EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

Dart Estuary – Devon
Pacific oysters at Long Wood

2011

Cover photo: Trestles at Long Wood with Noss Marina in the background.

CONTACTS:

For enquires relating to this report or further information on the implementation of sanitary surveys in England and Wales:

Simon Kershaw/Alastair Cook
Food Safety Group
Cefas Weymouth Laboratory
Barrack Road,
The Nothe
WEYMOUTH
Dorset
DT43 8UB

(+44 (0) 1305 206600
* fsq@cefas.co.uk

For enquires relating to policy matters on the implementation of sanitary surveys in England and Wales:

Karen Pratt/Mariam Aleem
Hygiene Delivery Branch
Enforcement and Delivery Division
Food Standards Agency
Aviation House
125 Kingsway
LONDON
WC2B 6NH

(+44 (0) 20 7276 8000
shellfish_hygiene@foodstandards.gsi.gov

STATEMENT OF USE: This report presents a sanitary assessment of Pacific oysters (*Crassostrea gigas*) at Long Wood, within the Dart estuary. Its primary purpose is to demonstrate compliance with the requirements for classification of bivalve production areas, laid down in EC Regulation 854/2004 of the European Parliament and of the Council. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	26/01/2012	26/01/2012
South Hams District Council	26/01/2012	26/04/2012

DISSEMINATION: Food Standards Agency, South Hams District Council.

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2011. Sanitary Survey of Dart Estuary (Devon). Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under Regulation (EC) No 854/2004.

CONTENTS

1. INTRODUCTION

1.1 LEGISLATIVE REQUIREMENT

In order to protect public health, under EC Regulation 854/2004[1], shellfish harvesting and relaying areas are classified on the basis of monitoring of levels of faecal indicator organisms (*Escherichia coli* in the EU) in shellfish. As part of these regulations, a sanitary survey is required to determine a representative microbiological monitoring programme which is suitably protective of public health.

The Dart estuary has been subject to two sanitary surveys in recent years (Cefas, 2009 and Cefas, 2010). The current sanitary survey was prompted by an application to harvest Pacific oysters at Long Wood, which falls outside of the currently classified zones for this species. This survey provides a sanitary assessment and sampling plan for this species at Long Wood. It also covers a new lease area operated by the same harvester on the opposite bank called Lords Wood, where juvenile Pacific oysters are held, but from which no mature stock is harvested. The assessment is based on the previous sanitary surveys and is intended to be an addendum to these sanitary survey reports. It incorporates details of the new fishery, and other updated information where appropriate, including a shoreline survey (Appendix I) and bacteriological survey (Appendix II). All other information, unless indicated otherwise, is taken from the previous sanitary survey reports for this estuary.

[1] EC Regulation 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organization of official controls on products of animal origin intended for human consumption.

1.2 GENERAL DESCRIPTION OF AREA

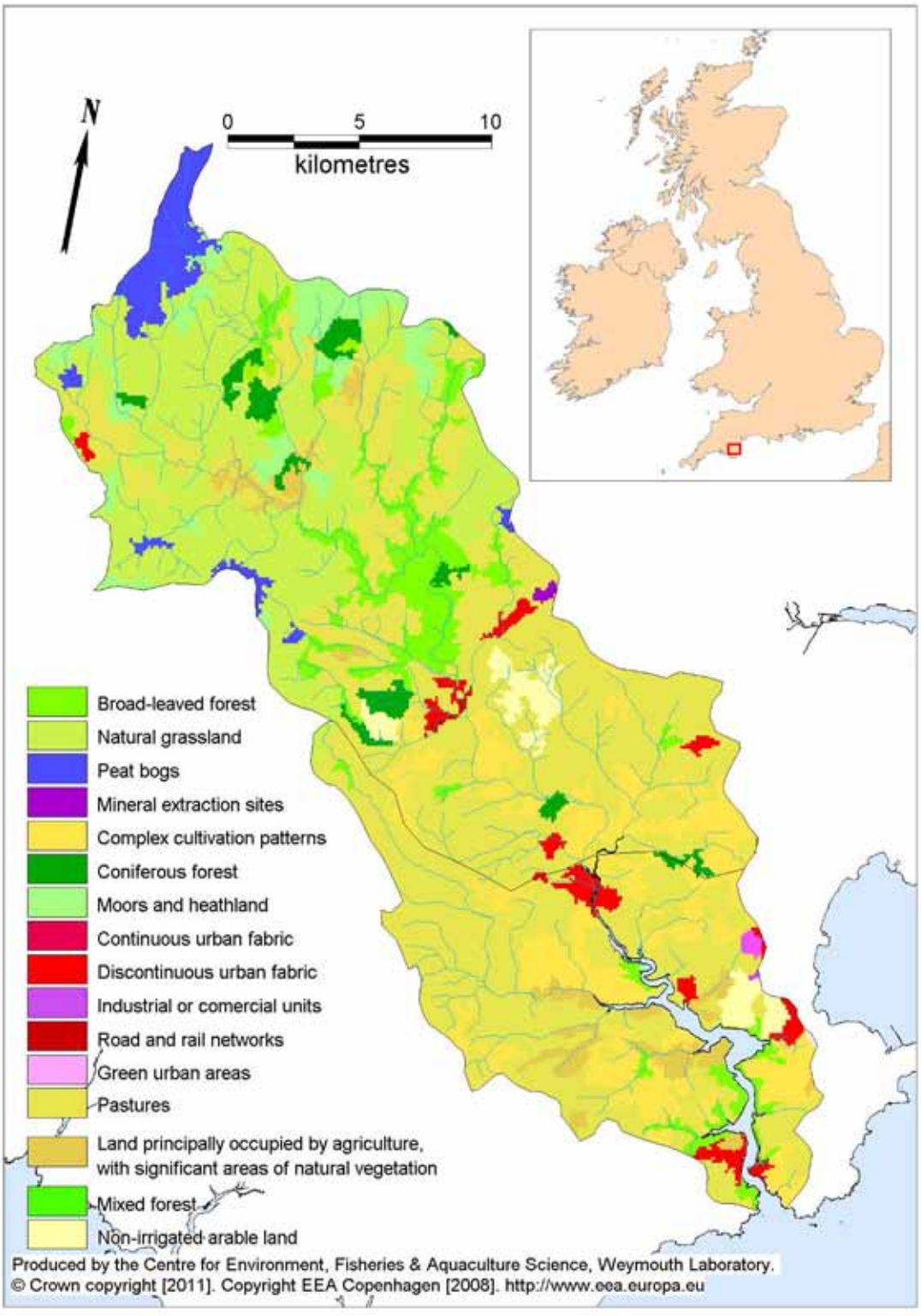


Figure 1.1 Overview of the area

The Dart Estuary is located on the south coast of Devon. It drains a catchment area of 470 km^2, with moorland drained by steep wooded valleys in the upper catchment and relatively low lying undulating land mainly used for agriculture in its lower reaches. The catchment is generally rural and sparsely populated, although there are some significant population centres, notably Totnes at the head of the estuary, and Dartmouth at its mouth.

The estuary is sheltered, branched with small tributaries, has a relatively short shoreline and narrows significantly towards its upper reaches. Its shores are predominantly rocky and bordered by woodland and agricultural land. Sandflats, mudflats and a few areas of saltmarsh comprise the majority of the intertidal area. Within the outer reaches of the estuary, much of the seafront is lined by slipways, marinas, moorings and boatyards. Commercial uses of the estuary include shipping, marine services, fisheries and tourism, the latter being mostly water-based (e.g. boating, fishing, canoeing).

The harvesting of oysters and mussels for human consumption has long been a tradition in the Dart Estuary. The culture of the Pacific oysters here dates back to the 1960s and there are several sites currently used for this purpose within the Dart.

2. SHELLFISHERY

2.1 SPECIES, LOCATION AND EXTENT

Figure 2.1 shows the location of the new oyster lease areas at Long Wood and Lords Wood, and the extent of the trestles at this site at the time of shoreline survey. It is located between about 2 and 4km downstream of the existing Pacific oyster culture sites. The trestles are actually located just inshore of the lease area, so the classified area should cover the lease area, and the area inshore of this up as far as mean high water springs. The second smaller and newer lease area on the opposite bank (Lords Wood) was yet to be established at the time of shoreline survey.

At the time of shoreline survey there was one row of trestles of approximately 100m in length at Lords Wood, the location of which is indicated in Figure 2.1. Although there is a limited natural spatfall of Pacific oysters, this is insufficient to supply the oyster farms in the Dart so they are all grown from hatchery seed. At the time of survey only juvenile stock was present, but the harvester may transfer stocks here from another site further up the estuary under the same ownership. The harvester is requested to note that oysters (apart from seed stock) may only be transferred to Long Wood from sites with the same (or better) classification. The Long Wood site is closer to the mouth of the estuary and hence less prone to salinity reductions after heavy rainfall than the existing sites. Sharp drops in salinity can potentially cause mortalities during the summer when mature Pacific oysters are recovering from spawning, so the Long Wood site offers a reduced likelihood of this occurring compared to sites further upstream.

The newer lease at Lords Wood is only used as a nursery area, where seed stock is raised to a size of around 10mm. The grower advised that the overhanging tree canopy makes this site ideal for this purpose and indicated that he does not plan to keep larger stock here or harvest directly from this area. Nevertheless, a sampling plan will be provided for this site in case the situation changes.

2.2 GROWING METHODS AND HARVESTING TECHNIQUES

The stocks are grown from hatchery seed within net bags on trestles within the intertidal zone. Harvesting is by hand.

2.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

Harvesting may occur throughout most of the year with the possible exception of July and August, when the oysters may be in relatively poor (post spawning) condition. Demand for oysters tends to peak around Christmas and Valentines Day. There are no conservation controls applicable to this fishery. The harvester plans to expand the area of trestles to occupy the entire Long Wood lease area over the next few years.

