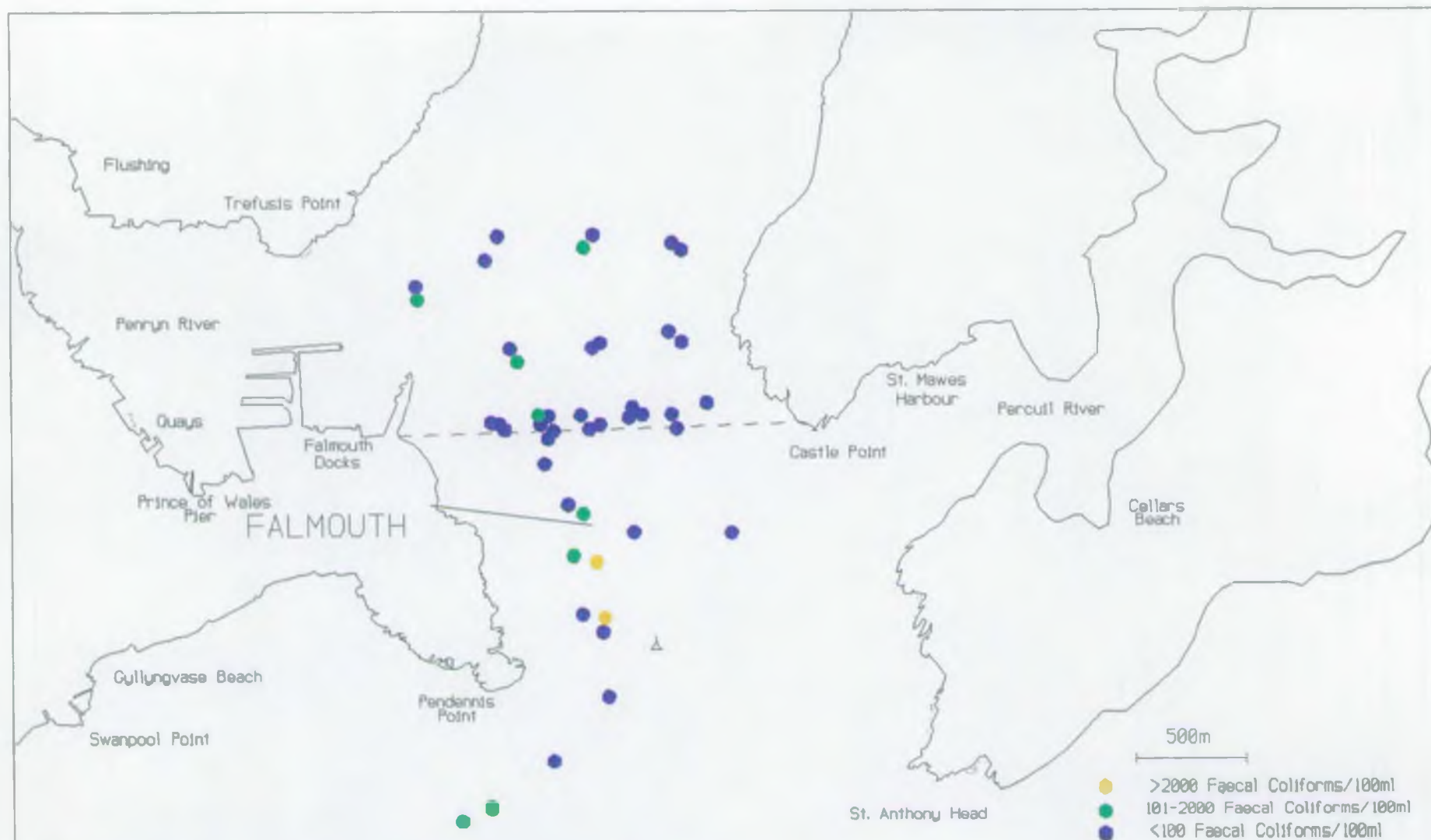


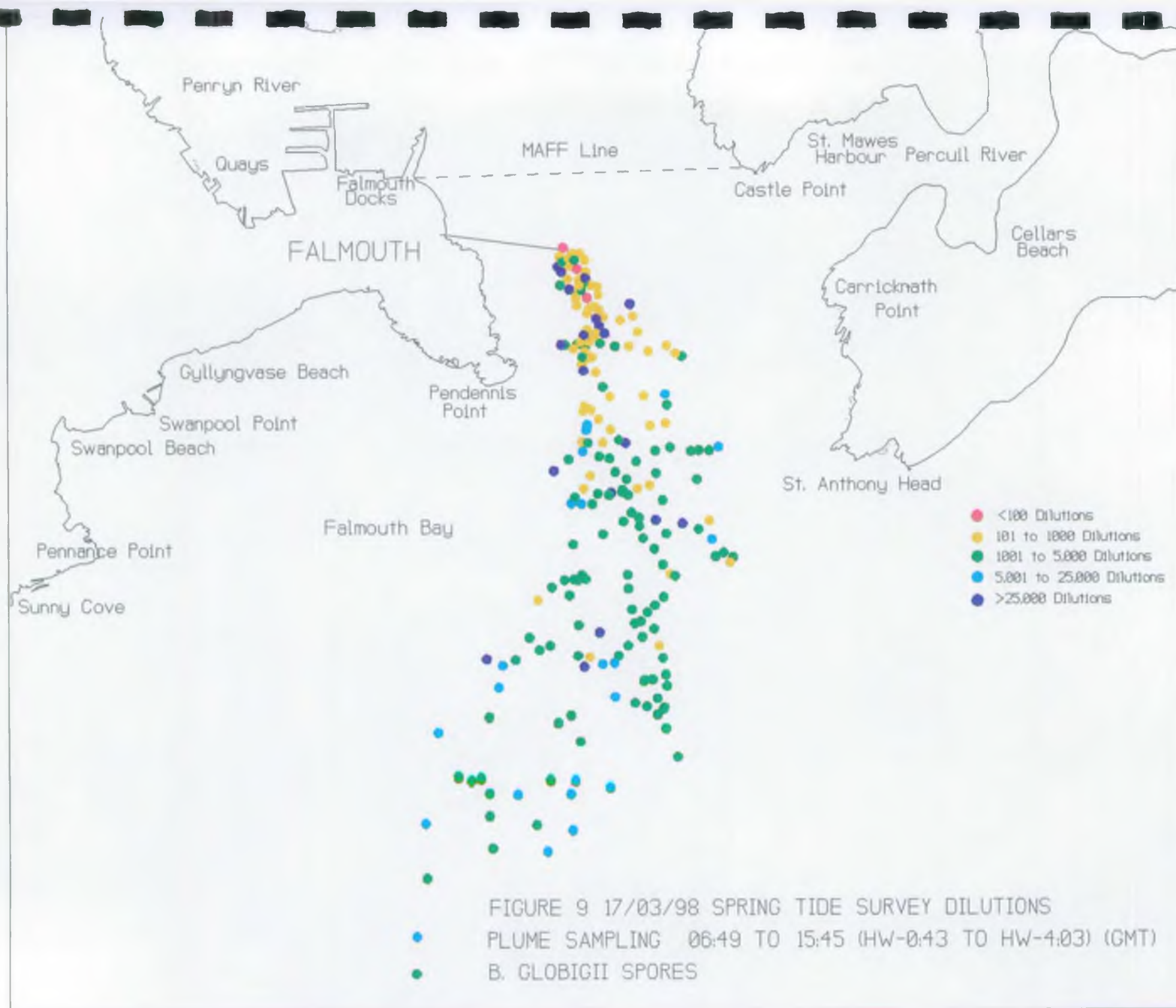
FIGURE 8 23/04/98 INTERMEDIATE TIDE SURVEY