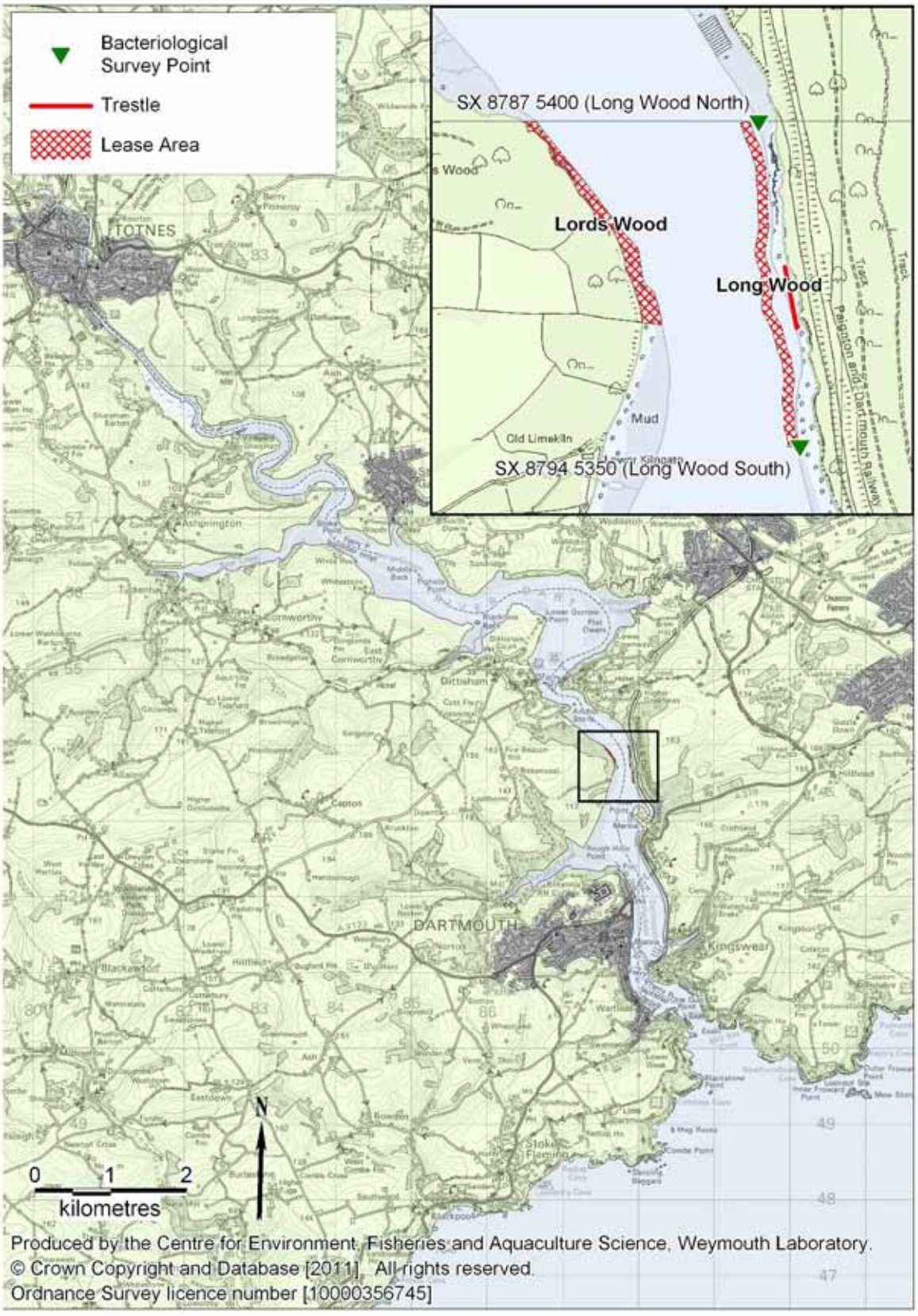


Figure 2.1. Long Wood Pacific oyster site location

3. OVERALL ASSESSMENT

AIM

This section presents an overall assessment of sources of contamination, their likely impacts, and patterns in levels of contamination observed in water and shellfish samples taken in the area under various programmes. This is summarised from supporting information presented in the previous sanitary survey reports for the Dart Estuary (Cefas, 2009 & 2010, and references therein) supplemented with additional information gained from a survey of the shoreline adjacent to the site. Its main purpose is to inform the sampling plan for the microbiological monitoring and classification of Pacific oysters at Long Wood and Lords Wood (if required) and the main features of significance discussed in this section are summarised in Figure 3.1.

SHELLFISHERY

The area for which classification (Long Wood) has been requested covers about 500m of the narrow shoreline between Greenway and Noss, where Pacific oysters are grown from hatchery seed on trestles. The classified area should cover the lease area, and the area inshore of this up as far as MHWS, in which trestles may potentially be placed. Additionally, a sampling plan should be provided for the site on the opposite bank (Lords Wood) as although it is currently used as a nursery area, it is possible that it may require classification in the future. This site is also within the intertidal, and is slightly smaller at 350m long.

POLLUTION SOURCES

FRESHWATER INPUTS

The principle freshwater is the River Dart, which enters the head of the estuary at Totnes, about 15km upstream of Long Wood. Its mean daily flow, as measured at a gauging station 10km upstream of the tidal limit, for the period 1958-2009 was 11.2m^3/s, and its flow exceeded 25.2m^3/s for 10% of this time (NERC, 2011). Discharge from this river responds quite rapidly to rainfall due to the hard geology and steep topography in its upper catchment. Discharge volumes are generally highest from October to January.

Two other minor but significant rivers discharge to the Dart estuary (Rivers Hems and Harbourne) approximately 14 and 7km upstream of Long Wood. These are likely to be significant pathways by which contamination from land runoff and possibly sewage discharges are carried into the estuary. The major freshwater inputs to the estuary are all located a significant distance upstream of the fishery, and whilst they are likely to carry a significant proportion of contamination observed within shellfish into the estuary, it is unlikely that they create significant and consistent spatial variation in levels of *E. coli* across the lease area at Long Wood.

In addition to these there are numerous smaller watercourses discharging at various points to the estuary, which may create areas of decreased microbiological quality in the vicinity of their discharge point. Of potential significance to the fishery at Long Wood is a stream which discharges to the east shore about 300m to the south of the lease area. This was sampled and measured during the shoreline survey, and was found to be discharging a calculated bacterial loading of 8.7×10^9 *E. coli* cfu/day at the time of survey. It is about 2km in length, and drains an area of pasture at its head, then flows through woodland and also passes through a pond before it reaches the estuary so may carry some contamination of livestock origin when the pastures are being grazed (or spread with manures). The concentration of *E. coli* within this watercourse was actually lower than that found in the estuary at Long Wood, indicating that it was not a major contaminating influence at the time of survey. This may not be the situation all of the time, and a representative monitoring point located at the southern end of the lease area would be best placed to capture any contamination arising from this watercourse. No other streams were observed discharging to the east shore near Long Wood. The Ordnance Survey map indicates a very small freshwater input from a spring fed pond about 350m upstream of the lease area, but no watercourse across the shore was seen here during the shoreline survey.

On the west shore, there is a small stream of about 500m in length discharging to the shore about 250m south of the southern boundary of the lease area, and another stream about 250m long discharging about 400m north of the lease area. As both of these are spring fed and flow through wooded areas neither are expected to have a major impact.

HUMAN POPULATION

Human population density within the catchment is relatively low (<166 people per hectare compared to an average of 383 for England). The most significant urbanised areas are Totnes (8,210 inhabitants) and Dartmouth (5,678 inhabitants) at the head and the mouth of the estuary, respectively. Therefore, the main sewage discharges may be expected in these areas. The resident human population in the catchment (>41,440) is significantly lower than the total number of farmed animals. Population in the area increases significantly during the summer holiday period, so the volumes of effluent discharged by sewage treatment plants may be expected to peak in July and August.

SEWAGE DISCHARGES

Five continuous water company sewage discharges lie within the estuary or within 10km of its tidal limits. The two largest of these are at Totnes (dry weather flow = 3,967 m^3/day, discharging about 13km up estuary from Long Wood) and at Dartmouth (dry weather flow = 4,644 m^3/day, discharging about 2km down estuary from Long Wood and Lords Wood). Both receive UV disinfection, and bacteriological testing of the final effluent indicated generally low bacterial concentrations (geometric mean of 77 and 31 faecal coliforms/100ml respectively) so their impacts at Long Wood and Lords Wood are anticipated to be negligible for most of the time. On occasions higher levels of faecal coliforms have been found

in the effluents from both Totnes and Dartmouth (highest concentrations of 11,000 and 15,000 respectively). There are two relatively small sewage works discharging to the Harbourne River (Harburtonford STW and Ashprington STW) within 3km of its tidal limit, which in turn lies about 8km up estuary from Long Wood and Lords Wood. Although dry weather flows from these are relatively small (242 and 98 m^3/day) they only receive secondary treatment, and so their effluent is likely to contain relatively high concentrations of *E. coli*. Finally, there is a small sewage works at Dittisham, about 1.5km up estuary from Long Wood and Lords Wood with a dry weather flow of 66 m^3/day. The effluent is membrane (tertiary) treated, a process which should remove a high proportion of the bacteria via filtration. Final effluent testing revealed higher than anticipated concentrations of faecal coliforms in this effluent in 2006 and 2007 as identified in the previous sanitary surveys, but the situation has since improved (Environment Agency, personal communication) and the two samples take in 2010 showed relatively low levels of faecal coliforms (maximum of 340 faecal coliforms/100ml). Overall, bacterial inputs from continuous water company sewage discharges are relatively minor given the high levels of treatment afforded to the two larger ones, and mainly enter the estuary upstream of the fishery. Given their distance from the fishery, there is significant scope for dilution and mixing on their passage to the fishery from their discharge location.

Associated with these sewerage networks are a series of 22 intermittent outfalls. Half of these discharge in the vicinity of Totnes at the head of the estuary. A further 9 discharge to watercourses or direct to the middle reaches of the estuary, between Dittisham and Stoke Gabriel. Of those for which spill data was examined, all were found to spill several times a year. The closest one to the fishery (Ferry Boat Inn, about 1.5km up estuary) recorded an average of 50 spills per year from 2006/7 to 2008/9. Therefore, increased impacts from sewage may occur regularly at Long Wood and Lords Wood, probably coinciding with high rainfall events, and these would mainly originate up estuary from the site.

Of major significance to the fishery at Long Wood is the Noss Marina development, which involves increasing the number of yacht berths, and the construction of housing, a hotel and a watersports academy. As part of this development, a (private) package plant treatment works will be installed which is consented to discharge 136 m^3/day of secondary treated effluent to the estuary around the low water mark on the east bank about 350m south of the fishery. This would therefore present a much larger bacterial loading than Dittisham STW, which is currently the closest discharge to the fishery. The Marina advised that the in river engineering works (including dredging) will be undertaken throughout the next year, to be completed some time in 2012, but at present there is no firm timescale for the completion of the land based works. Once completed, this discharge is likely to have a significant impact on the Long Wood site, and it is anticipated that these impacts will be consistently higher at the southern end of the site. As the development is largely related to watersports and recreation, some seasonality is anticipated with highest discharge volumes during the summer months.

AGRICULTURE

The predominant land use within the Dart catchment is agriculture, mainly cereals and livestock production. Livestock production is significant (total number of cattle and sheep is over 104,000) and is based on mixed cattle and sheep farming in areas of improved and natural grassland in the valleys and in the uplands. Numbers of animals grazing on pastures will be highest during the summer months, following the birth of calves and lambs in the spring. They will then decrease from autumn when they are sent to market. Cattle are likely to be kept indoors during the winter. Their slurry is collected and applied to agricultural land, generally from winter to early spring. Biosolids (treated sewage sludge) are applied to some arable fields in the autumn for winter cereals. Therefore, impacts from agricultural activities either from livestock on pastures or the spreading of organic fertilizers are anticipated year round. No information was available on the fine scale (field level) patterns of these applications.

Contamination from agricultural sources will be carried into the estuary by land runoff. Therefore, high rainfall events will tend to be associated with the peak fluxes of agricultural contamination. It is possible that the highest fluxes will arise after summer storms when largest numbers of animals are on pastures throughout the catchment, particularly if they are preceded by a dry period allowing the buildup of faecal matter on fields. High rainfall following the application of manures to agricultural land is also likely to result in significant but more localised contamination of watercourses.

A modelling study and supporting sampling has indicated that the Harbourne & Wash, the Hems, and the lower Dart sub-catchments are most vulnerable to diffuse pollution from agricultural land. The land bordering Long Wood and Lords Wood was classified as low or very low risk. Therefore, most contamination from agriculture is likely to originate up estuary, so an RMP set at the northern boundary of these sites may best capture this.

BOATS

There is significant small boat traffic with the Dart Estuary. There are 2,878 moorings of various types on the Dart Estuary, and more than 12,000 yacht visitor days have been recorded in the estuary during the year. There are no pump-out facilities within the estuary. Highest concentrations of yachts are found in the lower estuary at Dartmouth and Kingswear. Of more significance to the fishery, there are moorings and berths at Noss Marina on the west bank, with some moorings closer to the east bank. There are also moorings around Greenway, about 1.5km to the north of Long Wood and Lords Wood. Those at Noss generally host larger boats, which would be more likely to have an onboard toilet. A significant development is due to be made at Noss Marina, which will involve increasing the number of yacht berths to over 350, so an increased risk of contamination from these may be anticipated once the development is complete. Therefore, an RMP at the south end of these sites may be best placed to capture contamination from boats. The general risk of contamination from overboard discharges is highest in the summer when there are more boats on the water and a higher proportion are in overnight occupation.

WILDLIFE

No major wildlife populations which may affect the sampling plan for the Dart estuary have been identified.