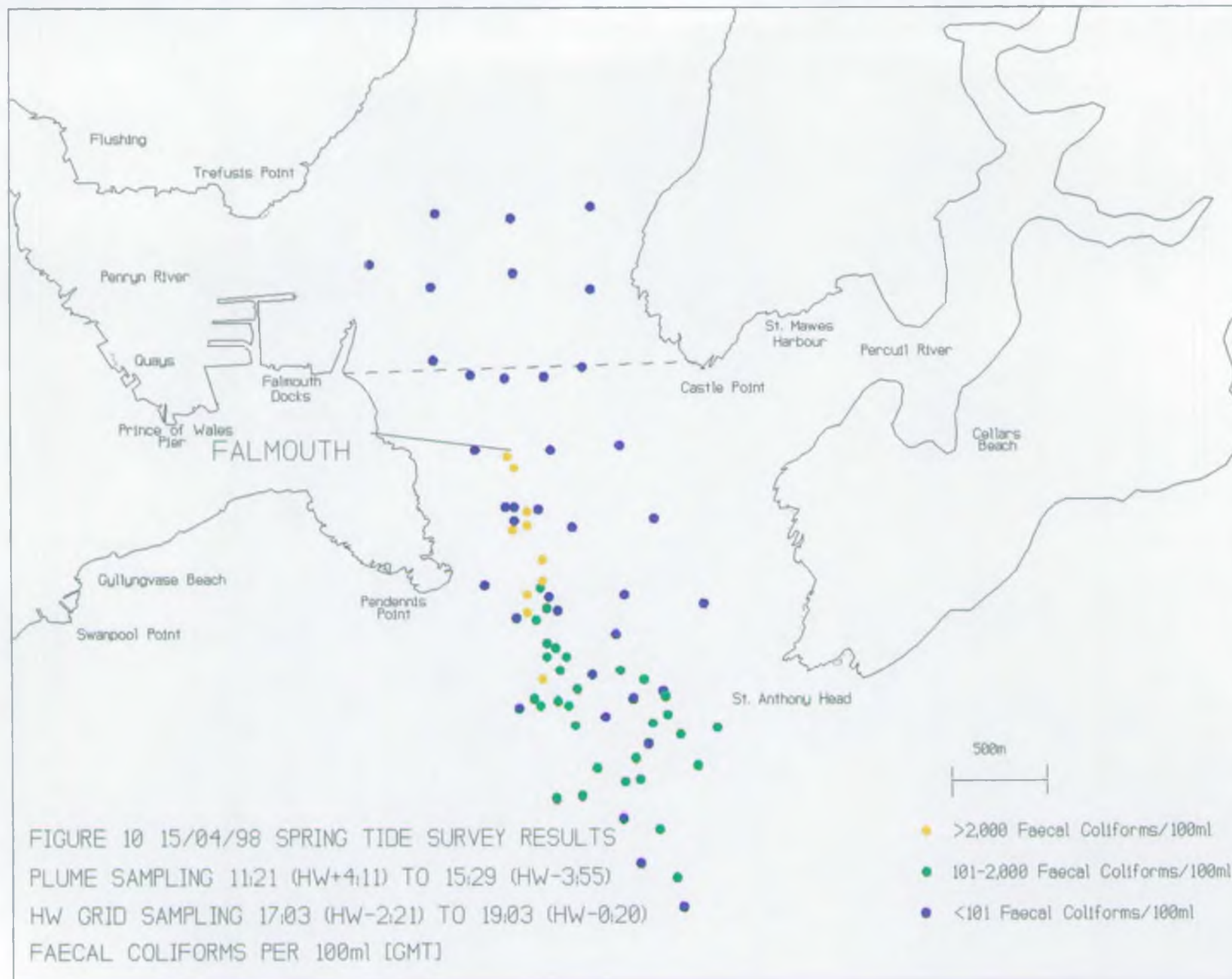
PLUME SAMPLING 05:48-06:08 (HW+3:40-HW+4) 08:41-10:22(HW-6:07-HW-4:26)

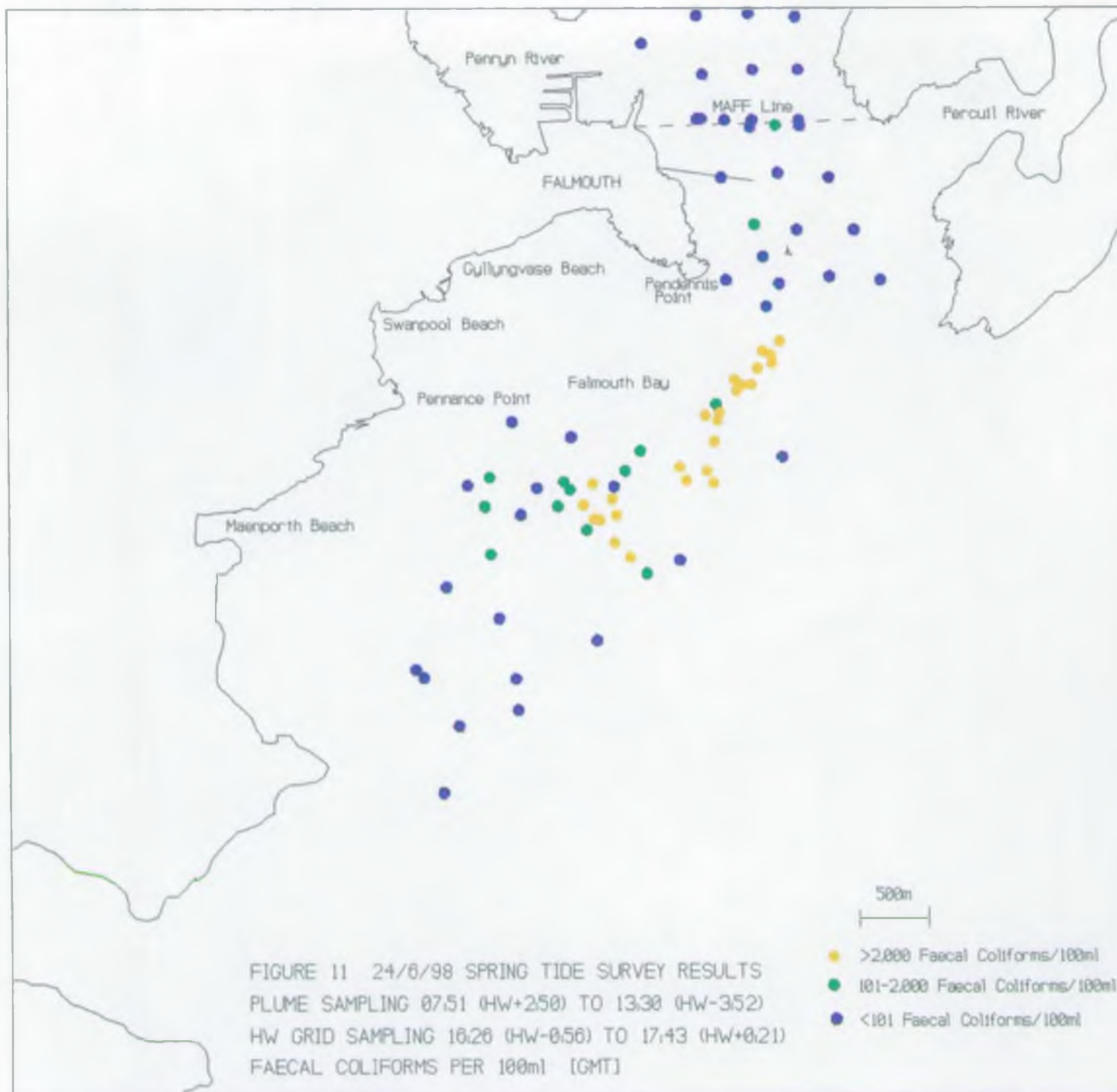
HW GRID SITES SAMPLED, 11:54(HW-2:54) TO 13:20(HW-1:28)

FAECAL COLIFORMS PER 100ml [GMT]

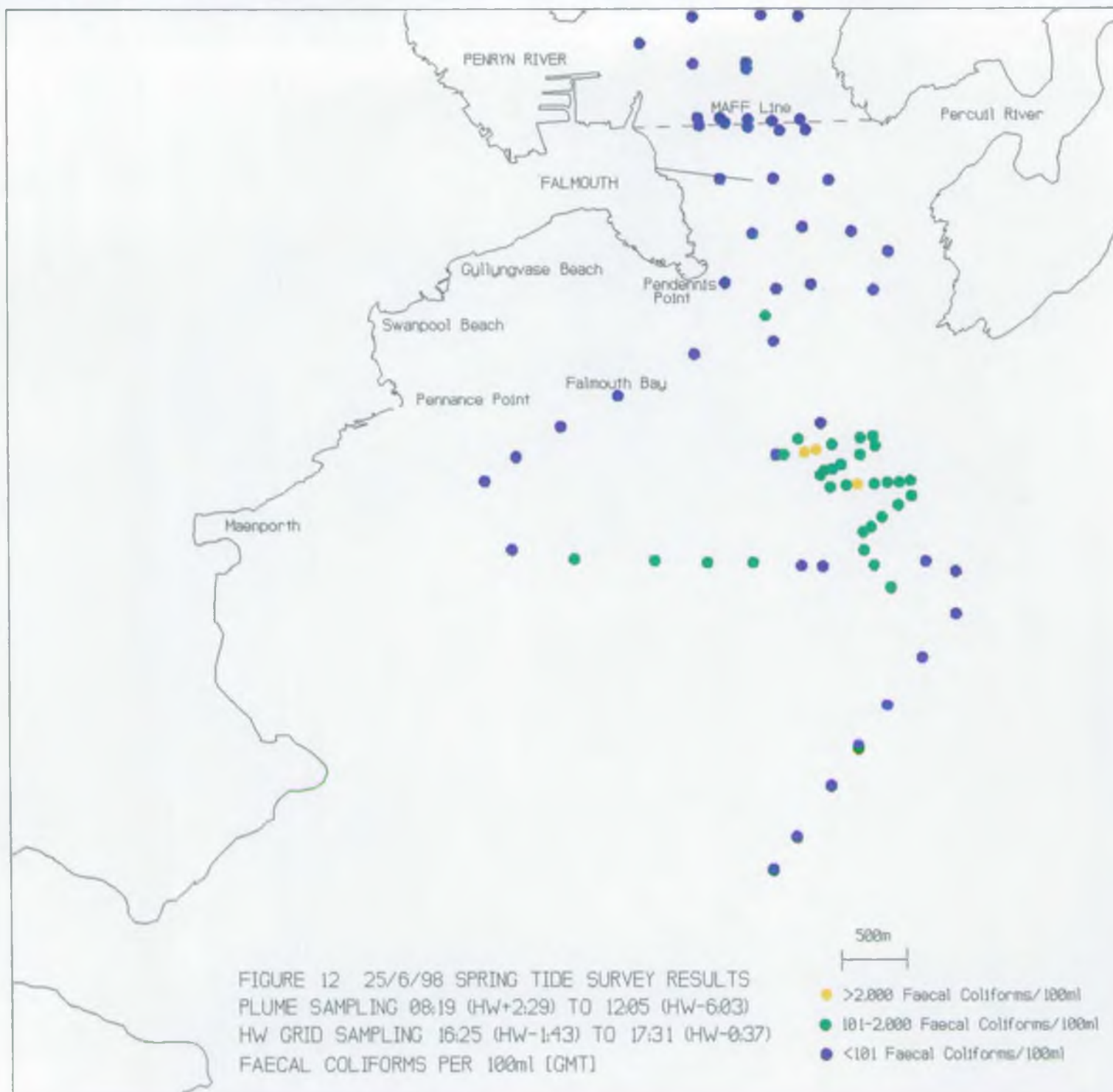




















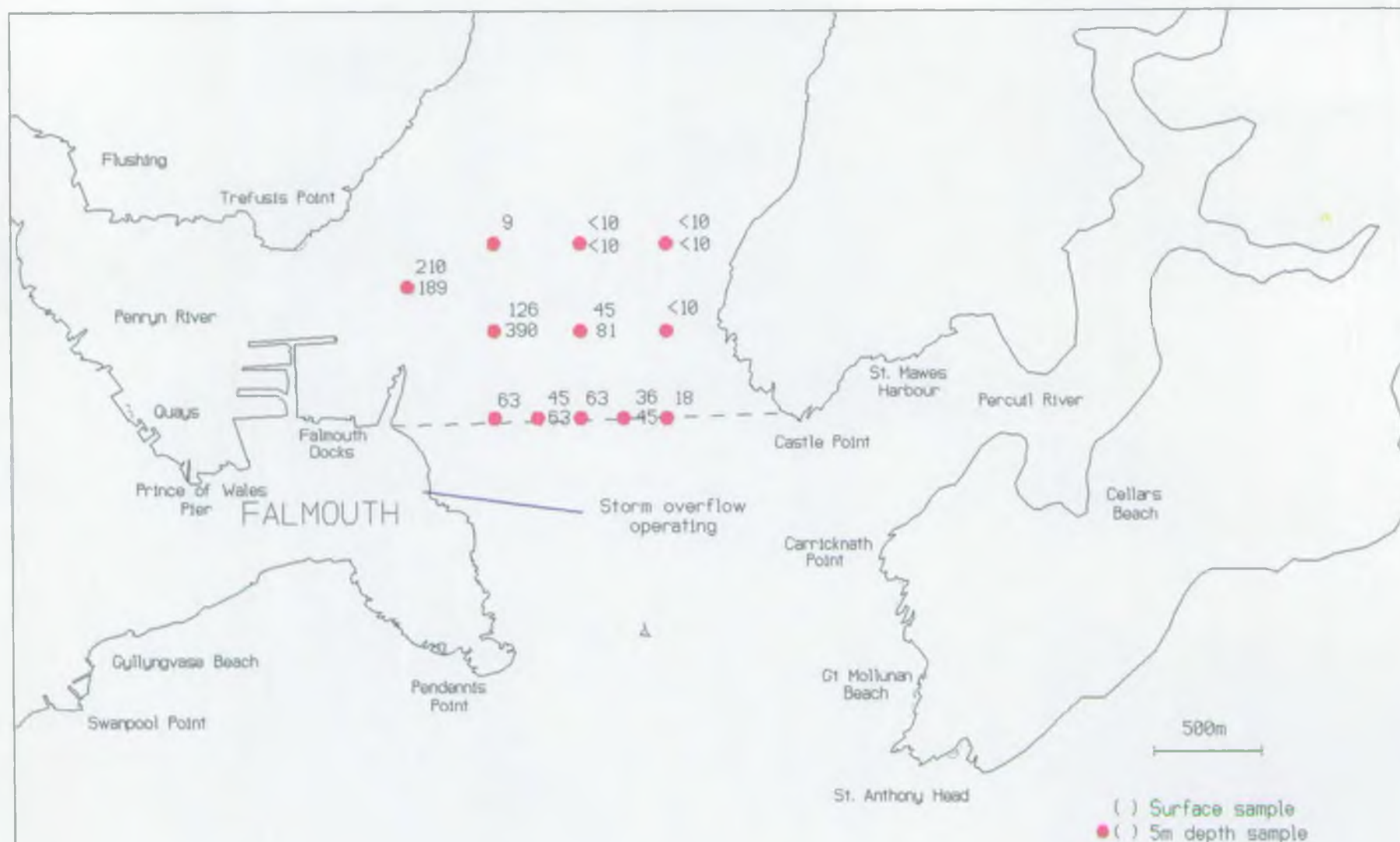


FIGURE 16 23/04/98 INTERMEDIATE TIDE FAECAL COLIFORM RESULTS  
 HW GRID SITES SAMPLED AT MID-FLOOD, 11:54 (HW-2:54) TO 12:26 (HW-2:22) GMT