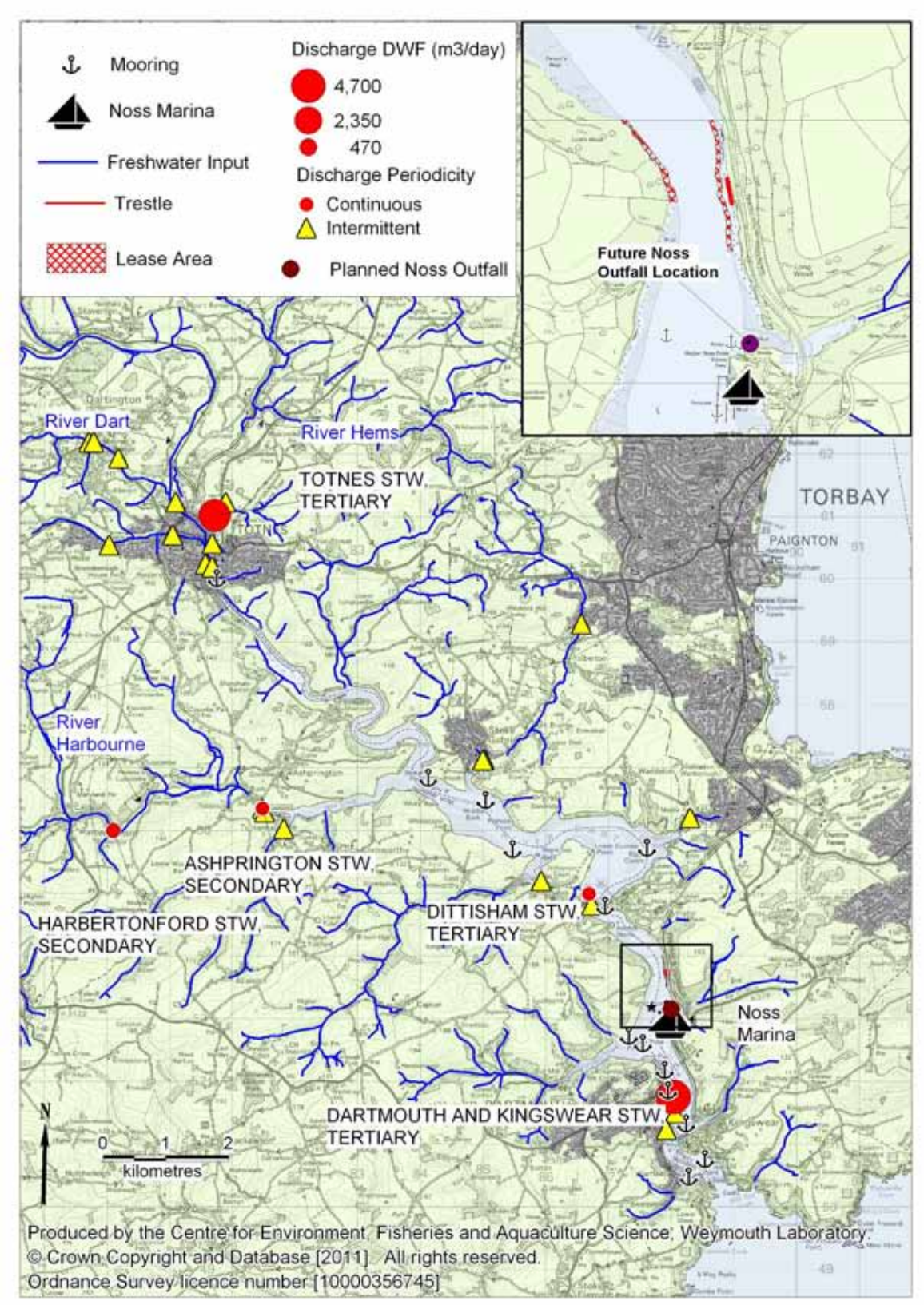


Figure 3.1 Potential sources of microbial contamination to Long Wood & Lords Wood

METEOROLOGY

Rainfall in the Dart catchment is highest on average from October to January, and lowest from June to September, although high rainfall events may occur at any time of the year. Higher rainfalls are generally recorded in the upper catchment. Prevailing winds are from the south west, and the strongest winds tend to blow from this direction. The local topography will tend to funnel winds up or down the estuary, so wind directions will be skewed towards the north-south axis at this part of the estuary, where winds will blow up the estuary for a large proportion of the time. The frequency of gales is highest during the autumn and winter.

HYDRODYNAMICS

The Dart estuary consists of a relatively narrow meandering channel about 19km in length, with several small side channels. The shores are generally rocky and steep, although there are some intertidal mudflats in places. The bathymetry in the vicinity of this fishery is uncomplicated, with a 2-300m wide channel within which the depth increases rapidly from the shore to a maximum depth of 13m below chart datum. The east shore on which the Long Wood site is located forms the outside of a very gentle bend in the estuary, and it slopes away below MLWS more rapidly than on the west side where the Lords Wood site is located.

The tidal range at Dartmouth is relatively large (4.3m on spring tides). Tidally driven currents move up the estuary on the flood, and back down on the ebb. Therefore, shoreline sources will tend to create 'hotspots' of contamination either side of their location. The closest sources of contamination to the fishery are a stream and the Noss Marina, just to its south, so on this basis an RMP set at the south end of the Long Wood site may show consistently highest results. It is unlikely that significant amounts of contamination will be directly carried across the river to the Lords Wood site as effluent from this discharge will tend to hug the east shore, although it will gradually mix across a wider area as it travels.

Tides within the Dart are asymmetrical, with slightly faster currents arising on the shorter duration ebb tide. Tidal diamonds indicate flows at Noss peak at about 0.3m/s on neap tides and 0.6m/s on spring tides and based on this tidal diamond, tidal excursions would be in the approximate order of 5-10km. Therefore, contamination from sources up to 10km away may be carried to the fishery during the course of a flood or ebb tide. Contamination from the secondary discharges to the Harbourne & Wash (about 8km upstream) would only be carried as far as the fishery on larger tides.

Superimposed on tidal streams are the effects of the freshwater inputs and winds, which will be somewhat more variable. Freshwater inputs will create a residual seaward flow, and at certain times and places, dependent on river discharge and tidal amplitude, may result in stratification and some vertical shear in current profiles, with less dense surface water tending to flow seawards. Of possible relevance to the Long Wood and Lords Wood sites, any stratification will bring the potentially more contaminated fresher water at the surface into more contact with the shellfish compared to the more saline water which will remain at lower depths in the channel. Stratification is reported to occur within the Dart estuary during

neap tides (Priestley and Thain, 2005), and will be more marked and widespread when river discharge is high.

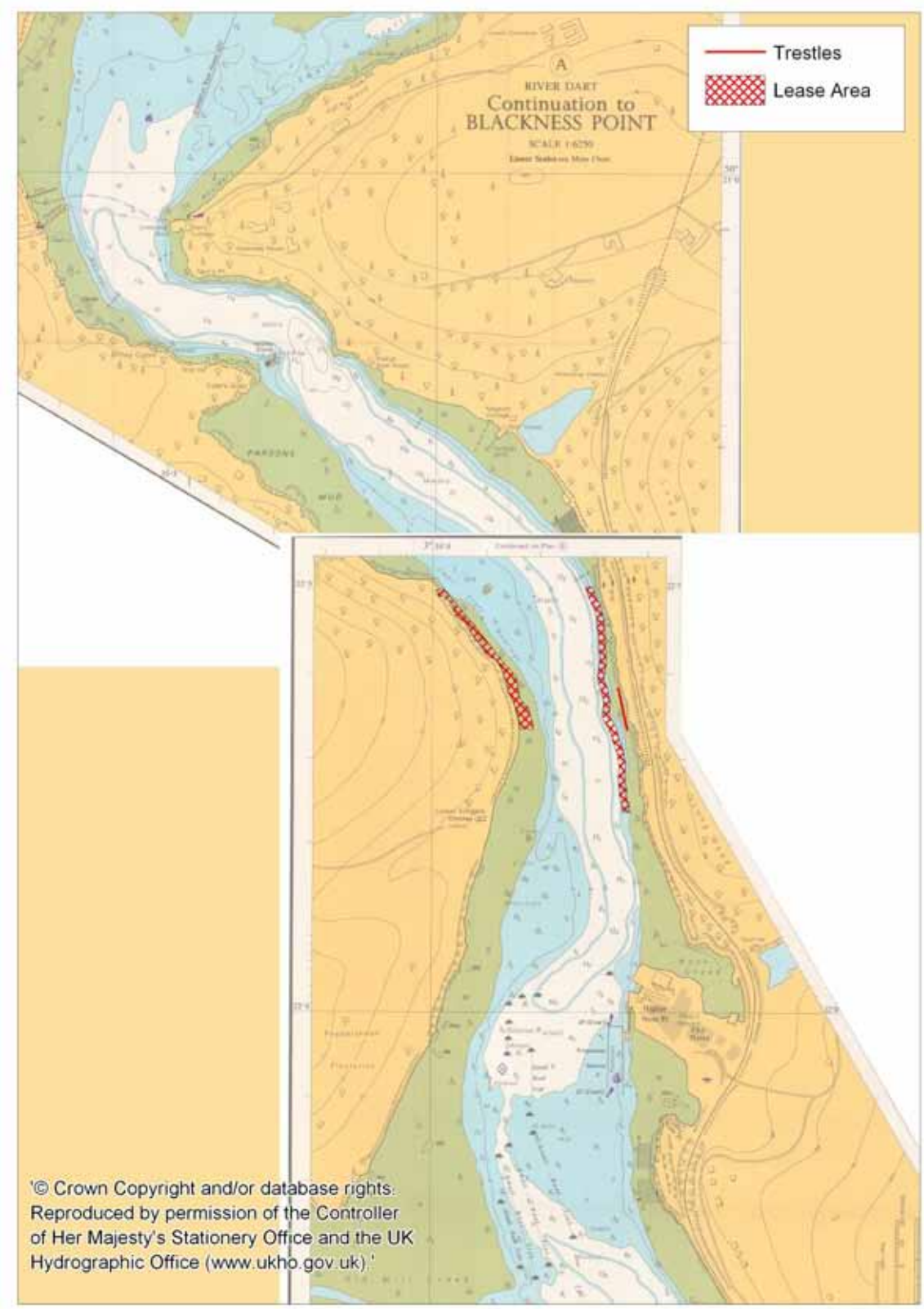


Figure 3.2 Bathymetry chart of Long Wood

As may be expected, salinity measurements taken at several locations between from just north of Long Wood to Totnes indicate that salinity gradually decreases towards the head of the estuary. As freshwater inputs will contain contamination from land runoff and in some cases sewage discharges, an underlying tendency for increased levels of *E. coli* towards the head of the estuary may be anticipated. Water samples analysed for *E. coli* alongside the salinity measurements showed that the tendency for increased levels of *E. coli* upstream was quite weak, although results were significantly lower at the two sites furthest downstream compared to some of the uppermost three sites, and when results from all sites were considered together a significant negative correlation between *E. coli* and salinity was found. Therefore, an RMP set at the northern boundary of the site may be best placed to capture freshwater borne contamination arising from up estuary, but, given their distance from the fishery, a strong gradient in levels of contamination across the Long Wood and Lords Wood sites is not anticipated to result from these sources.

Winds may modify circulation patterns within the estuary at times. Strong winds drive surface currents, which in turn create return currents either lower in the water column or along sheltered margins. At Long Wood and Lords Wood, winds will tend to be funnelled either up or down the estuary by the local topography so will generally either act directly with or against the tide. Wind effects are likely to be generally minor compared to tidal effects and density effects, and fairly dynamic and unpredictable so will not be explicitly considered in relation to the sampling plan.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

Several conclusions of relevance to the Long Wood and Lords Wood fishery can be drawn from the previous analyses carried out on microbiological sampling results from the Dart Estuary. Classification monitoring results for Pacific oysters and mussels were examined at the three sites by Waddeton (Sandridge Boathouse, Waddeton and Flat Owers). There was little overall difference in *E. coli* levels between these three sites, which is unsurprising as they are within 1km of each other. Occasionally, very high results of over 10,000 *E. coli* MPN/100g arose in mussels but not Pacific oysters. Strong positive correlations between *E. coli* results and rainfall/river discharge were found at all site species combinations, providing further evidence that runoff is an important source of contamination to the estuary. Even relatively light rainfall (daily totals of >2mm) was associated with higher levels of *E. coli* in shellfish. No significant seasonal peaks in *E. coli* levels were seen, suggesting that increased inputs from overboard discharges made by boats are not of major significance at these sites.

The last of the samples considered in the previous analyses were taken in February 2008, and since then sampling has continued at existing sites, and commenced at several new sites. As a consequence, further analyses of geographical and seasonal variation were carried out using sample results from the beginning of 2008 to the time of writing. It was not considered necessary to reinvestigate the relationships between rainfall/river flow and *E. coli* levels as these were demonstrated robustly in the previous reports, and are considered

unlikely to have changed since. As sampling was strongly targeted towards low water on the larger tides, analyses of *E. coli* levels against tidal states were not appropriate. These analyses are presented in detail in Appendix II, and concluded that *E. coli* results at Kingswear, near the mouth of the estuary were generally lower than those at the mid estuary sites, and that there was some (albeit weak) seasonality, with a tendency for higher results in the autumn and lower results in spring.

Also considered in Appendix II were the results of a bacteriological survey. 12 pairs of samples were taken from the north and south ends of the lease area. Results were very similar on average and in terms of the proportion of class A and class B results, but were slightly more variable at the north end of the site, where the highest overall result was recorded.

OVERALL CONCLUSIONS RELATING TO THE SAMPLING PLAN

The area requiring classification at Long Wood covers the lease area and the intertidal area inshore of this extending to MHWS. It covers a relatively uniform stretch of shore about 500m in length, within which there are no significant shoreline sources. As tidal flows run parallel to the shore, water quality is likely to be broadly similar throughout, so one RMP should be sufficient to monitor this zone. The same applies to Lords Wood, a slightly smaller site on the opposite bank.

A highly significant source to the estuary as a whole is likely to be land runoff, although the secondary treated sewage discharges to the Harbourne River, intermittent sewage discharges, and overboard discharges from boats may be of some importance. It is likely that the majority of contamination entering the estuary does so several km upstream of the fishery. Whilst these may be major contaminating influences at Long Wood and Lords Wood, they will probably not create a noticeable and/or consistent gradient in levels of *E. coli* in shellfish across the site given their distance away relative to the size of the site.

The closest potentially significant local sources lie to the south of Long Wood, and include a stream and yachts moored at Noss Marina. A major development will be made at Noss Marina over the next few years. The first phase will be undertaken in the next year, to be completed by summer 2012 and involves dredging work, which is likely to mobilise any contamination within the sediment. Once this phase is complete, the number of yacht berths at the marina will be significantly increased. Later phases of the development, for which there is currently no firm timescale, will result in a significant new continuous discharge of package plant treated effluent about 350m to the south of the site. Therefore, an RMP set at the south end of the site would capture any localised hotspots of contamination arising from sources to the south, and would also allow the impacts of the marina development on levels of *E. coli* to be tracked. It is also anticipated that an RMP at the south end of the site would be only slightly less effective at capturing contamination from upstream sources, if there is any difference at all. Bacteriological results indicate there is very little difference between levels of *E. coli* in shellfish at the north and south ends of the site, although results were

slightly higher at the north end in terms of both average and peak result. On balance, the Noss Marina discharge once installed will present the most significant local source of contamination so an RMP at the south end of this site is recommended.

At Lords Wood, the only local sources are some moorings to the south, and two small spring fed streams, one to the north and one to the south. Effluent from the future Noss Marina discharge are unlikely to be of significance as this will tend to be carried away along the east shore by the tidal streams. Therefore, in the absence of significant local sources, and RMP should be set at the northern end of the site in order to best capture contamination arising from up estuary sources.

4. RECOMMENDATIONS

4.1 The classification zone should encompass the lease area and the adjacent shoreline extending to MHWS.

4.2 An RMP should be set at SX 8794 5350 (B028P, Long Wood South) to be representative of the Long Wood site. A tolerance of 10m should be set around this RMP. Stock of a harvestable size, which has been placed in this location for no less than two weeks should be sampled.

4.3 Bacteriological survey sampling results from Long Wood South may be used for the preliminary classification of this site.

4.4 Lords Wood does not require classification at present so sampling should not be undertaken unless the harvester has requested otherwise. If classification this site be needed in the future, an RMP located at SX 8793 5400 (Lords Wood North) would be representative of this site. A tolerance of 10m should be set around this RMP. Stock of a harvestable size, which has been placed in this location for no less than two weeks should be sampled.

5. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area	Dart
Cefas Main Site Reference	M028
Cefas Area Reference	FDR 3531
Ordnance survey 1:25,000 map	Explorer OL 20 (South Devon)
Admiralty Chart	Admiralty 2253 (Dartmouth Harbour)

Shellfishery

Species/culture	Pacific oysters (*C. gigas*)	Cultured
Seasonality of harvest	Year round	

Local Enforcement Authority

Name	South Hams District Council, Environmental Health, Follaton House, Plymouth Road, TOTNES, Devon, TQ9 5NE
Environmental Health Officer	Peter J. Wearden (Divisional EHO)
Telephone number (	01803 861234
E-mail Š	Pete.Wearden@southhams.gov.uk

REQUIREMENT FOR REVIEW

The need for this sampling plan to be reviewed will be assessed by the competent authority within six years or in light of any obvious known changes in sources of pollution of human (e.g. improvements in sewage treatment works) or animal origin likely to be a source of contamination for the bivalve mollusc production area.

Table 5.1 Details of representative monitoring point for Pacific oysters at Long Wood.

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Long Wood	B028P	Long Wood South	SX 8794 5350	50°22.24'N 3°34.63'W	*C. gigas*	Trestle	Hand	Hand	10m	Monthly.	New classification zone
Lords Wood	TBA if and when required	Lords Wood North	SX 8753 5400	50°22.51'N 3°34.98'W	*C. gigas*	Trestle	Hand	Hand	10m	Monthly.	This site does not require classification at present as it is used as a nursery area only. Only to be sampled if and when this site requires classification.

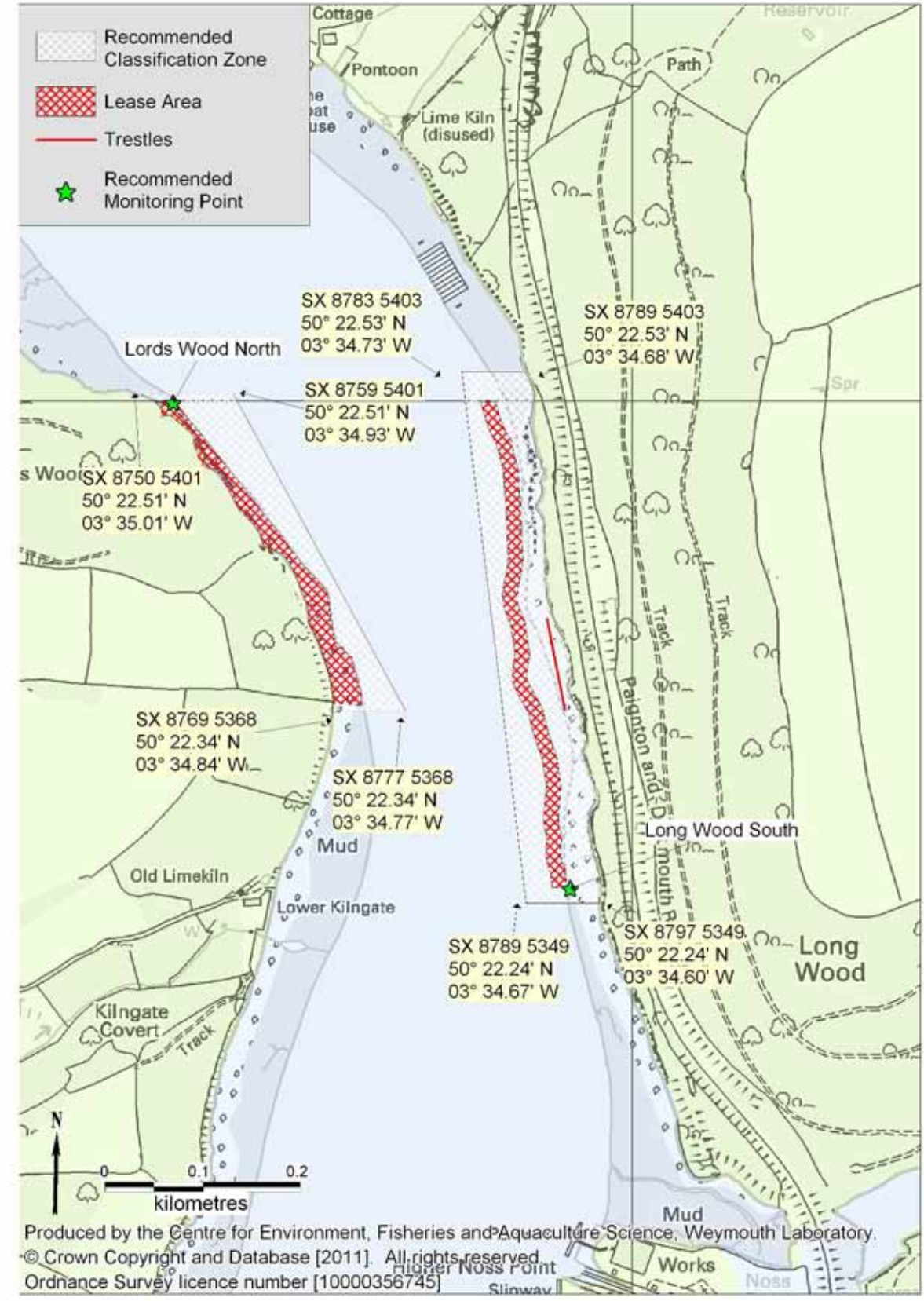


Figure 5.1 Classification monitoring recommendations

APPENDICES

APPENDIX I
SHORELINE SURVEY REPORT

Date (time): 22nd November 2010 (10:30−12:00 GMT)
Applicant: Mr G. Congdon
Cefas Officers: Alastair Cook
Area surveyed: Dart Estuary, Greenway Quay to Noss Marina (Figure XIII.1).
Weather: Winds north easterly force 4, 8°C, overcast.
Tidal predictions (Greenway Quay) for 22nd November 2010: High Water (4.86m) at 06:28 GMT, Low water (1.0m) at 12:20 GMT, High Water (4.73m) at 18:45 GMT.

Objectives: (a) establish the geographical extent of the fishery and its *modus operandus*; (b) obtain samples of seawater and freshwater inputs in the immediate vicinity of the fishery for bacteriological testing; and (c) identify any additional sources of contamination in the immediate vicinity of the fishery which may cause noticeable differences in levels of contamination across the lease area. A full list of recorded observations is presented in Table 1 and the locations of these observations are mapped in Figure 1. Photographs referenced in the text are presented in Figures 3-5.

Description of Fishery

At the time of survey there was one row of trestles of approximately 100m in length (Figure 2), the location of which is indicated in Figure 1. Pacific oysters are grown here from seed, and at the time of survey only juvenile stock was present. The harvester has been granted a lease for a larger area of the shoreline at Long Wood (Figure 1) into which expansion is planned. Therefore, the entire lease area will require classification. The trestles currently in place lie just inshore of the lease boundaries that were indicated on the application, so it would be appropriate for the classification zone here to include the adjacent intertidal area extending to MHWS. The harvester also indicated that in the future, there is the possibility he may apply for a lease to further expand the operation to the opposite bank of the estuary, but as this is unlikely to occur in the foreseeable future there is no point in classifying this potential site at present. Harvesting may occur throughout most of the year with the exception of July and August, when the oysters are in relatively poor (post spawning) condition.

Sources of contamination

Significant numbers of swinging moorings were observed at Noss (Figure 3) about 500m to the south of the site, and at Greenway, about 1km to the north of the site. Larger yachts were seen at Noss, whereas there was a mixture of smaller boats and yachts at Greenway (Figure 4). There is also a marina at Noss, and a small boatyard at Greenway. Therefore it is concluded that there is likely to be a higher risk of overboard discharges in the vicinity of Noss, to the south of the site. The grower advised that the risk of overboard discharges occurring is highest during the summer, when more yachts are in occupation.

Significant expansion of the Marina here is planned in the near future, which is likely to increase its importance as a source of contamination to the fishery.

Immediately to the south of the site is a significant freshwater input which was discharging at a rate of approximately 0.72m^3/sec at the time of survey. A water sample taken from this stream contained 140 *E. coli* cfu/100ml, so the calculated bacterial loading carried by this stream at the time is 8.7x10^9 cfu/day. It flows through a wooded valley with surrounded by pastures, then through a pond just upstream of where it discharges to the estuary. Therefore the woodland buffer strip is likely to reduce the impacts of livestock on this stream, and significant die-off of bacteria may occur within the pond, depending on residence time. No other streams were observed discharging to the east shore near Long Wood, although one concrete wall possibly concealing a surface water outfall or private sewer outfall was observed just to the north of the lease area (Figure 5), but as this was covered at the time of survey it was not possible to investigate further.