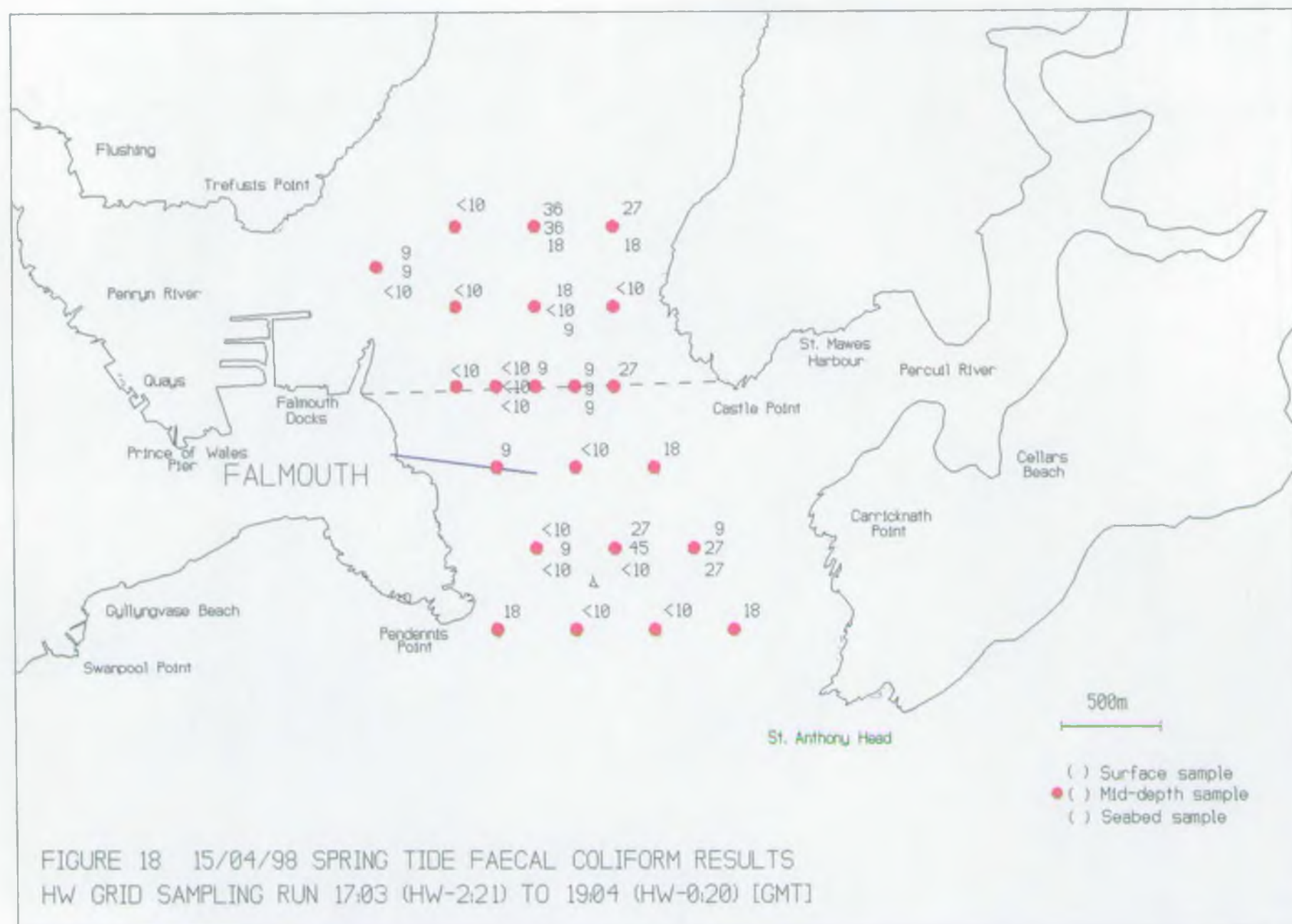
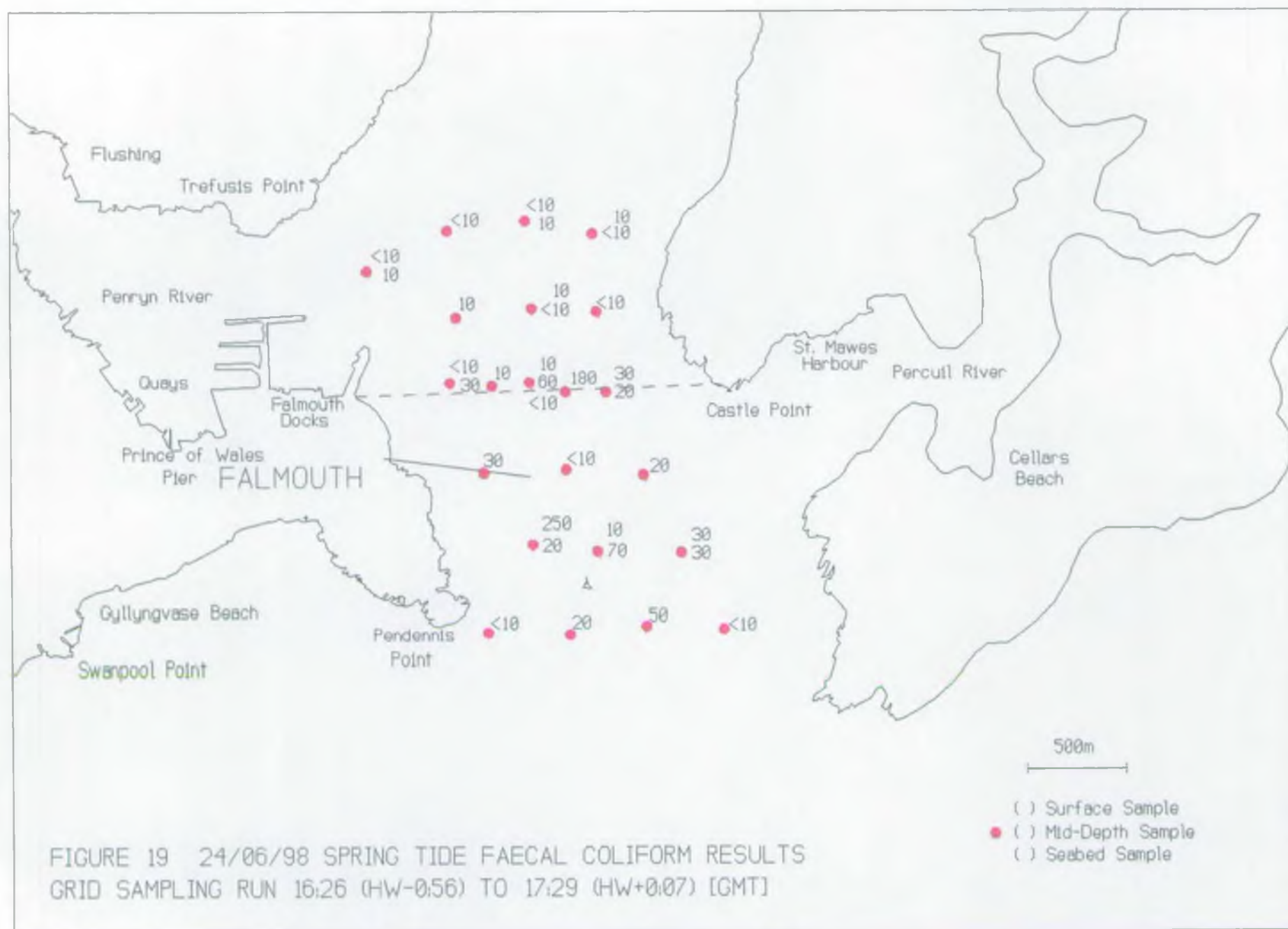
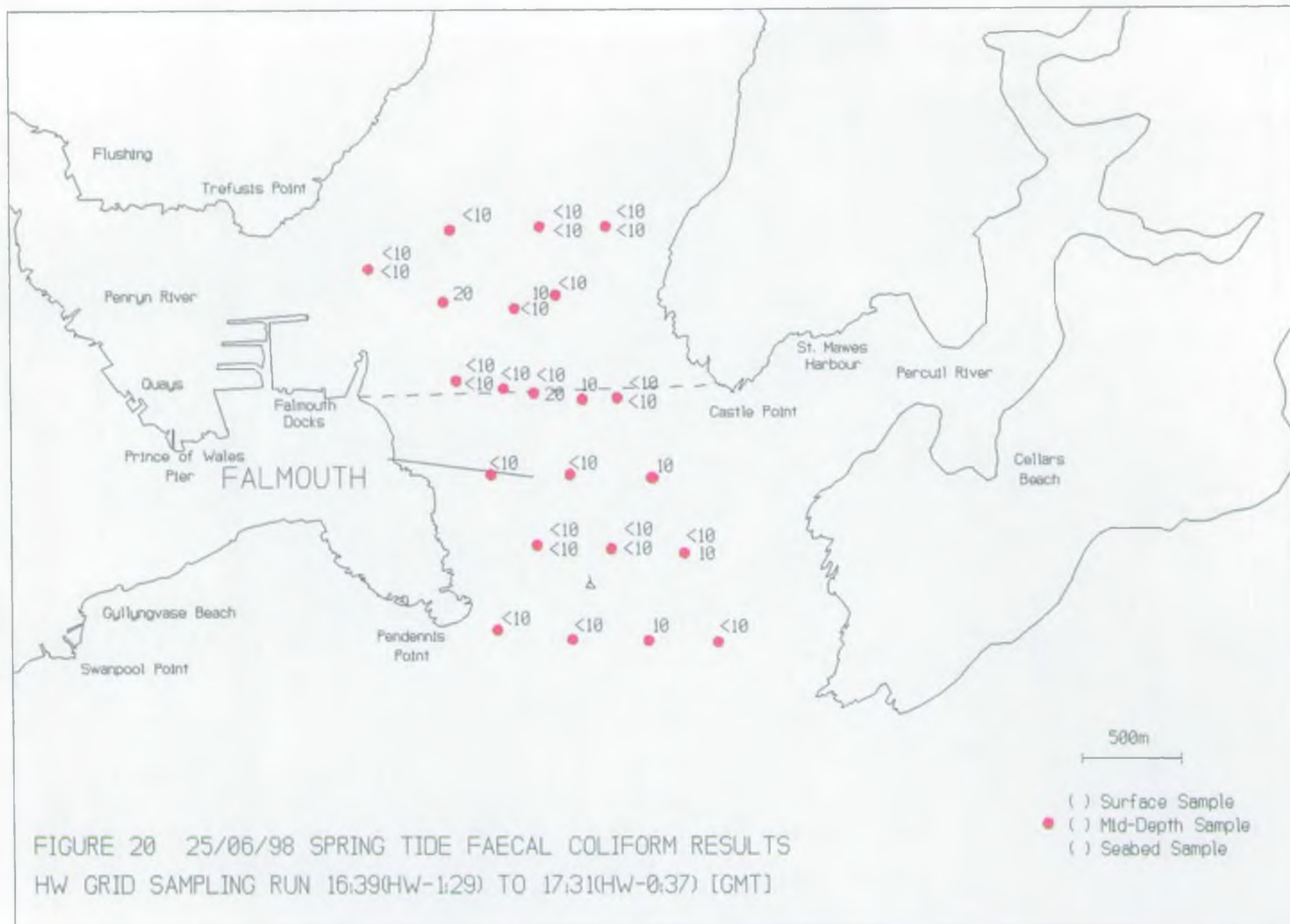