Sample results

Water sample results are presented in Table 2. These indicate that the freshwater input was actually less contaminated than the surface water samples from the Dart estuary, suggesting that at the time it did not constitute a significant source of contamination to the site under the condition on the day, although under other conditions the situation may be different.

Surface seawater samples contained relatively high levels of contamination which increased towards the upstream end of this stretch. However, the tide was ebbing quite strongly throughout the survey, and samples were taken starting from the downstream end working upstream. Therefore this is likely to be due to increasing levels of contamination in water arriving from further up the estuary, rather than such a distinct gradient in levels of contamination across the site at any given instant.

The two salinity profiles taken indicated slightly higher freshwater influence towards the upstream end of the site, but the same proviso applies to these as to the surface seawater samples. Vertical gradients were observed in both salinity profiles, with salinity increasing by about 6ppt from the surface down to 6m depth.

Table 1. Details of shoreline observations

No.	Date and Time	Position	Observation
1	22-NOV-10 10:49:19AM	SX 88148 53171	Stream 2.9mx0.16mx1.174m/s and 3.2mx0.2mx0.273m/s. Water sample 1
2	22-NOV-10 11:05:10AM	SX 87908 53411	Salinity profile 1. 19.2ppt and 10.3C at 0m, 20.4ppt and 10.3C at 2m, 21.5ppt and 11.1C at 4m, 25.2ppt and 11.2C at 6m. Water sample 2.
3	22-NOV-10 11:09:08AM	SX 87913 53777	End of single row of trestles
4	22-NOV-10 11:11:02AM	SX 87931 53684	Other end of single row of trestles
5	22-NOV-10 11:12:45AM	SX 87920 53735	Water sample 3
6	22-NOV-10 11:17:16AM	SX 87712 54035	Salinity profile 2. 17.6ppt and 10.4C at 0m, 20.8ppt and 10.8C at 2m, 23.3ppt and 11.2C at 4m, 23.2ppt and 11.2C at 6m. Water sample 2.
7	22-NOV-10 11:22:40AM	SX 87590 54308	Possible outfall pipe from private house
8	22-NOV-10 11:23:34AM	SX 87546 54336	Water sample 4

Table 2. Water sample results

Sample reference	Date and time	Position	Type	*E. coli* result (cfu/100ml)
1	22-NOV-10 10:49:19AM	SX 88148 53171	Freshwater	140
2	22-NOV-10 11:05:10AM	SX 87908 53411	Seawater	300
3	22-NOV-10 11:12:45AM	SX 87920 53735	Seawater	400
4	22-NOV-10 11:23:34AM	SX 87546 54336	Seawater	1200

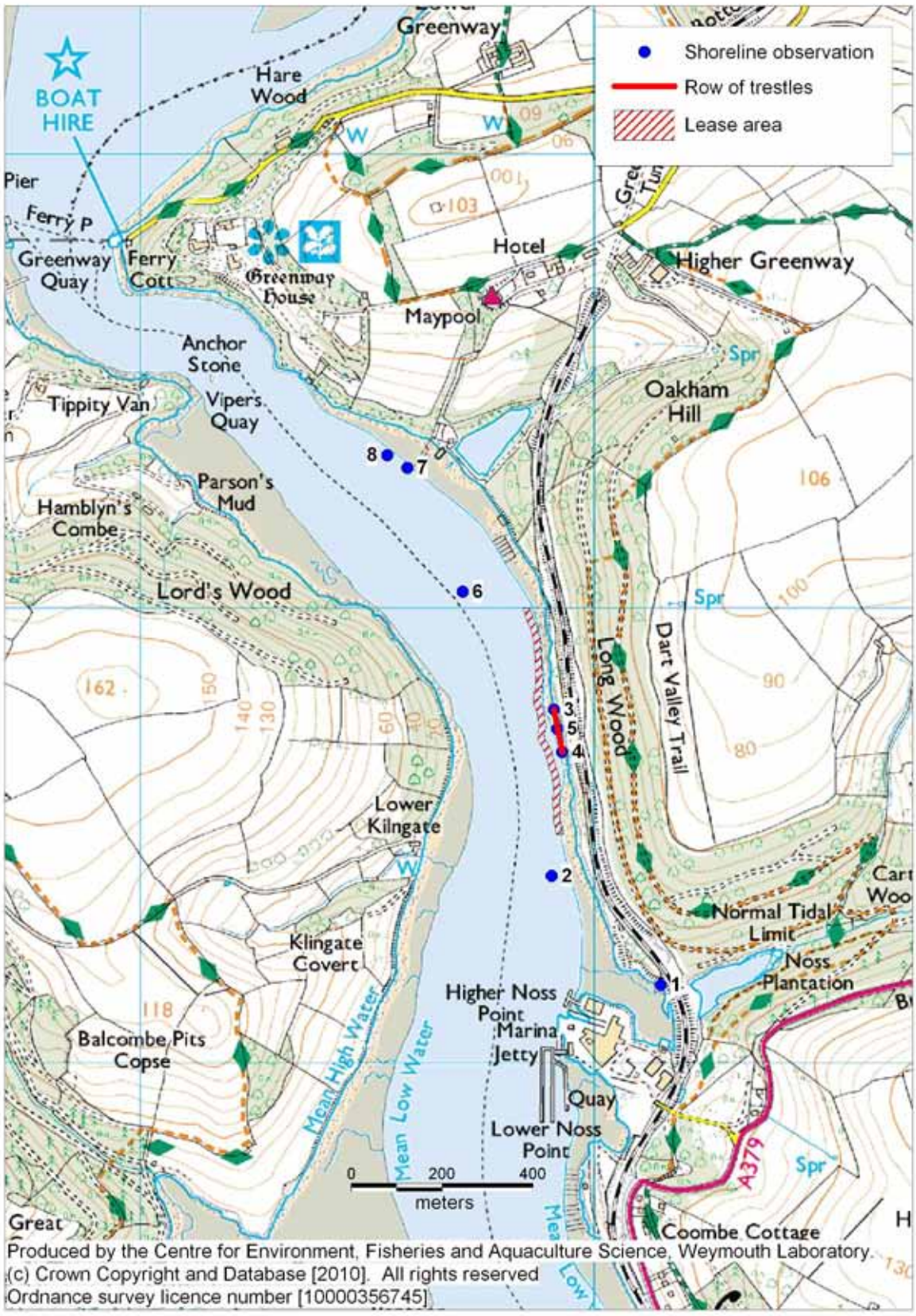


Figure 1. Locations of shoreline observations

Conclusions

Local sources which may cause a spatial variation across the lease area include the Noss Marina and moorings, and a watercourse, both of which are located just to the south of the lease area. The former is likely to be highly seasonal, and the latter was carried water which was less contaminated than that of the estuary at the time of sampling although it is unlikely that this is always the case. To the north there are some moorings at Greenway, and a possible surface water or private sewer outfall just south of Maypool. There are no contamination sources discharging within the lease area. Surface water sample results gave the impression of higher levels of contamination towards the upstream end of the reach surveyed, but this was probably due to the ebbing tide at the time.

A previous sanitary survey of the Dart estuary identified that the majority of sources of contamination to the Dart estuary are north of the fishery at Long Wood, although there are further significant sources in the lower estuary south of the fishery. There is a relatively uncomplicated bi-directional tidal current moving up and down the estuary in the vicinity of the fishery. There will be a residual seaward flow due to freshwater inputs. Tidal diamonds indicate flows here peak at about 0.6 m/s on spring tides so contamination from sources up to 10 km away may potentially be transported to the fishery during the course of a flood or ebb tide.

There may therefore be noticeable spatial variation in levels of contamination across the lease area along the north-south plane. As there are no shoreline sources within the lease area, highest levels of contamination will be experienced at either the north or the south end. Shoreline survey observations suggest indicate the south end is closest to potentially significant sources of contamination, whereas water sample results tentatively suggest the opposite. As the intertidal zone in which the fishery is located is less than 50m wide it is unlikely that there is a significant difference in levels of contamination on the east-west plane. Therefore it is recommended that a bacteriological survey points are established at the north and south ends of the site to assess whether there is any consistent spatial variation in levels of contamination across this site.

Recommendations for bacteriological survey

The number and location of final representative monitoring points (RMPs) will be determined by the results of the bacteriological survey and final assessment of the desk study. Where the final RMPs coincide with points monitored for the purposes of bacteriological survey, the results from these sites can be used towards classification providing they are collected and processed in accordance with the standard protocols. Provisional classifications may be awarded following 10 samplings (from final RMPs) at intervals of at least 1 week apart.

RMPs are set in locations to be best protective of public health – i.e. in places within the production area boundaries where highest levels of contamination are

recorded / expected. In order to determine the location of bacteriological survey points information on the location and nature of the fishery, the locations and magnitudes of sources of contamination, sampling results from the shoreline survey, and the pattern of water circulation within the estuary were taken into consideration.

It is recommended that a bacteriological survey points are established at the points indicated at the north and south ends of the site (Figure 2). Bagged oysters of a harvestable size should be laid here for at least 2 weeks before sampling to allow levels of *E. coli* within them to equilibrate properly. A total of 10 samples should be taken from each of these two monitoring points not less than 1 week apart.

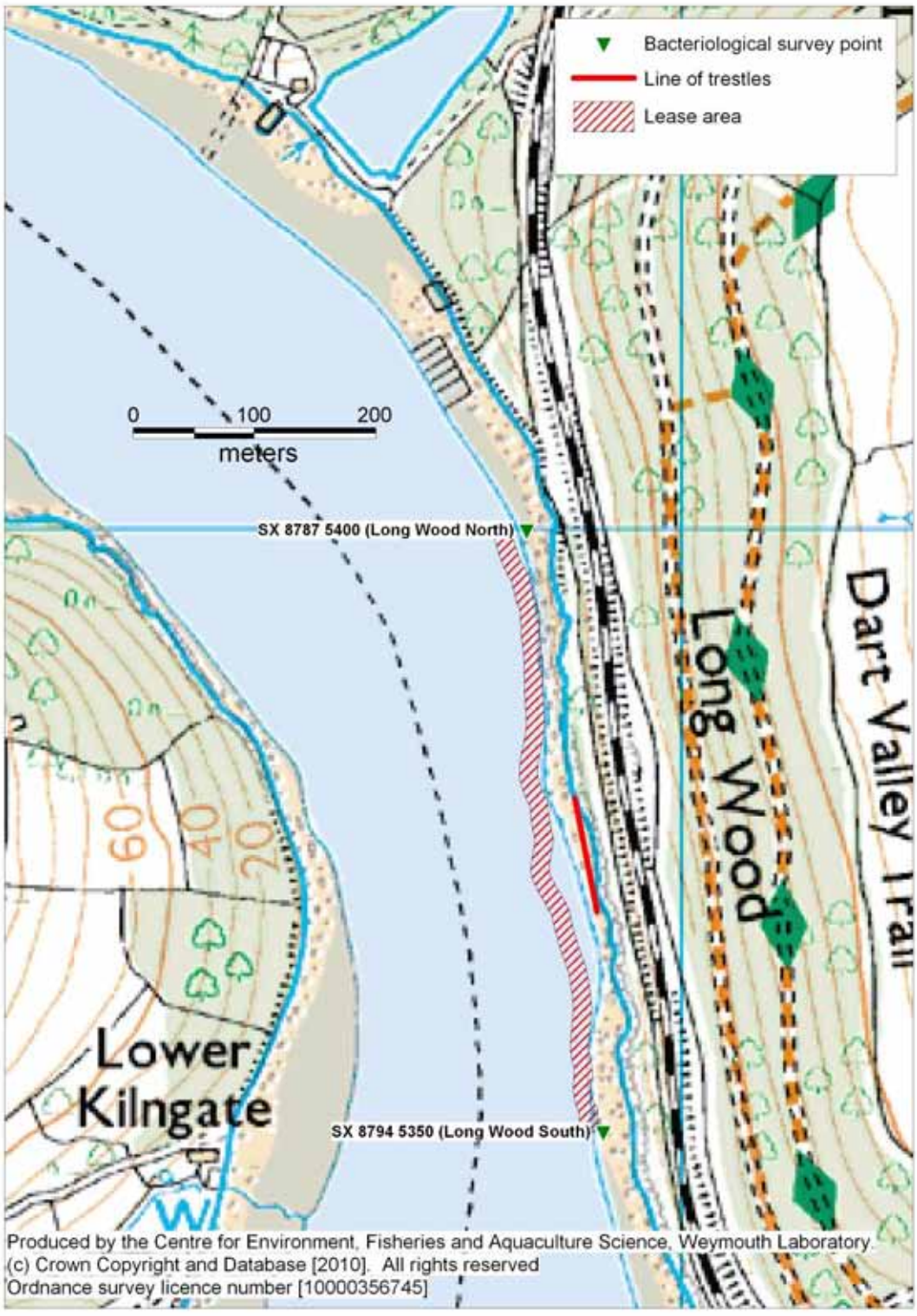


Figure 2. Bacteriological survey points, Pacific oysters at Long Wood, Dart estuary

Figure 3. Trestles at Long Wood with moorings at Noss in the background

Figure 4 Some of the moorings at Greenway

Figure 5 Wall extending from the boat house south of Maypool

APPENDIX II
ANALYSIS OF RECENT SHELLFISH HYGIENE MONITORING RESULTS

Details of all shellfish samples taken from under the classification monitoring programme since January 2008 were extracted from the SHS database in June 2011. The locations sampled are shown in Figure III.1 and III.2, and summary statistics are presented by RMP in Table II.1 for all sites sampled on at least 10 occasions.

Table II.1. Summary statistics for sites sampled more than 10 times since January 2008

RMP	Species	No.	Date of first sample	Date of last sample	*E. coli* results (MPN/100g)			
					Geometric mean	Min	Max	%>4600
Flat Owers	P. oysters	40	12/02/2008	15/06/2011	432	<20	11000	5%
Higher Gurrow Point	P. oysters	34	25/02/2009	15/06/2011	390	<20	35000	3%
Kingswear	P. oysters	16	05/05/2010	14/06/2011	196	<20	16000	13%
Sandridge Boathouse	P. oysters	39	12/02/2008	15/06/2011	349	40	5400	3%
Waddeton	P. oysters	41	22/01/2008	15/06/2011	475	<20	17000	7%
Flat Owers	Mussels	39	12/02/2008	15/06/2011	834	20	31000	21%
Kingswear	Mussels	16	05/05/2010	14/06/2011	105	<20	1700	0%
Sandridge Boathouse	Mussels	40	12/02/2008	15/06/2011	831	20	31000	13%
Waddeton	Mussels	41	22/01/2008	15/06/2011	858	<20	24000	17%

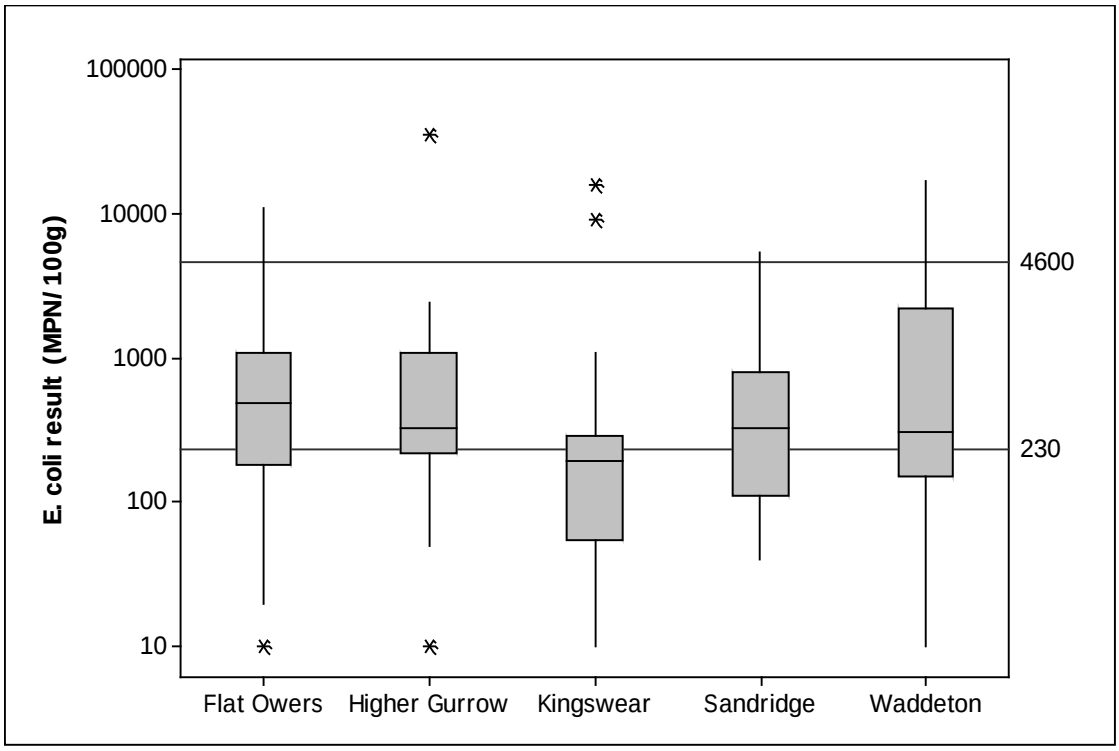


Figure II.2 Boxplot of Pacific oyster results by site

Results for Pacific oysters were similar at the four mid estuary sites and generally lower at Kingswear, but differences between mean results were not statistically significant (One way ANOVA, p=0.388).

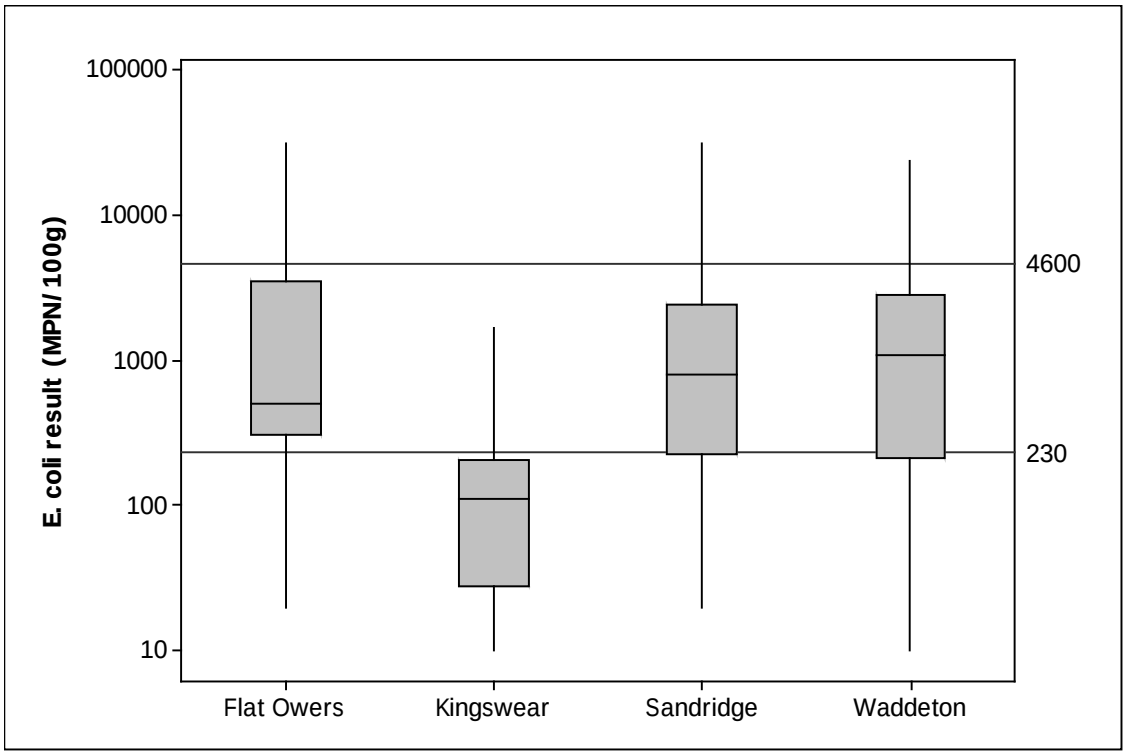


Figure II.3 Boxplot of mussel results by site

Again, results were similar for the mid estuary sites, and lower at Kingswear. In this instance the difference was statistically significant (One way ANOVA, p=0.000).

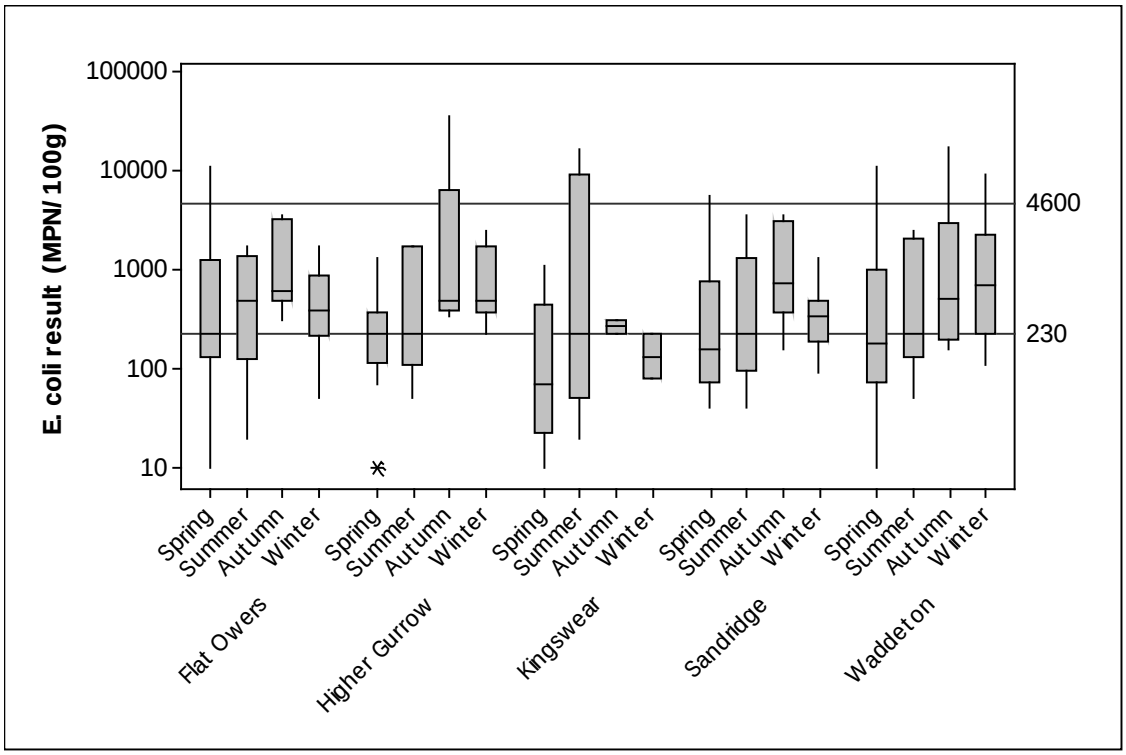


Figure II.4 Boxplot of Pacific oyster results by season and site

A similar seasonal pattern is apparent for all these sites, with a tendency for higher results in the autumn and lower results in the spring. This pattern was just statistically significant at Higher Gurrow Point only (One way ANOVA, p=0.043).