FIGURE 18 15/04/98 SPRING TIDE FAECAL COLIFORM RESULTS  
 HW GRID SAMPLING RUN 17:03 (HW-2:21) TO 19:04 (HW-0:20) [GMT]







## APPENDIX 1

### 1 Pre-Commissioning Baseline Spring Tide Water Quality Survey: 12 March 1998

This was the first of four surveys carried out in the weeks leading up to the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on a Spring tide (5.0m height, 4.2m range) between 07:53 and 18:35. Predicted High Waters at Falmouth were 04:42 and 17:05.

Daily rainfall totals measured at Camborne and Cudrose (9am to 9am the following day) on the 11 March were both 0.0mm, and on the 12 March were trace and 0.2mm respectively. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed ( $\text{ms}^{-1}$ )	Wind Direction	Cloud Cover
07:53	0.5	Northerly	3/8
08:24	2.0	Northerly	7/8
09:35	3.0	Northeasterly	3/8
11:05	4.0	Northwesterly	4/8
11:46	5.5	Northerly	7/8
12:32	4.0	Northerly	7/8
14:33	5.0	Nor-Northwestly	8/8
15:03	5.0	Northwesterly	8/8
15:59	4.5	Northwesterly	8/8
17:25	5.5	Northwesterly	8/8
18:04	4.0	Northwesterly	7/8
18:30	4.0	Northwesterly	7/8

#### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	07:53 to 09:35	HW+3:11 to HW+4:53	HW+4:02
Run 2	11:05 to 12:55	HW-6:00 to HW-4:10	HW-5:05
Run 3	14:24 to 16:07	HW-2:41 to HW-0:58	HW-1:50
Run 4	16:55 to 18:35	HW-0:10 to HW+1:30	HW+0:40

The survey results for all determinands are tabulated in the Data Annex.

### 2 Pre-Commissioning Baseline Neap Tide Water Quality Survey: 20 March 1998

This was the second of four surveys carried out in the weeks leading up to the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on a Neap tide (4.4m height, 2.7m range) between 08:10 and 19:01. Predicted High Waters at Falmouth were 09:11 and 21:34. Wind speed, direction, and cloud cover were recorded onboard the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
08:26	0.5	Northerly	0/8
09:50	0.5	Northerly	0/8
11:29	0.5	Southerly	0/8
12:41	2.5	Southerly	4/8
13:03	3.0	Southerly	6/8
14:36	0.5	Southwesterly	8/8
15:10	0.5	Southerly	7/8
15:50	0.5	-	8/8
17:38	4.0	Northerly	1/8
19:01	4.5	Northerly	0/8

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 19 and 20 March were 0.0mm.

#### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	08:10 to 10:12	HW-1:01 to HW+1:01	HW
Run 2	11:08 to 13:12	HW+1:57 to HW+4:01	HW+2:59
Run 3	14:15 to 15:54	HW+5:04 to HW-5:40	HW+5:53
Run 4	17:15 to 19:01	HW-4:19 to HW-2:33	HW-3:26

The survey results for all determinands are tabulated in the Data Annex.

### 3 Pre-Commissioning Baseline Spring Tide Water Quality Survey: 27 March 1998

This was the third of four surveys carried out in the weeks leading up to the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on a Spring tide (5.4m height, 5.0m range) between 06:37 and 18:07. Predicted High Waters at Falmouth were 04:24 and 16:53. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
06:54	0.5	Southwesterly	8/8
07:38	0.5	Southwesterly	8/8
10:12	0.5	Southwesterly	8/8
10:39	5.0	Southwesterly	8/8
11:15	0.5	Southwesterly	8/8
13:44	5.0	Southwesterly	8/8
14:26	7.5	Southerly	8/8
14:40	5.0	Southerly	8/8
16:36	0.5	Southwesterly	8/8
17:48	0.5	Southerly	8/8

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 26 March were 3.8mm and 4.6mm respectively, and on the 27 March were 3.2mm and 3.6mm respectively.

### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	06:37 to 08:30	HW+2:13 to HW+4:06	HW+3:10
Run 2	10:12 to 11:45	HW+5:48 to HW-5:08	HW-5:54
Run 3	13:36 to 15:01	HW-3:17 to HW-1:52	HW-2:34
Run 4	16:36 to 18:07	HW-0:17 to HW+1:14	HW+0:28

The survey results for all determinands are tabulated in the Data Annex.

## 4 Pre-Commissioning Baseline Neap Tide Water Quality Survey: 7 April 1998

This was the last of four surveys carried out in the weeks leading up to the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

### Environmental Conditions

The survey took place on a Neap tide (4.4m height, 2.7m range) between 05:25 and 15:40. Predicted High Waters at Falmouth were 01:59 and 14:35. Wind speed, direction, and cloud cover were recorded onboard the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
06:37	1.5	Westerly	Showers
07:35	2.0	Northerly	
09:55	1.0	Northerly	2/8
10:47	2.0	Southerly	2/8
12:47	3.5	Northwesterly	7/8
13:21	5.0	Northerly	6/8
14:05	1.5	Northerly	3/8
15:33	3.0	Southerly	7/8
15:53	1.0	Northerly	6/8
16:51	4.0	Northerly	4/8

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 6 April were 1.2mm and 0.4mm respectively, and on the 7 April were 0.0mm and 0.6mm respectively.

### Summary of Events

Water samples were collected from just below the surface in accordance with standard Agency sampling procedures. There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	05:25 to 07:52	HW+3:26 to HW+5:53	HW+4:39
Run 2	08:31 to 10:32	HW-6:04 to HW-4:03	HW-5:03
Run 3	11:27 to 13:05	HW-3:08 to HW-1:30	HW-2:19
Run 4	14:11 to 15:51	HW-0:24 to HW+1:16	HW+0:26

The survey results for all determinands are tabulated in the Data Annex.

## 5 Pre-Commissioning Spring Tide Freshwater Discharge: 17 March 1998

South West Water needed to empty the storage tunnel of 'ground' water which had collected in the tunnel before commissioning commenced, to allow a tunnel inspection and hand-over from the contractors. There was some flexibility in the timing of this operation (about 1 week) and ideally the survey would have taken place in moderate

southerly winds. However, the wind was firmly fixed in the northern sector for most of the survey window and the day of the survey proved to be the closest to this objective.