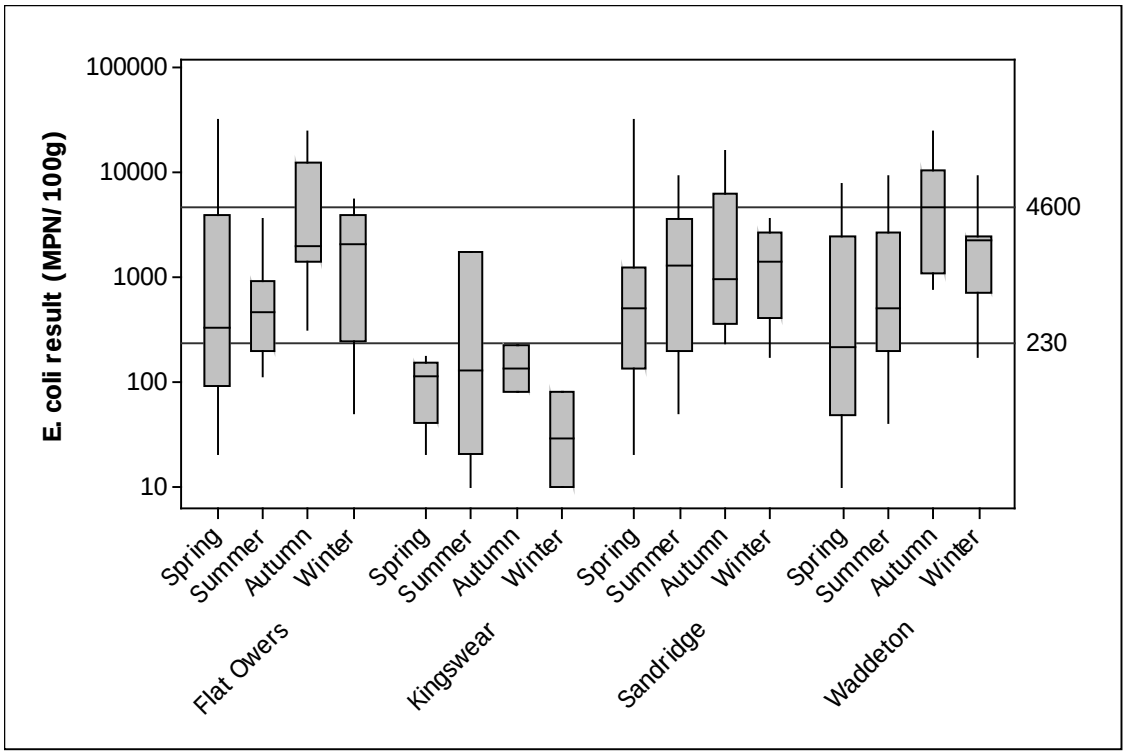


Figure II.5 Boxplot of mussel results by season and site

As for oysters, results tended to be lowest in the spring and highest in the summer, but this pattern was only statistically significant for one of the sites (Waddeton, One way ANOVA, p=0.010).

A bacteriological survey has been completed and a total of 12 pairs of samples have been collected from the two points indicated in Appendix I, Figure I.2. Results are summarised in Table II.2 and Figure II.6.

Table II.2. Summary of Long Wood bacteriological survey results to date

	***E. coli* results (MPN/100g)**	
Date	**Long Wood North**	**Long Wood South**
03/02/2011	110	40
21/02/2011	490	330
09/03/2011	80	230
16/03/2011	10	40
23/03/2011	1700	50
03/05/2011	230	330
31/05/2011	80	310
07/07/2011	490	330
15/08/2011	130	330
10/10/2011	330	170
10/11/2011	330	790
14/12/2011	490	230
Geometric mean	214	189
Maximum	1700	790
% over 230	42%	42%

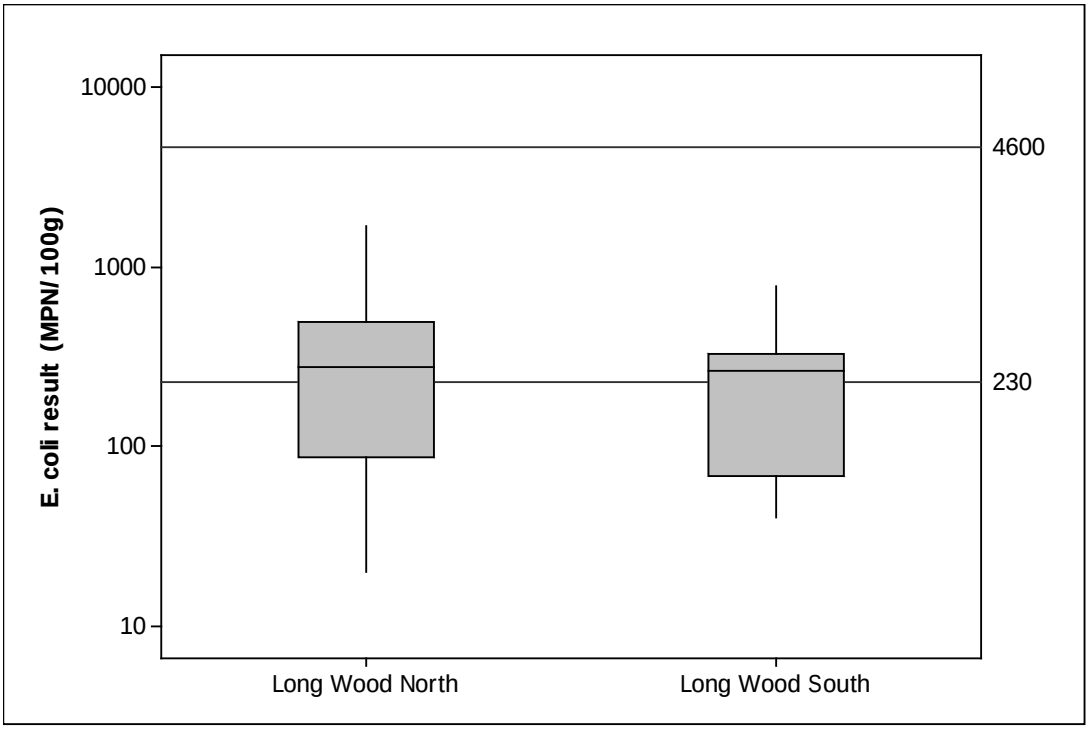


Figure II.6 Boxplot of Long Wood bacteriological survey results

Results were similar at both sites, although they were more variable with a higher peak result at Long Wood North. No significant difference was found between the two sites (Paired T-test, p=0.756).

APPENDIX III
EXISTING CLASSIFICATION MONITORING ARRANGEMENTS FOR THE DART ESTUARY

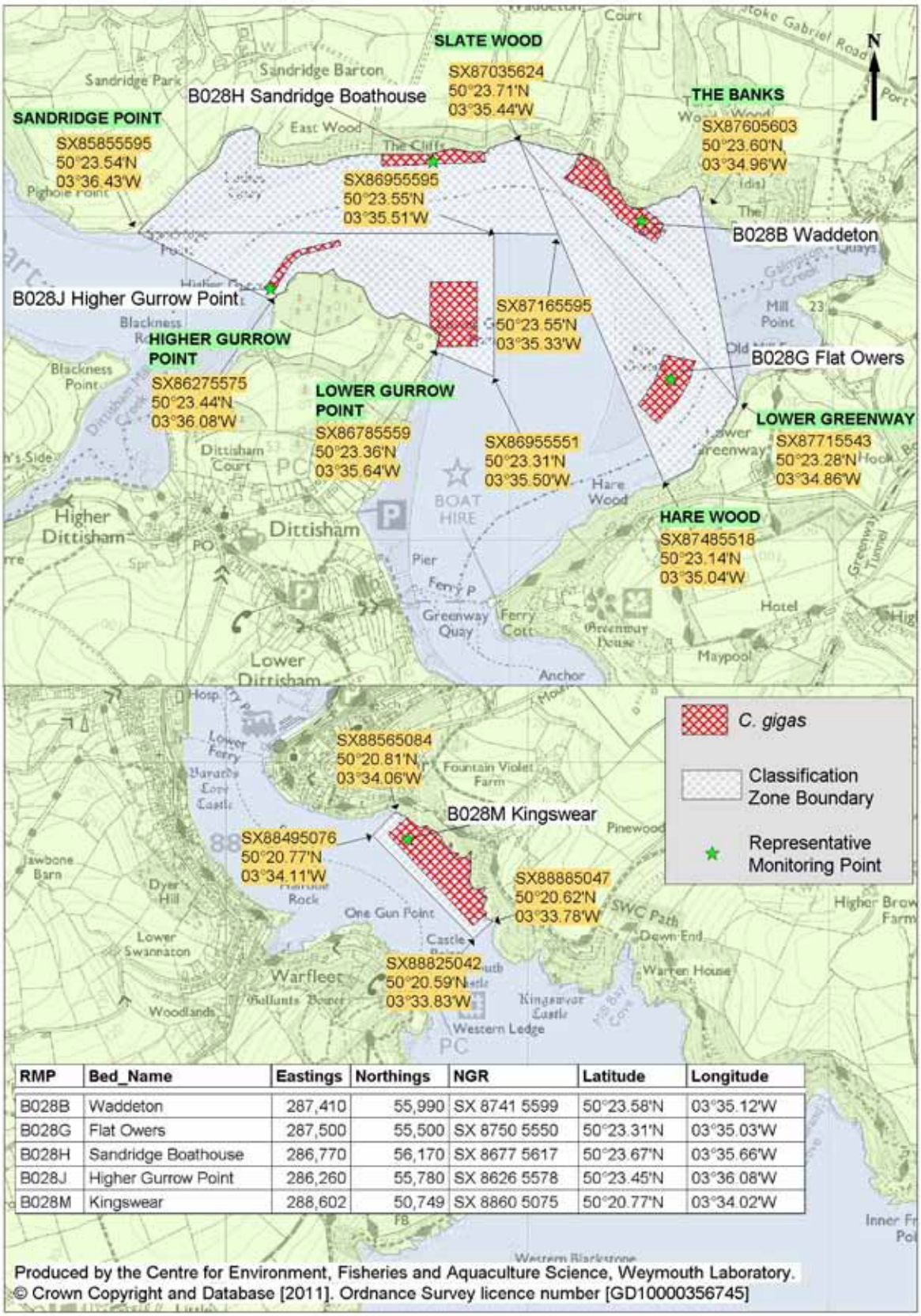
Table III.1 Number and location of representative monitoring points (RMPs) and frequency of sampling.

RMP	Bed name	Geographic grid references (datum) of sampling points*					Species	Growing method	Harvesting technique	Sampling method	Depth	Frequency
		OSGB36			WGS84							
		Easting	Northing	NGR	Latitude	Longitude						
B028J	Higher Gurrow Point	286260	055780	SX 8626 5578	50° 23.45'N	3° 36.08'W	Pacific oysters (*C. gigas*)	Trestles	Hand-picking	Hand-picked from bags via shore	Depth of trestles	At least monthly
B028K	Higher Gurrow Point	286260	055780	SX 8626 5578	50° 23.45'N	3° 36.08'W	Mussels (*Mytilus* spp.)	River-bed culture	Hand-picking	Hand-picked from river-bed	Riverbed	At least monthly
B028J	Higher Gurrow Point	286260	055780	SX 8626 5578	50° 23.45'N	3° 36.08'W	Pacific oysters (*C. gigas*)	Trestles	Hand-picking	Hand-picked from bags via shore	Depth of trestles	*Preliminary classification:* 10 samples taken over at least 3 months (interval between sampling not less than 1 week). *Full classification:* at least monthly over one year
B028N	Lower Gurrow Point	286780	55765	SX 8678 5577	50° 23.45'N	3° 35.64'W	Mussels (*Mytilus* spp.)	Trestles/ River-bed culture	Hand-picking	Hand-picked from river-bed	Riverbed	*Preliminary classification:* 10 samples taken over at least 3 months (interval between sampling not less than 1 week). *Full classification:* at least monthly over one year

B028H	Sandridge Boathouse	286580	056180	SX 8658 5618	50° 23.67'N	3° 35.82'W	Pacific oysters (*C. gigas*)	Trestles	Hand-picking	Hand-picked from bags via shore	Depth of trestles	At least monthly
B028E	Sandridge Boathouse	286580	056180	SX 8658 5618	50° 23.67'N	3° 35.82'W	Mussels (*Mytilus* spp.)	River-bed culture	Hand-picking	Hand-picked from river-bed	Riverbed	At least monthly
B028B	Waddeton	287410	55990	SX 8741 5599	50° 23.57'N	3° 35.12'W	Pacific oysters (*C. gigas*)	Trestles	Hand-picking	Hand-picked from bags via shore	Depth of trestles	At least monthly
B028F	Waddeton	287410	55990	SX 8741 5599	50° 23.57'N	3° 35.12'W	Mussels (*Mytilus* spp.)	River-bed culture	Hand-picking	Hand-picked from river-bed	Riverbed	At least monthly
B028G	Flat Owers	287500	055500	SX 8750 5550	50° 23.31'N	3° 35.03'W	Pacific oysters (*C. gigas*)	Trestles	Hand-picking	Hand-picked from bags via shore	Depth of trestles	At least monthly
B028C	Flat Owers	287500	055500	SX 8750 5550	50° 23.31'N	3° 35.03'W	Mussels (*Mytilus* spp.)	River-bed culture	Hand-picking	Hand-picked from river-bed	Riverbed	At least monthly
B028M	Kingswear	288602	50749	SX 8860 5075	50° 20.76'N	3° 34.02'W	Pacific oysters (*C. gigas*)	Bags in cage	Recovered by boat	Hand-picked from bags recovered by boat	3m	*Preliminary classification:* 10 samples taken over at least 3 months (interval between sampling not less than 1 week). *Full classification:* at least monthly over one year