The objectives of the survey were as follows:

- i. To measure the dilutions in the plume to the south of the outfall at the surface and at depth.
- ii. To monitor the plume trajectories at different release times within the consented release window, in particular at the beginning and end of the window.
- iii. To undertake the survey in moderate onshore winds (ie. SSE-SSW) if possible.

The survey included two continuous releases of *B. Globigii* spores into the pumped discharge, one at the beginning of the discharge window (70 minutes duration) and one at the end of the discharge window (80 minutes duration), marked on four occasions by pulses of dye. The dye patches were mapped whilst samples were collected for determination of *B. Globigii* concentrations and salinity.

#### Environmental Conditions

The survey took place on a Spring tide (5.0m height, 3.9m range) between 06:41 and 15:46. Predicted High Waters at Falmouth were 07:33 and 19:49. Wind speed and direction were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction
06:59	1.0	West Southwesterly
07:33	2.0	West Southwesterly
08:15	2.0	Southwesterly
09:00	4.0	Southwesterly
09:55	3.5	Southwesterly
10:27	2.5	Southwesterly
11:41	2.5	Southwesterly
13:30	3.5	Westerly
14:46	3.5	Southwesterly

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 16 and 17 March were 0.0 mm.

#### Summary of Events

The discharge was required within the then consented Spring tidal window of HW-0:45 to HW+4:15. The first release of *B. Globigii* spores from the Black Rock outfall was carried out at the beginning of the tidal window between 06:49 (HW-0:44) and 08:00 (HW+0:27). The discharge was pumped at an average rate of 330 ls<sup>-1</sup> which approaches that of the commissioned scheme, but the computed dilutions are calculated for an average pump rate of 347 ls<sup>-1</sup>. The spores were released into the pumped discharge at an average rate of  $1.04 \times 10^{10}$  per second. The beginning of the spore plume was marked by injecting 10 litres of green fluorescein dye (Patch 1) into the final effluent sampling chamber which emerged at the Black Rock outfall at HW-0:34. Approximately 12 litres of red rhodamine dye (Patch 2) were added to mark the end of the spore plume at HW+0:12. Two drogues were deployed in each dye patch with sails set at 1m and 5m below the surface. The movements of the dye and drogues were monitored by two survey vessels which also took surface and depth water samples and temperature/salinity/depth (TSD) profiles.

Dye patch 1 was followed south for 3 hours 28 minutes from release until HW+2:53. During this period the patch was traced on five occasions, two TSD profiles were taken, and a total of 66 samples were collected. Dye patch 2 was followed south for 2 hours 55 minutes from release until HW+3:07. During this period the patch was traced on three occasions, three TSD profiles were taken, and a total of 67 samples were collected.

The second release of *B. Globigii* spores was carried out at the end of the tidal window between 10:28 (HW+2:55) and 11:48 (HW+4:15). The beginning of the spore plume was marked by injecting 10 litres of fluorescein dye (Patch 3) which emerged at the Black Rock outfall at HW+3:09. Approximately 12 litres of rhodamine dye (Patch 4) marked the end of the spore plume at HW+4:05. Two drogues were deployed in each dye patch with sails set at 1m and 5m below the surface. The movements of the dye and drogues were again monitored by the two survey vessels

which also took surface and depth water samples and temperature/salinity/depth (TSD) profiles.

Dye patch 3 was followed for 4 hours 9 minutes until HW-4:58. During this period the patch was traced on four occasions, two TSD profiles were taken, and a total of 47 samples were collected. Dye patch 4 was followed for 4 hours 8 minutes until HW-4:03. During this period the patch was traced on three occasions, four TSD profiles were taken, and a total of 63 samples were collected.

The survey results are tabulated in the Data Annex. The *B. Globigii* spore dilutions in surface waters have been calculated from an initial concentration in the effluent of  $3 \times 10^6$  spores per 100ml.

## 6 Commissioning Spring Tide Survey: 15 April 1998

The objectives of the survey were as follows:

- i. To monitor the bacterial concentrations in the plume to the south on the ebb tide.
- ii. To monitor the impact of re-entrainment into the estuary to the north of the boundary of the classified shellfish harvesting area on the following flood tide.

The discharge was required within the then consented spring tidal window of HW-0:45 to HW+4:15.

### Environmental Conditions

The survey took place on a Spring tide (5.0m height, 3.9m range) between 05:01 and 19:04. Predicted High Waters at Falmouth were 07:10 and 19:24. Wind speed and direction were recorded onboard the survey vessel as follows:

Time (GMT)	Wind Speed ( $\text{ms}^{-1}$ )	Wind Direction
05:01	6.5	Northerly
05:20	10 (squall)	Northerly
05:30	5.0	Northerly
05:49	3.0	Northwesterly
06:17	4.0	Northwesterly
11:21	8.5	North Northwesterly
12:00	12.5	North Northwesterly
13:21	8.0	Northwesterly
14:35	6.5	Northwesterly
17:13	6.5	Northwesterly
18:48	4.5	Westerly

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 14 April were 6.8mm and 1.2mm respectively, and on the 15 April were 2mm and 4.6mm respectively.

### Summary of Events

South West Water started to release effluent at 09:30 (HW+2:20) at an average rate of  $380\text{ls}^{-1}$ . Average concentrations of Faecal Coliforms and Faecal Streptococci per 100ml measured in the effluent were  $2.0 \times 10^7$  and  $2.3 \times 10^6$  respectively. *B. Globigii* spores were released from the outfall at the end of the tidal window between 09:59 (HW+2:49) and 11:25 (HW+4:15) at an average rate of  $7.67 \times 10^9$  per second.

The effluent plume was marked by injecting 15 litres of Fluorescein dye at a rate of 3 litres per minute for the discharge period from HW+4:10 to HW+4:15. South West Water stopped discharging at the end of the prescribed tidal window at HW+4:15.

The dye patch was mapped on three occasions as it moved south and a total of 49 surface and 9 depth samples were taken for bacterial and spore analysis between HW+4:11 and HW-3:54. By this time the patch was very dispersed and situated mid way between Pendennis Point and St Anthony Head. Vertical profiling of temperature and salinity was also undertaken in the centre of the dye patch at HW+4:26 and HW+5:50.

For the remainder of the survey between HW-2:21 and HW-0:20, water sampling on the flood tide continued from a predetermined grid extending from Pendennis Point to St Mawes Bank and across the southern limit of the Classified Bivalve Mollusc Production Area. A total of 100 samples had been collected by the end of the survey.

The survey results are tabulated in the Data Annex.

## 7 Commissioning Neap Tide Survey: 21 April 1998

### Environmental Conditions

The survey took place on a Neap tide (4.2m height, 2.4m range) between 03:59 and 11:51. Predicted High Waters at Falmouth were 23:25 (20 April) and 12:15.

Daily rainfall totals measured at Camborne and Cudrose (9am to 9am the following day) on the 20 April were 2.8mm and 2.0mm respectively, and on the 21 April were 13.8mm and 6.4mm respectively. Wind speed and direction were recorded onboard the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction
04:14 (HW+4:48)	6.0	Southeasterly
04:40 (HW+5:15)	5.0	Southerly
05:25 (HW+6:00)	4.5	Southerly
06:05 (HW-6:09)	5.5	Southerly
06:33 (HW-5:41)	5.5	Southerly
07:09 (HW-5:06)	6.0	Southerly
09:12 (HW-3:03)	6.5	Southerly
09:42 (HW-2:32)	8.0	Southerly
10:41 (HW-1:33)	7.5	South Southeasterly

### Summary of Events

The survey represented the predicted worst case conditions of southerly wind and Neap tide with respect to the behaviour of the plume at the end of the discharge window. The discharge was required within the consented Neap tidal window of HW-0:15 to HW+4:45.

Effluent was discharged from the Black Rock outfall for approximately one hour, finishing at HW+4:45. At HW+4:34, a total of 12.5 litres of Fluorescein dye were injected into the final effluent sampling chamber and emerged at the outfall in darkness at approximately HW+4:42. The dye patch was mapped on four occasions as it moved south, and was located just south of Black Rock Buoy at the turn of the tide. A total of 31 surface and 7 depth samples were taken for bacterial analysis across the leading edge of the dye patch between HW+4:52 and HW-4:25 by which time the patch had returned to the vicinity of the outfall.

For the remainder of the survey between HW-4:25 and HW-0:24, water sampling on the flood tide continued from a predetermined grid extending from Pendennis Point to St Mawes Bank and across the southern limit of the Classified Bivalve Mollusc Production Area. The dye patch continued to move north and by HW-1:05, close to high slack water, it was very disperse and situated to the north of Trefusis Point. Additional water samples were collected from the dye patch at this time. A total of 89 samples had been collected by the end of the survey

The survey results are tabulated in the Data Annex.

## 8 Commissioning Intermediate Tide Survey: 23 April 1998

As a further test of the scheme, it was decided to carry out a survey under an intermediate tidal state. In the light of the results from the Neap tide survey conducted on 21 April 1998, this intermediate tide survey aimed to follow and sample that part of the effluent plume released one hour before the end of the consented window ie. ending at HW+3:30.

### Environmental Conditions

The survey took place on an Intermediate tide (4.8m height, 3.6m range) between 05:28 and 15:00. Predicted High Waters at Falmouth were 02:08 and 14:48. Wind speed, direction, and wave height were recorded onboard the survey vessel as follows:

Time (GMT)	Wind Speed	Wind Direction	Wave Ht.
05:36 (HW+3:28)	12.0	Southerly	2-3m
12:33 (HW-2:15)	5.0	Veering Westerly	1m choppy
13:20 (HW-1:27)	11.0 (gusty)	West Northwest	

Daily rainfall totals measured at Camborne and Culdrose (9am to 9am the following day) on the 22 April were 21.2mm and 13.2mm respectively, and on the 23 April were 2.8mm and 1.0mm respectively.

### Summary of Events

Effluent was discharged from the Black Rock outfall for approximately two hours, finishing at HW+4:30. At HW+3:20, 12.5 litres of Fluorescein dye were injected into the final effluent sampling chamber and emerged at the Black Rock outfall at HW+3:28.

During the period between emergence and HW+4:22, the visible extent of the patch was mapped three times and water samples were collected. At HW-6 the dye patch was very indistinct with its northern visible boundary situated 500m south of Pendennis Point. The dye patch was mapped on a further two occasions at HW-5 and HW-4.33 at which time its northern visible boundary was near to the outfall and very dispersed. The early dispersal of the dye compared to previous surveys underlines the higher rate of mixing afforded by the wave action.

Due to amount of rainfall preceding and throughout the survey, it was necessary to operate the Black Rock outfall outside the tidal window for storm sewage discharge in line with the consent. Storm discharges commenced at HW-5:12 and continued throughout the remainder of the survey for a period of four minutes in every ten reducing to four minutes in every twenty towards the end of the survey. Water sampling on the flood tide continued from a predetermined grid extending from Pendennis Point to St Mawes Bank and across the southern limit of the Classified Bivalve Mollusc Production Area. A total of 61 samples had been collected by the end of the survey at HW+0:12. The survey results are tabulated in the Data Annex.

## 9 Post-Commissioning Neap Survey: 2 - 5 June 1998

This was the first set of two surveys carried out after the commissioning of the scheme. Details of the sampling locations are presented in the Data Annex.

### Environmental Conditions

The mean neap range at Falmouth is 2.3m, predicted High and Low Waters for the survey period are detailed below.

DATE	TIME	HEIGHT (m)	RANGE (m)
02/06/98	04:48	1.7	2.8
	10:52	4.2	2.5
	17:08	2.0	2.2
	22:50	4.3	2.3
03/06/98	05:46	1.9	2.4
	12:09	4.1	2.2
	18:12	2.1	2.0
04/06/98	00:16	4.3	2.2
	06:52	1.9	2.4
	13:10	4.2	2.3



	19:19	2.0	2.2
05/06/98	01:24	4.3	2.3
	07:59	1.8	2.5
	14:02	4.4	2.6
	20:24	1.8	2.6

Daily rainfall totals measured at Falmouth Screening Plant (9am to 9am the following day) over 2-5 June were 1mm, 0.0mm, 0.0mm, and 13.2mm respectively. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

	Time (GMT)	Wind Speed ( $\text{ms}^{-1}$ )	Wind Direction	Cloud Cover
03-Jun-98	5.0	7.0	Southerly	
	7.0	7.5	Southerly	7
	9.0	8.0	Westerly	8
	10.0	7.0	Westerly	
	13.0	5.0	North Westerly	6
	16.0	5.0	Northerly	
	21.0	2.0	Northerly	
04-Jun-98	6.0	0.5	South Easterly	0
	8.0	0.5	North Westerly	1
	9.0	1.0	Easterly	
	12.0	5.0	South Easterly	3
	13.0	5.0	Southerly	8
	15.0	4.0	South Easterly	
05-Jun-98	6.0	9.0	South Easterly	
	8.0	9.5	South Easterly	
	11.0	10.0	South Easterly	
	14.0	11.0	South Easterly	

Daily rainfall totals measured at the Falmouth Screening plant for the 2 - 5 June were 1.0mm, 0.0mm, 0.0mm and 13.2mm respectively.

#### Summary of Events

- 2 June Pumped sewage and *B. Globigii* 22:37(HW-0:13) to 02:40(HW+3:50) Dye at outfall 23:40(HW+0:50)
- 3 June Pumped sewage and *B. Globigii* 11:56(HW-0:13) to 16:15(HW+4:06)
- 4 June Pumped sewage and *B. Globigii* 00:05(HW-0:11) to 04:05(HW+3:49) Dye at outfall 01:15(HW+0:59)
- Pumped sewage and *B. Globigii* 12:57(HW-0:13) to 17:05(HW+3:55)

The survey represented the predicted worst case conditions of southerly wind and Neap tide with respect to the behaviour of the plume at the end of the discharge window. The discharge was required within the revised consented Neap tidal window of HW-0:15 to HW+3:45.

Average concentrations, for all four releases, of Faecal Coliforms and Faecal Streptococci per 100ml measured in the effluent were  $4.7 \times 10^7$  and  $2.8 \times 10^6$  respectively. *B. Globigii* spores were released from the outfall at a constant rate commensurate with the effluent discharge at an average concentration of  $7.1 \times 10^5$  per 100ml. The *B. Globigii* concentration was quite variable and varied by an order of magnitude. The effluent plume was marked by injecting 15 litres of Fluoresceine dye on the 2 June (23:40, HW+0:50) and 1 litre of Rhodamine dye on the 3 June (12:04, HW-0:05) at a rate of approximately 3 litres per minute.

The dye patch was mapped twice for each release as it moved south and a total of 99 surface and 25 depth samples were taken for bacterial and spore analysis between HW+5:33 and HW-2:03. By this time the patch was well to the south of Pendennis Point/St Anthony Head and off the Helford River

For the remainder of the survey between HW-1:28 and HW-0:11, water sampling on the flood tide continued from a predetermined grid extending from Pendennis Point to St Mawes Bank and across the southern limit of the Classified Bivalve Mollusc Production Area. A total of 78 samples had been collected by the end of the survey. The survey results are tabulated in the Data Annex.

## 10 Post-Commissioning Spring Survey: 23 -26 June 1998

This was the second set of two surveys carried out after the commissioning of the scheme. Figures 1b shows the locations of the water quality sampling sites used during the surveys. The grid references are listed in the Data Annex. All samples were collected from just below the surface.

### Environmental Conditions

The mean spring range at Falmouth is 4.7m, predicted High and Low Waters for the survey period are detailed below.