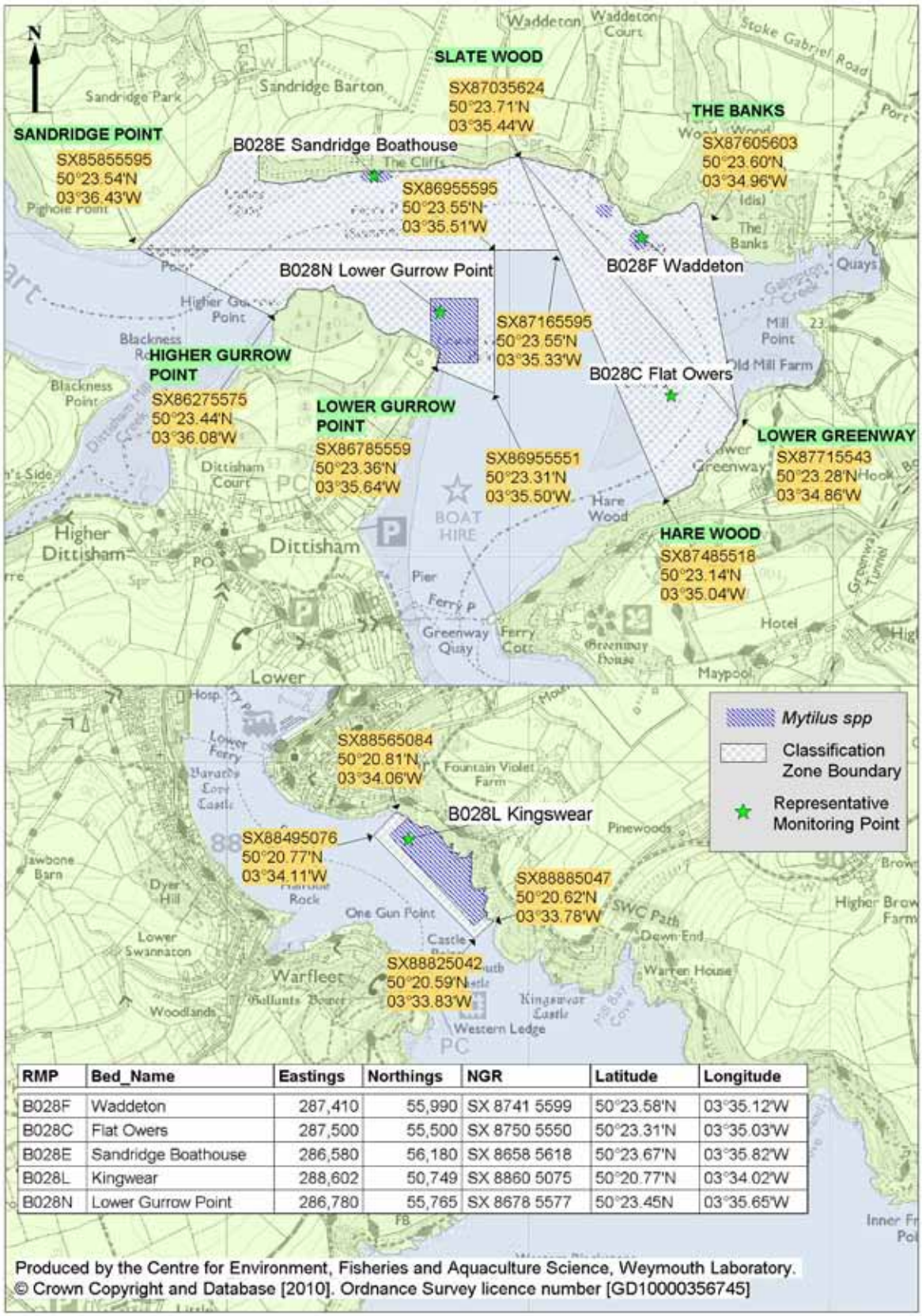
B028L	Kingswear	288602	50749	SX 8860 5075	50° 20.76'N	3° 34.02'W	Mussels (*Mytilus* spp.)	Bags in cage	Recovered by boat	Hand-picked from bags recovered by boat	3m	*Preliminary classification:* 10 samples taken over at least 3 months (interval between sampling not less than 1 week). *Full classification:* at least monthly over one year

* Tolerance for representative monitoring points: 10 metres.



RMP	Bed_Name	Eastings	Northings	NGR	Latitude	Longitude
B028B	Waddeton	287,410	55,990	SX 8741 5599	50°23.58'N	03°35.12'W
B028G	Flat Owers	287,500	55,500	SX 8750 5550	50°23.31'N	03°35.03'W
B028H	Sandridge Boathouse	286,770	56,170	SX 8677 5617	50°23.67'N	03°35.66'W
B028J	Higher Gurrow Point	286,260	55,780	SX 8626 5578	50°23.45'N	03°36.08'W
B028M	Kingswear	288,602	50,749	SX 8860 5075	50°20.77'N	03°34.02'W

Figure III.1 Location of representative monitoring points (RMPs) and production area boundaries for Pacific oysters (C. gigas) in the Dart Estuary.



RMP	Bed_Name	Eastings	Northings	NGR	Latitude	Longitude
B028F	Waddeton	287,410	55,990	SX 8741 5599	50°23.58'N	03°35.12'W
B028C	Flat Owers	287,500	55,500	SX 8750 5550	50°23.31'N	03°35.03'W
B028E	Sandridge Boathouse	286,580	56,180	SX 8658 5618	50°23.67'N	03°35.82'W
B028L	Kingwear	288,602	50,749	SX 8860 5075	50°20.77'N	03°34.02'W
B028N	Lower Gurrow Point	286,780	55,765	SX 8678 5577	50°23.45N	03°35.65'W

Figure III.2 Location of representative monitoring points (RMPs) and production area boundaries for mussels (Mytilus spp.) in the Dart Estuary.

References

CEFAS, 209. Sanitary survey of the Dart Estuary (Devon). Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under of Regulation (EC) No. 854/2004.

CEFAS, 2010. Sanitary survey of the Dart Estuary (Devon). Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under of Regulation (EC) No. 854/2004.

NERC, 2011b. UK guaging station network. Available at: http://www.ceh.ac.uk/data/nrfa/uk_gauging_station_network.html

PRIESTLEY, A. D. AND THAIN, R. H. C., 2005. The physical oceanography of the lower Dart Estuary: temporal trends and frontal dynamics. In ECSA Symposium. Estuaries of South West England. University of Plymouth, 6-8 April 2005.

List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
ISO	International Organization for Standardization
km	Kilometre
LEA (LFA)	Local Enforcement Authority formerly Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPN	Most Probable Number
OSGB36	Ordnance Survey Great Britain 1936
mtDNA	Mitochondrial DNA
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

Bathing Water	Element of surface water used for bathing by a large number of people. Bathing waters may be classed as either EC designated or non-designated OR those waters specified in section 104 of the Water Resources Act, 1991.
Bivalve mollusc	Any marine or freshwater mollusc of the class Pelecypoda (formerly Bivalvia or Lamellibranchia), having a laterally compressed body, a shell consisting of two hinged valves, and gills for respiration. The group includes clams, cockles, oysters and mussels.
Classification of bivalve mollusc production or relaying areas	Official monitoring programme to determine the microbiological contamination in classified production and relaying areas according to the requirements of Annex II, Chapter II of EC Regulation 854/2004.
Coliform	Gram negative, facultatively anaerobic rod-shaped bacteria which ferment lactose to produce acid and gas at 37°C. Members of this group normally inhabit the intestine of warm-blooded animals but may also be found in the environment (e.g. on plant material and soil).
Combined Sewer Overflow	A system for allowing the discharge of sewage (usually dilute crude) from a sewer system following heavy rainfall. This diverts high flows away from the sewers or treatment works further down the sewerage system.
Discharge	Flow of effluent into the environment.
Dry Weather Flow (DWF)	The average daily flow to the treatment works during seven consecutive days without rain following seven days during which rainfall did not exceed 0.25 mm on any one day (excludes public or local holidays). With a significant industrial input the dry weather flow is based on the flows during five working days if production is limited to that period.
Ebb tide	The falling tide, immediately following the period of high water and preceding the flood tide. Ebb-dominant estuaries have asymmetric tidal currents with a shorter ebb phase with higher speeds and a longer flood phase with lower speeds. In general, ebb-dominant estuaries have an amplitude of tidal range to mean depth ratio of less than 0.2.
EC Directive	Community legislation as set out in Article 189 of the Treaty of Rome. Directives are binding but set out only the results to be achieved leaving the methods of implementation to Member States, although a Directive will specify a date by which formal implementation is required.
EC Regulation	Body of European Union law involved in the regulation of state support to commercial industries, and of certain industry sectors and public services.
Emergency Overflow	A system for allowing the discharge of sewage (usually crude) from a sewer system or sewage treatment works in the case of equipment failure.
Escherichia coli (*E. coli*)	A species of bacterium that is a member of the faecal coliform group (see below). It is more specifically associated with the intestines of warm-blooded animals and birds than other members of the faecal coliform group.
E. coli O157	E. *coli* O157 is one of hundreds of strains of the bacterium *Escherichia coli*. Although most strains are harmless, this strain produces a powerful toxin that can cause severe illness. The strain O157:H7 has been found in the intestines of healthy cattle, deer, goats and sheep.
Faecal coliforms	A group of bacteria found in faeces and used as a parameter in the Hygiene Regulations, Shellfish and Bathing Water Directives, *E. coli* is the most common example of faecal coliform. Coliforms (see above) which can produce their characteristic reactions (e.g. production of acid from lactose) at 44°C as well as 37°C. Usually, but not exclusively, associated with the intestines of warm-blooded animals and birds.
Flood tide	The rising tide, immediately following the period of low water and

	preceding the ebb tide.
Flow ratio	Ratio of the volume of freshwater entering into an estuary during the tidal cycle to the volume of water flowing up the estuary through a given cross section during the flood tide.
Geometric mean	The geometric mean of a series of N numbers is the N^{th} root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the anti-log of that mean. It is often used to describe the typical values of a skewed data such as one following a log-normal distribution.
Hydrodynamics	Scientific discipline concerned with the mechanical properties of liquids.
Hydrography	The study, surveying, and mapping of the oceans, seas, and rivers.
Lowess	LOcally WEighted Scatterplot Smoothing, more descriptively known as locally weighted polynomial regression. At each point of a given data set, a low-degree polynomial is fitted to a subset of the data, with explanatory variable values near the point whose response is being estimated. The polynomial is fitted using weighted least squares, giving more weight to points near the point whose response is being estimated and less weight to points further away. The value of the regression function for the point is then obtained by evaluating the local polynomial using the explanatory variable values for that data point. The LOWESS fit is complete after regression function values have been computed for each of the *n* data points. LOWESS fit enhances the visual information on a scatterplot.
Telemetry	A means of collecting information by unmanned monitoring stations (often rainfall or river flows) using a computer that is connected to the public telephone system.
Secondary Treatment	Treatment to applied to breakdown and reduce the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage or further treatment of settled sewage, generally by biological oxidation.
Sewage	Sewage can be defined as liquid, of whatever quality that is or has been in a sewer. It consists of waterborne waste from domestic, trade and industrial sources together with rainfall from subsoil and surface water.
Sewage Treatment Works (STW)	Facility for treating the waste water from predominantly domestic and trade premises.
Sewer	A pipe for the transport of sewage.
Sewerage	A system of connected sewers, often incorporating inter-stage pumping stations and overflows.
Storm Water	Rainfall which runs off roofs, roads, gulleys, etc. In some areas, storm water is collected and discharged to separate sewers, whilst in combined sewers it forms a diluted sewage.
Waste water	Any waste water but see also “sewage”.

Acknowledgements

Kevan Connolly, Environment Agency, Mr G. Congdon (Harvester).