DATE	TIME	HEIGHT (m)	RANGE (m)
23/06/98	10:55	0.8	4.3
	16:36	5.3	4.5
	23:21	0.7	4.6
24/06/98	05:01	5.2	4.5
	11:44	0.8	4.4
	17:22	5.4	4.6
25/06/98	00:09	0.6	4.8
	05:50	5.2	4.6
	12:31	0.6	4.6
	18:08	5.4	4.8
26/06/98	00:55	0.6	4.8
	06:39	5.1	4.5
	13:14	0.7	4.4
	18:53	5.3	4.6

Wind speed, direction, and cloud cover were recorded onboard the survey vessel as follows:

	Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
24-Jun-98	7.5	6.6	South Westerly	8
	8.0	8.0	North Westerly	
	8.5	5.0	North Westerly	5
	12.0	6.0	South Westerly	4
	16.5	7.0	South Westerly	5
	18.0	5.0	South Westerly	7
25-Jun-98	8.0	4.5	Westerly	6
	10.5	2.0	Westerly	6
	11.0	8.0	Westerly	6
	18.0	7.5	South Westerly	6
26-Jun-98	7.0	8.5	South Westerly	8
	8.0	4.0	South Westerly	8
	10.0	9.0	South Westerly	8
	11.0	7.7	South Westerly	8
	13.0	8.2	South Westerly	8
	16.0	8.3	South Westerly	8

Daily rainfall totals measured at the Falmouth Screening plant for the 23 - 26 June were 8.2mm, 0.6mm, 4.4mm and 15.0mm.

#### Summary of Events

- 24 June Pumped sewage and *B. Globigii* 04:20(HW-0:41) to 08:48(HW+3:47) Dye at outfall 06:16(HW+1:15)  
Pumped sewage and *B. Globigii* 16:35(HW-0:47) to 21:09(HW+3:47)  
25 June Pumped sewage and *B. Globigii* 05:08(HW-0:28) to 09:18(HW+3:28) Dye at outfall 06:34(HW+0:44)  
Pumped sewage and *B. Globigii* 17:26(HW-0:42) to 21:31(HW+3:23)

The survey represented the predominant wind conditions with west to south westerly winds. The discharge was required within the revised consented Spring tidal window of HW-0:45 to HW+3:15.

Average concentrations, for all four releases, of Faecal Coliforms and Faecal Streptococci per 100ml measured in the effluent were  $5.8 \times 10^7$  and  $1.4 \times 10^6$  respectively. *B. Globigii* spores were released from the outfall at a constant rate commensurate with the effluent discharge at an average concentration of  $7.2 \times 10^5$  per 100ml

The effluent plume was marked by injecting 20 litres of Rhodamine dye on the 24 June (06:16, HW+1:15) and Fluorescein dye on the 25 June (05:34, HW-0:16) at a rate of approximately 3 litres per minute.

The dye patch was mapped twice for each release as it moved south and a total of 123 surface and 12 depth samples were taken for bacterial and spore analysis between HW+2:29 and HW-3:52. By this time the patch was very dispersed and situated to the south of Pendennis Point/St Anthony Head.

For the remainder of the survey between HW-1:29 and HW+0:07, water sampling on the flood tide continued from a predetermined grid extending from Pendennis Point to St Mawes Bank and across the southern limit of the Classified Bivalve Mollusc Production Area. A total of 95 samples had been collected by the end of the survey.

The survey results are tabulated in the Data Annex.

### 11 Post Commissioning Baseline Intermediate Tide Water Quality Survey 21 May 1998

This was the first of four surveys carried out following the commissioning of the interim scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on an intermediate tide (4.5m height, 3.0m range) between 09:23 and 20:24. Predicted High Waters at Falmouth were 13:12 and 01:38 on the following day.

Daily rainfall measured at the Falmouth Screening Plant from 19 - 21 May were all 0.0mm. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
09:28	5.0	Northerly	2
10:24	7.0	Northerly	
11:16	7.0	Easterly	
12:34	5.0	Northerly	
14:08	5.0	Northerly	5
15:54	5.0	Northerly	5
16:22	4.0	North Westerly	4
16:58	7.0	Northerly	3
19:10	5.0	Northerly	1
20:00	4.0	Northerly	1

### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	09:23 to 11:16	HW-3:49 to HW-1:56	HW-2:52
Run 2	12:25 to 14:17	HW-0:47 to HW+1:05	HW+0:09
Run 3	15:35 to 17:14	HW+2:25 to HW+4:02	HW+3:13
Run 4	19:10 to 20:28	HW+5:58 to HW-5:10	HW-5:49

The survey results for all determinands are tabulated in the Data Annex.

## 12 Post Commissioning Baseline Neap Tide Water Quality Survey: 2 July 1998

This was the second of four surveys carried out following the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

### Environmental Conditions

The survey took place on a Neap tide (4.2m height, 2.3m range) between 08:35 and 19:40. Predicted High Waters at Falmouth were 10:44 and 22:56.

Daily rainfall measured at the Falmouth Screening Plant from 1 - 2 July were all 0.0mm. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
07:40	2.0	Easterly	1
07:57	5.0	North Easterly	
08:31	5.0	North Easterly	
10:25	4.0	North Easterly	5
10:57	5.0	Easterly	
11:43	6.0	Easterly	
13:52	2.0	Easterly	
14:13	3.0	Easterly	6
14:23	5.0	Easterly	
15:01	6.0	Easterly	
17:15	1.0	Easterly	5
17:35	3.0	Easterly	2
18:17	2.0	Easterly	5

### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	07:35 to 09:04	HW-3:09 to HW-1:40	HW-2:24
Run 2	10:25 to 11:50	HW-0:19 to HW+1:16	HW+0:24
Run 3	13:53 to 15:13	HW+3:09 to HW+4:29	HW+3:49
Run 4	16:46 to 18:40	HW+6:02 to HW-4:16	HW-5:13

The survey results for all determinands are tabulated in the Data Annex.

### 13 Post Commissioning Baseline Intermediate Tide Water Quality Survey 15 July 1998

This was the third of four surveys carried out following the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on an intermediate tide (4.9m height, 3.7m range) between 08:31 and 19:01. Predicted High Waters at Falmouth were 09:14 and 21:29.

Daily rainfall measured at the Falmouth Screening Plant from 13 -15 July were 1.4mm, 0.0mm and 13.6mm respectively. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
08:34	2.0	Westerly	8
09:06	3.0	Westerly	8
09:26	4.0	Westerly	
11:34	7.0	South Westerly	6
11:56	6.0	South Westerly	7
12:16	8.0	South Westerly	8
15:08	5.0	South Westerly	8
15:32	2.0	South Westerly	8
15:52	5.0	South Westerly	8
17:58	4.0	South Westerly	8
18:28	4.0	South Westerly	8

#### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	08:30 to 09:52	HW-0:44 to HW+0:38	HW-0:03
Run 2	11:30 to 13:01	HW+2:16 to H+3:47	HW+3:02
Run 3	15:06 to 16:21	HW-6:23 to HW-5:07	HW-5:45
Run 4	17:50 to 19:01	HW-3:39 to HW-2:28	HW-3:03

The survey results for all determinands are tabulated in the Data Annex.

### 14 Post Commissioning Baseline Spring Tide Water Quality Survey 23 July 1998

This was the fourth of four surveys carried out following the commissioning of the scheme. The grid references of all the survey sites are listed in the Data Annex. All samples were collected from just below the surface.

#### Environmental Conditions

The survey took place on a Spring tide (5.3m height, 4.5m range) between 07:09 and 18:12. Predicted High Waters at Falmouth were 04:46 and 17:05.

Daily rainfall measured at the Falmouth Screening Plant from 21 - 23 July were 0.2mm, 3.2mm and 0.0mm. Wind speed, direction, and cloud cover were recorded on board the survey vessel as follows:

Time (GMT)	Wind Speed (ms <sup>-1</sup> )	Wind Direction	Cloud Cover
07:10	5.0	Westerly	
07:50	3.0	Westerly	
08:10	5.0	Westerly	
08:36	7.0	Westerly	
10:50	5.0	Westerly	7
11:30	4.0	Westerly	6
12:18	3.0	Westerly	7
14:06	7.0	Westerly	4
14:50	7.0	Westerly	3
15:06	6.0	Westerly	3
15:44	6.0	Westerly	3
16:48	5.0	Westerly	3
17:26	8.0	Westerly	3
18:12	5.0	Westerly	1

#### Summary of Events

There were four sampling runs as follows:

Run No.	Time	HW Relative Time	Run Central Time
Run 1	07:09 to 08:40	HW+2:23 to HW+3:54	HW+3:09
Run 2	10:50 to 12:21	HW+6:04 to HW-4:44	HW-5:29
Run 3	14:06 to 15:44	HW-2:59 to HW-1:21	HW-2:10
Run 4	16:48 to 18:12	HW-0:17 to HW+1:07	HW+0:25

The survey results for all determinands are tabulated in the Data Annex.